# Title XII Collaborative Research Support Program

# Eleventh Annual Administrative Report

**1 September 1992 to 31 August 1993**

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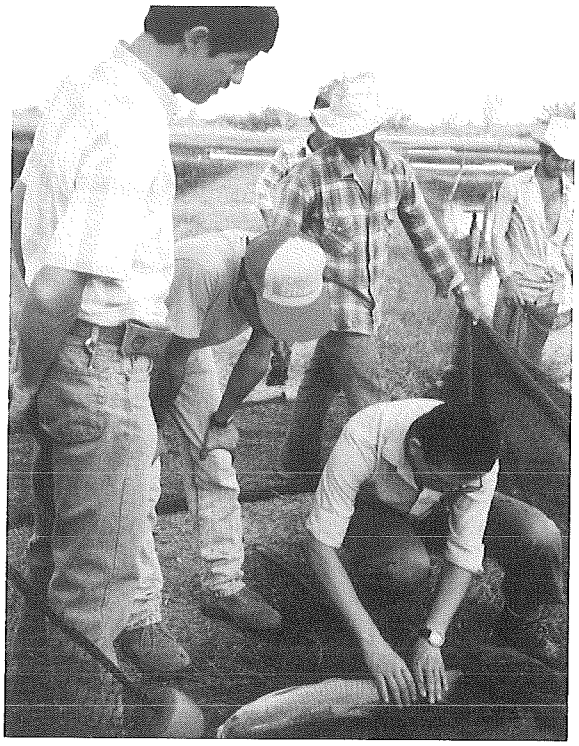
# I. Introduction

## Historical Overview

The Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) is an international effort to develop aquacultural technology as a means of confronting food security problems in developing countries. The PD/A CRSP is funded by the U.S. Agency for International Development (USAID), under authority of the International Development and Food Assistance Act of 1975 (P.L. 94-161), and by the universities and institutions that participate in the CRSP. Oregon State University (OSU) is the Management Entity (ME) for the CRSP and has technical, administrative, and fiscal responsibility for the performance of grant provisions.

The CRSP is a cohesive program of research carried out in selected developing countries and the United States by teams of U.S. and host country scientists. The resources of U.S. and host country institutions are brought together to improve the efficiency of pond culture systems through sustainable aquaculture. The U.S. institutions participating in the program are Auburn University, the University of California at Davis, the University of Oklahoma, and the Consortium for International Fisheries and Aquaculture Development (CIFAD). CIFAD members include the University of Arkansas at Pine Bluff, the University of Hawaii, the University of Michigan, Michigan State University, and Oregon State University. Host country institutions with formal linkages to the CRSP through Memoranda of Understanding are the National University of Rwanda, Royal Thai Department of Fisheries, Asian Institute of Technology, Department of Renewable Natural Resources, Agricultural Research Center of Egypt, and Central Luzon State University of the Philippines. Numerous linkages are also maintained with other U.S. and host country governmental and non-governmental institutions, and with private companies and farmers.


CRSP activities were formally initiated on 1 September 1982 after several years of planning. From 1982 to 1987, CRSP projects involved the participation of government agencies and educational institutions in six host countries: Honduras, Indonesia, Panama, the Philippines, Rwanda, and Thailand. Funding constraints during 1986 and 1987 forced a reduction in operations. A reorganization plan was submitted in December 1986 to the Joint Committee on Agricultural Research and Development (JCARD) Panel on CRSPs and the AID Agricultural Sector Council Subcommittee. The plan, which went into effect on 1 September 1987, called for maintaining a presence in each of the USAID geographical areas originally selected, and three country sites were chosen: Rwanda, Thailand, and Panama. However, following that decision, political initiatives in Panama in 1987 made it necessary for the CRSP to leave Panama and return to Honduras. Largely through the efforts of Auburn University and through continuing financial commitments of the USAID Mission, the CRSP was welcomed back into Honduras in April 1988 and began experiments with the assistance of the Honduran Department of Renewable Natural Resources (RENARE) in August 1988.



# New Projects and Opportunities

The termination of brackish water sites in Panama and the Philippines in 1987 altered the approach of the CRSP toward freshwater research.

Now, a new brackish water site in Choluteca, Honduras re-opens opportunities for studies of these environmentally and economically important systems. In accordance with the goals of the USAID Mission in Honduras, the CRSP is conducting research near the Gulf of Fonseca to evaluate environmental impacts and alternative production strategies associated with shrimp farming in that region. Closer collaboration between the PD/A CRSP and Honduran organizations, other CRSPs, and private aquaculture farms will be facilitated through the CRSP's involvement in this new site. CRSP research at the freshwater station in Comayagua, which continues to operate under host country supervision, now focuses on extensions of CRSP global technologies.

The initiation of a new site in Egypt in October 1992 offered the CRSP an exciting opportunity to investigate pond management strategies in an arid climate. The Egypt project is now part of the family of PD/A CRSP projects, but it is unique in that it is funded under a separate grant from USAID/Cairo and the National Agricultural Research Project of Egypt (USAID Grant No. 263-0152-G-00-2231-00). In addition to the mandatory Global Experiment, which is conducted at all CRSP sites, the Egypt project is credited with adding new research thrusts to the CRSP: polyculture, bioconversion, and biotechnology. Also, through the Egypt project, the CRSP has added new researchers to its list of cooperators and has expanded its institutional affiliations (new participants include the Central Laboratory of Aquaculture Research, Abbassa, and the University of Oklahoma). Longtime institutional members of the CRSP also participating in the Egypt project are Oregon State University, Auburn University, University of Hawaii, University of Michigan, and the Asian Institute of Technology.

The Egypt Project presents one example of the CRSP's active pursuit of new opportunities. Because collaborative projects must benefit both the host countries and U.S., as well as fulfilling overall CRSP goals, new opportunities are actually quite rare. Nevertheless, the CRSP has been successful in attracting new projects in four target areas: socioeconomics research, gender studies, on-farm studies, and outreach. Projects in these focus areas are showing their first results and are successfully adding a broader dimension to the CRSP experience. Natural resources management has always been a cornerstone of the CRSP; therefore, the continued efforts in this area are not new. What is new is the integration of natural resources work with sociocultural and economic dimensions of aquaculture.

The economics study initiated in Thailand in 1991 by researchers from the University of Arkansas at Pine Bluff and Michigan State University culminated in a technical report that described profit-making fish culture enterprises in the impoverished Northeast region. This study is complemented by the economics study currently under way in Rwanda—funded primarily through a buy-in from USAID's Historic Black Colleges and Universities (HBCU) Program—and the ongoing private sector research for commercial shrimp and tilapia farms in Honduras. The HBCU grant also enables the University of Arkansas at Pine Bluff to augment core CRSP biological research in Rwanda through much needed experiments on temperature tolerance of tilapia. Many of the technical summaries contained in the Annual Technical Report of this Eleventh Annual Report present practical economic information in addition to the biological analyses that are the mainstay of this CRSP.

The CRSP began a global social sciences project toward the end of this reporting period. Auburn University economists and sociologists are collaborating with researchers from the Philippines, Thailand, and Honduras in an examination of aquaculture technology adoption and diffusion. This project presents

one of the CRSP's first attempts to fully fund a social sciences activity that cuts across a number of CRSP sites. However, continued funding constraints (this CRSP is funded on average at 40 percent of the other CRSPs) may again relegate social science research to be funded primarily through extramural support.

When BIFADEC originally designed the CRSPs, the mandate called for greater focus on research than on outreach. The PD/A CRSP, however, sees the partnership of these two types of activities as critical to achieving positive social impacts. Therefore, greater emphasis during the past year has been placed on farmer participatory research, on extending research information to end users, and on adopting a research strategy that is sustainable and appropriate. The CRSP project in Rwanda, for example, regularly assists the USAID Mission with its natural resources projects and has helped transfer CRSP technologies to Rwandan farmers, who are now experiencing widespread success with fish culture. In Northeast Thailand, the CRSP is cooperating with scientists from other donor agencies in helping farmers help themselves. The direct input that farmers provide to the research process renders the results more relevant and cost-effective.

Other "buy-in" activities include expanding traditional pond dynamics work to encompass a broader analysis of the effects of aquaculture on the environment, a proposal to collaborate with the International Center for Living Aquatic Resources Management (ICLARM) on an aquaculture methods manual, and a proposal to USAID to support a workshop on integrating a social sciences perspective into mainline CRSP research. The CRSP continues to be one of the principal players in the CRSP Council's efforts to attract funding for a large-scale agroecological study in Honduras involving its two most important export products, shrimp and melons.

The CRSP's direct involvement with farmers, educators, and other end users of CRSP technology is one way to actively extend information generated by the program. Other information is extended through the CRSP's numerous publications, which are aimed at technical and non-technical audiences. The CRSP's

recently initiated international effort to write a comprehensive book on the principles of pond dynamics also involves the aquaculture community at-large. This book will be a useful addition to aquaculture researchers' and students' libraries, and an effort is being made to make it available at an affordable price to people in less economically advanced countries. The book will update and expand on an earlier CRSP book, *Principles and Practices of Pond Aquaculture,* which is in its third printing.

## Continuing activities

With the completion of the first three cycles of standardized global experiments (1982-1987), the CRSP began focusing on the statistical interpretation of data that were collected at the six project sites. The research program was successfully modified to reflect the reduction in sites without changing the overall emphasis of the CRSP. The global nature of the program therefore remained intact. Experimental protocol, as described in subsequent work plans, conforms to that of the original three cycles to allow comparison between sites over time. Field experiments blend program-oriented (see Global Experiment and Related Studies) and project-oriented (site-specific) considerations in response to the results of the earlier experiments.

After years of discussion, the CRSP is moving ahead with plans to incorporate much of the CRSP global data base into the International Center for Living Aquatic Resource Management (ICLARM) FISHBASE. This will further ensure safekeeping of the important data that have been collected through ten years of CRSP experiments. In an effort to transfer the CRSP Central Data Base from its present home in the Management Entity to a research project, an ad hoc committee of the Technical Committee undertook a rigorous evaluation of the data base in 1991. The ad hoc committee suggested that in addition to the administrative and maintenance functions now performed by the data base manager, new data base activities should include statistical analyses and a user manual. As a result of the evaluation, an RFP was issued by the Management Entity in 1992. The University of Hawaii at Hilo (UHH) submitted the winning proposal and the data base was transferred from Oregon State University to UHH in Spring of 1993.

The CRSP passed another milestone with the completion of PONDCLASS version 1.1, the expert system on pond management guidelines. This new version incorporates economic criteria and other important production variables. PONDCLASS is now being tested at several field locations, including CRSP sites in Rwanda, northeast Thailand, and the Philippines. PONDCLASS not only provides new technology for fish culturists but also serves as an excellent teaching tool for simulating pond responses to a variety of inputs. The PONDCLASS manual is now available in French; the Rwanda team translated the manual in a cooperative effort with the Data Analysis and Synthesis Team. A Spanish translation of the manual is in progress.

This Eleventh Annual Report contains some summaries of studies that were only partially funded by the CRSP; CRSP funds were used as seed money to leverage support from other sources. For example, the funds for testing CRSP models on farms in the Philippines were matched by University of Hawaii and Central Luzon State University. In addition to the many grants and cooperators affiliated with the CRSP project in Rwanda, the European Economic Community recently contributed funds to improve and expand the pond facilities at the Rwasave. In previous years, funds allocated to a Women in Development study helped to leverage funds from a number of sources.

Other continuing studies include investigations in tropical pond soils, which have allowed us to facilitate linkages with other soils projects such as the TropSoils CRSP in Honduras; polyculture research using native species; and research on ecologically sound alternatives to therapeutic drugs used in fish culture.

An additional annual 9 percent budgetary increase, which was received during this reporting period, was devoted to the new global social sciences project and to a comprehensive external review of the CRSP. The logistics for the External Evaluation were completed during this reporting period. The External Evaluation Panel (EEP) visited all established CRSP sites overseas, attended Technical and Annual CRSP Meetings, visited the Management Entity, and interviewed U.S. and host country participants. The draft EEP report received by the PMO in October 1993 rated the program as "exceptional." Special commendations were given to the Rwanda team, which kept its research project intact despite the ongoing war. The Thailand researchers also received praise for the quality of their basic research and their commitment to the Global Experiment.

The CRSP has benefited from its involvement in the CRSP Council, a group composed of USAID-funded Collaborative Research Support Programs, although full participation in this group extracts a high cost in terms of time and capital from the smaller CRSPs such as ourselves. Through the Council, the PD/A CRSP has over the years participated in presentations to Congress, the World Bank, USDA, USAID, JCARD, and environmental groups. One impact of this effort was to increase public awareness of CRSP programs.

Many other technical and programmatic accomplishments are described in detail in this Eleventh Annual Administrative Report, which covers the period from 1 September 1992 to 31 August 1993. Veteran readers of our Annual Reports will observe that this year's report has been divided into two sections: Program Accomplishments and Technical Reports. Each section has been designed to stand on its own. Program Accomplishments encompasses all administrative, research, and outreach activities during the reporting period and includes sections on program history, personnel, financial status, administrative and management activities, abstracts of all technical experiments conducted during the past year, and non-research activities such as training, publications, and service. Technical Reports focuses on the research accomplishments of the program and contains full technical reports.

# II. Summary of Activities and Accomplishments

## 1 SEPTEMBER 1992 TO 31 AUGUST 1993

Major accomplishments during the current reporting period include the completion of a number of the activities scheduled under the Sixth and Seventh Work Plans, further refinements to several CRSP aquaculture pond models, improvements to the PONDCLASS decision support system, successful transfer of the CRSP Data Base management function to the University of Hawaii at Hilo, and initiation of new projects at the brackish water site in Choluteca, Honduras, and at a freshwater site (Central Laboratory for Aquaculture Research) in Abbassa, Egypt. As in the previous reporting period, research was conducted both at the established CRSP research facilities and in farmers' ponds in the field. A number of Special Topics Research activities were completed, and other research activities of the Sixth and Seventh Work Plans continue. As always, efforts to disseminate research results continued through a variety of avenues.

## Overseas Research

### *Honduras*

This year, the primary research activities of the Honduras project were shifted from the original site at El Carao to a new brackish water site at Choluteca. Collaborative arrangements between the Honduran Ministry of Natural Resources, the National Association of Honduran Aquaculturists (ANDAH), the Federation of Export Producers (FPX), the Escuela Agricola Panamericana, and Auburn University were negotiated prior to the move. In addition, CRSP scientists were involved in renovating a laboratory facility at Choluteca, developing new laboratory techniques (for the analysis of brackish water samples), and training shrimp producers on proper sample collection procedures. Although the main CRSP research site in Honduras is now Choluteca, the freshwater site at El Carao continues to be operated as a CRSP substation, where the Global Experiment and other research is conducted.

A number of brackish water experiments were begun at Choluteca. A study comparing the effects of dietary protein levels on shrimp growout revealed that there was essentially no benefit, in either the wet or dry season, to increasing protein levels from 20 to 40 percent when shrimp were stocked at densities of 5-11/$m^2$. Results from the same study indicated that the lower stocking rate should be used in the dry season because it resulted in higher final mean weights of shrimp. In another study, the relationships of stocking time and several environmental variables to shrimp yield on two farms in southern Honduras were investigated. It was found that good yields usually resulted when juveniles were stocked between March and June, while poorer yields resulted when ponds were stocked between November and February.

Two studies investigated various aspects of soil respiration in bucket microcosms. The results of a study of the effects of soil humidity on respiration suggested that whereas flooding inhibits soil respiration, wetting a dry pond bottom to subsaturation humidity levels (≈35 percent) could beneficially increase respiration and the mineralization of carbon, which would normally decrease drastically after the first week or so of pond drying. In another study, the effects of chicken litter and urea applications on soil respiration were investigated. This study revealed possible reasons why total alkalinity and total hardness levels often increased in organically fertilized ponds at El Carao, and suggested why the use of urea as a supplemental fertilizer might result in pH increases.

## *Rwanda*

At Rwasave station, Rwanda project scientists conducted experiments to determine the maximum levels of primary production and fish production that could be achieved when nitrogen, phosphorus, and carbon were not limiting. The highest rate of fish production achieved in this experiment was 3850 kg/ha/yr. This rate is the highest yet reported for Rwanda, but is still lower than rates reported for the CRSP site in Thailand. Higher levels of fertilization in another treatment, however, actually produced chlorophyll concentrations exceeding those reported for Thailand, suggesting that the lower water temperatures in Rwandan ponds affect fish growth directly, rather than through a reduction of phytoplankton productivity. In another study, supplemental dietary energy (as cassava) was offered to one group of tilapia but withheld from another to determine whether dietary energy/dietary protein (DE/DP) ratios reported in the literature were applicable under Rwandan conditions. No significant difference between the two treatments was observed, suggesting that the DE/DP ratio for tilapia may be lower at lower temperatures, and that the supplementary provision of energy is unnecessary in Rwandan ponds enriched with fresh grass and chemical fertilizers.

Two on-farm studies were conducted in Rwanda during this reporting period. In one, tests of monosex tilapia growth in five high-elevation zones led to the conclusion that reduced yield generally occurring above elevations of about 1700 m may be due to reduced food consumption or utilization on the part of tilapia rather than to decreased primary productivity, because chlorophyll *a* levels remained very high even at the highest elevations. In another experiment, tilapia/*Clarias* polyculture was compared with monocultures of tilapia and *Clarias*. The greatest extrapolated annual yields after 130-150 days occurred in the polyculture systems, with yields of 1604 and 3108 kg/ha/yr at higher and lower elevations, respectively. Although there were no significant differences among yields at harvest, this may have been due to low water levels at the lower elevations or overgrowth of macrophytes at the higher elevations.

At Auburn University, aquarium studies were conducted to determine the effects of temperature on appetite, growth, food conversion efficiency, and final body composition of tilapia. Feed consumption was 37 percent greater at the higher of two temperatures studied (26°C) than at the lower (22°C), but consumption was not affected by daily temperature variations. Fish growth was also greater at 26°C, and was not affected by daily temperature variations. Feed conversion efficiency was affected by average temperature and feeding rate, whereas protein conversion efficiency was affected by average temperature and feeding consumption; neither of these efficiencies was affected by variations in daily temperature. Finally, body composition was affected by feeding rate, but not by temperature.

In an economics study conducted on small-scale fish culture operations, Rwanda project researchers found that other crops were more important in terms of carbohydrate (sweet potatoes) or protein (soybeans) production, but that fish were actually the best cash-generating crop among those studied, which included Irish potatoes, maize, cabbage, soybeans, and sweet potatoes.

## *Thailand*

Thailand project personnel conducted experiments to evaluate the benefits of supplementing fertilized ponds with feeds. After 155 days, high growth rates were observed for fish in treatments receiving feed at 0.5 *x* the *ad libitum* rate or more. Ponds receiving feed at the full *ad libitum* rate exhibited high ammonia levels and only intermediate fish growth, and ponds that were fertilized only (did not receive supplemental feed) had the lowest growth rates. These results indicate that farmers can save 50 percent of feed costs by fertilizing and providing supplemental feed at 0.5 *x* the *ad libitum* rate, rather than at the full *ad libitum* rate.

CRSP scientists in Thailand have been developing and refining an algal bioassay method for use in determining fertilization rates in production ponds. The method uses spikes of various combinations of nutrients to enrich samples of pond water. Color comparisons after three days of incubation indicate

which nutrients are limiting in the pond and the fertilization rates needed to correct deficiencies. The results of this method are generally supported by laboratory analyses. Field testing of CRSP fertilization guidelines, including the algal bioassay technique, have enabled the cost efficiency of tilapia production to be improved to less than THB4/kg on some farms.

In a study carried out in Hawaii, members of the Thailand team characterized photosynthesis and community respiration in a stable phytoplankton stock to provide a baseline for studies of *instability* in phytoplankton stocks. They found that the stocks and oxygen cycles were more resistant to disturbance by low light than was predicted by models for ponds 1 m deep. It was suggested that this stability was related to the shallow depth of the ponds; in such ponds there may be sufficient light penetration to the pond bottom for daytime net primary production to be positive on most dates. In another study conducted in Hawaii, three artificial mixing devices were evaluated as alternatives to active aeration in stratified ponds. All three devices cost considerably less than commercial aerators currently available, and each of them proved capable of destratifying ponds up to 1600 $m^2$.

Research is conducted in the Philippines (at the Freshwater Aquaculture Center) as a sub-project of the Thailand project. During this reporting period experiments were conducted to test CRSP pond management guidelines as suggested by the PONDCLASS decision support system. Preliminary conclusions from these experiments suggest that tilapia can be produced at rates of more than 4000 kg/ha/yr by fertilization alone when nitrogen input rates are 2-4 kg/ha/d. The results also indicate that fertilization at an N input rate of 4 kg/ha/d using only organic fertilizers can increase the risk of incurring fish mortalities due to adverse effects on water quality.

## *Egypt*

Seventh Work Plan experiments initiated in Egypt in 1993 center around four main areas: the Global Experiment, bioconversion, polyculture, and biotechnology. Many of the studies, although initiated in a timely manner, were not scheduled to be completed in time for inclusion in this report. One of these studies was the global study designed to validate, under the arid conditions of Egypt, CRSP pond management strategies developed at the other, more humid sites. Ninety days after stocking, mean fish weights in the "enhanced Egyptian" treatment were 107.5 g–greater than in all other treatments: fertilization-then-feed (97.1 g), chemical fertilization only (89.5 g), the traditional Egyptian system (72.5 g), and feed only (68.2 g). Analysis of the results at harvest (after 150 days) will indicate which of these treatments results in the greatest yield and in the greatest economic return.

Bioconversion studies to evaluate the control and utilization of nuisance plants by grass carp, the control and utilization of snails by black carp, and interactions between snails, nuisance plants, grass carp, and black carp were all initiated during the reporting period. Another bioconversion study was a polyculture experiment in which *Clarias* were stocked with tilapia to evaluate the effectiveness of *Clarias* in controlling recruitment from tilapia reproduction and wild fish that enter the ponds.

Several biotechnology studies were begun at diverse sites during this reporting period. At Oregon State University, researchers identified a binding site for the synthetic androgen mibolerone and initiated studies using short-term immersion of tilapia fry in 17α-methyltestosterone and 17α-ethynylestradiol to evaluate the efficacy of these treatments for masculinization and feminization. Identification of the mibolerone binding site is a first step toward understanding how steroids cause sex inversion in fish, and may provide a possible tool for screening potential sex-inverting compounds. Scientists at Auburn University tested the progeny of tilapia breeding groups to identify YY male tilapia among the broodfish. This effort is a step toward developing a YY tilapia breeding program, and may make a contribution to our ability to produce male tilapia for public consumption that have not been treated with androgenic hormones. At the University of Hawaii, hatchery studies to differentiate the growth-promoting effects of 17α-methyltestosterone from its sex-reversing effects were initiated.


Parallel to these studies at sites in the U.S., preliminary unreplicated clinical field trials using 17α-methyltestosterone to sex-reverse tilapia fry were initiated in ponds at the Central Laboratory for Aquaculture Research at Abbassa, Egypt. The treatment phase was completed and fry were transferred to ponds for growout prior to the end of the reporting period.

# Data Analysis and Synthesis

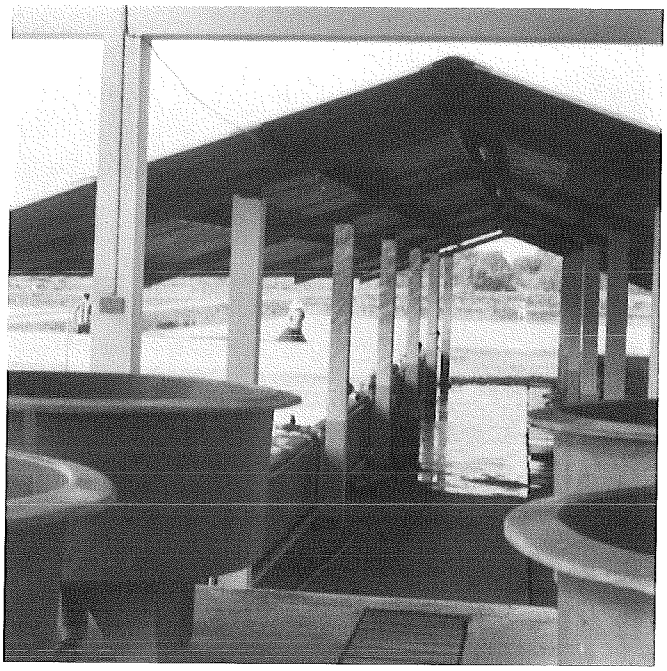
The Data Analysis and Synthesis Team (DAST) at the University of California, Davis (UCD), continued refining several pond models reported on in previous annual reports and publications. For example, a model designed to simulate temperature and dissolved oxygen concentrations in stratified ponds was modified to reduce input data requirements and the number of pond strata to be simulated. These changes were implemented while maintaining a reasonable degree of simulation accuracy in the model. In another effort, the UCD team developed and tested a prototype diel pond respiration measurement device. Preliminary data show the potential usefulness of this apparatus for examining respiration dynamics in shallow ponds.

The Oregon State University (OSU) component of the DAST was involved in major revisions and improvements to the PONDCLASS decision support system. This effort included developing simplified models of temperature and fish growth for incorporation into the computer program. The inclusion of these simplified models expands the functionality of the original software by making long-term simulations possible. Such long-term simulations can help pond operators make decisions about stocking density, stocking size, and harvest scheduling. Additional improvements were made to PONDCLASS in response to comments received from reviewers of Version 1.1. The result of these revisions has been the completion of PONDCLASS Version 1.2, which was released at the end of 1993.

The OSU DAST also began work on a new implementation of the PONDCLASS program, which will operate in the MS-DOS®/Windows™ environment. Additional features that will be available through this new implementation of PONDCLASS include provisions for short-term analyses of pond dynamics and long-term analyses of whole-enterprise economics. Development of the new program began in May of 1993, and will continue into the next reporting period. The release of the Windows version will occur in 1995.

# Central Data Base

A Central Data Base continues to be maintained by the CRSP for the storage and retrieval of standardized records from the research sites. At the individual research sites, data on physical variables (e.g., solar radiation, temperature, and rainfall) and chemical variables (e.g., water and soil chemical characteristics) are collected concurrently with biological measurements (e.g., primary productivity, fish growth, and fish production). Whereas the resulting sets of data are useful for site-specific studies, the compilation of all



the individual data sets into the Central Data Base provides opportunities for many kinds of global analyses. Detailed standardized records such as those found in the CRSP Central Data Base are rare in the aquaculture literature. All data from research activities conducted under the First through the Fourth Work Plans are already in the Data Base, and it has continued to expand, during this reporting period, through the inclusion of new data, generated under the Fifth and Sixth Work Plans, which have been transmitted from the research sites.

In response to a decision reached by the Management Entity and Board of Directors, with input from the Technical Committee, Central Data Base functions were transferred from the Program Management Office to the University of Hawaii at Hilo in May, 1993. As the quantity of data generated by CRSP research has increased, so have the data storage requirements. Consequently, during this reporting period the UHH group has begun efforts to reduce the storage requirements of the data base and to make the data more accessible by developing a user-friendly, menu-driven interface for data acquisition.

The utility of the Central Data Base extends to researchers outside those directly involved with the PD/A CRSP. The Data Base was designed to facilitate communications with other large data bases, such as the Tropsoils CRSP data base and ICLARM's FISHBASE, thereby creating opportunities for collaboration. It can also serve as a storage and retrieval center for standardized data from any research site. CRSP scientists as well as scientists in the aquaculture community at large may contribute to and access the data base. Data are available on computer diskettes or in print as *Pond Dynamics/Aquaculture Collaborative Research Data Reports*. Additionally, the outgoing OSU Data Base Manager initiated discussions with ICLARM (International Center for Living Aquatic Resources Management) to incorporate CRSP data into FISHBASE. The UHH Data Base Manager is continuing to work out the details of this arrangement.

# Annual Technical Committee Meeting

The annual meeting of the Technical Committee was held in Portland, Oregon, in March. Representatives from all of the collaborating institutions and field sites were present. A number of reports on work completed or in progress were given, new officers were elected, and the final decision regarding the transfer of Central Data Base Management was made.

# III. CRSP Research Program Background

At its inception, the Pond Dynamics/Aquaculture CRSP had a single, main theme: a common set of experiments to be implemented globally, following a standard experimental protocol at a number of research sites around the world. The Global Experiment, as it came to be called, was intended to facilitate comparative studies of aquaculture pond dynamics; such studies would help us begin to understand how and why ponds at different geographic locations function differently, and how the management of aquaculture ponds might be fine-tuned or adapted to different sets of environmental conditions to optimize production.

As CRSP research progressed, it became apparent that there were important additional needs to be addressed. To meet these needs, research components were added, so that in the past few years the main core of the program has included three components:

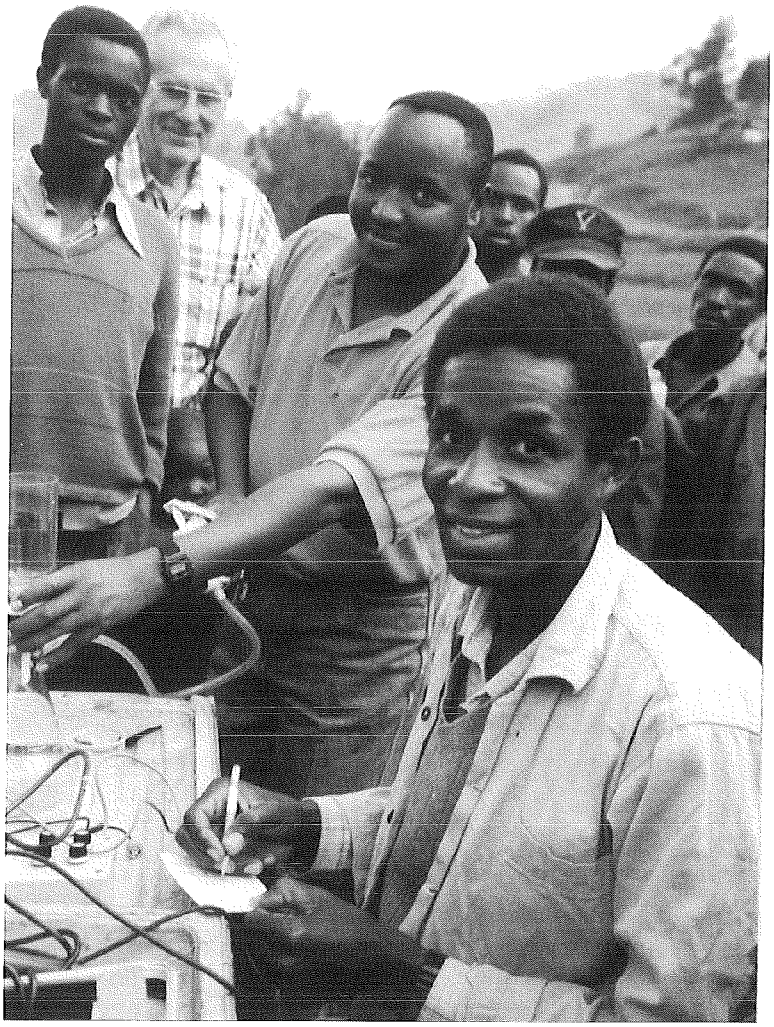
- The Global Experiment,
- Special Topics Research in Host Countries, and
- Data Analysis and Synthesis.

This main core of CRSP activities has been augmented by supplemental activities that are associated with the main components and complement them in unique ways. These supplemental activities have included socioeconomic studies, soil-water interactions research, the development of simple new techniques for the evaluation of pond conditions, and studies to develop improved techniques for fish reproduction.

## The CRSP Research Program

The CRSP's long-range goal is to increase the efficiency of pond culture operations. This goal has the benefits not only of increasing the availability of animal protein in less-developed countries, but also of improving the economic efficiency of aquacultural production in any country, including the U.S. A technical plan consistent with this goal was developed under a planning study funded by USAID in 1981. Under this planning study, the literature on state-of-the-art pond culture was reviewed and synthesized, resulting in the publication of the first edition of *Principles and Practices of Pond Aquaculture*, and overseas sites were surveyed to determine research needs and the potential for the establishment of research projects.

The technical plan that evolved from the planning study involved establishment of research projects at seven sites in six countries. Two brackish water and five freshwater research projects were begun at sites in Central America (Panama and Honduras), Africa (Rwanda), and Southeast Asia (Thailand, Indonesia, and the Philippines) in 1983. All of the sites were within a zone 15 degrees north or south of the equator and represented the three major tropical regions where advances in pond aquaculture would be most beneficial and most apt to succeed. Although subsequent changes (primarily in response to funding constraints) in the CRSP program required that research be continued only at the sites in Thailand, Rwanda, and Honduras, the three major regions continued to be represented. Since 1991 the CRSP program has been expanded by the initiation of a sub-project in the Philippines and the beginning of a completely new project in Egypt. The research in Egypt greatly increases the CRSP's scope by adding an arid site to the program, which had previously included sites only in relatively humid areas. Also in 1993, research in brackish water environments was resumed with the addition of a coastal site in Honduras.



# CRSP Work Plans

A Technical Committee has had the responsibility for developing technical work plans throughout the CRSP's history. The first three CRSP Work Plans, outlining annual research programs that were almost exclusively global in nature, covered activities from 1 September 1984 through 31 August 1987. The First Work Plan specified a standard procedure for the preparation and stocking of ponds, and the concept of a standard protocol for research at all sites has been maintained throughout the program. These standards have evolved into the CRSP's *Handbook of Analytical Methods*, which was completed and distributed to participants in 1992.

In response to the recommendations of the External Evaluation Panel during the first triennial review, work plans beginning with the Fourth Work Plan have been developed on a biennial basis to allow more time for the completion and evaluation of experiments before planning new ones. This change in the planning procedure is the logical outcome of the need to test hypotheses that develop directly from the results of previous CRSP experiments. Another significant change that began with the Fourth Work Plan is that site-specific studies have also been included. Although the global aspects of CRSP research are maintained by conducting similar experiments (referred to as the Global Experiment) at the various sites and by conducting these experiments in a standardized manner, other experiments are adjusted to more directly address the needs of aquaculture producers in the country or region in which the research is taking place.

The Fourth, Fifth, and Sixth Work Plans covered research conducted in two-year periods from 1987 through 1993. This reporting period constitutes the second year of activities conducted under the Sixth Work Plan, but it also includes research conducted in Egypt under the Seventh Work Plan. During the first half of 1993 the Technical Committee finalized and distributed the Seventh Work Plan, which describes experiments to be conducted between 1 September 1993 and 31 August 1995.

# IV. Public Service and Project Development

The Pond Dynamics/Aquaculture CRSP relies on its on-site researchers to recognize opportunities to support local research institutions' training activities, and to find efficient ways to extend CRSP research results to farmers. CRSP researchers in all countries have capitalized on these opportunities, enabling the CRSP to increase its impact at little or no additional cost. Although ancillary to the Global Experiment and site-specific studies, these activities contribute to institution building and increased food production, thereby furthering the main strategic approach. These activities also help to promote international scientific linkages through the exchange of technical information. As a result, research capabilities have been substantially strengthened in every developing country in which the CRSP has been active. Some of these important contributions are described below.

## Institution Building

The CRSP's research activity has resulted in major improvements to the research infrastructure of the collaborating host country institutions, both directly and by helping to attract other funding opportunities. In addition, CRSP scientists serve as advisers in the research programs of students at host-country universities and make contributions to curriculum development.

In Honduras, the CRSP spearheaded a public-private joint venture with the Ministry of Natural Resources, the National Association of Honduran Aquaculturists (ANDAH), the Panamerican Agriculture School (EAP), and the Federation of Producers and Exporters of Honduras (FPX). As a result, a newly refurbished laboratory was dedicated in the spring of 1993, and shrimp growers and farm managers have begun collaborating with the CRSP to study water quality issues that affect shrimp production and the estuarine environment surrounding the farms.

In this groundbreaking collaborative effort, the Ministry of Natural Resources provides laboratory and office space at La Lujosa, close to Choluteca. ANDAH provides equipment and supplies for the lab, with funds coming from a self-imposed assessment on shrimp exports. In addition, ANDAH members provide ponds and inputs to conduct CRSP experiments. FPX extensionists assist in collecting data from their members and disseminating research information. Students under the direction of EAP conduct research

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*"Give me a fish, and I eat for a day. Teach me to fish, and I eat for a lifetime." This Confucian proverb has special significance for the PD/A CRSP. Although growing fish is what usually springs to mind with thoughts of this CRSP, harvesting is certainly an important, not to mention rewarding, part of the aquaculture cycle. Last year, Karen Veverica, then the CRSP researcher in Rwanda, responded to a local need for technical assistance by conducting a seine-making workshop for aquaculture trainers. The Peace Corps volunteers in attendance got experience in guiding trainees, as well as learning how to make and maintain a seine. In addition to Peace Corps volunteers, representatives of various nongovernmental organizations—including the Red Cross, the Boy Scouts, German and Austrian international assistance associations, and a local Catholic convent—attended the workshop. Veverica purchased a large amount of seine material with her own funds, and resold it at cost to the trainees. Wherever possible, local or recycled materials were used: wood from local trees was used for floats, pieces of motorcycle chain or iron piping were used for leads. Each participant left the one-day workshop with a working seine, and more importantly, the working knowledge of how to construct a seine in the future. Veverica has already received requests to hold another workshop. Confucius probably knew intuitively what the work of the PD/A CRSP demonstrates—that "teaching people to fish" is a long-term approach to fighting hunger.*

in shrimp culture and water quality analysis. This extensive network of collaborators supports CRSP research in focusing on research issues—estuarine monitoring, pond fertilization, and shrimp feeding strategies—that will increase farmers' economic efficiency and minimize negative environmental impact. In Rwanda, the laboratory at Rwasave continues to be the premier water quality laboratory in East Africa, despite civil unrest that has seriously damaged national infrastructure and interfered with travel and communications. In August, the Rwasave Fish Culture Station and the PD/A CRSP marked their ten year anniversaries. The celebration at Rwasave also inaugurated the new *Clarias* project research ponds, which were built with funding from the European Economic Community. Fifty-one ponds and numerous aquaria are now available for research.

In addition to deep pond construction at AIT, the CRSP has helped establish research ponds at the Chaiyaphum Fisheries Station in northeast Thailand and at Phayao Station in northern Thailand.

In Egypt, the CRSP assists with facility maintenance and serves in an advisory capacity for various aquaculture-related institutions. Ponds at the Central Laboratory for Aquaculture Research in Abbassa were renovated to prepare them for the start of the CRSP experiments. The CRSP also emphasized and supported the refurbishing of an over-wintering facility for tilapia. The need for such a facility became apparent after excessive tilapia mortalities occurred during a cold snap in the winter of 1992. Egyptian aquaculture and fish research also benefits from the collaboration of U.S. and Egyptian scientists who developed a comprehensive list of 26 scientific journals on aquaculture, fisheries, and aquatic environments to be included for serial acquisition for the new library of the National Agricultural Research Project. The presence of CRSP researchers in Egypt also significantly enlarges the institutional and professional network available to students, and strengthens Egyptian universities through these increased international linkages.

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*Although the CRSP does not have a formal training component, the many short courses and workshops run by CRSP researchers attract trainees from all walks of life. The impact of these formal and informal training opportunities can be far-reaching. Some trainees return home with new information and skill to share with family and neighboring farmers. Some begin commercial fish farming operations. And some, like Pelagie Nyirahabimana, recognize the potential benefit of aquaculture in national development, and continue with advanced training.*

*Nyirahabimana, the university-trained daughter of a Rwanda farmer, is currently enrolled in Auburn University's master's program in Rural Development. In 1984, when Nyirahabimana first met Karen Veverica, former Rwanda PD/A CRSP Research Associate, both were new to their posts. Veverica had worked on the Natural Resource Project, a USAID-funded project staffed through Auburn University, and Nyirahabimana had just begun training extension agents for the Ministry of Agriculture. "My introduction to aquaculture was strictly on-the-job-training," jokes Nyirahabimana. Veverica introduced Nyirahabimana to aquaculture as part of a sustainable farm system, and Nyirahabimana immediately saw its potential for improving income and nutrition for farm households. Nyirahabimana went on to serve as Rwanda's Director of Aquaculture and Beekeeping in the Ministry of Agriculture, a post she used to help promote aquaculture as part of an integrated farm system.*

*Thus began a relationship with the PD/A CRSP, which continued when her husband, Nathenal Hishamundi, received funding to pursue master's and doctoral degrees at Auburn University, one of fourteen CRSP collaborating institutions. Now Nyirahabimana is also completing her degree, and focusing on communication methodologies that pay special attention to fish farmers. "When farmers don't want to adopt*

# Education and Professional Development

Formal training programs have not been funded by this CRSP; nevertheless, the involvement of students from host countries and the U.S. constitutes an important part of the CRSP's international outreach. Informal training activities such as short courses and workshops are frequently conducted. Almost 60 people received informal training during this reporting period; since the beginning of the program, over 400 individuals have benefited from informal training activities.

## *Thailand and Philippines*

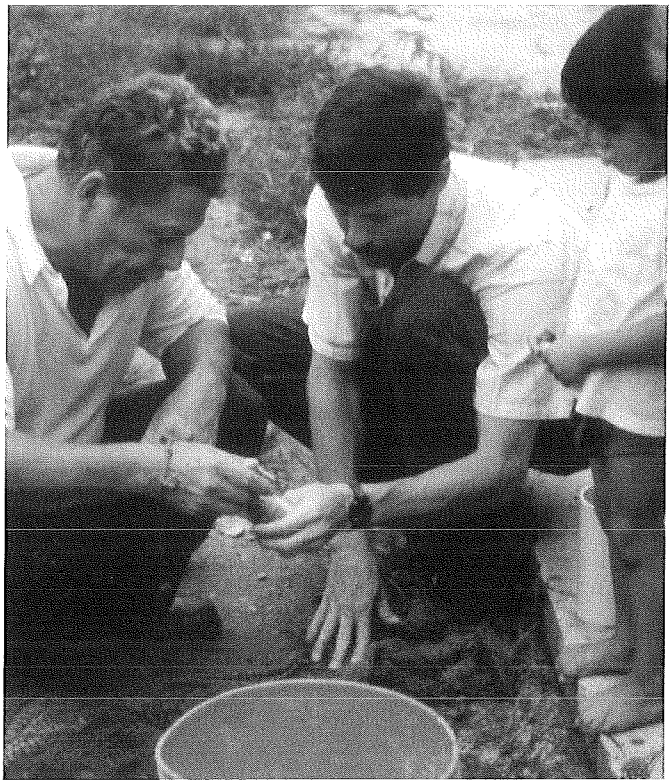
The CRSP is involved in training as a component of several studies that help extend CRSP research to farm ponds throughout Thailand. In June an AIT outreach project began field testing least-intensive aquaculture techniques on small integrated farms in northeast Thailand. Chris Knud-Hansen helped train the AIT outreach personnel who are now teaching farmers to evaluate their pond fertility by using the algal bioassay kit developed by Hans Guttman and Knud-Hansen. The CRSP provides the research component for an adaptive management system. The on-farm studies will help speed the extension of research to the farmers and, at the same time, will use the farmers' concerns to help create the research agenda. In the Philippines, the regional verification of the CRSP fertilizer guidelines continues at the Freshwater Aquaculture Center at Central Luzon State University (FAC/CLSU).

Several informal training seminars and workshops were held during this reporting period. In the Philippines, Kevin Hopkins conducted a seminar to explain CRSP research at the FAC/CLSU and the Bureau of Fisheries hatchery staff. C. Kwei Lin was invited by the Royal Thai Government Department of Fisheries to attend a panel session on commercial tilapia farming, and to give a seminar on pond fertilization.

*new technologies," she says, "it's tempting for the extension workers to blame the farmer, but part of the blame can usually be traced to faulty communication." When Nyirahabimana returns to Rwanda, she will make sure that she maintains her contact with the farmers. "I don't want to spend all my time in the office," she says. "I want to be with the people."*

*Although there is no outright discrimination against women in Rwanda, it is unusual for a woman to be the director of an agriculture office. Nyirahabimana is convinced that women can make a big contribution to aquaculture. When she first began training extension agents, other women seemed surprised to see a woman in that role, and then seemed inspired. If she can do it, they seemed to say, so can we. "It's unfortunate," Nyirahabimana says, "that in developing countries resources are often focused exclusively on men. Women also need access to food production technologies so they can contribute to the family economic process and they have some say in the decision-making process."*

*Women in Rwanda realized that managing fish ponds can provide food for their families and a source of income. Because the government owns the land, the first hurdle was convincing the government to let women have access to the land that ponds are built on. During the tenure of Veverica and Nyirahabimana, the percentage of women managing ponds has increased; at least one-quarter of all fish ponds in Rwanda are now managed by women. Nyirahabimana believes that besides providing food and income, aquaculture provides less tangible, but equally important benefits. "There's no better way of learning about a problem than by interacting with people. When you get together and start talking, you can solve many problems." Thus, women learn valuable organizing and management skills, in addition to the aquaculture basics.*



## *Honduras*

Claude Boyd, as part of the inauguration of the new laboratory at La Lujosa, Honduras, conducted a seminar for shrimp farmers. David Teichert-Coddington has trained six staff in laboratory techniques for water analysis, and approximately 20 farmers in Honduras receive ongoing training in data gathering for monitoring estuarine water quality.

## *Rwanda*

Karen Veverica conducted a seine-making workshop for Peace Corps and other volunteers (see inset), and a training session in reproduction techniques for *Clarias* culture was held at Rwasave for Peace Corps volunteers from Burundi. Joyce Newman continued CRSP participation with the Rwanda National Fish Culture Service in the Natural Resource Management Project, which is training extension agents in data collection techniques.

## *Egypt*

Academic advancement is the focus of the CRSP's professional development activities in Egypt. Ten students are supported by the Egypt project; six are working on advanced degrees, while four others conduct research at the University of Hawaii, at Auburn University, and at Oregon State University. The focal point of the CRSP's professional development activities in Egypt is the scholarly exchange program. Egyptian scientists visit their CRSP counterparts at their home institutions in the U.S. and abroad. While the main purpose of these visits is collaboration on the Egypt Project's experiments, the visitors also garner additional information that will help them become more effective scientists when they return to Egypt.

*Nyirahabimana's training at Auburn has had some unexpected benefits. In addition to learning new extension and communication techniques, she has learned how to use computers and how to analyze data, and has made important additions to the network of professionals she can reach.*

*Nyirahabimana misses the day-to-day contact with the farmers, and working with the Rwanda Women's Association. It is a wonderful network, she says, involving women from many professions, and actively involved in organizing training for other women. She recalls the workshop sponsored by the PD/A CRSP, USAID's Office of Women In Development, and the USAID/Kigali Mission as a valuable experience for women to talk directly to scientists and extension workers, and let them know what resources women farmers need in order to do a good job of growing fish.*

*What does she see as the biggest obstacles facing the fish farmers in her country? Getting enough inputs to fertilize the ponds is a big problem. It can be difficult to find enough animal manure to enrich the pond, and inorganic fertilizers are prohibitively expensive. This makes CRSP research into alternative pond inputs—such as green grass and cassava—all the more important to land-poor farmers. Nyirahabimana notes that even when farmers can make more cash from other uses of the land, fish farming is useful for several reasons. First, fish can provide high quality protein on an as-needed basis. The time requirements of pond management are flexible, and can be fit into the farmers' schedule. And perhaps most importantly, the social interaction involved in pond management helps farmers learn about cooperative action and management—tools essential to long-term, sustainable development.*

Discussions with other scientists while at the host institutions widens the visitors' horizons and helps them to better conceptualize research problems. Upon their return, these visiting scholars become a resource to their colleagues, informing them of what they have learned and further improving the research capacities in Egypt.

Enthusiasm generated by such informal training and by exposure to activities at the CRSP research sites has led some students to pursue university degree programs, either at institutions in their own countries or at participating U.S. universities. Students have pursued degrees at seven overseas institutions and at all of the collaborating universities in the U.S. Prior to this reporting period, over 108 degrees (B.S., M.S., and Ph.D.) were awarded, and during this period, another three were completed. Over 73 theses have been completed under the direction of CRSP researchers. Theses completed during this period are:

- Culberson, S.D. 1993. Simplified model for prediction of temperature and dissolved oxygen in aquaculture ponds using reduced data inputs. M.S. thesis. University of California, Davis.
- Hishamunda, N. 1993. The economic analysis of small-scale fish culture in Rwanda: a comparative study. M.S. thesis. Auburn University, Alabama.
- Green, B. 1992. Water and chemistry budgets for organically fertilized fish ponds in the dry tropics. Ph.D. dissertation. Auburn University, Alabama.

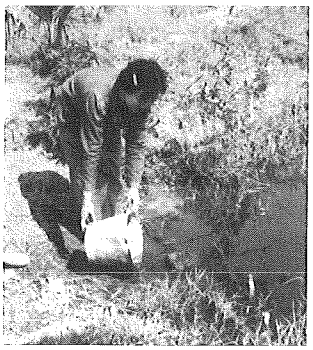
The number of individuals involved in all forms of training, from non-degree activities through work on advanced degrees, has climbed to well over 400 since the beginning of the program. Most of the trainees have come from PD/A CRSP host countries (Egypt, Honduras, Indonesia, Panama, Philippines, Rwanda, and Thailand); however, the benefits of CRSP-related training have extended well beyond the borders of the seven collaborating countries, as evidenced by the fact that participants have been drawn from at least 27 countries over the course of the program. Furthermore, the interdisciplinary nature of aquacultural research attracts students from a wide range of academic disciplines. Many participants take positions in schools, banks, agricultural research institutes, national parks services, development projects, and agricultural extension services, where they are able to increase public awareness of aquaculture's importance in food systems.

*Southwestern Honduras is ideal for growing shrimp. The land is open and flat. The Gulf of Fonseca rolls gently out to the Pacific, cradled between the arms of Nicaragua and El Salvador, framing the Gulf with two live volcanoes. And in the heat, you can almost hear the shrimp growing.*

*During the 1960s, southern Honduras was deforested, the result of cotton farming and cattle ranching combined with short-sighted land tenure laws. To this day, river siltation resulting from the deforestation requires frequent river dredging. The first shrimp farms began on a small scale in the early 1970s and today the industry is poised on the brink of rapid expansion. But long time residents who have seen get-rich-quick schemes scar the face of their land in the past most emphatically do not want a repeat performance.*

*Local shrimp farmers recognize the opportunity presented by the rapidly expanding market for their shrimp; they also recognize the challenge to protect the environment from ill-planned development. These farmers want to avoid the kinds of catastrophes that plagued the shrimp industry in Thailand and Taiwan; they want to base their economic decisions on environmental considerations. The PD/A CRSP is helping them face these tasks. Many of these shrimp farmers worked and studied at the CRSP's freshwater research station over the last decade. At the station, farmers learn about key issues such as water quality and phytoplankton dynamics, information which will contribute to sustaining the shrimp industry and the environment at the same time.*

*Out of the economic and environmental concerns of these farmers was born public-private joint venture. The CRSP, the Honduran Ministry of Natural Resources, the National Association of Honduran Aquaculturists (ANDAH), the Panamerican Agriculture School (EAP), and the Federation of Producers and Exporters of Honduras (FPX) have devised a strategy for cooperation. The Ministry provides laboratory and*



## Linkages

CRSP linkages in Honduras have been strengthened and broadened with the inauguration of the brackish water site in Choluteca. The CRSP was able to add this site largely because of the enthusiastic collaboration of private organizations and government institutions. Among the collaborators are the Ministry of Natural Resources, the National Association of Honduran Aquaculturists, the Panamerican Agriculture School, and the Federation of Producers and Exporters of Honduras, all of whom make substantial contributions to the ongoing operation of the project. In addition, CRSP researchers serve as consultants for Peace Corps volunteers, and volunteers have assisted with logistical arrangements for researchers involved with the social sciences project.

The CRSP continues to strengthen its ties with institutions in southeast Asia. In Thailand, CRSP researchers hold long- and short-term faculty appointments at the Asian Institute of Technology (AIT), and teach a variety of courses and seminars. AIT serves as a regional resource for technology development and dissemination in Southeast Asia, so CRSP researchers are able to form linkages with students and faculty from many countries. They also serve as advisers to the Thai government on aquaculture and fisheries related projects.

In the Philippines, CRSP ties with the International Center for Living Aquatic Resources Management (ICLARM) continue to grow. Discussions have begun to use genetically selected tilapia from an ICLARM-sponsored project for field testing at the FAC/CLSU as part of the regional verification trials being conducted by the CRSP in the Philippines. Another collaborator, the FAC/CLSU-University of Wales Swansea Research Project on Genetic Manipulations for Improved Tilapia (GMIT), provided genetically male tilapia (GMT) produced by breeding "YY supermales" with untreated females to provide all male tilapia for use in one treatment of the CRSP regional verification.

The Research Associate in Rwanda continues to advise the USAID/Kigali Mission and the USAID Natural Resources Management Project on natural resource issues. CRSP researchers also advise the Rwandan Ministry of Agriculture's Aquaculture Strategy Commission in establishing research priorities and in proposing suitable research and extension linkages. The CRSP makes major contributions to the Rwasave station in constructing facilities and supporting extension personnel and publications.

*office space at La Lujosa, close to Choluteca. ANDAH provides equipment and supplies for the lab, with funds coming from a self-imposed assessment on shrimp exports. In addition, ANDAH members provide ponds and inputs to conduct the CRSP experiments. FPX extensionists assist in collecting data from their members and disseminating research information back to them. Students under the direction of EAP conduct research in shrimp culture and water quality analysis. This extensive network of collaborators supports CRSP researchers in focusing on research issues—estuarine monitoring, pond fertilization and shrimp feeding strategies—that will help answer farmers' concerns. As a result, the newly refurbished laboratory was dedicated this spring, and shrimp growers and farm managers have begun collaborating with the CRSP to study water quality issues that affect shrimp production and the estuarine environment surrounding the farms. Already, money-saving feeding strategies that lessen the load of nutrients being pumped into the Gulf have been developed.*

*This public-private collaboration prompted one ANDAH member to write the CRSP Board of Directors, saying, "It is ANDAH's intention . . . to develop a sustainable industry in Honduras, dependent on a healthy aquatic environment in the Gulf of Fonseca. A sustainable industry will permit long term benefits to all, and would not be possible to achieve without programs such as yours."*

Raul Piedrahita, Principal Investigator for the UCD/DAST, spent a six-month sabbatical at the Norwegian Hydrotechnical Laboratory in Trondheim, Norway. He established contact with researchers at Wageningen Agricultural University in the Netherlands who are initiating a project in Costa Rica and indicate interest in collaboration with the CRSP. In addition to the CRSP's numerous formal connections with host country institutions through Memoranda of Understanding, the CRSP maintains ties with numerous other organizations, including many commercial fish producers in the U.S. and in host countries. A partial list of informal CRSP linkages follows:

American Tilapia Association, United States
Board for International Food and Agricultural Development and Economic Concerns (BIFADEC), Washington, D.C.
Boy Scouts, Rwanda
Cairo University, Egypt
CARE, Honduras
Catholic University of Leuven (CUL), Belgium, Rwanda
Central Luzon State University, Freshwater Aquaculture Center, Philippines
Consultative Group on International Agricultural Research (CGIAR), Washington , D.C.
Department of Aquaculture (DINAAC), Panama
Department of Fisheries, Udorn Thani, Thailand
Department of Renewable Natural Resources (DIGEPESCA), Honduras
Escuela Agrícola Panamericana, (EAP) Honduras
European Economic Community
Fish Breeding Centre, Israel
Fish Culture Research Institute, Szarvas, Hungary
Food and Agriculture Organization of the United Nations (FAO), Rome, Italy
Freshwater Aquaculture Center (FAC), Philippines
General Authority of Fisheries Resources Management, Egypt
Gondol Research Station, Ensenada, Mexico
Honduran Federation of Agricultural and Agroindustrial Producers and Exporters (FEPROEXAAH)
INTSORMIL CRSP, Honduras
Institut Pertanian Bogor (IPB), Indonesia
International Development Research Centre (IDRC) of Canada
International Rice Research Institute (IRRI), Philippines
International Center for Aquaculture (ICA), Auburn University, Alabama
International Center for Living Aquatic Resources Management (ICLARM), Philippines
J.F.K. Agricultural School, Honduras
Mariut Fish Farm, Egypt
Ministry of Agriculture, Agricultural Research Center, Egypt
National Agricultural Library, Washington, D.C.
National Agricultural Research Project (NARP), Egypt
National Association of Honduran Aquaculturists (ANDAH)


National Inland Fisheries Institute (NIFI), Thailand
National Marine Fisheries Service (NMFS), La Jolla, California
National Technical Information Services, Springfield, Virginia
North Central Regional Aquaculture Center (NCRAC), Michigan
Peace Corps: Honduras, Thailand, Burundi, Rwanda
Red Cross, Rwanda
Soil Management CRSP, Honduras
South East Asian Fisheries Development (SEAFDEC), Philippines
Sustainable Agriculture and Natural Resources Management (SANREM) CRSP
Special Program for African Agricultural Research (SPAAR), Washington, D.C.
The University of the Philippines in the Visayas
United States Department of Agriculture
Western Regional Aquaculture Consortium (WRAC), Seattle, Washington
Zagazig University, Egypt

# Project Development

With its extensive international network of researchers, the CRSP is well positioned to identify needed areas of research and opportunities for aquaculture development. Emerging themes in development and in aquaculture are being addressed by the CRSP. With worldwide attention now focused on sustainable development, the CRSP work in natural resource policy development and implementation in Rwanda and Honduras assumes greater importance. The CRSP has taken an active role in encouraging women in aquaculture, reflecting the recognition of women's pivotal role in agricultural production and family nutrition. A workshop planned for the next Annual Meeting will focus on building equitable roles for women in future aquaculture research and development. The private sector in many countries has been able to capitalize on CRSP research. The models and guidelines developed by CRSP researchers are being used in directing on-farm trials, the "acid-test" of new techniques and technologies. Finally, recognizing that new technology does not operate in a vacuum but is part of a larger socioeconomic system, the CRSP has devoted more resources to integrating the social sciences into the core research.

Continuing the CRSP's commitment to extending aquaculture development to appropriate sites, the PMO started discussions with Dr. Gordon Sato about possible future collaboration with Eritrea. This new nation just gained its independence in the spring of 1993 after 30 years of war with Ethiopia. Dr. Sato, who is a frequent traveler to Eritrea and familiar with its problems, has started the Manzanar Project to aid the Eritreans in their reconstruction efforts. The centerpiece of the Manzanar Project is the development of aquaculture ponds along the coast in otherwise unproductive lands in an attempt to provide the local population with an additional source of protein and income.

Planning began in August 1993 for the CRSP Continuation Plan beyond 1995. A strategic document is being prepared that includes an ecological perspective on aquaculture development.

# Development of Sustainable Aquaculture Systems

Environmental concerns are motivating the creation of more sustainable agricultural systems worldwide, at the same time as aquaculture production is being recognized as vital to the world's food economy. Diminishing stocks of wild fish, coupled with increasing demand for fish worldwide, have driven up the value of aquaculture products, especially fish and shellfish, and aquaculture is projected to continue filling an important niche as a food source and cash crop in developing countries. Pond production of animals and plants is an important component of integrated agricultural systems in several ways. Aquaculture ponds provide an efficient means of conserving water in areas where water supplies are limited. Further, effluent from ponds can be used for crop irrigation, thus avoiding pollution of natural waterways. Pond mud—often high in organic matter and rich in nutrients—can be partially removed and used as a fertile soil additive for land crops. Aquaculture is easily integrated with other forms of agricultural production, such as chicken-fish and duck-fish operations. Farm by-products such as manures, grasses, inedible plant parts, and composts can be used as nutrient sources in aquaculture ponds. CRSP research at all sites continues to emphasize efficient utilization of these agricultural by-products to enhance production in ponds, and to contribute to sustainability by recycling farm materials.

In Egypt, researchers investigate the possibilities of using biological controls to solve pond management problems. Experiments are conducted to evaluate the ability of grass carp to control nuisance aquatic weeds. Black carp, a voracious snail predator, is being tested for its potential to reduce the snail population. Since snails are hosts to the parasite that causes bilharzia, a reduction in the snail population may reduce fish farmers' danger of contracting bilharzia. These studies are designed as building blocks in the development of a polyculture system unique to Egypt. Polyculture studies will be conducted during the second year of CRSP research in Egypt. In a second line of inquiry, CRSP researchers are comparing different management strategies (e.g. traditional Egyptian aquaculture practices) with CRSP management guidelines in an attempt to determine which strategies might work best under the arid conditions found in Egypt, thus guaranteeing the most efficient use of precious water and nutrients.

Biotechnology—a new line of research for the CRSP—opens alternative avenues for the production of monosex tilapia. Research is being conducted in both Egypt and the U.S., focusing on the safe use of steroids with a special emphasis on minimizing impacts on humans, fish, and the environment.

In southern Honduras, CRSP researchers are making progress in developing efficient farming practices for shrimp farmers and in determining the carrying capacity of the Gulf of Fonseca. An understanding of the gulf's carrying capacity will give development planners information needed to ensure the protection the estuarine environment surrounding the gulf. Already, research results have shown farmers that they can reduce the percentage of protein in their shrimp feed without affecting yield, lowering both farmers' feed costs and the nutrient load in the estuary. Further research will continue to integrate environmental issues with production concerns.

Water quality concerns are also on the research agenda in Thailand. Experiments to determine the most efficient level of nutrient input will help Thai farmers plan for optimal resource use without polluting ground and surface waters. CRSP researchers at all sites demonstrate a concern for the effects of aquacultural production on the wider environment.

# Socioeconomic Studies

The CRSP has long recognized that social and economic factors play an important role in the development and adoption of aquaculture technologies and management strategies. Limited funding for this CRSP has constrained research in these areas, so that only small, site-specific studies could be conducted. Past socioeconomic research was limited to providing answers to specific questions, ranging from economic analyses of feeding strategies in Honduras to analysis of gender variables in Rwanda. However, CRSP researchers recognize the need to provide basic economic information to enable farmers to evaluate research recommendations in the light of financial profitability. Ongoing efforts are being made to include socioeconomic variables in core research.

- The OSU/DAST will include economic data in the expert system for pond management which is currently being redesigned. The user-friendly program runs on personal computers, and supports pond manager decisions regarding variables such as fertilization and stocking strategies.
- In Egypt, researchers collect economic data as well as biological information; thus, management strategies can be evaluated not only by fish yield but also by economic feasibility.
- In Honduras, brackish water research has already had an economic impact. Studies showed that no significant difference occurred in shrimp production when a 20 percent protein feed was substituted for a 40 percent protein feed. This finding will allow farmers to cut their feed costs substantially without affecting production.
- In Rwanda, enterprise budgets for fish production and production of 12 different crops commonly raised on Rwandan farms have been completed as the first step in comparing the economics of resource utilization. An unexpected result of this study showed that farmers enter aquaculture mainly to generate income, not as was thought, to have fish as an additional food item.
- In Thailand, feeding studies are designed to determine the optimal time for initial application of supplemental feed in fertilized ponds. The results of this study will help farmers make economically sound decisions regarding supplemental feeding by identifying the critical stages when the natural food supply is inadequate to support optimal fish production.

Efforts are under way to move socioeconomic studies from the periphery of the research agenda and to integrate them into the core program of future biophysical investigations that will be presented to USAID in the continuation proposal. The new global social sciences project began this year, "Socioeconomic Dimensions of Aquaculture Development: A Comparative Assessment of Financial Returns, Adoption Barriers, and Impacts of Tilapia Production Regimes." The study will identify the level and type of technology available to tilapia farmers in Honduras, Thailand, and the Philippines. The role played by CRSP technology in the evolution of tilapia production practice, and the relationship of these technologies to the larger research and technology development systems will be articulated, and the economic context that shapes farmers' decisions concerning technology adoption will be profiled. The results of the study will have implications for future research proposals, development policy, and farm-level decision-making about tilapia technology. Field work began in Honduras during this reporting period, and was greatly facilitated by the support of U.S. Peace Corps volunteers. Field work in Thailand and the Philippines will be conducted during the next reporting period and data analysis and report preparation will also be completed.

Planning is under way for a USAID-sponsored workshop at the 1994 Annual Meeting. Participants will identify opportunities to integrate the social sciences as a dimension of applied research, with the goal of improving the usefulness and relevance of CRSP research. The workshop will offer CRSP researchers the opportunity to reframe research proposals to reflect social, economic, and cultural variables, in addition to physical, biological and chemical variables, that affect pond production systems.

# Participation in International Scientific Meetings and Conferences

Raul Piedrahita presented the paper "Managing environmental impacts in aquaculture" at the United States-Japan Natural Resources Aquaculture Panel in Kyoto, Japan. Although his travel to the conference was not supported by the CRSP, CRSP research results were presented.

Martin Fitzpatrick presented a poster on methyltestosterone at the Third Asian Fisheries Forum in Singapore. His travel was not supported by the Egypt project, although the research is relevant to the studies to be undertaken by that project.

John Bolte attended the Annual Meeting of the American Society of Agricultural Engineers (ASAE) in Spokane, Washington.

The following papers were presented by CRSP researchers at the ASAE-sponsored meeting, Techniques for Modern Aquaculture, which was held in conjunction with the ASAE meeting:

Culberson, S.D., and R.H. Piedrahita. 1993. Model for predicting dissolved oxygen levels in stratified ponds using reduced data inputs.

Grace, G., and R.H. Piedrahita. 1993. Carbon dioxide control with a packed column aerator.

Lu, Z., and R.H. Piedrahita. 1993. Nitrifying characteristics of a high rate packed column.

Ernst, D.H., J.P. Bolte, and S.S. Nath. 1993. A decision support system for finfish aquaculture.

The following researchers attended the World Aquaculture Society meeting in Torremolinos, Spain: Jim Szyper, Raul Piedrahita, Bartholomew Green, Gamal Osman El Nagar, Fatma Abdel Fattah Hafez.

The following poster paper was presented:

Szyper, J.P., R.H. Piedrahita, and P. Giovannini. 1993. Requirements for maximizing bloom stability and net oxygen production in earthen ponds.

# V. Program Management and Technical Guidance

The CRSP is organized to facilitate collaboration. Believing that mutually beneficial development strategies have the best chance of being sustainable over time, the CRSP's organizational structure facilitates collaboration among research, institutions, and countries. The Management Entity, located at Oregon State University, administers the program. The Management Entity subcontracts with Auburn University, the University of California at Davis, and the Consortium for International Fisheries and Aquaculture Development (CIFAD), a five-member consortium of universities. Members of CIFAD are Michigan State University, Oregon State University, University of Arkansas at Pine Bluff, University of Hawaii, and University of Michigan. A new institution, University of Oklahoma, began its association with the CRSP as part of the newly inaugurated Egypt project. A Memorandum of Understanding (MOU) is executed between the host country institution and the lead university for each project (e.g., an MOU is executed between the Asian Institute of Technology and the University of Michigan), except for the Egypt project. The Central Laboratory for Aquaculture Research at Abbassa holds an MOU directly with the Management Entity.

This organizational structure also gives the CRSP the flexibility and depth of expertise to respond effectively to new opportunities and challenges. For example, when travel restrictions due to civil unrest in Rwanda made it impossible to post the newly assigned U.S. Research Associate to the Rwasave site, she was able to conduct laboratory experiments at Auburn University while host country researchers continued the experiments that had already been under way in Rwanda. Normally, a six-month delay would cause researchers to miss an entire growth cycle and delay activities by a whole year. It is a measure of the success of the CRSP that the project has become sufficiently institutionalized that the activities of the research agenda were only delayed by four months.

The Honduras project also faced delays, in this case due to the logistics involved with setting up a new research site. Again, CRSP efforts to institutionalize the program in the country paid off, as host country researchers at the freshwater site were able to maintain day-to-day station operations during the transition period. At the brackish water site, private sector collaborators such as the National Association of Honduran Aquaculturists help to fund research activities and take part in experiments. Linkages with these organizations, the result of ten years of research and training in Honduras, are further evidence of the efficacy of the CRSP in attracting local support for program activities. The Honduras project collaborates informally with experts from non-CRSP universities to evaluate water flux and waste assimilative capacity in estuaries.

The Egypt Project came on-line with experienced CRSP researchers who, together with their new Egyptian and U.S. counterparts, were able to adapt research plans to manage unforeseen problems. The die-off of broodfish due to an unusually harsh winter in Egypt was compensated for by buying as many fingerlings as possible from several hatcheries located in other parts of the country and by adjusting the experimental design to accommodate the fingerling shortage. An intensive program of Nile tilapia fingerling production was begun to prevent this problem in the future. One component of this effort is establishment of appropriate overwintering facilities to ensure fingerling survival during winter.

The bioconversion experiments, which call for testing black carp for their potential as a biological control agent of snails, are another example of collaborative problem solving. Concern about the possible negative effects of introducing this non-native species led CRSP researchers to design safety features to prevent the escape, reproduction, or other distribution of the black carp, and to ensure that disease-free stock was used. This array of safety features satisfied the Egyptian authorities and USAID.

The CRSP drew on its multi-disciplinary collaborative network to pioneer and refine a global project in socioeconomics. Following input from the Technical Committee at the Annual Meeting regarding the need for a closer integration of the social sciences with CRSP research, the Board directed the Management Entity to issue a Request for Proposals to participating CRSP institutions. The Management Entity executed a rigorous review of the proposals submitted, including seven external and three internal reviewers, thus initiating a process that will be repeated for other new projects. The proposal submitted by Auburn University, "Socioeconomic Dimensions of Aquaculture Development: A Comparative Assessment of Financial Returns, Adoption Barriers, and Impacts of Tilapia Production Regimes," was selected, on the condition that the proposal be modified to address the reviewers' concerns. The study began in June, and will identify the level and type of technology available to tilapia farmers at three sites, and the role that CRSP technology has played in the evolution of tilapia production practice. The relationship of CRSP technologies to the larger research and technology development systems will be articulated, and the economic context that shapes farmers' decisions concerning technology adoption will be profiled. The resulting data will be summarized and the implications for research management, development policy, and farm-level decision-making about tilapia technology will be presented. Field work began in Honduras during this reporting period, and was greatly facilitated by the support of U.S. Peace Corps volunteers. Field work in Thailand and the Philippines will be conducted during the next reporting period and data analysis and report preparation will also be completed.

Finally, the CRSP will use the strength of its collaborative network as it begins planning for the next five years. The process began at the 1993 Annual Meeting, as areas of interest were identified. The Board authorized a plan calling for the active participation of the Technical Committee in developing the Continuation Plan.

# Management Entity

Oregon State University is the Management Entity (ME) for the Pond Dynamics/Aquaculture CRSP and is the primary grantee of USAID. The Program Management Office (PMO) is the operational component of the ME. The PMO is the link between USAID and the CRSP projects, which are subcontracted to Auburn University, the University of California at Davis, CIFAD, and the University of Oklahoma.

The Management Office is located in the Office of International Research and Development (OIRD) on the main campus of Oregon State University, in Corvallis, Oregon. OIRD provides accounting, purchasing, and travel support. The CRSP reports directly to the Vice Provost for Research and International Programs through the Director of the OIRD. Ties to the Department of Fisheries and Wildlife, and to the Department of Bioresource Engineering, are maintained through faculty appointments, academic interests, and research subcontracts.

During this reporting period, members of the Program Management Office included:
Hillary Egna, Director (1.0 FTE)
Brigitte Goetze, Deputy Director and Egypt Coordinator (0.5 FTE 3/93 through 5/93, .75 FTE 6/93 through 8/93–not funded on core CRSP funds)
Marion McNamara, Assistant Director (1.0 FTE–partially funded on core CRSP funds)
Hilary Berkman, Data Base Manager (0.5 FTE through 6/93)
Nancy Astin, Secretary (0.5 FTE through 6/93)
Naomi Weidner, Secretary (0.5 FTE from 6/93)

***The Management Entity (ME) is responsible for:***

- Receiving funds committed by USAID to the CRSP and assuming accountability for their use;
- Providing funds to the participating institutions, and ensuring compliance with the terms of the grant;
- Providing a focal point for the interaction of the Technical Committee, Board of Directors, External Evaluation Panel, USAID staff, and BIFADEC/JCARD;
- Executing the decisions of the governing and advisory bodies;
- Spearheading program development efforts;
- Implementing the program; and
- Maintaining liaisons with overseas and domestic participants.

The PMO is also responsible for communications and publications.

Prior to the transfer of the CRSP Central Data Base, the PMO was responsible for its management.

***Specific accomplishments this year include:***

- Preparation of CRSP budgets and subcontract modifications for extending funding and performance periods;
- Coordination of new administrative and contractual details for collaborative research projects in Thailand, the Philippines, Rwanda, Egypt, and Honduras;
- Site visit to Egypt to evaluate project progress and investigate possible linkages with other institutions;
- Coordination of planning and logistics for the External Evaluation Panel review, including logistical support for travel and report production;
- Organization of the eleventh annual CRSP meeting in Portland, Oregon, from 21 to 23 March 1993, and OSU site visits for the Board, the EEP, and USAID representative;
- Participation at Annual Meeting in Board and Technical Committee meetings;
- Development of questionnaires for evaluating the Annual and Technical Committee meetings;
- Assistance in processing travel clearances for all CRSP personnel and approvals for purchases of restricted goods for country projects;
- Coordination of travel schedules for U.S. researchers and Egyptian counterparts;
- Coordination of Request for Proposals for Management of the CRSP Central Data Base and selection of the new site;
- Publication of research results in technical report series;
- Preparation, publication, and distribution of detailed quarterly reports summarizing technical and administrative progress;
- Assistance in production of PONDCLASS, including editing, layout, printing, and distribution;
- Assistance in production of the Seventh Work Plan, including editing, layout, printing, and distribution;
- Training and supervising graduate student interns working on producing a slide program, a detailed training inventory, and a project description.
- Streamlining of the distribution procedure for CRSP communications and maintenance of the CRSP mailing list, which reaches approximately 300 people in 42 countries;
- Maintenance of the CRSP directory, which lists participants' addresses, and telephone, fax, and email numbers;
- Coordination and execution of a tour for Egyptian collaborators of aquaculture facilities in Oregon and as part of their visit to other U.S. aquaculture research institutions and facilities;
- Organization of and participation in Board Meetings and Technical Committee meetings;

• Development of new management information systems to track projects;
• Collection of information about technology transfer and economic impact of various CRSP activities;
• Development, with Claude Boyd (AU), of an updated version of Principles and Practices, Dynamics of Pond Aquaculture.

The PD/A CRSP maintains technical linkages with the Tropsoils and the SANREM CRSPs. Maintenance of programmatic linkages with all the CRSPs, increases the visibility of the PD/A CRSP and of aquaculture in general. The cost of participation in CRSP Council activities is disproportionately high for the PD/A CRSP, which is funded at a much lower level than other CRSPs and which is thus more financially strained by participation. Nevertheless, the Management Office contributed to the CRSP Council educational presentations for USAID and Congress in May 1993. Hillary Egna joined the other CRSP Directors in meeting with representatives of USAID regional bureaus and the House and Senate Foreign Operations Committees. John Yohe, CRSP Council Chairman and INTSORMIL Director, gave a presentation entitled "CRSP Contributions to Science and Technology for Development" for all interested Congressional representatives and staff. The Management Office also participated in the following CRSP Council conference calls:

1 October 1992
7 January 1993
4 February 1993
6 May 1993
7 June 1993
2 July 1993

Three advisory groups, the Board of Directors (BOD), the Technical Committee (TC), and the External Evaluation Panel (EEP), support the management of the CRSP. These groups work closely with the PMO to guide the CRSP through policy decisions, budget allocations, research strategy, review, and evaluation.

# The Board of Directors

As the primary policy-making body for the CRSP, the Board of Directors takes an active role in program guidance. The Board is composed of three members, one of whom is elected chair. Auburn University, the University of California at Davis, and CIFAD are each represented on the Board. In addition, the USAID Program Manager for the CRSP and the CRSP Director serve as ex-officio members. All Board members function in the objective interest of the CRSP regardless of their institutional affiliation. During this reporting period, the Board members were:

Dr. Robert Fridley, University of California at Davis, Chair;
Dr. Philip Helfrich, University of Hawaii (CIFAD institution);
Dr. R. Oneal Smitherman, Auburn University;
Dr. Lamarr Trott, NMFS, RSSA to R&D/AGR, ex-officio member;
Ms. Hillary Egna, Oregon State University, CRSP Director, ex-officio member.

***The Board of Directors is responsible for:***

- Review of program budgets and allocation of funds to research projects and the Management Office;
- Recommendations to the Management Entity on budget allocations;
- Evaluation of the administrative and technical accomplishments of overseas research projects and U.S.-based research activities;
- Advice to the Management Entity on policy guidelines; and
- Review of the performance of the Program Director and Management Entity.

The Board of Directors convened twice during this reporting period, once in an extended meeting during the Annual Meeting (23 and 24 March 1993) in Portland, Oregon, and once by telephone conference call on 11 June 1993. Informal discussions are held regularly with the Board and approvals for some decisions are made through correspondence.

***Specific accomplishments and recommendations made during this reporting period include:***

- Approval of management and research budgets;
- Annual meeting agenda input and approval;
- Participation in on-site reviews of the External Evaluation Panel and in responding to the External Evaluation Panel's observations and recommendations;
- Input on Data Base transfer and enhanced activities;
- Outlining of process for balanced participation of the Technical Committee in developing the continuation proposal;
- Approval of a special work plan for the OSU/DAST; subsequent progress has been highly satisfactory;
- Participation in the Eleventh Annual Program Meeting in March 1993;
- Participation in the review of proposals for a socioeconomic project; and
- Clarification of voting privileges on the Technical Committee.

# Technical Committee

Researchers from U.S. universities and host country institutions comprise the Technical Committee, which advises the Management Entity on technical matters. The membership of the Technical Committee is listed in Table 1 in alphabetical order, with institutional affiliations and subcommittee assignments. Voting privileges are accorded each institutional partner in each project receiving CRSP funds. Institutions holding a vote on the Technical Committee are listed in Table 2 by project. The CRSP Director and the USAID Project Manager serve as ex-officio members, and at-large members are appointed by the Board of Directors. This year, Dr. Ted Batterson was selected as the At-large Technical Committee member. The Technical Committee has four standing subcommittees: Work Plans, Materials and Methods, Budgets, and Technical Progress. Special committees are convened as needed.

# Table 1.
# Membership of Technical Committee

| Name | Institution | Subcommittees• |
|---|---|---|
| Abdel Faried | Central Laboratory for Aquaculture Research | |
| Ali Abdelghany (from 8/93) | Central Laboratory for Aquaculture Research | |
| Seham Ahmed | Central Laboratory for Aquaculture Research | |
| Valentin Ake | Auburn University | |
| Bo Alexander | University of Hawaii | |
| Ted Batterson (through 8/31/93) | Michigan State University | |
| John Bolte | Oregon State University | |
| Claude Boyd | Auburn University | M |
| Jean-Damascéne Bucyanayandi | National University of Rwanda | W |
| Steve Culberson | University of California, Davis | |
| Jim Diana | University of Michigan | T*, EP |
| Bryan Duncan | Auburn University | |
| Peter Edwards | Asian Institute of Technology | |
| Hillary Egna | Oregon State University, Management Entity | |
| Abdel El Gamal (through 7/93) | Central Laboratory for Aquaculture Research | T |
| Hussein El Ghobashy | Central Laboratory for Aquaculture Research | |
| Gamal El Nagar | Central Laboratory for Aquaculture Research | |
| Fatma El Nemaky | Central Laboratory for Aquaculture Research | |
| Mahmoud El Nour | Central Laboratory for Aquaculture Research | |
| Samir Elabeden | Central Laboratory for Aquaculture Research | |
| Zeinab Elnagdy | Central Laboratory for Aquaculture Research | |
| Wahied Elwan | Central Laboratory for Aquaculture Research | |
| Carole Engle | University of Arkansas at Pine Bluff | |
| Doug Ernst | Oregon State University | |
| Namat Fatah | Central Laboratory for Aquaculture Research | |
| Martin Fitzpatrick | Oregon State University | |
| William Gale | Oregon State University | |
| Anaclet Gatera | National University of Rwanda | |
| Satwat Ghany | Central Laboratory for Aquaculture Research | |
| Phil Giovannini | University of California, Davis | |
| Brigitte Goetze | Oregon State University, Management Entity | |
| Gordon Grau | University of Hawaii, Manoa | |
| Bart Green | Auburn University | W, EP |
| Fatma Hafez | Central Laboratory for Aquaculture Research | |
| Mona Hamed | Central Laboratory for Aquaculture Research | |
| Hussein Hebicha | Central Laboratory for Aquaculture Research | |
| Kevin Hopkins, Chair | University of Hawaii, Hilo | M |
| Nabil Ibrahim | Central Laboratory for Aquaculture Research | |
| Tharwat Ismail | Central Laboratory for Aquaculture Research | |
| Ahmed Khater | Central Laboratory for Aquaculture Research | |
| Jim Lannan | Oregon State University | T |
| Watana Leelapatera | Department of Fisheries, Thailand | |
| C. Kwei Lin | University of Michigan and AIT | B |

• W=Work Plans; B=Budgets; T=Technical Progress; M=Materials and Methods; EP=Executive Panel
* Subcommittee Chairpersons
# Temporary Member of Technical Committee

| | | |
|---|---|---|
| Eduardo Lopez | Central Luzon State University | |
| Lucas Lopez | DIGEPESCA | |
| Mostafa Mohsen | Central Laboratory for Aquaculture Research | |
| Joseph Molnar# | Auburn University | |
| Abdel Mostafa | Central Laboratory for Aquaculture Research | |
| Gamal Nasser | Central Laboratory for Aquaculture Research | |
| Shree Nath | Oregon State University | |
| Joyce Newman | Auburn University | |
| Raul Piedrahita | University of California, Davis | M*, EP |
| Tom Popma, Secretary | Auburn University | W |
| Dia Rahiem | Central Laboratory for Aquaculture Research | |
| Harry Rea | R&D/AGR, USAID | |
| Hal Richmond | University of Hawaii, Manoa | |
| Ahmed Said | Central Laboratory for Aquaculture Research | |
| Samir Said | Central Laboratory for Aquaculture Research | |
| Carl Schreck | Oregon State University | |
| Wayne Seim | Oregon State University | B* |
| Ibrahim Shaker | Central Laboratory for Aquaculture Research | |
| William Shelton | University of Oklahoma | M |
| Chaninthorn Sritongsuk | Thailand Dept. of Fisheries | |
| Ashrat Suliman | Central Laboratory for Aquaculture Research | |
| Jim Szyper | University of Hawaii, Hilo | W*, M |
| David Teichert-Coddington | Auburn University | B |
| Andrea Van Ballenburg | University of Hawaii | |
| Karen Veverica | Auburn University | M |

## At-large Members

| | |
|---|---|
| Donald Garling | Michigan State University |
| George Tchobanoglous | University of California, Davis |
| Ted Batterson (from 8/31/93) | Michigan State University |

## Ex-officio Members

| | |
|---|---|
| Hillary Egna | Oregon State University, Management Entity |
| Brigitte Goetze | Oregon State University, Management Entity |
| Harry Rea | R&D/AGR, USAID |
| Lamarr Trott | R&D/AGR, USAID |

• W=Work Plans; B=Budgets; T=Technical Progress; M=Materials and Methods; EP=Executive Panel
* Subcommittee Chairpersons
# Temporary Member of Technical Committee

# Table 2.
# Institutional Voting Privileges on Technical Committee

| Projects | Voting Institutions |
|---|---|
| DAST | Oregon State University<br>University of California at Davis |
| Data Base Management | University of Hawaii |
| Egypt | Central Laboratory for Aquaculture Research<br>Asian Institute of Technology/University of Michigan<br>Auburn University<br>Oregon State University<br>University of Hawaii<br>University of Oklahoma |
| Honduras | DIGEPESCA<br>Auburn University |
| Philippines | Central Luzon State University<br>University of Hawaii |
| Rwanda | National University of Rwanda<br>Auburn University<br>Oregon State University<br>University of Arkansas, Pine Bluff |
| Thailand | Asian Institute of Technology<br>Royal Thai Department of Fisheries<br>Michigan State University (through 8/31/93)<br>University of Hawaii<br>University of Michigan |
| **Special Projects** | |
| Social Sciences | Auburn University |

# External Evaluation Panel

A committee of external aquaculture specialists periodically evaluates the accomplishments of the individual research projects and the overall program to ensure that research projects and the program remain focused, relevant, and cost-effective. The External Evaluation Panel (EEP) is responsible directly to USAID and BIFADEC for the review and evaluation of the technical progress of the CRSP. Drs. Homer Buck, Illinois Natural History Survey (retired), Richard Neal, National Marine Fisheries Service (NMFS), and Roger Pullin, International Center for Living Aquatic Resources Management (ICLARM) served on this panel.

During this reporting period, members of the External Evaluation Panel evaluated all CRSP sites using a Scope of Work drafted by the Management Office and the USAID Missions and approved by USAID. A review team was chosen for each site, consisting of representatives from the following entities: the External Evaluation Panel, the Board of Directors, the Management Entity, and USAID. Homer Buck, Phil Helfrich, Hillary Egna, and Harry Rea reviewed the Rwanda project from 3 to 10 September 1992. Homer Buck, Dick Neal, R.O. Smitherman, Marion McNamara, and Harry Rea reviewed the Honduras project from 28 September to 3 October 1992. Dick Neal, Roger Pullin, Bob Fridley, Hillary Egna, and Lamarr Trott reviewed the Thailand project, including the regional verification project in the Philippines and the outreach activities in northeast Thailand from 1 to 11 November 1992. All External Evaluation Panel members attended the Eleventh Annual Program Meeting in Portland, Oregon, and visited the management offices in Corvallis, Oregon, in March 1993.

The final report of the External Evaluation Panel was due after the close of this reporting period. The Management Office, with the input of the Board and Technical Committee members, will respond to the findings and recommendations of the External Evaluation Panel prior to printing and distributing the report.

# CRSP Publications

CRSP publications are an important part of the CRSP's technology dissemination. A broad domestic and international audience receives our technical and program reports. Approximately 300 people in 42 countries now receive CRSP publications. Technical reports are issued through two series, *Collaborative Research Data Reports* and *CRSP Research Reports.* The goal of *CRSP Research Reports* is to publish all research produced by CRSP activities, with the exception of research related directly to the Global Experiment.

*Collaborative Research Data Reports* contains the results and data from the Global Experiment, along with interpretations of site-specific results. The first volume of *Collaborative Research Data Report* was re-issued this year; it contains description of sites and experimental protocols for the Global Experiment. Subsequent volumes focus on each research site separately by experimental cycle.

Other reports published by the CRSP Management Office include Annual Administrative Reports, Quarterly Reports, Program Grant Proposals, Work Plans, CRSP Directories, brochures describing the CRSP and the Egypt project, and Instructions for Data Entry. The Quarterly Report format was redesigned during this reporting period, and a new format will also be used for trip reports from researchers returning from on-site visits. The *Handbook of Analytical Methods* compiled by the Materials and Methods Committee of the Technical Committee and the *PONDCLASS Users' Guide* were also published through the Management Office.

The *PONDCLASS Users' Guide* accompanies the PONDCLASS software, a user-friendly expert system for pond management designed to run on personal computers. The Management Office coordinated an extensive internal and external review of PONDCLASS prior to its release, and many of the reviewers'

suggestions were incorporated into the first release. In addition, the Management Office assumed primary responsibility for editing, layout, printing, and distribution of the *Users' Guide*. Personnel from the Rwanda project have translated the *Users' Guide* into French, and are providing the Oregon State University DAST with the information required to complete the translation of the software into French. A Spanish version is also planned.

*Principles and Practices of Pond Aquaculture* was one of the founding documents of this CRSP. At the time of its production, this volume was state of the art and filled a neglected niche in the field of aquaculture. Since its publication in 1983, it has been one of the most requested of CRSP publications. But advances in pond aquaculture made by the CRSP and others require that this valuable resource be updated. A new volume that approaches aquaculture production as part of the larger agroecosystem is in progress, *Dynamics of Pond Aquaculture.* The Management Office has contracted with Lewis Publications to publish the book in 1995. CRSP researchers are collaborating in writing the sixteen chapters that make up the book, and that approach aquaculture production as part of the larger agroecosystem. The book should be available after 1995.

Other publications that were worked on during this year and will become available during the next reporting period are: *A Ten Year Summary of Activities in Honduras, The Proceedings of the Third High Altitude Tilapia Conference,* and *The Final Report of the External Evaluation Panel.*

In addition to PD/A CRSP-produced publications, the Management Office contributes to USAID's program reviews, publications, and presentations. Administrative and technical reports prepared and disseminated during this reporting period are briefly described below and may be ordered from the Management Office. Technical reports that were not processed by the Management Office are listed in the Appendix.

# Administrative Reports

***Annual Administrative Report***

Egna, H., M. McNamara, J. Bowman, and N. Astin. 1993. Tenth Annual Administrative Report, Pond Dynamics/Aquaculture Collaborative Research Support Program. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 275 pp.

***Quarterly Reports***

Pond Dynamics/Aquaculture CRSP, Program Management Office. October 1993. Quarterly Report. July-September 1993. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 10 pp.

Pond Dynamics/Aquaculture CRSP, Program Management Office. July 1993. Quarterly Report. April-June 1993. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 11 pp.

Pond Dynamics/Aquaculture CRSP, Program Management Office. April 1993. Quarterly Report. January-March 1993. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 8 pp.

Pond Dynamics/Aquaculture CRSP, Program Management Office. January 1993. Quarterly Report. October-December 1992. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 8 pp.

***Brochures***

CRSP brochures are designed to inform a general audience about the activities of the CRSP. Two brochures were published this year, one describing the overall CRSP program and one describing the Egypt Project.

***Directory***

The CRSP directory contains an organizational chart and the addresses of current CRSP members from USAID, BIFADEC, USAID Missions, the CRSP Council, the External Evaluation Committee, the Technical Committee, the Management Entity, the Board of Directors, and the Collaborative Research Projects. The chart is updated annually or semi-annually, as needed.

CRSP Directory. May 1993. Pond Dynamics/Aquaculture CRSP, Program Management Office. Office of International Research and Development, Oregon State University, Corvallis, Oregon.

***Newsletters***

*Aquanews, The Newsletter of the Pond Dynamics/Aquaculture Collaborative Research Support Program*, resumed quarterly publication during this reporting period. *Aquanews* serves to inform CRSP participants and others of program activities that are not of a technical nature. It contains information on project activities, meetings, travel of CRSP participants, and site visits. The following issues were published during this reporting period:

Aquanews, Summer 1993, Volume 8, Number 1. McNamara, M., ed. ISSN 1062-4996. PD/A CRSP Program Management Office, Office of International Research & Development, Snell Hall 400, Oregon State University, Corvallis, Oregon.
Aquanews, Fall 1993, Volume 8, Number 2. McNamara, M., ed. ISSN 1062-4996. PD/A CRSP Program Management Office, Office of International Research & Development, Snell Hall 400, Oregon State University, Corvallis, Oregon.

The Data Analysis and Synthesis Team publishes a quarterly newsletter with the goal of improving communication between the DAST and the Principal Investigators in the field. During this reporting period, DAST Newsletter Nos. 11 through 14 were produced and distributed.

# Technical Reports

***CRSP Research Reports***

Knud-Hansen, C.F. 1993. Analyzing standard curves in the chemistry of waters used for aquaculture. CRSP Research Reports 93-51, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in *NAGA, The ICLARM Quarterly*, January 1992.]

Lin, C.K., K. Jaiyen, and V. Muthuwan. 1993. Integration of intensive and semi-intensive aquaculture: concept and example. CRSP Research Reports 93-54, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA.

Liu, K.M., and W.Y.B. Chang. 1993. Bioenergetic modelling of effects of fertilization, stocking density, and spawning on growth of the Nile tilapia, *Oreochromis niloticus* (L.). CRSP Research Reports 93-48, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in *Aquaculture and Fisheries Management*, 23: 291-301, 1992.]

Suresh, A.V., and C.K. Lin. 1993. Tilapia culture in saline waters: a review. CRSP Research Reports 93-50, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in *Aquaculture*, 106 (1992) 201-226.]

Szyper, J.P., and J.M. Ebeling. 1993. Photosynthesis and community respiration at three depths during a period of stable phytoplankton stock in a eutrophic brackish water culture pond. CRSP Research Reports 93-55, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in *Marine Ecology Progress Series* 94:229-238, 1993.]

Szyper, J.P., and J.Z Rosenfeld. 1993. Diel Cycles of Planktonic Respiration Rates in Briefly incubated water samples from a fertile earthen pond. CRSP Research Reports 93-52, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in *Limnology and Oceanography*, 37(6), 1992, 1193-1201.]

Teichert-Coddington, D.R., B.W. Green, and R.P. Phelps. 1993. Influence of site and season on water quality and tilapia production in Panama and Honduras. CRSP Research Reports 93-49, Pond Dynamics/ Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in *Aquaculture*, 105 (1992) 297-314.]

# VI. Financial Summary

This section summarizes the expenditures of USAID, non-federal, and host country funds for CRSP research activities and program management. This unaudited summary is intended to provide an overview of CRSP program budgets and matching support.

The expenditure of USAID funds by Collaborative Research Projects, Special Topics Research, and Program Management is presented in Table 3 for the period 1 September 1992 through 31 August 1993. This is the third year of the third CRSP grant, which runs through 31 August 1995, and which provides core funding of $920,000 per year. Program enhancement funds of 20 percent were allocated for 1992-93. Because the budget period for the enhancement funding is not congruent with the core funding budget year, these enhancement funds appeared in last year's financial summary as well as in this year's summary.

Program Management Office expenditures include three main categories: Operations and Administration, Communications, and Data Base Management. This CRSP is unique in including the research-oriented functions of technical communications and Data Base Management in the Program Management Office. During this reporting period, the Data Base Management was transferred to the University of Hawaii. Expenditures for this function for 1992-93 are divided between the Management Office and the U.S. Research Component; in subsequent years, these expenditures will be assumed completely by the U.S. Research Component of the budget. The U.S. Research Component also includes expenditures to support the Data Analysis and Synthesis Team's activities at the University of California at Davis and at Oregon State University.

Cost-sharing contributions from the U.S. institutions and contributions from host countries are presented in Table 3. The average percentage of funding borne by U.S. universities is 24 percent, which fulfills the USAID requirement. Although host country cost-sharing is not required, these contributions reflect a continuing commitment to participation in the CRSP by our collaborators. These data were provided by the Principal Investigators of the projects.

The expenditure of USAID funds on the Egypt Project is summarized in Table 4. for the period 1 October 1992 through 31 August 1993. This is the first year of this grant, which runs through 30 September 1995. Contributions of U.S. institutions, though not required under the terms of this grant, are also included in Table 4.

# Table 3.
# Expenditure of funds

| | | USAID Funds | | U.S. Cost Sharing | | Total, all U.S. funds | | Host Country Contribution | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1992-93 | Cumulative | 1992-93 | Cumulative | 1992-93 | Cumulative | 1992-93 | Cumulative |
| **Research Program** | | | | | | | | | |
| **Honduras** | | | | | | | | | |
| | Auburn | $174,257 | $476,636 | $43,564 | $119,159 | $217,821 | $595,795 | $52,000 | $142,000 |
| **Rwanda** | | | | | | | | | |
| | Auburn | $93,661 | $277,766 | $23,415 | $69,442 | $117,076 | $347,208 | $25,977 | $87,521 |
| | OSU | $101,129 | $241,725 | $25,282 | $60,431 | $126,411 | $302,156 | | |
| | UAPB | $5,000 | $15,000 | $1,250 | $3,750 | $6,250 | $18,750 | | |
| | OSU/WID | | $5,942 | | $1,486 | | $7,428 | | |
| **Thailand** | | | | | | | | | |
| | MSU | $167,503 | $252,632 | $41,876 | $63,158 | $209,379 | $315,790 | $26,000 | $112,000 |
| | UH* | $97,936 | $204,668 | $24,484 | $51,167 | $122,420 | $255,835 | | |
| | UM | $196,683 | $447,298 | $49,171 | $111,825 | $245,854 | $559,123 | | |
| **Global Social Science Project** | | | | | | | | | |
| | Auburn# | $3,333 | $3,333 | $833 | $833 | $4,167 | $4,167 | | |
| **Subtotal** | | $839,503 | $1,925,001 | $209,876 | $481,250 | $1,049,378 | $2,406,251 | $103,977 | $341,521 |
| **U.S. Research Program** | | | | | | | | | |
| | DAST/UCD | $50,171 | $150,833 | $12,543 | $37,708 | $62,714 | $188,542 | | |
| | DAST/OSU | $25,618 | $105,634 | $6,405 | $26,409 | $32,023 | $132,043 | | |
| | Soils/OSU | | $16,064 | | $4,016 | | $20,080 | | |
| **Subtotal** | | $75,790 | $272,532 | $18,947 | $68,133 | $94,737 | $340,664 | | |
| Management Entity• (includes some research funds) | | $174,107 | $588,862 | | | $174,107 | $588,862 | | |
| External Evaluation funds | | $67,400 | $95,000 | | | $67,400 | $95,000 | | |
| **TOTAL** | | $1,156,799 | $2,881,394 | $228,823 | $549,383 | $1,385,622 | $3,430,777 | $103,977 | $341,521 |

** Includes 5 months of Data Base Management.*
*• Includes Technical Publications and 10 months of Data Base Management.*
*# This project period is 6/11/93 through 6/10/94. The subcontract was executed 8/93; therefore, expenses for one month are estimated.*

# Table 4.
# Egypt Project expenditure from 10/1/92 through 8/31/93

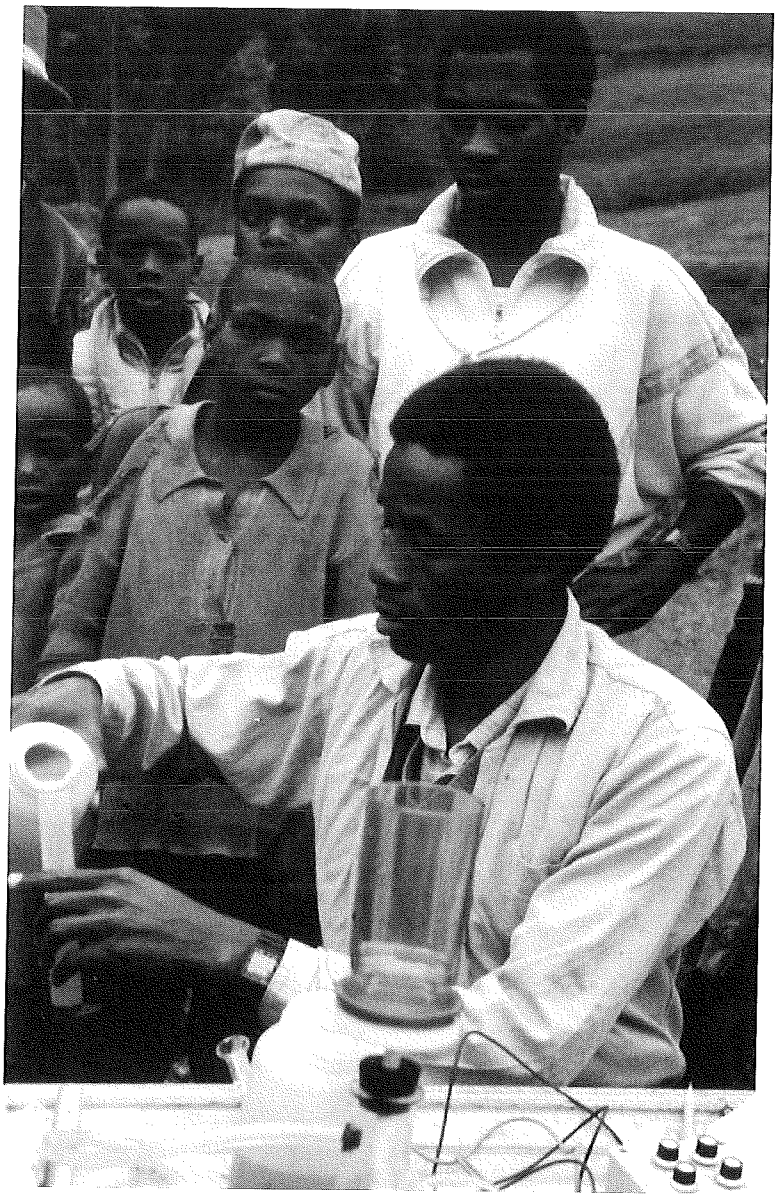
| | USAID Funds | | U.S. Contribution* | | Total, all U.S. funds | |
|---|---|---|---|---|---|---|
| | 1992-93 | Cumulative | 1992-93 | Cumulative | 1992-93 | Cumulative |
| **Research conducted in Egypt** | | | | | | |
| Auburn University | $218,252 | $218,252 | $54,563 | $54,563 | $272,815 | $272,815 |
| University of Oklahoma | $35,533 | $35,533 | $8,883 | $8,883 | $44,416 | $44,416 |
| **Subtotal** | $253,785 | $253,785 | $63,446 | $63,446 | $317,231 | $317,231 |
| **Research conducted in U.S.** | | | | | | |
| University of Hawaii | $1,438 | $1,438 | $360 | $360 | $1,798 | $1,798 |
| Oregon State University | $23,976 | $23,976 | $5,994 | $5,994 | $29,970 | $29,970 |
| **Subtotal** | $25,414 | $25,414 | $6,354 | $6,354 | $31,768 | $31,768 |
| **Support for Egyptian Institution Building** | $9,780 | $9,780 | $3,162 | $3,162 | $12,942 | $12,942 |
| **Management Entity** | $68,252 | $68,252 | $12,736 | $12,736 | $80,988 | $80,988 |
| **TOTAL** | $357,231 | $357,231 | $85,698 | $85,698 | $442,929 | $442,929 |

**U.S. contributions are not required under the terms of this grant, but are included to indicate U.S. support of the project.*

# VII. Staff Summary

The Pond Dynamics/Aquaculture CRSP represents the joint efforts of more than 45 professional and support personnel from U.S. universities. It also represents the collaborative efforts of over 75 scientists, technicians, and graduate students from project sites in five host countries. The expertise of host country and U.S. personnel is broad-based and encompasses the major fields of specialization included in this CRSP: Limnology and Water Quality; Fisheries and Aquaculture; Soil Science; Sociology; Data Management, Analysis, and Modeling; Sociology; Biotechnology; Agricultural Economics; and Research Administration.

The major United States-based research activity, Data Analysis and Synthesis, involves eight researchers from the University of California at Davis and Oregon State University. Scientists from Auburn University, the University of Arkansas at Pine Bluff, Oregon State University, and the University of Hawaii also participate in additional U.S.-based research activities.



The CRSP regularly collaborates with other groups and institutions in the development of host country projects. For example, in northeast Thailand, the CRSP supports the outreach efforts of the Asian Institute of Technology by providing the research component for an adaptive management system. In Egypt, researchers from institutions such as the Institute of National Planning or Al Azhar University are interested in the implications of CRSP research for planning the future direction of Egyptian aquaculture development. In Rwanda, the CRSP researcher regularly meets with the Ministry of Agriculture's Aquaculture Strategy Commission to advise on establishing research priorities and in proposing suitable research-extension linkages. Researchers also meet with the USAID/Kigali Mission and personnel from the Natural Resources Management Project to advise on natural resource issues. Numerous private voluntary organizations take advantage of the training offered by the CRSP. Peace Corps volunteers in Rwanda and Honduras consult regularly with CRSP researchers on project design and implementation. Private sector farmers in Honduras take advantage of CRSP expertise by attending seminars conducted by resident and visiting researchers. While these trainees are not formally part of the CRSP staff, they enhance the outreach ability of the CRSP by transmitting CRSP technologies and information.

## FIELD(S) OF SPECIALIZATION

| Individual | CRSP Function | Research Administration | Limnology/Water Quality | Fisheries/Aquaculture | Data Management | Social Sciences | Location of Work (1) |
|---|---|---|---|---|---|---|---|
| **BOARD OF DIRECTORS** | | | | | | | |
| Robert Fridley | Chairman | X | X | X | | | Davis, California |
| Philip Helfrich | Member | X | | X | | | Kaneohe, Hawaii |
| R. Oneal Smitherman | Member | X | | X | | | Auburn, Alabama |
| **EXTERNAL EVALUATION PANEL** | | | | | | | |
| Homer Buck | Member | X | | X | | | Salem, Illinois |
| Richard Neal | Chairman | X | | X | | | La Jolla, California |
| Roger Pullin | Member | X | | X | | | Manila, Philippines |
| **AT-LARGE TECHNICAL COMMITTEE** | | | | | | | |
| Donald Garling | Member | | | X | | | East Lansing, Michigan |
| George Tchobanoglous | Member | | | X | | | Davis, California |
| **MANAGEMENT ENTITY** | | | | | | | |
| Hillary Egna | Director | X | X | X | | | Corvallis, Oregon |
| Marion McNamara | Assistant Director | X | | | | | Corvallis, Oregon |
| Hilary Berkman (to 5/93) | Data Base Manager | | X | X | X | | Corvallis, Oregon |
| Nancy Astin (to 6/93) | Office Assistant | X | | | | | Corvallis, Oregon |
| Naomi Weidner (from 6/93) | Admin. Assistant | X | | | | | Corvallis, Oregon |
| Brigitte Goetze (from 3/93) | Deputy Director & Egypt Coordinator | X | X | | | | Corvallis, Oregon |

(1) Denotes primary work location and excludes host country site visits and travel for attending meetings.
(2) Personnel involved in multiple projects.

| Individual | CRSP Function | FIELD(S) OF SPECIALIZATION: Research Administration | Limnology/Water Quality | Fisheries/Aquaculture | Data Management | Social Sciences | Location of Work (1) |
|---|---|---|---|---|---|---|---|
| **DATA ANALYSIS AND SYNTHESIS TEAM** | | | | | | | |
| **DATA ANALYSIS AND SYNTHESIS TEAM – OREGON STATE UNIVERSITY** | | | | | | | |
| James Lannan | Co-Principal Investigator | X | | X | X | | Newport, Oregon |
| John Bolte | Co-Principal Investigator | | X | X | X | | Corvallis, Oregon |
| Shree Nath | Graduate Student | | X | X | | | Corvallis, Oregon |
| **DATA ANALYSIS AND SYNTHESIS TEAM – UNIVERSITY OF CALIFORNIA AT DAVIS** | | | | | | | |
| Raul Piedrahita | Principal Investigator | | X | X | X | | Davis, California |
| Steven Culberson | Research Assistant | | X | X | X | | Davis, California |
| Philip Giovannini | Research Assistant | | X | X | X | | Davis, California |
| Zhimin Lu | Research Assistant | | | | X | | Davis, California |
| Cristiano dos Santos Neto | Visiting Scholar | | X | X | X | | Davis, California |
| George Max | Fiscal Officer | X | | | | | Davis, California |
| **EGYPT** | | | | | | | |
| **EGYPT – AUBURN UNIVERSITY** | | | | | | | |
| Claude Boyd (2) | U.S. Co-Principal Investigator | | X | | | | Auburn, Alabama |
| Bryan Duncan (2) | U.S. Co-Principal Investigator | X | | | | | Auburn, Alabama |
| Bartholomew Green | U.S. Co-Principal Investigator | X | X | X | X | | Abbassa, Egypt |
| P. Parks | Fiscal Officer | X | | | | | Auburn, Alabama |

(1) Denotes primary work location and excludes host country site visits and travel for attending meetings.
(2) Personnel involved in multiple projects.

## FIELD(S) OF SPECIALIZATION

| Individual | CRSP Function | Research Administration | Limnology/Water Quality | Fisheries/Aquaculture | Data Management | Social Sciences | Location of Work (1) |
|---|---|---|---|---|---|---|---|
| **EGYPT – CENTRAL LABORATORY FOR AQUACULTURE RESEARCH** | | | | | | | |
| Ali E. Abdelghany (from 8/93) | H.C. Principal Investigator | X | | X | | | Abbassa, Egypt |
| Abdel Rahman El Gamal (to 8/93) | H.C. Principal Investigator | X | X | X | | | Abbassa, Egypt |
| Gamal El Nagar | Researcher | | | X | | | Abbassa, Egypt |
| Fatma El Nemaky | Researcher | | | | X | | Abbassa, Egypt |
| Zeinab Attia Elnagdy | Researcher | | X | | | | Abbassa, Egypt |
| Abdel Moez Faried | Researcher | | X | | | | Abbassa, Egypt |
| Fatma Hafez | Researcher | | | X | | | Abbassa, Egypt |
| Hussein Hebicha | Researcher | | | | X | | Abbassa, Egypt |
| Abdel Rahman Mostafa | Researcher | | | X | | | Abbassa, Egypt |
| Ahmed Said | Researcher | | | X | | | Abbassa, Egypt |
| Hussein El Ghobashy | Research Associate | X | | X | | | Abbassa, Egypt |
| Ahmed Khater | Research Associate | | | X | | | Abbassa, Egypt |
| Gamal Abdel Nasser | Research Associate | | | X | | | Abbassa, Egypt |
| Ibrahim Shaker | Research Associate | | X | | | | Abbassa, Egypt |
| Safwat Abdel Ghany | Research Assistant | | X | | | | Abbassa, Egypt |
| Nabil Ibrahim | Research Assistant | | X | | | | Abbassa, Egypt |
| Dia Abdel Rahiem | Research Assistant | | X | | | | Abbassa, Egypt |
| Namat Abdel Fatah | Chemist | | X | | | | Abbassa, Egypt |
| Samir Said | Chemist | | X | | | | Abbassa, Egypt |
| Mona Hamed | Biologist | | X | | | | Abbassa, Egypt |
| Mostafa Abdel Mohsen | Biologist | | X | | | | Abbassa, Egypt |
| Samir Zain Elabeden | Technical Engineer | X | | X | | | Abbassa, Egypt |

(1) Denotes primary work location and excludes host country site visits and travel for attending meetings.
(2) Personnel involved in multiple projects.

## FIELD(S) OF SPECIALIZATION

| Individual | CRSP Function | Research Administration | Limnology/Water Quality | Fisheries/Aquaculture | Data Management | Social Sciences | Location of Work (1) |
|---|---|---|---|---|---|---|---|
| Wahied Elwan | Technical Engineer | X | | X | | | Abbassa, Egypt |
| Tharwat Ismail | Technical Engineer | X | | X | | | Abbassa, Egypt |
| Ashraf Soluman | Technical Engineer | X | | X | | | Abbassa, Egypt |
| Seham Ahmed | Laboratory Assistant | | X | | | | Abbassa, Egypt |
| Mahmoud Abou El Nour | Accountant | X | | | | | Abbassa, Egypt |
| **EGYPT – OREGON STATE UNIVERSITY** | | | | | | | |
| Carl Schreck | U.S. Co-Principal Investigator | X | | X | | | Corvallis, Oregon |
| Martin Fitzpatrick | U.S. Co-Principal Investigator | X | | X | | | Corvallis, Oregon |
| William Gale | U.S. Research Assistant | | | X | | | Corvallis, Oregon |
| Robert Halvorsen (2) | Fiscal Officer | X | | | | | Corvallis, Oregon |
| **EGYPT – UNIVERSITY OF HAWAII** | | | | | | | |
| Gordon Grau | U.S. Principal Investigator | X | | X | X | | Kaneohe, Hawaii |
| Kevin Hopkins (2) | U.S. Principal Investigator | X | | X | X | | Hilo, Hawaii |
| Hal Richmond | U.S. Research Assistant | | | X | X | | Kaneohe, Hawaii |
| Steve Shimoda | U.S. Research Assistant | X | | X | | | Kaneohe, Hawaii |
| Bo Alexander | U.S. Research Assistant | | | X | | | Kaneohe, Hawaii |
| A. Chang | Fiscal Officer | X | | | | | Kaneohe, Hawaii |
| **EGYPT – UNIVERSITY OF MICHIGAN** | | | | | | | |
| James Diana (2) | U.S. Principal Investigator | X | | X | | | Ann Arbor, Michigan |
| P. Stemple | Fiscal Officer | X | | | | | Ann Arbor, Michigan |

(1) Denotes primary work location and excludes host country site visits and travel for attending meetings.
(2) Personnel involved in multiple projects.

| Individual | CRSP Function | FIELD(S) OF SPECIALIZATION: Research Administration | Limnology/Water Quality | Fisheries/Aquaculture | Data Management | Social Sciences | Location of Work (1) |
|---|---|---|---|---|---|---|---|
| **EGYPT – UNIVERSITY OF MICHIGAN/ASIAN INSTITUTE OF TECHNOLOGY** | | | | | | | |
| C. Kwei Lin (2) | Principal Investigator | | X | | X | | Bangkok, Thailand |
| **EGYPT – UNIVERSITY OF OKLAHOMA** | | | | | | | |
| William Shelton | U.S. Principal Investigator | | | | X | | Norman, Oklahoma |
| Venkatesh Wanningham (from 6/93) | Research Assistant | | | | X | | Norman, Oklahoma |
| B. Quinn | Fiscal Officer | X | | | | | Norman, Oklahoma |
| **HONDURAS** | | | | | | | |
| **HONDURAS – AUBURN UNIVERSITY** | | | | | | | |
| Bryan Duncan (2) | U.S. Principal Investigator | X | | | X | | Auburn, Alabama |
| Claude Boyd (2) | U.S. Researcher | X | X | | X | | Auburn, Alabama |
| David Teichert-Coddington | U.S. Research Associate | X | X | | X | | Comayagua and Choluteca, Honduras |
| Bartholomew Green (through 10/92) | U.S. Research Associate | X | X | | X | | Auburn, Alabama |
| Karen Veverica (2) (from 10/92) | U.S. Research Associate | | X | | X | | Auburn, Alabama |
| Donald Large (2) | Fiscal Officer | X | | | | | Auburn, Alabama |
| **HONDURAS – HOST COUNTRY PERSONNEL** | | | | | | | |
| Ricardo Gomez | H.C. Principal Investigator | X | | | X | | Comayagua, Honduras |
| Luis Lopez | H.C. Research Associate | | | | X | | Comayagua, Honduras |
| Sagrario Calix | Secretary | X | | | | | Comayagua, Honduras |
| Nelson Claros | Chemist | | X | | | | Choluteca, Honduras |
| Jaime Lopez | Lab Technician | | | | | | Comayagua, Honduras |

(1) Denotes primary work location and excludes host country site visits and travel for attending meetings.
(2) Personnel involved in multiple projects.

## FIELD(S) OF SPECIALIZATION

| Individual | CRSP Function | Research Administration | Limnology/Water Quality | Fisheries/Aquaculture | Data Management | Social Sciences | Location of Work (1) |
|---|---|---|---|---|---|---|---|
| Delia Martinez | Asst. Chemist | | | | | | Comayagua, Honduras |
| Herburt Ramos | Biologist | | | | | | Comayagua, Honduras |
| Miguel Zelaya | Lab Technician | | | X | | | Choluteca, Honduras |

# RWANDA

## RWANDA – OREGON STATE UNIVERSITY

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wayne Seim | U.S. Co-Principal Investigator | | X | X | | | Corvallis, Oregon |
| Richard Tubb | U.S. Co-Principal Investigator | X | X | X | | | Corvallis, Oregon |
| Felicien Rwangano | Graduate Student | | | X | | | Corvallis, Oregon |
| Revathi Balakrishnan (to 1/93) | U.S. Principal Investigator | | | | | X | Corvallis, Oregon |
| Robert Halvorsen | Fiscal Officer | X | | | | | Corvallis, Oregon |

## RWANDA – AUBURN UNIVERSITY

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tom Popma | U.S. Principal Investigator | X | | X | | | Auburn, Alabama |
| Joyce R. Newman (from 1/93) | U.S. Research Associate | | | X | | | Butare, Rwanda |
| Karen Veverica (2) | U.S. Research Associate | | X | X | | | Auburn, Alabama |
| Claude Boyd (2) | U.S. Researcher | X | | | | | Auburn, Alabama |
| Donald Large (2) | Fiscal Officer | X | | | | | Auburn, Alabama |

## RWANDA – UNIVERSITY OF ARKANSAS AT PINE BLUFF

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Carole Engle | U.S. Principal Investigator | X | | X | | | Pine Bluff, Arkansas |
| Peter Pershbacher (from 4/93) | U.S. Researcher | | X | X | | | Pine Bluff, Arkansas |
| Harold Phillips | U.S. Research Assistant | | | X | | | Pine Bluff, Arkansas |

(1) Denotes primary work location and excludes host country site visits and travel for attending meetings.
(2) Personnel involved in multiple projects.

## FIELD(S) OF SPECIALIZATION

| Individual | CRSP Function | Research Administration | Limnology/Water Quality | Fisheries/Aquaculture | Data Management | Social Sciences | Location of Work (1) |
|---|---|---|---|---|---|---|---|
| **RWANDA – HOST COUNTRY PERSONNEL** | | | | | | | |
| J. Bucyanayandi | H.C. Principal Investigator | X | | X | | | Butare, Rwanda |
| Anaclet Gatera | Research Assoc. & Asst. Station Mgr. | | | X | | | Butare, Rwanda |
| Maurice Ntahobari | Rector of UNR | X | | | | | Butare, Rwanda |
| J. Nshimyumuremyi | Vice Rector | X | | | | | Butare, Rwanda |
| A. Muhawenimana | Dean, Faculty | X | | | | | Butare, Rwanda |
| Vincent Kayijuka | Professor | X | | | | | Butare, Rwanda |
| Venantie Mukasikubwabo | Station Manager | X | | X | | | Butare, Rwanda |
| Lieven Verheust | UNR Researcher | X | | X | | | Butare, Rwanda |
| Dirk Lamberts | Production Manager | | X | | | | Butare, Rwanda |
| Ngoy Kasongo | Lab Technician | | X | | | | Butare, Rwanda |
| G. Ndahimana | Asst. Lab Technician | | X | | | | Butare, Rwanda |
| Janvier Murayire | Asst. Lab Technician | | X | | | | Butare, Rwanda |
| L. Umugiraneza | Sec./Computer Operator | | | | X | | Butare, Rwanda |
| F. Sindikubwabo | Lab Assistant | | X | | | | Butare, Rwanda |
| Evariste Ndabazi | Lab Assistant | | X | | | | Butare, Rwanda |
| Immaculee Nyabenda | Station Agronome | | | X | | | Butare, Rwanda |
| J. B. Munyandege | Extension Agent/Ngoma | | | X | | | Ngoma, Rwanda |
| S. Nyirakamana | Extension Agent/Shyanda | | | X | | | Shyanda, Rwanda |
| T. Ruhumuliza | Station Foreman | | | X | | | Butare, Rwanda |
| Eugenie Uwizeyimana | Storekeeper/Cashier | X | | | | | Butare, Rwanda |
| P. Nsabimana | Seine Crew Leader | | | X | | | Butare, Rwanda |
| E. Kajyibwami | Hatchery Technician | | X | | | | Butare, Rwanda |
| A. Dushimabategetsi | Pond Manager | | | X | | | Butare, Rwanda |
| J. Uwumuremyi | Pond Manager | | | X | | | Butare, Rwanda |

(1) Denotes primary work location and excludes host country site visits and travel for attending meetings.
(2) Personnel involved in multiple projects.

## FIELD(S) OF SPECIALIZATION

| Individual | CRSP Function | Research Administration | Limnology/Water Quality | Fisheries/Aquaculture | Data Management | Social Sciences | Location of Work (1) |
|---|---|---|---|---|---|---|---|
| **THAILAND** | | | | | | | |
| **THAILAND – UNIVERSITY OF MICHIGAN** | | | | | | | |
| James Diana (2) | U.S. Co-Principal Investigator | | X | X | X | | Ann Arbor, Michigan |
| C. Kwei Lin (2) | U.S. Co-Principal Investigator | X | X | X | | | Bangkok, Thailand |
| Barbara Diana | Research Assistant | X | | | X | | Ann Arbor, Michigan |
| Tracy Willoughby | Fiscal Officer | X | | | | | Ann Arbor, Michigan |
| **THAILAND – MICHIGAN STATE UNIVERSITY** | | | | | | | |
| Ted Batterson | U.S. Principal Investigator | X | X | | X | | East Lansing, Michigan |
| Chris Knud-Hansen | U.S. Research Associate | | X | X | X | | Bangkok, Thailand |
| Colleen J. Sober | Fiscal Officer | X | | | | | East Lansing, Michigan |
| **THAILAND – HOST COUNTRY PERSONNEL** | | | | | | | |
| Chaninthorn Sritongsuk | H.C. Co-Principal Investigator | X | X | X | | | Bangkok, Thailand |
| Peter Edwards | H.C. Co-Principal Investigator | | | X | | | AIT, Thailand |
| Watana Leelapatera | Research Associate | | X | X | | | Bangkok, Thailand |
| Vichai | Research Associate | X | | | | | Bangkok, Thailand |
| Kiri | Research Associate | X | | | | | Bangkok, Thailand |
| Chintana Boonthamchinda | Research Assistant | X | | X | | | Bangkok, Thailand |
| Archin Chamnankuruwet | Research Assistant | | | X | | | AIT, Thailand |
| Kiengkai | Research Assistant | | X | X | | | AIT, Thailand |
| Wongbathom Konmonrat | Research Assistant | | | | X | | Bangkok, Thailand |
| Vorathep Muthuwam | Research Assistant | | X | | | | AIT, Thailand |
| Ye Qifeng | Research Assistant | | | | X | | AIT, Thailand |

(1) Denotes primary work location and excludes host country site visits and travel for attending meetings.
(2) Personnel involved in multiple projects.

| Individual | CRSP Function | FIELD(S) OF SPECIALIZATION: Research Administration | Limnology/Water Quality | Fisheries/Aquaculture | Data Management | Social Sciences | Location of Work (1) |
|---|---|---|---|---|---|---|---|
| **THAILAND – HOST COUNTRY PERSONNEL (Continued)** | | | | | | | |
| Kriengkrai Satapornvanit | Research Assistant | | X | | | | AIT, Thailand |
| Sunil Shrestha | Research Assistant | | | X | | | AIT, Thailand |
| Tanaporn | Research Assistant | | | X | | | Bangkok, Thailand |
| Somchai Vaipoka | Research Assistant | | | X | | | Ayutthaya, Thailand |
| Somchai Wangwubulkit | Research Assistant | | X | X | | | AIT, Thailand |
| Pasu Wiwantrangsan | Research Assistant | | | | | | AIT, Thailand |
| Manoj Yomjinda | Research Assistant | | X | | | | AIT, Thailand |
| **THAILAND/PHILIPPINES – UNIVERSITY OF HAWAII** | | | | | | | |
| Kevin Hopkins (2) | U.S. Co-Principal Investigator | X | | X | X | | Hilo, Hawaii |
| James Szyper | U.S. Co-Principal Investigator | X | X | X | | | Kaneohe, Hawaii and AIT, Thailand |
| **PHILIPPINES – HOST COUNTRY PERSONNEL** | | | | | | | |
| Eduardo Lopez | H.C. Principal Investigator | X | | X | | | Munoz, Nueva Ecija, Philippines |
| **SOCIOECONOMIC DIMENSIONS - AUBURN UNIVERSITY** | | | | | | | |
| Joseph Molnar | Co-Principal Investigator | | | | | X | Auburn, Alabama |
| Leonard Lovshin | Co-Principal Investigator | | | | | X | Auburn, Alabama |
| Terry Hanson | Research Associate | | | | | X | Auburn, Alabama |
| German Cerezo | Graduate Student | | | | | X | Auburn, Alabama |

(1) Denotes primary work location and excludes host country site visits and travel for attending meetings.
(2) Personnel involved in multiple projects.

# VIII. CRSP List of Publications

## through 31 August 1993

# Data Analysis and Synthesis Team

## Oregon State University

### Publications and Reports


Lannan, J.E. 1990. Farming and ranching an aquatic system. Food Reviews International 6:293-298.

Lannan, J.E., G.A.E. Gall, J.E. Thorpe, C.E. Nash, and B.A. Ballachey. 1989. Genetic resource management of fish. Genome 31:798-804.


## University of California, Davis

### Theses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Giovannini, P. 1989. Analysis and modeling of dissolved oxygen concentrations and photosynthesis in warm water aquaculture ponds. M.S. thesis. 133 pp.


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Fridley, R.B., R.H. Piedrahita, and T.M. Losordo. 1988. Challenges in aquacultural engineering. Agricultural Engineering 69(4):12-15.

Giovannini, P., and R.H. Piedrahita. 1993. In press. Modeling net primary production optimization in aquaculture ponds: Depth and turbidity management. Aquacultural Engineering.

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Giovannini, P., and R.H. Piedrahita. 1992. Modeling net primary production optimization in aquaculture ponds: Depth and turbidity management. Aquacultural Engineering (in press).

Giovannini, P., and R.H. Piedrahita. 1991. Engineering of non-fed pond systems. Proceedings, WAS/ASAE sessions at World Aquaculture Society meeting. San Juan, Puerto Rico. American Society of Agricultural Engineers, Saint Joseph, Michigan.

Giovannini, P., and R.H. Piedrahita. 1990. Measuring primary production efficiency in aquacultural ponds. American Society of Agricultural Engineers Paper Number 90-7034.

Giovannini, P., and R.H. Piedrahita. 1989. Analysis and modeling of diel pond dynamics. American Society of Agricultural Engineers Paper Number 89-7556.

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Grace, G., and R.H. Piedrahita. 1993. Carbon dioxide control with a packed column aerator. Pages 496-505 *in* Techniques for Modern Aquaculture, Proceedings. American Society of Agricultural Engineers, June 1993.

Grace, G., and R.H. Piedrahita. 1992. Carbon dioxide control. In review.

Grace, G., and R. H. Piedrahita. 1989. Carbon dioxide removal in packed column aerators. American Society of Agricultural Engineers Paper no. 89-7556.

Losordo, T.M., and R.H. Piedrahita. 1990. Modelling temperature variation and thermal stratification in shallow aquaculture ponds. Ecological Modeling 54:189-226.

Lu, Z., and R.H. Piedrahita. 1993. Nitrifying characteristics of a high rate packed column. Pages 345-351 *in* Techniques in Modern Aquaculture, Proceedings. American Society of Agricultural Engineers, June 1993.

Piedrahita, R.H. 1991. Modeling water quality in aquaculture ecosystems. Pages 322-362 *in* D.E. Brune and J.R. Tamasso, (editors). Aquaculture and Water Quality. World Aquaculture Society. Baton Rouge, Louisiana.

Piedrahita, R.H. 1991. Simulation of short-term management actions to prevent oxygen depletion in ponds. Journal of the World Aquaculture Society 22(3):157-166.

Piedrahita, R.H. 1991. Engineering aspects of warmwater hatchery design. Proceedings, WAS/ASAE sessions at World Aquaculture Society meeting. San Juan, Puerto Rico. American Society of Agricultural Engineers, Saint Joseph, Michigan.

Piedrahita, R.H. 1990. Aquaculture: Engineering and construction. Pages 117-126 *in* Y.H. Hui, editor. Wiley Encyclopedia of Food Science and Technology. Wiley and Sons, New York.

Piedrahita, R.H. 1990. Detritus based aquaculture systems. Food Reviews International 6(3):317-331.

Piedrahita, R.H. 1990. Calibration and validation of TAP, an aquaculture pond water quality model. Aquacultural Engineering 9:75-76.

Piedrahita, R.H. 1989. Modeling water quality in aquaculture ecosystems. *In* D.E. Brune and J.R. Tamasso, editors. Aquaculture and Water Quality. World Aquaculture Society. Baton Rouge, Louisiana (in press).

Piedrahita, R.H. 1989. Simulation of short-term management actions to prevent oxygen depletion in ponds. American Society of Agricultural Engineers Paper Number 89-7555.

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Piedrahita, R.H., and D.E. Brune. 1989. Aquacultural engineering: Aquatic habitat commands innovative thrusts. Agricultural Engineering 70(1):30-32.

Piedrahita, R.H., and J.M. Ebeling. 1993. Automated data acquisition and control in aquaculture ponds. American Fisheries Society (in press).

Piedrahita, R.H., and J.K. Wang. 1988. Engineering in aquaculture, an overview. Proceedings of the Joint U.S. India International Symposium on Aquaculture Research Needs for the Year 2000. New Delhi, India.

Szyper, J.P., L.Z. Rosenfeld, R.H. Piedrahita, and P. Giovannini. 1992. Diel cycles of planktonic respiration rates in briefly-incubated water samples from a fertile earthen pond. Limnology and Oceanography 37(6):1193-1201.


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Brune, D.E., C.M. Drcho, and R.H. Piedrahita. May 1992. Pond oxygen dynamics; design and management strategies. Aquaculture Meeting, Orlando, Florida. Paper No. AQUA-92-101, American Society of Agricultural Engineers.

Culberson, S.D., and R.H. Piedrahita. May 1992. Modification of stratified temperature model to accommodate reduced data inputs: Identifying critical requirements. Aquaculture Meeting. Orlando, Florida. Paper No. AQUA-92-102.

Piedrahita, R.H. November 26-27, 1992. Managing environmental impacts in aquaculture. Presented at United States-Japan Natural Resources (UJRN) Aquaculture Panel. Kyoto.

Piedrahita, R.H. September 1991. Carbon dioxide removal for intensive aquaculture. Workshop on Recirculating Aquaculture Systems. Baton Rouge, Louisiana.

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Piedrahita, R.H., and G. Grace. June 1990. Removal of carbon dioxide and intensive aquaculture systems. Presented at the Annual Meeting of the World Aquaculture Society, Halifax, Nova Scotia.

Szyper, J.P., R.H. Piedrahita and P. Giovannini. May 1993. Requirements for maximizing bloom stability and net oxygen production in earthen ponds. Poster paper presented at World Aquaculture Society meeting, Torremolinos, Spain.

Whitman, M. H., and R. H. Piedrahita. February 1989. Water quality requirements of Pacific oysters (*Crassostrea gigas*) in holding systems. Annual Meeting of the World Aquaculture Society. Los Angeles.

### Manuscripts

Grace, G., and R.H. Piedrahita. 1992. Carbon dioxide control. In review.

Piedrahita, R.H., and Grace, G. 1991. Carbon dioxide removal for intensive aquaculture. Paper presented at the Workshop on Recirculating Aquaculture Systems, Baton Rouge, Louisiana, September, 1991. In review.

## University of Hawaii

### Publications and Reports

Szyper, J.P., L.Z. Rosenfeld, R.H. Piedrahita, and P. Giovannini. 1992. (In Press) Diel cycles of planktonic respiration rates in briefly-incubated water samples from a fertile earthen pond. Limnology and Oceanography.

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## University of Michigan

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Chang, William. 1989. Integrated lake farming to manage fish and environment in the large shallow lakes in China. Aquaculture and Fisheries Management 20:441-452.

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Springborn, R. R., A. L. Jensen, and W.Y.B. Chang. A multivariate approach for examining *Tilapia nilotica* growth in aquaculture experiment using Von Bertalanffy's growth solution (submitted).

# Honduras

## Universidad Nacional Autonoma de Honduras

### Theses

Berrios, J. In preparation. Growth and survival of hybrid tilapia (*Tilapia nilotica* x *Tilapia honorum*) fingerlings during the nursery phase. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

Carlos Hernandez, W.N. 1992. Respuesta de fitoplancton y zooplancton a fertilizante orgánico y alimento en estanques piscicolas. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

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Gomez, R. 1988. Effect of fertilizer type on the production of male *Tilapia nilotica*. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

Lopez, L. In preparation. Production of *Tilapia nilotica* in ponds fertilized with layer chicken litter. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

Mejia, C. In preparation. Rainy season phytoplankton dynamics in ponds stocked with *Tilapia nilotica*. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

Paz, S.A. In preparation. The relationship between primary productivity and chlorophyll and their relation to tilapia production. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

Sherman, C. 1992. All female culture of *Tilapia nilotica* in ponds fertilized with chicken litter. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

## Auburn University

### Publications and Reports

Alvarenga, H.R., and B.W. Green. 1986. Growth and production of all male *Tilapia nilotica* and all male hybrid tilapia (*Tilapia nilotica* x *Tilapia honorum*) in ponds. Rev. Latinoamericana de Acuicultura 29:6-10. (In Spanish.)

Alvarenga, H.R., and B.W. Green. 1985. Production of hybrid tilapia (*Tilapia nilotica* x *Tilapia honorum*) fingerlings. CRSP Technical Report, unpublished. 12 pp. (In Spanish.)

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Ayub, M., C.E. Boyd and D.R. Teichert-Coddington. 1993. Effects of urea application, aeration, and drying on total carbon concentrations in pond bottom soils. The Progressive Fish-Culturist. In Press.

Berrios, J.M. 1986. Growth and survival of hybrid tilapia (*Tilapia nilotica* x *Tilapia honorum*) fingerlings during the nursery phase in ponds. CRSP Technical Report, unpublished. 16 pp. (In Spanish.)

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Green, B.W., and D.R. Teichert-Coddington. 1993. Production of *Oreochromis niloticus* fry for hormonal sex reversal in relation to water temperature. Journal of Applied Ichthyology. In Press.

Green, B.W., and D.R. Teichert-Coddington. 1991. A comparison of two samplers used with an automated data acquisition system in whole-pond community metabolism studies. The Progressive Fish-Culturist 53(4):236-242.

Green, B.W., and D.R. Teichert-Coddington. 1990. Comparison of two sampler designs for use with automated data acquisition systems in whole-pond community metabolism studies. Proceedings of FAO-EIFAC Symposium on Production Enhancement in Still-Water Pond Culture, Prague. Research Institute of Fish Culture and Hydrobiology, 38925 Vodnany, Czechoslovakia.

Green, B.W., R.P. Phelps, and H.R. Alvarenga. 1989. The effect of manures and chemical fertilizers on the production of *Oreochromis niloticus* in earthen ponds. Aquaculture 76:37-42.

Green, B.W., H.R. Alvarenga, R.P. Phelps, and J. Espinoza. 1988. Technical Report: Honduras Aquaculture CRSP Cycle III Rainy and Dry Season Phases. CRSP Technical Report, unpublished. Auburn University, Alabama.

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Teichert-Coddington, D.R., B. Green, and M.I. Rodriguez. 1989. Effectos de la tasa de alimentacion sobre la produccion de tilapia en estanques fertiliazdos con gallinaza. Presented at the annual regional meeting of the Programa Cooperativo Centroamericana para el Mejoramiento de Cultivos Alimenticios (PCCMCA), San Pedro Sula, Honduras. Presented by M.I. Rodriguez.

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## University of Hawaii

### Manuscripts

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Szyper, J.P., K. Hopkins, and C.K. Lin. Production of *Oreochromis nilotica* (L.) and ecosystem dynamics in manured ponds of three depths. Submitted to Aquaculture and Fisheries Management. In review.

# Indonesia

## Agricultural University of Bogor

### Theses

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## Michigan State University

### Theses

Abdalla, Abdelmoez A.F. 1989. The effect of ammonia on *Oreochromis niloticus* (Nile tilapia) and its dynamics in fertilized tropical fish ponds. Ph.D. dissertation, Michigan State University, East Lansing, Michigan. 62 pp.

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# IX. Abstracts of Technical Papers

In a departure from the format of past years, this Annual Report is divided into two volumes. This volume, Eleventh Annual Program Report, describes the program and administrative accomplishments; technical papers are found in their entirety in the companion volume, Eleventh Annual Technical Report. In order to indicate the scope of the CRSP research activities, abstracts for the technical papers appear here; for the complete paper, refer to the Technical Reports volume. The last five abstracts are identified as "Progress Summary." These abstracts represent research in progress, and the papers will appear in their entirety in the Twelfth Annual Technical Report.

## Validation of PD/A CRSP Pond Management Strategies

***Work Plan 7, Study 1A***

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***Abstract***

Production pond trials were initiated in July 1993 to test performance of PD/A CRSP-developed pond management strategies under the climatic and edaphic conditions of Egypt as well as to compare tilapia yields from these systems to yields from ponds managed according to traditional or modified Egyptian pond management systems. Five treatments were tested: "Traditional" Egyptian system; "Enhanced" Egyptian system; Feed only; Fertilization then feed; and Chemical fertilization. Ponds were stocked with monosex or mixed-sex *Oreochromis niloticus* at 20,000/ha. After 90 days of growth, mean fish weights were 89.5 g for chemical fertilization treatment, 107.5 g for enhanced Egyptian system treatment, 97.1 g for fertilization-then-feed treatment, 68.2 g for feed only treatment, and 72.5 g for traditional Egyptian system treatment. The research plan calls for this experiment to continue for an additional 60 days. Data continue to be collected and will be analyzed on completion of the experiment.

## Soil Respiration: Effects of Chicken Litter and Urea

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***Abstract***

Respiration, total alkalinity (TA), total hardness (TH), and pH were monitored for 16 days in 5-gallon bucket microcosms that had been filled with water and treated with soil, chicken litter, and urea (SCLU); soil and chicken litter (SCL); soil (S); or chicken litter (CL). The objective was to observe the effects of chicken litter and urea fertilization on respiration, total alkalinity (TA), total hardness (TH), and pH in order to verify pond data.

Respiration in soil-treated buckets was very low relative to those receiving allochthonous organic matter. Carbon dioxide that was evolved in SCLU and SCL buckets during respiration combined with soil carbonates to raise TA and TH higher than in those buckets not treated with soil (CL). Total alkalinity and pH were both consistently higher in the SCLU than the SCL treatment, because hydrolysis of urea forms ammonia, which is alkaline in water.

This experiment illustrated why in TA and TH in El Carao ponds have always increased during production cycles in organically but not in inorganically fertilized ponds. It also partly illustrates why pond pH has increased with use of urea as a supplemental nitrogen fertilizer.

# Intensive Fertilization of Tilapia Ponds in the Philippines

***Work Plan 6, Experiment 10***

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***Abstract***
Three experiments to test CRSP fertilizer guidelines were conducted in the Philippines from late 1991 to mid 1993. Six fixed combinations of inorganic and organic fertilizers and a variable fertilization scheme based on PONDCLASS (a computerized expert-system for pond fertilization developed by the CRSP) were tested. Sex-reversed FAC-strain *Oreochromis niloticus* were used except during the third experiment when *O. niloticus* produced by YY males were included as one of the treatments.

Average yields of sex-reversed *O. niloticus* ranged from 3941 to 4818 kg/ha/yr for both the inorganic fertilizer and combination inorganic fertilizer/manure treatments with nitrogen inputs of 4-5 kg N/ha/d and N:P ratio of 1:5. Production of small fish (below market size) because of incomplete sex-reversal increased total yields to almost 6000 kg/ha/yr. *O. niloticus* produced by YY males yielded 5324 kg/ha/yr of market size fish.

A preliminary estimate of profitability indicates that fertilization can be more profitable than feeding with considerably less risk because of reduced operating capital requirements.

# Field Testing Least Intensive Aquaculture Techniques on Small-Scale Farms in Thailand

***Work Plan 6, Study 9***

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***Abstract***
Growout field trials of Nile tilapia *(Oreochromis niloticus)* were conducted at several small-scale fish farms in Central and Northeast Thailand. The field trials assessed the efficacy of several Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) guidelines for pond fertilization and fish stocking. In addition, fish ponds in Northeast Thailand were assessed for nutrient limitation for algal production using an algal bioassay technique developed at the Asian Institute of Technology. The results of field trials demonstrated the importance of algal-based pathways for Nile tilapia production. Yields consistently averaged around 8,000 kg/ha/year at a fertilization input cost of about Baht (THB) 6/kg harvested fish. Since farm-gate prices for tilapia are around THB 15-20/kg, using only triple superphosphate (TSP) and urea to fertilize ponds and stimulate algal production proved economical and maintained consistently high dissolved oxygen concentrations (>2.5 mg/L) at dawn, even in highly productive ponds. Algal bioassays proved to be effective and simple tools for assisting farmers in applying more nutrient-efficient fertilization strategies. A growout field trial using algal bioassays as the only indicator of fertilization requirements improved cost efficiency to less than THB 4/kg harvested tilapia.

# Nitrogen Requirements for Maximum Fish Production in Rwandan Ponds

***Work Plan 6, Experiment 2***

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***Abstract***

Nutrient input rates and resulting fish production have been lower in Rwandan ponds than in ponds at other CRSP sites in Asia and Latin America. This experiment was designed to determine, under the environmental conditions of Rwasave Station (1625 m elevation), maximum primary and fish production when neither nitrogen, phosphorus, nor inorganic carbon were limiting.

Total ammonia nitrogen (TAN) concentrations in individual ponds reached as high as 7.3 mg/L; the unionized portion reached as high as 2.1 mg/L. Polynomial regression of chlorophyll *a* against TAN ($r^2$=0.62) suggested that increases in TAN concentrations above about 1.5 mg/L were not accompanied by increased chlorophyll *a* concentrations. The growth rate of fish in ponds receiving 3.8 kg N/ha/d was significantly greater (P<0.10) than that of fish in ponds receiving 1.0 kg N/ha/d, but average growth rate decreased at the highest fertilization level. High rates of N and P fertilization in Rwanda produced average chlorophyll concentrations exceeding levels reported for similarly fertilized ponds in Thailand, but maximum net fish production in Rwanda (3850 kg/ha/year at the 3.8 kg N/ha/d input rate) was still only 55% of the reported rate for Thailand. Water temperature appears to be one of the primary reasons for the lower growth rates observed in Rwanda.

## Optimization of Gender Control Techniques for Tilapia

***Work Plan 7, Study 4C1***

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***Abstract***

A binding site for the synthetic androgen mibolerone was identified in cytosolic preparations of testes from tilapia, *Oreochromis niloticus*. A single class of high-affinity, low-capacity binding sites was found with $K_d$ = 1.03 ± 0.11 nM (n=2) and $B_{max}$ = 5.65 ± 0.42 fmol/mg protein (n=2). The binding site was specific for mibolerone, but also demonstrated affinity for 17α-methyltestosterone, 17α-ethynylestradiol, and 5α-dihydrotestosterone. Identification and characterization of this binding site may represent the first steps towards understanding how steroids cause sex inversion and may provide a tool for screening potentially sex inverting compounds.

## Progeny Testing to Identify "YY" Male Tilapia

***Work Plan 7, Study 4A1***

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***Abstract***

Males from ten groups thought to contain YY individuals were mated with normal females. To date, the offspring of 24 of 82 matings have been examined. The observed sex ratios do not suggest that a YY male was included in any of the matings.

## Growth-Promoting Action of 17α-Methyltestosterone on Two Species of Tilapia, *Oreochromis mossambicus* and *Oreochromis aureus*

***Work Plan 7, Study 4B1***

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***Abstract***

The objectives of our first year of study are to separate the growth-promoting effects of 17α-methyltestosterone (MT) from the sex-reversal effects on *Oreochromis mossambicus* and *Oreochromis aureus* under hatchery conditions. Experiments are conducted using a factorial design with three factors and replicate treatments. The factors are species, sampling dates, and either dose level of MT (Experiment I) or feeding regime of MT (Experiment II). Methyltestosterone is administered orally as a feed additive. Because male tilapia tend to grow faster than females, this study separates the growth-promoting effects of MT from its masculinizing effects. Data collection for fish weight, length, sex and gonadosomatic index, and tissue sample collection to evaluate residual MT levels is ongoing.

# Use of 17α-Methyltestosterone for Tilapia Sex Reversal: Participation in the 1993 Clinical Field Trial under U.S. Food and Drug Administration Investigational New Animal Drug Exemption (INAD 8479 C-002 and C-003)

***Work Plan 7, Study 4A2***

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***Abstract***
The U.S. Food and Drug Administration granted a "compassionate" Investigational New Animal Drug (INAD) exemption to Auburn University, the American Tilapia Association, and a commercial feed producer to collect data to support a New Animal Drug Application for the use of 17α-methyltestosterone for sex reversal of newly hatched tilapia. Implementation of clinical field trials at research institutions and by commercial tilapia growers throughout the United States and overseas was one activity contemplated under this INAD exemption. U.S. and Egyptian researchers involved with the Pond Dynamics/Aquaculture Collaborative Research Support Program participate in the field trials. In August 1993, preliminary, unreplicated experiments were initiated in Egypt. Four trials each for *Oreochromis niloticus* and *O. aureus* were begun. A total of approximately 25,000 *O. niloticus* fry and 16,000 *O. aureus* fry have been submitted to androgen treatment to date. The collection of data from these trials will continue as long as water temperatures permit.

# Interaction of Plant/Snail Bioconversion by Grass Carp and Black Carp in Egyptian Fish Culture Ponds

***Work Plan 7, Study 2C1***

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***Abstract***
Combination stocking of black and grass carps tests interactions of the two species with reference to snail control. Snails benefit from plants as cover and food, thus the presence of grass carp may affect snails indirectly. Stocking black carp without vegetative control may limit their success in foraging for snails. Data to evaluate the potential synergism of grass carp and black carp will be obtained at draining in December 1993.

# Variation Of Soil Respiration With Humidity Using Pond Soil From Honduras

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***Abstract***
The influence of soil humidity on pond bottom soil respiration in laboratory microcosms was tested. Soil respiration and moisture were linearly correlated. Slopes of the curves revealed that moisture level had a greater effect on respiration initially than it did later. Respiration was highest on day four after wetting and decreased to a generally steady level by day eight. Maintenance of a higher level of soil moisture resulted in higher steady state rates of respiration. Saturation of soil resulted in an immediate dramatic drop in respiration as gas transfer was inhibited. Wetting of a dried soil (14% soil moisture) increased respiration more than seven-fold. In the absence of rains or frequent wettings, ponds will efficiently mineralize carbon only during the first week of drying. High steady state respiration rates can be maintained on soils of high organic C content for several weeks in the presence of sufficient soil moisture to satisfy the needs of bacteria.

# On-farm Production of Monosex *Oreochromis niloticus* at Altitudes above 1300 Meters

***Work Plan 6, Experiment 1***

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***Abstract***
Twenty-three farmer-owned ponds and five research station ponds in five altitude zones in Rwanda were stocked with tilapia *(Oreochromis niloticus)* fingerlings in five-month experiments designed to quantify the relationships of elevation with fish growth, production, and survival. Altitudes ranged from 1370 m (Zone 1) to 2180 m (Zone 5). Growth rates at higher altitudes were significantly lower (0.55 and 0.61 g/d) than at lower elevations (0.81 to 0.86 g/d). Growth rates were generally depressed above elevations of about 1700 m. Net extrapolated annual fish production was significantly less in ponds at the highest elevation than in ponds at the four lower altitudes. Higher survival rates in Zones 3 and 4 might account for their relatively high net production as compared to Zone 5. Chlorophyll *a* concentrations were highest in ponds at the highest elevation, suggesting that phytoplankton was plentiful and that low growth resulted from reduced food consumption or utilization by tilapia in the cooler environment.

# Benefits of Supplemental Dietary Energy in Tilapia Ponds Enriched with Fresh Grass and Chemical Fertilizer

***Work Plan 6, Experiment 4***

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***Abstract***
Results from a previous experiment[1] suggested that natural food organisms resulting from fertilization with fresh grass and chemical fertilizer provided less than the recommended optimum digestible energy (DE) to digestible protein (DP) ratio of 9.7 kcal DE/g DP for tilapia. An earlier study resulted in increased fish production when a high-energy feed (cassava) was added to ponds fertilized with fresh grass.

Fifteen 6.6-are ponds stocked with 13 g *Oreochromis niloticus* mixed sex fingerlings at 2/m$^2$ were fertilized with weekly applications of fresh grass at 350 kg/ha dry weight, urea at 6.75 kgN/ha, and triple superphosphate at 1.6 kgP/ha. Five ponds received 450 g of cassava meal daily. Five other ponds received the same amount of cassava but the fish were prevented from consuming it directly.

There were no significant differences in fish growth, survival, or production between treatments. Net annualized fish yield averaged 3,055 kg/ha over all treatments. Optimum digestible energy/protein ratios published for tilapia had been calculated at temperatures higher than the average pond water temperatures in Rwanda; the optimum DE/DP ratio at lower temperatures may be lower, suggesting that the natural food organisms may not have been energy deficient. Another possible explanation for no response to supplemental dietary energy is that the change was too small to detect in relation to the additional nutritional contribution of phytoplankton resulting from chemical fertilization. Added energy did not appear to spare protein for growth in this environment for these input rates.

[1] Ndikumwami, R., K.L. Veverica, T.J. Popma, and W.K. Seim. 1993. Supplemental dietary energy to enhance utilization of natural food organisms for growth by tilapia. Pages 48-51 *in* H. Egna, M. McNamara, J. Bowman, and N. Astin, editors. Tenth Annual Administrative Report, Pond Dynamics/Aquaculture Collaborative Research Program, Office of International Research and Development, Oregon State University, Corvallis, Oregon.

# Temperature Affects Appetite, Growth, Feed Conversion Efficiency, and Body Composition of Tilapia

***Work Plan 7, Study 4***

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***Abstract***
A controlled-temperature study was conducted in aquaria at Auburn University to determine maximum feed consumption, growth, feed conversion ratios (FCR), and body composition of Nile tilapia *(Oreochromis niloticus)* fingerlings as a function of three feeding rates (30, 60, and 100% of satiation) under constant or diurnally fluctuating temperature regimes (22±0, 22±4, 26±0, and 26±4°C). A floating catfish pellet consisting of 32% crude protein was offered at two-hour intervals from 0800 to 1800 hours daily for 28 days. The satiation feeding rate was determined weekly and feeding rates were adjusted weekly by weighing all fish individually.

Average maximum feed consumption for fish fed to satiation was 37% greater at 26°C than at 22°C [4.5 vs 3.3% body weight per day (BW/d)]. At a given average temperature, appetite was not affected (P>0.20) by daily variations in temperature.

Average weight gain for fish fed to satiation was 81% of initial weight at 22°C and 142% of initial weight at 26°C. The relative superiority of weight gain at warmer temperatures decreased at lower feeding rates: 75% superior weight gain at full satiation, 69% superior growth at 0.6 satiation, and 47% superior growth at 0.3 satiation. Daily variations in temperature did not affect growth rate (P>0.20). At feeding rates (converted from percent satiation to percent of body weight per day) between 2.0% and 3.3% BW/d, fish grew faster at 26°C than at 22°C; at feeding rates of 1.5% BW/d, weight gain was similar at both temperatures.

Feed conversion ratios (FCRs in g feed/g gain) were a function of average temperature and feeding rate (P<0.01) but not of daily variation in temperature (P>0.20). For a given average temperature, FCRs were similar for fish fed to 60 or 100% satiation, but 20 to 28% more feed was required per unit weight gain at feeding rates of 30% satiation.

Average protein conversion efficiency (g protein gain/g dietary protein) was 0.34, and was affected by average temperature and feed consumption (P<0.01) but not by daily variation in temperature. Fish fed at 30 to 100% satiation converted dietary protein 9 to 15% more efficiently at 26°C than at 22°C.

Final body composition of tilapia after 28 days was affected by feeding rate (P<0.01) but not by temperature (P>0.20). Crude protein content of whole fresh fish ranged from 15.3% for fish fed at 30% satiation to 16.5% for fish fed to full satiation. Lipid content averaged 2.8% of fish fed at 30% and rose to 7.0% at full satiation.

## A Comparative Economic Analysis of Small-Scale Fish Culture in Rwanda

***Work Plan 6, Study 5***

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***Abstract***

Results of a survey of 280 fish farmers in Rwanda indicated that sweet potatoes were one of the major crops also raised by fish farmers. *Oreochromis niloticus* was the leading fish species raised and the overall stocking density varied from 15 to 210 fish/are with a mean of 84 fish/are. Fifty-six percent of the fish harvested was sold and 28% was consumed by producers. Enterprise budget analysis of all "marais" crops identified in the survey showed positive income above variable costs and positive net returns to land, labor, and management for all crops except Irish potatoes. Fish farming yielded the highest net returns to land, labor, and management, and cabbage production ranked second. In terms of carbohydrate production, sweet potatoes gave the highest yield, while maize production produced the greatest amount of energy per are of land. Soybeans were the least expensive source of protein. Government and international donor policies related to fish farming should take into consideration the importance of fish farming in generating cash income for Rwandan small-scale farmers.

## Pond Dynamics Under Semi-Intensive and Intensive Culture Practices

***Work Plan 6, Study 5***

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***Abstract***

The addition of feed to fertilized fish ponds was evaluated by adding fertilizer alone, feed alone *(ad libitum)*, or fertilizer and feed at 75%, 50%, and 25% of the *ad libitum* rate to 15 ponds stocked with Nile tilapia *(Oreochromis niloticus)* at 750 fish per 250 $m^3$ pond. Fertilizers in the fertilizer and feed treatments were used mainly to balance nutrient inputs of phosphorus and nitrogen to the ponds. Growth and yield over 155 days differed significantly among treatments, with feed levels of 5% *ad libitum* or greater producing similar, high growth rates. Growth was also negatively correlated to high ammonia levels in ponds, which occurred mainly in ponds fed *ad libitum,* particularly late in the experiment. While growth improved in fed ponds, size at harvest did not generally exceed 450 g, which was the target size for this experiment. This was probably due to deteriorating water quality late in the experiment.

# Evaluation of Low Cost Methods for Destratification and Oxygen Conservation in Tropical Ponds

***Work Plan 6, Study 8***

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***Abstract***

Artificial mixing of water in earthen ponds, as distinct from active aeration, has the potential to conserve naturally produced dissolved oxygen, and thus to lower costs by reducing or eliminating the need for aeration. The performance of three mixing devices in ponds of four different sizes was assessed. The following mixing devices were tested: 1) a submersible pump (SP); 2) an air lift tube (AL); and 3) a vertical fan blade aerator (IE).

Pairs of unmixed ponds showed very similar isotherm patterns on the same dates. Differences in isotherm patterns were greater between dates of paired unmixed ponds than between pairs of unmixed ponds on the same dates. All of the devices were able to modify typical intense midday stratification in tropical ponds. The most powerful mixing device in ponds of all sizes was the IE.

There is little doubt that any of the mixers, in particular the least powerful (AL), could prevent development of stratification in ponds up to 1600 $m^2$ if mixing is initiated earlier in the day. The performance of the AL suggests that it was more efficient than the IE at reducing the energy involved in stratification, which is consistent with the author's earlier suggestion that slower and more diffuse application of mixing energy would be more efficient than rapid point-source application. Both systems are of much lower cost than active aerators.

# Decision Support Systems for Pond Aquaculture

***Work Plan 6, Study 1***

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***Abstract***

The Oregon State University component of the Data Analysis and Synthesis Team is involved with the development of computerized tools (decision support systems) for analyzing and managing fish ponds. The user-friendliness of an earlier version of such a system called PONDCLASS has been improved, and existing fertilization and lime requirement routines modified to permit more efficient resource utilization. New functionality has been added in the form of fish growth and water temperature models. Model formulation, parameter estimation and data requirements are discussed in detail. Results of simulations with CRSP data suggest that the models can be reasonable predictors of fish growth and water temperature patterns in ponds. These models allow users to simulate fish growth and water temperature over long periods, and can be used as analysis tools to guide decisions relating to fish stocking density and size and to harvest scheduling. Much of the functionality of the original PONDCLASS program has been implemented in an entirely new software environment that is based on the Windows operating system for IBM-PC computers. This new generation of decision support systems is being designed to allow pond operators to conduct short-term simulations of single or multiple ponds in order to diagnose potential production problems and generate possible management strategies for counteracting those problems. The environment will also support long-term and lower resolution simulations of ponds and record resource inputs, thus allowing users to conduct facility-level economic analyses.

# Simulation of Water Quality in Stratified CRSP Ponds: Dissolved Oxygen Concentration

***Work Plan 6, Study 3***

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***Abstract***

Previous attempts at predicting dissolved oxygen (DO) levels in aquaculture ponds have often relied on the assumption of homogeneous water quality throughout the water column. Using a stratified temperature model as a basis for structure, we have modified a mass-balance model for the prediction of dissolved oxygen levels in shallow aquaculture ponds. This model has been updated with recent information concerning the behavior of pond phytoplankton throughout the diurnal cycle, rendering accurate predictions of DO levels in both stratified and fully mixed ponds. In addition, the overall data requirements of the model have been significantly reduced from those of previous models. Simulations for sites in Northern California are presented, as well as for several sites located in various places around the globe, using data from the CRSP Central Data Base. The strategies used for dealing with reduced data sets and the associated assumptions made are also presented.

# Water Column Respiration in Aquaculture Ponds

***Work Plan 6, Study 2***

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***Abstract***
A prototype automated diel pond respiration measurement device was developed and tested. The system was used to record respiration and other data from experimental tilapia ponds at the Mariculture Research and Training Center (MRTC) of the University of Hawaii. Data from these tests show the potential for this type of apparatus for examining the respiration dynamics of shallow ponds. Some examples of these preliminary data are presented to show the relationships between some of the processes and variables mentioned and respiration rates. However, it is not possible to determine cause and effect relationships from simple correlations with other process variables, and no attempt is made to do so here. These results are presented to illustrate the dynamic behavior of pond respiration rates observed in some tests and to examine how these respiration rates change with respect to other observed variables under field conditions.

# Causes of Cyclical Variation in Honduran Shrimp Production

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***Abstract***
The relationships between stocking, harvest, and environmental variables for two commercial shrimp farms in southern Honduras were evaluated. Data were analyzed from consecutive production cycles between 1986 and 1991 at Farm A and between 1988 and 1991 at Farm B. Stocking ponds between March and June resulted in good yields, whereas stocking ponds between November and February resulted in poor yields. Step-wise regression analyses revealed that survival, stocking density, salinity, and temperature accounted for up to 80% of the total variation in shrimp yield. The environmental variables alone accounted for only a third of the total variation. A similar analysis of monthly means, which emphasized time-related variation by minimizing inter-pond variability, revealed that temperature accounted for 75 to 85%, and percentage of *P. vannamei* stocked accounted for up to 88% of the total monthly variation. The effects of salinity were minor. Shrimp yield variation within a farm was mainly related to non-environmental factors, whereas cyclical variation over a calendar year was primarily related to temperature and the proportion of *P. vannamei* stocked.

# Effect of Diet Protein Level on Semi-Intensive Commercial Growout of *Penaeus vannamei* in Honduras During Wet and Dry Seasons

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***Abstract***
Complete diets composed of 20 or 40% crude protein were tested in earthen ponds stocked with juvenile *Penaeus vannamei* at densities of 5 or 11/m$^2$. A randomized 2x2 factorial design was used. Feed was offered three times daily, six days a week. Dissolved oxygen concentrations were maintained above 3 mg/L. The study was repeated during wet and dry seasons. Ponds were completely drained and harvested when weekly shrimp growth stopped; trial periods lasted 20 and 16 weeks for the wet and dry seasons, respectively.

Protein level had no significant effect ($P > 0.05$) on survival, yield, or average weight of shrimp stocked at either density during either season. Higher stocking rates resulted in significantly greater shrimp production during both seasons. During the wet season, mean shrimp weight was significantly smaller in high density ponds than in low density ponds, but there was no significant difference between mean weight because of stocking density during the dry season. Mean survival was significantly lower at the higher stocking rate during both seasons. Net income was not significantly different between stocking densities during the wet season, but was significantly less for the high density treatment during the dry season. Mean production was 380 percent greater in the wet season than in the dry season.

This study suggests that diets offered to shrimp stocked at 5 to 11/m$^2$ should contain no more than 20% protein, regardless of season. Higher protein levels will increase costs and contribute more waste nitrogen to the estuarine system without resulting in greater shrimp yields. The lower stocking density should be used during the dry season. The higher stocking density tended to increase profitability in the wet season, but long-term sustainable production may be more feasible at the lower stocking rates, because of reduced waste discharge to the estuaries.

# High Elevation Monoculture and Polyculture of *Oreochromis niloticus* and *Clarias gariepinus* in Rural Rwandan Ponds

***Work Plan 6, Special Topics Study***

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***Abstract***

Growth and production of *Oreochromis niloticus* and *Clarias gariepinus* were studied in relation to three different stocking strategies (100% tilapia, 100% catfish, and 2/3 tilapia-1/3 catfish), at a total stocking rate of one fish per $m^2$ in rural ponds at elevations of 1570 and 2180 m. All ponds received weekly applications of fresh grass of the genus Cyperus at a rate of 250 kg/ha total solids, plus urea and triple superphosphate to provide 15 kg N/ha and 4 kg P/ha.

Extrapolated net production after 130 to 150 days, based on average weights of a large sample and assuming 100% survival, was significantly different for two of the three stocking strategies. Polyculture provided the greatest extrapolated production–3108 kg/ha/yr at the lower elevation and 1604 kg/ha/yr at the high elevation. Net yields at harvest were much less than the extrapolated five-month yield, however, and differences between stocking strategies were not significant. Low survival due to low pond water levels at the low elevation and macrophyte growth at the high elevations are possible causes.

# Photosynthesis and Community Respiration at Three Depths During a Period of Stable Phytoplankton Stock in a Eutrophic Brackish Water Culture Pond

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***Abstract***

A 14-day period of dense but stable phytoplankton stock in a brackish water earthen pond (0.2 ha area, 0.7 m depth) was characterized to provide a baseline for study of instability. Results illustrate the potential of ponds to serve as microcosms of natural systems. Primary production and community respiration were assessed by diel curve analysis of oxygen and inorganic carbon sampled every 30 minutes at 3 depths. Neither stocks nor diel oxygen regimes were destabilized by two isolated days of low light, the first accompanied by heavy rainfall. Among nutrient elements, only inorganic nitrogen exhibited marginally limiting values. Daytime net production (dNPP) of oxygen ranged from 0 to 0.26 mol $m^{-2}$ $d^{-1}$, carbon uptake from 0.01 to 0.22 mol $m^{-2}$ $d^{-1}$. Nighttime respiration (nR) approximately matched dNPP, resulting in low mean diel net production (NPP). Minimal estimates of daytime respiration (dR) were substantially greater than nR and dNPP; minimal gross production (GPP = dR + dNPP) averaged 2.5 times dNPP. Estimated dR varied with dNPP in a stabilizing negative feedback, possibly mediated by photosynthetic products. Both dNPP and NPP varied with diel irradiance, but nR did not. Both dNPP and nR decreased with depth; positive NPP was concentrated in the upper layer. Stocks and oxygen cycles were more resistant to disturbance by low light than predicted by models assuming 1.0 m pond depth. We suggest for further examination that stability was related to the shallow depth of this pond, which permitted sufficient light penetration to the bottom layer for positive dNPP on most dates.

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## Diel Cycles of Planktonic Respiration Rates in Briefly Incubated Water Samples from a Fertile Earthen Pond

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***Abstract***
Planktonic community respiration rates were assessed every 30 minutes through two 48-hour periods in near-surface water taken automatically from a fertilized earthen pond and incubated in a plastic chamber for 21 minutes of each sampling cycle. Parallel records of water temperature, air temperature, wind speed, and solar irradiance permitted calculation of gross and net primary production and photosynthesis-irradiance relationships. Nighttime respiration rates generally matched oxygen depletion rates in pond water, indicating that incubation-based rates were representative of a quickly darkened pond community throughout the day. Daytime rates averaged nearly 2 times the mean night rate, and 58% higher than the mean day rate determined by a typical interpolation used in free-water production calculations. Daily gross production ranged from 0.7 to 1.2 μmol $O_2$ liter$^{-1}$ d$^{-1}$; respiration constituted 65 to 75% of gross rates. Gross oxygen production per unit Chl *a* during sampling intervals was light-saturated at irradiance values greater than 600 μEinst m$^{-2}$ s$^{-1}$, with an asymptotic value of 1.58 μmol $O_2$ (μg Chl *a*)$^{-1}$ h$^{-1}$. This system and method were capable of resolving respiration and gross and net production when chlorophyll concentrations were near 40 μg liter$^{-1}$.

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# Summaries of Research in Progress

## Bioconversion of Nuisance Aquatic Plants by Grass Carp in Egyptian Fish Culture Ponds

***Work Plan 7, Study 2A***

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***Progress Summary***
Bioconversion of nuisance aquatic plants in fish culture ponds is being tested to determine effective levels of grass carp stocking. This species will be a component of polyculture systems. Efficacy and production will be evaluated in December of 1993.

## Bioconversion of Gastropods by Black Carp in Egyptian Fish Culture Ponds

***Work Plan 7, Study 2B***

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***Progress Summary***
Bioconversion of snails by black carp will utilize an abundant resource and potentially reduce risk from bilharzia. Experiments started in 1993. Fish and snail data will be evaluated at draining in December of 1993.

## Predator/Prey Bioconversion of Tilapia Reproduction by *Clarias*

***Work Plan 7, Study 2D***

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***Progress Summary***

Tilapia population control by *Clarias* will be tested as part of the Global Experiment. The late start of year-one studies seems to have deferred the need for reproductive control. Artificial *Clarias* reproduction was attempted early in the summer.

## Socioeconomic Dimension of Aquaculture Development: A Comparative Assessment of Financial Returns, Adoption Barriers, and Impacts of Tilapia Production Regimes

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***Progress Summary***

This investigation aims to study the process by which PD/A CRSP research findings are implemented on host country farms as well as to illuminate the importance of major institutions for the aquaculture industry's development. To this end, farmers and officials at different PD/A CRSP host countries will be interviewed. By September 1993, Honduran farmers and officials had been questioned. Further interviews in Thailand and the Philippines will be conducted in 1994.

## An Algal Bioassay Method for Pond Fertilization

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and
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***Progress Summary***

A practical algal bioassay technique for managing fertilizer inputs in aquaculture ponds is described. The method involves adding concentrated spikes of nitrogen (N), phosphorus (P), and carbon (C) to 25-mL pond water samples in combinations of N, P, C, N+P, N+C, P+C, N+P+C, and control. After three days of incubation, samples are filtered and relative algal responses are evaluated by comparing filter coloration with each other. Results from selected spike combinations reveal primary and secondary limiting nutrient(s) of phytoplankton productivity. Water chemistry analyses generally agreed with algal responses to spike combinations in algal bioassays performed on farm and station ponds. Results from routine algal bioassays can provide pond management guidelines for fertilizing with N, P, or C at maximum rates, half the maximum rates, or not at all.

# Appendix. List of Acronyms and Definitions

| | |
|---|---|
| **AID** | Agency for International Development |
| **AIT** | Asian Institute of Technology, Thailand |
| **ANOVA** | Analysis of Variance |
| **AU** | Auburn University |
| **$B_{max}$** | number of binding sites |
| **Baseline Data** | that information and data base in some sector or aspect of a developing country which is necessary to measure change in the future |
| **BFAR** | Board for Food and Agriculture Research |
| **BIFADEC** | Board for International Food and Agricultural Development and Economic Cooperation |
| **Bilateral Programs** | assistance programs involving arrangements between a single developing country and a single donor country |
| **Board of Directors** (for a CRSP) | an advisory body selected to assist, advise, and make policy recommendations to the ME in the execution of a CRSP; members represent the interests of the CRSP |
| **BW** | body weight |
| **CGIAR** | Consultative Group on International Agricultural Research |
| **CIFAD** | Consortium for International Fisheries and Aquaculture Development |
| **Collaborating Institutions** | institutions which form a partnership arrangement with a lead participating U.S. institution to collaborate on a specific research project |
| **CRSP** | Collaborative Research Support Program |
| **d** | day |
| **DAST** | Data Analysis and Synthesis Team |
| **Data Analysis and Synthesis** | the process of compiling and analyzing information about pond culture systems from diverse sources into a coherent, usable format that can be applied to the development of predictive models and to the improvement of the efficiency of these systems |
| **DE** | digestible energy |
| **dNPP** | diel net primary productivity |
| **DO** | dissolved oxygen |

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| **DOF** | Royal Thai Department of Fisheries |
| **DP** | digestible protein |
| **dR** | daytime respiration |
| **EE** | 17a-ethynylestradiol |
| **EEP** | External Evaluation Panel - senior scientists not involved in the CRSP and selected externally for their ability to evaluate objectively the scientific progress and relevance of a CRSP program on an ongoing basis |
| **Experimental Protocol** | a detailed plan of a field experiment which specifies experimental methods, sampling schedules, data collection, etc. |
| **Experimental Treatment** | fish cultural practices (e.g., fertilizer application, supplemental feeding, etc.) which modify the physical, chemical, and biological environment |
| **Expert System** | a computerized compilation of knowledge that is used to make "intelligent" decisions about the management or status of a process or system |
| **FAC** | Freshwater Aquaculture Center, Central Luzon State University, Philippines |
| **FCR** | feed conversion ratio |
| **FDA** | U.S. Food and Drug Administration |
| **Field Experiments** | controlled fish production experiments in which quantitative responses to different levels of treatments are measured |
| **FTE** | Full Time Equivalent |
| **GFY** | gross fish yield |
| **Global Experiment** | the overall plan of a CRSP for research on problems and constraints, global in nature, whose results are applicable and transferable regionally and globally (worldwide) |
| **GOR** | Government of Rwanda |
| **Grant Agreement** | the formal legal document which represents a binding agreement between AID and the ME institution for a CRSP; this is the legal document for the CRSP recognized as such by AID and the recipient institutions |
| **Grant Proposal** | the formal document submitted by an ME to AID, proposing a CRSP for receiving a grant outlining the manner of implementation of the program and showing the budgetary requirements |
| **Host Country (HC)** | a developing country in which a CRSP has formal activities |
| **i.d.** | inner diameter |
| **INAD** | Investigational New Animal Drug permit |
| **INRP** | International Research Project |

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| **Institutional Development** | improvement in the capability of institutions in developing countries to conduct development programs for agriculture and other sectors, or for implementing educational/training, research, health, and other public programs. This may include improvements in physical facilities, equipment, furnishings, transportation, organization, but refers primarily to the development and training of a professional cadre. |
| **JCARD** | Joint Committee on Agricultural Research and Development (formerly Joint Research Committee), BIFADEC |
| **JRC** | Joint Research Council, USAID |
| **LDC** | Lesser Developed Countries |
| **Lps** | Lampiras, Honduran currency |
| **Matching Requirement document** | that sum of resources, financial or in-kind, which participating U.S. institutions must collectively contribute to a CRSP program as defined in the grant (also called "cost sharing") |
| **mb** | mibolerone |
| **ME** | Management Entity |
| **MINAGRI** | Ministere de l'Agriculture, de l'Elevage, et de l'Environement (Ministry of Agriculture, Livestock and Environment) |
| **Mission** | a formally organized USAID unit in a developing country led by a Mission Director or a country representative |
| **MOU** | Memorandum of Understanding |
| **MRTC** | Mariculture Research and Training Center, University of Hawaii |
| **MSU** | Michigan State University |
| **MT** | 17$\alpha$-methyltestosterone |
| **NFY** | net fish yield |
| **NGO** | Non Government Organization |
| **NIFI** | National Inland Fisheries Institute, Thailand |
| **NMFS** | National Marine Fisheries Service |
| **NPP** | net primary productivity |
| **nR** | nighttime respiration |
| **NRP** | National Research Project |
| **OIRD** | Office of International Research and Development |
| **OSU** | Oregon State University |
| **PAR** | photosynthetically active radiation |

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| **Participating Institutions** | those institutions that participate in the CRSP under a formal agreement with the Management Entity which receives the AID grant |
| **PD/A CRSP** | Pond Dynamics/Aquaculture Collaborative Research Support Program |
| **PI** | Principal Investigators - scientists in charge of the research for a defined segment or a scientific discipline of a CRSP |
| **PMO** | Program Management Office |
| **PPC** | Program and Policy Coordination |
| **Practices** | fish cultural activities related to design, management, and operation of pond culture systems |
| **Predictive Models** | mathematical models used to simulate the processes occurring in pond systems; in the context of this CRSP, predictive models are used as analytical and management tools to improve the efficiency of pond systems |
| **Principles** | the physical, chemical, and biological processes occurring in pond systems and their interactions |
| **PVC** | polyvinyl chloride, common thermoplastic resin |
| **RENARE** | Department of Renewable Natural Resources, Honduras. Now known as Dirección General de Pesca y Acuicultura, Honduras |
| **R&D Bureau (R&D/AGR)** | (Formerly S&T/AGR Bureau of Science and Technology) central bureau of AID in Washington, charged with administering worldwide technical and research programs for the benefit of USAID-assisted countries |
| **RWF** | Rwandan franc |
| **SPN** | Service de Pisciculture Nationale (National Fish Culture Service) |
| **SRP** | soluble reactive phosphorus |
| **Subgrant Agreement** | a document representing a subagreement made between the ME and a participating institution under authority of the grant agreement by the ME and AID |
| **TA** | total alkalinity |
| **TAN** | total ammonia nitrogen |
| **TC** | Technical Committee - a group of scientists participating in the research of the CRSP as PI's, selected to help guide the scientific aspects of the research program of a CRSP |
| **TH** | total hardness |
| **THB** | Baht, Thai currency |
| **Title XII** | the Title XII Amendment to the International Development and Food Assistance Act of 1975 as passed by the United States Congress and subsequently amended |
| **TSS** | total suspended solids |
| **TVS** | total volatile solids |

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| **UAPB** | University of Arkansas at Pine Bluff |
| **UCD** | University of California at Davis |
| **UH** | University of Hawaii |
| **UM** | University of Michigan |
| **UNR** | Universite Nationale du Rwanda |
| **UO** | University of Oklahoma |
| **USAID** | United States Agency for International Development |
| **USAID Project Officer** | an official AID employee designated to oversee a CRSP on behalf of AID |
| **WID** | Women In Development |
| **yr** | Year |