Pond Dynamics/Aquaculture Collaborative Research Support Program

Thirteenth Annual Administrative Report

1 September 1994 to 31 August 1995

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This report addresses program accomplishments of the Pond Dynamics/ Aquaculture Collaborative Research Support Program during the reporting period of 1 September 1994 to 31 August 1995. Program activities are funded in part by the United States Agency for International Development (USAID) under Grant No. DAN-4023-G-00-0031-00.

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This year's Annual Report is dedicated to the continuing struggle of the Rwandan people who are working and hoping for a return of peace and stability. The members of the Pond Dynamics/Aquaculture Collaborative Research Support Program mourn the loss of the many individuals who worked with our program, and we, too, hope for a return of peace that will allow us to be reunited with our remaining friends and colleagues.

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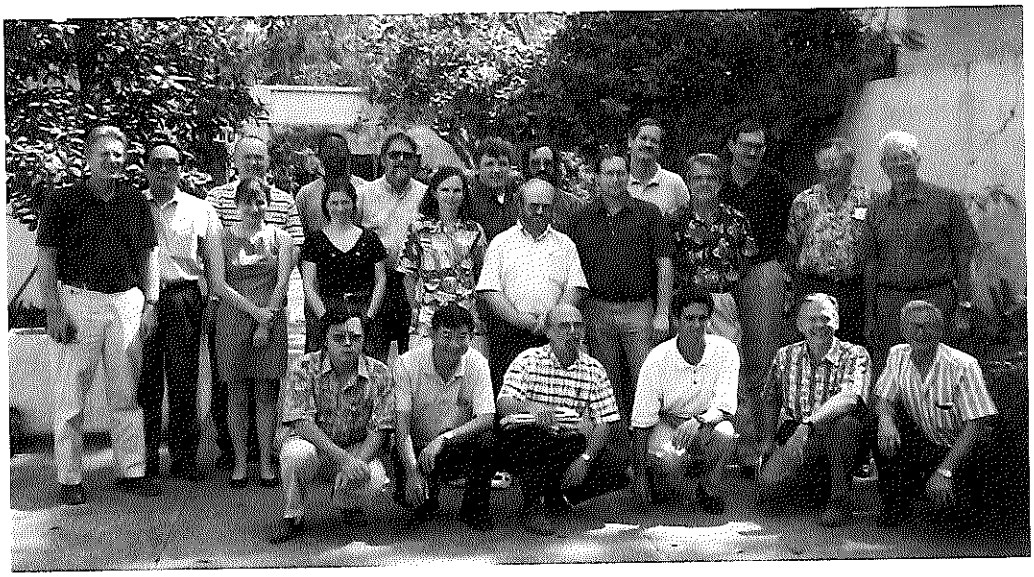
I. Introduction

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 that is 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. In the original structure of the CRSP, Auburn University, the Consortium for International Fisheries and Aquaculture Development (CIFAD), and the University of California at Davis participated in a tripartite management of the CRSP, with Oregon State University serving as lead institution and Management Entity. However, beginning with the new grant in 1996 and the dissolution of CIFAD, a new advisory structure will allow for greater representation among participating institutions and provide an effective mechanism for new institutions to be represented on the Board of Directors and Technical Committee.



A Memorandum of Understanding (MOU) is executed between the host country institution and the lead university for each project or with the Management Entity. Host country institutions with formal linkages to the CRSP through MOUs are the Royal Thai Department of Fisheries, Asian Institute of Technology, Department of Renewable Natural Resources in Honduras, the Agricultural Research Center of Egypt through March 1995, and Central Luzon State University of the Philippines. Until 1994, the National University of Rwanda held a formal MOU with OSU. Numerous linkages are 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 1986 to the Joint Committee on Agricultural Research and Development (JCARD) Panel on CRSPs and the AID Agricultural Sector Council Subcommittee. The plan, effective September 1987, called for maintaining the PD/A CRSP presence in each of the USAID geographical areas originally selected. Three country sites were chosen: Rwanda, Thailand, and Panama. However, subsequent political initiatives in Panama 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.

The long collaboration between the CRSP and the Universite Nacional de Rwanda came to a tragic and untimely end when the civil war of 1994 necessitated abandoning the Rwasave Fish Culture Station. Despite the cessation of formal ties, CRSP members have actively assisted former colleagues and their families, where possible. The linkages created by the CRSPs long term presence in East Africa has facilitated the selection of a new research site and Host Country collaborators for the next PD/A CRSP grant.

Recently, USAID has undergone an overall restructuring to better serve the strategic and humanitarian goals of U.S. foreign policy. This restructuring has had little effect on day-to-day operations of the CRSP, but it has changed the USAID bureau in which the PD/A CRSP program officer is located. Previously, all CRSP program officers were housed in the Office of Agriculture within the Bureau of Science and Technology located in Rosslyn, Virginia. Currently, the PD/A CRSP program manager is in the Sustainable Technology Division of the Office of Agriculture and Food Security in the Center for Economic Growth, which is located in the Global Bureau in Washington, DC.

New Activities

A survey of reproduction control as a constraint to aquaculture research and development was conducted, polling over 45 researchers and aquaculturists worldwide. Survey participants were asked to rank the nine CRSP research themes in reproduction control for their importance to extensive, semi-intensive, and intensive aquaculture systems, and to different geographical areas. In addition, participants were asked to score ten different areas of reproduction control, including some outside the themes addressed by the CRSP proposals. The small sample and low response rate caution against drawing firm conclusions from the survey, but the CRSP may consider using survey instruments as a part of future research planning.

When the continuing unrest in Rwanda forced the CRSP to discontinue its research activities, the Rwanda section of the Seventh Work Plan was also revised and submitted to the Technical Committee chairs, the Program Director, and the Board of Directors. The document was subsequently approved and activities initiated. Data analysis of Rwandan experiments and laboratory studies of the Rwandan research themes continues at OSU and Auburn universities.

In addition, researchers began the difficult task of selecting a new site from which to re-build regional capacity in aquaculture research. The process, which is still underway, has entailed research, site visits, correspondence, analyses of soils and water samples, and other exploratory efforts. Selection criteria were developed and several promising sites have been identified.

The PD/A CRSP continues to be one of the principal players in the CRSP Council, which is pursuing a new opportunity to establish a multi-CRSP natural resource project in West Africa. The project aims to strengthen National Agricultural Research Systems (NARS) and to assist in that group's plans to produce sustainable natural resources in high demand and short supply. The CRSP benefits 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 is to increase public awareness of CRSP programs.

Direct involvement with farmers, educators, and other end-users of CRSP technology actively extends information generated by the program.

Continuing activities

After completing 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 while maintaining its presence in the major agroecological zones for which it was designed. 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 Investigations) and project-oriented (site-specific) considerations in response to the results of the earlier experiments.

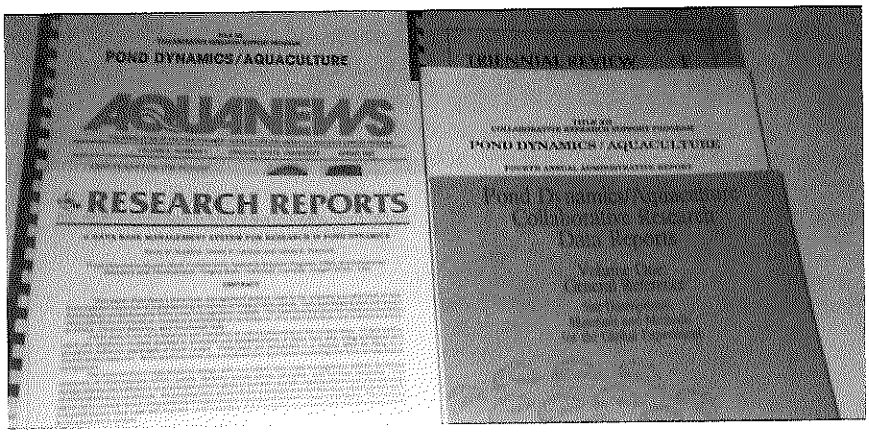
Brackish water studies continue in Choluteca, Honduras. As stakeholders in Honduras become more aware of the economic impact of environmental quality, increased attention is directed to the environmental influences and impacts of shrimp farming in southern Honduras. The baseline data on estuarine water quality were collected at the onset of this project. Researchers continue to monitor water quality on an on-going basis, looking for correlations between seasonal influences on water quality and shrimp farm operations. Local support and USAID Mission support for this project remains strong, and additional collaborators from both the U.S. and Honduras have joined this effort. George Ward, University of Texas in Austin, helped set up a system to monitor estuarine water exchange, and a Peace Corps volunteer helps with data collection. The Panamerican Agriculture School at Zamorano, a long-time CRSP collaborator, has assumed a more active role, with several students conducting research in collaboration with the CRSP. The strength of the collaborative research network is evidenced by the adaptation of some experiments originally planned for the Africa site to be undertaken at El Carao in Honduras. Researchers investigated the reproductive efficiency of adult Nile tilapia and compared their growth rate, survival, and response to sex reversal of fry.

The Egypt Project came to a successful close during this reporting period. The project is credited with adding new research thrusts to the CRSP–polyculture, bioconversion, and biotechnology. All Egypt Project related activities are summarized in the *Egypt Project Final Report*, which may be ordered from the Program Management Office. The CRSP activities at the Central Laboratory for Aquaculture Research (CLAR) spurred interest in the site from the International Center for Living Aquatic Resources Management (ICLARM). ICLARM now plans to help CLAR become a regional center, and conducted several events to investigate the feasibility of these activities. The CRSP was invited to participate in one of these activities, ICLARM's research planning workshop in Cairo, Egypt, in September 1995. Participants discussed research and related programs which could be conducted out of the Abbassa facility. Harry Rea, PD/A CRSP Program Officer, attended the meeting to discuss possible linkages with the CRSP.

The global social sciences project to identify the social, economic, and institutional impacts of CRSP research in the host countries was completed during this reporting period. Auburn University economists and sociologists collaborated with researchers from the Philippines, Thailand, and Honduras in an examination of aquaculture technology adoption and diffusion.

The CRSPs 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 CRSPs numerous publications, which are aimed at technical and non-technical audiences alike. Members of the CRSP have completed a draft of a comprehensive book, *Dynamics of Pond Aquaculture*, on the principles and practice of pond aquaculture. Other members of the aquaculture community have also contributed to this effort. The 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.

When the Board for International Food and Agricultural Development and Economic Concerns (BIFADEC) originally designed the CRSPs, the mandate called for greater focus on research than on outreach. The PD/A CRSP sees the partnership of these two types of activities as critical to achieving positive social impacts. Therefore, the CRSP continues to place increasing emphasis on farmer participatory research, on extending research information to end users, and on adopting a research strategy that is sustainable and appropriate. In Honduras, farmers cooperate with researchers to monitor water quality of the Gulf of Fonseca and its estuaries. In Northeast Thailand, the CRSP cooperates 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.



CRSP Continuation Plan

During this reporting period, the 1996-2001 Continuation Plan for the PD/A CRSP was the focus of efforts by the Technical Committee and the Program Management Office (PMO). One result of the exhaustive reviews conducted by the PD/A CRSP External Evaluation Panel in 1991-92, and by the consulting firm Tropical Research and Development in 1994, was that the PD/A CRSP was invited to submit a proposal for continuation of the CRSP. The process leading to the continuation proposal has been complex. In 1993, the Director initiated a review of the aquaculture literature, which yielded information on constraints to aquaculture development. A Proposal Coordinating Committee, composed of members of the Board, the Technical Committee, and the Program Management Office, developed a Request for Proposals (RFP) based on these constraints. In response to the RFP, 25 institutions submitted preproposals. The PMO classified each preproposal into one of seven research focus areas in preparation for the annual meeting.

The main focus of the 1994 Annual Meeting was the development of the Continuation Proposal. Host country representatives advised the group about the specific constraints facing aquaculture research and development in their home countries of Egypt, Honduras, the Philippines, Rwanda, and Thailand. Meeting attendees also participated in a workshop supported by the USAID/Women in Development/Policy and Program Coordination Office to hone their strategic planning skills by focusing on improving project sustainability and equity of impact. Expert working groups were formed for each of the seven focus areas; these groups examined the preproposals to determine how well they addressed the objectives of the focus areas. The working groups also prioritized the focus areas and preproposals.

The Proposal Coordinating Committee aligned the focus areas with the CRSP areas of comparative strength and developed a draft outline for the proposal, which was reviewed by the Food and Agriculture Organization of the United Nations (FAO). The Proposal Coordinating Committee and the PMO prepared a first draft, which formed the basis of discussion during the 1995 Annual Meeting. At this time, a Technical Committee member was selected to develop a second draft. This draft was sent to USAID for internal review and comment, and returned with the suggestion to strengthen the constraints section and modify the program management section to incorporate USAID's current thinking on CRSP management. USAID also requested that the CRSP consider collaboration with other international research organizations.

In response to USAID's suggestions, the Director once again reviewed the literature and developed a constraints matrix and a donor matrix. To increase collaborative links, the CRSP invited representatives of ICLARM and Aquaculture for Local Community Development (ALCOM)/FAO to meet with CRSP researchers, students, and administrators at OSU, and participated in a USAID-sponsored session to develop aquaculture research strategies for USAID. A Technical Committee member distributed a survey of reproduction research needs to 45 research administrators, researchers, and industry representatives worldwide. Finally, the Director of OSU's Women in Development Program reviewed the CRSP Continuation Plan in October 1995.

CRSP Administrative Reports

Two volumes–Volume 1, *Program Accomplishments* and Volume 2, *Technical Reports*–comprise the PD/A CRSP Annual Administrative Report. Each volume is designed to stand on its own. *Program Accomplishments* reports 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 & Accomplishments

The strength of the CRSP network can be seen in the portability of research activities between sites.

1 September 1994 to 31 August 1995

Major accomplishments during the current reporting period include the completion of a number of the activities scheduled under the Sixth and Seventh Work Plans. Among these were further refinements to several CRSP aquaculture pond models, improvements to the *POND*© decision support system, increased on-farm research trials, and continued environmental monitoring. Activities described in the Interim Work Plan were begun during this reporting period. As in the previous reporting periods, research was conducted both at the established CRSP research facilities and in farmers' ponds in the field. Research activities of the Sixth, Seventh, and Interim Work Plans continue. As always, efforts to disseminate research results continued through a variety of avenues.

Global Studies & Activities

The strength of the CRSP network is evidenced by the portability of research activities between sites. Several studies that were originally scheduled for Rwanda have been modified and conducted at other sites, an indicator of the global nature of CRSP research. These research projects are now being carried out in Honduras, the Philippines, and the U.S.

In Thailand and Honduras, researchers began the Global Experiment. The objectives are to develop nutrient budgets for nitrogen and phosphorus for semi-intensively managed freshwater and brackish water production ponds, and to quantify the effect of pond management strategies on water and sediment quality. This study will help researchers quantify the potential pollution impact of ponds using semi-intensive management strategies.

In an effort to characterize African soils to support new site selection, research was conducted to determine the most reliable estimators of lime requirements for specific soil types. Research was carried out both in the laboratory and in isolation columns in ponds at OSU. Results indicate that no lime requirement estimator can be used for every soil type. At Auburn, researchers studied the phosphorus adsorption capacity and availability of added phosphorus in soils collected in Thailand. Results indicate that the relative abilities of pond bottom soils to adsorb and release phosphorus added to ponds in fertilizers or feeds can be assessed from the phosphorus adsorption capacity of the soil. This appears to be a more useful technique than traditional phosphorus extraction methods as an index of phosphorus status in aquaculture ponds. Since the phosphorus adsorption capacity was highly correlated with the clay content of soils, a knowledge of clay content will permit a rough assessment of phosphorus status.

Researchers on the Global Social Sciences Project investigated how and to what extent CRSP research is reaching the institutions that serve farmers, and whether these institutions influence the practices of fish farmers. This study will facilitate the conduct of research that meets farm-level needs in an environmentally and socially sustainable way. The institutional context and connections of the CRSP are portrayed based on information obtained from U.S. scientists, host country counterparts, and others knowledgeable about the program. Researchers interviewed over 125 farmers in Rwanda, Honduras, Thailand, and the Philippines and collected data from cooperating institutions in each Host Country. An economic analysis examined the financial viability of different feeding and pond fertilization approaches associated with several years of parallel experimentation.

Results indicate that tilapia growers in each of the countries face vastly different institutional systems supporting tilapia production. Therefore, the researchers believe that CRSP efforts should emphasize infrastructure development and improved functioning of the private sector when the CRSP has the opportunity to do so. Currently, poorly organized markets and distribution systems hinder aquaculture development. As markets for tilapia expand, so will demand for production and support services. The development of private sector marketing services are crucial for sustained aquacultural development. Efforts to enhance the transfer and utilization of CRSP research results will require greater attention to actual and potential pathways of influence and information flow to the farm and village. Although the provision of information directly to end-users is not a mandate of the CRSP, a better understanding of the actual and potential pathways of influence and information flow will help researchers focus their efforts to include appropriate influential institutions as research partners.

The Central Data Base, the world's largest standardized aquacultural data base, is used for global analyses and model building. The Data Base is the central repository for data from the CRSP global experiments. Data from other CRSP experiments, particularly those experiments conducted in the Philippines and Thailand, are also included. The Central Data Base has been housed at the University of Hawaii at Hilo since mid-1993. During this reporting period, all incoming data were processed, all data requests were filled, a new data entry manual was drafted, database structure was modified to handle textual data, and the possibilities of creating a World Wide Web site were explored in cooperation with the PMO.

Central America

The Honduras site continues to facilitate linkages among private sector aquaculturists, the Government of Honduras, universities and schools in Honduras and the U.S., and USAID. Researchers continued monitoring estuarine water quality in the riverine and embayment estuaries of the Gulf of Fonseca. They participated in discussions with other project leaders in the area to share ideas about approaches to solving problems of water quality. David Teichert-Coddington, the CRSP researcher in Honduras, was instrumental in organizing the Third Central American Shrimp Symposium, which attracted participants from throughout the region.

Researchers at the Choluteca station characterized shrimp farm effluents as the first step in estimating the carrying capacities of local estuarine systems for shrimp. Intake and discharge from shrimp farms located on the estuaries of the Gulf of Fonseca were sampled during both the rainy and dry seasons during 1993-94. Results showed a mean net consumption of inorganic nitrogen and phosphorus, and a mean net discharge of organic matter. Most of the nitrogen entered and left the ponds through water exchange; most phosphorus entered the ponds as feed but left by water exchange. Pond discharge of both nitrogen and phosphorus increased linearly with the feed conversion ratio. The conversion of feed and nitrogen to shrimp flesh was greater during the wet season than the dry season.

Earlier studies had demonstrated that shrimp production was similar at protein levels between 20% and 40%, when shrimp were stocked at densities between 5 and 11/m^2, and that feed efficiency was relatively low. In a related trial, shrimp stocked at 7.5/m^2 during the dry season were not significantly affected by a 50% reduction in feeding rate. Although wet season production in this trial was significantly impacted by the 50% reduction in feeding, feed efficiency was improved. These results suggest that too much feed was applied during both the dry and wet seasons, although more overfeeding occurred during the dry season. It is possible that a comparatively high protein diet might improve shrimp growth and feed conversion. If a high protein feed is used at a comparatively low feeding rate (low compared with that employed with lower protein diets), it is possible that nitrogen levels in pond effluents will be reduced. Researchers are testing the effect of diet protein level on food conversion and nitrogen effluents during both the wet and dry seasons. If the results indicate that nitrogen discharge responds to both feeding rate and diet protein level, farmers will have economic and ecological incentives to feed at appropriate rates with an appropriate protein level.

Taura Syndrome is the cause of high mortality in some Central American shrimp ponds. In response to an urgent need for information on how to manage ponds affected by Taura Syndrome, researchers at the Choluteca station investigated the relationships among stocking density, survival, and shrimp yield in affected ponds. *Penaeus vannamei* were stocked in ponds on two farms during the wet season and on three farms during the dry season. At each farm, four different stocking rates were used. Researchers found no significant correlation between stocking density and survival during either the wet or dry season, nor did they find a seasonal influence on survival. Shrimp production rose with increased density, regardless of the season. Farming income is related to both biomass and shrimp size. Thus, farmers' net income increased with density during the wet season, but decreased or remained neutral with an increase in density in the dry season. During the wet season, production increased without a decrease in size of harvested shrimp; however, during the dry season, mean shrimp size decreased.

Although the main CRSP research site in Honduras is now in Choluteca, the freshwater site at El Carao continues to be operated as a CRSP sub-station. Researchers there studied the effects of nitrogen fertilization on water quality and tilapia yield in ponds supplied with adequate phosphorus. They found that fish yields were not significantly correlated with nitrogen input, despite higher phytoplankton biomass. Cool water temperatures apparently inhibited fish growth, rendering the fish unable to take advantage of higher available nutrient supply.

It is an indicator of the resiliency of the collaborative research process that research experiments are portable among sites. As an example, researchers noted that worldwide, red tilapia have generally been perceived by producers as having greater consumer acceptance, although existing research indicates that the growth rate of Nile tilapia is superior. In trials currently underway, Auburn researchers working at the El Carao Fish Culture Station in Comayagua, Honduras, are investigating reproductive efficiency of Nile tilapia and red tilapia, their comparative growth and the efficacy of sex reversal. The work is being carried out at the El Carao Station, but the impact of the results will be important for tilapia farmers throughout the world. Researchers at El Carao are also investigating the growth and efficiency of sex reversal of Nile tilapia that are fed hormone-treated feed stored under different storage regimes, another study that was originally programmed for the Rwanda site.

East Africa

The continuing unrest in Rwanda forced the CRSP to close its research site there. The losses, in terms of lost and disrupted lives, and lost expertise of both the professional staff and the area farmers, are immeasurable. In an effort to minimize the overall loss to the region and to the aquaculture community, the CRSP has been actively engaged in selecting a new site from which to build regional capacity in aquaculture research. The selection process has entailed much research, several site visits, extensive correspondence, laboratory analyses of soils and water samples, and other exploratory efforts. The process is still underway. Site selection criteria have been developed, data have been collected from several sites, promising sites have been evaluated, and work has begun on a characterization of African soils. Promising sites were identified as: Sagana Fish Culture Station in Kenya, Bunda College Station and Domasi Experimental Fish Farm in Malawi, and several sites in Zimbabwe, Zambia, and Tanzania. A final determination will be made by the time the Continuation Plan is effected.

In addition to soil studies, members of the Africa team at Auburn are investigating the effect of temperature on appetite and growth response of tilapia fry. The results of the study will enable researchers to investigate the effects of growth rate on the timing of gonadal differentiation and the efficacy of sex reversal, leading to more efficient use of hormone-treated feed. Preliminary studies have not yielded sufficient data, and further trials are planned to obtain the needed data points.

Work at OSU examined the efficacy of a short-term immersion procedure for masculinizing tilapia. Two synthetic androgens–17α-methyldihydrotestosterone (mestanolone) and 17α-methyltestosterone–were evaluated at two concentrations, using 3-hour exposures at 10 and 13 days after fertilization. Results indicate that short-term immersion in 17α-methyldihydrotestosterone at a concentration of 500μg/l shortens the treatment period, thereby reducing possible worker exposure to anabolic steroids.

Southeast Asia

Thailand project personnel directed considerable resources into outreach efforts during this reporting period. Two workshops were held for ten fisheries officers from four provinces in Northeast Thailand, including Udorn, Nong Khai, Sakon Nakhon, and Loei. Each of the fisheries officers attending selected four to six small-scale farmers from his or her province to participate in the high-input green water scheme recommended by the CRSP program based at the Asian Institute of Technology (AIT). Biologists from the Udorn station monitored the farmers' activities. Most farmers started their growout cycle at the beginning of the rainy season in May and June 1995. The researchers are faced with complications in attaining the production data because most farmers harvest fish in small numbers upon demand by local consumers or keep fish for their own consumption. Despite the difficulties in data collection, the farmers provided positive feedback about the trials.

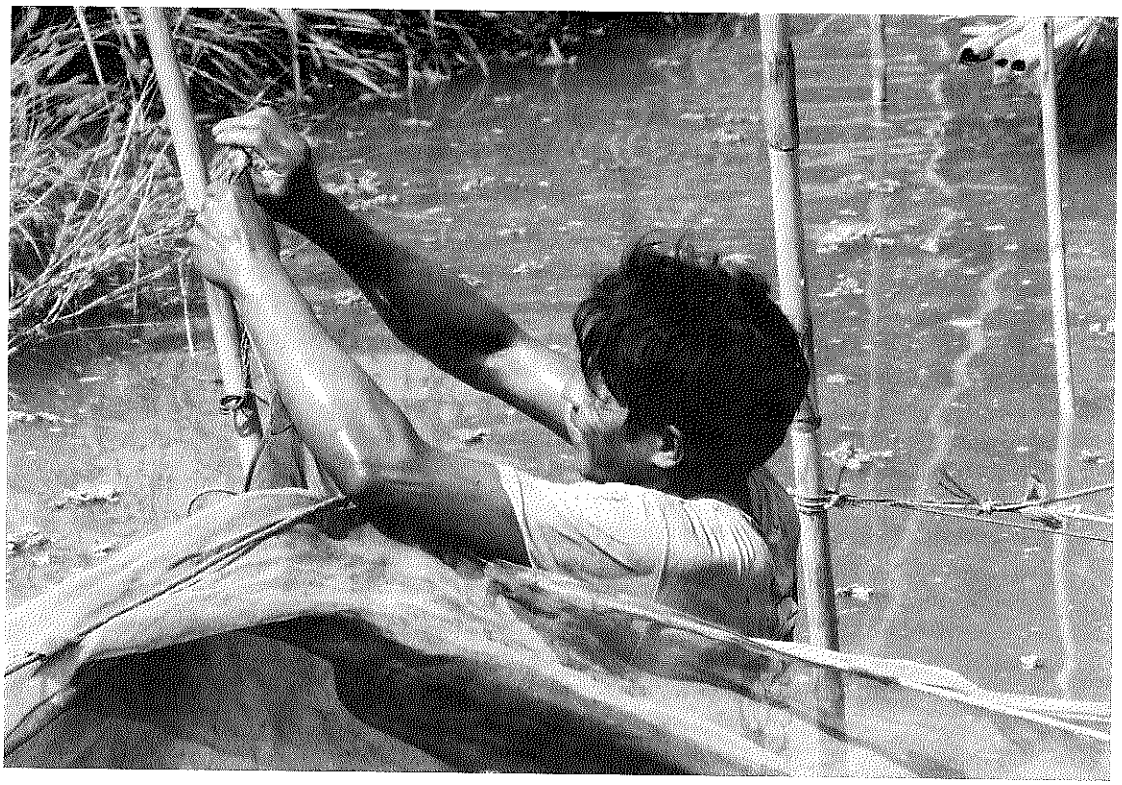
Researchers at AIT undertook a study to evaluate caging densities and pond loading rates for tilapia that were caged and fed within semi-intensive ponds with small tilapia at large. Such a system could be an effective means to produce large tilapia efficiently. Caged tilapia were stocked at five densities, and held in ponds loaded at two rates for 90 days of culture. Growth rates of the caged tilapia were similar regardless of stocking density; however, survival rates differed significantly with cage density, with fish at higher densities exhibiting very high mortality rates. Growth and mortality rates of the uncaged tilapia were similar to rates found using other culture systems, even though the only source of nutrients was the unused feed, fecal matter, and excretory products of the caged fish. Water quality did not deteriorate within the ponds at either loading rate. Cage stocking densities of 64 fish per m^3 resulted in good survival and significant growth.

The effects of fertilization on growth and production of tilapia in rain-fed ponds in Thailand were studied during this reporting period. Researchers evaluated fertilization strategies for these ponds based on strategies developed for ponds that receive regular water inputs. Regular pond fertilization resulted in the highest fish growth rates. Irregular fertilization yielded lower growth, and fertilizing only at time of stocking yielded the lowest growth. Results of this study will impact farmers in northeast Thailand, whose ponds are typically rain-fed, and who have lacked research-based information on appropriate fertilization regimes.

A different study is currently underway to assess the effect of another fish species on the water quality and yield of tilapia, and of all fish, in deep, rain-fed ponds. Treatments differed in stocking density of common carp into earthen ponds stocked with tilapia and fertilized with chicken manure, urea, and phosphorus. After five months, the ponds will be harvested. Standard protocol will be used for physical and chemical monitoring of ponds for most sampling procedures.

Increasing the carrying capacity of the pond or size at harvest of tilapia requires more intensive management, which largely involves supplemental feeding. Researchers attempted to determine the upper limits to tilapia production using supplemental feeds. Fish were stocked at four densities and fed to satiation during the 146-day culture period. The highest growth rate and survival occurred in lower-density ponds. Researchers could not explain why the higher densities did not have correspondingly high growth and survival rates. The best recommendation currently is to stock fish at $3/m^2$ under intensive feeding regimes.

Deep (approximately 2.5 m) rain-fed ponds become more highly stratified than do shallow ponds and are therefore less likely to be stirred by convective overturn at night or by wind-induced mixing. Thus, oxygen depletion in the hypolimnion is more likely. A study was conducted at AIT to describe and quantify the diel temperature cycles and dissolved oxygen (DO) stratification in these deep ponds. During sunny days in the dry season, the deep pond had a slightly deeper mixed layer than is characteristic of ponds at more sheltered sites. The bottom water below 2 m depth was almost completely isolated from the upper water, receiving only minimal transport of oxygen from above. During the rainy season, the isolation below 2 m was maintained even through a dark rainy day. These results show that active mixing may be necessary to maintain deep ponds as suitable culture environments for some species.



Following up a study of the relationship of pond depth to fish production, the Thailand group investigated the effects of pond surface area on fish production. Researchers examined earthen ponds that are similar in area to those used by farmers in Thailand and the Philippines, and the results of this experiment should have general applicability in the region.

Researchers at University of Hawaii investigated carbon dioxide (CO_2) exchange between pond water and the atmosphere. Although oxygen exchange is routinely estimated in free water studies, far less attention has been given to diffusion of carbon dioxide, which may be significant. Researchers analyzed data from their pond research facility in the U.S. to quantify the rates of exchange of carbon dioxide between pond water and the atmosphere in fertile earthen ponds, and to identify factors which determine these rates of exchange. An analysis of these data showed that total carbon dioxide concentrations varied little during the day, but showed a perceptible dip during mid-day, reflecting photosynthetic uptake. Wind speeds directly above the water surface were measured, and researchers observed that the windiest periods occurred mainly during daylight hours. Analysis showed that the concentration of free carbon dioxide and wind speed together accounted for 81% of the variation in the diffusion rates during the diel cycle. Thus, prediction of diffusion rates requires only observed carbon dioxide concentrations and wind speed, although photosynthetic demand can be the primary determinant of concentrations under some conditions.

Researchers investigated whether adding carp to a tilapia monoculture would increase the productivity of the pond system. Because tilapia are primarily planktivores, researchers hypothesized that the addition of carp would increase productivity by converting currently unutilized benthic matter into fish flesh. Researchers stocked ponds with tilapia and added carp at varying stocking rates. Ponds were fertilized weekly with chicken manure, urea and TSP. Preliminary results indicate slow, uniform growth for tilapia, possibly because larger tilapia than called for in the experimental protocol were stocked erroneously. Carp growth proved to be extremely sensitive to and inversely related to stocking density. Although turbidity was higher in ponds stocked with carp, there was little indication of any other difference in water quality between the monoculture and the polyculture ponds.

In the Philippines, three strains of *Oreochromis niloticus* were grown at Central Luzon State University's Freshwater Aquaculture Center (FAC) to compare their growth performance. The three strains were: a FAC strain that had descended from tilapia imported to the Philippines in the 1970s; a Thai strain descended from tilapia imported from Thailand in the 1980s and maintained by the Bureau of Fisheries and Aquatic Resources and ICLARM; and an Egypt-Swansea strain originated from tilapia collected from Lake Manzala in 1979 and transferred to the Philippines by University College of Swansea in 1989. The extrapolated yields of the Thai and Egypt-Swansea strains were not significantly different from each other and averaged approximately 5,000 kg/ha/yr. The average extrapolated yield of the FAC strain was only 2,389 kilograms per hectare per year (kg/ha/yr), which probably reflects the introgression of *O. mossambicus*. Researchers also compared the yield of Egypt-Swansea fish grown in ponds fertilized at two different rates of nitrogen and phosphorus fertilization, observing no significant difference between the two rates.

United States – Data Analysis and Synthesis

The Data Analysis and Synthesis Team (DAST) at the University of California, Davis (UCD) is developing a preliminary model to investigate the effects of integrated aquaculture and agriculture on nutrient cycling and whole system productivity. The model will concurrently evaluate the impacts of various management actions for enhancement of pond sediment quality. The model consists of three modules: fishpond, crop, and terrestrial soil nitrogen. Inputs of nitrogen into the pond include feed and/or fertilizer and water. Outputs from the pond include uptake by fish, effluent water, and removal of pond sediments. The three modules are linked through the use of sediment from ponds as crop fertilizer and/or the use of wastes from crops as feed/fertilizer to aquaculture ponds. Preliminary results demonstrate that feed quality and digestibility of feed need to be considered to improve overall estimation of organic matter and nitrogen production in the fish pond, and to improve estimation of fish growth.

Researchers at OSU continued work on model refinement in the decision support system *POND*© (Version 2.5). These models allow users to simulate pond aquaculture facilities at three levels of complexity. At Level 1, models are geared toward applied management and rapid analysis of pond facilities. Simulation results agree reasonably well with observed data under a wide range of culture conditions, suggesting that the models used at this level are relatively robust and will likely be useful for a diverse audience, including pond managers, planners, and educators. The water temperature model in *POND*© has been validated by the use of CRSP data from Honduras, Rwanda, and Thailand. The fish bioenergetics model has also been calibrated for channel catfish, tambaquí, and pacu.

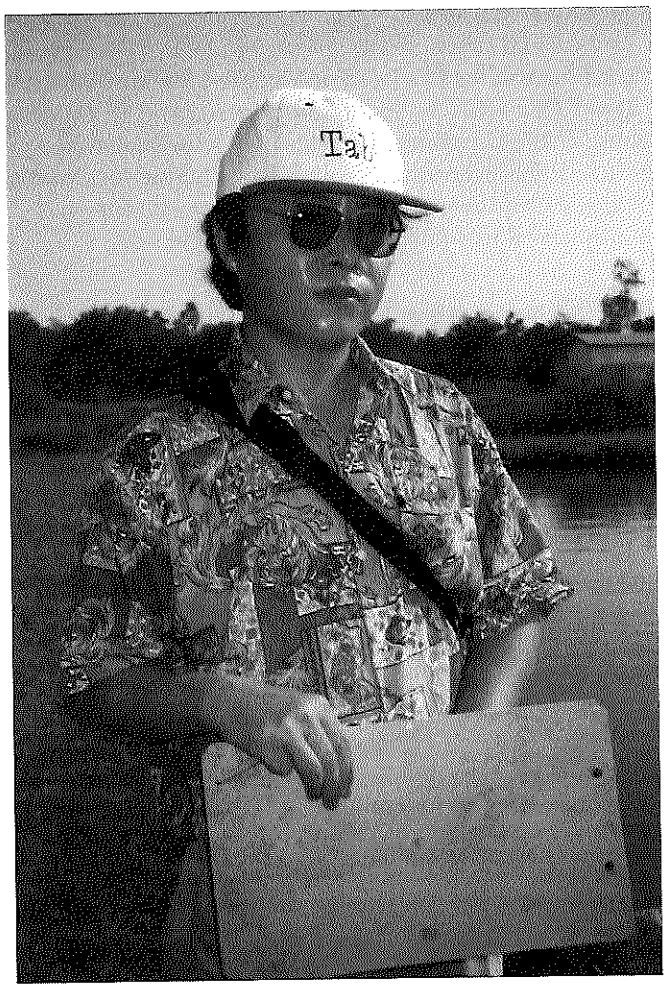
Level 2 models allow for more detailed pond analysis, management optimization and numerical experimentation. Plankton and nutrient dynamics in ponds are part of this model. Level 3 models explore in greater detail fundamental aspects of pond dynamics such as detailed nutrient transformations in pond water/sediments, and atmospheric diffusion.

A methodology to enable users to customize *POND*© for alternate culture species and locations has been incorporated directly into the software. Because of the high level of complexity of interactions among variables in the model, manually changing the parameters proved to be extremely time-consuming, limiting the use of the software for examining production potential for different pond culture species. An iterative, non-linear, adaptive search method (genetic algorithm or GA) for automatically generating new parameters for the fish growth model has been developed. Adequate convergence to acceptable parameter values was obtained for the three species (channel catfish, tambaquí and pacu) chosen to evaluate GA's as an effective parameter estimation technique.

Special Topics Research

A water temperature and dissolved oxygen model using stochastically-generated weather parameters is being developed. Currently, the model can be executed for an 85-day simulation. Prediction of temperature and dissolved oxygen match well with measured values, but algorithms to estimate fish growth and chlorophyll-*a* concentrations are still in development.

Special topics research included investigations into whether sex reversal of newly hatched tilapia may be accomplished by administering naturally occurring sources of testosterone obtained from frozen bull testes as an alternative to using 17-α methyltestosterone (MT), a synthetic androgen which is also an anabolic steroid.



III. Program Background

At its inception, the Pond Dynamics/Aquaculture CRSP had a single, main theme—that of 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 lead to an understanding of 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 additional 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
- 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.

CRSP activities include studies in socioeconomics, soil-water interactions, new techniques to evaluate pond conditions and improved techniques for fish reproduction.

The CRSP Research Program

The long-range goal of the CRSP is to increase the efficiency of pond culture operations. This goal benefits less-developed countries by increasing the availability of animal protein and can also improve 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*. 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 called for the 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. 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; still, the three original tropical regions continued to be represented.

The CRSP program expanded in 1991 with the initiation of a companion site in the Philippines and the beginning of a new project in Egypt. The research conducted in Egypt greatly increased the scope of the program by adding an arid sub-tropical site to the program, which had previously included sites only in relatively humid areas. Although research activities in Egypt ended in March 1995, the research begun there will continue at other sites during the next grant period. In 1993, research in brackish water environments was resumed with the addition of a coastal site in Honduras. In 1994, the tragic events that unfolded in Rwanda made it necessary for the CRSP to withdraw from that country; the selection of a new Africa site continues.

CRSP Work Plans

The CRSP Technical Committee has had the responsibility for developing technical work plans throughout the CRSPs 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; the concept of a standard protocol for research at all sites has been maintained throughout the program. These standards have evolved into the CRSPs *Handbook of Analytical Methods*, which was completed and distributed to participants in 1992.

In response to recommendations of the External Evaluation Panel during the first triennial review, the Fourth Work Plan and all plans developed since have been based on a biennial schedule to allow more time to complete and evaluate 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 where the research is taking place.

The Fourth, Fifth, Sixth, and Seventh Work Plans covered research conducted in two-year periods from 1987 through April 1995. The Interim Work Plan was developed during the current reporting period for activities undertaken between the end of the third and the initiation of the fourth CRSP grant, which is anticipated for May 1996. The abstracts in the following section summarize research activities during this reporting period. The abstracts are unedited, and are printed as submitted by the authors.

IV. Abstracts of Technical Papers

A. Global Experiment and Related Investigations

Effect of Pond Management Strategy on Nutrient Budgets

Global Experiment

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Abstract
PD/A CRSP pond management strategies rely on high nutrient loading rates to increase pond productivity. However, there is little information on the effect of semi-intensive pond management strategies on quality of pond effluents. Discharge of nutrient-rich pond water may result in deteriorated quality of receiving waters. Development of nutrient budgets would permit quantification of potential pollution impact of a specific pond management strategy. The objectives of the Global Experiment for this reporting period are, therefore, to develop nutrient budgets for nitrogen and phosphorus for semi-intensively managed freshwater and brackish water production ponds and to quantify the effect of pond management strategy on water and sediment quality. Two treatments, each replicated three times will be tested in each environment. Freshwater treatments for Nile tilapia *(Oreochromis niloticus)* consist of chemical fertilization plus commercially formulated fish ration (min. 20% crude protein) beginning on day 80 (Treatment 1) and chemical fertilization followed by commercially formulated fish ration (min. 20% crude protein) beginning on day 80 (Treatment 2). Brackish water treatments for *Penaeus vannamei* consist of feeding a commercially formulated shrimp ration containing 20% crude protein, (Treatment 1) and feeding a commercially formulated shrimp ration containing 30% crude protein (Treatment 2). The culture period will be 240 days for tilapia and 120 days for shrimp. Standard PD/A CRSP protocol will be followed to determine water budget, water quality, and sediment quality data. The experiment was started at the Honduras and Thailand sites.

Experimental Evaluation of Lime Requirement Estimators for Global Sites

Work Plan 7, Africa Study B

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Abstract
Low pond mud pH or pond water alkalinity are indications that lime should be applied to produce more favorable chemical environments for pond aquaculture. A number of methods are available for estimating the lime requirement. A number of workers have suggested the relationship between soil pH and soil base saturation differs with the amount of clay and organic matter present, and the mineralogy of the clay fraction. This study was designed to evaluate the suitability of several lime requirement (LR) estimators for a variety of soils from global sites. Soil samples were tested for LR and then added to beakers with 750 ml of soft water and the estimated amount of limestone. Water alkalinity was then monitored over the following 28 days. Results suggest different estimators perform better with specific soil types. Some estimators indicated lime should be added to soils already alkaline, even though water alkalinity did not increase with added lime. Additional analysis of these results is underway to identify the most suitable LR estimators for specific soil types.

Experimental Evaluation of Lime Requirement Estimators for Global Sites - Isolation Column Experiment

Interim Work Plan, Africa Study 3

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Abstract
Work Plan 7, Africa Study B was designed to evaluate the suitability of several different lime requirement (LR) estimators for different soil types by testing them in glass beakers containing soil samples, 750 ml of soft water and specific lime treatments. The present study was designed to investigate the use of artificial enclosures (isolation columns) as in-pond test units and to compare alkalinity response to liming in such enclosures with results obtained in the laboratory studies. The isolation columns (IC) were polyethylene tubes, 29 cm in diameter, secured to bottomless plastic buckets driven into the pond soils. Six columns were placed in one pond at a water depth of about 1 m. Three columns were limed according to its estimated LR; three were controls. Alkalinity response was monitored over the following 28 days. Soil samples from the same pond were added to 750 ml of similar quality water in glass beakers, along with the appropriate lime treatment and alkalinity measured over the following 28 days as a comparison with the IC model. Preliminary analysis of the alkalinity response patterns for each approach indicate alkalinities for laboratory "microcosms" and IC were similar after 28 days although the time course of alkalinity differed. Total alkalinities in unlimed isolation columns remained close to those in the open pond, while microcosm alkalinities in unlimed treatments differed from pond patterns, suggesting the columns did not greatly influence water quality dynamics.

Phosphorus Adsorption Capacity and Availability of Added Phosphorus in Soils from Aquaculture Areas in Thailand

Work Plan 7, Africa Study A

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Abstract
A series of 20 soil samples were collected from aquaculture areas in 14 provinces of Thailand. Samples represented 10 soil suborders, and exhibited wide variation in physical and chemical properties. Soil samples were treated with 0, 25, 50, 100, and 200 ppm phosphorus and incubated under water-saturated conditions for one month. Results show that amounts of added phosphorus recoverable by water extraction decreased markedly as phosphorus adsorption capacity (PAC) of samples increased ($r=0.88$ to 0.96, $P<0.01$). This suggests that relative abilities of bottom soils to adsorb and release phosphorus added to ponds in fertilizers or feeds can be assessed from PAC data. Because of the importance of phosphorus adsorption by soil in regulating phosphorus availability to phytoplankton in ponds, the PAC appears to be a more useful technique than traditional phosphorus extraction methods as an index of phosphorus status in aquaculture ponds. The PAC was highly correlated with clay content of soils ($r=957$: $P<0.01$), and a knowledge of clay content will permit a rough assessment of phosphorus status.

Problem Perceptions, Production Practices, and Economic Incentives for Tilapia Producers in Four PD/A CRSP Countries

Global Socioeconomic Study

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Abstract
As a synopsis of the three main aspects of a larger study conducted under the aegis of the Pond Dynamics/Aquaculture CRSP, this article summarizes the main findings of a larger report that establishes how and to what extent the research is reaching institutions serving farmers in PD/A CRSP countries and whether they in turn influence the practices of fish farmers. An economic analysis of experiments featuring various combinations of inputs made in wet and dry seasons are presented. The primary contours of farmer practices and perception related to feeding, fertilizing, and marketing tilapia are summarized. The economic analysis utilizes the survey data and other information obtained from PD/A CRSP publications, interviews with participating scientists, and others to examine the economic viability of various experimental outcomes associated with several years of parallel experimentation. Economic viability was assessed with primary data obtained from PD/A CRSP scientists according to their 1983-92 work plan, and nutrient input regime testing.

Interviews were conducted with tilapia farmers in four PD/A CRSP countries: Rwanda, Honduras, Thailand, and the Philippines. In Rwanda, 21 active Rwandan fish farmers in eight local administrative districts (communes) were interviewed in the Kinyarwanda language during the winter and early spring of 1992. Data were obtained in Spanish from a sample of 51 active Honduran fish farmers in nine of 15 Honduran departments during the fall 1993. Data were obtained from a sample of Philippine fish farmers in four of 15 provinces on the main island of Luzon during winter 1994. The survey was revised and adapted in English; some interviews were conducted in the Tagalog language. Data were obtained in Thai language interviews with 51 active fish farmers in three of 75 Thai provinces during winter 1994.

The institutional connections of the PD/A CRSP were profiled using information obtained in published documents and from interviews and other fieldwork conducted during visits to each country. Based on information obtained from PD/A CRSP scientists, host country counterparts, and other knowledgeables, the institutional context and connections of the research program is portrayed.

Tilapia growers in each of the countries face vastly different institutional systems supporting tilapia production. Where PD/A CRSP activities have the opportunity to influence host country governmental assistance to aquaculture, efforts should emphasize infrastructure and improved functioning of the private sector. Poorly organized fish product markets and input distribution systems often hinder aquaculture development. As markets for tilapia expand, production and support services demand will also expand. Development of private sector marketing services for both production inputs and fish outputs are needed for sustained aquacultural development. Weak connections to the farm level characterize the institutional context in each PD/A CRSP country. Thus, efforts to enhance the transfer and utilization of PD/A CRSP research results will require greater attention to actual and potential pathways of influence and information flow to the farm and village. Better understanding of these relationships will facilitate the conduct of a research program that meets farm-level needs in an environmentally and socially sustainable way.

Central Data Base

Hillary Berkman
Consultant

Summary of Activities
At the time the Central Data Base was transferred to the University of Hawaii it was complete through the Fourth Work Plan and nearly complete through the Fifth Work Plan. Since then data from two experiments in Rwanda and two experiments in Thailand were added to the Fifth Work Plan data.

The Sixth Work Plan included 19 experiments to be conducted between September 1, 1991 and August 31, 1993. Supplemental Work Plans included nine more experiments to be conducted during that period. All data collected using standard CRSP methods, and which the database could accommodate, were to be reported. (See Sixth Work Plan, page 1). Currently, the CRSP data base includes the following Sixth Work Plan data: two experiments from Honduras, three experiments from the Philippines and five experiments from Thailand. There are no data from Rwanda reported in the data base. In summary, ten experiments from the Sixth Work Plan have been included in the data base.

The Seventh Work Plan experiments covered the period from September 1, 1993 to August 31, 1995. Nine experiments were to be conducted in Honduras; none are reported in the database. Ten studies were to be conducted in Thailand; the results of four of those studies are included in the data base. Two experiments from the Philippines are reported. No data from Egypt are included in the database. Rwanda data are understandably absent. In summary, six experiments from the Seventh Work Plan have been added to the database.

B. Central America

Characterization of Shrimp Farm Effluents in Honduras and Chemical Budget of Selected Nutrients

Work Plan 7, Honduras Study 2

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Abstract
Intake and discharge from six shrimp farms located on riverine or embayment estuaries of the Gulf of Fonseca were sampled during rainy and dry seasons of 1993 to 1994. There was a mean net consumption of inorganic nitrogen and phosphorus, and a mean net discharge of organic matter. Discharged material was greater in embayment estuaries. Use of inorganic fertilizers promoted discharge of phosphorus and nitrogen. Total settleable solids and most nutrients were greater at the end than at the beginning of pond draining. An exception was BOD, which did not change during the course of pond draining. The majority of nitrogen entered and left ponds by water exchange. Most phosphorus entered ponds with feed, but left ponds by water exchange. Mean conversion ratios of feed nitrogen to shrimp flesh ranged from 1.4 to 4.1. Mean phosphorus conversion ratio was 6.3. Pond discharge of both nitrogen and phosphorus increased linearly with the feed conversion ratio. Nitrogen conversion ratios were not different for embayment or riverine estuaries. However, the conversion of feed and nitrogen to shrimp flesh was greater during the wet than the dry season.

Relationships among Stocking Density, Survival and Yield in Ponds Affected by the Taura Syndrome During Wet and Dry Seasons in Honduras

Work Plan 7, Honduras Study 3C

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Abstract
Relationships among stocking density, survival, and yield were evaluated in ponds affected by the Taura Syndrome during wet and dry seasons in Honduras. Ponds were stocked with juvenile *Penaeus vannamei* at 6, 8, 10, or 12/m ^{2}. The design was tested on two farms during the wet season and on three farms during the dry season. There was no significant correlation between shrimp stocking density and survival during either season. Season did not affect survival. Production increased with density during both seasons. Net income increased with density during the wet season, but decreased or remained neutral with an increase in density during the dry season. Net income was related to both production and individual shrimp weight. Mean shrimp weight did not decrease predictively with stocking density. Management strategies for ponds affected by Taura are discussed.

Nitrogen Fertilization in the Presence of Adequate Phosphorus

Work Plan 7, Honduras Study 4D

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Abstract
Effects of nitrogen fertilization on water quality and tilapia yields in earthen fish ponds supplied with adequate levels of phosphorus was tested. Ponds were stocked with tilapia at a density of 2/m ^{2}. Nitrogen was supplied as urea at 0, 7, 14, or 28 kg/ha-wk. Primary productivity responded positively to nitrogen fertilization. Chlorophyll *a* increased linearly ($P < 0.01$), and Secchi disk visibility decreased curvilinearly ($P < 0.05$) with increasing rate of fertilization. However, fish yields were not significantly correlated with nitrogen input, despite higher phytoplankton biomass. Cool dry season water temperatures apparently inhibited fish growth. Fish were unable to take advantage of higher available nutrient supply.

Effect of Diet Protein on Food Conversion and Nitrogen Discharge during Semi-Intensive Production of *Penaeus vannamei*

Interim Work Plan, Honduras Study 1

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Abstract
Previous studies demonstrated that shrimp production is similar at protein levels between 20% and 40%, when shrimp are stocked at densities between 5 and 11/m ^{2}. Feeding rates in these studies were such that feed efficiency was relatively low. Another trial conducted in Choluteca with shrimp stocked at 7.5/m ^{2} demonstrated that production during the dry season was not significantly affected by a 50% reduction in feeding rate. Wet season production was impacted significantly by the 50% reduction in feeding, but feed efficiency was improved. These results indicated that too much feed was applied during the dry season, and that wet season feeding rates might be reduced, but not by half. It is possible that a comparatively high protein diet might improve shrimp growth and feed conversion, if used at a feeding rate that is low compared with that employed with lower protein diets while reducing nitrogen levels in pond effluents. Pond chemical budget studies indicate that nitrogen discharge increases with both feeding rate and diet protein level. Primary productivity in estuaries appears to be limited by nitrogen. It is therefore economically and ecologically important to feed at appropriate rates with an appropriate protein level.

The objective of this research is to test the effect of diet protein level on food conversion and nitrogen effluents during the production of *Penaeus vannamei* at semi-intensive stocking levels during the warm (wet) season and cool (dry) season. The null hypotheses to be tested are: 1) Shrimp growth, yield, and feed conversion during each season will be independent of feeding rate and dietary protein level, and 2) Nitrogen discharge from shrimp ponds during each season will be independent of shrimp feeding rate and dietary protein level.

A completely randomized design in 2x2 factorial arrangement was used to test two feeding rates (50% and 75% of feeding curve) each at two levels of protein (20% and 30% protein); each treatment was replicated three times. *Penaeus vannamei* post-larvae (PL 8-10) were stocked at 25/m ^{2} (250,000/ha) in earthen ponds (0.7-1.0 ha) on 10 August 1995. A survival rate of 30% was assumed because of Taura Syndrome-induced mortality. Inlet and outlet water samples were collected for analyses of water quality variables. The experiment is scheduled to be harvested in December 1995.

C. East Africa

Masculinization of Nile Tilapia (*Oreochromis niloticus*) through Immersion in 17α-Methyltestosterone or 17α-Methyldihydrotestosterone

Interim Work Plan, Africa Study 2

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Abstract
The use of all-male populations increases the efficiency and feasibility of tilapia aquaculture. The objective of this study was to examine the efficacy of a short term immersion procedure for masculinizing Nile tilapia (*Oreochromis niloticus*). Two synthetic androgens were evaluated, 17α-methyldihydrotestosterone (mestanolone) and 17α-methyltestosterone. Exposures of fry at 10 and 13 days post fertilization for 3 hours to 17α-methyldihydrotestosterone at 500 µg/l produced sex ratios greater than 93 percent male. Immersions in 17α-methyldihydrotestosterone at 100 µg/l and 17α-methyltestosterone at 500 or 100 µg/l were unsuccessful at producing all-male populations. Neither steroid treatment affected mortality nor growth of fry. When compared to current techniques for steroid-induced sex inversion of tilapia, short term immersion in 17α-methyldihydrotestosterone (500 µg/l) shortens the treatment period and reduces possible worker exposure to anabolic steroids.

Maximum Voluntary Feed Intake and Growth of Nile Tilapia Fry as a Function of Water Temperature

Work Plan 7, Africa Study 4

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Abstract
Temperature and growth rate have long been suspected to influence timing of gonadal differentiation and efficacy of sex reversal, but little research data is currently available. However, before these investigations can be conducted, more information is needed on appetite and growth response of tilapia fry grown at different temperatures. As maximum voluntary feed intake (satiation) of fry fed a powdered feed cannot be measured using standard techniques, for this study satiation was defined as the feed rate beyond which growth no longer increased. One trial was run at each of the following three temperatures: 30° C, 26° C and 22° C. For each trial, treatments of four replicates were fed at seven feed rates, ranging from 10-28% BW/d at 30° C, 7-25% BW/d at 26° C and 4-22% BW/d at 22° C. Fish were sampled every four days and the trials completed at 28 days (30° C and 26° C) or 32 days (22° C). Fish at 30° C increased 412-884 mg in 28 days, depending on feed rate, with overall growth rates of 14.7-31.6 mg/d. At 26° C, they increased 161-513 mg with growth rates of 5.6-18.3 mg/d, and at 22° C gain was 66-288 mg at rates of 2.1-9.0 mg/d. In these trials, the highest feed rates used at each temperature did not exceed maximum voluntary feed intake for the smallest sizes of fish, and fish at the lower feed rates did not reach a size sufficient for adequate comparison with fish fed at the higher rates. Further trials are planned to obtain the needed data points.

Characterization of African Soils and Site Evaluation

Work Plan 7, Africa Study C

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Abstract
On-site PD/A CRSP research in Africa ended in April, 1994 as a result of war and civil violence in Rwanda. Continued lack of security has prompted the initiation of a search for a replacement African site. Study 3 objectives included the development of site selection criteria, collection of data and evaluation of promising sites, and characterization of African soils. Prime and companion site evaluation criteria were developed with input from the Technical Committee and ME. Information on potential sites and USAID planning documents for all Sub-Saharan African countries were used to identify promising countries and sites. Promising sites were identified at Sagana, Kenya; Malawi (Bunda College station and Domasi Experimental Fish Farm) and several sites in Zimbabwe. Travel approval was requested for the most promising sites in Malawi and Kenya. Travel to Malawi was not approved by USAID Malawi; the trip to Kenya was completed November, 1994 by Seim and Egna. Sagana Fish Culture Farm, about 100 km northeast of Nairobi met most selection criteria for a new site, but support from the Kenya Department of Fisheries was not encouraging. A Kenya policy of one international project per site made location there uncertain in light of the current Belgian studies at Sagana. New leadership in the Department of Fisheries is now enthusiastic about CRSP presence at Sagana and would support a direct agreement with the CRSP should that site be selected. Further investigation of Sagana appears warranted. That station is quite large, having some 40 ponds now in operation with a total water area of about 15.3 ha, with additional land area and water capacity in reserve. Information on other potential sites in Africa was also received and Malawi, Zimbabwe, Zambia and Tanzania remain under consideration. The selected site will be chosen both for local and regional impact in Africa. Countries south of Kenya are organized within SADC (Southern African Development Community). Ties with SADC will be sought regardless of the prime site location to extend the regional impact of the CRSP activities in Africa. Site evaluation and development planning continue under the Interim Work Plan. Soils were collected from two African sites; at least two cores were taken from five locations at two sites in Kenya. Additional soils from Rwanda were also characterized. Soils were characterized for CEC, sand, silt, and clay content, pH, exchangeable bases, base saturation and lime requirement. Sagana pond soils were quite high in clay content and low (5.1) in pH for a pond not recently in use, near neutrality for ponds more recently in use.

Reproductive Efficiency of Nile Tilapia (*Oreochromis niloticus*) and Red Tilapia (*Oreochromis spp.*) and a Comparison of Fry Growth and Susceptibility to Being Sex Reversed

Interim Work Plan, Africa Studies 6 and 7

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Abstract
Red tilapia, a cross between *O. niloticus*, *O. aureus*, and *O. mossambicus*, were compared with Nile tilapia, *O. niloticus*, in regard to brood reproductive efficiency and fry growth, survival, feed conversion, and sex reversibility. In four trials, brooders of each type were stocked in separate ponds and allowed to spawn for 215-230 degree-days (13-19 days) using two ponds per fish type. Fry were collected by a complete harvest of the pond collecting fry from the harvest basin. Fry were graded (>14 mm, <14 mm) and enumerated. Fry (>14 mm) from both types of brooders were stocked at 4000/m ^{3} in outdoor hapas and fed a feed containing 60 mg/kg 17α-methyltestosterone. Hormone treatment periods were 0, 14, 21, and 28 days. After 28-d of confinement, fry were harvested and growth and survival determined. Fry were cultured an additional 58 days and the sex determined by gonadal squash. Brood survival was similar for both types of fish (>95%). There was no difference in the number of fry/kg of brood produced by each brood type. Fecundity was correlated to temperature with greater fry production the higher the temperature. Red x Red brooders gave an average of 77% red and 23% wild type (black) fry. Harvest survival of fry from both brood types were similar. There was no difference in the percent males obtained from hormone-treated fry of either parent line. Mean fry survival and growth was similar for fry of both sources.

Growth and Efficiency of Sex Reversal of Nile Tilapia (*Oreochromis niloticus*) Fed 17α-Methyltestosterone-Treated Feed Stored Under Different Storage Regimes

Interim Work Plan, Africa Study 5

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Abstract
Effects of storage conditions of 17α-methyltestosterone-treated rations and the effects on fish growth and sex reversal were evaluated using rations held under six conditions. A common source of feed was treated with 60 mg 17α-methyltestosterone/kg, stored frozen and then held under one of the following conditions: 26 days at ambient conditions before use; 7 days at ambient conditions before use; 0 days at ambient conditions before use;
2 months at 40° C and 0 days at ambient conditions before use; 2 months at 40° C and 7 days at ambient conditions before use; and 2 months at 40° C and 26 days at ambient conditions before use. These rations were fed to *O. niloticus* fry for 28-d. Fry with an initial length of 10.4 mm were stocked at 4000/m ^{3} in outdoor hapas and fed at 15, 12, 8, and 4% BW per day during weeks 1, 2, 3, and 4 respectively. Growth and survival were determined at 4000/m ^{3} in outdoor hapas and fed at 15, 12, 8, and 4% BW per day during weeks 1, 2, 3, and 4 respectively. Growth and survival were determined after the 28-d treatment period. Fry were cultured until a minimum size of 4 cm. Fish were sexed using the gonadal squash technique and the percent male, female, and intersex fish determined. Feed storage conditions had no effect on the percent males produced. All hormone-treated feeds resulted in > 99% male populations. Storage conditions had no effect on growth, feed conversion ratio, or fish survival when fish were treated in fertile fish ponds. Mean fish weight after 28-d of treatment was 0.9 g, the feed conversion ratio was <1, and survival averaged > 55%.

D. Southeast Asia

The Effects of Fertilization on Growth and Production of Nile Tilapia in Rain-Fed Ponds

Work Plan 7, Thailand Study 1

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Abstract
The purpose of this study was to evaluate fertilization strategies for rain-fed ponds based on strategies developed for ponds with regular water inputs. Rain-fed ponds might be expected to have different fertilization schedules because the water depth changes with time and evaporation may concentrate nutrients and metabolites. Four experimental treatments were used: A) fertilization every two weeks with water replacement, B) fertilization every two weeks with no water replacement, C) fertilization once at the start of culture without water replacement, and D) fertilization irregularly when water nutrient levels declined without water replacement. Fertilization rates were similar to earlier optimal rates for CRSP ponds. Fish were stocked at 2 per m^2 (1600 per pond) and cultured for 150 days. Growth, survival, and yield were determined, and water quality was evaluated throughout the experiment. Treatments A and B (regular fertilization with or without water replacement) resulted in the highest growth rates, with irregular fertilization yielding lower growth and one fertilization the lowest growth. Survival was not significantly different among treatments. Several water quality variables, particularly nitrogen levels, varied among treatments, with A and B having higher levels than the other treatments. Regularly fertilized ponds with or without water addition both showed significant accumulation of nutrients over time, but there was no difference between these treatments. Fertilization strategies developed for ponds with regulated water depth worked effectively for ponds with evaporation losses that were not replaced. This study used input additions on a per areal basis, which were lower (by about one-half) than inputs would be on a per volume basis since the guidelines were developed for 1 m deep ponds and the study ponds began with water depths at 2.5 m. Growth and yields were slightly reduced compared to experiments in other pond systems, probably due to slightly lower nutrient input rates.

A Finishing System for Large Tilapia

Work Plan 7, Thailand Study 3

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Abstract
The objective of this study was to evaluate caging densities and pond loading rates for tilapia caged and fed in semi-intensive ponds with small tilapia at large. Such a system could be an effective means to produce large tilapia efficiently, as well as produce smaller tilapia and keep culture facilities at a reasonable level. Caged tilapia were held at five densities; 16, 32, 64, 128, and 256 fish per m^3 cage. Pond loading rates were 2 tilapia per m^2 (626 fish per pond) and caged tilapia were loaded at two rates: 224 or 560 caged fish per pond. Growth, survival, and yield of tilapia in cages and in ponds were estimated over 90 days of culture. Growth rates of tilapia in cages were similar regardless of density, and average tilapia size at harvest was 700g. Survival differed significantly with cage density, with fish from 16-64 per cage showing no differences in mortality, while fish at higher densities had very high morality rates. Fish at large in the ponds showed similar growth and mortality rates to other culture systems, even though the only source of nutrients was through the unused feed, fecal matter, and excretory products of the caged fish. Water quality did not deteriorate within the ponds at either loading rate. Cage stocking densities of 64 fish per m^3 were most reasonable for tilapia culture, and resulted in good survival and significant growth. The results on pond loading rates were not clear, since significant mortality occurred for some caged fish in the high loading ponds, yet it is unclear if the problem was a cage effect or a pond effect.

Stocking Density and Supplemental Feeding

Work Plan 6, Thailand Study 6

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Abstract
The purpose of this experiment was to determine the upper limits to tilapia production utilizing supplemental feeds. In order to test this, fish were stocked at 3, 6, and 9 fish per m^2. These fish were supplementally fed to satiation during culture for 146 days. Growth, survival, yield, and water quality were evaluated during the experiment. Growth continued in a linear fashion throughout the experiment, and density dependent growth occurred with the lowest density having significantly higher growth rate than the intermediate density, and with the highest density having the lowest growth rate. Survival also differed significantly among treatments, with lowest survival at highest density. Feeding rate averaged 1.9 %BW/d and was not significantly different among treatments. Feed conversion rate averaged 0.89 and was also similar among treatments. Water quality was not significantly different among treatments, and did not deteriorate during culture. The highest growth rate and survival occurred in low density ponds, yet there was no measured deterioration in water quality even in higher density ponds. It is unclear whether the higher density ponds had behavioral differences among tilapia to result in lower growth and higher mortality, or whether water quality actually differed but was not measured with our sampling regime. At present, the best system seems to be culture at 3 fish per m^2 with intensive feeding.

Carp/Tilapia Polyculture on Acid-Sulfate Soils

Work Plan 7, Thailand Study 5

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Abstract
CRSP research in Thailand has concentrated on the dynamics of *Oreochromis niloticus* monocultures. As *Oreochromis niloticus* is primarily a planktivore, the addition of the benthic detritivore *Cyprinus carpio* was hypothesized to lead to increased system productivity through the conversion of currently unutilized benthic matter into fish flesh.

A five-month experiment was conducted in earthen ponds of 200 m^2 surface area at the Asian Institute of Technology. Fifteen ponds were allocated to five treatments: carp stocking densities of 0, 0.1, 0.3, 0.5, and 0.7 fish/m^2, with three replicates, in three blocks which represented common carp of different sizes at stocking. Ponds were fertilized weekly with chicken manure, urea, and TSP.

Only preliminary results are available for this experiment. Tilapia growth was slow and uniform across blocks and treatments, likely because larger fish (>25 g/fish) had been erroneously selected from the batch to stock a different experiment before this experiment was stocked. Carp growth was extremely sensitive and inversely related to stocking density; carp of initial (pond mean) weights 11-40 g/fish grew to pond means 41-270 g/fish during five months.

Through the first half of the experiment, there was little indication of treatment-related differences in water quality except in measures of turbidity. Total suspended solids were markedly lower in ponds without carp. The parameters chosen for this experiment were appropriate to produce treatment-related differences in suspended solids and to reveal the density dependence of carp growth.

Diel Cycles of Temperature and Dissolved Oxygen Stratification in Deep Rain-fed Ponds

Work Plan 7, Thailand Study 7

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Abstract
In regions of large seasonal differences in rainfall, many farms have reservoir ponds. These can be used in addition for fish culture, but are often deeper (2-3 m) than those in which the CRSP fertilization protocols and other aspects of pond dynamics have been studied. The greater depth potentiates more severe density stratification than is common in shallower ponds, and therefore less often dissolved by convective overturn at night or by wind-induced mixing. This makes oxygen depletion of the hypolimnion more likely. This study attempted to describe and quantify diel cycles of temperature and DO stratification in the deep rain-fed ponds of current focus in the AIT Outreach activities, and to compare these patterns with those of shallower ponds typical of CRSP experiments.

Ponds of 800 m^2 area and 2.5 m depth at the Huay Luang station were monitored during fish growth experiments; diel cycles of temperature and DO were recorded with an automated monitoring system. During sunny, dry season days, the pond had a slightly deeper mixed layer (at least 35 but much less than 75 cm) than is characteristic of ponds at the more sheltered AIT site. The bottom water below 2 m depth was almost completely isolated from the upper water, receiving only minimal transport of oxygen from above. During the rainy season, the isolation below 200 cm was maintained even through a dark rainy day. These assessment techniques showed that active mixing may be necessary to maintain deep ponds as suitable culture environments for some animal species; the techniques can be used to assess low-cost mixing strategies.

Carbon Dioxide Exchange between Pond Water and the Atmosphere

Work Plan 7, Thailand Study 8

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Abstract
Rates of exchange of dissolved oxygen and carbon dioxide between pond waters and the atmosphere are often significant components of a pond's budget for these materials. Oxygen exchange is routinely estimated in free water studies, but far less attention has been given to diffusion of carbon dioxide, which may, however, be significant. The objectives of this work were to quantify the rates of exchange of carbon dioxide between pond water and the atmosphere in fertile earthen ponds, and to elucidate major factors which determine these rates. An analysis of data from the University of Hawaii pond research facility in the U.S. was made, detailing the diel cycles of total carbon dioxide, the component species aqueous ("free") carbon dioxide, net changes in CO_2 concentrations, and wind speed.

Total CO_2 concentrations varied little during the day, but showed a perceptible dip during mid-day, reflecting photosynthetic uptake. Wind speeds at 0.5 m above water surface ranged from about 0.6 to 1.8 m/s, with the windiest periods concentrated into daylight hours. The free CO_2 fraction of total CO_2 (about 1% of the total) varies in parallel with total CO_2, but accounted for only about 25% of the diel variation in the total CO_2. Multiple regression analysis showed that the concentration of free CO_2 and wind speed together accounted for 81% of the variation in the diffusion rates during this diel cycle. The net rates of change in CO_2 concentration during the 30 minute sampling intervals contributed no significant effect to diffusion rates and did not add to the percentage of the diel variation in diffusion rates which was explained by the other two factors. Model prediction of diffusion rates thus requires only observed concentrations and wind speed, though photosynthetic demand can be the primary determinant of concentrations under some conditions.

Growth Comparison of Three Strains of Nile Tilapia in Fertilized Ponds

Work Plan 7, Thailand Study 9

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Abstract
Three strains of *Oreochromis niloticus* were grown in ponds fertilized with 4 kg N/ha/d plus 0.8 kg P/ha/d to compare growth performance. The FAC strain were descendants of *O. niloticus* imported to the Philippines in the 1970s and kept at the Freshwater Aquaculture Center (FAC). The Thai strain were descendants of fish imported from Thailand in the 1980s and maintained by the Bureau of Fisheries and Aquatic Resources and ICLARM. The Egypt-Swansea strain originated from fish collected from Lake Manzala in 1979. These fish were used to create a laboratory strain at University College of Swansea during the 1980s and were subsequently transferred to FAC in 1989. Extrapolated yields of the Thai and Egypt-Swansea strains were not significantly different from each other and averaged approximately 5,000 kg/ha/yr. The average extrapolated yield of the FAC strain was only 2,389 kg/ha/yr reflecting the probable introgression of *O. mossambicus*.

Additionally, the yield of Egypt-Swansea fish grown in ponds fertilized at 2 kg N/ha/d plus 0.4 kg P/ha/d was compared to yield of fish grown at 4 kg N/ha/d. No significant difference was observed.

Polyculture in Deep Ponds

Work Plan 7, Thailand Study 2

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Abstract
The objective of this study was to assess the effect of other fish species on the water quality and yield of tilapia and of all fish in deep, rain-fed ponds. The experimental design included three fish stocking treatments with four replicates per treatment. Sex-reversed *Oreochromis niloticus* were stocked at 2 fish/m^2 into 12 earthen ponds at Udorn. Stocking occurred in late June 1995. They are to be cultured for five months, with a final harvest in late November 1995. Three treatments differed in stocking density of common carp *Cyprinus carpio*, with 0 carp in treatment 1,500 carp per hectare in treatment 2, and 1,000 carp per hectare in treatment 3. Carp were stocked at 500 g in size. All treatments will receive fertilizer application at the optimum frequency and rate, which is 70 kg/ha/wk of chicken manure, with sufficient urea and phosphorus added to provide 0.5 g/m^2/d N and 0.125 g/m^2/d P. Ponds were filled initially to 2.5 m, further water addition will only occur by rainfall. Standard protocols will be utilized for physical and chemical monitoring of ponds with the following exceptions. Diurnal sampling will be done every month at 4 depths (stratification can be quantified by top to bottom differentials in O_2 or temperature). Secchi disk depth will also be measured in diurnal analyses. Evaporation rate will be measured weekly. Final comparisons will be made to determine if the addition of carp influenced the stratification or turbidity of these ponds, as well as the yield of tilapia.

Outreach Assistance

Work Plan 7, Thailand Study 4

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Abstract
This study was initiated by holding two workshops with 10 fisheries officers from four provinces in Northeast Thailand, including Udorn, Nong Khai, Sakon Nakhon, Loei. Each provincial fisheries officer solicited four to six small-scale farmers from his or her province to participate in the high input green water scheme recommended by AIT-CRSP program. Biologists from Udorn station monitored the farmers activities.

Most farmers started their growout at the beginning of the rainy season in May and June 1995. There were complications getting production data because most farmers do not harvest their fish in one harvest; instead they catch fish in small numbers upon demand by local consumers or simply for their own consumption. In addition, the farmers mostly keep their fish until ponds dry out during the dry season. However, preliminary feedback from the farmers was very positive.

We will follow up to collect production data. We are planning to expand the number of farmers.

Effect of Pond Size

Work Plan 5, Thailand Study 9

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Abstract
Extrapolation, particularly scaling upward the results of trials in small impoundments to production scale ponds, is a classical and unsolved problem in aquaculture. Our interest here was not in solving the lager problem, but rather to examine earthen ponds of available different sizes for potential effects on CRSP experimental results at the Asian Institute of Technology (AIT). A five month experiment was conducted in 11 earthen ponds of four different surface areas (approximately 200, 380, 610, and 1390 m^2) with triplicate ponds of each size. Ponds were stocked with sex-reversed fingerlings of Nile tilapia (*Oreochromis niloticus*) at 2 fish per m^2. Ponds were fertilized with chicken manure at 250 kg dry matter/ha/wk supplemented with urea and TSP to attain rates of 35 kg N/ha/wk and 7 kg P/ha/wk. Water sampling and analysis were performed according to standard protocols, with detailed water sampling/analyses conducted every month. Extrapolated yields ranged from 1,921 to 8,631 kg/ha/yr. Single-factor ANOVA showed no significant relationship between yield and pond size. This means that areal fish yields may be expected to increase as ponds become larger. However, extrapolation to pond sizes beyond the largest used here is unwarranted.

E. United States

Decision Support for Pond Aquaculture: Simulation Models and Applications

Work Plan 7, DAST Studies 3, 4, and 5

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Abstract
Models in the decision support system *POND*© (Version 2.5) provide users with the capability of simulating pond aquaculture facilities at three levels of complexity depending on the types of analyses desired, data availability and output resolution requirements. Level 1 models are geared towards applied management and rapid analysis of pond facilities. Fish mass, water temperature and pond volume are the primary state variables at this level. Level 2 models allow for more rapid analysis of pond facilities. Fish mass, water temperature and pond volume are the primary state variables at this level. Level 2 models allow for more detailed pond analysis, management optimization and numerical experimentation. Additional complexity is introduced by considering plankton and nutrient dynamics in ponds. Level 3 models are intended for exploring fundamental aspects of pond dynamics (e.g., detailed nutrient transformations in pond water/sediments, and atmospheric diffusion) in addition to Level 2 functionality. A summary of source and sink processes considered at each modeling level is presented. The water temperature model in *POND*© has been validated by the use of CRSP data from Honduras, Rwanda and Thailand. The fish bioenergetics model in the software has also been parameterized for channel catfish *(Ictalurus punctatus)*, tambaquí *(Colossoma macropomum)* and pacu *(Piaractus mitrei)* by the use of data collected from the literature. In general, Level 1 simulation results agree well with observed data under a wide range of culture conditions suggesting that the models used at this level are relatively robust and

will likely be useful for a diverse audience including pond managers, planners and educators. Applications of the *POND*© models for species selection and facility-level analysis, economic optimization, estimation of resource requirements, examination of stocking and harvest strategies and water/sediment quality management are demonstrated.

Decision Support for Pond Aquaculture: Parameter Estimation Techniques

Work Plan 7, DAST Study 5

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Abstract
Manual parameterization of the fish growth model in the decision support system *POND*© has proven to be time-consuming and complicated because of interactions among variables considered in the model and the large parameter space to be searched. This has limited the use of the software for examining production potential for different pond culture species. Traditional parameter estimation techniques typically require partial derivative evaluations; however, because this is a difficult task for simulation models that consider several variables, the use of an iterative, non-linear, adaptive search method (genetic algorithm or GA) for automatic parameterization of the fish growth model was explored. As with other parameter estimation techniques, the objective function to be optimized must be specified. The objective function chosen for GA testing is the minimization of the absolute error between observed and predicted fish growth. Adequate convergence to acceptable parameter values was obtained for the three species (channel catfish, tambaqui and pacu) chosen to evaluate GA's as an effective parameter estimation technique. This methodology has been incorporated directly into *POND*© to enable users to rapidly customize the software for alternate culture species and locations.

Aquaculture Pond Modeling for the Analysis of Integrated Aquaculture/Agriculture Systems

Interim Work Plan, DAST Study 2

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Abstract
Enhanced nutrient cycling through waste reuse and sustainable production are the major objectives for integrating aquaculture and agriculture. This report describes the initial steps in the development of a simulation model to analyze the effects of integrating aquaculture with agriculture on nutrient cycling, whole system productivity, and of the impacts of various management actions on the potential for enhancing pond sediment quality. The model consists of three modules: fishpond, crop, and terrestrial soil nitrogen. Inputs of nitrogen into the pond include feed/fertilizer and influent water and outputs from the pond include uptake by fish, effluent water, and removal of pond sediments. The three modules are linked through the use of sediment from ponds as crop fertilizer and/or the use of wastes from crops as feed/fertilizer to aquaculture ponds. Preliminary results demonstrate that feed quality and digestibility of feed need to be considered to improve overall estimation of organic matter and nitrogen production in the fish pond, and of fish growth.

F. Special Topics Research

Stochastic Modeling of Temperature and Dissolved Oxygen in Stratified Fish Ponds

Work Plan 7, DAST Study 2; Interim Work Plan, DAST Study 1

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Abstract
A model of water temperature, dissolved oxygen (DO), and fish growth in stratified fish culture ponds has been developed. The model uses stochastically-generated weather parameters as inputs. A Monte Carlo technique is used in generating hourly values for solar radiation, wind speed, and wind direction based on probabilistic functions obtained from historical weather records for the pond site. The model can be executed for a maximum of 32,768 steps, corresponding to an 85 day simulation with a time step of 0.0625 h. Temperature and dissolved oxygen predictions match well with measured values, but fish growth and chlorophyll-*a* concentrations are consistently overestimated.

Sex Reversal of Tilapia: 17-α Methyltestosterone Dose Rate by Environment, and Efficacy of Bull Testes

Interim Work Plan, Honduras Special Study 1

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Progress Report Abstract
Sex reversal of newly hatched tilapia generally is accomplished via oral administration of 17-α methyltestosterone (MT), which has been incorporated into a starter fish feed at 60 mg MT/kg feed. While use of the 60 mg MT/kg feed dose consistently yields populations comprised of less than 5% females (i. e., > 95% males), this has not been shown to be the optimal dose. Other investigators have reported sex reversal of tilapia at dose rates less than 60 mg MT/kg feed; however results from some of these studies are inconsistent, and it is difficult to separate treatment environment effects. Naturally occurring sources of testosterone may be an alternative to using a synthetic androgen, which also is an anabolic steroid, for tilapia sex reversal. Bull testes are a by-product of beef industry in the US, and are a potential source of dietary testosterone for tilapia sex reversal. The objectives of this research were to determine the efficacy of sex reversal of different dosage rates of MT to fish treated in different environments, and to evaluate the potential of freeze-dried bull testes as a dietary source of testosterone for tilapia sex reversal.

Newly hatched Nile tilapia *(Oreochromis niloticus)* were stocked at 8 fry/L into 80-L glass aquaria located inside a hatchery building or into hapas (45-L volume) suspended in 20-m^3 outdoor concrete tanks. Trout chow (42% protein) was the carrier for MT, which was incorporated into the feed at 0, 15, 30, 45 or 60 mg MT/kg of feed. Fry in each treatment were fed at 20% body weight during week 1; the daily ration was divided into four meals. Feed rate was decreased by 2.5%/wk during weeks 2-4. Treatment duration was 28 days.

Frozen bull testes, obtained from a meat packing plant, were freeze-dried and ground, and mixed with trout chow either in a 1:1 or 1:3 freeze-dried testes:trout chow ratio. Mixed feed was offered as described above.

Preliminary data is available now; data collection and analysis continues through December 1995. After the 28-d MT treatment period, fry total length ranged from 32.8-39.6 mm and 40.7-44.3 mm for fry treated in aquaria (indoors) and hapas (outdoors), respectively. Average respective final weight ranges were 0.7-1.0 and 1.2-1.9 g/fry. Fry survival in both environments was low and ranged from 16.7-27.7% and 25.7-43.6% in aquaria (indoors) and hapas (outdoors), respectively.

Fry fed feed containing bull testes were 55.6 and 59.7 mm total length for 1:1 and 1:3 ratio feeds, respectively, following the 28-d treatment period. Mean final weights were 2.0 and 0.7 g/fry for 1:1 and 1:3 ratio feeds, respectively, which undoubtedly reflected the difference in respective survival during treatment (28.3% versus 69.2%).

V. Public Service

The Pond Dynamics/Aquaculture CRSP relies on its on-site researchers to recognize opportunities to support training activities at local research institutions 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. Such activities also help promote international scientific linkages through the exchange of technical information. As a result, research capabilities have been substantially strengthened in every developing country where the CRSP has been active. Some of these important contributions are described below.

Research capabilities have been substantially strengthened in every developing country where the CRSP has been active.

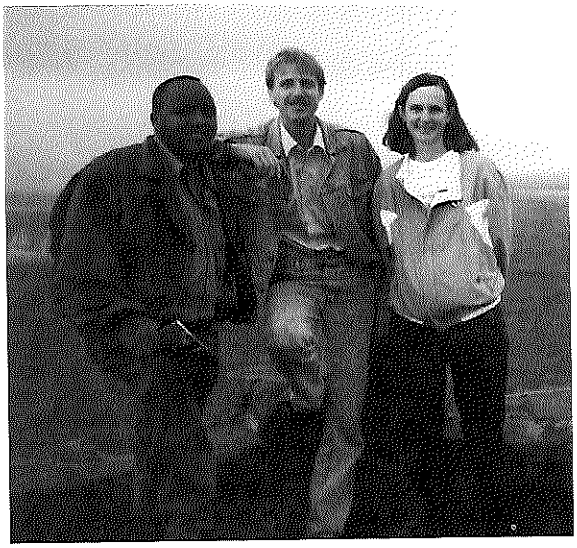
Institution Building

The research activity of the CRSP 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 advisors in the research programs of students at host-country universities and contribute to curriculum development.

In Honduras, a CRSP-led public-private joint venture continues to produce economic benefits while increasing the understanding of water quality issues associated with the shrimp industry in southern Honduras. The CRSP works 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) to study water quality issues affecting shrimp production and the estuarine environment surrounding the farms. The refurbishment of the laboratory in La Lujosa, near Choluteca, was made possible by the active participation of all the partners in this joint venture. The Ministry of Natural Resources provides the laboratory and office space at La Lujosa. ANDAH provides equipment and supplies for the lab, funded by a self-imposed assessment on shrimp exports. ANDAH members also provide ponds and materials such as fertilizer and feed needed for CRSP experiments. FPX extensionists assist in collecting data from their members and disseminating research information. Students under the direction of EAP conduct research in shrimp culture and water quality analysis.

The laboratory in Choluteca was dedicated in 1993 and makes important contributions to research issues including estuarine monitoring, pond fertilization, and shrimp feeding strategies. The results of this research will help increase farmers' economic efficiency and minimize negative environmental impact.

The CRSP continues to be an active partner in the establishment of research ponds at the Chaiyaphum Fisheries Station in northeast Thailand and at Phayao Station in northern Thailand. The CRSP has also been instrumental in providing outreach assistance in northeast Thailand. The CRSP researcher there conducted a workshop for fisheries officers from four northeast provinces; each fishery officer in turn solicited small-scale farmers to participate in the high input green water regimen recommended by the AIT/CRSP.



Education and Professional Development

Formal training programs have rarely been funded by this CRSP; nevertheless, the involvement of students from host countries and the U.S. constitutes an important part of the CRSPs international outreach. Informal training activities such as short courses and workshops are frequently conducted. Since the beginning of the program, over 400 individuals have benefited from CRSP training activities.

Thailand

The CRSP is involved in training as a component of several studies that help extend CRSP research to farm ponds throughout Thailand. C. Kwei Lin organized a three-week training course entitled "Water quality and pond soil management for sustainable aquaculture." The course was held at AIT from 17 April to 5 May 1995. The CRSP provides the research component for an adaptive management system in which on-farm studies help speed the extension of research to the farmers while the farmers' concerns help create the research agenda. As an example, during this reporting period researchers investigated deep rain-fed ponds, an important element of the farm system in northeast Thailand.

Honduras

The CRSP has maintained informal linkages with the Panamerican Agriculture School at Zamorano for many years. During this reporting period, a student from the school will complete a fourth year degree with a CRSP study of the interaction among biological oxygen demand (BOD), chemical oxygen demand (COD), and nutrient changes over a period of 21 days in shrimp farm intake and discharge water. Two other students began a study on the effects of tides on nutrients, oxygen, temperature, and salinity profiles in two major shrimp-producing estuaries of southern Honduras.

United States

Joseph Molnar of Auburn University organized a symposium on aquaculture for the 1995 Annual Meeting of the American Association for the Advancement of Science (AAAS) in Atlanta, Georgia. Entitled "Augmenting World Food Supplies through Aquaculture: Recent Advances in Fish Culture and the Technology of Aquatic Systems," the symposium featured presentations by CRSP presenters Claude E. Boyd (on "Control of water quality as a fundamental aspect of aquaculture") and James P. Szyper (on "Photosynthesis and reproduction in culture ponds"). CRSP researchers offer seminars on topics related to CRSP research at the participating U.S. universities whenever appropriate.

Degree programs

Enthusiasm generated by informal training opportunities and by exposure to research activities at the CRSP 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. Before this reporting period, over 130 degrees (B.S., M.S., and Ph.D.) were awarded, and during this period, another nine were completed under the direction of CRSP researchers.

Over 87 theses have been completed under the direction of CRSP researchers. Theses completed during this period are:

- Amechi, Enc O. 1995. An Assessment of By-Catch Biomass in Experimental Fish Ponds. M.S. Thesis. Asian Institute of Technology.
- Ahmed, Saleh. 1995. Assessment of Chlorine as a Piscicide in Freshwater Fish Culture. M.S. Thesis. Asian Institute of Technology.
- Baouthong, Pompimon. 1995. The Effect of Feeding Regime on Growth and Body Composition of Shrimp *(P. monodon)*. M.S. Thesis. Asian Institute of Technology.
- Chughtai, Muhammad A. 1995. Effects of Water Spinach *(Ipomoea Aquatic)* on Nutrient Regime and Fish Growth. M.S. Thesis. Asian Institute of Technology.
- Rungruengwudhikrai, Em-om. 1995. Characterization and Classification of Off-Flavour of Nile Tilapia. M.S. Thesis. Asian Institute of Technology.
- Vuthana, Hean. 1995. Fish Pond Turbidity in Cambodia. M.S. Thesis. Asian Institute of Technology.
- Ungsethaphan, Theapparath. 1995. An On-Farm Trial to Investigate Feeding Strategies for Nile Tilapia *(Oreochromis niloticus)* Broodfish. M.S. Thesis. Asian Institute of Technology.
- Xie, Jian Jun. 1995. Alternative Methods for Maggot Production. M.S. Thesis. Asian Institute of Technology.
- Md, Rafiqul Islam, 1995. A Field Survey of the Factors Involved in the Use of Ponds for Fish Culture in Bangladesh, With Emphasis on Water Quality. M.S. Thesis. Asian Institute of Technology.

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. Figure 1 indicates the distribution of degree and non-degree training.

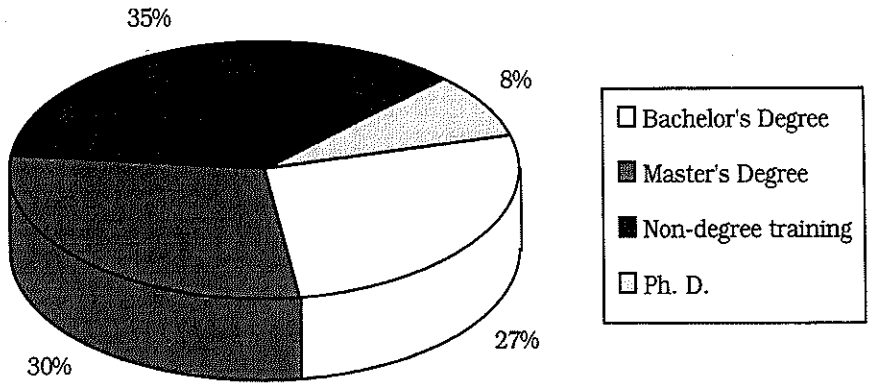


FIGURE 1. CRSP TRAINEES BY DEGREE

Most of the trainees have come from PD/A CRSP host countries–Egypt, Honduras, Indonesia, Panama, the Philippines, Rwanda, and Thailand (Figure 2); 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, development projects, and agricultural extension services, where they are able to increase public awareness of aquaculture's importance in food systems.

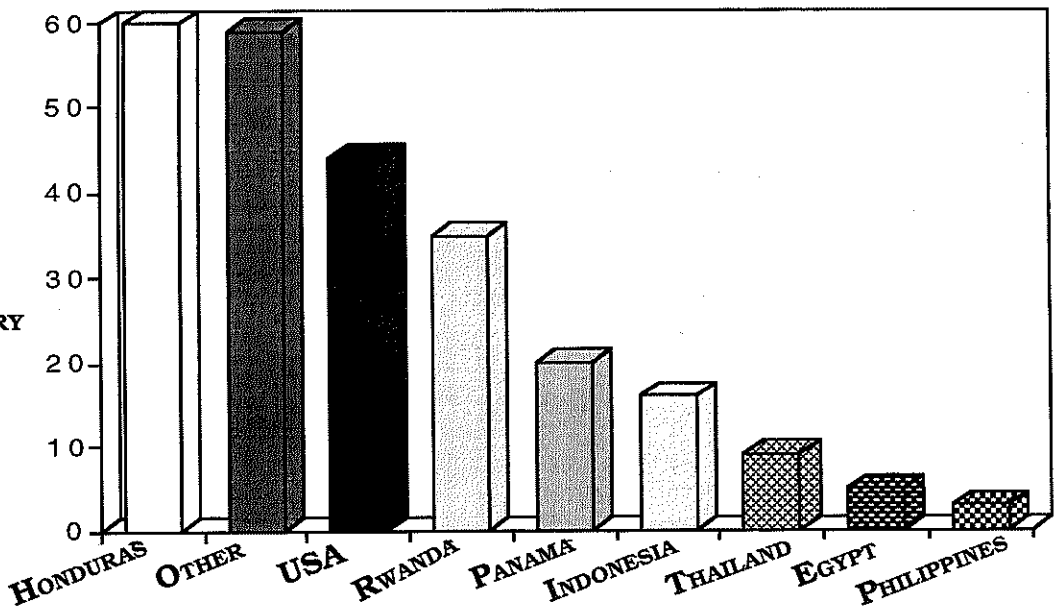


FIGURE 2. CRSP TRAINEES BY COUNTRY OF ORIGIN

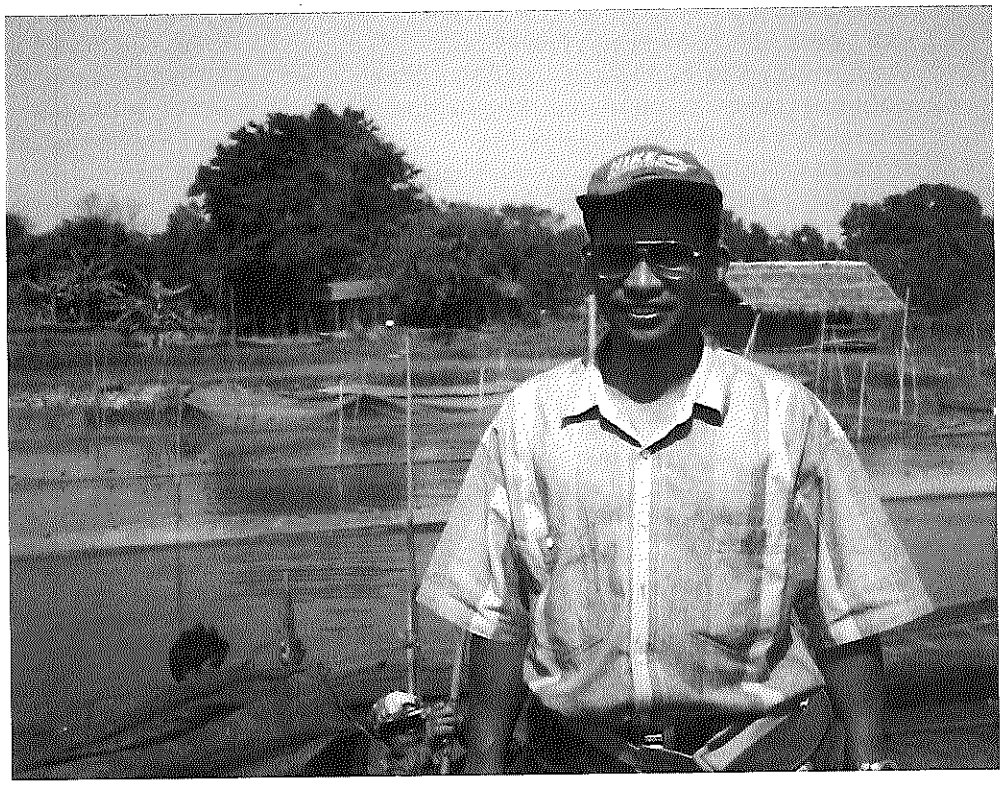
Linkages

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, ANDAH, EAP, and FPX, who each make substantial contributions to the on-going operation of the project. In addition, CRSP researchers serve as consultants for Peace Corps volunteers, who also have assisted with logistical arrangements for researchers involved with the social sciences project. During this reporting period, the in-country CRSP researcher held a field trip for members of the Programa Regional de Apoyo al Desarrollo de la Pesca en el Istmo Centroamericano (PRADEPESCA), a project funded by the European Union for aquaculture and fisheries work in Honduras, Nicaragua, Costa Rica, and Panama. Participants had the opportunity to view the CRSP work first-hand and to discuss potential collaboration between the two projects. The in-country CRSP researcher also conducted a field trip and seminar for 12 USAID personnel, including the Mission Director from Honduras, and representatives from environmental offices in Nicaragua, El Salvador, and Guatemala. Representatives from the Ministry of Natural Resources and the Ministry of the Environment of Honduras also attended. The group toured the water quality lab and several farms and estuaries, before convening a seminar to discuss potential interaction among USAID, ANDAH, and the La Lujosa Water Quality Lab.

A four-person team from USDA visited Choluteca after conducting workshops on shrimp culture in Nicaragua. The team toured the lab and a local shrimp farm. As a follow-up the CRSP researcher and representatives from USDA, the Panamerican School in Zamorano, and ANDAH created a plan of action for presenting a project proposal to the International Development Bank (IDB) for funding an aquaculture training and demonstration project in Honduras and the Central American region. The Country Director of the IDB joined in some of the planning meetings. The project will be led by a local institution.

The CRSP continues to strengthen its ties with institutions in southeast Asia. In Thailand, CRSP researchers hold long- and short-term faculty appointments at 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 advisors to the Thai government on aquaculture and fisheries related projects. CRSP researchers working on outside projects in Vietnam and Laos have added to the regional network of potential CRSP collaborators.

The CRSP presence in the Philippines, once a primary CRSP site, was re-established by setting up a companion site at the Freshwater Aquaculture Center at Central Luzon State University (FAC/CLSU). In addition, the CRSP maintains ties with ICLARM. Genetically selected tilapia from an ICLARM-sponsored project are used for field testing at the FAC/CLSU as part of the regional verification trials being conducted by the CRSP in the Philippines. Another collaborator is the FAC/CLSU-University of Wales Swansea Research Project on Genetic Manipulations for Improved Tilapia (GMIT). This research program provides all male tilapia for use in one treatment of the CRSP regional verification. These genetically male tilapia are produced by breeding "YY supermales" with untreated females.



In addition to the CRSPs numerous formal connections with host country institutions through Memoranda of Understanding, the CRSP maintains ties with numerous other organizations, including some commercial fish producers in the U.S. and in host countries. A partial list of informal CRSP linkages follows:

American Association for the Advancement of Science (AAAS)
Al Azhar University, Egypt
American Tilapia Association, United States
American Fisheries Society
Board for International Food and Agricultural Development (BIFAD, Washington, D.C.)
Cairo University, Egypt
CARE, Honduras
Catholic University of Leuven (CUL), Belgium, Rwanda
Central Luzon State University, Freshwater Aquaculture Center, Philippines (FAC/CLSU)
Consultative Group on International Agricultural Research (CGIAR), Washington, D.C.
Department of Fisheries, Udorn Thani, Thailand
Department of Renewable Natural Resources (DIGEPESCA), Honduras
Eastern Fish Cultural Laboratory, Marion, Alabama
Escuela Agrícola Panamericana (EAP), Honduras
European Economic Community
European Inland Fisheries Advisory Commission (EIFAC)
Fish Breeding Centre, Israel
Food and Agriculture Organization of the United Nations (FAO), Rome, Italy
Honduran Federation of Agricultural and Agroindustrial Producers and Exporters (FPX)
International Development Bank (IDB)
International Sorghum and Millet (INTSORMIL) CRSP
Institut Pertanian Bogor (IPB), Indonesia
International Development Research Centre (IDRC) of Canada
International Center for Aquaculture (ICA), Auburn University, Alabama
International Center for Living Aquatic Resources Management (ICLARM), Philippines
J.F.K. Agricultural School, Honduras
Ministry of Agriculture, Agricultural Research Center, Abbassa, Egypt
National Agricultural Library, Washington, D.C.
National Association of Honduran Aquaculturists (ANDAH), Honduras
National Inland Fisheries Institute (NIFI), Thailand
National Marine Fisheries Service (NMFS), La Jolla, California
National Technical Information Services, (NTIS) Springfield, Virginia
North Central Regional Aquaculture Center (NCRAC), Michigan
Northwest Fisheries Sciences Center, Seattle, Washington
Programa Regional de Apoyo al Desarrollo de la Pesca en el Istmo Centroamericano (PRADEPESCA), Honduras
Peace Corps, Honduras
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 (USDA), Washington, D.C.
United States Fish and Wildlife Service, Washington, D.C.
University of Washington, Seattle, Washington
World Aquaculture Society (WAS), Baton Rouge, Louisiana
Western Regional Aquaculture Consortium (WRAC), Seattle, Washington

VI. 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 addressed by the CRSP in the Continuation Plan for 1996-2001.

Regional research centers in Asia, Africa, and Central and South America would serve as springboards for extending activities to other countries in the region.

An analysis of constraints to aquaculture revealed seven main areas:

- Aquacultural productivity
- Socioeconomics
- Environmental effects of aquaculture
- Information management
- Networking
- Human capacity
- Target economies

The focus of the CRSP efforts will consist of research in production systems and capacity building through research support activities. Production systems research will concentrate on specific themes in the areas of production optimization, social and economic aspects, and environmental effects. Research support activities are proposed in information management, networking, and human capacity development. The structural changes needed to remove constraints to target economies are beyond the scope of this program. However, the CRSP is specifically designed to address the other constraints, through its multidisciplinary systems approach to the task of generating information and developing more sustainable production technologies.

The PD/A CRSP is committed to extending aquaculture development to appropriate sites. The Continuation Plan calls for establishment of regional research centers in Asia, Africa, and Central and South America. These centers will serve as springboards for extending activities to other countries in the region while maintaining the research focus at the main site. Several new institutions and new sites have been included in the Continuation Plan. The Sagana Fish Culture Farm in Kenya is under consideration as a possible primary site in Africa. Possible companion sites include the Kibos fish culture station near Kisumu in Kenya and the Bunda College of Agriculture and the Domasi Fish Farm in Malawi. The Honduras site at La Lujosa in Choluteca will continue to be the primary Central American site, with continuing activities funded at the El Carao station in Comayagua. Guatemala, Panama, and Nicaragua are being considered as possible companion sites. In South America, the Universidad Nacional de la Amazonia Peruana aquaculture facility at Iquitos and the Instituto de Investigaciones de la Amazonia Peruana are being considered as primary sites. Bolivia and Ecuador are being considered as possible companion sites. AIT in Bangkok will continue to serve as the primary CRSP site in southeast Asia, with companion sites planned for the Philippines and other countries in Indochina.

New U.S. institutional collaborators will include: Harbor Branch Oceanographic Institute, Ohio State University, Southern Illinois University at Carbondale, University of Alabama at Birmingham, University of Arizona, University of Oklahoma, and University of Pittsburgh. Potential new host country institutional collaborators are the National University of the Peruvian Amazon and the Kenya Ministry of Tourism & Wildlife/Department of Fisheries.

Development of Sustainable Aquaculture Systems

Aquaculture is projected to continue filling an important niche as a food source and cash crop in developing countries. The greatest challenge of aquaculture development is to help create systems that can be self-sustaining. The CRSP recognizes that the development of sustainable aquaculture systems depends upon identifying and addressing major constraints. Major areas that limit the development of sustainable aquaculture systems currently include: inefficient and inconsistent aquacultural productivity; a poor understanding of the socioeconomic factors that impact aquaculture; negative environmental effects resulting form aquaculture operations; insufficient human capacity development; poor or outdated information management; and limited networking capacities. The Continuation Plan directly addresses these constraints in the major research areas mapped out by CRSP researchers. Past CRSP accomplishments have helped further the sustainability of aquaculture endeavors, as evidenced by the continued growth and interest in aquaculture at all sites.

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 insure the protection the estuarine environment surrounding the gulf. The impact of the CRSP as a research and education project is evidenced by the increased awareness on the part of Honduran shrimp farmers that the health of the Gulf of Fonseca and its estuaries is essential for their continued economic survival. For example, research results have shown farmers that they can lower their feed costs while lessening the nutrient load in the estuary. Further research will continue to integrate environmental issues with production concerns.

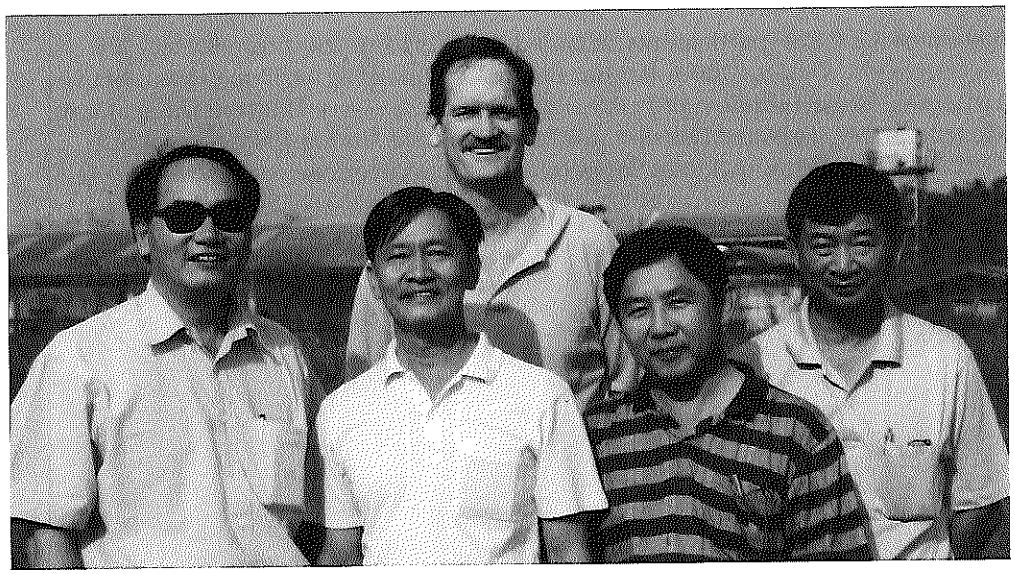
Water quality concerns are also on the research agenda in Thailand. Studies of deep rain-fed ponds help farmers determine the most efficient and effective fertilizer regime to boost yield while maintaining water quality. CRSP researchers at all sites demonstrate a concern for the effects of aquacultural production on the wider environment.

Biotechnology opens alternative avenues for the production of monosex tilapia. Although the Egypt project ended during this reporting period, research begun under that project is being continued in the U.S., focusing on the safe use of masculinizing hormones with a special emphasis on minimizing impacts on humans, fish, and the 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. In the Continuation Plan, the CRSP allocates significant resources to the study of socioeconomic issues that constrain aquaculture. Socioeconomic concerns are identified as one of the core themes in the new Continuation Proposal and will be firmly integrated into the CRSP research agenda.

The global social sciences project, "Socioeconomic Dimensions of Aquaculture Development: A Comparative Assessment of Financial Returns, Adoption Barriers, and Impacts of Tilapia Production Regimes," identifies the level and type of technology available to tilapia farmers in Honduras, Thailand, and the Philippines. That work describes the role of CRSP technology in the evolution of tilapia production practice, and the relationship of these technologies to the larger research and technology development systems. It also profiles the economic context that shapes farmers' decisions concerning technology adoption. The results of the study will have implications for future research proposals, development policy, and farm-level decision-making about tilapia technology.



Participation in International Scientific Meetings and Conferences

CRSP researchers contribute to the general aquaculture community through their participation in international scientific meetings and conferences. During this reporting period, CRSP researchers took part in the following activities.

Jim Diana served as president of the North Central Division of the American Fisheries Society. Diana attended the 1994 Midwest Fish and Wildlife Conference in Indianapolis, Indiana.

David Teichert-Coddington served on the technical organizing committee of the Third Central American Shrimp Symposium, which was held in Tegucigalpa in April 1995. The shrimp symposium has helped to establish Honduras as a leader in shrimp culture in Central America. In addition to Teichert-Coddington, other CRSP-related symposium presenters included: Daniel Meyers, L. Milla, R. Rodriguez, W. Toyofuku, J. Harvin, Delia Martinez, Bart Green, and Claude Boyd.

J-J Newman attended the Fifth International Symposium on Reproductive Physiology of Fish in Austin, Texas, in July.

C.K. Lin and Claude E. Boyd served as Technical Program Chairmen for the 1996 World Aquaculture Society (WAS) meeting in Bangkok, Thailand, held 29 January–2 February 1996. Other CRSP participants who served on the Technical Program Committee were Gary Jensen, Raul Piedrahita, David Teichert-Coddington, and Kamonporn Tonguthai. Kitjar Jaiyen, former CRSP Host Country Principle Investigator, served on the Organizing Committee for the WAS meeting.

The following CRSP participants attended the World Aquaculture Society '95 meeting in San Diego, California: Jim Bowman, Hillary Egna, Doug Ernst, Martin Fitzpatrick, Robert Fridley, Bill Gale, Brigitte Goetze, Terry Hanson, Daniel Jamu, Eduardo Lopez, Leonard Lovshin, Joe Molnar, Shree Nath, J-J Newman, Raul Piedrahita, Tom Popma, James Szyper, and Karen Veverica.

The following papers were presented at WAS '95 by CRSP researchers:

- Abdelghany, A.E. Effects of feeding 17α-methyltestosterone and withdrawal on feed utilization and growth of Nile tilapia *(Oreochromis niloticus L.)* fingerlings, presented by Abdelghany;
- Bowman, J.R. and J.E. Baham. Effects of calcium carbonate treatments on soil and water chemistry in laboratory microcosms, presented by Bowman;
- Boyd, C. E. Chemistry and efficacy of amendments used to treat water and soil quality imbalances in shrimp ponds, presented by Boyd;
- Boyd, C. E. Sustainability of channel catfish farming in the southeastern United States, presented by Boyd;
- Boyd, C. E. Water quality characterization needs related to effluent permitting, presented by Boyd;
- Brinkop, W.S., and R.H Piedrahita. Intensive aquaculture systems model, presented by Brinkop;
- Emberson, C. and K. Hopkins. Intensive culture of *Penaeus stylirostris* in plastic-lined tanks, poster presentation;
- Gale, W.L., M.S. Fitzpatrick, C.B. Schreck. Binding sties for the masculinizing steroid mibolerone in the gonadal tissue of adult tilapia *(Oreochromis niloticus)*, presented by Gale;
- Green, B.W., Z. El Nagdy, H. Hebicha, and A. R. El Gamal. Nile tilapia grow-out pond management strategies in Egypt, presented by Green;
- Hanson, T.R., J.J. Molnar, and L.L. Lovshin. A socio-economic analysis of *Oreochromis niloticus* production in Thailand, Philippines, Honduras, and Rwanda, presented by Hanson;
- Kastner, R.J. and C.E. Boyd. Evaluation of controlled release fertilizers for use in fish ponds, presented by Boyd;
- Lin, C.K. Progression of intensive marine shrimp culture in Thailand, presented by Lin;
- Lin, C.K., J.S. Diana, C.F. Yi. Optimal rate of supplementary feeding for Nile tilapia *(Oreochromis niloticus)* in fertilized ponds, presented by Lin;
- Munsiri, P. and C.E. Boyd. Physical and chemical properties of soil profiles in aquaculture ponds at Auburn, Alabama, presented by Boyd;
- Schwartz, M.F. and C.E. Boyd. Constructed wetlands for treatment of effluents from channel catfish ponds, presented by Boyd;
- Szyper, J. P. and W. Havanont. Effects of controlled concentration of dissolved oxygen on growth and food conversion of juveniles of two carnivorous fishes in tanks, presented by Szyper.

Teichert-Coddington was an invited speaker at the WAS Special Session on Shrimp Farming. He presented the paper, "Estuarine water quality and sustainable shrimp culture in Honduras."

Also at the WAS meeting, CRSP researcher Shree Nath demonstrated *POND* © during the session on "Education in the Age of the Information Highway."

In January 1995, Lin presented a seminar on pond fertilization to fishery officers from five provinces in northeast Thailand. A practical protocol was formulated for farmers interested in adopting high fertilizer input for tilapia culture.

Joseph Molnar organized a symposium on aquaculture as part of the 1995 annual meeting of the American Association for the Advancement of Science. The symposium, held on February 17 in Atlanta, Georgia, addressed how recent advances in aquaculture are augmenting world food supplies. Szyper and Boyd each presented papers at the symposium.

Hillary Egna and Bryan Duncan participated in a workshop on "Developing Strategy Objectives for the Office of Agriculture and Food Security," 21-23 February 1995 in Fair Oaks, Virginia.

Bryan Duncan served on the organizing committee of the Pacific Congress on Marine Science and Technology (PACON) Conference on Sustainable Aquaculture '95 in Honolulu, Hawaii, in June 1995. Other CRSP members attending the conference were: Claude Boyd, Hillary Egna, Phil Helfrich, C. Kwei Lin, Shree Nath, Harry Rea, and James Szyper.

The following papers were presented:

- Boyd, C.E. Source water, soil, and water quality impacts on sustainability in aquaculture, presented by Boyd;
- Nath, S., J.P. Bolte, and D.H. Ernst. Decision support for pond aquaculture planning and management, presented by Nath;
- Szyper, J., C. Lin, D. Little, A. Yakupitiyage, and S. Sethboonsorng. Techniques for efficient and sustainable mass production of tilapia in Thailand, presented by Szyper;
- Teichert-Coddington, D. and G. Ward. Pond management, estuarine water quality, and sustainable shrimp culture in Central America, presented by Boyd.
- Veverica, K. and T. Popma. Cut grass as fertilizer for tilapia ponds: composting methods, presented by Duncan;
- Veverica, K. and T. Popma. Cut grass as fertilizer for tilapia ponds: application rates and timing, presented by Duncan.

VII. Program Management and Technical Guidance

The CRSP is organized to facilitate multidisciplinary research and collaboration among institutions and countries around the world.

The CRSP is organized to facilitate multidisciplinary research and collaboration among institutions and countries around the world. This structure is based on the premise that mutually beneficial development strategies have the best chance of being sustainable over time. Primary management responsibilities for the PD/A CRSP are vested in OSU as the Management Entity (ME). The ME is the institution with the legal status of a juridical body that administers the grant from USAID and manages the total research program. Accountability for the CRSP rests with the ME. Therefore, the ME is the decision-making body on fiscal and programmatic matters and is advised in this function by a Board of Directors (BOD), a Technical Committee (TC), and an External Evaluation Panel (EEP). The ME appoints a Program Director to administer the CRSP. The Program Director serves as an ex-officio member of the BOD and TC and serves on the steering committee of the CRSP Council.

ME functions at OSU are carried out through a Program Management Office (PMO), which 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, Michigan State University, Oregon State University, University of Arkansas at Pine Bluff, University of Hawaii, and the University of Michigan.

The PMO, currently housed at the Office of International Research and Development (OIRD) at OSU, is an integral component of, and derives benefits from, the international programs at OSU. The CRSP presently is also linked to the Department of Fisheries and Wildlife and the Department of Bioresource Engineering through faculty appointments and professional and academic interests. 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.

During this reporting period, members of the PMO included:

Hillary Egna, Director
Brigitte Goetze, Deputy Director and Egypt Coordinator
Marion McNamara, Assistant Director
Naomi Weidner, Administrative Assistant (through 6/95)
Faye Trupka, Temporary Clerical Support

Through BIFAD, the ME has responsibility to:

- Receive funds committed by USAID to the CRSP and assume accountability for their use;
- Provide funds to participating institutions and ensure compliance with the terms of the grant;
- Hold participating institutions responsible for programs and accountable for use of funds;
- Manage the program and control and account for funds, including matching resources contributed by participating institutions;
- Implement the program;
- Coordinate and lead the development of annual budgets and work plans;
- Spearhead program development efforts;
- Facilitate internal and external communications;
- Maintain contact with overseas and domestic participants;
- Represent the CRSP in dealings with USAID/Washington and USAID Missions;
- Produce and distribute CRSP publications; and
- Provide a focal point for members of the TC, BOD, EEP, and USAID to interact.

The last year was a busy and productive one for the PMO. In the reporting period, this group:

- Coordinated, contributed to, and edited the continuation proposal for the PD/A CRSP;
- Assisted in executing a survey on research needs in tilapia reproduction;
- Conducted an analysis of constraints to aquaculture development worldwide;
- Negotiated with USAID for a one-year extension of the CRSP through 31 April 1996;
- Prepared CRSP budgets and subcontract modifications for extending funding and performance periods;
- Coordinated administrative and contractual details for collaborative research projects in Thailand, the Philippines, and Honduras;
- Visited Kenya to investigate a potential new African site for the CRSP and continued coordination of new site selection process;
- Participated in the planning of the InterCRSP activity in West Africa;
- Initiated development of a home page on the World Wide Web;
- Processed proposals for New Research Initiatives;
- Participated in an internal audit of the CRSP conducted by the Program Associate for Financial Management in the OIRD at OSU;
- Conducted a comprehensive review of U.S. universities' cost-sharing commitments for the CRSP;
- Selected a new EEP member;
- Reviewed the Tropical Research and Development Report, *An Evaluation of the USAID and Universities Collaborative Research Support Programs* ;
- Organized the thirteenth annual CRSP meeting in San Diego, California, from 29-31 January 1995;

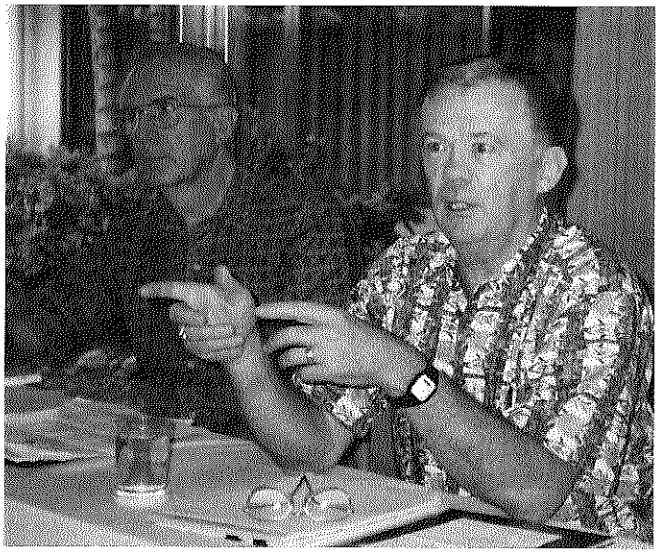
- Wrote subcontracts for the transition year;
- Participated in the Annual Meeting, including BOD and TC meetings;
- Processed travel clearances for all CRSP personnel and approvals for purchases of restricted goods for country projects;
- Published research results in technical report series;
- Prepared, published, and distributed detailed quarterly reports summarizing technical and administrative progress;
- Maintained the CRSP mailing list, which reaches approximately 550 people in 42 countries;
- Maintained the CRSP directory, which lists participants' mailing addresses, telephone and fax numbers and email addresses;
- Maintained management information systems to track projects;
- Coordinated, with Claude Boyd of Auburn University, *Dynamics of Pond Aquaculture*, an updated version of *Principles and Practices* ;
- Initiated the review process for the submitted chapters of the new book, *Dynamics of Pond Aquaculture;*
- Developed, with TC co-chairs, a process and schedule for Work Plan reviews for the 1996-1998 Work Plan;
- Commissioned a review of the Central Data Base;
- Responded to USAID requests to improve openness and collaboration with other institutions;
- Negotiated an extension of the Egypt Project;
- Processed subcontracts for Egypt Project extension;
- Coordinated Work Plan development for the Egypt Project extension;
- Wrote and published final report of Egypt Project;
- Closed out Egypt Project; and
- Participated as an observer in "International Centers Week."

The PD/A CRSP maintains technical linkages with the Tropsoils and the SANREM CRSPs. Maintaining 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 is thus more financially strained by participation. The PMO participated in CRSP Council Conference calls on:

15 September 1994
13 October 1994
3 November 1994
9 February 1995
8 June 1995

In addition to serving on the CRSP Council, the Director and the TC Co-Chair attended a workshop on "Developing Strategy Objectives for the Office of Agriculture and Food Security." The workshop was sponsored by USAID to develop global strategies for each sector and focus each program on USAID's strategic objectives. The Director and Deputy Director presented a poster at the USAID/AFR conference on "Income, Employment, and Food Security for the 21st Century Africa" in Baltimore, Maryland.

Advisory Groups



Three advisory groups–the Board of Director, Technical Committee, and External Evaluation Panel–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.

Board of Directors

The Board consists of representatives from participating institutions and operates under a defined charter to deal with policy issues, to review and approve plans and proposed budgets, to assess progress, and to advise the PMO on these and other matters. The Project Officer from USAID and the CRSP Director serve as ex-officio Board members. All Board members function in the objective interest of the CRSP regardless of their institutional affiliation. The Board elects a chair by simple majority vote; at present, the Chair serves for one two-year term.

During the existence of CIFAD, Board members represented each U.S. CRSP institution (Auburn University, the University of California, and CIFAD). With the dissolution of CIFAD, Board members represent three of the CRSP participating institutions.

Current Board members are:

- Dr. R. Oneal Smitherman, Chair, Auburn University
- Dr. Robert Fridley, University of California at Davis
- Dr. Philip Helfrich, University of Hawaii
  (former CIFAD representative through 3/95).

Board operations have been modified in response to recommendations made by three recent reviews and the dissolution of CIFAD. As a result, the CRSP Board will more closely follow the BIFAD Guidelines. In the future, the Board will consist of a minimum of four members. The ME will have a permanent member on the Board, but that member will not serve as chair. The three other Board members will come from participating U.S. CRSP institutions on a rotating basis from the pool of institutional representatives. Outside members may be appointed to the Board based on availability of funding and need. Board members are selected by their participating institutions from their higher administrative management level, based on their responsibilities and relevant experience. The term length on the Board will be three years, typically with service as chair in the third year. Active Board members receive compensation related only to invitational travel. Such travel will be financed jointly by the CRSP and the Board member's institution.

The Board meets at least twice annually, either in person or by conference call or other means of electronic communication. The PMO prepares minutes of all meetings which are distributed to the members of the Board, TC and EEP, and to Institutional Representatives and the USAID Project Officer. The Board's advice and guidance is carefully considered by the ME. Departures from the Board's recommendations by the ME are justified, recorded, and reported in writing by the PMO.

Responsibilities of the Board are to:

- Review program budgets and allocate funds to research projects and the PMO;
- Recommend budget allocations to the ME;
- Evaluate the administrative and technical accomplishments of overseas research projects and U.S.-based research activities; and
- Advise the ME on policy guidelines.

The BOD convened once during this reporting period in an extended meeting during the Annual Meeting (29-31 January 1995) in San Diego, California. Informal discussions are held regularly with the Board, and approvals for some decisions are made through correspondence.

In this reporting period the Board:

- Approved management and research budgets;
- Assisted in developing and approved the annual meeting agenda;
- Provided input on project monitoring by the Program Director and the BOD;
- Directed the TC and PMO in developing the continuation proposal;
- Participated in the Thirteenth Annual Program Meeting in January 1995;
- Participated in the review of proposals for the continuation plan; and
- Participated in the selection of a new EEP member.

Technical Committee

Technical guidance for the program is provided by the TC, whose purpose is to monitor the technical research of the PD/A CRSP, propose modifications in the program, and recommend allocations of funds for research activities.

The PD/A CRSP Technical Committee:

- Develops the biennial work plans and budgets for the research projects;
- Reviews and recommends to the PMO overall research plans, biennial work plans, and budgets for the research projects;
- Assists in the development of annual and intensive five-year reviews;
- Assists in the development and review of the Annual Report;
- Makes necessary recommendations on program progress and problems to the PMO, including, but not limited to, an analysis of the recommendations of the EEP; and
- Gives necessary input to the CRSP Council through Council representation by the CRSP Director or TC Co-Chairs.

At present, the organization of the TC is based on institutional representation. The TC includes voting and non-voting members. Voting members are Principal Investigators from each funded project at U.S. institutions based on the issuance of subcontracts and from each Host Country institution with an MOU/MOA (Memorandum of Agreement). Institutions holding a vote on the TC are listed in Table 1 by project.

TABLE 1. INSTITUTIONAL VOTING PRIVILEGES ON TECHNICAL COMMITTEE

Data Analysis & Synthesis Team	Oregon State University
	University of California at Davis
Data Base Management	University of Hawaii
Honduras	DIGESPESCA
	Auburn University
Africa Site	Oregon State University
	Auburn University
	University of Arkansas, Pine Bluff
Thailand	Asian Institute of Technology
	Royal Thai Department of Fisheries
	University of Michigan
	University of Hawaii
Special Projects: Social Sciences	Auburn University

The membership of the TC, as of August 1995, is listed in Table 2 in alphabetic order, with institutional affiliations, subcommittee assignments, and voting status also indicated. Other U.S. and Host Country scientists participate in the TC meetings as non-voting members. Members volunteer to serve on one of four subcommittees: budget, materials and methods, work plan, and technical progress. In the future, the budget and work plan subcommittee will be merged.

TABLE 2. MEMBERSHIP OF THE TECHNICAL COMMITTEE

Name	Institution	Subcommittee	Voting Members
John Bolte	Oregon State University		✓
Claude Boyd	Auburn University	✍*	shared vote
Steve Culberson	University of California, Davis		
Jim Diana	University of Michigan	⚘ * ■	shared vote
Bryan Duncan, Co-Chair	Auburn University		shared vote
Peter Edwards	Asian Institute of Technology		✓
Carole Engle	University of Arkansas at Pine Bluff		✓
Doug Ernst	Oregon State University		
Martin Fitzpatrick	Oregon State University		shared vote
William Gale	Oregon State University		
Bart Green	Auburn University	✍ ∴ *	✓
Terry Hanson	Auburn University	∴	
Kevin Hopkins, Co-Chair (to 11/94)	University of Hawaii, Hilo		✓
Watana Leelapatera	Department of Fisheries, Thailand		
C. Kwei Lin	University of Michigan and AIT		shared vote
Eduardo Lopez	Central Luzon State University		✓
Lucas Lopez	DIGEPESCA		
Joseph Molnar	Auburn University	∴	✓
Shree Nath	Oregon State University	∴	
Joyce Newman	Auburn University		
Raul Piedrahita, Co-Chair (from 4/95)	University of California, Davis	✍ $ ■	✓
Tom Popma, Secretary	Auburn University	$*	✓
Carl Schreck	Oregon State University		shared vote
Wayne Seim	Oregon State University		✓
Chaninthorn Sritongsuk	Department of Fisheries, Thailand		shared vote
Jim Szyper	University of Hawaii, Hilo	✍ $	✓
David Teichert-Coddington	Auburn University	$	
Karen Veverica	Auburn University		
At-large Members			
Ted Batterson	Michigan State University		
Ex-officio Members			
Hillary Egna	Oregon State University		
Brigitte Goetze	Oregon State University		
Harry Rea	USAID/R&D/AGR		

Subcommittees:
⚘ Technical Progress
■ Executive Panel
✍ Materials and Methods
$ Budgets
∴ Work Plans
* Subcommittee Chair

Egypt Project participants who served on the Technical Committee through 3/95 appear in the Egypt Project Final Report (6/95), available from the Program Management Office.

In order to better perform its functions, the TC will be substantially restructured under the new grant. This new organization will be centered around three strategic research areas: production optimization, environmental effects, and social and economic aspects. TC members will be selected based on their expertise in these areas and once selected will represent their respective disciplines. Host country members will be included in the selection process. To ensure diversity there will be at least three members representing each of the three strategic research areas. TC members will serve for three-year terms. Each member, with the exception of the Chair or Co-Chairs, will be an active member of one of three standing subcommittees: Work Plan and Budget (newly merged under the new grant), Technical Progress, or Materials and Methods.

The TC will create bylaws, subject to the PMO's approval, to select members based on expertise and institutional diversity. The PMO may appoint, after consultation with the BOD, additional members to the TC to provide expertise in unrepresented areas. The USAID Project Officer, CRSP Director, and Deputy Director will continue to serve as ex-officio members to the TC. Currently, at-large members are appointed by the BOD. Dr. Ted Batterson continued to serve as the at-large TC member during this reporting period.

External Evaluation Panel

The primary function of the EEP is to provide counsel to USAID and critical feedback to the ME, BOD, and TC. It does so by evaluating the status, funding, progress, plans, and prospects of the research program. The EEP also periodically evaluates the accomplishments of CRSP research activities and of the program as a whole. This committee of external aquaculture specialists is drawn from the international aquatic resources community to evaluate the accomplishments of the individual research projects and the overall program. The members are selected so that collectively they will cover the substance of the CRSP, including socioeconomic factors that can influence research and adoption of technology generated from research. The EEP is specifically charged by BIFAD to help maintain programmatic focus and effective scientific balance of research. Its chief objectives are to:

- Identify inadequate performances;
- Identify activities that are irrelevant or marginal to CRSP objectives;
- Consider effective balance between research and training for the development of institutional research capability;
- Assess the balance of domestic versus overseas research in terms of effectiveness of solving constraints in developing countries;
- Evaluate the cost-effectiveness of the entire CRSP operation by comparing the actual cost of business to alternatives that may be less costly and more efficient and effective;
- Examine how research results are disseminated, evaluate the effectiveness of use of the results, and provide a measure of the appropriateness of the research; and
- Report findings and recommendations annually to the ME, BOD, USAID, and JCARD/BIFAD.

The PMO recommends EEP candidates to USAID, considering the advice of the Board, TC, participating institutions and other sources. After USAID receives concurrence from BIFAD, the PMO appoints the new EEP member. Currently, the EEP consists of three scientists who represent the major disciplines of the CRSP. During this reporting period, Dr. Gary Jensen, USDA, joined Richard Neal, NMFS, and Roger Pullin, ICLARM on the EEP. To enhance future reviews, four scientists will comprise the EEP. New members will be rotated in as members resign or are replaced.

One member of the EEP attends each annual meeting to evaluate the progress of the CRSP on a year-to-year basis. The PMO provides the EEP with copies of significant CRSP documents in order to keep the panel advised of CRSP activities. The EEP reviews the CRSP annually and provides an in-depth review every five years. During the year of the five-year review at least two EEP members visit each of the overseas research sites. Also during that year, the EEP may visit the PMO and attend significant CRSP meetings. The EEP interact with the TC and Board during the quinquennial review year, and all EEP members attend the annual meeting for that year. At the conclusion of the review, the EEP submits its report to the PMO and Board, with copies to BIFAD through USAID's Project Director for use in its review. To promote objectivity, membership on the EEP is limited to one three-year term or participation in one quinquennial review.

The last comprehensive review of the CRSP by the EEP took place in 1992-93. The final report, which includes program responses to the findings and recommendations of the EEP, is available from the PMO. The PMO makes full use of the EEP and considers its recommendations. Where there is disagreement with an EEP recommendation, a record is made of the reason for the disagreement. Any decision contrary to the EEP recommendations is justified in writing and reported by the PMO to USAID.

The EEP serves without compensation but receives reimbursement for all travel expenses during the quinquennial review. Other travel may be jointly financed. Members may receive honoraria during the year of the quinquennial review.

CRSP Administrative and Technical Reports

CRSP publications are an important part of the CRSPs technology dissemination. A broad domestic and international audience of approximately 550 people in 42 countries receive CRSP technical and program reports. Technical reports are issued through two series, *Collaborative Research Data Reports* and *CRSP Research Reports.*

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 Reports* contains descriptions of sites and experimental protocols for the Global Experiment. Subsequent volumes focus on each research site separately by experimental cycle. Data from cycles I through III are available in book format from the PMO; data from later cycles can be accessed through the CRSP Central Data Base. The goal of *CRSP Research Reports* is to publish all other research produced by CRSP activities.

Other reports published by the CRSP PMO include Annual Administrative Reports, Quarterly Reports, Program Grant Proposals, Work Plans, and CRSP Directories. Past publications include a ten year summary of activities in Honduras, compiled by the Auburn/Honduras team of researchers, the *Handbook of Analytical Methods*, compiled by the Materials and Methods Committee of the TC and the *PONDCLASS Users' Guide*, which was developed by the OSU/DAST researchers.

Principles and Practices of Pond Aquaculture was one of the founding documents of this CRSP. At the time of its production, this state-of-the-art volume 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. As advances are made in pond aquaculture by the CRSP and others, this valuable resource must be updated. A new volume that approaches aquaculture production as part of the larger agroecosystem is in progress, *Dynamics of Pond Aquaculture.* CRSP researchers are collaborating in writing the 16 chapters that comprise the book to be published by Lewis Publications in 1996.

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

AQUANEWS
THE NEWSLETTER OF THE POND DYNAMICS/AQUACULTURE COLLABORATIVE RESEARCH SUPPORT PROGRAM
Volume 10, Number 1/Fall 1995 Oregon State University ISSN 1062-4996

CRSP PROPOSAL IS TOPIC OF STRATEGIC MEETING

By Brigitte Goetze

Boyd Haight, Senior Aquaculturist for FAO/ALCOM, points out topographical features of Zimbabwe to OSU researchers. Haight worked with site selection committee members to explore the potential of Zimbabwe and other southern African countries as new sites for PD/A CRSP research.

In July, CRSP representatives met with USAID in Washington, DC to discuss the status of the CRSP's continuation proposal and to determine an action plan for the proposal submission process. The CRSP was represented by Board of Directors Chair Oneal Smitherman, board members Robert Fridley and Phil Helfrich, Technical Committee Co-Chair Bryan Duncan, External Evaluation Panel member Gary Jensen, Director Hillary Egna, and Deputy Director Brigitte Goetze. They conferred with Ann van Dusen, Senior Deputy Assistant Administrator of the Global Bureau, and the following Center for Economic Growth members: John Lewis, Director of the Office of Agriculture and Food Security, Harvey Hortik, Division Chief of the Sustainable Technology Division, Harry Rea, Aquaculture Specialist, Mildred Blakeney, Program Analyst, and Fred Johnson, BIFAD Support Staff. Part of the meeting was also attended by Lamarr Trott, Senior Fisheries Advisor of the Office of Environment and Natural Resources in the Center for Environment. The attendees discussed the importance of aquaculture for food security and economic growth, and the lessons learned from the administration of all CRSPs. They developed a proposal submission schedule for the PD/A CRSP's continuation proposal. USAID informed the CRSP that a new Board for International Food and Agriculture Development (BIFAD) has been selected (see story, p.10). BIFAD will convene in September and will be involved in the review process of the continuation proposal, which is slated for late November or early December. Submission of the best and final proposal is planned for early January.

SITE SELECTION COMMITTEE CONTINUES SEARCH

The PD/A CRSP site selection committee has been actively researching opportunities to establish a new CRSP site in Africa. Members of the committee have engaged in site visits, attended meetings with possible collaborators, and established contacts with researchers from many institutions in order to further the selection process.

Recently, Boyd Haight, of ALCOM, visited the OSU campus to discuss the opportunities for collaboration in Zimbabwe and other parts of eastern and southern Africa. He indicated that the CRSP approach to regionalizing aquaculture research resonates with the approach taken by the major research organizations already in place.

Representatives of the site selection committee will visit Zimbabwe this fall to attend the ALCOM planning meeting, and to explore with the assembled researchers the potential for PD/A CRSP collaboration in several eastern and southern African countries. Catherine Knott, a rural sociologist and Director of Women in International Development at OSU, will join the site visit team in order to respond to the expressed needs of Missions and other donor agencies to expand CRSP research to include social variables. In addition, the team will stop in Kenya to follow up on earlier meetings which identified possible areas of mutual interest and cooperation.

Administrative Reports

Annual Reports

Egna, H., M. McNamara and N. Weidner. 1995. Twelfth Annual Administrative Report, Pond Dynamics/Aquaculture Collaborative Research Support Program. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 95 pp.

Egna, H., J. Bowman, B. Goetze, and N. Weidner, eds. 1995. Twelfth Annual Technical Report 1993, Pond Dynamics/Aquaculture Collaborative Research Support Program. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 209 pp.

Quarterly Reports

Pond Dynamics/Aquaculture CRSP, Program Management Office. January 1995. Quarterly Report. October-December 1994. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 15 pp.

Pond Dynamics/Aquaculture CRSP, Program Management Office. April 1995. Quarterly Report. January-March 1995. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 6 pp.

Pond Dynamics/Aquaculture CRSP, Program Management Office. July 1995. Quarterly Report. April-June 1995. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 10 pp.

Pond Dynamics/Aquaculture CRSP, Program Management Office. October 1995. Quarterly Report. July-September 1995. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 15 pp.

Directory

The CRSP directory contains an organizational chart and the addresses of current CRSP members from USAID, BIFAD, USAID Missions, the CRSP Council, the EEP, the TC, the ME, the Board, and the Collaborative Research Projects. The chart is updated annually or semi-annually, as needed.

CRSP Directory. June 1995. Pond Dynamics/ Aquaculture CRSP, Program Management Office. Office of International Research and Development, Oregon State University, Corvallis, Oregon.

Newsletter

Aquanews, The Newsletter of the Pond Dynamics/ Aquaculture Collaborative Research Support Program, 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. *Aquanews* is generally published quarterly; however, reductions in personnel over the past year resulted in a reduction in the number of issues published. In this reporting period the PMO published:

Aquanews, Fall 1995, Volume 10, 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.

Technical Reports

CRSP Research Reports/Notices Of Publications

Bowman, J.R. and J.E. Lannan. 1995. Evaluation of soil pH-percent base saturation relationships for use in estimating the lime requirements of earthen aquaculture ponds. CRSP Research Report 95-86, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in *Journal of the World Aquaculture Society*, Vol. 26, No. 2, June 1995, pp. 172-182.]

Culberson, S.D. and R.H. Piedrahita. 1993. Model for predicting dissolved oxygen levels in stratified ponds using reduced data inputs. CRSP Research Report 95-80, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in J.K Wang (ed.), *Techniques for Modern Aquaculture, Proceedings of an Aquacultural Engineering Conference*, pp. 543-552. 1993.]

Culberson, S.D. and R.H. Piedrahita. 1992. Modification of stratified temperature model to accommodate reduced data inputs: identifying critical requirements. CRSP Research Report 95-81, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in American Society of Agricultural Engineers Paper No. AQUA-92-102, 37 pp. 1992.]

Egna, H.S. 1995. Psychological distress as a factor in environmental impact assessment: some methods and ideas for quantifying this intangible intangible. CRSP Research Report 95-85, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in *Environmental Impact Assessment Review* 12:115-137, 1995.]

Giovannini, P. and R.H. Piedrahita. 1994. Modeling photosynthetic production optimization for aquaculture ponds. CRSP Research Report 95-79, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in *Aquacultural Engineering* 13:83-100, 1994.]

Szyper, J.P., C.K. Lin, D. Little, S. Setboonsarng, A. Yakupitiyage, P. Edwards, and H. Demaine. 1995. Techniques for efficient and sustainable mass production of tilapia in Thailand. CRSP Research Report 95-84, Pond Dynamics/ Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in *Proceedings, Sustainable Aquaculture 95*. Pacific Congress on Marine Science and Technology. pp. 349-356]

Teichert-Coddington, D. 1993. Development of production technologies for semi-intensive fish farming during the past decade in Central America. CRSP Research Report 95-82, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally presented at Actas del Simposia Investigación Acuicola en Centroamerica, 25-29 October 1993, Heredia, Costa Rica.]

Teichert-Coddington, D. 1988. Effects of protein diet and sowing density on the production of *Penaeus vannamei* in land tanks. CRSP Research Report 95-83, Pond Dynamics/Aquaculture CRSP, Office of International Research & Development, Oregon State University, Corvallis, Oregon, USA. [Originally published in *Rev. Lat. Acui.*, No. 35-29-44 Marz. 1988.]

VIII. 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. During this reporting period, OSU instituted a new electronic Financial Information System, which has improved the timeliness of financial reporting. Therefore, this year's summary is based solely on actual expenditures through 31 August 1994. Previous reports contained estimated expenditures for part of the reporting period.

The expenditure of USAID funds by Collaborative Research Projects and Program Management is presented in Table 3 for the period 1 September 1994 through 31 August 1995. This is the fifth year of the third CRSP grant; the program was originally contracted to end 31 August 1995, but a change in USAID's allocation pattern and a one-year extension resulted in a change of the end of project date to 31 April 1996. The Continuation Plan for the PD/A CRSP will extend the program through April 2001.

This CRSP is unique in including research-oriented functions in the PMO. At the suggestion of USAID, the PMO has developed a method for disaggregating research expenses from administrative functions. PMO expenditures now include categories for Operations and Administration, Research Support, New Research Initiatives, Special Research Funds, and funds for the EEP and Other Advisory Groups. The PMO was also responsible for Data Base Management until 1993, when this function was transferred to the University of Hawaii.

Cost-sharing contributions from the U.S. institutions and contributions from host countries are presented in Table 3. The overall average percentage of funding borne by U.S. universities is 25%, 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.

Table 3. Expenditure of Funds

	USAID Funds		US Cost Sharing Funds		Total US Funds		Host Country Funds	
Research Program	9/94 - 8/95	Cumulative	9/94 - 8/95	Cumulative	9/94 - 8/95	Cumulative	9/94 - 8/95	Cumulative
• Honduras								
Auburn University	$168,684	$747,953	$22,422	$163,255	$191,106	$911,208		
• Rwanda							$0	$99,880
Auburn University	$76,176	$420,415	$13,446	$124,507	$89,622	$544,922		
Oregon State University	$99,390	$423,833	$17,839	$83,248	$117,229	$507,081		
Univ. of Arkansas, Pine Bluff	$10,782	$22,613	$0	$1,394	$10,782	$24,007		
OSU/Women in Development	$0	$5,942	$0	$3,127	$0	$9,069		
• Thailand							$26,000	$164,000
University of Michigan	$132,939	$580,134	$26,160	$122,080	$159,099	$702,214		
University of Hawaii*	$112,159	$383,693	$16,613	$56,478	$128,772	$440,171		
Michigan State University	$0	$252,533	$0	$63,596	$0	$316,129		
• Global Social Science Project								
Auburn University	$24,287	$60,682	$18,309	$28,366	$42,596	$89,048		
• US Research Program								
DAST/UCD	$43,477	$220,190	$13,189	$89,687	$56,666	$309,877		
DAST/OSU	$65,616	$230,862	$5,162	$31,164	$70,778	$262,026		
Soils/OSU	$0	$16,064	$0	$5,499	$0	$21,563		
Research Program Subtotal	**$733,510**	**$3,364,914**	**$133,140**	**$772,401**	**$866,650**	**$4,137,315**		
Management Entity								
Operations & administration	$149,444	$1,061,975			$149,444	$1,061,975		
Research support	$18,928	$18,928			$18,928	$18,928		
New research initiatives	$4,996	$4,996			$4,996	$4,996		
Special research fund	$8,611	$8,611			$8,611	$8,611		
External Evaluation	$0	$96,236			$0	$96,236		
Other advisory groups	$3,091	$3,091			$3,091	$3,091		
Indirect cost	$8,014	$8,014			$8,014	$8,014		
Management Entity Subtotal	**$193,084**	**$1,201,851**			**$193,084**	**$1,201,851**		
PROGRAM TOTAL	**$926,594**	**$4,566,765**	**$133,140**	**$772,401**	**$1,059,734**	**$5,339,166**	**$26,000**	**$263,880**

* Figure includes Data Base Management.

IX. Staff Summary

The CRSP represents the collaborative efforts of over 75 scientists, technicians, and graduate students in three host countries.

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 three 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 and Al Azhar University are interested in the implications of CRSP research for planning the future direction of Egyptian aquaculture development. While the CRSP operated in Rwanda, our researcher advised the Aquaculture Strategy Commission of the Ministry of Agriculture on establishing research priorities and suitable research-extension linkages. Researchers also met 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 Honduras consult with CRSP researchers on project design and implementation. Private sector farmers in Honduras and Thailand take advantage of CRSP expertise through 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.

Individual	CRSP Role	Research Administration	Limnology/Water Quality	Fisheries/Aquaculture	Data Management	Social Sciences	Location of Work
Program Management Office							
Hillary Egna	Director	✓	✓	✓			Corvallis, Oregon
Brigitte Goetze	Deputy Director	✓	✓	✓			Corvallis, Oregon
Marion McNamara	Assistant Director	✓					Corvallis, Oregon
Naomi Weidner (through 6/95)	Admin. Assistant	✓					Corvallis, Oregon
Advisory Panels							
Board of Directors							
R. Oneal Smitherman	Chairman	✓		✓			Auburn, Alabama
Robert Fridley	Member	✓	✓	✓			Davis, California
Philip Helfrich	Member	✓		✓			Kaneohe, Hawaii
External Evaluation Panel							
Richard Neal	Chairman	✓		✓			La Jolla, California
Gary Jensen (from 4/95)	Member	✓		✓			Washington, DC
At-Large Technical Committee							
Ted Batterson	Member	✓	✓	✓			East Lansing, Michigan
Data Base Management							
University of Hawaii							
Kevin Hopkins[1]	Data Base Manager	✓		✓	✓		Hilo, Hawaii
John Wassell	Assistant Data Base Manager				✓		Hilo, Hawaii
Data Analysis and Synthesis Team							
Oregon State University							
John Bolte	USPI	✓	✓	✓	✓		Corvallis, Oregon
Shree Nath	Graduate Student		✓	✓			Corvallis, Oregon
Doug Ernst	Graduate Student		✓	✓			Corvallis, Oregon
University of California at Davis							
Raul Piedrahita	USPI		✓	✓	✓		Davis, California
Daniel Jamu	Research Assistant				✓		Davis, California
Zhimin Lu	Research Assistant				✓		Davis, California

[1] Personnel involved in multiple projects.

Individual	CRSP Role	Research Administration	Limnology/Water Quality	Fisheries/Aquaculture	Data Management	Social Sciences	Location of Work
Honduras							
AUBURN UNIVERSITY							
Bryan Duncan[1]	USPI	✓		✓			Auburn, Alabama
Claude Boyd[1]	US Researcher	✓	✓	✓			Auburn, Alabama
D. Teichert-Coddington	US Research Associate	✓	✓	✓			Comayagua & Choluteca
Karen Veverica[1]	US Research Associate		✓	✓			Auburn, Alabama
Donald Large[1]	Fiscal Officer	✓					Auburn, Alabama
HOST COUNTRY PERSONNEL							
Marco Polo Micheletti	HCPI						Tegucigalpa, Honduras
Nelson Claros	Chemist		✓				Comayagua, Honduras
Jaime Lopez	Lab Technician		✓				Choluteca, Honduras
Delia Martinez	Chemist	✓	✓				Choluteca, Honduras
Eneida Ramirez	Asst. Chemist		✓				Choluteca, Honduras
Herburt Ramos	Biologist	✓		✓			Comayagua, Honduras
Miguel Zelaya	Lab Technician			✓			Comayagua, Honduras
Africa							
OREGON STATE UNIVERSITY							
Wayne Seim	US Co-PI		✓	✓			Corvallis, Oregon
Martin Fitzpatrick	US Co-PI			✓			Corvallis, Oregon
Jim Bowman	US Research Associate			✓			Corvallis, Oregon
Bill Gale	Graduate Student			✓			Corvallis, Oregon
Robert Halvorsen[1]	Fiscal Officer	✓					Corvallis, Oregon
AUBURN UNIVERSITY							
Tom Popma	USPI	✓		✓			Auburn, Alabama
Joyce R. Newman	Graduate Student			✓			Auburn, Alabama
Karen Veverica[1]	US Research Associate		✓	✓			Auburn, Alabama
Donald Large[1]	Fiscal Officer	✓					Auburn, Alabama
UNIVERSITY OF ARKANSAS AT PINE BLUFF							
Carole Engle	USPI	✓				✓	Pine Bluff, Arkansas
Peter Pershbacher	US Researcher		✓	✓			Pine Bluff, Arkansas
Hugh Blaney	Fiscal Officer	✓					Pine Bluff, Arkansas

[1] Personnel involved in multiple projects.

Individual	CRSP Role	Research Administration	Limnology/Water Quality	Fisheries/Aquaculture	Data Management	Social Sciences	Location of Work
Thailand							
UNIVERSITY OF MICHICAN							
James Diana	US Co-PI		✓	✓	✓		Ann Arbor, Michigan
C. Kwei Lin	US Co-PI	✓	✓	✓			Bangkok, Thailand
Barbara Diana	Research Assistant	✓			✓		Ann Arbor, Michigan
Tracy Willoughby	Fiscal Officer	✓					Ann Arbor, Michigan
HOST COUNTRY PERSONNEL							
Chaninthorn Sritongsuk	HC Co-PI (DOF)	✓	✓	✓			DOF, Thailand
Peter Edwards	HC Co-PI (AIT)			✓			AIT, Thailand
Watana Leelapatera	Research Associate		✓	✓			DOF, Thailand
Kiri	Research Associate	✓					DOF, Thailand
Chintana Boonthamchinda	Research Admin.	✓		✓			AIT, Thailand
Sunil Shrestha	Research Assistant			✓			AIT, Thailand
Somchai Vaipoka	Research Assistant			✓			Ayutthaya, Thailand
Pasu Wiwantrangsan	Research Assistant			✓			AIT, Thailand
Manoj Yomjinda	Research Assistant		✓				AIT, Thailand
Yang Yi	Research Associate	✓	✓	✓	✓		AIT, Thailand
Thailand ~ Philippines							
UNIVERSITY OF HAWAII							
Kevin Hopkins[1]	US Co-PI	✓		✓	✓		Hilo, Hawaii
James Szyper	US Co-PI	✓	✓	✓			Kaneohe, Hawaii and AIT, Thailand
PHILIPPINES ~ HOST COUNTRY PERSONNEL							
Eduardo Lopez	HC PI	✓		✓			Munoz, Nueva Ecija, Philippines
Socioeconomic Dimensions							
AUBURN UNIVERSITY							
Leonard Lovshin	US Co-PI				✓		Auburn, Alabama
Joseph Molnar	US Co-PI					✓	Auburn, Alabama
Terry Hanson	Research Associate					✓	Auburn, Alabama
Eric Stewart	Graduate Student					✓	Honduras

[1] Personnel involved in multiple projects.

X. CRSP Publications

through 31 August 1995

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Oregon State University

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Universidad Nacional Autonoma de Honduras

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87-1 Hopkins, K.D., J.E. Lannan, and J.R. Bowman. A data base management system for research in pond dynamics. (10/87)

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88-4 Lin, C.K. Acidification and reclamation of acid sulfate soil fishponds in Thailand. (1/88)

88-5 Ver, L.M.B., and Y.N. Chiu. The effect of paddlewheel aerators on ammonia and carbon dioxide removal in intensive pond culture. (2/88)

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93-50* Suresh, A.V., and C.K. Lin. Tilapia culture in saline waters: A review. (4/93)

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93-53 This report is a duplicate of an earlier number.

93-54 Lin, C.K., K. Jaiyen, and V. Muthuwan. Integration of intensive and semi-intensive aquaculture: Concept and example. (5/93)

93-55* Szyper, J.P., and J.M. Ebeling. Photosynthesis and community respiration at three depths during a period of stable phytoplankton stock in a eutrophic brackish water culture pond. (9/93)

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Appendix A. Acronyms

AIT	Asian Institute of Technology, Thailand
ALCOM	Aquaculture for Local Community Development
BOD	biological ogygen demand
BOD (for a CRSP)	Board of Directors
BW	body weight
° C	degrees centigrade
CEC	cation exchange capacities
CIFAD	Consortium for International Fisheries and Aquaculture Development
CLAR	Central Laboratory for Aquaculture Research, Abbassa, Egypt
CRSP	Collaborative Research Support Program
d	day
DAST	Data Analysis and Synthesis Team
DO	dissolved oxygen
DOF	Royal Thai Department of Fisheries
EEP	External Evaluation Panel
GA	genetic algorithm
GMIT	Genetic Manipulation for Improving Tilapia
h	hour
ha	hectare
HC	Host Country
HC Co-PI	Host Country Co-Principal Investigator
HCPI	Host Country Principal Investigator
IC	isolation column
JCARD	Joint Committee on Agricultural Research and Development, BIFAD
kg	kilogram
LR	lime requirements
µg	microgram

mg	milligram
mm, m, m^2, m^3	millimeter, meter, square meter, cubic meter
ME	Management Entity
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
OIRD	Office of International Research and Development
OSU	Oregon State University
PAC	phosphorus adsorption capacity
PD/A CRSP	Pond Dynamics/Aquaculture Collaborative Research Support Program
PI	Principal Investigator
***POND*©**	Pond aquaculture computer modeling software
PMO	Program Management Office
PPC	Program and Policy Coordination
ppm	parts per million
RFP	request for proposal
TC	Technical Committee
TSP	triple super phosphate
UCD	University of California at Davis
UNR	Universite Nationale du Rwanda
USAID	United States Agency for International Development
US Co-PI	United States Co-Principal Investigator
USPI	United States Principal Investigator
WID	Women In Development
yr	year

Appendix B.
Contents of Thirteenth Annual Technical Report