POND DYNAMICS / AQUACULTURE COLLABORATIVE RESEARCH SUPPORT PROGRAM

FIFTH ANNUAL ADMINISTRATIVE REPORT

MARCH 1988

This administrative report addresses the management and technical accomplishments of the Pond Dynamics/Aquaculture Collaborative Research Support Program during the reporting period from 1 September 1986 to 31 August 1987. Program activities are funded in part by the United States Agency for International Development Grant Number: DAN-4023-G-SS-2074-00.

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INTRODUCTION

The Pond Dynamics/Aquaculture Collaborative Research Support Program (CRSP) is an international effort to develop aquacultural technology as a means of confronting food and nutritional problems. The program is supported in part by a U.S. Agency for International Development (AID) grant awarded in 1982, under authority of the International Development and Food Assistance Act of 1975 (P.L. 94-161). Oregon State University is the Management Entity 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 U.S. by teams of U.S. and Host Country scientists. The U.S. institutions participating in the program are Auburn University, the University of California at Davis, and the Consortium for International Fisheries and Aquaculture Development (CIFAD). CIFAD members include the University of Arkansas at Pine Bluff, the University of Hawaii, the University of Michigan, Michigan State University, and Oregon State University.

CRSP activities were formally initiated on September 1, 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. Due to funding constraints during the past two years, the CRSP was faced with reducing its operations. A plan for reorganization was submitted in December 1986 to the joint JCARD Panel on CRSP's and the USAID Agricultural Sector Council Subcommittee. The plan, which went into effect on 31 August 1987, calls for maintaining a presence in each of the USAID geographical areas originally selected. Country sites would be reduced to three: Rwanda, Thailand, and Panama. (However, political initiatives in Panama during the past year have made it necessary for the CRSP to relocate to another site in Latin America.)

The end of this reporting period marked the beginning of a new phase of research for the CRSP. With the completion of the first three cycles of standardized global experiments, the CRSP began to focus on the statistical interpretation of data that were collected at the six project sites. The research program was modified successfully to reflect the reduction in sites without changing the overall emphasis of the CRSP. The global nature of the program will remain intact; experimental protocol will conform to that of the previous three cycles. Field experiments will blend program-oriented and project-oriented (site-specific) considerations in response to the results of the earlier experiments. Subsequent experiments also will emphasize calibration and verification of predictive models under field conditions, and field testing of pond management practices.

The purpose of this report is to summarize technical accomplishments, program organization and management during the period from September 1, 1986 through August 31, 1987. The CRSP Global Experiment and the attendant analysis of data were the dominant activities during this reporting period. Notable progress also was made in the Host Country and U.S. Special Topics Research Projects, and in the area of institution building. Another area of emphasis was the planning necessary to achieve the CRSP's goals and objectives with the limited funding available and the establishment of several new and long-awaited technical publications.

CRSP RESEARCH PROGRAM BACKGROUND

CRSP RESEARCH PROGRAM

The CRSP Research Program has three components:

- the Global Experiment;
- a U.S. research component composed of projects conducted by the Data Synthesis Team as part of the Global Experiment and of Special Topics Projects at participating U.S. universities; and
- Special Topics Projects in Host Countries.

The Global Experiment and related data synthesis activities are the major research focus of this CRSP and account for more than 90% of the total research program. Special Topics Projects in the U.S. and in Host Countries complement the Global Experiment. These research activities, their purposes, and their present statuses are described in this section.

The Global CRSP Experiment

BACKGROUND OF THE GLOBAL EXPERIMENT

The long-range goal of the CRSP is to increase the availability of animal protein in less developed countries through pond aquaculture. The strategy adopted by the CRSP in pursuit of this goal is to undertake the basic research required to improve the efficiency of pond culture systems. A technical plan consistent with this strategy was developed under a planning study funded by USAID (Specific Support Grant AID/DSAN-G-0264). The technical plan reviewed and synthesized literature on state-of-the-art pond aquaculture and undertook overseas site visits to determine research needs and availability of local support in less developed countries. The findings from these surveys were then translated into planning guidelines.

In the course of the planning activities it became apparent that there are two important aspects of improving the efficiency of pond culture systems. First, there is a need to improve the technological reliability of pond production systems. Second, there is a need for economic optimization consistent with local cultures.

The need for improved production technologies is manifest in the extensive variation observed in the performance of pond aquaculture systems. Pond aquaculture has been practiced for centuries as a highly developed art form and the literature is replete with reports about practices that have produced high yields. However, when the same practices are applied to other ponds, the results are not reproducible. It is clear that there are subtle differences regulating productivity from pond to pond, but the nature of this regulation remains obscure.

The need for rigorous economic analyses of pond aquaculture systems is typically encountered in attempting to formulate appropriate fisheries and aquaculture development strategies, both in developing countries and in the U.S. In order to determine if contemporary pond management practices are the most efficient approach to fish production, it is necessary to develop quantitative production functions to facilitate analyses of the various strategies or combinations thereof. It is not presently possible to develop these functions without making numerous and often tenuous assumptions because the dynamic mechanisms regulating the productivity of the ponds are poorly understood and the existing data base is inadequate. The common denominator in improving production technologies on the one hand and facilitating economic analyses on the other, therefore, is clearly related to understanding pond dynamics.

The Pond Dynamics/Aquaculture CRSP is unique relative to other CRSP's in several ways. The most visible difference is that it is funded at a substantially lower level than some CRSP's. A less obvious difference is that whereas other CRSP's are composed of a cluster of related projects organized on disciplinary or geographical bases, this CRSP is organized around a single global experiment that involves all of its participants. Additionally, this CRSP is one of the few that was planned by the participating institutions.

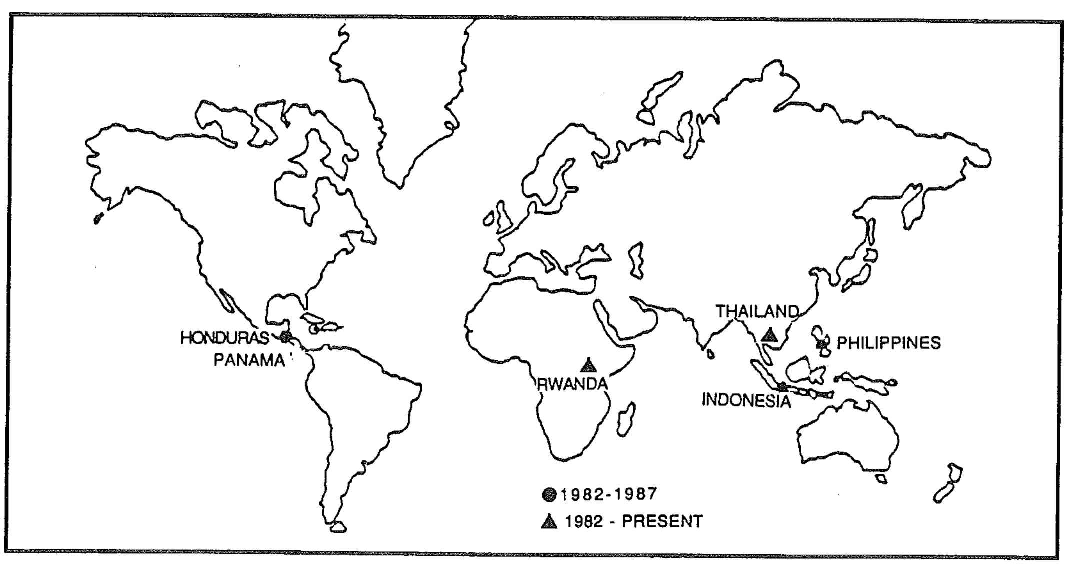
Experimental Design

EXPERIMENTAL DESIGN

During the planning of this CRSP, it became apparent that the inadequacy of the existing pond aquaculture data base was a major constraint to improving the efficiency of pond culture systems. The abundant technical literature about pond aquaculture can provide general guidelines for the operation of pond culture systems. However, because of the lack of standardization in experimental design, data collection, and analysis, these reports can not be statistically compared to one another and, consequently, are of limited utility for predicting the performance of pond culture systems. The approach taken by the CRSP to develop quantitative expressions to improve production technologies and facilitate economic analyses has been to develop a standardized data base that can be used to quantitatively evaluate pond performance over a broad range of environments.

The statistical design for the experiment involves monitoring environmental and fish production variables at seven geographical locations. The location of project sites was carefully selected to include a geographical cross-section of the world where advances in pond aquaculture would be most beneficial and apt to succeed. All of the projects lie within a zone 15 degrees north or south of the equator. Observations specified in annual work plans are made on 12 or more ponds of similar size at each location. The variables observed, frequency of observation, and materials and methods are uniform for all locations.

Observations at each location are analyzed by the research team involved at that location and then collectively by the Data Synthesis Team. Additionally, data are filed in a centralized CRSP data base. Standard statistical methods are used to test hypotheses about correlations between variables and to evaluate the sources of variance within ponds, between ponds within locations, and between locations. Because of the relatively large number of locations and ponds at each location, the experimental design has substantial statistical power.



CRSP Work Plans

The CRSP technical plans are developed by the CRSP Technical Committee. Each work plan represents a detailed experimental protocol for one experimental cycle. A cycle involves two series of observations of four to five months duration. One set of observations is made during the dry season and the other during the wet season.

WORK PLANS

Four work plans have been developed to date. The rationale of the first work plan was to manage all ponds in exactly the same way to establish a detailed baseline of data on pond variables. Then in subsequent experiments, the pond environments were manipulated in different ways and the responses observed. The plan specified standardized methods for pond preparation and monitoring. It was developed at a meeting of CRSP participants in Davis, California on March 2-3, 1983.

The plan for the second experimental cycle was developed at a meeting of CRSP participants in Atlanta, Georgia on April 10-12, 1984. At this meeting, participants reviewed accomplishments and discussed problems encountered during the first cycle of experiments. They then developed a detailed plan for the second experimental cycle. In this experiment, the responses of ponds receiving organic fertilizers were compared to that of ponds receiving inorganic fertilizers.

The third cycle of pond dynamics experiments was developed by CRSP participants at their meeting in Honolulu, Hawaii on March 18-20, 1985. Based upon their experiences to date, they developed an experimental plan to compare the responses of ponds to varying levels of organic fertilizer.

The fourth work plan was developed by the CRSP Technical Committee at their meeting in Portland, Oregon on February 25-26, 1987. CRSP participants reviewed the progress of the first three cycles of the Global Experiment. Specific statistical hypotheses were formulated for research in Host Countries and the United States based upon results of previous experiments. New experiments were designed to allow the collection of standardized data for the CRSP Central Data Base.

Data Management

Consistent with its long-term goal, the CRSP proposes to develop practical pond management models to improve the efficiency of pond culture systems. The development of quantitative models is dependent upon the efficient management of standardized data.

DATA MANAGEMENT

Standardized data are tabulated at each research location in accordance with CRSP work plans. Project teams may conduct independent analyses of their data and publish results if they so desire. However, in all cases, the data tabulations are filed in a centralized CRSP Data Base maintained by the Management Entity. In this way, the entire data set is available to all CRSP participants, but especially to the CRSP Data Synthesis Team. The latter body was appointed by the CRSP Board of Directors to accomplish data analysis, synthesis, and model development. The various activities of Team members are supported as part of the U.S. Research Component. Table 1 presents the current status of the CRSP Data Base.

Plans for Reorganization

During this reporting period, the CRSP planned for a new phase of operations. CRSP participants, under the guidance of BIFAD and USAID, staff developed a plan to continue CRSP activities after the original CRSP grant period ended on 31 August 1987. Proposals for reorganization were submitted to two meetings of the joint JCARD Panel on CRSP's and the Agricultural Sector Council Subcommittee. The first plan, submitted in December 1986, was revised and resubmitted in January 1987. With minor modification the revised plan was accepted as the continuation plan.

PLANS FOR REORGANIZATION

The erosion of funding over the past two years (FY 1986 and 1987) made it necessary to discontinue four of the seven CRSP projects in order to maintain a high quality research program within budgetary constraints. The three remaining sites are representative of the three USAID geographical areas in which the CRSP conducts overseas research: Southeast Asia, Latin America, and Africa. The CRSP was able to incorporate these changes without altering the overall emphasis of the research program.

The continuation plan centers on a conceptual model of pond culture systems that was developed by CRSP scientists (Figure 1). The model was used to identify research needs. New experiments will build on the results of previous CRSP research in a continuing effort to enhance the understanding of the dynamic processes that regulate the productivity of aquaculture ponds.

The fourth work plan, which represents the new phase of research under the reorganization of the CRSP, will be implemented on September 1, 1987. The CRSP Technical Committee will develop subsequent work plans during the second year of work on each experiment. Future work plans will emphasize the calibration and verification of predictive models under field conditions, and field testing pond management practices.

Table 1. STATUS OF THE CENTRAL DATA BASE MANAGEMENT SYSTEM (1)

Data Files Submitted to the CRSP Program Management Office

	1		2		3	
SITE CODES:	DRY	WET	DRY	WET	DRY	WET
Aquadulce (Panama)	X	X	X	X	X	X
Gualaca (Panama)	X	X	/////	/////	X	X
Ayutthaya (Thailand)	/////	X	X	X	X	X
Nong Sua (Thailand)	X	/////	/////	/////	/////	/////
Bogor (Indonesia)	X	X	/////	X	X	X
Comayagua (Honduras)	X	X	X	X	X	X
Iloilo (Philippines)	X	X	X	X	X	X
Butare (Rwanda)	X	X	/////	/////	X	X

(1) The Central Data Base Management System is maintained by the CRSP Program Management Office
///// No experiment conducted

PROGRAM ACCOMPLISHMENTS

THE GLOBAL EXPERIMENT

Interrelationships

PROGRAM ACCOMPLISHMENTS

The global nature of the Pond Dynamics/Aquaculture CRSP is evident in the interrelationships among projects. The program consists of tightly knit research projects that share the long-term goal of increasing the availability of animal protein in less developed countries through pond aquaculture.

Project emphasis is placed on standardized experimental design. Standardization permits the comparison of data from diverse geographical locations. The experimental design involves monitoring environmental and fish production variables in twelve or more ponds at each of seven geographical locations in accordance with standardized work plans.

The three cycles of the global experiment that were completed followed one another logically. While the main objectives changed from cycle to cycle, consistency in experimental design allows the comparison of results between cycles. The global nature of the program will be preserved in the experimental cycles to come. The experimental protocol for the next cycles will remain consistent with that used in the Global Experiment. Furthermore, with the completion of the central data base, the world aquaculture community may contribute to and begin to use the wealth of data amassed by the CRSP during the first three cycles of the global experiment.

Results of the Global Experiment

RESULTS OF THE GLOBAL EXPERIMENT

The third and final cycle of the CRSP'S global experiment was successfully completed at all seven research locations during this reporting period. Cycle III experiments at the freshwater sites focused on the chemical, physical, and biological responses of ponds treated with varying rates of organic fertilizers. *Oreochromis niloticus* (*Tilapia nilotica*) was stocked at all freshwater sites. Freshwater project sites include Panama (Gualaca), Honduras, Thailand, Indonesia, and Rwanda. At the brackishwater sites, the objectives were: to observe differences in physical, chemical, and biological responses to ponds stocked with shrimp, with shrimp and bivalves, and with shrimp, bivalves, and fish; to determine physical, chemical, and biological responses to nutrient pretreatment; and to compare physical, chemical, and biological responses to ponds subjected to varying rates of water exchange. Brackishwater research was conducted in the Philippines and in Panama (Aguadulce).

The first experimental cycle in addition to Cycle III was completed in Rwanda during this reporting period. The objectives of Cycle I were: to compile a quantitative baseline of physical, chemical, and biological parameters; to observe quantitative physical, chemical, and biological responses of ponds subjected to varying rates of inorganic fertilizers; and to observe and document technical constraints limiting fry availability. The experimental protocol for each cycle of the global experiment is provided in its corresponding work plan. Technical progress for the third cycle is described briefly for each site.

HONDURAS, Cycle III of the Global Experiment

HONDURAS

The wet season experiment of Cycle III was successfully completed during this reporting period. CRSP personnel followed the objectives and experimental protocol as stated in the Third CRSP Work Plan. The CRSP team in Honduras, like the teams at other CRSP project sites, studied the effects of varying manure rates on fish production and water quality in freshwater ponds stocked with *Oreochromis niloticus*.

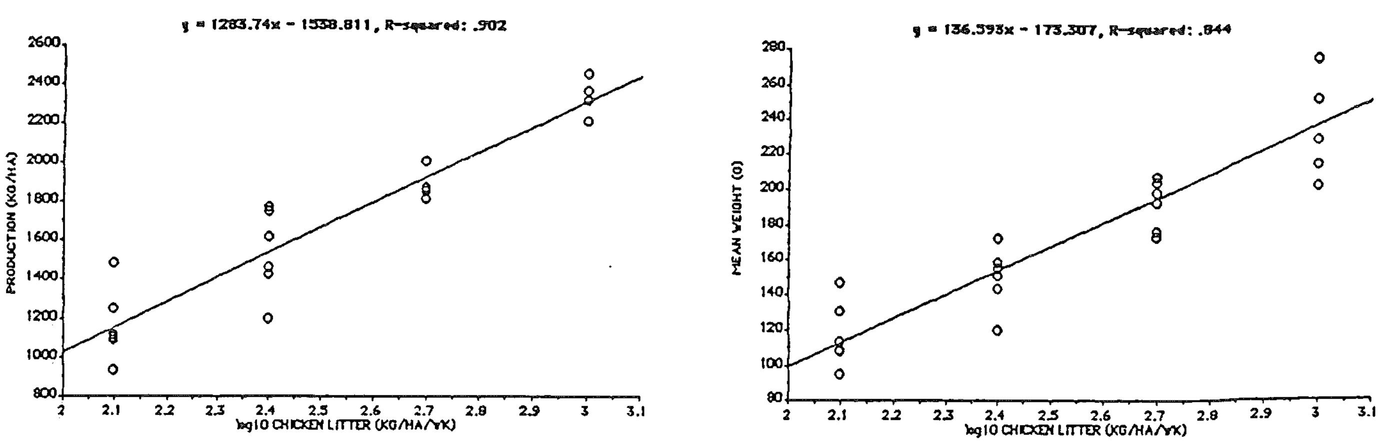
Quantity and quality of nutrient additions plays a key role in establishing an optimal production system for fish culture. Animal manure often is used as a nutrient input in tilapia ponds. The objective of this study was to determine if the biologically optimal level of manure application is independent of site-specific characteristics. If not, variation which occurs between sites may be attributable to some biological, chemical, or physical factors.

In the wet season of Cycle III, net fish production was 895, 3121, 1612, and 1950 kg/ha for respective manure rates of 125, 250, 500, and 1000 kg/ha/wk. In the dry season, net fish production was 1158, 1589, 1857, and 2230 kg/ha for the above manuring rates. No significant differences in survival of fish were observed between treatments for the dry or wet seasons. Mean survival was 94.1% in the dry season and 75.5% in the wet season.

The average weight of fish at harvest was 115, 155, 177, and 208 g for the respective treatments in the wet season. In the dry season, average weight per fish was 117, 158, 170, and 215 g. The quantity of offspring produced by the initial stock averaged 264 kg/ha in the wet season, and there were no significant differences between treatments. In the dry season, the quantity of offspring averaged 104 kg/ha with larger quantities by weight occurring at the higher manuring rates.

Chlorophyll *a* values were similar in both seasons. Values ranged from a mean of 40.6 µg/l at the 125 kg/ha/wk manure rate to a mean of 167.9 µg/l at 1000 kg/ha/wk. Increased manuring rates resulted in increased Secchi disk measurements. The chronic condition of high clay turbidity at this site was reduced with increased manuring.

Mean water temperature was 0.73°C higher in the wet season than in the dry. During either season, water temperature was higher at the highest manuring rate. Total alkalinity, total hardness, orthophosphate, and Kjeldahl nitrogen increased with increasing manuring rates. There were no significant seasonal effects on these parameters. Levels of nitrate and nitrite nitrogen were similar in all treatments.



Relationship between chicken litter (manure) input and fish production (a), and mean fish weight (b) during Cycle III, wet and dry seasons combined.

INDONESIA, Cycle III of the Global Experiment

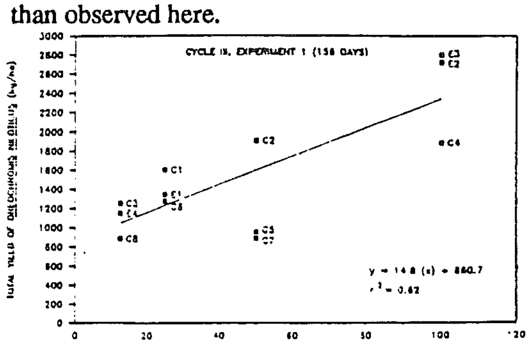
During this reporting period, the third experimental cycle of the CRSP was completed at the Babakan Fisheries Station of Institut Pertanian in Indonesia. Researchers adhered to the protocol described in the third CRSP work plan. Results of earlier CRSP research are presented as supporting information to the results from the third cycle.

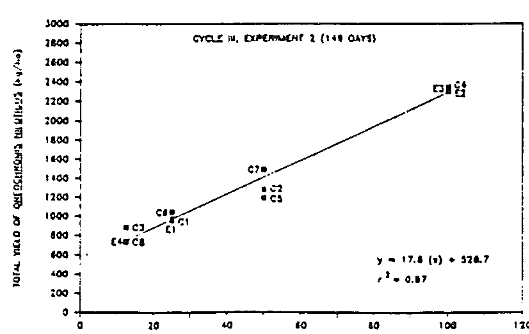
INDONESIA

Baseline fish production in ponds without feed supplements was on the order of 1200 kg/ha/yr at Babakan with two crops per year. This was near average production reported for farm ponds in West Java: 1500 kg/ha/year. Successive experiments in the CRSP, using fertilizers without supplemental feeds, nearly quadrupled pond production over baseline, and tripled average production for farm ponds of the region. Closing CRSP experiments at Babakan (Cycle III) produced 4600 kg/ha/yr. Data showed that higher yields could be obtained with proper manipulation of fertilizers. The literature reports that maximum production with the fish used in CRSP experiments, namely Nile tilapia, is expected to reach 5000 kg/ha/yr in well-managed ponds using supplemental feeds as well as fertilizers. Thus, the CRSP demonstrated that production much higher than average for the region can be obtained, and it laid groundwork for Indonesian scientists to continue pursuit of management practices that will push fish production even higher.

A key component of obtaining high fish production at Babakan was adequate inorganic carbon (CO_2) for high algal production. This is also important for fish production in fertilized ponds across the wet tropical regions that receive their water from drainage basins with heavily leached volcanic soils. Such water is poor in minerals and has carbonate-bicarbonate alkalinity on the order of 20-25 mg $CaCO_3$/l. Babakan Station was the one CRSP site that existed in such a setting. Production responses to fertilizers used initially at the site were unconventional and low. This led to closer examination of fertilizer dynamics in ponds than otherwise may have been the case. Algal production and fish production was increased by increasing alkalinity and associated CO_2 reserves with lime, or by supplying high rates of organic fertilizer that yielded CO_2 during decomposition. Inorganic fertilizer performance was poor. Optimum use of fertilizer, particularly phosphorus, was not obtained during experiments at Babakan, even at highest fish yield. Continuing research in Cycle IV of the CRSP is aimed at achieving maximum fertilizer efficiency. Experience from accomplishments in these years of the CRSP provides assurance of reaching that goal as well as others of the program.

High fish yield (4600 kg/ha/yr) was obtained at Babakan without undue stress on dissolved oxygen in ponds, or developing growth inhibiting concentrations of un-ionized ammonia sometimes associated with high loading rates of manures. Mean water column loss of oxygen at night was on the order of 4.5 mg/l. Losses 25% higher commonly are reported in the literature for productive fertilized ponds. Concentrations of oxygen at dawn were near 2.0 mg/l. Un-ionized ammonia concentrations increased six-fold in ponds from 24-hour lows to afternoon highs in response to photosynthesis-related pH increases and small rises in water temperature. Maximum concentrations (0.06 mg un-ionized NH_3-N/l) during 24-hour periods were low relative to concentrations that have adverse effects on fish growth. Fertilizer experiments conducted at Babakan suggest that higher photosynthetic yields and fish yields can be expected with appropriate mixes of organic and inorganic fertilizers without greater influence on oxygen or un-ionized ammonia concentrations than observed here.





Relationship between chicken manure loading rates and total fish yield in Cycle III, wet season (a), and dry season (b) in Indonesia.

PANAMA, AGUADULCE, Cycle III of the Global Experiment

AGUADULCE, PANAMA

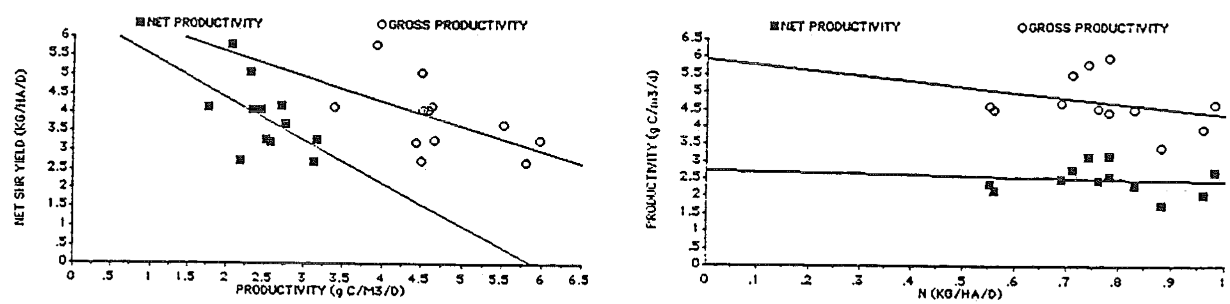
CRSP personnel in Aguadulce completed the wet season experiment of Cycle III of the Global Experiment during this reporting period. Experimental protocol as outlined in the Third CRSP Work Plan was followed.

Aquaculture practices for marine shrimp culture commonly include a daily water exchange of 5% or more of pond volume. How this affects the dynamics of the ponds or shrimp production is poorly understood. The emphasis of the Cycle III study was to determine the effects of this management practice on pond dynamics.

Juvenile *Penaeus vannamei* were stocked at 5 shrimp/m^2 in a series of ponds having a daily water exchange of 0, 5, 10, and 20%. Each water exchange was replicated in three ponds. Shrimp received a pelleted feed (25% protein) five days a week at an initial rate of 22% body weight/day. The feeding rate gradually was reduced to 5.6% by the end of the experiment. Water quality and other biological parameters were monitored following the general CRSP Cycle III protocol.

Shrimp yields were not affected by increased water exchange. Mean yields were 415 kg/ha in the dry season and 545 kg/ha in the wet season. Yields varied greatly among ponds in the dry season. In the wet season, survival was highest (94%) at the highest water exchange rate and lowest in the 0% water exchange rate. This resulted in the largest average weight per individual at the low exchange rate and the smallest average weight at the high exchange rate. However, total yields were similar for the high and low exchange rates. In the dry season, water quality parameters, except salinity and silicate concentration, were not affected by water exchange. Salinity and silicate concentration decreased with increased water exchange. In the rainy season, ammonia nitrogen and nitrates were not affected by water exchange rates.

Mean early morning oxygen levels were not affected by water exchange rates in the dry season. In the wet season, dissolved oxygen levels were slightly higher with the 20% exchange rate. Phytoplankton species composition varied between seasons. Diatoms predominated in the dry season and bluegreen algae in the wet season. Green algae was scarce in both seasons. Chlorophyll *a* values were not significantly different among the water exchange rates in either season.



Relationship between primary productivity and net shrimp yield (a), and between nitrogen input and primary productivity (b) for Cycle III, wet season.

PANAMA, GUALACA, Cycle III of the Global Experiment

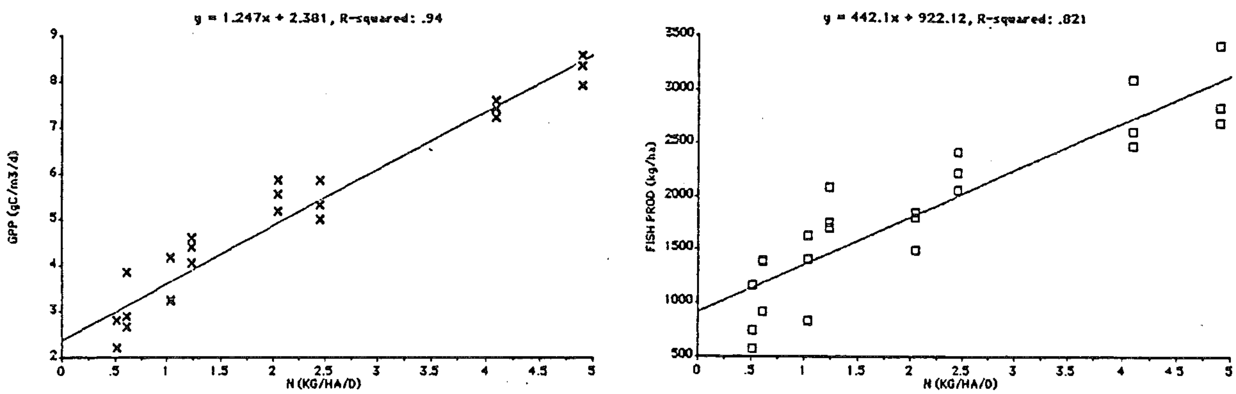
GUALACA, PANAMA

CRSP personnel in Gualaca completed the wet season experiment of Cycle III of the Global Experiment. Experimental protocol as outlined in the Third CRSP Work Plan was followed. Chicken litter was added to earthen ponds at 125, 250, 500, and 1000 kg/ha/wk, based on total solids. The ponds were stocked with *Oreochromis niloticus* at 1 fish/m^2. Each treatment was replicated three times and the same experiment was conducted during the dry and wet seasons of 1986.

The indicators of biological productivity, chlorophyll *a*, net primary productivity, and community respiration increased linearly with an increase in manuring rate, whereas Secchi disk depth decreased linearly. Fish production also increased linearly with an increase in manuring rate. Mean fish production ranged from 827 to 2984 kg/ha. Of the chemical variables measured, Kjeldahl nitrogen, total alkalinity, total hardness, and the logarithm of total phosphorus increased linearly with an increase in manuring rate, while dissolved oxygen decreased linearly. Total ammonia nitrogen and soluble orthophosphate were significantly greater only at the highest treatment rate. Nitrate nitrogen showed no significant response to treatment rate.

Primary productivity was greater during the dry season probably because of the greater solar radiation. Chlorophyll *a* was significantly greater at the two lowest treatment rates, and gross and net primary productivity were significantly greater at the highest rate. Community respiration was significantly greater at all rates except 500 kg/ha/wk. Fish production was numerically greater at all treatment rates during the dry season than during the wet season, but only showed significant differences at 500 kg/ha/wk. Greater fish production was attributed to higher primary productivity.

Pond seepage was reduced by 66% within the first month of manure application at the highest three rates. By the end of the dry season, ponds at all manuring rates had been sealed almost equally well.



Relationship between the rate of nitrogen input and gross primary productivity (a) and fish production (b) for Cycle III, wet and dry seasons combined.

PHILIPPINES, Cycle III of the Global Experiment

The third cycle of the CRSP global experiment was completed in the Philippines during this reporting period. The overall objective was to develop an economically viable, intensive polyculture system with shrimp as the primary crop, and with bivalves and fish used to maintain suitable water quality while minimizing energy requirements for water flushing and emergency aeration.

PHILIPPINES

Eighteen, 1000-m^2 ponds were used in this study. Three treatments consisting of shrimp only (shrimp stocking density at 4/m^2 in all treatments), shrimp and bivalves (bivalve stocking density at 90,000/ha in all treatments with bivalves), and shrimp, bivalves and milkfish (milkfish stocking density of 3,000/ha) were each maintained in six ponds. Three ponds in each of the treatments were circulated during daytime using a motor-driven, 20-inch, propeller blade at approximately 90 rpm. Two 120-day trials were conducted. During the experiment, shrimp and fish growth, dissolved oxygen, salinity, temperature, un-ionized ammonia concentration, pond depth, Secchi disk depth, nitrate concentration, nitrite concentration, available phosphorus, total phosphorus, pH, chlorophyll levels, primary productivity, phytoplankton abundance and zooplankton abundance were monitored at regular intervals.

Results are currently being analyzed. Problems were encountered with survival of oysters, which were later replaced with green mussels.

RWANDA, Cycle I of the Global Experiment

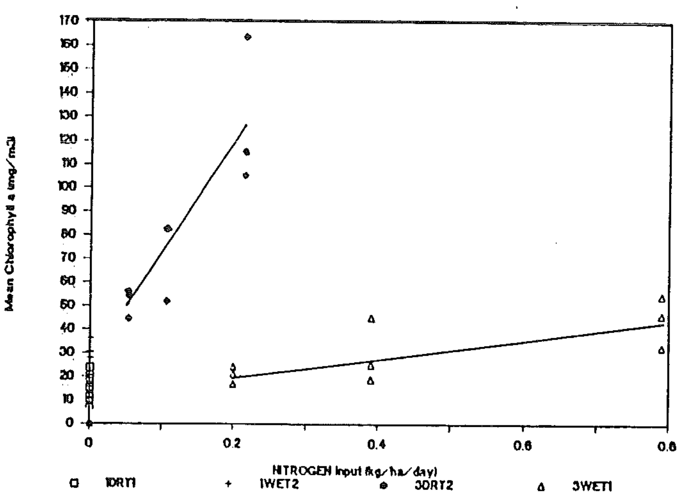
RWANDA

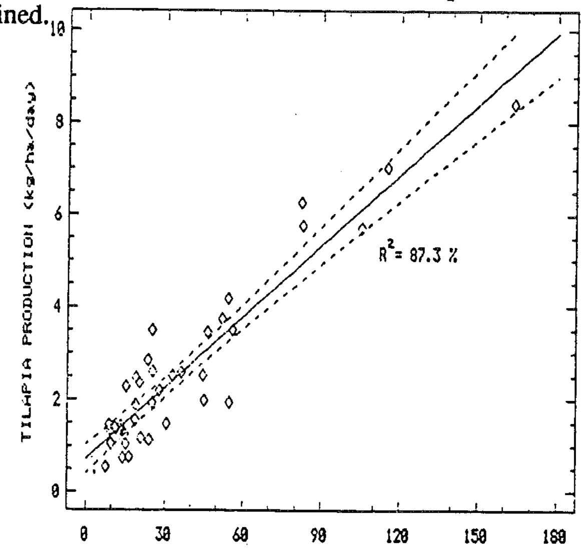
This experiment established baseline values for tilapia (*Oreochromis niloticus*) production and characterized the pond environment for a wet season in which all ponds received equivalent doses of inorganic fertilizer. Objectives of Cycle I experiments were: (1) to evaluate variations among individual ponds; (2) to study the performance of *O. niloticus* under the specific environment of Rwanda; and (3) to determine the influence of season on productivity. This experiment duplicated a Cycle I experiment conducted in 1985-86 during the dry season.

Male tilapia were stocked at 1 fish per m² in ten 600-m² ponds. Mean initial fish weight was 42 g. The experiment was conducted over 150 days from 1 October 1986 to 26 February 1987. Dissolved oxygen, pH, and water temperature were measured weekly and once a month at two-hour increments over a 24-hour period. Alkalinity and hardness were measured weekly; ammonia nitrate, total phosphorus, and orthophosphate were measured monthly; and chlorophyll *a* and Secchi disk visibility were measured biweekly. Primary productivity, from light-dark bottles, was estimated monthly. Climatological data were also collected. The Cycle I Work Plan outlined the specific analytical techniques.

Net fish production ranged from 427 to 1266 kg/ha/yr. Most ponds exhibited significantly greater production than for the Cycle I dry season experiment. The average increase was 34%. Ponds having high production during the Cycle I dry season experiment tended to be high in the wet season experiment. Surface water temperature ranged from 20 to 29°C. Rwanda appears to be near the lower acceptable temperature range for tilapia culture. Variability in other water quality parameters has been described using Duncan's Multiple Range test. Evaluation of these results is in progress.

These results provide a basis for evaluating tilapia culture in high altitude (1700 m), cool, tropical environments. Variability between ponds, the effects of seasonality, and estimates of fish production at low inorganic input levels were also determined.





Relationship between mean chlorophyll *a* and tilapia production (a), and between the rate of nitrogen input and mean chlorophyll *a* during Cycles I and III, wet and dry seasons combined.

RWANDA, Cycle III of the Global Experiment

The objective of this experiment was to determine the relationship between organic input rate and fish yield. Inorganic fertilizers are unavailable or economically infeasible for widespread use in Rwandan fish culture. Animal manures were used in these experiments as appropriate technology for enhancing fish production. The impact of seasonal factors and pond environmental factors important in pond dynamics also were determined.

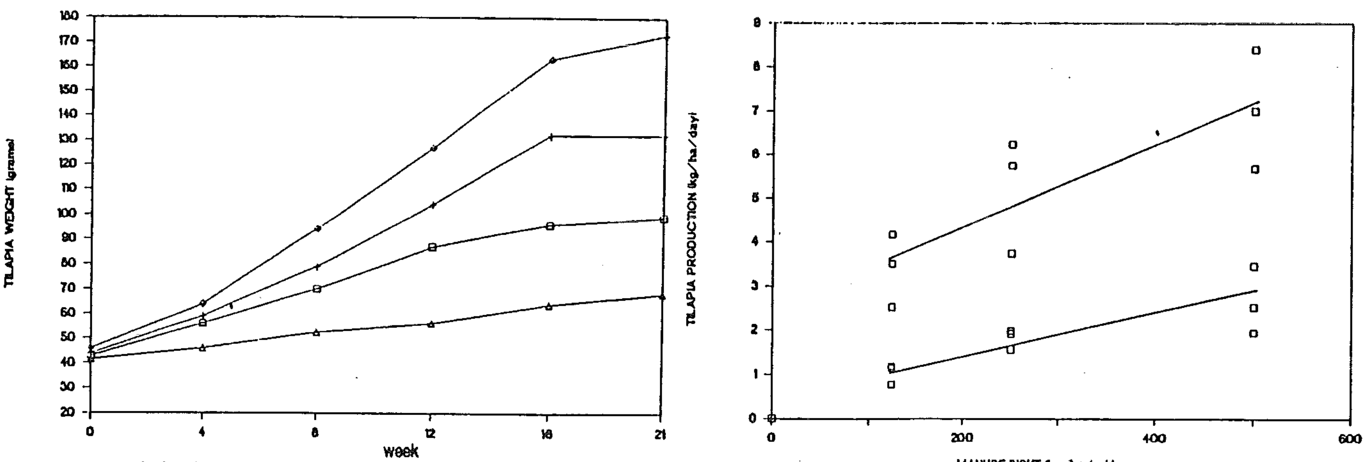
Nine 600-m² ponds at the Rwasave Fish Culture Station in Butare, Rwanda were stocked at one fish per m². Tilapia (*Oreochromis niloticus*) were hand-sorted twice to eliminate females. Mean initial weight was 44 g/fish. Fish were sampled and weighed monthly. At least 50 individuals were captured and weighed as a group. Twenty-five of those fish were weighed and measured individually. At the termination of the experiment (150 days), all fish were weighed and measured individually. Water temperature, pH, and dissolved oxygen were measured weekly and once a month at two-hour intervals over a 24-hour period. Total Kjeldahl nitrogen, ammonia nitrate, total phosphorus, orthophosphate, chlorophyll *a*, Secchi disk visibility, alkalinity, and hardness also were measured weekly. Primary productivity was estimated monthly using light-dark bottle techniques. The nine ponds were assigned the same treatments that they received during the wet season. Three ponds at each treatment level received a weekly dose of chicken manure at either 125, 250, or 500 kg/ha/week.

RWANDA

Mean fish size for the three treatment levels was 95.3, 127.6, and 161.3 grams, respectively. Fish production was 1110, 1874, and 2683 kg/ha/yr for respective manure input levels of 125, 250, and 500 kg/ha/wk ($r^2 = 0.97$, std. error= 192.3). Thus, fish production was higher during the dry season than during the wet season experiment. However, in Cycle I, wet season experiments exhibited higher production rates than those noted for dry season experiments. The second series of experiments demonstrated greater tilapia production regardless of season. The carry-over effect for these relatively young ponds may be more important than seasonality, where measured seasonal differences are not large.

Estimates of total phosphorus appeared to increase with treatment level while no relationship was apparent between primary productivity and manure input. Decreased light penetration at higher manure input levels may have restricted photosynthesis at the measurement site. Analysis of results is still in progress.

This experiment provides a basis for estimating tilapia production for given manure inputs in a high elevation, tropical African environment. Taken with earlier experiments, the importance of carry-over effects is indicated. These data also provide baseline values for the global objectives of the Pond Dynamics/Aquaculture CRSP program. Greater understanding of causative factors in pond dynamics is another general benefit anticipated as detailed analyses and comparisons with results from other sites progresses.



☐ 125 kg/ha/wk + 250 kg/ha/wk ◊ 500 kg/ha/wk ΔTriple Superphosphate

Mean individual *Tilapia nilotica* weight through time for Cycles I and III, dry seasons (a). Relationship between manure input and fish production for Cycle III, wet and dry seasons combined.

THAILAND, Cycle III of the Global Experiment

The third cycle of the CRSP global experiment was completed successfully during this reporting period. Pond experiments have been conducted at two sites during the past four years: Nong Sua Station for Cycle I dry season (1984), and Bang Sai Station (Ayutthaya) for the remainder of the experiments. The three cycles of experiments have evaluated the effects of differential fertilization rates and fertilizer types on pond limnology and productivity.

THAILAND

THAILAND

Three main objectives of the study were to determine the effects of low and high inputs of inorganic fertilizer on pond dynamics, to compare graded levels of manure input and their effects on pond dynamics, and to compare inorganic and organic fertilizers for their effects on pond dynamics. A secondary objective was to compare results between ponds treated similarly, and also between ponds run during dry and wet seasons.

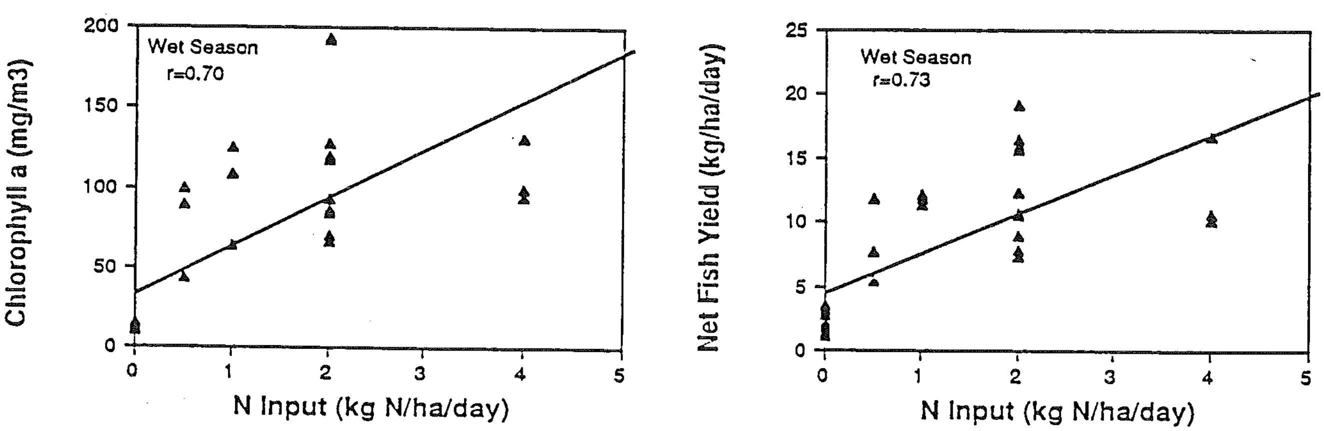
The first treatment (Cycle I) was low input of inorganic fertilizer (8 kg P_2O_5/ha/mo). This experiment was conducted in twelve replicate ponds both during the dry season 1983 and wet season 1984. The second treatment (Cycle II) was high input of chicken manure (500 kg/ha/wk) or inorganic fertilizer at similar NPK (nitrogen, phosphorus, and potassium) loading rates. Six replicate ponds for each treatment were run during the dry and wet seasons of 1985. The third treatment (Cycle III) was graded input of chicken manure (at levels of 125, 250, 500, and 1,000 kg/ha/wk). These were run with three replicate ponds each during dry and wet seasons of 1986.

Periodic measurements of weather variables, water temperature, dissolved oxygen, phosphate, nitrate, Secchi disk depth, primary productivity, chlorophyll *a* concentration, fish size, and fish yield were made. Methods for data collection are described in the work plan for each cycle. Data collected at different frequencies were averaged for monthly values. Monthly change in fish biomass (yield) was calculated assuming a constant mortality rate and observed growth rates.

Treatments were compared using analysis of variance, with an alpha value of 0.05. Most treatments yielded results much as expected, with significant differences between treatments and no significant differences between ponds within a treatment. Seasonality had no significant effect on primary productivity or yield. This was apparently due to unusual weather patterns, as the three wet seasons actually included an extremely dry season, a moderate wet season, and an extremely wet season. Initiation and magnitude of rainfall proved very irregular each year.

Increased input of inorganic nutrients yielded increased nutrient concentration, primary productivity, and fish biomass. Maximum average output values were 12.2 g $C/m^3/d$ for primary productivity and 8.6 kg/ha/mo for fish yield. Increased manure application was less predictable. Primary productivity and yield at high nutrient input rates (500 and 1,000 kg/ha/mo) were much higher than at low rates (125 and 250 kg/ha/mo), but the highest primary productivity and yield occurred at intermediate loadings of 500 kg/ha/wk. Maximum average values were 100 kg/ha/day for carbon fixation and 24 kg/ha/day for fish yield.

At similar loading rates, organic fertilizer produced higher fish yields than inorganic fertilizer. However, primary production was similar between these two treatments. Manure may have been consumed directly by the fish, resulting in higher fish yields.



Relationship between nitrogen input and chlorophyll *a* (a) and net fish yield (b) in Cycle III, wet season in Thailand.

UNITED STATES RESEARCH COMPONENT OF THE GLOBAL EXPERIMENT

Introduction

UNITED STATES RESEARCH COMPONENT

Implicit throughout Title XII of the International Development and Food Assistance Act of 1975 is that activities should be mutually beneficial to developing countries and to the United States. In planning this CRSP, consensus among CRSP participants was that improving the efficiency of pond culture systems through collaborative research involving both U.S. and developing country institutions would be mutually beneficial. However, subsequent to awarding the CRSP grant, USAID interpreted "mutually beneficial" to mean that the CRSP should fund research activities both in the U.S. and in developing countries and instructed the CRSP to direct some of its funds to support research activities at the U.S. institutions.

A U.S. research component was organized during the third year of the CRSP. Several projects have been funded and some have been successfully completed during the past year. These projects study timely research problems that could not be addressed in the overseas component. Consequently, the projects help to strengthen the overall effectiveness of the CRSP.

In organizing the U.S. research component, the CRSP endeavored to ensure that the projects included in this activity are of high technical merit. Formal project proposals are subjected to critical review by peers not affiliated with institutions participating in the CRSP. The proposals and reviews are then submitted to the CRSP Board of Directors for approval. The Board considers the relevance of the proposed work to CRSP goals as well as its technical merit.

The Special Topics Research Studies described above are only one part of the U.S. Research Component. The overall success of the CRSP depends heavily on the management, analysis, and modelling of data collected from the seven overseas CRSP sites. The comprehensive analysis of the global data base is accomplished at several U.S. universities as part of the Data Synthesis Team's activities. Although the CRSP Central Data Base is not part of the U.S. Research Component, it is described in this section because its output provides the foundation for activities conducted by the Data Synthesis Team.

Data Synthesis Team and The CRSP Central Data Base

DATA SYNTHESIS ACTIVITIES

The CRSP recognized at the outset that aquaculture ponds are extremely complex ecosystems. The choice of sites, the experimental protocols, the monitoring of variables, and the frequency of measurements were all determined with an understanding of the complexity of the system. Results obtained to date have confirmed this initial perception and have made computerized analysis of the data a necessity.

A major focus of the CRSP is on the analysis and synthesis of data collected at seven overseas locations during the global experiment. The Data Synthesis Team was established in September 1985 to provide comprehensive, global interpretations of the CRSP Central Data Base. The Data Synthesis Team's activities are decentralized; members of the Team operate from offices at the University of California at Davis, the University of Michigan, and Oregon State University. Through their involvement on the Technical Committee, members of the Data Synthesis Team interact with scientists from the field-based research component of the global experiment. The Data Synthesis Team works in concert with the Data Base manager to translate and verify the large amounts of data that have been compiled into the CRSP Central Data Base.

The primary objectives of the Data Synthesis Team include:

- the development of data management techniques;
- the definition of site-specific as well as global relationships; and
- the development of computer models that make optimum use of the Central Data Base and are suitable for diverse applications such as teaching, management, planning, and research.

The CRSP Central Data Base is maintained by the Program Management Office. Field personnel send data to their principal investigators at U.S. universities who check the data sets and forward them to the Program Management Office. The data sets then are electronically translated into a standardized format and sent back to the principal investigators for verification. (Data entry already is standardized through the use of templates that were developed by the Data Base manager and approved by the Technical Committee.) Verified files are entered into the Central Data Base for use by the Data Synthesis Team. Specific data sets may be retrieved from the mainframe in virtually any format desired. All project teams also independently analyze their data and most have had their results published in journals or proceedings of scientific meetings (see Appendix A).

The CRSP, through its data base, provides a great service for the world aquaculture community by collecting daily measurements of photosynthetically active radiation, rainfall, evaporation, air temperature, and wind speed concurrently with experimental data from ponds. Detailed records such as these are rare in the aquaculture literature. This is particularly true for photosynthetically active radiation and on-site rainfall, which are important features of water and nutrient budgets for ponds in the wet tropics. Other records collected by the CRSP also are useful in interpreting pond measurements in relation to physical processes occurring at the surface.

A major accomplishment that occurred toward the end of this reporting period is the near completion of the Central Data Base (Table 2). Complete and verified data sets from all sites except Panama are available to members of the Data Synthesis Team and to other participants. The data sets from Panama have been submitted from the field and presently are being processed by the Data Base manager.

The Data Synthesis Team also performed preliminary statistical analyses (simple regression analyses) on the data. A few significant relationships were revealed. These relationships were constructed with the incomplete data base and do not necessarily provide a general relationship for all research sites. The results do, however, show the existence of possible statistical relationships in the data. Significant differences ($P<0.05$) were found between chlorophyll *a*, and total nitrogen, pH, alkalinity, and Secchi disk depth. No statistical difference was found between chlorophyll *a* and phosphorus. These results may indicate that phosphorus is not a limiting nutrient for phytoplankton growth in the ponds for which data were analyzed. Nitrate and total nitrogen, however, may be more important than is generally assumed for algal growth in fish ponds. Additional interpretations of the data presently are being conducted with other statistical methods such as principal component analysis and multiple regression.

During this past year, the Data Synthesis Team conducted a survey to identify the degree of uniformity with which data were collected at the seven overseas locations. Research personnel were asked to record deviations from the standardized work plans. Results of the survey indicate that the procedures used by field personnel closely followed those specified in the work plans. Digressions from the work plan are taken into account as the data are analyzed by the Data Synthesis Team.

The CRSP aims to increase the usefulness of aquaculture models by addressing the limitations inherent in previous computer models, such as difficulty of use, non-compatibility between computers, and oversimplification of system dynamics. Developers of previous models did not have the benefit of a large standardized data base such as the one created by the CRSP. The Data Synthesis Team is using this data base to develop two computer models. The models are designed to utilize the data collected at weekly or biweekly intervals to calculate oxygen production and consumption. One of the models is programmed in FORTRAN and is based on a generalized model of pond ecosystems (Figure 1). The other is designed to be "user friendly." It is programmed with a dynamic modelling language (STELLA™) on a microcomputer and simulates dissolved oxygen. The models are being used to study the factors that affect the dissolved oxygen cycles and how these factors change between sites in response to varying management practices or treatment effects (Figure 2).

Benefits of analyzing results and developing computer models that simulate pond conditions at the experimental sites will occur on several levels: management and production, design, and planning. The quantification of relationships between variables and the effect of treatments will allow farmers to adopt management practices to achieve production goals within local constraints of climate, water, feed, and fertilizer availability. Design of production systems will be improved by matching production facilities and costs with production goals. As the Data Synthesis Team moves closer to meeting its objectives, the CRSP will begin to realize its goal of confronting food and nutritional problems through improved aquaculture technologies.

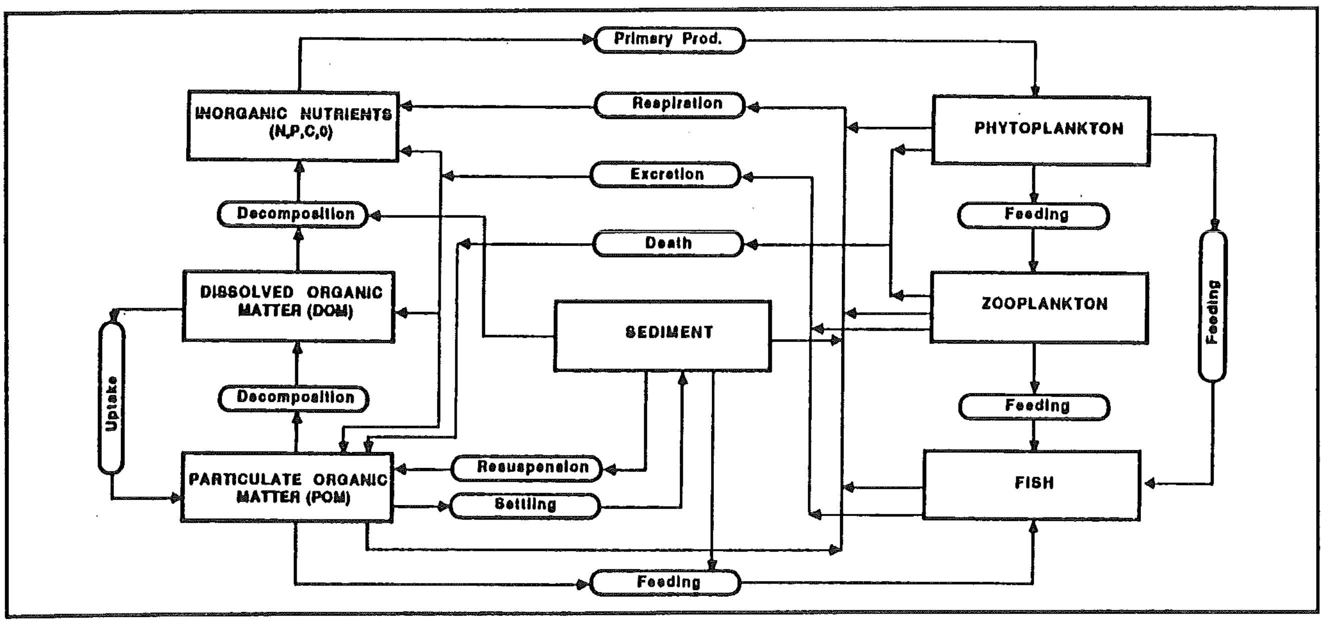


Figure 1. A conceptual model of an aquaculture pond. The arrows connecting the model's components represent the paths for movement of mass in the system. The system includes both biological and non-biological components. The strictly biological components are phytoplankton, zooplankton, and fish, whereas the non-biological components are the inorganic nutrients that are considered likely to limit productivity. Examples of limiting nutrients are nitrogen, carbon, and phosphorus, which are possible limiting nutrients for photosynthesis, and oxygen and nitrogen (ammonia), which affect fish growth, health, and survival. Sediments include decomposing organic matter that settles from the water, the parent soil material, and benthic organisms. Particulate organic matter is a composite of dead particulate organics and bacteria that either coat the particles or are in free suspension. Most research on fertilized aquaculture ponds has been based on the premise that yields and production rates are determined by primary productivity. Nutrients added to a pond must undergo transformations that include fixation by phytoplankton before they are available to fish. The importance of the heterotrophic food chain has not been recognized until recently.

Table 2. Summary of Data received by the CRSP Program Management Office.

TEMPLATE CODES;	SITE: Iloilo (Philippines)						SITE: Bogor (Indonesia)					
	1		2		3		1		2		3	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Weather	X	X	X	X	X	X	X	X	////	X	X	X
Daypond	X	X	X	X	X	X	X	X	////	X	X	X
Miscel			X	X	X	X			////		X	
Weekly	X	X	X	X	X	X	X	X	////	X	X	X
Diurnal					X	X	X	X	////	X	X	X
Fish			X	X	X	X	X	X	////	X	X	X
Plankton			X	X	X	X			////			
Waterq	X	X	X	X	X	X	X	X	////	X	X	X
Soil	X	X	X	X	X		X	X	////	X	X	X
Morph			X			X	X		////			
Nutrient			X	X	X	X	X	X	////	X	X	X
Inputs			X	X	X	X	X	X	////	X	X	X

TEMPLATE CODES;	SITE: Ayutthaya (Thailand)						SITE: Nong Sua (Thailand)					
	1		2		3		1		2		3	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Weather	////	X	X	X	X	X	X	////	////	////	////	////
Daypond	////	X	X	X	X	X	X	////	////	////	////	////
Miscel	////							////	////	////	////	////
Weekly	////	X	X	X	X	X	X	////	////	////	////	////
Diurnal	////	X	X	X	X	X		////	////	////	////	////
Fish	////	X	X		X	X		////	////	////	////	////
Plankton	////	X			X	X		////	////	////	////	////
Waterq	////	X			X	X		////	////	////	////	////
Soil	////	X			X	X	X	////	////	////	////	////
Morph	////							////	////	////	////	////
Nutrient	////							////	////	////	////	////
Inputs	////							////	////	////	////	////

TEMPLATE CODES;	SITE: Butare (Rwanda)						SITE: Comayagua (Honduras)					
	1		2		3		1		2		3	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Weather		X	////	////		X	X	X	X	X	X	X
Daypond	X	X	////	////	X	X	X	X	X	X	X	X
Miscel			////	////								
Weekly	X	X	////	////	X	X	X	X	X	X	X	X
Diurnal	X	X	////	////	X	X	X	X	X	X	X	X
Fish	X	X	////	////	X	X	X	X	X	X	X	X
Plankton	X	X	////	////	X	X	X		X	X		
Waterq	X	X	////	////	X	X	X		X	X		
Soil	X	X	////	////	X	X	X	X	X	X	X	X
Morph			////	////		X						
Nutrient	X	X	////	////	X	X	X	X	X	X	X	X
Inputs	X	X	////	////	X	X	X	X	X	X	X	X

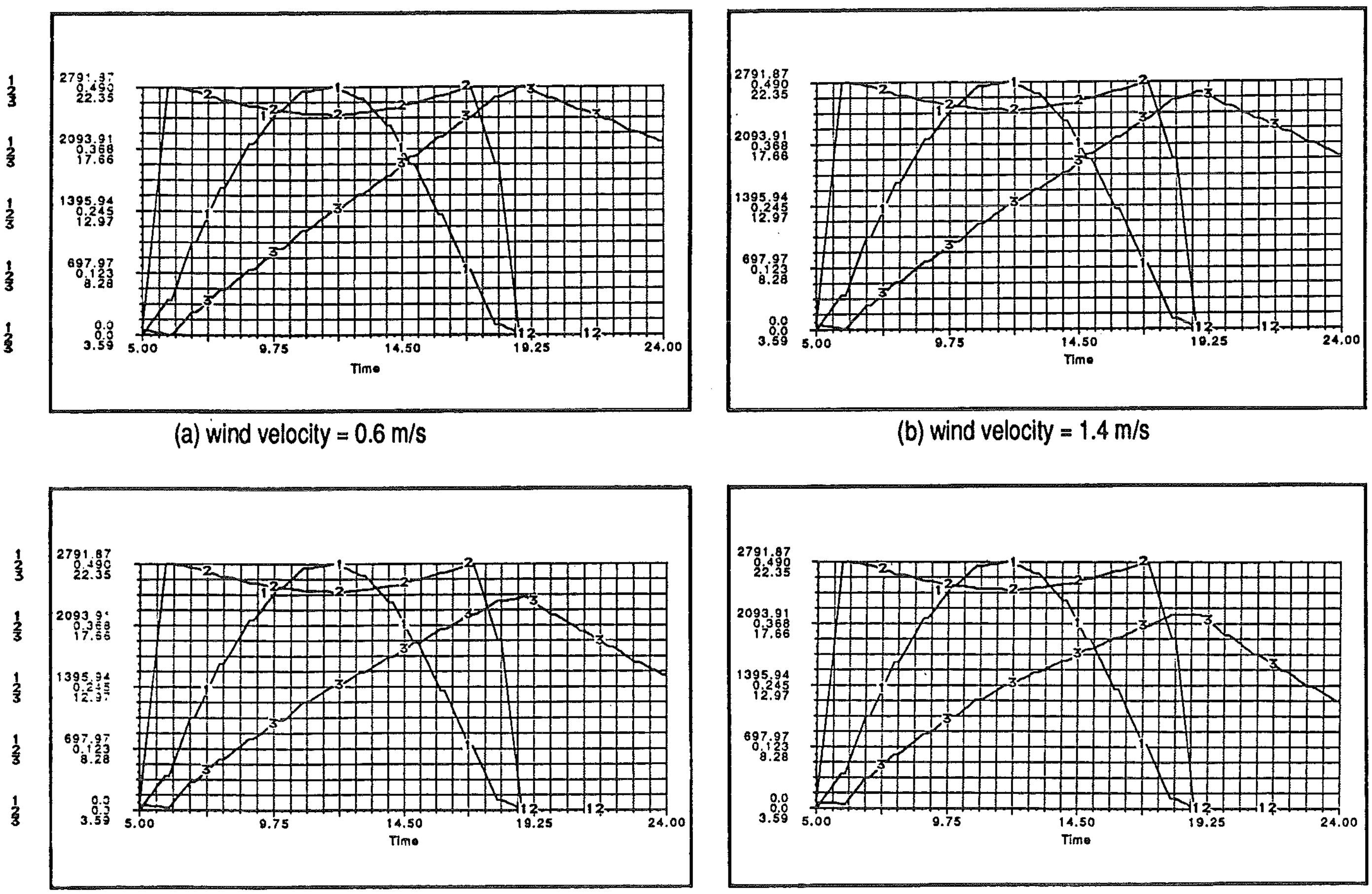
//// No experiment conducted

Table 2 (continued). Summary of Data received by the CRSP Program Management Office.

TEMPLATE CODES;	SITE: Aquadulce (Panama)						SITE: Gualaca (Panama)					
	1		2		3		1		2		3	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Weather	X	X	X	X	X	X	X	X	////	////	X	X
Daypond		X	X	X	X	X	X	X	////	////	X	X
Miscel			X	X					////	////	X	
Weekly	X	X	X	X	X	X	X	X	////	////	X	X
Diurnal	X	X	X		X	X		X	////	////	X	X
Fish	X	X	X	X	X	X	X	X	////	////	X	X
Plankton	X		X		X	X			////	////	X	X
Waterq		X	X	X	X		X	X	////	////	X	X
Soil		X	X				X	X	////	////	X	X
Morph	X	X		X					////	////	X	
Nutrient	X	X	X	X		X	X		////	////	X	X
Inputs	X	X		X		X	X	X	////	////	X	X

//// No experiment conducted

1 Actual Radiation (KJ/m²/hr) 2 Photosynthesis (mg O_2 produced/l/hr) 3 Dissolved Oxygen (mg/l)



(a) wind velocity = 0.6 m/s

(b) wind velocity = 1.4 m/s

(c) wind velocity = 5.0 m/s

(d) wind velocity = 10.0 m/s

Figure 2. The effects of varying wind velocities on CRSP ponds in Indonesia. This computer simulation of pond conditions reveals that dissolved oxygen (3) decreases as wind velocity increases from 0.6 m/s (a) to 10 m/s (d). These graphs were generated by the Data Synthesis Team and are indicative of the type of graphical analyses that will be performed for the entire CRSP data base.

Disposition and Elimination of [3H] Methyltestosterone (MT) in Nile Tilapia (*Oreochromis niloticus*)

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Methyltestosterone (MT) is under consideration for use in commercial production of all male cohorts of *Oreochromis niloticus*, a popular food fish in Asia, Africa, and Latin America. Sexually undifferentiated fish received a control diet or 30 mg MT/kg ration for 30 days. Control and MT pretreated fish received a single dietary dose of [3H] MT 1 day after pretreatment and were killed 1, 3, 7, and 10 days later. Elimination was similar in control and MT pretreated fish. [3H]MT whole body residues decreased logarithmically with a 1-day half-life. At 1 and 3 days after dosing, 95% of [3H]MT was polar metabolites. This decreased to 70% at 7 days and by 10 days only parent (at a trace concentration) was detected. Six months after MT pretreatment, control and pretreated fish received a single oral dose of [3H]MT and were killed after 1, 3, 7, and 10 days. In both groups, at all time points, biliary >> liver = kidney > muscle concentrations of [3H]MT residues. Bile contained 97-99% polar metabolites of [3H]MT in all cases and appeared to be the major route of excretion. These data indicate that MT was readily eliminated by *O. niloticus* and that the pretreatment regimen proposed for commercial use did not substantially alter disposition of subsequent doses.

Genetic homogeneity of *Oreochromis niloticus (Tilapia nilotica)* in Africa, Central America, and Southeast Asia

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Thirty-eight enzyme loci were examined in seven populations of *Oreochromis niloticus* using starch-gel electrophoresis. Populations were from CRSP research stations in Honduras, Indonesia, Panama, the Philippines, Rwanda, Thailand, and a control line maintained at Auburn University. Eighteen loci were polymorphic. The average percentage of polymorphic (P) loci was 26%, and the average heterozygosity (H) was 0.053. Several loci exhibited unique alleles with frequencies less than 0.05. Nei's Genetic Identity (I), Roger's Genetic Similarity (S), and F-statistics were used to measure the level of genetic homogeneity among populations. Little genetic divergence was found among populations, and there was a high level of genetic variability within populations.

Genetic contamination from related species, *Tilapia aurea*, *T. mossambica*, and *T. hornorum*, was detected at seven loci. Only the control line of *T. nilotica* showed no evidence of introgression. *T. mossambica* and *T. aurea* contributed the most contamination. The percentage of contaminated loci ranged from 0-16% among the populations. Introgression increased mean heterozygosity by 76% in these populations.

HOST COUNTRY SPECIAL TOPICS RESEARCH

Introduction

HOST COUNTRY SPECIAL TOPICS RESEARCH

This component of the Pond Dynamics/Aquaculture CRSP was created to provide opportunities for host country and U.S. researchers to collaborate on original research directed towards the needs and priorities of the host country. The intent was to strengthen linkages within the host country institution and to contribute to the development of research capabilities within the institution by providing opportunities for scholarly involvement of faculty and advanced students. This component also provides host country institutions and agencies with access to the human resources of the CRSP in seeking solutions to shorter term local problems. Projects focus on specific aspects of the global experiment that would benefit from site-specific, detailed investigations. They complement the U.S-based Special Topics Research Projects.

Proposals for these Special Topics Research Projects are developed collaboratively by the host country and U.S. scientists. The proposals are endorsed by the host country institution and are reviewed by the CRSP Board of Directors for technical merit and relevance to the CRSP global experiment. The Board also requires that investigators discuss the proposed project with USAID Missions to ensure that the projects are consistent with USAID and host country development strategies and priorities.

Although the special topics projects are an important part of the CRSP, they are not a major component in terms of funding support or time expenditures. Twenty to twenty-five percent of each research associate's time typically is devoted to this activity. The CRSP places highest priority on the long-term research defined as the global experiment. Host country agencies and institutions and USAID Missions, however, often consider basic research activities to be of low priority. Consequently, administrators sometimes have difficulty justifying participation in the CRSP. The CRSP support for the special topics research activities helps to justify this participation.

Host Country Special Topics Research Reports

Latin America

LATIN AMERICA

Evaluation of soybean-based diets for the production of *Penaeus vannamei*

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Hughes, D., Auburn University, Alabama

Soybean meal is a rich source of protein and meets most of the amino acid requirements of aquatic organisms. It has potential as a substitute for fish meal in production diets where natural food organisms are also available. In a study conducted at the Brackishwater Aquaculture Station, Aguadulce, Panama, four diets containing different percentages of soybean meal were compared using juvenile *Penaeus vannamei* of initial average weight of 0.6 g. The shrimp were stocked into 2 m^2 net hapas at a density of 5/m^2. Each treatment was replicated in four hapas. Hapas were located in one 500-m^2 earthen pond that had a 5% daily water exchange. The shrimp were fed once a day over a 120-day period. The initial feeding rate was 10% of body weight per day and was reduced gradually to 3%.

The diet containing 100% fish meal as its protein source gave the greatest shrimp production (76.9 g/m^2) and the best survival (85%), whereas the 100% soybean-based protein diet gave the lowest production (65.6 g/m^2) and lowest survival (70%). The two diets that were mixtures of soybean and fish meal, gave intermediate results.
A significant result from this experiment was that net hapas were effective experimental units. The yields and individual mean weight of shrimp in hapas were representative of values that have been obtained in earthen ponds for similar stocking densities and culture periods. These results suggest that many nutritional studies may be possible using hapas as experimental units rather than ponds.

Effect of formulated feed and natural productivity on the growth and survival of marine shrimp during the nursery phase

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Hughes, D., Auburn University, Alabama

A nursery phase is an essential part of many aquaculture systems because it ensures a reliable, healthy source of seed for the commercial grow-out phase. Management techniques for shrimp nursery ponds, however, are not well established. The value of supplemental feeds or fertilizers for enhancing growth and survival of shrimp during the nursery phase is unknown. This study was designed to test the effects of organic fertilization and supplemental feed on growth and survival of post-larval Pena*eus vannamei* and *P. stylirostris*..

Three nutrient treatments were tested in a 2 x 3 factorial experiment: organic fertilizer only; organic fertilizer and 35% protein feed; and feed only. Each treatment was repeated four times in 38 days in ponds stocked with 150 hatchery-produced, post-larvae per m^2. Feeding rates were adjusted weekly.

Both P. *vannamei* and *P. stylirostris* showed a strong positive response to the addition of feed. Total production and average size of individuals doubled for both species when supplemental feed was added relative to that obtained by organic fertilization only. The greatest biomass (837 kg/ha/yr) was obtained with *P. vannamei* receiving feed and fertilizer. Mean survival was similar for all treatments and averaged 63.6%. Individual ponds varied in survival and ranged from 24 to 90.8%. The ponds stocked with *P. stylirostris* had greater variability in survival than those stocked with *P. vannamei.*

Comparative production of *Colossoma macropomum* and *Oreochromis niloticus* in Panama

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Peralta, M., National Department of Aquaculture, Panama

Interest in commercial-scale tropical aquaculture is growing rapidly. Tilapia are the main freshwater species presently cultured but another species native to the Amazon basin, *Colossoma macropomum*, shows commercial potential. Techniques for its cultivation are not well known. A comparison of *Oreochromis niloticus* (tilapia) and *C. macropomum* was conducted at the Brackishwater Aquaculture Station in Aguadulce, Panama. Both species were grown simultaneously. A 2 x 2 factorial design was used and experiments were repeated three times. Each species was stocked at densities of 1 fish/m^2 and 0.25 fish/m^2 in earthen ponds and fed a commercial 25% protein diet and harvested after 126 days.

The mean net production at high and low stocking densities was 3,361 and 917 kg/ha for tilapia, respectively, and 3,682 and 977 kg/ha for colossoma, respectively. The production difference between species was not significant, whereas the difference between densities was highly significant ($P < 0.01$). Although net production was not different for the two species, individual colossoma gained significantly more weight. At low stocking density, mean weight gain for tilapia and colossoma was 379 and 471 g, respectively. Increasing stocking density fourfold resulted in an almost fourfold increase in net production for both species. Mean weight gain was not significantly affected by density. *Ceteris paribus*, the production of a 400 g fish with prepared diets could be achieved equally well with *O. niloticus* and *C. macropomum*. Both species should be stocked at a rate of at least 1 fish/m^2 for high production and high mean fish weight.

Africa

A descriptive study of the plankton in Rwandan fish ponds fertilized with chicken manure and triple superphosphate

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Hanson, B.J., Oregon State University, Oregon

AFRICA

The plankton populations in ponds receiving different fertilizer inputs were studied to determine the influence of fertilizer input rate and type on plankton populations, and to determine food habits of *Oreochromis niloticus* under these conditions. Two pond groups were studied. The first group consisted of nine ponds, with three ponds each receiving 125, 250, or 500 kg chicken manure/ha/wk. The second group of ten ponds received 8 kg/ha/mo per pond of superphosphate. Plankton were sampled twice per month for five months. Three fish per pond were sampled monthly for analyses of stomach contents. Identification of plankton was to the level of genera.

A total of 94 genera were identified. In the manure-treated ponds, bluegreen algae were most abundant in pond and stomach samples. However, *O. niloticus* consumed diatoms and green algae in greater percentages than their percent abundance in the pond. In ponds receiving inorganic fertilizer, bluegreen algae were again most abundant in the water although diatoms were most abundant in stomach samples. Rotifers were selected at a lower percentage than their percent composition in the pond.

This preliminary study shows that different energy and material pathways influence pond productivity for tilapia culture. A clearer understanding of these dynamic processes will enable scientists to determine optimal enhancement techniques in pond aquaculture.

Pond culture of tilapia in a high altitude equatorial African country

Hanson, B.J., Oregon State University
Moehl, J.F., and K.L. Veverica, Rwanda Fish Culture Project, Auburn University, Alabama
Rwangano, F., and M. Van Speybroeck, National University of Rwanda, Rwanda

Reproductive and growth performances of *Oreochromis niloticus* at the Rwasave Fish Culture Station, at the National Fish Culture Program Station, and in rural Rwandan ponds were used to investigate the suitability of this species for use in the cool, tropical environment of Rwanda. Survival and growth of *O. niloticus*, *Tilapia macrochir*, and *T. rendalli* were compared during a 13-month experiment.

O. niloticus culture was shown to be suitable to Rwandan conditions under appropriate management protocols. Well-managed ponds generally produced 1500-2000 kg/ha/yr, with O. *niloticus* showing better performance than *T. macrochir* and *T. rendalli*. Reproductive performance of *O. niloticus* in Rwanda was strikingly different than that reported for other areas of Africa. Rwanda's cooler climate contributes to delays in the age at first reproduction and lower production of fingerlings (number per unit area). However, the number of fingerlings produced per female was similar. The seasonal effect on reproduction was evident; reproduction decreased during the colder, dry season.

This study provided a basis for designing management strategies that compensate for the cooler environment of high elevation central Africa. This study also demonstrated the importance of regional fingerling production centers to the success of rural tilapia production.

A comparative study of sampling methods of *Oreochromis niloticus* in Rwandan fish ponds

Hanson, B.J., Oregon State University, Oregon
Uwera, M.J., M. Van Speybroeck, F. Rwangano, and E. Rurangwa,
National University of Rwanda, Rwanda

Fishing with seines, a common method of sampling fish populations in ponds, cannot be depended on to provide random unbiased samples. An additional bias may be added through subsampling, which is often done when the sample is too large. The objective of this study was to examine sampling bias and to compare three methods of subsampling.

A series of 11 ponds comprising three experiments were sampled to obtain samples of at least 10% of the population. Samples were taken repetitively over the course of the experiments, including the day before harvest (draining). All individuals in each sample were weighed and measured individually, then divided into four groups according to length. A stratified subsample of 25 individuals was selected using the four groups as strata and the selected individuals were re-weighed and re-measured. The first 25 individuals weighed and measured initially were used as a second subsample. A third subsample was constituted by systematically sampling 25 individuals from the initial sample. At harvest, all fish in the pond were weighed and measured individually.

In two of the three experiments, estimation of the mean weight from the sample of the day before harvest did not differ significantly from the population mean at harvest. For the other experiment, the population mean was overestimated by 8%. The mean estimates of the stratified and systematic subsamples generally did not differ from the mean estimated from the total sample. However, the mean estimate from the "first 25" subsample consistently overestimated the sample mean. The differences were found between the means of morning and afternoon samples taken on the same day. Accurate estimates of fish size and population biomass during the production period are important to research and fish farmers alike. These figures serve as the basis for following growth trends and for the calculation of feeding rates.

Carbon limitation in fertilized fish ponds in Java

McNabb, C.D. and T.R. Batterson,
Michigan State University, Michigan
Eidman, H.M. and K. Sumantadinata,
Institute Pertanian Bogor, Indonesia

The backbone of the Island of Java consists of about 25 major volcanic peaks in a chain 940 km long. Among the peaks are ridges of uplifted coral reef limestone. Ground water and runoff from volcanic regions were mineral poor with carbonate-bicarbonate alkalinity on the order of 20 mg/l. By contrast, the alkalinity of water emerging from limestone was approximately 160 mg/l. When phosphorus and nitrogen fertilizers were added to low alkalinity water in ponds in a volcanic region, the growth of algae and subsequent yield of Nile Tilapia were low: 1.1 g $C/m^2/day$ and 1080 kg fish/ha per 150-day grow-out period, respectively. With low alkalinity, carbon dioxide limited pond production, and phosphorus and nitrogen remained in pond water unused by the algae. When alkalinity was increased to 50-60 mg /l and fertilizer was applied at the same rate used above, algal productivity and fish yield increased to 1.5 g $C/m^2/day$ and 1475 kg fish/ha per 150-day grow-out period. With increased abundance of CO_2 and increased growth of algae, phosphorus and nitrogen uptake from pond water increased, thus improving the efficiency of fertilizer application. However, CO_2 continued to be in short supply at the highest levels of pond production obtained in the experiment. If fertilizer used in the experiment was applied at the same rate to ponds in limestone drainage systems of Java, greater alkalinity and CO_2 availability would likely allow pond productivity to exceed that obtained here. This work shows that CO_2 availability needs to be assessed during the design of fertilizer application schemes in order to use fertilizers economically and to obtain consistent fertilizer-based yields from site to site in Java. This approach appears to be needed in many tropical volcanic regions outside of Java as well.

Nitrate and ammonia depletion in Indonesian aquaculture ponds fertilized with chicken manure

Knud-Hansen, C.F. and T.R. Batterson,
Michigan State University, Michigan
Harahat, I.S., Institute Pertanian Bogor, Indonesia

Twelve 0.2 ha aquaculture ponds for Nile tilapia production in West Java were fertilized weekly with four levels of chicken manure: 12.5, 25, 50, and 100 g/m^2. During a 150-day grow-out period, ammonia-N, nitrate-N, Kjeldahl-N, total and dissolved phosphorus, and several other water quality parameters were monitored weekly. Ammonia-N and nitrate-N levels were often greater than 0.05 mg/l in ponds with 12.5 and 25 g/m^2/week, but less than 0.05 mg/l in ponds fertilized with 50 and 100 g/m^2/week. These differences in dissolved inorganic nitrogen (DIN) between treatment levels, and an apparent nitrogen limitation of algal production at higher loading rates, were examined by making daily and diurnal measurements of ammonia-N and nitrate-N. Data suggest that algal production was limited by a shortage of CO_2 at the low fertilization rates and by a shortage of DIN at high fertilization rates. At high fertilization rates, CO_2 for algae was more abundantly supplied by microbial respiration of organic materials in chicken manure. Laboratory experiments measuring the release of ammonia-N and nitrate-N from chicken manure and urea were conducted to evaluate nitrogen transfer rates from these materials to aquaculture ponds. An economic analysis also was conducted to relate appropriate application rates to cost of fertilizer in West Java. By maximizing nutrient utilization, and therefore algal production, Nile tilapia production can be maximized while minimizing cost to the farmer.

Production and consumption of freshwater prawns-the Thai way

Lin, C.K., University of Michigan, Ann Arbor, Michigan

Production of farmed freshwater prawns (*Macrobrachium rosenbergii* de Man) in Thailand has increased exponentially during the past ten years. The present production, involving more than 2,000 farms over approximately 4,000 ha of pond area, reaches 4,000 tons annually. Most production farms practice intensive monoculture, applying appropriate technology developed locally. Vertically integrated management is adopted by medium- and large-scale farms, who produce their own post-larvae, manufacture supplemental feed, manage ponds, harvest, and wholesale the products. Year-round favorable temperatures, abundant surface water, relatively inexpensive feed and labor, and innovative local technology have been the main factors contributing to profitable and thriving prawn farming in Thailand. Domestic consumption has been the major market for farmed prawns. As prawns are native to Thai waters, many traditional ways of preparing prawn dishes have been developed. Undoubtedly, the success of prawn farming has been intertwined with Thailand's unique anthropological background.

Culture of the walking catfish (*Clarius batrachus*)

McNabb, C. D., T. R. Batterson, and C. F. Knud-Hansen,
Michigan State University, Michigan
Eidman, H. M. and Darnas Dana,
Institut Pertanian Bogor, Indonesia

The walking catfish, *Clarius batrachus*, is a prized commodity in the markets of Indonesia. Supply from wild populations has diminished recently, prompting development of intensive pond culture. High mortality of eggs and fry (70-80%) has slowed progress with culture in Indonesia. The CRSP responded to a local need and built complete spawning and fry/fingerling production facilities for walking catfish at Babakan Station in 1986. In a series of experiments with nesting materials for spawning, fungicidal treatment of eggs, hatchery water quality, and food particle requirements for different stages of fry development, CRSP scientists developed procedures for greater than 90% survival from egg to juvenile plant-out stage. Survival of juveniles to a size suitable for planting in farmers' grow-out ponds was approximately 60% in CRSP facilities at Babakan. This exciting success attracted fish growers to the Station to study the technology developed by the CRSP.

PROJECT DEVELOPMENT AND PUBLIC SERVICE

INSTITUTIONAL DEVELOPMENT

As Pond Dynamics/Aquaculture CRSP projects in developing countries become integrated into USAID's "country strategy," opportunities for providing scientific research support to research institutions and people of these countries has arisen. In each country project of the CRSP, researchers have recognized these opportunities and have assisted their counterparts in initiating activities. Although ancillary to the Global Experiment, these activities contribute to institution building and as such, further the main objectives of the CRSP without interfering with the main strategic approach. These activities also help to promote international scientific linkages through the exchange of technical information. As a result of these contributions, research capabilities have been substantially strengthened in every developing country in which the CRSP has been active. Some of these important contributions are described below.

TRAINING

Although training is not a formal component of this CRSP, the involvement of students from host countries constitutes an important part of the CRSP's international outreach. Enthusiasm for our projects and for learning new skills has led some of these students to graduate school at our participating U.S. universities. The involvement of these universities also has served to extend the domestic outreach of the CRSP.

	Number of Host Country student theses
Rwanda	12
Thailand	0
Indonesia	17
Philippines	1
Honduras	9
Panama	12

CURRICULUM DEVELOPMENT

CRSP participants from the U.S. also were involved in curriculum development at Host Country institutions. In Indonesia, the CRSP project was conducted at the premier agricultural university, Institut Pertanian Bogor (IPB). The CRSP was established at a time in the history of IPB when facilities, graduate programs, and student enrollments were expanding rapidly. The CRSP became an element in this expansion. During the past few years, CRSP researchers had a lead role in writing a research plan for the Faculty of Fisheries of IPB. The plan was written in English and Bahasa Indonesian and was submitted to the USAID Mission in Jakarta in December 1986.

FACILITIES DEVELOPMENT

The CRSP has been instrumental in developing facilities for aquaculture research at Host Country institutions. Babakan Fisheries Station in Indonesia was built in 1982 to accommodate staff and student research, and training in pond aquaculture. CRSP participants established an advanced analytical laboratory for water chemistry at the Station: the first of its kind in IPB's Department of Aquaculture. The laboratory was an important addition because it provided staff and students first-time access to key tools for aquaculture technology. Other major contributions of the CRSP to the development of the station were a deep well to provide groundwater, a hatchery facility for walking catfish, and a weather station. Additionally, the CRSP contributed to the general maintenance and operational needs of the station. When the CRSP terminated its project in Indonesia in September 1987, Babakan Station had the capacity to operate as a full-fledged research site for pond aquaculture.

SHORT COURSES

In Rwanda, building the facilities at the Universite Nationale de Rwanda (UNR) was only one of the steps undertaken by the CRSP in developing adequate support for aquaculture research. Dr. Boyd Hanson taught courses in aquaculture at the University and started a series of small research projects to interest students in fish culture. He introduced biometry into the curriculum and wrote a biometry textbook in French that provides students with examples from the cultivation of bananas, beans, tea, and aquaculture. Dr. Hanson also cooperated with staff from the National Fish Culture Project, UNR, and USAID to produce a reorganization plan for fish culture and development in Rwanda.

EXTENSION

In Honduras, the CRSP greatly contributed to the renewal of interest in aquaculture. The CRSP built on existing infrastructure and assisted the Hondurans in developing an effective aquaculture program. Mr. Bart Green, the U.S. field scientist, was instrumental in the development of an extension program in aquaculture. The CRSP established an excellent water quality laboratory capable of meeting the CRSP's needs as well as those of RENARE (Honduras' Department of Natural Resources). Under the CRSP's guidance, production at the El Carao facility increased nearly three-fold. The station now also produces Chinese carp fingerlings. These improvements were achieved even though pond area for production was decreased to provide more area for research.

COOPERATION WITH HOST COUNTRY AGENCIES AND OTHER GROUPS

The Honduras CRSP also has served as a catalyst in linking together various groups involved in aquaculture. A Honduran national advisory committee has been formed, which represents government agencies, private and state universities, the Peace Corps, and the CRSP. Through the committee's efforts, the first national aquaculture seminar has been held and a second is planned. The ability of the CRSP to work with other programs led the USAID mission in Honduras to fund this outreach for an additional year after the termination of this CRSP project in September 1987.

IMPROVEMENTS IN PRODUCTION AT HOST COUNTRY HATCHERIES

The Panama CRSP has been an effective complement to existing aquaculture activities in Panama. Under the leadership of Dr. Richard Pretto, aquaculture developed rapidly in Panama with emphasis placed on production, demonstration, and extension. The CRSP's focus on research added another dimension to Panama's aquaculture program. At the freshwater station in Gualaca, technical assistance from the CRSP enabled Panama's Department of Aquaculture (DINAAC) to improve its fingerling production techniques and double its production of tilapia fingerlings. Spin-offs of the Global Experiment have resulted in techniques that are applicable to local conditions. In Gualaca, techniques for reducing pond seepage through manuring were offshoots of the Cycle III experiment. These techniques can result in a considerable savings in water while increasing pond fertility.

PRIVATE SECTOR INVOLVEMENT

The CRSP project site in Aguadulce is one of the few brackishwater aquaculture research stations in Latin America. Brackishwater aquaculture is widely practiced in the region; over 110,000 hectares are devoted to the cultivation of marine shrimp. This CRSP project has assisted both DINAAC and private industry with its research on penaeid shrimp. CRSP researchers also have assisted USAID consultants and have given training courses to host country scientists and shrimp farmers. The quality of the staff and facilities developed as part of the CRSP has enabled DINAAC to attract funding from both private and public sources for additional research activities.

In Thailand, the CRSP has developed professional linkages with the Asian Institute of Technology, an international post-graduate technological institute. Dr. Kwei

Lin, the U.S. field scientist, engages in cooperative research activities with scientists from the Asian Institute of Technology and has been appointed a faculty position. The CRSP project in Thailand also enjoys strong cooperation from the USAID mission. In October 1986, the mission contributed $30,000 to the Thailand CRSP.

LINKAGES WITH OTHER INTERNATIONAL AGRICULTURAL INSTITUTIONS

CRSP Scientists from the University of the Visayas, Philippines and the University of Hawaii were awarded a USAID Program on Science and Technology Cooperation (PSTC) grant to study culture techniques of the spotted scat. The PSTC project was closely linked to the CRSP; both projects shared equipment, personnel, and other resources.

Participation in International Scientific Meetings and Conferences

CRSP researchers from the U.S. and Host Countries participated in a number of international aquaculture conferences and meetings.

- CRSP researchers in Rwanda presented papers at a fish culture seminar in Burundi. Participants in the seminar agreed that regional collaboration would benefit fish culture in Rwanda, Burundi, and Zaire. Plans were made to hold the third conference in Zaire (the first was in Rwanda) and to invite representatives from Kenya, Tanzania, and Uganda. The Rwasave station (site of the CRSP) and the Kigembe station (USAID/Auburn-Rwanda Fish Culture Project) were selected as regional centers for research and training. Rwasave would serve as the center for coordinating research activities in the region.
- Ten papers were presented by CRSP researchers from Rwanda, Thailand, Indonesia, and the Philippines at the Second International Symposium on Tilapia in Aquaculture held in Bangkok, Thailand in March 1987.
- CRSP researchers from Panama, Honduras, and the Philippines presented papers at the 1987 World Aquaculture Society Meeting in Ecuador.
- CRSP researchers from Panama presented papers at the Third National Scientific Congress in Panama City in November 1986.
- The Host Country research associate in Rwanda, Mr. Felicien Rwangano, helped to plan activities for the Sixth Annual World Food Day, which was held in October 1986.
- CRSP researchers in Honduras participated in a meeting of the Inter-Agency Committee for Aquacultural Development in Honduras, where they discussed the initiation of an FAO (Food and Agriculture Organization) aquaculture network in Honduras.

PROGRAM MANAGEMENT AND TECHNICAL GUIDANCE

The organizational structure of the Pond Dynamics/Aquaculture CRSP remained the same as in previous years although there were some notable changes in membership of the various governing bodies. New appointments were made to the Management Entity, the Board of Directors, and the Technical Committee. Many participants deemed this a logical time to step down from their positions or to take new assignments in the CRSP. With the imminent reorganization of the program in response to funding constraints, these changes increased the efficiency with which the program operates.

Management Entity

Oregon State University continued to function as the Management Entity for the Pond Dynamics/Aquaculture CRSP. The Management Entity moved to the Office of International Research and Development (OIRD) in the summer of 1986 from its original home in Newport, where it had been based since 1982. The new location, which is next to the Oregon State University Administration Building, facilitates the streamlining of many administrative details essential to properly servicing the CRSP Grant. The CRSP also is part of OSU International Fisheries at OIRD, which is comprised of the Consortium for International Fisheries and Aquaculture Development (CIFAD), the Foreign Fisheries Observer Program, and the International Institute of Fisheries Economics and Trade. The new arrangement with OIRD affords the Management Entity increased support in accounting, purchasing, and other services. The Management Entity is now fully integrated into the larger framework of international agricultural programs at Oregon State University and derives benefits from interacting with these programs. The CRSP, formerly part of the Department of Fisheries and Wildlife in the College of Agriculture, now reports directly to the Vice President for Research, Graduate Studies, and International Programs through the Director of OIRD.

The Program Management Office provides executive linkage between the Management Entity and operations under the CRSP. During this reporting period, members of the Program Management Office included:

- Dr. James E. Lannan, Director (0.5 FTE) to April 30, 1987. Dr. Lannan's continued involvement as a member of the Data Synthesis Team facilitates an orderly transition of CRSP management
- Dr. Howard H. Horton, Director (0.55 FTE) from April 1, 1987
- Ms. Hillary S. Egna, Assistant Director (1.0 FTE)
- Dr. Kevin Hopkins, Associate Director of Data Management (0.5 FTE)
- Mrs. Lydia Perry, Secretary (0.5 FTE)

The Management Entity is responsible for:

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

The ME also is responsible for communications, publications, and management of the Central Data Base.

Specific accomplishments include:

- Preparation of a continuation plan, which was approved as the new CRSP Grant, and of new subcontracts with participatory U.S. universities;
- Preparation of CRSP budgets and subcontractual modifications for extending funding and performance periods;
- Continued assistance in processing travel clearances for CRSP personnel and approvals for purchases of restricted goods for country projects;
- Continuation of a technical information service for overseas research staff—abstracts and tables of contents of current journals are sent to each U.S. Research Associate as requested;
- Publication of research results in two new technical report series and in the quarterly program newsletter;
- Organization of the fifth annual CRSP meeting in Portland, Oregon on February 25-26, 1987 and participation in attendant Board Meetings and Technical Committee Meetings;
- Coordination of the development of the fourth work plan;
- Initiation of planning for the Second Triennial Review by USAID and the major review by the External Evaluation Panel;
- Compilation of the standardized data sets from the three work plans (experimental cycles) completed at seven overseas locations;
- Coordination of activities for the CRSP Data Synthesis Team, the principal U.S.-based research component of this CRSP;
- Participation in the Title XII Regional Seminar (BIFAD) at Michigan State University on January 29-30, 1987;
- Participation with the Planning Subcommittee (of the CRSP Technical Committee) in meetings with USAID staff, BIFAD, and JCARD in January and April 1987;
- Participation in CRSP Directors and Program Managers Workshop ("Decade Two Preparation") in Virginia on July 13-15, 1987;
- Participation in Board Meetings and Technical Committee meetings;
- Assistance to S&T/Agr through participation in its Committee for International Fisheries Research and Assistance Institutions (CIFRAI) on April 27-28, 1987; and
- Coordination of administrative and contractual details for the collaborative research project in Thailand, through meetings in Hawaii, Thailand, and subsequent Board meetings.

Technical Committee

Technical guidance is provided by a Technical Committee composed of the Principal Investigators of CRSP Research Projects and at-large members appointed by the Board of Directors. The Technical Committee has four standing subcommittees: Work Plans, Materials and Methods, Budgets, and Technical Progress. The membership of the Technical Committee and subcommittees is presented in Table 3.

During the past year, the Technical Committee drafted a technical plan for the next phase of the CRSP Global Experiment. A Planning Subcommittee was formed early in the year to begin developing the Technical Plan for continuation of the Global Experiment. The Planning Subcommittee, an ad hoc group composed of one member from each of the participatory institutions (CIFAD, Auburn University, and the University of California at Davis) met with USAID staff in Washington, D.C. on January 21-22, 1987. In their presentations to the Technical Committee, which convened in Portland, Oregon on 25-26 February, 1987, the Planning Subcommittee responded to suggestions from BIFAD/JCARD and USAID staff.

These suggestions later were incorporated into the final technical plan for the continuation of the Global Experiment. This plan formed the backbone of the proposal that was approved by USAID as the new program grant. The plan is based on specific research needs identified from earlier CRSP research activities and from the preliminary model developed by the Data Synthesis Team, and includes experimental protocol for conducting standardized experiments at three overseas locations: Thailand, Rwanda, and Panama.

Technical Committee members, in conjunction with the Program Management Office, wrote a book entitled, *Principles and Practices of Pond Aquaculture* (Lannan, Smitherman, and Tchobanoglous, 1986).

Table 3. THE CRSP TECHNICAL COMMITTEE.

Name	Institution	Subcommittees [2]
Members-at-Large		
Dr. Donald Garling	Michigan State University	W
Dr. R.O. Smitherman	Auburn University	T[3]
Dr. George Tchobanoglous	University of California	T
Principal Investigators		
Dr. Ted Batterson	Michigan State University	M[3]
Dr. Kitjar Jaiyen	National Inland Fisheries Institute, Thailand	B
Dr. Rogelio Juliano	University of the Philippines in the Visayas	M
Dr. William Chang	University of Michigan	T
Dr. James Diana	University of Michigan	W[3]
Dr. Muhammed Eidman	Institute Pertanian Bogor, Indonesia	T
Lic. Jonathan Espinoza	Directorate of Renewable Natural Resources, Honduras	B
Dr. Arlo Fast	University of Hawaii	W
Dr. Philip Helfrich	University of Hawaii	B
Dr. C.D. McNabb	Michigan State University	B
Dr. Valens Ndoreyaho	National University of Rwanda	T
Dr. Ronald Phelps	Auburn University	M
Dr. Raul Piedrahita	University of California	W
Dr. Richard Pretto Malca	National Directorate of Aquaculture, Panama	W
Mr. Wayne Seim	Oregon State University	M
Dr. Richard Tubb	Oregon State University	B[3]
Dr. Howard Horton	Oregon State University	ex-officio
Dr. Richard Neal	USAID Program Manager	ex-officio

1 This list shows the composition of the Technical Committee at the end of the reporting period (31 August 1987)
2 W=Work Plans; B=Budgets; T=Technical Progress; M=Materials and Methods
3 Denotes Subcommittee Chairman Elect

Board of Directors

As the primary policy-making body for the CRSP, the Board of Directors has taken an active role in program guidance. The Board is composed of three members, one of whom is elected chairman. Each of the participatory institutions is represented on the Board. The Program Manager from USAID and the CRSP Director serve as ex-officio members. All Board members function in the objective interest of the CRSP regardless of their institutional affiliation. During this reporting period, the Board members were:

- Dr. Alfred Beeton, University of Michigan (CIFAD institution), Interim Chairman (to 12/86);
- Dr. Donovan Moss, Auburn University, Chairman (from 2/87);
- Dr. Wallis Clark, Jr., University of California at Davis, Member (to 4/87);
- Dr. Robert Fridley, University of California at Davis, Member (from 5/87);
- Dr. Philip Helfrich, University of Hawaii (CIFAD institution), Member (from 12/86);
- Dr. Richard Neal, USAID S&T/AGR, Ex-Officio Member;
- Dr. Howard Horton, Oregon State University, CRSP Director from April 1987, Ex-Officio Member; and
- Dr. James Lannan, Oregon State University, CRSP Director to April 1987, Ex-Officio Member.

The Board of Directors convened eight times during this reporting period.

Sep 9, 1986	Telephone Conference Call
Oct 13, 1986	Telephone Conference Call
Feb 4, 1987	Telephone Conference Call
Feb 25-26, 1987	Portland, Oregon
Mar 24, 1987	Telephone Conference Call
Jul 8, 1987	San Francisco, California
Aug 13, 1987	Telephone Conference Call

The Board of Directors is responsible for:

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

Specific accomplishments and recommendations made during this reporting period include:

- Review of progress of Data Management and the Data Synthesis Team;
- Reorganization of the CRSP in response to recent budget cuts;
- Appointment of the ad hoc Planning Subcommittee of the Technical Committee;
- Approval of Board membership and CRSP directorship;
- Collaboration and coordination of the research program in Thailand;

- Annual meeting agenda input and approval;
- Advice on international travel procedures;
- Guidance on efforts to strengthen the program in the face of funding constraints; and
- Participation in the fifth annual program meeting in February, 1987.

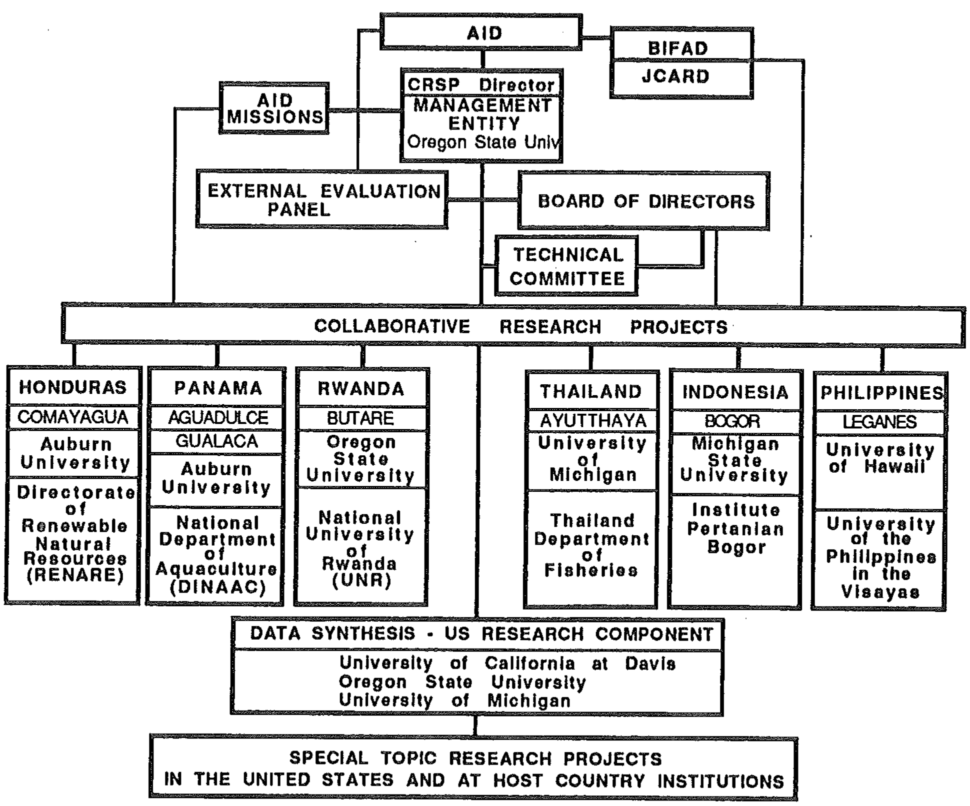
External Evaluation Panel

The External Evaluation Panel is composed of impartial senior aquaculture scientists who were selected on a world-wide basis. The three members of the Panel represent the major disciplines of the CRSP. All have considerable international experience in aquatic sciences. During this reporting period, the members of the External Evaluation Panel were:

- Dr. Homer Buck, Illinois Natural History Survey
- Dr. Kenneth Chew, University of Washington, Seattle, Washington
- Dr. Peter Edwards, Asian Institute of Technology, Thailand

The External Evaluation Panel reviewed the technical plan for continuation of the Global Experiment from 1987 to 1990. They provided input on policy matters and on the agenda and discussion topics for the 1988 annual meeting. They also initiated their second major review of the program. Their review, with the USAID Administrative Management Review, will provide guidance for the Triennial Review, which is conducted by the JCARD CRSP panel and USAID's Agriculture Sector Council Subcommittee.

Figure 3. CRSP Organizational Chart, 1986-1987.



CRSP PUBLICATIONS

The CRSP has facilitated technology dissemination through the establishment of various publications. These publications reach a broad domestic and international audience. During this reporting period, the number of reports and documents of CRSP-supported research increased substantially. To date, over 200 reports and theses have resulted from CRSP research.

PUBLICATIONS

Two new publications were launched this year: *CRSP Research Reports* and *Collaborative Research Data Reports*. *CRSP Research Reports* contains scientific papers written by CRSP researchers on a variety of subjects related to aquaculture. *CRSP Research Reports* was created to respond to needs identified by CRSP participants and USAID staff. The goal of *CRSP Research Reports* is to publish all research produced by CRSP activities, with the exception of research related directly to the Global Experiment. For this purpose, *Collaborative Research Data Reports* was created.

Collaborative Research Data Reports contains the results and data from the Global Experiment, which is the major research activity of the CRSP. *Collaborative Research Data Reports* presents the CRSP Central Data Base along with interpretations of site-specific results. The rate of output of CRSP publications is expected to accelerate as the CRSP Central Data Base becomes more and more complete. The first volume of *Collaborative Research Data Reports* is a reference for the series; it contains descriptions of sites and the experimental protocol for conducting the Global Experiment. Subsequent volumes focus on each of the seven project sites separately by experimental cycle.

These publications add to the informational base that the CRSP has established over five years. *Aquanews*, the program's newsletter, contains informative articles on CRSP projects, a summary of training courses and meetings about aquaculture, and brief notes on the program and its participants. *Aquanews* provides a forum for host country and U.S. participants to share ideas and preliminary research findings. Other reports published by the CRSP include Annual Administrative Reports, Program Grant Proposals, Work Plans, CRSP Directories, and Instructions for Data Entry.

LIST OF REPORTS AND DOCUMENTS

A number of documents were prepared and disseminated during this reporting period. These are briefly described below. Reports of CRSP research that were *not* processed by the Program Management Office are listed in Appendix A.

REPORTS AND DOCUMENTS

Annual Administrative Report

Pond Dynamics/Aquaculture CRSP, Program Management Office. December 1986. Fourth Annual Administrative Report. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 76 pp.

CRSP Grant Proposal

Pond Dynamics/Aquaculture CRSP, Program Management Office. May 8, 1987. Pond Dynamics/ Aquaculture Continuation Plan. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 51 pp.

The Continuation Plan is a proposal for the continuation of the Global Experiment that began in 1982. It contains the technical plan and the program budget for three years of research in pond dynamics and aquaculture. It also presents a conceptual model and a description of program organization and management. The Continuation Plan was incorporated into the new Program Grant.

Directory

Pond Dynamics/Aquaculture CRSP, Program Management Office. 1987. CRSP Directory. Office of International Research and Development, Oregon State University, Corvallis, Oregon.

The CRSP Directory was updated twice in 1987, in April and August, to account for changes in program personnel. The directory contains an organizational flowchart and addresses of current CRSP members of USAID, BIFAD, USAID Missions, and the External Evaluation Committee, Technical Committee, Management Entity, Board of Directors, and Collaborative Research Projects.

Newsletter

Pond Dynamics/Aquaculture CRSP, Program Management Office. Fall 1986, Winter 1987, Spring 1987, and Summer/Fall 1987. Aquanews. Office of International Research and Development, Oregon State University, Corvallis, Oregon.

Four issues of *Aquanews* were published during this reporting period. *Aquanews* is widely distributed and reaches a diverse audience, such as USAID and BIFAD personnel, the world scientific community, USAID Missions, farmers in less developed countries, students, Pond Dynamics/Aquaculture CRSP participants, other CRSP's, and USAID projects. The number of people receiving *Aquanews* has grown from 150 to 250 in the past year alone.

Technical Reports

CRSP Research Reports

Hopkins, K.D., J.E. Lannan, and J.R. Bowman. 1987. A Data Base Management System for Research in Pond Dynamics. CRSP Research Reports 87-1, Program Management Office, Pond Dynamics/Aquaculture CRSP, Office of International Research and Development, Oregon State University, Corvallis, Oregon. 4 pp.

Nash, G., S. Chinabut, and C. Limsuwan. 1987. Idiopathic muscle necrosis in the freshwater prawn, *Macrobrachium rosenbergii* de Man, cultured in Thailand. CRSP Research Reports 87-2, Program Management Office, Pond Dynamics/ Aquaculture CRSP, Office of International Research and Development, Oregon State University, Corvallis, Oregon.

Tavarutmaneegul, P. and C. K. Lin. 1987. Breeding and rearing of sand goby (*Oxyeleotris marmoratus*, Blk.) fry. CRSP Research Reports 87-3, Program Management Office, Pond Dynamics/Aquaculture CRSP, Office of International Research and Development, Oregon State University, Corvallis, Oregon.

CRSP Research Reports 87-2 and 87-3 were issued as Notices of Publication, which provide the abstract of the paper and information on where copies may be obtained. *CRSP Research Reports* and Notices of Publication provide a means for the CRSP to comprehensively document all of the research activities conducted by CRSP personnel.

Collaborative Research Data Reports

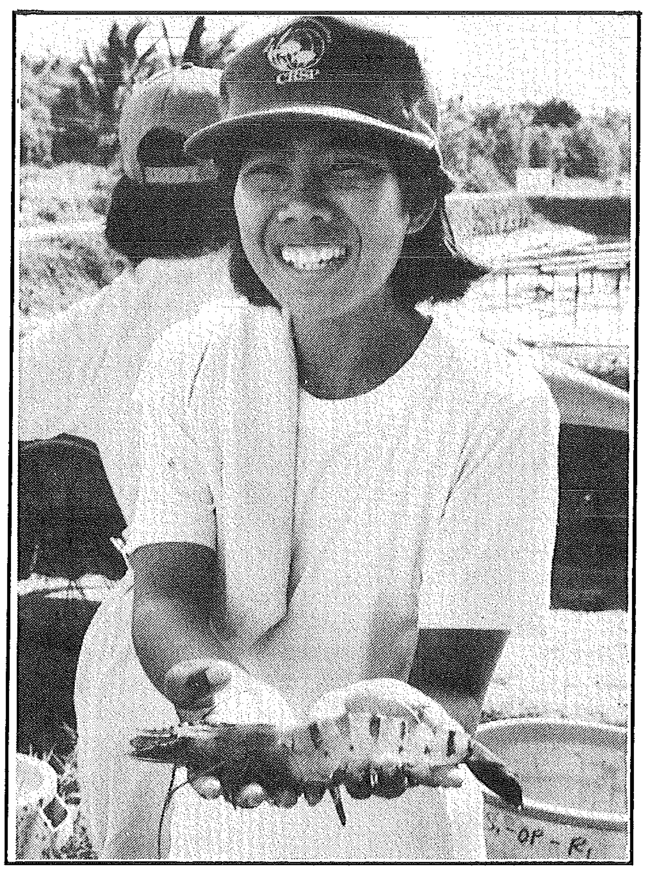
Egna, H.S., N. Brown, and M. Leslie. 1987. General Reference: Site Descriptions, Materials and Methods for the Global Experiment. Collaborative Research Data Reports, Volume 1. Program Management Office, Pond Dynamics/Aquaculture CRSP, Office of International Research and Development, Oregon State University, Corvallis, Oregon. 84 pp.

Diana, J.S., C.K. Lin, T. Bhukaswan, and V. Sirsuwanatach. 1987. Thailand: Cycle I of The Global Experiment. Collaborative Research Data Reports, Volume 2. Program Management Office, Pond Dynamics/Aquaculture CRSP, Office of International Research and Development, Oregon State University, Corvallis, Oregon. 47 pp.

Books

J.E. Lannan, R.O. Smitherman, and G. Tchobanoglous, eds. 1986. Principles and Practices of Pond Aquaculture. Oregon State University Press, Corvallis, Oregon, 272 pp.

This book is a state-of-the-art synthesis of the principles and practices of pond aquaculture and provides original insights into the mechanisms that regulate productivity in pond culture systems. It was published during the previous reporting period, in July 1986, but only during this period has it shown its popularity with a three-fold increase in sales. Oregon State University Press describes it as a very successful book that has been a popular request as a textbook for aquaculture courses taught at various U.S. and foreign universities. The book also has succeeded in reaching the world aquaculture community -- copies have been sent to over 21 countries.



STAFF SUMMARY

The Pond Dynamics/Aquaculture CRSP represents the joint efforts of more than 50 professionals and a number of support personnel from U.S. universities. It also represents the collaborative efforts of over 80 scientists, technicians, and graduate students from seven project sites in six developing 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; Data Management, Analysis, and Modelling; and Research Administration.

In addition to staff with formal CRSP assignments, many individuals have participated in the development of host country projects. The CRSP team in the Philippines reported that over 20 professors, instructors, and research assistants at the University of the Philippines in the Visayas played a major role in the success of the research program at the Brackishwater Aquaculture Center in Iloilo. CRSP research in Indonesia benefited from the participation of a number of undergraduate and graduate students conducting pond dynamics experiments at the Bogor site. Growing interest in the CRSP program has resulted in an increase in the number of host country research assistants and scientists participating in the Thailand, Panama, Honduras, and Rwanda CRSP projects.

The major United States-based research activity, Data Synthesis and Data Management, is represented by 10 researchers from three universities: University of California at Davis, Oregon State University, and the University of Michigan. Scientists from Michigan State University, Auburn University, University of Arkansas at Pine Bluff, and the University of Hawaii also participate in U.S.-based

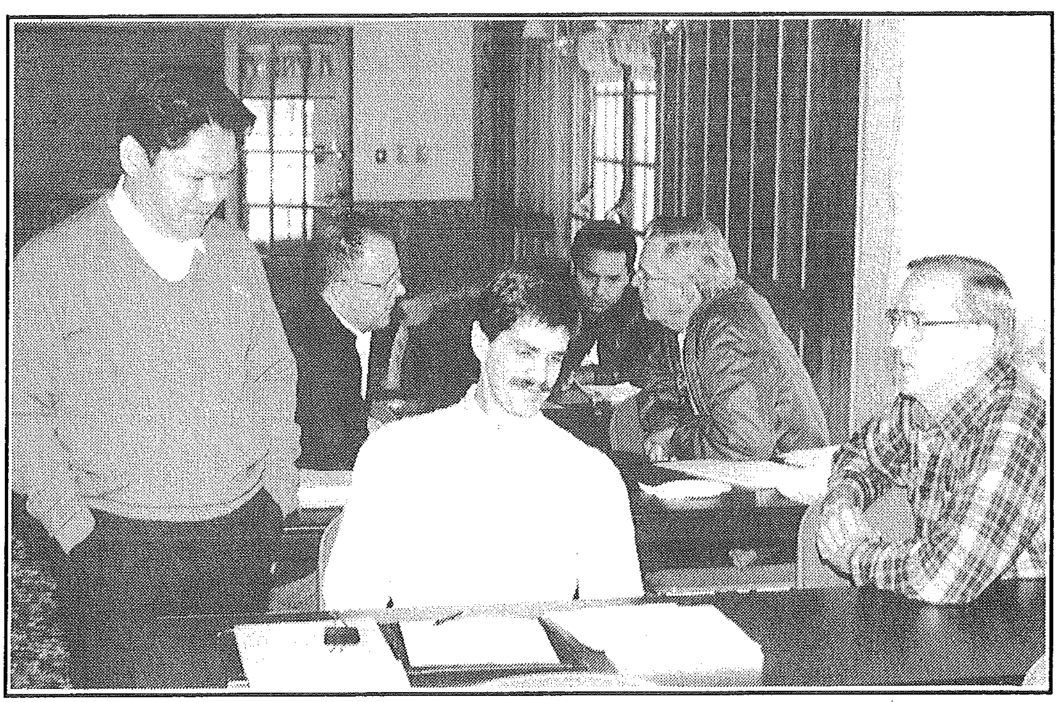


TABLE 4

STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization: Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Location of Work (1)
BOARD OF DIRECTORS						
Dr. Alfred Beeton	Interim Chairman (to 12/86)	x	x			Ann Arbor, MI
Dr. Philip Helfrich	Member (from 12/86)	x		x		Kaneohe, HI
Dr. Robert Fridley	Member (from 5/87)	x	x	x		Davis, CA
Dr. Wallis Clark, Jr.	Member (to 4/87)	x		x		Davis, CA
Dr. Donovan D. Moss	Chairman	x		x		Auburn, AL
TECHNICAL COMMITTEE						
Dr. Donald Garling	Member			x		East Lansing, MI
Dr. R. Oneal Smitherman	Member			x		Auburn, AL
Dr. G. Tchobanoglous	Member			x		Davis, CA
MANAGEMENT ENTITY						
Dr. James Lannan	Director (to 4/87)	x		x	x	Corvallis, OR
Dr. Howard Horton	Director (from 4/87)	x		x		Corvallis, OR
Ms. Hillary Egna	Assistant Director	x	x	x		Corvallis, OR
Dr. Kevin Hopkins	Associate Director of Data Mgmt.	x		x	x	Corvallis, OR
Mr. James Bowman	Graduate Research Assistant (to 8/87)			x	x	Corvallis, OR
Ms. Hilary Berkman	Graduate Research Assistant (from 3/87)		x	x	x	Corvallis, OR
Mrs. Lydia Perry	Secretary	x				Corvallis, OR
Mr. Bruce Sorte	Fiscal Officer	x				Corvallis, OR

TABLE 4. (Continued)
STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization: Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Location of Work (1)
HONDURAS - AUBURN UNIVERSITY PROJECT						
Dr. Ronald P. Phelps	U.S. Principal Investigator	x		x		Auburn, AL
Lic. Jonathan Espinoza	H.C. Principal Investigator			x		Tegucigalpa, Honduras
Mr. Bartholomew Green	U.S. Research Associate		x	x		Comayagua, Honduras
Ing. Hermes Alvarenga	H.C. Research Associate		x	x		Comayagua, Honduras
Mr. James McDonough	Fiscal Officer	x				Auburn, AL
Mr. Ricardo Gomez	H.C. Lab Assistant			x		Comayagua, Honduras
Mr. Cesar Salinas	H.C. Research Assistant			x		Comayagua, Honduras
Mr. Miguel Zelanya	H.C. Lab Technician			x		Comayagua, Honduras
Mr. J. Ludovico Ayala	H.C. Lab Assistant		x	x		Comayagua, Honduras
Mr. Victor Pineda	H.C. Student			x		Comayagua, Honduras
Mr. Sagrario Calix	H.C. Secretary	x				Comayagua, Honduras
INDONESIA - MICHIGAN STATE UNIVERSITY PROJECT						
Dr. Clarence McNabb	U.S. Co-Principal Investigator		x	x		East Lansing, MI
Dr. Ted Batterson	U.S. Co-Principal Investigator	x	x		x	East Lansing, MI
Dr. Muhammed Eidman	H.C. Principal Investigator	x		x		Institut Pertanian Bogor, Indonesia
Dr. Chris Knud-Hansen	U.S. Research Associate		x	x	x	Institut Pertanian Bogor, Indonesia
Mr. Komar Sumantadinata	H.C. Research Associate			x		Institut Pertanian Bogor, Indonesia
Mr. Darnas Dana	H.C. Research Associate			x		Institut Pertanian Bogor, Indonesia
Mr. Gerald Jacobs	Fiscal Officer	x				East Lansing, MI
Mr. Ralph Beebe	U.S. Graduate Research Assistant		x		x	East Lansing, MI
Mr. Odang Carman	H.C. Research Assistant		x	x		Institut Pertanian Bogor, Indonesia
Ms. Pipih Suptijah	H.C. Research Assistant		x			Institut Pertanian Bogor, Indonesia
Ms. Yani Hadiroseyani	H.C. Research Assistant			x		Institut Pertanian Bogor, Indonesia
Mr. Dedi Yusadi	H.C. Research Assistant			x		Institut Pertanian Bogor, Indonesia
Ms. Ella Salamah	H.C. Research Assistant			x		Institut Pertanian Bogor, Indonesia

TABLE 4. (Continued)

STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization: Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Location of Work (1)
PANAMA, AGUADULCE - AUBURN UNIVERSITY PROJECT						
Dr. Ronald P Phelps (2)	U.S. Principal Investigator	x		x		Auburn, AL
Dr. Richard Pretto Malca (2)	H.C. Principal Investigator	x		x		Santiago de Veraguas, Panama
Dr. David Hughes	U.S. Research Associate		x	x		Aguadulce, Panama
Mr. James McDonough	Fiscal Officer	x				Auburn, AL
Mr. Jorge Garcia	H.C. Station Chief			x		Aguadulce, Panama
Ms. Graciela de Gomez	H.C. Chemistry Lab Director		x			Aguadulce, Panama
Mr. Ernesto Lasso de la Vega	H.C. Field Biologist			x		Aguadulce, Panama
Ms. Cenobia Quintero	H.C. Field Biologist			x		Aguadulce, Panama
Mrs. Marquisela Arrue de Friedman	H.C. Field Biologist			x		Aguadulce, Panama
Ms. Illeana de Zapata	H.C. Technician			x		Aguadulce, Panama
Mr. Modaldo Bonilla	H.C. Technician			x		Aguadulce, Panama
Mr. Rugierro del Valle	H.C. Data Processor				x	Aguadulce, Panama
Mr. Lenin Santamaria	H.C. Field Biologist		x	x		Aguadulce, Panama
Mrs. Dora Hernandez de Santamaria	H.C. Field Biologist			x		Aguadulce, Panama
Mr. Hipolito Chavez	H.C. Field Biologist			x		Aguadulce, Panama
Mr. Miguel de Leon	H.C. Field Biologist			x		Aguadulce, Panama
Mr. Hamed Tunon	H.C. Field Biologist			x		Aguadulce, Panama
Ms. Aida de Urriola	Administrative Assistant	x				Aguadulce, Panama
Ms. Eva Yaniselli	H.C. Chemist		x			Aguadulce, Panama
Ms. Luz Divina	H.C. Computer Technician	x			x	Aguadulce, Panama
Ms. Blanca Canto	H.C. Librarian	x				Aguadulce, Panama

TABLE 4. (Continued)

STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization: Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Location of Work (1)
PANAMA, GUALACA - AUBURN UNIVERSITY PROJECT						
Dr. Ronald Phelps (2)	U.S. Principal Investigator	x		x		Auburn, AL
Dr. Richard Pretto Malca (2)	H.C. Principal Investigator	x		x		Santiago de Veraguas, Panama
Dr. David Teichert-Coddington	U.S. Research Associate			x		Gualaca, Panama
Mr. Medardo Peralta	H.C. Research Associate			x		Gualaca, Panama
Mr. James McDonough	Fiscal Officer	x				Auburn, AL
Mr. Nelly Serano	H.C. Technician		x			Gualaca, Panama
Mr. Ricardo Rios	H.C. Technician			x		Gualaca, Panama
Ms. Itozela Davis	H.C. Technician			x		Gualaca, Panama
PHILIPPINES - UNIVERSITY OF HAWAII PROJECT						
Dr. Arlo Fast	U.S. Co-Principal Investigator	x		x		Univ. of Hawaii
Dr. Philip Helfrich	U.S. Co-Principal Investigator	x		x		Univ. of Hawaii
Dr. Rogelio Juliano	H.C. Co-Principal Investigator	x		x		Univ. Philippines in the Visayas
Dr. Jose Carreon	H.C. Co-Principal Investigator	x		x		Univ. Philippines in the Visayas
Dr. Kent Carpenter	U. S. Research Associate			x		Brackish Water Aquaculture Center, Philippines
Dr. Romeo Fortes	H.C. Research Associate			x		Brackish Water Aquaculture Center, Philippines
Mr. William Coops	Fiscal Officer	x				Univ. of Hawaii
Dr. Yvonne Chiu	Special Project Leader			x		Univ. Philippines in the Visayas
Ms. Cecilia Minsalan	Special Project Leader			x		Univ. Philippines in the Visayas
Ms. Lea Ver	Special Project Leader			x		Univ. Philippines in the Visayas

TABLE 4. (Continued)

STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization: Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Location of Work (1)
PHILIPPINES (CONTINUED) - UNIVERSITY OF HAWAII PROJECT						
Prof. V.L. Corre	H.C. Research Coordinator			x		Brackish Water Aquaculture Center, Philippines
Mr. V. Estilo	H.C. Data Manager			x	x	Brackish Water Aquaculture Center, Philippines
Ms. E. Pudadera	H.C. Technician			x		Brackish Water Aquaculture Center, Philippines
Ms. G.T. Aaron	H.C. Technician			x		Brackish Water Aquaculture Center, Philippines
Ms. P.J. Carpio	H.C. Technician		x			Brackish Water Aquaculture Center, Philippines
Ms. Z. Feliciano	H.C. Technician		x			Brackish Water Aquaculture Center, Philippines
Ms. I.G. Pahila	H.C. Technician		x			Brackish Water Aquaculture Center, Philippines
Ms. E. Naret	H.C. Technician		x			Brackish Water Aquaculture Center, Philippines
Mr. H. Gonzales	H.C. Technician			x		Brackish Water Aquaculture Center, Philippines
Mr. R. Sanares	H.C. Technician				x	Brackish Water Aquaculture Center, Philippines
Mr. G. Domingo	H.C. Technician			x		Brackish Water Aquaculture Center, Philippines
Ms. R.L. Janeo	H.C. Technician			x		Brackish Water Aquaculture Center, Philippines
Ms. Mary Sastrillo	Special Project			x		Brackish Water Aquaculture Center, Philippines
RWANDA - OREGON STATE UNIVERSITY PROJECT						
Dr. Richard Tubb	U.S. Co-Principal Investigator	x	x	x		Corvallis, OR
Mr. Wayne Seim	U.S. Co-Principal Investigator	x	x			Corvallis, OR
Dr. Valens Ndoreyaho	H.C. Principal Investigator		x			Rwanda
Dr. Boyd Hanson	U.S. Research Associate		x	x	x	Corvallis, OR
Mr. Felicien Rwangano	H.C. Research Associate			x		Rwanda
Mr. Eugene Rurangwa	H.C. Research Associate			x		Rwanda
Mr. Bruce Sorte	Fiscal Officer	x				Corvallis, OR
Mr. Joseph Murangwa	H.C. Computer Technician				x	Rwanda
Mr. Marijke Van Speybroeck	H.C. Participant			x		Rwanda
Mr. Celestin Harwanimbaga	H.C. Student		x			Rwanda
Ms. Marie Jeanne Uwera	H.C. Student		x			Rwanda
Mr. Ngoy Kasongo	H.C. Technician		x			Rwanda
Mr. Alfonsine Murekeyisoni	H.C. Technician		x			Rwanda

TABLE 4. (Continued)

STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization: Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Location of Work (1)
THAILAND - UNIVERSITY OF MICHIGAN PROJECT						
Dr. James Diana	U.S. Principal Investigator			x		Ann Arbor, MI
Dr. Thiraphan Bhukaswan	H.C. Principal Investigator (to 2/87)			x		NIFI, Thailand
Dr. Kitjar Jaiyen	H.C. Principal Investigator (from 2/87)		x	x		NIFI, Thailand
Dr. C. Kwei Lin	U.S. Research Associate		x	x		NIFI, Thailand
Dr. Sompong Hiranyawat	H.C. Research Associate			x		NIFI, Thailand
Dr. Sompotte Ukatawewat	H.C. Research Associate			x		Ayutthaya, Thailand
Ms. Barbara Murphy	Fiscal Officer	x				Ann Arbor, MI
Dr. Philip Schneeberger	U.S. Research Associate			x		Ann Arbor, MI
Mr. Vinij Tansakul	H.C. Data Processor			x	x	NIFI, Thailand
Mr. Somlek Auworatham	H.C. Research Assistant			x		NIFI, Thailand
Mr. Worathep Muthuwana	H.C. Research Assistant		x			Ayutthaya, Thailand
Mr. Wirawan Chinaksorn	H.C. Research Assistant			x		Ayutthaya, Thailand
Mr. Agaluck Saloaw	H.C. Research Assistant			x		Chacheongsao, Thailand
Mr. Tongsuk Saelee	H.C. Research Assistant			x		Chacheongsao, Thailand
Mr. Supranee Chinabut	H.C. Scientific Collaborator			x		NIFI, Thailand
Mr. Chalor Limsuwan	H.C. Scientific Collaborator			x		Kasetsart Univ., Thailand

TABLE 4. (Continued)

STAFF SUMMARY: COLLABORATIVE RESEARCH PROJECTS

Individual	CRSP Function	Field(s) of Specialization: Research Admin.	Limnology/ Water Quality	Fisheries/ Aquaculture	Data Management	Location of Work (1)
DATA SYNTHESIS AND ANALYSIS - COLLABORATIVE PROJECT WITH UNIV. OF CALIFORNIA, DAVIS AND UNIV. OF MICHIGAN						
Dr. Raul Piedrahita	Data Synthesis Team Leader		x	x	x	Davis, CA
Dr. William Chang	Data Synthesis Team Member		x	x	x	Ann Arbor, MI
Dr. James Lannan	Data Synthesis Team Member	x		x	x	Newport, OR
Mr. Steven Francis	Data Synthesis Assistant				x	Davis, CA
Ms. Cory Pannatoni	Data Synthesis Assistant				x	Davis, CA
Mr. Philip Giovannini	Data Synthesis Assistant				x	Davis, CA
U.S. SPECIAL TOPIC RESEARCH PROJECTS						
Dr. Rex Dunham	U. S. P.I., Special Topics			x		Auburn, AL
Dr. Lawrence Curtis	U. S. P.I., Special Topics		x	x		Corvallis, OR

(1) Denotes primary work location and excludes host country site visits and travel for attendance of meetings.
(2) Researchers involved in two projects

FINANCIAL SUMMARY

This section summarizes the expenditure of USAID and non-federal funds for CRSP research activities and program management. This unaudited summary is intended to provide an overview of CRSP progress relative to program budgets.

The Pond Dynamics/Aquaculture CRSP, like the other CRSP's, endured two substantial Gramm-Rudman budget cuts in 1986 and 1987. The 1985 budget of $1,300,000 was reduced approximately 17.5% to an obligation of $1,070,000 in 1986. The 1986 budget was further reduced by approximately 13% to a final obligation of $936,000.

The expenditure of USAID funds by Collaborative Research Projects, Special Topics research, and Program Management functions is presented in Table 5 for the CRSP contract year of September 1, 1986 to August 31, 1987. The 1987 total includes expenditures of funds obligated in 1986. This lag in expenditure of appropriated funds is often referred to as the "pipeline" accumulation. These accumulations result from a variety of sources including delays in finalizing obligations from USAID, delays in negotiating subcontracts with CIFAD and the collaborating universities, delays in processing purchase orders and in the delivery goods, delays in receiving and processing invoices, and delays in billing OSU for project costs. Because 1987 marked the end of our five-year grant, all pipeline funds had to be spent by August 31, 1987. As a consequence, the $1,161,483 spent is considerably in excess of the $936,000 obligated for 1987.

The data for the Collaborative Research Projects includes all expenditures made to support research efforts at the seven project sites from September 1, 1982 to August 31, 1987. The data for Special Topics includes expenditures to support Data Synthesis at the University of California, Davis, and at the University of Michigan, as well as special research projects at the University of Hawaii, University of Michigan, Oregon State University, and Auburn University.

The information on Program Management expenditures includes expenses to support the Program Management Office, the Board of Directors, the External Evaluation Panel, the at-large members of the Technical Committee, and the data base management function. The five-year total for Program Management expenses accounts for 15% of the USAID funds. This level of expenditure for Program Management reflects the philosophy of the CRSP to minimize overhead costs and expend the major share of limited funds on research activities. However, compliance with USAID and BIFAD guidelines that have evolved since implementation of the CRSP continues to strain the CRSP Program Management budget. The minimum managements costs for a CRSP are fixed and independent of total funding. We note that the management costs of most of the CRSP's are near 20%.

Cost sharing contributions from the U.S. institutions are presented in Table 5. These data reflect continuing commitments to participation in the CRSP. It appears that the amounts reported approximate the 25 percent cost sharing requirement. However, confirmation of this requires further accounting because the amounts to be excluded in calculating cost sharing requirements in accordance with BIFAD guidelines must be determined after the fact.

Host country contributions (in U.S. dollars) are also presented in Table 5. The data were provided by the Principal Investigators of the projects. Although Host Country cost sharing is not required, these data indicate a continuing commitment to participation in the CRSP.

Table 5. Financial Summary of the Pond Dynamics/Aquaculture CRSP by USAID Funds, Cost Sharing, and Host Country Contributions

	USAID Funds		Cost Sharing		Total		Host Country	
	1987	Cumulative	1987	Cumulative	1987	Cumulative	1987	Cumulative
Collaborative Research Projects								
Honduras-Auburn U.	95,526	434,052	5,030	87,442	100,556	521,494	56,868	327,668
Indonesia-Michigan S.U.	167,018	705,071	13,143	185,050	180,161	890,121	13,565	284,365
Panama-Auburn U.	138,594	641,514	40,798	164,067	179,392	805,581	150,000	509,090
Philippines-U. Hawaii	161,666	685,194	86,203	226,503	247,869	911,697	38,325	128,625
Rwanda-Oregon S.U.	147,130	631,667	17,558	66,414	164,688	698,081	48,010	300,682
Thailand-U. Michigan	162,192	637,415	36,248	99,480	198,440	736,895	10,000	145,450
Subtotal	872,126	3,734,913	198,980	828,956	1,071,106	4,563,869	316,768	1,695,880
Special Topics								
Auburn University	45,984	50,965	383	10,240	46,367	61,205		
Oregon State University	4,034	24,993	5,003	13,325	9,037	38,318		
Univ. California, Davis	50,798	78,393	7,500	14,600	58,298	92,993		
University of Hawaii	981	16,668	1,725	5,647	2,706	22,315		
University of Michigan	25,620	55,640	5,210	14,753	30,830	70,393		
Subtotal	127,417	226,659	19,821	58,565	147,238	285,224		
Program Management								
Management Office-OSU	148,547	589,797			148,547	589,797		
Boards, Committees, Panels	13,393	120,368			13,393	120,368		
Subtotal	161,940	710,165			161,940	710,165		
TOTAL	1,161,483	4,671,737	218,801	887,521	1,380,284	5,559,258	316,768	1,695,880

APPENDIXES

APPENDIX A. LIST OF PUBLICATIONS

Pond Dynamics/Aquaculture
Collaborative Research Support Program
As of 12/87

AUBURN/HONDURAS

Theses

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

Cerna, C. In preparation. Zooplankton dynamics in Tilapia nilotica production ponds fertilized with triple superphospate. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

Echeverria, M.A. In preparation. Primary production in Tilapia nilotica production ponds fertilized with triple superphosphate. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

Garces, C. 1986. Quantitative analysis of zooplankton in fish ponds fertilized with triple superphosphate during the rainy season. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

Gomez, R. In preparation. Production of Tilapia nilotica in ponds fertilized with dairy cow manure. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

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

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

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

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

Reports

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

Alvarenga, H.R. and B.W. Green. 1984. Growth and production of all male *Tilapia nilotica* and all male hybrid tilapia (*Tilapia nilotica* x *Tilapia honorum*) in ponds. C.R.S.P. Technical Report, unpublished. 11 pp. (In Spanish.)

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APPENDIX B. LIST OF ACRONYMS

Administrative Council (for a CRSP)	a group of university administrators, composed of a representative from each U.S. institution in a CRSP; sometimes called Board of International Representatives; each member represents the interests of higher institutions as well as the CRSP
AID	Agency for International Development
ALA	Latin American Aquaculture Association (1st Symposium Venez. 1977; 2nd Mexico 1972)
AU	Auburn University
BAC	Brackishwater Aquaculture Center
Baseline Data	that information and data base in some sector or aspect of a developing country which is necessary to measure change in the future
BFAR	Board for Food and Agriculture Research
BIFAD	Board for International Food and Agricultural Development, U.S.
Bilateral Programs	assistance programs involving arrangements between a single developing country and a single donor country
Board of Directors (for a CRSP)	an advisory body selected to assist, advise, and make policy recommendations to the ME in the execution of a CRSP; members represent the interests of the CRSP
CIFAD	Consortium for International Fisheries and Aquaculture Development
COFINA	Development Finance Corporation
Collaborating Institutions	institutions which form a partnership arrangement with a lead participating U.S. institution to collaborate on a specific research project
CRSP	Collaborative Research Support Program, USAID Title XII
DINAAC	Direccion Nacional de Acuicultura (National Department of Aquaculture), Panama
DST	Data Synthesis Team (also called Data Synthesis and Analysis Team)
EEP	External Evaluation Panel - senior scientists not involved in the CRSP and selected externally for their ability to evaluate objectively the scientific progress and relevance of a CRSP program on an ongoing basis
EOP	Equal Opportunity Programs
FTE	Full Time Equivalent

Global Plan	the overall plan of a CRSP for research on problems and constraints, global in nature, whose results are applicable and transferable regionally and globally worldwide)
Grant Agreement	the formal legal document which represents a binding agreement between AID and the ME institution for a CRSP; this is the legal document for the CRSP recognized as such by AID and the recipient institutions
Grant Proposal	The formal document submitted by an ME to AID, proposing a CRSP for receiving a grant outlining the manner of implementation of the program, and showing the budgetary requirements
Host Country (HC)	a developing country in which a CRSP has formal activities
Institutional Development	improvement in the capability of institutions in developing countries to conduct development programs for agriculture and other sectors, or for implementing educational/training, research, health, and other public programs; improvements may include physical facilities, equipment, furnishings, transportation, organization, but refers primarily to development and training of professional cadre
IPB	Institut Pertanian Bogor, Indonesia
JCARD	Joint Committee on Agricultural Research and Development (formerly Joint Research Committee), BIFAD
JRC	Joint Research Council, USAID
LDC	Lesser Developed Countries
Matching Requirement document	that sum of resources, financial or in-kind, which participating U.S. institutions must collectively contribute to a CRSP program as defined in the grant
ME	Management Entity
MIDA	Ministerio de Desarrolo Agropecuario (Ministry of Agricultural Development), Panama
Mission	a formally organized USAID unit in a developing country led by a Mission Director or a country representative
MOU	Memorandum of Understanding
MSU	Michigan State University
NIFI	National Inland Fisheries Institute, Thailand
OIRD	Office of International Research and Development

OSU	Oregon State University
Participating Institutions	those institutions that participate in the CRSP under a formal agreement with the management institution which receives the AID grant
PD/A CRSP	Pond Dynamics/Aquaculture Collaborative Research Support Program
PI	Principle Investigators - scientists in charge of the research for a defined segment or a scientific discipline of a CRSP
PMO	Program Management Office
Program Manager	an official AID employee designated to oversee a CRSP on behalf of AID
RENARE	Directorate of Renewable Natural Resources, Honduras
S&T Bureau (S&T AGR)	Bureau of Science and Technology, a central bureau of AID in Washington, charged with administering worldwide technical and research programs for the benefit of U.S. AID-assisted countries
SELA	Latin American Economic System
Subgrant Agreement	a document representing a subagreement made between the ME and a participating institution under authority of the grant agreement by the ME and AID
TC	Technical Committee - a group of scientists participating in the research of the CRSP as PI's, selected to help guide the scientific aspects of the research program of a CRSP
TDY	Temporary Duty
Title XII	the Title XII Amendment to the International Development and Food Assistance Act of 1975 as passed by the United States Congress and subsequently amended
UAPB	University of Arkansas at Pine Bluff
UC Davis	University of California at Davis
UH	University of Hawaii
UM	University of Michigan
UNR	Universite Nationale de Rwanda (National University of Rwanda)
UPV	University of the Philippines in the Visayas
USAID	United States Agency for International Development