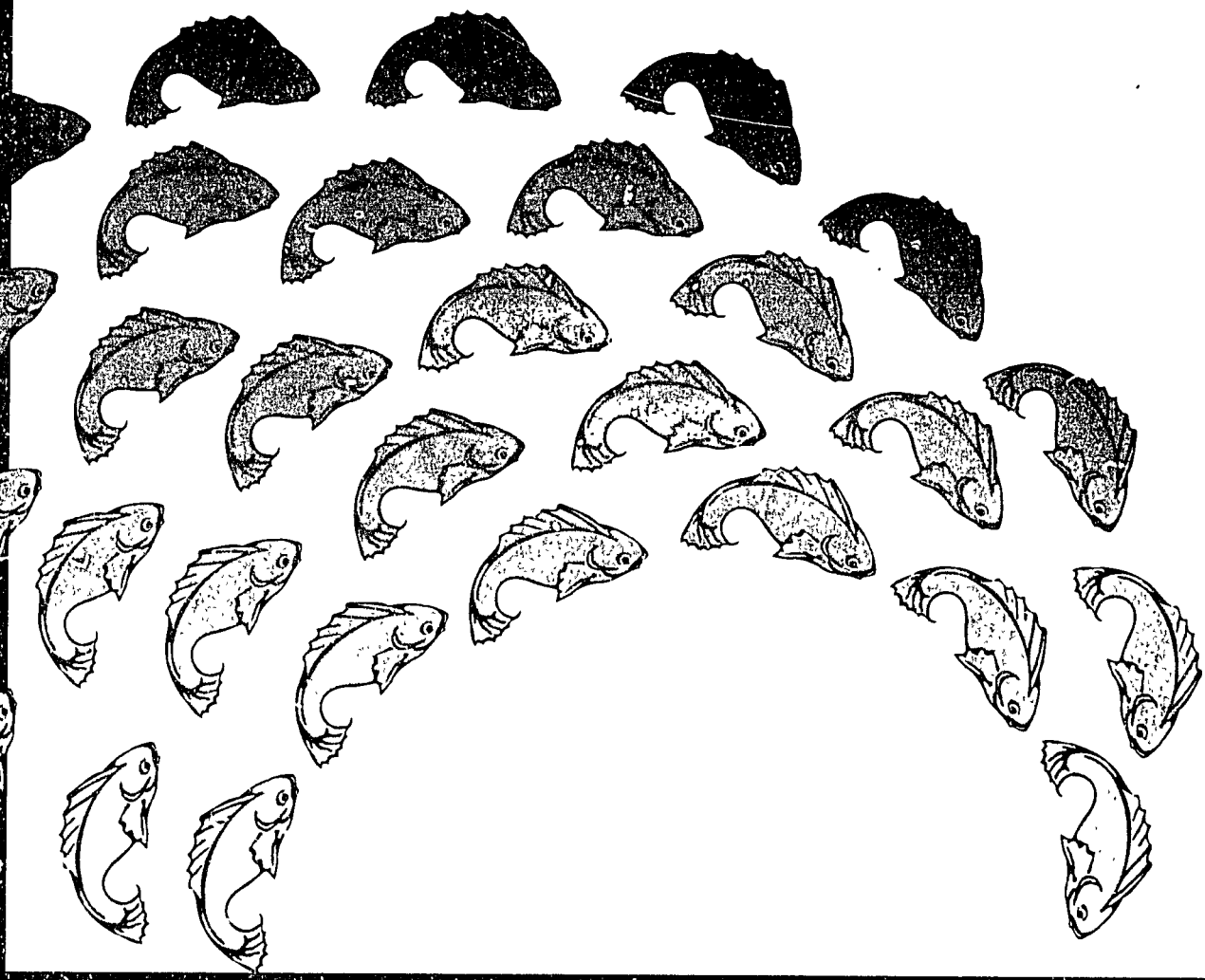
TITLE XII

COLLABORATIVE RESEARCH SUPPORT PROGRAM
ELEVENTH ANNUAL ADMINISTRATIVE REPORT



1 SEPTEMBER 1992 TO 31 AUGUST 1993

-PN-ABS-241 TSN=89761

Title XII Collaborative Research Support Program

Eleventh Annual Administrative Report

1 September 1992 to 31 August 1993

Printed in July 1994

Disclaimer
The contents of this document do not necessarily represent an official position or policy of the United States Agency for International Development (USAID) Also, the mention of trade names or commercial products in this report does not constitute endorsement or recommendation for use on the part of USAID or the Pond Dynamics Aquaculture Collaborative Research Support Program

This report addresses program accomplishments of the Pond Dynamics/Aquaculture Collaborative Research Support Program during the reporting period of 1 September 1992 to 31 August 1993. Program activities are funded in part by the United States Agency for International Development (USAID) under Grant No DAN-4023-G-00-0031-00. The Egypt Project of the PD/A CRSP is funded by USAID Grant No. 263-0152-G-00-2231-00.

Edited by Hillary Egna and Marion McNamara

Acknowledgements
The Program Management Office of the Pond Dynamics/Aquaculture CRSP gratefully acknowledges the support provided by the Central Laboratory for Aquaculture Research in Abbassa, the Royal Thai Department of Fisheries, the Department of Renewable Natural Resources in Honduras, the Asian Institute of Technology, the National University of Rwanda, The Freshwater Aquaculture Center at Central Luzon State University in the Philippines, and the contributions of researchers from these institutions and from the U.S. institutions involved in this CRSP.

Pond Dynamics/Aquaculture CRSP Management Office
Office of International Research and Development
Oregon State University
Snell Hall 400
Corvallis, Oregon 97331-1641 USA

Table of Contents

I. Introduction 5

Historical Overview 5
New Projects and Opportunities 6
Continuing Activities 8

II. Summary of Activities and Accomplishments 10

Overseas Research 10
- Honduras 10
- Rwanda 11
- Thailand 11
- Egypt 12

Data Analysis and Synthesis 13
Central Data Base 13
Annual Technical Committee Meeting 14

III. CRSP Research Program Background 15

The CRSP Research Program 15
CRSP Work Plans 16

IV. Public Service and Project Development 17

Institution Building 17
Education and Professional Development 19
- Thailand and Philippines 19
- Honduras 20
- Rwanda 20
- Egypt 20

Linkages 22
Project Development 24
Socioeconomic Studies 25
Participation in International Scientific Meetings and Conferences 27

V. Program Management and Technical Guidance 28

Management Entity 29
The Board of Directors 31
Technical Committee 32
Membership of Technical Committee 33
Institutional Voting Privileges on Technical Committee 35
External Evaluation Panel 36
CRSP Publications 36
Administrative Reports 37
Annual Administrative Report 37
- Quarterly Reports 37
- Brochures 38
- Directory 38
- Newsletters 38

Technical Reports 39
- CRSP Research Reports 39

VI. Financial Summary 40

Expenditure of Funds 41
Egypt Project Expenditure from 10/1/92 through 8/31/93 42

VII. Staff Summary 43

VIII. CRSP List of Publications 53

Data Analysis and Synthesis Team 53
Honduras 54
Indonesia 56
Panama – Aguadulce 57
Panama – Gualaca 58
The Philippines 58
Rwanda 59
Thailand 61
CRSP Research Reports 63

IX. Abstracts of Technical Papers 65

Appendix.
List of Acronyms and Definitions 76

I. Introduction

Historical Overview

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

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

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

New Projects and Opportunities

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

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

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

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

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

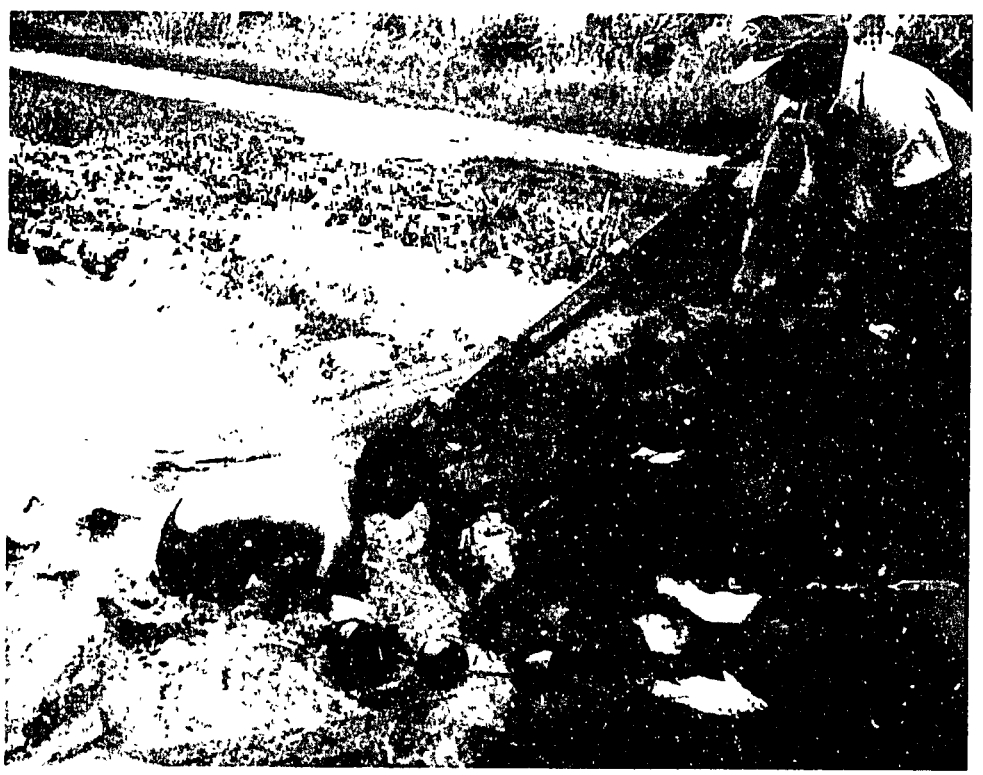
The CRSP began a global social sciences project toward the end of this reporting period. Auburn University economists and sociologists are collaborating with researchers from the Philippines, Thailand, and Honduras in an examination of aquaculture technology adoption and diffusion. This project presents

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

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

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

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



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

Continuing activities

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

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

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

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

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

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

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

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

II. Summary of Activities and Accomplishments

1 SEPTEMBER 1992 TO 31 AUGUST 1993

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

Overseas Research

Honduras

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

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

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

Rwanda

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

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

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

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

Thailand

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

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

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

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

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

Egypt

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

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

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

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

Data Analysis and Synthesis

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

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

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

Central Data Base

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

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

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

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

Annual Technical Committee Meeting

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

III. CRSP Research Program Background

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

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

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

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

The CRSP Research Program

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

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

CRSP Work Plans

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

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

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

IV. Public Service and Project Development

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

Institution Building

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

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

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

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

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

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

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

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

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

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

Education and Professional Development

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

Thailand and Philippines

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

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

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

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

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

Honduras

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

Rwanda

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

Egypt

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

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

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

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

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

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

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

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

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

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

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

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

Linkages

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

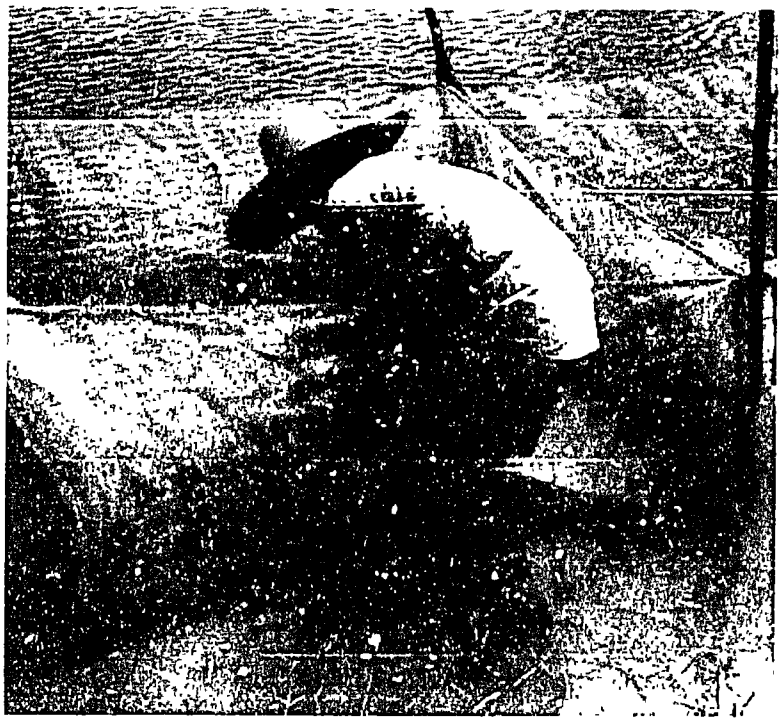
The CRSP continues to strengthen its ties with institutions in southeast Asia. In Thailand, CRSP researchers hold long- and short-term faculty appointments at the Asian Institute of Technology (AIT), and teach a variety of courses and seminars. AIT serves as a regional resource for technology development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

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

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

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

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



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

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

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

Project Development

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

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

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

Development of Sustainable Aquaculture Systems

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

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

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

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

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

Socioeconomic Studies

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

• The OSU/DAST will include economic data in the expert system for pond management which is currently being redesigned. The user-friendly program runs on personal computers, and supports pond manager decisions regarding variables such as fertilization and stocking strategies.

• In Egypt, researchers collect economic data as well as biological information, thus, management strategies can be evaluated not only by fish yield but also by economic feasibility.

• In Honduras, brackish water research has already had an economic impact. Studies showed that no significant difference occurred in shrimp production when a 20 percent protein feed was substituted for a 40 percent protein feed. This finding will allow farmers to cut their feed costs substantially without affecting production.

• In Rwanda, enterprise budgets for fish production and production of 12 different crops commonly raised on Rwandan farms have been completed as the first step in comparing the economics of resource utilization. An unexpected result of this study showed that farmers enter aquaculture mainly to generate income, not as was thought, to have fish as an additional food item.

• In Thailand, feeding studies are designed to determine the optimal time for initial application of supplemental feed in fertilized ponds. The results of this study will help farmers make economically sound decisions regarding supplemental feeding by identifying the critical stages when the natural food supply is inadequate to support optimal fish production.

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

Planning is under way for a USAID-sponsored workshop at the 1991 Annual Meeting. Participants will identify opportunities to integrate the social sciences as a dimension of applied research, with the goal of improving the usefulness and relevance of CRSP research. The workshop will offer CRSP researchers the opportunity to reframe research proposals to reflect social, economic, and cultural variables, in addition to physical, biological and chemical variables, that affect pond production systems.

Participation in International Scientific Meetings and Conferences

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

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

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

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

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

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

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

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

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

The following poster paper was presented:

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

V. Program Management and Technical Guidance

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

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

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

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

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

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

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

Management Entity

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

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

During this reporting period, members of the Program Management Office included:

Hillary Egna, Director (1.0 FTE)

Brigitte Goetze, Deputy Director and Egypt Coordinator (0.5 FTE 3/93 through 5/93, .75 FTE 6/93 through 8/93–not funded on core CRSP funds)

Marion McNamara, Assistant Director (1.0 FTE–partially funded on core CRSP funds)

Hilary Berkman, Data Base Manager (0.5 FTE through 6/93)

Nancy Astin, Secretary (0.5 FTE through 6/93)

Naomi Weidner, Secretary (0.5 FTE from 6/93)

The Management Entity (ME) is responsible for:

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

The PMO is also responsible for communications and publications.

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

Specific accomplishments this year include:

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

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

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

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

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

The Board of Directors

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

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

The Board of Directors is responsible for:

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

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

Specific accomplishments and recommendations made during this reporting period include:

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

Technical Committee

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

Table 1.
Membership of Technical Committee

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

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

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

At-large Members

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

Ex-officio Members

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

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

Table 2.
Institutional Voting Privileges on Technical Committee

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

External Evaluation Panel

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

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

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

CRSP Publications

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

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

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

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

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

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

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

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

Administrative Reports

Annual Administrative Report

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

Quarterly Reports

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

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

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

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

Brochures

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

Directory

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

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

Newsletters

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

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

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

Technical Reports

CRSP Research Reports

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

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

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

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

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

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

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

VI. Financial Summary

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

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

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

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

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

Table 3.
Expenditure of funds

		USAID Funds		U.S. Cost Sharing		Total, all U.S. funds		Host Country Contribution	
		1992-93	Cumulative	1992-93	Cumulative	1992-93	Cumulative	1992-93	Cumulative
Research Program									
Honduras									
	Auburn	$174,257	$476,636	$43,564	$119,159	$217,821	$595,795	$52,000	$142,000
Rwanda									
	Auburn	$93,661	$277,766	$23,415	$69,442	$117,076	$347,208	$25,977	$87,521
	OSU	$101,129	$241,725	$25,282	$60,431	$126,411	$302,156		
	UAPB	$5,000	$ 5,000	$1,250	$3,750	$6,250	$18,750		
	OSU/WID		$5,942		$1,486		$7,428		
Thailand									
	MSU	$167,503	$252,632	$41,876	$63,158	$209,379	$315,790	$26,000	$112,000
	UH*	$97,936	$204,668	$24,484	$51,167	$122,420	$255,835		
	UM	$196,683	$447,298	$49,171	$111,825	$245,854	$559,123		
Global Social Science Project									
	Auburn#	$3,333	$3,333	$833	$833	$4,167	$4,167		
Subtotal		$839,503	$1,925,001	$209,876	$481,250	$1,049,378	$2,406,251	$103,977	$341,521
U.S. Research Program									
	DAST/UCD	$50,171	$150,833	$12,543	$37,708	$62,714	$188,542		
	DAST/OSU	$25,618	$105,634	$6,405	$26 409	$32,023	$132,043		
	Soils/OSU		$16,064		$4,016		$20,080		
Subtotal		$75,790	$272,532	$18,947	$68,133	$94,737	$340,664		
Management Entity• (includes some research funds)		$17 ,107	$588,862			$174,107	$588,862		
External Evaluation funds		$67,400	$95,000			$67,400	$95,000		
TOTAL		$1,156,799	$2,881,394	$228,823	$549,383	$1,385,622	$3,430,777	$103,977	$341,521

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

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

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

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

VII. Staff Summary

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

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

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

FIELD(S) OF SPECIALIZATION

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

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

FIELD(S) OF SPECIALIZATION

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

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

FIELD(S) OF SPECIALIZATION

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

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

FIELD(S) OF SPECIALIZATION

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

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

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

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

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

RWANDA

RWANDA – OREGON STATE UNIVERSITY

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

RWANDA – AUBURN UNIVERSITY

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

RWANDA – UNIVERSITY OF ARKANSAS AT PINE BLUFF

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

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

FIELD(S) OF SPECIALIZATION

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

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

FIELD(S) OF SPECIALIZATION

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

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

FIELD(S) OF SPECIALIZATION

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

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

VIII. CRSP List of Publications

through 31 August 1993

Data Analysis and Synthesis Team

Oregon State University

Publications and Reports

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

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

University of California, Davis

Theses

Culberson, S.D. 1993. Simplified model for prediction of temperature and dissolved oxygen in aquaculture ponds using reduced data inputs. M.S. thesis. University of California, Davis.

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

Publications and Reports

Culberson, S.D., and R.H. Piedrahita. 1993. Model for Predicting Dissolved Oxygen Levels in Stratified Ponds Using Reduced Data Inputs. Pages 543-552 *in* Techniques for Modern Aquaculture, Proceedings. American Society of Agricultural Engineers, June 1993.

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

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

Giovannini, P., and R.H. Piedrahita. 1992. Modeling diel phytoplankton light sensitivity changes in aquaculture ponds. In review.

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

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

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

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

Giovannini, P., and R.H. Piedrahita. 1988. Analysis and modeling of dissolved oxygen in warm water aquaculture ponds. American Society of Agricultural Engineers Paper Number 88-5004.

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

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

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

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

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

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

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

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

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

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

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

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

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

Piedrahita, R.H. 1988. Introduction to computer modeling of aquaculture pond ecosystems. Aquaculture and Fisheries Management 19:1-12.

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

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

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

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

Presentations

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

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

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

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

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

Piedrahita, R.H. 1989. Engineering aspects of warmwater hatchery design. Presented at Workshop on Milkfish Fry Production Technology, Bali, Indonesia. Oceanic Institute, Hawaii.

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

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

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

Manuscripts

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

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

University of Hawaii

Publications and Reports

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

Presentations

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

University of Michigan

Publications and Reports

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

Chang, William. 1989. Estimates of hypolimnetic oxygen deficits in ponds. Aquaculture and Fisheries Management 20:163-172.

Chang, W., and H. Ouyang. 1988. Dynamics of dissolved oxygen and vertical circulation in fish ponds. Aquaculture 71:263-276.

Manuscripts

Springborn, R.R., A.L. Jensen, and W.Y.B. Chang. Application of the initial value solution of Von Bertalanffy's solution to *Tilapia nilotica* growth in aquaculture experiment. Aquaculture (submitted).

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

Honduras

Universidad Nacional Autonoma de Honduras

Theses

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

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

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

Echeverria, M.A. 1992. 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. 1988. Effect of fertilizer type on the production of male *Tilapia nilotica*. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (In Spanish.)

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

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

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

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

Auburn University

Publications and Reports

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

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

Alvarenga, H.R., B.W. Green, and M.I. Rodriguez. 1987. Production of hybrid tilapia (*Tilapia nilotica* x *Tilapia honorum*) in ponds using corn gluten as a supplemental feed. CRSP Technical Report, unpublished. 13 pp. (In Spanish.)

Alvarenga, H.R., B.W. Green, and M.I. Rodriguez. 1985. Pelleted fish feed vs. corn gluten as feed for tilapia and Chinese carp polyculture in ponds. CRSP Technical Report, unpublished. (In Spanish.)

Alvarenga, H.R., B.W. Green, and M.I. Rodriguez. 1984. A system for producing hybrid tilapia (*Tilapia nilotica* x *Tilapia honorum*) fingerlings at the El Carao Aquaculture Experiment Station, Comayagua, Honduras. CRSP Technical Report, unpublished. 9 pp. (In Spanish.)

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

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

Boyd, C E , and D R Teichert-Coddington 1992 Relationship between wind speed and reaeration in small aquaculture ponds Aquacultural Engineering 11:121-131

Green, B W 1992 Substitution of organic manure for pelleted feed in tilapia production Aquaculture 101 213-222

Green, B W 1990 Substitution of organic manure for pelleted feed in tilapia production Proceedings of FAO EIFAC Symposium on Production Enhancement in Still-Water Pond Culture, Prague Research Institute of Fish Culture and Hydrobiology, 38925 Vodnany, Czecheslovakia

Green, B W 1985 Report on the induced spawning of the silver and grass carps CRSP Technical Report, unpublished 8 pp (In Spanish)

Green, B W , and H R Alvarenga 1985 Tilapia and carp polyculture in ponds receiving organic fertilization and supplemental feed CRSP Technical Report, unpublished 10 pp (In Spanish)

Green, B W , and F A López 1990 Factibilidad de la producción masiva de alevines machos de *Tilapia nilotica* a traves de la inversión hormonal de sexo en Honduras Agronomia Mesoamericana 1 21-26

Green, B W , and D R Teichert Coddington 1993 Growth of control and androgen-treated Nile tilapia during treatment, nursery and growout phases in tropical fish ponds Fisheries and Aquaculture Management In press

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

Green, B W , and D R Teichert Coddington 1991 A comparison of two samplers used with an automated data acquisition system in whole-pond community metabolism studies The Progressive Fish-Culturist 53(1) 236-242

Green, B W , and D R Teichert Coddington 1990 Comparison of two sampler designs for use with automated data acquisition systems in whole-pond community metabolism studies Proceedings of FAO EIFAC Symposium on Production Enhancement in Still-Water Pond Culture, Prague Research Institute of Fish Culture and Hydrobiology, 389 15 Vodnany, Czechoslovakia

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

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

Green, B W , H R Alvarenga, R P Phelps, and J Espinoza 1987 Technical Report Honduras Aquaculture CRSP Cycle II Rainy Season Phase CRSP Technical Report, unpublished Auburn University, Alabama

Green, B W , H R Alvarenga, R P Phelps, and J Espinoza 1986 Technical Report Honduras Aquaculture CRSP Cycle II Dry Season Phase CRSP Technical Report, unpublished Auburn University, Alabama

Green, B W , H R Alvarenga, R P Phelps, and J Espinoza 1986 Technical Report Honduras Aquaculture CRSP Cycle I Rainy Season Phase CRSP Technical Report, unpublished Auburn University, Alabama 77 pp

Green, B W , H R Alvarenga, R P Phelps, and J Espinoza 1985 Technical Report Honduras Aquaculture CRSP Cycle I Dry Season Phase CRSP Technical Report, unpublished Auburn University, Alabama 51 pp

Meckenstock, D , D R Coddington, J C Rosas, H van Es , M S Chinnan and M M Murillo 1991 CRSP Council Honduras concept paper towards a sustainable agriculture in Southern Honduras Proceedings of the International Sorghum and Millet CRSP Conference, Corpus Christi, Texas, USA INISORMIL Publication No 92-1 INISORMIL Management Entity Office, 54 Nebraska Center, U of Nebraska, Lincoln, Nebraska

Sherman, C 1986 Growth of all female *Tilapia nilotica* in earthen ponds fertilized with chicken litter CRSP Technical Report, unpublished 14 pp (In Spanish)

Teichert Coddington, D R , and B W Green In press Comparison of two techniques for determining community respiration in tropical fish ponds Aquaculture

Teichert-Coddington, D R , and B W Green In press Tilapia yield improvement through maintenance of minimal oxygen concentrations in experimental grow-out ponds in Honduras Aquaculture

Teichert-Coddington, D R and B W Green 1993 Influence of daylight and incubation interval on dark-bottle respiration in tropical fish ponds Hydrobiologia 250 159 165

Teichert Coddington, D R , and B W Green 1990 Influence of primary productivity, season and site on tilapia production in organically fertilized ponds in two Central American countries Proceedings of FAO-EIFAC Symposium on Production Enhancement in Still Water Pond Culture, Prague Research Institute of Fish Culture and Hydrobiology, 38925 Vodnany, Czechoslovakia

Teichert-Coddington, D R., B W Green, and R.P. Parkman 1992 Substitution of chicken litter for feed in production of Panaeid shrimp in Honduras, Central America The Progressive Fish-Culturist 53(3):150-156

Teichert-Coddington D R , B.W. Green, and R P Phelps 1992 Influence of water quality, season and site on tilapia production in Panama and Honduras Aquaculture 105 297-314.

Teichert-Coddington, D R , B W Green, N Matamoros, and R Rodriguez 1990 Substitución de alimentos por gallinaza en la produccion comercial de camarones peneidos en Honduras Agronomía Mesoamericana 1 73-78

Presentations

Alvarenga, H R , and B W Green 1988 Produccion y aspectos economicos del cultivo de tilapia en estanques fertilizados con gallinaza (Production and economic aspects of tilapia culture in ponds fertilized with chicken litter) Presented by H Alvarenga at the 3 th Annual Meeting of the Programa Colaborativo Centro Americano para el Mejoramiento de Cultivos Alimenticios (PCCMCA), San Jose, Costa Rica

Green, B W 1990 Substitution of organic manure for pelleted feed in tilapia production European Inland Fisheries Advisory Commission's Symposium on production enhancement in still water pond culture, Prague, Czechoslovakia, May, 1990

Green, B , and H Alvarenga 1989 Sistemas de produccion de tilapia utilizando fertilizacion organica y alimentacion Presented at the annual regional meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (PCCMCA), San Pedro Sula, Honduras Presented by H Alvarenga

Green, B W , and H R Alvarenga 1987 Efecto de diferentes tasas de aplicacion de gallinaza en la produccion de tilapia (The effect of different rates of chicken litter application on the production of tilapia) Presented at the 33rd Annual Meeting of the Programa Colaborativo Centro Americana para el Mejoramiento de Cultivos Alimenticios (PCCMCA), Instituto de Ciencia y Technologia Agricola, Guatemala, 30 March-4 April, 1987 Presented by H. Alvarenga (In Spanish)

Green, B W , and H R Alvarenga 1987 Intensive fingerling production of hybrid tilapia *Tilapia nilotica* x *Tilapia honorum* in earthen ponds Presented at the 18th Annual Meeting of the World Aquaculture Society, Guayaquil, Ecuador Presented by B Green

Green, B , and L Lopez 1989 Factabilidad de la produccion masiva de alevines machos de *tilapia nilotica* atraves de la inversion hormonal de sexo en Honduras Presented at the annual regional meeting of the Programa Cooperativo Centroamericana para el Mejoramiento de Cultivos Alimenticios (PCCMCA), San Pedro Sula, Honduras Presented by F Lopez

Green, B W , H R Alvarenga, and R P Phelps 1988 The effect of stocking rate on the production of *Tilapia nilotica* in ponds Presented at the 3 th Annual Meeting of the Programa Colaborativo Centro Americano para el Mejoramiento de Cultivos Alimenticios (PCCMCA), San Jose, Costa Rica (In Spanish) Presented by B Green

Green, B W , R P Phelps, and H R Alvarenga 1987 The effect of nitrogen and phosophorus sources in fertilizers used for the production of *Tilapia nilotica* Presented by B Green at the 18th Annual Meeting of the World Aquaculture Society, Guayaquil, Ecuador

Green, B W , D R Teichert Coddington, and F A Lopez 1992 Production of *Oreochromis niloticus* fry in earthen ponds for hormonal sex inversion Presented at the 23rd Annual World Aquaculture Conference May, 1992, Orlando, Florida

Rodriguez, R , O J O hara and D R Teichert Coddington 1991 Efecto de la tasa de fertilización inorganica y calidad de agua sobre el crecimiento y economía en el cultivo semi-intensivo de camaron *Penaeus* SPP en Granja Marinas San Bernardo Simposio Centroamericano Sobre Camarón Cultivado, 1 26 de abril de 1991, Tegucigalpa, Honduras

Teichert Coddington, D R , and B W Green 1993 Usefulness of inorganic nitrogen in organically fertilized tilapia production ponds Poster paper presented at the World Aquaculture Society annual meeting, Torremolinos, Spain, May 1993

Teichert Coddington, D R , and B W Green 1992 Yield improvement through maintenance of minimal oxygen concentrations in tilapia grow out ponds in Honduras Presented at the 23rd Annual World Aquaculture Conference May, 1992, Orlando, Florida

Teichert-Coddington, D R , and B Green 1990 Influence of primary productivity, season and site on tilapia production in organically fertilized ponds in two Central American countries European Inland Fisheries Advisory Commission's Symposium on production enhancement in still water pond culture, Prague, Czechoslovakia, May, 1990

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

Teichert-Coddington, D R , R Rodriguez and W Toyofuku 1993 Causes of cyclical variation in Honduran shrimp production Poster paper presented at the World Aquaculture Society annual meeting, Torremolinos, Spain, May 1993

Teichert Coddington, D , B Green, N Matamoros, and R Rodriguez 1989 Substitucion de alimento por gallinaza en la produccion comercial de camarones peneidos en Honduras Presented at the annual regional meeting of the Programa Cooperativo Centroamericana para el Mejoramiento de Cultivos Alimenticios (PCCMCA), San Pedro Sula, Honduras Presented by D Teichert Coddington

University of Hawaii

Manuscripts

Hopkins, K , and A Yakupitiyage Bias in seine sampling of tilapia Submitted to Journal of the World Aquaculture Society In review

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

Indonesia

Agricultural University of Bogor

Theses

Ilmawati N 1987 The effect of *Oreochromis niloticus* Trewavas production by increasing surface area for attached microorganisms B S thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia 41 pp

Gartini, E 1986 Flow rate dependent changes in turbidity and phosphorus in the water conditioning system at Darmaga B S thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia 66 pp

Harahat I S 1987 Changes of nitrogen concentration of the Nile tilapia ponds which were fertilized with chicken manure B S thesis Faculty of Fisheries, Agricultural University of Bogor, Indonesia 41 pp

Haryani, G S 1985 The growth rate, mortality and feeding habits of *Tilapia nilotica* (L) B S thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia 76 pp

Irtasari E 1985 The composition and abundance of macrobenthos in relation to pond productivity B S thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia 71 pp

Radhastuti, E 1986 The balance of nitrogen from an irrigation canal that flows through a water conditioning system in Darmaga B S thesis Faculty of Fisheries Agricultural University of Bogor, Indonesia 63 pp

Subyakto, S 19 The relationship between chlorophyll *a* and Secchi disk visibility in tilapia fish ponds at Darmaga Bogor B S thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia 51 pp

Suratman, H 1985 Composition and abundance of zooplankton in *Tilapia nilotica* (L) fish pond fertilized with triple superphosphate at Darmaga B S thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia 58 pp

Tumbelaka, R 1986 Primary productivity of aquaculture ponds at Darmaga B S thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia 87 pp

Widjaja 1985 Flushing rate of experimental *Tilapia nilotica* (L) ponds at Darmaga and its relationship to some physical and chemical factors of the ponds B S thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia 61 pp

Yuhanti, S 1986 Removal of detergents in irrigation canal water by the water conditioning system at Darmaga, Bogor B S thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia 71 pp

Yulisto 1985 Effect of fish predation on macrobenthos density in aquaculture ponds B S thesis, Faculty of Fisheries, Agricultural University of Bogor, Indonesia 82 pp

Michigan State University

Theses

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

Yusoff, F 1987 Fish production, primary productivity and nutrient availability in fertilized fish ponds in Malaysia Ph D dissertation Michigan State University, Lansing, Michigan 69 pp

Publications and Reports

Batterson, T R , C D McNabb, C E Knud-Hansen, H M Eidman, and K Sumantadinata 1988 Effect of chicken manure additions on fish production in ponds in West Java, Indonesia CRSP Research Report 88-8 6 pp

Guttman, H , and C E Knud-Hansen (In Press) Fish pond management by algal assay Journal of the World Aquaculture Society (Abstract presented at the 23rd Annual Meeting of the World Aquaculture Society Meeting, Orlando, Florida, May 1992)

Knud-Hansen, C E , T R Batterson, and I S Harahat 1988 Nitrate and ammonia depletion in Indonesian aquaculture ponds fertilized with chicken manure Abstract Journal of the World Aquaculture Society 19 42A

Knud-Hansen, C E , C D McNabb, and T R Batterson 1991 Application of limnology for efficient nutrient utilization in tropical pond aquaculture Proceedings of the International Association of Theoretical and Applied Limnology 24 2541-2543

Knud Hansen, C E , C D McNabb, and T R Batterson 1989 Application of limnology for efficient nutrient utilization in tropical pond aquaculture Abstract XXIVth Congress of the International Association of Theoretical and Applied Limnology

Knud-Hansen, C E , T R Batterson, C D McNabb Y Hadirosewan, D Dana, and H M Eidman 1990 Hatchery techniques for egg and fry production of *Clarias batrachus* (Linnaeus) Aquaculture 89 9-19

Knud-Hansen, C E , T R Batterson, C D McNabb I S Harahat, K Sumantadinata, and H M Eidman 1991 Nitrogen input, primary productivity and fish yield in fertilized freshwater ponds in Indonesia Aquaculture 94 49 63

McNabb, C D , T R Batterson, H M Eidman, and K Sumantadinata 1988 Carbon limitation in fertilized fish ponds in Java Abstract Journal of the World Aquaculture Society 19 51A

McNabb, C D , C E Knud-Hansen, T R Batterson, and K Janven 1991 A systemic approach to maximizing nutrient efficient and growth of Nile tilapia *(Oreochromis niloticus)* under semi intensive pond culture Abstract Journal of the World Aquaculture Society 22 40A

McNabb, C D , K Sumawidjaja, B J Premo and K Sumantadinata March, 1984 Aquaculture-CRSP Indonesia project report, Cycle I, first 5-month experiment Michigan State University, East Lansing, Michigan 107 pp

McNabb, C D , T R Batterson, M Eidman, C S Annett and K Sumantadinata September 1985 Aquaculture CRSP Indonesia project report, Cycle II, first 5-month experiment (January June 1985) Michigan State University, East Lansing, Michigan 105 pp

McNabb, C D , T R Batterson, M Eidman, B J Premo, and K Sumantadinata January 1985 Aquaculture CRSP Indonesia project report second five month experiment Michigan State University, East Lansing, Michigan 71 pp

McNabb, C D , T R Batterson, C K Lin, K Janven, J L Hanson, and R Chuenpagdee 1989 Fish yield with nitrogen supplemented organic fertilizers Abstract Journal of the World Aquaculture Society 20 56A

McNabb, C D , T R Batterson, B J Premo, C E Knud Hansen, H M Eidman C K Lin, K Janven, J L Hanson, and R Chuenpagdee 1990 Managing fertilizers for fish yield in tropical ponds in Asia Pages 169 192 *in* R Hirano and I Hanyu editors Proceedings of the Second Asian Fisheries Forum Asian Fisheries Society, Manila, Philippines

McNabb, C D , T R Batterson, B J Premo, C E Knud Hansen, H M Eidman, C K Lin, K Janven, J L Hanson, and R Chuenpagdee 1989 Managing fertilizers for fish yield in tropical ponds in Asia Abstract The Second Asian Fisheries Forum

Yusoff, F M , and C D McNabb 1989 Effects of nutrient availability on primary productivity and fish production in fertilized tropical ponds Aquaculture 78 303-319

Presentations

Batterson, T R December 1985 The problems of water quality for Indonesian fisheries Seminar series of the Bogor Chapter of the Indonesian Fisheries Society, Bogor, Indonesia

Knud-Hansen, C F , and C K Lin November 1991 Strategies for stocking Nile tilapia (*Oreochromis niloticus*) in fertilized ponds The Third International Symposium on Tilapia in Aquaculture, Abidjan Cote d voire, Africa

Knud-Hansen, C F , T R Batterson, and D S Darshat January 1988 Nitrate and ammonia depletion in Indonesian aquaculture ponds fertilized with chicken manure World Aquaculture Society, 19th Annual Meeting, Honolulu, Hawaii

Knud-Hansen, C F , C D McNabb, and T R Batterson August 1989 Application of limnology for efficient nutrient utilization in tropical pond aquaculture XXIVth Congress of the International Association of Theoretical and Applied Limnology

McNabb, C D March 1986 Carbon limitation in fish culture ponds in Indonesia Visiting Scientists Seminar Series Lake Biwa Research Center, Shiga University, Otsu, Japan

McNabb, C D February 1986 Limnology of fish ponds in Java Visiting Scientists Seminar Series, College of Fisheries and Marine Science Agricultural University of Malaysia, Serdang Malaysia

McNabb, C D December 1984 Application of limnological technology to fish pond management National Institute of Biological Science, Bogor, Indonesia

McNabb, C D , T R Batterson, H M Eidman, and K Sumantadinata January 1988 Carbon limitation in fertilized fish ponds in Java World Aquaculture Society Meeting 19th Annual Meeting, Honolulu, Hawaii

McNabb, C D , T R Batterson, B J Premo and J R Craig March 1984 Photosynthetically active radiation in tropical and temperate zone habitats 88th Annual Meeting of the Michigan Academy of Science, Arts, and Letters, Big Rapids Michigan

McNabb, C D , C F Knud Hansen, T R Batterson, and K Javen June 1991 A systematic approach to maximizing nutrient efficiency and growth of Nile tilapia (*Oreochromis niloticus*) under semi-intensive pond culture World Aquaculture Society Meeting, 22nd Annual Meeting, San Juan, Puerto Rico

McNabb, C D , T R Batterson, C K Lin, K Javen, J F Hanson, and R Chuenpagdee February 1989 Fish yield with nitrogen supplemented organic fertilizers World Aquaculture Society Meeting, Aquaculture 89, Los Angeles, California

McNabb, C D , T R Batterson, B J Premo, C F Knud Hansen, H M Eidman, C K Lin, K Javen, J F Hanson, and R Chuenpagdee April 1989 Managing fertilizers for fish yield in tropical ponds in Asia Second Asian Fisheries Forum, Tokyo, Japan

Sumantadinata, K February 1985 Genetic characteristics of strains of Indonesian carps Special Symposium of the Japanese Fisheries Society, Tokyo, Japan

Other

Batterson, T R 1985-1987 Indonesia PD/A CRSP data diskettes for Cycles I, II, and III using LOTUS 1-2-3

Batterson, T R , and C D McNabb June-August 1986 MSU/CIFAD Visiting Scientist Program Wardana Ismail, Head, Fisheries Research Facilities, Central Research Institute for Fisheries (CRIFI), Agency for Agricultural Research and Development (AARD), Department of Agriculture, Republic of Indonesia, Jakarta Eight-week program on water quality techniques, and laboratory equipment and design in support of freshwater aquaculture in Indonesia

Kinnunen, R E , and C D McNabb March 1986 Collaborative aquaculture research Institute of Pertanian Bogor and Michigan State University Improvement of pond culture technology and production Broadcast National Educational Television, Jakarta, Indonesia, 15 minutes

Kinnunen, R E , and C D McNabb March 1986 Water treatment for small pond fisheries Broadcast National News Network, Television of the Republic of Indonesia (TVRI), Jakarta, Indonesia, 3 minutes

Knud-Hansen, C F November 23 29, 1986 Workshop on Water Quality Analyses for Aquaculture Ponds Invited by Faculty of Fisheries, University of Brawijaya at Malang, East Java, Indonesia

McNabb, C D March 1986 Fisheries in the tropics World Food Day National Teleconference Michigan State University Response Panel, East Lansing, Michigan

McNabb, C D , H M Eidman, P Suwignyo D E Garling, K Sumawidjaja, H C Lampe, S M H Simandjuntak, R E Kinnunen, R R Stubaskara, J McAlister, T R Batterson, and C F Knud Hansen 1986 A research plan for Faculty of Fisheries, Institut Pertanian Bogor, Bogor, Indonesia Michigan State University, East Lansing, Michigan 30 pp (Written in both English and Bahasa Indonesian)

National Educational Television and Television of the Republic of Indonesia (TVRI), Jakarta, Indonesia 1986 Collaborative aquaculture research Institut Pertanian Bogor and Michigan State University Improvement of pond culture technology and production (Videotape, 33 minutes)

Premo, B J , and K Sumantadinata 1984 Laboratory manual of water quality techniques Julia Press, Bogor, Indonesia 43 pp

Panama – Aguadulce

University of Panama

Theses

Abrego, R 1985 Uso de androgenos en alevines de *Tilapia nilotica* para la produccion de tilapias monosexuales Licenciatura Thesis in Biology, University of Panama

Avila, M In preparation El efecto del policultivo del pez, *Mugil curema*, a varios densidades de siembra con la produccion de *Penaeus vannamei* y en la calidad de agua en estanques de tierra Licenciatura Thesis in Biology, Catholic University of Chile, Santiago, Chile

Chavez, H 1984 Estudio trofodinamico de *Penaeus vannamei* cultivado en estanques experimentales de aguas salobres Licenciatura Thesis in Biology, University of Panama

Hernandez de Santamaria, D 1987 El efecto de dietas experimentales en el crecimiento y sobrevivencia de *Penaeus vannamei* cultivado en estanques Licenciatura Thesis in Biology, University of Panama

Lasso de la Vega, E 1985 Variacion del zooplancton en estanques de cria de camarones blanco durante la estacion seca Licenciatura Thesis in Biology, University of Panama

Tore, D , H Tunon, and R Visuetti 1984 Efecto de la aplicacion de abonos organicos, concentrados y pescado fresco (*Dormitator latifrons*) en la produccion de *Penaeus stylirostris* y *Penaeus vannamei* Licenciatura Thesis in Biology, University of Panama

Quesada E In preparation Ocurrencia de organismos bentonicos en estanques no alimentados sembrados con *Penaeus vannamei* durante la estacion seca Licenciatura Thesis in Biology, University of Panama

Quiroz, V In preparation Efectos de varios niveles de recambio de agua a la calidad de agua y en la produccion de *Penaeus vannamei* en estanques de tierra Licenciatura Thesis in Biology, University of Panama

Auburn University

Publications and Reports

Teichert-Coddington, D R , and M Arriaga 1988 Efectos de dietas de proteinas y densidades de siembra sobre la producción de *Penaeus vannamei* en estanques de Herra Rev Lat Acui 35 29-33

Van Wyk, P 1986 The relationship of pump discharge and fuel efficiency to tidal height for a brackishwater aquaculture pumping station Masters of Aquaculture Special Project, Auburn University, Alabama

Presentations

Chavez, H December 1984 Estudio trofodinamico de *Penaeus vannamei* cultivado en estanques experimentales de aguas salobres Presented to the First National Scientific Congress, University of Panama, Panama

De Leon, V November 1985 El efecto de aplicar fertilizantes inorganicos en la produccion de *Penaeus vannamei* en estanques Presented to the Second National Scientific Congress, University of Panama, Panama

Hughes, D G November 1985 Prediction of pond productivities A challenge for aquaculture Presented to the Pontifical Catholic University of Ecuador, Quito, Ecuador

Hughes, D G November 1984 The marine shrimp culture industry in Panama Presented to the First Annual Shrimp World Marketing Conference, Acapulco, Mexico

Hughes, D G , and O M Garcia A June 1984 La produccion de semilla de *Tilapia nilotica* en hapas una comparacion de productividades de clima templada con clima tropical Presented by David Hughes to First National Aquaculture Seminar in University Nacional, Heredia, Costa Rica

Hughes, D G , A Torres and R P Phelps January 1985 Production and growth characteristics of *Penaeus stylirostris* and *P vannamei* in monoculture and polyculture in fed and unfed earthen ponds Presented by D Hughes at the Annual Meeting of the World Mariculture Society, Orlando, Florida

Hughes, D G , G de Gomez, I Lasso de la Vega, R P Phelps and R Pretto Maica January 1987 Rainy and dry season comparisons in *Penaeus vannamei* production ponds in Panama receiving various water exchange rates Water quality variation Poster session at World Aquaculture Society Meeting, Guayaquil, Ecuador

Kivers, A December 1984 Comparacion de dos rangos y dietas alimenticias con alevines de *Tilapia nilotica* en piletas de concreto Presented to the First National Scientific Congress, University of Panama, Panama

Kivers, A December 1984 Comparacion de tres densidades de siembra de alevines de *Tilapia nilotica* en piletas de concreto Presented to the First National Scientific Congress, University of Panama, Panama

Lasso de la Vega, I , and M Villareal November 1985 Variacion del zoo-plancton en estanques de cria de camarones blanco durante la estacion seca Presented to the Second National Scientific Congress University Panama, Panama

Lore, D , H Tunon, and R Visuetti December 1984 Efecto de la aplicacion de abonos organicos, concentrados y pescado fresco (*Dormitator latifrons*) en la produccion de *Penaeus stylirostris* y *Penaeus vannamei* Presented by H Tunon to the First National Scientific Congress, University of Panama, Panama

Moreno, J M December 1984 Alimentacion de la *Tilapia nilotica* en la etapa de alevinaje Presented to the First National Scientific Congress, University of Panama, Panama

Moreno, J M December 1984 El uso del androgeno 17-metil testosterona en alevinaje de *Tilapia nilotica* para la produccion de Tilapia monosexuales en Panama Presented to the First National Scientific Congress, University of Panama, Panama

Pretto, R , G Garson, V Batista, and M de Leon September 1983 Estudio preliminar del policultivo de Peneidos con peces nativos de aguas salobres Presented by R Pretto to the Fifth Symposium of Latin American Aquaculture, University Austral de Chile, Valdivia, Chile

Torres, A December 1984 Produccion de *Penaeus stylirostris* bajo la influencia del *Penaeus vannamei*, en estanques experimentales de agua salobre con y sin alimentacion durante la epoca seca Presented to the First National Scientific Congress, University of Panama, Panama

Panama – Gualaca

Auburn University

Theses

Atencio, A 1987 Phosphorus saturation of acidic soils in tropical fish culture ponds

Barrios, C M 1985 Analysis of water quality in new freshwater ponds at the Freshwater Aquaculture Station in Gualaca

Friele, M E I 1985 Stomach analyses of *Macrobrachium rosenbergii*, *Tilapia nilotica*, *Colossoma macropomum* and the hybrid *Hypophthalmichthys molitrix* x *Aristichthys nobilis* in polyculture at the Gualaca Freshwater Aquaculture Experiment Station, Panama

Hughes, David G 1988 Evaluation of seed production and sex-reversal methods for *Tilapia nilotica* and field verification in a tropical hatchery

Perez, M J 1985 Economic and marketing study of fish and shrimp in polyculture systems in freshwater ponds at Gualaca, Chiriqui Province

Pimentel, C A B 1984 Effect of liming on new unfertilized ponds at the Gualaca Aquaculture Experiment Station

Rios, R A In preparation Identification and dynamics of zooplankton found in tropical earthen ponds receiving chicken litter at four rates

Rodriguez, Ivonne 1987 Feeding *Penaeus vannamei* and *Penaeus stylirostris* in nursery ponds Master's Thesis, Auburn University, Alabama

Serrano, A 1987 Economics of tilapia production in monoculture or in polyculture with prawns, and utilizing manure or a commercial pellet as the nutrient input in Gualaca, Panama

Publications and Reports

Peralta, M., and D.R. Teichert-Coddington. 1989 Comparative production of Colossoma macroponum and *Tilapia nilotica* in Panama Journal of the World Aquaculture Society 20(4)·236-239

Teichert-Coddington, D R , and R P Phelps 1989 Effects of seepage on water quality and productivity of inorganically fertilized tropical ponds Journal of Aquaculture in the Tropics 4 85-92

Teichert-Coddington, D R , M Peralta, and R P Phelps 1989 Seepage reduction in tropical fish ponds using chicken litter Aquacultural Engineering 8 147-154

Teichert-Coddington, D R , N Stone, and R P Phelps 1988 Hydrology of Fish Culture Ponds in Gualaca, Panama Aquacultural Engineering 7 309 320

Teichert-Coddington, D R , M Peralta, R P Phelps, and R Pretto 1985 CRSP Technical Report First cycle, dry season 1985, Freshwater Aquaculture Research Station, Gualaca, Panama

Teichert-Coddington, D R , M Peralta, R P Phelps, and R Pretto 1985 CRSP Technical Report First cycle, wet season 1985, Freshwater Aquaculture Research Station, Gualaca, Panama

Presentations

Peralta, M , and D R Teichert-Coddington January, 1988 Comparative production of *Colossoma macroponum* and *Tilapia nilotica* in Panama Presented at the 20th World Aquaculture Society Meeting in Honolulu, Hawaii

Teichert-Coddington, D R , D B Rouse, A Khater, and R O Smitherman 1987 Effects of two rates of organic fertilization and two levels of alkalinity on prawn production in a prawn-tilapia polyculture Presented at the World Aquaculture Society Meeting, Ecuador

The Philippines

University of The Philippines in the Visayas

Theses

Pahila, I G 1986 Sorbed and soil solution phosphorus in relation to the optimum phosphorus level of lablab in some brackishwater ponds M S thesis, Department of Fisheries, University of the Philippines in the Visayas

University of Hawaii

Publications and Reports

Corre, V L , Carpenter, E J Pudadera, and R D Fortes 1986 The effects of feeds and fertilizer on the production of *Oreochromis niloticus* in brackishwater ponds. Unpublished paper University of Hawaii and University of the Philippines in the Visayas

Fast, A W , K E Carpenter, V L Corre, and R L Janeo 1986 The effects of water depth and circulation on the productivity of *Penaeus monodon* and water quality in earthen ponds Unpublished paper University of Hawaii and University of the Philippines in the Visayas

Olin, P , D Barclay, and A W Fast In preparation Induced spawning and larval rearing of the Chinese catfish *Clarias fuscus* in Hawaii

Presentations

Carpenter, K E , A W Fast, R D Fortes, V L Corre, Jr , J Woessner, and R L Janeo May 1986 The effects of water depth and circulation on the growth of *Penaeus monodon* in semi-intensive culture in earthen ponds Presented to the Asian Fisheries Forum Meeting, Manila

Chiu, Y , V. Estilo, and K L Carpenter Effects of water exchange rates on nutrient levels and productivity of brackishwater fish ponds

Chiu, Y., M.P. Macahilig, and M.A. Sastrillo. May 1986. Factors affecting the feeding rhythm of milkfish (*Chanos chanos* Forsskal). Proceedings of the Asian Fisheries Forum Meeting, Manila.

East, A.W., K.E. Carpenter, E.J. Estilo, and H.J. Gonzales. January 1987. Effects of water depth on dynamics of Philippines brackishwater shrimp ponds. Presented at the World Aquaculture Society Meeting, Ecuador.

Fortes, R.D., V.E. Corre, and E.J. Pudadera. May 1986. The effects of fertilizers and feeds as nutrient sources in the production of *Oreochromis niloticus* in Philippines brackishwater ponds. Presented to the Asian Fisheries Forum Meeting, Manila.

Minsadan, G.E., and Y.N. Chiu. May 1986. Studies on the use of teaseed cake for the selective elimination of finfishes in shrimp ponds. Presented to the Asian Fisheries Forum Meeting, Manila.

Sanares, R.C., S.A. Katase, A.W. East, and K.E. Carpenter. May 1986. Water quality dynamics in brackishwater shrimp ponds with artificial aeration and circulation. Presented to the Asian Fisheries Forum Meeting, Manila.

Ver, L.M., and Y.N. Chiu. May 1986. The effects of paddlewheel aerators on ammonia and carbon dioxide removal in intensive pond culture. Presented to the Asian Fisheries Forum Meeting, Manila.

Rwanda

National University of Rwanda (UNR)

Theses

Bizimana, V. 1985. Essais de triage mecanique en vue d'un elevage monosexe des tilapias et controle de la croissance sur *T. macrochir* et *T. rendalli*. (The use of mechanical sorting for the monosex culture of tilapias. Growth trials with *T. macrochir* and *T. rendalli*.) Thesis for the degree of Ingenieur Agronome, Université Nationale du Rwanda, Butare, Rwanda. 111 pp.

Gatera, V. 1990. Effect of stocking rate and composting regime on production of fish in ponds. Université National du Rwanda, Butare, Rwanda.

Habineza, C. 1986. Analyse de l'effet de la fumure organique (Fientes de poules) sur la croissance du *Tilapia nilotica*. (The influence of chicken manure on the growth of *Tilapia nilotica* in Rwandan fish ponds.) Thesis for the degree of Ingenieur Agronome, Universite Nationale du Rwanda, Butare, Rwanda.

Franco, E. 1991. Nile tilapia (*Oreochromis niloticus*) production in tropical microcosms fertilized with rabbit excreta. M.S. thesis. Oregon State University, Corvallis, Oregon. (September 1991). 63 pp.

Hakuzwaremye, E. 1981. Etude des effets de l'alimentation sur la croissance des tilapias. Essais en bacs sur *T. macrochir* et *T. rendalli*. (A study of the effects of feeding on the growth of tilapias. Tank studies with *T. macrochir* and *T. rendalli*.) Thesis for the degree of Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda. 132 pp.

Harwanimbaga, C. 1987. A preliminary study of the plankton population in fish ponds at Rwasave (Butare, Rwanda). Thesis for the degree of Licensié en Sciences, Université Nationale du Rwanda, Butare, Rwanda.

Hatangimbabazi, J.D. 1989. Description des communautes planctoniques des différents habitats de quelques étangs piscicoles de Rwasave (Butare). (Study of the plankton communities of different habitats in fish ponds.) Thesis for the degree of Licencié en Biologie Animale, Université National du Rwanda, Butare, Rwanda. 93 pp.

Isangu M.M. 1989. L'association porc-poissons en station: etude de rentabilite financiere. (Integrated pig-fish culture: An economic analysis.) Thesis for the degree of Ingenieur Agronome, Université Nationale du Rwanda, Butare, Rwanda. 107 pp.

Kakuze, V. 1989. Contribution à létude du regime alimentaire de *Tilapia nilotica* (L. 1758) des etangs fertilisés de Rwasave (Butare). (A preliminary study of the feeding habits of *Tilapia nilotica* in fertilized ponds at Rwasave (Butare).) Thesis for the degree of Licensié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda. 93 pp.

Mbarerereme, P. 1992. Contribution a l'étude de l'influence de la température et de la durée de traitement sur la production des alevins monosexes du *Oreochromis niloticus*. Memoire présenté en vue de l'obtention du Diplôme d'Ingénieur Technicien A1. Institut Superieur d'Agriculture et d'Elevage de Busogo, Ruhengeri. 63 pp. (The influence of temperature and treatment duration on the production of all-male *Oreochromis niloticus* fry.)

Mukakarera, C. 1990. An aquatic biology study of Uwagangita National du Rwanda, Butare Rwanda. 101 pp.

Munyangaju, V. 1990. A study of the lakes in the Bugesera region for the purpose of developing an optimal fishing effort. Université National du Rwanda, Butare, Rwanda. 102 pp.

Murangira, J. 1992. Contribution a l'étude de la productivité de quelques graminées fourrageres vis-a-vis trois fréquences de coupe. Rapport de stage, Ecole Agricole et Vétérinaire de Kabutare, Butare, Rwanda. 52 pp. (Comparative productivity of eight forage grasses at three cutting frequencies.)

Murwanashyaka, J.N. 1989. Study of the food of *Clarias gariepinus* of Lake Ihema. B.S. thesis, Universite Nationale du Rwanda, Butare, Rwanda. 116 pp.

Murwanashyaka, J.N. 1989. Alimentation et parasitisme de *Clarias gariepinus* (Burchell, 1822) au Lac Ihema: impact de sa predation sur l'evolution du stock en *Haplochromis*. (Feeding habits and parasitism in Clarias gariepinus (Burchell, 1822) in Lake Ihema: Impact of its predation on *Haplochromis* stocks.) Thesis for the degree of Ingenieur Agronome, Université Nationale du Rwanda, Butare, Rwanda. 101 pp.

Ndisebuye, A. 1986. Etude des conditions de reproduction de *Tilapia nilotica* en etangs de pisciculture. (A study of conditions affecting the reproduction of *Tilapia nilotica* in Rwandan fish ponds.) Thesis for the degree of Ingénieur Agronome, Universite Nationale du Rwanda, Butare, Rwanda.

Ngarambe, O. 1986. Etude de l'influence de la fumure organique (fientes de poules) sur la dynamique des elements fertilisants de l'eau et du sol de quelques étangs piscicoles de Rwasave. (The influence of chicken manure on soil and water fertility in several fish ponds at Rwasave.) Thesis for the degree of Ingenieur Agronomie, Universite Nationale du Rwanda, Butare, Rwanda. 105 pp.

Nyitegeka, D. 1990. Nitrogen budgets in fish ponds enriched with fertilizers of different C:N:P ratios at Rwasave, Butare. Universite National du Rwanda, Butare, Rwanda. 117 pp.

Nsengiyumva, V. 1989. Production des alevins monosexes de *Tilapia nilotica* Linnaeus par la méthode du sex-reversal. (Production of *Tilapia nilotica* fingerlings by sex reversal methods.) Thesis for the degree of Ingénieur Agronome, Universite Nationale du Rwanda, Butare, Rwanda. 107 pp.

Rutikanga, P. 1992. Contribution à l'étude des facteurs intervenant dans de taux d'infestation des *Tilapia nilotica* par les Diplostomatidae (maladie des points noirs). Rapport de stage efectu a la SPIR dur 15-07-91 au 15-02-92. Ecole Agricole et Veterinaire de Kabutare, Butare, Rwanda. (Factors affecting the infestation rate of *Oreochromis niloticus* by Diplostamatid cysts (black spot disease). 48 pp.

Rwalinda, P. 1990. Enrichment of compost with nitrogen and phosphorus and its effects on the production of *Tilapia nilotica*. Université National du Rwanda, Butare, Rwanda. 107 pp.

Rwangano, E. 1990. Interactions of input types and water quality on the production of *Orechromis niloticus* (L.) in Rwandan ponds. M.S. thesis, Oregon State University, Corvallis. 99 pp.

Uwera, M.J. 1987. Une étude des modalités d'échantillonage des poissons en etangs piscicoles. (A comparative study of methods for sampling fish in ponds.) Thesis for the degree of Ingenieur Agronomie, Universite Nationale du Rwanda, Butare, Rwanda.

Publications and Reports

Karangwa, E., G.E. Mitchell, Jr., and R.E. Tucker. 1990. High performance liquid chromatographic determination of 4-methylidiazole in sheep plasma and in ammoniated tall fescue hay. Journal Chromatogr. 532: 105-133.

Karangwa, E., G.E. Mitchell, Jr., and R.E. Tucker. 1990. Pharmacokenetics of 4-methylidiazole in sheep. Journal of Animal Science 68: 3277-3284.

Presentations

Rurangwa, E., and E. Verheust. June 10-12, 1991. *Oreochromis niloticus* culture in Rwanda: Optimal density and feeding ration in earthen ponds. Poster presented at International Aquaculture Conference and Trade Show. Dublin, Ireland.

Rurangwa, E., and E. Verheust. June 10-12, 1991. Comparative growth and mortality of *Oreochromis niloticus* and *Clarias gariepinus* fingerlings in earthen ponds (Rwanda). Poster presented at International Aquaculture Conference and Trade Show. Dublin, Ireland.

Rurangwa, E., and E. Verheust. June 10-12, 1991. Slide presentation: Fish culture in Rwanda: A high altitude, developing country in central Africa. International Aquaculture Conference and Trade Show. Dublin, Ireland.

Auburn University

Theses

Hishamunda, Nathanael 1993 The economic analysis of small-scale fish culture in Rwanda A comparative study M S Thesis, Auburn University, 240 p

Publications and Reports

Hanson, B J , J E Moehl, K L Veverica, E Rwangano, and M Van Speybroeck 1988 Pond culture of tilapia in Rwanda, a high altitude equatorial African country Pages 553-559 *in* R S V Pullin, T Bhukaswan, K Tonguthai and J L Maclean, editors The Second International Symposium on Tilapia in Aquaculture ICLARM Conference Proceedings 15, 623 pp Department of Fisheries, Bangkok, Thailand and International Center for Living Aquatic Resources Management, Manila Philippines

Hishamunda, N , and J E Moehl 1989 Rwanda National Fish Culture Project International Center for Aquaculture R and D Series No 34, Auburn University Alabama

Moehl, J E Jr , K L Veverica B J Hanson, and N Hishamunda 1987 Development of appropriate pond management techniques for use by Rwandan farmers *In* R S V Pullin, T Bhukaswan K Tonguthai and J L Maclean (editors) The Second International Symposium on Tilapia in Aquaculture ICLARM Conference Proceedings 15, Department of Fisheries Bangkok, Thailand, and ICLARM, Manila, Philippines 623 p

Molnar, J J , C E Cox P Nyirabumana, and A Rubagumya 1993 Socioeconomic factors affecting the transfer and sustainability of aquacultural technology in Rwanda Research and Development Series No 38, Alabama Agricultural Experiment Station, Auburn University, Alabama (in press)

Popma, T J , and B W Green 1990 Sex reversal of tilapia in earthen ponds Research and Development Series No 35 Alabama Agricultural Experiment Station Auburn University Alabama

Verheust L E E Veverica, and L Rurangwa 1991 Comparative growth and mortality of *Oreochromis niloticus* and *Clarias gariepinus* fingerlings in earthen ponds (Rwanda) Pages 318 319 *in* N De Pauw and J Joyce, editors EAS Special Publication No 14 (1991) Aquaculture and the Environment 332 pp

Veverica, K 1992 (In Progress) Proceedings The Third Conference on High Elevation Tilapia Culture Butare, Rwanda

Presentations

Hanson B , V Adorevaho, E Rwangano, E Rurangwa, M Van Speybroeck, R Tubb, and W Seim January 1988 Relationship between water chemistry and the growth of *Tilapia nilotica* in Rwandan (Central Africa) fish ponds fertilized with chicken manure Paper presented at World Aquaculture Society Meeting, Honolulu, Hawaii

Harwanmbaga G , E Rwangano, and B Hanson January 1988 A descriptive study of plankton in Rwandan (Central Africa) fish ponds fertilized with chicken manure or triple superphosphate Paper presented at World Aquaculture Society Meeting, Honolulu, Hawaii

Rwangano, E , M Van Speybroeck, E Rurangwa, K Veverica, and B Hanson January 1988 Fingerling production of *Tilapia nilotica* at the Rwasave Fish Culture Station of the National University of Rwanda Paper presented at World Aquaculture Society Meeting, Honolulu Hawaii

Oregon State University

Publications and Reports

Balakrishnan, R , K Veverica and P Nyirabumana 1993 Rwanda Women in Aquaculture Context, Contributions and Constraints Office of Women in Development, Oregon State University, Corvallis, Oregon 39 pp

Balakrishnan, R , K Veverica and P Nyirabumana 1992 Proceedings of the Colloquium on Rwanda Women in Aquaculture Kigembe Station, Rwanda WID, Oregon State University, Corvallis, Oregon

Balakrishnan, R , K Veverica, P Nyirabumana, and R Runey 1992 An Approach to Integrate Gender Variable in Rwanda Pond Dynamics and Aquaculture Collaborative Research Program WID, Oregon State University, Corvallis, Oregon

Curtis, E R , E T Diren, M D Hurley, W K Seim, and R A Tubb 1991 Disposition and elimination of 17α methyltestosterone in Nile tilapia (*Oreochromis niloticus*) Aquaculture 99 192-201

Sikoki, E D , R A Tubb, and E R Curtis 1986 Inhibition of hepatic UDP glucuronyl transferase (UDP GT) activity coincident with elevated plasma sex steroid concentrations during gonadal maturation in carp Pages 553 559 *in* R S V Pullin, T Bhukaswan, The Toxicologist V 6(1)

Proceedings of the Colloquium of Rwanda Women in Aquaculture 1992 English/French version and Kinarwanda/French version

Presentations

Balakrishnan, R , and P Nyirabumana 1992 Rwanda Women's Role in Integrated Aquaculture Systems for Resource Sustainability Farming Systems Research and Extension Symposium Working paper series Michigan State University, East Lansing, Michigan

Curtis, E , E Diren, M Hurley, and R Tubb April 1988 Minimal residue levels after sex reversal of *Tilapia nilotica* by methyltestosterone but persistent alterations in hepatic detoxication systems Paper presented at Federation of American Societies for Experimental Biology, Las Vegas, Nevada

Seim, W 1993 Using Eco region classification to order pond management strategies U S Forest Service Workshop on Warm Water Fish Management June 28-30, Bend, Oregon

Sikoki, E , E Curtis, and R Tubb 1986 Inhibition of hepatic UDP Glucuronyl transferase (UDP GT) activity coincident with elevated plasma sex steroid concentrations during gonadal maturation in carp Paper presented at Society of Toxicologists, Atlanta, Georgia

Tubb, R March 1986 The reduction of estradiol by liver enzymes in carp and rainbow trout Paper presented at Toxicology Meetings, New Orleans

University of Arkansas at Pine Bluff

Publications and Reports

Engle, C , M Brewster, and E Hitayezu 1993 An economic analysis of fish production in a subsistence agricultural economy The case of Rwanda The Journal of Aquaculture in the Tropics 8 151-165

Springborn, R R , A L Jensen, W Y B Chang, and C Engle 1992 Optimum harvest time in aquaculture An application of economic principles to a tilapia growth model Aquaculture and Fisheries Management 23 639 647

University of Michigan

Publications and Reports

Springborn, R R , A L Jensen, W Y B Chang, and C Engle 1992 Optimum harvest time in aquaculture An application of economic principles to a tilapia growth model Aquaculture and Fisheries Management 23 639-647.

Thailand

Asian Institute of Technology

Theses

Boonsong, S. Role of zooplankton in feeding juvenile tilapia (*Oreochromis niloticus*). M.S. thesis.

Guttman, H. 1990. Assessment of nutrient limitation in fertilized fish ponds by algal assay. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

Jiwyam, W. 1990. The role of sediments in pond fertility. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand. 347 pp.

Muthuwan, V. 1991. Nutrient budget and water quality in intensive marine shrimp culture ponds. M.S. Thesis. Asian Institute of Technology, Bangkok, Thailand.

Narong, V. Effects of phytoplankton on nursing walking catfish fry in static and flow-through water systems.

Pautong, A.K. 1991. Role of urea in fertilizing fish ponds. M.S. thesis. Asian Institute of Technology, Bangkok, Thailand.

Qifeng, Y. 1991. Nutrient budget and water quality in integrated walking catfish tilapia culture. M.S. Thesis. Asian Institute of Technology, Bangkok, Thailand.

Rao, I.V.G. 1989. Gonadal development in environmentally induced breeding of walking catfish *Clarias batrachus* (Linnaeus). M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

Shrestha, M.K. 1989. Impact of attached microorganism biomass on tilapia (*Oreochromis niloticus*) production. M.S. thesis. Asian Institute of Technology, Bangkok, Thailand.

Suresh, A.V. Influence of stocking density on red tilapia production in a recirculation system.

Ullah, Md. A. 1989. Nutrient release characteristics of duck manure for Nile tilapia production. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

Michigan State University

Publications and Reports

Guttman, H., and C.E. Knud-Hansen. 1992. Fish pond management by algal assay. Abstract in Journal of the World Aquaculture Society.

Knud-Hansen, C.F. 1992. Pond history as a source of error in fish culture experiments: A quantitative assessment using covariate analysis. Aquaculture 105:21-36.

Knud-Hansen, C.F. 1992. Analyzing standard curves in the chemistry of waters used for aquaculture. Naga, the ICLARM Quarterly (January) 16:19.

Knud-Hansen, C.F., and C.K. Lin. 1992. Strategies for stocking Nile tilapia (*Oreochromis niloticus*) in fertilized ponds. The Third International Symposium on Tilapia in Aquaculture, Abidjan, Cote d'Ivoire, Africa.

Knud-Hansen, C.F., and A.K. Pautong. 1993. On the role of urea in pond fertilization. Aquaculture 114:273-283.

Knud-Hansen, C.F., T.R. Batterson, and C.D. McNabb. 1993. The role of chicken manure in the production of Nile tilapia (*Oreochromis niloticus*). Aquaculture and Fisheries Management 24:483-493.

Knud-Hansen, C.F., C.D. McNabb, and T.R. Batterson. 1991. Application of limnology for efficient nutrient utilization in tropical pond aquaculture. Proceedings of the International Association of Theoretical and Applied Limnology 24:2541-2543.

Knud-Hansen, C.F., C.D. McNabb, and T.R. Batterson. 1989. Application of limnology for efficient nutrient utilization in tropical pond aquaculture. Abstract in XXIVth Congress of the International Association of Theoretical and Applied Limnology.

McNabb, C.D., C.F. Knud-Hansen, T.R. Batterson, and K. Jayen. 1991. A systematic approach to maximizing nutrient efficiency and growth of Nile tilapia (*Oreochromis niloticus*) under semi-intensive pond culture. Abstract in Journal of the World Aquaculture Society 22:404.

McNabb, C.D., T.R. Batterson, C.K. Lin, K. Jayen, J.F. Hanson, and R. Chuenpagdee. 1989. Fish yield with nitrogen supplemented organic fertilizers. Abstract in Journal of the World Aquaculture Society 20:564.

McNabb, C.D., T.R. Batterson, B.J. Premo, C.F. Knud-Hansen, H.M. Ladman, C.K. Lin, K. Jayen, J.F. Hanson, and R. Chuenpagdee. 1990. Managing fertilizers for fish yield in tropical ponds in Asia. Pages 169-172 *in* R. Hirano and I. Hanyu, editors. Proceedings of the Second Asian Fisheries Forum.

McNabb, C.D., T.R. Batterson, B.J. Premo, C.F. Knud-Hansen, H.M. Ladman, C.K. Lin, K. Jayen, J.F. Hanson, and R. Chuenpagdee. 1989. Managing fertilizers for fish yield in tropical ponds in Asia. Abstract in The Second Asian Fisheries Forum.

Shrestha, M.K., and C.F. Knud-Hansen. In press. Increasing attached microorganisms biomass as a management strategy for Nile tilapia (*Oreochromis niloticus*) production. Aquacultural Engineering.

Yusoff, F.M., and C.D. McNabb. 1989. Effects of nutrient availability on primary productivity and fish production in fertilized tropical ponds. Aquaculture 78:303-319.

Presentations

Guttman, H., and C.F. Knud-Hansen. May 1992. Fish pond management by algal assay. World Aquaculture Society, 23rd Annual Meeting, Orlando, Florida.

Knud-Hansen, C.F., and A.K. Pautong. May 1992. The role of urea in fishpond fertilization. World Aquaculture Society, 23rd Annual Meeting, Orlando, Florida.

Knud-Hansen, C.F., C.D. McNabb, and T.R. Batterson. August 1989. Application of limnology for efficient nutrient utilization in tropical pond aquaculture. XXIVth Congress of the International Association of Theoretical and Applied Limnology.

McNabb, C.D., C.F. Knud-Hansen, T.R. Batterson, and K. Jayen. June 1991. A systematic approach to maximizing nutrient efficiency and growth of Nile tilapia (*Oreochromis niloticus*) under semi-intensive pond culture. World Aquaculture Society Meeting, 22nd Annual Meeting, San Juan, Puerto Rico.

McNabb, C.D., T.R. Batterson, C.K. Lin, K. Jayen, J.F. Hanson, and R. Chuenpagdee. February 1989. Fish yield with nitrogen supplemented organic fertilizers. Presented at the World Aquaculture Society Meeting, Aquaculture 1989, Los Angeles, California.

McNabb, C.D., T.R. Batterson, B.J. Premo, C.F. Knud-Hansen, H.M. Ladman, C.K. Lin, K. Jayen, J.F. Hanson, and R. Chuenpagdee. April, 1989. Managing fertilizers for fish yield in tropical ponds in Asia. Second Asian Fisheries Forum, Tokyo, Japan.

Shrestha, M.K., and C.F. Knud-Hansen. In press. Increasing attached microorganisms biomass as a management strategy for Nile tilapia (*Oreochromis niloticus*) production. Aquacultural Engineering.

Manuscripts

Hopkins, K., and C.F. Knud-Hansen. Submitted. Comparison of three fertilization strategies: Algal assay, nutrient concentration, and empirically determined constant rate. Journal of the World Aquaculture Society.

Knud-Hansen, C.F., and T.R. Batterson. Submitted. Effect of fertilization frequency on the production of Nile tilapia (*Oreochromis niloticus*). Aquaculture.

Knud-Hansen, C.F., and H. Guttman. Submitted. Algal assay method for pond fertilization. Journal of the World Aquaculture Society.

Other

Knud-Hansen, C.F., and T.R. Batterson. 1987-1992. Thailand PD/A CRSP data diskettes for Work Plans IV, V, and VI experiments using IOTUS 1-2-3.

University of Hawaii

Publications and Reports

Hopkins, K.D. 1992. Reporting fish growth, a review of the basics. Journal of World Aquaculture Society 23(3):173-179.

Hopkins, K.D. 1988. Reporting fishpond yields to farmers. Aquabyte 1(2):6.

Hopkins, Kevin. Reporting fish growth: a review of the basics. World Aquaculture. Accepted for publication.

Hopkins, K.D., and D. Pauly. (In Press). Instantaneous mortalities and multivariate models: Applications to tilapia culture in saline water. *In* M. Prein, G. Hulata and D. Pauly (eds.), Multivariate methods in aquaculture research: Case studies of tilapias in experimental and commercial systems. Israel Agricultural Research Organization/Bundesministerium fur Wirtschaftliche Zusammenarbeit/International Center for Living Aquatic Resources Management, Manila.

Hopkins, K., and A. Yakupitiyage. Bias in seine sampling of tilapia. Journal of the World Aquaculture Society. Accepted for publication.

Hopkins, K.D., M.L. Hopkins, and D. Pauly. 1988. A multivariate model of tilapia growth, applied to seawater tilapia culture in Kuwait. Pages 29-39 *in* R.S.V. Pullin, T. Bhukaswan, K. Tonguthai, and J.L. Maclean, editors. The Second International Symposium on Tilapia in Aquaculture. ICLARM Conference Proceedings 15. International Center for Living Aquatic Resources Management, Manila, Philippines.

Sayer, J P , and J M Ebeling 1993 Photosynthesis and community respiration at three depths during a period of stable phytoplankton stock in a eutrophic brackish water culture pond Marine Ecology Progress Series 94 229-238

Sayer, J , and K D Hopkins 1993 Effects of pond depth and mechanical mixing on production of *Oreochromis niloticus* in manured earthen ponds *In* R S V Pullin, J Lazard, M Legendre, and J B Amon Kothias (editors), The Third International Symposium on Tilapia in Aquaculture ICLARM Conference Proceedings 41, International Center for Living Aquatic Resources Management, Manila, Philippines

Sayer, J , and C K Lin 1990 Techniques for assessment of stratification and effects of mechanical mixing in tropical fish ponds Aquacultural Engineering 9 151-165

Sayer, J P , K Hopkins, and C K Lin 1991 Production of *Oreochromis niloticus* (L) and ecosystem dynamics in manured ponds of three depths Aquaculture and Fisheries Management 22 169-180

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

Presentations

Lin, C K , and J Sayer June 1990 Stratification of temperature and dissolved oxygen in tropical fish ponds World Aquaculture '90 Halifax

Manuscripts

Hopkins, K D Systemic variation in the growth parameter phi prime Submitted to Aquabyte November, 1992

Hopkins K , and C E Knud Hansen Submitted Comparison of three fertilization strategies Algal assay, nutrient concentration, and empirically determined constant rate Journal of the World Aquaculture Society

University of Michigan

Theses

Buurma, B J 1991 The effects of feeding frequency and handling in culture of the walking catfish, *Clarias fuscus* M S thesis, University of Michigan

Publications and Reports

Buurma, B J , and J S Diana 1993 The effects of feeding frequency and handling on growth and mortality of cultured walking catfish, *Clarias fuscus* Journal of the World Aquaculture Society

Diana, J S 1993 Conservation and utilization of genetic resources in capture and culture fisheries Pages 89 104 *in* C S Potter, J I Cohen, and D Janczewski, editors Perspectives on Biodiversity Case Studies of Genetic Resource Conservation and Development American Association for the Advancement of the Sciences, Washington, D C

Diana, J S , and A Lazt 1989 The effects of water exchange rate and density on yield of the walking catfish, *Clarias fuscus* Aquaculture 78 267-276

Diana, J S , and D Ottey 1986 Biological principles of pond culture Fish Pages 39-52 *in* James F Lannan, R O Smitherman and George Tchobanoglous, editors Principles and Practices of Pond Aquaculture A State of the Art Review Oregon State University Press, Corvallis Originally published as internal report in 1983

Diana, J S , D J Dettweiler, and C K Lin 1991 Effect of Nile tilapia *Oreochromis niloticus* on the ecosystem of aquaculture ponds, and its significance to the trophic cascade hypothesis Canadian Journal of Fisheries Aquatic Science 48 183-190

Diana, J S , S E Kohler, and D R Ottey 1988 A yield model for walking catfish production in aquaculture systems Aquaculture 71 23-35

Diana, J , C K Lin, P Schneeburger 1990 Relationships among nutrient inputs, nutrient concentrations, primary production, and yield of *Oreochromis niloticus* in ponds Aquaculture 92 323-341

Diana, J S , P J Schneeberger, and C K Lin 1988 Relationships between primary production and yield of *Tilapia nilotica* in ponds Pages 1 6 *in* R S V Pullin, T Bhukaswan, K Tonguthai, and J L MacLean, editors The Second International Symposium on Tilapia in Aquaculture ICLARM Conference Proceedings 15 Manila, Philippines

Knud-Hansen, C F , and C K Lin 1992 Strategies for stocking Nile tilapia (*Oreochromis niloticus*) in fertilized ponds The Third International Symposium on Tilapia in Aquaculture, Abidjan, Cote d'Ivoire, Africa

Lin, C K 1990 Integrated culture of walking catfish and tilapia Pages 209-212 *in* R Hirano and I Hanyu, editors Proceedings of the Second Asian Fisheries Forum Asian Fisheries Society, Manila

Lin, C K 1989 Prawn culture in Taiwan What went wrong? World Aquaculture 20 19-20

Lin, C K 1989 Occurrence of mass mortality of black tiger prawns in Taiwan Thai Fisheries Gazette 42 209 216

Lin, C K 1986 Acidification and reclamation of acid sulfate soil fishponds in Thailand Pages 71-74 *in* J L MacLean, L B Dizon, and L V Hosillos, editors The First Asian Fisheries Forum Asian Fisheries Society, Manila, Philippines

Lin, C K 1986 Nutrient dynamics between inorganic and organic fertilization in tilapia culture ponds Proceedings of the 24th Kasetsart University Conference on Fisheries 174-182

Lin, C K 1986 Biological principles of pond culture Phytoplankton and macrophytes Pages 21-26 *in* James F Lannan, R O Smitherman, and George Tchobanoglous, editors Principles and Practices of Pond Aquaculture A State of the Art Review Oregon State University Press, Corvallis (Originally published internally in 1983)

Lin, C K , and M Boonyaratpalin 1988 An analysis of biological characteristics of *Macrobrachium rosenbergii* in relation to pond production and marketing in Thailand Aquaculture 74 205-215

Lin, C K , and P Tavarutmaneegul 1986 Acidification and reclamation of acid sulfate soil fish ponds in Thailand First Asian Fisheries Society Forum, Manila, Philippines Published in Forum proceedings

Lin, C K , C Apinhapath, and V Lansakul 1988 Biological nitrogen fixation as a source of nitrogen input in fishponds Pages 53-58 *in* R S V Pullin, T Bhukaswan, K Tonguthai, and J L MacLean, editors The Second International Symposium on Tilapia in Aquaculture ICLARM Conference Proceedings 15 Manila, Philippines

McNabb, C D , T R Batterson, B J Premo, C F Knud-Hansen, H M Eidman, C K Lin, K Jaiven, J F Hanson, and R Chuenpagdee 1990 Managing fertilizers for fish yield in tropical ponds in Asia Pages 169 172 *in* R Hirano and I Hanyu, editors Proceedings of The Second Asian Fisheries Forum Asian Fisheries Society, Manila, Philippines

Muthuwana W , V Lansakul, and C K Lin 1986 Nutrient dynamics between inorganic and organic fertilized ponds for tilapia culture Proceedings of the Kasetsart University Agricultural Conference (January 1985)

Muthuwana W , V Lansakul, and C K Lin 1986 Production and utilization of organic carbon in tilapia culture ponds Proceedings of the Kasetsart University Agricultural Conference (January 1985)

Nash, G , S Chinabut, and C Limsuwan 1987 Idiopathic muscle necrosis in the freshwater prawn, *Macrobrachium rosenbergii* (de Man), cultured in Thailand Journal of Fish Diseases 10 109 120

Suresh, A V , and C K Lin 1992 Effect of stocking density on water quality and production of red tilapia in a recirculated water system Journal of Aquaculture Engineering (accepted for publication)

Tansakul, V , T Sae Lee, and E Sae-Loaw 1987 Acute toxicity and treatment effect of formalin to early larvae prawn, *Macrobrachium rosenbergii* (de Man) Proceedings of the 25th Kasetsart University Conference on Fisheries

Tavarutmanegul, P , and C K Lin 1987 Breeding and rearing of sand goby (*Oxyeleotris rosenbergii*, Blk) fry Aquaculture 69 299-305

Presentations

Diana, J S , and C K Lin January 1988 Effects of fertilization rate on primary production and yield of tilapia in ponds World Aquaculture Society, Honolulu, Hawaii

Diana, J S , C K Lin, and D Dettweiler February 1989 Cascading trophic interactions A test of the hypothesis using tilapia culture data World Aquaculture Society, Los Angeles, California

Diana, J S , P J Schneeberger, and C K Lin 1987 Relationships among nutrient input, primary production, and yield of *Tilapia nilotica* in ponds Second International Symposium on Tilapia in Aquaculture, Bangkok Thailand

Lin, C K April 1990 Integrated culture of walking catfish and tilapia Second Asian Fisheries Forum Tokyo

Lin, C K , and S Auworatham 1987 Effects of inorganic and organic fertilizers on zooplankton production in tilapia ponds 25th Kasetsart University Conference, Bangkok, Thailand

Lin, C K , and J S Diana February 1989 Integrated culture of walking catfish and tilapia in earthen ponds World Aquaculture Society, Los Angeles, California

Lin, C.K., and J.S. Diana. 1987. Fertilization effects on pond carrying capacity in extensive culture of tilapia (*Oreochromis niloticus*). Second International Symposium on Tilapia in Aquaculture, Bangkok.

Lin, C.K., and J. Szyper. June 1990. Stratification of temperature and dissolved oxygen in tropical fish ponds. World Aquaculture '90. Halifax.

Lin, C.K., A. Apinapat, and V. Tansakul. 1987. Biological nitrogen fixation as a source of nitrogen input in fish ponds. Second International Symposium on Tilapia in Aquaculture, Bangkok, Thailand.

Lin, C.K., S. Auworatham, and V. Tansakul. 1986. Dietary consumption of zooplankton by tilapia in fertilized ponds. Thai Fisheries Academy Seminar.

Lin, C.K., M. Boonvaratpalin, and Y. Musig. 1986. Biological characteristics of *Macrobrachium rosenbergii* (de Man) in relation to pond production and marketing. First Asian Fisheries Society Forum, Manila, Philippines.

Lin, C.K., E. Sae-Loaw, and V. Tansakul. 1987. Rearing post-larvae of *Macrobrachium rosenbergii* at high stocking density in concrete tanks. 25th Kasetsart University Conference, Bangkok.

Lin, C.K., V. Tansakul, W. Muthuwana, and S. Auworatham. 1986. Production and utilization of organic carbon in tilapia culture and ponds. Thai Fisheries Academy Seminar.

Lin, C.K., W. Muthuwana, V. Tansakul, S. Auworatham, and C. Apinapat. 1986. Nutrient dynamics between inorganic and organic fertilized ponds for tilapia culture. Thai Fisheries Academy Seminar.

Musig, Y., M. Boonvaratpalin, and C.K. Lin. 1987. Water quality in Macrobrachium grow-out ponds. 25th Kasetsart University Conference, Bangkok.

Tansakul, V., T. Sae-Lee, and F. Sae-Loaw. 1987. Acute toxicity and treatment effect of formalin on early larval prawns (*Macrobrachium rosenbergii* (de Man). 25th Kasetsart University Conference, Bangkok.

Manuscripts

Buurma, B.J., and J.S. Diana. 1993. The effects of feeding frequency and handling on growth and mortality of cultured walking catfish, *Clarias fuscus*. Journal of the World Aquaculture Society. (Accepted for publication).

Lin, C.K. 1990. Production and consumption of freshwater prawns (*Macrobrachium rosenbergii*). Journal of the World Aquaculture Society. (Accepted for publication).

Lin, C.K., K. Jaiven, V. Muthuwana. 1990. Integrated culture of intensive and semi-intensive aquaculture. Concept and example. Thai Fisheries Gazette (in review).

Suresh, A.V., and C.K. Lin. 1992. A review on tilapia culture in saline water. Aquaculture (submitted).

Szyper, J.P., and C.K. Lin. 1990. Stratification of temperature and dissolved oxygen in mixed and unmixed ponds. Journal Aquaculture Engineering (in press).

Other

Lin, C.K. 1990. Effects of intensive shrimp culture on coastal environment in upper Gulf of Thailand. Seminar at Royal Thai Government Department of Fisheries and Shrimp Farmers Associations. 15-16 February 1990.

Lin, C.K. 1990. Current status of freshwater prawn and marine shrimp culture in Thailand. Seminar at Great Lakes Fisheries Research Laboratory, Ann Arbor, Michigan.

Lin, C.K. 1989. Intensive pond culture of freshwater prawns and marine shrimps in Thailand. Seminar at Auburn University, Auburn, Alabama. 23 May 1989.

Lin, C.K. 1989. The problems of marine shrimp culture in Taiwan. Seminar at Royal Thai Government Department of Fisheries and Shrimp Farmers Association, Bangkok, Thailand. July 1989.

Lin, C.K. 1989. Overview of current aquaculture in the Orient and the USA. Seminar at United States Agency for International Development, Bangkok, Thailand. 28 July 1989.

Lin, C.K. 1989. Aquaculture in Thailand and ARS Program. Seminar at Citizens Ambassadors, Bangkok, Thailand. August 1989.

CRSP Research Reports

The following publications have been issued by the Pond Dynamics/Aquaculture Collaborative Research Support Program, Oregon State University, Corvallis, Oregon 97331-1611. Copies may be obtained from the PD/A CRSP office.

Data Reports by CRSP Researchers

Batterson, T.R., C.D. McNabb, C.E. Knud-Hansen, H.M. Fidman, and K. Sumantadinata. 1989. Indonesia. Cycle III of The Global Experiment. Collaborative Research Data Reports Volume Three, Number Three. PD/A CRSP, Corvallis, Oregon. 145 pp.

Carpenter, K.E., A.W. Fast, J. Carreon, and R. Juliano. 1991. Philippines. Cycle III of the Global Experiment. Collaborative Research Data Reports Volume Four, Number Three. PD/A CRSP, Corvallis, Oregon. 257 pp.

Carpenter, K.E., J. Woessner, R.D. Fortes, A. Fast, and P. Helfrich. 1991. Philippines. Cycle II of The Global Experiment. Collaborative Research Data Reports Volume Four, Number Two. PD/A CRSP, Corvallis, Oregon. 501 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 Two, Number One. PD/A CRSP, Corvallis, Oregon. 47 pp.

Diana, J.S., C.K. Lin, T. Bhukaswan, V. Sirsuwanatach, and B.J. Buurma. 1991. Thailand. Cycle III of the Global Experiment. Collaborative Research Data Reports, Volume Two, Number Three. PD/A CRSP, Corvallis, Oregon. 86 pp.

Diana, J.S., C.K. Lin, T. Bhukaswan, V. Sirsuwanatach, and B.J. Buurma. 1990. Thailand. Cycle II of the Global Experiment. Collaborative Research Data Reports, Volume Two, Number Two. PD/A CRSP, Corvallis, Oregon. 54 pp.

Egna, H.S., N. Brown, and M. Teshe (editors). 1989. General Reference Site Descriptions, Materials and Methods for the Global Experiment. Collaborative Research Data Reports, Volume One. PD/A CRSP, Corvallis, Oregon. 84 pp.

Green, B.W., H.R. Alvarenga, R.P. Phelps, and J. Espinoza. 1990. Honduras. Cycle II of The Global Experiment. Collaborative Research Data Reports, Volume Six, Number Two. PD/A CRSP, Corvallis, Oregon. 94 pp.

Green, B.W., H.R. Alvarenga, R.P. Phelps, and J. Espinoza. 1990. Honduras. Cycle I of The Global Experiment. Collaborative Research Data Reports, Volume Six, Number One. PD/A CRSP, Corvallis, Oregon. 94 pp.

Green, B.W., H.R. Alvarenga, R.P. Phelps, and J. Espinoza. 1989. Honduras. Cycle III of The Global Experiment. Collaborative Research Data Reports, Volume Six, Number Three. PD/A CRSP, Corvallis, Oregon. 114 pp.

Hanson, B., V. Ndorevaho, F. Rwangano, R. Tubb, and W.K. Semu. 1991. Rwanda. Cycle III of the Global Experiment. Collaborative Research Data Reports Volume Five, Number Two. PD/A CRSP, Corvallis, Oregon. 102 pp.

Hanson, B., V. Ndorevaho, R. Tubb, F. Rwangano, and W.K. Semu. 1989. Rwanda. Cycle I of The Global Experiment. Collaborative Research Data Reports Volume Five, Number One. PD/A CRSP, Corvallis, Oregon. 62 pp.

Hughes, D., R.P. Phelps, and R.P. Malca. 1991. Aguadulce, Panama. Cycle III of the Global Experiment. Collaborative Research Data Reports Volume Eight, Number Three. PD/A CRSP, Corvallis, Oregon. 240 pp.

Hughes, D., R.P. Phelps, and R.P. Malca. 1991. Aguadulce, Panama. Cycle II of The Global Experiment. Collaborative Research Data Reports Volume Eight, Number Two. PD/A CRSP, Corvallis, Oregon. 143 pp.

Hughes, D., A.T. Diaz, R.P. Phelps, and R.P. Malca. 1991. Aguadulce, Panama. Cycle I of The Global Experiment. Collaborative Research Data Reports Volume Eight, Number One. PD/A CRSP, Corvallis, Oregon. 122 pp.

McNabb, C.D., T.R. Batterson, B.J. Premo, H.M. Fidman, and K. Sumantadinata. 1991. Indonesia. Cycle II of The Global Experiment. Collaborative Research Data Reports Volume Three, Number Two. PD/A CRSP, Corvallis, Oregon. 49 pp.

McNabb, C.D., T.R. Batterson, B.J. Premo, H.M. Fidman, and K. Sumantadinata. 1988. Indonesia. Cycle I of The Global Experiment. Collaborative Research Data Reports, Volume Three, Number One. PD/A CRSP, Corvallis, Oregon. 67 pp.

Teichert-Coddington, D.R., M. Peralta, R.P. Phelps, and R.P. Malca. 1991. Gualaca, Panama. Cycle III of The Global Experiment. Collaborative Research Data Reports Volume Seven, Number Two. PD/A CRSP, Corvallis, Oregon. 56 pp.

Teichert-Coddington, D.R., M. Peralta, R.P. Phelps, and R.P. Malca. 1991. Gualaca, Panama. Cycle I of The Global Experiment. Collaborative Research Data Reports Volume Seven, Number One. PD/A CRSP, Corvallis, Oregon. 97 pp.

Woessner, J., R.D. Fortes, and V. Corre, Jr. 1991. Philippines. Cycle I of The Global Experiment. Collaborative Research Data Reports Volume Four, Number One. PD/A CRSP, Corvallis, Oregon. 141 pp.

Other Publications by CRSP Researchers

Publications

Brune, D E , and R H Piedrahita 1982 Operation of a retained biomass nitrification system for treating aquaculture water for reuse Proceedings of the First International Conference on Fixed-Film Biological Processes, pp 845-869

Chang, W 1987 Fish culture in China Fisheries 12(3) 11-15

Chang, W 1987 Historical center of fish center in China in Lake Tai/Yangtze River Delta Aquaculture Magazine 13 39 42

Chang, W 1987 Large lakes of China J Great Lakes Res 13(3) 235-249

Chang, W 1986 Aquaculture research in China China Exchange News, CSCPRC, National Academy of Sciences 14(2) 13 16

Chang, W 1986 Practical methods for treating fish during oxygen stress in ponds Aquaculture Magazine 13(4) 20 22

Chang, W , and R Rossmann Changes in the abundance of blue green algae related to nutrient loadings in the nearshore of Lake Michigan Hydrobiologia 157 271 278

Chang, W , J Diana, and W Chapochuk 1983 Strengthening of Southeast Asian Aquaculture Institutions Workshop Report to Agency for International Development

Ebeling, J M and R H Piedrahita 1985 Microcomputer based data acquisition system for aquaculture use American Society of Agriculture Engineers Paper Number 85-5014 8 pp

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

Grace, G and R H Piedrahita 1989 Carbon dioxide removal in packed column aerators American Society of Agricultural Engineers Paper Number 89-7014

Hopkins K D , J L Lannan and J R Bowman 1988 Managing a data base for pond research data—the CRSP experience Aquabyte 1(1)

Losordo, J M and R H Piedrahita 1988 Simulating aquacultural pond thermal stratification with a spreadsheet model American Society of Agricultural Engineers Paper Number 88 5003

Losordo, J M and R H Piedrahita 1988 Modeling vertical water quality profiles in aquaculture ponds, review and evaluation Pages 313 327 *in* Proceedings of the Conference Aquacultural Engineering Technologies for the future, Stirling, Scotland I Chemie Symposium Series No 111, EFCE Publications Series No 66 Rubgy United Kingdom

Losordo, J M , J M Ebeling, and R H Piedrahita 1986 Stratification measurement techniques in aquaculture ponds American Society of Agricultural Engineers Paper Number 86-5047 14 pp

Losordo, J M , R H Piedrahita, and J M Ebeling 1988 An automated water quality acquisition system for use in aquaculture ponds Aquacultural Engineering 7 265 278

Piedrahita, R H 1988 Introduction to computer modeling of aquaculture pond ecosystems Aquaculture and Fisheries Management 19 1 12

Piedrahita, R H 1987 Sensitivity analysis for an aquacultural pond model Pages 119-123 *in* J G Balchen, editor Automation and Data Processing in Aquaculture Pergamon Press New York

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

Piedrahita, R H and G Tchobanoglous 1987 The use of human wastes and sewage in aquaculture Pages 336 352 *in* D J W Moriarty and R S F Pullin, editors Detritus and microbial ecology in aquaculture ICLARM Conference Proceedings 14, International Center for Living Aquatic Resources Management, Manila, Philippines 420 pp

Piedrahita, R H , J M Ebeling and J M Losordo 1987 Use of data acquisition systems in aquaculture Pages 259 262 *in* J G Balchen, editor Automation and Data Processing in Aquaculture Pergamon Press, New York

Piedrahita, R H , G Tchobanoglous, and B Moore 1987 Effect of organic matter addition to fish culture systems Transactions of ASAE 30(1) 233-237

Piedrahita R H D E Brune, G Tchobanoglous and G E Orlob 1984 General model of the aquaculture pond ecosystem Journal of the World Mariculture Society 15 355 366

Popma, T J , and B W Green 1990 Aquaculture Production Manual Sex reversal of tilapia in earthen ponds Research and Development Series No 35 International Center for Aquaculture, Auburn University, Alabama

Sikoki, F D , R A Tubb, and L R Curtis 1989 Elevation of sex steroids and inhibition of UDP-glucuronyl transferase are out of phase during gonadal maturation in the common carp Comp Biochemical Physiol 92C 2 267-272

Smith, D W , and R H Piedrahita 1988 The relation between phytoplankton and dissolved oxygen concentration in fish ponds Aquaculture 68 249 265

Teichert Coddington, D R , and R O Smitherman 1988 Lack of response by *tilapia nilotica* to mass selection for rapid early growth Transactions of the American Fisheries Society 117 297 300

Teichert-Coddington, D R , L L Behrends, and R O Smitherman 1990 Effects of manuring regime and stocking rate on primary production and yield of tilapia using liquid swine manure Aquaculture 88 61-68

Scientific Papers Presented

Chang, W 1987 China integrated aquaculture An efficient ecological system Abstract, The Limnology & Oceanography 1987 Annual Meeting

Chang, W 1987 The world's highest lake Tibetan Lakes Abstract 30th Great Lakes Res

Chang, W 1986 Large lakes in China Abstract 29th Great Lakes Res

Chang, W 1986 Vertical oxygen dynamics of shallow tropical impoundments in the Pearl River Delta, China Tran Amer Phys Union 66(51) 13-1

Whitman, M H , and R H Piedrahita 1989 Water quality requirements of Pacific oysters (*Crassostrea gigas*) in holding systems Presented at the Annual Meeting of the World Aquaculture Society, Los Angeles, February 12 pp

IX. Abstracts of Technical Papers

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

Validation of PD/A CRSP Pond Management Strategies

Work Plan 7, Study 1A

Bartholomew W. Green
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

Zeinab A. Elnagdy
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Sharkia, Egypt

Abstract

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

Soil Respiration: Effects of Chicken Litter and Urea

David R. Teichert-Coddington
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

Nelson Claros
El Carao National Fish Culture Research Center
Ministry of Natural Resources
Comayagua, Honduras

Abstract

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

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

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

Intensive Fertilization of Tilapia Ponds in the Philippines

Work Plan 6, Experiment 10

Kevin D. Hopkins
College of Agriculture
University of Hawaii at Hilo
Hilo, Hawaii

Eduardo Lopez
Freshwater Aquaculture Center
Central Luzon State University
Munoz, Nueva Ecija, Philippines

James P. Szyper
Hawaii Institute of Marine Biology
University of Hawaii at Manoa
Kaneohe, Hawaii

Abstract

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

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

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

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

Work Plan 6, Study 9

Christopher F. Knud-Hansen
Agriculture & Food Engineering Division
Asian Institute of Technology
Bangkok, Thailand

Ted R. Batterson
Department of Fisheries and Wildlife
Michigan State University
East Lansing, Michigan

Hans Guttman, C. Ewer Lin, and Peter Edwards
Agriculture & Food Engineering Division
Asian Institute of Technology
Bangkok, Thailand

Abstract

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

Nitrogen Requirements for Maximum Fish Production in Rwandan Ponds

Work Plan 6, Experiment 2

Joyce R. Newman
Station Piscicole de Rwasave
Université Nationale du Rwanda
Butaré, Rwanda
and Auburn University
Auburn, Alabama

Anaclet Gatera
Station Piscicole de Rwasave
Université Nationale du Rwanda
Butaré, Rwanda

Wayne K. Seim
Department of Fisheries & Wildlife
Oregon State University
Corvallis, Oregon

Thomas J. Popma and Karen L. Veverica
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

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

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

Optimization of Gender Control Techniques for Tilapia

Work Plan 7, Study 4C1

Martin S. Fitzpatrick, Carl B. Schreck, and William L. Gale
Oregon Cooperative Fishery Research Unit
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon

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

Progeny Testing to Identify "YY" Male Tilapia

Work Plan 7, Study 4A1

Ronald P. Phelps
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

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

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

Work Plan 7, Study 4B1

E. Gordon Grau
University of Hawaii
Honolulu, Hawaii

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

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

Work Plan 7, Study 4A2

Bartholomew W. Green
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

Gamal El Naggar and Ali F. Abdelghany
Central Laboratory for Aquaculture Research
Agricultural Research Center
Ministry of Agriculture and Land Reclamation
Abbassa, Sharkia, Egypt

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

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

Work Plan 7, Study 2C1

William L. Shelton
University of Oklahoma
Norman, Oklahoma

Kevin D. Hopkins
University of Hawaii at Hilo
Hilo, Hawaii

Ashraf Soluman
Central Laboratory for Aquaculture Research
Abbassa, Egypt

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

Variation Of Soil Respiration With Humidity Using Pond Soil From Honduras

David R. Teichert-Coddington
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

Nelson Claros
El Carao National Fish Culture Research Center
Ministry of Natural Resources
Comayagua, Honduras

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

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

Work Plan 6, Experiment 1

Wayne K. Seim
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon

Karen L. Veverica and Thomas J. Popma
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

Anaclet Gatera
Université National du Rwanda
Butaré, Rwanda

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

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

Work Plan 6, Experiment 4

Karen L. Veverica and Thomas J. Popma
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

Anaclet Gatera
Station Piscicole de Rwasave
Université Nationale du Rwanda
Butare, Rwanda

Wayne K. Seim
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon

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

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

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

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

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

Work Plan 7, Study 4

Thomas J. Popma and Joyce R. Newman
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

Wayne Seim
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon

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

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

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

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

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

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

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

Work Plan 6, Study 5

Nathaniel Hishamunda
Rwandan National Fish Culture Service
Kigembe, Rwanda

Maria Thomas, David Brown, and Carole Engle
Aquaculture Fisheries Center
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas

Abstract

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

Pond Dynamics Under Semi-Intensive and Intensive Culture Practices

Work Plan 6, Study 5

James S. Diana
University of Michigan
Ann Arbor, Michigan

C. Kwei Lin
Asian Institute of Technology
Bangkok, Thailand

Kitjai Jaiyen
Royal Thai Department of Fisheries
Bangkok, Thailand

Abstract

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

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

Work Plan 6, Study 8

James P. Szyper
Institute of Marine Biology
University of Hawaii
Kaneohe, Hawaii

C. Kwei Lin
Asian Institute of Technology
Bangkok, Thailand

Abstract

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

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

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

Decision Support Systems for Pond Aquaculture

Work Plan 6, Study 1

Shree S. Nath, John P. Bolte, and Doug H. Ernst
Department of Bioresource Engineering
Oregon State University
Corvallis, Oregon

James E. Lannan
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon

Abstract

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

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

Work Plan 6, Study 3

Steve D. Culberson and Raul H. Piedrahita
Department of Biological and Agricultural Engineering
University of California, Davis
Davis, California

Abstract

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

Water Column Respiration in Aquaculture Ponds

Work Plan 6, Study 2

Philip Giovannini and Raul H. Piedrahita
Department of Biological and Agricultural Engineering
University of California, Davis

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

Causes of Cyclical Variation in Honduran Shrimp Production

David R. Teichert-Coddington
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

R. Rodriguez
Granjas Marinas de San Bernardo, S. A.
Choluteca, Honduras

W. Toyofuku
Aquacultivos de Honduras, S. A.
Choluteca, Honduras

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

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

David R. Teichert-Coddington
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

R. Rodriguez
Granjas Marinas de San Bernardo, S. A.
Choluteca, Honduras

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

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

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

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

Work Plan 6, Special Topics Study

Lieven Verheust and Frans Ollevier
Katholieke Universiteit Leuven
Leuven, Belgium

Karen Veverica and Thomas Popma
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama

Anaclet Gatera
Université Nationale du Rwanda
Butaré, Rwanda

Wayne Seim
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon

Abstract

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

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

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

James P. Szyper
Hawaii Institute of Marine Biology
University of Hawaii at Manoa
Kaneohe, Hawaii

James M. Ebeling
Piketon Research and Extension Center
P.O. Box 549
Piketon, Ohio

Abstract

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

Published in Marine Ecology Progress Series 94 229-238

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

James P. Szyper and Joel Z. Rosenfeld
Hawaii Institute of Marine Biology
University of Hawaii at Manoa
Kaneohe, Hawaii

Raul H. Piedrahita and Philip Giovannini
Department of Agricultural Engineering
University of California at Davis
Davis, California

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

Published in Limnology and Oceanography 37: 1193-1201

Summaries of Research in Progress

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

Work Plan 7, Study 2A

William L. Shelton
University of Oklahoma
Norman, Oklahoma

Abdel Rahman Mostafa
Central Laboratory for Aquaculture Research
Abbassa, Egypt

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

Bioconversion of Gastropods by Black Carp in Egyptian Fish Culture Ponds

Work Plan 7, Study 2B

William L. Shelton
University of Oklahoma
Norman, Oklahoma

Ashraf Soluman
Central Laboratory for Aquaculture Research
Abbassa, Egypt

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

Predator/Prey Bioconversion of Tilapia Reproduction by *Clarias*

Work Plan 7, Study 2D

William L. Shelton
University of Oklahoma
Norman, Oklahoma

C. Kwei Lin
Asian Institute of Technology
Bangkok, Thailand

Bartholomew W. Green
Auburn University
Auburn, Alabama

Abdel R. El Gamal
Central Laboratory for Aquaculture Research
Abbassa, Egypt

Progress Summary

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

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

Joseph J. Molnar
Auburn University
Auburn, Alabama

Leonard L. Lovshin
Auburn University
Auburn, Alabama

Terry R. Hanson
Auburn University
Auburn, Alabama

Progress Summary

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

An Algal Bioassay Method for Pond Fertilization

Christopher F. Knud-Hansen
Asian Institute of Technology
Bangkok, Thailand
and
Michigan State University
East Lansing, Michigan

Hans Guttman
Asian Institute of Technology
Bangkok, Thailand

Progress Summary

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

Appendix. List of Acronyms and Definitions

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

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

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

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

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

RECEIVED
AUG 4 1994