Pond Dynamics/Aquaculture Collaborative Research Support Program

Twentieth Annual Administrative Report

1 August 2001 to 31 July 2002

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This report addresses program accomplishments of the Pond Dynamics/Aquaculture Collaborative Research Support Program during the reporting period of 1 August 2001 to 31 July 2002. Program activities are funded in part by the United States Agency for International Development (USAID) under Grant No. LAG-G-00-96-90015-00.

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NOTE: THE BREADTH AND SCOPE OF THIS YEAR'S ANNUAL REPORT IS SUBSTANTIALLY REDUCED FROM PREVIOUS ANNUAL REPORTS. THE NEW FORMAT IS IN RESPONSE TO RECOMMENDATIONS MADE TO THE PD/A CRSP IN THE REPORT OF THE PROGRAM'S MARCH 2002 ADMINISTRATIVE MANAGEMENT REVIEW (AMR) COMMISSIONED BY USAID. THE AMR RECOMMENDED THAT THE PROGRAM SIMPLIFY REPORTING SYSTEMS AND REQUIREMENTS, REDUCE THE NUMBER OF PUBLICATIONS, AND PRESENT SOME PUBLICATIONS SOLELY ONLINE.

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INTRODUCTION

The Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) conducts research that contributes significantly to the removal of major constraints to aquacultural development, thereby promoting economic growth and enhancing food security. This report describes the activities and accomplishments of the PD/A CRSP from 1 August 2001 to 31 July 2002.

The PD/A CRSP is funded by the United States Agency for International Development (USAID), under authority of the Foreign Assistance Act of 1961 (PL 87-195) as amended, and by the universities and institutions that participate in the CRSP. This cohesive program of research is carried out in selected developing countries and the United States by teams of US and host country scientists. Now operating under its fourth USAID grant since 1982, the CRSP is guided by the concepts and direction set down in the Continuation Plan 1996, which was awarded funding under USAID Grant No. LAG-G-00-96-90015-00. This grant authorizes program activities from 1 August 1996 to 31 July 2003. An overview of CRSP history and how the program has evolved since its inception is provided in Appendix 1.

The activities of this multinational, multi-institutional, and multidisciplinary program are administered by Oregon State University (OSU), which functions as Management Entity (ME) and has technical, programmatic, and fiscal responsibility for the performance of grant provisions. ME activities at OSU are carried out through a Program Management Office (PMO), which is supported in the task of program administration by three advisory bodies: the Board of Directors (BOD), the Technical Committee (TC), and the External Evaluation Panel (EEP). PMO staff as well as advisory group membership during the reporting period appears in Appendix 2.

ADMINISTRATIVE HIGHLIGHTS

- The PMO convened an ad hoc committee—the Database Task Force (DBT)—composed of members from the TC and PMO. The purpose of the DBT was to determine the extent of use of the PD/A CRSP Central Database as well as its perceived value. A survey of current and past program participants indicated that the Database, while regarded as a valuable asset, was in practice little used. The DBT recommended that the Central Database be archived. A Request for Pre-proposals was disseminated throughout the CRSP network, and the DBT received four pre-proposals. The Asian Institute of Technology was commissioned to manage the Central Database during the transition. The primary objectives of the project are to complete the processing of outstanding data submissions, finalize data analysis procedures, and archive the database for permanent storage and access via the web and compact disks.

- The Director and Assistant Director of Operations participated in CRSP Council meetings in November and December 2001 and in January, March, and May 2002.

- The Proposal Planning Executive Committee (PPEC), a committee convened by the PMO to coordinate and lead the planning effort for a new grant proposal, held telephone and in-person meetings in August, September, October, and December 2001, and in January, April, and May 2002.

  One facet of developing the new proposal included identifying regional constraints to the success of small-holder fish farms. To that end the PD/A CRSP hosted a series of meetings. The first meeting was a stakeholder meeting held in Honduras in August 2001. The outcome of this meeting is a brief report that documents the regional constraints to the success of small-holder fish farms as identified and prioritized by the stakeholders.

  In the second phase of information gathering, the CRSP held three regional Expert Panel meetings. Panels comprised ten experts as well as a chair and a facilitator from PPEC. Panel members came to the meeting having previously reviewed a broad selection of relevant literature.

  The Expert Panel meeting for the Latin America and the Caribbean Region took place in conjunction with the program's annual meeting and the meeting of the US chapter of the World Aquaculture Association in January in San Diego, California; the meeting for the Asia Region was held in April in Beijing just before the World Aquaculture Association meeting; and the Africa Region Expert Panel meeting took place in Nairobi, Kenya, in June, and was followed by a field trip to Moi University and Sagana Fish Farm.

  The constraints identified by each of the three expert panels formed the basis for the PPEC to develop a synthesized set of global researchable priorities for the new proposal.

  In July the PMO released a Request for Proposals (RFP) for the Eleventh Work Plan. The deadline for proposals was 1 October 2002. The Eleventh Work Plan was to be the first work plan of the 2003–2008 grant, and the RFP solicited proposals guided by the constraints identified in the Expert Panel meetings.

- The PMO organized the PD/A CRSP Annual Meeting held in San Diego, California, on 31 January 2002, in conjunction with Aquaculture America 2002. Newly elected to the TC were CRSP principal investigators Claude Boyd, Joe Molnar, and Chris Brown. Jim Diana was re-elected as co-chair. The complete listing of TC and Subcommittee members appears in Appendix 2.

- The Board of Directors met in Washington DC in March 2002 and participated in email discussions throughout the reporting period. Ronald Jones, Florida International University, joined the Board in October 2001. Jones is the Director of the Southeast Environmental Research Center. Dennis Balogu, University of Arkansas at Pine Bluff, rotated off the Board. The listing of the Board members appears in Appendix 2.

- In Washington, DC, the PD/A CRSP joined the other eight CRSPs in presenting program goals, methods, and accomplishments to the interested public. The fourth annual exhibition on Capitol Hill, which was sponsored by the National Association of State Universities and Land-Grant Colleges (NASULGC), was held on 5 March 2002. The event allowed the CRSPs and other exhibitors to highlight the benefits gained from federal investments in food and agricultural research and education. The CRSP Council presented a display entitled "Stronger Agriculture Worldwide: Collaborative Research Support Programs."

- Also in March 2002, five US PD/A CRSP institutions hosted members of a USAID-commissioned Administrative Management Review (AMR) team. The PD/A CRSP was the seventh of the nine CRSPs to be reviewed. The AMR team visited four participating US institutions—Auburn University, University of Arkansas at Pine Bluff, Southern Illinois University, Carbondale, and The University of Michigan—as well as the Management Entity, Oregon State University.

- The PD/A CRSP was a co-sponsor of World Aquaculture 2002, hosted by the China Society of Fisheries and the World Aquaculture Society, which took place 23 to 27 April 2002 in Beijing, China. The conference featured the annual meetings of WAS and CFS, as well as numerous informational sessions ranging from training and education to fish nutrition. The program of the conference covered most species involved in aquaculture around the world and addressed the issues and concerns facing the aquaculture industry.

- The PD/A CRSP was a co-sponsor of the Global Livestock CRSPs international conference on "Animal Source Foods and Nutrition in Developing Countries" held in Washington, DC, on 24-26 June 2002. The main goals of the Conference were to: present what is known about the importance of animal source foods (ASF) for the nutrition, function, and economic status of populations in developing countries; to examine recently-completed efficacy trials where ASF were fed to specific groups; to review Case Studies of programs intended to increase ASF production and/or consumption; to examine constraints on ASF production and utilization and how these might be alleviated; to articulate and integrate economic, nutritional and agricultural issues; and to develop a policy and research agenda based on these discussions.

- The PD/A and Global Livestock CRSPs are partners in a new interCRSP activity in Kenya's Njoro River watershed. Kenyan partners include Egerton University, Kenya Department of Fisheries, and Moi University. The Njoro River watershed planning project will include input from stakeholders on water quantity and water quality, preparation of a problem model, and eventually a water resources management proposal for the watershed.

PROGRAM IMPACTS 2001–2002

- Based on Adoption/Diffusion research in Honduras, two Excel®-based models were developed to evaluate the feasibility and costs of maintaining levee and hillside ponds. These computer models will aid farmers and extensionists in building and maintaining ponds for sustainable aquaculture.

- On-farm trials conducted in Kenya under the Appropriate Technology research theme demonstrated to farmers that improved pond management can indeed lead to increased fish production. CRSP trials exposed farmers and extensionists to new pond management practices and technology alternatives and led to participants' increased pond productivity, interest, and confidence in pond aquaculture in Kenya.

- Results of a Feeds and Fertilizers study in Kenya showed that feeding Nile tilapia with diets made up of locally available feedstuffs resulted in significantly higher weight gains than fish fed with wheat bran and pig finisher pellets, which are more expensive feeds. These findings suggest that farmers could potentially use feedstuffs found locally instead of using higher-cost prepared feeds.

- Decreased pond water acidity improves water quality and increases pond production. Preliminary analyses from Effluents and Pollution research in Brazil showed that different approaches to applying agricultural limestone increased the alkalinity and hardness of water in roughly equal amounts. Findings suggest that agricultural limestone can be applied before or after filling of ponds; it can also be applied to pond bottoms that are tilled before filling.

- A Pond Dynamics research study found that ponds near two Thai cities have been excessively treated with liming materials. Although large inputs of liming materials were originally necessary to increase the pH of naturally acidic soils, the pond soils now have rather high soil pH. This can be counterproductive and lead to decreased pond production. The study also found that about half of commercial available liming materials were of low quality or were mislabeled. Potential

correctives are for farmers to use liming materials only if their ponds require them and for vendors to analyze liming materials and include the information on labels.

- CRSP researchers trained nongovernmental organization (NGO) extension agents from Central America in the use of the Web-based Information Delivery System for Tilapia (WIDeST), which provides information and assistance for decision-making processes for small- and medium-scale fish farmers. Developed by a CRSP Appropriate Technology project, the training sessions resulted in user feedback from the extensionists that will allow researchers to better tailor the WIDeST program to the needs of Central American NGOs and farmers.

- The insulin-like growth factor (IGF-1) gene in Nile tilapia was cloned by Philippines Project researchers in an experiment in Reproduction Control research. The isolation of a viable clone of this gene will allow PD/A CRSP researchers to conduct subsequent studies on the growth regulation of Nile tilapia. This area of study will provide researchers with tools necessary to monitor the regulatory mechanisms involved in growth and thus determine optimal grow-out conditions without having to wait for a complete growth cycle to be completed.

- In a Pond Dynamics project, a total of 138 people from academic and research institutions, fisheries and extension offices, nongovernmental organizations, and the private sector attended seven three-day workshops on optimizing fertilization efficiency. The participants learned how to determine pond fertilization require-ments, about the ecological and economic implications of different fertilizer types, and how to use their knowledge of pond ecology for more effective pond management. The workshops were held in Thailand, Laos, Cambodia, Vietnam, Bangladesh, and Nepal.

RESEARCH AGENDA

In developing the Continuation Plan 1996, the CRSP undertook an in-depth constraints analysis. That analysis led to the identification of a number of major constraints that limit the development of extensive to semi-intensive sustainable aquaculture systems. Chief among these were:

- Inefficient and inconsistent aquacultural productivity
- Negative environmental effects resulting from aquaculture operations
- A poor understanding of social and economic factors
- Insufficient human capacity development
- Poor or outdated information management
- Limited networking capacities

The PD/A CRSPs multidisciplinary team of researchers and advisors represents a wide range of US and international aquacultural experience. During the reporting period, participating US institutions included:

- Auburn University
- Florida International University
- Michigan State University
- Oregon State University
- Southern Illinois University at Carbondale
- The Ohio State University
- The University of Michigan
- University of Arizona
- University of Arkansas at Pine Bluff
- University of California at Davis
- University of Georgia
- University of Hawaii

Work under the Tenth Work Plan is being conducted at sites in Mexico, Honduras, Peru, Kenya, the Philippines, and Thailand, with regional outreach and extension activities taking place in El Salvador, Nicaragua, Brazil, South Africa, Bangladesh, Cambodia, Laos, Nepal, and Vietnam. Memoranda of understanding, representing formal ties between US and host country institutions, that were in place during the reporting period include those between:

- Auburn University and Moi University, Kenya
- Auburn University and Stellenbosch University, South Africa
- Florida International University and the Freshwater Aquaculture Center, Central Luzon State University, the Philippines
- Oregon State University and ICLARM-Malawi
- Oregon State University and Moi University, Kenya
- Oregon State University and the Department of Fisheries, Ministry of Agriculture and Rural Development, Kenya
- Oregon State University and the Universidad Juárez Autónoma de Tabasco, Mexico
- Southern Illinois University at Carbondale and the Instituto de Investigaciones de la Amazonia Peruana and the Universidad Nacional de la Amazonia Peruana, Peru
- The University of Michigan and the Asian Institute of Technology, Thailand
- University of Georgia and Escuela Agrícola Panamericana, Zamorano, Honduras
- The University of Hawaii at Manoa and the Freshwater Aquaculture Center, Central Luzon State University, the Philippines

In addition, the following international institutions are involved in regional CRSP activities under the Tenth Work Plan:

- Bangladesh Agricultural University, Bangladesh
- Cambodia Department Of Fisheries, Phnom Penh, Cambodia
- Department of Fisheries, Kasetsart University, Thailand
- Embrapa Meio Ambiente, Brazil
- Institute of Agriculture and Animal Science, Nepal
- Regional Development Coordination for Livestock and Fisheries, Laos
- Research Institution for Aquaculture No. 1, Vietnam
- Universidad Centroamericana, Nicaragua
- Universidad Nacional del Comahue, Argentina

- Universidad Nacional Mayor de San Marcos, Lima, Peru
- University of Agriculture and Forestry, Vietnam
- University of Cantho, Vietnam

RESEARCH PROGRAM FRAMEWORK

The Continuation Plan 1996 program framework, and the foundation for the current portfolio of PD/A CRSP research projects, consists of two building blocks: research in sustainable production systems and research support activities.

The sustainable production systems research framework is organized into the areas of production optimization, environmental effects, and social and economic aspects. Each area is further subdivided into specific research themes, which are the thematic areas of research needed to remove constraints to the development of more sustainable aquaculture. The results framework for research areas as presented in the Continuation Plan 1996 is summarized in Table 1, and the results framework for research themes is provided in Tables 2 through 4.

Research areas and their respective themes are listed here:

Research Area:	Production Optimization
Research Themes:	Pond Dynamics
	Feeds and Fertilizers
	Reproduction Control
	Aquaculture Systems Modeling
	New Aquaculture Systems/New Species
Research Area:	Environmental Effects
Research Themes:	Effluents and Pollution
	Appropriate Technology
	Responsible Science Policy
	Geographic Information Systems: Planning, Policy, and Global Data Analysis
Research Area:	Social and Economic Aspects
Research Themes:	Marketing and Economic Analysis
	Adoption/Diffusion
	Food Security
	Regional Analysis: Human-Environment Interactions
	Decision Support Systems
	Product Diversification

RESEARCH WORK PLANS

Earlier PD/A CRSP work plans—the first through the third—specified identical experiments (called Global Experiments) at all CRSP sites to provide a baseline for comparisons among sites. This approach was changed starting with the Fourth Work Plan when different but related experiments were also conducted at the various sites. The particular topics studied at each site were based on the research and information needs in each country, as identified by the Technical Committee.

The body of investigations funded under the Eighth, Ninth, and Tenth Work Plans reflects a broadening of research, as was proposed in the Continuation Plan 1996, as well as increased integration among sites and responsiveness to input from organizations and experts outside the CRSP. In addition to site activities, CRSP research now underway includes a cross-cutting, thematic approach for investigations that may be conducted at one or more PD/A CRSP sites and whose results may have wider application than results from prime and companion site investigations.

The portfolio of research reported upon in the current period is summarized in Appendix 4. With a few exceptions, Tenth Work Plan research was conducted in the reporting period and is described in this report. The Tenth Work Plan describes activities to be conducted by the CRSP from 1 July 2001 through 30 April 2003.

DEVELOPMENT OF THE TENTH WORK PLAN

In developing the Tenth Work Plan, the ME issued a Request for Proposals (RFP) in February 2001 with an April deadline for proposal submission. The RFP solicited proposals from 17 US institutions for regional and cross-cutting research and in research areas that were underrepresented in the Eighth and Ninth Work Plans, with the intent to fill gaps in the body of research carried out under the current grant.

The proposals submitted in response to the RFP were peer reviewed by external experts and internally by CRSP researchers. The Technical Committee then evaluated the reviews and made recommendations to the ME. The Board of Directors and External Evaluation Panel also made recommendations to the ME. Proposals were selected for funding based on technical merit and programatic relevance. Tenth Work Plan funding decisions were announced in July 2001.

WORK PLAN REPORTING

Projects' adherence to work plan schedules and methods and fulfillment of work plan objectives is tracked to assure continuing accountability for program awards. These types of changes are collected and published in work plan addenda as needed.

The CRSPs Information Management and Networking Component (IMNC) solicits research progress reports on a quarterly basis. To reflect methods and schedule changes to the funded research under the Eighth Work Plan, work plan addenda were printed in Spring 1998, Spring 1999, and Fall 2000. Changes to Ninth Work Plan research are documented in a Fall 2000 addendum and a Summer 2002 second addendum. Changes to Tenth Work Plan research will be documented in a forthcoming addendum.

Table 1. Results Framework for Research Areas within the *Production Systems* PD/A CRSP Building Block.

PRODUCTION SYSTEMS				
PD/A CRSP RESEARCH AREA	OBJECTIVE	CAUSAL ASSUMPTIONS	MEASURE	TARGET
Production Optimization	* To increase the overall sustainability of aquacultural production systems through production optimization.	* Productivity and sustainability can be increased with better management of pond inputs, waste reduction, use of underutilized resources, and the conservation of non-renewable resources.	* More sustainable, efficient production systems appropriate for the biophysical environment.	* Improved scientific understanding of pond processes. * Improved pond management strategies. * Significant advances in reproduction technology. *Development of alternative aquacultural systems.
Environmental Effects	* To minimize the detrimental environmental impacts of aquaculture operations through improved pond management.	* Sustainable aquaculture is possible only in a healthy environment. * Detrimental effects of aquaculture operations can be reduced or eliminated through changed management development.	* Reduced detrimental environmental impact of aquaculture operations.	* Development of methodologies to assess and reduce negative environmental impacts of aquaculture operations.
Social and Economic Aspects	* To increase our understanding of the social and economic implications of aquaculture development.	* Successful aquaculture development is contingent upon the social and economic constraints of each location.	* Improved viability of subsistence and commercial aquaculture farms at various sites.	* Positive net returns to capital investment. * Positive financial and nutritional impact on participating household communities.

Table 2. Results Framework for Research Themes within the *Production Optimization* PD/A CRSP Research Area.

PRODUCTION OPTIMIZATION				
RESEARCH THEME	OBJECTIVE	CAUSAL ASSUMPTIONS	MEASURE	TARGET
Pond Dynamics	* To further our understanding of the influence of pond processes on pond productivity.	* Knowledge of pond processes and organisms is necessary to improve productivity and fine-tune existing pond management guidelines as well as to reduce production losses and waste as aquaculture systems become more intensified.	* Improved predictability of pond processes and pond productivity.	* Illumination of the role of heterotrophy on pond production. * Development of pond bottom management techniques through a better understanding of pond soil-water interactions.
Feeds and Fertilizers	* To optimize use of pond inputs.	* Optimal fish growth can be achieved if the culture species' nutritional needs are addressed.	* Improved capabilities for prescribing optimal feed/fertilizer inputs to meet economic and environmental criteria.	* Reduce inputs of fertilizers and/or feeds to produce one unit of fish.
Reproduction Control	* To develop short- and long-term solutions to reproduction technology problems.	* Guaranteed seed supply and reliable broodstock is essential for the undertaking and maintenance of fish farming. Gender manipulations add management options which increase economic viability in intensified systems.	* Improved efficiency, efficacy, and safety of steroid use. * Successful production of sufficient amounts of YY-males. * Successful use of piscivorous fish to control excess tilapia offspring.	* Development of procedures that guarantee the safety of animals and farmers during steroid use. * Demonstration of the functional nature of YY-males for producing all male tilapia offspring. * Demonstration of the effects of piscivorous fish on tilapia production.
Aquaculture Systems Modeling	* To analyze and synthesize research results into models which better describe system processes.	* Models demonstrate the state of our current understanding of systems and system processes and provide direction for further inquiries.	* Improved representation of systems processes.	* Simulations which adequately describe biophysical processes in ponds.
New Aquaculture Systems/New Species	* To develop alternative aquaculture systems through the use of new or under-utilized resources or through resource partitioning. * To develop culture systems for local and native species.	* Production can be tailored to local conditions through diversification of aquaculture systems.	* Development of production procedures for new species, combinations of species and/or the establishment of new aquaculture systems.	* Foundation for the use of other species and/or new species combinations in pond aquaculture.

Table 3. Results Framework for Research Themes within the *Environmental Effects* PD/A CRSP Research Area.

ENVIRONMENTAL EFFECTS				
RESEARCH THEME	OBJECTIVE	CAUSAL ASSUMPTIONS	MEASURE	TARGET
Effluents	* To improve effluent water quality and water use efficiency.	* Reduction of excess nutrient loads will lessen environmental impact.	* Reduced nutrient loading.	* Demonstration of the effectiveness of CRSP guidelines to reduce effluent load.
Appropriate Technology	* To develop socially acceptable and environmentally friendly aquaculture technologies.	* Modification of current practices, tools, and facilities will lessen environmental impact.	* Reduced resource use in socially acceptable ways.	* Development of innovative approaches which result in a reduction of pond inputs, energy and/or excessively intensive management practices.
Responsible Science Policy	* To develop policies and guidelines that will govern the CRSPs work with exotic species, pharmaceuticals, and biotechnology.	* Communication and cooperation between potential host countries and the CRSP will be facilitated by a codified set of guidelines.	* Improved interaction with host country researchers and government officials in the area of exotics/drugs.	* Faster processing of necessary paperwork by host country officials.
GIS: Planning, Policy, Global Data Analysis	* To analyze and synthesize existing information at local, national, and regional scales.	* Integrating tools are required to assess potential and impact of aquaculture operations at scales above individual ponds.	* Analysis tools to determine environmental effects of proposed aquaculture locations.	* Assembly of datasets containing relevant summaries of CRSP research and data.

Table 4. Results Framework for Research Themes within the *Social and Economic Aspects* PD/A CRSP Research Area.

SOCIAL AND ECONOMIC ASPECTS				
RESEARCH THEME	OBJECTIVE	CAUSAL ASSUMPTIONS	MEASURE	TARGET
Marketing and Economic Analysis	* To develop marketing strategies for aquacultural products based on analysis of markets.	* Financial success is dependent upon meeting market demands.	* Improved pricing of aquaculture products. * Improved sales of products. * Reduced risk of adopting CRSP pond management technologies.	* Provision of information which (when applied) will allow the targeted aquaculture industry to access new markets and increase the volume of sold goods.
Adoption/Diffusion	* To identify barriers to the acceptance of new aquaculture technologies.	* Aquaculture technology will be adopted if the social, economic, and technological requirements of the local community are addressed. In order to create a successful aquaculture development, these requirements must be known by decision-makers.	* Successfully identified barriers to adoption of CRSP practices.	* Provision of guidance to extension workers to further increase acceptance of CRSP technologies in host countries.
Food Security	* To improve understanding of food security issues and their relationship to aquacultural practices.	* Extensive fish farming can successfully provide a source of necessary animal protein for the rural poor.	* Assessment of food security needs of the rural poor, and the impact of aquaculture on dietary intake of animal protein.	* Provision of information on nutritional status and needs of rural poor. * Assessment of technology transfer impact on rural poor.
Regional Analysis: Human-Environment Interactions	* To develop an information base of the effects of socio-economic conditions on the development of a local, national or regional aquaculture industry.	* Aquacultural development is often seriously constrained by the regulatory, social, and economic environment. These large-scale constraints must be known in order to implement a successful aquaculture development strategy.	* Improved understanding of the socioeconomic conditions that constrain aquaculture development.	* Development of recommendations that enable host countries to establish a successful aquaculture development strategy.
Decision Support Systems	* To refine computer applications to assist planners and managers in the development of economically efficient production technologies.	* Profitability can be improved through computer exploration of the effects of different management strategies on pond production potential and economic performance.	* Increased use of DSS by target clientele.	* Delivery of completed DSS to CRSP researchers, in-country personnel, development agencies, US producers, and extension agents. * Positive feedback from DSS users.
Product Diversification	* To develop a range of aquaculture products.	* Consumption of aquaculture products will increase if consumers are given a variety of product options.	* Availability of new aquaculture products in local markets.	* Development of processes and guidelines for the production of new aquacultural products.

RESEARCH PROJECTS

POND DYNAMICS AND EFFLUENTS AND POLLUTION RESEARCH

South Africa, Thailand, Brazil
Subcontract No. RD010E-07

Staff

Auburn University, Auburn, Alabama

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Mali Boonyaratpalin	Host Country Principal Investigator

Embrapa Meio Ambiente, Sao Paulo, Brazil

Julio Queiroz	Host Country Principal Investigator

Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigations:

- Effects of pond age on bottom soil quality/10PDR1. The report submitted for this investigation was an abstract.
- Reaction of liming materials in pond bottom soils—Brazil/10ER1A. The report submitted for this investigation was an abstract.
- Reaction of liming materials in pond bottom soils—South Africa/10ER1B. The report submitted for this investigation was an abstract.

Publications

Boyd, C.E., 2002. Management of bottom soil condition and pond water and effluent quality. In: C. Lim and C.D. Webster (Editors), Tilapias: Culture, Nutrition, and Feeding. The Haworth Press, Binghamton, New York. (in press)

Boyd, C.E., T. Thunjai, and M. Boonyaratpalin, 2002. Dissolved salts in water for inland, low-salinity shrimp culture. Global Aquaculture Advocate, 5(2).

Boyd, C.E., C.W. Wood, and T. Thunjai, 2002. Aquaculture pond bottom soil quality management. Pond Dynamics/Aquaculture CRSP, Corvallis, Oregon, 41 pp.

Boyd, C.E., C.W. Wood, and T. Thunjai, 2001. On-the-ground uses of CRSP pond soil research results. Aquanews, 16(4):1–3.

Rowan, M., 2001. Chemical phosphorus removal from aquaculture pond water and effluent. Ph.D. dissertation, Auburn University, Alabama.

Conferences

Aquaculture America 2002 at San Diego, California, 27–30 January 2002. (Boyd, Wood, Thunjai)

PD/A CRSP Annual Meeting at San Diego, California, 31 January 2002. (Boyd, Wood)

Latin American and the Caribbean Region Expert Panel Meeting at San Diego, California, 1 February 2002. (Queiroz)

World Aquaculture 2002 at Beijing, China, 23–27 April 2002. (Boyd)

Asia Region Expert Panel Meeting at Beijing, China, 23 April 2002. (Bolivar, Boyd)

Africa Regional Expert Panel Meeting at Nairobi, Kenya, 8 July 2002. (Brink)

EFFECTS OF POND AGE ON BOTTOM SOIL QUALITY

Tenth Work Plan, Pond Dynamics Research 1 (10PDR1)
Abstract

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Auburn University, Alabama, USA

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ABSTRACT

Pond water and bottom soil samples were collected from 35 tilapia ponds near Samutprakarn, Thailand, and from 17 tilapia ponds near Chiangrai, Thailand. The ponds ranged in age from 3 to 38 years. Ponds had been treated with large amounts of liming materials, and soils usually had pH above 7. Total alkalinity and total hardness concentrations in pond water usually exceeded 100 mg l^{-1}. Total carbon concentrations in pond soils were mostly between 1 and 3%. About two-thirds of the carbon was in organic form and the remainder was bound in carbonate. Soil carbon concentrations in ponds at Samutprakarn were similar to those in ponds at Chiangrai. The source of the inorganic carbon was liming materials. Although large inputs of liming materials originally were necessary to increase the pH of the naturally acidic soils, the pond soils now have rather high pH. Thus, liming is no longer necessary, and it is possibly counterproductive in some ponds. Soil respiration rates averaged higher in ponds at Samutprakarn than those at Chiangrai. The reason for this difference has not yet been determined because all analyses have not been completed. There is a weak tendency for soil organic carbon to increase with increasing pond age. Sediment had been removed one or more times from some of the ponds at Samutprakarn. Nevertheless, soil quality was not different between ponds as a result of sediment removal.

Samples of liming materials used in Thai aquaculture were analyzed. About half of the brands had mislabeled liming compounds or were of low quality. Farmers should insist that vendors analyze liming materials and report results of analyzed labels.

REACTION OF LIMING MATERIALS IN POND BOTTOM SOILS—BRAZIL

Tenth Work Plan, Effluents and Pollution Research 1A (10ER1A)
Abstract

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Auburn University, Alabama, USA

Julio Queiroz
Embrapa Meio Ambiente
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ABSTRACT

The ponds for this research were acquired on a private farm in Brazil, and the study was initiated in December 2001. The treatments are as follows: 1) agricultural limestone was applied over pond water surface after filling (3 ponds); 2) agricultural limestone was applied over pond bottom before filling (3 ponds); 3) agricultural limestone was applied over pond bottom followed by tilling of soil before filling (3 ponds); and 4) control (no agricultural limestone was applied).

Water samples are being collected weekly for analyses of total alkalinity and total hardness concentrations. Soil cores are being collected monthly and divided into 2 cm segments that are being analyzed for pH and exchangeable acidity. Pond aspects of the study will be completed in October 2002, but analyses of soil will not be completed until early 2003. Preliminary analyses reveal that all methods of liming increased the alkalinity and hardness of water in roughly equal amounts. Furthermore, there does not appear to be large differences in rates and depths of reaction in bottom soils related to method of application of agricultural limestone.

REACTION OF LIMING MATERIALS IN POND BOTTOM SOILS—SOUTH AFRICA

Tenth Work Plan, Effluents and Pollution Research 1B (10ER1B)
Abstract

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Auburn University, Alabama, USA

Danie Brink
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ABSTRACT

Ponds for this research were arranged by the University of Stellenbosch. The treatments are as follows: 1) agricultural limestone was applied over pond water surface after filling (3 ponds); 2) agricultural limestone was applied over pond bottom before filling (3 ponds); 3) agricultural limestone was applied over pond bottom followed by tilling of soil before filling (3 ponds); and 4) control (no agricultural limestone was applied).

Water samples are being collected weekly for analyses of total alkalinity and total hardness concentrations. Soil cores are being collected monthly and divided into 2 cm-long segments, that are being analyzed for pH and exchangeable acidity. The experiment was initiated in July 2002, and the pond sampling will be completed in February 2003. The study has not progressed far enough to have preliminary information on the performance of the different treatments.

POND DYNAMICS AND APPROPRIATE TECHNOLOGY RESEARCH

Thailand, Cambodia, Laos, Nepal, Vietnam, Bangladesh
Subcontract No. RD010E-B

Staff

Michigan State University, East Lansing, Michigan
Ted Batterson — US Principal Investigator
Christopher F. Knud-Hansen — US Principal Investigator
Donald Garling — US Principal Investigator

Asian Institute of Technology, Pathumthani, Thailand
Amrit Bart — Host Country Principal Investigator
De Run Yuan — Ph.D. Student (China; CRSP funded from September 2001)

Cambodia Department of Fisheries, Phnom Penh, Cambodia
Hav Viseth — Host Country Partner

Regional Development Coordination for Livestock and Fisheries, Savannakhet, Laos
Duangchith Litdamlong — Host Country Partner

Institute of Agriculture and Animal Science, Rampur, Nepal
Madhav Shrestha — Host Country Partner

University of Agriculture and Forestry, Ho Chi Minh City, Vietnam
Trinh Truong Giang — Host Country Partner

Research Institute for Aquaculture #1, Dinh Bang, Tu Son, Bac Ninh, Vietnam
Pham Anh Tuan — Host Country Partner

Bangladesh Agricultural University, Mymensingh, Bangladesh
Md. Abdul Wahab — Host Country Partner

Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigations:

- Use of clinoptilolite zeolites for ammonia-N transfer and retention in integrated aquaculture systems and for improving pond water quality before discharge/ 10ATR5. The report submitted for this investigation was an abstract.
- Workshops on using principles of pond dynamics to optimize fertilization efficiency/10PDR2. The report submitted for this investigation was an abstract.

Note: The schedules for 10ATR5 and 10PDR2 were modified. The revised schedules appear in the forthcoming *Addendum to the Tenth Work Plan*. Owing to cost savings on materials, the researchers conducted seven rather than the five workshops originally proposed for 10PDR2.

Publication

Knud-Hansen, C.F., K.D. Hopkins, and H. Guttman. A comparative analysis of the fixed-input, computer modeling, and algal bioassay approaches for identifying pond fertilization requirements for semi-intensive aquaculture. Aquaculture. (in press)

Conferences

Asia Region Expert Panel meeting at Beijing, China, 23 April 2002. (Shrestha, Wahab)

Aquaculture America 2002 at San Diego, California, 27–30 January 2002. (Bart)

USE OF CLINOPTILOLITE ZEOLITES FOR AMMONIA-N TRANSFER AND RETENTION IN INTEGRATED AQUACULTURE SYSTEMS AND FOR IMPROVING POND WATER QUALITY BEFORE DISCHARGE

Tenth Work Plan, Appropriate Technology Research 5 (10ATR5) Abstract

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De Run Yuan
Asian Institute of Technology
Pathumthani, Thailand

ABSTRACT

This research evaluated the ability of clinoptilolite zeolites to 1) transfer ammonia-N from animal manures to ponds without adding biochemical oxygen demand (BOD); 2) stabilize both ammonia-N concentrations and availability in fertilized culture systems; and 3) capture ammonia-N from pond water discharge for subsequent reuse in pond

fertilization. The experiments took place at the Asian Institute of Technology (AIT), and the final experiment was completed at the end of July 2002. Preliminary analyses show that clinoptilolite zeolites can sequester ammonia-N from pig and chicken manures through cation exchange and release it again in ponds for algal uptake. Actual production and nitrogen exchange rates are not yet calculated, so the economic viability of this technology has yet to be determined.

WORKSHOPS ON USING PRINCIPLES OF POND DYNAMICS TO OPTIMIZE FERTILIZATION EFFICIENCY

Tenth Work Plan, Pond Dynamics Research 2 (10PDR2)
Abstract

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ABSTRACT

During June and July 2002, Chris Knud-Hansen gave a total of seven three-day workshops in Thailand, Laos, Cambodia, Vietnam, Bangladesh, and Nepal. There were a total of 138 participants from academic and research institutions, national and provincial fisheries and extension offices, nongovernmental organizations (NGOs), and the private sector. The workshops focused on 1) the application of the algal bioassay test kit for determining pond fertilization requirements; 2) understanding the ecological and economic implications of different fertilizer types; and 3) how to use knowledge of pond ecology for more effective pond management. The participants of all workshops expressed enthusiastic appreciation for both the practical simplicity and specificity of fertilization requirement identifications when using the algal bioassay approach. Post-workshop communications indicate that algal bioassays are already beginning to be used at Asian universities, government agencies, NGOs, and private farms.

REPRODUCTION CONTROL AND NEW SPECIES/NEW SYSTEMS RESEARCH

Mexico, Peru
Subcontract No. RD010E-A

Staff

The Ohio State University, Columbus, Ohio

Konrad Dabrowski	US Principal Investigator
Mary Ann Abiado	US Principal Investigator
Kyeong-Jun Lee	Postdoctoral Researcher
Gustavo R. Montes de Oca	Ph.D. Student (Mexico; CRSP funded from January 2002)
Kyle Ware	Undergraduate Student (from January 2002)

Universidad Juárez Autónoma de Tabasco, Villahermosa, Tabasco, Mexico

Wilfrido Contreras-Sánchez	Host Country Principal Investigator
Gabriel Márquez Courturier	Host Country Principal Investigator
Maria de Jesus Contreras Garcia	Host Country Undergraduate Student Researcher
Guadalupe Morales Lara	Host Country Undergraduate Student Researcher

Auburn University, Auburn, Alabama

Ronald P. Phelps	US Principal Investigator (Collaborator)

Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru

Fernando Alcántara Bocanegra	Host Country Principal Investigator
Salvador Tello	Host Country Principal Investigator

Instituto de Investigaciones de la Amazonia Peruana, Pucallpa, Peru

Rebaza A. Mariano	Host Country Study Leader
Sonia D. Taboada	Host Country Study Research Associate

Universidad Nacional Mayor de San Marcos, Lima, Peru

Maria Esther Palacios	Graduate Student (Peru; CRSP funded from June 2002)

Universidad Nacional del Comahue, Argentina

Patricia Noguera	Cooperator

Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigations:

- Studies on fate of methyltestosterone and its metabolites in tilapia and on the use of phytochemicals as an alternative method to produce a monosex population of tilapia/10RCR1. The report submitted for this investigation was an abstract.
- Studies on reproduction and larval rearing of Amazonian fish/10NSR2A. See Peru Project summary, pp. 30-33.

Note: OhSU collaborates with Universidad Juárez Autónoma de Tabasco and Auburn University on 10RCR1. In addition, OhSU is a collaborator with Southern Illinois University, Carbondale (SIUC), and University of Arkansas at Pine Bluff on the Peru Project, "Sustainable Aquaculture in the Peruvian Amazon." SIUC is the lead institution for the Peru Project. The methods for 10RCR1 were modified.

Publication

Dabrowski, K., J. Rinchard, J.S. Ottobre, F. Alcántara, P. Padilla, A. Ciereszko, M.J. de Jesus, and C. Kohler. Effect of oxygen saturation in water provided to broodstock and embryos of *Piaractus brachypomus* on viability of larvae. Aquaculture. (in press)

Conference

PD/A CRSP Annual Meeting at San Diego, California, 31 January 2002. (Dabrowski)

STUDIES ON FATE OF METHYLTESTOSTERONE AND ITS METABOLITES IN TILAPIA AND ON THE USE OF PHYTOCHEMICALS AS AN ALTERNATIVE METHOD TO PRODUCE A MONOSEX POPULATION OF TILAPIA

Tenth Work Plan, Reproduction Control Research 1 (10RCR1) Abstract

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Universidad Juárez Autónoma de Tabasco
Villahermosa, Tabasco, Mexico

ABSTRACT

All-male populations are desirable in tilapia (*Oreochromis niloticus*) aquaculture because males demonstrate superior growth compared to females. The increasing use of 17α-methyltestosterone (MT) for sex reversal in tilapia, especially in developing countries, necessitates comprehensive studies on the fate of MT and its metabolites in order to address human and environmental safety issues. Alternative methods of sex reversal, such as the use of phytochemicals from locally available plants, need to be explored to minimize the cost of producing monosex populations and to prevent the occurrence of intersex fish and paradoxical feminization associated with high dosages and prolonged use of MT.

Quercetin is a flavonoid commonly present in plants. It has been considered an aromatase inhibitor in fish and has been shown to manifest mutagenic and enzyme-inhibitory properties. In order to evaluate the possibility of the use of quercetin as an alternative to MT for sex reversal in tilapia, four semi-purified, casein/gelatin-based diets were used. The diets [1) control, 2) quercetin 1%, 3) vitamin C (1,000 ppm), and 4) quercetin 1% plus vitamin C (1,000 ppm)] were formulated and fed to tilapia (genetically all-male XY) larvae, average weight 9.6 ± 1 mg. Fish were distributed (150 fish per aquarium) and held in a water recirculation system consisting of 12 glass aquariums maintained at 27 ± 2°C, with three replicates per diet. Ten fish per replicate (Bouin's fixative) were sampled after three to five weeks to evaluate histological appearance of gonads (presence of cellular apoptosis) or any changes in the sex ratio within treatments. On week 20, sex determination by squash aceto-carmine method was performed. Histological observations of gonads will be presented in the final report.

Preliminary results show that quercetin inclusion in the diet did not have any effect on sex determination in the fish studied. A toxic consequence, manifested by promoting apoptosis of gonad cells, as described in other fish species, was not observed.

The possible positive effects of the interaction of quercetin and ascorbic acid (vitamin C) were examined on the growth performance of all-male tilapia. Individual final weight, hepatosomatic index (HSI), and condition factor (CF) were evaluated for each dietary treatment. After 19 weeks no significant differences ($P > 0.05$) were observed in these parameters. The average values were mean weight 7.7 ± 2.3 g, CF 0.98 ± 0.21, and HSI 1.18 ± 0.48%. Preliminary determinations of the level of total ascorbic acid in whole body in fish fed for 15 weeks showed 15.8 ± 2.8, 10.6 ± 2.2, 28.3 ± 7.0, and 31.4 ± 2.7 μg g-1 wet weight for diets 1 through 4, respectively. Parallel studies with the same diets using mixed-sex populations of tilapia were performed at the Universidad Juárez Autónoma de Tabasco (UJAT), Tabasco, Mexico. After eight weeks similar growth was observed in all treatments (final fish weight 0.73 ± 0.15 g). Data on quercetin and ascorbic acid levels in several tissues (whole body, liver, and intestine) and possible interactions among dietary components will be presented in the final report.

Quercetin and ascorbic acid exhibit a potent antioxidant activity, characteristics that make them excellent dietary additives for ultraviolet (UV) damage prevention. One of the many consequences of UV exposure is skin damage due to the formation of free radicals; therefore, administration of antioxidants that scavenge these molecules might be a promising strategy to minimize such impairment. Results from this study will be presented in the final report.

NEW AQUACULTURE SYSTEMS/NEW SPECIES RESEARCH

Mexico, Honduras, Thailand, Vietnam, Philippines
Subcontract No. RD010E-11

Staff

University of Arizona, Tucson, Arizona

Kevin Fitzsimmons	US Principal Investigator

Asian Institute of Technology, Pathumthani, Thailand

Yang Yi	Host Country Principal Investigator
Potjanee Nadtirom	Graduate Student (Thailand)
Wanwisa Saelee	Undergraduate Student (Thailand; from March 2002)

Central Luzon State University, Muñoz, Nueva Ecija, Philippines

Remedios Bolivar	Host Country Principal Investigator
Bong Bolivar	Host Country Principal Investigator
JunRey Sugue	Research Assistant

Universidad Juárez Autónoma de Tabasco, Villahermosa, Mexico

Wilfrido Contreras-Sánchez	Host Country Principal Investigator
Alejandro MacDonal Vera	Graduate Student (Mexico; CRSP funded)

Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigations:

- Survey of tilapia-shrimp polycultures in Vietnam and Thailand/10NSR3A. The report submitted for this investigation was a final report.
- Stocking densities for tilapia-shrimp polyculture in Thailand/10NSR3B. The report submitted for this investigation was an abstract.
- Survey of tilapia-shrimp polycultures in Mexico and Honduras/10NSR3C. The report submitted for this investigation was an abstract.
- Stocking densities for tilapia-shrimp polyculture in Mexico/10NSR3D. The report submitted for this investigation was an abstract.
- Survey of tilapia-shrimp polycultures in Philippines/ 10NSR3E. The report submitted for this investigation was an abstract.

Note: The schedules for 10NSR3C and 10NSR3E were modified. The revised schedules appear in the forthcoming *Addendum to the Tenth Work Plan*.

Conferences

Latin America and Caribbean Stakeholders Meeting at Tegucigalpa, Honduras, 21 August 2001. (Fitzsimmons)

Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 August 2001. (Fitzsimmons)

Aquaculture America 2002 at San Diego, California, 27–30 January 2002. (Fitzsimmons)

Asia Region Expert Panel meeting at Beijing, China, 23 April 2002. (Bolivar, Fitzsimmons)

SURVEY OF TILAPIA-SHRIMP POLYCULTURES IN VIETNAM AND THAILAND

Tenth Work Plan, New Aquaculture Systems/New Species Research 3A (10NSR3A)
Final Report

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ABSTRACT

The survey on tilapia-shrimp polyculture was conducted in Thailand and Vietnam from March through June 2002. The survey conducted in Thailand was to assess the current status of farmers' practice of tilapia-shrimp polyculture, while the survey conducted in Vietnam was to find out why Vietnamese shrimp farmers do not grow tilapia in shrimp ponds. In twelve provinces of Thailand, 61 farmers who culture fish in their shrimp farms were selected and interviewed using a structured checklist and open-ended type of questionnaires. In the Mekong Delta of Vietnam, university researchers, local shrimp farmers association and local government fisheries staff, and shrimp farmers were interviewed.

Results showed that three versions of tilapia-shrimp polyculture—namely simultaneous, sequential, and crop rotation systems—are practiced by Thai shrimp farmers. Among all interviewed farmers, 42.6% use a simultaneous polyculture

system, while percentages of farmers using sequential and crop rotation systems are 34.4 and 6.6%, respectively. The remaining 16.4% of farmers stock fish in reservoir ponds and use a monoculture system for shrimp. Among the farmers who adopt the simultaneous tilapia-shrimp polyculture system, 76.9% released tilapias directly into shrimp ponds, and 23.1% stocked tilapias in cages suspended in shrimp ponds. Tilapia-shrimp polyculture is practiced in a wide range of salinity levels from 0 to 30 ‰. Tilapias used in the polyculture include red tilapia (*Oreochromis* spp.), Nile tilapia (*O. niloticus*), and Mossambique tilapia (*O. mossambicus*).

The survey revealed that shrimp production and economic returns from the two simultaneous polyculture systems and in sequential polyculture systems were higher than those in their respective shrimp monoculture systems practiced before. Also shrimp production and economic returns from these polyculture systems were higher than those in the crop rotation polyculture system and in the currently practiced monoculture system. Many farmers responded that tilapia-shrimp polyculture could improve water quality in shrimp ponds, reduce diseases, and reduce the use of chemicals. In the direct style of tilapia-shrimp polyculture, about 40% farmers believed tilapias compete for feed with shrimp, while the remaining 60% were not aware of such feed competition. The major reasons given by Vietnamese shrimp farmers for not growing tilapia in shrimp ponds are that tilapia would compete with the costly shrimp feeds, water quality in shrimp ponds was good enough and there was no need to use tilapia to improve water quality due to low shrimp stocking density, and added tilapia might bring dissolved oxygen down thus adversely affecting shrimp growth.

It can be concluded from the survey that polyculture of shrimp with tilapias may provide an alternative approach for shrimp farming, which could ultimately lead to a more sustainable shrimp industry. However, further research is needed on the merits for converting from shrimp monoculture to polyculture with tilapia.

STOCKING DENSITIES FOR TILAPIA-SHRIMP POLYCULTURE IN THAILAND

Tenth Work Plan, New Aquaculture Systems/New Species Research 3B (10NSR3B)
Abstract

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ABSTRACT

This study, consisting of two experiments, was conducted at the Asian Institute of Technology, Thailand for 65 days from 20 February to 23 May 2002. The first experiment investigated the growth performance of shrimp *(Penaeus monodon*) and Nile tilapia (*Oreochromis niloticus),* water quality, and nutrient budget in different stocking combinations of tilapia-shrimp polyculture, while the second experiment assessed different harvest draining techniques in terms of nutrients and solids discharged from effluent water.

The first experiment was conducted in nine 200-m^2 earthen ponds. There were three treatments in triplicate: 1) shrimp stocked alone at 30 fish m^{-2} (T1); 2) shrimp stocked at 30 fish m^{-2} and Nile tilapia stocked at 0.25 fish m^{-2} (T2); 3) shrimp stocked at 30 fish m^{-2} and Nile tilapia stocked at 0.50 fish m^{-2} (T3). The treatments were randomly allocated to the experimental ponds. Three ponds each from one treatment of the first experiment were designed as a block, and the treatments were in triplicate each in one of three blocks. The second experiment was conducted in the same ponds used in the first experiment in a randomized complete block design. There were three treatments in the second experiment: (A) ponds were completely drained with a pump placed on pond bottom, and shrimp and Nile tilapia were collected from a harvesting pit; (B) ponds were drawn from top to 20 cm deep with a pump placed on pond bottom, and shrimp and Nile tilapia were harvested by seining three times, followed by complete draining and collection of the remaining shrimp and Nile tilapia from a harvesting pit; (C) ponds were drawn with a pump firstly from top to 50 cm, then to 20 cm, and finally to 0 cm through lowering a pump to the respective water depth, and shrimp and Nile tilapia were collected from a harvesting pit.

Growth performance of shrimp, including mean individual weight, total length, mean daily weight gain, and net and gross yields was not significantly different ($P > 0.05$) among all treatments. Although the feed conversion ratio of shrimp was not significantly different among all treatments ($P > 0.05$), shrimp monoculture had significantly lower feed input than tilapia-shrimp polyculture ($P < 0.05$). Growth and survival of Nile tilapia were not significantly different between the low- and high-density tilapia treatments (T2 and T3, respectively) ($P > 0.05$), while fish yields were significantly higher in the high-density tilapia treatment than in the low-density tilapia treatment ($P < 0.05$). Approximate nutrients recovered by shrimp and tilapia were 1,459.7, 1,793.1, and 1,784.0 g N and 204.9, 302.3, and 391.1 g P in T1, T2, and T3, respectively. Nutrients lost in sediment were 69.86, 48.81, and 61.69% of total nitrogen (TN) and 46.96, 40.46, and 29.96% of total phosphorus (TP) in T1, T2, and T3, respectively. Nutrients lost to the water column were less than 1% in all treatments. Salinity was 5‰ initially and decreased quickly to 0‰ within three weeks in all treatments. Overall mean values of all water quality parameters except total ammonia nitrogen (TAN) and soluble reactive phosphorus (SRP) were not significantly different among all treatments ($P > 0.05$), while the final values of all water quality parameters except Secchi disk visibility were also not significantly different among all treatments ($P > 0.05$). Final

values of Secchi disk visibility were significantly greater in the tilapia-shrimp polyculture than in the shrimp monoculture ($P < 0.05$).

Concentrations of all measured effluent parameters except for TN in draining schemes A and C increased significantly with the decreased water depths ($P < 0.05$). Draining scheme B resulted in significantly lower concentration of total solids (TS) at all depths when compared with those in schemes A and C ($P < 0.05$). The concentrations of all measured effluent quality parameters except TN were significantly higher in the bottom water (20 to 0 cm depth) than in upper depths in all draining schemes ($P < 0.05$). For the weighted mean concentrations estimated from four depths, there were no significant differences in total volatile solids, total suspended solids, and TN among all draining schemes ($P > 0.05$). However, the weighted mean concentrations of TS were the lowest in draining scheme B, intermediate in draining scheme A, and highest in draining scheme C ($P < 0.05$), while the weighted mean concentrations of TP in draining schemes A and B were significantly lower than that in draining scheme C ($P < 0.05$).

All treatments resulted in positive net returns. The highest net return was achieved in the shrimp monoculture (US$41.09 200 m^{-2} crop), intermediate in the high-density tilapia treatment (US$15.65 200 m^{-2} crop), and lowest in the low-density tilapia treatment (US$35.09 200 m^{-2} crop). However, there were no significant differences in net returns among all treatments ($P > 0.05$).

The present study showed that tilapia-shrimp polyculture is feasible technically; however, it is not attractive economically. More research needs to be conducted to optimize feeding management in the tilapia-shrimp polyculture.

SURVEY OF TILAPIA-SHRIMP POLYCULTURES IN MEXICO

Tenth Work Plan, New Aquaculture Systems/New Species Research 3C (10NSR3C)
Abstract

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ABSTRACT

The majority of the Mexican shrimp farming industry is situated in northwest Mexico. However, shrimp aquaculture in Mexico is in crisis due to a mix of the depressed world shrimp market, and disease outbreaks causing decreased yields (Panorama Acuícola, 2002).

To determine the potential for tilapia-shrimp polyculture in the area, we are conducting surveys in the states of Sinaloa and Nayarit. We have visited 37 farms, which represent 18.5% of the total number of farms in the northwest. Twenty of those were closed because they produce shrimp only during one cycle.

The data collected showed that farm size ranged from 40 to 1,000 ha, and the production varied significantly from 1 to 2,400 t yr^{-1}. Most farms work two cycles per year (January through June and July through December). However, three farms were reported to work one cycle only (January through June), and one farm claimed to be able to produce shrimp in three cycles per year. The density used to stock ponds varied form 5 to 40 shrimp m^{-2}, but most farms used 12 to 20 shrimp m^{-2}. The average weight of shrimp harvested in the farms surveyed was 16.9 g, ranging from 12 to 24 g. The size of the shrimp harvested was directly related to the density used to stock the ponds.

The main cause of low yields was the viral disease White Spot Syndrome, which accounted for 59% of the reported problems causing low production. Low yields due to disease outbreaks combined with a low world price for shrimp have made many operations unprofitable.

The results from the survey also show that 76% of the shrimp farms experienced production problems, and many of these farms are considering alternative aquaculture strategies as an opportunity to stabilize production. Tilapia culture in shrimp ponds is being considered by 53% of the farmers because tilapia can be raised during the rainy season when salinity is too low for shrimp culture. The two main constraints in Mexico for the development of tilapia culture in shrimp ponds are knowledge of the biotechnologies required for culture in seawater and supply of salinity-tolerant strains of tilapia. This is a unique opportunity to continue harnessing the strengths of the PD/A CRSPs expertise and aid the development of a sustainable aquaculture system that would both safeguard jobs and provide work to low-income fishermen in coastal areas.

STOCKING DENSITIES FOR TILAPIA-SHRIMP POLYCULTURE IN MEXICO

Tenth Work Plan, New Aquaculture Systems/New Species Research 3D (10NSR3D)
Abstract

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ABSTRACT

The majority of the Mexican shrimp farming industry is situated in the northwest of Mexico. However, shrimp aquaculture in Mexico is in crisis due to both the depressed world shrimp market and disease outbreaks causing

decreased yields. To determine the potential for shrimp-tilapia polyculture in the area, we are conducting surveys in the states of Sinaloa and Nayarit. So far we have surveyed 37 farms, which represent 18.5% of the total number of farms in the northwest. The data collected to date showed that the main cause of low yields was white spot syndrome, a viral disease, which accounted for 59% of the reported instances of low production. These low yields due to disease outbreaks combined with a globally low prices for shrimp have pushed many operations into a situation where they are no longer profitable. The results from the survey also show that 76% of the shrimp farms experienced production problems, and many of these farms are considering alternative aquaculture species as an opportunity to stabilize production. Tilapia culture in shrimp ponds is being considered by 53% of the farmers. The two main constraints in Mexico for the development of tilapia as an alternative species for culture in shrimp ponds are knowledge of the biotechnologies required for culture in seawater and supply of salinity-tolerant strains of tilapia. This is a unique opportunity to continue harnessing the strengths of the PD/A CRSPs expertise and aid the development of a sustainable aquaculture system that would both safeguard the jobs of many local inhabitants and provide work to low-income fishermen in coastal areas.

The majority of disease outbreaks have been observed during the rainy season (July to October). The rains cause large fluctuations in salinity, temperature, and turbidity. It is suspected that these environmental fluctuations stress the shrimp and trigger disease outbreaks. In the past couple of years, a number of farmers have operated for just one cycle, stocking at low densities after the rainy season (December to February) and harvesting before the start of the rainy season (May to July). This is a longer production cycle, and larger shrimp were harvested, giving good yields per hectare. Although this system enables these farms to continue operating, they are not fully utilizing the shrimp ponds, which are being abandoned for a part of the year. This results in a seasonal job market for many of the local people or even those who operate the social cooperative farms. It is considered that tilapia would be well-suited to culture during this part of the year when ponds are not being used. Lower salinities associated with the rain would favor tilapia culture. Tilapia and low densities of shrimp could be stocked at the start of the rainy season in lower salinities and cultured through to December for Christmas markets. The combination of one shrimp cycle and one cycle of tilapia-shrimp polyculture using the culture system developed in collaboration between researchers and industry in the PD/A CRSP project would help the social cooperatives operate throughout the year. This would give a higher financial return from the infrastructure and providing fuller employment for the cooperatives and other local people.

We will initiate an experiment during the next cycle (starting December or January) and will have results by the end of April.

SURVEY OF TILAPIA-SHRIMP POLYCULTURE IN THE PHILIPPINES

Tenth Work Plan, New Aquaculture Systems/New Species Research 3E (10NSR3E)
Abstract

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ABSTRACT

Four provinces were surveyed, namely Pampanga, Pangasinan, Bulacan, and Negros Occidental. A total of 19 farmers were interviewed for this study. The most successful province in terms of applying tilapia-shrimp polyculture in a sustainable way is Negros Occidental.

Farmers in Negros Occidental have adopted a tilapia-shrimp polyculture system that utilizes hapa net pens stocked with tilapia and placed in the center of the pond. Shrimp are stocked outside the hapas, and paddlewheels circulate water, which carries wastes to the center where they are consumed by the fish. In addition, the reservoir pond at the head of the farm intake water supply is heavily stocked with tilapia. Farmers observed that the tilapia seem to maintain a favorable algae bloom in the system, encourage a beneficial bacterial community, and reduce the numbers of zooplankters. Farmers in Negros Occidental follow a technology called TIPS (Tilapia Integration to Prawn Culture System), which combines the techniques of crop rotation, biological pretreatment using tilapia reservoirs, and polyculture. The TIPS technology appears to have reduced the incidence of disease in polyculture ponds more than in monoculture ponds.

One advantage of the farmers in Negros Occidental who are using the TIPS technology in the tilapia-shrimp polyculture is their access to a saline-tolerant hybrid of tilapia known as "Jewel tilapia" that makes it possible for farmers to rear the fish in brackish water along with the shrimp.

The consistency of results using the TIPS technology in the province of Negros Occidental has revived the enthusiasm of the prawn growers to verify the management strategies in their farms. Slowly, the industry is gaining back momentum after the white spot virus has caused low survival if not wiped out all of the shrimp stocks in the province.

Different practice of integration was observed in the three provinces in Luzon. Farmers typically use milkfish and shrimp in their polyculture. However, in general their idea of integration is not systematic. Farmers integrate species such as crab, tilapia, milkfish, and shrimp if these become available or if the farmer has the money to buy the fry or larvae. The management system is very extensive with very low feed and fertilizer input. Most of the time cultured species are dependent on natural food available in the ponds. Large ponds are used with little attention to pond management.

PLANNING AND POLICY PROJECT

MOU No. RD009L

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Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigation:

- Identification of constraints facing aquaculture in the next two decades and formulation of a five-year research agenda to address key constraints through collaborative research/10GISR3. The report submitted for this activity was an abstract.

Note: 10GISR3 was approved after the printing of the Tenth Work Plan. The published work plan appears in the forthcoming *Addendum to the Tenth Work Plan*.

IDENTIFICATION OF CONSTRAINTS FACING AQUACULTURE IN THE NEXT TWO DECADES AND FORMULATION OF A FIVE-YEAR RESEARCH AGENDA TO ADDRESS KEY CONSTRAINTS THROUGH COLLABORATIVE RESEARCH

Tenth Work Plan, GIS: Planning, Policy, and Global Data Analysis 3 (10GISR3)
Abstract

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ABSTRACT

The goal of this project is to identify the most important constraints to aquaculture development, especially to poor farmers in low-income food-deficit (LIFD) countries. An advisory panel, the Proposal Planning Executive Committee (PPEC), was established by the Program Management Office (PMO) to coordinate and lead the planning effort for the CRSP continuation proposal, 2003–2008. PD/A CRSP hosted a series of meetings. The first phase of information gathering was a stakeholder meeting held in Honduras in August 2001. The outcome of this meeting is a brief report documenting regional constraints to the success of small-holder fish farms as identified and prioritized by the stakeholders. The second phase of information gathering involved three expert panel meetings for the Latin America and Caribbean Region, Asia Region, and Africa Region. Each expert panel had 10 experts, as well as a chair and a facilitator from PPEC. The expert panel members were selected based on their area of expertise/disciplinary focus, region, and gender. Panel members came to the meeting having previously reviewed a broad selection of relevant literature. The expert panel meeting for the Latin America and Caribbean Region took place in February 2002 in conjunction with the PD/A CRSPs annual meeting and the US chapter of the World Aquaculture Association in San Diego, California; the meeting for the Asia Region was held in April in Beijing just before the World Aquaculture Association meeting; the Africa region expert panel meeting took place in Nairobi, Kenya, in July, and was followed by site visits to Moi University and Sagana Fish Farm. Expert panelists were asked to consider, "What are the issues that constrain small-holder fish farms from becoming more successful in the [relevant] region?") and "What are the researchable priorities arising from these constraints?" The constraints and researchable priorities identified by each of the three expert panels formed the basis for the PPEC to develop a synthesized set of global researchable priorities for the five-year strategy for collaborative research.

MARKETING AND ECONOMIC ANALYSIS AND PRODUCT DIVERSIFICATION RESEARCH

Honduras, Nicaragua, Peru, Kenya
Subcontract No. RD010E-01

Staff

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Daniel E. Meyer — Host Country Principal Investigator
Freddy Arias — Host Country Principal Investigator
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Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigations:

- Characteristics of fish buyers likely to purchase farm-raised tilapia in Honduras and Nicaragua/10PDVR1. The report submitted for this investigation was an abstract.
- Optimal (profit-maximizing) target markets for small- and medium-scale tilapia farmers in Honduras and Nicaragua/10MEAR1. The report submitted for this investigation was an abstract.
- Development and evaluation of a simple market feasibility assessment methodology/10MEAR2. The report submitted for this investigation was an abstract.
- Regional enterprise budget and business plan development/10MEAR3. The report submitted for this investigation was an abstract.
- Economic and risk analysis of tilapia production in Kenya/10MEAR4. The report submitted for this investigation was an abstract.

Publications

Engle, C.R. Marketing and Economics. In: C. Webster and C. Lim (Editors). Tilapia Culture, Nutrition, and Feeding. CABI Publishers. (in press)

Funez, O., I. Neira, and C. Engle, 2002. Open-air market outlets for tilapia in Honduras. Global Aquaculture Advocate, 5(1):88.

Neira, I. Analysis of the potential market for farm-raised tilapia in Nicaragua. M.S. thesis, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas.

Valderrama, D. and C.R. Engle. Economic optimization of shrimp farming in Honduras. J. World Aquacult. Soc. (in review)

Valderrama, D. and C.R. Engle, 2001. Optimizacion economica del cultivo del camaron en Honduras. Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 August 2001. (in Spanish)

Valderrama, D. and C.R. Engle. The effect of survival rates of white shrimp *Litopenaeus vannamei* on net farm income and optimal management strategies of Honduran shrimp farms. Aquaculture. (in review)

Presentations

Funez, O., I. Neira, and C.R. Engle, 2001. Supermarket outlets for tilapia in Honduras: An overview of survey results. Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 August 2001.

Neira, I. and C. Engle, 2001. Markets for tilapia (*Oreochromis* spp.) in Nicaragua: A descriptive analysis of restaurants, supermarkets, and stands in open markets. Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 August 2001.

Neira, I., K. Quagrainie, and C. Engle, 2002. Markets for tilapia in Nicaragua: A quantitative analysis of restaurant markets. Annual Research Forum 2002, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas.

Valderrama, D. and C.R. Engle, 2002. Economic optimization of shrimp farming in Honduras. Aquaculture America 2002, San Diego, California.

Conferences

Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 August 2001. (Engle, Meyer, Neira)

Aquaculture America 2002 at San Diego, California, 27–30 January 2002. (Engle, Neira)
PD/A CRSP Annual Meeting at San Diego, California, 31 January 2002. (Engle)
Latin American and the Caribbean Region Expert Panel Meeting at San Diego, California, 1 February 2002. (Engle)
Africa Regional Expert Panel Meeting at Nairobi, Kenya, 8 July 2002. (Muchiri)

CHARACTERISTICS OF FISH BUYERS LIKELY TO PURCHASE FARM-RAISED TILAPIA IN HONDURAS AND NICARAGUA

Tenth Work Plan, Product Diversification Research 1 (10PDVR1)
Abstract

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ABSTRACT

Analysis of the characteristics and preferences of restaurants in Nicaragua is completed, and a manuscript is currently under review. The analysis of Honduran restaurants is also complete, and we are working on a manuscript. The last analysis will be a combined analysis with all market channels in both countries to sort out impacts across market segments. This abstract summarizes the results from the analysis of Nicaraguan restaurants.

Nicaragua has the physical resources to develop a farm-raised tilapia industry. However, no marketing studies have been done to assess the potential to develop a domestic market for farm-raised tilapia in Nicaragua. The purposes of this study were to assess the domestic restaurant market in Nicaragua and to evaluate its potential for increasing sales of farm-raised tilapia. Direct personal interviews were conducted with 118 restaurant managers selected as a random sample from telephone listings. Information was collected on tilapia and other seafood sales, restaurant and market characteristics, attitudes towards tilapia characteristics, and willingness to add tilapia to the menu. Logit analyses were used to measure the effects of consumer attitudes, entrée preferences, and restaurant characteristics on binary choice variables related to whether or not restaurants sold tilapia and the likelihood of adding tilapia to the menu. The most promising restaurant market for tilapia appeared to be older restaurants that offered a variety of food on the menu and those that served steak. Larger restaurants that considered tilapia to be a high-quality product and that offered ceviche on the menu were those that tended to sell tilapia. Tilapia farmers and processors in Nicaragua will need to guarantee and ensure the flavor, quality, and safety of their product and promote these attributes.

OPTIMAL (PROFIT-MAXIMIZING) TARGET MARKETS FOR SMALL- AND MEDIUM-SCALE TILAPIA FARMERS IN HONDURAS AND NICARAGUA

Tenth Work Plan, Marketing and Economic Analysis Research 1 (10MEAR1)
Abstract

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ABSTRACT

A Honduran graduate student has been recruited to work on this project. Costs associated with transportation and storage for both live and processed fish were collected. Direct personal interviews were conducted with wholesalers who were identified in the Ninth Work Plan surveys as principal suppliers of fish and seafood. Costs were developed for transportation over various distances, for different product forms, for different volumes, and for different sizes of trucks and equipment. These data have been compiled and are being organized into "activities" for subsequent use in the quantitative analysis. Target market data, obtained from the surveys completed in the Ninth Work Plan, are being compiled into "market activities" that specify the prices and quantities by product form for each geographic market (Tegucigalpa, San Pedro Sula, and a number of small towns) and for each market segment and channel in each geographic market. We have begun to construct the mathematical programming model that will be used to define profit-maximizing target markets for small- and medium-scale tilapia farmers. We have a simple version of the model working and are beginning to add in the various transportation and marketing activities that will be considered. The model will then be solved for a variety of farm sizes to determine which marketing strategies maximize profits. Other versions of the model will simulate farms located in different regions of the country.

DEVELOPMENT AND EVALUATION OF A SIMPLE MARKET FEASIBILITY ASSESSMENT METHODOLOGY

Tenth Work Plan, Marketing and Economic Analysis Research 2 (10MEAR2)
Abstract

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ABSTRACT

We have developed a draft of the tool for rapid assessment of market feasibility for aquaculture species. The key parameters included in this tool are those variables that were significant in the logit analyses conducted in 10PDVR1, "Characteristics of Fish Buyers Likely to Purchase Farm-Raised Tilapia in Honduras and Nicaragua" (see abstract previous page). As we continue to complete the logit analyses, we may add or otherwise modify the rapid market assessment tool. To accomplish the objective related to the evaluation of the rapid market assessment tool, we have initiated a survey in Mexico City, Mexico. Mexico City is a very large, cosmopolitan urban area with a long history of tilapia consumption. We have initiated full surveys of restaurants, supermarkets, and open-air markets. We are simultaneously completing the rapid market assessment tool and will be testing to see if those parameters that were significant in the Honduran and Nicaraguan datasets were also those that are significant in Mexico City. Likewise, we will be conducting similar surveys in Peru later this fall. In Peru we will have the opportunity to test the rapid market assessment tool in Iquitos, an area where tilapia are not allowed and are not marketed, as well as in Lima, a South American metropolitan area where some tilapia are sold. Based on the outcomes of these subsequent analyses of the most important parameters in determining market feasibility, we will make final modifications to the rapid market assessment tool. We will also draw some conclusions as to whether or not it is possible to utilize a generalized rapid market assessment tool for many different Latin American countries with differing market characteristics.

REGIONAL ENTERPRISE BUDGET AND BUSINESS PLAN DEVELOPMENT

Tenth Work Plan, Marketing and Economic Analysis Research 3 (10MEAR3)
Abstract

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ABSTRACT

Templates were developed to collect all of the necessary price and quantity data required for the development of enterprise budgets. The production technologies most appropriate for development have been selected. We are currently completing the data collection phase of this project. With all the data in hand, we will then enter the price and quantity data means into the spreadsheet templates to generate the enterprise budgets. From the enterprise budgets, we will then prepare the *pro forma* balance sheets, income statements, and cash flow budgets required to have a complete business plan example for prospective farmers, lenders, and policy-makers.

ECONOMIC AND RISK ANALYSIS OF TILAPIA PRODUCTION IN KENYA

Tenth Work Plan, Marketing and Economic Analysis Research 4 (10MEAR4)
Abstract

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ABSTRACT

This project is underway as described in the abstract for 10MEAR3, "Regional Enterprise Budget and Business Plan Development." Once the enterprise budgets have been compiled, we will complete the risk analysis. The risk analysis will be conducted as a stochastic simulation in which ranges of values of random variables such as yield and price may be defined by probability distributions instead of the sample averages used in standard enterprise budgets. Monte Carlo simulation techniques will be used to generate values for individual cost and quantity items based on the probability distributions. Results presented will include the entire range of possible outcomes for parameters such as gross receipts, total costs, and net returns, as well as their associated probabilities.

MEXICO PROJECT

MOU No. RD009C

Staff

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Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigations:

- Elimination of methyltestosterone (MT) from intensive masculinization systems: Use of activated charcoal in concrete tanks/10ER2. The report submitted for this investigation was an abstract.
- Diversification of aquacultural practices by incorporation of native species and implementation of alternative sex inversion techniques/10ATR3. The report submitted for this investigation was an abstract.
- Selection of a new Nile tilapia genetic line to provide broodstock for Southeastern Mexico/10RCR2. The report submitted for this investigation was an abstract.

Note: In addition to the above investigations, Universidad Juárez Autónoma de Tabasco also collaborates with University of Arizona (10NSR3C and 10NSR3D), Ohio State University (10RCR1), and University of Arkansas at Pine Bluff (10MEAR2A). The schedule for 10ER2 was modified. The revised schedule appears in the forthcoming *Addendum to the Tenth Work Plan*.

Publications

Bart, A., W.M. Contreras-Sánchez, and M. Fitzpatrick. Ultrasound enhanced masculinization of Nile tilapia, *Oreochromis niloticus*, in immersion protocol. J. World Aquacult. Soc. (in review)

Contreras-Sánchez, W.M. Identification of unique genes expressed during sex inversion of Nile tilapia, *Oreochromis niloticus* by cDNA subtractive hybridization. Gen. Comp. Endocrinol. (in review)

Lara, G.M., 2001. Ictiofauna Asociada a las Escolleras del Puerto Marítimo de Dos Bocas, Paraíso, Tabasco, México. División Académica de Ciencias Biológicas, B.S. thesis, Universidad Juárez Autónoma de Tabasco.

ELIMINATION OF METHYLTESTOSTERONE (MT) FROM INTENSIVE MASCULINIZATION SYSTEMS: USE OF ACTIVATED CHARCOAL IN CONCRETE TANKS

Tenth Work Plan, Effluents and Pollution Research 2 (10ER2)
Abstract

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ABSTRACT

This study tested the hypothesis that activated charcoal eliminates 17a-methyltestosterone (MT) from the water used in intensive sex-inversion systems. Two charcoal amounts (2.5 and 5.0 kg) placed in filters and a control group (no charcoal) were evaluated for both sex-inversion efficacy and MT persistence in water. Fry (2,200 to 2,945 fry m^{-3}) were kept in concrete ponds with 7.13 m^3 of water and were fed a masculinizing dose of MT (60 mg kg^{-1}) during their first four weeks. Water samples were collected from the sex-inversion tank before the treatment and on a weekly basis starting with the first day of treatment. The activated charcoal used in this experiment was exposed to direct sunlight for 24 and 48 h, and samples were collected at different times for MT detection. All samples will be extracted using ether, and the concentration of MT will be determined by radioimmunoassay at Oregon State University. Masculinization rates were not significantly different ($P > 0.05$) between treatments in a trial or between trials. Mean percentage of males for treatments with 0.0, 2.5, and 5.0 kg of activated charcoal were 92.0, 94.3, and 92.7%, respectively. Control groups averaged 51.7% males and had significantly fewer males than the MT-fed groups ($P < 0.0001$). Once the concentration of MT in the water is known, we will be able to recommend a system that efficiently masculinizes tilapia without producing steroid-contaminated effluents.

DIVERSIFICATION OF AQUACULTURAL PRACTICES BY INCORPORATION OF NATIVE SPECIES AND IMPLEMENTATION OF ALTERNATIVE SEX INVERSION TECHNIQUES

Tenth Work Plan, Appropriate Technology Research 3 (10ATR3)
Abstract

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ABSTRACT

This project aims to determine if administration of steroids via bioencapsulation is an efficient method for sex inversion of carnivorous species of fish in aquaculture. This technique offers the advantage that the larvae of such species strongly prefer live food over artificial diets. To determine accumulation of estradiol (E2) and trenbolone acetate (TA) in *Artemia* (brineshrimp), we immersed nauplii in solutions containing 1,000 mg l^{-1} of steroid. The steroid was dissolved in ethanol to a concentration of 1 mg ml^{-1} and then added to the water. Controls were immersed in water containing only the ethanol vehicle. Each treatment consisted of three replicates. Water samples (50 ml) from glass jars containing *Artemia* spp. nauplii were collected at 0, 2, 4, 6, 12, 16, 20, and 24 h. Nauplii were washed in nanopure water and dried, and samples were frozen (–20°C) and preserved until processing. All samples were extracted using ether, and the concentration of steroid was determined by radioimmunoassay for E2 or high performance liquid chromatography for TA. Immediately after addition of the steroid, nauplii had E2 concentrations greater than 1,500 pg g^{-1} and TA concentrations greater than 2,000 pg g^{-1}. The nauplii treated with E2 had 5,500 pg g^{-1} at 2 h, remained at that level until 6 h, and then accumulated more estrogen to reach a concentration of 7,000 pg g^{-1} at 12 h; this concentration remained until 24 h. A similar pattern was observed when TA was used; however, at 24 h, concentrations declined to 5,000 pg g^{-1}. Controls showed background levels. Our results indicate that *Artemia* spp. readily accumulates steroids and can be used for sex-inversion purposes. We are currently evaluating the efficacy of bioencapsulated steroids for sex inversion.

SELECTION OF A NEW NILE TILAPIA GENETIC LINE TO PROVIDE BROODSTOCK FOR SOUTHEASTERN MEXICO

Tenth Work Plan, Reproduction Control Research 2 (10RCR2)
Abstract

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ABSTRACT

Because of its geographic and hydrological components, the southeastern region of Mexico has been considered one of the top areas in Mexico for aquaculture and especially for tilapia culture. However, good quality fry is not available, and this problem affects farmers interested in culturing tilapia. We have initiated a selective breeding program using 220 females and 110 males selected from a batch of fish purchased from Egypt by the Tabasco State government. This first batch was selected using a discriminant analysis for fish that best resembled Nile tilapia (*Oreochromis niloticus*). The analysis was based on length, weight, number of scales, fins, head length, mouth diameter and eye diameter. These fish were stocked in 200 m^2 ponds for grow-out. From the fry obtained from breeding of these fish, three selections were made: 1) at day 60 post-harvest; 2) at 120 d (at this point the fish were separated by sex); and 3) at 11 months post-harvest. A total of six hundred females and 400 males were selected based on a combination of best length and condition factor of the F1 generation. These fish were stocked in 200 m^2 ponds and allowed to breed. From the fry obtained from this second breeding, 60% of the total were selected for grow-out. After four months, two lines were separated based on 50% of the fish stocked—one based on length and one based on a combination of best length and condition factor. We are currently growing these fish, and the final selection will be conducted in September 2002. We were able to combine the efforts of two projects, one supported by the Consejo Nacional de Ciencia y Tecnología (CONACYT) and the other one by the PD/A CRSP. This combined effort has allowed us to work at the Mariano Matamoros Hatchery using 200, 1,000, and 2,000 m^2 ponds and to use fish originally selected by Mario Fernández-Perez in 2000.

HONDURAS PROJECT

Subcontract No. RD010E-16 (AU)
Subcontract No. RD010E-17 (UG)

Staff

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Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigations:

- Institutionalizing techniques for building hillside and levee ponds for water supply and aquacultural development in Latin America/10ADR1 (UG). The report submitted for this investigation was an abstract.
- Regionalizing training and technical assistance for nongovernmental organizations/10ATR1 (UG). The report submitted for this investigation was an abstract.
- Institutionalizing web-based information systems for tilapia culture in Latin America/10ATR2 (UG). The report submitted for this investigation was an abstract.
- Income, food security, and poverty reduction: Case studies of functioning clusters of successful small-scale aquaculture producers/10FSR1 (AU). The report submitted for this investigation was an abstract.

Note: The Honduras Project, "Institutionalizing Small- and Medium-Scale Aquacultural Development in Latin America: Case Studies, Water Supply Analysis and Information Transfer," is a collaborative effort among University of Georgia, Auburn University, and the host country partner.

Presentations

Arias, F., J. Molnar, B. Esquivel, F.M. Quispe, J.A. Martinez, and G.M. Mejia, 2001. Production and marketing strategies used by small- and medium-scale producers in Honduras. Presented to the Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 August 2001.

Meyer, D., 2001. Nutrition and feeding of tilapia. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 August 2001, pp. 61–70.

Molnar, J., E. Trejos, P. Martinez, B. Verma, E.W. Tollner, S. Triminio, and D. Meyer, 2002. Advancing aquacultural development through the third sector: Advantages and liabilities of NGO networks for technology transfer in Honduras. Poster presented at the Annual Meeting of the American Association for the Advancement of Science at Boston, Massachusetts, 15 February 2002.

Popma, T. and D. Meyer, 2001. Training and technical assistance in warm-water fish culture. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 August 2001, pp. 118–125.

Tollner, E.W., 2001. Levee pond design model. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 August 2001, pp. 116–117.

Verma, B.P., D. Meyer, T. Popma, J. Molnar, and E.W. Tollner, 2001. Web-based information delivery system for tilapia for sustainable development of aquaculture in Honduras. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 August 2001, pp. 126–134.

Conferences

Aquacultural Stakeholder's Meeting at Tegucigalpa, Honduras, 21 August 2001. (Meyer)

Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 August 2001. (Meyer, Molnar, Tollner, Popma, Verma)

PD/A CRSP Annual Meeting at San Diego, California, 31 January 2002. (Tollner, Molnar)

Latin American and the Caribbean Region Expert Panel Meeting at San Diego, California, 1 February 2002. (Triminio de Meyer, Molnar)
World Aquaculture 2002 at Beijing, China, 23–27 April 2002. (Meyer)

INSTITUTIONALIZING TECHNIQUES FOR BUILDING HILLSIDE AND LEVEE PONDS FOR WATER SUPPLY AND AQUACULTURAL DEVELOPMENT IN LATIN AMERICA

Tenth Work Plan, Adoption/Diffusion Research 1 (10ADR1) Abstract

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ABSTRACT

The modeling effort was separated into water supply feasibility and economics phases. Excel®-based models were developed for evaluating feasibility and costs of levee ponds and hillside ponds. The difference between the levee pond and the hillside pond in this report is that the levee pond must be supplied by pipe and the hillside pond may capture runoff from surrounding areas. The hillside pond is intended to supply water for a variety of uses including fish production. The levee pond is the primary containment for fish production. Levee and hillside ponds are of similar construction.

The feasibility of a levee pond size in a given area was evaluated by determining the peak, average, and minimum monthly water balance. The model predicts the supply flowrate required to maintain a full pond given the pond surface area, depth, and climate variables (evaporation, seepage, and precipitation) in the region.

The hillside pond model evaluates the feasibility of developing a sustainable pond with springs and surface water runoff. Placing a watershed pond in the main runoff conveyance is likely not feasible due to steep valley slopes. A diversion structure may be designed to capture nearly all of the runoff during dry months and a small fraction of the runoff during the rainy season. Water in this pond may be used for a variety of uses including fish pond supply. The Excel®-based model performs a water balance, as with the levee pond, with the addition of runoff prediction from the watershed above the pond.

Future goals include completing the Spanish translation of the models. We also plan to move the models to a more friendly web-enabled platform. The main disadvantage of using any package for model development is that the user must have the package. Using a common spreadsheet such as Excel® probably minimizes the disadvantage. Another disadvantage of the Excel® platform is that substantial programming is required to move the models to geographic regions. Moving the models to a web-enabled platform will enable us to jettison the Excel® platform and use a more conventional programming platform that can be placed on a central server and accessed via the web from various locations.

REGIONALIZING TRAINING AND TECHNICAL ASSISTANCE FOR NONGOVERNMENTAL ORGANIZATIONS

Tenth Work Plan, Appropriate Technology Research 1 (10ATR1) Abstract

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ABSTRACT

Our technical training and outreach activities to build a nongovernmental organization (NGO) and institutional network for aquaculture development in Central American countries have encouraged interest and promoted a dynamic dialog between our project team members and those with whom we have interacted.

We have locally and regionally trained various NGO extension agents, government officials, women's groups, and college and high school students in the fundamentals of tilapia culture as a tool for rural development activities. Connections have also been forged with other training organizations that will extend our aquaculture network. New relationships have developed as we plan and organize our two four-day workshops for extension agents in El Salvador and Nicaragua in October 2002.

We have trained NGO extension agents in the use of our Web-based Information Delivery System for Tilapia (WIDeST) that provides information and assistance for decision-making processes for small- and medium-scale fish farmers. We have structured sessions to obtain user feedback so that we may better understand our target web audience and how they approach our site and interactive aquaculture models related to this work plan contained therein. We will structure additional sessions with users regarding our site's redesign as part of the October 2002 workshops. We have also identified additional web production support from the host country institution, Escuela Agrícola Panamericana El Zamorano, Zamorano, Honduras.

We spent considerable time reworking information available on our site and preparing new documents particularly structured for web delivery. This included rewriting documents and producing new information in both English and Spanish. New information for implementing and providing technical assistance to rural farmers includes low-cost inputs for raising water temperature at elevations above 600 m and methods to protect fish from predatory birds.

We believe that our efforts are contributing significantly to strengthening institutional capabilities in Central America.

INSTITUTIONALIZING WEB-BASED INFORMATION SYSTEMS FOR TILAPIA CULTURE IN LATIN AMERICA

Tenth Work Plan, Appropriate Technology Research 2 (10ATR2)
Abstract

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ABSTRACT

Countries with predominantly small- and medium-scale farms, poor infrastructure for transportation and communication, and limited material resources have large populations with marginal economic income. Lack of ability to receive this information, which can lead to creative alternatives for economic development, is a major impediment to making informed decisions. Thus, "foreign" capacity-building interventions giving technical assistance end up being temporary fixes. The challenge is to conceptualize ways by which small-scale farmers, nongovernmental organizations (NGOs), and decision-makers in host countries can easily find usable data and knowledge and develop the know-how to use the information for decision-making. These abilities will "institutionalize" host countries' capacity for economic development and free them of their dependence on others.

The work in this project has focused on developing an integrated framework that supports a systematic method of creating partnerships and communication among stakeholders and builds decision-making capacity locally. The target group is the small- and medium-scale farmers. This is being accomplished by developing a user-friendly Web-based Information Delivery System for Tilapia (WIDeST) and using it to coalesce Escuela Agrícola Panamericana El Zamorano, local NGOs and extension agents, and the US universities in partnerships. The WIDeST is central to workshop and training sessions for training the host country trainers who will extend to small- and medium-scale farmers. This way we are training the trainers both in the methods of tilapia production and use and in the methods by which to receive new information.

We have taken a systems approach by identifying and connecting all components in tilapia production systems in a logical way. The system model outlines and classifies types of variations in the components and provides a way to collect information related to each component in all stages of fish production. Economic and marketing information is being sought to be included in the model. This approach provides the framework for organizing the content of the website.

Organization of tilapia culture information that is usable by extension agents and NGOs to train small- and medium-scale farmers is critical to the success of this approach. We have trained host country NGOs in user-oriented information design for an international web audience. Marco Aleman and Suyapa Meyer, both from Zamorano, have received training. They now evaluate and produce modifications for the website (WIDeST). These modifications include preparing the website for the training workshops scheduled in Nicaragua and El Salvador in October 2002.

Information on tilapia culture is being contextualized to capture questions of small- and medium-scale farmers. Questions from each farmer will potentially be different. The web-based approach makes it easy to present multivariate information and links that are versatile. The most important aspect of this is that information is made available to those who should be making decisions. This gives them a chance to make informed decisions by using a systemic process and therefore develop many alternatives.

Overall, this work is contributing to diminish dependence of small- and medium-scale farmers on technical assistance from outside sources, as the web-based approach will enable host country NGOs and private firms to provide services and technical assistance locally.

INCOME, FOOD SECURITY, AND POVERTY REDUCTION: CASE STUDIES OF FUNCTIONING CLUSTERS OF SUCCESSFUL SMALL-SCALE AQUACULTURE PRODUCERS

Tenth Work Plan, Food Security Research 1 (10FSR1)
Abstract

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ABSTRACT

Aquaculture plays an identifiable role in helping rural Hondurans achieve food and income security, but there is a need for better understanding of how aquaculture works at the village level. Lessons learned from actual circumstances where tilapia culture is a regularized component of local farming systems could provide realistic guidance for the network of national and regional institutions dedicated to advancing aquacultural development. Another constituency for this information lays in the broader aggregate of agencies and organizations that feature aquaculture as one component in their array of development interventions. Understanding gained from case studies of successful clusters of practicing fish farmers can contribute to the goal of better directing aquaculture's inclusion in current and future integrated community development initiatives. Case studies in selected communities that have experiences with aquacultural development are being developed based on reviews of available documents, interviews with officials, extended conversations with fish farmers, and other sources of information. Because aquacultural development may operate in different ways in different regions, an attempt has been made to choose locations that are geographically dispersed and represent diversity in rainfall and elevation. Both locations (Olancho and Santa Barbara, Honduras) have known clusters of successful tilapia producers, yet they represent contrasting physical and social settings for aquacultural development. A cattle and forestry area, Olancho represents somewhat lower elevations, broad valleys, and low mountains. The Olancho case study profiles a cluster of 12 medium-scale producers. The case study describes the resources utilized, production system implemented, commercialization channels, production budget, and production cost curve. A coffee-producing region, Santa Barbara represents conditions of higher elevations, shaper valleys, and more evenly distributed rainfall. A higher proportion of the population of Santa Barbara is descended from indigenous peoples. The Santa Barbara study focuses on two locales (El Mosquito and Las Vegas), communities where many small-scale producers have repeatedly cultured tilapia for an extended period of time, some for more than a decade.

PERU PROJECT

Subcontract No. RD010E-12 (SIUC)
Subcontract No. RD010E-13 (UAPB)
Subcontract No. RD010E-A (OhSU)

Staff

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Konrad Dabrowski	US Principal Investigator
Mary Ann G. Abiado	US Principal Investigator

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Rebecca Lochmann	US Principal Investigator
Felicia Bearden	Assistant
Joseph Biny	Graduate Student (India; partially funded by CRSP from January 2002)

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Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigation:

- Amazon aquaculture outreach/10NSR1. The report submitted for this investigation was an abstract.
- Studies on reproduction and larval rearing of Amazonian fish/10NSR2 (SIUC). The report submitted for this investigation was an abstract.
- Studies on reproduction and larval rearing of Amazonian fish/10NSR2A (OhSU). The report submitted for this investigation was an abstract.
- Nutrition of *Colossoma macropomum* and *Piaractus brachypomus*/10FFR1 (SIUC). The report submitted for this investigation was an abstract.
- Broodstock diets and spawning of *Colossoma macropomum* and/or *Piaractus brachypomus*/10FFR2. The report submitted for this investigation was an abstract.
- Broodstock diets and spawning of *Colossoma macropomum* and/or *Piaractus brachypomus*/10FFR2A (UAPB). The report submitted for this investigation was an abstract.

Note: The Peru Project, "Sustainable Aquaculture in the Peruvian Amazon," is a collaborative effort among Southern Illinois University, Carbondale, University of Arkansas at Pine Bluff, Ohio State University, and the host country partners. SIUC is the lead institution for the Peru Project. SIUC and UAPB share components of 10FFR2. SIUC and OhSU share components of 10NSR2.

Publications

Alcántara, F., C.C. Kohler, S.T. Kohler, and W.N. Camargo, 2002. Cartilla de Acuacultura en la Amazonia. Manual in Spanish. IIAP-SIUC-CRSP-USAID.

Alcántara, F., S. Tello, C.V. Chávez, L.C. Rodríguez, C. Kohler, W.N. Camargo, and M. Colace. Gamitana (*Colossoma macropomum*) and paco (*Piaractus brachypomus*) culture in floating cages in the Peruvian Amazon, J. World Aquacult. Soc. (in review)

Fernandes, J.G.K., R. Lochmann, and F. Alcántara. Apparent digestible energy and nutrient digestibility coefficients of diet ingredients for pacu *Piaractus brachypomus*. J. World Aquacult. Soc. (in review)

Conferences

Aquaculture America 2002 at San Diego, California, 27–30 January 2002. (Alcántara, Camargo, Dabrowski, C. Kohler, S. Kohler, Lochman)

PD/A CRSP Annual Meeting at San Diego, California, 31 January 2002. (Alcántara, Camargo, C. Kohler, S. Kohler)

Latin American and the Caribbean Region Expert Panel Meeting at San Diego, California, 1 February 2002. (Alcántara, S. Kohler)

AMAZON AQUACULTURE OUTREACH

Tenth Work Plan, New Aquaculture Systems/New Species
Research 1 (10NSR1)
Abstract

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ABSTRACT

The first international training course titled "Aquaculture of Amazon Species for Extensionists and Producers," has successfully concluded. Eighteen participants from the following institutions and organizations attended: Instituto de Investigaciones de la Amazonia Peruana (IIAP); Fondo Nacional de Desarrollo Pesquero (FONDEPES); Organizaciones Sociales de Base; and the private sector from Peru, Brazil, Ecuador, and Colombia. We trained farmers, entrepreneurs, and technicians from government organizations and indigenous people from three Indian communities (Quichua, Shipibo, and Cocama) of the Amazon region. The next training course will be held in Iquitos (IIAP) from 25 to 30 August 2002. The outreach impact has been expanded to the Tigre River region (Santa Helena and Huayococha). By September 2002, we will visit this community under the auspices of CRSP-USAID and provide them with extension services, fish seed, and if possible basic materials (nets, nails, and ropes) to build 10 more cages, in addition to the 16 cages that Terra Nuova and IIAP built for this community. The two extensionists since February 2002 have trained 170 high school and vocational students and seven teachers (from Colegio Técnico Agropecuario El Milagro, Centro de Formación de Maestros Indígenas, and Instituto Superior Tecnológico Pedro A. Del Aguila Hidalgo), along the Iquitos-Nauta Road, with short-duration aquaculture training courses containing both theoretical and practical work. We will design a survey based on Terra Nuova's existing survey to be applied in November to the producers along the Iquitos-Nauta Road. The chat room idea proposed for the website changed to a more efficient system called the Amazon AquaForum, which was added in early August 2002 to the webpage about Amazonian aquaculture. This AquaForum allows users to formulate questions, which can be readily answered by other users sharing the same area of knowledge.

STUDIES ON REPRODUCTION AND LARVAL REARING OF AMAZONIAN FISH, I

Tenth Work Plan, New Aquaculture Systems/New Species
Research 2 (10NSR2)
Abstract

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ABSTRACT

The larviculture nutrition experiment has been conducted in both Pucallpa and Iquitos, Peru. These data are currently undergoing analysis. The *Pseudoplatystoma tigrinum* and *P. fasciatum* reproduction experiment was also initiated. One broodstock of *P. tigrinum* and eight of *P. fasciatum* were sampled on May 2002. The last sampling campaign for the broodstock study will be October or November 2002.

STUDIES ON REPRODUCTION AND LARVAL REARING OF AMAZONIAN FISH, II

Tenth Work Plan, New Aquaculture Systems/New Species
Research 2A (10NSR2A)
Abstract

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ABSTRACT

Gamitana (*Colossoma macropomum*) and paco (*Piaractus brachypomus*) have good commercial value in South America because of their high growth rate and superior flesh quality. Two Amazonian catfishes, doncella (*Pseudoplatystoma fasciatum*) and tiger (*P. tigrinum*), have been recognized as potential aquaculture species in the region. Hence, our study was focused on evaluating and comparing the growth

performance of gamitana and paco larvae fed different feeds and determining changes in plasma sex steroid hormones during the annual reproductive cycle of doncella and tiger.

At the Instituto de Investigaciones de la Amazonia Peruana (IIAP)-Pucallpa, feeding studies were conducted with paco larvae using live zooplankton and dry feed (Biokyowa). Paco larvae administered with dry feed showed 99 to 100% mortality while larvae fed zooplankton had only 47 to 53% mortality. Paco larvae preferred to feed on cladocerans (*Daphnia* sp. and *Moina* sp.), copepods (*Cyclops*), and rotifers (*Brachionus*). Gamitana was successfully spawned using carp pituitary hormone, but egg mortalities were observed 8 h after incubation due to water quality problems.

Nutritional studies were also conducted at IIAP-Pucallpa involving the use of a local plant, camu-camu (*Myrciaria dubia*), as an ingredient of feed for gamitana broodstock. Nine compartments were constructed in a large pond to allow three dietary treatments, to be replicated three times. Diets included: 1) diet devoid of vitamin C; 2) diet supplemented with an equivalent of 250 mg kg^{-1} ascorbic acid in the form of ascorbyl phosphate; and 3) diet supplemented with an Amazonian fruit, camu-camu at the equivalent of 250 mg kg^{-1} ascorbic acid. Results of this study will be presented in the final report.

Broodstock of doncella and tiger were collected, measured, and tagged, and blood samples were taken for steroid analyses. Doncella and tiger broodstock are currently being conditioned in IIAP-Pucallpa ponds in preparation for controlled reproduction studies. Data on plasma sex steroid levels will be presented in the final report.

At The Ohio State University, we conducted a study on the effect of semi-purified diets formulated with native Peruvian plants on growth and feeding efficiency of juveniles of paco (*Piaractus brachypomus*). The study aims to evaluate the effects of semi-purified casein-gelatin diets alone or supplemented with native plants on growth and feed efficiency in paco juveniles (2.01 ± 0.08 g initial weight). Fish were distributed into 12 tanks at a density of 20 fish per tank. Three tanks were randomly assigned to one of four diets: 15% wheat meal (diet 1 or control); 15% camu-camu substitution (diet 2); 15% aguaje (*Mauritia flexuosa*) substitution (diet 3); and 15% maca (*Lepidium meyenii*) substitution (diet 4). The fish were fed experimental diets three times per day at 2.6 to 4% of body weight. Every two weeks weight gain was evaluated, and every three days the amount of food was readjusted for predicted weight gain. At the start of the experiment and biweekly sampling, three fish per tank were euthanized for histology and physiological analyses. Data obtained from these analyses will be presented in the final report. After six weeks of rearing, we observed that fish fed diet containing 15% substitution of maca meal (diet 4) showed the largest weight increase and greatest feed intake among the treatment groups.

NUTRITION OF *COLOSSOMA MACROPOMUM* AND *PIARACTUS BRACHYPOMUS*

Tenth Work Plan, Feeds and Fertilizers Research 1 (10FFR1)
Abstract

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ABSTRACT

The grow-out experiment for paco (*Piaractus brachypomus*) and gamitana (*Colossoma macropomum*) was initiated 20 April 2002 and is expected to continue until September 2002. Data for the various native Amazonian plant products that were fed to paco and gamitana have been collected from the producers along the Iquitos-Nauta Road and will soon be processed. The PD/A CRSP funded Ph.D. student, Fred Chu, conducted some preliminary seed dispersal experiments with the small and large fish portion of the experimental design this summer in Iquitos. Next summer he will conduct the remaining portion of the experiment. The partial results of this experiment are very exciting since the seeds of a couple of different fruits ingested by the fish germinated after they were collected and planted in sterilized humus, thus giving a strong indication of the seed dispersal capacity of some Amazon fish.

BROODSTOCK DIETS AND SPAWNING OF *COLOSSOMA MACROPOMUM* AND/OR *PIARACTUS BRACHYPOMUS*, I

Tenth Work Plan, Feeds and Fertilizers Research 2 (10FFR2)
Abstract

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ABSTRACT

The broodstock nutrition experiment was initiated May 2002 and is being conducted until October or November 2002. Blood samples have been obtained according to plan and analyzed at The Ohio State University. The results of this study will be available by the end of 2002.

BROODSTOCK DIETS AND SPAWNING OF *COLOSSOMA MACROPOMUM* AND/OR *PIARACTUS BRACHYPOMUS*, II

Tenth Work Plan, Feeds and Fertilizers Research 2A (10FFR2A)
Abstract

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ABSTRACT

The overall objective of this study is to determine the effect of improved broodstock nutrition on maturation and spawning performance of gamitana (*Colossoma macropomum*) and/or paco (*Piaractus brachypomus*). In October 2001, gametes and blood samples from gamitana and paco broodstock were collected for laboratory analysis at the University of Arkansas at Pine Bluff (UAPB). No gamitana eggs were obtained, even after injection with luteinizing hormone-releasing hormone analog (LHRHa), so the females were apparently not ready to spawn. Total lipid analysis of all samples has been completed, and analyses of lipid classes and fatty acid composition are still in progress. Diet samples being used for different species at different facilities, Instituto de Investigaciones de la Amazonia Peruana (IIAP) and Fondo Nacional de Desarrollo Pesquero (FONDEPES), were also analyzed for proximate composition to determine whether dietary differences could be affecting the reproductive performance of gamitana or paco. Paco spawned consistently at IIAP but not at FONDEPES, while the reverse is true for gamitana. The broodstock diets at FONDEPES contain 5% less protein than those used for gamitana broodstock at IIAP and 22% less protein than those used for paco broodstock at IIAP. The feedstuffs used are very similar for all diets. Although previously vitamin C was identified as a potentially limiting factor in broodstock diets at IIAP, no vitamin C is added to the diets at FONDEPES, and their gamitana spawn consistently. Since the calculated vitamin C level of the FONDEPES diets is below the requirement of most fish species, it is possible that they are fulfilling some of their nutrient requirements from natural foods. However, other factors besides nutrition must also be considered as causes of the differences in spawning success of characids between IIAP and FONDEPES. Another goal of this project is to increase use of locally available ingredients in fish diets in Iquitos, Peru. We processed pijuayo fruit (*Bactris gasipaes*) and tested it as a feed ingredient compared to corn in a feeding trial at UAPB with paco. Pijuayo performed similarly to corn in terms of sustaining growth and survival, and it contributes beta-carotene to the diets, which might enhance spawning success. In other feeding trials at UAPB with paco, apparent protein and lipid digestibility coefficients as well as digestible energy values were determined for soybean meal, fish meal, corn meal, and wheat bran. The digestible values of soybean meal, when fed to paco, were somewhat low compared to digestible energy values of soybean meal when fed to other warmwater omnivores, but values for the other feedstuffs were comparable.

KENYA PROJECT/OSU

MOU No. RD009A

Staff

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Emmy Amwayi	Undergraduate Student (Partially CRSP funded)
Joseph Onyango	Undergraduate Student (Partially CRSP funded)

Work Plan Research

The following Ninth Work Plan investigations were completed in the reporting period:

- On-farm trials: evaluation of alternative aquaculture technologies by local farmers in Kenya/9ATR1. The report submitted for this investigation was a final report.
- Aquaculture training for Kenyan fisheries officers and university students/9ADR3. The report submitted for this investigation was a final report.

This subcontract was awarded funding to conduct the following Tenth Work Plan investigations:

- Aquaculture training for Kenyan fisheries officers and university students/10PDR3. The report submitted for this investigation was an abstract.
- Techniques for the production of *Clarias gariepinus* fingerlings as baitfish for the Lake Victoria Nile Perch longline fishery/10NSR5. The report submitted for this investigation was an abstract.

Note: 10PDR3 and 10NSR5 commenced in Year 2 of the Tenth Work Plan. The published work plans appear in the forthcoming *Addendum to the Tenth Work Plan*.

Publication

Mac'Were, E., 2002. Comparison of tilapia and *Clarias* polyculture yields and economic benefits resulting from a locally available animal feed (pig finisher pellet), agricultural by-product (rice bran), and a pelleted test diet in fertilized ponds. M.S. thesis, Moi University, Eldoret, Kenya.

Presentations

Ngugi, C., J. Macharia, and J. Rasowo. Comparative study of hatching rates of catfish eggs on different substrates. Presented to First National LVEMP Scientific Conference at Nairobi, Kenya, 15–19 October 2001.

Ngugi, C., J.O. Manyala, and T. Mboya. Fish introduction and their impact on the biodiversity and the fisheries of Lake Victoria. Presented to the First National LVEMP Scientific Conference at Nairobi, Kenya, 15–19 October 2001.

Conferences

Aquaculture America 2002 at San Diego, California, 27–30 January 2002. (Bowman, Gitonga, Langdon, Muchiri, Veverica)

PD/A CRSP Annual Meeting at San Diego, California, 31 January 2002. (Bowman, Muchiri)

Africa Regional Expert Panel Meeting at Nairobi, Kenya, 8 July 2002. (Gitonga, Muchiri, Ngugi)

Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 August 2001. (Popma)

ON-FARM TRIALS: EVALUATION OF ALTERNATIVE AQUACULTURE TECHNOLOGIES BY LOCAL FARMERS IN KENYA

Ninth Work Plan, Appropriate Technology Research 1 (9ATR1)
Final Report

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ABSTRACT

Research conducted by the PD/A CRSP at Sagana Fish Farm has identified alternative management practices and technologies that may be suitable in the region, but it should not be assumed that results obtained under controlled experimental conditions at Sagana are directly transferable to farms in the area. On-farm testing is therefore a logical step in transferring research-based technologies to the farm. On-farm testing of various alternatives allows farmers to assess their costs and benefits under local conditions as well as to receive instruction and training in basic pond management skills. It also allows project personnel to work with and train the fisheries extension officers, complementing the experience the extension officers gain through formal training activities.

On-farm trials were conducted in two phases in two different parts of Kenya. Thirty farmers were selected to participate in the trials in Central Province and Eastern Province, Kenya in 1999 and 2000. A pre-trial workshop was held in December 1999 to discuss and select management schemes for testing. Fifty-two ponds were stocked with monosex male tilapia (*Oreochromis niloticus*), mixed-sex tilapia, and/or catfish (*Clarias gariepinus*) between January and March 2000. Stocking densities were 2.0 fish m^{-2} for tilapia, 0.2 fish m^{-2} for catfish stocked with tilapia, and 1.0 fish m^{-2} for catfish stocked alone. Management schemes tested included high, medium, and low management levels. Ponds were sampled for fish growth at four- to six-week intervals, and farmers kept records of input type and weight, input costs, pond water additions, fish mortality, and fish sampling data. A post-trial workshop was held in March 2001 to summarize and evaluate the results of the trials. Farmers learned that improved management can indeed lead to increased production, something that they were not convinced of prior to the trials. The average increase in fish harvested during these trials was 330% (3.5 t ha^{-1}, as compared with an estimate of just over 1 t ha^{-1} prior to the trials). Almost two-thirds of the ponds gave net annualized revenues (NAR) exceeding KSh 250,000 ha^{-1} yr^{-1}; the average was KSh 310,832 ha^{-1} yr^{-1}. Farmers also concluded that increasing the size of their ponds would contribute to increases in production.

In western Kenya (Rift Valley and Western Provinces), 28 ponds were stocked following pre-trial workshops. Twenty-one of these had harvested their fish and five remained to be harvested by the time of the post-trial workshop (two ponds that had dried up during the course of the trials were eliminated). Five ponds had gross annualized production of less than 5.0 t ha^{-1} yr^{-1}, but the overall average was 7.4 t ha^{-1} yr^{-1}. Yields from this trial were 163 to 873% higher than yields reported for the year proceeding the trial. The average increase was 420%. Net annualized revenue (not counting fingerling costs) averaged KSh 487,270 ha^{-1} yr^{-1}, which was higher than for the Central and Eastern Provinces. Seventy-six percent of the ponds netted over KSh 250,000 ha^{-1} yr^{-1}. When fingerling costs were included, average NAR was KSh 431,368 ha^{-1} yr^{-1}. Although farmers had not kept detailed records of their expenditures during previous years, many of them claimed enormous increases in net revenues because they had never made money from their fishponds before. Better results, compared to previous fish yields, were achieved by 80% of the farmers who participated in the trials.

These trials have helped farmers and extensionists to gain a better understanding of pond management. Application of feed and fertilizers stood out as the most important management technique learned by the farmers. According to participating farmers, at least 1,000 people in each of the two regions got to know about the trials. In the region containing the Central and Eastern Provinces, 28 new ponds had been constructed and 31 new farmers had reportedly begun growing fish during the time of the trials. In the western region, 24 new farmers reportedly began culturing fish during the trial period.

AQUACULTURE TRAINING FOR KENYAN FISHERIES OFFICERS AND UNIVERSITY STUDENTS, I

Ninth Work Plan, Adoption/Diffusion Research 3 (9ADR3)
Final Report

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ABSTRACT

Lack of technical training has been cited as a major reason for the low output of fish ponds in Kenya. The lack was observed at all levels, from the lowest level extension agent through university levels. This training program, undertaken under the Ninth Work Plan by the PD/A CRSP Kenya Project, has sought to improve training and to provide a cadre of trainers who have extensive practical fish production experience.

Full scholarship support was provided for two M.S. students under this activity, one at Moi University's Chepkoilel Campus, Eldoret, Kenya, and the other at Auburn University, Alabama. Stipends were provided to allow graduate and undergraduate university students to work at Sagana Fish Farm to conduct thesis research and gain valuable field experience, and a small research project program has allowed the station staff to further their professional development and carry out their own research, which is expected to have a positive impact on station management.

A series of five short courses for personnel of the Kenya Fisheries Department (FD) was begun in 1999 and concluded in 2000. In the first four sessions of the series, more than 80 FD staff received two weeks of training in pond construction methods and pond management techniques, and in the final session an additional 26 persons (24 fisheries officers and two outside-funded participants) received three weeks of advanced training in pond construction, pond management, and business planning.

Following requests from farmers, a program of farmer education days was developed to complement the short-course training undertaken in this activity. During the first half of 1999, five farmer education days were held in which 107 farmers and 40 extensionists participated. All districts in the Central Province were covered, and one district each from the Eastern and Rift Valley Provinces was included. The farmer education days were continually improved, following feedback from farmers. A one-day farmer field day, sponsored by the World Bank (Lake Victoria Management Project), was held in April 2002 in which 20 fish farmers from Kisumu District were trained in pond construction and management techniques. Four additional farmer field days for 31 farmers, including fisheries extension workers, were conducted at Moi University and at Sagana Fish Farm in August 2002.

AQUACULTURE TRAINING FOR KENYAN FISHERIES OFFICERS AND UNIVERSITY STUDENTS, II

Tenth Work Plan, Pond Dynamics Research 3 (10PDR3)
Abstract

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Bethuel Omolo
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ABSTRACT

This activity was undertaken at the request of the Kenya Fisheries Department to provide in-service training for Kenyan fisheries officers and to support Kenyan university students in graduate and undergraduate aquaculture programs. Fisheries officers need in-service training to learn about pond design and construction and about current aquaculture techniques so that they can transmit this information to fish farmers. Selected university students receive support for more in-depth aquaculture studies; some of them will become fisheries officers and fill the extension role in the future. The training activity was planned for one year, beginning on the first of May 2002 and concluding on 30 April 2003.

Support for four graduate students began in May 2002, when they enrolled at Moi University's Chepkoilel Campus in Eldoret, Kenya to begin their studies. These students are currently involved in coursework and in developing their research proposals; at least two of them will be conducting aspects of the *Clarias* fingerling production research described in another PD/A CRSP investigation (see "Techniques for the production of *Clarias gariepinus* fingerlings as baitfish for the Lake Victoria Nile Perch Longline Fishery," 10NSR5, facing page). In addition, five undergraduate students have received stipend support for aquaculture work conducted in association with their special projects. Three three-week training sessions for fisheries officers will be conducted under this activity. The first was scheduled for 12 to 31 August 2002 in Eldoret, while the second and third sessions will be conducted in mid -November 2002 and by April 2003, respectively. These courses focus on pond design and construction and on pond management techniques and business plan preparation for commercial aquaculture.

TECHNIQUES FOR THE PRODUCTION OF *CLARIAS GARIEPINUS* FINGERLINGS AS BAITFISH FOR THE LAKE VICTORIA NILE PERCH LONGLINE FISHERY

Tenth Work Plan, New Aquaculture Systems/New Species Research 5 (10NSR5)
Abstract

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ABSTRACT

Clarias gariepinus is widely distributed throughout Africa, is highly valued as a food fish, and has a high potential for aquaculture. It has also become increasingly important as a baitfish in the Lake Victoria Nile Perch Fishery, which is of enormous economic importance in Kenya, Uganda, and Tanzania because of its foreign currency earnings and the employment it provides for people near the lake. The annual demand for fingerlings has been estimated to be between 1.5 and 15 million. Fishers have traditionally captured *C. gariepinus* fingerlings from Lake Victoria for use as bait using small-mesh beach seines and mosquito nets, but beach seining is highly destructive to the spawning habitats of native cichlids and is illegal. The development of practical pond production methods for *C. gariepinus* fingerlings could contribute to the supply of bait fish for lake fisheries and help protect spawning habitats, while at the same time providing a highly profitable business for fish farmers. Spawning of *C. gariepinus* is easily performed with simple hatchery techniques, but further work is needed to increase survival during the fry-to-fingerling stage using methods that do not require electricity or high levels of inputs. Basic studies on larval stocking densities, provision of shade in rearing ponds, and length of grow-out period are also required.

The objective of this particular set of experiments is to determine the effects of a shading regime, larval stocking density, and larval grow-out period on the production of *C. gariepinus* fingerlings in earthen ponds. Each set of experiments will be conducted in 12 to 24 ponds of 100 to 150 m^2 in area. Initial fertilization will be with urea and diammonium phosphate at 10 kg N ha^{-1} and 4 kg P ha^{-1} plus cow manure at 500 kg ha^{-1}, applied two days prior to stocking; repeat doses will be applied at the initial dose on days 7, 14, and 21. Trout feed (36% protein) will be added twice daily at a rate of 10 kg ha^{-1} d^{-1} beginning on the fourth day. Treatments in the pond shading experiments are expected to be 25, 50, 75, and 100% coverage of the pond surface using cut sedges. For the stocking density and grow-out period experiments, larvae will be stocked at three densities (20, 50, and 100 larvae m^{-2}) for two different grow-out periods (21 and 42 d) in a 3 x 2 factorial design with three or four replicates per treatment. Supplies for this research are currently being acquired, and test runs will be conducted from August through October; in-pond research is expected to begin by December 2002.

KENYA PROJECT/AU

Subcontract No. RD010E-08

Staff

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Karen L. Veverica	US Principal Investigator

Moi University, Eldoret, Kenya

David M. Liti	Host Country Principal Investigator
Mucai Muchiri	Host Country Principal Investigator
Leah Cherop	Graduate Student (Kenya; from October 2001)

Kenya Fisheries Department, Kenya

Nancy Gitonga	Host Country Principal Investigator

Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigation:

- Development of economically feasible feeds for semi-intensive culture of tilapia, *Oreochromis niloticus*, using locally available agricultural by-products/10FFR4. The report submitted for this investigation was an abstract.

Conferences

Africa Regional Expert Panel Meeting at Nairobi, Kenya, 8 July 2002. (Muchiri)

Aquaculture America 2002 at San Diego, California, 27–30 January 2002. (Lim, Liti)

DEVELOPMENT OF ECONOMICALLY FEASIBLE FEEDS FOR SEMI-INTENSIVE CULTURE OF TILAPIA, *OREOCHROMIS NILOTICUS*, USING LOCALLY AVAILABLE AGRICULTURAL BY-PRODUCTS

Tenth Work Plan, Feeds and Fertilizers Research 4 (10FFR4)
Abstract

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ABSTRACT

A study was conducted to evaluate, under a semi-intensive culture system, the growth performance and economic feasibility of feeding Nile tilapia (*Oreochromis niloticus*) with diets made up of locally available feedstuffs. Juvenile sex-reversed male tilapia (22 g average weight) were stocked in 16 earthen ponds (800 m^2) at a density of 20,000 fish ha^{-1} on 20 November 2001. Juvenile *Clarias* sp. were stocked into each pond at 1,000 fish ha^{-1} to control snails. Two weeks prior to stocking, ponds were fertilized with inorganic fertilizers at 20 kg N ha^{-1} and 5 kg P ha^{-1}. Four diets [two laboratory prepared diets (with and without 0.5% trout vitamin premix) containing about 25% crude protein and 6% crude fat; a pig finisher pellet; and wheat bran] were each fed to fish in one of four replicate ponds two times daily at a rate of 2% of tilapia biomass for approximately 8 months. The average final weight gains were similar for tilapia fed the two formulated diets (with or without vitamin premix), and these were significantly higher than those of the groups fed wheat bran and pig finisher. There were no significant differences between the weight gain of fish fed wheat bran and pig finisher diets. Net production followed the same trend as that of the weight gain. No significant differences were observed among the survival of fish fed different diets. Proximate analysis of the experimental fish data and economic assessment of the experimental diets are being evaluated.

KENYA PROJECT/AU

Subcontract No. RD010E-C

Staff

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Kenya Fisheries Department, Ministry of Natural Resources, Kenya

Bethuel Omolo	Research Associate

Moi University, Eldoret, Kenya

David M. Liti	Host Country Principal Investigator
Mucai Muchiri	Host Country Principal Investigator
George Osure	Graduate Student (Kenya; CRSP funded from January 2002)

Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigation:

- Evaluation of growth and reproductive performance of three strains of Nile tilapia *Oreochromis niloticus* found in Kenya for use in aquaculture/10NSR4. The report submitted for this investigation was an abstract.

Conferences

Aquaculture America 2002 at San Diego, California, 27–30 January 2002. (Phelps, Liti, Muchiri)

PD/A CRSP Annual Meeting at San Diego, California, 31 January 2002. (Phelps, Liti)

Africa Regional Expert Panel Meeting at Nairobi, Africa, 8 July 2002. (Muchiri)

Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 August 2001. (Phelps)

EVALUATION OF GROWTH AND REPRODUCTIVE PERFORMANCE OF THREE STRAINS OF NILE TILAPIA *OREOCHROMIS NILOTICUS* FOUND IN KENYA FOR USE IN AQUACULTURE

Tenth Work Plan, New Aquaculture Systems/New Species Research 4 (10NSR4)
Abstract

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Sagana, Kenya

ABSTRACT

Nile tilapia (*Oreochromis niloticus*) is the most important species in tropical freshwater aquaculture in the world and is the focus of the aquaculture extension efforts in Kenya. There are several strains of *O. niloticus* found in different geographical areas of the country, of which one or more may have specific production advantages that favor its use. Which strain of tilapia to use is an important question in terms of optimizing production while maintaining biodiversity. Most of the *O. niloticus* being cultured worldwide are from introductions made 20 to 30 years ago from the wild. In most cases these populations have become highly inbred with little genetic potential for improvement. New stocks from the wild are needed to improve the genetic diversity of tilapia culture worldwide. The Kenya Project has begun an effort to evaluate the strains currently available and establish protocols and techniques for evaluating other strains of *O. niloticus*.

Three strains of tilapia currently present in Kenya are being evaluated to determine if any have unique culture characteristics that favor its use in aquaculture. They include the Sagana strain, the Lake Turkana strain, and the Lake Victoria strain. The evaluation consists of three phases: 1) fingerling evaluation; 2) foodfish evaluation; and 3) reproductive efficiency. Tilapia fry of the three strains, averaging 0.50 to 0.56 g, were stocked at 7 fish m^{-2} and after 50 days averaged 6.15 to 6.60 g with no difference among the strains.

At Auburn University, two strains of *O. niloticus* (Egypt and Ivory Coast) were compared. Both had similar fecundity, 1.17 and 1.29 seed g^{-1} female, respectively. Ivory Coast strain females were better in egg incubation, with 92% of spawns being successfully incubated versus 55% for Egypt strain. Survival from egg to swim-up fry was 63.5% for Egypt strain and 81.25% for Ivory Coast strain. Growth in primary nursery was similar for both strains, with fish averaging 2.6 g after 28 days. In secondary nursery where a commercial feed or cow manure was given as a nutrient source, both strains grew similarly. Differences in growth as related to nutrient input were distinct at 27 days, with fish given manure averaging 15.3 g and 31.2 g for fish given a commercial feed.

THAILAND PROJECT

Subcontract No. RD010E-04

Staff

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James S. Diana	US Principal Investigator
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Nguyen Thanh Phoung	Host Country Principal Investigator

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Md. Abdul Wahab	Host Country Principal Investigator

Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigations:

- Polyculture of grass carp and Nile tilapia with napier grass as the sole nutrient input in the subtropical climate of Nepal/10FFR3. The report submitted for this investigation was an abstract.
- Development of a trophic box model to assess potential of ecologically sound management for cove aquaculture systems in Tri An Reservoir, Vietnam/10ASMR1. The report submitted for this investigation was an abstract.
- Environmental impacts of cage culture for catfish in Hongngu, Vietnam/10ER3. The report submitted for this investigation was an abstract.
- On-station trial of different fertilization regimes used in Bangladesh/10ATR4A. The report submitted for this investigation was a final report.
- On-farm trials of different fertilization regimes used in Bangladesh/10ATR4B. The report submitted for this investigation was an abstract.
- A study of aquaculture brownfields: Abandoned and converted shrimp ponds in Thailand/10GISR1. The report submitted for this investigation was an abstract.
- Assessing watershed ponds for aquaculture development in Thai Nguyen, Vietnam/10GISR2. The report submitted for this investigation was an abstract.
- Transfer of production technology to Nepal for Nile tilapia, *Oreochromis niloticus*/10PDVR3. The report submitted for this investigation was an abstract.
- PD/A CRSP Aquaculture Database/10DSSR1. The report submitted for this investigation was an abstract.

Note: In addition to the above investigations, the Asian Institute of Technology also collaborates with Michigan State University (10PDR2) and University of Arizona (10NSR3A and 10NSR3B). 10DSSR1 was approved after the printing of the Tenth Work Plan. The published work plan appears in the forthcoming *Addendum to the Tenth Work Plan*.

Publications

Bart, A.N., 2001. The use of ultrasound to enhance transport of compound into fish and fish embryos: A review. Asian Fish. Soc., 14(4):36–45.

Bart, A.N., S. Athauda, M. Fitzpatrick, and W.M. Contreras-Sánchez, 2002. The use of ultrasound to enhance sex reversal in tilapia using immersion protocol. World Aquacult. Soc. (in review)

Lin, C.K. and Y. Yi, 2001. Development in integrated aquaculture in Southeast Asia. In: L.M.B. Garcia (Editor), Responsible Aquaculture Development in Southeast Asia. Proceedings of the Seminar-Workshop on Aquaculture Development in Southeast Asia, 12–14 October 1999. Southeast Asian Fisheries Development Center (SEAFDEC), Iloilo, Philippines, pp. 77–88.

Lin, C.K. and Y. Yi. Minimizing environmental impacts and reuse of pond effluents and mud. Special Volume for the Proceedings of AIP Workshop: Management of Aquaculture Effluents. Aquaculture. (in review)

Mon, A.A., Y. Yi, and C.K. Lin. Use of lotus (*Nelumbo nucifera*) for nutrient retrieval from fishpond mud. Aquacult. Eng. (in review)

Nadtirom, P., 2001. Comparison of growth performance of different sex genotypes (XX and XY) of Nile tilapia (*Oreochromis niloticus*) and the effect of androgen treatment. M.S. thesis, Asian Institute of Technology, Pathumthani, Thailand.

Nadtirom, P., Y. Yi, and G.C. Mair. Comparison of growth performance of different sex genotypes (XX and XY) of Nile tilapia (*Oreochromis niloticus L.*) and the effect of androgen treatment. Aquaculture. (in review)

Weerasooriya, A.C., 2001. Effects of AquaMats on Nile tilapia (*Oreochromis niloticus*) fry in earthen ponds. M.S. thesis, Asian Institute of Technology, Pathumthani, Thailand.

Yi, Y. and C.K. Lin. Cage-cum-pond—Integrated aquaculture systems recycle wastes. Global Aquaculture Advocate, 4(6):65–66.

Yi, Y. and C.K. Lin, 2001. Low-cost fertilization in inland pond aquaculture. In: IIRR, IDRC, FAO, NACA, and ICLARM, Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book. International Institute of Rural Reconstruction, International Development Research Center, Food and Agriculture Organization of the United Nations, Network of Aquaculture Centers in Asia-Pacific, and International Center for Living Aquatic Resources and Management, pp. 250–253.

Yi, Y. and A. Yakupitiyage, 2001. Feeds in small-scale aquaculture. In: IIRR, IDRC, FAO, NACA, and ICLARM, Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book. International Institute of Rural Reconstruction, International Development Research Center, Food and Agriculture Organization of the United Nations, Network of Aquaculture Centers in Asia-Pacific, and International Center for Living Aquatic Resources and Management, pp. 263–268.

Yi, Y., C.K. Lin, and J.S. Diana. Effects of clay turbidity on fertilization, and analyses of techniques to mitigate turbidity problems. Aquacult. Eng. (in review)

Yi, Y., C.K. Lin, and J.S. Diana. Hybrid catfish (*Clarias macrocephalus* x *C. gariepinus*) and Nile tilapia (*Oreochromis niloticus*) culture in an integrated pen-cum-pond system: Growth performance and nutrient budgets. Aquaculture. (in press)

Yi, Y., C.K. Lin, and J.S. Diana, 2001. Integrating intensive and semi-intensive culture system to utilize feeding waste. In: IIRR, IDRC, FAO, NACA, and ICLARM, Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book. International Institute of Rural Reconstruction, International Development Research Center, Food and Agriculture Organization of the United Nations, Network of Aquaculture Centers in Asia-Pacific, and International Center for Living Aquatic Resources and Management, pp. 250–253.

Yi, Y., C.K. Lin, and J.S. Diana. Optimization of nitrogen fertilization rate and carrying capacity in Nile tilapia (*Oreochromis niloticus*) ponds. J. World Aquacult. Soc. (in review)

Yi, Y., C.K. Lin, and J.S. Diana, 2002. Recycling pond mud nutrients in integrated lotus-fish culture. Aquaculture, 212(1–4):213-226.

Yi Y., C.K. Lin, and J.S. Diana. Waste recycling in fish pond culture through integrated cage-cum-pond and pen-cum-pond culture systems. Proceedings of the Third World Fisheries Congress. American Fish. Soc. (in press)

Presentations

Bart, A.N. Progress towards cryopreservation of fish embryos. Presented to World Aquaculture 2002 at Beijing, China, 23–27 April 2002.

Bart, A.N. and A.K. Htin, 2002. Advances in cryopreservation of zebrafish, *Brachydanio rerio*, embryos. Presented to Aquaculture America 2002 at San Diego, California, 27–30 January 2002.

Bart, A.N., A.R.S.B. Athauda, M.S. Fitzpatrick, and W.M. Contreras-Sánchez. Ultrasound enhanced masculinization of Nile tilapia in immersion protocol. Presented to World Aquaculture 2002 at Beijing, China, 23–27 April 2002.

Chen, G.Z., Y. Yi, Z.W. Wu, H. Miu, and Q.M. Zhang, 2001. Recent development of integrated rice-fish culture in China. Presented to the Sixth Asian Fisheries Forum at Kaoshiung, Taiwan, 25–30 November 2001.

Luu, L.T., Y. Yi, C.K. Lin, J.S. Diana, and N.X. Cuong. Assessing watershed ponds for aquaculture development: A case study in Thai Nguyen Province, Vietnam. Presented at the annual meeting of WAS in Beijing, China, 23–27 April 2002.

Nadtirom, P., Y. Yi, and G. Mair. Comparison of growth performance of different sex genotypes (xx and xy) of Nile tilapia (*Oreochromis niloticus L.)* and the effect of androgen treatment. Presented to World Aquaculture 2002 at Beijing, China, 23–27 April 2002.

Phuong, N.T., Y. Yi, C.K. Lin, and J.S. Diana. Current status of Pangasius catfish cage culture in Vietnam. Presented to World Aquaculture 2002 at Beijing, China, 23–27 April 2002.

Wahab, M.A., Y. Yi, C.K. Lin, and J.S. Diana. Comparison of effects of different fertilization regimes on fish production, water quality, effluent and economic returns in Bangladesh. Presented to World Aquaculture 2002 at Beijing, China, 23–27 April 2002.

Wu, Z.W. and Y. Yi, 2001. Culture-based reservoir fisheries in

China. Presented to Aquaculture America 2002 at San Diego, California, 27–30 January 2002.
Wu, Z.W. and Y. Yi, 2001. Fertilization regime and application method in reservoirs. Presented to the Sixth Asian Fisheries Forum at Kaoshiung, Taiwan, 25–30 November 2001.
Yi, Y., C.K. Lin, and J.S. Diana, 2001. Red tilapia (*Oreochromis* sp.) culture in brackishwater ponds. Presented to the Sixth Asian Fisheries Forum at Kaoshiung, Taiwan, 25–30 November 2001.

Conferences

AquaBusiness Seminar and Exhibition at Malaysia, 16–19 January 2002. (Yi)
Aquaculture America 2002 at San Diego, California, 27–30 January 2002. (Bart, Yi)
PD/A CRSP Annual Meeting at San Diego, California, 31 January 2002. (Bart, Diana, Lin, Yi)
Asia Region Expert Panel meeting at Beijing, China, 23 April 2002. (Lin, Luu, Wahab)
International Seafood Production Symposium at Rongcheng, China, 10–12 September 2001. (Lin)
Sixth Asian Fisheries Forum at Kaoshiung, Taiwan, 25–30 November 2001. (Yi)
World Aquaculture 2002 at Beijing, China, 23–27 April 2002. (Bart, Diana, Lin, Luu, Nadtirom, Yi)

Polyculture of Grass Carp and Nile Tilapia with Napier Grass as the Sole Nutrient Input in the Subtropical Climate of Nepal

Tenth Work Plan, Feeds and Fertilizers Research 3 (10FFR3)
Abstract

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Abstract

The experiment started in May 2002 and will be terminated in November 2002. The experiment is being conducted in 15 cement tanks of 24 m^2 in surface area in a randomized complete block design. The purposes of the experiment are to evaluate the growth of grass carp (*Ctenopharyngodon idella*) and Nile tilapia (*Oreochromis niloticus*), to assess the nutrient and water quality regimes, to determine the composition of foods consumed by Nile tilapia, and to optimize the ratio of grass carp to Nile tilapia in the polyculture with napier grass (*Pennisetum purpureum*) as the sole nutrient input. There are five treatments with three replicates each: A) grass carp only at 0.5 fish m^{-2} (control); B) grass carp plus Nile tilapia stocked at 0.25 fish m^{-2}; C) grass carp plus Nile tilapia stocked at 0.5 fish m^{-2}; D) grass carp plus Nile tilapia stocked at 1.0 fish m^{-2}; E) grass carp plus Nile tilapia stocked at 2.0 fish m^{-2}. Grass carp fingerlings of 36 to 48 g in size were stocked at 0.5 fish m^{-2} in all tanks on 26 May 2002, and Nile tilapia fingerlings of 8.7 to 10.4 g in size were stocked at different densities in different treatments on 1 June 2002.

Development of a Trophic Box Model to Assess Potential of Ecologically Sound Management for Cove Aquaculture Systems in Tri An Reservoir, Vietnam

Tenth Work Plan, Aquaculture Systems Modeling Research 1 (10ASMR1)
Abstract

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Abstract

This study started in June 2002 and will be finished in March 2003. The fieldwork for this study is being conducted in Truong Dang Aquaculture Cove of Tri An Reservoir, Vietnam. The purposes of this study are to determine biomass production of various trophic levels in the fish culture cove, to construct a trophic box model for the selected cove, and to recommend ecologically sound stocking and management strategies for cove aquaculture. Biomass of terrestrial vegetation in the drawn down area has been determined before inundation in June and July 2002. The first bimonthly sampling has been done to measure water quality parameters and to determine the biomass of detritus, phytoplankton, zooplankton, and benthos. The species and biomass of different species of cultured fish has been recorded at stocking in August 2002 and will be assessed at harvest. Finally, a trophic box model will be developed to assess potential of ecologically sound management for cove aquaculture.

ENVIRONMENTAL IMPACTS OF CAGE CULTURE FOR CATFISH IN HONGNGU, VIETNAM

Tenth Work Plan, Effluents and Pollution Research 3 (10ER3)
Abstract

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ABSTRACT

This study started in November 2001 and will finish in October 2002. The work is being conducted on the So Thuong Canal and Tien River (one branch of Mekong River) in the Hongngu district, Dong Thap province of Vietnam. The purposes of this study are to investigate the cage culture system and its related environmental conditions, to determine the quality and quantity of pollutants produced by cages, to detect the fate of pollutants in the river, and to recommend methods for pollution mitigation in cage culture.

Ninety cage farmers were selected randomly and equally from each category (small-, medium-, and large-size cages) for interviews to investigate socioeconomic characteristics of farmers, cage culture practices, investment cost and return, problems, and other information using a structured checklist and open-ended type of questionnaires. The cage culture area was divided into three equal sessions (upstream, middle, and downstream) in both So Thuong Canal and Tien River. One cage in So Thuong Canal and two cages in Tien River were randomly selected from each culture session, giving a total of nine cages.

Composite water samples have been taken monthly at three depths (surface, middle, and bottom of the cages) from incoming water, inside-cage water, and outgoing water of each cage between 0800 to 1000 h. One extra composite water sample has also been taken 200 m downstream from the cage culture area. The water samples have been analyzed for total ammonia nitrogen (TAN), total suspended solids (TSS), volatile suspended solids (VSS), organic carbon, total nitrogen (TN), and total phosphorus (TP). Dissolved oxygen (DO), pH, and temperature have been measured at three depths just before taking water samples. Diel measurements of DO, pH, temperature, TSS, and VSS have been conducted for three sessions, one in the rainy season and two in the dry season. Sediment samples have been taken every two months at 20 m downstream of the selected cages for the analysis of moisture, organic carbon, TN, and TP.

Feed and fish samples have been collected from the owners of the selected cages for analysis of moisture, organic matter, TN, and TP. Feed inputs, feed conversion ratio, and fish biomass data are to be collected from the owners of the selected cages.

ON-STATION TRIAL OF DIFFERENT FERTILIZATION REGIMES USED IN BANGLADESH

Tenth Work Plan, Appropriate Technology Research 4A (10ATR4A)
Final Report

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ABSTRACT

An on-station trial was conducted in fourteen 100-m^2 earthen ponds at the Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh from July through December 2001. This trial was designed to evaluate different fertilization regimes currently used for aquaculture in Bangladesh and to compare effects of different fertilization regimes on fish production, water quality, and economic returns. There were five fertilization regimes used as treatments during the culture period: A) PROSHIKA fertilization regime, weekly application of 1,000 kg cow dung ha^{-1}; B) Bangladesh Rural Advancement Committee (BRAC) fertilization regime, weekly application of 156 kg cow dung ha^{-1}, 28.125 kg urea ha^{-1}, and 13.1 kg triple superphosphate (TSP) ha^{-1}; C) Caritas fertilization regime, fortnightly application of 1,500 kg cow dung ha^{-1}; D) BAU fertilization regime, fortnightly application of 1,250 kg cow dung ha^{-1}, 31.25 kg urea ha^{-1}, and 15.625 kg TSP ha^{-1}; E) PD/A CRSP fertilization regime developed from Nile tilapia (*Oreochromis niloticus*) ponds, weekly application of 250 kg cow dung (dry matter) ha^{-1} supplemented with urea and TSP to give 28 kg N and 7 kg P ha^{-1} wk^{-1}. The six carp species used in this on-station trial were silver carp (*Hypophthalmichthys molitrix*), mrigal (*Cirrhinus mrigala*), rohu (*Labeo rohita*), catla (*Catla catla*), grass carp (*Ctenopharyngodon idella*), and common carp (*Cyprinus carpio*) stocked at a ratio of

9:8:6:6:3:2 at a stocking density of 1.02 fish m^{-2}, giving 27, 24, 18, 18, 9, and 6 fish per 100-m^2 pond, respectively. Mean stocking sizes of carps ranged from 6.3 to 10.1 g.

Among all tested fertilization regimes, the PD/A CRSP fertilization regime resulted in the highest fish production, followed by the BAU, BRAC, Caritas, and PROSHIKA fertilization regimes ($P < 0.05$). The two fertilization regimes (PROSHIKA and Caritas) using cow dung as the sole nutrient input during the culture period gave very poor fish growth performance and low production due mainly to the low soluble nutrients derived from cow dung. The other three fertilization regimes (PD/A CRSP, BAU, and BRAC) using the combinations of organic and inorganic fertilizers resulted in much higher carp production. Analysis of water quality showed that the nutrients from the PD/A CRSP fertilization regime were oversupplied probably because this regime was developed in Nile tilapia monoculture with higher intensification compared to the carp polyculture used in the present trial. The BAU fertilization regime gave the highest profitability among all fertilization regimes, followed by the BRAC and PD/A CRSP regimes. Therefore, the BAU fertilization regime is the most appropriate for carp polyculture ponds in Bangladesh while the PD/A CRSP fertilization regime is suitable for carp polyculture ponds with higher intensification.

ON-FARM TRIALS OF DIFFERENT FERTILIZATION REGIMES USED IN BANGLADESH

Tenth Work Plan, Appropriate Technology Research 4B (10ATR4B)
Abstract

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ABSTRACT

On-farm trials started in late June 2002 and will be terminated in March 2003. The best fertilization regime from the on-station trial conducted during July through December 2001 at Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh, was the BAU fertilization regime: fortnightly application of 1,250 kg cow dung ha^{-1}, 31.25 kg urea ha^{-1}, and 15.625 kg triple superphosphate (TSP) ha^{-1}. The on-farm trial is comparing the best fertilization regime with respective fertilization regimes of three nongovernmental organizations (NGOs) [Caritas, Bangladesh Rural Advancement Committee (BRAC), and PROSHIKA] in their own working sites. Twelve ponds in each NGOs working site have been chosen, and six ponds are being used for the best fertilization regime and the remaining six for the respective NGOs fertilization regime. The NGOs fertilization regimes are fortnightly application of 1,500 kg cow dung ha^{-1} for Caritas; weekly application of 156 kg cow dung ha^{-1}, 28.125 kg urea ha^{-1}, and 12.1 kg TSP ha^{-1} for BRAC; and weekly application of 1,000 kg cow dung ha^{-1} for PROSHIKA. No fish sampling will be done except for harvest. A partial budget will be conducted to compare economic performance of these fertilization regimes.

A STUDY OF AQUACULTURE BROWNFIELDS: ABANDONED AND CONVERTED SHRIMP PONDS IN THAILAND

Tenth Work Plan, GIS: Planning, Policy, and Global Data Analysis Research 1 (10GISR1)
Abstract

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ABSTRACT

The objectives of this study are to determine the current state of abandoned and converted shrimp ponds in the study area; to assess attitudes, concerns, and interests of a number of stakeholders, such as farmers, government personnel, and community and business leaders, about abandoned ponds and possible alternative uses; and to assess the social and technical conditions necessary for diffusion and adoption of alternative uses.

Three provinces have been selected as study sites: Chachoengsao, Chanthaburi, and Samut Sakhon. The provinces selected have all undergone a rapid expansion and subsequent collapse of intensive shrimp culture. Fieldwork is being conducted in districts within the provinces that have been most affected by collapse of shrimp culture.

Numerous factors are hypothesized to impact the viability of options for conversion and reclamation of failed or poorly functioning farms. These factors include: historical land use patterns, land prices, urban growth pressure, population density, ecological conditions, access to agricultural extension, social dynamics, and economic stability. The selected study areas vary greatly in respect to these components and therefore comprise a representative sample of the spectrum of feasible future land use options.

Information will be gathered primarily through field interviews with supplemental demographic and geographic information to be obtained through relevant governmental departments. Information will be compiled in a Geographic Information System database.

Surveys have been designed for interviews with the various groups that will be consulted (farmers, stakeholders, and village heads). A methodology to use a Global Positioning System unit in conjunction with remote sensing imagery to assess the level of farm abandonment has also been developed.

Over 100 interviews have been conducted with culturalists and stakeholders in the provinces of Chanthaburi and Chachoengsao. Work will continue in Samut Sakhon on 10 September 2002. The diversity of use options has been surprising and impressive.

ASSESSING WATERSHED PONDS FOR AQUACULTURE DEVELOPMENT IN THAI NGUYEN, VIETNAM

Tenth Work Plan, GIS: Planning, Policy, and Global Data Analysis Research 2 (10GISR2)
Abstract

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ABSTRACT

The data collection for this study started in October 2001 and finished in September 2002. The purposes of this study are to conduct a survey on biophysical features, land and water uses, and socioeconomic conditions of watershed areas in Thai Nguyen, Vietnam; to develop a detailed Geographic Information System database for planning of aquaculture development in the study area; and to identify and estimate suitable watershed ponds for aquaculture. The secondary data have been collected and are being analyzed. These include socioeconomic data (land use, water use, infrastructure, population density, and income distribution); physical and environmental data (water resource, climate, soil, and topography); constraints for aquaculture (water availability, protected land, polluted area, and urban centers); and a map of the study area. One hundred households have been selected for interviews using a structured checklist and an open-ended type of questionnaire, which consists of farmers' socioeconomic status (land use, water use, infrastructure, family size, and income); current aquaculture practices (culture systems, culture species, production, cost, and benefits) and attitudes; and potential constraints for aquaculture (protected land, polluted area, and urban centers). One hundred watershed ponds have been selected for weekly recording of change in water depth and for sampling pond soil for analyses of texture and acidity. Out of the 100 selected ponds, 60 ponds have been randomly selected for monthly water sampling to determine conductivity, temperature, pH, total alkalinity, total hardness, total suspended solids, total volatile solids, total nitrogen, and total phosphorus.

TRANSFER OF PRODUCTION TECHNOLOGY TO NEPAL FOR NILE TILAPIA, *OREOCHROMIS NILOTICUS*

Tenth Work Plan, Product Diversification Research 3 (10PDVR3)
Abstract

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ABSTRACT

This activity was intended to assist in the transfer of PD/A CRSP developed technology about tilapia culture to Nepal through on-station trials with feeding and fertilizing. Chitralada and Genetically Improved Farmed Tilapia (GIFT) strain fry (21 days post-fertilization) were transported to the Tarahara research station in Nepal in mid-December. There was large mortality during handling of the GIFT strain fry due to cool temperatures (18 to 19°C). However, sufficient Chitralada strain fry survived to carry out the growth trial. The Chitralada strain fry were stocked in six different ponds (three with feed and fertilization and three with fertilization only) at 4 fish m^{-2}. Those receiving feed were first fed 80 days after hatch.

Fish were harvested in early August 2002. The fish did not grow from December 2001 to the end of February 2002 due to cool temperatures (16 to 20°C). At harvest, mean weight of fish ranged from 113 to 144 g among six ponds. While the largest individual harvested was 257 g, the smallest was 43 g. There was no significant difference ($P > 0.05$) between fed and fertilized (139.00 ± 30.53 g) and fertilized only (122.38 ± 28.00 g) treatments. Recruitment was observed in all ponds. However, a fertilized-only pond had the greatest production of mixed size-fingerlings by weight (1,325 g) while the fed and fertilized ponds had only 486 g mixed-size fingerlings. Slower growth of tilapia may have been due to a combination of stocking during the cooler month (December) and adaptation to the new environment.

The uniform sizes of fingerlings from this new recruitment were selected and again stocked (mid-August 2002) in the same six ponds. This will allow us to determine their growth when stocked during the warmer months and compare with winter stocking (with the fertilization-only regime). We expect to harvest these ponds during December 2002.

PD/A CRSP DATABASE: FINALIZATION, MANAGEMENT, AND DISTRIBUTION

Tenth Work Plan, Decision Support Systems Research 1 (10DSSR1)
Abstract

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ABSTRACT

Since this study started in May 2002, the database and files residing on the server at Department of Bioengineering at Oregon State University have been transferred to AIT, and the web-based PD/A CRSP database <www.serd.ait.ac.th/CRSPdb> has been established and will be published soon. Several institutions such as Asian Fisheries Society, WorldFish Center (previously ICLARM), and Network of Aquaculture Centers in Asia-Pacific (NACA) have been contacted to request links to the PD/A CRSP database from their websites. Upon the receiving the complete dataset, the PD/A CRSP database will be finalized. A disk backup of the final version PD/A CRSP database will then be created, and CDs of the database will be distributed.

PHILIPPINES PROJECT

Subcontract No. RD010E-20

Staff

Florida International University, Miami, Florida

Christopher L. Brown	US Principal Investigator
Emmanuel Vera Cruz	Graduate Assistant (Philippines)

University of Hawaii, Manoa, Hawaii

Robert Howerton	Associate Investigator
James Szyper	Associate Investigator

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Remedios B. Bolivar	Host Country Principal Investigator
Michael Aragones	Undergraduate Student (Philippines; partially CRSP funded from April 2002)
Joshue Ian B. Falla	Undergraduate Student (Philippines; partially CRSP funded through April 2002)
Jibb Maniego	Undergraduate Student (Philippines; partially CRSP funded from September 2001)
Michelle Zamora	Undergraduate Student (Philippines; partially CRSP funded from April 2002)

Work Plan Research

This subcontract was awarded funding to conduct the following Tenth Work Plan investigations:

- Cost containment options for tilapia production in Central Luzon, Republic of the Philippines/10PDVR2. The report submitted for this investigation was an abstract.
- IGF as a growth rate indicator in *Oreochromis niloticus*/ 10RCR3. The report submitted for this investigation was an abstract.

Note: In addition to the above investigations, Central Luzon State University also collaborates with University of Arizona (10NSR3E).

Publication

Falla, J.I.B., 2002. Hematological characteristics of genetically male tilapia (GMT) strain of Nile tilapia (*Oreochromis niloticus*) under intensive tank culture. B.S. thesis, Central Luzon State University, Philippines.

Presentation

Bolivar, R.B. Overview of Tilapia Production in the Philippines. Presentation given at the International Technical and Trade Symposium on Tilapia at Hainan, Haikou, China, on 17–22 April 2002.

Conferences

Aquaculture America 2002 at San Diego, California, 27–30 January 2002. (Bolivar, Sevilleja)

PD/A CRSP Annual Meeting at San Diego, California, 31 January 2002. (Bolivar, Sevilleja)

Asia Region Expert Panel meeting at Beijing, China, 23 April 2002. (Bolivar)

World Aquaculture 2002 at Beijing, China, 23–27 April 2002. (Bolivar)

National Trainers' Training on Freshwater Aquaculture Updated Technologies, BFAR-National Freshwater Fisheries Technology Center, BFAR, CLSU, Science City of Muñoz, Nueva Ecija, 21–26 May 2002. (Bolivar)

COST CONTAINMENT OPTIONS FOR TILAPIA PRODUCTION IN CENTRAL LUZON, REPUBLIC OF THE PHILIPPINES

Tenth Work Plan, Product Diversification Research 2 (10PDVR2) Abstract

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ABSTRACT

An on-farm trial was conducted to evaluate the possible additive effects of combining two feeding strategies—delayed onset of feeding and feeding at sub-satiation levels—in the culture of tilapia in ponds. The present study was based on results of the aforementioned feeding strategies (experiments 9FFR4 and 9FFR3, respectively), which independently showed that feed reduction was possible in tilapia grow-out production.

Ten farmers were enlisted for the on-farm trial. The first stage of feed reduction was through onset of supplemental feeding 75 days after stocking fingerlings in the ponds. The second stage was feeding the fish at 100 or 67% satiation. Satiation level was experimentally determined once a week in each farm by the project staff. The fish were given pre-pared feeds consisting of 67% rice bran and 33% fish meal (crude protein = 28.6%). Supplemental feeding was started 75 days after stocking fingerlings in the ponds. After 150 days of culture, the fish were harvested and the growth performance was compared between the two treatments.

Mean final weights of fish were 104 and 91 g for the 100 and 67% satiation feeding, respectively, but this difference was not statistically significant ($P > 0.05$). The general poor growth of the fish can be attributed to the low temperatures recorded during the on-farm trial. A simple cost-benefit analysis showed a negative net return in the 100% satiation treatment.

IGF AS A GROWTH RATE INDICATOR IN *OREOCHROMIS NILOTICUS*

Tenth Work Plan, Reproduction Control Research 3 (10RCR3)
Abstract

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ABSTRACT

Emmanuel Vera Cruz, a member of the Central Luzon State University faculty, arrived with his family at the Florida International University in mid-August 2002 and is officially enrolled in the doctoral program in the Department of Biological Sciences. His doctoral research began immediately, and his studies will be based on the use of the insulin-like growth factor 1 (IGF-1) gene to develop molecular probes and to use them in the study of growth regulation in Nile tilapia (*Oreochromis niloticus*). This work begins as soon as new student orientation is concluded, and it will address all of the objectives in the Tenth Work Plan.

The IGF-1 gene of Nile tilapia has been cloned. Cloning has taken two attempts, both carried out at North Carolina State University in the laboratory of Russell Borski, a project collaborator. This process used primers developed to recognize short DNA sequences characteristic of the IGF-1 gene and possible fragments (isolated by electrophoresis) that appear to conform to the known properties of comparable genes already isolated from other species. The putative clone was then subjected to nucleic acid sequence analysis and compared with published sequences of known IGF-1s that are available online. Our first attempt was a non-confirming sequence—the sequence homology with IGF-1 was not sufficient to confirm the results of the isolation of the desired gene, and in fact it confirmed that the process had resulted in the isolation of an altogether unrelated sequence due to a recognition error by the primer. The second attempt was successful, and we now have a viable clone of the *O. niloticus* IGF-1 gene available for all of the proposed studies on the detection and expression of this gene. We believe we are on track for a successful project and doctoral program on the part of Vera Cruz.

RESEARCH SUPPORT

INFORMATION MANAGEMENT AND NETWORKING

MOU No. RD009K

Staff

Oregon State University, Corvallis, Oregon

Danielle Clair	Director of Information Management (0.5 FTE)
Kris McElwee	Assistant Information Manager; System Administrator (through April)
Madeleine von Laue	Research Assistant (May–July)
Stephen Sempier	Graduate Assistant (to July 2002)
Ian Courter	Graduate Assistant (from July 2002)
Jeff Burright	Undergraduate Student Worker
Kristen Lewis	Undergraduate Student Worker
Mary Olson	Undergraduate Student Worker

ANNUAL ACTIVITIES OF THE INFORMATION MANAGEMENT AND NETWORKING COMPONENT

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BACKGROUND

The mission of the Information Management and Networking Component (IMNC) is to increase awareness and visibility of the PD/A CRSP by publishing and providing accessible technical and programmatic information, to monitor and report CRSP impacts, and to foster networking among persons involved in aquaculture.

IMNC works closely with the Program Management Office (PMO) to disseminate technical and programmatic information in accordance with grant reporting requirements and to collect and analyze program impact information. Component objectives are to:

- Identify target audiences for publications;
- Disseminate technical and programmatic information generated by the CRSP by providing appropriate materials and avenues;
- Track outputs of CRSP investigations; and
- Promote networking of CRSP participants with aquaculturists around the world.

In the reporting period IMNC activities have encompassed publication production and distribution, Internet activities, impact monitoring, and program networking.

CRSP PUBLICATIONS

Data and Resource Management

An ongoing IMNC activity is managing the program's mailing database. The database currently numbers more than 1,200 entries from almost one hundred countries. IMNC staff also maintain a detailed inventory of PD/A CRSP publications and track publication circulation.

Production

IMNC has produced and distributed a variety of publications and informational materials during the reporting period, listed below.

Nineteenth Annual Administrative Report
Clair, D., J. Burright, K. McElwee, M. Olson, S. Sempier, and H. Egna (Editors), 2002. PD/A CRSP, Oregon State University, Corvallis, Oregon, 116 pp.

Nineteenth Annual Technical Report
K. McElwee, K. Lewis, M. Olson, and P. Buitrago (Editors), 2002. PD/A CRSP, Oregon State University, Corvallis, Oregon, 206 pp.

Tenth Work Plan
Printed December 2001, 148 pp.

Second Addendum to the Ninth Work Plan
Printed Summer 2002, 15 pp.

Aquaculture Pond Bottom Soil Quality Management
Boyd, C.E., C.W. Wood, and T. Thunjai, 2002, Oregon State University, Corvallis, Oregon, 41 pp.

Pond Fertilization Algal Bioassay Test Kit Manual
Produced Summer 2002, 8pp.

Aquanews, quarterly newsletter (distributed by hard copy and available on the CRSP website): Vol. 15, No. 4 and Vol. 16, Nos. 1–3.

EdOp Net, monthly newsletter of aquaculture-related education and employment opportunities (distributed by hard copy and electronic mail and available on the CRSP website): Vol. 7, Nos. 8–12; Vol. 8, Nos. 1– 7.

CRSP Research Reports, an in-house publication series that includes Notices of Publication:

01-172 Lin, C.K., M.K. Shrestha, and Y. Yi. Management to minimize the environmental impacts of pond

effluent: Harvest draining techniques and effluent quality. (10/01)
01-173 Lin, C.K. and Y. Yi. Developments in integrated aquaculture in Southeast Asia. (10/01)
01-174 Phelps, R.P. Sex reversal: The directed control of gonadal development in tilapia. (10/01)
01-175 Meyer, D.E. Nutrition and feeding of tilapia. (10/01)
02-176 Fitzsimmons, K. Tilapia markets in the Americas, 2001 and beyond. (01/02)
02-177 Omar Fúnez, N., I. Neira, and C. Engle. Supermarket outlets for tilapia in Honduras: An overview of survey results. (01/02)
02-178 Neira, I. and C. Engle. Markets for tilapia (*Oreochromis* sp.) in Nicaragua: A descriptive analysis of restaurants, supermarkets and stands in open markets. (01/02)
02-179 Meyer, D.E. Technology for successful small-scale tilapia culture. (01/02)
02-180 Martinez Ayala, J.A., J.J. Molnar, F. Arias, and T. J. Popma. Production and marketing strategies used by small and medium-scale tilapia farms. (01/02)
02-181 Tollner, E.W. Levee pond design model. (01/02)
02-182 Popma, T.J., and D.E. Meyer. Training and technical assistance in warm-water fish culture. (01/02)
02-183 Verma, B.P., D.E. Meyer, T.J. Popma, J.J. Molnar, and E. W. Tollner. Web-based information delivery system for tilapia for sustainable development of aquaculture in Honduras. (01/02)
02-184 Corrales, H.L., C.A. Lara, J.E. Heerin, J.M. Wigglesworth, and B.W. Green. A sustainable shrimp aquaculture system from Honduras. (04/02)

The following publications were submitted electronically to and are available to download as PDF files from the USAID Development Experience Clearinghouse:

- *Tenth Work Plan*
- *Nineteenth Annual Administrative Report*
- *Nineteenth Annual Technical Report*

WORLD WIDE WEB

Online Publications

The Publications page of the PD/A CRSP website is an important source of programmatic and research material. Documents are placed on the site in one of two formats: PDF and HTML. Documents containing many complex graphics and a detailed layout are generally placed on the site in PDF format. These documents can be read with Adobe Acrobat Reader. Documents added in this format to the Publications page in the last year include:

- *Aquanews*—PD/A CRSP quarterly newsletter (4 issues)
- *Nineteenth Annual Technical Report*
- *Nineteenth Annual Administrative Report*
- *Tenth Work Plan*
- *Aquaculture Pond Bottom Soil Quality Management*
- Information on reporting requirements, travel regulations and forms, and a link to the PD/A CRSP Policy and Operating Guidelines

Documents that can be divided into relatively short sections are placed on the web in HTML format. Publications added in the last year in this format include:

- *Aquanews*—PD/A CRSP quarterly newsletter (4 issues)
- *Nineteenth Annual Technical Report*
- *Nineteenth Annual Administrative Report*

Tables of contents of most publications are placed on the web in HTML format to allow rapid browsing of publication contents.

Employment and Educational Opportunities Online

EdOp Net is a popular source of aquaculture-related employment and education opportunities made available from the PD/A CRSP website, via monthly email, and in a mailed, printed format. *EdOp Net* is delivered from the CRSP website via a searchable relational database and its web-enabling plug-in. In the reporting period, almost 200 new subscribers were added to the electronic mail membership of *EdOp Net*. On a monthly basis *EdOp Net* is specifically distributed to about 800 individuals in electronic and paper formats; additionally, the website receives thousands of visitors on an annual basis.

IMPACT MONITORING

The CRSP uses impact indicators to monitor the effects of its research on stakeholders, beneficiaries, extension services, the research community, and the field of aquaculture. The IMNC is responsible for annually soliciting and collecting researchers' quantifications of their impacts.

In addition to these formal impact indicators, IMNC staff collect project-specific impact information designed to capture CRSP participants' activities that were sponsored by the CRSP or came about as a result of CRSP work. These forms are requested on a quarterly basis and allow the IMNC to monitor, track, and report progress in the areas of outreach, public service, and professional development. The types of information collected include:

- Research progress
- Institution building (contacts with host country scientists, government officials, extension agents, farmer organizations, farmers, nongovernmental organizations)
- New host country involvement
- Physical support for host country institutions (e.g., pond renovation)
- Linkage development (technical or professional communications with USAID missions, host country institutions, nongovernmental organizations, and regional institutions)
- Conferences attended
- Students advised
- Lectures, seminars, presentations, and workshops given
- Outreach activities undertaken
- Electronic linkages made
- Publications, including technical papers and book chapters, authored
- Theses published
- Awards or commissions received
- Informational material developed

TRAINING INFORMATION

IMNC collects information related to student activities supported by CRSP researchers. Support typically includes providing graduate research assistantships, hiring undergraduate student workers, providing research materials, and advising student workers' research papers. During this reporting period, CRSP-sponsored students completed 22 formal degree programs (one doctorate, six masters, and fifteen bachelors). Students working with CRSP researchers completed the following theses:

Carpenter, R.H., 2002. Sex Determination and Inheritance of Sex Ratio in Families of *Oreochromis niloticus*. M.S. thesis, Auburn University, Alabama.

Chan Rodriguez, R., 2002. Preferential temperature and oxygen consumption of the native cichlid, *Petenia splendida*. B.S. thesis, División de Ciencas Biológicas, Universidad Juárez Autónoma de Tabasco, Mexico.

Falla, J.I.B., 2002. Hematological characteristics of genetically male tilapia (GMT) strain of Nile tilapia (*Oreochromis niloticus*) under intensive tank culture. B.S. thesis, Central Luzon State University, Philippines.

Frias Lopez, M., 2002. Masculinization of Nile tilapia using aromatase inhibitors. B.S. thesis, División de Ciencas Biológicas, Universidad Juárez Autónoma de Tabasco, Mexico.

Gonzalez Marquez, T.R., 2001. Masculinization of Nile tilapia fry obtained from multiple spawnings using short-term immersions. B.S. thesis, División de Ciencas Biológicas, Universidad Juárez Autónoma de Tabasco, Mexico.

Mac'Were, E., 2002. Comparison of tilapia and *Clarias* polyculture yields and economic benefits resulting from a locally available animal feed (pig finisher pellet), agricultural by-product (rice bran), and a pelleted test diet in fertilized ponds. M.S. thesis, Moi University, Eldoret, Kenya.

Morales Lara, G., 2001. Ictiofauna Asociada a las Escolleras del Puerto Marítime de Dos Bocas Paraíso, Tabasco, México. B.S. thesis, División de Ciencas Biológicas, Universidad Juárez Autónoma de Tabasco, Mexico.

Nadtirom, P., 2001. Comparison of growth performance of different sex genotypes (XX and XY) of Nile tilapia (*Oreochromis niloticus*) and the effect of androgen treatment. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

Neira, I., 2002. Analyses of the Potential Market for Farm-raised Tilapia in Nicaragua. M.S. thesis, University of Arkansas, Pine Bluff.

Olendi, R., 2001. Effects of suspended silt on primary production and fish growth. M.S. thesis, Moi University, Eldoret, Kenya.

Omolo, B.O., 2001. Feed Conversion Efficiency in Channel Catfish (*Ictalurus punctatus*) as a Function of Size. M.S. thesis, Auburn University, Alabama.

Ramos Montero, A., 2002. Effects of density on the growth performance of tropical gar juveniles kept in hapas. B.S. thesis, División de Ciencas Biológicas, Universidad Juárez Autónoma de Tabasco, Mexico.

Rowan, M., 2001. Chemical phosphorus removal from aquaculture pond water and effluent. Ph.D. dissertation, Auburn University, Alabama.

Weerasooriya, A.C., 2001. Effects of AquaMats on Nile tilapia (*Oreochromis niloticus*) fry in earthen ponds. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

Besides the above formal training, CRSP researchers provided non-degree training to 410 individuals in the reporting period.

PROGRAM NETWORKING

IMNC headed up and participated in numerous program outreach efforts throughout the reporting period. Specifically:

- The PD/A CRSP, via IMNC, participated in OSUs September 2001 University Days event. This annual event attracts faculty, staff, and interested students; the CRSP booth received over one hundred visitors.
- IMNC and the PD/A CRSP co-sponsored World Aquaculture 2002, which took place 23–27 April 2002. The conference featured the annual meeting of the World Aquaculture Society and the China Society of Fisheries. More than 3,000 people attended.
- IMNC participated in the April 2002 Earth Days event at OSU. The IMNCs booth included a large poster display of the program's goals and design, and several CRSP publications were assembled as well for those curious to learn more about the program.
- IMNC and the PD/A CRSP were co-sponsors of Global Livestock CRSPs international conference entitled, "Animal Source Foods and Nutrition in Developing Countries," which took place 24–26 June 2002 in Washington, DC.
- A connection was made with representatives of the Science and Math Investigative Learning Experiences Program (SMILE). This organization focuses on education of children. IMNC staff was asked to present a class about aquaculture.

IMNC also receives frequent requests for information from around the world, typically via email. In the last year, contacts were made and information exchanges took place with individuals from Guatemala, Ghana, Vietnam, England, India, Brazil, Colombia, Iran, Jamaica, Japan, Mexico, Italy, Panama, Ecuador, Thailand, Namibia, Bangladesh, Philippines, Nicaragua, Morocco, Eritrea, Nigeria, and Chile.

APPENDIX 1. PD/A CRSP HISTORY

The PD/A CRSP was initiated formally on 1 September 1982 as a Title XII program under the International Development and Food Assistance Act of 1975. The Consortium for International Fisheries and Aquaculture Development (CIFAD), Auburn University (AU), and the University of California, Davis (UCD) were chosen to participate in a tripartite management of the PD/A CRSP, and CIFAD was designated as the lead group in the management of the program, with Oregon State University (OSU) serving as lead institution. CIFAD, no longer a functional entity, consisted of the University of Arkansas at Pine Bluff (UAPB), the University of Hawaii (UH), the University of Michigan (UM), Michigan State University (MSU), and OSU. All of the CIFAD institutions are current participants. The current advisory structure allows greater equity among participating institutions and provides an effective mechanism for new institutions to be represented on the Board of Directors. Oregon State University is the Management Entity for the PD/A CRSP. Under the CRSPs current grant, the program is authorized through 31 July 2003.

HISTORICAL OVERVIEW OF PROGRAM OBJECTIVES

Following passage of Title XII legislation, USAID began to organize efforts for fisheries and aquaculture activities. In 1977 a research planning workshop was held (under an award to Resources Development Associates) and, because of the size of the sector, it was decided to go forward with separate CRSPs in fisheries and aquaculture. In 1980 the first grant to OSU for an aquaculture CRSP ("Specific Support Grant to OSU as Management Entity for an Aquaculture CRSP") was approved by the Joint Committee on Agricultural Research and Development (JCARD). The approach for designing the PD/A CRSP included a review and synthesis of the state-of-the-art of pond aquaculture, overseas site visits to determine research needs in host countries, and negotiation of provisional administrative agreements with collaborating institutions. Findings from the literature and field surveys were translated into planning guidelines. The most important needs identified for improving the efficiency of pond culture systems were 1) the need for technological advances to improve the reliability of pond production and 2) the need for economic optimization based on local conditions. The common link was to improve the understanding of pond dynamics.

The 1980 Specific Support Grant identified four systems which were considered to have the greatest potential for contributing to the supply of low-cost animal protein. These systems, listed in priority sequence according to the proportion of rural poor they would expect to serve, are:

- small, low-intensity tropical pond systems characterized by limited external inputs of feed or fertilizers;
- cooler-water (15 to 25°C) tropical ponds at medium to high elevations;
- brackishwater and hypersaline ponds, including those in tropical mangrove zones; and
- higher-intensity tropical pond systems, characterized by high external inputs of feed and fertilizers.

The main research objectives for the first five years of the PD/A CRSP (1982–1987 PD/A CRSP Grant) were:

- to compile a quantitative baseline of chemical, physical, and biological parameters for each work location, and to correlate responses of these parameters to various levels of organic and inorganic fertilizer applications to pond culture systems (referred to as the "Global Experiment");
- to compile a baseline of information on hydrology, locally available nutrient inputs, geography, and water quality in each participating country, utilizing available host country resources;
- to observe and document technical constraints limiting fry availability in each participating host country, and to test alternative fry production methods where appropriate; and
- to develop models describing the principles of pond culture systems.

These objectives were modified in 1986 because of technical, geopolitical, and financial considerations. A data analysis and synthesis component was added in 1987 with the following objectives:

- to statistically analyze data from the field experiments to describe global and site-specific variations in pond culture systems;
- to synthesize data from the Global Experiment and develop descriptive models of the physical, chemical, and biological processes that regulate the productivity of pond culture systems;
- to develop conceptual frameworks for one or more pond management models and develop operating instructions consistent with each conceptual framework; and
- to compile a manual of operating instructions describing pond management procedures for optimizing yields, increasing the reliability, and improving the efficiency of pond culture systems.

The 1987–1990 Continuation Plan addressed the most important objectives of the original plan, with the goal of synthesizing the results of the first three work plans as a staged progression into a conceptual model of pond aquaculture systems. This model was used to identify research needs, which were prioritized and translated into objectives for field research projects specific for each host country.

The programmatic and operational objectives in the 1990–1995 Continuation Plan were:

- to continue to develop technology, through research, to overcome major problems and constraints affecting the efficiency of pond aquaculture in developing countries;
- to maintain or improve environmental quality through proper management of aquacultural systems;

- to stimulate and facilitate the processing and flow of new technologies and related information to researchers, to extension workers, and ultimately, to fish farmers in developing countries;
- to promote activities that encourage faculty and researchers to build and maintain linkages;
- to create opportunities for greater multidisciplinary research in aquaculture and to enhance the socioeconomic and ecological aspects of the PD/A CRSP;
- to encourage informational and data exchange among international agricultural research centers, universities, the non-government research community, and United States Agency for International Development centrally funded and mission-funded projects;
- to expand results derived from the site-specific research to regional recommendations through a global analysis of the data; and
- to use an ecosystem approach to arrange the research agenda and integrate technologies.

While many program objectives have been met over the more than two decade of PD/A CRSP research, the original program goal, that advances in pond aquaculture are based on greater understanding of pond dynamics, continues to be relevant. It serves as an effective organizing principle for new research that aims at resolving constraints faced by aquaculturists in the US and host countries.

CRSP MEMORANDA OF UNDERSTANDING, 1996 TO 2002

Since the initiation of the current grant, the Continuation Plan 1996, new lead projects have been established in Mexico, Peru, Kenya, and the Philippines and institutional relationships were restructured for the Honduras Project.

In 1996 Southern Illinois University at Carbondale (SIUC) was awarded funding as the lead US institution for research in Peru. By 1997, MOUs were in place between SIUC and the Instituto de Investigaciones de la Amazonia Peruana and the Universidad Nacional de la Amazonia Peruana, Peru.

In Kenya, CRSP research was underway in 1997, under a new MOU between OSU and the Kenya Department of Fisheries, Ministry of Wildlife and Tourism (the Department moved in 1998 to the Ministry of Natural Resources and again in 2000 to the Ministry of Agriculture and Rural Development). Under the Eighth and Ninth Work Plans, OSU was the lead US institution for the Kenya Project, sharing responsibility with AU for a joint research work plan. Moi University also now has formal Memoranda of Understanding in place with OSU and with AU.

Under previous grants, the Philippines served as a companion site to the lead Southeast Asia site at the Asian Institute of Technology in Thailand; however, the Continuation Plan 1996 identified the Philippines as a potential lead site. In 1997, the Management Entity issued a restricted Request for Proposals (RFP) for lead US and host country institutions for a new Philippines Project. Upon completion of internal and external peer reviews and evaluations of proposals, UH was awarded funding to serve as lead institution of the Philippines Project. A new subcontract with UH was established in July 1998; the host country collaborating institution is Central Luzon State University (CLSU). In 2000, the US Regional Coordinator moved to Florida International University (FIU). A new subcontract with FIU was established in June 2000, and a new MOU between FIU and CLSU has also since been formalized.

In early 1999 the extant Honduras Project, led by AU, declined an award offer for Ninth Work Plan research and dissolved its MOU with the Secretaría de Agricultura y Ganadería in Honduras in April 1999. To identify new lead US and host country institutions for a new Honduras Project, the ME issued a restricted RFP. The University of Georgia (UG) was selected as the new Honduras lead US institution with Escuela Agrícola Panamericana El Zamorano as the host country institution and AU as a collaborating US institution. Under subcontracts with OSU, UG and AU commenced work on the Honduras Project in May 1999. A new MOU with South Africa was also put in place during the Tenth Work Plan.

At the close of the present reporting period, Memoranda of understanding are in place among the following CRSP partner institutions:

- Auburn University and Moi University, Kenya
- Auburn University and Stellenbosch University, South Africa
- Florida International University and the Freshwater Aquaculture Center, Central Luzon State University, the Philippines
- Oregon State University and ICLARM-Malawi
- Oregon State University and Moi University, Kenya
- Oregon State University and the Department of Fisheries, Ministry of Agriculture and Rural Development, Kenya
- Oregon State University and the Universidad Juárez Autónoma de Tabasco, Mexico
- Southern Illinois University at Carbondale and the Instituto de Investigaciones de la Amazonia Peruana and the Universidad Nacional de la Amazonia Peruana, Peru
- The University of Michigan and the Asian Institute of Technology, Thailand
- University of Georgia and Escuela Agrícola Panamericana, Zamorano, Honduras
  The University of Hawaii at Manoa and the Freshwater Aquaculture Center, Central Luzon State Univerity, the Philippines

The PD/A CRSP also has formal agreements with the following organizations:

- West Africa InterCRSP
- CRSP Council
- Global Livestock CRSP

Many other informal agreements exist with nongovernmental organizations, private voluntary organizations, private industry, government agencies, universities, and other groups and organizations. A small sample of these linkages appears in Appendix 5.

Appendix 2. Program Participants

The Pond Dynamics/Aquaculture CRSP represents the joint efforts of more than 75 professional and support personnel from US universities. It also represents the collaborative efforts of over 45 scientists, technicians, and students from project sites in six host countries—Mexico, Honduras, Peru, Kenya, the Philippines, and Thailand. The expertise of host country and US personnel is broad-based and encompasses the major fields of specialization included in this CRSP: limnology and water quality; fisheries and aquaculture; soil science; geography; zoology; ecology; engineering; information systems; data management, analysis, and modeling; endocrinology; genetics; environmental hazard management; sociology; agricultural economics; policy development; adult education; and research administration.

The program's US-based participants are drawn from CRSP partner institutions—Auburn University (AU), Florida International University (FIU), Michigan State University, The Ohio State University, The University of Michigan (UM), Oregon State University (OSU), Southern Illinois University at Carbondale, University of Arkansas at Pine Bluff (UAPB), University of Arizona (UA), University of California, Davis, University of Georgia, University of Hawaii), University of Oklahoma (UO), and University of Texas.

Host country staff participate in the CRSP through their involvement with:

- Asian Institute of Technology, Thailand
- Bangladesh Agricultural University, Bangladesh
- Cambodia Department Of Fisheries, Cambodia
- Kasetsart University, Thailand
- Department of Fisheries, Ministry of Agriculture and Rural Development, Kenya
- Embrapa Meio Ambiente, Brazil
- Escuela Agrícola Panamericana, Honduras
- Central Luzon State University, the Philippines
- WorldFish Center (ICLARM)-Malawi
- Institute of Agriculture and Animal Science, Nepal
- Instituto de Investigaciones de la Amazonia Peruana, Peru
- Moi University, Kenya
- Regional Development Coordination for Livestock and Fisheries, Laos
- Research Institution for Aquaculture No. 1, Vietnam
- Stellenbosch University, South Africa
- Universidad Centroamericana, Nicaragua
- Universidad Juárez Autónoma de Tabasco, Mexico
- Universidad Nacional de la Amazonia Peruana, Peru
- Universidad Nacional del Comahue, Argentina
- Universidad Nacional Mayor de San Marcos, Peru
- University of Agriculture and Forestry, Vietnam
- University of Cantho, Vietnam

Researchers and research project staff are named within each research project report in the body of this report. Following are listings for staff of the Program Management Office as well as members of the program's three advisory groups—Board of Directors, External Evaluation Panel, and Technical Committee.

Program Management Office Staff

Oregon State University, Corvallis, Oregon

Hillary Egna	Director
Danielle Clair	Assistant Director of Operations (0.5 FTE)
Cormac Craven	Assistant Director of Research (to July 2001)
Steve Sempier	Assistant Director of Research (from July 2001)
Joan Westfall	Office/Financial Manager
Gwyn Newcombe	Accounting Technician (0.5 FTE)
Heidi Furtado	Student Worker/Research Assistant
Kelli Lewis	Student Worker
Katy Lloyd	Student Worker

United States Agency for International Development

Washington, DC

Harry Rea	Cognizant Technical Officer

ADVISORY BODIES

Board of Directors

Ronald Jones	Florida International University
Stephanie Sanford	Oregon State University
T.H. Lee Williams	University of Oklahoma
Anthony Young, Chair	Southern Illinois University at Carbondale

Ex-Officio Board Members

Harry Rea	USAID
Hillary Egna	Oregon State University

External Evaluation Panel

Kevan Main, Chair	Mote Marine Laboratory, Sarasota, Florida
Edna McBreen	University of Connecticut, Tarrington
Dave Cummins	University of Georgia, Athens (retired)
Christine Crawford	University of Tasmania, Hobart, Australia

Technical Committee*	**Institution**
Co-Chairs	
Kevin Fitzsimmons	UA
Jim Diana	UM

Material and Methods Subcommittee	*Research Area of Expertise*	
Freddy Arias	Zamorano	Social and economic aspects
Yang Yi	AIT	Environmental effects
Claude Boyd	AU	Production optimization

Technical Progress Subcommittee		
Amrit Bart	AIT	Environmental effects
Jim Bowman	OSU	Production optimization
Joe Molnar	AU	Social and economic aspects

Work Plan and Budget Subcommittee		
Carole Engle	UAPB	Social and economic aspects
Wilfrido Contreras-Sánchez	OSU	Environmental effects
Chris Brown	FIU	Production optimization

External At-Large Members

Damon Seawright	US tilapia producer

Ex-Officio Members

Harry Rea	USAID
Hillary Egna	OSU
Cormac Craven	OSU (to July 2001)
Steve Sempier	OSU (from July 2001)

* Membership as of 2002 Technical Committee election; see *Nineteenth Annual Administrative Report* for previous roster. Subcommittee members are listed in order of seniority.

APPENDIX 3. FINANCIAL SUMMARY

This section summarizes the expenditures of USAID, non-federal, and host country funds for CRSP research activities and program management. This unaudited information is intended to provide an overview of CRSP program budgets and matching support for the period 1 August 2001 to 31 July 2002. Official financial reports are submitted to USAID via the Management Entity's Research Accounting Office.

Cost sharing contributions from the US institutions and contributions from host countries are presented in the table on the following page. Not all sites reported host country contributions, and those that did may not have fully accounted for in-kind contributions, typically including water, electricity, fish stock, labor, and supplies.

Financial Summary, Continuation Plan 1996
August 1, 2002–July 31, 2003

Subcontract Number	Project Leader	Institution	USAID[1] 8/01-7/02	USAID[1] Since 8/96	Cost Share[2] 8/01-7/02	Cost Share[2] Since 8/96	Total US Funds	Host Country Contributions[3] 8/01-7/02	Host Country Contributions[3] Since 8/96
Research									
RD009A-01	Bowman	Kenya: OSU	131,040	839,098	11,022	76,685	915,783	40,512	122,512
RD009B-01	Bolte	Global: OSU	0	313,524	0	85,835	399,359		
	Heikes [4]	*Global: UAPB*	0	7,900	0	4,148	12,048		
RD009C-01	Schreck	Mexico: OSU	87,744	567,244	21,996	125,924	693,168	13,850	28,850
RD009L-01	Clair	Global: OSU	216,614	404,636	67,045	101,159	505,795		
RD010E-01	Engle	Global: UAPB	92,482	426,910	21,642	101,856	528,766		
RD010E-02	Shelton	Global: UO	0	117,280	0	31,194	148,474		
RD010E-03	Piedrahita	Global: UCD	0	78,101	0	26,611	104,712		
RD010E-04	Diana	Thailand: UM	287,627	1,078,798	28,869	157,118	1,235,916	21,000	125,000
RD010E-05	Ward	Honduras: UT	0	19,767	0	4,066	23,833		
RD010E-06	Green	Honduras: AU	0	502,056	0	78,435	580,491	0	140,484
RD010E-07	Boyd/Wood	Brazil/South Africa: AU	59,744	267,103	20,495	75,503	342,606		
RD010E-07	Wood	Global: AU	0	95,170	0	24,434	119,604		
RD010E-08	Lim	Kenya: AU	3,021	520,679	0	120,018	640,697		
RD010E-09/C	Phelps	Global/Kenya: AU	38,119	175,352	9,530	42,171	217,523		
RD010E-10	Molnar	Global: AU	0	68,293	0	14,489	82,782		
RD010E-11	Fitzsimmons	Mexico/Honduras/Philippines: UA	20,010	131,598	623	40,899	172,497	0	7,050
RD010E-12	Kohler	Peru: SIUC	146,848	577,047	42,612	182,068	759,115	43,218	128,607
	Dabrowski [4]	*Peru: OhSu*	0	13,000	0	11,963	24,963		
RD010E-13	Lochmann	Peru/Kenya: UAPB	31,122	110,306	8,750	33,304	143,610		
RD010E-14	Lovshin	Guatemala: AU	0	67,168	0	16,792	83,960		
RD010E-15	Brown	Philippines: UH	0	100,061	0	25,015	125,076		
RD010E-16	Verma	Honduras: UGA	100,714	321,147	11,092	65,325	386,472	11,200	18,200
RD010E-17	Molnar	Honduras: AU	53,947	163,267	13,487	40,817	204,084		
RD010E-18	Hatch	Honduras: AU	0	55,266	0	13,816	69,082		
RD010E-19	Boyd	Honduras: AU	0	45,947	0	11,487	57,434		
RD010E-20	Brown	Philippines: FIU	87,977	306,264	31,254	115,776	422,040	6,500	14,500
RD010E-A	Dabrowski	Mexico/Peru: OhSU	51,869	119,093	49,366	73,966	193,059		
RD010E-B	Batterson	Thailand: MSU	0	57,020	0	14,274	71,294		
Regional Projects	TBA	TBA	250,000	250,000	0	0	0		
Special Activities									
ISTA 5 Sponsorhip	Fitzsimmons	Global: UA	0	12,500	0	5,000	17,500	15,000	15,000
IIFET Conference Sponsorhip	Shriver	Global: OSU	0	10,000	0	2,500	12,500		
Côte d'Ivoire Report	Kaplan	Côte d'Ivoire: Hofstra University	0	4,000	0	0	4,000		
Impact Assessment Report	TBA	Global: TBA	98,676	128,676	24,669	32,199	160,875		
Research Support									
RD009G-01	Central Database Management	Global: OSU	0	279,714	0	73,083	352,797		
RD009E-01	Education Development	Global: OSU	0	244,970	0	61,242	306,212		
RD009K-01	Information Management & Networking	Global: OSU	313,501	1,925,283	79,300	482,246	2,407,529		
Subcontract Administration		Indirect on Subs up to 25,000	13,000	154,640	0	0	154,640		
Research Subtotal			2,084,055	10,558,878	441,752	2,371,418	12,680,296	151,280	600,203
MANAGEMENT									
Program Management									
Operations and Administration [5]		OSU Management	343,635	2,754,635			2,754,635		
Advisory Groups		OSU Advisory	0	459,710			459,710		
Program Management Subtotal			343,635	3,214,345			3,214,345		
Total			2,427,690	13,773,223	441,752	2,371,418	15,894,641	151,280	600,203

Notes: 1. Reflects funding received and committed under six USAID allocations; 2. Cost share figures reflect subcontract commitments; 3. Host country contributions are voluntary; 4. Subcontract off of previous subcontract; 5. Cost sharing is not required for management operations.

RESEARCH AREA: PRODUCTION OPTIMIZATION				
Research Theme	**Reporting PI**	**Report Title**	**Research Theme Code**	**Report Received**
Pond Dynamics	Boyd	Effects of Pond Age on Bottom Soil Quality	10PDR1	Abstract
	Batterson	Workshops on Using Principles of Pond Dynamics to Optimize Fertilization Efficiency	10PDR2	Abstract
	Bowman	Aquaculture Training for Kenyan Fisheries Officers and University Students	10PDR3	Abstract
Feeds and Fertilizers	Kohler	Nutrition of *Colossoma macropomum* and *Piaractus brachypomus*	10FFR1	Abstract
	Kohler	Broodstock Diets and Spawning of *Colossoma macropomum* and/or *Piaractus brachypomus*, I	10FFR2	Abstract
	Lochmann	Broodstock Diets and Spawning of *Colossoma macropomum* and/or *Piaractus brachypomus*, II	10FFR2A	Abstract
	Diana	Polyculture of Grass Carp and Nile Tilapia with Napier Grass as the Sole Nutrient Input in the Subtropical Climate of Nepal	10FFR3	Abstract
	Lim	Development of Economically Feasible Feeds for Semi-Intensive Culture of Tilapia, *Oreochromis niloticus*, Using Locally Available Agricultural By-Products	10FFR4	Abstract
Reproduction Control	Dabrowski	Studies on Fate of Methyltestosterone and Its Metabolites in Tilapia and on the Use of Phytochemicals as an Alternative Method to Produce a Monosex Population of Tilapia	10RCR1	Abstract
	Schreck	Selection of a New Nile Tilapia Genetic Line to Provide Broodstock for Southeastern Mexico	10RCR2	Abstract
	Brown	IGF as a Growth Rate Indicator in *Oreochromis niloticus*	10RCR3	Abstract
Aquaculture Systems Modeling	Diana	Development of a Trophic Box Model to Assess Potential of Ecologically Sound Management for Cove Aquaculture Systems in Tri An Reservoir, Vietnam	10ASMR1	Abstract
New Aquaculture Systems/ New Species	Kohler	Amazon Aquaculture Outreach	10NSR1	Abstract
	Kohler	Studies on Reproduction and Larval Rearing of Amazonian Fish, I	10NSR2	Abstract
	Dabrowski	Studies on Reproduction and Larval Rearing of Amazonian Fish, II	10NSR2A	Abstract
	Fitzsimmons	Survey of Tilapia-Shrimp Polyculture in Vietnam and Thailand	10NSR3A	Abstract
	Fitzsimmons	Stocking Densities for Tilapia-Shrimp Polyculture in Thailand	10NSR3B	Abstract
	Fitzsimmons	Survey of Tilapia-Shrimp Polyculture in Mexico †	10NSR3C	Abstract
	Fitzsimmons	Stocking Densities for Tilapia-Shrimp Polyculture in Mexico	10NSR3D	Abstract
	Fitzsimmons	Survey of Tilapia-Shrimp Polyculture in the Philippines	10NSR3E	Abstract
	Phelps	Evaluation of Growth and Reproductive Performance of Three Strains of Nile Tilapia *Oreochromis niloticus* Found in Kenya for Use in Aquaculture	10NSR4	Abstract
	Bowman	Techniques for the Production of *Clarias gariepinus* Fingerlings as Baitfish for the Lake Victoria Nile Perch Longline Fishery	10NSR5	Abstract

RESEARCH AREA: ENVIRONMENTAL EFFECTS

Research Theme	Reporting PI	Report Title	Research Theme Code	Report Received
Effluents and Pollution	Boyd	Reaction of Liming Materials in Pond Bottom Soils—Brazil †	10ER1A	Abstract
	Boyd	Reaction of Liming Materials in Pond Bottom Soils—South Africa †	10ER1B	Abstract
	Schreck	Elimination of Methyltestosterone (MT) from Intensive Masculinization Systems: Use of Activated Charcoal in Concrete Tanks	10ER2	Abstract
	Diana	Environmental Impacts of Cage Culture for Catfish in Hongngu, Vietnam †	10ER3	Abstract
Appropriate Technology	Bowman	On-Farm Trials: Evaluation of Alternative Aquaculture Technologies by Local Farmers in Kenya	9ATR1	Final
	Verma	Regionalizing Training and Technical Assistance for Nongovernmental Organizations	10ATR1	Abstract
	Verma	Institutionalizing Web-based Information System for Tilapia Culture in Latin America	10ATR2	Abstract
	Schreck	Diversification of Aquacultural Practices by Incorporation of Native Species and Implementation of Alternative Sex Inversion Techniques	10ATR3	Abstract
	Diana	On-Station and On-Farm Trials of Different Fertilization Regimes Used in Bangladesh	10ATR4A/B	Final/Abstract
	Batterson	Use of Clinoptilolite Zeolites for Ammonia-N Transfer and Retention in Integrated Aquaculture Systems and for Improving Pond Water Quality before Discharge	10ATR5	Abstract
GIS: Planning, Policy, and Global Data Analysis	Diana	A Study of Aquaculture Brownfields: Abandoned and Converted Shrimp Ponds in Thailand	10GISR1	Abstract
	Diana	Assessing Watershed Ponds for Aquaculture Development in Thai Nguyen, Vietnam	10GISR2	Abstract
	Clair	Identification of Constraints Facing Aquaculture in the Next Two Decades and Formulation of a Five-Year Research Agenda to Address Key Constraints Through Collaborative Research	10GISR3	Abstract

RESEARCH AREA: SOCIAL AND ECONOMIC ASPECTS

Research Theme	Reporting PI	Report Title	Research Theme Code	Report Received
Marketing & Economic Analysis	Engle	Optimal (Profit-Maximizing) Target Markets for Small- and Medium-Scale Tilapia Farmers in Honduras and Nicaragua	10MEAR1	Abstract
	Engle	Development and Evaluation of a Simple Market Feasibility Assessment Methodology	10MEAR2	Abstract
	Engle	Regional Enterprise Budget and Business Plan Development	10MEAR3	Abstract
	Engle	Economic and Risk Analysis of Tilapia Production in Kenya	10MEAR4	Abstract
Adoption/ Diffusion	Bowman	Aquaculture Training for Kenyan Fisheries Officers and University Students, I	9ADR3	Final
	Bowman	Aquaculture Training for Kenyan Fisheries Officers and University Students, II	10ADR3	Abstract
	Verma	Institutionalizing Techniques for Building Hillside and Levee Ponds for Water Supply and Aquacultural Development in Latin America	10ADR1	Abstract
Food Security	Molnar	Income, Food Security, and Poverty Reduction: Case Studies of Functioning Clusters of Successful Small-Scale Aquaculture Producers	10FSR1	Abstract
Decision Support Sys	Diana	PD/A CRSP Database: Finalization, Management, and Distribution	10DSSR1	Abstract
Product Diversification	Engle	Characteristics of Fish Buyers Likely to Purchase Farm-Raised Tilapia in Honduras and Nicaragua	10PDVR1	Abstract
	Brown	Cost Containment Options for Tilapia Production in Central Luzon, Republic of the Philippines	10PDVR2	Abstract
	Diana	Transfer of Production Technology to Nepal for Nile Tilapia, *Oreochromis niloticus*	10PDVR3	Abstract

† TITLE OF REPORT IS DIFFERENT THAN INVESTIGATION TITLE LISTED IN THE *TENTH WORK PLAN*.

APPENDIX 5. LINKAGES

Developing and maintaining links among collaborating universities and government ministries, departments of agriculture, and private sector aquaculturists around the world forms a significant ancillary contribution to the CRSPs research effort and to the goal of expanding the role of aquaculture in the developing world. The following list includes informal linkages and connections made by CRSP researchers in the field as well as those maintained by the Program Management Office.

Alabama Catfish Producers Association, Montgomery, Alabama
Alpha Aquaculture, Kenya
American Association for the Advancement of Science (AAAS), Washington, DC
American Association of State Colleges and Universities International Higher Education Linkages Project (IHELP), Washington, DC
American Fisheries Society, Bethesda, Maryland
American Tilapia Association, Arlington, Virginia
Aqua Technics, Carlsborg, Washington
Aquacorporacion, International, Honduras
Arid and Semi-Arid Lands (ASAL) Project, Government of Kenya, Laikipia, Kenya
Asian Development Bank, Tarahara, Nepal
Asociación Nacional de Acuicultores de Honduras (ANDAH), Tegucigalpa, Honduras
Association for International Agriculture and Rural Development (AIARD), Washington, DC
Australian Center for International Agricultural Research (ACIAR), Nelson Bay, Australia
Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh
Bangladesh Rural Advancement Committee (BRAC), Bangladesh
Bean/Cowpea CRSP, East Lansing, Michigan
Board for International Food and Agricultural Development (BIFAD) Washington, DC
Brackish Water Shrimp Culture Station, Ranot, Thailand
Broadening Access and Strengthening Input Market Systems (BASIS) CRSP, Madison, Wisconsin
Brunell Engineering Works, Kenya
Bunda College of Agriculture, University of Malawi, Lilongwe, Malawi
Bureau of Fisheries and Aquatic Resources (BFAR), Manila, Philippines
Can Tho University, Vietnam
Canadian International Development Agency (CIDA), Hull, Quebec, Canada
Caritas, Bangladesh and Iquitos, Peru
Central Laboratory for Aquaculture Research (CLAR), Abbassa, Egypt
Centro de Adiestamiento de la Agricultura Sostenible (CEASO), Honduras
Chiang Mai Rehabilitation Center, Thailand
Chulalongkorn University, Bangkok, Thailand
Clackamas County Extension Office, Oregon City, Oregon
Clemson University, Clemson, South Carolina
Coastal Resources Center, Narragansett, Rhode Island
Comite para la Defensa y Desarrollo de la Flora y Fauna del Golfo de Fonseca (CODDEFFAGOLF), Tegucigalpa, Honduras
Consejo Nacional de Ciencia y Technologia (CONACYT), Mexico
Commonwealth Agricultural Bureau International,
Consejo Nacional del Ambiente (CONAM), Lima, Peru
Consortium for International Earth Science Information Network (CIESIN), Washington, DC
Consultative Group on International Agricultural Research (CGIAR), Washington, DC
Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia
International Center for Research in Agroforestry (ICRAF), Nairobi, Kenya
West African Rice Development Association (WARDA), Bouaké, Côte d'Ivoire
World Fish Center (ICLARM), Penang, Malaysia
Cooperative for Relief and Assistance Everywhere (CARE), Bangladesh, Honduras, Peru, and Atlanta, Georgia
CP Group, Thailand
CSIRO Livestock Industries Chiswick Pastoral Research Laboratory, Armidale, Australia
Danish International Development Agency (DANIDA), Copenhagen, Denmark
Dar es Saalam University, Dar es Saalam, Tanzania
Department for International Development (DFID) Fish Genetics Research Programme, Swansea, Wales, United Kingdom
Department of Agriculture, Yunnan Province, China
Department of Aquaculture, Nepal
Department of Fisheries, Phnom Penh, Cambodia
Department of Fisheries, Udorn Thani, Thailand
Department of Livestock and Fisheries, Savannakhet, Laos
Derby Holding Company, Kenya
Development for the Municipality of Centro, Tabasco, Mexico
Egerton University, Njoro, Kenya
Ejido Rio Playa, Comalcalco, Tabasco, Mexico
El Carao Fish Culture Station, Comayagua, Honduras
Empresa Brasileira de Pesquisa Agropecuária (Embrapa) Environmental Laboratory, Campinas, Brazil
Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina (Epagri), Brazil
Empresa Nacional de Energia Electrica, Tegucigalpa, Honduras
Escuela de Agricultura de la Region Tropical Humeda (EARTH), San José, Costa Rica
Escuela Superior Politécnica del Litoral (ESPOL)/Centro Nacional de Acuicultura e Investigaciones Marinas (CENAIM), Guayaquil, Ecuador

European Foundation for the Improvement of Living and Working Conditions, Dublin, Ireland
Farm-Level Applied Research Methods for East and Southern Africa (FARMESA), Swedish International Development Cooperation Agency (SIDA), Stockholm, Sweden
Fe y Alegria, Lima, Peru
Federación de Agroexportadores de Honduras (FPX), San Pedro Sula, Honduras
Fideicomisos Institutos en Relación con la Agricultura (FIRA), Morelia, Michoacán, Mexico
Fisheries Society of Africa (FISA), Nairobi, Kenya
Fondo Nacional de Desarrollo Pesquero (FONDEPES), Lima, Peru
Food and Agriculture Organization of the United Nations (FAO), Rome, Italy
Aquaculture for Local Community Development Programme (ALCOM), Harare, Zimbabwe
European Inland Fisheries Advisory Commission (EIFAC), Rome, Italy
Inland Water Resources and Aquaculture Service (FIRI), Rome, Italy
Forum for Organic Resource Management (FORMAT), Nairobi, Kenya
General Directorate of Fisheries and Aquaculture (DIGEPESCA), Tegucigalpa and San Pedro Sula, Honduras
Genetically Improved Farmed Tilapia Program (GIFT), Muñoz, Nueva Ecija, Philippines
German Development Service, Kenya
Global Aquaculture Alliance, St. Louis, Missouri
Global Livestock CRSP, Davis, California
Global Village, Honduras
Henry Spira/GRACE Project on Industrial Production, School of Hygiene and Public Health, Johns Hopkins University
Hofstra University, Hempstead, New York
Institut Pertanian Bogor (IPB), Bogor, Indonesia
Institute for the Regional Ecodevelopment of the Amazon, Ecuador
Institute of Agricultural and Food Information, Prague, Czech Republic
Institute of Agriculture and Animal Science (IAAS), Tribhuvan University, Rampur Campus, Chitwan, Nepal
Instituto del Mar del Perú (IMARPE), Callao, Peru
Instituto Politécnico Nacional, Mexico City, Mexico
Integrated Pest Management CRSP, Blacksburg, Virginia
International Development Research Centre (IDRC), Ottawa, Canada
International Service for National Agricultural Research (ISNAR), Honduras
International Sorghum and Millet (INTSORMIL) CRSP, Lincoln, Nebraska
Japan International Cooperation Agency (JICA), Japan
Katholieke Universiteit Leuven (KUL), Belgium
Kenya Fisheries Department, Kenya
Kenya Marine and Fisheries Research Institute
Kenya Medical Research Institute (KEMRI), Nairobi, Kenya
Kenyatta University, Nairobi, Kenya
Lake Basin Development Authority, Kenya
Lake Victoria Environmental Management Programme, Kenya
Land Tenure Center, Madison, Wisconsin
Louisiana State University, Baton Rouge, Louisiana
Magarini Aquafarmers, Malindi, Kenya
Malawi National Aquaculture Center, Malawi
Marine Farms ASA, Norway
Mekong River Commission, Phnom Penh, Cambodia
Mesta de Bombon Maca Producers Association, Peru
Microcredit Summit Campaign, Washington, DC
Ministry of Agricultural Development, Panama
Ministry of Agriculture, Animal Husbandry, and Fisheries, Entebbe, Uganda
Ministry of Environment and Natural Resources, Tegucigalpa, Honduras
Ministry of Fisheries, Iquitos, Peru
Ministry of Tourism, Natural Resources, and Environment, Fisheries Division, Dar es Salaam, Tanzania
Mount Kenya Fish Farmers Association, Central Province, Kenya
National Agricultural Library, Washington, DC
National Agricultural Research Council, Nepal
National Agriculture University (NAU), La Molina, Peru
National Aquaculture Centre, Zomba, Malawi
National Council for Science and Technology, Mexico
National Inland Fisheries Institute (NIFI), Bangkok, Thailand
National Museums of Kenya, Nairobi, Kenya
National Research Initiative, Thailand
National Shrimp Culture Advisory Group, Tegucigalpa, Honduras
National Technical Information Services (NTIS), Springfield, Virginia
Nepal Agricultural Research Council, Lalitpur, Nepal
Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok, Thailand
Noorul Islam College of Engineering, Tamil Nadu, India
North Central Regional Aquaculture Center (NCRAC), East Lansing, Michigan
Nuestros Pequeños Hermanos (NPH), Honduras
Oceanic Institute, Waimanalo, Hawaii
Oceanol, Centro, Tabasco, Mexico
Ohio State University Research Foundation (OSURF), Columbus, Ohio
Oregon Sea Grant, Corvallis, Oregon
Organization of African Unity, Addis Ababa, Ethiopia
Inter-African Committee on Oceanography, Sea and Inland Fisheries
Patani Fisheries College, Patani, Thailand
Peace Corps, Ecuador
Peanut CRSP, Griffin, Georgia
Population and Fish Genetics Group
Programa Cooperativo de Investigacion y Transferencia de Tecnologia Agropecuaria para los Tropicos (PROCITROPICS), Peru
Programa Regional de Apoyo al Desarrollo de la Pesca en el Istmo Centroamericano (PRADEPESCA), Panama
Project Globale, Honduras
Project Rural Reconstruction, Santa Barbara, Honduras
PROMIPAC, Nicaragua and El Salvador
PROSEAL, Iquitos, Peru
PROSHIKA, Dhaka, Bangladesh
Red de Desarrollo Sostenible Honduras (RDS-HN), Honduras
Research Institute for Aquaculture No. 1, Dinh Bang, Tu Son,

Bac Ninh, Vietnam
Roche Aquaculture Research Centre Asia Pacific, Bangkok, Thailand
Royal Institute of Technology, Stockholm, Sweden
Rural Reconstruction Program (PRR), Santa Barbara, Honduras
Sagana Women's Group, Sagana, Kenya
Santo Tomás, Mexico
Sarasawathi Foundation, Thailand
Science and Math Investigative Learning Experiences Program (SMILE), Oregon State University
Secretaria de Agricultura e Abastecimento do Estado de Sao Paolo, Brazil
Sichuan Provincial Fisheries Association, Ziyang, Sichuan Province, People's Republic of China
Sisaket College of Agriculture and Technology, Thailand
Socio-Economic Development Centre (SEDEC), Binh Thuan Province, Vietnam
Soil Management CRSP, Honolulu, Hawaii
Southeast Asian Fisheries Development Center (SEAFDEC), Iloilo, Philippines
Southeast Asian Outreach (SAO) Cambodia Aquaculture at Low Expenditure (SCALE) Project, Cambodia
Southern African Development Community (SADC), Harare, Zimbabwe
Special Program for African Agricultural Research (SPAAR), Washington, DC
Sustainable Agricultural Centre for Research and Development in Africa (SACRED-Africa), Bungoma, Kenya
Sustainable Agriculture and Natural Resources Management (SANREM) CRSP, Watkinsville, Georgia
Taiwanese Mission, Honduras
Technical Integration Asia Network, Yangon, Myanmar
Terra Nuova, Lima, Peru
Texas A&M University, College Station, Texas
Texas Tech University, Lubbock, Texas
Thai Lux, Thailand
Training and Occupation for Disabled Association, Poi Pet, Cambodia
Uganda Wetlands and Resource Conservation Association (UWRCA), Uganda
United Aqua Farms, Bangladesh
United States Department of Agriculture (USDA), Washington, DC
Foreign Agricultural Service, Research and Scientific Exchange Division
United States Fish and Wildlife Service (USFWS), Washington, DC
United States Food and Drug Administration (FDA), Washington, DC
Universidad Autónoma Metropolitana, Mexico City, Mexico
Universidad Nacional Agraria La Molina, Lima, Peru
Universidad Nacional Federico Villareal, Lima, Peru
Universidad Nacional Mayor de San Marcos, Lima, Peru
Universidad Técnica de Machala, Machala, Ecuador
Universidad de Santiago de Compostela, Santiago, Spain
Universidade de São Paulo, Brazil
Universidade Federal de Minas Gerais, Belo Horizonte, Minas Gerais, Brazil
Universität Hohenheim, Stuttgart, Germany
Université Nationale du Rwanda, Butare, Rwanda
University of Agriculture and Forestry, Ho Chi Minh City, Vietnam
University of Cantho, Vietnam
University of Fisheries, Nhatrang, Vietnam
University of Stirling, United Kingdom
University of the North, Pietersburg, South Africa
University of the Philippines in the Visayas, Iloilo, Philippines
University of Wales, Swansea, UK
University of Washington, Seattle, Washington
University of Wisconsin-Madison, Madison, Wisconsin
Virginia Polytechnic Institute, Blacksburg, Virginia
Wageningen University, The Netherlands
Western Regional Aquaculture Consortium (WRAC), Seattle, Washington
Winrock International, Lima, Peru
World Aquaculture Society (WAS), Baton Rouge, Louisiana
World Bank, Washington, DC
World Conservation Union (IUCN), Nairobi, Kenya
World Neighbors, Honduras
World Wildlife Fund, Washington, DC

Appendix 6. Publications

Regional Research

Central America

Honduras

Asian Institute of Technology

Publication

Munsiri, P. and B.F. Hajek, 1996. Texture and chemical composition of soils from shrimp ponds near Choluteca, Honduras. Aquaculture International, 4:154–168.

Auburn University

Thesis

Green, B., 1992. Water and chemistry budgets for organically fertilized fish ponds in the dry tropics. Ph.D. dissertation, Auburn University, Alabama.

Publications and Reports

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

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

Alvarenga, H.R. and B.W. Green, 1989. Production and economic aspects of tilapia culture in ponds fertilized with chicken litter. Rev. Latinoamericana de Acuicultura, 40:35–39. (in Spanish)

Alvarenga, H.R., B.W. Green, and M.I. Rodriguez, 1984. A system for producing hybrid tilapia (*Tilapia nilotica* × *Tilapia honorum*) fingerlings at the El Carao Aquaculture Experiment Station, Comayagua, Honduras. CRSP Technical Report (unpubl.), 9 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 (unpubl.), 2pp≠. (in Spanish)

Alvarenga, H.R., B.W. Green, and M.I. Rodriguez, 1987. Production of hybrid tilapia (*Tilapia nilotica* × *Tilapia honorum*) in ponds using corn gluten as a supplemental feed. CRSP Technical Report (unpubl.), 13 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, 55:210–213.

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

Boyd, C.E. and B. Green, 1998. Dry matter, ash, and elemental composition of pond-cultured tilapia (*Oreochromis aureus* and *O. niloticus*). Journal of the World Aquaculture Society, 29:125–128.

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

Boyd, C.E. and D.R. Teichert-Coddington, 1994. Pond bottom soil respiration during fallow and culture periods in heavily-fertilized tropical fish ponds. Journal of the World Aquaculture Society, 25(3):210–213.

Boyd, C.E. and D.R. Teichert-Coddington, 1995. Dry matter, ash, and elemental composition of pond-cultured *Penaeus vannamei* and *P. stylirostris*. Journal of the World Aquaculture Society, 26(1):88–92.

Boyd, C.E. and M.C. Haws, 1999. Good management practices (GMPs) to reduce environmental impacts and improve efficiency of shrimp aquaculture in Latin America. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 9–33.

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

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

Green, B.W., 1995. Polyculture of tilapia with marine shrimp. Actas del Primer Simposio Centroamericano sobre cultivo de tilapia, pp. 117–125.

Green, B.W., 1997. Inclusion of tilapia as a diversification strategy for penaeid shrimp culture. In: D.E. Alston, B.W. Green, and H.C. Clifford (Editors), IV Symposium on Aquaculture in Central America: Focusing on Shrimp and Tilapia, 22–24 Apr 1997, at Tegucigalpa, Honduras. Asociación Nacional de Acuicultores de Honduras and the Latin American Chapter of the World Aquaculture Society, pp. 84–93.

Green, B.W., 1999. Sistemas de producción de tilapia en Honduras (Tilapia production systems in Honduras). In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture, 18–20 Aug 1999 at San Pedro Sula, Honduras, pp. 254–257. (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 (unpubl.), 10 pp. (in Spanish)

Green, B.W. and H.R. Alvarenga, 1989. The effect of different application rates of chicken litter on tilapia production. Rev. Latinoamericana de Acuicultura, 40:31–34. (in Spanish)

Green, B.W. and C.R. Engle. Commercial tilapia aquaculture in Honduras. In: B. Costa-Pierce and J. Rakocy (Editors), Tilapia Aquaculture in the Americas, Volume 2. World Aquaculture Society, Baton Rouge, Louisiana. (in press)

Green, B.W. and L.A. López, 1990. Implementing the large-scale production of young males of *Tilapia nilotica* using hormonal sex inversion in Honduras. Agronomía Mesoamericana, 1:21–25. (in Spanish)

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 at Prague: Research Institute of Fish Culture and Hydrobiology, Vodnany, Czechoslovakia.

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

Green, B.W. and D.R. Teichert-Coddington, 1993. Production of *Oreochromis niloticus* fry for hormonal sex reversal in relation to water temperature. Journal of Applied Ichthyology, 9:230–236.

Green, B.W. and D.R. Teichert-Coddington, 1994. Growth of control and androgen-treated Nile tilapia during treatment, nursery and growout phases in tropical fish ponds. Aquaculture and Fisheries Management, 25:613–621.

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., D.Teichert-Coddington, and T.Hanson, 1994. Development of semi-intensive aquaculture technologies in Honduras: Summary of freshwater aquacultural research conducted from 1983 to 1992. International Center for Aquaculture and Aquatic Environments Research and Development Series No. 39, Auburn University, Alabama, 48 pp.

Green, B.W., D.R. Teichert-Coddington, and R.P. Phelps, 1990. Response of tilapia yield and economics to varying rates of organic fertilization and season in two Central American countries. Aquaculture, 90:279–290.

Green, B., D.Teichert-Coddington, M. Micheletti, and C.Lara, 1997. A collaborative project to monitor water quality of estuaries in the shrimp

producing regions of Honduras. Proceedings of the IV Ecuadorian Aquaculture Symposium, 22–27 Oct 1997. CENAIM, ESPOL, Camera Nacional de Acuicultura, Guayaquil, Ecuador. CD-ROM.

Green, B.W. D.R. Teichert-Coddington, C.E. Boyd, J. Wigglesworth, H. Corrales, D. Martinez, and E. Ramirez, 1999. Efecto del recambio de agua en la producción semi-intensiva de *Penaeus vannamei* (Boone, 1831) (Crustacea Penaidae) en una granja pilota. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 209–212. (in Spanish)

Meckenstock, D., D.R. Teichert-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, 8–12 Jul 1991, at Corpus Christi, Texas, USA: INTSORMIL Publication No. 92-1, pp. 107–119.

Rodriguez, R., G. Nuñez, and D. Teichert-Coddington, 1993. Evaluación de dos dietas alimenticias con diferente porcentaje de proteina, bajo dos densidades de siembra epoca de invierno en Granjas Marinas San Bernardo. II Simposio Centralamericano Sobre Camarón Cultivado, Tegucigalpa, Honduras. Federación de Productores y Exportadores (FPX), San Pedro Sula, Honduras, 267 pp.

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

Teichert-Coddington, D.R., 1988. Effects of protein diet and sowing density on the production of *Penaeus vannamei* in land tanks. Rev. Latinoamericana de Acuicultura, 35:29–44.

Teichert-Coddington, D.R., 1993. Development of production technologies for semi-intensive fish farming during the past decade in Central America. Proceedings of Symposium on Aquacultural Research in Central America at Heredia, Costa Rica: Programa UNA/LUW Acuicultura, Escuela de Ciencias Biológicas, Heredia, Costa Rica, pp. 71–88.

Teichert-Coddington, D.R., 1995. Estuarine water quality and sustainable shrimp culture in Honduras. Proceedings of the Special Session on Shrimp Farming, Swimming Through Troubled Water, Aquaculture '95: World Aquaculture Society, pp. 144–156.

Teichert-Coddington, D.R., 1996. Effect of stocking ratio on semi-intensive polyculture of *Colossoma macropomum* and *Oreochromis niloticus* in Honduras, Central America. Aquaculture, 143:291–302.

Teichert-Coddington, D.R. and B.W. Green, 1993. Comparison of two techniques for determining community respiration in tropical fish ponds. Aquaculture, 114:41–50.

Teichert-Coddington, D.R. and B.W. Green, 1993. Influence of daylight and incubation interval on water column respiration in tropical fish ponds. Hydrobiologia, 250:159–165.

Teichert-Coddington, D.R. and B.W. Green, 1993. Tilapia yield improvement through maintenance of minimal oxygen concentrations in experimental grow-out ponds in Honduras. Aquaculture, 118:63–71.

Teichert-Coddington, D.R. and B.W. Green, 1993. Usefulness of inorganic nitrogen in organically fertilized tilapia production ponds. Abstracts of World Aquaculture Meeting at Torremolinos, Spain: European Aquaculture Society Special Publication No. 19, Oostende, Belgium, p. 273.

Teichert-Coddington, D.R. and B.W. Green, 1993. Yield improvement through maintenance of minimal oxygen concentration in tilapia growout ponds in Honduras. Aquaculture, 118:1–2.

Teichert-Coddington, D.R. and B.W. Green, 1997. Experimental and commercial culture of tilapia in Honduras. In: B.A. Costa-Pierce and J.E. Rakocy (Editors), Tilapia Aquaculture in the Americas, Vol. I. World Aquaculture Society, Baton Rouge, Louisiana, pp. 142–162.

Teichert-Coddington, D.R. and R. Rodriguez, 1994. Relationship of penaeid shrimp yields to diet protein level, stocking density and season: a field test on commercial farms of southern Honduras. Abstracts of World Aquaculture '94, New Orleans, Louisiana. World Aquaculture Society, Louisiana State University, Baton Rouge, Louisiana.

Teichert-Coddington, D.R. and R. Rodriguez, 1995. Semi-intensive commercial growout of *Penaeus vannamei* fed diets containing differing levels of crude protein during wet and dry seasons in Honduras. Journal of the World Aquaculture Society, 26(1):72–79.

Teichert-Coddington, D.R., B.W. Green, and R.P. Parkman, 1991. Substitution of chicken litter for feed in production of penaeid shrimp in Honduras. The Progressive Fish-Culturist, 53(3):150–156.

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

Teichert-Coddington, D.R., D. Martinez, and C.E. Boyd, 1997. Solubility of selected inorganic fertilizers in brackish water. Journal of the World Aquaculture Society, 28(2):205–210.

Teichert-Coddington, D.R., R. Rodriguez, and W. Toyofuku, 1994. Cause of cyclic variation in Honduran shrimp production. World Aquaculture, 25(1):57–61.

Teichert-Coddington, D.R., B.W. Green, N. Matamoros, and R. Rodriguez, 1990. The substitution of chicken litter for feed in the commercial production of penaeid shrimp in Honduras. Agronomia Mesoamericana, Vol. 1.

Teichert-Coddington, D.R., D. Martinez, E. Ramirez, J. Harvin, W. Toyofuku, R. Zelaya, and B.W. Green, 1997. Semi-intensive shrimp pond management and quality of effluents. In: D.E. Alston, B.W. Green, and H.C. Clifford (Editors), Asociación Nacional de Acuicultores de Honduras and the Latin American Chapter of the World Aquaculture Society. IV Symposium on Aquaculture in Central America: Focusing on Shrimp and Tilapia, 22–24 Apr 1997, at Tegucigalpa, Honduras, pp. 203–204.

Presentations

Alvarenga, H.R. and B.W. Green. 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 34th Annual Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at San Jose, Costa Rica, 1988.

Boyd, C.E. Shrimp farming and the environment. Presented to AAAS Annual Meeting at Philadelphia, Pennsylvania, 12–17 Feb 1998.

Boyd, C.E. and L. Massaut. Perspectives for sustainable aquaculture through use of better environmental management. IV Congresso Ecuatoriano de Acuicultura, Guayaquil, Ecuador, 1997.

Boyd, C.E. and J.F. Queiroz. Effluent management in pond aquaculture. III Symposium on Nutritional Strategies and Management of Aquaculture Wastes, Vila Real, Portugal, 1997.

Boyd, C.E. and M.C. Haws. Good management practices to reduce environmental impacts and improve efficiency of shrimp aquaculture in Latin America. Presented to the V Central American Symposium on Aquaculture at San Pedro Sula, Honduras, 18–20 Aug 1999.

Boyd, C.E. Codes of conduct and better management practices in shrimp farming. Presented to the Fifth Ecuadorian Aquaculture Conference at Guayaquil, Ecuador, 28–30 Oct, 1999.

Boyd, C.E. Environmental issues in shrimp farming. Plenary address. Presented to the V Central American Symposium on Aquaculture at San Pedro Sula, Honduras, 18–20 Aug 1999.

Boyd, C.E. Pond water and soil management procedures to minimize the effects of disease epidemics in shrimp farming. Presented to the Fifth Ecuadorian Aquaculture Conference at Guayaquil, Ecuador, 28–30 Oct, 1999.

Green, B.W. Substitution of organic manure for pelleted feed in tilapia production. Presented to the FAO-EIFAC Symposium on Production Enhancement in Still-Water Pond Culture at Prague, Czechoslovakia, May 1990.

Green, B.W. Mass production of *Oreochromis niloticus* and *Oreochromis aureus* fry in relation to water temperature. Presented to the Fourth International Symposium on Tilapia in Aquaculture at Orlando, Florida, 9–12 Nov 1997.

Green, B.W. and H.R. Alvarenga. 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 by H. Alvarenga to the 33rd Annual Meeting of the Programa Colaborativo Centroamericana para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at Instituto de Ciencia y Technologia Agricola, Guatemala, 30 Mar–4 Apr 1987.

Green, B.W. and H.R. Alvarenga. Intensive fingerling production of

hybrid tilapia *Tilapia nilotica* × *Tilapia honorum* in earthen ponds. Presented by B. Green to the World Aquaculture Society Meeting at Guayaquil, Ecuador, 1987.

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

Green, B.W. and L. Lopez. Factabilidad de la produccion masiva de alevines machos de *Tilapia nilotica* atraves de la inversion hormonal de sexo en Honduras. Presented by L. Lopez to the Annual Regional Meeting of the Programa Cooperativo Centroamericana para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at San Pedro Sula, Honduras, 1989.

Green, B.W., H.R. Alvarenga, and R.P. Phelps. The effect of stocking rate on the production of *Tilapia nilotica* in ponds. Presented to the 34th Annual Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at San Jose, Costa Rica, 1988.

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

Green, B.W., D.R. Teichert-Coddington, and L.A. Lopez. Production of *Oreochromis niloticus* fry in earthen ponds for hormonal sex inversion. Presented to the World Aquaculture Society Meeting at Orlando, Florida, May 1992.

Green, B.W., D.R. Teichert-Coddington, G.H. Ward, and C.E. Boyd. Collaborative research to support sustainable shrimp culture in Honduras: A model program. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.

Martinez, D. and D.R. Teichert-Coddington. Solubility of inorganic fertilizers in brackish water. Presented to the Third Central American Shrimp Symposium at Tegucigalpa, Honduras, Apr 1995.

Milla, L., D.R. Teichert-Coddington, and D. Meyer. Biological demand of oxygen in shrimp farm water. Presented to the Third Central American Shrimp Symposium, at Tegucigalpa, Honduras, Apr 1995.

Rodriguez, R. and D.R. Teichert-Coddington. Substitution of inorganic fertilization for feeding in the commercial production of *Penaeus vannamei* during the rainy and dry season in Honduras. Presented to the Third Central American Shrimp Symposium at Tegucigalpa, Honduras, Apr 1995.

Rodriguez, R., O.J. O'Hara, and D.R. Teichert-Coddington. Efecto de la tasa de fertilización inorgánica y calidad de agua sobre el crecimiento y economía en el cultivo semi-intensivo de camarón *Penaeus* spp. en Granja Marinas San Bernardo. Simposio Centroamericano Sobre Camarón Cultivado at Tegucigalpa, Honduras, Apr 1991.

Teichert-Coddington, D.R. Problemática detectada en la dinámica del Golfo de Fonseca Hondureño y su repercusión en el cultivo de camarones. Primera Gran Reunión Nacional Camaronera, Choluteca, Honduras, Jan 1994.

Teichert-Coddington, D.R. Water quality and its management in shrimp ponds. Presented to the Camarón '94 conference at Mazatlan, Mexico, Feb 1994.

Teichert-Coddington, D.R. Florecimiento de algas en el Rio Choluteca. Foro: La industria de la camaricultura buscando asegurar la viabilidad a largo plaza, Choluteca, Honduras, Mar 1994.

Teichert-Coddington, D.R. Relación entre calidad de agua de esteros y descarga de fincas camaroneras en el sur de Honduras. Encuentro Regional Sobre el Desarrollo Sostenido del Golfo de Fonseca y sus Cuencas at Choluteca, Honduras, May 1994.

Teichert-Coddington, D.R. Water quality in the shrimp farming estuaries and the "X" Syndrome: Are they related? Segundo Encuentro de Gerentes y Propietarios de la industria de la Camaronicultura (Second Conference of Managers and Owners in the Honduran Shrimp Culture Industry) at Choluteca, Honduras, Jan 1995.

Teichert-Coddington, D.R. Characterization of shrimp farm effluents in Honduras and chemical budget of selected nutrients. Presented to the Third Central American Shrimp Symposium at Tegucigalpa, Honduras, Apr 1995.

Teichert-Coddington, D.R. Pond management, estuarine water quality, and sustainable shrimp culture in Central America. Presented by Claude Boyd to the Sustainable Aquaculture '95 Conference at Honolulu, Hawaii, Jun 1995.

Teichert-Coddington, D.R. and B. Green. Influence of primary productivity, season and site on tilapia production in organically fertilized ponds in two Central American countries. Presented to the FAO-EIFAC Symposium on Production Enhancement in Still-Water Pond Culture at Prague, Czechoslovakia, May 1990.

Teichert-Coddington, D.R., B. Green, and M.I. Rodriguez. Efectos de la tasa de alimentacion sobre la producción de tilapia en estanques fertilizados con gallinaza. Presented by M.I. Rodriguez to the Annual Regional Meeting of the Programa Cooperativo Centroamericana para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at San Pedro Sula, Honduras, 1989.

Teichert-Coddington, D.R., R. Rodriguez, and W. Toyofuku. Causes of cyclical variation in Honduran shrimp production. Poster presented to the World Aquaculture Society Meeting at Torremolinos, Spain, 26–28 May 1993.

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

Teichert-Coddington, D.R., W. Toyofuku, J. Harvin and R. Rodriguez. Stocking density effects on survival and production. Presented to the Third Central American Shrimp Symposium at Tegucigalpa, Honduras, Apr 1995.

Zelaya, O., C.E. Boyd, D.R. Teichert-Coddington, and D.B. Rouse. Effects of water circulation on water quality and bottom soil in shrimp ponds. Presented to Aquaculture America 2001, Orlando, Florida, 21–25 Jan 2001.

Escuela Agrícola Panamericana el Zamorano

Theses

Martínez, J.A., 2000. Socioeconomic characterization of farmers with and without a system of tilapia production in Honduras. B.S. thesis, Escuela Agrícola Panamericana El Zamorano, Honduras. (in Spanish)

Mejía, G.M., 2000. Study of the production costs for culture of tilapia on small and medium farms in five departments of Honduras. B.S. thesis, Escuela Agrícola Panamericana El Zamorano, Honduras. (in Spanish)

Molina, J.C., 2000. Study of the actual and potential demand for tilapia in five secondary cities in Honduras. B.S. thesis, Escuela Agrícola Panamericana El Zamorano, Honduras. (in Spanish)

Quan, Vivian, 2000. Evaluation of the reproduction of tilapia (*Oreochromis niloticus*) in plastic and concrete lined and earthen ponds. B.S. thesis, Escuela Agrícola Panamericana El Zamorano, Honduras. (in Spanish)

Quispe, F., 2000. Evaluation of the production costs for tilapia fingerlings in Honduras. B.S. thesis, Escuela Agrícola Panamericana El Zamorano, Honduras. (in Spanish)

Publications

Charris, F., B. Green, and D. Meyer, 1999. Efectividad de cinco métodos para la enumeración de alevines de tilapia (*Oreochromis* sp.). In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 240–242.

Meyer, D. and E. Caamaño, 1999. Frecuencia de la alimentación y consumo en tilapia (*Oreochromis niloticus*). In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 262–265.

Verma, B., J. Renew, E.W. Tollner, T. Popma, J.L. Molnar, and D. Meyer, 2000. Concurrent design of hillside ponds for tilapia production. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 311–315.

Presentations

Arias, F., J. Molnar, B. Esquivel, F.M. Quispe, J.A. Martinez, and G.M. Mejia, 2001. Production and marketing strategies used by small- and medium-scale producers in Honduras. Presented to the Sixth Central American Symposium on Aquaculture, Tegucigalpa, Honduras, 22–24 Aug 2001.

Meyer, D., 2001. Nutrition and feeding of tilapia. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 Aug 2001, pp. 61–70.

Molnar, J., E. Trejos, P. Martinez, B. Verma, E.W. Tollner, S. Triminio, and D. Meyer, 2002. Advancing aquacultural development through the third sector: Advantages and liabilities of NGO networks for technology transfer in Honduras. Poster presented at the Annual Meeting of the American Association for the Advancement of Science at Boston, Massachusetts, 15 Feb 2002.

Popma, T. and D. Meyer, 2001. Training and technical assistance in warm-water fish culture. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 Aug 2001, pp. 118–125.

Tollner, E.W., 2001. Levee pond design model. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 Aug 2001, pp. 116–117.

Verma, B.P., D. Meyer, T. Popma, J. Molnar, and E.W. Tollner, 2001. Web-based information delivery system for tilapia for sustainable development of aquaculture in Honduras. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 Aug 2001, pp. 126–134.

UNIVERSIDAD NACIONAL AUTÓNOMA DE HONDURAS

Theses

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)

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

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

UNIVERSITY OF ARKANSAS AT PINE BLUFF

Thesis

Valderrama, D., 2000. Economic analysis of shrimp farming in Honduras. M.S. thesis, University of Arkansas, Pine Bluff, Arkansas.

Publications

Dasgupta, S. and C.R. Engle, 1999. Non-parametric estimation of returns to investment in Honduras shrimp research. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 201–203.

Dasgupta, S. and C.R. Engle, 2000. Non-parametric estimation of returns to investment in Honduras shrimp research. Aquaculture Economics and Management, 4(3–4):141–156.

Engle, C.R. Marketing and Economics. In: C. Webster and C. Lim (Editors). Tilapia Culture, Nutrition, and Feeding. CABI Publishers. (in press)

Fúnez, O., I. Neira, and C. Engle, 2001. Honduras survey: 50% of supermarket to sell tilapia. Global Aquaculture Advocate, 4(2):89.

Fúnez, O., I. Neira, and C. Engle, 2002. Open-air market outlets for tilapia in Honduras. Global Aquaculture Advocate, 5(1):88.

Neira, I., O. Fúnez, and C. Engle, 2001. Honduras survey shows potential for tilapia. Global Aquaculture Advocate, 4(1):86.

Valderrama, D. and C.R. Engle, 1999. Risk analysis of shrimp farming in Honduras. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 236–239.

Valderrama, D. and C. Engle, 2001. Risk analysis of shrimp farming in Honduras. Aquaculture Economics and Management, 5(1-2):49–48.

Valderrama, D. and C.R. Engle, 2001. Efectos en la rentabilidad y las estrategias de manejo de las fincas en Honduras, por las tasa de sobrevivencia del camarón blanco. Panorama Acuícola, 6(4):40–41.

Valderrama, D. and C.R. Engle. Economic optimization of shrimp farming in Honduras. J. World Aquacult. Soc. (in review)

Valderrama, D. and C.R. Engle. The effect of survival rates of white shrimp *Litopenaeus vannamei* on net farm income and optimal management strategies of Honduran shrimp farms. Aquaculture. (in review)

Presentations

Fúnez, O., I. Neira, and C.R. Engle, 2001. Supermarket outlets for tilapia in Honduras: An overview of survey results. Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 Aug 2001.

Neira, I. and C. Engle, 2001. Markets for tilapia (*Oreochromis* spp.) in Nicaragua: A descriptive analysis of restaurants, supermarkets, and stands in open markets. Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 Aug 2001.

Neira, I. and C. Engle. The Honduran market for tilapia: Restaurant and supermarket surveys. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.

Neira, I., K. Quagrainie, and C. Engle, 2002. Markets for tilapia in Nicaragua: A quantitative analysis of restaurant markets. Annual Research Forum 2002, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas.

Valderrama, D. A risk programming model for shrimp farming in Honduras. Presented to the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET 2000) at Corvallis, Oregon, 10–13 Jul 2000.

Valderrama, D. and C.R. Engle. Risk analysis of shrimp farming in Honduras. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1–4 Feb 2000.

Valderrama, D. and C.R. Engle. The effect of survival rates of white shrimp *Litopenaeus vannamei* on net farm income and optimal management strategies of Honduran shrimp farms. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.

Valderrama, D. and C.R. Engle, 2001. Optimizacion economica del cultivo del camaron en Honduras. Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 Aug 2001. (in Spanish)

Valderrama, D. and C.R. Engle, 2002. Economic optimization of shrimp farming in Honduras. Aquaculture America 2002, San Diego, California.

UNIVERSITY OF TEXAS, AUSTIN

Publication

Ward, G.W., B.W. Green, and D.R. Teichert-Coddington, 1999. Estimation of carrying capacity for shrimp aquaculture in the eastern estuaries of the Gulf of Fonseca. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 34-63.

Mexico

UNIVERSDAD JUAREZ AUTONOMA DE TABASCO

Thesis

Lara, G.M., 2001. Ictiofauna Asociada a las Escolleras del Puerto Marítimo de Dos Bocas, Paraíso, Tabasco, México. División Académica de Ciencias Biológicas, B.S. thesis, Universidad Juárez Autónoma de Tabasco.

Publication

Contreras-Sánchez, W.M. Identification of unique genes expressed during sex inversion of Nile tilapia, *Oreochromis niloticus,* by cDNA subtractive hybridization. Gen. Comp. Endocrinol. (in review)

Nicaragua

UNIVERSITY OF ARKANSAS AT PINE BLUFF

Thesis

Neira, I. Analysis of the potential market for farm-raised tilapia in Nicaragua. M.S. thesis, University of Arkansas at Pine Bluff, Arkansas.

Panama ~ Aguadulce

AUBURN UNIVERSITY

Thesis

Van Wyk, P., 1986. The relationship of pump discharge and fuel efficiency to tidal height for a brackish water aquaculture pumping station. M.S. thesis, Auburn University, Alabama.

Publications

Lovshin, L.L., 2000. Criteria for selecting Nile tilapia and red tilapia for culture. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 49–57.

Lovshin, L.L., 2000. Evaluation of tilapia culture by resource limited farmers in Panama and Guatemala. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 633–638.

Lovshin, L.L. and N.B. Schwartz, 1999. Evaluation of integrated tilapia culture by resource limited farmers in Panama and Guatemala. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 258–261.

Teichert-Coddington, D.R. and M. Arrue, 1988. Efectos de dietas de proteinas y densidades de siembra sobre la producción de *Penaeus vannamei* en estanques de terra. (Effects of protein diets and stocking density on production of *Penaeus vannamei* cultured in earth ponds.) Revista Latinoamericana de Acuicultura, 35:29–33.

Presentations

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

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

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

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

Hughes, D.G. and O.M. Garcia A. La producción de semilla de *Tilapia nilotica* en hapas: una comparacion de productividades de clima templada con clima tropical. Presented to the First National Aquaculture Seminar at University Nacional, Heredia, Costa Rica, Jun 1984.

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

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

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

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

Lasso de la Vega, E. and M. Villareal. Variacion del zooplancton en estanques de cria de camarones blanco durante la estacion seca. Presented to the Second National Scientific Congress at University of Panama, Panama, Nov 1985.

Lore, D., H. Tunon, and R. Visuetti. 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 at University of Panama, Panama, Dec 1984.

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

Moreno, J.M. 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 at University of Panama, Panama, Dec 1984.

Pretto, R., G. Garson, V. Batista, and M. de Leon. Estudio preliminar del policultivo de peneidos con peces nativos de aguas salobres. Presented to the Fifth Symposium of Latin American Aquaculture at Universidad Austral de Chile, Valdivia, Chile, Sep 1983.

Torres, A. Producción 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 at University of Panama, Panama, Dec 1984.

UNIVERSITY OF PANAMA

Theses

Abrego, R., 1985. Uso de androgenos en alevines de *Tilapia nilotica* para la produccion de tilapias monosexuales. B.S. thesis, University of Panama.

Chavez, H., 1984. Estudio trofodinamico de *Penaeus vannamei* cultivado en estanques experimentales de aguas salobres. B.S. thesis, University of Panama.

Hernandez de Santamaria, D., 1987. El efecto de dietas experimentales en el crecimiento y sobrevivencia de *Penaeus vannamei* cultivado en estanques. B.S. thesis, University of Panama.

Lasso de la Vega, E., 1985. Variacion del zooplancton en estanques de cria de camarones blanco durante la estacion seca. B.S. thesis, University of Panama.

Lore, D., 1984. Efecto de la aplicacion de abonos organicos, concentrados y pescado fresco (*Dormitator latifrons*) en la producción de *Penaeus stylirostris* y *Penaeus vannamei*. B.S. thesis, University of Panama.

Panama ~ Gualaca

AUBURN UNIVERSITY

Thesis

Hughes, D.G., 1988. Evaluation of seed production and sex-reversal methods for *Tilapia nilotica* and field verification in a tropical hatchery. Ph.D. dissertation, Auburn University, Alabama.

Publications

Peralta, M. and D.R. Teichert-Coddington, 1989. Comparative production of *Colossoma macropomum* 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.

Presentation

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

UNIVERSITY OF PANAMA

Theses

Atencio, A., 1987. Phosphorus saturation of acidic soils in tropical fish culture ponds. B.S. thesis, University of Panama.

Barrios, C.M., 1985. Analysis of water quality in new freshwater ponds at the Freshwater Aquaculture Station in Gualaca. B.S. thesis, University of Panama.

Friele, M.E.F., 1985. Stomach analyses of *Macrobrachium rosenbergii*, *Tilapia nilotica*, *Colossoma macropomum* and the hybrid *Hypophthalmichthys molitrix* × *Aristichthys nobilis* in polyculture at the Gualaca Freshwater Aquaculture Experiment Station, Panama. B.S. thesis, University of Panama.

Perez, M.J., 1985. Economic and marketing study of fish and shrimp in polyculture systems in freshwater ponds at Gualaca, Chiriqui Province. B.S. thesis, University of Panama.

Pimentel, C.A.B., 1984. Effect of liming on new unfertilized ponds at the Gualaca Aquaculture Experiment Station. B.S. thesis, University of Panama.

Rios, R.A., 1986. Identification and dynamics of zooplankton found in tropical earthen ponds receiving chicken litter at four rates. B.S. thesis, University of Panama.

Rodriguez, I., 1987. Feeding *Penaeus vannamei* and *Penaeus stylirostris* in nursery ponds. M.S. thesis, University of Panama.

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. B.S. thesis, University of Panama.

Peru

AUBURN UNIVERSITY

Presentations

Molnar, J.J., F. Alcántara, and S. Tello. Small-scale aquaculture in the Peruvian Amazon: Marketing practices and strategies. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.

Molnar, J.J., F. Alcántara, and S. Tello. Sustaining livelihoods, ecologies, and rural communities. Presented to the American Association for the Advancement of Science 2000 AAAS Annual Meeting and Science Innovation Exposition at Washington, DC, 17–22 Feb 2000.

Molnar, J.J., F. Alcántara, and S. Tello. Sustaining small-scale aquaculture in the Peruvian Amazon: Producer perceptions of constraints and opportunities. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1–4 Feb 2000.

Molnar, J.J., F. Alcántara, and S. Tello. Sustaining small-scale aquaculture in the Peruvian Amazon: Producer perceptions of constraints and oppor-tunities. Presented to World Aquaculture 2000 at Nice, France, 2–6 May 2000.

Molnar, J., F. Alcántara, C.C. Kohler, S. Tello, and M.J. De Jesus. Aquaculture in the Amazon: Sustaining livelihoods, food security, and species in a complex ecological context. Presented to the V Central American Symposium on Aquaculture at San Pedro Sula, Honduras, 18–20 Aug 1999.

INSTITUTO DE INVESTIGACIONES DE LA AMAZONIA PERUANA

Publication

Alcántara, F., S. Tello, C.V. Chávez, L.C. Rodríguez, C. Kohler, W.N. Camargo, and M. Colace. Gamitana (*Colossoma macropomum*) and paco (*Piaractus brachypomus*) culture in floating cages in the Peruvian Amazon, Journal of the World Aquaculture Society. (in review)

Presentations

Alcántara, F. Performance of *Piaractus brachypomus* and *Colossoma macropomum* stocked in ponds at different densities in Iquitos, Peru. Presented to Development of Aquaculture in the Amazon at Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru, 30 Nov–4 Dec 1999.

Alcántara, F. Status of aquaculture in the Peruvian Amazon. Presented to Development of Aquaculture in the Amazon at Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru, 30 Nov–4 Dec 1999.

SOUTHERN ILLINOIS UNIVERSITY AT CARBONDALE

Publications

De Jesus, M.J. and C.C. Kohler. The commercial fishery of the Peruvian Amazon: Is it sustainable? Fisheries (in revision).

De Jesus, M.J., C.C. Kohler, and S.T. Kohler, 1998. Sustainable aquaculture in Peru. Aquaculture Magazine, 24(4):23–25.

Fernandes, J.G.K., R. Lochmann, and F. Alcántara. Apparent digestible energy and nutrient digestibility coefficients of diet ingredients for pacu *Piaractus brachypomus*. Journal of the World Aquaculture Society. (in review)

Presentations

Alcántara, F., C. Kohler, S.T. Kohler, and M.J. De Jesus. Performance of *Piaractus brachypomus* and *Colossoma macropomum* stocked in ponds at different densities. Presented to the World Aquaculture Society Annual Meeting at Sydney, Australia, 26 Apr–2 May 1999.

De Jesus, M.J. and C.C. Kohler. Analysis of the commercial fisheries in the Peruvian Amazon. Presented to the Illinois Renewable Natural Resources Conference, Springfield, Illinois, 4–6 Mar 1998.

Kohler, C., M. De Jesús, S. Kohler, L.B. Campos, and F. Alcántara. Culture of *Colossoma macropomum* in South America. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.

Kohler, C.C., S.T. Kohler, M.J. De Jesus, and F. Alcántara. Use of *Colossoma macropomum* and *Piaractus brachypomus* for sustainable aquaculture in the Peruvian Amazon. Presented to World Aquaculture 2000 at Nice, France, 2–6 May 2000.

THE OHIO STATE UNIVERSITY

Publication

Dabrowski, K., J. Rinchard, J.S. Ottobre, F. Alcántara, P. Padilla, A. Ciereszko, M.J. de Jesus, and C. Kohler. Effect of oxygen saturation in water provided to broodstock and embryos of *Piaractus brachypomus* on viability of larvae. Aquaculture. (in press)

Presentation

Dabrowski, K., J. Rinchard, F. Alcántara, P. Padilla, A. Ciereszko, and M. De Jesus. Preliminary assessment of gamete quality of *Piaractus brachypomus* cultured in ponds in Iquitos, Peru. Presented to Development of Aquaculture in the Amazon at Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru, 30 Nov–4 Dec 1999.

AFRICA

Egypt

AUBURN UNIVERSITY

Publications

Green, B.W. and C.E. Boyd, 1995. Chemical budgets for organically fertilized fish ponds in the dry tropics. Journal of the World Aquaculture Society, 26(3):284–296.

Green, B. and C.E. Boyd, 1995. Water budgets for fish ponds in the dry tropics. Aquacultural Engineering, 14:347–356.

Munsiri, P., C.E. Boyd, B.W. Green, and B.F. Hajek, 1996. Chemical and physical characteristics of bottom soil profiles in ponds on haplaquents in an arid climate at Abbassa, Egypt. Journal of Aquaculture in the Tropics, 11:319–326.

Presentations

Green, B. and C.E. Boyd. Chemical budgets for fish ponds in the dry tropics. Presented to the World Aquaculture Society Meeting at New Orleans, Louisiana, 1994.

Green, B. and C.E. Boyd. Water budgets for fish ponds in the dry tropics. Presented to the World Aquaculture Society Meeting at New Orleans, Louisiana, 1994.

CENTRAL LABORATORY FOR AQUACULTURE RESEARCH, ABBASSA, EGYPT

Publications

Abdalla, A.A.F., C.D. McNabb, and T.R. Batterson, 1996. Ammonia dynamics in fertilized fish ponds stocked with Nile tilapia. The Progressive Fish-Culturist, 58:117–123.

Green, B., Z. Elnagdy, H. Hebida, and A.R. El Gamal, 1994. Pond management strategies for production of Nile tilapia in Egypt. NARP Harvest No. 2.

Presentations

Abdelghany, A. Optimum protein requirements for Nile tilapia. Presented to the Sixth International Symposium on Fish Nutrition and Feeding at Hobart, Tasmania, Australia, 1993.

Abdelghany, A. Optimum ratio of animal to plant protein in formulated diets for Nile tilapia. Presented to the Sixth International Symposium on Fish Nutrition and Feeding at Hobart, Tasmania, Australia, 1993.

MICHIGAN STATE UNIVERSITY

Publication

Abdalla, A.A.F. and C.D. McNabb, 1998. Acute and sublethal growth effects of un-ionized ammonia to Nile tilapia *Oreochromis niloticus*. In: D. Randall and D. MacKinlay (Editors), Nitrogen Production and Excretion in Fish. International Congress on the Biology of Fish, Symposium Proceedings, Jul 27–30, 1998, pp. 35–44.

OREGON STATE UNIVERSITY

Thesis

Gale, W.L., 1996. Sexual differentiation and steroid-induced sex inversion in Nile tilapia (*Oreochromis niloticus*): 1. Characterization of a gonadal androgen receptor; 2. Masculinization by immersion in methyldihydrotestosterone. M.S. thesis, Oregon State University, Corvallis, Oregon.

Publications

Fitzpatrick, M.S., W.L. Gale, C.H. Slater, and C.B. Schreck, 1995. Gonadal androgen receptors in fishes. In: F.W. Goetz and P. Thomas (Editors), Proceedings of the Fifth International Symposium on Reproductive Physiology of Fish at Austin, Texas, p. 308.

Fitzpatrick, M.S., G. Feist, W.L. Gale, C.H. Slater, and C.B. Schreck, 1994. Gonadal sex differentiation in fishes. In: D.D. MacKinlay (Editor), High Performance Fish. Proceedings of an International Fish Physiology Symposium, Fish Physiology Association, Vancouver, BC, pp. 146–149.

Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck, 1995. Immersion of Nile tilapia (*Oreochromis niloticus*) in 17α-methyltestosterone and mestanolone for the production of all-male populations. In: F.W. Goetz and P. Thomas (Editors), Proceedings of the Fifth International Symposium on Reproductive Physiology of Fish at Austin, Texas, p. 117.

Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck, 1996. Masculinization of Nile tilapia by short-term immersion in methyldihydrotestosterone. In: E.M. Donaldson and D.D. MacKinlay (Editors), Aquaculture Biotechnology Symposium. Proceedings of an International Fish Physiology Symposium. Cong. Biol. Fishes, Physiology Section, American Fisheries Society, Vancouver, BC, p. 29.

Gale, W.L., M.S. Fitzpatrick, M. Lucero, W.M. Contreras-Sánchez, and C.B. Schreck, 1999. Masculinization of Nile tilapia by immersion in androgens. Aquaculture, 178:349–357.

Presentations

Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck. Binding sites for the masculinizing steroid mibolerone in the gonadal tissue of adult tilapia (*Oreochromis niloticus*). Presented to the Western Regional Conference on Comparative Endocrinology at San Diego, California, 1994.

Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck. Binding sites for the masculinizing steroid mibolerone in the gonadal tissue of adult tilapia (*Oreochromis niloticus*). Presented to the World Aquaculture Society Annual Meeting at San Diego, California, 1–4 Feb 1995.

Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck. Binding characteristics of a gonadal androgen receptor in Nile tilapia (*Oreochromis niloticus*). Presented to the Western Regional Conference on Comparative Endocrinology at Berkeley, California, 1996.

Kenya

AUBURN UNIVERSITY

Thesis

Lockhart, M., 1999. Farmer perceptions of constraints on aquaculture development in Central Kenya: Market, household, and resource considerations. M.S. thesis, Auburn University, Alabama.

Presentations

Liti, D., E. Mac'Were, and K. Veverica. Growth performance and economic benefits of *Oreochromis niloticus* and *Clarias gariepinus* polyculture in fertilized tropical ponds. Poster presented to the Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.

Molnar, J., M. Lockhart, and J. Amadiva. Aquacultural development in central Kenya: Farming system, household, and community considerations. Poster presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

Veverica, K.L. Commercial tilapia production recommendations and enterprise budgets of East Africa in the absence of formulated feeds. Presented to Lake Victoria 2000 at Jinja, Uganda, 14–19 May 2000.

Veverica, K.L., B.W. Green, J. Bowman, D.R. Teichert-Coddington, and C.E. Boyd. Optimization of nitrogen fertilization rate in freshwater tilapia production ponds in Honduras and Kenya. Presented to World Aquaculture 2000 at Nice, France, 2–6 May 2000.

Veverica, K., D. Mirera, and G. Matolla. Optimization of phosphorus fertilization rate in freshwater tilapia production ponds in Kenya. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.

MOI UNIVERSITY

Thesis

Mac'Were, E., 2002. Comparison of tilapia and *Clarias* polyculture yields and economic benefits resulting from a locally available animal feed (pig finisher pellet), agricultural by-product (rice bran), and a pelleted test diet in fertilized ponds. M.S. thesis, Moi University, Eldoret, Kenya.

Presentations

Muchiri, M. Break-even price and investment costs under different loan schemes for small-scale fish farmers in Kenya. Presented to IIFET 2000 at Corvallis, Oregon, 10–14 Jul 2000.

Ngugi, C., J. Macharia, and J. Rasowo. Comparative study of hatching rates of catfish eggs on different substrates. Presented to First National LVEMP Scientific Conference at Nairobi, Kenya, 15–19 Oct 2001.

Ngugi, C., J.O. Manyala, and T. Mboya. Fish introduction and their impact on the biodiversity and the fisheries of Lake Victoria. Presented to the First National LVEMP Scientific Conference at Nairobi, Kenya, 15–19 Oct 2001.

UNIVERSITY OF NAIROBI

Theses

Gichuri, W.M., 1999. Relative contribution of rice bran and inorganic fertilizers in semi-intensive tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*) polyculture in Kenya. M.S. thesis, University of Nairobi, Nairobi, Kenya.

Mwau, P., 2000. Nutrient dynamics with special reference to nitrogen and phosphorus in tilapia (*Oreochromis niloticus*)/catfish (*Clarias gariepinus*) polyculture ponds at Sagana Fish Farm, Central Kenya. M.S. thesis, University of Nairobi, Nairobi, Kenya.

Presentations

Bilal, P., K.M. Mavuti, J.G. Omondi, and K.L. Veverica. Plankton dynamics in tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*) polyculture ponds in Central Kenya. Presented to Shallow Water Bodies in the Tropics Conference at Naivasha, Kenya, 12–16 Apr 1999.

Gichuri, W.M., J.G. Omondi, K.L. Veverica. Relative condition factors (Kn) for *Oreochromis niloticus* (Cichlidae) and *Clarias gariepinus* (Clariidae) in small managed ponds. Presented to Shallow Water Bodies in the Tropics Conference at Naivasha, Kenya, 12–16 Apr 1999.

Meso, B. Application of fish pond effluent to French beans through drip irrigation at Sagana, Kenya. Presented to the Soil Science Society of East Africa (SSSEA) Silver Jubilee (25th Annual) Conference at Kampala, Uganda, 6–10 Sep 1999.

Mwau, P.N., K.M. Mavuti, P.I. Bilal, and K.L. Veverica. Nitrogen and phosphorus budgets in polyculture fish ponds. Presented to Shallow Water Bodies in the Tropics Conference at Naivasha, Kenya, 12–16 Apr 1999.

Oenga, D., B. Wangila, M. Muchiri, and K.L. Veverica. The history of largemouth bass *Micropterus salmoides* introduction and transfers in East Africa. Presented to Shallow Water Bodies in the Tropics Conference at Naivasha, Kenya, 12–16 Apr 1999.

Rwanda

AUBURN UNIVERSITY

Theses

Hishamunda, N., 1993. The economic analysis of small-scale fish culture in Rwanda: a comparative study. M.S. thesis, Auburn University, Alabama.

Smith, E.S., 1996. Factors affecting sex reversal of tilapia: species characteristics and feed storage conditions. M.S. thesis, Auburn University, Alabama.

Publications

Hishamunda, N. and J.E. Moehl, 1989. Rwanda National Fish Culture Project. International Center for Aquaculture and Aquatic Environments Research and Development Series No. 34, Auburn University, Alabama, 19 pp.

Moehl, J.F. and J.J. Molnar, 1996. Institutional requirements for aquacultural development in Africa: Lessons from Rwanda. In: C. Bailey, S. Jentoft, and P. Sinclair (Editors), Aquacultural Development: Social Dimensions of an Emerging Industry, Westview Press, Boulder, CO, USA/Oxford, United Kingdom, pp. 233–248.

Moehl, J.F., K.L. Veverica, B.J. Hanson, and N. Hishamunda, 1988. 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, Manila, Philippines, pp. 561–568.

Molnar, J.J., C.L. Cox, P. Nyirahabimana, and A. Rubagumya, 1994. Socioeconomic factors affecting the transfer and sustainability of aquacultural technology in Rwanda. International Center for Aquaculture and Aquatic Environments Research and Development Series No. 38, Auburn University, Alabama, 16 pp.

Popma, T.J. and B.W. Green, 1990. Sex reversal of tilapia in earthen ponds. International Center for Aquaculture and Aquatic Environments Research and Development Series No. 35, Auburn University, Alabama, 15 pp.

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

Veverica, K., 1997. The PD/A CRSP–Sponsored Proceedings of the Third Conference on the Culture of Tilapias at High Elevations in Africa. International Center for Aquaculture and Aquatic Environments Research and Development Series No. 42, Auburn University, Alabama, 26 pp.

Presentations

Hanson, B., V. Ndoreyaho, F. Rwangano, E. Rurangwa, M. Van Speybroeck, R. Tubb, and W. Seim. Relationship between water chemistry and the growth of *Tilapia nilotica* in Rwandan (Central Africa) fish ponds fertilized with chicken manure. Presented to the World Aquaculture Society Meeting at Honolulu, Hawaii, 4–8 Jan 1988.

Harwanimbaga, C., F. Rwangano, and B. Hanson. A descriptive study of plankton in Rwandan (Central Africa) fish ponds fertilized with chicken manure or triple superphosphate. Presented to the World Aquaculture Society Meeting at Honolulu, Hawaii, 4–8 Jan 1988.

Newman, J.R., T.J. Popma, and W.K. Seim. Effects of temperature on

maximum feed consumption and growth of juvenile Nile tilapia. Poster presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Jan 1996.

Veverica, K.L., N. Hishamunda, and P. Nyirahabimana. Aquaculture extension in Rwanda. Presented to the ALCOM Technical Consultation on Extension Methods for Small-holder Fish Farming in Southern Africa at Lilongwe, Malawi, 20–24 Nov 1995.

Veverica, K.L., W.K. Seim, T.J. Popma, and E. Rurangwa. Cut grass as fertilizer for tilapia ponds: Composting methods, application rates and timing. Presented to the Pacific Conference on Marine Science and Technology (PACON) Symposium on Sustainable Aquaculture at Honolulu, Hawaii, 11–14 Jun 1995.

Veverica, K.L., W.K. Seim, T.J. Popma, and E. Rurangwa. Pond dynamics and tilapia production resulting from in-pond composting. Invited paper at the World Aquaculture Society Meeting at Bangkok, Thailand, Jan 1996.

Université Nationale du Rwanda

Theses

Bizimana, V., 1985. Essaies de triage mécanique de *Tilapia rendalli* Boulenger et *Tilapia macrochir* Boulenger en vue d'un élevage monosexe. (Mechanical grading to obtain mostly male fingerlings of *Tilapia rendalli* and *Tilapia macrochir*.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur, Université Nationale du Rwanda, Butare, Rwanda.

Gatera, A., 1990. Effet du taux d'empoissonnement et du mode de compostage sur la production des poissons en étang. (Effect of stocking rate and composting regime on production of fish in ponds.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Habineza, C., 1986. Analyse de l'effet de la fumure organique (fientes de poules) sur la croissance du *Tilapia nilotica* en étang. (The influence of chicken manure on the growth of *Tilapia nilotica* in ponds.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Hakziyaremye, E., 1984. Etude des effets de l'alimentation sur la croissance des tilapias: essaies en bacs sur *T. macrochir* et *T. rendalli*. Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Harwanimbaga, C., 1987. Etude préliminaire des populations planktoniques dans des étangs de Rwasave, Butare, Rwanda. (A preliminary study of the plankton populations in fish ponds at Rwasave, Butare, Rwanda.) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.

Hatangimbabazi, J.D., 1989. Description des communautés planctoniques des différentes habitats de quelques étangs piscicoles de Rwasave (Butare). (Description of plankton communities in different habitats of fish ponds at Rwasave (Butare).) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.

Hishamunda, N., 1984. Contribution a l'étude des effets de *Serranochromis macrocephala* Boulenger, sur la prolifération de *Tilapia macrochir* Boulenger, en etangs de pisciculture. (Effects of a predator fish, *Serranochromis macrocephala*, on the proliferation of *Tilapia macrochir* in fish culture ponds). Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Isangu, M.M., 1989. L'association porcs-poissons en station: étude de rentabilité financière. (Integrated pig-fish culture: An economic analysis.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Kakuze, A., 1989. Contribution à l'étude du régime alimentaire de *Tilapia nilotica* (L. 1758) des étangs fertilisés de Rwasave (Butare). (A preliminary study of the feeding habits of *T. nilotica* in fertilized ponds at Rwasave, Butare.) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.

Mbarererehe, F., 1992. Contribution à l'étude de l'influence de la température et de la durée de traitement sur la production des alevins monosexes du *Oreochromis niloticus*. (The influence of temperature and treatment duration on the production of all-male *O. niloticus* fry.) Mémoire présenté en vue de l'obtention du Diplôme d'Ingénieur Technicien A1, Institut Supérieur d'Agriculture et d'Elevage de Busogo, Ruhengeri, Rwanda.

Mukakarera, C., 1990. Etude hydrobiologique des ruisseaux Uwagatigita et Mbirurume de la fôret naturelle de Nyungwe. (An aquatic biology study of Uwagatigita and Mbirurume streams in the Nyungwe natural forest.) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.

Munyangaju, A., 1990. Etude des lacs du Bugesera en vue de proposer l'effort de pêche optimale. (A study of the lakes in the Bugesera region in order to propose an optimal fishing effort.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

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

Murwanashyaka, J.N., 1989. Alimentation et parasitisme de *Clarias gariepinus* (Burchell, 1822) au Lac Ihema: impact de sa prédation sur l'évolution du stock en haplochromis. (Parasitism and feeding habits of *C. gariepinus* in Lake Ihema: impacts of its predation on haplochromis stocks.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Ndisebuye, A., 1986. Etude des conditions de reproduction de *Tilapia nilotica* en étangs de pisciculture. (A study of the conditions affecting the reproduction of *T. nilotica* in Rwandan fish ponds.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Ngarambe, O., 1986. Etude de l'influence de la fumure organique (fientes de poule) sur la dynamique des éléments fertilisants du sol de quelques étangs piscicoles de Rwasave. (The influence of chicken litter on soil and water fertility in several fish ponds at Rwasave.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Niyitegeka, D., 1990. Bilan d'azote dans les étangs piscicoles enrichis par les fertilisants de différents rapports C:N:P, Rwasave, Butare. (Nitrogen budgets in fish ponds enriched with fertilizers of different C:N:P ratios at Rwasave, Butare.) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.

Nsengiyumva, D., 1985. Effet de l'alimentation sur la croissance de la carpe herbivore *Ctenopharyngodon idella* Valenciennes. (Growth of the grass carp, *Ctenopharyngodon idella* Valenciennes, in response to feeding.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Nsengiyumva, V., 1989. Production des alevins monosexes de *Tilapia nilotica* Linnaeus par la méthode du "sex-reversal." (Production of *T. nilotica* fingerlings by sex reversal methods.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Rutikanga, P., 1992. Contribution à l'étude des facteurs intervenant dans le taux d'infestation des *O. niloticus* par les Diplostomatidae (maladie des points noirs). (Factors affecting the infestation rate of O*reochromis niloticus* by diplostomatid cysts (black spot disease).) Rapport de stage, Ecole Agricole et Vétérinaire de Kabutare, Butare, Rwanda.

Rwalinda, P., 1990. Enrichissement du compost en azote et phosphore et ses effets sur la production du *Tilapia nilotica* (L.). (Enrichment of compost with nitrogen and phosphorus and its effects on the production of *Tilapia nilotica*, L.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Uwera, M., 1987. Une étude des modalités d'échantillonage des poissons en étangs piscicoles. (A comparative study of methods for sampling fish in ponds.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.

Uzabakiriho, J.D., 1989. Etude hydrobiologique des lacs Rwanyakizinga,

Mihindi, Hago et Kivumba (dépression de l'Akagera, Rwanda). (Hydrobiological study of Lakes Rwanyakizinga, Mihindi, Hago and Kivumba (Akagera River Basin, Rwanda).) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.

Publication

Hanson, B.J., J.F. Moehl, K.L. Veverica, F. Rwangano, and M. Van Speybroeck, 1988. Pond culture of tilapia in Rwanda, a high altitude equatorial African country. 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, pp. 553–559.

Presentations

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

Rurangwa, E. and L. Verheust. Fish culture in Rwanda: A high altitude, developing country in central Africa. Presented to the International Aquaculture Conference and Trade Show at Dublin, Ireland, Jun 1991.

OREGON STATE UNIVERSITY

Theses

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

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

Rwangano, F., 1998. Growth and reproduction of *Oreochromis niloticus* (L.) in tropical aquatic microcosms at fluctuating temperature regimes. Ph.D. dissertation, Oregon State University, Corvallis, Oregon.

Publications

Balakrishnan, R., K. Veverica, and P. Nyirahabimana, 1992. Proceedings of the colloquium on Rwanda women in aquaculture. Kigembe Station, Rwanda. Women in International Development, Oregon State University, Corvallis, Oregon, 11 pp.

Balakrishnan, R., K. Veverica, and P. Nyirahabimana, 1993. Rwanda women in aquaculture: Context, contributions and constraints. Office of Women in International Development, Oregon State University, Corvallis, Oregon, 39 pp.

Balakrishnan, R., K. Veverica, P. Nyirahabimana, and R. Rainey, 1992. An approach to integrate gender variable in Rwanda PD/A CRSP. Women in International Development, Oregon State University, Corvallis, Oregon, 28 pp.

Bowman, J.R. and J.E. Lannan, 1995. Evaluation of soil pH-percent base saturation relationships for use in estimating the lime requirements of earthen aquaculture ponds. Journal of the World Aquaculture Society, 26(2):172–182.

Curtis, L.R., F.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, F.D., R.A. Tubb, and L.R. Curtis, 1986. Inhibition of hepatic UDP-glucuronyl transferase (UDP-GT) activity coincident with elevated plasma sex steroid concentrations during gonadal maturation in carp. In: R.S.V. Pullin and T. Bhukaswan (Editors), The Toxicologist, 6(1):553–559.

Sikoki, F.D., R.A. Tubb, and L.R. Curtis, 1988. Elevation of sex steroids and inhibition of UDP-glucuronyltransferase are out of phase during gonadal maturation in the common carp. Comparative Biochemistry and Physiology, 92(2):267–272.

Presentations

Balakrishnan, R. and P. Nyirahaimana. Rwanda women's role in integrated aquaculture systems for resource sustainability. Presented to the Farming Systems Research and Extension Symposium: working paper series at Michigan State University, East Lansing, Michigan, 1992.

Curtis, L., F. Diren, M. Hurley, and R. Tubb. Minimal residue levels after sex reversal of *Tilapia nilotica* by methyltestosterone but persistent alterations in hepatic detoxication systems. Presented to Federation of American Societies for Experimental Biology at Las Vegas, Nevada, Apr 1988.

Rwangano, F., M. Van Speybroeck, E. Rurangwa, K. Veverica, and B. Hanson. Fingerling production of *Tilapia nilotica* at the Rwasave Fish Culture Station of the National University of Rwanda. Presented to the World Aquaculture Society Meeting at Honolulu, Hawaii, 4–8 Jan 1988.

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

Tubb, R. The reduction of estradiol by liver enzymes in carp and rainbow trout. Presented to Toxicology Meetings, New Orleans, Mar 1986.

UNIVERSITY OF ARKANSAS AT PINE BLUFF

Publications

Engle, C.R., 1997. Optimal resource allocation by fish farmers in Rwanda. Journal of Applied Aquaculture, 7(1):1–17.

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

Hishamunda, N., C.M. Jolly, and C.R. Engle, 1996. Estimating *Oreochromis niloticus* production function for small-scale fish culture in Rwanda. Journal of Aquaculture in the Tropics, 11:49–57.

Presentation

Engle, C., D. Brown, and M. Thomas. Optimal resource allocation by fish farmers in Rwanda. Presented to the Tenth Biennial Research Symposium, Association of Research Directors at New Orleans, 1994.

SOUTHEAST ASIA

Indonesia

INSTITUT PERTANIAN BOGOR

Theses

Etnawati, N., 1987. The effect of *Oreochromis niloticus* Trewavas production by increasing surface area for attached microorganisms. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.

Gartini, T., 1986. Flow rate dependent changes in turbidity and phosphorus in the water conditioning system at Darmaga. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.

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, Institut Pertanian Bogor, Indonesia.

Haryani, G.S., 1985. The growth rate, mortality and feeding habits of *Tilapia nilotica* (L.). B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.

Litasari, L., 1985. The composition and abundance of macrobenthos in relation to pond productivity. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.

Radiastuti, F., 1986. The balance of nitrogen from an irrigation canal that flows through a water conditioning system in Darmaga. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.

Subyakto, S., 1985. The relationship between chlorophyll *a* and Secchi disk visibility in tilapia fish ponds at Darmaga, Bogor. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.

Suratman, I.F., 1985. Composition and abundance of zooplankton in *Tilapia nilotica* (L.) fish ponds fertilized with triple superphosphate at Darmaga. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
Tumbelaka, R., 1986. Primary productivity of aquaculture ponds at Darmaga. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
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, Institut Pertanian Bogor, Indonesia.
Yulianti, S., 1986. Removal of detergents in irrigation canal water by the water conditioning system at Darmaga, Bogor. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
Yulisto, 1985. Effect of fish predation on macrobenthos density in aquaculture ponds. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.

MICHIGAN STATE UNIVERSITY

Theses

Abdalla, A.A.F., 1989. The effect of ammonia on *Oreochromis niloticus* (Nile tilapia) and its dynamics in fertilized tropical fish ponds. Ph.D. dissertation, Michigan State University, East Lansing, Michigan.
Yusoff, F., 1987. Fish production, primary productivity and nutrient availability in fertilized fish ponds in Malaysia. Ph.D. dissertation, Michigan State University, East Lansing, Michigan.

Publications

Knud-Hansen, C.F., 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.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., T.R. Batterson, C.D. McNabb, Y. Hadiroseyani, 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.F., 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.F. Knud-Hansen, T.R. Batterson, and K. Jaiyen, 1991. A systematic 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, 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, 1985. Aquaculture-CRSP Indonesia project report, Cycle II, first 5-month experiment (Jan–Jun 1985). Michigan State University, East Lansing, Michigan, 105 pp.
McNabb, C.D., T.R. Batterson, M. Eidman, B.J. Premo, and K. Sumantadinata, 1985. Aquaculture-CRSP Indonesia project report second five-month experiment. Michigan State University, East Lansing, Michigan, 71 pp.
McNabb, C.D., T.R. Batterson, B.J. Premo, C.F. Knud-Hansen, H.M. Eidman, C.K. Lin, K. Jaiyen, J.E. Hanson, and R. Chuenpagdee, 1990. Managing fertilizers for fish yield in tropical ponds in Asia. In: R. Hirano and I. Hanyu (Editors), Proceedings of The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines, pp. 169–172.
Premo, B.J. and K. Sumantadinata, 1984. Laboratory manual of water quality techniques. Julia Press, Bogor, Indonesia, 43 pp.
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. The problems of water quality for Indonesian fisheries. Presented to the Seminar series of the Bogor Chapter of the Indonesian Fisheries Society at Bogor, Indonesia, 20 Nov 1985.
Guttman, H. and C.F. Knud-Hansen. Fish pond management by algal assay. Presented to the World Aquaculture Society Meeting at Orlando, Florida, May 1992.
McNabb, C.D. Application of limnological technology to fish pond management. Presented to the National Institute of Biological Science at Bogor, Indonesia, Dec 1984.
McNabb, C.D. Limnology of fish ponds in Java. Presented as part of the Visiting Scientists Seminar Series to College of Fisheries and Marine Science, Agricultural University of Malaysia at Serdang, Malaysia, Feb 1986.
McNabb, C.D. Carbon limitation in fish culture ponds in Indonesia. Presented as part of the Visiting Scientists Seminar Series, at Lake Biwa Research Center, Shiga University, Otsu, Japan, Mar 1986.
McNabb, C.D., T.R. Batterson, B.J. Premo, and J.R. Craig. Photosynthetically active radiation in tropical and temperate zone habitats. Presented to the 88th Annual Meeting of the Michigan Academy of Science, Arts, and Letters at Grand Rapids, Michigan, Mar 1984.
Sumantadinata, K. Genetic characteristics of strains of Indonesian carps. Presented to Special Symposium of the Japanese Fisheries Society at Tokyo, Japan, Feb 1985.

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, Jun–Aug 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, Mar 1986. Collaborative aquaculture research: Institut 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, Mar 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., 23–29 Nov 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., Mar 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. Suwignjo, D.L. Garling, K. Sumawidjaja, H.C. Lampe, S.M.H. Simandjuntak, R.E. Kinnunen, R.R. Nitibaskara, 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)

The Philippines

CENTRAL LUZON STATE UNIVERSITY

Theses

Falla, J.I.B., 2002. Hematological characteristics of genetically male tilapia (GMT) strain of Nile tilapia (*Oreochromis niloticus*) under intensive tank culture. B.S. thesis, Central Luzon State University, Philippines.

Lanuza, J.A.D., 2000. Effect of stocking sizes on the growth and survival performance of Nile tilapia (*Oreochromis niloticus*) in ponds. Undergraduate thesis, Central Luzon State University, Muñoz, Nueva Ecija, Philippines.

Publications

Bolivar, R.B. and G.F. Newkirk, 2000. Response to selection for body weight of Nile tilapia (*Oreochromis niloticus*) in different culture environments. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 12–23.

Bolivar, R.B., EB.T. Jimenez, and C.L. Brown, 2000. Tilapia feeding strategy to optimize production in ponds. Fisheries and Aquatic Resources Gazette, 2(2):2–3.

Brown, C.L., R. Bolivar, EB. T. Jimenez, and J. Szyper, 2000. Timing of the onset of supplemental feeding of Nile tilapia (*Oreochromis niloticus*) in ponds. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 237–240.

Presentation

Bolivar, R.B. Overview of Tilapia Production in the Philippines. Presentation given at the International Technical and Trade Symposium on Tilapia at Hainan, Haikou, China, on 17–22 Apr 2002.

UNIVERSITY OF HAWAII

Publications and Reports

Carpenter, K.E., A.W. Fast, V.L. Corre, J.W. Woessner, and R.L. Janeo, 1986. The effects of water depth and circulation on the water quality and production of *Penaeus monodon* in earthen ponds. Proceedings of the First Asian Fisheries Forum at Manila, Philippines, 26–31 May 1986, pp. 21–24.

Chiu, Y., M.P. Macahilig, and M.A. Sastrillo, 1986. Preliminary studies of factors affecting the feeding rhythm of milkfish (*Chanos chanos* Forskal). Proceedings of the First Asian Fisheries Forum Meeting at Manila, Philippines, 26–31 May 1986, pp. 547–550.

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

Fast, A.W., K.E. Carpenter, V.J. Estilo, and H.J. Gonzales, 1988. Effects of water depth and artificial mixing on dynamics of Philippines brackish water shrimp ponds. Aquacultural Engineering, 7:349–361.

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

Hopkins, K.D. and J.D. Bowman, 1993. A research methodology for integrated agriculture-aquaculture farming systems. In: J.K. Wang (Editor), Techniques for Modern Aquaculture. Proceedings of an Aquacultural Engineering Conference, 21–23 Jun 1993, at Spokane, Washington. American Society of Agricultural Engineers. St. Joseph, Michigan, pp. 89–98.

Hopkins, K.D. and D. Pauly, 1993. Instantaneous mortalities and multivariate models: Applications to tilapia culture in saline water. In: M. Prein, G. Hulata and D. Pauly, (Editors), Multivariate methods in aquaculture research: Case studies of tilapias in experimental and commercial systems. ICLARM, Manila, Philippines, pp. 105–111.

Szyper, J.P., 1996. Comparison of three mixing devices in earthen culture ponds of four different surface areas. Aquacultural Engineering, 15(5):381–396.

Szyper, J.P., 1996. Observations and model predictions of daily areal primary production in a eutrophic brackish water culture pond. Ecological Modelling International Journal on Ecological Modelling and Systems Ecology, 88:83–92.

Young, M.J.A., A.W. Fast, and P. Olin, 1989. Induced maturation and spawning of the Chinese catfish (*Clarias fuscus*). Journal of the World Aquaculture Society, 20(1):7–11.

Presentation

Fast, A.W., K.E. Carpenter, F.J. Estilo, and H.J. Gonzales. Effects of water depth on dynamics of Philippines brackish water shrimp ponds. Presented to the World Aquaculture Society Meeting at Guayaquil, Ecuador, Jan 1987.

UNIVERSITY OF THE PHILIPPINES IN THE VISAYAS

Thesis

Pahila, I.G., 1986. Sorbed and soil solution phosphorus in relation to the optimum phosphorus level of lab-lab in some brackish water ponds. M.S. thesis, Dept. of Fisheries, University of the Philippines, Visayas, Philippines.

Publications

Fortes, R.D., V.L. Corre, Jr., and E. Pudadera, 1986. Effects of fertilizers and feeds as nutrient sources on *Oreochromis niloticus* production in Philippine brackish water ponds. Proceedings of the First Asian Fisheries Forum at Manila, Philippines, May 1986, pp. 121–124.

Minsalan, C.L.O. and Y.N. Chiu, 1986. Effects of teaseed cake on selective elimination of finfish in shrimp ponds. Proceedings of the First Asian Fisheries Forum at Manila, Philippines, May 1986, pp. 79–82.

Sanares, R.C., S.A. Katase, A.W. Fast, and K.E. Carpenter, 1986. Water quality dynamics in brackish water shrimp ponds with artificial aeration and circulation. Proceedings of the First Asian Fisheries Forum at Manila, Philippines, May 1986, pp. 83–86.

Ver, L.M.B. and Y.N. Chiu, 1986. The effect of paddlewheel aerators on ammonia and carbon dioxide removal in intensive pond culture. Proceedings of the First Asian Fisheries Forum, Manila, Philippines, 26–31 May 1986, pp. 97–100.

Thailand

ASIAN INSTITUTE OF TECHNOLOGY

Theses

Ahmed, S., 1995. Assessment of chlorine as a piscicide in freshwater fish culture. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

Amechi, M.E.O., 1995. An assessment of by-catch biomass in experimental fish ponds. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

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

Arifin, Z., 1996. Efficacy of liming and uses of liming materials for shrimp pond management. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

Athauda, A.R.S.B., 2000. Ultra-sound immersion techniques to improve the efficiency of sex inversion of male tilapia population. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

Baouthong, P., 1995. The effect of feeding regime on growth and body composition of shrimp (*Penaeus monodon*). M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

Barte, M., 1996. Effect of aeration on water quality and fish growth in intensive culture of Nile tilapia. M.S. thesis, Asian Institute of

Technology, Bangkok, Thailand.
Boonsong, S., 1990. Role of zooplankton in feeding juvenile tilapia (*Oreochromis niloticus*). M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Cao, T.B., 1998. Development of pond culture of Thai Nile tilapia (*Oreochromis niloticus* L.) and its marketability in Hanoi, Vietnam. Ph.D. dissertation, Asian Institute of Technology, Bangkok, Thailand.
Chan, R., 1997. Interactive effect of feeding frequency and time of feeding for tilapia. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Chughtai, M.A., 1995. Effects of water spinach (*Ipomoea aquatica*) on nutrient regime and fish growth. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Guttman, H., 1991. Assessment of nutrient limitation in fertilized fish ponds by algal assay. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Islam, Md.R., 1995. A field survey of the factors involved in the use of ponds for fish culture in Bangladesh, with emphasis on water quality. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Jatuporn, B., 1997. Effect of aeration on water quality and fish production in fertilized ponds. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Mon, A.A., 2000. Use of lotus (*Nelumbo nucifera*) for nutrient retrieval from pond mud. M.S. Thesis, Asian Institute of Technology, Bangkok, Thailand.
Muthuwan, V., 1991. Nutrient budget and water quality in intensive marine shrimp culture ponds. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Nadtirom, P., 2001. Comparison of growth performance of different sex genotypes (XX and XY) of Nile tilapia (*Oreochromis niloticus*) and the effect of androgen treatment. M.S. thesis, Asian Institute of Technology, Pathumthani, Thailand.
Narong, V., 1990. Effects of phytoplankton on nursing walking catfish fry in static and flow-through water systems. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Nguyen, P.H., 1996. Effects of salinity on fertilization for tilapia culture. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
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.
Rachada, M., 1997. Turbidity in fish ponds in northeast Thailand. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Raghunath, B. Shivappa, 1997. Efficacy of probiotics and disinfectant in controlling luminescent bacteria in shrimp postlarvae under normal and stressed conditions. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Rai, S., 1997. Co-culture of walking catfish with Indian major carps. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Rao, V.G.T., 1989. Gonadal development in environmentally induced breeding of walking catfish *Clarias batrachus* (Linnaeus). M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Rungreungwudhikrai, E.O., 1995. Characterization and classification of off-flavour of Nile tilapia. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Ruttanagosrigit, W., 1997. Organic matter dynamics in a closed intensive culture system for black tiger prawn (*Penaeus monodon*). Ph.D. dissertation, 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., 1990. Influence of stocking density on red tilapia production in a recirculation system. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Thakur, D.P., 1996. Water quality and nutrient budget in closed intensive shrimp culture systems. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Ungsethaphan, T., 1995. An on-farm trial to investigate feeding strategies for Nile tilapia (*Oreochromis niloticus*) broodfish. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Vuthana, H., 1995. Fish pond turbidity in Cambodia. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Weerasooriya, A.C., 2001. Effects of AquaMats on Nile tilapia (*Oreochromis niloticus*) fry in earthen ponds. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Wirat, J., 1990. The role of sediments in pond fertility. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Xie, J.J., 1995. Alternative methods for maggot production. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
Yi, Y., 1997. An integrated rotation culture system for fattening large Nile tilapia (*Oreochromis niloticus*) in cages and nursing small Nile tilapia in open ponds. Ph.D. dissertation, Asian Institute of Technology, Bangkok, Thailand.

Publications

Bart, A.N., 2001. The use of ultrasound to enhance transport of compound into fish and fish embryos: A review. Asian Fish. Soc., 14(4):36–45.
Bart, A.N., S. Athauda, M. Fitzpatrick, and W.M. Contreras-Sánchez, 2002. The use of ultrasound to enhance sex reversal in tilapia using immersion protocol. World Aquacult. Soc. (in review)
Bart, A., W.M. Contreras-Sánchez, and M. Fitzpatrick. Ultrasound enhanced masculinization of Nile tilapia, *Oreochromis niloticus*, in immersion protocol. J. World Aquacult. Soc. (in review)
Cao, T.B., C.K. Lin, and H. Demaine. Evaluation of low-cost supplemental diets for culture of Nile tilapia in North Vietnam: I. Selection of supplemental diets. Journal of Asian Fisheries Science. (in revision)
Cao, T.B., C.K. Lin, and H. Demaine. Evaluation of low-cost supplemental diets for culture of Nile tilapia in North Vietnam: II. Supplemental feeding rates in fertilized ponds. Journal of Asian Fisheries Science. (in revision)
Edwards, P., C.K. Lin, and A. Yakupitiyage, 2000. Semi-intensive pond aquaculture. In: M.C.M. Beveridge and B.J. McAndrew (Editors), Tilapias: Biology and Exploitation. Kluwer Academic Publishers, Netherlands, pp. 377–403.
Liao, I.C. and C.K. Lin (Editors), 2000. Proceedings of the First International Symposium on Cage Aquaculture in Asia. Asian Fisheries Society, Manila, the Philippines. 312 pp.
Mon, A.A., Y. Yi, and C.K. Lin. Use of lotus (*Nelumbo nucifera*) for nutrient retrieval from fishpond mud. Aquacult. Eng. (in review)
Nadtirom, P., Y. Yi, and G.C. Mair. Comparison of growth performance of different sex genotypes (XX and XY) of Nile tilapia (*Oreochromis niloticus L.*) and the effect of androgen treatment. Aquaculture. (in review)
Yi, Y. and C.K. Lin, 2000. Analyses of various inputs for pond culture of Nile tilapia (*Oreochromis niloticus*): Profitability and possible environmental impacts. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 247–257.
Yi, Y. and C.K. Lin, 2001. Effects of biomass of caged Nile tilapia (*Oreochromis niloticus*) and aeration on the growth and yields in a cage-cum-pond integrated culture system. Aquaculture, 195:253–267.
Yi, Y. and C.K. Lin, 2001. Low-cost fertilization in inland pond aquaculture. In: IIRR, IDRC, FAO, NACA, and ICLARM, Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book. International Institute of Rural Reconstruction, International Development Research Center, Food and Agriculture Organization of the United Nations, Network of Aquaculture Centers in Asia-Pacific, and International Center for Living Aquatic Resources and Management, pp. 250–253.
Yi, Y. and C.K. Lin, 2001. Cage-cum-pond—Integrated aquaculture systems recycle wastes. Global Aquaculture Advocate, 4(6):65–66.
Yi, Y. and A. Yakupitiyage, 2001. Feeds in small-scale aquaculture. In: IIRR, IDRC, FAO, NACA, and ICLARM, Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book. International Institute of Rural Reconstruction, International Development Research Center, Food and Agriculture Organization of the United Nations, Network of Aquaculture Centers in Asia-Pacific, and International Center for Living Aquatic Resources and Management, pp. 263–268.
Yi, Y., C.K. Lin, and J.S. Diana, 2001. Integrating intensive and semi-intensive culture system to utilize feeding waste. In: IIRR, IDRC, FAO,

NACA, and ICLARM, Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book. International Institute of Rural Reconstruction, International Development Research Center, Food and Agriculture Organization of the United Nations, Network of Aquaculture Centers in Asia-Pacific, and International Center for Living Aquatic Resources and Management, pp. 250–253.

Yi, Y., C.K. Lin, and J.S. Diana. Comparison of economic returns for various strategies of Nile tilapia (*Oreochromis niloticus*) pond culture. Asian Fisheries Science. (in review)

Yi, Y., C.K. Lin, and J.S. Diana. Effects of clay turbidity on fertilization, and analyses of techniques to mitigate turbidity problems. Aquacult. Eng. (in review)

Yi, Y., C.K. Lin, and J.S. Diana. Hybrid catfish (*Clarias macrocephalus* x *C. gariepinus*) and Nile tilapia (*Oreochromis niloticus*) culture in an integrated pen-cum-pond system: Growth performance and nutrient budgets. Aquaculture. (in press)

Yi, Y., C.K. Lin, and J.S. Diana. Optimization of nitrogen fertilization rate and carrying capacity in Nile tilapia (*Oreochromis niloticus*) ponds. J. World Aquacult. Soc. (in review)

Yi, Y., C.K. Lin, and J.S. Diana, 2002. Recycling pond mud nutrients in integrated lotus-fish culture. Aquaculture, 212(1–4):213-226.

Yi, Y., C.K. Lin, and J.S. Diana. Waste recycling in fish pond culture through integrated cage-cum-pond and pen-cum-pond culture systems. In: Proceedings of the Third World Fisheries Congress. (in press)

Presentations

Bart, A.N. Seed production of farmed fish: Critical issues for Asia. Presented to the Ag-Asia 2000 Conference, Bangkok, Thailand, 9–12 Nov 2000.

Bart, A.N. The use of ultrasound in mass marking of fish population, drug delivery, DNA transfer and cryopreservation of fish embryos. Presented to the International Conference on Advanced Technologies in Fisheries and Marine Sciences at Nagercoli, India, 2–6 Feb 2001.

Bart, A.N. Progress towards cryopreservation of fish embryos. Presented to World Aquaculture 2002 at Beijing, China, 23–27 Apr 2002.

Bart, A.N. and A.K. Htin, 2002. Advances in cryopreservation of zebrafish, *Brachydanio rerio*, embryos. Presented to Aquaculture America 2002 at San Diego, California, 27–30 Jan 2002.

Bart, A.N., A.R.S.B. Athauda, M.S. Fitzpatrick, and W.M. Contreras-Sánchez. Ultrasound enhanced masculinization of Nile tilapia in immersion protocol. Presented to World Aquaculture 2002 at Beijing, China, 23–27 Apr 2002.

Chen, G.Z., Y. Yi, Z.W. Wu, H. Miu, and Q.M. Zhang, 2001. Recent development of integrated rice-fish culture in China. Presented to the Sixth Asian Fisheries Forum at Kaoshiung, Taiwan, 25–30 Nov 2001.

Lin, C.K. and Y. Yi, 2001. Development in integrated aquaculture in Southeast Asia. In: L.M.B. Garcia (Editor), Responsible Aquaculture Development in Southeast Asia. Proceedings of the Seminar-Workshop on Aquaculture Development in Southeast Asia, 12–14 Oct 1999. Southeast Asian Fisheries Development Center (SEAFDEC), Iloilo, Philippines, pp. 77–88.

Lin, C.K. and Y. Yi. Minimizing environmental impacts and reuse of pond effluents and mud. Special Volume for the Proceedings of AIP Workshop: Management of Aquaculture Effluents. Aquaculture. (in review)

Luu, L.T., Y. Yi, C.K. Lin, J.S. Diana, and N.X. Cuong. Assessing watershed ponds for aquaculture development: A case study in Thai Nguyen Province, Vietnam. Presented at the annual meeting of WAS in Beijing, China, 23–27 Apr 2002.

Nadtirom, P., Y. Yi, and G. Mair. Comparison of growth performance of different sex genotypes (XX and XY) of Nile tilapia (*Oreochromis niloticus L.)* and the effect of androgen treatment. Presented to World Aquaculture 2002 at Beijing, China, 23–27 Apr 2002.

Phuong, N.T., Y. Yi, C.K. Lin, and J.S. Diana. Current status of *Pangasius* catfish cage culture in Vietnam. Presented to World Aquaculture 2002 at Beijing, China, 23–27 Apr 2002.

Wahab, M.A., Y. Yi, C.K. Lin, and J.S. Diana. Comparison of effects of different fertilization regimes on fish production, water quality, effluent and economic returns in Bangladesh. Presented to World Aquaculture 2002 at Beijing, China, 23–27 Apr 2002.

Wu, Z.W., J.W. Guo, and Y. Yi. Current status and sustainability of cage culture in reservoirs: A case study in China. Presented to the First International Symposium on Cage Aquaculture in Asia at Tungkang, Taiwan, 2–6 Nov 1999.

Wu, Z.W. and Y. Yi, 2001. Culture-based reservoir fisheries in China. Presented to Aquaculture America 2002, San Diego, California, 27–30 Jan 2002.

Wu, Z.W. and Y. Yi, 2001. Fertilization regime and application method in reservoirs. Presented to the Sixth Asian Fisheries Forum at Kaoshiung, Taiwan, 25–30 Nov 2001.

Yi, Y., C.K. Lin, and J.S. Diana. Comparison of economic return, nutrient utilization efficiency and environmental impact among different culture systems of Nile tilapia *Oreochromis niloticus*. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.

Yi, Y., C.K. Lin, and J.S. Diana, 2001. Red tilapia (*Oreochromis* sp.) culture in brackishwater ponds. Presented to the Sixth Asian Fisheries Forum at Kaoshiung, Taiwan, 25–30 Nov 2001.

AUBURN UNIVERSITY

Publications

Boyd, C.E. and P. Munsiri, 1996. Phosphorus adsorption capacity and availability of added phosphorus in soils from aquaculture areas in Thailand. Journal of the World Aquaculture Society, 27(2):160–167.

Boyd, C.E. and P. Munsiri, 1997. Water quality in laboratory soil-water microcosms with soils from different areas of Thailand. Journal of the World Aquaculture Society, 28(2):165–170.

Presentation

Boyd, C.E. Water quality in laboratory soil-water microcosms with soils from different areas of Thailand. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.

CENTRAL LUZON STATE UNIVERSITY

Presentation

Sevilleja, R. Adoption and economics of tilapia farming technology in the Philippines. Presented to the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET 2000) at Corvallis, Oregon, 10–13 Jul 2000.

MICHIGAN STATE UNIVERSITY

Publications

Knud-Hansen, C.F., 1992. Analyzing standard curves in the chemistry of waters used for aquaculture. NAGA, 15:16–19.

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. and A.K. Pautong, 1993. On the role of urea in pond fertilization. Aquaculture, 114:273–283.

Knud-Hansen, C.F. and T.R. Batterson, 1994. Effect of fertilization frequency on the production of Nile tilapia (*Oreochromis niloticus*). Aquaculture, 123:271–280.

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* (L.). Aquaculture and Fisheries Management, 24:483–493.

Knud-Hansen, C.F., K.D. Hopkins, and H. Guttman. A comparative analysis of the fixed-input, computer modeling, and algal bioassay approaches for identifying pond fertilization requirements. Aquaculture. (in press)

McNabb, C.D., T.R. Batterson, C.K. Lin, K. Jaiyen, J.E. Hanson, and R. Chuenpagdee, 1989. Fish yield with nitrogen supplemented organic fertilizers [abstract]. Journal of the World Aquaculture Society, 20:56A.

Shevgoor, L., C.F. Knud-Hansen, and P.E. Edwards, 1994. An assessment of the role of buffalo manure for pond culture of tilapia, part 3: Limiting factors. Aquaculture, 126:107–118.

Shrestha, M.K. and C.F. Knud-Hansen, 1994. Increasing attached microorganism biomass as a management strategy for Nile tilapia (*Oreochromis niloticus*) production. Aquacultural Engineering, 13:101–108.

Presentations

Knud-Hansen, C.F. and C.K. Lin. Strategies for stocking Nile tilapia (*Oreochromis niloticus*) in fertilized ponds. Presented to the Third International Symposium on Tilapia in Aquaculture at Abidjan, Côte d'Ivoire, Africa, Nov 1991.

Knud-Hansen, C.F. and A.K. Pautong. The role of urea in fishpond fertilization. Presented to the World Aquaculture Society Meeting at Orlando, Florida, May 1992.

Other

Knud-Hansen, C.F. and T.R Batterson, 1987-1992. Thailand PD/A CRSP data diskettes for Work Plans IV-VI experiments using LOTUS 123.

UNIVERSITY OF HAWAII

Publications

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

Hopkins, K.D. and A. Yakupitiyage, 1991. Bias in seine sampling of tilapia. Journal of the World Aquaculture Society, 22(4):260–262.

Hopkins, K.D., M.L. Hopkins, and D. Pauly, 1988. A multivariate model of tilapia growth, applied to seawater tilapia culture in Kuwait. 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, pp. 29–39.

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. Marine Ecology Progress Series, 94:229–238.

Szyper, J. and K.D. Hopkins, 1996. 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, Manila, Philippines, pp. 152–159.

Szyper, J.P. and C.K. Lin, 1990. Techniques for assessment of stratification and effects of mechanical mixing in tropical fish ponds. Aquacultural Engineering, 9:151–165.

Szyper, 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, 22:385–396.

Szyper, J., J. 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.

Szyper, J.P., C.K. Lin, D. Little, S. Setboonsarng, A. Yakupitiyage, P. Edwards, and H. Demaine, 1995. Techniques for efficient and sustainable mass production of tilapia in Thailand. Proceedings, Sustainable Aquaculture 95. Pacific Congress on Marine Science and Technology, pp. 349–356.

Presentation

Emberson, C. and K. Hopkins. Intensive culture of *Penaeus stylirostris* in plastic-lined tanks. Poster presented to the World Aquaculture Society Meeting at San Diego, California, 1–4 Feb 1995.

UNIVERSITY OF MICHIGAN

Theses

Tain, F.H., 1999. Impacts of aquaculture extension on small-scale *Oreochromis niloticus* production in northeastern Thailand. M.S. thesis, The University of Michigan, Ann Arbor, Michigan.

Wirat, J., 1996. Nutritional input of nitrogen in fish ponds through fixation by blue-green algae. Ph.D. dissertation, Asian Institute of Technology, Bangkok, Thailand.

Publications

Buurma, B.J. and J.S. Diana, 1994. The effects of feeding frequency and handling on growth and mortality of cultured walking catfish, *Clarias fuscus*. Journal of the World Aquaculture Society, 25:175–182.

Cao, T.B. and C.K. Lin, 1995. Shrimp culture in Vietnam. World Aquaculture, 26:27–33.

Diana, J.S., 1993. Conservation and utilization of genetic resources in capture and culture fisheries. 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 Science, Washington, DC, pp. 89–104.

Diana, J.S., 1995. Biology and Ecology of Fishes. Biological Sciences Press, Carmel, Indiana, 441 pp.

Diana, J.S. and A. Fast, 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 C.K. Lin, 1998. The effects of fertilization on growth and production of Nile tilapia in rain-fed ponds. Journal of the World Aquaculture Society, 29:405–413.

Diana, J.S. and D. Ottey, 1983. Biological principles of pond culture: Fish. In: J.E. Lannan, R.O. Smitherman, and G. Tchobanoglous (Editors), Principles and Practices of Pond Aquaculture: A State of the Art Review. Oregon State University Press, Corvallis, Oregon, pp. 55–66.

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 and Aquatic Sciences, 48(2):183–190.

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

Diana, J.S., C.K. Lin, and K. Jaiyen, 1994. Supplemental feeding of tilapia in fertilized ponds. Journal of the World Aquaculture Society, 25:497–506.

Diana, J.S., C.K. Lin, and P.J. Schneeberger, 1991. Relationships among nutrient inputs, water nutrient concentrations, primary production, and yield of *Oreochromis niloticus* in ponds. Aquaculture, 92:323–341.

Diana, J., C.K. Lin, and Y. Yi, 1996. Timing of supplemental feeding for tilapia production. Journal of the World Aquaculture Society, 27:410–419.

Diana, J.S., P.J. Schneeberger, and C.K. Lin, 1988. Relationships between primary production and yield of tilapia in ponds. 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, pp. 1–6.

Edwards, P., C.K. Lin, and A. Yakupitiyage, 2000. Semi-intensive pond aquaculture. In: M.C.M. Beveridge and B.J. McAndrew (Editors), Tilapias: Biology and Exploitation. Kluwer Academic Publishers, Dordrecht, the Netherlands, pp. 377–403.

Lin, C., 1983. Biological principles of pond culture: Phytoplankton and macrophytes. In: J.E. Lannan, R.O. Smitherman, and G. Tchobanoglous (Editors), Principles and Practices of Pond Aquaculture: A State of the Art Review. Oregon State University Press, Corvallis, Oregon, pp. 39–43.

Lin, C.K., 1986. Acidification and reclamation of acid sulfate soil fishponds in Thailand. In: J.L. MacLean, L.B. Dizon, and L.V. Hosillos (Editors), The First Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines, pp. 71–74.

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

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

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

Lin, C.K., 1990. Integrated culture of walking catfish (*Clarias macrocephalus*) and tilapia (*Oreochromis niloticus*) in earthen ponds. In: R. Hirano and I. Hanyu (Editors), Proceedings of the Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines, pp. 209–212.

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., M.K. Shrestha, Y. Yi, and J.S. Diana, 2001. Management to minimize the environmental impacts of pond effluent: Harvest draining techniques and effluent quality. Aquacultural Engineering, 25(2):125–135.
Lin, C.K. and J.S. Diana, 1995. Co-culture of catfish (*Clarias macrocephalus* × *C. gariepinus*) and tilapia (*Oreochromis niloticus*) in ponds. Aquatic Living Resources, 8:449–454.
Lin, C.K. and K. Kaewpaitoon, 2000. An overview of freshwater cage culture in Thailand. In: I.C. Liao and C.K. Lin (Editors), Proceedings of the First International Symposium on Cage Aquaculture in Asia. Asian Fisheries Society, Manila, the Philippines, pp. 237–242.
Lin, C.K. and Y. Yi. Development of integrated aquaculture in Southeast Asia. In: Proceedings of the SEAFDEC Workshop. (in press)
Lin, C.K., J.S. Diana, and Y. Yi. Stocking densities and fertilization regimes for Nile tilapia (*Oreochromis niloticus*) production in ponds with supplemental feeding. Journal of the World Aquaculture Society. (in review)
Lin, C.K., K. Jaiyen, and W. Muthuwana, 1990. Integrated culture of intensive and semi-intensive aquaculture: Concept and example. Thai Fisheries Gazette, 43:425–430.
Lin, C.K., V. Tansakul, and C. Apinhapath, 1988. Biological nitrogen fixation as a source of nitrogen input in fishponds. 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, pp. 53–58.
Liu, K.M. and W.Y.B. Chang, 1992. Bioenergetic modelling of effects of fertilization, stocking density, and spawning on growth of the Nile tilapia, *Oreochromis niloticus* (L.). Aquaculture and Fisheries Management, 23:291–301.
Muthuwana, W., V. Tansakul, and C.K. Lin, 1986. Nutrient dynamics between inorganic and organic fertilized ponds for tilapia culture. Proceedings of the Kasetsart University Agricultural Conference, Jan 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.
Nguyen, M.N. and C.K. Lin, 1996. *Penaeus monodon* seed production in central Vietnam. World Aquaculture, 27:6–18.
Shrestha, M.K. and C.K. Lin, 1996. Phosphorus fertilization strategy in fish ponds based on sediment phosphorus saturation level. Aquaculture, 142:207–219.
Shrestha, M. and C.K. Lin. Recycling of pond mud nutrients to cowpea and taro crops. Nutrient Cycling in Agri-Ecosystems. (submitted)
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. Aquaculture Engineering, 11:1–22.
Suresh, A.V. and C.K. Lin, 1992. Tilapia culture in saline waters: A review. Aquaculture, 106:201–226.
Tavarutmaneegul, P. and C.K. Lin, 1988. Breeding and rearing of sand goby (*Oxyeleotris marmoratus*, Blk.) fry. Aquaculture, 69:299–305.
Yi, Y., 1998. A bioenergetics growth model for Nile tilapia (*Oreochromis niloticus*) based on limiting nutrients and fish standing crop in fertilized ponds. Aquacultural Engineering, 18:157–173.
Yi, Y., 1999. Modeling growth of Nile tilapia (*Oreochromis niloticus*) in a cage-cum-pond integrated culture system. Aquacultural Engineering, 21:113–133.
Yi, Y. and C.K. Lin, 2000. Integrated cage culture in ponds: Concepts, practice and perspectives. In: I.C. Liao and C.K. Lin (Editors), Proceedings of the First International Symposium on Cage Aquaculture in Asia. Asian Fisheries Society, Manila, the Philippines, pp. 217–224.
Yi, Y. and C.K. Lin. Analyses for various inputs for pond culture of Nile tilapia (*Oreochromis niloticus*): Profitability and possible environmental impacts. Aquaculture Economics and Management. (accepted)
Yi, Y. and C.K. Lin. Comparative economic analyses for various grow-out strategies of Nile tilapia (*Oreochromis niloticus*) in earthen ponds. Aquaculture Economics and Management. (accepted)
Yi, Y., C.K. Lin, and J.S. Diana, 1996. Influence of Nile tilapia (*Oreochromis niloticus*) stocking density in cages on their growth and yield in cages and in ponds containing the cages. Aquaculture, 146:205–215.

Presentations

Alimuzaman, C. and C.K. Lin. Aeration effects on erosion and water circulation in round and rectangular ponds. Presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.
Diana, J.S. and C.K. Lin. Effects of fertilization rate on primary production and yield of tilapia in ponds. Presented to the World Aquaculture Society Meeting at Honolulu, Hawaii, Jan 1988.
Diana, J.S. and C.K. Lin. Supplemental feeding for production of Nile tilapia *Oreochromis niloticus*. Presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.
Diana, J.S., C.K. Lin, and D. Dettweiler. Cascading trophic interactions: A test of the hypothesis using tilapia culture data. Presented to the World Aquaculture Society Meeting at Los Angeles, California, Feb 1989.
Kaewprakaisaengkul, C., C.K. Lin, and Y. Yi. Construction and application of hapa washer. Poster presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10–14 Nov 1998.
Lin, C.K. Status of aquaculture and fisheries management in Mekong Delta. Presented to the International Symposium on Mahakum Delta at Jakarta, Indonesia, 4 Apr 2001.
Lin, C.K. and S. Auworatham. Effects of inorganic and organic fertilizers on zooplankton production in tilapia ponds. Presented to the 25th Kasetsart University Conference at Bangkok, Thailand, 1987.
Lin, C.K. and J.S. Diana. Fertilization effects on pond carrying capacity in extensive culture of tilapia (*Oreochromis niloticus*). Presented to the Second International Symposium on Tilapia in Aquaculture at Bangkok, Thailand, 1987.
Lin, C.K. and S. Kaewchum. Application of bioremediation in intensive culture of black tiger shrimp (*Penaeus monodon*). Presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.
Lin, C.K. and K. Kaewpaitoon. An overview of freshwater cage culture in Thailand. Presented to the First International Symposium on Cage Aquaculture in Asia at Tungkang, Taiwan, 2–6 Nov 1999.
Lin, C.K. and J. Szyper. Stratification of temperature and dissolved oxygen in tropical fish ponds. Presented to the World Aquaculture Meeting at Halifax, Jun 1990.
Lin, C.K. and Y. Yi. Comparative economic analyses for different grow-out strategies of Nile tilapia in earthen ponds. Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10–14 Nov 1998.
Lin, C.K. and Y. Yi. Development of integrated aquaculture in Southeast Asia. Presented to the Workshop on Responsible Aquaculture Development in Southeast Asia at the Southeast Asian Fisheries Development Center (SEAFDEC), Iloilo, Philippines, 11–15 Oct 1999.
Lin, C.K., S. Auworatham, and V. Tansakul. Dietary consumption of zooplankton by tilapia in fertilized ponds. Presented to the Thai Fisheries Academy Seminar, 1986.
Lin, C.K., M. Boonyaratpalin, and Y. Musig. Biological characteristics of *Macrobrachium rosenbergii* (de Man) in relation to pond production and marketing. Presented to the First Asian Fisheries Society Forum at Manila, Philippines, May 1986.
Lin, C.K., E. Sae-Loaw, and V. Tansakul. Rearing post-larvae of *Macrobrachium rosenbergii* at high stocking density in concrete tanks. Presented to the 25th Kasetsart University Conference at Bangkok, Thailand, 1987.
Lin C.K., Y. Yi, and J.S. Diana. Effects of management strategy on nutrient budgets in Nile tilapia (*Oreochromis niloticus*) ponds. Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10–14 Nov 1998.
Lin C.K., M.K. Shrestha, J.S. Diana, and D.P. Thakur. Management to minimize the environmental impacts of pond draining: Harvest draining technique and effluent quality, Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10–14 Nov 1998.
Lin, C.K., V. Tansakul, W. Muthuwana, and S. Auworatham. Production and utilization of organic carbon in tilapia culture and ponds. Presented to the Thai Fisheries Academy Seminar, 1986.
Lin, C.K., W. Muthuwana, V. Tansakul, S. Auworatham, and C. Apinapat. Nutrient dynamics between inorganic and organic fertilized ponds for tilapia culture. Presented to the Thai Fisheries Academy Seminar, 1986.
Musig, Y., M. Boonyaratpalin, and C.K. Lin. Water quality in *Macrobrachium* growout ponds. Presented to the 25th Kasetsart University Conference at Bangkok, Thailand, 1987.

Muthuwana, W. and C.K. Lin. Water quality and nutrient budget in intensive shrimp culture ponds. Presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.
Pant J., P. Promthong, C.K. Lin, and H. Demaine. Fertilization of ponds with inorganic fertilizers: Low cost technologies for small-scale farmers. Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10–14 Nov 1998.
Tansakul, V., T. Sae-Lee, and E. Sae-Loaw. Acute toxicity and treatment effect of formalin on early larval prawns, *Macrobrachium rosenbergii* (de Man). Presented to the 25th Kasetsart University Conference at Bangkok, Thailand, 1987.
Yi, Y. An integrated cage culture system in earthen ponds: A bioenergetics growth model for Nile tilapia. Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10–14 Nov 1998.
Yi, Y. A bioenergetics growth model for Nile tilapia (*Oreochromis niloticus*) based on limiting nutrients and fish standing crop in fertilized ponds. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
Yi, Y. and C.K. Lin. An integrated cage culture system in earthen ponds: Stocking densities of caged Nile tilapia (*Oreochromis niloticus*). Presented to the Fourth Asian Fisheries Forum at Beijing, China, Oct 1995.
Yi, Y. and C.K. Lin. An integrated cage culture system in earthen ponds: biomass of caged Nile tilapia (*Oreochromis niloticus*). Presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.
Yi, Y. and C.K. Lin. An integrated rotation culture system for fattening large Nile tilapia in cages and nursing small Nile tilapia in open ponds. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
Yi, Y. and C.K. Lin. Integrated cage culture in ponds: Concepts, practice and perspectives. Presented to the First International Symposium on Cage Aquaculture in Asia at Tungkang, Taiwan, 2–6 Nov 1999.
Yi, Y., C.K., Lin, J.S. Diana, R.B. Shivappa, and M.A.K. Chowdhury. Management of organic matter and nutrient regeneration in pond bottoms. Presented to the World Aquaculture Society Annual Meeting at Sydney, Australia, 26 Apr–2 May 1999.

Other

Lin, C.K., 1989. Intensive pond culture of freshwater prawns and marine shrimps in Thailand. Seminar at Auburn University, Alabama, 23 May 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 Jul 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, Jul 1989.
Lin, C.K., 1989. Aquaculture in Thailand and AITs Program. Seminar at Citizens Ambassadors, Bangkok, Thailand, Aug 1989.
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., 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 Feb 1990.
Yi, Y. Cage culture in ponds. Seminar presented to the Sichuan Provincial Fisheries Association, Sichuan, China, 9–20 Jun 1999.

Global Activities

AUBURN UNIVERSITY

Theses

Gross, A., 1999. Nitrogen cycling in aquaculture ponds. Ph.D. dissertation, Auburn University, Alabama.
Massaut, L., 1998. Planktonic trophic interactions in catfish and sportfish ponds in the presence of an omnivorous filter-feeding fish. Ph.D. dissertation, Auburn University, Alabama.
Rowan, M., 2001. Chemical phosphorus removal from aquaculture pond water and effluent. Ph.D. dissertation, Auburn University, Alabama.
Sonnenholzner, S., 1999. Chemical and physical properties of shrimp pond sediment in Ecuador and some management strategies for pond preparation. Ph.D. dissertation, Auburn University, Alabama.
Thunjai, T., 2001. Pond soil pH measurement. M.S. thesis, Auburn University, Alabama.
Warrington, L., 2000. Sex ratio variation and sex determining mechanisms in *Oreochromis niloticus*. M.S. thesis, Auburn University, Auburn, Alabama.
Zelaya, O., 2001. Effects of water recycling on water quality and bottom soils in shrimp ponds. M.S. thesis, Auburn University, Alabama.

Publications

Boyd, C.E., 1998. Water quality for pond aquaculture. Alabama Agricultural Experiment Station, Research and Development Series 43. Auburn University, Alabama, 37 pp.
Boyd, C.E., 2000. Water Quality, An Introduction. Kluwer Academic Publishers, Boston, 330 pp.
Boyd, C.E., 2002. Management of bottom soil condition and pond water and effluent quality. In: C. Lim and C.D. Webster (Editors), Tilapias: Culture, Nutrition, and Feeding. The Haworth Press, Binghamton, New York. (in press)
Boyd, C.E. and J.R. Bowman, 1997. Pond bottom soils. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 135–162.
Boyd, C.E. and A. Gross, 1998. Use of probiotics for improving soil and water quality in aquaculture ponds, In: T.W. Flegel (Editor), Advances in Shrimp Biotechnology. BIOTEC, Bangkok, Thailand, pp. 101–106.
Boyd, C.E. and L. Massaut, 1999. Risks associated with the use of chemicals in pond aquaculture. Aquacultural Engineering, 20:113–132.
Boyd, C.E., T. Thunjai, and M. Boonyaratpalin, 2002. Dissolved salts in water for inland, low-salinity shrimp culture. Global Aquaculture Advocate, 5(2).
Boyd, C.E., C.W. Wood, and T. Thunjai, 2002. Aquaculture pond bottom soil quality management. PD/A CRSP, Corvallis, Oregon, 41 pp.
Green, B.W., K.L. Veverica, and M.S. Fitzpatrick, 1997. Fry and fingerling production. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 215–244.
Lovshin, L.L. and N.B Schwartz, 1999. Evaluation of integrated tilapia culture by resource limited farmers in Panama and Guatemala. In B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture, 18–20 Aug 1999 in San Pedro Sula, Honduras, pp. 258–261.
Molnar, J., 2000. Sound policies for food security: The role of culture and social organization. Reviews of Agricultural Economics, 21(2):489–498.
Molnar, J., T. Hanson, and L. Lovshin, 1996. Impacts of the Pond Dynamics/Aquaculture Collaborative Support Research Program as a development intervention. NAGA: The ICLARM Quarterly, 19(2):31–40.
Phelps, R.P. and T.J. Popma, 2000. Sex reversal of tilapia. In: B.A. Costa-Pierce and J.E. Rakocy (Editors), Tilapia Aquaculture in the Americas, Volume 2. The World Aquaculture Society, Baton Rouge, Louisiana, pp. 34–59.
Sonnenholzner, S. and C.E. Boyd. Aerobic organic matter decomposition in aquaculture pond soils as measured by respiration chambers. Journal of the World Aquaculture Society. (in press)
Sonnenholzner, S. and C.E. Boyd. Decomposition of organic matter as measured by soil respiration in shrimp ponds treated with chemical and biological amendments. World Aquaculture. (submitted)
Sonnenholzner, S. and C. E. Boyd, 2000. Chemical and physical properties of shrimp pond bottom soils in Ecuador. Journal of the World Aquaculture Society, 31:358–375.
Sonnenholzner, S. and C.E. Boyd, 2000. Managing the accumulation of organic matter deposited on the bottom of shrimp ponds... Do chemical and biological probiotics really work? World Aquaculture, 31(3):24–28.
Sonnenholzner, S. and C. E. Boyd, 2000. Vertical gradients of organic matter concentration and respiration rate in pond bottom soils. Journal of the World Aquaculture Society, 31:376–380.
Teichert-Coddington, D.R., T.J. Popma, and L.L. Lovshin, 1997. Attributes of

tropical pond-cultured fish. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 183–198.
Thunjai, T., C.E. Boyd, and K. Dube, 2001. Pond soil pH measurement. Journal of the World Aquaculture Society, 32(2):141–152.
Veverica, K.L. and J.J. Molnar, 1997. Developing and extending aquaculture technology for producers. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 397–414.
Wood, C.W. and C.E. Boyd, 2000. Carbon and nitrogen in pond bottom soils. World Aquaculture Society Special Publication, 28:754.

Presentations

Boyd, C.E. Phosphorus chemistry in pond soils. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
Boyd, C.E. Water quality management in pond aquaculture. Presented to the International Aquaculture Conference at Sao Paulo, Brazil, 26–27 Aug 1998.
Boyd, C.E. Environmental management in aquaculture. Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10–14 Nov 1998.
Boyd, C.E. Environmental and sustainability issues in aquaculture. Keynote address presented to Aquaculture America '99 at Tampa, Florida, 27–30 Jan 1999.
Boyd, C.E. Measurement of pH in pond bottom soils. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting, Sydney, Australia, 26 Apr–2 May 1999.
Boyd, C.E. Pond soil management and shrimp aquaculture. Presented to the First National Symposium on Aquaculture at Penang, Malaysia, 22–24 Nov 1999.
Boyd, C.E. Aquaculture and the environment. Plenary address. Presented to the Western Regional Aquaculture Expo 2000 at Desert Hot Springs, California, 27 Feb–1 Mar 2000.
Boyd, C.E. Substance exchange between pond sediments and water. Presented to the Western Regional Aquaculture Expo 2000 at Desert Hot Springs, California, 27 Feb–1 Mar 2000.
Boyd, C.E. Use of BMPs in a systems approach to aquaculture. Presented to the Conference on Aquaculture in the Third Millennium at Bangkok, Thailand, 20–25 Feb 2000.
Boyd, C.E. Water quality characteristics of overflow from aquaculture ponds. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1–4 Feb 2000.
Boyd, C.E. Reduction in environmental impact of pond aquaculture through proper site selection, design, and construction. Presented to World Aquaculture 2000 at Nice, France, 2–6 May 2000.
Boyd, C.E. BMPs in aquaculture. Presented to AquaMexico at Culiacan, Mexico, 5–7 Oct 2000.
Boyd, C.E. BMPs in aquaculture. Presented to the 4th Latin American Aquaculture Congress at Panama City, Panama, 25–28 Oct 2000.
Boyd, C.E. Best management practices (BMPs) for pond aquaculture. Presented to Aquaculture America 2001, Orlando, Florida, 21–25 Jan 2001.
Boyd, C.E. and C.W. Wood. Conceptual model of aquacultural pond soil development. Presented to the Soil Science Society of America Annual Meeting, Anaheim, California, 25–30 Oct 1997.
Boyd, C.E., J. Clay, and J. Hargreaves. Codes of conduct for improving environmental and social performance in shrimp farming. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
Boyd, C.E., A. Gross, and M. Rowan. Laboratory studies of sedimentation as a technique for treating pond effluents. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
Hatch, U. Rapid economic evaluation tool. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
Massaut, L. and C.E. Boyd. Risks associated with use of chemicals in pond aquaculture. Poster presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
Molnar, J. Doing development by growing fish: A cross-national analysis of the impacts of aquacultural research. Presented to the Annual Meeting of the Rural Sociological Society, Toronto, Canada, 1997.
Molnar, J., T. Hanson, and L. Lovshin. Doing science, growing fish, teaching people: Human capital impacts of the PD/A CRSP. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
Queiroz, J.F. Soil consideration in site selection, pond construction, and pond management. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
Smith, E.S. and R.P. Phelps. Effect of feed storage time and storage temperature on growth rate of tilapia fry and efficacy of sex reversal. Presented to the Fourth International Symposium on Tilapia in Aquaculture at Orlando, Florida, 9–12 Nov 1997.
Sonnenholzner, S. and C.E. Boyd. Chemical and physical properties of shrimp pond bottom soils in Ecuador. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
Thunjai, T., C.E. Boyd, and W. Wood. Vertical profiles of bulk density, total carbon, total nitrogen, and total phosphorus in pond soil cores. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
Wood, W. Perspectives on use of best management practices in agriculture. Presented to Aquaculture America 2001, Orlando, Florida, 21–25 Jan 2001.
Wood, C.W., C.E. Boyd, and J. Queiroz. Aquaculture pond soil development. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

Other

Boyd, C.E. Aquaculture pond soils with emphasis on shrimp culture. Soil Science Graduate Seminar, Texas A&M University, 1997.
Boyd, C.E. Food safety considerations related to chemical use for water and soil quality enhancement in ponds. FAO/NACA/WHO Study Group on Food Safety Issues Associated with Products of Aquaculture, Bangkok, Thailand, 1997.
Boyd, C.E. Workshop on soil management in shrimp ponds (4 days), Guayaquil, Ecuador, (32 participants) Aug 1997.
Boyd, C.E. Workshop on water quality and pond bottom soils (½ day), China, four locations (total of 385 participants) Aug 1997.
Boyd, C.E. Workshop on water quality in shrimp ponds (3 days), Guayaquil, Ecuador (22 participants) Nov 1997.
Boyd, C.E. Farm level indicators and criteria for sustainable shrimp farming. FAO Ad-Hoc Expert Meeting on Indicators and Criteria for Sustainable Shrimp Farming, Rome, Italy, 1998.
Boyd, C.E. Workshop on water and soil quality in shrimp farming (2 days), Mazatlan, Mexico (41 participants) Jan 1998.
Boyd, C.E. Workshop on water quality (½ day), Pietersburg, South Africa (25 participants) Mar 1998.
Boyd, C.E. Workshop on shrimp pond water quality (2 hr), Chantaburi and Surat Thani, Thailand (total 73 participants) May 1998.
Boyd, C.E. Shrimp pond fertilization. Three two-hour lectures at Machelle, Perdinalis and Guayaquil, Ecuador, 11–14 Aug 1998.
Boyd, C.E. Workshop on pond soil and water quality management. Conducted in Tumbes, Peru, 18–19 Aug 1998.
Boyd, C.E. Pond dynamics workshop. Conducted for commercial aquaculturists, Melbourne, Australia, 3 May 1999.
Boyd, C.E. Water quality in aquaculture workshop. Conducted for commercial aquaculturists, Adelaide, Australia, 4 May 1999.
Boyd, C.E. Aquaculture and the environment workshop. Conducted for the Western Australia Fisheries Department, Perth, Australia, 6 May 1999.
Boyd, C.E. Water quality in shrimp ponds workshop. Conducted for shrimp farm employees, Mahajama, Madagascar, 23 May 1999.
Boyd, C.E. Environment management in aquaculture. Conducted for the conference sponsored by Pacific Economic Cooperation Council, Lima, Peru, 1999.
Boyd, C.E. Dissolved oxygen management in ponds workshop. Conducted for the Asociación Nacional de Acuicultores de Honduras, Choluteca, Honduras, 16 Jun 1999.
Boyd, C.E. Soil and water quality management in shrimp ponds and Water quality management in low-water use systems lectures. Presented to the Regional Shrimp Culture Conference, Panama City, Panama, 1999.
Lovshin, L. Integrated fish culture systems: Do they work? Presented to faculty and students of the Aquaculture Research Unit, University of the North, Pietersburg, South Africa, 20 Apr 1999.
Molnar, J. (Organizer and Chair). Global shrimp farming, mangroves, and people: finding a sustainable path. 1998 Annual Meeting of the

American Association for the Advancement of Science at Philadelphia, Pennsylvania, 12–17 Feb 1998.

MICHIGAN STATE UNIVERSITY

Publication

Knud-Hansen, C.F., K.D. Hopkins, and H. Guttman. A comparative analysis of the fixed-input, computer modeling, and algal bioassay approaches for identifying pond fertilization requirements for semi-intensive aquaculture. Aquaculture. (in press)

OREGON STATE UNIVERSITY

Theses

Bowman, J., 1992. Classification and management of earthen aquaculture ponds, with emphasis on the role of the soil, Ph.D. dissertation, Oregon State University, Corvallis, Oregon.

Burke, D.A., 1999. An analysis of social relationships at a development site in Kenya. M.A. thesis, Oregon State University, Corvallis, Oregon.

Contreras-Sánchez, W., 2001. Sex determination in Nile tilapia, *Oreochromis niloticus*: Gene expression, masculinization methods, and environmental effects. Ph.D. dissertation, Oregon State University, Corvallis, Oregon.

Egna, H.S., 1998. Network analysis of international aquaculture research and development efforts in Rwanda: Tracing the flows of knowledge and technology in a USAID-funded CRSP. Ph.D. dissertation, Oregon State University, Corvallis, Oregon.

Ernst, D., 2000. AquaFarm©: Simulation and decision-support soft-ware for aquaculture facility design and management planning. Ph.D. dissertation, Oregon State University, Corvallis, Oregon.

Hayes, J., 2001. The safe handling of 17α-methyltestosterone in tilapia aquaculture. M.S. project report, Oregon State University, Corvallis, Oregon.

Nath, S.S., 1992. Total and available nutrients in manures for pond aquaculture. M.S. thesis, Oregon State University, Corvallis, Oregon.

Nath, S.S., 1996. Development of a decision support system for pond aquaculture. Ph.D. dissertation, Oregon State University, Corvallis, Oregon.

Publications

Bolte, J., S. Nath, and D. Ernst, 2000. Development of decision support tools for aquaculture: The POND© experience. Aquacultural Engineering, 23:103–119.

Contreras-Sánchez, W., M.S. Fitzpatrick, G. Márquez-Couturier, and C.B. Schreck, 1999. Masculinization of the Nile tilapia (*Oreochromis niloticus*) by immersion in synthetic androgens: Timing and efficacy. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 246–248.

Contreras-Sánchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck, 1998. Masculinization of Nile tilapia (*Oreochromis niloticus*) by single immersion in 17α-methyldihydrotestosterone and trenbolone acetate. In: K. Fitzsimmons (Editor), Tilapia Aquaculture: Proceedings from the Fourth International Symposium on Tilapia in Aquaculture. NRAES, Ithaca, New York, pp. 783–790.

Contreras-Sánchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck. Masculinization of Nile tilapia with steroids: Alternate treatments and environmental effects. In: Proceedings of the Sixth International Symposium on Reproductive Physiology of Fish, Bergen, Norway, 4–9 Jul 1999. (submitted)

Contreras-Sánchez, W.S., M. Fitzpatrick, R.H. Milston, and C.B. Schreck, 2000. Masculinization of Nile tilapia: Alternate treatments and environmental effects. In: B. Norberg, O.S. Kjesbu, G.L. Taranger, E. Andersson, and S.O. Stefansson (Editors), Proceedings of the Sixth International Symposium on the Reproductive Physiology of Fish. Institute of Marine Research and University of Bergen, Bergen, Norway, pp. 250–252.

Egna, H.S., 1989. Fish pond management guidelines: A CRSP goal. Science and Technology Agricultural Reporter, US Agency for International Development, Washington, DC.

Egna, H.S., 1990. The PD/A CRSP. In: Global Research for Sustainable Food Production. The CRSP Council, USAID, Washington, DC, pp. 28–32.

Egna, H.S., 1991. Collaboration, aquaculture style. BIFADEC Briefs. Board for International Food and Agriculture Development and Economic Cooperation, USAID, Washington, DC, Vol. XV, No. 6, 8 pp.

Egna, H.S., 1993. Introduced technologies and changes in food consumption in Rwanda. Proceedings of the Oregon Academy of Sciences, vol. XXIX.

Egna, H.S., 1994. Monitoring water quality in tropical freshwater fishponds: General applications of aircraft and satellite imagery. Fisheries Management and Ecology, 1(3):165–178.

Egna, H.S., 1995. Psychological distress as a factor in environmental impact assessment: Some methods and ideas for quantifying this intangible intangible. Environmental Impact Assessment Review, 12:115–137.

Egna, H.S., 1997. History of the PD/A Collaborative Research Support Program. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 19–52.

Egna, H.S., 1999. Environment, aquaculture, and food policy nexus: Case study of two USAID aquaculture projects in Rwanda. In: D.L. Soden and B.S. Steel (Editors), Handbook of Global Environmental Policy and Administration. Marcel Dekker, Inc., New York, pp. 281–314.

Egna, H.S. and C.E. Boyd (Editors), 1997. Dynamics of Pond Aquaculture. CRC Press, Boca Raton, 437 pp.

Egna, H.S., C.E. Boyd, and D.A. Burke, 1997. Introduction. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 1–18.

Ernst, D.H., J.P. Bolte, and D. Lowes, 1997. PD/A CRSP Central Database: An information resource for pond-based aquaculture. In: K. Fitzsimmons (Editor), Tilapia Aquaculture: Proceedings from the Fourth International Symposium on Tilapia in Aquaculture. NRAES, Ithaca, New York, pp. 683–700.

Ernst, D.H., J.P. Bolte, and S. Nath, 2000. AquaFarm: Simulation and decision-support software for aquaculture facility design and management planning. Aquacultural Engineering, 23:121–179.

Fitzpatrick, M., W. Contreras-Sánchez, R.H. Milston, and C.B. Schreck, 1999. Fate of masculinizing agent methyltestosterone in the pond environment. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 249–250.

Gale, W.L., M. Fitzpatrick, M. Lucero, W. Contreras–Sánchez, and C.B. Schreck, 1999. Masculinization of Nile tilapia (*Oreochromis niloticus*) by immersion in androgens. Aquaculture, 178(1999): 349–357.

Kapetsky, J.M. and S.S. Nath, 1997. A strategic assessment of the potential for freshwater fish farming in Latin America. FAO COPESCAL Technical Paper, No. 10, FAO, Rome, 128 pp.

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.

Nath, S., J.P. Bolte, L.G. Ross, and J. Aguilar-Manjarrez, 2000. Applications of geographic information systems (GIS) for spatial decision support in aquaculture. Aquacultural Engineering, 23:233–278.

Pome, S.S., 2002. Fish sticks, fish sticks, yum. Eat them in the morning time. You must fill your tum, 3 ll.

Seim, W.K., C.E. Boyd, and J.S. Diana, 1997. Environmental considerations. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 163–182.

Yohe, J.M., P. Barnes-McConnell, H. Egna, J. Rowntree, J. Oxley, R.G. Hanson, D. Cummins, and A. Kirksey, 1991. The CRSPs: 1978 to 1990. In: Toward Sustainability—A Plan for Collaborative Research on Agriculture and Natural Resource Management. National Academy Press, Washington, DC, 36 pp.

Yohe, J.M., P. Barnes-McConnell, H. Egna, J. Rowntree, J. Oxley, R.G. Hanson, D. Cummins, and A. Kirksey, 1995. The CRSPs: International CRSPs. In: J.F. Leslie and R.A. Frederiksen (Editors), Disease Analysis through Genetics and Biotechnology. Iowa State University Press, Ames, Iowa, 321 pp.

Presentations

Bolte, J. and S. Nath. POND©: A decision tool for warmwater aquaculture. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.

Bolte, J., D. Lowes, and S. Nath. Geographic Information System technologies for aquaculture decision support. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

Bolte, J.P., S.S. Nath, P. Darakjian, and J.M. Kapetsky. Regional-scale analysis of aquaculture development potential. Poster presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.

Contreras-Sánchez, W.M., M.S. Fitzpatrick, and C.B. Schreck. Masculinization of Nile tilapia (*Oreochromis niloticus*) by immersion in trenbolone acetate. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1–4 Feb 2000.

Contreras-Sánchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck. Masculinization of Nile tilapia with steroids: Alternate treatments and environmental effects. Presented to 6th International Symposium on Reproductive Physiology of Fish at Bergen, Norway, 4–9 Jul 1999.

Contreras-Sánchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck. Masculinization of Nile tilapia with steroids: Alternate treatments and environmental effects. Presented to the Gilbert Ichthyological Society Meeting at Newport, Oregon, 18 Oct 1999.

Contreras-Sánchez, W.M., M.S. Fitzpatrick, M. Alonso, C.B. Schreck, and J.C. Leong. Identification of unique genes induced by trenbolone acetate during sex inversion of Nile tilapia (*Oreochromis niloticus*). Presented to the Eleventh Western Regional Conference on Comparative Endocrinology at Corvallis, Oregon, 24–25 Mar 2000.

Contreras-Sánchez, W.M., M.S. Fitzpatrick, M. Alonso, C.B. Schreck, and J.C. Leong. Identification of unique genes expressed during sex inversion of Nile tilapia (*Oreochromis niloticus*) induced by short immersions in the synthetic steroid trenbolone acetate. Presented to Fourth International Symposium on Fish Endocrinology at Seattle, Washington, 31 Jul–3 Aug 2000.

Craven, C. and H.S. Egna. The PD/A CRSP–developed technologies: Domestic rewards and returns. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1–4 Feb 2000.

Craven, C. and H.S. Egna. The PD/A CRSP: Strengthening linkages and developing technologies for sustainable aquaculture in the United States and worldwide. Poster presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.

Crawford, T.W., Jr., J.M. Yohe, B. Gebrekidan, J.H. Williams, C.L. Neely, P.W. Barnes-McConnell, H.S. Egna, and M.W. Demment. CRSP's: Vital Links. Poster presented to American Society of Agronomy Annual Meeting at Minneapolis, Minnesota, 5–9 Nov 2000.

Egna, H. International aquaculture: Research. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.

Egna, H.S. and C. Craven. The PD/A CRSP and best management practices for small-scale warmwater aquaculture. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.

Egna, H.S., J.M Baker, and D.A. Burke. The PD/A CRSP: Contributions to International Aquaculture. Poster presented to the Annual Meetings of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Baltimore, Maryland, 19 Oct 1998.

Egna, H.S., C. Craven, and D. Burke. The PD/A CRSP–Developed Technologies: Domestic Rewards and Returns. Poster presented to Aquaculture America 2000, at New Orleans, Louisiana, 1–4 Feb 2000.

Egna, H.S., C.K. Lin, and D.Z. Clair. The PD/A CRSP: Developing technologies and networks for sustainable aquaculture and rural development. Presented to Joint FAO/NACA Expert Consultation on Sustainable Aquaculture for Rural Development at Chiang Rai, Thailand, Mar 1999.

Egna, H.S., M. Niles, and C. Boyd. Research Priorities and Highlights: An Overview of the PD/A CRSP. Presented to the Western Regional Aquaculture Expo 2000 at Desert Hot Springs, California, 27 Feb–1 Mar 2000.

Ernst, D.H. Computer tools for aquaculture management and design. Lecture presented to the Western Regional Aquaculture Expo at Sacramento, California, 1996.

Ernst, D.H., J.P. Bolte, and S.S. Nath. Application of decision support software for aquaculture facility design. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.

Ernst, D.H., S.S. Nath, and J.P. Bolte. Software for design and manage-ment of aquaculture facilities. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

Fitzpatrick, M.S., W.M. Contreras-Sánchez, and C.B. Schreck. Methyltestosterone persists in the environment after use for masculinizing Nile tilapia. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1–4 Feb 2000.

Kapetsky, J.M., S. Nath, and J.P. Bolte. A fish farming GIS for Latin America. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.

Nath, S. Planning, design, and management tools for aquaculture. Presented to National Aquaculture Extension Conference at Annapolis, Maryland, 9–10 Apr 1997.

Nath, S., J.P. Bolte, and D.H. Ernst. A fish bioenergetics model for pond aquaculture. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.

Nath, S.S., J.P. Bolte, and D.H. Ernst. Decision support for pond aquaculture planning and management. Presented to Sustainable Aquaculture '95 at Honolulu, Hawaii, 11–14 Jun 1995.

Nath, S.S., J.P. Bolte, and D.H. Ernst. Simulation models and economic optimization techniques for pond aquaculture. Poster presentation to the World Aquaculture Society Meeting, Bangkok, Thailand, Feb 1996.

J.M. Yohe, J.M., P. Barnes-McConnell, D.C. Cummins, H.S. Egna, H.J. Hortik, and W.P. Warren. Introduction, Historical Development, and Overview of the CRSPs. Presented to the Annual Meetings of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America at Baltimore, Maryland, 19 Oct 1998.

SOUTHERN ILLINOIS UNIVERSITY AT CARBONDALE

Publication

Kelly, A.M. and C.C. Kohler, 1997. Climate, site, and pond design. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 109–134.

UNIVERSITY OF ARKANSAS AT PINE BLUFF

Publications

Engle, C.R., R. Balakrishnan, T.R. Hanson, and J.J. Molnar, 1997. Economic considerations. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 377–396.

Perschbacher, P. and R. Lochmann, 1999. Effects of feeding pelleted versus non-pelleted defatted rice bran on Nile tilapia *Oreochromis niloticus* production and water quality in ponds. Asian Fisheries Science, 12(1999):49–55.

Presentation

Engle, C.R. Teaching aquaculture economics. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

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, California.

Giovannini, P., 1994. Water quality dynamics in aquaculture ponds: an investigation of photosynthetic production and efficiency variations. Ph.D. dissertation, University of California, Davis, California.

Jamu, D., 1998. Modeling organic matter and nitrogen dynamics in integrated aquaculture/agriculture systems: Effects of cycling pathways on nitrogen retention and system productivity. Ph.D. dissertation, University of California, Davis, California.

Publications

Culberson, S.D. and R.H. Piedrahita, 1993. Model for predicting dissolved oxygen levels in stratified ponds using reduced data inputs. In: Jaw-Kai Wang (Editor), Techniques for Modern Aquaculture. Proceedings of an Aquacultural Engineering Conference, 21–23 Jun 1993, at Spokane, Washington. American Society of Agricultural Engineers, pp. 543–552.

Culberson, S.D. and R.H. Piedrahita, 1996. Aquaculture pond ecosystem model: temperature and dissolved oxygen prediction—mechanism and application. Ecological Modeling, 89:231–258.

Eikebrokk, B., R.H. Piedrahita, and Y. Ulgenes, 1995. Rates of fish waste production and effluent discharge from a recirculating system (Biofish) under commercial conditions. Aquaculture Research, 26:589–599.

Giovannini, P. and R.H. Piedrahita, 1988. Analysis and modeling of dissolved oxygen in warm water aquaculture ponds. American Society of Agricultural Engineers, 88-5004, 30 pp.

Giovannini, P. and R.H. Piedrahita, 1989. Analysis and modeling of diel pond dynamics: measuring phytoplankton light adaptation and saturation. American Society of Agricultural Engineers, 89-7556, 29 pp.

Giovannini, P. and R.H. Piedrahita, 1990. Measuring primary production efficiency in aquacultural ponds. American Society of Agricultural Engineers, 90-7034, 24 pp.

Giovannini, P. and R.H. Piedrahita, 1991. Engineering of non-fed pond systems. Proceedings of WAS/ASAE sessions at World Aquaculture Society Meeting at San Juan, Puerto Rico, 16–20 Jun 1991. American Society of Agricultural Engineers, Saint Joseph, Michigan.

Giovannini, P., and R.H. Piedrahita, 1994. Modeling photosynthetic production optimization for aquaculture ponds. Aquacultural Engineering, 13:83–100.

Grace, G. and R.H. Piedrahita, 1989. Carbon dioxide removal in packed column aerators. American Society of Agricultural Engineers, 89-7011, 21 pp.

Grace, G. and R.H. Piedrahita, 1993. Carbon dioxide control with a packed column aerator. In: Jaw-Kai Wang (Editor), Techniques for Modern Aquaculture. Proceedings of an Aquacultural Engineering Conference, 21–23 Jun 1993, at Spokane, Washington. American Society of Agricultural Engineers, pp. 496–505.

Grace, G. and R.H. Piedrahita, 1994. Carbon dioxide control. In: M. Timmons and T.M. Losordo (Editors), Engineering Design and Management of Aquaculture Water Reuse Systems. Developments in Aquaculture and Fisheries Science, 27:209–234.

Jamu, D.M., Z. Lu, and R.H. Piedrahita, 1998. Secchi disk visibility and chlorophyll *a* relationships in aquaculture ponds. In: M.B. Timmons and T. Losordo (Editors), Advances in Aquacultural Engineering: Proceedings from the Aquacultural Engineering Society (AES) Technical Sessions at the Fourth International Symposium on Tilapia in Aquaculture. NRAES, Ithaca, New York, pp. 159–162.

Jamu, D.M., Z. Lu, and R.H. Piedrahita, 1999. Relationship between Secchi disk visibility and chlorophyll *a* in aquaculture ponds. Aquaculture, 170(1999):205–214.

Losordo, T.M. and R.H. Piedrahita, 1991. Modeling temperature variation and thermal stratification in shallow aquaculture ponds. Ecological Modelling, 54:189–226.

Lu, Z. and R.H. Piedrahita, 1993. Nitrifying characteristics of a high rate packed column. In: J.-K. Wang (Editor), Techniques for Modern Aquaculture. Proceedings of an Aquacultural Engineering Conference, 21–23 Jun 1993, at Spokane, Washington. American Society of Agricultural Engineers, pp. 345–351.

Lu, Z., R.H. Piedrahita, and C. Dos Santos Neto, 1999. Generation of daily and hourly solar radiation values for modeling water quality in aquaculture ponds. Transactions of the American Society of Agricultural Engineers, 41:1853–1859.

Piedrahita, R.H., 1989. Simulation of short-term management actions to prevent oxygen depletion in ponds. American Society of Agricultural Engineers, 89-7555, 20 pp.

Piedrahita, R.H., 1990. Aquaculture: Engineering and construction. In: Y.H. Hui (Editor), Wiley Encyclopedia of Food Science and Technology. Wiley and Sons, New York, pp. 117–126.

Piedrahita, R.H., 1990. Calibration and validation of TAP, an aquaculture pond water quality model. Aquacultural Engineering, 9:75–96.

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

Piedrahita, R.H., 1991. Engineering aspects of warmwater hatchery design. Proceedings of WAS/ASAE sessions at World Aquaculture Society Meeting at San Juan, Puerto Rico, 16–20 Jun 1991. American Society of Agricultural Engineers, Saint Joseph, Michigan, pp. 85–100.

Piedrahita, R.H., 1991. 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, pp. 322–362.

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

Piedrahita, R.H. and P. Giovannini, 1991. Fertilized non-fed pond systems. Aquaculture Systems Engineering. Proceedings of WAS/ASAE sessions at World Aquaculture Society Meeting at San Juan, Puerto Rico, 16–20 Jun 1991. American Society of Agricultural Engineers, Saint Joseph, Michigan, pp. 1–14.

Piedrahita, R.H. and A. Seland, 1995. Calculation of pH in fresh and sea water aquaculture systems. Aquacultural Engineering, 14:331–346.

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 at New Delhi, India.

Piedrahita, R.H., S.S. Nath, J. Bolte, S.D. Culberson, P. Giovannini, and D.H. Ernst, 1997. Computer applications in pond aquaculture—Modeling and decision support systems. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 289–324.

Presentations

Batterson, T. and R.H. Piedrahita. Current trends, interests and concerns related to aquacultural wastes and their treatment in the United States. Proceedings of the European Inland Fisheries Advisory Commission (EIFAC)/Food and Agriculture Organization (FAO) Workshop on Economics of Waste Water Management at Stirling, Scotland, Jun 1994.

Brune, D.E., C.M. Drcho, and R.H. Piedrahita. Pond oxygen dynamics: Design and management strategies. Presented to Aquaculture '92 International Conference at Orlando, Florida, 21–25 May 1992.

Culberson, S.D. and R.H. Piedrahita. Modification of stratified temperature and dissolved oxygen model to accommodate reduced data inputs: Identifying critical requirements. Presented to Aquaculture '92 International Conference at Orlando, Florida, 21–25 May 1992.

Jamu, D.M. and R.H. Piedrahita. A nitrogen and organic matter cycling model for an integrated aquaculture-crop system. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.

Lu, Z. and R.H. Piedrahita. Modeling of temperature and dissolved oxygen in stratified aquaculture ponds using stochastic weather variables. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.

Lu, Z. and R.H. Piedrahita. The probability distributions of temperature and dissolved oxygen in stratified fish ponds under stochastic input weather variables. Presented to Aquaculture America '99 at Tampa, Florida, 27–30 Jan 1999.

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

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

Piedrahita, R.H. and G. Grace. Carbon dioxide removal for intensive aquaculture. Presented to the Workshop on Recirculating Aquaculture Systems at Baton Rouge, Louisiana, Sep 1991.

Piedrahita, R.H., Z. Lu, and D. Jamu. Dissolved oxygen modeling in tropical aquaculture ponds under the PD/A CRSP. Presented to the World Aquaculture Society Meeting, Bangkok, Thailand, Jan 1996.

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

Other

Piedrahita, R.H. Aquacultural Engineering, a five-day course at the Universidad Autonoma de Baja California, Ensenada, Baja California, 23–28 Nov 1997.

UNIVERSITY OF GEORGIA

Presentations

Nath, S. Geographic Information System technologies for aquaculture decision support. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

Nath, S.S., B.P. Verma, G. Rosenberg, and D. Nute. Integrated, multi-perspective approaches to decision support: Case study in Honduras. Presented to the 1998 Institute of Biological Engineering Meeting at Orlando, Florida, 10–12 Jul 1998.

UNIVERSITY OF HAWAII

Presentation

Szyper, J.P., R.H. Piedrahita, and P. Giovannini. Requirements for maximizing bloom stability and net oxygen production in earthen ponds. Poster presented to the World Aquaculture Society Meeting at Torremolinos, Spain, 26–28 May 1993.

UNIVERSITY OF MICHIGAN

Publications

Diana, J.S., 1997. Feeding strategies. In: H. Egna and C. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 245–262.

Diana, J.S., J.P. Szyper, T.R. Batterson, C.E. Boyd, and R.H. Piedrahita, 1997. Water quality in ponds. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture, CRC Press, Boca Raton, pp. 53–71.

Lin, C.K., D. Teichert-Coddington, B. Green, and K. Veverica, 1997. Fertilization regimes. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 73–108.

Springborn, R.R., A.L. Jensen, and W.Y.B. Chang, 1994. A variable growth rate modification of Von Bertalanffy's equation for aquaculture. Aquaculture and Fisheries Management, 25:259–267.

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 Nile tilapia, *Oreochromis niloticus* (L.), growth model. Aquaculture and Fisheries Management, 23:639–647.

UNIVERSITY OF OKLAHOMA

Publication

Rubinshtein, I., S. Rothbard, and W.L. Shelton, 1997. The relationship between the embryological age, cytokinesis-1 and the timing of ploidy manipulation in fish. Israeli Journal of Aquaculture/ Bamidgeh, 49:99–110.

Presentation

Shelton, W. and R. Phelps. Sex manipulation in *Oreochromis niloticus*. Presented to Aquaculture America '99 at Tampa, Florida, 27–30 Jan 1999.

UNIVERSITY OF TEXAS

Publication

Ward, G.H., 1996. A strategic approach to carrying-capacity analysis for aquaculture on estuaries. In: United States/Japan Natural Resource Panel on Aquaculture, United States-Japan Cooperative Program in Natural Resources. Sea Grant, Texas A&M University, 24:71–84.

OTHER

Publications

Aguilar-Manjarrez, J. and S. Nath, 1998. A Strategic Reassessment of Fish Farming Potential in Africa. CIFA Technical Paper, No. 32. FAO, Rome, 170 pp.

Kapetsky, J.M. and S.S. Nath, 1997. A Strategic Assessment of the Potential for Freshwater Fish Farming in Latin America. COPESCAL Technical Paper, No. 10. FAO, Rome, 124 pp.

Nath, S.S. and J.P. Bolte, 1998. A water budget model for pond aquaculture. Aquacultural Engineering, 18(3):175–188.

PD/A CRSP Publications

NOTICES OF PUBLICATION AND RESEARCH REPORTS

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

87-2 Nash, G., S. Chinabut, and C. Limsuwan. Idiopathic muscle necrosis in the freshwater prawn, *Macrobrachium rosenbergii* de Man, cultured in Thailand.

87-3 Tavarutmaneegul, P. and C.K. Lin. Breeding and rearing of sand goby (*Oxyeleotris marmoratus*, Blk.) fry.

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

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

88-6 Carpenter, K.E., A.W. Fast, V.L. Corre, J.W. Woessner, and R.L. Janeo. The effects of water depth and circulation on the water quality and production of *Penaeus monodon* in earthen ponds.

88-7 Sanares, R.C., S.A. Katase, A.W. Fast, and K.E. Carpenter. Water quality dynamics in brackish water shrimp ponds with artificial aeration and circulation.

88-8 Batterson, T.R., C.D. McNabb, C.F. Knud-Hansen, H.M. Eidman, and K. Sumatadinata. Effect of chicken manure additions on fish production in ponds in West Java, Indonesia.

88-9 Teichert-Coddington, D.R., N. Stone, and R.P. Phelps. Hydrology of fish culture ponds in Gualaca, Panama.

88-10 Sikoki, F.D., R.A. Tubb, and L.R. Curtis. Elevation of sex steroids and inhibition of UDP-glucuronyltransferase are out of phase during gonadal maturation in the common carp.

88-11 Minsalan, C.L.O. and Y.N. Chiu. Effects of teaseed cake on selective elimination of finfish in shrimp ponds.

88-12 Fortes, R.D., V.L. Corre, Jr., and E. Pudadera. Effects of fertilizers and feeds as nutrient sources on *Oreochromis niloticus* production in Philippine brackish water ponds.

89-13 Fast, A.W., K.E. Carpenter, V.J. Estilo, and H.J. Gonzales. Effects of water depth and artificial mixing on dynamics of Philippines brackish water shrimp ponds.

89-14 Chang, W.Y.B. and H. Ouyang. Dynamics of dissolved oxygen and vertical circulation in fish ponds.

89-15 Green, B.W., R.P. Phelps, and H.R. Alvarenga. The effect of manures and chemical fertilizers on the production of *Oreochromis niloticus* in earthen ponds.

89-16 Lin, C.K. and M. Boonyaratpalin. An analysis of biological characteristics of *Macrobrachium rosenbergii* (de Man) in relation to pond production and marketing in Thailand.

89-17 Chang, W.Y.B. Estimates of hypolimnetic oxygen deficits in ponds.

89-18 Diana, J.S. and A.W. Fast. The effects of water exchange rate and density on yield of the walking catfish, *Clarias fuscus*.

89-19 Diana, J.S., P.J. Schneeberger, and C.K. Lin. Relationships between primary production and yield of tilapia in ponds.

89-20 Lin, C.K., V. Tansakul, and C. Apinhapath. Biological nitrogen fixation as a source of nitrogen input in fishponds.

89-21 Teichert-Coddington, David R. and Ronald P. Phelps. Effects of seepage on water quality and productivity of inorganically fertilized tropical ponds.

90-22 Chang, W.Y.B. Integrated lake farming for fish and environmental

management in large shallow Chinese lakes: A review.

90-23 Hopkins, K.D., M.L. Hopkins, and D. Pauley. A multivariate model of tilapia growth, applied to seawater tilapia culture in Kuwait.

90-24 Hopkins, K.D. Reporting fishpond yields to farmers.

90-25 Peralta, M. and D. Teichert-Coddington. Comparative production of *Colossoma macropomum* and *Tilapia nilotica* in Panama.

90-26 Teichert-Coddington, D.R., B.W. Green, N. Matamoros, and R. Rodriguez. The substitution of chicken litter for feed in the commercial production of penaeid shrimp in Honduras.

90-27 Green, B.W. and L.A. Lopez. Implementing the large-scale production of young males of *Tilapia nilotica* using hormonal sex inversion in Honduras.

90-28 Hanson, B.J., J.F. Moehl, Jr., K.L. Veverica, F. Rwangano, and M. Van Speybroek. Pond culture of tilapia in Rwanda, a high altitude equatorial African country.

90-29 Knud-Hansen, C.F., T.R. Batterson, and C.D. McNabb. Hatchery techniques for egg and fry production of *Clarias batrachus* (L.).

91-30 Green, B.W., D.R. Teichert-Coddington, and R.P. Phelps. Response of tilapia yield and economics to varying rates of organic fertilization and season in two Central American countries.

91-31 Szyper, J.P. and C.K. Lin. Techniques for assessment of stratification and effects of mechanical mixing in tropical fish ponds.

91-32 Knud-Hansen, C.F., T.R. Batterson, C.D. McNabb, I.S. Harahat, K. Sumantadinata, and H.M. Eidman. Nitrogen input, primary productivity and fish yield in fertilized freshwater ponds in Indonesia.

91-33 Piedrahita, R.H. Calibration and validation of TAP, an aquaculture pond water quality model.

91-34 Piedrahita, R.H. Modeling water quality in aquaculture ecosystems.

91-35 Piedrahita, R.H. Engineering aspects of warmwater hatchery design.

91-36 Piedrahita, R.H. and P. Giovannini. Fertilized non-fed pond systems.

91-37 McNabb, C.D., T.R. Batterson, B.J. Premo, C.F. Knud-Hansen, H.M. Eidman, C.K. Lin, K. Jaiyen, J.E. Hanson, and R. Chuenpagdee. Managing fertilizers for fish yield in tropical ponds in Asia.

91-38 Green, B.W. and H.R. Alvarenga. The effect of different application rates of chicken litter on tilapia production.

91-39 Alvarenga, H.R. and B.W. Green. Production and economic aspects of tilapia cultivation in ponds fertilized with chicken litter.

92-40 Szyper, J.P., K.D. Hopkins, and C.K. Lin. Production of *Oreochromis niloticus* (L.) and ecosystem dynamics in manured ponds of three depths.

92-41 Piedrahita, R.H. Simulation of short-term management actions to prevent oxygen depletion in ponds.

92-42 Teichert-Coddington, D.R., B.W. Green, and R.W. Parkman. Substitution of chicken litter for feed in production of penaeid shrimp in Honduras.

92-43 Knud-Hansen, C.F., C.D. McNabb, and T.R. Batterson. Application of limnology for efficient nutrient utilization in tropical pond aquaculture.

92-44 Hopkins, K. and A. Yakupitiyage. Bias in seine sampling of tilapia.

92-45 Engle, C.R. and M. Skladany. The economic benefit of chicken manure utilization in fish production in Thailand.

92-46 Green, B.W. Substitution of organic manure for pelleted feed in tilapia production.

92-47 Green, B.W., and D.R. Teichert-Coddington. Comparison of two samplers used with an automated data acquisition system in whole-pond, community metabolism studies.

92-48 Liu, K.M. and W.Y.B. Chang. Bioenergetic modeling of effects of fertilization, stocking density, and spawning on growth of the Nile tilapia, *Oreochromis niloticus* (L.).

93-49 Teichert-Coddington, D.R., B.W. Green, and R.P. Phelps. Influence of site and season on water quality and tilapia production in Panama and Honduras.

93-50 Suresh, A.V. and C.K. Lin. Tilapia culture in saline waters: A review.

93-51 Knud-Hansen, C.F. Analyzing standard curves in the chemistry of waters used for aquaculture.

93-52 Szyper, J.P., J.Z. Rosenfeld, R.H. Piedrahita, and P. Giovannini. Diel cycles of planktonic respiration rates in briefly incubated water samples from a fertile earthen pond.

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

93-54 Lin, C.K., K. Jaiyen, and W. Muthuwana. Integration of intensive and semi-intensive aquaculture: Concept and example.

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

93-56 Knud-Hansen, C.F., T.R. Batterson, and C.D. McNabb. The role of chicken manure in the production of Nile tilapia, *Oreochromis niloticus* (L.).

93-57 Boyd, C.E. and D. Teichert-Coddington. Relationship between wind speed and reaeration in small aquaculture ponds.

93-58 Teichert-Coddington, D.R. and B.W. Green. Influence of daylight and incubation interval on water column respiration in tropical fish ponds.

93-59 Knud-Hansen, C.F. and A.K. Pautong. On the role of urea in pond fertilization.

94-60 Shrestha, M.K. and C.F. Knud-Hansen. Increasing attached microorganism biomass as a management strategy for Nile tilapia (*Oreochromis niloticus*) production.

94-61 Springborn, R.R., A.L. Jensen, W.Y.B. Chang, and C. Engle. Optimum harvest time in aquaculture: An application of economic principles to a Nile tilapia, *Oreochromis niloticus* (L.), growth model.

94-62 Hopkins, K.D. and D. Pauly. Instantaneous mortalities and multivariate models: Applications to tilapia culture in saline water.

94-63 Green, B.W. and D.R. Teichert-Coddington. Production of *Oreochromis niloticus* fry for hormonal sex reversal in relation to water temperature.

94-64 Engle, C.R., M. Brewster, and F. Hitayezu. An economic analysis of fish production in a subsistence agricultural economy: The case of Rwanda.

94-65 Knud-Hansen, C.F. and T.R. Batterson. Effect of fertilization frequency on the production of Nile tilapia (*Oreochromis niloticus*).

94-66 Teichert-Coddington, D.R., R. Rodriguez, and W. Toyofuku. Cause of cyclic variation in Honduran shrimp production.

94-67 Springborn, R.R., A.L. Jensen, and W.Y.B. Chang. A variable growth rate modification of von Bertalanffy's equation for aquaculture.

94-68 Diana, J.S., D.J. Dettweiler, and C.K. Lin. Effect of Nile tilapia (*Oreochromis niloticus*) on the ecosystem of aquaculture ponds, and its significance to the trophic cascade hypothesis.

94-69 Ayub, M., C.E. Boyd, and D. Teichert-Coddington. Effects of urea application, aeration, and drying on total carbon concentrations in pond bottom soils.

94-70 Boyd, C.E. and D. Teichert-Coddington. Pond bottom soil respiration during fallow and culture periods in heavily-fertilized tropical fish ponds.

94-71 Hopkins, K.D. Reporting fish growth: A review of the basics.

94-72 Hopkins, K.D. and J.D. Bowman. A research methodology for integrated agriculture-aquaculture farming systems.

94-73 Diana, J.S. and K. Jaiyen. Supplemental feeding of tilapia in fertilized ponds.

94-74 Knud-Hansen, C.F. Pond history as a source of error in fish culture experiments: A quantitative assessment using covariate analysis.

94-75 Green, B. and D. Teichert-Coddington. Growth of control and androgen-treated Nile tilapia, *Oreochromis niloticus* (L.), during treatment, nursery and growout phases in tropical fish ponds.

94-76 Teichert-Coddington, D. and B. Green. Comparison of two techniques for determining community respiration in tropical fish ponds.

94-77 Teichert-Coddington, D. and B. Green. Tilapia yield improvement through maintenance of minimal oxygen concentrations in experimental growout ponds in Honduras.

94-78 Teichert-Coddington, D., M. Peralta, and R.P. Phelps. Seepage reduction in tropical fish ponds using chicken litter.

95-79 Giovannini, P. and R.H. Piedrahita. Modeling photosynthetic production optimization for aquaculture ponds.

95-80 Culberson, S.D. and R.H. Piedrahita. Model for predicting dissolved oxygen levels in stratified ponds using reduced data inputs.

95-81 Culberson, S.D. and R.H. Piedrahita. Modification of stratified

temperature model to accommodate reduced data inputs: Identifying critical requirements.

95-82 Teichert-Coddington, D. Development of production technologies for semi-intensive fish farming during the past decade in Central America.

95-83 Teichert-Coddington, D. Effects of protein diet and sowing density on the production of *Penaeus vannamei* in land tanks.

95-84 Szyper, J.P., C.K. Lin, D. Little, S. Setboonsarng, A. Yakupitiyage, P. Edwards, and H. Demaine. Techniques for efficient and sustainable mass production of tilapia in Thailand.

95-85 Egna, H.S. Psychological distress as a factor in environmental impact assessment: Some methods and ideas for quantifying this intangible intangible.

95-86 Bowman, J.R. and J.E. Lannan. Evaluation of soil pH-percent base saturation relationships for use in estimating the lime requirements of earthen aquaculture ponds.

96-87 Green, B.W. and C.E. Boyd. Water budgets for fish ponds in the dry tropics.

96-88 Green, B.W. and C.E. Boyd. Chemical budgets for organically fertilized fish ponds in the dry tropics.

96-89 Teichert-Coddington, D.R. and R. Rodriguez. Semi-intensive commercial grow-out of *Penaeus vannamei* feed diets containing differing levels of crude protein during wet and dry seasons in Honduras.

96-90 Boyd, C.E. and D. Teichert-Coddington. Dry matter, ash, and elemental composition of pond-cultured *Penaeus vannamei* and *P. stylirostris*.

95-91 Green, B.W., Z.E. Nagdy, H. Hebicha, I. Shaker, D.A.R. Kenawy, and A.R.E. Gamal. Evaluation of Nile tilapia production systems in Egypt.

96-92 Egna, H.S. Monitoring water quality for tropical freshwater fisheries and aquaculture: A review of aircraft and satellite imagery applications.

96-93 Lin, C.K. and J.S. Diana. Co-culture of catfish (*Clarias macrocephalus* × *C. gariepinus*) and tilapia (*Oreochromis niloticus*) in ponds.

96-94 Lin, C.K. *Clarias* and tilapia interaction in polyculture.

96-95 Abdalla, A.A.F. and C.D. McNabb. Ammonia dynamics in fertilized fish ponds stocked with Nile tilapia.

96-96 Boyd, C.E. and P. Munsiri. Phosphorus adsorption capacity and availability of added phosphorus in soils from aquaculture areas in Thailand.

96-97 Teichert-Coddington, D.R. Effect of stocking ratio on semi-intensive polyculture of *Colossoma macropomum* and *Oreochromis niloticus* in Honduras, Central America.

96-98 Munsiri, P. and B.F. Hajek. Texture and chemical composition of soils from shrimp ponds near Choluteca, Honduras.

97-99 Moehl, J.F. and J.J. Molnar. Institutional requirements for aquacultural development in Africa: Lessons from Rwanda.

97-100 Hishamunda, N., C.M. Jolly, and C.R. Engle. Estimating *Oreochromis niloticus* production function for small-scale fish culture in Rwanda.

97-101 Shrestha, M.K. and C.K Lin. Phosphorus fertilization strategy in fish ponds based on sediment phosphorus saturation level.

97-102 Green, B.W. Polyculture of tilapia with marine shrimp.

97-103 Diana, J.S., C.K. Lin, and Y. Yi. Timing of supplemental feeding for tilapia production.

97-104 Engle, C.R. Optimal resource allocation by fish farmers in Rwanda.

97-105 Szyper, J.P. Observations and model predictions of daily areal primary production in a eutrophic brackish water culture pond.

97-106 Szyper, J.P. Comparison of three mixing devices in earthen culture ponds of four different surface areas.

97-107 Green, B.W. Inclusion of tilapia as a diversification strategy for penaeid shrimp culture.

97-108 Teichert-Coddington, D., J. Harvin, and D. Martinez. Semi-intensive shrimp pond management and quality of effluents.

97-109 Veverica, K. The PD/A CRSP–sponsored proceedings of the third conference on the culture of tilapias at high elevations in Africa.

97-110 Yohe, J.M., P.B. McConnell, H.S. Egna, J. Rowntree, J. Oxley, R.G. Hanson, D. Cummins, and A. Kirksey. The CRSPs: International CRSPs.

97-111 Teichert-Coddington, D. and D. Martinez de Pinel. Solubility of selected inorganic fertilizers in brackish water.

97-112 Boyd, C. Water quality in laboratory soil-water microcosms with soils from different areas of Thailand.

97-113 Shrestha, M. and C.K. Lin. Determination of phosphorus saturation level in relation to clay content in formulated pond muds.

97-115 Yi, Y., C.K. Lin, and J.S. Diana. Influence of Nile tilapia (*Oreochromis niloticus*) stocking density in cages on their growth and yield in cages and in ponds containing the cages.

97-116 Munsiri, P., C.E. Boyd, B.W. Green, and B.F. Hajek. Chemical and physical characteristics of bottom soil profiles in ponds on haplaquents in an arid climate at Abbassa, Egypt.

97-117 Ward, G.H. Water effluent and quality, with special emphasis on finfish and shrimp aquaculture.

97-118 Green, B.W., M.P. Micheletti, and C.A. Lara. A collaborative project to monitor the water quality of estuaries in the shrimp producing regions of Honduras.

98-119 Ernst, D.H., J.P. Bolte, D. Lowes, and S.S. Nath. PD/A CRSP Central Database: A standardized information resource for pond aquaculture.

98-120 Jamu, D.M., Z. Lu, and R. Piedrahita. Secchi disk visibility and chlorophyll *a* relationship in aquaculture ponds.

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98-122 Kapetsky, J.M. and S.S. Nath. A strategic assessment of the potential for freshwater fish farming in Latin America.

98-123 Teichert-Coddington, D.R. and B.W. Green. Experimental and commercial culture of tilapia in Honduras.

98-124 Hishamunda, N., M. Thomas, D. Brown, C. Engle, and C. Jolly. Small-scale fish farming in Rwanda: Economic characteristics.

98-124a Hishamunda, N., M. Thomas, D. Brown, C. Engle, and C. Jolly. Small-scale fish farming in Rwanda: Data report.

98-125 Abdalla, A.A.F. and C.D. McNabb. Acute and sublethal growth effects of un-ionized ammonia to Nile tilapia *Oreochromis niloticus.*

98-126 Nath, S.S. and J.P. Bolte. A water budget model for pond aquaculture.

98-127 Aguilar-Manjarrez, J. and S.S. Nath. A strategic reassessment of fish farming potential in Africa.

98-128 Yi, Y. A bioenergetics growth model for Nile tilapia (*Oreochromis niloticus*) based on limiting nutrients and fish standing crop in fertilized ponds.

99-129 Veverica, K.L., N. Hishamunda, and P. Nyirahabimana. Aquaculture extension in Rwanda.

99-130 Boyd, C.E. and B.W. Green. Dry matter, ash, and elemental composition of pond-cultured tilapia (*Oreochromis aureus* and *O. niloticus*).

99-131 Diana, J.S. and C.K. Lin. The effects of fertilization and water management on growth and production of Nile tilapia in deep ponds during the dry season.

99-132 Jamu, D.M., Z. Lu, and R.H. Piedrahita. Relationship between Secchi disk visibility and chlorophyll *a* in aquaculture ponds.

99-133 Gale, W.L., M.S. Fitzpatrick, M. Lucero, W.M. Contreras-Sánchez, and C.B. Schreck. Masculinization of Nile tilapia (*Oreochromis niloticus*) by immersion in androgens.

99-134 Boyd, C.E. and L. Massaut. Risks associated with the use of chemicals in pond aquaculture.

99-135 Lu, Z., R.H. Piedrahita, and C. Dos Santos Neto. Generation of daily and hourly solar radiation values for modeling water quality in aquaculture ponds.

99-136 Boyd, C.E. and M.C. Haws, 1999. Good management practices (GMPs) to reduce environmental impacts and improve efficiency of shrimp aquaculture in Latin America.

99-137 Ward, G.W., B.W. Green, and D.R. Teichert-Coddington. Estimation of carrying capacity for shrimp aquaculture in the eastern estuaries of the Gulf of Fonseca.

99-138 Dasgupta, S. and C.R. Engle. Non-parametric estimation of returns to investment in Honduras shrimp research.

99-139 Valderrama, D. and C.R. Engle. Risk analysis of shrimp farming in Honduras.

99-140 Contreras-Sánchez, W.M., M.S. Fitzpatrick, G. Márquez-Couturier, and C.B. Schreck. Masculinization of Nile tilapia (*Oreochromis niloticus*) by immersion in synthetic androgens: Timing and efficacy.
99-141 Fitzpatrick, M., W.M. Contreras-Sánchez, R.H. Milston, C.B. Schreck. Fate of the masculinizing agent methyltestosterone in the pond environment.
99-142 Green, B.W. Sistemas de produccíon de tilapia en Honduras (Tilapia production systems in Honduras).
99-143 Lovshin, L.L. and N.B. Schwartz. Evaluation of integrated tilapia culture by resource limited farmers in Panama and Guatemala.
99-144 Green, B.W., D.R. Teichert-Coddington, C.E. Boyd, J.M. Wigglesworth, H. Corrales, D. Martínez, and E. Ramírez. Efecto del recambio de agua en la producción semi-intensiva de *Penaeus vannamei* (Effect of water exchange on semi-intensive production of *Penaeus vannamei*).
99-145 Yi, Y. Modeling growth of Nile tilapia (*Oreochromis niloticus*) in a cage-cum-pond integrated culture system.
00-146 Perschbacher, P. and R. Lochmann. Effects of feeding pelleted versus non-pelleted defatted rice bran on Nile tilapia *Oreochromis niloticus* production and water quality in ponds.
00-147 Molnar, J.J. Sound policies for food security: The role of culture and social organization.
00-148 Yi, Y. and C.K. Lin. Integrated cage culture in ponds: Concepts, practice and perspectives.
00-149 Lin, C.K. and K. Kaewpaitoon. An overview of freshwater cage culture in Thailand.
00-150 Ward, Jr., G.H. Effects of shrimp farming on the hydrography and water quality of El Pedregal and San Bernardo estuaries, Gulf of Fonseca, Honduras.
00-151 Sonnenholzner, S. and C.E. Boyd. Chemical and physical properties of shrimp pond bottom soils in Ecuador.
00-152 Sonnenholzner, S. and C.E. Boyd. Vertical gradients of organic matter concentration and respiration rate in pond bottom soils.
00-153 Bolte, J., S. Nath, and D. Ernst. Development of decision support tools for aquaculture: The POND© experience.
00-154 Ernst, D.H., J.P. Bolte, and S. Nath. AquaFarm: Simulation and decision support for aquaculture facility design and management planning.
00-155 Nath, S.S., J.P. Bolte, L.G. Ross, and J. Aguilar-Manjarrez. Application of geographical information systems (GIS) for spatial decision support in aquaculture.
00-156 Bolivar, R.B. and G.F. Newkirk. Response to selection for body weight on Nile tilapia (*Oreochromis niloticus*) in different culture environments.
00-157 Lovshin, L.L. Criteria for selecting Nile tilapia and red tilapia for culture.
00-158 Brown, C.L., R.B. Bolivar, EB.T. Jimenez, and J. Szyper. Timing of the onset of supplemental feeding of Nile tilapia (*Oreochromis niloticus*) in ponds.
00-159 Yi, Y. and C.K. Lin. Analysis of various inputs for pond culture of Nile tilapia (*Oreochromis niloticus*): Profitability and potential environmental impacts.
00-160 Verma, B., E.W. Tollner, J. Renew, T. Popma, J.L. Molnar, and D. Meyer. Concurrent design of hillside ponds for tilapia production.
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00-163 Jamu, D. A pilot study on the spatial and temporal soil moisture and distribution in integrated crop-fish-wetland and crop-wetland agroecosystems in Zomba-East, Malawi.
00-164 Lovshin, L.L. Evaluation of tilapia culture by resource limited farmers in Panama and Guatemala.
01-165 Contreras-Sánchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck. Masculinization of Nile tilapia with steroids: Alternate treatments and environmental effects.
01-166 Sonnenholzner, S. and C.E. Boyd. Managing the accumulation of organic matter deposited on the bottom of shrimp ponds… Do chemical and biological probiotics really work?
01-167 Egna, H. Environment, aquaculture, and food policy nexus: Case study of two USAID aquaculture projects in Rwanda.
01-168 Yi, Y. and C.K. Lin. Effects of biomass of caged Nile tilapia (*Oreochromis niloticus*) and aeration on the growth and yields in an integrated cage-cum-pond system.
01-169 Thunjai, T., C.E. Boyd, and K. Dube. Pond soil pH measurement.
01-170 Dasgupta, S. and C.R. Engle. Nonparametric estimation of returns to investment in Honduras shrimp research.
01-171 Valderrama, D. and C.R. Engle. Risk analysis of shrimp farming in Honduras.
01-172 Lin, C.K., M.K. Shrestha, and Y. Yi. Management to minimize the environmental impacts of pond effluent: Harvest draining techniques and effluent quality.
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01-174 Phelps, R.P. Sex reversal: The directed control of gonadal development in tilapia.
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02-176 Fitzsimmons, K. Tilapia markets in the Americas, 2001 and beyond.
02-177 Omar Fúnez, N., I. Neira, and C. Engle. Supermarket outlets for tilapia in Honduras: An overview of survey results.
02-178 Neira, I. and C. Engle. Markets for tilapia (*Oreochromis* sp.) in Nicaragua: A descriptive analysis of restaurants, supermarkets and stands in open markets.
02-179 Meyer, D.E. Technology for successful small-scale tilapia culture.
02-180 Martinez Ayala, J.A., J.J. Molnar, F. Arias, and T. J. Popma. Production and marketing strategies used by small and medium-scale tilapia farms.
02-181 Tollner, E.W. Levee pond design model.
02-182 Popma, T.J., and D.E. Meyer. Training and technical assistance in warm-water fish culture.
02-183 Verma, B.P., D.E. Meyer, T.J. Popma, J.J. Molnar, and E. W. Tollner. Web-based information delivery system for tilapia for sustainable development of aquaculture in Honduras.
02-184 Corrales, H.L., C.A. Lara, J.E. Heerin, J.M. Wigglesworth, and B.W. Green. A sustainable shrimp aquaculture system from Honduras.

DATA REPORTS BY PD/A CRSP RESEARCHERS

Batterson, T.R., C.D. McNabb, C.F. Knud-Hansen, H.M. Eidman, and K. Sumantadinata, 1989. Data Report, Vol. 3, No. 3, Indonesia: Cycle III of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 135 pp.

Bowman, J. and D. Clair, 1996. Data Report, Volume 1, Second Edition, General Reference: PD/A CRSP Site Descriptions. PD/A CRSP, Oregon State University, Corvallis, Oregon, 74 pp.

Carpenter, K.E., A.W. Fast, J. Carreon, and R. Juliano, 1991. Data Report, Vol. 4, No. 3, Philippines: Cycle III of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 257 pp.

Carpenter, K.E., J. Woessner, R.D. Fortes, A. Fast, and P. Helfrich, 1991. Data Report, Vol. 4, No. 2, Philippines: Cycle II of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 501 pp.

Diana, J.S., C.K. Lin, T. Bhukaswan, and V. Sirsuwanatach, 1987. Data Report, Vol. 2, No. 1, Thailand: Cycle I of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 47 pp.

Diana, J.S., C.K. Lin, T. Bhukaswan, V. Sirsuwanatach, and B.J. Buurma, 1990. Data Report, Vol. 2, No. 2, Thailand: Cycle II of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 54 pp.

Diana, J.S., C.K. Lin, T. Bhukaswan, V. Sirsuwanatach, and B.J. Buurma, 1991. Data Report, Vol. 2, No. 3, Thailand: Cycle III of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 86 pp.

Egna, H.S., N. Brown, and M. Leslie (Editors), 1989. Data Report, Vol. 1, General Reference: Site Descriptions, Materials and Methods for the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 84 pp.

Green, B.W., H.R. Alvarenga, R.P. Phelps, and J. Espinoza, 1989. Data Report, Vol. 6, No. 3, Honduras: Cycle III of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 114 pp.

Green, B.W., H.R. Alvarenga, R.P. Phelps, and J. Espinoza, 1990. Data Report, Vol. 6, No. 1, Honduras: Cycle I of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 94 pp.

Green, B.W., H.R. Alvarenga, R.P. Phelps, and J. Espinoza, 1990. Data Report, Vol. 6, No. 2, Honduras: Cycle II of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 94 pp.

Hanson, B., V. Ndoreyaho, F. Rwangano, R. Tubb, and W.K. Seim, 1991. Data Report, Vol. 5, No. 2, Rwanda: Cycle III of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 102 pp.

Hanson, B., V. Ndoreyaho, R. Tubb, F. Rwangano, and W.K. Seim, 1989. Data Report, Vol. 5, No. 1, Rwanda: Cycle I of The Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 62 pp.

Hughes, D., R.P. Phelps, and R.P. Malca, 1991. Data Report, Vol. 8, No. 2, Aguadulce, Panama: Cycle II of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 143 pp.

Hughes, D., R.P. Phelps, and R.P. Malca, 1991. Data Report, Vol. 8, No. 3. Aguadulce, Panama: Cycle III of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 230 pp.

Hughes, D., A.T. Diaz, R.P. Phelps, and R.P. Malca, 1991. Data Report, Vol. 8, No. 1, Aguadulce, Panama: Cycle I of The Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 122 pp.

McNabb, C.D., T.R. Batterson, B.J. Premo, H.M. Eidman, and K. Sumantadinata, 1991. Data Report, Vol. 3, No. 2, Indonesia: Cycle II of the Global Experi-ment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 49 pp.

McNabb, C.D., T.R. Batterson, B.J. Premo, H.M. Eidman, and K. Sumantadinata, 1988. Data Report, Vol. 3, No. 1, Indonesia: Cycle I of the Global Experi-ment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 67 pp.

Teichert-Coddington, D.R., M. Peralta, R.P. Phelps, and R.P. Malca, 1991. Data Report, Vol. 7, No. 1, Gualaca, Panama: Cycle I of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 97 pp.

Teichert-Coddington, D.R., M. Peralta, R.P. Phelps, and R.P. Malca, 1991. Data Report, Vol. 7, No. 2, Gualaca, Panama: Cycle III of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 56 pp.

Woessner, J., R.D. Fortes, and V. Corre, Jr., 1991. Data Report, Vol. 4, No. 1, Philippines: Cycle I of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 141 pp.

CRSP WORK PLANS

PD/A CRSP, 1983. CRSP Work Plan: First Experimental Cycle. PD/A CRSP, Oregon State University, Corvallis, Oregon, 99 pp.

PD/A CRSP, 1984. CRSP Work Plan: Second Experimental Cycle. PD/A CRSP, Oregon State University, Corvallis, Oregon, 143 pp.

PD/A CRSP, 1985. CRSP Work Plan: Third Experimental Cycle. PD/A CRSP, Oregon State University, Corvallis, Oregon, 128 pp.

PD/A CRSP, 1989. Revised CRSP Work Plan: Fourth Experimental Cycle. PD/A CRSP, Oregon State University, Corvallis, Oregon, 39 pp.

PD/A CRSP, 1989. Fifth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 151 pp.

PD/A CRSP, 1991. Sixth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 71 pp.

PD/A CRSP, 1993. Revised Seventh Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 85 pp.

PD/A CRSP, 1996. Interim Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 47 pp.

PD/A CRSP, 1997. Eighth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 171 pp.

PD/A CRSP, 1998. Addendum to the Eighth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 31 pp.

PD/A CRSP, 1999. Second Addendum to the Eighth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 18 pp.

PD/A CRSP, 2000. Third Addendum to the Eighth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 5 pp.

PD/A CRSP, 1999. Ninth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 92 pp.

PD/A CRSP, 2000. Addendum to the Ninth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 41 pp.

PD/A CRSP, 2001. Tenth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 148 pp.

PD/A CRSP, 2002. Second Addendum to the Ninth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 15 pp.

CRSP ADMINISTRATIVE REPORTS

PD/A CRSP, 1983. First Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 29 pp.

PD/A CRSP, 1984. Second Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 35 pp.

PD/A CRSP, 1985. Third Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 37 pp.

PD/A CRSP, 1986. Fourth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 28 pp.

PD/A CRSP, 1988. Fifth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 49 pp.

Egna, H.S. and H. Horton (Editors), 1989. Sixth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 91 pp.

Egna, H.S., J. Bowman, and M. McNamara (Editors), 1990. Seventh Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 114 pp.

Egna, H.S., J. Bowman, and M. McNamara (Editors), 1991. Eighth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 166 pp.

Egna, H.S., M. McNamara, and N. Weidner (Editors), 1992. Ninth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 172 pp.

Egna, H.S., M. McNamara, J. Bowman, and N. Astin (Editors), 1993. Tenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 275 pp.

Egna, H.S. and M. McNamara (Editors), 1994. Eleventh Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 80 pp.

Egna, H.S., J. Bowman, B. Goetze and N. Weidner (Editors), 1994. Eleventh Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 178 pp.

Egna, H.S., M. McNamara, and N. Weidner (Editors), 1995. Twelfth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 95 pp.

Egna, H.S., J. Bowman, B. Goetze, and N. Weidner (Editors), 1995. Twelfth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 209 pp.

Goetze, B., H. Berkman, and H. Egna (Editors), 1995. Egypt Project Final Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 30 pp.

McNamara, M., H. Egna, B. Goetze, B. Herbison, and D. Clair (Editors), 1996. Thirteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 96 pp.

Egna, H.S., B. Goetze, D. Burke, M. McNamara, and D. Clair (Editors), 1996. Thirteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 206 pp.

Clair, D., B. Goetze, D. Burke, M. McNamara, and H. Egna, (Editors), 1997. Fourteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 94 pp.

Burke, D., B. Goetze, D. Clair, and H. Egna (Editors), 1997. Fourteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 192 pp.

Clair, D., B. Goetze, D. Burke, J. Baker. and H. Egna (Editors), 1998. Fifteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 113 pp.

Burke, D., J. Baker, B. Goetze, D. Clair, and H. Egna (Editors), 1998. Fifteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 187 pp.

Clair, D., D. Burke, K. McElwee, M. Niles, and H. Egna, 1999. Sixteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 100 pp.

McElwee, K., D. Burke, M. Niles, and H. Egna (Editors), 1999. Sixteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 189 pp.

Clair, D., K. McElwee, D. Burke, M. Niles, and H. Egna (Editors), 1999. Seventeenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 124 pp.
McElwee, K., D. Burke, M. Niles, X. Cummings, and H. Egna (Editors), 2000. Seventeenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 178 pp.
Clair, D., K. McElwee, A. Gupta, D. Burke, and H. Egna (Editors), 2001. Eighteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 118 pp.
Gupta, A., K. McElwee, D. Burke, J. Burright, X. Cummings, and H. Egna (Editors), 2001. Eighteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 163 pp.
Clair, D., J. Burright, K. McElwee, M. Nidiffer, S. Sempier, and H. Egna (Editors), 2002. Nineteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 116 pp.
McElwee, K., K. Lewis, M. Nidiffer, and P. Buitrago (Editors), 2002. Nineteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 163 pp.

Other Work by CRSP Researchers

Publications

Boyd, C.E., 1998. Mechanical aeration in pond aquaculture, In: Proceedings Second International Symposium on Aeration Technology, American Society of Mechanical Engineers, Washington, DC, pp. 1–6.
Boyd, C.E., 1998. Pond water aeration systems. Aquacultural Engineering, 18:9–40.
Boyd, C.E., 1999. Aquaculture sustainability and environmental issues. World Aquaculture, 30(2):10–13 and 71–72.
Boyd, C.E., 1999. Codes of practice for responsible shrimp farming. Global Aquaculture Alliance, St. Louis, Missouri. 42 pp.
Boyd, C.E. and J.W. Clay, 1998. Shrimp aquaculture and the environment. Scientific American, Jun 1998, 278(6):42–49.
Boyd, C.E. and A. Gross, 1999. Biochemical oxygen demand in channel catfish pond waters. Journal of the World Aquaculture Society, 30:349–356.
Boyd, C.E. and H.R. Schmittou, 1999. Achievement of sustainable aquaculture through environmental management. Aquaculture Economics and Management, 3(1):59–70.
Boyd, C.E. and C.S. Tucker, 1998. Pond Aquaculture Water Quality Management, Kluwer Academic Publishers, Boston, Massachusetts, 700 pp.
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.Y.B., 1986. Aquaculture research in China. China Exchange News, CSCPRC, National Academy of Sciences, 14(2):13–16.
Chang, W.Y.B., 1986. Practical methods for treating fish during oxygen stress in ponds. Aquaculture Magazine, 13(4):20–22.
Chang, W.Y.B., 1986. Vertical oxygen dynamics of shallow tropical impoundments in the Pearl River Delta, China. Tran. Amer. Phys. Union, 66(51):13–1.
Chang, W.Y.B., 1987. A historical center of fish culture in China: Lake Tai/Yangtze River Delta. Aquaculture Magazine, 13:39–42.
Chang, W.Y.B., 1987. Fish culture in China. Fisheries, 12(3):11–15.
Chang, W.Y., 1987. Large lakes of China. J. Great Lakes Res., 13(3):235–249.
Chang, W.Y.B., 1989. Estimates of hypolimnetic oxygen deficits in ponds. Aquaculture and Fisheries Management, 20:167–172.
Chang, W.Y.B., 1989. Integrated lake farming for fish and environmental management in large shallow Chinese lakes: A review. Aquaculture and Fisheries Management, 20:441–452.
Chang, W.Y.B. and H. Ouyang, 1988. Dynamics of dissolved oxygen and vertical circulation in fish ponds. Aquaculture, 74:263–276.
Chang, W.Y.B. and R. Rossmann, 1988, Changes in the abundance of blue-green algae related to nutrient loadings in the nearshore of Lake Michigan. Hydrobiologia, 157:271–278.
Chang, W.Y.B., J. Diana, and W. Chapoehuk, 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, 85-5014, 9 pp.
Fitzsimmons, K. Future trends for tilapia aquaculture in the Americas. In: B. Costa-Pierce (Editor), Tilapia Aquaculture in the Americas, Volume 2. World Aquaculture Society and American Tilapia Association, Baton Rouge, Louisiana. (in press)
Fitzsimmons, K. Tilapia aquaculture in Mexico. In: B. Costa-Pierce (Editor), Tilapia Aquaculture in the Americas, Vol. 2. World Aquaculture Society and American Tilapia Association, Baton Rouge, Louisiana. (in press)
Fridley, R.B., R.H. Piedrahita, and T.M. Losordo, 1988. Challenges in aquacultural engineering. Agricultural Engineering, 69(4):12–15.
Gross, A., C.E. Boyd, and J. Seo, 1999. Evaluation of the ultraviolet spectrophotometric method for the measurement of total nitrogen in water. Journal of the World Aquaculture Society, 30:388–393.
Gross, A., C.E. Boyd, and C.W. Wood, 1999. Ammonia volatilization from freshwater ponds. Journal of Environmental Quality, 28:793–797.
Hopkins, K.D., J.E. Lannan, and J.R. Bowman, 1988. Managing a data base for pond research data—the CRSP experience. Aquabyte, 1(1):3–4.
Jamu, D., 2000. A pilot study on the spatial and temporal soil moisture and distribution in integrated crop-fish-wetland and crop-wetland agroecosystems in Zomba-East, Malawi. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 582–587.
Liu, K.M. and W.Y.B. Chang, 1992. Bioenergetic modeling of effects of fertilization, stocking density, and spawning on growth of the Nile tilapia, *Oreochromis niloticus* (L.). Aquaculture and Fisheries Management, 23:291–301.
Losordo, T.M. and R.H. Piedrahita, 1988. Modeling vertical water quality profiles in aquaculture ponds, review and evaluation. Proceedings of the Conference Aquacultural Engineering: Technologies for the Future at Stirling, Scotland. I. Cheme Symposium Series No. 111: EFCE Publications Series No. 66, Rubgy, United Kingdom, pp. 313–327.
Losordo, T.M. and R.H. Piedrahita, 1988. Simulating aquacultural pond thermal stratification with a spreadsheet model. American Society of Agricultural Engineers, 88-5003, 38 pp.
Losordo, T.M., J.M. Ebeling, and R.H. Piedrahita, 1986. Stratification measurement techniques in aquaculture ponds. American Society of Agricultural Engineers, 86-5047, 14 pp.
Losordo, T.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.
McKeon, C., E. Glenn, C.P. Gerba, and K. Fitzsimmons, 2001. Microbiological hazards of tilapia culture systems. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 479–485.
Piedrahita, R.H., 1987. Sensitivity analysis for an aquaculture pond model. In: J.G. Balchen (Editor), Automation and Data Processing in Aquaculture. IFAC Proc. Ser. No. 9, Proceedings of the IFAC Symposium, Trondheim, Norway, 18–21 Aug 1986, pp. 119–123.
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 thrusts. Agricultural Engineering, 70(1):30–32.
Piedrahita, R.H. and G. Tchobanoglous, 1987. The use of human wastes and sewage in aquaculture. In: D.J.W. Moriarty and - R.S.V. Pullin (Editors), Detritus and microbial ecology in aquaculture: ICLARM Conference Proceedings 14, Manila, Philippines, pp. 336–352.
Piedrahita, R.H., J.M. Ebeling, and T.M. Losordo, 1987. Use of data acquisition systems in aquaculture. In: J.G. Balchen (Editor), Automation and Data Processing in Aquaculture. IFAC Proc. Ser. No. 9, Proceedings of the IFAC Symposium, Trondheim, Norway, 18–21 Aug 1986, pp. 259–262.
Piedrahita, R.H., G. Tchobanoglous, and B. Moore, 1987. Effect of organic matter addition to fish culture systems. Transactions of American Society of Agricultural Engineers, 30(1):233–237.
Piedrahita, R.H., D.E. Brune, G. Tchobanoglous, and G.T. Orlob, 1984. A general model of the aquaculture pond ecosystem. Journal of the World Mariculture Society, 14:355–366.

Potts, A.C. and C.E. Boyd, 1998. Chlorination of channel catfish ponds. Journal of the World Aquaculture Society, 29:432–440.

Rodriquez, F. and T. Popma. Tilapia aquaculture in Colombia. In: B.A. Costa-Pierce and J.E. Rakocy, (Editors), Tilapia Aquaculture in the Americas, Volume 2. World Aquaculture Society, Baton Rouge, Louisiana. (in press)

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.

Verdegem, M.C.J., A.A. van Dam, A.A. Cabarcas-Nuñez, and L. Oprea, 2000. Bio-energetic modeling of growth and waste production of Nile tilapia (*Oreochromis niloticus*) in recirculation systems. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 368–381.

Presentations

Bowman, J. Soil pH and liming: A review of acidity/alkalinity management practices in aquaculture. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

Boyd, C.E. Use of probiotics in aquaculture. Presented to Fifth Asian Aquaculture Conference, Chiang Mai, Thailand, 1998.

Boyd, C.E. Shrimp farming and the environment. Presented to the IV Ecuadorian Symposium on Aquaculture, Guayaquil, Ecuador, 22–27 Oct 1997.

Boyd, C. E. Soil and water quality management in shrimp farming. Presented to Aquaculture Brazil '98 at Recife, Brazil. 1998.

Boyd, C.E. Control of suspended solids in effluents from coastal aquaculture ponds. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting, Sydney, Australia, 26 Apr–2 May 1999.

Boyd, C.E. Promoting environmentally responsible aquaculture to meet world food needs. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting at Sydney, Australia, 26 Apr–2 May 1999.

Boyd, C.E.. The Global Aquaculture Alliance Codes of Practice. Aquaculture '99, World Aquaculture Society Annual Meeting, Sydney, Australia, 26 Apr–2 May 1999.

Boyd, C.E. Water quality in channel catfish farming. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting, Sydney, Australia, 26 Apr–2 May 1999.

Brown, C. Ontogeny of digestive enzymes in marine larvae: Dietary and hormone effects. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting at Sydney, Australia, 26 Apr–2 May 1999.

Brown, J.J., E.P. Glenn, and K.M. Fitzsimmons. Forage crop production on highly saline aquaculture effluent. Presented to Aquaculture '98, World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

Chang, W.Y.B. Large lakes in China. Presented to 29th Conference of the International Association for Great Lakes Research, 26–29 May 1986.

Chang, W. China integrated aquaculture: An efficient ecological system. Presented to the Limnology & Oceanography 1987 Annual Meeting.

Chang, W. The world's highest lake: Tibetan Lakes. Presented to 30th Conference of the International Association for Great Lakes Research, 1987.

Diana, J.S., D. Clapp, P. Hudson, and G. Regal. Movements of brown trout in the AuSable River, Michigan. Presented to the American Fisheries Society meeting at Dearborn, Michigan, Aug 1996.

Fitzsimmons, K. High school students and aquaculture projects. Presented to Aquaculture America '99 at Tampa, Florida, 27–30 Jan 1999.

Fitzsimmons, K. and B.C. Posadas. Consumer demand for tilapia products in the U.S. and the effects on local markets in exporting countries. Presented to the Fourth International Symposium on Tilapia in Aquaculture at Orlando, Florida, 9–12 Nov 1997.

Lin, C.K. Inland marine shrimp culture and its legislative, environmental and socio-economic implications in Thailand. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting at Sydney, Australia, 26 Apr–2 May 1999.

Lin, C.K. and C. Limsuwan. Management strategies and approaches for water quality improvement in shrimp farming. Presented to the American Association for the Advancement of Science at Philadelphia, Pennsylvania, 12–17 Feb 1998.

Lin, C.K., J.B. Hambrey, and J. Szyper. Environmental impact assessment for a shrimp farm project in Tanzania: A case study. Presented to Aquaculture '98, World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

Lin, C.K., W. Ruttanagosrigit, D. Thakur, and P. Wanuchsoontorn. Organic matter and nutrients in sludge of closed ponds for intensive shrimp culture. Presented to Aquaculture '98, World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

Muthuwan, V. and C.K. Lin. Green water recirculating system for intensive culture of marine shrimp (*Penaeus monodon*). Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10–14 Nov 1998.

Phelps, R.P., K.L. Veverica, R.S. Weyers, and J.J. Duffy. Induced spawning of the red snapper, *Lutjanus campechanus*, using three different hormone treatments. Poster presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Jan 1996.

Appendix 7. Acronyms

ACIAR	Australian Center for International Agricultural Research
ADR	Adoption/Diffusion Research
AIT	Asian Institute of Technology
AMR	Administrative Management Review
ANDAH	Asociación Nacional de Acuicultores de Honduras
ASF	Animal source foods
ASMR	Aquaculture Systems Modeling Research
ATR	Appropriate Technology Research
AU	Auburn University
BAU	Bangladesh Aqucultural University
BOD	Biochemical oxygen demand
BOD	Board of Directors
BRAC	Bangladesh Rural Advancement Committee
CF	Condition factor
CFS	China Society of Fisheries
CIFAD	Consortium for International Fisheries and Aquaculture Development
CLSU	Central Luzon State University
CONACYT	Consejo Nacional de Ciencia y Tecnología (National Council for Science and Technology)
CRSP	Collaborative Research Support Program
DBT	Database Task Force
DIGEPESCA	General Directorate of Fisheries and Aquaculture
DO	Dissolved oxygen
E2	Estradiol
EdOp Net	Educational Opportunities Network
EEP	External Evaluation Panel
ER	Effluents and Pollution Research
FFR	Feeds and Fertilizers Research
FIU	Florida International University
FONDEPES	Fondo Nacional de Desarrollo Pesquero (National Fund for Fishing Development)
FSR	Food Security Research
GAFY	Gross annualized fish yield
GIFT	Genetically Improved Farmed Tilapia
GIS	Geographic Information System
GISR	GIS: Planning, Policy, and Global Data Analysis Research
HSI	Hepatosomatic index
HTML	Hypertext Markup Language
IAAS	Institute of Agriculture and Animal Science
ICLARM	International Center for Living Aquatic Resources Management
IIAP	Instituto de Investigaciones de la Amazonia Peruana (Research Institute of the Peruvian Amazon)
IIFET	International Institute of Fisheries Economics and Trade
IGF-1	Insulin-like growth factor 1
IMNC	Information Management and Networking Component
JCARD	Joint Committee on Agricultural Research and Development
LHRHa	Luteinizing hormone-releasing hormone analog
LIFD	Low-income food-deficit
ME	Management Entity
MEAR	Marketing and Economic Analysis Research
MOU	Memorandum of Understanding
MRC	Mekong River Commission
MSU	Michigan State University
MT	17α-methyltestosterone
NAR	Net annualized revenue
NASULGC	National Association of State Universities and Land-Grant Colleges
NAU	National Agriculture University
NGO	Nongovernmental organization
NSR	New Aquaculture Systems/New Species Research
OhSU	The Ohio State University
OSU	Oregon State University
OSURF	Ohio State University Research Foundation
PD/A CRSP	Pond Dynamics/Aquaculture CRSP
PDF	Portable Document Format
PDR	Pond Dynamics Research
PDVR	Product Diversification Research
PMO	Program Management Office
PPEC	Proposal Planning Executive Committee
PRR	Rural Reconstruction Program
RCR	Reproduction Control Research
RFP	Request for Proposals
SIUC	Southern Illinois University at Carbondale
SMILE	Science and Math Investigative Learning Experiences Program
SRP	Soluble reactive phosphorus
TA	Trenbolone acetate
TAN	Total ammonia nitrogen
TC	Technical Committee
TIPS	Tilapia Integration to Prawn Culture System
TN	Total nitrogen
TP	Total phosphorus
TS	Total solids
TSP	Triple superphosphate
TSS	Total suspended solids
UAPB	University of Arkansas at Pine Bluff
UCD	University of California, Davis
UG	University of Georgia
UH	University of Hawaii
UJAT	Universidad Juárez Autónoma de Tabasco
UM	The University of Michigan
UO	University of Oklahoma
US	United States
USAID	United States Agency for International Development
UT	University of Texas
UV	Ultraviolet
VSS	Volatile suspended solids
WAS	World Aquaculture Society
WIDeST	Web-Based Information Delivery System for Tilapia