# Aquaculture Collaborative Research Support Program

# Twenty-First Annual Administrative Report

**1 August 2002 to 31 July 2003**



Acknowledgments
*The Program Management Office of the Aquaculture CRSP gratefully acknowledges the contributions of all the CRSP researchers and the support provided by the participating US and Host Country universities and institutions*

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Edited by Danielle Clair, Jeff Burright, Roger Harris, Ian Courter, and Hillary Egna. Assistance provided by Steve Sempier and Kristen Lewis.


Aquaculture CRSP Management Office
Oregon State University
418 Snell Hall
Corvallis, Oregon 97331-1643 USA

NOTE: THE BREADTH AND SCOPE OF THIS YEAR'S ANNUAL REPORT IS 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 Aquaculture Collaborative Research Support Program (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 Aquaculture CRSP from 1 August 2002 to 31 July 2003.

The Aquaculture 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. The Aquaculture CRSP is housed in USAIDs Economic Growth, Agriculture, and Trade (EGAT) Bureau's Office of Natural Resources Management and is part of USAIDs Water Team.

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 2004.

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 1.

## RESEARCH HIGHLIGHTS 2002–2003

- **Pond bottom soil analysis shows expensive, labor-intensive liming practices may not be necessary to maintain high production**
  Liming is an important but expensive and labor-intensive part of the pond management cycle. An investigation undertaken by collaborating scientists at the Asian Institute of Technology in Thailand and Auburn University analyzed soil from the bottoms of ponds in Thailand and showed that, owing to the residual effects of the prior applications, yearly liming was unnecessary in ponds that had had lime applied in large amounts over a number of years. High soil quality was maintained without continual application. Furthermore, evaluation of commercial liming materials indicated highly variable quality, thereby cautioning farmers against injudicious purchase of liming materials.

- **International research shows ways to conserve water, protect the environment, and reduce costs**
  Researchers at Stellenbosch University in South Africa, Embrapa Meio Ambiente in Brazil and Auburn University conducted joint studies that demonstrated new methods of pond management desirable for water conservation and environmental protection. The research shows that rather than liming bottoms of drained ponds between harvests, liming of full ponds is equally effective at maintaining suitable water and pond soil conditions. Since tilling pond bottoms to incorporate liming materials is unnecessary and expensive, adoption of these practices promises to reduce costs for farmers.

- **Optimizing feeding regimes maximizes cost benefit for Filipino tilapia farmers**
  Supplemental feed is one of the biggest costs of tilapia farming and can make the difference between profit and loss for typical rural farmers. Joint research at Central Luzon State University, the Philippines, and Florida International University showed that in the Philippines, when feeds were applied every two days rather than daily, weights, survival, and yields were not significantly different. Yet, due to the cost of feed, daily feeding resulted in a net loss whereas alternate day feeding realized a substantial net return.

- **Polyculture of carp and tilapia provides low-cost alternative to conventional aquaculture regimes in Nepal**
  Tilapia are a valued species for aquaculture, but their need for expensive supplemental feeds is a potential deterrent for farmers. One alternative being explored in Nepal is to raise tilapia together with grass carp, using readily available grass as a supplement. The carp eat the grass, and the tilapia benefit from the carp waste that is used by algae and micro-organisms that in turn increase the amount of food available to tilapia. But what ratio of carp and tilapia will yield the best harvests? Scientists at the Institute of Agriculture and Animal Science (IAAS) in Nepal, the Asian Institute of Technology in Thailand, and The University of Michigan tackled the problem. Experiments carried out at IAAS tested various combinations of carp and tilapia to determine which stocking ratio provided the highest yields. These data are invaluable guidelines to farmers who want to know the best methods to use with polyculture techniques employing low-cost supplemental feeds.

- **GIS technology provides data on watershed usage for aquaculture development in Vietnam**
  Efficiently assessing land suitability for aquaculture remains an impediment to the rapid sustainable development of natural resources. Geographical Information

Systems (GIS) technology offered a solution, but had not been applied to aquaculture situations for this purpose in Vietnam. Ground-breaking collaborative work carried out at Asian Institute of Technology in Thailand, Research Institute for Aquaculture No. 1 in Vietnam, and The University of Michigan synthesized extensive satellite and on-ground data to provide an efficient analysis of suitability of the Dai Tu district in Vietnam for aquaculture development. Geo- and biophysical features were mapped with *Systéme Pour l'observation de la Terre* satellite imagery, then integrated with data from surveys of farmers and measurement of soil and water quality to assess the suitability of the watershed for aquaculture development. Over 85% of available land was suitable for pond construction and therefore offered good prospects for successful aquaculture.

- **Combined field and station trials establish optimal criteria for polyculture regimes in Bangladesh**
  It is difficult for a farmer to weigh the different aquaculture strategies to decide which will be most profitable for a specific situation. In joint studies carried out by the Asian Institute of Technology in Thailand, Bangladesh Agricultural University, and The University of Michigan, a series of research station and on-farm trials were conducted to tease apart some of the threads in this complex decision-making process. In Bangladesh, an on-farm trial established which of five different regimes would best suit a farmer in a given situation, with various combinations of fish within a polyculture system, and whether resources were available for supplemental feeds. Annualized fish production with the specially-devised Aquaculture CRSP fertilization regime was the highest of any of the regimes, giving 3.6 tons per hectare annually compared with 1.7 tons per hectare annually for the traditional regime. Profitability tests of the different regimes with on-farm trials showed the best option for low-income farmers was a regime based on cow dung fertilizer with a modest input of chemical supplements.

- **Workshops promote ecologically and economically efficient water assay method**
  Aquaculture CRSP researchers developed a pond fertilization strategy based on assays of pond water algae because of its ready accessibility to rural farmers in developing countries. Part of this project involved the development of a bioassay test kit that is affordable and easy to use with minimal training. To extend this knowledge to where it would be most useful, collaborating researchers at the Asian Institute of Technology in Thailand, Michigan State University, the International Center for Living Aquatic Resources Management in Nepal, Regional Development Coordination for Livestock and Fisheries, Laos, Research Institute for Aquaculture No. 1 in Vietnam, and the Cambodia Aquaculture Office of the Department of Fisheries conducted eight workshops in Southeast Asia—attended by 150 participants—in Bangladesh, Cambodia, Laos, Nepal, and Vietnam. Researchers and farmers are adopting the fertilization strategy because it is a simple, practical, and economically efficient approach to identify pond-specific fertilization requirements.

- **Wide-ranging programs provide Kenyans with training to enhance aquaculture production**
  A pervasive lack of aquaculture training in Kenya has been identified as a significant limitation on fish production. This problem was addressed by researchers at the Department of Fisheries, Moi University in Kenya, the Kenya Fisheries Department, and Oregon State University, who created and implemented a major training program at Sagana Fish Farm, Kenya's premier aquaculture institution. The program provided training for undergraduates, Kenyan graduate students both in-country and in the US, and over 100 Fisheries Department personnel. Advanced training included pond construction and management and business planning. Of direct benefit to farmers was a series of "Farmer Education Days" held in several areas of the country, including one co-sponsored by the World Bank's Lake Victoria Management Project. Close to 200 farmers participated in this popular program.

- **Adoption of improved pond management techniques quadruples fish production**
  Previous Aquaculture CRSP research at Sagana Fish Farm, Kenya, identified management practices that could improve fish production, but proof of benefits was needed to convince farmers to adopt the new techniques. On-farm tests provided realistic conditions to get the evidence. Researchers at Auburn University, Moi University in Kenya, Sagana Fish Farm, and Oregon State University conducted the necessary studies. Following workshops to discuss and choose appropriate management schemes to be tested, 80 ponds were stocked with fish, and farmers kept records of feed and fertilizer inputs and fish yields. The results showed that improved management more than tripled fish production in one set of trials and quadrupled it in another (actual increase was 420%). Eighty percent of the participating farmers achieved higher yields than before the trials. Farmers claimed enormous increases in revenues, and many had in fact never made money from their ponds prior to the trials.

- **Hundreds benefit from Amazon aquaculture outreach**
  Acquiring knowledge useful to farmers is only one half of the equation. To benefit farmers, the knowledge must be transferred to where it can be put to practical use. This problem was addressed by researchers at Instituto de Investigaciones de la Amazonia Peruana (IIAP), Universidad Nacional de la Amazonia Peruana in Peru, and Southern Illinois University at Carbondale, who focused on remote areas of the Peruvian Amazon. Over 100 local producers were surveyed to gauge the success of IIAPs extension program. The extension workers implemented a certification system to enable farmers to provide technical assistance to one another. In addition, over 400 students and teachers received aquaculture training, and a further 40 workers from Bolivia, Brazil, Colombia, and Ecuador attended aquaculture courses. A website on Amazonian aquaculture is showing promise to greatly extend the outreach program.

- **High-tech method to reverse sex of fish broadens farmers' options**
  The ability to artificially manipulate the sex of fish enables farmers to maximize yields because males may be bigger than females or vice versa. Hence, single sex populations will yield bigger harvests than mixed-sex populations. Typically, sex reversal has been achieved by adding hormones to artificial diets. However, this limits the diversity of species used for aquaculture to those that accept artificial feeds. Joint studies by researchers at Universidad Juárez Autónoma de Tabasco in Mexico and Oregon State University showed that hormone incorporated into live brine shrimp (*Artemia* spp.) successfully inverted the sex of a carnivorous fish, the tropical gar, that takes only live (non-artificial) feed. So-called "bioencapsulation" broadens the options for farmers, reduces their dependence on feed suppliers, as they can raise their own *Artemia* on-site, and simplifies management of hormone-treated water.

- **Use of activated charcoal effectively removes masculinizing hormone from intensive sex-inversion systems**
  Although excess masculinizing hormone (MT) poses significant ecological risks, it is used widely in the tilapia industry. Scientists at Universidad Juárez Autónoma de Tabasco in Mexico and Oregon State University have developed an effective method to remove excess hormone using activated charcoal, a widely available and inexpensive filtering substance. This system promises to eliminate excess MT from wastewater discharges while at the same time reducing costs and increasing profits by facilitating more efficient utilization of the hormone.

- **Degree and non-degree training accomplishments**
  CRSP researchers provided non-degree training to 951 individuals in the reporting period. In addition, CRSP-sponsored students completed 7 formal degree programs—one doctorate, four masters', and two bachelors' degrees.

**ADMINISTRATIVE HIGHLIGHTS 2002–2003**

- In September 2002 a CRSP Impact Assessment Workshop was sponsored by the CRSP Council. Aquaculture CRSP representatives at this Washington DC meeting were Aquaculture CRSP Principal Investigators (PIs) Joe Molnar, Auburn University, Bill Tollner, University of Georgia, and Yang Yi, Asian Institute of Technology. Representatives from the Management Entity included Danielle Clair, Assistant Director of Operations, and Stephen Sempier, Assistant Director of Research.

- As part of a United States Department of Agriculture-sponsored fact-finding mission to the US, seven delegates from the People's Republic of China were hosted by the Aquaculture CRSP at Oregon State University, 30-31 October 2002. CRSP staff organized the delegation's visits with numerous university departments and programs. Affiliated with Guangxi Fishery Research Institute, the visitors were particularly interested in a CRSP-developed technology, the POND© software package, which is designed to facilitate decision-making by aquaculturists and which is, as a result of the visit, being discussed for translation into Chinese.

- In October 2002 CRSP PI Kevin Fitzsimmons, University of Arizona participated on behalf of Director Egna in a major new international project in aquaculture knowledge management called the "Aquaculture Compendium." The meeting was organized by CAB International and took place at the Asian Institute of Technology

- In February 2003, CRSP PI Konrad Dabrowski organized a special session on international aquaculture at the World Aquaculture Society Meeting in Louisville, Kentucky, 18–21 February 2003. The session included presentations by Aquaculture CRSP PIs and was co-moderated by Dabrowski and Sempier.

- The Director participated in CRSP Council conference call meetings on 17 September and 29 October 2003, and on 23 January, 25 February, and 1 July 2003. In addition, the CRSP was represented at CRSP Council retreats in Spring Green, Wisconsin, 15–18 September 2002 and in Bodega Bay, California, 21-25 July 2003. CRSP Director Egna traveled to Washington DC to attend an EGAT/USAID–CRSP Council meeting 14–15 2003. The CRSP was also represented at SPARE meetings in Washington DC on 30 April and 1 May and on 16–17 June 2003.

- Within the reporting period the PMO initiated a study to define opportunities to enhancing linkages between CRSP capabilities and USAID Field Mission and Water Team strategic objectives. This project is designed to foster stronger relationships among the PMO, US PIs, HC PIs, and USAID.

- The Aquaculture CRSP library donation program, now in its third year, continues to grow. One thousand seven hundred nine books and journals were donated to the program in the reporting period, while 1,182 books and journals were distributed to host country partners in Kenya, the Philippines, and Brazil.

- The Aquaculture CRSP commissioned a report on aquaculture and nutrition by Albert Tacon. This report was to be used for an anticipated five-year proposal for 2003–2008.

- The PMO followed up on recommendations put forward by a USAID-commissioned Administrative Management Review that took place in Spring 2002. Specifically, the PMO simplified the research budget format for proponents, providing clear and explicit guidance on cost share requirements and exceptions included in RFP as well as incorporating directly into subcontract language; and instituted new measures to assure that all projects develop MOUs that are standardized and consistent.

- After submission of an Eleventh Work Plan proposal and budget, the Aquaculture CRSP was formally awarded a one-year extension on 30 July 2003. Work is

planned for Africa, Asia, Central America and South America. Several new innovative projects are planned in addition to work that builds on the foundation of established projects.

**Kenya-Related Activities**

- In August 2002 the Aquaculture CRSP sponsored the US visit of CRSP PI Nancy Gitonga, Director of the Kenya Department of Fisheries. Gitonga met with CRSP researchers at The Ohio State University and the University of Arkansas at Pine Bluff. She also presented a poster at the American Fisheries Society meeting in Baltimore, Maryland, and spoke at USAID on "The Role of Aquaculture in Fisheries Development in Kenya."

- In October 2002 Mucai Muchiri, Aquaculture CRSP PI, and Godfrey Monor, Fisheries Officer for the Kenya Department of Fisheries, traveled to Oregon to discuss the development of a new Kenya watershed project. The multi-disciplinary project includes social, economic, GIS, and ecological components with a focus on the Njoro watershed.

- In February 2003 Aquaculture CRSP Kenyan PI Charles Ngugi and US PI Jim Bowman met with CRSP Director Egna to discuss progress on the Kenya project and develop new training sessions based on CRSP research to benefit Kenyan fisheries officers, fisheries assistants, and farmers.

- Also in February the Director and staff of the Aquaculture and Global Livestock CRSPs met, along with the Njoro project Lead PI, to discuss the current progress and future plans related to the Njoro watershed project.

- In March 2003 Nancy Gitonga participated in a Programme Formulation Workshop in Ghana as a CRSP PI. The stakeholder meeting focused on the sub-Saharan Africa region and was linked to the CGIAR sub-Saharan African Challenge Programme.

**US AND HOST COUNTRY PARTNERS**

The Aquaculture 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 undertaken in the reporting period comprised mainly the completion Tenth Work Plan activities but also the commencement of Eleventh Work Plan research. Tenth Work Plan activities were conducted at sites in Mexico, El Salvador, Honduras, Nicaragua, Panama, Brazil, Peru, Kenya, South Africa, Bangladesh, Cambodia, Laos, Nepal, the Philippines, Thailand, and Vietnam. Under the Eleventh Work Plan all of the above sites have been retained, and new activities in Bolivia, Guatemala, Colombia, Ecuador, Ghana, and Tanzania have been added. 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 Moi University, Kenya
- Oregon State University and the Department of Fisheries, Ministry of Livestock and Fisheries 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 were involved in regional CRSP activities in the reporting period:

- Bangladesh Agricultural University, Bangladesh
- Cambodia Department Of Fisheries, Cambodia
- Kasetsart University, Thailand
- Embrapa Meio Ambiente, Brazil
- Escuela Agrícola Panamericana, Honduras
- 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, Peru
- University of Agriculture and Forestry, Vietnam
- University of Cantho, Vietnam
- Centro de Aqüicultura, Universidade Estadual Paulista, Jaboticabal, São Paulo, Brazil
- Centro de Investigación en Alimentación y Desarrollo, Mexico

### Continuation Plan Framework

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 sustainable production systems research framework , which guided research under the Eighth, Ninth, and Tenth Work Plans, 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. 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 |

### Tenth Work Plan

Proposals for funding consideration under the Tenth Work Plan were solicited in a Request for Proposals (RFP) distributed in early 2001. Funding decisions were announced in July 2001, with work getting underway in the fall. With minor exceptions, all Tenth Work Plan research was completed as scheduled in 2003 and is reported on herein.

### Eleventh Work Plan

In anticipation of the program's submittal of a new five-year grant proposal to USAID in early 2003, Aquaculture CRSP broadly distributed the Eleventh Work Plan RFP to institutions of higher learning in the United States and overseas in summer 2002. The RFP incorporated constraints to aquaculture development as identified by stakeholders and experts that attended Aquaculture CRSP regional meetings throughout the world in 2001 and 2002.

Proposals for two-year projects that focused on one of three program areas—Production Technology, Watershed Management, or Human Welfare, Health, and Nutrition—were submitted by 1 October 2002. The CRSP employed a National Science Foundation-style panel review process to evaluate and rate the proposals. Additional programmatic reviews of proposals by the TC, BOD, and ME followed.

In late fall of 2002 USAID notified the CRSP that the program would be given a one-year extension on the current grant—through 31 July 2004—rather than the two years that would have been needed for completing a full work plan cycle. High ranking proposals were shortened to reflect the timeline of the now one-year Eleventh Work Plan. As work under the Eleventh Work Plan is just now getting underway, research results are not yet available.

### 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) collects research progress reports on a quarterly basis.

Table 1. Results Framework for Research Areas within the *Production Systems* ACRSP 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.<br>* Improved pond management strategies.<br>* Significant advances in reproduction technology.<br>*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.<br>* 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.<br>* Positive financial and nutritional impact on participating household communities. |

Table 2. Results Framework for Research Themes within the *Production Optimization* ACRSP 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.<br>* 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.<br>* Successful production of sufficient amounts of YY-males.<br>* Successful use of piscivorous fish to control excess tilapia offspring. | * Development of procedures that guarantee the safety of animals and farmers during steroid use.<br>* Demonstration of the functional nature of YY-males for producing all male tilapia offspring.<br>* 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.<br>* 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* ACRSP 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* ACRSP 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.<br>* Improved sales of products.<br>* 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.<br>* 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.<br>* 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*

| | |
|---|---|
| Claude E. Boyd | US Principal Investigator |
| C. Wesley Wood | US Principal Investigator |
| Brenda Wood | Technician |
| Taworn Thunjai | Ph.D. Student (Thailand) |
| Kom Silapajarn | Ph.D. Student (Thailand) |
| Orawan Silapajarn | Ph.D. Student (Thailand) |

*University of Stellenbosch, South Africa*

| | |
|---|---|
| Danie Brink | Host Country Principal Investigator |
| Khalid Salie | Research Assistant |

*Kasetsart University, Bangkok, Thailand*

| | |
|---|---|
| Mali Boonyaratpalin | Host Country Principal Investigator |

*Embrapa Meio Ambiente, Brazil*

| | |
|---|---|
| Julio Queiroz | Host Country Principal Investigator |

*Centro de Aqüicultura, Universidade Estadual Paulista, Jaboticabal, São Paulo, Brazil*

| | |
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| Lucia Sipauba Tavares | 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 a final report.
- Reaction of liming materials in pond bottom soils/10ER1. The report submitted for this investigation was a final report.

**Publications**


Boyd, C.E., 2002. Water and sediment quality in pond aquaculture. In: Indigenous Aquaculture of Sustainable Development, 6th Conference of the Aquaculture Association of Southern Africa, Stellenbosch, South Africa, 10–13 September 2002. Paper 28, pp. 19–20.

Boyd, C.E., M. Boonyaratpalin, and T. Thunjai, 2002. Properties of liming materials. Aquaculture Asia, 7(3):7–8.

Thunjai, T., 2002. Bottom soil quality in fish ponds of different ages in Thailand and suggestions for its management. Ph.D. dissertation, Auburn University, Alabama. 126 pages.


**Presentations**


Boyd, C.E. Bottom soil and water quality management in shrimp ponds. Seminar presented to employees of Unima Shrimp Farm in Besalampy, Madagascar, 2002.

Boyd, C.E. Effects of pond age on bottom soil quality. WAS Annual Meeting, Salvador, Brazil, May 2003.

Boyd, C.E. Environmental issues in shrimp farming. Presented at the Sustainable Shrimp Farming Conference in Antananarivo, Madagascar, 3 December 2002.

Boyd, C.E. U.S. PD/A CRSP pond soil research in Brazil, South Africa, Thailand, and other countries. Presentation given at the Chapter of the World Aquaculture Society, Louisville, Kentucky, February 2003.

Boyd, C.E. Water and bottom soil management in pond aquaculture. 6th Conference of the Aquaculture Association of Southern Africa, Stellenbosch, South Africa, 13 September 2002.

Wood, C.W. Reaction of liming materials in pond bottom soils. World Aquaculture Society Annual Meeting, Salvador, Brazil, May 2003.

## EFFECTS OF POND AGE ON BOTTOM SOIL QUALITY

*Tenth Work Plan, Pond Dynamics Research 1 (10PDR1)*
*Final Report*

Claude E. Boyd and Taworn Thunjai
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama, USA

Mali Boonyaratpalin
Department of Fisheries
Kasetsart University
Bangkok, Thailand

### ABSTRACT

Bottom soil samples were collected from 35 ponds in the vicinity of Samutprakarn, Thailand. Ponds ranged in age from 3 to 39 years and had been used continuously for production of tilapia. Liming materials had been applied in large amounts, and bottom soils of all ponds had pH above 7, low exchangeable acidity, and free carbonates. Pond soils often contained between 1 and 2% total sulfur, suggesting that they were potential acid-sulfate soils. However, acidity from sulfide oxidation was not expressed because carbonates in the soil neutralized it. Although farmers apply liming materials to ponds during each crop, this practice is no longer necessary in many of the ponds because of residual effects from previous years. Cessation of liming would be acceptable in ponds with soil pH above 7, but pH should be checked annually and applications resumed when necessary. Where liming is practiced, Thai fish farmers should be careful about the selection of liming materials. Evaluation of available liming products revealed that only about 50% of them were correctly labeled and of good quality. Concentrations of total carbon in pond soils seldom exceeded 4%, and the average for organic carbon was 1.90%. The correlations between pond age and both total carbon and organic carbon were weak (r = 0.34 and 0.36, respectively). Concentrations of nitrogen in bottom soils did not differ with pond age and ranged from 0.1 to 0.3% with an average of 0.19%. The average carbon:nitrogen ratio was 11:1 at both sites. Acid-extractable phosphorus concentrations averaged 217 ppm, but the phosphorus adsorption capacity averaged 768 ppm, suggesting that the soils still have considerable reserve capacity to adsorb phosphorus. Results of this study revealed that ponds can be used annually for semi-intensive production of tilapia and presumably other species for many years without serious deterioration of bottom soil quality.

## REACTION OF LIMING MATERIALS IN POND BOTTOM SOILS

*Tenth Work Plan, Effluents and Pollution Research 1 (10ER1)*
*Final Report*

Claude E. Boyd
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama, USA
C. Wesley Wood
Department of Agronomy and Soils
Auburn University
Auburn, Alabama, USA

Julio Queiroz
Embrapa Meio Ambiente
Brazil

Khalid Salie
Division of Aquaculture
University of Stellenbosch
Stellenbosch, South Africa

### ABSTRACT

Three techniques for treating fish ponds with agricultural limestone were evaluated in ponds with clayey soils in Brazil and in ponds with sandy soils in South Africa. Amounts of agricultural limestone equal to the lime requirement of bottom soils were applied by the following methods to each of three ponds: (1) direct application over the pond surface; (2) spread uniformly over the bottom of the empty pond; (3) spread uniformly over the bottom of the empty pond followed by tilling of the bottom. The effectiveness of agricultural limestone applications did not differ among treatment methods. Agricultural limestone also reacted quickly to increase total alkalinity and total hardness of pond water to acceptable concentrations within two weeks after application. Data on soil pH and exchangeable acidity suggested that the reaction of liming material to increase soil pH was essentially complete after one to two months. In the clayey soil, agricultural limestone had no effect below a depth of 8 cm. Agricultural limestone reacted to a depth of at least 20 cm in the sandy soil. This research suggests that full ponds can be limed effectively. Aquaculture methods that allow ponds to be operated for several years without draining are highly desirable from standpoints of water conservation and environmental protection. Moreover, findings suggest that tilling of pond bottoms to incorporate liming materials is unnecessary, considering that tilling consumes time and is an expensive practice.

# 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 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)

*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

*Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh*
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 a final report.
- Workshops on using principles of pond dynamics to optimize fertilization efficiency/10PDR2. The report submitted for this investigation was a final report.

**Publication**

Knud-Hansen, C.F., K.D. Hopkins, and H. Guttman, 2003. A comparative analysis of the fixed-input, computer modeling, and algal bioassay approaches for identifying pond fertilization requirements for semi-intensive aquaculture. Aquaculture, 228:189–224.

**Presentation**

Knud-Hansen, C. The algal bioassay fertilization strategy: an ecological approach for efficient natural food production in aquaculture ponds. Presented at Institute for Social, Economic and Ecological Sustainability Second International Organic Aquaculture Workshop, Minneapolis, Minnesota, July 2003.

## 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)*
*Final Report*

Ted R. Batterson and Christopher F. Knud-Hansen
Department of Fisheries and Wildlife
Michigan State University
East Lansing, Michigan, USA

Yang Yi and Yuan Derun
Aquaculture & Aquatic Research Management
School of Environment, Research, and Development
Asian Institute of Technology
Pathumthani, Bangkok, Thailand

**ABSTRACT**

Five experiments were conducted at the Asian Institute of Technology (AIT, Thailand) during February–July 2002 to assess the potential of crushed (1–2 mm diameter) clinoptilolite zeolite to: 1) transfer ammonia-N from animal manures to fertilize aquaculture ponds, 2) moderate ammonia concentrations in fertilized culture water, and 3) remove ammonia-N from discharged pond water. The clinoptilolite used

in this study was found to absorb about 1.91 g N $kg^{-1}$ when soaked in an ammonium chloride solution, but absorbed very little nitrogen when soaked in a solution of urea. When soaked in either fresh swine or chicken manure slurries, the clinoptilolite absorbed about 0.43 g N $kg^{-1}$ after one week—with most of the absorption occurring within the first 2 days of immersion. Other molecules in the manures likely out-competed ammonium ions for ion exchange sites in the clinoptilolite. Nevertheless, plastic mesh bags containing crushed clinoptilolite soaked in swine manure and replaced weekly were able to provide sufficient N to culture waters to promote algal productivities and Nile tilapia yields similar to tanks fertilized with urea. Results indicate that clinoptilolite technologies applied to livestock-fish integrated systems could increase on-farm nitrogen utilization efficiencies by capturing and recycling manure-N before it is otherwise lost through ammonia volatilization or nitrate leaching, and to use that nitrogen as a fertilizer to promote algal productivity in culture ponds. Unfortunately, a simple economic analysis does not encourage this approach for small-scale farmers. In addition, the anticipated effect of moderating ammonia levels in culture water by clinoptilolite was not obvious in the experiments. It was also found that clinoptilolite did not significantly reduce nitrogen levels (both total ammonia and total nitrogen) of aquaculture discharge water. These results were likely due to the relatively low ammonia concentrations in the water and the limited contact time with the clinoptilolite. Adequately assessing the potential for clinoptilolite to capture and recycle nitrogen from aquaculture wastewater will require further research.

## WORKSHOPS ON USING PRINCIPLES OF POND DYNAMICS TO OPTIMIZE FERTILIZATION EFFICIENCY

*Tenth Work Plan, Pond Dynamics Research 2 (10PDR2)*
*Final Report*

Ted R. Batterson, Christopher F. Knud-Hansen, and Donald Garling
Department of Fisheries and Wildlife
Michigan State University
East Lansing, Michigan, USA

Amrit Bart
Aquaculture and Aquatic Resources Management
Agricultural and Aquatic Systems Engineering Program
School of Environment, Research, and Development
Asian Institute of Technology
Pathumthani, Thailand

### ABSTRACT

Eight three-day workshops were given in Bangladesh, Cambodia, Laos, Nepal, Thailand, and Vietnam during June to July 2002. These workshops focused on practical aspects of how to use principles of pond dynamics to improve pond management and optimize fertilization efficiencies for natural food production in semi-intensive aquaculture systems. The centerpiece of the workshops was learning how to apply the algal bioassay fertilization strategy (ABFS) using the simple algal bioassay test kit developed by Michigan State University (MSU) through the Aquaculture Collaborative Research Support Program (CRSP). Fifteen test kits were left at each workshop site. Nearly 150 total participants representing universities, government fisheries offices, non-profit organizations, and community farming groups participated in the workshops. Responses to the workshops have been very positive. Reports from several countries indicate that researchers and farmers alike are adopting the ABFS because it is practical and promotes economically-efficient natural food production by using a simple ecological approach to identify pond-specific fertilization requirements.

## 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 |
| Jacques Rinchard | Postdoctoral Researcher |
| Kyeong-Jun Lee | Postdoctoral Researcher |
| Gustavo R. Montes de Oca | Ph.D. Student (Mexico) |
| Kyle Ware | Research Aide |
| Vanessa Reed | Undergraduate Student |
| Zachary Brown | Undergraduate Student |

*Universidad Juárez Autónoma de Tabasco, Tabasco, Mexico*

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

*Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru*

| | |
|---|---|
| Fernando Alcántara | 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 | Visiting Scholar (Peru) |

*Universidad Nacional del Comahue, Argentina*

| | |
|---|---|
| Patrcia Noguera | Cooperator |

*Sao Paulo State University Jaboticabal, Sao Paulo, Brazil*

| | |
|---|---|
| Marcelo Tesser | Graduate Student |

*Department of Fish Pathology, College of Ocean Science and Technology, Kunsan National University, Chonbuk, Korea*

| | |
|---|---|
| Kwan Park | Visiting Associate Professor |

*Auburn University, Auburn, Alabama*

| | |
|---|---|
| Ronald Phelps | 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 a final report.
- Studies on reproduction and larval rearing of Amazonian fish/10NSR2. See Peru Project summary, p. 35.
- Broodstock diets and spawning of Colossoma macropomum and/or Pairactus brachypomus/10FFR2. See Peru Project summary, p. 35.

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.

**Publications**

Palacios, M.E., 2003. Local Peruvian cooperatives recognize use of maca in fish nutrition. Envision (online), http://envision.osu.edu/news.asp?ID=384, 10 August 2003.

Reed, V., 2003. Effects of 17α-methyltestosterone and 17β-estradiol on reproductive development of *Amphilosoma citrinellum*. Research project, The Ohio State University. 8 pp.

**Presentations**

Dabrowski, K. New developments in diet formulations for larval fish: peptides and growth enhancers. University of Sao Paolo, Pirassununga. 29 October 2002.

Dabrowski, K. Tocopherols in aquatic organisms. Aquacul-

ture America Conference, Louisville, Kentucky, 18–21 February 2003.

Rodriguez, G., K. Dabrowski, M.A. Abiado, W.M. Contreras, G. Morales, and M. de Jesus Contreras. Possible use of phytosteroids (quercetin) as alternative chemicals to produce a monosex population of tilapia. Oral presentation at Aquamar Internacional, Cancun, Mexico, 3–7 September 2002.

Rodriguez, G., K. Dabrowski, K.J. Lee, M. Teresk, W.M. Contreras, G. Morales, and M. de Jesus Contreras. Interaction of two antioxidants, quercetin and vitamin C and impact on the growth performance of tilapia (*Oreochromis niloticus*). Aquamar Internacional, Cancun, Mexico, 3–7 September 2002.

Ostaszewska, T., M.E. Palacios, and K. Dabrowski. Growth and morphological changes in digestive tract of rainbow trout and pacu due to fish meal protein replacement with soybean products. Aquaculture America 2004, Honolulu, Hawaii. (submitted)

**Conference**

Aquamar Internacional, Cancun, Mexico, 3–7 September 2002. (Contreras-Sánchez and Rodriguez)

## 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)*
*Final Report*

Konrad Dabrowski, Gustavo Rodriguez, Kyeong-Jun Lee, and Mary Ann G. Abiado
School of Natural Resources
The Ohio State University
Columbus, Ohio, USA

Wilfrido Contreras-Sánchez and Gabriel Márquez-Couturier
Universidad Juarez Autonoma de Tabasco
Tabasco, Mexico

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

### ABSTRACT

All-male tilapias are desirable because they manifest superior growth characteristics compared to females. The synthetic steroid, 17α-methyltestosterone (MT) has been commonly used to sex-reverse tilapia but because of its potential health and environmental hazards, the use of phytochemicals as alternative means to affect sex differentiation has to be explored. We addressed objective 1 by using the high performance liquid chromatography (HPLC) technique to determine MT concentrations in the water and in fish. We determined the rate of excretion/degradation of MT following dietary uptake. We addressed objective 2 by examining the dietary intake of quercetin, genistein, and complex of flavonoids in the form of maca meal or "propolis." The phytochemicals that we tested in this study showed potential for affecting sex ratios although their potency was lower compared to MT. Further studies are needed to evaluate other phytochemicals that contain flavonoids and/or isoflavonoids and how these substances are metabolized.

# 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
Wanwisa Saelee — Undergraduate Student

*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 McDonal-Vera — Graduate Student

**Work Plan Research**

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

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

**Presentations**

Fitzsimmons, K. Global Tilapia Research and Production. Public presentation, Guadalajara, Mexico, 20 March 2003.

Fitzsimmons, K. Introduction to Tilapia Production and Research in the Americas. Aquaculture America 2003, Louisville, Kentucky, February 2003.

## STOCKING DENSITIES FOR TILAPIA-SHRIMP POLYCULTURE IN THAILAND

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

Yang Yi, Wanwisa Saelee and Potjanee Naditrom
Aquaculture and Aquatic Resources Management
Asian Institute of Technology
Pathumthani, Thailand

Kevin Fitzsimmons
Department of Soil, Water, and Environmental Science
University of Arizona
Tucson, Arizona, USA

### ABSTRACT

This study, consisting of two experiments, was carried out at the Asian Institute of Technology (AIT), Thailand, to determine optimal conditions for stocking and rearing Nile tilapia (*Oreochromis niloticus*) and shrimp (*Penaeus monodon*) in a polyculture system at low salinity. Both experiments were conducted in nine 200 $m^2$ earthen ponds with three treatments in triplicate each: shrimp alone at 30 per $m^2$ (monoculture, control); shrimp at 30 per $m^2$ and Nile tilapia at 0.25 per $m^2$ (low tilapia density polyculture); shrimp at 30 per $m^2$ and Nile tilapia at 0.50 per $m^2$ (high tilapia density polyculture). In experiment one, the feed ration was varied and determined daily by feeding-tray method in every pond during the 65-day culture period, while the fixed same feed ration for all ponds was determined by a feeding table during 75-day culture period in experiment two.

In experiment one with varied feed rations, the growth, yield and survival of shrimps was not significantly different among all treatments ($P > 0.05$). Although FCR (1.62–2.24) of shrimps were not significantly different among all treat-

ments ($P > 0.05$), shrimp monoculture had significantly lower feed input than tilapia-shrimp polyculture ($P < 0.05$). However, in experiment two with fixed feed rations, the low tilapia density polyculture resulted in significantly higher shrimp yield than the monoculture and high tilapia density polyculture ($P < 0.05$). FCR of 1.44 in the low tilapia density polyculture was significantly better than those (1.73 and 1.69) in both monoculture and high tilapia density polyculture, respectively ($P < 0.05$).

In both experiments, Nile tilapia showed fast growth (3.98–4.70 g $fish^{-1}$ $d^{-1}$). There was no significant difference in growth and survival of Nile tilapia between the low and high tilapia density polyculture ($P > 0.05$), while fish yields were significantly higher in the high tilapia density polyculture than those in the low tilapia density polyculture ($P < 0.05$).

Partial budget analyses indicated that under varied feed input (experiment one), the highest net return was achieved in the shrimp monoculture, intermediate in the high tilapia density polyculture, and lowest in the low tilapia density polyculture, while under the fixed feed input (experiment two) the low tilapia density polyculture gave the highest net return, followed by the high tilapia density polyculture and shrimp monoculture. Under varied feed input, the added cost produced negative added return in the low tilapia density polyculture, and the ratio of added return to added cost in the high tilapia density polyculture was 0.73. However, under fixed feed input, the ratio of added return to added cost in the low tilapia density polyculture reached 22.69, which is higher than that (5.04) in the high tilapia density polyculture.

The present study indicated that the addition of Nile tilapia into shrimp ponds can improve feed utilization efficiency, resulting in better economic returns and less environmental pollution. The present study showed that the tilapia-shrimp polyculture with appropriate feeding strategy is technically feasible, economically attractive, and environmentally friendly.

## SURVEY OF TILAPIA-SHRIMP POLYCULTURES IN MEXICO

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

Wilfrido M. Contreras-Sánchez and Alejandro MacDonal Vera
Laboratorio de Acuacultura
Universidad Juárez Autónoma de Tabasco
Villahermosa, Tabasco, Mexico

Kevin Fitzsimmons
Department of Soil, Water and Environmental Science
University of Arizona
Tucson, Arizona, USA

### 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*

Wilfrido M. Contreras-Sánchez and Alejandro MacDonal Vera
Laboratorio de Acuacultura
Universidad Juárez Autónoma de Tabasco
Villahermosa, Tabasco, Mexico

**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 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 POLYCULTURES IN THE PHILIPPINES

*Tenth Work Plan, New Species/New Systems Research 3E (10NSR3E)*
*Final Report*

Kevin Fitzsimmons
Environmental Research Lab
Department of Soil, Water and Environmental Science
University of Arizona
Tucson, Arizona, USA
Remedios Bolivar and JunRey Sugue
Freshwater Aquaculture Center
Central Luzon State University
Nueva Ecija, Philippines

**ABSTRACT**

A survey was conducted of farmers who had adopted some form of shrimp-finfish polyculture. The respondents included producers from 13 separate provinces in eight regions of the Philippines. Four separate techniques were reported for rearing fish with their shrimp: simultaneous, sequential, rotational, and cages inside ponds. The majority of the respondents stocked tilapia with the shrimp, milkfish being the primary alternative.

Most of the respondents reported that the integration of finfish and shrimp culture lessened disease problems especially vibriosis. Several farm trials have been conducted which showed that luminous bacterial counts in the water and in the shrimp were below 10 colony forming units (cfu) per ml and below 1,000 cfu per hepatopancreas, respectively. These were conducted in ponds which previously had been used for tilapia culture (rotation) and whose water was previously taken from a tilapia reservoir (sequential) as well as the stocking of tilapia in cages with shrimps (cages) and stocking directly in the ponds (simultaneous). Several of the respondents also reported that the tilapia contributed to "conditioning" the water. Specifically the density of green algae increased providing "greenwater."

The Philippines has developed wide-ranging forms of integrated tilapia-shrimp farming. The severe impact of diseases on the yield and profitability of shrimp culture provided much of the impetus. Adoption of polyculture has provided jobs to many people who had lost positions with the earlier shrimp operations and has led to what appears to be a more sustainable culture method.

# PLANNING AND POLICY PROJECT

MOU No. RD009L

**Staff**

*Oregon State University, Corvallis, Oregon*
Danielle Clair — Principal Investigator
Gwyn Newcombe — Project Coordinator

**Collaborators**

Jim Diana, University of Michigan
Kevin Fitzsimmons, University of Arizona
Hillary Egna, Oregon State University
Dan Meyer, Zamorano, Honduras
Suyapa Triminio, Zamorano, Honduras
Yang Yi, AIT, Thailand
Amrit Bart, AIT, Thailand
Kwei Lin, AIT, Thailand
Nancy Gitonga, Kenya Dept of Fisheries
David Liti, Zoology Dept, Moi Univ, Kenya
Mucai Muchiri, Fisheries Dept, Moi Univ, Kenya

**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.

## 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)*
*Final Report*

Danielle Clair and Gwyn Newcombe
Pond Dynamics/Aquaculture CRSP
College of Agricultural Sciences
Oregon State University
Corvallis, Oregon, USA

**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. PD/A CRSP hosted a series of meetings: a stakeholder meeting held in Honduras in August 2001; and three expert panel meetings for the Latin America and Caribbean Region, Asia Region, and Africa Regions. Each expert panel had 10 experts, as well as a chair and a facilitator from PPEC. 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. Each Expert Panel meeting was summarized in a report, and the findings formed the basis of the framework for the Eleventh Work Plan Request for Proposals. The reports are available in PDF format on the Aquaculture CRSP website.

## MARKETING AND ECONOMIC ANALYSIS AND PRODUCT DIVERSIFICATION RESEARCH

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

**Staff**

*University of Arkansas at Pine Bluff, Pine Bluff, Arkansas*

| | |
|---|---|
| Carole Engle | US Principal Investigator |
| Ivano Neira | Research Associate |

*Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru*

| | |
|---|---|
| Fernando Alcántara Bocanegra | Host Country Principal Investigator |

*Universidad Juárez Autónoma de Tabasco, Villahermosa, Mexico*

| | |
|---|---|
| Wilfrido Contreras-Sánchez | Host Country Principal Investigator |
| Raymundo Sury | Undergraduate Student |

*Universidad Centroamericana, Nicaragua*

| | |
|---|---|
| Agnes Saborio | Host Country Principal Investigator |

*Moi University, Eldoret, Kenya*

| | |
|---|---|
| Mucai Muchiri | Host Country Principal Investigator |

*Escuela Agrícola Panamericana, El Zamorano, Honduras*

| | |
|---|---|
| Daniel Meyer | Host Country Principal Investigator |
| Freddy Arias | Host Country Principal Investigator |
| Carlos Leyva Carias | Graduate Student |

**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 a final report.
- 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. and I. Neira, 2003. Potential for open-air fish markets outlets for tilapia in Nicaragua. Aquaculture Collaborative Research Support Program, Oregon State University, Corvallis, Oregon. 18 pp.

Engle, C.R. and I. Neira, 2003. Potential for supermarket outlets for tilapia in Nicaragua. Aquaculture Collaborative Research Support Program, Oregon State University, Corvallis, Oregon. 18 pp.

Fúnez, O., I. Neira, and C.R. Engle, 2003. Potential for open-air fish markets outlets for tilapia in Honduras. Aquaculture Collaborative Research Support Program, Oregon State University, Corvallis, Oregon. 14 pp.

Fúnez, O., I. Neira, and C.R. Engle, 2003. Potential for supermarket outlets for tilapia in Honduras. Aquaculture Collaborative Research Support Program, Oregon State University, Corvallis, Oregon. 24 pp.

Monestime, D., I. Neira, O. Fúnez, and C.R. Engle, 2003. Potential for restaurant markets for tilapia in Honduras. Aquaculture Collaborative Research Support Program, Oregon State University, Corvallis, Oregon. 18 pp.

Neira, I. and C.R. Engle, 2003. Potential for restaurant markets for tilapia in Nicaragua. Aquaculture Collaborative Research Support Program, Oregon State University, Corvallis, Oregon. 28 pp.

Neira, I., C.R. Engle, and K. Quagrainie, 2002. Potential restaurant markets for farm-raised tilapia in Nicaragua. Aquaculture Economics and Management. (accepted)

Valderrama, D. and C.R. Engle, 2003. Economic optimization of shrimp farming in Honduras. Journal of the World Aquaculture Society 33(4): 398–409.

Valderrama, D. and C.R. Engle. Farm-level economic effects of viral diseases on Honduran shrimp farms. Journal of Applied Aquaculture. (accepted)

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

*Tenth Work Plan, Product Diversification Research 1 (10PDVR1)*
*Final Report*

Ivano Neira, Carole R. Engle, and Kwamena Quagrainie
Aquaculture/Fisheries Center
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas, USA

**ABSTRACT**

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 purpose of this study was to assess the potential for increasing sales of farm-raised tilapia through the domestic restaurant market in Nicaragua. Direct personal interviews were conducted with 118 restaurant managers selected at random 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 steaks. Larger restaurants that considered tilapia to be a high-quality product and that offered "ceviche" (fish marinated in lime juice) 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*

Carole R. Engle and Ivano Neira
Aquaculture/Fisheries Center
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas, USA

**ABSTRACT**

Tilapia exports from Honduras to the United States have increased dramatically in recent years. However, small and medium-scale farmers have expressed difficulty in obtaining and maintaining markets. Identification of optimal markets to target within the domestic economy of Honduras could provide a market alternative for small and medium-scale tilapia farmers in Honduras. Market survey data from the previous work plan will be used as a basis for establishing market characteristics of various alternative types of market outlets in various regions of the country. Data have been collected on location of tilapia farms of different sizes. Data also have been collected to estimate marketing costs for various farm sizes located in various regions of Honduras. A prototype mathematical programming model—a spatial allocation transportation model—has been constructed. The model includes demand, supply, transportation, and marketing submatrices. Farm scenarios have been defined. Supply origins and capacities have been mapped and categorized. Demand requirements have been determined from secondary government sources and from market survey data. Price data likewise have been compiled from the previous surveys. After validation, the model will be used to analyze a variety of scenarios and a wide variety of sensitivity analyses will be conducted. Results will be summarized and a journal article drafted.

## DEVELOPMENT AND EVALUATION OF A SIMPLE MARKET FEASIBILITY ASSESSMENT METHODOLOGY

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

Carole R. Engle and Ivano Neira
Aquaculture/Fisheries Center
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas, USA

**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 10PVDR1. As we continue to complete the logit analyses, we may add or otherwise modify the rapid market assessment tool. Three surveys have been completed in Mexico City, Mexico, and in three cities in Peru (Lima, Tarapoto, and Iquitos). To date, we have received data summaries from the restaurant and supermarket surveys done in Mexico City, and will receive the summaries of the open-air market survey shortly. In Peru, we completed restaurant, supermarket, and open-air market surveys in the three cities and have completed the bulletins of the descriptive data for the restaurant and supermarket surveys. The descriptive version of the open-air market surveys will be completed soon. These surveys will allow us to compare results of the rapid market assessment tool under the following conditions:

- A very large, cosmopolitan urban area with a long history of tilapia consumption;
- An area where tilapia are not allowed, not marketed, and little known; and
- 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*

Carole R. Engle
Aquaculture/Fisheries Center
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas, USA

**ABSTRACT**

Templates were developed to collect all 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 also 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 policymakers.

## ECONOMIC AND RISK ANALYSIS OF TILAPIA PRODUCTION IN KENYA

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

Carole R. Engle
Aquaculture/Fisheries Center
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas, USA

**ABSTRACT**

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 prices may take are 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 probability.

# MEXICO PROJECT

MOU No. RD009C

**Staff**

*Oregon State University, Corvallis, Oregon*

| | |
|---|---|
| Carl B. Schreck | US Principal Investigator |
| Guillermo R. Giannico | US Principal Investigator |

*Universidad Juárez Autónoma de Tabasco, Villahermosa, Mexico*

| | |
|---|---|
| Wilfrido M. Contreras-Sánchez | Host Country Principal Investigator |
| Gabriel Márquez Couturier | Host Country Principal Investigator |
| Mario Fernández Perez | Host Country Principal Investigator |
| Eunice Pérez-Sánchez | Host Country Principal Investigator |
| Arlette Hernández-Franyutti | Researcher |
| Alfredo Ramos Montero | Technician |
| Guadalupe Morales Lara | Technician Student |
| Bernardita Campos Campos | Graduate Student |
| Candelario Bautista Cruz | Graduate Student |
| Alejandro McDonal Vera | Graduate Student |
| Ulises Hernández Vidal | Graduate Student |
| María Fernanda Cifuentes Alonso | Undergraduate Student |
| Gisela Filigrana Celorio | Undergraduate Student |
| Maria de Jesús Contreras Garcia | Undergraduate Student |
| Gabriel Real Ehuan | Undergraduate Student |
| Caleb Ramirez Feria | Undergraduate Student |
| Rafael Martinez Garcia | Undergraduate Student |
| Gabriel Hernández Hernández | Undergraduate Student |
| Gabriela Arias Jiménez | Undergraduate Student |
| Guadalupe Morales Lara | Undergraduate Student |
| Emil Paolo Ramon López | Undergraduate Student |
| Juan Manuel Vidal López | Undergraduate Student |
| Luis Arturo Dorantes López | Undergraduate Student |
| Mariela Frias López | Undergraduate Student |
| Abigael Chávez Méndez | Undergraduate Student |
| Isidro López Ramos | Undergraduate Student |
| Milciades De la Cruz Rodríguez | Undergraduate Student |
| Rocío Chan Rodrígues | Undergraduate Student |
| Daniel Alejandro López Sanlucar | Undergraduate Student |
| Sergio Gómez Triano | Undergraduate Student |
| Luis Emanuel Pascual Valencia | Undergraduate Student |
| Federico V. Aguilar-Tellez | Undergraduate Student |
| Lander Lara-Aguilar | Undergraduate Student |
| Luis A. Dormantes-López | Undergraduate Student |

**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 a final report.
- Diversification of aquacultural practices by incorporation of native species and implementation of alternative sex inversion techniques/10ATR3. The report submitted for this investigation was a final report.
- Selection of a new Nile tilapia genetic line to provide broodstock for Southeastern Mexico/10RCR2. The report submitted for this investigation was a final report.

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).

**Publications**

Campos Campos, B., 2002. Tilapia Fry Production. Training pamphlet, independently published, January 2002.

Campos Campos, B., 2002. Filtration System for the Elimination of Methyltestosterone in Tilapia Masculinization Systems. Training pamphlet, independently published, January 2002.

Hernández-Vidal, U., 2002. Tropical gar (*Atractosteus tropicus*) sex identification and hormonal induced spawn evaluation. M.S. thesis. 83 pp.

Zacarías-Sánchez, A., 2003. Effects of feeding schedule on growth and survival of tropical gar (*Atractosteus tropicus*) larvae. Undergraduate thesis. 42 pp.

**Presentations**

Contreras-Sánchez, W. Bioencapsulation of 17 β-estradiol and trenbolone acetate in *Artemia* nauplii for sex-inversion purposes. Aquamar Internacional 2002, Cancún, México, 3–7 September 2002.

Contreras-Sánchez, W. Effects of stress on reproduction, gamete quality and progeny of rainbow trout, *Oncorhynchus mykiss*. Reunión internacional sobre la calidad e inocuidad alimentaria en la producción trutícola. Toluca, Mexico, 23–25 October 2002.

Contreras-Sánchez, W. Masculinization of Nile tilapia, *Oreochromis niloticus,* using a combination of short immersions in the synthetic steroid trenbolone acetate and high temperatures. AQUAMAR Internacional 2002, Cancún, Mexico, 3–7 September 2002.

Contreras-Sánchez, W. Nile tilapia line selection. Villahermosa, Tabasco, Mexico, 8 August 2003.

Contreras-Sánchez, W. Use of clean technologies for aquaculture to eliminate MT from intensive masculinization systems. Villahermosa, Tabasco, Mexico, 8 August 2003.

**Achievement**

Wilfrido Contreras was invited to serve in the research and doctoral committees of the Biological Sciences Division at UJAT.

## Elimination of Methyltestosterone (MT) from Intensive Masculinization Systems: Use of Activated Charcoal in Concrete Tanks

*Tenth Work Plan, Effluents and Pollution Research 2 (10ER2)*
*Final Report*

Wilfrido M. Contreras-Sánchez and Gabriel Márquez-Couturier
Laboratorio de Acuacultura
Universidad Juárez Autónoma de Tabasco
Villahermosa, Tabasco, Mexico

Grant W. Feist and Guillermo Giannico
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA

Carl B. Schreck
Oregon Cooperative Fish and Wildlife Research Unit
Biological Resources Division—US Geological Survey
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA.

### Abstract

This study tested the hypothesis that activated charcoal can eliminate 17α-methyltestosterone (MT) from water used in intensive sex-inversion systems. Two amounts of charcoal (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 the water. Fry (2,200 to 2,945 $m^{-3}$) were treated with a masculinizing dose of MT (60 mg $kg^{-1}$ feed) for four weeks beginning at the initiation of feeding in concrete ponds containing 7.13 $m^3$ of water. Water samples were collected from the sex-inversion tank before the onset of treatment and weekly beginning on the first day of treatment. Activated charcoal used in the treatment was exposed to direct sunlight for 24 or 48 h, and samples were collected at different times for MT detection. All samples were extracted using ether, and the concentration of MT determined by radioimmunoassay at Oregon State University. Masculinization rates were not significantly different between treatments in a trial or between trials ($P > 0.05$). Mean percentage of males for treatments with 0.0, 2.5 and 5.0 kg of activated charcoal were 93.8, 93.5, and 94.0%, respectively. Controls averaged 51.7% males, which was significantly less than the MT-fed groups ($P < 0.001$). MT concentrations in the water ranged between 0.14 and 9.17 ng $ml^{-1}$, and the largest detected value occurred as an isolated case with all other values being below 1.0 ng $ml^{-1}$. Our data demonstrate that activated charcoal efficiently captures MT and that vegetal charcoal has a higher adsorption capacity than mineral charcoal. We recommend the use of activated charcoal filtration systems to eliminate excess MT and potentially increase masculinization.

## Diversification of Aquacultural Practices by Incorporation of Native Species and Implementation of Alternative Sex Inversion Techniques

*Tenth Work Plan, Appropriate Technology Research 3, 10ATR3*
*Final Report*

Wilfrido M. Contreras-Sánchez and Gabriel Márquez-Couturier
Laboratorio de Acuacultura
Universidad Juárez Autónoma de Tabasco
Villahermosa, Tabasco, Mexico

Grant W. Feist
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA

Arlette Hernández-Franyutti
Laboratorio de Acuacultura
Universidad Juárez Autónoma de Tabasco
Villahermosa, Tabasco, Mexico

Carl B. Schreck
Oregon Cooperative Fish and Wildlife Research Unit
Biological Resources Division—US Geological Survey
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA

Guillermo Giannico
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA

### Abstract

This study sought to determine whether administration of steroids via bioencapsulation into live food is an efficient method for sex inversion of carnivorous species of fish in aquaculture. This technique may offer an alternative for sex

reversing such species because the larvae strongly prefer live food compared to artificial diets. To determine whether steroids could accumulate in *Artemia*, nauplii were immersed in solutions containing 2,500 _g $l^{-1}$ of either estradiol (E2) or trenbolone acetate (TA). Steroids were dissolved in ethanol (1 mg $ml^{-1}$) and then added to the water. Controls were immersed in water containing ethanol vehicle only. Each treatment consisted of three replicates. Water samples (50 ml) from glass jars containing *Artemia* 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 processed. All samples were extracted using ether, and the concentration of steroids were determined by radioimmunoassay (E2) or High Performance Liquid Chromatography (HPLC, TA). Immediately after addition of steroids, nauplii contained > 1,500 ng $g^{-1}$ of E2 and > 2,000 ng $g^{-1}$ of TA. The nauplii treated with E2 contained 5,500 ng $g^{-1}$ at 2 h, remained at that level until 6 h, and then reached a concentration of 7,000 ng $g^{-1}$ at 12 h, which remained until 24 h. A similar pattern was observed when TA was used; however, at 24 h concentrations declined to 5,000 ng $g^{-1}$. TA concentrations in *Artemia* nauplii enriched with highly unsaturated fatty acids (HUFA) ranged between 500 and 800 ng $g^{-1}$. Despite these large differences in steroid concentrations between HUFA enriched and non-enriched *Artemia*, both methods resulted in significant sex inversion of fish fry. Both Nile tilapia and mojarra castarrica fry were masculinized (> 90% males) after being fed TA-enriched nauplii for 20 and 45 d, respectively. Tropical gars were also feminized (> 60% females) when fry were fed E2-enriched *Artemia* nauplii. It appears that bioencapsulation of steroids into *Artemia* nauplii is an efficient method for sex inversion of fish.

## Selection of a New Nile Tilapia Genetic Line to Provide Broodstock for Southeastern Mexico

*Tenth Work Plan, Reproduction Control Research 2 (10RCR2)*
*Final Report*

Mario Fernández-Perez
División Académica de Ciencias Agropecuarias
Universidad Juárez Autónoma de Tabasco
Villahermosa, Tabasco, Mexico

Wilfrido M. Contreras-Sánchez
Laboratorio de Acuacultura
Universidad Juárez Autónoma de Tabasco
Villahermosa, Tabasco, Mexico

Grant W. Feist and Guillermo Giannico
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA

Carl B. Schreck
Oregon Cooperative Fish and Wildlife Research Unit
Biological Resources Division—US Geological Survey
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA

### Abstract

Since 1964, Mexico has imported five species of tilapia for aquaculture purposes. Despite the establishment and long use of tilapia culture as a major economic activity and as a high-quality source of food, the emergence of this activity from a technical standpoint has been minimal. Some of the most important factors for the development of tilapia culture in Mexico are access to genetically improved species for better growth, characterization of species and lines present in Mexico, and the development of dependable methods for the production of monosex populations of males. The use of improved tilapia with high mass production has contributed to increasing its popularity among producers. We initiated a selective breeding program using 220 females and 110 males selected from a batch of fish purchased from Egypt by the State government. This first batch was selected using discriminant analysis for fish that best resembled Nile tilapia. 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, three selections were made: one at 60 days, a second at 120 days (at this point the fish were separated by sex), and a third at 11 months. Six hundred females and 400 males were selected based on a combination of the best length and condition factor to obtain an F1 generation. These fish were stocked in 200 $m^2$ ponds and allowed to breed. From the fry obtained, 60% of the total were selected for grow-out and a second round of selection was performed to obtain the F2 generation. Progeny obtained from the F2 broodstock were compared to both fry produced from a wild stock from the San Pedro River and from the San Pedro State hatchery. In general the selected Egypt line had better reproductive performance and good survival and growth. This study was conducted as a collaborative effort between the Universidad Juárez Autónoma de Tabasco, the National Council for Science and Technology, and the Office for Agriculture and Fisheries Development in Tabasco, Mexico. This combined effort has allowed us to work at the Jose Narciso Rovirosa hatchery (using 200, 1,000, and 2,000 $m^2$ ponds) and to use fish first selected by Mario Fernández-Perez in 2000.

# HONDURAS PROJECT

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

**Staff**

*University of Georgia, Athens, Georgia*

| | |
|---|---|
| Brahm P. Verma | US Principal Investigator |
| E. William Tollner | US Principal Investigator |
| Jennifer Maldonado | Collaborator |
| Tom Popma | US Technical Support |

*Auburn University, Auburn, Alabama*

| | |
|---|---|
| Joseph J. Molnar | US Principal Investigator |
| Elizabeth Trejos-Castillo | Graduate Student (Costa Rica) |
| Pablo Martinez-Mejia | Graduate Student (Honduras) |
| Julian Montoya | Undergraduate Student (Colombia; partially CRSP funded) |

*Escuela Agrícola Panamericana, El Zamorano, Honduras*

| | |
|---|---|
| Daniel E. Meyer | Host Country Principal Investigator |
| Freddy Arias | Host Country Principal Investigator |
| George Pilz | Research Associate |
| Suyapa Triminio de Meyer | Research Assistant |
| Hector Lagos | Research Assistant |

**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 non-governmental 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*

E. William Tollner and Brahm P. Verma
Department of Biological and Agricultural Engineering
University of Georgia
Athens, Georgia, USA

Daniel E. Meyer
Department of Biology
Escuela Agrícola Panamericana El Zamorano
Zamorano, Honduras

Joseph J. Molnar
Department of Agricultural Economics and Rural Sociology
Auburn University, Alabama, USA

Jennifer Maldonado
New Media Institute
University of Georgia
Athens, Georgia, USA

### 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 flow-rate 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 convey-ance 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*

Brahm P. Verma and E. William Tollner
Department of Biological and Agricultural Engineering
University of Georgia
Athens, Georgia, USA

Daniel E. Meyer
Department of Biology
Escuela Agrícola Panamericana El Zamorano
Zamorano, Honduras

Joseph J. Molnar
Department of Agricultural Economics and Rural Sociology
Auburn University, Alabama, USA

Jennifer Maldonado
New Media Institute
University of Georgia
Athens, Georgia, USA

### ABSTRACT

Our technical training and outreach activities to build a non-governmental 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 iden-tified 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*

Brahm P. Verma and E. William Tollner
Department of Biological and Agricultural Engineering
University of Georgia
Athens, Georgia, USA

Daniel E. Meyer
Department of Biology
Escuela Agrícola Panamericana El Zamorano
Zamorano, Honduras

Joseph J. Molnar
Department of Agricultural Economics and Rural Sociology
Auburn University, Alabama, USA

Jennifer Maldonado
New Media Institute
University of Georgia
Athens, Georgia, USA

### 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*

Joseph J. Molnar
Department of Agricultural Economics and Rural Sociology
Auburn University, Alabama, USA

Brahm P. Verma and E. William Tollner
Department of Biological and Agricultural Engineering
University of Georgia
Athens, Georgia, USA

Daniel E. Meyer
Department of Biology
Escuela Agrícola Panamericana El Zamorano
Zamorano, Honduras

George Pilz
Soil Science
Escuela Agrícola Panamericana El Zamorano
Zamorano, Honduras

### 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

*Southern Illinois University at Carbondale, Carbondale, Illinois*

| | |
|---|---|
| Christopher C. Kohler | US Principal Investigator |
| Susan T. Kohler | US Principal Investigator |
| William Camargo | Research Associate |
| Fred Chu Koo | Ph.D. Student (Peru) |

*The Ohio State University, Columbus, Ohio*

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

*University of Arkansas at Pine Bluff, Pine Bluff, Arkansas*

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

*Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru*

| | |
|---|---|
| Fernando Alcántara Bocanegra | Host Country Principal Investigator |
| Salvador Tello | Host Country Principal Investigator |
| Lamberto Arevalo | Technician |
| Cesar A. Flores | Technician |
| Arturo Flores Huang | Technician |

*Universidad Nacional de la Amazonia Peruana, Iquitos, Peru*

| | |
|---|---|
| Marina del Aguila | Host Country Principal Investigator |

## 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*

Christopher C. Kohler and William Camargo
Fisheries and Illinois Aquaculture Center
Southern Illinois University at Carbondale
Carbondale, Illinois, USA

Susan T. Kohler
Economic and Regional Development Office
Southern Illinois University at Carbondale
Carbondale, Illinois, USA

Salvador Tello, Fernando Alcántara Bocanegra, and Palmira Pascuala Padilla Pérez
Instituto de Investigaciones de la Amazonia Peruana
Iquitos, Peru

Marina del Aguila
Universidad Nacional de la Amazonia Peruana
Iquitos, Peru

### 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*

Christopher C. Kohler and William Camargo
Fisheries and Illinois Aquaculture Center
Southern Illinois University at Carbondale
Carbondale, Illinois, USA

Konrad Dabrowski and Jaques Rinchard
School of Natural Resources
The Ohio State University
Columbus, Ohio, USA

Salvador Tello and Fernando Alcántara Bocanegra
Instituto de Investigaciones de la Amazonia Peruana
Iquitos, Peru

### 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*

Konrad Dabrowski and Mary Ann G. Abiado
School of Natural Resources
The Ohio State University
Columbus, Ohio, USA

Fernando Alcántara Bocanegra and Salvador Tello
Instituto de Investigaciones de la Amazonia Peruana
Iquitos, Peru

Maria Esther Palacios
Departamento de Zoologia
Universidad Nacional Mayor de San Marcos
Lima, Peru

### 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 ef-fects 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*

Christopher C. Kohler and William Camargo
Fisheries and Illinois Aquaculture Center
Southern Illinois University at Carbondale
Carbondale, Illinois, USA

Susan T. Kohler
Economic and Regional Development Office
Southern Illinois University at Carbondale
Carbondale, Illinois, USA

Salvador Tello, Fernando Alcántara Bocanegra, Rosa Izmiño, and Palmira Pascuala Padilla Pérez
Instituto de Investigaciones de la Amazonia Peruana
Iquitos, Peru

Marina del Aguila
Universidad Nacional de la Amazonia Peruana
Iquitos, Peru

Rebecca Lochmann
Department of Aquaculture and Fisheries
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas, USA

### 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*

Christopher C. Kohler and William Camargo
Fisheries and Illinois Aquaculture Center
Southern Illinois University at Carbondale
Carbondale, Illinois, USA

Susan T. Kohler
Economic and Regional Development Office
Southern Illinois University at Carbondale
Carbondale, Illinois, USA

Salvador Tello and Fernando Alcántara Bocanegra
Instituto de Investigaciones de la Amazonia Peruana
Iquitos, Peru

Marina del Aguila
Universidad Nacional de la Amazonia Peruana
Iquitos, Peru

Rebecca Lochmann
Department of Aquaculture and Fisheries
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas, USA

Konrad Dabrowski
School of Natural Resources
The Ohio State University
Columbus, Ohio, USA

### 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*

Rebecca Lochmann
Department of Aquaculture and Fisheries
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas, USA

### 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, Insti-tuto de Investigaciones de la Amazonia Peruana (IIAP) and Fondo Nacional de Desarrollo Pesquero (FONDEPES), were also analyzed for proximate composition to determine whe-ther 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

*Oregon State University, Corvallis, Oregon*

| | |
|---|---|
| James R. Bowman | US Principal Investigator |
| Christopher Langdon | US Principal Investigator |

*Auburn University, Auburn, Alabama*

| | |
|---|---|
| Tom Popma | US Principal Investigator (through September 2001) |
| Karen L. Veverica | US Principal Investigator |

*Fisheries Department, Nairobi, Kenya*

| | |
|---|---|
| Nancy Gitonga | Host Country Principal Investigator |
| John Kinyanjui | Host Country Research Associate/Head of Station, Sagana Fish Farm (through January 2002) |
| Bethuel Omolo | Host Country Research Associate/Head of Station, Sagana Fish Farm (from January 2002) |

*Moi University, Eldoret, Kenya*

| | |
|---|---|
| Mucai Muchiri | Host Country Principal Investigator |
| Charles C. Ngugi | Host Country Principal Investigator |
| Rachel Kamau | Graduate Student (from May 2002) |
| Norman Munala | Graduate Student (from May 2002) |
| Daniel Omwansa | Graduate Student (from May 2002) |
| John Rauni | Graduate Student (from May 2002) |
| James Bundi | Undergraduate Student (Partially CRSP funded) |
| Daniel Ochola | Undergraduate Student (Partially CRSP funded) |
| Geoffrey Mwangi | Undergraduate Student (Partially CRSP funded) |
| 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*

Karen L. Veverica
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, USA

Charles C. Ngugi and Geraldine K. Matolla
Department of Fisheries
Moi University
Eldoret, Kenya

Judith M. Amadiva
Sagana Fish Farm
Sagana, Kenya

James R. Bowman
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA

### ABSTRACT

Research conducted by the PD/A CRSP at Sagana Fish Farm has identified alternative management practices and tech-nologies 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 trans-ferring 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 differ-ent parts of Kenya. Thirty farmers were selected to partici-pate 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 pro-duction, 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 increas-ing 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. Twen-ty-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 partici-pated 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 manage-ment technique learned by the farmers. According to parti-cipating 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 grow-ing 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*

Karen L. Veverica
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, USA

Charles C. Ngugi and Mucai Muchiri
Department of Fisheries
Moi University
Eldoret, Kenya

Judith M. Amadiva
Sagana Fish Farm
Sagana, Kenya
Bethuel Omolo
Kenya Fisheries Department
Sagana, Kenya

James R. Bowman
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA

### 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*

Charles C. Ngugi
Department of Fisheries
Moi University
Eldoret, Kenya

James R. Bowman
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA

Bethuel Omolo
Kenya Fisheries Department
Sagana, Kenya

### 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*

Charles C. Ngugi and B.C.C. Wangila
Department of Fisheries
Moi University
Eldoret, Kenya

Karen L. Veverica
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, USA

Bethuel Omolo
Kenya Fisheries Department
Sagana, Kenya
James R. Bowman
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA

### 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

*Auburn University, Auburn, Alabama*

| | |
|---|---|
| Chhorn Lim | US Principal Investigator |
| 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*

David M. Liti
Zoology Department
Moi University
Eldoret, Kenya

Chhorn Lim and Karen L. Veverica
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, USA

Mucai Muchiri
Department of Fisheries
Moi University
Eldoret, Kenya
Nancy Gitonga
Kenya Fisheries Department
Nairobi, Kenya

**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

*Auburn University, Auburn, Alabama*
Ronald P. Phelps — US Principal Investigator
Karen L. Veverica — US Principal Investigator

*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*

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

David M. Liti
Zoology Department
Moi University
Eldoret, Kenya

George O. Osure
Kenya Fisheries Department
Ministry Agriculture and Rural Development
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

*The University of Michigan, Ann Arbor, Michigan*

| | |
|---|---|
| James S. Diana | US Principal Investigator |
| C. Kwei Lin | US Principal Investigator (stationed in Pathumthani, Thailand) |
| Barbara A. Diana | Research Assistant |
| Melinda Clarke | Graduate Assistant (CRSP funded from January 2002) |

*Asian Institute of Technology, Pathumthani, Thailand*

| | |
|---|---|
| Amrit Bart | Host Country Principal Investigator |
| Yang Yi | Host Country Principal Investigator |
| Htin Aung Kyaw | Research Associate (Myanmar; October 2000) |
| Aye Aye Mon | Research Associate (Myanmar; partially CRSP funded from July 2002) |
| Potjanee Nadtirom | Research Associate (Thai; partially CRSP funded from September 2001) |
| Nguyen Thanh Long | Graduate Student (Vietnam; partially CRSP funded from January 2002) |
| Vu Cam Luong | Graduate Assistant (Vietnamese; partially CRSP funded from September 2001) |
| De Run Yuan | Graduate Assistant (Chinese; from January 2002) |
| Gautum Shrestha | Graduate Student (Nepal; partially CRSP funded from July 2002) |
| Saelee Wanwisa | Graduate Student (Thailand; partially CRSP funded January 2002 through August 2002) |
| A.C. Weerasooriya | Graduate Student (Sri Lanka; partially CRSP funded September 2000 through August 2001) |

*Tribhuvan University, Rampur, Chitwan, Nepal*

| | |
|---|---|
| Madhav K. Shrestha | Host Country Principal Investigator |

*Regional Agricultural Research Station, Tarahara, Nepal*

| | |
|---|---|
| A.K. Rai | Host Country Principal Investigator |

*University of Agriculture and Forestry, Ho Chi Minh City, Vietnam*

| | |
|---|---|
| Le Thanh Hung | Host Country Principal Investigator |

*Research Institute for Aquaculture No. 1, Dinh Bang, Tu Son, Bac Ninh Province, Vietnam*

| | |
|---|---|
| Le Thanh Luu | Host Country Principal Investigator |

*Can Tho University, Can Tho, Vietnam*

| | |
|---|---|
| Nguyen Thanh Phoung | Host Country Principal Investigator |

*Bangladesh Agricultural University, Mymensingh, Bangladesh*

### 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*.

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cation method in reservoirs. Presented to the Sixth Asian Fisheries Forum at Kaoshiung, Taiwan, 25–30 November 2001.
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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)
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## 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*

Yang Yi
Aquaculture and Aquatic Resources Management
Agricultural & Aquatic Systems and Engineering Program
School of Environment, Resources and Development
Asian Institute of Technology
Pathumthani, Thailand

Madhav K. Shrestha
Institute of Agriculture and Animal Science
Tribhuvan University
Rampur, Chitwan, Nepal

C. Kwei Lin and James S. Diana
School of Natural Resources and Environment
The University of Michigan
Ann Arbor, Michigan, USA

### 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*

Yang Yi and Vu Cam Luong
Aquaculture and Aquatic Resources Management
Agricultural & Aquatic Systems and Engineering Program
School of Environment, Resources and Development
Asian Institute of Technology
Pathumthani, Thailand

Le Thanh Hung
Faculty of Fisheries
University of Agriculture and Forest
Ho Chi Minh City, Vietnam

C. Kwei Lin and James S. Diana
School of Natural Resources and Environment
The University of Michigan
Ann Arbor, Michigan, USA

### 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*

Yang Yi
Aquaculture and Aquatic Resources Management
Agricultural & Aquatic Systems and Engineering Program
School of Environment, Resources and Development
Asian Institute of Technology
Pathumthani, Thailand

Nguyen Thanh Phuong
Aquaculture & Fisheries Sciences Institute
College of Agriculture
Can Tho University
Can Tho, Vietnam

C. Kwei Lin and James S. Diana
School of Natural Resources and Environment
The University of Michigan
Ann Arbor, Michigan, USA

### 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*

Yang Yi
Aquaculture and Aquatic Resources Management
Agricultural & Aquatic Systems and Engineering Program
School of Environment, Resources and Development
Asian Institute of Technology
Pathumthani, Thailand

Md. Abdul Wahab
Faculty of Fisheries
Bangladesh Agricultural University
Mymensingh, Bangladesh

C. Kwei Lin and James S. Diana
School of Natural Resources and Environment
The University of Michigan
Ann Arbor, Michigan, USA

### 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 (*Hypophthal-michthys 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*

Yang Yi
Aquaculture and Aquatic Resources Management
Agricultural & Aquatic Systems and Engineering Program
School of Environment, Resources and Development
Asian Institute of Technology
Pathumthani, Thailand

Md. Abdul Wahab
Faculty of Fisheries
Bangladesh Agricultural University
Mymensingh, Bangladesh

C. Kwei Lin and James S. Diana
School of Natural Resources and Environment
The University of Michigan
Ann Arbor, Michigan, USA

### 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), Mymen-singh, Bangladesh, was the BAU fertilization regime: fort-nightly 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*

Melinda Clarke, C. Kwei Lin, James S. Diana,
and Steve R. Brechin
School of Natural Resources and Environment
The University of Michigan
Ann Arbor, Michigan, USA

### 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*

Yang Yi
Aquaculture and Aquatic Resources Management
Agricultural & Aquatic Systems and Engineering Program
School of Environment, Resources and Development
Asian Institute of Technology
Pathumthani, Thailand

Le Thanh Luu
Research Institute for Aquaculture No. 1
Dinh Bang, Tu Son, Bac Ninh Province, Vietnam

C. Kwei Lin and James S. Diana
School of Natural Resources and Environment
The University of Michigan
Ann Arbor, Michigan USA

### 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*

Amrit Bart
Aquaculture and Aquatic Resources Management
Agricultural & Aquatic Systems and Engineering Program
School of Environment, Resources and Development
Asian Institute of Technology
Pathumthani, Thailand

### 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*

Yang Yi and Sahdev Singh
Aquaculture and Aquatic Resources Management
Agricultural & Aquatic Systems and Engineering Program
Asian Institute of Technology
Pathumthani, Thailand

James S. Diana
School of Natural Resources and Environment
The University of Michigan
Ann Arbor, USA

### 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 |

*Central Luzon State University, Muñoz, Nueva Ecija, Philippines*

| | |
|---|---|
| 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*

Christopher L. Brown
Marine Biology Program
Florida International University
North Miami, Florida, USA

Remedios B. Bolivar
Freshwater Aquaculture Center
Central Luzon State University
Nueva Ecija, Philippines

### 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*

Christopher L. Brown
Marine Biology Program
Florida International University
North Miami, Florida, USA

Remedios B. Bolivar
Freshwater Aquaculture Center
Central Luzon State University
Nueva Ecija, Philippines

### 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 |
| Roger Harris | Assistant Information Manager |
| Ian Courter | Graduate Student |
| Brody Lowe | Undergraduate Student Worker |
| Kristen Lewis | Undergraduate Student Worker |
| Mary Nidiffer Olson | Undergraduate Student Worker (through March) |
| Jeff Burright | Undergraduate Student Worker (from March) |


## ANNUAL ACTIVITIES OF THE INFORMATION MANAGEMENT AND NETWORKING COMPONENT


*Danielle Clair, Ian Courter, Roger Harris*
*Oregon State University*
*Corvallis, Oregon, USA*


### BACKGROUND

The mission of the Information Management and Networking Component (IMNC) is to increase awareness and visibility of the Aquaculture 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 promotion and networking.

### CRSP PUBLICATIONS

#### Data and Resource Management

An ongoing IMNC activity is managing the program's mailing database. The database numbers more than 1,200 entries from almost one hundred countries. IMNC staff also maintain a detailed inventory of Aquaculture 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.

*Twentieth Annual Administrative Report*
Clair, D., K. Lewis, M. Olson, I. Courter, and H. Egna (Editors), 2002. Aquaculture CRSP, Oregon State University, Corvallis, Oregon, 94 pp.

*Aquanews*, quarterly newsletter (distributed by hard copy and available on the CRSP website): Vol. 17, No. 4 and Vol. 18, 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.

Latin America and the Caribbean Region Expert Panel Report, 15pp.

Asia Region Expert Panel Report, 13pp.

Africa Region Expert Panel Report, 10pp.

Aquaculture CRSP Participants Directory, January 2003 and August 2003.

CRSP Research Reports is an in-house publication series that includes Notices of Publication, which are the published abstracts of CRSP-sponsored work that has been published in the peer review literature, as well as complete technical reports that are edited and produced by IMNC. Notices of publication are printed in *Aquanews* and are also accessible on the website in HTML and PDF formats.

Notices of Publication in the reporting period include:

| | |
|---|---|
| 02-185 | Recycling Pond Mud Nutrients in Integrated Lotus–Fish Culture |
| 03-186 | Evaluation of Nile Tilapia Pond Management Strategies in Egypt |

03-187 Techniques to Mitigate Clay Turbidity Problems in Fertilized Earthen Fish Ponds
03-188 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
03-189 Potential for Supermarket Outlets for Tilapia in Honduras
03-190 Potential for Supermarket Outlets for Tilapia in Nicaragua
03-191 Potential for Restaurant Markets for Tilapia in Honduras
03-192 Potential for Restaurant Markets for Tilapia in Nicaragua
03-193 Potential for Open-Air Fish Market Outlets for Tilapia in Honduras
03-194 Potential for Open-Air Fish Market Outlets for Tilapia in Nicaragua
03-195 Ultrasound Enhanced Immersion Protocols for Masculinization of Nile Tilapia, *Oreochromis niloticus*

Full research reports edited and published by IMNC in the reporting period include:

Fúnez, O., I. Neira, and C. Engle, 2003. Potential for Supermarket Outlets for Tilapia in Honduras, Aquaculture Research Report Series 03-189, Oregon State University, 24 pp.

Engle, C.R., and I. Neira, 2003. Potential for Supermarket Outlets for Tilapia in Nicaragua, Aquaculture Research Report Series 03-190, Oregon State University, 18 pp.

Monestime, D., I. Neira, O. Fúnez, and C.R. Engle, 2003. Potential for Restaurant Markets for Tilapia in Honduras, Aquaculture Research Report Series 03-191, Oregon State University, 18 pp.

Neira, I., and C. Engle, 2003. Potential for Restaurant Markets for Tilapia in Nicaragua, Aquaculture Research Report Series 03-192, Oregon State University, 28 pp.

Fúnez, O., I. Neira, and C. Engle, 2003. Potential for Open-Air Fish Market Outlets for Tilapia in Honduras, Aquaculture Research Report Series 03-193, Oregon State University, 14 pp.

Engle, C.R., and I. Neira, 2003. Potential for Open-Air Fish Market Outlets for Tilapia in Nicaragua, Aquaculture Research Report Series 03-194, Oregon State University, 18 pp.

## WORLD WIDE WEB

### Aquaculture CRSP Website Activities

Numerous updates and routine maintenance of the Aquaculture CRSP website have been carried out, including:

- Improved search efficiency by utilizing a Google-based function
- An ongoing short on-line survey conducted to gauge user needs more precisely
- A site map added to aid user navigation of the site
- Fully-featured on-line reporting form for Quarterly Progress Reports, streamlining and simplifying this routine procedure
- A map of Aquaculture CRSP international sites
- Automated submission form for EdOp Net opportunities

Visitor activity appears consistent with previous years, but due to several web hosting and reporting changes implemented by Oregon State University, meaningful trend figures are unavailable. The most recent (and accurate) numbers indicate traffic averages about 7,000 unique visitors per month, with about 1,500 site "hits" per day. In the reporting year, traffic totalled about 1.6 million hits.

On completion of the database project, the CRSP Database was successfully moved to Asian Institute of Technology servers.

### Online Publications

Distribution of Aquaculture CRSP publications remains a core function of the website. A variety of publications were made available in both HTML and PDF formats.

These include:

*Aquanews*, the Aquaculture CRSP quarterly newsletter (4 issues)
Twentieth Annual Administrative Report
*The Pond Dynamics/Aquaculture Collaborative Research Support Program: Enhancing World Food Security for Twenty Years* (Poster presented at the World Aquaculture Society Annual Meeting)
Notices of Publication—Abstracts (03-186 to 03-194)
CRSP Research Reports 03-189 to 03-194

Other documents made available:

Aquaculture CRSP Latin America and the Caribbean Region Expert Panel Report, 15pp.
Aquaculture CRSP Asia Region Expert Panel Report, 13pp.
Aquaculture CRSP Africa Region Expert Panel Report, 10pp.
SPARE Review Report
SPARE Recommendations to BIFAD

### Employment and Educational Opportunities Online

EdOp Net is a popular source of aquaculture-related employment and education opportunities made available from the Aquaculture 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, 65 new subscribers were added to the electronic mail membership of EdOp Net. On a monthly basis EdOp Net is specifically distributed to more than 800 individuals in electronic and paper formats; additionally, the EdOp Net database receives around 8,000 visitors annually, which reflects a high degree of interest from the public, given the pool of aquaculture job seekers may be on the order of 100,000 per year.

## 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 submitted via the CRSP website 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, and 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 (community or school extension 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 seven formal degree programs (one doctorate, four masters, and two bachelors). Students working with CRSP researchers completed the following theses:

Thunjai, T., 2002. Bottom Soil Quality in Fish Ponds of Different Ages in Thailand and Suggestions for its Management. Ph.D. dissertation, Auburn University, Alabama. 126 pp.

Zamora, M.N., 2002. Effect of Commercial Growth Promotant on the Growth and Survival of Genetically Male Nile Tilapia (*Oreochromis niloticus*). B.S. thesis, Central Luzon State University, Philippines. 45 pp.

Clarke, M. 2003. Shrimp Aquaculture Brownfields: Social, Environmental, and EconomicIssues Determining Rehabilitation Options. M.S. thesis, University of Michigan. 95 pp.

Hernández-Vidal, U., 2002. Tropical Gar (*Atractosteus tropicus*) Sex Identification and Hormone Induced Spawn Evaluation. M.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico. 83 pp.

Zacarías-Sánchez, A., 2003. Effects of Feeding Schedule on Growth and Survival of Tropical Gar (*Atractosteus tropicus*) Larvae. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico. 42 pp.

Long, N.T., 2003. Stocking Ratios of Hybrid Catfish (*Clarias macrocephalus* × *C. gariepinus*) and Nile Tilapia (*Oreochromis niloticus*) in an Intensive Polyculture. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

Trejos-Castillo, E., 2003. Income, Food Security, and Poverty Reduction: Case Studies of Small-Scale Aquaculture Producers in Santa Barbara, Honduras. M.S. thesis, Auburn University, Alabama.

Besides the above formal training, CRSP researchers provided non-degree training to 951 individuals in the reporting period.

### WORK IN PROGRESS

Work in progress in the reporting period includes the production of a digital video disk (DVD), entitled "Ponds for Life." This DVD is a brief introduction to the research efforts of the Aquaculture CRSP. The format is a series of segments from interviews that were conducted with CRSP researchers and students. The four main sections of "Ponds for Life" are Pond, Inputs, Sustainability, and Harvest. In a fifth section, a sampling of local- and global-level success stories will be presented. Other work in progress includes production of an updated publications order catalog and booklet entitled, "A Manual of Fertilization and Supplemental Feeding Strategies for Small-Scale Nile Tilapia Culture in Ponds."

### PROGRAM NETWORKING

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

- The Aquaculture CRSP, via IMNC, participated in OSUs September 2002 University Days event. This annual event attracts faculty, staff, and interested students; the CRSP booth received over one hundred visitors.
- IMNC sponsored the October 2002 US visit of Nancy Gitonga, Director of the Kenya Department of Fisheries. Gitonga met with CRSP researchers at The Ohio State University and the University of Arkansas at Pine Bluff. She also presented a poster at the American Fisheries Society meeting in Baltimore, Maryland, and spoke at USAID, Washington, DC., on "The Role of Aquaculture in Fisheries Development in Kenya."
- IMNC sponsored the attendance of CRSP Principal Investigator Kevin Fitzsimmons, University of Arizona, at a meeting organized by CAB International at the Asian Institute of Technology in October 2002. The meeting introduced potential partners to a major new international project in aquaculture knowledge management called the "Aquaculture Compendium."
- IMNC participated in the April 2003 Earth Days event at OSU. The IMNCs booth included a large poster display of the program's goals and design; informational handouts, and CRSP publications were available as well for those curious to learn more about the program.

IMNC also receives frequent requests for information from

around the world, typically via email. Inquiries came this year from Brazil, Cameroon, Ecuador, Eritrea, France, Guyana, Honduras, India, Indonesia, Nepal, Nigeria, Pakistan, Philippines, Poland, Taiwan, Turkey, and the United States.

Posters developed and presented in the reporting period included:

Sempier, S.H., R.J. Harris, and I.I. Courter. The Pond Dynamics/Aquaculture Collaborative Research Support Program: Enhancing World Food Security for Twenty Years. Presented to the World Aquaculture Society Meeting in Louisville, Kentucky, 18–21 February 2003.

Sempier, S.H., R.J. Harris, and I.I. Courter. The Pond Dynamics/Aquaculture Collaborative Research Support Program: Enhancing World Food Security for Twenty Years. Presented to the Oregon Chapter of the American Fisheries Society meeting in Eugene, Oregon, 26–28 February 2003.

Sempier, S.H., R.J. Harris, K.A. Lewis, and H.S. Egna. Sustainable International Aquaculture: A Focus on Emerging Species and Low-cost Appropriate Technology. Presented to the National Organic Aquaculture Conference in Minneapolis, Minnesota, 11–13 July 2003.

# Appendix 1. Program Participants

The 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 activities in 21 host countries—Mexico, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Colombia, Ecuador, Brazil, Peru, Kenya, Ghana, Tanzania, South Africa, Bangladesh, Cambodia, Laos, Nepal, the Philippines, Vietnam, 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 (MSU), Oregon State University (OSU), Southern Illinois University at Carbondale (SIUC), Texas Tech University, The Ohio State University (OhSU), The University of Michigan (UM), University of Arizona (UA), University of Arkansas at Pine Bluff (UAPB), University of Georgia (UG), and University of the Virgin Islands.

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
- Institute of Agriculture and Animal Science, Nepal
- Instituto de Investigaciones de la Amazonia Peruana, Peru
- Regional Development Coordination for Livestock and Fisheries, Laos
- Moi University, Kenya
- 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
- Centro de Aqüicultura, Universidade Estadual Paulista, Jaboticabal, São Paulo, Brazil
- Centro de Investigación en Alimentación y Desarrollo, Mexico

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 |
| Steve Sempier | Assistant Director of Research |
| Joan Westfall | Office/Financial Manager |
| Gwyn Newcombe | Accounting Technician |

### United States Agency for International Development

*Washington, DC*

| | |
|---|---|
| Harry Rea | Cognizant Technical Officer |

### PROPOSAL PLANNING EXECUTIVE COMMITTEE

| | |
|---|---|
| Hillary Egna | Oregon State University |
| Danielle Clair | Oregon State University |
| Jim Diana | The University of Michigan |
| Chris Brown | Florida International University |
| Kevin Fitzsimmons | University of Arizona |

### ADVISORY BODIES

**Board of Directors**

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

*Ex-Officio Board Members*

| | |
|---|---|
| Harry Rea | USAID |
| Hillary Egna | Oregon State University |

**External Evaluation Panel**

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

| **Technical Committee*** | **Institution** |
|---|---|
| *Co-Chairs* | |
| Jim Diana | UM |
| Chris Brown | FIU |

| *Material and Methods Subcommittee* | *Research Area of Expertise* | |
|---|---|---|
| Yang Yi | AIT | Environmental effects |
| Claude Boyd | AU | Production optimization |
| Suyapa Meyer | Zamorano | Social and economic aspects |

| *Technical Progress Subcommittee* | | |
|---|---|---|
| Jim Bowman | OSU | Production optimization |
| Joe Molnar | AU | Social and economic aspects |
| Bill Tollner | UG | Environmental effects |

| *Work Plan and Budget Subcommittee* | | |
|---|---|---|
| Wilfrido Contreras-Sánchez | UJAT | Environmental effects |
| Dan Meyer | Zamorano | Production optimization |
| Nancy Gitonga | Kenya DOF | Social and economic aspects |

| *External At-Large Members* | |
|---|---|
| Damon Seawright | US tilapia producer |

*Ex-Officio Members*

| | |
|---|---|
| Harry Rea | USAID |
| Hillary Egna | OSU |
| Steve Sempier | OSU |

* Membership as of the 2003 Technical Committee election, with new members taking office in February 2003; see *Twentieth Annual Administrative Report* for previous roster. Subcommittee members are listed in order of seniority.

# Appendix 2. 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 2002 to 31 July 2003. 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] 8/02-7/03 | USAID[1] Since 8/96 | Cost Share[2] 8/02-7/03 | Cost Share[2] Since 8/96 | Total US Funds | Host Country Contributions[3] 8/02-7/03 | Host Country Contributions[3] Since 8/96 |
|---|---|---|---|---|---|---|---|---|---|
| **Research** | | | | | | | | | |
| RD009A-01 | Bowman | Kenya: OSU | 55,000 | 894,098 | 2,411 | 79,096 | 973,194 | 13,000 | 135,512 |
| 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 | 143,068 | 710,312 | 21,386 | 147,310 | 857,622 | 16,820 | 45,670 |
| | *Patino* [4] | *Mexico: Texas Tech* | 28,107 | 28,107 | 9,273 | 9,273 | 37,380 | | |
| RD009L-01 | Clair | Global: OSU | 100,000 | 404,636 | 25,000 | 98,052 | 502,688 | | |
| RD010E-01 | Engle | Global: UAPB | 10,000 | 436,910 | 4,013 | 105,869 | 542,779 | 42,000 | 42,000 |
| 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 | Southeast Asia: UM | 340,111 | 1,418,909 | 26,631 | 183,749 | 1,602,658 | 21,000 | 146,000 |
| | *Rakocy* [4] | *Southeast Asia : UVI* | 9,889 | 9,889 | 0 | 0 | 9,889 | | |
| 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 | Global: AU | 40,000 | 402,273 | 10,000 | 109,937 | 512,210 | 31,000 | 31,000 |
| RD010E-08 | Lim | Kenya: AU | 0 | 520,679 | 0 | 120,018 | 640,697 | | |
| RD010E-09/C | Phelps | Global/Kenya: AU | 0 | 175,352 | 0 | 42,171 | 217,523 | | |
| RD010E-10 | Molnar | Global: AU | 0 | 68,293 | 0 | 14,489 | 82,782 | | |
| RD010E-11 | Fitzsimmons | Global: UA | 63,107 | 207,205 | 28,722 | 76,673 | 283,878 | 0 | 7,050 |
| RD010E-12 | Kohler | Peru: SIUC | 134,972 | 712,019 | 39,040 | 233,071 | 945,090 | 47,000 | 175,607 |
| | *Dabrowski* [4] | *Peru: OhSu* | 0 | 13,000 | 0 | 11,963 | 24,963 | | |
| RD010E-13 | Lochmann | Peru/Kenya: UAPB | 11,999 | 122,305 | 4,318 | 37,622 | 159,927 | | |
| 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 [6] | Tollner | Kenya/Honduras: UGA | 155,121 | 476,268 | 16,092 | 86,065 | 562,333 | 11,025 | 29,225 |
| RD010E-17 | Molnar | Honduras: AU | 67,996 | 231,263 | 7,386 | 48,203 | 279,466 | | |
| 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 | 61,263 | 367,527 | 21,705 | 137,481 | 505,008 | 6,500 | 21,000 |
| | *Borski* [4] | *Philippines: NCSU* | 8,737 | 8,737 | 2,929 | 2,929 | 11,666 | | |
| RD010E-A | Dabrowski | Mexico/Peru: OhSU | 38,080 | 157,173 | 19,450 | 93,416 | 250,589 | | |
| RD010E-B | Batterson | Thailand: MSU | 0 | 57,020 | 0 | 14,274 | 71,294 | | |
| RD010E-D [6] | Haws | Mexico/LAC: UH | 100,000 | 100,000 | 16,500 | 16,500 | 116,500 | | |
| International Extension Exchange | TBA | Global: TBA | 250,000 | 250,000 | 0 | 0 | 250,000 | | |
| **Special Activities** | | | | | | | | | |
| ISTA 5 Sponsorhip | Fitzsimmons | Global: UA | 0 | 12,500 | 0 | 5,000 | 17,500 | | 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 | 0 | 128,676 | 0 | 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 | 300,000 | 2,225,283 | 75,000 | 556,321 | 2,781,604 | | |
| **Subcontract Administration** | | Indirect on Subs up to 25,000 | 6,500 | 154,640 | 0 | 0 | 154,640 | | |
| **Research Subtotal** | | | 1,923,950 | 12,138,828 | 329,856 | 2,695,905 | 14,834,733 | 188,345 | 788,548 |
| **MANAGEMENT** | | | | | | | | | |
| **Program Management** | | | | | | | | | |
| Operations and Administration [5] | | OSU Management | 430,000 | 3,284,685 | n/a | n/a | 3,284,685 | | |
| Advisory Groups | | OSU Advisory | 40,000 | 499,710 | 0 | 124,928 | 624,638 | | |
| **Program Management Subtotal** | | | 430,000 | 3,784,395 | | | 3,909,323 | | |
| **Total** | | | 2,353,950 | 15,923,223 | 329,856 | 2,695,905 | 18,744,056 | 188,345 | 788,548 |

| 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 | Final |
| | Batterson | Workshops on Using Principles of Pond Dynamics to Optimize Fertilization Efficiency | 10PDR2 | Final |
| | Bowman | Aquaculture Training for Kenyan Fisheries Officers and University Students | 10PDR3 | Final |
| Feeds and Fertilizers | Kohler | Nutrition of *Colossoma macropomum* and *Piaractus brachypomus* | 10FFR1 | Final |
| | Dabrowski | Broodstock Diets and Spawning of *Colossoma macropomum* and/or *Piaractus brachypomus* | 10FFR2 | Final |
| | Lochmann | Broodstock Diets and Spawning of *Colossoma macropomum* and/or *Piaractus brachypomus* | 10FFR2A | Final |
| | Diana | Polyculture of Grass Carp and Nile Tilapia with Napier Grass as the Sole Nutrient Input in the Subtropical Climate of Nepal | 10FFR3 | Final |
| | 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 | Final |
| | Schreck | Selection of a New Nile Tilapia Genetic Line to Provide Broodstock for Southeastern Mexico | 10RCR2 | Final |
| | Brown | IGF as a Growth Rate Indicator in *Oreochromis niloticus* | 10RCR3 | Final |
| 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 | Final |
| New Aquaculture Systems/ New Species | Kohler | Amazon Aquaculture Outreach | 10NSR1 | Final |
| | Dabrowski | Studies on Reproduction and Larval Rearing of Amazonian Fish | 10NSR2 | Final |
| | Fitzsimmons | Stocking Densities for Tilapia-Shrimp Polyculture in Thailand | 10NSR3B | Final |
| | Fitzsimmons | Survey of Tilapia-Shrimp Polyculture in Mexico † | 10NSR3C | Final |
| | Fitzsimmons | Stocking Densities for Tilapia-Shrimp Polyculture in Mexico | 10NSR3D | Abstract |
| | Fitzsimmons | Survey of Tilapia-Shrimp Polyculture in the Philippines | 10NSR3E | Final |
| | 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 | Final |

**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 | 10ER1 | Final |
| | Schreck | Elimination of Methyltestosterone (MT) from Intensive Masculinization Systems: Use of Activated Charcoal in Concrete Tanks | 10ER2 | Final |
| | Diana | Environmental Impacts of Cage Culture for Catfish in Hongngu, Vietnam † | 10ER3 | Final |
| Appropriate Technology | Verma | Regionalizing Training and Technical Assistance for Nongovernmental Organizations | 10ATR1 | Final |
| | Verma | Institutionalizing Web-based Information System for Tilapia Culture in Latin America | 10ATR2 | Final |
| | Schreck | Diversification of Aquacultural Practices by Incorporation of Native Species and Implementation of Alternative Sex Inversion Techniques | 10ATR3 | Final |
| | Diana | On-Farm Trials of Different Fertilization Regimes Used in Bangladesh | 10ATR4B | Final |
| | Batterson | Use of Clinoptilolite Zeolites for Ammonia-N Transfer and Retention in Integrated Aquaculture Systems and for Improving Pond Water Quality before Discharge | 10ATR5 | Final |
| GIS: Planning, Policy, and Global Data Analysis | Diana | A Study of Aquaculture Brownfields: Abandoned and Converted Shrimp Ponds in Thailand | 10GISR1 | Final |
| | Diana | Assessing Watershed Ponds for Aquaculture Development in Thai Nguyen, Vietnam | 10GISR2 | Final |
| | 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 | Final |

**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 | Verma | Institutionalizing Techniques for Building Hillside and Levee Ponds for Water Supply and Aquacultural Development in Latin America | 10ADR1 | Final |
| Food Security | Molnar | Income, Food Security, and Poverty Reduction: Case Studies of Functioning Clusters of Successful Small-Scale Aquaculture Producers | 10FSR1 | Final |
| 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 | Final |
| | Brown | Cost Containment Options for Tilapia Production in Central Luzon, Republic of the Philippines | 10PDVR2 | Final |
| | Diana | Transfer of Production Technology to Nepal for Nile Tilapia, *Oreochromis niloticus* | 10PDVR3 | Final |

# APPENDIX 4. 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 Interna-tional, 4:154–168.


#### AUBURN UNIVERSITY

***Theses***


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

Trejos-Castillo, E. Fish Culture as a Sustainable Rural Livelihood: Case study of the functioning clusters of successful small-scale tilapia producers in Santa Barbara, Honduras. Agricultural Workers Conference, Tuskegee University, Alabama, December 2002.


***Publications and Reports***


Alvarenga, H.R. and B.W. Green, 1985. Production of hybrid tilapia (*Tilapia nilotica* x *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* x *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* x *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* x *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* x *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.

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## The Philippines

### CENTRAL LUZON STATE UNIVERSITY

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### *Presentations*

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Bart, A. Conservation of aquatic biodiversity in Southeast Asia. Seminar, Burapha University, Chonburi, Thailand, June 2003. Audience consisted of graduates.

Bart, A. Conservation of fish biodiversity. Gondol Institute of Marine Culture, Gondol, Bali, Indonesia, 14 March 2003.

Bart, A. Research paper writing for publication in international journals in aquaculture and fisheries. 7 day workshop, Rajandrapur, Bangladesh, 1–7 February 2003. Audience included aquaculture and fisheries university faculty from 5 universities.

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# Global Activities

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# 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. Acronyms

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|---|---|
| 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 |