
Aquaculture Collaborative Research Support Program

Twenty-Second Annual Administrative Report

1 August 2003 to 31 July 2004

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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

Program activities are funded in part by the United States Agency for International Development (USAID) under Grant No. LAG-G-00-96-90015-00.



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INTRODUCTION

The Aquaculture Collaborative Research Support Program's (CRSP) mission is to enrich livelihoods and promote health by cultivating international multidisciplinary partnerships that advance science, research, education, and outreach aquatic resources. This report describes the activities and accomplishments of the Aquaculture CRSP from 1 August 2003 to 31 July 2004.

The United States Agency for International Development (USAID) funds the Aquaculture CRSP under authority of the Foreign Assistance Act of 1961 (PL 87-195), as amended; funding is also provided by the universities and institutions that participate in the CRSP. The Aquaculture CRSP is a partner of USAID's Economic Growth, Agriculture, and Trade (EGAT) Bureau's Office of Natural Resources Management and USAID's Water Team.

The CRSP's cohesive program of research is carried out in selected developing countries and the United States by teams of US and host country researchers, faculty, and students. 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 2006.

The activities of this multinational, multi-institutional, and multidisciplinary program are administered by Oregon State University (OSU), which functions as the 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 advisory bodies. PMO staff as well as advisory group membership during the reporting period appears in Appendix 1.

RESEARCH HIGHLIGHTS

- Low supply of high quality tilapia fingerlings has hindered growth of the tilapia aquaculture sectors throughout Central America. Auburn University researchers collaborated with researchers at Escuela Agrícola Panamericana Zamorano to assess fingerling production in Honduras. Socioeconomic data were collected from fingerling producers and fingerlings obtained for grow-out trials to compare quality. Improvements to fingerling quality will greatly benefit tilapia production in Honduras.
- Two Aquaculture CRSP projects are developing methods to culture indigenous fish species in the Peruvian Amazon Basin. Surubim (*Pseudoplatystoma* sp.) broodstock development and larval feeding experiments are being conducted by researchers from The Ohio State University and Universidad Nacional Mayor de San Marcos. Concurrently, researchers at Southern Illinois University Carbondale and University of Arkansas at Pine Bluff are collaborating with colleagues at the Instituto de Investigaciones de la Amazonía Peruana to determine the feasibility of using wild fruits and plant products as feed components to culture two native fish species, *Piaractus brachipomus* and *Colossoma macropomum*.
- Researchers from University of Hawaii, University of Rhode Island, and Universidad Autónoma de Sinaloa are collaborating to address cross-sectoral issues that affect aquaculture. Extension efforts are directed at implementing best management practices for established aquaculture sectors while diversifying local aquaculture production through production of other freshwater finfish and native bivalve species. Inclusion of previously neglected stakeholder groups such as women, youth, and the physically disadvantaged is also a priority.
- During the Aquaculture CRSP Ninth and Tenth Work Plans, Oregon State University, the Kenya Fisheries Department, and Moi University conducted training sessions for Kenyan Fisheries Officers. These workshops were considered so valuable that in 2004 additional short courses were provided to 36 Fisheries Department Fisheries Assistants—who work most directly with fish farmers in Kenya—through funds provided by the Aquaculture CRSP and leveraged with host country funds from the Kenya Fisheries Department. The workshops focused on pond construction, fish handling, and pond and fish stock management. Training materials have been organized into a training manual that can be used for future references as well as additional training sessions throughout the region.
- Normal procedures of pond soil management (e.g., drying bottoms between crops, liming, and periodic sediment removal) were confirmed to be effective in maintaining good sediment quality in freshwater aquaculture ponds over a period of at least 30 years through Aquaculture CRSP research conducted in Thailand by researchers from Auburn University and the Thailand Department of Fisheries. This information will be useful to pond culturists in Thailand, and the information should be applicable to pond culture both abroad and in the US.

- Numerous Aquaculture CRSP studies were conducted by researchers at The University of Michigan and the Asian Institute of Technology to determine the feasibility of various integrated polyculture methods in countries throughout Southeast Asia. Specific examples include co-culture of lotus plants and hybrid catfish in Thailand, cage-cum-pond culture with carp and catfish in Bangladesh, cage-cum-pond culture with tilapia and perch in Vietnam, and cage-cum-cove culture in Vietnam. Anticipated benefits to farmers include reduced environmental impacts from farming practices and increased economic opportunities through product diversification.

ADMINISTRATIVE HIGHLIGHTS

During this period the PMO assisted in facilitating several new initiatives:

- A new collaboration between US partners University of Hawaii and University of Rhode Island and host country partners Universidad Autónoma de Sinaloa, Mexico and Ecocostas, Ecuador, is entitled Human Health Impacts and Aquaculture: International Extension Exchange and Health Impact Studies.
- A new project entitled "Sustainable Development of Aquaculture in Africa" links the University of Arkansas at Pine Bluff with: Sokoine University of Agriculture, Tanzania; Fisheries and Aquaculture Development Division, Government of Tanzania; University of Science and Technology, Ghana; and the Ministry of Food and Agriculture, Ghana; and Moi University, Kenya.
- The PMO has sponsored the initiation of a Host Country Tilapia and Native Cichlids Project, the first of its kind, which brings together CRSP researchers from Mexico, Honduras, Thailand, the Philippines, and Kenya to exchange information about CRSP-funded technologies directly among host country participants.
- The PMO sponsored a New Principal Investigator Workshop in June in Portland, Oregon. The purpose of this meeting was to introduce new participants to CRSP policies, procedures, and philosophies.
- The PMO pursued new funding for a joint project with Heifer International and the Indigenous Environmental Network. The project's goal is to bring the knowledge of Native Americans in the North and South to bear on pressing aquatic resources management issues.
- The PMO assisted in the conceptual development of two new studies that will look into the status and future of offshore aquaculture.
- The ACRSP is sponsoring an initiative that brings prominent researchers in aquaculture, aquatic sciences, and international development to Washington, DC, to present up-to-date information on water-related issues to the USAID community, including the Water Team within USAID's Office of Natural Resources Management. Among the presenters so far have been:
 - Barry Costa-Pierce, Director of Rhode Island Sea Grant as well as USAID subsector review panelist, presented "Aquaculture Status and Trends" in late January;
 - Hillary Egna, Aquaculture CRSP Director, presented "Overview of International Aquaculture Priorities" in March; and
 - Kevin Fitzsimmons, Professor at the University of Arizona, Aquaculture CRSP Principal Investigator, Vice President of the American Tilapia Association, and President of the World Aquaculture Society presented "Markets for African Tilapia Products and Impacts on Local Supplies" in April.

Electronic copies of these PowerPoint® presentations are available at the CRSP website

<<http://pdacrsp.oregonstate.edu/miscellaneous/WTpresentations/WTpresentations.html>>.

- The director participated in CRSP Council conference calls meetings on 4, 11, and 24 September 2003 and on 5 and 11 March and 24 May 2004. In addition, the CRSP was represented at a USAID/CRSP retreat in Shepherdstown, West Virginia on 3–5 December 2003. The Aquaculture CRSP also contributed to comments submitted by the CRSP Council on the Rubin–Miller report "Making Good Programs More Effective." A refinement of the advisory structure was made in response to suggestions in this report and by new trends emerging in the CRSP Council. The Board of Advisors and the External Evaluation Panel were merged into an External Advisory Panel. The structural change will be staged to allow for current BOD and EEP members to retain positions until they are scheduled to cycle off the panel and new positions offered to external advisors.
- The Aquaculture CRSP was represented at Oregon State University's Earth Day celebration and "University Days" event in September 2003 and April 2004, respectively.
- The Aquaculture CRSP PMO presented the poster "Sustainable International Aquaculture Research: A focus on low food chain species," authored by Stephen H. Semper, Katy R. Lloyd, Roger J. Harris, and Hillary S. Egna, at the January 2004 meeting of the National Council for Science and the Environment Water for a Sustainable and Secure Future in Washington, DC.
- Aquaculture CRSP researcher Joseph Molnar from Auburn University organized a symposium on aquaculture at the February 2004 meeting of the American Association for the Advancement of Science in Seattle, Washington. A number of CRSP researchers presented papers at this session, including: Chhorn Lim (New Direction in Fish Feeds and Feeding: Long Term Implications); Claude E. Boyd (Environmental Barriers to Aquacultural Development); and Nguyen Thanh Phuong (Shrimp Farming in Vietnam: An Overview). The PMO was also represented at the AAAS meeting, presenting the poster, "Sustainable International Aquaculture Research: A Focus on Low Food Chain Species."

- At the CRSP Technical Committee meeting, held in conjunction with the World Aquaculture Society meeting in March in Honolulu, HI, the PMO took the opportunity to organize and hold three Regional Networking Opportunity Meetings for all of the participants from the Asia, Africa, Latin America, and Caribbean regions.
- The Aquaculture CRSP also sponsored a series of awards in conjunction with the 2004 World Aquaculture Society meeting. These included: six student pre-conference awards, two professional pre-conference awards, one first place and two second place Student Poster Awards, and one Aquaculture CRSP Lifetime Achievement Award.
- Two Aquaculture CRSP collaborators, Kevin Fitzsimmons of the University of Arizona and Wilfrido Contreras-Sánchez of the Universidad Juárez Autónoma de Tabasco, were awardees of a Training, Internships, Exchanges, and Scholarships (TIES) grant. The US-Mexico Training, Internships, Exchanges, and Scholarships Partnership Initiative is a program initiated by the State Department as an adjunct to the North American Free Trade Agreement (NAFTA). It covers all fields of education with the goal of increasing academic interactions between US and Mexican institutions of higher education. The intention is that TIES will address a variety of issues including job creation, environmental stewardship, food security, and education.
- The Aquaculture CRSP produced a DVD that showcases the projects and people of the program. "Ponds for Life" combines factual information and interviews with CRSP researchers in a framework that explains the challenges of small-scale aquaculture and some of our successes that have made it easier and safer.
- The "Solution Finder" website was developed by the Aquaculture CRSP PMO to present the depth and breadth of Aquaculture CRSP capabilities available to USAID Missions and to assist Aquaculture CRSP Ambassadors as they interact with USAID Mission officials. Using the "Solution Finder," visitors can access the developmental goals for each of the countries under USAID's strategic objectives umbrella. The site also features a menu of services that the CRSP can offer to solve specific problems in areas such as natural resource management, food security, health, and economic development, with links to relevant CRSP research.
- The PMO launched the ACRSP Ambassador Program. As CRSP Ambassadors to USAID Missions, host country partners are serving as country and regional resource persons on aquaculture and related water issues.
- The Aquaculture CRSP provided comments on "Linkages Between Development Assistance and Invasive Alien Species in Freshwater Systems in Southeast Asia," a report to USAID by Alexis T. Gutiérrez and Jamie K. Reaser on behalf of the Global Invasive Species Programme.

US AND HOST COUNTRY PARTNERS

The Aquaculture CRSP's multidisciplinary team of researchers and advisors represent a wide range of US and international aquacultural experience. During the reporting period, participating US institutions included:

- Auburn University
- Florida International University
- Heifer International, Arkansas
- Louisiana State University
- Michigan State University
- North Carolina State University
- Oregon State University
- Purdue University, Indiana
- Southern Illinois University at Carbondale
- Texas Tech University
- The Ohio State University
- The University of Michigan
- University of Arizona
- University of Arkansas at Pine Bluff
- University of Georgia
- University of Hawaii, Hilo
- University of Rhode Island
- University of the Virgin Islands

Work undertaken in the reporting period comprised the Eleventh Work Plan and involved activities at sites in Bangladesh, Bolivia, Brazil, Cambodia, Colombia, Ecuador, El Salvador, Ghana, Guatemala, Honduras, Kenya, Laos, Mexico, Nepal, Nicaragua, Panama, Peru, South Africa, Tanzania, Thailand, the Philippines, and Vietnam.

Memoranda of Understanding, representing formal ties between US and host country institutions, that were in place during the reporting period include those between:

- Auburn University and Moi University, Kenya
- Auburn University and Stellenbosch University, South Africa
- Florida International University and the Freshwater Aquaculture Center, Central Luzon State University, the Philippines
- Oregon State University and 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 CRSP activities in the reporting period:

- Bangladesh Agricultural University, Bangladesh
- Can Tho University, Vietnam
- Centro de Aquicultura, Jaboticabal, SP, Brazil
- Centro de Investigación en Alimentación y Desarrollo, Mexico
- Centro Internacional de Agricultura Tropical (CIAT), Colombia
- Comunidad Indígena Sarayuku, Ecuador
- Corporación Regional del Amazonas, Colombia
- Department of Fisheries, Thailand
- Ecocostas, Ecuador
- EMBRAPA, Brazil
- Fisheries and Aquaculture Development Division, Tanzania
- Fondo Nacional del Desarrollo Pesquero, Peru
- Fundación Arcoiris, Ecuador
- Institute of Agriculture and Animal Science, Nepal
- Instituto Amazónico de Investigaciones Científicas, Colombia
- Instituto de Investigaciones, Colombia
- Instituto Nacional de Pesquisas da Amazonia, Brasil
- Instituto Tecnológico Saieciano, Ecuador
- Kasetsart University, Thailand
- KMFR Sangora Aquaculture Station, Ondito Kisumu, Kenya
- Ministry of Agriculture, Tanzania
- Ministry of Agriculture and Rural Development, Kenya
- Ministry of Food and Agriculture, Ghana
- Nong Nam University, Ho Chi Minh City, Vietnam
- Peace Corps, Ecuador
- Research Institute for Aquaculture No. 1, Vietnam
- Sao Paulo State University, Jaboticabal, Brazil
- Sokoine University of Agriculture, Tanzania
- Universidad Autónoma de Sinaloa, Mexico
- Universidad Federal do Amazonia, Brasil
- Universidad Mayor de San Simón, Bolivia
- Universidad Nacional Mayor de San Marcos, Peru
- Universidade Estadual Paulista, Brasil
- University of Agriculture & Forestry, Vietnam
- University of Science and Technology, Ghana

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; and
- 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

ELEVENTH WORK PLAN

In anticipation of the program's submittal of a new five-year grant proposal to USAID in 2003, the Aquaculture CRSP issued the Eleventh Work Plan RFP 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 focused on one of three program areas—Production Technology, Watershed Management, or Human Welfare, Health, and Nutrition. Within these program areas, researchers focused their investigations on any of the following research themes:

- Environmental Impacts Analysis
- Sustainable Development and Food Security
- Production System Design and Integration
- Indigenous Species Development
- Water Quality and Availability
- Economic/Risk Assessment and Social Analysis
- Applied Technology and Extension Methodologies
- Seedstock Development and Availability
- Disease, Predation Prevention, and Food Safety
- Fish Nutrition and Feed Technology
- Aquaculture and Human Health Impacts

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 the CRSP was subsequently awarded another extension through 31 July 2006, Eleventh Work Plan proposals will be able to be completed as originally envisioned.

WORK PLAN REPORTING AND MONITORING

Projects' adherence to Work Plan schedules and methods and their 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 PMO collects research progress reports on a quarterly basis.



RESEARCH PROJECTS

SOUTHEAST ASIA PROJECT

Subcontract No. RD010E-04

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Work Plan Research

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

- Co-Culture of Lotus and Hybrid Catfish to Recycle Wastes from Intensive Feeding/11EIAR1. The report submitted for this investigation was a final report.
- Controlled Reproduction of an Important Indigenous Species, *Spinibarbus denticulatus*, in Southeast Asia/11ISDR2. The report submitted for this investigation was a final report.
- New Paradigm in Farming of Freshwater Prawn (*Macrobrachium rosenbergii*) with Closed and Recycle Systems/11PSDR2. The report submitted for this investigation was a final report.
- Integrated Cage-Cum-Pond Culture Systems with High-Valued Fish Species in Cages and Low-Valued Species in Open Ponds/11PSDR3. The report submitted for this investigation was a final report.
- Mitigating Environmental Impact of Cage Culture through Integrated Cage-Cum-Cove Culture System in Tri An Reservoir of Vietnam/11PSDR4. The report submitted for this investigation was a final report.
- Optimization of Nitrogen Fertilization Regime in Fertilized Nile Tilapia Ponds With Supplemental Feed/11PSDR5. The report submitted for this investigation was a final report.
- Workshop on Fertilization Strategies for Pond Culture in Bangladesh/11PSDR6. The report submitted for this investigation was a final report.
- Tilapia (*Oreochromis niloticus*) Production Constraints in Bangladesh/11SDFR2. The report submitted for this investigation was a final report.
- Reproductive Performance and Growth of Improved Tilapia, *Oreochromis niloticus*/11SDFR3. The report submitted for this investigation was a final report.
- Mitigating the Effects of High Temperature and Turbidity on Seed Production of Nile Tilapia from Hapa-in-Pond Systems/11SDAR1. The report submitted for this investigation was a final report.

Publications

- Bart, A.N. 2001. The use of ultrasound to enhance-transport of compound into fish and fish embryos: A review. Asian Fisheries Society. (in press)
- Giap, D.H., Y. Yi, and C.K. Lin. Effect of Different Fertilization and Feeding Regimes on the Production of Integrated Rice-Prawn (*Macrobrachium rosenbergii*) Culture. Proceedings of International Symposium on Freshwater Prawns. (in press)
- Giap, D.H., Y. Yi, N.X. Cuong, L.T. Luu, C.K. Lin, J.S. Diana. Application of GIS and Remote Sensing for Assessing Watershed Ponds for Aquaculture Development In Thai Nguyen, Vietnam. Proceedings of Map Asia 2003 (<http://gisdevelopment.net/application/nrm/water/overview/ma03166.htm>), October, 2003.
- Lin, C.K. and Y. Yi. Minimizing Environmental Impacts of Freshwater Aquaculture and Reuse of Pond Effluents and Mud. Aquaculture 226(1-4):57-68.
- Luong, N.T. Stocking Ratios of Hybrid Catfish (*Clarias macrocephalus* x *C. Gariepinus*) and Nile Tilapia (*Oreochromis niloticus*) in Intensive Polyculture System. M.S. thesis, AIT.

Thakur, D.P. New Fish Species Studied for Aquaculture Potential by Aquaculture CRSP Researchers. Aquanews, 18(4):1-3.

Yi, Y. and C.K. Lin. Cage-Cum-Pond—Integrated Aquaculture Systems Recycle Wastes. Global Aquaculture Advocate. (in press)

Yi, Y., C.K. Lin and J.S. Diana. Recycling pond mud nutrients in integrated lotus-fish culture. Aquaculture. (in press)

Yi, Y., C.K. Lin, and J.S. Diana. Waste recycling in fish pond culture through integrated cage-cum-pond and pen-cum-pond culture systems. In: Proceedings of the 3rd World Fisheries Congress (in press).

Yi, Y., K. Fitzsimmons, and P. Clayden. Stocking Densities of Nile Tilapia in Tilapia-Shrimp Polyculture Under Fixed Feeding Regime. Proceedings of the 5th National Symposium on Marine Shrimp, BIOTECH, Thailand, pp. 100-113.

Presentations

- Bart, A. Controlled Reproduction of Indigenous Species to Prevent the Loss of Biodiversity: A Case Study of Herbivorous Species *Spinibarbus denticulatus* in Southeast Asia. Presented at World Aquaculture Society Annual Meeting, Honolulu, Hawaii, March, 2004.
- Bart, A. and A. Wahab. Technological Constraints and Future of Tilapia Culture in Bangladesh. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka Bangladesh, April, 2004.
- Bolivera, R. Tilapia Culture in Philippines. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka, Bangladesh, April, 2004.
- Chiang, C. Export Prospects for the Thai Tilapia Industry. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Clayden, P. Stocking Densities of Nile Tilapia in Tilapia-Shrimp Polyculture Under Fixed Feeding Regime. Presented at Thai National Symposium of Marine Shrimp, Bangkok, Thailand, March, 2004.
- Clayden, P. Tilapia-Shrimp Polyculture Under Fixed Feed Rations at Low Salinity Water. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Derun, Y. Effect of Water Depth on Growth and Survival of *Penaeus monodon* in Hapas in Outdoor Concrete Tanks. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Diana, J. Intergrated Cage-Cum Pond Aquaculture Systems: A Conceptual Model. Presented at World Aquaculture Society Annual Meeting, Honolulu, Hawaii, March, 2004.
- Giap, D.H. Comparison of Larval Performance Between Thai and Vietnamese Freshwater Giant Prawn, *Macrobrachium rosenbergii* (de Man): A Preliminary Study. Presented at the International Symposium of Freshwater Prawns. Kochi, India, August, 2003.
- Giap, D.H. Current Status and Socio-Economic Comparisons of Small-Scale Coastal Shrimp Culture Systems in Northern Vietnam. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Giap, D.H. Effect of Different Fertilization and Feeding Regimes on the Production of Integrated Rice-Prawn (*Macrobrachium rosenbergii*) Culture. Presented at the International Symposium of Freshwater Prawns. Kochi, India, August, 2003.

- Giap, D.H. and N.X. Cuong. Application of GIS and Remote Sensing for Assessing Watershed Ponds for Aquaculture Development in Thai Nguyen Vietnam. Presented at Map Asia 2003. Kuala Lumpur, Malaysia, October 2003.
- Lin, C.K. Recycling Wastewater from Intensive Hybrid Catfish (*Clarias macrocephalus* x *C. gariepinus*) Culture for Semi-Intensive Nile Tilapia (*Oreochromis niloticus*) Culture in Cement Tanks. Presented at First International Symposium On Southeast Asian Water Environment. Asian Institute of Technology, October, 2003.
- Lin, C.K. Tilapia Culture in Thailand. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka, Bangladesh, April, 2004.
- Luong, V.C. Development of a Trophic Box Model to Assess Potential of Ecologically Sound Management for Cove Aquaculture Systems in Tri An Reservoir of Vietnam. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Phuong, N.T. Environmental Impacts for Cage Culture for Catfish in Vietnam. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Phuong, N.T. Tilapia in Vietnam. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka, Bangladesh, April, 2004.
- Shivakoty, G. and J. Mazumder. Socioeconomic Constraints of Tilapia Production in Bangladesh. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka, Bangladesh, April, 2004.
- Shrestha, M.K. and Rai, A. Tilapia Culture in Nepal. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka, Bangladesh, April, 2004.
- Shrestha, M.K. Polyculture of Grass Carp and Nile Tilapia With Napier Grass as the Sole Nutrient Input. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Wahab, A. On-Farm Trials of Different Fertilization Regimes in Bangladesh. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Yi, Y. Integrated Cage-Cum-Pond Aquaculture Systems: Stocking Densities of Caged High Valued Species in Carp Polyculture Ponds. Presented at World Aquaculture Society Annual Meeting, Honolulu, Hawaii, March, 2004.
- Yi, Y. Strategies of Fertilization and Supplemental Feeding for Nile Tilapia Culture. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka, Bangladesh, April, 2004.

Conferences

- Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003. (Yi, Luong, Giap, Shrestha, Phuong, Waheb, Clayden, Derun, Chiang)
- First International Symposium On South East Asian Water Environment. Asian Institute of Technology, October, 2003. (Yi, Sethteethunyan, Lin)
- International Mechanisms for the Control and Responsible Use of Alien Species in Aquatic Ecosystems. Jihong, China, August, 2003. (Yi)
- International Symposium of Freshwater Prawns. Kochi, India, August, 2003. (Giap, Yi, Lin, Bart, Truong Yen)
- Map Asia 2003. Kuala Lumpur, Malaysia, October 2003. (Giap, Yi, Cuong, Luu, Lin, Diana)
- Thai National Symposium of Marine Shrimp. Bangkok, Thai-

- land, March, 2004. (Clayden)
- Tilapia Culture in Bangladesh: Constraints and Potentials. Dhaka, Bangladesh, April, 2004. (Bart, Wahab, Shivakoty, Mazumder, Bolivera, Lin, Phuong, Shrestha, Rai, and Yi)
- World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004. (Lin, Diana, Bart, Yi, and Phuong)

CO-CULTURE OF LOTUS AND HYBRID CATFISH TO RECYCLE WASTE FROM INTENSIVE FEEDING

*Eleventh Work Plan, Environmental Impacts Analysis Research 1 (11EIAR1)
Final Report*

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ABSTRACT

An experiment was conducted in nine 200-m² earthen ponds at the Asian Institute of Technology (AIT), Thailand from 17 July 2003 to 3 March 2004 (230 days). The objectives of the study were to assess the feasibility of co-culture of lotus and hybrid catfish in intensively fed ponds, to assess nutrient recovery from feed waste by lotus plants, to assess pond mud characteristics after lotus-fish co-culture, and to compare catfish growth with and without lotus integration. There were three treatments in triplicate: (1) catfish at 25 fish m⁻²; (2) lotus at 50 seedlings pond⁻¹; and (3) lotus-catfish co-culture (lotus 50 seedlings pond⁻¹ and catfish at 25 fish m⁻²). Lotus plants, root intact, were transplanted to ponds of treatments with lotus at a density 50 plants pond⁻¹. Hybrid catfish were stocked at a density 25 fish m⁻² in treatments with catfish. Experimental catfish were fed with commercial floating pelleted feed. Feeding rate was adjusted for each pond separately based on the monthly fish growth measurement and estimated average catfish survival. There were no nutrient inputs in lotus ponds. Catfish growth performance was not significantly different ($P > 0.05$) between catfish and co-culture treatments. However, catfish survival was unpredictably low. There were no significant differences in lotus growth performance between lotus and co-culture treatments; however, total harvested lotus biomass was lower in comparison with previous production records in similar ponds. Lotus co-culture with catfish or lotus culture in ponds resulted in reduced pond mud nutrient concentrations. Nutrient loss from mud in a 1-ha pond was 0.32 tonnes N, and 0.44 tonnes P, out of which 44 kg N and 9.3 kg P were incorporated into the harvested lotus biomass. Most of the water quality parameters remained in the safe range for catfish growth and thus, integration of lotus and catfish could be a potential strategy to recover nutrient from intensive catfish feeding systems.

**CONTROLLED REPRODUCTION OF AN IMPORTANT
INDIGENOUS SPECIES, *SPINIBARBUS DENTICULATUS*, IN
SOUTHEAST ASIA**

*Eleventh Work Plan, Indigenous Species Development Research 2
(11ISDR2)*

Final Report

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ABSTRACT

Preliminary studies were conducted to understand some basic reproductive parameters of the indigenous carp *Spinibarbus denticulatus* as a prelude to more specific research studies and subsequent development of hatchery technology. The study objectives were to: 1) Understand the seasonal pattern of gonad development, sexual maturation, and various reproductive parameters; 2) Induce this species to spawn in captivity using natural and artificial methods; and 3) Assess larval growth and survival using available low-cost food items. The first two objectives have been achieved, and the final experiments are underway.

The study was carried out on sub-adult and adult fish. Gonad and egg development was assessed over a 12-month period. Observation of the annuli rings on fish scales was found to be a reliable measure of age. In a population of males and females of similar age, males were generally smaller (2.54 ± 0.34 kg) than females (3.46 ± 0.45 kg). The age at sexual maturation of a natural stock was earlier for males (4 years) than females (5 or older). The gonadosomic index revealed two peaks, April and October. Further examination of the ovaries and eggs during January, February, and March suggested that eggs were developing at various stages. During January, the eggs in the ovary of mature females were uniformly small (0.7 ± 0.1 mm diameter). Two distinct egg groups (0.7 ± 0.1 mm, 36% and 1.0 ± 0.2 mm, 54%) were observed in February. Three distinct size groups were observed during March (1.1 ± 0.03 mm, 1.6 ± 0.01 mm and 2.1 ± 0.03 mm). The proportion of large eggs (55%) was higher compared to mid (26%) and small eggs (19%) during the near-peak spawning month. The average number of eggs in the ovary of a female (3.1 ± 0.4 kg) was 31,041 (12,632–45,359). Males synchronized milt production with egg maturation and ovulation under pond conditions. Milt flowed out readily during the spawning season. Sperm characteristics were similar to those of most teleosts. The mean sperm concentration was 8.42 ± 0.36 million cells per ml with only a small amount (3.3 ± 0.2 ml) of total expressible milt per male. However, when induced with LH-RHa ($10 \mu\text{g kg}^{-1}$) the milt production increased to 6.2 ± 0.5 ml without an increase

in the total number of sperm cells. While this new species for aquaculture shows potential for mass production of seed, low fecundity and late puberty could present obstacles.

A second series of experiments indicated that natural induction methods (rain simulation, decreased/increased water depth and flow) did not induce mature females to spawn in ponds. A series of injection using locally available hormones (e.g., HCG, LH-RHa+Dom, PG) were used to induce females to ovulate. Although all inducing agents resulted in ovulation, the combination of LH-RH and Domperidone resulted in the most consistent results.

**NEW PARADIGM IN FARMING OF FRESHWATER PRAWN
(*MACROBRACHIUM ROSENBERGII*) WITH CLOSED AND
RECYCLE SYSTEMS**

*Eleventh Work Plan, Production System Design and Integration
Research 2 (11PSDR2)*

Final Report

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ABSTRACT

An experiment was conducted in 15 cement tanks ($2 \times 2.5 \times 1$ m) at the Asian Institute of Technology, Thailand, during 5 January–12 May 2004, to develop closed and recycle systems for culture of giant freshwater prawn (*Macrobrachium rosenbergii*). Juvenile prawns were cultured in three systems as three treatments, each in triplicate: (A) open system with water exchange, (B) closed system with aeration, and (C) recycle system, in which water from a prawn tank was circulated through a Nile tilapia (*Oreochromis niloticus*) tank to a water mimosa (*Neptunia oleracea*) tank and back to the prawn tank. Prawn juveniles of 2.8 g were stocked in all prawn tanks at an average density of 19 prawns m^{-2} , sex-reversed Nile tilapia of 10.6 g were stocked in tilapia tanks at 2 fish m^{-2} , and water mimosa seedlings at 0.4 kg m^{-2} were planted in mimosa tanks. Prawns were fed *ad libitum* two times daily.

Survival of prawns, ranging from 40.64% to 88.72%, was highest in the closed system, intermediate in the recycle system, and lowest in the open system ($P < 0.05$). There were also mass mortalities in one open and one recycle tank. Growth of prawns was not significantly different among all three systems ($P > 0.05$), while gross and net yields of prawn were significantly lower in the open system than in closed and recycle systems ($P < 0.05$). Feed conversion ratio (FCR) in the open system was 2.81, which was significantly higher than in the closed (1.67) and recycle (1.78) systems ($P < 0.05$).

Prawn recovered 12.02% N and 7.01% P from feed and fertilizer in the open system, and 25.26% N and 13.67% P in the closed system. Prawn, tilapia, and water mimosa together recovered 39.55% N and 25.53% P in the recycle system. Economic analyses showed that there were no significant differences in net returns among the three systems.

The present study demonstrated that the closed and recycle systems are more environmentally friendly and have good profit potential compared to the open system. Further study is needed to determine appropriate ratio of culture area for prawn, tilapia, and mimosa to minimize environmental pollution, optimize production and maximize profits in the recycle system.

INTEGRATED CAGE-CUM-POND CULTURE SYSTEMS WITH HIGH-VALUED STINGING CATFISH (*HETEROPNEUSTES FOSSILIS*) IN CAGES AND LOW-VALUED CARPS IN OPEN PONDS

*Eleventh Work Plan, Production System Design and Integration Research 3A (11PSDR3A)
Final Report*

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ABSTRACT

An experiment was conducted over 237 days at Bangladesh Agricultural University to adapt an integrated cage-cum-pond system to local conditions in Bangladesh, to determine appropriate stocking density of fish in cages, to assess growth and production of fishes in both cages and open ponds, and to assess the economic and environmental benefits of this integrated system.

Stinging catfish and carp were stocked in cages and open water of ponds to give caged to open-pond fish ratios of 0.5:1, 1:1, 1.5:1, and 2:1 as four treatments with three replicates each. Stinging catfish fingerlings with a mean weight of 12.6 g were stocked at 50, 100, 150, and 200 fish per 0.85-m³ cage, while fingerlings of silver carp (*Hypophthalmichthys molitrix*), catla (*Catla catla*), rohu (*Labeo rohita*) and common carp (*Cyprinus carpio*) were stocked at 100 fish per pond with a species ratio of 2:2:3:3 in open water of all ponds. Commercial pelleted feed (30% crude protein) was given to caged fish

twice daily at a rate of 10% body weight per day. No feed or fertilizer was added into open water of the ponds.

Survival of caged catfish was low, ranging from 39.33% to 60.67% with the highest survival in the 1:1 treatment. Caged catfish in all treatments grew slowly, giving daily weight gains of about 0.06 g fish⁻¹. Net yields in the 0.5:1 and 1:1 treatments were 0.10 and 0.18 kg m⁻³ crop⁻¹, respectively, while the other two treatments gave negative net yields. FCRs were extremely high in the 0.5:1 and 1:1 treatments (131 and 148, respectively), while FCRs were negative in the 1.5:1 and 2:1 treatments (-66 and -311, respectively). Survival of open-pond carps was high, ranging from 71.67% to 100% without significant differences for each carp species among all treatments. All carp species grew steadily throughout the experimental period, with daily weight gains of 0.76 to 1.62 g fish⁻¹. Net and gross yields of all carps were significantly higher in the 1:1, 1.5:1 and 2:1 treatments than in the 0.5:1 treatment. Overall FCRs were best in the 2:1 treatment (0.42), intermediate in the 1:1 and 1.5:1 treatments (0.76 and 0.59, respectively), and poorest in the 0.5:1 treatment (0.86). Net revenues were positive but low in all treatments. This experiment demonstrated the potential of the cage-cum-pond integrated culture system, but more research is needed.

INTEGRATED CAGE-CUM-POND CULTURE SYSTEMS WITH HIGH-VALUED SAHAR (*TOR PUTITORA*) IN CAGES SUSPENDED IN CARP POLYCULTURE PONDS

*Eleventh Work Plan, Production System Design and Integration Research 3B (11PSDR3B)
Final Report*

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ABSTRACT

This experiment was conducted for 150 days in 15 earthen ponds, 100 m² in surface area and 1.2 m in depth, at the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal. One cage (1.5 × 1.5 × 1 m and water volume of 2-m³) covered with 1-cm mesh net was suspended in each of the treatment ponds. There were one control and four treatments with three replicates each: carps at 1 fish m⁻² in open ponds without cages (control); Sahar at 5 fish m⁻³ in cages and carps at 1 fish m⁻² in open ponds (5 fish m⁻³); (3) Sahar at 25 fish m⁻³ in cages and carps at 1 fish m⁻² in open ponds (25 fish m⁻³); Sahar at 50 fish m⁻³ in cages and carps

at 1 fish m⁻² in open ponds (50 fish m⁻³); Sahar at 100 fish m⁻³ in cages and carps at 1 fish m⁻² in open ponds (100 fish m⁻³), giving ratios of caged to open-pond fish of 0:1, 0.1:1, 0.5:1, 1:1, and 2:1. Caged Sahar were fed with a locally made pelleted feed (28% crude protein), while no feed or fertilizer was added into open water of treatment ponds. The control ponds were fertilized weekly using DAP and urea at rates of 4 kg N and 2 kg P ha⁻¹ d⁻¹.

Survival of Sahar was high without significant differences among treatments. Daily weight gains of Sahar, ranging from 0.11 to 0.25 g fish⁻¹, were significantly higher at low stocking densities of Sahar. Feed conversion ratio (FCR) of Sahar ranged from 2.2 to 2.8, and was not significantly different among treatments. The total net and gross yields of all carps were significantly higher in the control than in treatments. The total net and gross yields of carps in the control were significantly higher than the combined net and gross yields of Sahar and carps in all treatments. The overall FCRs in the treatments were 0.15–0.95, and were significantly better in the lower Sahar density treatments. The control and all treatments produced positive net returns, and the highest net returns were produced by the control, followed by treatments with high to low stocking density of Sahar.

This study demonstrated that high-valued Sahar has potential to be cultured in an integrated cage-cum-pond system, but it is necessary to fine-tune stocking ratios of Sahar to carps. This can be accomplished by adjusting stocking density of Sahar in cages, cage size, or cage number. Growth could also be improved by providing higher quality feed.

INTEGRATED CAGE-CUM-POND CULTURE SYSTEMS WITH HIGH-VALUED CLIMBING PERCH (*ANABAS TESTUDINEUS*) IN CAGES SUSPENDED IN NILE TILAPIA (*OREOCHROMIS NILOTICUS*) PONDS

*Eleventh Work Plan, Production System Design and Integration Research 3C (11PSDR3C)
Final Report*

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ABSTRACT

An experiment was conducted over a period of 150 days at Can Tho, Vietnam to adapt integrated cage-cum-pond

systems to local conditions in Vietnam, to determine appropriate stocking density of selected fish species in cages, to assess growth and production of fishes in both cages and open ponds, and to assess the economic and environmental benefits of this integrated system.

Nile tilapia (*Oreochromis niloticus*) fingerlings (10.1 g) were stocked at 2 fish m⁻² in all ponds of 100-m² area, while climbing perch (*Anabas testudineus*) fingerlings (9.0 g size) were stocked in a 4-m³ cage suspended in each pond. Stocking density of *Anabas* was the treatment variable and was 50, 100, 150, and 200 fish m⁻³, giving caged climbing perch to open-pond Nile tilapia ratios of 1:1, 2:1, 3:1, and 4:1. There were also control ponds without a cage (0:1), and control ponds were fertilized weekly with urea and diammonium phosphate (DAP) at 28 kg N and 7 kg P ha⁻¹ week⁻¹. Pelleted feed (26–28% crude protein) was given to caged fish twice daily at a rate of 5–2% body weight per day. No fertilizer was added into treatment ponds.

Survival of climbing perch in cages ranged from 97.1% to 99.6%, without significant difference among treatments. Mean weight of climbing perch at harvest was not significantly different among treatments, indicating that stocking density of climbing perch in cages did not affect growth. Net and gross yields were significantly higher in the treatments at higher stocking ratios. FCRs were very high in all treatments, ranging from 4.97 to 6.07. Survival and growth of Nile tilapia did not differ significantly among treatments. Combined net and gross yields ranged from 3.0 to 6.6 and 4.0 to 8.7 t ha⁻¹ year⁻¹, respectively, in the treatments. Overall FCRs ranged from 0.98 to 1.58, which, however, did not differ among treatments. The highly valued climbing perch has potential to be cultured in a cage-cum-pond culture system, but it is necessary to fine-tune stocking ratios, provide high quality feed, and improve growth of *Anabas*.

MITIGATING ENVIRONMENTAL IMPACT OF CAGE CULTURE THROUGH INTEGRATED CAGE-CUM-COVE CULTURE SYSTEM IN TRI AN RESERVOIR OF VIETNAM

*Eleventh Work Plan, Production System Design and Integration Research 4 (11PSDR4)
Final Report*

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ABSTRACT

A study was conducted at Truong Dang Cove of Tri An Reservoir during June 2003–June 2004 to assess the feasibility of an integrated cage-cum-cove system, to assess effects of cages on water quality and plankton abundance in both the cove and the main reservoir, to assess effects of cages on fish production in coves, and to assess effects of accumulated wastes on terrestrial vegetation.

Five 16-m³ net-cages were set up at the middle of the cove for the culture of red tilapia (*Oreochromis niloticus* × *O. mossambicus*) and stocked at 50, 75, 100, 125, and 150 fish m⁻³ during 19 August 2003–17 January 2004. Water samples were collected at 20 sampling stations grouped into 6 locations at different distances from the cage sites for water quality analyses. Ten plots (1 × 1 m quadrat) were selected for sampling sediment and terrestrial vegetation, with five plots at the cage culture sites and five at random sites, for sampling soil and terrestrial vegetation before and after cage culture to determine vegetation biomass as well as nitrogen, phosphorus, and organic matter content of sediments.

Red tilapia grew well in cages, and cage wastes may have enhanced the growth performance of open-water fish in the cove. Nutrients released from cages to the cove did not significantly affect water quality in the main reservoir, and there were no significant accumulations of cage wastes on the cove bottom. Fish in the cove and terrestrial vegetation during the dry season may efficiently utilize the surplus nutrients derived from the cage culture.

The integrated cage-cum-cove culture system can enhance fish production in coves through cage-cultured fish and increased production of open-water fish by using wastes from cage culture. The integrated cage-cum-cove system can stock appropriate species composition in open water to more efficiently use cage wastes, manage the terrestrial vegetation to use the cage wastes at the cove bottom, and also allow the dry period of the cove to decompose organic cage wastes. However, cage culture in a cove is a new practice and needs more research to develop an environmentally sound integrated cage-cum-cove culture system.

OPTIMIZATION OF NITROGEN FERTILIZATION REGIME IN FERTILIZED NILE TILAPIA PONDS WITH SUPPLEMENTAL FEED

*Eleventh Work Plan, Production System Design and Integration Research 5 (11PSDR5)
Final Report*

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ABSTRACT

An experiment was conducted in fifteen 200-m² earthen ponds at the Asian Institute of Technology, Thailand during October 2003 to June 2004. The objectives of the study were to assess effects of different nitrogen fertilization regimes on tilapia production, to assess effects of different fertilization regimes on pond water quality, to quantify nutrient budgets, and to analyze the cost and return for fish with different fertilization regimes and supplemental feed. Ponds were stocked with sex-reversed male Nile tilapia (*Oreochromis niloticus*) of 10–12 g in size at a density of 3 fish m⁻². Urea and triple super phosphate were applied to all ponds at rates of 28 kg N and 7 kg P ha⁻¹·wk⁻¹ until fish reached 100 g in size. Supplemental feeding was then provided at 50% satiation level, and nitrogen fertilization was adjusted for different treatments while phosphorus fertilization was kept unchanged for all ponds. Five nitrogen fertilization rates were used as treatments with three replicates each: 0%, 25%, 50%, 75%, and 100% (control) of 28 kg N·ha⁻¹·wk⁻¹, giving 0, 7, 14, 21, and 28 kg N·ha⁻¹·wk⁻¹, respectively.

Average survival of Nile tilapia ranged from 79.2% to 85.7%, without significant differences among treatments. Mean weight, mean weight gain, daily weight gain, and net yield were significantly higher in the 75% N treatment than in the 0% N treatment, while no significant differences were observed among the other treatments. There was considerable natural reproduction in all ponds and a variable biomass of recruits produced. There were no significant differences in gross and net yield of combined adult and recruited tilapias among treatments. Estimated nutrient inputs showed that fertilizer was the major source of nitrogen and phosphorus, accounting for 63.63–75.23% of N and 65.64–71.84% of P in different treatments. Nutrients from pelleted feed represented 24.77–36.37% N and 28.16–34.36% P. Harvested tilapia incorporated 16.40–22.02% N and 12.11–16.27% P of the total inputs from both fertilizer and feed, without significant differences among all treatments. All treatments resulted in negative revenue due to poor tilapia growth. However, there were indications that reduced fertilization rates improved culture conditions. Further research should be conducted using better tilapia seed to fine-tune the nitrogen fertilization rate.

WORKSHOP ON FERTILIZATION STRATEGIES FOR POND CULTURE IN BANGLADESH

*Eleventh Work Plan, Production System Design and Integration
Research 6 (11PSDR6)
Final Report*

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ABSTRACT

A one-day workshop was held on 26 June 2003 at BRAC Center in Dhaka, Bangladesh, and was organized by Aquaculture CRSP, the Asian Institute of Technology, and Bangladesh Agricultural University in cooperation with the three nongovernmental organization (NGO) partners, namely, BRAC, CARITAS, and PROSHIKA. The objectives of this workshop were to disseminate information of Aquaculture CRSP fertilization technologies, to transfer appropriate fertilization strategies developed by Aquaculture CRSP to aquaculture extension agencies in Bangladesh, and to enhance cooperation between Aquaculture CRSP with academic institutions, government agencies, NGOs, and international organizations in Bangladesh.

Forty-seven participants, including government fisheries officers, researchers, university teachers and students, NGO extension workers, and international organization/project staff attended the workshop. During the workshop, speakers briefed Aquaculture CRSP activities and achievements in the past two decades, overviewed the current status of pond aquaculture in Bangladesh, introduced pond fertilization practices of NGOs, BAU, BFRI, and DOF in Bangladesh, summarized the results of Aquaculture CRSP on-station and on-farm trials of different fertilization regimes used in Bangladesh, presented fertilization strategies for tilapia culture developed by the Aquaculture CRSP, and discussed environmental impacts of the intensification of pond culture. This workshop has increased impacts of the Aquaculture CRSP in Bangladesh and will help aquaculture development in Bangladesh.

TILAPIA (*Oreochromis niloticus*) PRODUCTION CONSTRAINTS IN BANGLADESH: A SOCIO-ECONOMIC PERSPECTIVE

*Eleventh Work Plan, Sustainable Development and Food Security
Research 2A (11SDFR2A)
Final Report*

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ABSTRACT

The purpose of this study was to identify underlying socio-economic constraints to the adoption of tilapia culture and to formulate appropriate policy guidelines to promote this species in existing aquaculture systems. The overall goal was to promote and sustain tilapia production in Bangladesh and other South Asian countries. The specific objectives included identifying sets of constraints impeding tilapia production, formulating appropriate policy guidelines, and suggesting research priorities to promote tilapia in Bangladesh.

Farm households from five major tilapia growing areas (Mymensingh, Dhaka, Chittagong, Jessore, and Patuakhali) were evaluated by observational tours and in-depth discussion with relevant actors. A total of 30 households were selected from each study location. The interpretation of qualitative data was conducted by content analysis.

Tilapia producers' responses on tilapia adoption trends (TAT) were analyzed through correlation (Spearman's rho), which identified 17 major constraining factors. These were grouped into five major categories, including physical resources, technology, support services, market and financial, and environmental constraints. About 80 percent of variation in the negative trend for tilapia adoption was explained by limited availability of technical information, high seed price, poor seed quality, and difficult technology. All important variables from the regression fell within the upper 7 of the 17 ranked variables.

Limited availability of technical information was one of the major significant constraining factors of TAT. To address this problem, a public-private partnership is needed in extension activities. Strategically important private sectors, such as hatcheries, should become involved not only in improved seed supply but also in technology generation and dissemination.

**TILAPIA (*OREOCHROMIS NILOTICUS*) PRODUCTION
CONSTRAINTS IN BANGLADESH:
B. TECHNOLOGICAL CONSTRAINTS**

*Eleventh Work Plan, Sustainable Development and Food Security
Research 2B (11SDFR2B)
Final Report*

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ABSTRACT

Tilapia was introduced to Bangladesh in 1954. Culture of this species is still in infancy compared to neighboring countries, including Indonesia, Philippines, Thailand, and Vietnam. Despite many positive culture attributes of tilapia, culture in Bangladesh may be constrained by different technical, socio-economic and institutional factors. Some attempts have been made by the Department of Fisheries, Bangladesh Fisheries Research Institute, and Bangladesh Agricultural University over last decades to develop production technology and disseminate this through their own channels. However, production levels failed to increase despite reasonably high prices for tilapia. In order to better understand the causes of this problem, we reviewed published literature on tilapia in Bangladesh and conducted a nation-wide survey of farmers. The survey was designed to identify factors that constrained adoption of this species. Results indicated several technological and socioeconomic constraints impeding adoption of tilapia culture in this country. Among the technological constraints, the perceptions were that this is difficult technology, there is not appropriate technical information and technical support, there is poor quality of seed, seed is limited in availability and high price, and that feed is also limited in availability.

**TILAPIA (*OREOCHROMIS NILOTICUS*) PRODUCTION
CONSTRAINTS IN BANGLADESH:
WORKSHOP AND EXPERT PANEL MEETING ON TILAPIA
CULTURE IN BANGLADESH**

*Eleventh Work Plan, Sustainable Development and Food Security
Research 2C (11SDFR2C)
Final Report*

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ABSTRACT

A one-day workshop was held on 4 April 2004 at BRAC Center in Dhaka of Bangladesh organized by Aquaculture CRSP, the Asian Institute of Technology, and Bangladesh Agricultural University. The objectives of this workshop were to bring together all stakeholders to an open discussion on the present status as well as future potentials and directions for tilapia production in Bangladesh, and to enhance cooperation among the stakeholders in order to set proper strategies to promote tilapia culture in Bangladesh.

Seventy-four participants, including government fishery officers, researchers, university teachers and students, NGO extension workers, and international project staff attended the workshop. During the workshop, speakers explained Aquaculture CRSP activities and achievements in the past two decades, overviewed the status of tilapia culture in Bangladesh, Nepal, Thailand, The Philippines, and Vietnam, and also presented strategies for Nile tilapia culture.

An expert panel meeting was held on 5 April 2004 at BRAC Center in Dhaka of Bangladesh to identify constraints to developing tilapia culture in Bangladesh, and to develop a list of researchable topics for development of tilapia culture. A total of 33 experts attended the meeting, which included CRSP experts, experts from neighboring countries facing problems similar to Bangladesh in promoting tilapia culture, experts from countries successful in adopting tilapia culture, and national experts working for universities, fisheries departments and also from NGOs working in Bangladesh. The expert panel members discussed local conditions that impact development of tilapia culture and identified the most important constraints to development of tilapia culture in Bangladesh. Then they moved to discuss researchable priorities arising from constraints and worked out a list of prioritized researchable topics for promotion of tilapia culture in Bangladesh.

GROWTH AND REPRODUCTIVE PERFORMANCE OF IMPROVED TILAPIA (*OREOCHROMIS NILOTICUS*)

*Eleventh Work Plan, Sustained Development and Food Security Research 3 (11SDFR3)
Final Report*

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ABSTRACT

Currently, there are four lines (GIFT, IDRC, Fishgen, and Chitralada) of established and productive stocks of Nile tilapia in Asia, and three of them have been selected for improved growth. Although the selected lines are thought to have higher growth rates under extensive culture systems, there may have been a number of correlated responses to selection that could impact other traits such as reproduction. Such traits have not been subjected to comparative evaluation. Therefore, this study examined reproduction as well as growth, under an intensive culture system, for these four strains of tilapia.

The study has two components with the following objectives:

- 1) Compare reproductive performance (fecundity, spawning frequency, fertilization, hatch and larval survival) of three improved (GIFT, IDRC, Fishgen) and the Thai Chitralada strain of Nile tilapia; and
- 2) Compare growth, as well as age and size at sexual maturation, of the four strains in earthen ponds and in an intensive recirculation system.

Significant progress has been made on the first of these objectives, but experiments relating to the second objective are in progress.

Our study compared growth, survival, sexual maturation, and various reproductive parameters in four tilapia strains, three of which have been improved through various selective breeding approaches (GIFT, IDRC, and Fishgen-selected), and a local stock (Chitralada) was included as a non-improved control. The four strains were originally reared in extensive culture systems with fertilization only. Growth (weight and length) and reproductive parameters (gonadosomatic index, hepatosomatic index, and stages of sexual maturation) were measured on fish sampled every 21 days. Based on staging of gonad development, GIFT were found to become sexually mature somewhat later than the other two strains. At nine months, broodstock from each strain were stocked in 5-m² breeding hapas, with 5 males and 15 females per hapa and four replicate hapas per strain. Broodstock were sampled for eggs every week, and data on fecundity and inter-spawning interval for the four strains were assessed. Seasonal and environmental variances appear to be major determinants of egg/fry production, with the only strain difference observed being a lower relative fecundity in GIFT. Across all strains, fecundity per female increased over time, while fecundity per unit weight of female remained constant. Spawning frequency and interval of spawning

fluctuated widely between individual fish. Spawning interval was highly variable within individual females making it difficult to identify trends. Many females spawned very infrequently, and the means to identify fecund females could have huge impacts upon hatchery efficiency.

MITIGATING THE EFFECTS OF HIGH TEMPERATURE AND TURBIDITY ON SEED PRODUCTION OF NILE TILAPIA FROM HAPA-IN-POND SYSTEMS

*Eleventh Work Plan, Seedstock Development and Availability Research 1 (11SDAR1)
Final Report*

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ABSTRACT

A study, consisting of two experiments, was conducted at the Asian Institute of Technology (AIT), Thailand, for 95 days for Experiment A and 113 days for Experiment B during May 2003–March 2004 to investigate effects of high temperature and turbidity on seed production of Nile tilapia. Experiment A was conducted using a randomized complete block design in a 300-m² earthen pond of 1.6 m deep, and had three treatments with three replicates each: (A) 70-cm water depth in hapas (control); (B) 100-cm water depth in hapas; and (C) 140-cm water depth in hapas. Experiment B was conducted using a complete randomized design in six 200-m² earthen ponds of 1.2 m deep, and had two treatments with three replicates each: (A) without underwater walkways (control); (B) with underwater walkways.

Egg production was increased by about 72% and 96% in the 100- and 140-cm treatments, compared to the control. There was no significant difference in mean individual egg weight among all three treatments ($P > 0.05$). Fertilization rates in the two deeper treatments (37.49% and 42.05% in the 100- and 140-cm deep treatments, respectively) were significantly higher than that (21.06%) in the control ($P < 0.05$), however, hatching rates were not significantly different among all three treatments ($P > 0.05$). Lowering water temperature by using deep ponds is an effective way to increase reproductive performance of Nile tilapia during the hot season.

The turbidity at the end of the experiment and its change throughout the experiment was significantly lower in the

treatment with walkways than in the treatment without walkways ($P < 0.05$), however, there was no significant difference in egg production, fertilization rate and hatching rates between the two treatments ($P > 0.05$). Lowering tur-

bidity and fouling caused by egg collection through underwater walkways may not be effective in improving reproductive performance. However, further research is needed on the effects of fouling on reproductive performance of Nile tilapia.

MEXICO PROJECT

MOU No. RD009C

Subcontract No. RD010E-A

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Work Plan Research

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

- Training Local Farmers on Safe Handling of Steroids and Masculinization Techniques in Central America/11ATER1. The report submitted for this investigation was a final report.
- Continuation of a Selective Breeding Program for Nile Tilapia to Provide Quality Broodstock for Central America/11SDAR3. The report submitted for this investigation was a final report.
- Development of Aquaculture Techniques for the Indigenous Species of Southern Mexico, *Centropomus undecimalis*: Sex Determination and Differentiation and Effects of Temperature/11ISDR3. The report submitted for this investigation was a final report.
- Elimination of Methyltestosterone from Intensive Masculinization Systems: Use of Ultraviolet Irradiation of Water/11WQAR1. The report submitted for this investigation was a final report.
- Use of Phytochemicals as an Environmentally-Friendly Method to Sex-Reverse Nile Tilapia/11FNFR3. The report submitted for this investigation was a final report.
- Diversification Into Sustainable Tilapia-Shrimp Polyculture and Small-Scale Tilapia Cage Culture in Mexico/11PSDR1. The report submitted for this investigation was a final report.

Publications

Abiado, M.A. CRSP Receives Scholarship from Mexico National Council. *Aquanews*, 18(4):2.

Campos-Campos, B. Evaluación de un sistema de filtración continua con Carbono activado para la eliminación de la 17α -metiltestosterona de sistemas intensivos de reversión sexual de *Oreochromis niloticus*. M.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.

Chávez-Mendez, A. Masculinización de Crías de Mojarra Paleta, *Vieja bifasciata*, por Inmersión y Administración Oral Con 17α -Metiltestosterona y Actetato de Trenbolona. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.

Contreras-García, M.J. Inversión sexual de las mojarra nativas *Cichlasoma salvini* y *Petenia splendida*, mediante la administración oral de esteroides sintéticos. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.

Fitzsimmons, K. 2003. Producción y mercado internacional de tilapia. pp:134-150. In: Memorias de la Reunión Nacional de Tilapia. Instituto de la Pesca. Guadalajara, Mexico.

Fitzsimmons, K. 2003. Tilapia aquaculture in recirculating systems. *Aquaculture Magazine* 29(2):73-76.

Fitzsimmons, K. 2003. Tilapia Evolution: Growing industry moves from live fish to value-added products. *Global Aquaculture Advocate* 6(6):50-52.

Frias-Lopez, M. Evaluación de la Factibilidad de Producción de Poblaciones Monosexo de Machos de Tilapia, *Oreochromis niloticus*, Mediante el Empleo de Tamoxifeno y Letrozol. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.

Hernández-Vera, B.A. Comparación de seis líneas de tilapia (*Oreochromis niloticus*). B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.

López-Ramos, I. Comparación del crecimiento de las descendencias de cuatro líneas de tilapia *Oreochromis niloticus* desde la fase de alevín, hasta la etapa de post-madurez. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.

McDonal Vera, A. Avances en la investigación científica y tecnológica para el cultivo del pejelagarto (*Atractosteus tropicus*) en Tabasco. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.

McIntosh, D. and K. Fitzsimmons. 2003. Characterization of effluent from an inland, low-salinity shrimp farm: What contribution could this water make if used for irrigation? *Aquacultural Engineering* 27:147-156.

McIntosh, D., K. Fitzsimmons, J. Aguilar and C. Collins 2003. Towards Integrating Olive Production with Inland Shrimp Farming. *World Aquaculture* 34(1):16-20.

Ramon-Zapata, F. Frecuencia de alimentación y su efecto sobre el desarrollo, crecimiento y supervivencia de las larvas de pejelagarto, *Atractosteus tropicus*, en condiciones de laboratorio. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.

Real-Ehuan, G. Masculinización de crías de mojarra castarrica *Cichlasoma urophthalmus*, mediante la administración de la 17α -metiltestosterona. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.

Vidal-López, J.M. Masculinización de crías de la mojarra tenhuayaca *Petenia splendida* (Gunther, 1862), mediante bioencapsulado del esteroide 17α -metiltestosterona en nauplios de *Artemia salina*.

Yang Yi, Kevin Fitzsimmons and Potjane Clayden, 2004. Stocking densities of Nile tilapia in tilapia-shrimp polyculture under fixed feeding regime. In: Proceedings of the 5th National Symposium on Marine Shrimp, 29-30 March 2004, Bangkok, Thailand, pp. 100-113. BIOTEC, Thailand.

Presentations

Contreras-Sánchez W., C. Shreck, U. Hernandez, and G. Feist. Elimination of Methyltestosterone from Intensive Masculinization Systems Using Activated Charcoal Fil-

- ters. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Contreras-Sánchez W., C. Shreck, U. Hernandez, and G. Feist. Feminization of the Tropical Gar (*Atractosteus tropicus*) and Masculinization of the Cichlid Castarica (*Cichlasoma urophthalmus*) Using Steroid-Enriched Artemia Nauplii. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Contreras-Sánchez W., C. Shreck, U. Hernandez, and G. Feist. Reproductive and Growth Performance of Three Lines of Nile Tilapia (*Oreochromis niloticus*) in Tabasco, Mexico. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Contreras-Sánchez W., C. Shreck, U. Hernandez, and G. Feist. Use of Steroid-Enriched Artemia Nauplii for Sex-Reversal: Validation of the Technique Using Nile Tilapia as a Model. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Contreras-Sánchez, W. Advances in Fish Culture at Universidad Juárez Autónoma de Tabasco. 7 October 2003. Audience consisted of government workers.
- Contreras-Sánchez, W. Induced Sex Inversion in Fishes. Seminar presented to public audience at Universidad Juárez Autónoma de Tabasco, 24 September 2003.
- Contreras-Sánchez, W. MT Elimination from Intensive Masculinization Systems. Seminar presented to public audience at Universidad Juárez Autónoma de Tabasco, 29 October 2003.
- Contreras-Sánchez, W., U. Hernández-Vidal, A. Hernández-Franyutti, M.A. Contreras-García, and G. Real-Ehuan. Induced Sex Inversión in Native Fish. Curso-taller Reproducción en peces teleosteos. Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Morelos, Cuernavaca, Mor. México. November 20, 2003. Audience consisted of researchers, professors and students.
- Dabrowski, K. New Developments in Diet Formulations for Larval Fish: Peptide and Growth Enhancers. Universidad Juarez Autonoma de Tabasco, Tabasco, Mexico. 27 October, 2003 (Oral Presentation).
- Dabrowski, K. New Developments in Diet Formulations for Larval Fish: Peptide and Growth Enhancers. Universidad Nacional Autonoma de Mexico. 29 October, 2003 (Oral Presentation).
- Fitzsimmons, K. Advanced Technologies in Aquaculture: Advantages and Concerns. Presented at AquaBio Brazil and Latin America Chapter of World Aquaculture Society Meeting in Vitoria, Brazil, May, 2004.
- Fitzsimmons, K. International Tilapia Production and Markets. Presented to farmers and government officials in Honolulu, Hawaii, March, 2004.
- Fitzsimmons, K. Opening European Markets to Value-Added Tilapia Products. Presented at a Seafood Business Conference in London, England, November, 2003.
- Fitzsimmons, K. Tilapia Production and Markets. Presented to farmers and government officials in Obregon, Mexico, October, 2003.
- Rodriguez, G. A., K.J. Lee, W.M. Contreras, and K. Dabrowski. 17α -Methyltestosterone Detection in Fish Tissue (Tilapia) and Water By a Simplified HPLC Technique Analysis. Presented at the World Aquaculture Society Meeting, Honolulu, Hawaii. 1-5 March, 2004 (Poster presentation).
- Rodriguez, G. and K. Dabrowski. Studies on the Use of Phytochemicals as an Alternate to Methyltestosterone to Produce Monosex Populations in Nile Tilapia (*Oreochromis niloticus*) for Aquaculture. 2004 OARDC Annual Conference, Ohio State University, Wooster, Ohio. 29 April, 2004 (Poster Presentation).
- Rodriguez, G., K.J. Lee, W.M. Contreras, K. Park, and K. Dabrowski. Evaluation of Two Phytochemicals, Genistein and Quercetin as Possible Sex Differentiation-Affecting Agents in *Tilapia nilotica* By Dietary Administration. Presented at the World Aquaculture Society Meeting, Honolulu, Hawaii. 1-5 March, 2004 (Oral Presentation).
- Treadway, K., G. Rodriguez, and K. Dabrowski. Social and Feeding Interactions of Two Cichlid Species, Midas and Nile Tilapia Reared at High Density. Inaugural CFAES Undergraduate Research Forum, College of Food, Agricultural and Environmental Sciences, Columbus, Ohio. 29 April, 2004 (Poster Presentation).

Conferences

Alltech's 20th International Feed Industry Symposium. Lexington, Kentucky, May, 2004. (Dabrowski)

Curso-taller Reproducción en peces teleosteos. Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Morelos, Cuernavaca, Morelos, México. November 20, 2003

Seafood Business Conference. London, England, November, 2003. (Fitzsimmons)

World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004. (Contreras, Shreck, Hernandez, Feist, Rodriguez, Palacios, Dabrowski, and Ostaszewska, and Fitzsimmons).

TRAINING LOCAL FARMERS ON SAFE HANDLING OF STEROIDS AND MASCULINIZATION TECHNIQUES IN CENTRAL AMERICA

*Eleventh Work Plan, Applied Technology and Extension Methodologies Research 1 (11ATER1)
Final Report*

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ABSTRACT

The need to deliver recently generated information and technological packages to the immediate users (students, extension agents, and farmers) is fundamental for aquaculture development. Training workshops are one way to achieve these goals. Through workshops, researchers can obtain feedback information from farmers and identify problems that may compromise advances in the field of interest. Developing new techniques, such as methods for sex reversal or production of clean effluents, would be futile unless the information that is generated is transferred to people conducting aquacultural activities. This is especially difficult in Mexico and Central America because information is not readily accessible. Workshops conducted in Mexico under CRSP support have already impacted tilapia culture in Tabasco and Chiapas and most farmers are growing sex-reversed tilapias—this activity was not conducted until only a few years ago. To complement research for the production of clean sex-inversion techniques, we implemented three regional workshops and one local workshop on safe handling of steroids and masculinization techniques in Mexico. We have also generated printed and electronic materials for safe handling of steroids and masculinization techniques.

**CONTINUATION OF A SELECTIVE BREEDING PROGRAM
FOR NILE TILAPIA TO PROVIDE QUALITY BROODSTOCK
FOR CENTRAL AMERICA**

*Eleventh Work Plan, Seedstock Development and Availability
Research 3 (11SDAR3)
Final Report*

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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 have been conducting a selective breeding program for three years which has produced an F3 generation of broodstock that performs better than the line traditionally used by local farms. We have been using selection on three lines of tilapia the line that the hatchery has traditionally used (Teapa), a wild line from the Usumacinta river basin (San Pedro), and a line obtained from Egypt by the State government (DS1). Three selections were performed. The first was conducted at 70 days of age, the second at 160 days and the last at 11 months. Initially, 10% of the population was measured and tables of frequency distributions were constructed. The mean, median, and standard deviations were estimated and the fish were divided into three groups, based on the median of the total length (TL). During the first selection (all fish, no sex separation), the mid-sized fish were grown-out until the next selection. For the second selection, fish were separated by sex, and then selected in the same manner as the first selection. For the third selection, 60% of the females with the largest size (TL) were selected, and from these fish, 50% of the individuals with the highest condition factor were selected as breeders. Thirty percent of the males with the largest size (TL) were also selected, and from these fish, 35% of the individuals with the highest condition factor were selected as sires. Fry obtained from spawnings of the three lines were analyzed for growth performance. Fry from the DS1 line had consistently higher growth rates than the other two lines. This study was conducted as a collaborative effort between UJAT, the National Council for Science and Technology (SIGOLFO-CONACyT), and the office for Agriculture and Fisheries Development (SEDAFOP) in Tabasco.

DEVELOPMENT OF AQUACULTURE TECHNIQUES FOR THE INDIGENOUS SPECIES OF SOUTHERN MEXICO, *CENTROPOMUS UNDECIMALIS*: SEX DETERMINATION AND DIFFERENTIATION AND EFFECTS OF TEMPERATURE

*Eleventh Work Plan, Indigenous Species Development Research 3 (11ISDR3)
Final Report*

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ABSTRACT

Species of "robalo," or snook, are an important indigenous food fish in southern Mexico. Over fishing has resulted in diminishing catch volumes of the common snook (*Centropomus undecimalis*). This has led to concerns for the health of the regional fisheries and to calls for improved management practices. An important step in reducing pressure on native populations, while ensuring a reliable food source, would be incorporation of the species into aquaculture systems. An understanding of the reproductive biology of a fish species is necessary in order to begin an aquaculture program, yet little is known regarding these processes in snook. As an important first step, we conducted a workshop on the biology and culture of snook which brought together specialists from North and Central American and the Caribbean. The workshop was conducted for four days at the División Académica de Ciencias Biológicas, Universidad Juárez Autónoma de Tabasco in Villahermosa and was attended by 51 people from 23 institutions. The workshop covered general snook biology, people's experiences with the culture of snook, and culminated with a visit to a grow-out farm in Tabasco. Knowledge gained from this workshop will aid us during our next phase of research, which will examine the timing and morphological pattern of gonadal sex differentiation in common snook, and also determine the effect of early treatment with low or high water temperature or sex steroids on sex ratios and growth rate.

ELIMINATION OF METHYLTESTOSTERONE FROM INTENSIVE MASCULINIZATION SYSTEMS: USE OF ULTRAVIOLET IRRADIATION OF WATER

*Eleventh Work Plan, Water Quality and Availability Research 1 (11WQAR1)
Final Report*

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ABSTRACT

This study tested the hypothesis that 17 α -methyltestosterone (MT) could be eliminated from the water used in intensive sex-inversion systems using sunlight and UV sterilizers. Different concentrations of MT diluted in water were exposed to UV or sunlight and measured through time for 48 hours. Water samples were collected from aquaria at the onset of treatments and at 2, 4, 8, 24, and 48 hours. All samples were extracted using ether and the concentration of MT was determined by radioimmunoassay. We also evaluated the elimination of MT in masculinization systems and the masculinizing effects of effluents produced in these systems on tilapia. MT was partially eliminated when water was exposed to direct sunlight; however, MT was completely eliminated from water following exposure to UV. At the end of the treatments, sunlight exposure eliminated between 48 and 62% of the MT detected at the beginning of the trials. When water with MT was exposed to UV light, MT was not detectable after 48 h of treatment. When intensive masculinization systems were used, MT was only detected in 7.1% of the water samples. Five of the detections were from tanks that received MT that had no UV sterilizers and six samples were from tanks with UV sterilizers. Significant masculinization was obtained when MT was administered through the food and the results indicate that UV treatment allowed for higher masculinization rates. Our results also indicate that effluents from masculinization systems can masculinize fish that are not the target of the treatment. This may be due to the sterilizers degrading MT slowly over time or perhaps that the UV degradation products resulted in compounds that increased masculinization. More research is needed regarding treatment methods for masculinization effluents to eliminate the risks of unintended exposure to humans and other non-target organisms.

**USE OF PHYTOCHEMICALS AS AN ENVIRONMENTALLY
FRIENDLY METHOD TO SEX REVERSE NILE TILAPIA**

*Eleventh Work Plan, Fish Nutrition and Feed Technology Research
3 (11FNFR3)
Final Report*

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ABSTRACT

This study evaluated the use of daidzein, chrysin, and caffeic acid as potential sex reversal agents in Nile tilapia by dietary administration or immersion treatments. Three feeding experiments were conducted at two locations: Aquaculture Laboratory at the Ohio State University (Experiment 1 and 2) and the Aquaculture laboratory at the Universidad Juarez Autonoma de Tabasco UJAT-Mexico (Experiment 3). An immersion treatment experiment took place at the Aquaculture Laboratory of The Ohio State University (Experiment 4). The dietary administration experiments were as follows: for Experiments 1 and 3, diets control, chrysin (500 mg/kg), daidzein (500 mg/kg) and caffeic acid (500 mg/kg) along with the steroidal compounds spironolactone (500 mg/kg), 1,4,6-androstratiene-3-17-dione ATD (150 mg/kg) and 17 α -methyltestosterone (MT) (60 mg/kg) were fed for 8 weeks. For Experiment 3, the diets were control, chrysin (500 mg/kg), daidzein (500 mg/kg) and caffeic acid (500 mg/kg) along with the steroidal compounds spironolactone (500 mg/kg) were offered for 6 weeks. In all cases, semi-purified casein gelatin diets were used to avoid contamination with external sources of either phytochemicals or steroid-like compounds. For the immersion experiment (Experiment 4), four immersion trials were carried out at 10, 17, 21, and 28 day post-hatching on the following chemicals and concentrations, vehicle DMSO (1 ml/l), daidzein 400 (mg/l), chrysin (20 mg/l), caffeic acid (40 mg/l), spironolactone (5 mg/l), ATD (1.2 mg/l) and MT (400 μ g/l). In all experiments, final sex ratio was determined by gonad squash; in feeding trials, the final individual body weight and survival were evaluated. Results of experiments conducted at The Ohio State University indicate that the presence of the tested phytochemicals in food or in immersion baths has no effect on the final sex ratio of tilapia or growth performance. In Experiment 1, ATD and MT had a significant effect on final sex ratio (50% and 100% masculinization, respectively); in Experiment 3 (UJAT-Mexico) MT and ATD along with SPIRO affected the male ratio significantly. No effects were observed in Experiment 2 (97 \pm 3% males) or Experiment 4 (60-40% male:female ratio) across experimental groups.

AMAZON BASIN PROJECT

Subcontract No. RD010E-12 (SIUC)

Subcontract No. RD010E-13 (UAPB)

Subcontract No. RD010E-A (OhSU)

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Work Plan Research

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

- Amazon Aquaculture Outreach/11SDFR1. The report submitted for this investigation was a final report.
- Nutrition and Nutrient Utilization in Native Peruvian Fishes/11FNFR1. The report submitted for this investigation was a final report.
- Broodstock Development and Larval Feeding of Amazonian Fishes/11ISDR1. The report submitted for this investigation was a final report.

Publications

Alcantara, F.B., C.V. Chávez, L.C. Rodríguez, W.N. Camargo, C. Kohler, M. Colace, and S. Tello. Gamitana (*Colossoma macropomum*) and Pacu (*Piaractus brachypomus*) Culture in Floating Cages in the Peruvian Amazon. *World Aqua.*, 34(4):22-24.

Alcantara, F.B., S.M. Tello, C.V. Chávez, L.C. Rodríguez, C.C. Kohler, S.T. Kohler, and W.N. Camargo. Pond Culture of *Arapaima gigas* in the Peruvian Amazon. *World Aqua.*, 35(1):45-46.

Camargo, W.N., C. Kohler, S. Kohler, M. Rebaza, C. Rebaza, S. Deza, E. Villafana, and C. Alvarez. Fish Culture

at the Pucallpa Navy Base in the Peruvian Amazon. *Aquanews*, 18(4):7-8.

Camargo, W.N. International Training Courses in Aquaculture and Nutrition of Prominent Amazon Species. *Aquanews*, 18(4):3.

Dabrowski, K. and M.C. Portella. 2004. Feeding Plasticity and Nutritional Physiology in Tropical Fish. In: *Fish Physiology*, vol. 22, Eds.. A.L. Val and D.J. Randall. (in press).

Dabrowski, K., J. Rinchar, J. Ottobre, F. Alcantara, P. Padilla, A. Ciereszko, M. J. De Jesus and C.C. Kohler. 2003. Effect of Oxygen Saturation in Water Provided to Broodstock and Embryos of *Piaractus brachypomus* on Viability of Larvae. *J. World. Aquacult. Soc* 34:441-449.

Fernandes, J.B.K., R. Lochmann, and F.A. Bocanegra. Apparent Digestible Energy and Nutrient Digestibility Coefficients of Diet Ingredients for pacu (*Piaractus brachypomus*). *Journal of World Aquaculture Society* 35:237-244.

Lee, K.J., K. Dabrowski, J. Rinchar, L. Gomez, Guz, and C. Vilchez. Supplementation of Maca (*Lepidium meyenii*) Tuber Meal in Diet Improves Growth Rate and Survival of Fish. *Aquaculture Research*. 35:215-223.

Ostaszewska, T., K. Dabrowski, M. Wegiel, and M.E.

Palacios. Growth and Morphological Changes in the Digestive Tract of Rainbow Trout and Paku Due to Casein Protein Replacement With Soybean Protein. Aquaculture. (submitted).

Silva, M., 2004. Reproductive Strategies for the *Cichlasoma Amazonarum* (bujurqui). B.S. thesis, Universidad Nacional de la Amazonia Peruana, Peru.

Tello, S. Aquaculture in the Peruvian Amazon: A Case Study of Microenterprise. *Aquanews*, 18(4):5.

Presentations

Camargo, W.N. I Curso de Internacional Nutrición de Peces Tropicales. Seminar presented to public audience in Pucallpa, Peru, 2003.

Camargo, W.N. III Curso de Internacional Acuicultura con Especies Promisorias de la Amazonia. Seminar presented to public audience in Pucallpa, Peru, 2003.

Camargo, W.N. Sustainable Small-Scale Aquaculture in the Amazon Region. Seminar presented to public audience in Carbondale, Illinois, March, 2004.

Dabrowski, K. Peptide Utilization in Larval Fish Diet Formulation: Basic and Applied Aspects. Presented at the World Aquaculture Society Meeting, Honolulu, Hawaii. 1-5 March, 2004 (Oral presentation).

Dabrowski, K., K. Ware, and M. Tesser. Larval and juvenile rearing of pacu *Piaractus mesopotamicus* using live food and formulated diets (Poster presentation).

Lochmann, R. Broodstock Diet Development for Tropical Amazonia Fishes. Presented at III Curso de Internacional Acuicultura con Especies Promisorias de la Amazonia and I Curso de Internacional Nutrición de Peces Tropicales in Pucallpa, Peru, 2003.

Lochmann, R. Clues to Characid Broodstock Diet Development. Presented at World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.

Ostaszewska, T., K. Dabrowski, M. Wegiel, and M.E. Palacios. Growth and Morphological Changes in the Digestive Tract of Rainbow Trout and Paku Due to Casein Protein Replacement With Soybean Protein. Presented at the World Aquaculture Society Meeting, Honolulu, Hawaii. 1-5 March, 2004. (Oral Presentation).

Palacios, M.E., K. Dabrowski, and C.C. Kohler. Growth and Diet Utilization in Pacu (*Piaractus mesopotamicus*) Using Soybean Replacement of Casein Gelatin as a Protein Source. Presented at the World Aquaculture Society Meeting, Honolulu, Hawaii. 1-5 March, 2004 (Oral Presentation).

Tesser, M., K. Dabrowski, B. Terjesen, J.M. Pizauro, and M.C. Portella. Free- and peptide-based arginine supplementation into arginine-deficient diets for South American fish *Piaractus mesopotamicus*. (Poster Presentation).

Tesser, M., M.C. Portella, and K. Dabrowski. Growth and survival of pacu *Piaractus mesopotamicus* larvae fed formulated diets and live *Artemia* (Oral Presentation).

Conferences

I Curso de Internacional Nutrición de Peces Tropicales in Pucallpa, Peru, 2003. (Lochmann)

III Curso de Internacional Acuicultura con Especies Promisorias de la Amazonia in Pucallpa, Peru, 2003. (Lochmann)

World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004. (Camargo, Chu, C. Kohler, S. Kohler, Lochmann, and Tello)

AMAZON AQUACULTURE OUTREACH

Eleventh Work Plan, Sustainable Development and Food Security Research 1 (11SDFR1)
Final Report

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ABSTRACT

Outreach activities significantly benefited over 150 producers and their families (346 ponds, 110 ha.) in the Peruvian Amazon. The certification of six master aquaculturists and on-farm research activities helped provide technical assistance in aquaculture techniques to local and prospective fish farmers. The on-farm research activities, conducted with four local fish farmers, was part of an undergraduate thesis project on species diversification. Several aquarium fish species (*Osteoglossum bicirrhosum*, *Astronotus ocellatus*, and *Cichla monoculus*), also consumed in some local markets, were found to be suitable for culture. The two CRSP-funded extensionists provided aquaculture training to 777 vocational, high school, and university students in the Amazon Basin (Brazil, Colombia, Ecuador, and Peru). Sixty-two individuals representing Ecuador, Bolivia, Brazil, Colombia, Venezuela, and Peru participated in aquaculture short courses. The Amazonian aquaculture website, developed during the Tenth Work Plan, was expanded. This website is an important tool to communicate the work done by research institutions in the US, many Amazon nations, and elsewhere (over 6,000 hits from 1 May 2003 through 31 May 2004).

NUTRITION AND NUTRIENT UTILIZATION IN NATIVE PERUVIAN FISHES

*Eleventh Work Plan, Fish Nutrition and Feed Technology Research 1 (11FNFR1)
Final Report*

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ABSTRACT

Numerous wild fruits and plant products are reportedly utilized as fish feed in the Amazon region. To assess the feasibility of utilizing these and other plant products for small-scale sustainable aquaculture production of *Piaractus brachypomus* and *Colossoma macropomum*, samples of several fruits and plant products were collected in Iquitos Peru in the Tenth Work Plan. Proximate analysis was performed in the Eleventh Work Plan on fruit samples available during the summer or through the year. Proteins, lipids, calories and fiber content were analyzed using standard techniques (Kjeldahl, Folch, spectrophotometry, and chromatography). In addition, data on the seasonal availability of the plants/plant products were collected. Digestibility trials with *P. brachypomus* were conducted on three native feedstuffs (plantain, *Musa paradisiacal*; yucca, *Manihot sculenta*; and pijuayo, *Bactris gasipaes*) in 110-L tanks in a flow-through system at Southern Illinois University at Carbondale (SIUC). Digestible energy, protein, lipid and dry matter digestibility coefficients were determined for each feedstuff. The reference diet was similar in composition to those used currently for Characid fishes at Instituto de Investigaciones de la Amazonia Peruana (IIAP), Peru. Digestibility coefficients were determined by using an indirect method, involving chromic oxide (Cr_2O_3) as a non-digestible marker. The digestibility of crude proteins (85.6%), crude fat (90.4%), and energy (70.3%) of pijuayo in *P. brachypomus* was far superior to that of yucca and plantain. The digestibility of plantain and yucca by *P. brachypomus* were very similar to each other for crude proteins (57.5 vs. 53.0%), crude fat (54.9 vs. 64.8%), and energy (29.0 vs. 21.0%). Pijuayo appears to be an excellent ingredient to be employed in formulated diets for *P. brachypomus*. Additionally, the abundance of pijuayo in the Amazon Basin makes this fruit economically viable to the small-scale farmers to reduce feed manufacturing cost.

BROODSTOCK DEVELOPMENT AND LARVAL FEEDING OF AMAZONIAN FISHES

*Eleventh Work Plan, Indigenous Species Development Research
1A (11ISDR1A)
Final Report*

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ABSTRACT

Larvae of *C. macropomum* and *P. brachypomus* were obtained from fish induced to spawn by hormonal injections. The feeding experiment was initiated 19 February 2004, and was conducted in a flow-through system consisting of 18 70-L aquaria (3 aquaria/dietary treatment; 9 aquaria per species) supplied with aeration. Water quality was monitored throughout the larval rearing process. Temperature was maintained between 26–28°C and dissolved oxygen ranged from 5–6 mg/L. Larvae were randomly distributed at a density of 500 larvae/aquarium and conditioned for 10 days using plankton as feed; thereafter larvae were fed their respective experimental diets at a restricted ration up to 8% their body weight (8 times per day) for 2 weeks. Larvae were fed three diets: 1) freshly hatched *Artemia* nauplii; 2) decapsulated *Artemia* cysts; and 3) local plankton (*Moina* sp.) produced in raceways with anchovy fishmeal. Larval samples (n=5) were taken every week from each tank (45 larvae total per species) and fixed in buffered formalin for biometric measurements (total length, standard length, mouth opening). At the end of the experiment, growth performance was evaluated in terms of final individual body weight, specific growth rate (SGR, %), weight gain (%), condition factor (*k*) and survival (%). Larvae of *C. macropomum* and *P. brachypomus* fed decapsulated *Artemia* cysts and *Moina* sp. performed better than those fed freshly hatched *Artemia* nauplii. However, the survival of *C. macropomum* larvae did not differ significantly in any of the treatments (decapsulated *Artemia* cysts 34%, *Artemia* nauplii 26%, and *Moina* sp. 46%). In contrast, survival of *P. brachypomus* larvae was significantly different between treatments; larvae fed *Moina* sp. had higher mean survival (44.3%) compared to those fed nauplii (39.6%) or decapsulated *Artemia* cysts (36.5%). Though *Artemia* are a more readily available and reliable larval food source, *Moina* sp. appear to be a cost-effective substitute for use in the Amazon Basin.

BROODSTOCK DEVELOPMENT AND LARVAL FEEDING OF AMAZONIAN FISHES

*Eleventh Work Plan, Indigenous Species Development Research
1B (11ISDR1B)
Final Report*

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ABSTRACT

Growth and plasma sex steroid hormone (including, estradiol-17 β , testosterone, and 11-ketotestosterone) levels were investigated in surubim *Pseudoplatystoma* sp. over a 1-year period. Growth of surubim in laboratory conditions was high. The gonadosomatic index (<1%) and the histological analysis (presence of only perinucleolar oocytes in female and spermatogonia in males) of the gonads indicated that the fish would not reach sexual maturity for at least a year. All three steroids measured (estradiol, testosterone, and 11-ketotestosterone) did not show any significant variation throughout the year. Moreover, the concentrations were low in comparison to those reported in other catfish species and confirmed the results of the histological and morphological analysis. As a result, we postponed the induction of ovulation or spermiation until spring 2005.

AFRICA PROJECT

MOU No. RD009A

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

- Aquaculture Training for Kenyan Fisheries Assistants/11ATER4. The report submitted for this investigation was a final report.
- Evaluation of Aquaculture Training Provided to Fisheries Officers and Fisheries Assistants of the Kenya Fisheries Department/11ATER5. The report submitted for this investigation was a final report.
- Development of an Aquaculture Handbook for Extension Workers and Trainers of Extension Workers in Sub-Saharan Africa/11ATER6. The report submitted for this investigation was a final report.

Publications

Ngugi, C.C., J. Amadiva, K. Veverica, J. Bowman, S. Imende, B. Nyandatt, and G. Matolla. On Farm Trials in Kenya Change Attitudes of Fish Farmers and Extensionists. Samaki News, Vol. 2 July 2003.

PresentationsNgugi, C.C. Development of a National Fisheries Policy. Seminar presented to government officials in Nairobi, Kenya, 2003.
Ngugi, C.C., J. Nzeve, and J.R. Bowman. Growth and survival of African catfish *Clarias gariepinus* larvae fed *Artemia* nauplii, freshwater rotifers, and whole, freeze-dried *Cyclops* in indoor tanks. Aquaculture 2004, March 1-5, 2004. Honolulu, Hawaii.**Conferences**

Third International Conference of Panafrican Fish and Fisheries in Cotonou, Benin, West Africa, November, 2003. (Omolo)

AQUACULTURE TRAINING FOR KENYAN FISHERIES ASSISTANTS

*Eleventh Work Plan, Applied Technology and Extension Methodologies Research 4 (11ATER4)
Final Report*

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ABSTRACT

Increasing aquaculture production in a sustainable way requires trained manpower, but for several decades up until 1998, opportunities for aquaculture training in Kenya had been limited. Sustained funding and well-thought-out training strategies were lacking. In response to this deficiency, as part of its Ninth and Tenth Work Plans, the Aquaculture Collaborative Research Support Program (ACRSP) provided technical and monetary support for a series of twelve two- and three-week short courses for officers of the Kenya Fisheries Department (FD), who are the officials responsible for carrying out aquaculture extension activities.

Feedback from the training sessions conducted under the Ninth and Tenth Work Plans indicated that they had been extremely valuable to the participants, giving them the ability to construct fish ponds properly and to give sound pond management advice to farmers. The FD was so satisfied with the results of those training sessions that they sought and secured their own funding for additional training sessions. This report describes two short courses funded by matching contributions from the FD and the ACRSP under the ACRSP's Eleventh Work Plan. These two additional courses were targeted specifically towards the FD's Fisheries Assistants, the Department's officers who work most directly with fish farmers in Kenya.

EVALUATION OF AQUACULTURE TRAINING PROVIDED TO FISHERIES OFFICERS AND FISHERIES

*Eleventh Work Plan, Applied Technology and Extension Methodologies Research 5 (11ATER5)
Final Report*

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ABSTRACT

Following a series of twelve short courses in pond construction, pond management, and farm management planning sponsored by the Aquaculture CRSP and conducted in Kenya by the CRSP, the Moi University Department of Fisheries, and the Kenya Fisheries Department between 2000 and 2003, a study was undertaken to evaluate the effectiveness of these training courses. The evaluation focused on the content and quality of the courses as well as on their usefulness to the trainees, as perceived by the trainees themselves.

The study used a mail-out questionnaire to ask for input from all but the most recent participants in the courses. Questions related to the participants' perceptions about course content and presentation as well as to ways they had been able to apply what they had learned in the field after completion of their respective sessions. Included in the latter category was an attempt to quantify changes in numbers and areas of ponds, pond productivity, and income earned from fish farming in the participants' areas of responsibility.

The questionnaire used is shown, along with summaries of the major findings of the survey and a summary table of pond data from before and after the training courses. Significant findings and possible areas for improvement of future training courses are discussed.

In addition to the report on the survey and its results, direct and indirect results from CRSP-sponsored training efforts are reported on through four case studies. Two of the case studies focus on Kenyan fish farmers whose farm operations have been positively influenced by CRSP training efforts and two are about individuals who received training under CRSP programs and have subsequently gone on to make valuable contributions to the development of aquaculture in Kenya.

**DEVELOPMENT OF AN AQUACULTURE HANDBOOK FOR
EXTENSION WORKERS AND TRAINERS OF EXTENSION
WORKERS AND SUB-SAHARAN AFRICA**

*Eleventh Work Plan, Applied Technology and Extension Method-
ologies Research 6 (ILATER6)
Final Report*

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ABSTRACT

Between 2000 and 2003, a series of twelve short courses focusing on pond construction, pond management, and the economics of fish farming were offered to Fisheries Officers (FOs) and Fisheries Assistants (FAs) of the Kenya Fisheries Department as part of the research and training efforts of the Aquaculture Collaborative Research Support Program (ACRSP). The training materials used in these courses were developed by the collaborating principal investigators to meet the specific needs of these two groups of trainees, drawing on past experience in Kenya (CRSP-sponsored research at Sagana Fish Farm and in On-Farm Trials), information from CRSP research sites in other countries, and published aquaculture literature, and recognizing that most of the intended audience (FOs and FAs) had never previously received any kind of training in aquaculture. Insofar as possible, training materials were organized into PowerPoint® "modules" for use in the classroom setting and supplemented with a large amount of practical work in the field.

Following completion of the twelfth training session it was deemed desirable to organize the PowerPoint® module material into a handbook that could be used not only for future short courses but also as a reference manual for workers involved in aquacultural extension activities in Kenya. This report describes the development of the draft of that manual and a companion document, an "Instructor's Guide" containing supplemental material for instructors in future training sessions.

AFRICA PROJECT*Subcontract No. RD010E-D**Participants**University of Arkansas at Pine Bluff*

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Charles Ngugi	Host Country Principal Investigator
Enos Were	Research Associate

Fisheries and Aquaculture Development Division, Tanzania

Raphael Mapunda	Host Country Principal Investigator
Kajitanus Osewe	Host Country Principal Investigator
Japhet Mwampulo	Research Assistant
Regina Nzeyakufanga	Research Assistant
Aggney Lishela	Research Assistant
Gideon Phelimon	Research Assistant

Kwame Nkrumah University of Science & Technology, Ghana

Stephen Amisah	Host Country Principal Investigator
Irene Anane-Kyeremeh	Research Assistant
Alfred Dassah	Research Associate
Nelson Agbo	Research Associate

Fisheries Department, Ministry of Agriculture and Rural Development, Kenya

Nancy Gitonga	Host Country Principal Investigator
Judith Amadiva	Research Associate

Sokoine University of Agriculture, Tanzania

Berno Mnembuka	Host Country Principal Investigator
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Fisheries Department, Ministry of Food and Agriculture, Ghana

Linus Kumah	Host Country Principal Investigator
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Work Plan Research

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

- Preliminary Work on Site Description, Evaluation, and Development Planning: Tanzania, Ghana, and Kenya/11ERAR1. The report submitted for this investigation was an abstract.
- Cost Evaluation and Benefit Assessment of Fish Farming in Selected African Nations/11ERAR2. The report submitted for this investigation was an abstract.
- An Economic Assessment of Aquaculture in Rural Africa: The Case of Tanzania, Kenya, and Ghana/11ERAR3. The report submitted for this investigation was an abstract.
- A Cross-National Analysis of the Potential Economic Impact of Aquaculture in Africa/11ERAR4. The report submitted for this investigation was an abstract.

PRELIMINARY WORK ON SITE DESCRIPTION, EVALUATION AND DEVELOPMENT PLANNING: TANZANIA, GHANA AND KENYA

*Eleventh Work Plan, Economic/Risk Assessment and Social Analysis 1 (11ERAR1)
Final Abstract*

Kwamena Quagrainia
Aquaculture/Fisheries Center
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas

Osewe Kajitanus
Fisheries and Aquaculture Development Division
Ministry of Agriculture
Tanzania

Charles Ngugi
Department of Fisheries
Moi University
Eldoret, Kenya

Stephen Amisah
Department of Freshwater Fisheries and Watershed Management
University of Science and Technology
Ghana

ABSTRACT

Requests for proposals under the Eleventh Work Plan encouraged the inclusion of new host countries and new researchers in Aquaculture CRSP activities. Ghana and Tanzania were proposed as potential new host countries in Africa, and as such, some preliminary work on site descriptions and updates were required. The activity verified the existence of basic institutional research capacities needed to make collaborative research viable. It also studied government policies to ascertain support for aquaculture, research, and extension. In Tanzania, a number of aquaculture projects funded by other non-governmental organizations including the FAO have been going on. A government aquaculture policy was obtained, which indicated a commitment to developing aquaculture. Two universities are engaged in aquaculture and fisheries research, University of Dar-es-Salaam and Sokoine University of Agriculture. In Ghana, the Kwame Nkrumah University of Science and Technology offers a degree program in aquaculture and has aquaculture research facilities. The government has a research center that is involved in aquaculture research called the Aquaculture Research and Development Center. The center is adequately staffed with aquaculture professionals and is well equipped. International agencies that are currently active in aquaculture development in Ghana include FAO, Danish International Development Agency, German International Development Agency, and the World Fish Center. Both Tanzania and Ghana are recommended to be included as new sites for Aquaculture CRSP research in Africa.

COST EVALUATION AND BENEFIT ASSESSMENT OF FISH FARMING IN SELECTED AFRICAN NATIONS

*Eleventh Work Plan, Economic/Risk Assessment and Social Analysis Research 2 (11ERAR2)
Final Abstract*

Kwamena Quagrainie
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas

ABSTRACT

This activity required identification of socio-economists in the respective countries who will assist in the development of teaching modules for farmers. The following have now been identified; K. A. Osei Fosu, Kwame Nkrumah University of Science and Technology, Ghana, Ephraim M. M. Senkondo, Sekione University of Agriculture, Tanzania, and John Mackambo, Moi University, Kenya. These individuals have started developing teaching materials to be used in teaching farmers simple methods for assessing and evaluating costs and benefits as well as principles of record keeping.

AN ECONOMIC ASSESSMENT OF AQUACULTURE IN RURAL AFRICA: THE CASE OF TANZANIA, KENYA, AND GHANA

*Eleventh Work Plan, Economic/Risk Assessment and Social Analysis Research 3 (11ERAR3)
Final Abstract*

Kwamena Quagrainie
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas

ABSTRACT

The study involves a comprehensive questionnaire for households involved in fish farming or other aquaculture ventures. A draft questionnaire has been developed with inputs from the host country Principal Investigators. The questionnaire has been pre-tested in Tanzania and is currently being pre-tested in Kenya and Ghana.

**A CROSS-NATIONAL ANALYSIS OF THE POTENTIAL
ECONOMIC IMPACT OF AQUACULTURE IN AFRICA**

*Eleventh Work Plan, Economic/Risk Assessment and Social
Analysis Research 4 (11ERAR4)
Final Abstract*

Kwamena Quagraine
University of Arkansas at Pine Bluff
Pine Bluff, Arkansas

ABSTRACT

The study involves an estimation of the potential economic impact of small- and medium-scale aquaculture developments on community development. A draft questionnaire required for collecting data has been developed and pre-tested in Tanzania. The questionnaire is currently being pre-tested in Kenya and Ghana. Some secondary data has been collected from Tanzania and some preliminary analysis is underway.

PHILIPPINES PROJECT

Subcontract No. RD010E-20

Participants*Florida International University, Miami, Florida*

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

Central Luzon State University, Muñoz, Nueva Ecija, Philippine

Remedios B. Bolivar Host Country Principal Investigator
Eddie Boy Jimenez Research Associate
Juan Rey Sugue Research Assistant
Emmanuel Angeles Administrative Assistant
Richard Babas Undergraduate Student (from June 2004)
Ronaldo Bernardino Undergraduate Student (through April 2004)
Nova Marie Pesebre Undergraduate Student (through April 2004)
Mark Joseph Rafael Undergraduate Student (through April 2004)

North Carolina State University, Raleigh, North Carolina

Russell Borski US Principal Investigator

Work Plan Research

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

- Evaluation of Tilapia Aquaculture Best Practices in Central Luzon, the Philippines/11FNFR2. The report submitted for this investigation was a final report.
- Insulin-like Growth Factor-I as a Growth Indicator in Tilapia/11FNFR4 The report submitted for this investigation was a final report.

Publications

Bolivar, R.B Meet a Tilapia Farming Husband and Wife Team. *Aquanews*, 18(4):5.
Bolivar, R.B. On-Farm Trial Participants Share Successes. *Aquanews*, 18(4):3-6.
Bolivar, R.B. The CLSU-Aquaculture CRSP Project Funds Four Undergraduate Students. *Aquanews*, 18(4):8.
Bolivar, R.B, E.B.T. Jimenez, and C.L. Brown. Large-scale application of an alternate-day feeding strategy for tilapia growout in the Philippines (submitted by invitation). *North American Journal of Aquaculture (NAJA)*
Bolivar, R.B., E.B.T. Jimenez, J.R. Sugue, and C.L. Brown. Effect of stocking size on the yield and survival of Nile tilapia (*Oreochromis niloticus* L.) on-grown in ponds. Submitted, International Society for Tilapia Aquaculture (ISTA) for inclusion in proceedings.
Brown, C.L., R.B. Bolivar, and E.B. Jimenez. Feeding Moderation in Tilapia, An Overview of Economic and Environmental Implications. *Global Aquaculture Advocate*. (in press)

Jimenez, E.B., R.B. Bolivar, and C.L. Brown. 2004. Cost Containment Options in Semi-Intensive Tilapia Culture: Evaluation of Alternate-Day Feeding Strategy (abstract). *World Aquaculture Society Book of Abstracts*, page 291.
Vera Cruz, E., C.L. Brown, J.A. Luckenbach, M.E. Picha, R.J. Borski, and R.B. Bolivar. PCR-cloning of Nile tilapia, *Oreochromis niloticus* L., insulin-like growth factor-I and its possible use as an instantaneous growth indicator. Submitted to *Aquaculture*.

Presentations

Brown, B. Cost Containment Options in Semi-Intensive Tilapia Culture: Evaluation of Alternate-Day Feeding Strategy. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
Brown, B. Tilapia Culture in Bangladesh: Constraints and Potential. Presented at Tilapia Culture in Bangladesh: Constraints and Potential. Dhaka, Bangladesh, April, 2004.

Conferences

Philippine Society for Microbiology Annual Meeting. Manila, Philippines, April, 2004. (Babas)
Shrimp Congress 2004. Cebu Grand Convention Center, Cebu City, March, 2004. (Bolivar, Jimenez, Sugue, Angeles)
Tilapia Culture in Bangladesh: Constraints and Potential. Dhaka, Bangladesh, April, 2004. (Bolivar)
World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004. (Brown, Bolivar)

EVALUATION OF TILAPIA AQUACULTURE BEST PRACTICES IN CENTRAL LUZON, THE PHILIPPINES

*Eleventh Work Plan, Fish Nutrition and Feed Technology Research 2 (11FNFR2)
Final Report*

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

Remedios B. Bolivar
Freshwater Aquaculture Center
Central Luzon State University
Science City of Muñoz, Nueva Ecija, Philippines

ABSTRACT

Work under this investigation included farm survey, extension, and research components using both the CLSU research station and demonstration farms. An experiment was conducted for the determination of optimal stocking sizes, considering the growth and survival performance of various sizes of fingerlings along with economic factors.

Size #22 sex-reversed nursery phase fingerlings of Nile tilapia (*Oreochromis niloticus*) of the Genomar Supreme Tilapia or GST strain were grown in fifteen (15) 2 x 2 x 1m hapas in pond at a stocking density of 200 fish m⁻³ to attain size #10. After two weeks, another batch of size #22 sex-reversed fingerlings were grown in 15 nursery hapas at 200 fish m⁻³ to attain size #14.

In the grow-out phase, twelve (12) 500m² ponds were used in the study to determine the growth, yield and survival of Nile tilapia (*Oreochromis niloticus* L.) in ponds. The treatments consisted of the following: I- direct stocking at size #22; II- stocking at size #14; and III- stocking at size #10. The various treatments and replicates were assigned randomly in the ponds following a completely randomized design.

Treatment III gave the highest extrapolated fish yield (3,799 kg ha⁻¹), followed by Treatment II (3,065 kg ha⁻¹) then Treatment I (2,738 kg ha⁻¹). Analysis of variance on fish yield showed significant difference between Treatments I and III ($P < 0.05$). Specific growth rate likewise significantly differed among treatments ($P < 0.01$). Survival rate of Nile tilapia was also significantly affected by stocking size of fingerlings. Higher survival rate was obtained with larger size of fingerlings at stocking for grow-out production

In addition, a farm survey was conducted, in which 70 participating farmers were queried on a range of practical issues. This has established a database of farm practices (see appendix 1) which is being expanded upon by additional survey work, and which will be useful for a variety of applications.

INSULIN-LIKE GROWTH FACTOR-I AS A GROWTH INDICATOR IN TILAPIA

*Eleventh Work Plan, Fish Nutrition and Feed Technology Research 4 (11FNFR4)
Final Report*

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

Remedios B. Bolivar
Freshwater Aquaculture Center
Central Luzon State University
Science City of Muñoz, Nueva Ecija, Philippines

ABSTRACT

A set of studies was carried out on the expression of the IGF-I gene in juvenile tilapia, using fish approximately of the initial size that is stocked for growout in commercial aquaculture in the Philippines (~1–1.5 g). IGF-I is a mitogenic polypeptide that is an important regulator of growth in fish. The potential of IGF-I mRNA abundance as an instantaneous growth indicator in juvenile Nile tilapia, *Oreochromis niloticus*, was evaluated. Hepatic IGF-I cDNA was isolated and cloned and partially cloned. The partial sequence having 539 bp was found to code for the signal peptide (44 amino acids), mature protein (68 aa) and a portion of the E domain (19 aa). The deduced 68 aa sequence for mature IGF-I showed 84–90% and 77–79% sequence identity with fish and mammalian counterparts, respectively, confirming the highly conserved sequence homology among species. The B and A domains were even more highly conserved with respect to the deduced amino acid sequence (90–96%). Based on the mature IGF-I peptide, a sensitive TaqMan real time qRT-PCR assay for *O. niloticus* was developed for measures of hepatic IGF-I mRNA levels. Hepatic IGF-I mRNA levels were found to be significantly correlated with growth rate of individual juvenile fish reared under different feeding regimes and temperature conditions. Higher feed consumption and water temperature produced faster growing fish and increased hepatic IGF-I mRNA expression. These findings suggest that hepatic IGF-I plays a key role in controlling growth in *O. niloticus* and indicates IGF-I mRNA measures could prove useful to assess current growth rate in this species.

GLOBAL PROJECTS

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

Participants

University of Arizona

Kevin Fitzsimmons US Principal Investigator
Huruy Zerzghi Graduate Student (Eritrea)

Asian Institute of Technology Thailand

Yang Yi Host Country Principal Investigator
Potjane Nadtiro Graduate Student
Wanwisa Saelee Graduate Student

Central Luzon State University, Phillipines

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

Private Sector Collaborators

John Clarke Schering-Plough, Phillipines
Fu-Sung Frank Chiang President, Taiwan Tilapia Farmers
Calvin Burgess Private tilapia farm owner, Kenya

Work Plan Research

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

- Aquaculture CRSP Sponsorship of the Sixth International Symposium on Tilapia in Aquaculture/11ATER2. The report submitted for this investigation was a final report.
- Aquaculture CRSP—Global Contributions to Sustainable Aquaculture: A Special Session at the 2004 World Aquaculture Conference/11ATER3. The report submitted for this investigation was a final report.

Presentations

Fitzsimmons, K. Aquaculture CRSP Contributions to Sustainable Aquaculture. Presented to farmers and government officials in Honolulu, Hawaii, March, 2004.

Fitzsimmons, K. Tilapia Aquaculture in Africa. Presented to government officials and visitors from World Fish Center at AID Headquarters in Washington D.C., April, 2004

**AQUACULTURE CRSP SPONSORSHIP OF THE SIXTH
INTERNATIONAL SYMPOSIUM ON TILAPIA IN
AQUACULTURE**

*Eleventh Work Plan, Applied Technology and Extension Methodologies Research 2 (11ATER2)
Final Report*

Kevin Fitzsimmons
University of Arizona
Tucson, Arizona

Remedios Bolivar
Freshwater Aquaculture Center
Central Luzon State University
Science City of Muñoz, Nueva Ecija, Philippines

ABSTRACT

This project supported the planning and conduct of the Sixth International Symposium on Tilapia in Aquaculture. The ISTA 6 conference held 12–16 Sept 2004 in Manila, Philippines, was widely hailed as the most successful symposium yet held on tilapia aquaculture. Total attendance at the conference was almost 700 people, with 80 oral presentations and a dozen posters presented. ISTA 6 included a heavily attended trade show and field trips to tilapia production and processing centers at Lake Taal and Pampanga Province; research and development sites at the Science City of Muñoz; and supporting industries including feed mills, hatcheries, and other government institutions in the provinces of Laguna and Nueva Ecija.

**AQUACULTURE CRSP—GLOBAL CONTRIBUTIONS TO
SUSTAINABLE AQUACULTURE: A SPECIAL SESSION AT
THE 2004 WORLD AQUACULTURE CONFERENCE**

*Eleventh Work Plan, Applied Technology and Extension Methodologies Research 3 (11ATER3)
Final Report*

Kevin Fitzsimmons
University of Arizona
Tucson, Arizona

ABSTRACT

Aquaculture CRSP sponsored several events, awards, and a special session at the Triennial World Aquaculture Society meetings in Hawaii in March 2004. The triennial meeting of the WAS is the premier aquaculture technical and trade show held globally. Every third year WAS meets in conjunction with the American Fisheries Society and National Shellfish Association, as well as over 20 smaller aquaculture organizations.

The sponsorship included organizing the session, providing the chair, the speakers, and collecting all of the Powerpoint and audio files for posting on the Internet for additional viewing. Travel funds were provided for eleven scientists and students to attend the WAS conference and present their research findings. The special session titled: Aquaculture CRSP—Global Contributions to Sustainable Aquaculture, was well attended by CRSP and non-CRSP scientists. At the end of the presentations, two panel discussions were conducted.

Panel Discussion 1: Tilapia Production: Subsistence Culture to International Markets; and

Panel Discussion 2: Indigenous Fish for Aquaculture.

In addition to funding travel and registrations, the grant purchased subscriptions to the online presentations at the WAS website for the session presenters and students. This allowed them to view Web-based streaming video and audio of WAS conference presentations from meetings in Kentucky, Brazil, Hawaii, and Australia. It also included a CD-ROM version of the Kentucky and Brazil meetings. More importantly the subscription number allowed them (or their students and colleagues) to log on from anywhere and view the presentations. The CD-ROM version accommodates computers without internet connections and allows for easy use in the classroom.

Another aspect of the grant was to organize and present a Lifetime Achievement Award. The Award was to recognize a career dedicated to developing sustainable aquaculture systems in CRSP host countries. C. Kwei Lin, who recently retired from the Asian Institute of Technology, was selected as the recipient. The award included a lifetime membership in the World Aquaculture Society. The project also included cash awards for Best Student Posters at the conference. A team of judges evaluated student posters that dealt specifically with aquaculture research that was directed toward sustainable aquaculture systems in or for developing countries. A first place award of \$400 and two runner up awards of \$200 were presented at a WAS student function.

GLOBAL PROJECTS

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

Participants*Autburn University*

Claude E. Boyd	US Principal Investigator
Chhorn Lim	US Principal Investigator
Taworn Thunjai	Ph.D. Student (Thailand)
Kom Silapajarn	Ph.D. Student (Thailand; through Spring 2004)
Orawan Silapajarn	Ph.D. Student (Thailand)
Idsariya Wudtisin	Ph.D. Student (Thailand)
Wararat Wudtisin	Ph.D. Student (Thailand)

University of Stellenbosch, South Africa

Danie Brink	Host Country Principal Investigator
Lourens de Wet	Host Country Principal Investigator
Khalid Salie	Research Assistant

Kasetsart University, Bangkok, Thailand

Mali Boonyaratpalin	Host Country Principal Investigator
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Embrapa Meio Ambiente, Brazil

Julio Queiroz	Host Country Principal Investigator
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Centro de Aqüicultura, Universidade Estadual Paulista, Jaboticabal, São Paulo, Brazil

Lúcia Sipaúba-Tavares	Host Country Principal Investigator
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Work Plan Research

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

- Use of a Wetland to Treat Effluent from a Flow-Through Aquaculture System/11WQAR2. The report submitted for this investigation was a final report.
- Influence of Daily Feed Allowance on Pond Water and Effluent Quality/11WQAR4. The report submitted for this investigation was a final report.
- Further Studies on Soil Quality in Aquaculture Ponds in Thailand/11EIAR2. The report submitted for this investigation was a final report.

Publications

- Salie, K. Small-Scale Aquaculture Enterprises for the People. *Aquanews*, 18(4):4-5.
- Silapajarn, K, C.E. Boyd, and O. Silapajarn. An Improved Method for Determining the Fineness Value of Agricultural Limestone for Aquaculture. *North American Journal of Aquaculture* 66:113-118.
- Thunjai T., C.E. Boyd, and M. Boonyaratapalin. Bottom Soil Quality in Tilapia Ponds of Different Age in Thailand. *Aquaculture Research* 35:698-705.
- Thunjai T., C.E. Boyd, and M. Boonyaratapalin. Quality of Liming Materials Used in Aquaculture in Thailand. *Aquaculture International* 12:161-168.

Presentations

- Boyd, C.E. Aquaculture and the Environment. Seminar presented AAAS meeting in Seattle, Washington, February, 2004
- Boyd, C.E. Aquaculture and the Environment. Seminar presented to upper level undergraduate students at Rungkhumhaeng University in Bangkok, Thailand, December, 2003
- Boyd, C.E. Overcoming Environmental Barriers to Aquaculture Development. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Boyd, C.E. Quality of Liming Materials Used in Shrimp Farming in Thailand. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Silapajarn, K. Particle Size and Reaction of Agricultural Limestone. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Silapajarn, O. Nitrogen and Phosphorus Concentration and Loads in a Stream Receiving Catfish Farm Effluents. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.

Conferences

- AAAS Annual Meeting. Seattle, Washington, February, 2004 (Boyd)
- World Aquaculture Society Annual Conference. Honolulu, Hawaii, February, 2004. (O. Silapajarn, K. Silapajarn)
- World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004. (Boyd)

MACROPHYTE BIOFILTER FOR TREATING EFFLUENT FROM AQUACULTURE

*Eleventh Work Plan, Water Quality and Availability Research 2
(11WQAR2)
Final Report*

Lúcia Helena Sipaúba Tavares
Universidade Estadual Paulista
Centro de Aqüicultura
Jaboticabal, SP, Brazil

Claude E. Boyd
Department of Fisheries and Allied Aquacultures
Auburn, Alabama

ABSTRACT

A study was conducted at Jaboticabal, São Paulo, Brazil to evaluate the effectiveness of a wetland consisting of a 90 m long by 2 m wide ditch as a treatment system for effluent from a 3-ha aquaculture research station. The wetland (vegetated ditch) contained four major species of aquatic macrophytes as follows: *Ludwigia elegans*, *L. sericia*, *Alternanthera philoxeroides*, and *Myriophyllum aquaticum*. The biofilter action of the wetland caused an annual reduction in five day biochemical oxygen demand of 48.1% and a 26.4% reduction in total suspended solids. Although nutrient concentrations were not reduced in water passing through the wetland, the chlorophyll *a* concentration was about 14% less in the discharge of the wetland than in the incoming aquaculture effluent. Results of this study suggest that a wetland biofilter consisting of a vegetated ditch could cause modest improvements in the quality of aquaculture effluents.

INFLUENCE OF DAILY FEED ALLOWANCE ON POND WATER AND EFFLUENT QUALITY

*Eleventh Work Plan, Water Quality and Availability Research
(11WQAR4)
Final Report*

Lourens F. de Wet
Feed Technology Project, Division of Aquaculture,
University of Stellenbosch, Matieland, South Africa

Khalid Salie
Feed Technology Project, Division of Aquaculture,
University of Stellenbosch, Matieland, South Africa

Chhorn Lim
Aquatic Animal Health Research Unit
USDA-ARS
Auburn, Alabama

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

ABSTRACT

A feeding trial was conducted towards optimization of feeding regimes for semi-intensive culture of Mozambique tilapia in earthen ponds in order to improve pond and effluent water quality, and reduce feeding cost. Fifty Mozambique tilapia fingerlings with an average weight of 17.8 ± 1.6 g were stocked in each of the 40 hapas. The experimental layout consisted of five feeding treatments of 20, 40, 60, 80, and 100% of apparent satiation with 8 replicates each. Fish were fed three times a day for 111 days. Specific growth rate (SGR) and feed conversion ratio (FCR) were used to measure the response to the various feeding regimes. Results were analyzed at three separate periods: at days 27, 55, and 111. At 27 and 55 days no significant improvement in FCR and SGR were observed at feeding levels above levels 60 and 80%, respectively. At 111 days, no significant difference in SGR was observed at feeding levels of 60% and above. This is an indication that 60% is the optimum feeding management regime. Natural food intakes calculated based on SGR and FCR were 0.34, 0.29, and 0.20% of body weight per day at 27, 55, and 111 days, respectively. Results from water quality analyses sampled fortnightly indicated no significant difference between the ponds. Analyses for correlations between production performance parameters and water quality parameters provided a regression equation to predict the natural food intake at specific water quality parameters, viz. Natural food intake (expressed as percentage of bodyweight per day) = $27.2 - 0.0962$ morning measured oxygen - 0.0328 conductivity - 0.911 pH + 13.0 ammonia-nitrogen - 2.52 nitrate + 41.2 nitrite - 7.72 phosphate + 0.337 TSS ($R^2 = 80.9$, $P = 0.000$). These results may provide useful data to quantify the utilization of natural pond productivity in the feeding management of Mozambique tilapia.

**FURTHER STUDIES ON SOIL QUALITY IN AQUACULTURE
PONDS IN THAILAND**

*Eleventh Work Plan, Environmental Impacts Analysis (11EIAR2)
Final Report*

Idsariya Wudtisin
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama

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

Kom Silapajarn
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama

Mali Boonyaratpalin
Thailand Department of Fisheries
Kasetsart University Campus
Bangkok 10900 Thailand

ABSTRACT

Bottom soil samples were collected from 42 catfish (*Clarius* hybrid) ponds, 40 freshwater prawn (*Macrobrachium rosenbergii*) ponds, and 18 carp (*Puntius* spp.) ponds in Thailand. The ponds ranged from 1 to 30 years in age. Regression analysis revealed that pond age was not a factor influencing the physical and chemical composition of pond soils.

Sediment depth, S horizon thickness, and bulk density of S horizon were greater for carp ponds than for catfish and prawn ponds. This resulted because sediment was removed from catfish and prawn ponds more frequently than from carp ponds. Total, organic, and inorganic carbon and total nitrogen concentrations were higher in carp ponds than prawn and catfish ponds. However, few ponds had sediment organic carbon concentrations above 3%, and carbon:nitrogen ratios did not differ among the three cultured species.

The results of this study confirm that normal procedures of pond soil management e.g., drying bottoms between crops, liming, and periodic sediment removal, were effective in maintaining good sediment quality in freshwater, aquaculture ponds over a period of at least 30 years.

GLOBAL PROJECT

Subcontract No. RD010E-E

Participants

University of Hawaii, Hilo, Hawaii

Maria Haws US Principal Investigator
Candace Martin Research Assistant (from February 2004)

University of Rhode Island, Kingston, Rhode Island

James Tobey Co-US Principal Investigator (from February 2004)
Donald Robadue Research Associate (from February 2004)

Universidad Autonoma de Sinaloa, Culiacan, Mexico

Eladio Gaxiola Camacho Host Country Principal Investigator (from February 2004)

Universidad Autonoma de Sinaloa, Mazatlan, Mexico

Guillermo Rodriguez Professor of Aquaculture (from February 2004)
Emilio Ochoa Moreno Host Country Principal Investigator (from February 2004)

Regional Center of Education and Qualification for Sustainable Development (CREDES), Mazatlan, Mexico

Ana Luisa Toscano Director of CREDES and Gender specialist (from February 2004)

Wetlands Conservation Program, Mazatlan, Mexico

Armando Villalba Loera Head of Wetlands Conservation Program (from February 2004)

Institution for Research in Food and Development, Hermosillo, Sonora, Mexico

Maria Christina Chavez-Sanchez Director CIAD (from February 2004)

Work Plan Research

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

- Cross-Sectoral and International Extension Exchange and Learning/11AHHR1. The report submitted for this investigation was an abstract.
- Connectivity of Water Resource Status, Environment Quality, Aquaculture, and Human Health/11AHHR2. The report submitted for this investigation was an abstract.
- Analysis of Critical Points in Aquaculture Production Affecting Participation and Level of Benefits to Women, Youth, and Disadvantaged Stakeholders/11AHHR3. The report submitted for this investigation was an abstract.
- Food Safety and Handling: Increasing Local Consumption and Aquaculture Products and Improving Quality/11DPPR1. The report submitted for this investigation was an abstract.

**CROSS-SECTORAL AND INTERNATIONAL EXTENSION
EXCHANGE AND LEARNING**

*Eleventh Work Plan, Aquaculture and Human Health Research 1
(11AHHR1)
Final Abstract*

Maria Haws
College of Agriculture
Forestry and Natural Resources Management
University of Hawaii, Hilo
Hilo, Hawaii

Eladio Gaxiola
Universidad Autonoma de Sinaloa
Culiacan, Mexico

Emilio Ochoa
Universidad Autonoma de Sinaloa
Mazatlan, Mexico

James Tobey
University of Rhode Island
Kingston, Rhode Island

ABSTRACT

Extension is a recognized vehicle to raise awareness, modify behavior and transfer technology, but it also represents one of the principal obstacles to developing and improving aquaculture in many part of the world. Long-term efforts have been made in Sinaloa, Mexico to establish a corps of extension agents to support the aquaculture sector and to work with other specialist to tackle cross-sectoral problems that affect aquaculture. Extension efforts are directed at implementing best management practices for the major form of aquaculture in the region (shrimp culture) and diversifying the industry through increasing production of freshwater finfish and native species of bivalves. Inclusion of neglected stakeholder groups such as women, youth, and the physically disadvantaged is also a goal. The CRSP Cross-Sectoral and International Extension Exchange and Learning Workshop builds on these efforts and extends them into new areas of learning to include sharing of experiences from other sectors such as public health, agriculture, gender equity efforts, and work with the physically challenged. A three day workshop was held in Mazatlan, Mexico on 14-16 June during which training was provided and sharing of experience occurred. Participants included aquaculture extension agents and NGO representatives from Mexico, representatives from other CRSP initiatives (Mexico, Peru, and Honduras) and project personnel from other innovative aquaculture extension efforts (UCA/Nicaragua and Ecocostas/Ecuador). An additional two days were spent reviewing the research and progress of the three case studies associated with this project. Course materials from the workshop are being compiled and will be distributed widely for the benefit of extension workers elsewhere.

CONNECTIVITY OF WATER RESOURCE STATUS, ENVIRONMENTAL QUALITY

*Eleventh Work Plan, Aquaculture and Human Health Research 2
(11AHHR2)
Final Abstract*

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ABSTRACT

The goal of this investigation is to characterize the relationships between water resources and aquaculture and aquaculture development in relation to human health. Sinaloa, Mexico is an ideal study site to elucidate the inter-connectivity of water resources, aquaculture production, environmental quality and human health being a state rich in both agriculture and industrial activities with rapid urbanization, like many developing regions of the world. Pressures on water resources are rapidly increasing in terms of quality and available volume at the precise moment that aquaculture development is accelerating. Previous work suggested that the status of water resources and aquaculture development affect and are affected by human health parameters. This study is focused on watersheds within Sinaloa where aquaculture (shrimp, bivalves, and freshwater finfish) development is growing and health-related effects have been observed. To date, extensive literature research, field investigations, interviews, site observations, and studies have been conducted. Multidisciplinary teams including specialists from the University of Sinaloa, University of Rhode Island, University of Hawaii Hilo, NGOs such as Conservation International, and government agencies are responsible for this research. Four workshops have been held to plan the work, define research methodologies, present preliminary results and analyze findings have been held. A draft of the case study has been produced and is now under review. It is expected that work will be completed by March 2005.

**ANALYSIS OF CRITICAL POINTS IN AQUACULTURE
PRODUCTION AFFECTING PARTICIPATION AND LEVEL OF
BENEFITS TO WOMEN, YOUTH, AND DISADVANTAGED
STAKEHOLDERS**

*Eleventh Work Plan, Aquaculture and Human Health Research 3
(11AHHR3)
Final Abstract*

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ABSTRACT

Preliminary work with the predominant form of aquaculture in Sinaloa, Mexico (shrimp culture) to improve management practices and increase direct benefits to local communities indicated that women and other marginalized stakeholders play a key role in this industry and must be included in participatory, community-based efforts to implement Best Management Practices. Other efforts to increase aquaculture production, particularly in the case of freshwater fish and local species of bivalves, suggested that women would be primary target groups for these efforts given their roles as producers, fishers, and vendors. Additionally, Sinaloa like many other regions in the world is dealing with issues associated with urbanization, globalization, and impacts of the growing drug trade. There are large numbers of young, unemployed youth and a high level of physically challenged individuals due to locally high rates of birth defects, HIV/AIDS, cancer, vehicular accidents, and drug-related violence. It is clear that many stakeholders from these groups already participate in aquaculture in aquaculture or wish to do so, but confront challenges to entering or increasing their participation in this activity. This work is designed to better understand key obstacles (technical, social, and economic) to increased participation and develop simple and immediately applicable strategies to encourage more aquaculture production among these groups. For example, a key deliverable will be a feasibility study and plan to guide the physically disabled in establishing tilapia culture. Research is being carried out with women's oyster cultivating cooperatives, women working with impoundment tilapia culture, seafood vendors, women fishers, and two groups of physically challenged, rural adults who are currently engaged in manufacturing occupations who now wish to cultivate tilapia. The latter operate

an NGO called PROJIMO that engages in community-based work to address the needs of the rural handicapped. To date, extensive literature research, field investigations, interviews, site observations and studies have been conducted. Multi-disciplinary teams including specialists from the University of Sinaloa, University of Rhode Island, University of Hawaii Hilo, NGOs such as Conservation International, CIAD, and government agencies are responsible for this research. Four workshops have been held to plan the work, define research methodologies, present preliminary results and analyze findings have been held. A draft of the case study has been produced and is now under review. It is expected that work will be completed by March 2005. The women's groups and PROJIMO have also participated in the Cross-sectoral and International Extension Exchange and Learning (11AHHR1) to share their experience working with extension to their respective stakeholder groups and to learn from the aquaculture extension agents.

**FOOD SAFETY AND HANDLING: INCREASING LOCAL
CONSUMPTION OF AQUACULTURE PRODUCTS AND
IMPROVING QUALITY**

*Eleventh Work Plan, Aquaculture and Human Health Research 4
(11DPPR1)
Final Abstract*

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ABSTRACT

Food safety and handling have become major issues for aquaculture in much of the world, including Sinaloa, Mexico, where efforts are underway to sustainably manage and improve benefits from aquaculture. Shrimp culture is the predominant form of aquaculture in the region, and preliminary work has shown that there is a need for small producers, processor employees, and seafood vendors to improve their ability to safely harvest, handle, store, and market shrimp and shrimp products. Many of these workers are women and the rural poor. Additionally, other forms of aquaculture have had their development slowed through the general lack of capacity in this area. Tilapia and other freshwater fish are major aquaculture products, but their

full potential cannot be exploited unless means are found to process and transport under safe conditions beyond the immediate local market. A major effort is being made to diversify aquaculture away from shrimp to local species of bivalves in coastal areas. Constraints exist for both local and international marketing of bivalves as water quality deteriorates and standards become more rigorous. Thus, addressing bivalve sanitation issues is a focal point not only for aquaculture development, but for environmental management and public health. As the multi-sectoral working group proceeds in its investigations, new, previously unrecognized risks are being uncovered. High level of gnathosome infection in most bodies of freshwater, which coupled with the customary and growing habit of eating raw fish products is poised to become a greater health issue as this parasite can cause severe illness and death. Contaminant levels appear to be increasing in aquatic products as urban, agricultural, and industrial pollution increases unchecked. Previously undetected levels of gastrointestinal illness associated with consumption of fish and shellfish is beginning to be documented and rates appear to be high and increasing. Public perception of the safety of aquatic products appears to be

diminishing. Given that much of the work focuses on sectors of society most at risk for food-borne illnesses, including the physically disabled, the challenge of finding practical means of ensuring food safety is critical to maintaining aquaculture as a source of healthy and quality food. Research is being carried out with women's oyster cultivating cooperatives, women working with impoundment tilapia culture, seafood vendors, women fishers and two groups of physically challenged, rural adults who are currently engaged in manufacturing occupations who wish to cultivate tilapia. To date, extensive literature research, field investigations, interviews, site observations, and studies have been conducted. Multi-disciplinary teams including specialists from the University of Sinaloa, University of Rhode Island, University of Hawaii Hilo, NGOs such as Conservation International, CIAD, and government agencies are responsible for this research. Four workshops have been held to plan the work, define research methodologies, present preliminary results and analyze findings have been held. A draft of the case study has been produced and is now under review. It is expected that work will be completed by March 2005.

CENTRAL AMERICA PROJECT

Subcontract No. RD010E-16 (AU)

Subcontract No. RD010E-17 (UG)

Participants

Auburn University, Auburn, Alabama

Joseph Molnar	US Principal Investigator
Elizabeth Trejos Castillo	Graduate Student
Pablo Martinez Mejia	Graduate Student (through August 2003, return 2005)
Julian Montoya	Undergraduate Student
Abel Carias	Undergraduate Student

University of Georgia, Athens, Georgia

Brahm P. Verma	US Principal Investigator
E. William Tollner	US Principal Investigator
Jennifer Maldonado	Collaborator (through 2003)
Tom Popma	US Technical Support (retired in 2003)

Escuela Agrícola Panamericana, El Zamorano, Honduras

Daniel Meyer	Host Country Principal Investigator
Freddy Arias	Collaborator
George Pilz	Collaborator
Suyapa Triminio de Meyer	Research Assistant
Hector Lagos	Research Assistant (through 2003)
Franklin Martinez	Research Associate

Work Plan Research

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

- Evaluation and Improvement of Tilapia Fingerling Production and Availability in Honduras/11SDAR2. The report submitted for this investigation was a final report.
- Pond Design and Watershed Analyses Training/11WQAR3 The report submitted for this investigation was a final report.

Publications

Martinez, P.R., J. Molnar, E. Trejos, S. Meyer, D. Meyer, and E.W. Tollner. Cluster Membership As a Competitive Advantage in Aquacultural Development: Case Study of Tilapia Producers in Olancho, Honduras. *Journal of Aquaculture and Management*. (submitted)

Martinez-Mejia, P. Case Study of Commercial Tilapia Production in Olancho, Honduras. M.S. thesis, Auburn University, Alabama, USA.

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

Trejos-Castillo, E., J. Molnar, S. Meyer, and D. Meyer. Income, Food Security, and Poverty Reduction: Case Studies of Small-Scale Aquaculture Producers in Santa Barbary, Honduras. *Community Development Journal*. (submitted)

Presentations

Molnar, J. Fingerling Production and Distribution. Presented to farmers and NGO agents in Zamorano, Honduras, December, 2003.

Molnar, J. Symposium: Aquaculture: Recent Advances in Fish Culture, Breeding, and the Mitigation of Environmental Impact. Presented at the American Association for the Advancement of Science. Seattle, Washington, February, 2004.

Trejos-Castillo, E., J. Molnar, P. Martinez, E.W. Tollner, B. Verma, G. Pilz, and S. Meyer. Income, Food Security and Poverty Reduction: Case Studies of Small-Scale Aquaculture Producers in Santa Barbara, Honduras. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.

Triminio-Meyer, S. and C. Ponciano. Programa de Enseñanza y Proyección Acuícola en Zamorano, Honduras. Presented in The Workshop International Exchange on Aquaculture Extension. Mazatlan, Mexico, June 2004

Triminio-Meyer, S., D.E. Meyer and J. Molnar. Productores de Alevines de Tilapia en Honduras, Características, Prácticas y Necesidades de Apoyo. Presented in the First Latin American workshop for the Tilapia Sector. Puerto Vallarta, Mexico, June, 2004

Triminio-Meyer, S., D.E. Meyer, and J. Molnar. Tilapia Fingerling Producers in Honduras: Characteristics, Practices and Needs. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.

Triminio-Meyer, S., J. Molnar and D.E. Meyer. Opciones de Mercadeo para productores de Tilapia de Mediana y Pequeña escala en Honduras. Presented in the V Symposium of Aquaculture of Guatemala, October, 2003

Conferences

American Association for the Advancement of Science. Seattle, Washington, February, 2004. (Molnar)

World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004. (Meyer, Trejos, Molnar, Triminio, Tollner)

EVALUATION AND IMPROVEMENT OF TILAPIA FINGERLING PRODUCTION AND AVAILABILITY IN HONDURAS

*Eleventh Work Plan, Seedstock Development and Availability Research 2 (11SDAR2)
Final Report*

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ABSTRACT

One important factor limiting tilapia culture development in Honduras as well as in the rest of the Central America is the lack of supply of fingerlings in sufficient quantity and quality. To assess the situation, we endeavored to obtain information and purchase fingerlings from every seed producer in Honduras. Sixteen tilapia fingerling producers were visited and interviewed during September of 2003 to April 2004. They provided information about their production facilities and techniques, the quality and quantity of fingerlings produced, their socio-economic situation, and their technical needs. Fingerlings were obtained from 12 farms, and then transported to the Zamorano campus for grow-out and comparison. Most samples (70%) contained more than 10% females. Only three of the 10 samples of sex-reversed tilapia fingerlings had less than 3% females. There was a high degree of variability in the sizes of the fingerlings in each sample. Two of the 16 fingerling producers do not use MT sex-reversal. Seven fingerling farms are family-owned, four are private companies, one is a cooperative, and the remaining four are operated by non-profit organizations (NGOs), universities, and government agencies). In aggregate, they produce approximately 15.3 million fingerlings a year. Most (75%) of the fingerling producers interviewed also raise tilapia, produce other aquaculture species, and have other farm enterprises.

POND DESIGN AND WATERSHED ANALYSES TRAINING

*Eleventh Work Plan, Water Quality and Availability Research 3 (11WQAR3)
Final Report*

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Joseph Molnar
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ABSTRACT

Variable rainfall distribution and terrain make surface water harvesting and storage a challenge in many developing countries. The overall goal of this study is to collect and develop information required to equip extension, nongovernmental organization (NGO) agents, contractors, and engineers for surface water development and aquaculture enterprise development in Honduras and Latin America. A pond water balance for the levee production pond enabling determination of water flow required to balance seepage, evaporation, and direct rainfall was developed in English and Spanish on the Microsoft Excel® platform. The pump-in flow rate can also be determined for reaching a volume change per month target. A second model was formulated for evaluating surface water capture by watershed and/or hillside ponds for meeting the levee pond demand. Using hillside ponds that fill by impounding a fraction of total runoff (e.g., diverting water upstream) from streams appears to have promise for meeting water needs. A systematic approach using both models to reach a sustainable water supply target emerged from this work. Both the levee pond model and the water harvest model are based on balancing inputs and outputs given monthly rainfall patterns. A simple approach to mechanical spillways preliminary design was developed. The models are adaptable to any location if key input data is available, particularly average monthly rainfall and storm frequency-duration data. The models do not address water quality issues. The software is intended for watershed sizes not larger than 500 ha and storage ponds of less than 5 ha surface area and 4 m depth due to relationship limitations and safety concerns. Coupling with other cooperative development concerns such as marketing associations provides a platform for helping groups of people in a watershed to realize further the potential of enlightened self-interest in developing common solutions to water problems.

TENTH WORK PLANS

NEW AQUACULTURE SYSTEMS/NEW SPECIES RESEARCH

Mexico

Subcontract No. RD010E-11

Participants*University of Arizona*

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Huruy Zerzghi

US Principal Investigator

Graduate Student (Eritrea)

Universidad Juárez Autónoma de Tabasco, Mexico

Wilfrido Contreras-Sanchez

Alejandro McDonal Vera

Host Country Principal Investigator

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 Mexico/10NSR3D. The report submitted for this investigation was a final report.

EFFECT OF STOCKING DENSITY OF RED HYBRID TILAPIA (*Oreochromis* Sp.) ON GROWTH AND SURVIVAL OF JUVENILE TILAPIA AND SHRIMP (*LITOPENAEUS VANNAMEI*) IN POLYCULTURE

*Tenth Work Plan, New Species Research 3D (10NSR3D)
Final Report*

Wilfrido M. Contreras-Sánchez and Alejandro Macdonald-Vera

Division Académica de Ciencias Biológicas
Universidad Juárez Autónoma de Tabasco
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Neil J. Duncan
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Kevin Fitzsimmons
University of Arizona
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ABSTRACT

A single earth pond (3/4 hectare) was prepared and divided into nine (7 x 30 m) enclosures that were considered to be three blocks of three enclosures. During water exchange, the water passed first through block A (first use water), then block B (second use) and finally block C (third use).

Each block was randomly stocked with shrimp (*Litopenaeus vannamei*) and three different densities of red tilapia hybrids (with an *Oreochromis mossambicus* genetic component) to give three different treatments: T0: zero tilapia per m² and 30 shrimp m²; T25: 0.25 tilapia per m² and 30 shrimp m²; T50: 0.50 tilapia per m² and 30 shrimp m². Tilapia and shrimp populations in each enclosure were sampled and growth was estimated approximately every two weeks. During the two month experiment temperature ranged from 16.2 to 25.6 °C and salinity from 28 to 35ppt. Growth rates of the tilapia and shrimp across the different treatments were similar and no significant differences were observed in mean sample weights for any sample date. Growth of the tilapia was also similar across the experimental blocks and no significant differences were observed. The tilapia grew from 4.6 ± 0.9g to mean final weights from the replicates that ranged from 32.8 ± 8.1g to 38.8 ± 10.0g.

However, the experimental blocks had a significant ($P < 0.05$) affect on mean sample weight of shrimp and when the experiment finished shrimp in blocks B and C were significantly ($P < 0.05$) bigger than shrimp from block A. The shrimp grew from 0.004 g to mean weights from the replicates that ranged from 1.82 ± 0.40 g to 2.07 ± 0.45 g in block A and from 2.08 ± 0.48 g to 2.29 ± 0.47 g in blocks B and C. There was no significant difference in survival of tilapia among the different treatments and blocks, survivals ranged from 86 to 92%. A larger variation was observed in the survival of the shrimp, the replicates exhibited a range from 46.6 to 73.9%. Survivals from block C that ranged from 66.4 to 73.9% were significantly ($P < 0.05$) higher than in blocks A and B that exhibited survivals that ranged from 46.6 to 57.0%. The three stocking densities of tilapia (0, 0.25, and 0.50 tilapia per m²) did not affect survival or growth of the tilapia or shrimp. Shrimp survival and growth was affected by position of the enclosure in the pond, survival and growth was significantly higher with water that had previously passed through other enclosures.

NEW AQUACULTURE SYSTEMS/NEW SPECIES PROJECT

Subcontract No. RD010E-C

Participants*Auburn University*

Ronald P. Phelps	US Principal Investigator
Karen Veverica	US Principal Investigator
George Osure	Graduate Student (Kenya) (through fall 2003)

Fisheries Department, Nairobi, Kenya

Bethuel Omolo	HC Research Associate/Head of Station, Sagana Fish Farm
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Moi University

David Liti	Host Country Principal Investigator
Mucaj Muchiri	Host Country Principal Investigator
James Barasa	Graduate Student

KMFRI Sangoro Aquaculture Station, Onditi Kisumu, Kenya

Jonathan Munguti	Host Country Principal Investigator
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Work Plan Research

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

- Evaluation of growth and reproductive performance in three strains of Nile tilapia *Oreochromis niloticus* found in Kenya for use in Aquaculture/10NSR4A. The report submitted for this investigation was a final report.

Publications

Osure, G. Evaluation of Growth and Reproductive Performance and Microsatellite Variability of Four Strains of Nile Tilapia, *Oreochromis niloticus*. M.S. thesis, Auburn University.

Presentations

Osure, G. Evaluation of Growth and Reproductive Performance and Microsatellite Variability of Four Strains of Nile Tilapia, *Oreochromis niloticus*. Seminar presented at Auburn University and Wageningen University.

EVALUATION OF GROWTH AND REPRODUCTION CAPACITY OF THREE STRAINS OF NILE TILAPIA, *OREOCHROMIS NILOTICUS*, FOUND LOCALLY IN KENYA FOR USE IN AQUACULTURE

Tenth Work Plan, New Aquaculture Systems/New Species Research 4 A (10NSR4A)
Final Report

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Moi University
Eldoret, Kenya

Jonathan Munguti
KMFRI Sangoro Aquaculture Station
Onditi Kisumu, Kenya

Ron Phelps
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ABSTRACT

In a series of experiments, the performance of three strains of Nile Tilapia, *Oreochromis niloticus*, was evaluated in 0.015 ha earthen ponds at Sagana Fish Farm. The strains were acquired from Lake Victoria, Lake Turkana, and Sagana fish farm. The first experiments were conducted from June 2002 to May 2003 and the other from October 2003 to April 2004. Nine ponds were limed at 3.3 tons/ha and treated weekly with urea and di-ammonium phosphate (DAP) at rates of 20 kg N/ha and 8 kg P/ha. The brood stock was conditioned in the ponds, and the F1 generation for each strain was produced. The experimental ponds were stocked with fry from the broodstock strains at 70,000 fry/ha, and raised from 0.5g to between 6-7g for a period of 66 days; their growth performance and survival were evaluated. The 6g fry were harvested and restocked at 50,000 fish/ha and further raised to 22g fingerlings. Later the 22g fingerlings were hand-sexed

and the male *O. niloticus* post fingerlings from each strain were stocked at 20,000/ha. Their growth performance was then compared under two different feeding regimes. Relative fecundity was evaluated by counting fry from the buccal cavity of females from a broodstock that was placed in cages. Victoria strain had the highest growth performance, survival and relative fecundity while Turkana and Sagana strains

had lower but similar performance. Sagana strain recorded the lowest survival and relative fecundity. The sex ratio of the Sagana strain was highly skewed towards females while the wild strains had sex ratios close to 1:1. The results of the present study revealed that the Victoria strain was the fastest grower and survivor while the Sagana strain was an inbred strain.

MARKETING AND ECONOMIC ANALYSIS AND PRODUCT DIVERSIFICATION RESEARCH

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

Participants

University of Arkansas at Pine Bluff

Carole Engle	US Principal Investigator
Ivano Neira	Research Associate
Carlos Leyva Carias	Graduate Student
Yong-Suhk Wui	Collaborator

Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru

Fernando Alcántara Bocanegra	Host Country Principal Investigator
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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
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Moi University, Eldoret, Kenya

Mucaí Muchiri	Host Country Principal Investigator
Charles Ngugi	Host Country Principal Investigator

Escuela Agrícola Panamericana, El Zamorano, Honduras

Daniel Meyer	Host Country Principal Investigator
Freddy Arias	Host Country Principal Investigator

Work Plan Research

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

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

Publications

Neira, I. and C. Engle. Domestic Marketing Strategies for Small-Scale Farmers in Nicaragua. *Aquanews*, 19(1):3–6.

A MIXED-INTEGER TRANSSHIPMENT MODEL FOR TILAPIA (*OREOCHROMIS SP.*) MARKETING IN HONDURAS

*Tenth Work Plan, Marketing and Economic Analysis Research 1A (MEAR1A)
Final Report*

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University of Arkansas at Pine Bluff, Pine Bluff, Arkansas

Yong-Suhk Wui
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ABSTRACT

Tilapia production in Honduras has increased in recent years. However, a lack of thorough understanding of domestic markets and coordinated production efforts has hampered the development of a domestic market. This study quantified domestic Honduran marketing costs for tilapia and developed a mixed-integer transshipment mathematical programming model to identify the most profitable marketing alternatives for small- and medium-scale farmers. Of the total marketing costs of \$0.07-\$0.41/kg, 40-73% were for transportation and 13-30% for packaging, depending upon farm size, location, and specific market targeted. Model results suggested restaurants as primary targets with supplemental production delivered to supermarkets in relative proximity to the selected restaurants. The model selected cities with sufficient restaurant demand to absorb the farm's

total production. Farms with high production levels can take advantage of the reduced transport cost of larger trucks and sell excess product to alternative outlets, whereas small-scale farm volumes were too low to supply markets on a weekly basis. Farms located in the East and South regions had a marketing advantage over farms in other regions due to proximity to the most profitable Distrito Central outlets. To successfully compete for Honduran markets other than the low-priced local open-air markets will require farm sizes greater than 6 ha for a minimum weekly production of 900 kg.

A MIXED-INTEGER TRANSSHIPMENT MODEL FOR OPTIMIZING TILAPIA (*Oreochromis sp.*) MARKETING STRATEGIES IN NICARAGUA

*Tenth Work Plan, Marketing and Economic Analysis Research 1B (10MEAR1B)
Final Report*

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ABSTRACT

Tilapia production in the Central American region has increased in recent years. Yet in Nicaragua, a country with great potential for aquaculture, commercial tilapia aquaculture has not developed on the scale that it has in other neighboring countries. Although demand for tilapia products exists, the lack of a thorough understanding of domestic markets and coordinated production and marketing efforts has hampered the development of a domestic market. The objectives of this study were to quantify domestic marketing costs for tilapia produced in Nicaragua and develop a mixed-integer transshipment mathematical programming model that represents the Nicaraguan tilapia market to identify the most profitable marketing alternatives for tilapia farmers. Results from the model suggested targeting primarily outlets with higher sales prices, such as restaurants, with supplemental production delivered to local supermarkets. The model chooses cities with restaurant demand capable of absorbing the farm's production. Excess product is sold to alternative outlets. The pattern of satisfying restaurant demand first and delivering to less profitable markets later in order to coordinate production with sales is common to all the scenarios considered in the model. Currently, farm-raised tilapia production in most regions of the country is insufficient, resulting in problems associated with dependable and regular deliveries required by higher-paying outlets (restaurants and supermarkets). Significant efforts will be required to overcome these obstacles in addition to quality issues such as freshness and off-flavor.

DEVELOPMENT AND ASSESSMENT OF A SIMPLE MARKET FEASIBILITY ASSESSMENT METHODOLOGY

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

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Raymundo Sury and Wilfrido Contreras-Sánchez
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ABSTRACT

Market surveys require extensive time and funding on the part of skilled researchers to develop useful answers on the market feasibility of aquaculture species. Comprehensive surveys were done in Peru and in Mexico to test a simplified market feasibility assessment methodology. A followup of the methodology was conducted in Kenya. Three interview guides have been developed based on the most important variables from the previous surveys conducted in Honduras and Nicaragua and the surveys in Peru and Mexico conducted as part of this project. The interview guides solicit information on competing, preferred products, such as freshwater versus marine species and the preferred product forms, sizes, current supply quantities, and prices of the four most preferred species. Availability of the proposed aquaculture species product is assessed at each market level. Attitudes are evaluated through simple scaled questions on the consistency of supply, consumer preferences, quality, flavor, price, and size. The interview guides end with sociodemographic and store size characteristics. Interview guides were developed for restaurants, supermarkets, and wholesalers. Open-air markets were not included because, in many areas, prices paid by vendors in open-air markets are too low to cover costs of producing farm-raised aquaculture products. These interview guides can be used to rapidly assess market potential for new aquaculture products.

**REGIONAL ENTERPRISE BUDGET AND BUSINESS PLAN
DEVELOPMENT**

*Tenth Work Plan, Marketing and Economic Analysis Research 3
(10MEAR3)
Final Report*

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ABSTRACT

The objective of this activity was to develop pro forma financial statements for use as components of business plans. These materials were deemed important to provide a basis for encouraging lending to the incipient commercial tilapia industry in Kenya. The primary deliverable of this activity was a training manual that presents the pro forma financial statements accompanied by instructions for tailoring these statements to specific farm situations. The manual includes a disk with the spreadsheets, instructions, exercises, and an answer guide to the exercises. This manual can be used as a self-guided tutorial to build feasible business plans.

**ECONOMIC AND RISK ANALYSIS OF TILAPIA
PRODUCTION IN KENYA**

*Tenth Work Plan, Marketing and Economic Analysis Research 4
(10MEAR4)
Final Report*

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Pine Bluff, Arkansas

Charles Ngugi
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Eldoret, Kenya

ABSTRACT

Fish farming in Kenya has potential to further develop commercial production of tilapia. Further growth and development of the tilapia industry in Kenya will depend upon its profitability and the effect of associated risks. Data from pond experiments, on-farm trials, and farm surveys were used to develop enterprise budgets and a risk analysis for two mixed-sex tilapia monoculture production scenarios: 1) stocking tilapia at 2 m² fed with rice bran; and 2) stocking tilapia at 3 m² fed with a pelleted diet. Net returns/ha were highest for the farms feeding pellets while lower net returns/ha were obtained by the rice-bran fed alternative. Profitability was affected by feed cost, survival, and farm size. The lower yields from the rice-bran feed scenario resulted in its greater sensitivity to fluctuating survival and costs.

FEEDS AND FERTILIZERS PROJECT

Kenya

Subcontract No. RD010E-08

Participants

Auburn University

Chhorn Lim

Karen Veverica

US Principal Investigator

US Principal Investigator

Moi University

David M. Liti

Mucui Muchiri

Leah Cherop

James Baraza Echessa

Host Country Principal Investigator

Host Country Principal Investigator

Graduate Student

Graduate Student

Kenya Fisheries Department

Nancy Gitonga

Host Country Principal Investigator

Work Plan Research

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

- Effect of feeding duration of sodium chloride diets on some osmoregulatory parameters of Nile tilapia (*Oreochromis niloticus*) after transfer from fresh water to saline water/10FFR4A. The report submitted for this investigation was a final report.
- Development of economically feasible feeds for semi-intensive culture of tilapia, *Oreochromis niloticus*, using locally available agricultural by-products/10FFR4B. The report submitted for this investigation was a final report.

EFFECT OF FEEDING DURATION OF SODIUM CHLORIDE DIETS ON SOME OSMOREGULATORY PARAMETERS OF NILE TILAPIA (*Oreochromis niloticus*) AFTER TRANSFER FROM FRESH WATER TO SALINE WATER

*Tenth Work Plan, Feeds and Fertilizers Research 4A (10FFR4A)
Final Report*

Chhorn Lim

Department of Fisheries and Allied Aquaculture
Auburn University, Alabama

ABSTRACT

Two feeding studies were conducted to evaluate the effect of feeding duration of dietary salt (NaCl) on hematocrit, blood glucose, and serum osmolarity and cortisol of Nile tilapia acclimated for various time periods to salt water of different salinities (three-factor experiment). Quadruplicate groups of fish averaging 5.52 ± 0.13 g (Study I) and 10.04 ± 0.19 g (Study II) were fed to apparent satiation twice daily with a basal diet without NaCl for 6 weeks, and the basal diet sup-

plemented with 6% NaCl for 2 (4 week basal diet + 2 week NaCl diet), 4 (2 weeks basal diet + 4 weeks NaCl diet) and 6 weeks (6 weeks NaCl diet). Fish from each replicate aquarium in study I were transferred to salt water at 0, 15, and 30 ppt whereas those from Study II were transferred to salt water at 0, 10 and 20 ppt. Hematocrit (Study II only), blood glucose, and serum osmolarity and cortisol were determined at 48 and 96 h, and 0, 6, 12, 24, and 48 h for Studies I and II, respectively, after transfer to salt water. In both studies, weight gain after 6 weeks of feeding did not differ ($P > 0.05$) among treatments, although all fish fed various durations of the NaCl-containing diet had consistently higher weight gain than those fed the basal diet. Dry matter feed intake and survival were similar in both studies. Feed efficiency was significantly lower in fish fed the basal diet in Study I, but in Study II, the value of this parameter did not differ among treatments. All fish transferred to 30 ppt salinity died within 8 h. No mortality occurred in fish transferred to 0, 10, 15 or 20 ppt salinity. Feeding dietary salt had no effect on blood glucose and hematocrit levels in either study. Serum osmolarity of fish in Study I decreased in fish fed dietary salt, but the differences were not always significant. This value was similar among fish fed dietary salt in Study II. In both studies, blood glucose and serum osmolarity significantly increased, whereas hematocrit decreased with increasing water salinity. Duration of exposure to salt water also significantly increased blood glucose levels but decreased hematocrit values. Duration of salt water exposure had no effect on serum osmolarity. The interaction between duration of feeding dietary salt and water salinity, water salinity and exposure time, and exposure time and duration of feeding dietary salt had no effect on hematological values in both studies except blood glucose and serum osmolarity in Study II were significantly affected by water salinity and exposure time. The interaction between the three main factors had no effect on measured hematological parameters. Serum samples for cortisol assays are stored at -80°C pending the installation and demonstration of the equipment by Perkin Elmer's specialist.

**ECONOMICS OF A HYPOTHETICAL TILAPIA-SHRIMP
POLY CULTURE FARM IN SINALOA, MEXICO**

*Eleventh Work Plan, Production System Design and Integration
Research 1 (11PSDR1)
Final Report*

Francisco Javier Martínez Cordero
Aquaculture Economics Laboratory, CIAD
A.C. Unidad Mazatlán, Mexico

ABSTRACT

An economic model was developed to consider and test the potential advantages of incorporating tilapia polyculture into existing shrimp farms in Northeastern Mexico. The model is developed from a "standard" farm representative of farms operating in 2003. The standard model could eventually be adapted and tested in other regions of the world where shrimp farming has been impacted by disease and over-supply. The result of the analyses conducted using the Mexican model found that there was not a significant increase in profitability by incorporating tilapia production into an existing shrimp farm. A sensitivity analysis was conducted to determine if tilapia polyculture could maintain profitability in the face of further declines in shrimp prices or in the event of lower shrimp production due to disease. In both cases, profits decreased and the net present value of the farm became negative. Further analyses considering higher tilapia prices, or increases in shrimp survival commonly reported from tilapia-shrimp polycultures, will be conducted in the future.

DECISION SUPPORT SYSTEM PROJECT

Thailand

Subcontract No. RD010E-04

Participants

The University of Michigan

James S. Diana

US Principal Investigator

Asian Institute of Technology

Yang Yi

Host Country Principal Investigator

Sahdev Singh

Host Country Principal Investigator

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

- PD/A CRSP Aquaculture Database/10DSSR1. The report submitted for this investigation was a final report.

AQUACULTURE CRSP DATABASE: FINALIZATION, MANAGEMENT, AND DISTRIBUTION

*Tenth Work Plan, Decision Support System Research 1
(10DSSR1)
Final Report*

Sahdev Singh and Yang Yi
Aquaculture and Aquatic Resources Management
School of Environment, Resources and Development
Asian Institute of Technology
Pathumthani, Thailand

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

ABSTRACT

The Asian Institute of Technology (AIT) recently established a mirror site (<http://www.aqua-information.aif.ac.th>) to make available experimental data generated by the Aquaculture Collaborative Research Support Program (CRSP). The experimental data cover a variety of culture environments and practices from a number of countries across the world and span a period of about 20 years. The Aquaculture CRSP Database is a unique global aquaculture research resource

and invaluable for researchers, educators and extension staff in aquaculture research/outreach worldwide. Wider and easier availability of the Database is of global importance to aquaculture planning, management and development, and also results in larger impacts of the Aquaculture CRSP. By providing the web-based Database, establishing an additional manned outlet (mirror website at AIT), expanding web linkages, distributing the Database in the forms of CD and Zip disk, the Aquaculture CRSP Database can be accessed by a wider international audience. It also ensures continuous availability of the Database in the event of any temporary shutdown of the main Aquaculture CRSP Database website, which is maintained at Oregon State University.

This mirror site not only enhances worldwide availability of the Aquaculture CRSP Database, but also helps reduce the Database download time for users in Asian countries and to some extent in African countries. The same is true in terms of service time for user queries about the Database as well as requests for CD-based copies. The database is being promoted through flyers, technical workshops and paper presentations in aquaculture related conferences and meetings. Technical workshops and papers have been presented at the recent Joint Conference of the "Asian Federation for Information Technology in Agriculture (AFITA)" and the "World Congress on Computers in Agriculture (WCCA)" demonstrating various example applications of the database, including creation and download of datasets based on a number of user preferences.



APPENDIX 1. STAFF SUMMARY

The Pond Dynamics/Aquaculture CRSP represents the joint efforts of more than 75 professional and support personnel from US universities. It also represents the collaborative efforts of over 45 scientists, technicians, and students from project 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 (OSU), 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 (through 5/04)
Joan Westfall	Office/Financial Manager
Gwyn Newcombe	Accounting Technician (through 11/03)

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

Washington, DC

Harry Rea Cognizant Technical Officer

ADVISORY BODIES

External Advisory Panel

Christine Crawford, Chair	University of Tasmania, Hobart, Australia
T.H. Lee Williams	University of Oklahoma
Anthony Young, Chair	Southern Illinois University at Carbondale
Ronald Jones	Florida International University
Edna McBreen	University of Connecticut
Dave Cummins	University of Georgia, Athens (retired)
Colin Kaltenbach	University of Arizona
Stephanie Sanford	Oregon State University institutional representative

Ex-Officio Members

Harry Rea	USAID
Hillary Egna	Oregon State University

Technical Committee*

<i>Co-Chairs</i>	Institution
Jim Diana	UM
Chris Brown	FIU

Material and Methods Subcommittee

		<i>Research Area of Expertise</i>
Yang Yi	AIT	Environmental Effects
Claude Boyd	AU	Production Optimization
Suyapa Meyer	Zamorano	Social and Economic Aspects

Technical Progress Subcommittee

Maria Haws	UH	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



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 2003 to 31 July 2004. 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.



APPENDIX 2. FINANCIAL SUMMARY

Financial Summary, Continuation Plan 1996 August 1, 2003–July 31, 2004

Subcontract Number	Project Leader	Institution	USAID ¹		Cost Share ²		Total US Funds	Host Country Contributions ³ 8/03-7/04	Since 8/96
			8/03-7/04	Since 8/96	8/03-7/04	Since 8/96			
Research									
RD009A-01	Bowman	Kenya: OSU	894,098	79,096		973,194		135,512	
RD009B-01	Bolte	Global: OSU	313,524	85,835		399,359			
	Hékes ⁴	Global: UAPB	7,900	4,148		12,048			
RD009C-01	Schreck	Mexico: OSU	710,312	147,310		857,622		45,670	
	Pattino ⁴	Mexico: Texas Tech	28,107	9,273		37,380			
RD009L-01	Clair	Global: OSU	404,636	98,052		502,688			
RD010E-01	Engle	Global: UAPB	436,910	105,869		542,779		42,000	
RD010E-02	Shelton	Global: UO	117,280	31,194		148,474			
RD010E-03	Piedrahita	Global: UCD	78,101	26,611		104,712			
RD010E-04	Diana	Southeast Asia: UM	1,418,909	183,749		1,602,658		146,000	
	Rakocy ⁴	Southeast Asia: UVI	9,889	0		9,889			
RD010E-05	Ward	Honduras: UT	19,767	4,066		23,833			
RD010E-06	Green	Honduras: AU	502,056	78,435		580,491		140,484	
RD010E-07	Boyd	Global: AU	402,273	109,937		512,210		31,000	
RD010E-08	Lim	Kenya: AU	520,679	120,018		640,697			
RD010E-09/C	Phelps	Global/Kenya: AU	175,352	42,171		217,523			
RD010E-10	Molnar	Global: AU	68,293	14,489		82,782		7,050	
RD010E-11	Fitzsimmons	Global: UA	207,205	76,673		283,878		175,607	
RD010E-12	Kohler	Peru: SIUC	712,019	233,071		945,090			
	Dabrowski ⁴	Peru: OHSU	13,000	11,963		24,963			
RD010E-13	Lochmann	Peru/Kenya: UAPB	122,305	37,622		159,927			
RD010E-14	Lovshin	Guatemala: AU	67,168	16,792		83,960			
RD010E-15	Brown	Philippines: UH	100,061	25,015		125,076			
RD010E-16 ⁶	Tollner	Kenya/Honduras: UGA	476,268	86,065		562,333		29,225	
RD010E-17	Molnar	Honduras: AU	231,263	48,203		279,466			
RD010E-18	Hatch	Honduras: AU	55,266	13,816		69,082			
RD010E-19	Boyd	Honduras: AU	45,947	11,487		57,434			
RD010E-20	Brown	Philippines: FIU	367,527	137,481		505,008		21,000	
	Borski ⁴	Philippines: NCSU	8,737	2,929		11,666			
RD010E-A	Dabrowski	Mexico/Peru: OHSU	157,173	93,416		250,589			
RD010E-B	Batterson	Thailand: MSU	57,020	14,274		71,294			
RD010E-D ⁶	Haws	Mexico/LAC: UH	100,000	16,500		116,500			
	TBA	Global: TBA	250,000	0		250,000			
Special Activities									
ISTA 5 Sponsorship	Fitzsimmons	Global: UA	12,500	5,000		17,500		15,000	
IIFET Conference Sponsorship	Shriver	Global: OSU	10,000	2,500		12,500			
Côte d'Ivoire Report	Kaplan	Côte d'Ivoire: Hofstra University	4,000	0		4,000			
Impact Assessment Report	TBA	Global: TBA	128,676	32,199		160,875			
Research Support									
RD009G-01	Central Database Management	Global: OSU	279,714	73,083		352,797			
RD009E-01	Education Development	Global: OSU	244,970	61,242		306,212			
RD009K-01	Information Management & Networking	Global: OSU	2,225,283	556,321		2,781,604			
Subcontract Administration									
	Indirect on Subs up to 25,000		154,640	0		154,640			
Research Subtotal			0	2,695,905	0	14,834,733	0	788,548	
MANAGEMENT									
Program Management									
Operations and Administration ⁵		OSU Management	3,284,685	n/a		3,284,685			
Advisory Groups		OSU Advisory	499,710	0		624,638			
Program Management Subtotal			3,784,395	0		3,909,323			
Total			15,923,223 ^{0*}	2,695,905	0	18,744,056	0	788,548	



APPENDIX 3. RESEARCH PORTFOLIO

Research Theme	Reporting PI	PRODUCTION TECHNOLOGY		
		Report Title	Research Theme Code	Report Received
Sustainable Development and Food Security	Kohler Diana	Amazon Aquaculture Outreach Tilapia (<i>Oreochromis niloticus</i>) Production Constraints in Bangladesh: A Socio-Economic Perspective	11SDFR1 11SDFR2A	Final Final
	Diana	Tilapia (<i>Oreochromis niloticus</i>) Production Constraints in Bangladesh: Technological Constraints	11SDFR2B	Final
	Diana	Tilapia (<i>Oreochromis niloticus</i>) Production Constraints in Bangladesh: Workshop and Expert Panel Meeting on Tilapia Culture in Bangladesh	11SDFR2C	Final
	Diana	Reproductive Performance and Growth of Improved Tilapia, <i>Oreochromis niloticus</i>	11SDFR3	Final
Production System Design and Integration	Diana	New Paradigm in Farming of Freshwater Prawn (<i>Macrobrachium rosenbergii</i>) with Closed and Recycle Systems	11PSDR2	Final
	Diana	Integrated Cage-Cum-Pond Culture Systems with High-Valued Stingray Catfish (<i>Heteropneustes fossilis</i>) in Cages and Low-Valued Species in Open Ponds	11PSDR3A	Final
	Diana	Integrated Cage-Cum-Pond Culture Systems with High-Valued Shar (<i>Lor putilora</i>) In Cages Suspended In Carp Polyculture Ponds	11PSDR3B	Final
	Diana	Integrated Cage-Cum-Pond Culture Systems with High-Valued Climbing Perch (<i>Anabas testudineus</i>) In Cages Suspended in Nile Tilapia (<i>Oreochromis niloticus</i>) Ponds	11PSDR3C	Final
Indigenous Species Development	Diana	Mitigating Environmental Impact of Cage Culture through Integrated Cage-Cum-Cove Culture System in Tri An Reservoir of Vietnam	11PSDR4	Final
	Diana	Optimization of Nitrogen Fertilization Regime in Fertilized Nile Tilapia Ponds With Supplemental Feed	11PSDR5	Final
	Kohler Diana	Workshop on Fertilization Strategies for Pond Culture in Bangladesh	11PSDR6	Final
	Dabrowski Diana	Broodstock Development and Larval Feeding of Amazonian Fishes	11SDR1A	Final
	Diana	Broodstock Development and Larval Feeding of Amazonian Fishes: Controlled Reproduction of an Important Indigenous Species, <i>Spirobolus denticalatus</i> , in Southeast Asia	11SDR1B 11SDR2	Final Final
Economic/Risk Assessment and Social Analysis	Quagraine	Preliminary Work on Site Description, Evaluation, and Development Planning: Tanzania, Ghana, and Kenya	11ERAR1	Abstract
	Quagraine	Cost Evaluation and Benefit Assessment of Fish Farming in Selected African Nations	11ERAR2	Abstract
	Quagraine	An Economic Assessment of Aquaculture in Rural Africa: The Case of Tanzania, Kenya, and Ghana	11ERAR3	Abstract
	Quagraine	A Cross-National Analysis of the Potential Economic Impact in Africa	11ERAR4	Abstract
Fish Nutrition and Feed Technology	Kohler Brown	Nutrition and Nutrient Utilization in Native Peruvian Fishes: Evaluation of Tilapia Aquaculture Best Practices in Central Luzon, the Philippines	11FNFR1 11FNFR2	Final Final
	Dabrowski	Reproductive Performance and Growth of Improved Tilapia, <i>Oreochromis niloticus</i> †	11FNFR3	Final
Fish Nutrition and Feed Technology	Brown	Insulin-like Growth Factor-I as a Growth Indicator in Tilapia	11FNFR4	Final

PRODUCTION TECHNOLOGY (CONTINUED)			
Research Theme	Reporting PI	Report Title	Research Theme Code Report Received
Water Quality and Availability	Tollner	Pond Design and Watershed Analyses Training	11WQAR3 Final
Seedstock Development and Availability	Diana	Mitigating the Effects of High Temperature and Turbidity on Seed Production of Nile Tilapia from Hapa-in-Pond Systems	11SDAR1 Final
	Molnar	Evaluation and Improvement of Tilapia Fingerling Production and Availability in Honduras	11SDAR2 Final
Applied Technology and Extension Methodologies	Fitzsimmons	Aquaculture CRSP Sponsorship of the Sixth International Symposium on Tilapia in Aquaculture	11ATER2 Final
	Fitzsimmons	Global Contributions to Sustainable Aquaculture: A Special Session at the 2004 World Aquaculture Conference	11ATER3 Final
	Bowman	Aquaculture Training for Kenyan Fisheries Assistants	11ATER4 Final
	Bowman	Evaluation of Aquaculture Training Provided to Fisheries Officers and Fisheries Assistants of the Kenya Fisheries Department	11ATER5 Final
	Bowman	Development of an Aquaculture Handbook for Extension Workers and Trainers of Extension Workers in Sub-Saharan Africa	11ATER6 Final
Environmental Impacts Analysis	Diana	Co-Culture of Lotus and Hybrid Catfish to Recycle Wastes from Intensive Feeding [†]	11E1AR1 Final
WATERSHED MANAGEMENT			
Research Theme	Reporting PI	Report Title	Research Theme Code Report Received
Environmental Impacts Analysis	Boyd	Further Studies on Soil Quality in Aquaculture Ponds in Thailand	11E1AR2 Final
Production System Design and Integration	Fitzsimmons	Diversification Into Sustainable Tilapia-Shrimp Polyculture and Small-Scale Tilapia Cage Culture in Mexico	11PSDR1 Final
Indigenous Species Development	Schreck	Development of Aquaculture Techniques for the Indigenous Species of Southern Mexico, <i>Centropomus undecimalis</i> : Sex Determination and Differentiation and Effects of Temperature	11ISDR3 Final
Water Quality and Availability	Schreck	Elimination of Methyltestosterone from Intensive Masculinization Systems: Use of Ultraviolet Irradiation of Water	11WQAR1 Final
	Boyd	Use of a Wetland to Treat Effluent from a Flow-Through Aquaculture System [†]	11WQAR2 Final
	Boyd	Influence of Daily Feed Allowance on Pond Water and Effluent Quality	11WQAR4 Final
Applied Technology and Extension Methodologies	Schreck	Training Local Farmers on Safe Handling of Steroids and Masculinization Techniques in Central America	11ATER1 Final
Seedstock Development and Availability	Schreck	Continuation of a Selective Breeding Program for Nile Tilapia to Provide Quality Broodstock for Central America	11SDAR3 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 International*, 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.

Martinez-Mejia, P. Case Study of Commercial Tilapia Production in Olancho, Honduras. M.S. thesis, Auburn University, Alabama, USA.

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.

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

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.
- Boyd, C.E. and D.R. Teichert-Coddington, 1992. Relationship between wind speed and reaeration in small aquaculture ponds. *Aquacultural Engineering*, 11:121–131.
- Boyd, C.E. and D.R. Teichert-Coddington, 1994. Pond bottom soil respiration during fallow and culture periods in heavily-fertilized tropical fish ponds. *Journal of the World Aquaculture Society*, 25(3):210–213.
- Boyd, C.E. and D.R. Teichert-Coddington, 1995. Dry matter, ash, and elemental composition of pond-cultured *Penaeus vannamei* and *P. stylirostris*. *Journal of the World Aquaculture Society*, 26(1):88–92.
- Boyd, C.E. and M.C. Haws, 1999. Good management practices (GMPs) to reduce environmental impacts and improve efficiency of shrimp aquaculture in Latin America. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaño (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 9–33.
- Green, B., D. Teichert-Coddington, and T. Hanson, 1994. Development of semi-intensive aquaculture technologies in Honduras: Summary of freshwater aquacultural research conducted from 1983 to 1992. International Center for Aquaculture and Aquatic Environments Research and Development Series No. 39, Auburn University, Alabama, 48 pp.
- Green, B., D. Teichert-Coddington, M. Micheletti, and C. Lara, 1997. A collaborative project to monitor water quality of estuaries in the shrimp producing regions of Honduras. Proceedings of the IV Ecuadorian Aquaculture Symposium, 22–27 Oct 1997. CENAIM, ESPOL, Camera Nacional de Acuicultura, Guayaquil, Ecuador. CD-ROM.
- Green, B.W. and C.R. Engle, 2002. Commercial tilapia aquaculture in Honduras. In: B.A. Costa-Pierce and J.E. Rakocy (Editors), *Tilapia Aquaculture in the Americas*, Volume 2. World Aquaculture Society, Baton Rouge, Louisiana, pp. 151–170.
- Green, B.W. and D.R. Teichert-Coddington, 1990. Comparison of two sampler designs for use with automated data acquisition systems in whole-pond community metabolism studies. Proceedings of FAO-EIFAC Symposium on Production Enhancement in Still-Water Pond Culture at Prague: Research Institute of Fish Culture and Hydrobiology, Vodnany, Czechoslovakia.
- Green, B.W. and D.R. Teichert-Coddington, 1991. Comparison of two samplers used with an automated data acquisition system in whole-pond community metabolism studies. *The Progressive Fish-Culturist*, 53(4):236–242.
- Green, B.W. and D.R. Teichert-Coddington, 1993. Production of *Oreochromis niloticus* fry for hormonal sex reversal in relation to water temperature. *Journal of Applied Ichthyology*, 9:230–236.
- Green, B.W. and D.R. Teichert-Coddington, 1994. Growth of control and androgen-treated Nile tilapia during treatment, nursery and growout phases in tropical fish ponds. *Aquaculture and Fisheries Management*, 25:613–621.
- Green, B.W. and H.R. Alvarenga, 1985. Tilapia and carp polyculture in ponds receiving organic fertilization and supplemental feed. CRSP Technical Report (unpubl.), 10 pp. (in Spanish)
- Green, B.W. and H.R. Alvarenga, 1989. The effect of different application rates of chicken litter on tilapia production. *Rev. Latinoamericana de Acuicultura*, 40:31–34. (in Spanish)
- Green, B.W. and L.A. López, 1990. Implementing the large-scale production of young males of *Tilapia nilotica* using hormonal sex inversion in Honduras. *Agronomía Mesoamericana*, 1:21–25. (in Spanish)

- Green, B.W. D.R. Teichert-Coddington, C.E. Boyd, J. Wigglesworth, H. Corrales, D. Martinez, and E. Ramirez, 1999. Efecto del recambio de agua en la producción semi-intensiva de *Penaeus vannamei* (Boone, 1831) (*Crustacea Penaidae*) en una granja pilota. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaña (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 209–212. (in Spanish)
- Green, B.W., 1985. Report on the induced spawning of the silver and grass carps. CRSP Technical Report (unpubl.), 8 pp. (in Spanish)
- Green, B.W., 1992. Substitution of organic manure for pelleted feed in tilapia production. *Aquaculture*, 101:213–222.
- Green, B.W., 1995. Polyculture of tilapia with marine shrimp. *Actas del Primer Simposio Centroamericano sobre cultivo de tilapia*, pp. 117–125.
- Green, B.W., 1997. Inclusion of tilapia as a diversification strategy for penaeid shrimp culture. In: D.E. Alston, B.W. Green, and H.C. Clifford (Editors), IV Symposium on Aquaculture in Central America: Focusing on Shrimp and Tilapia, 22–24 Apr 1997, at Tegucigalpa, Honduras. Asociación Nacional de Acuicultores de Honduras and the Latin American Chapter of the World Aquaculture Society, pp. 84–93.
- Green, B.W., 1999. Sistemas de producción de tilapia en Honduras (Tilapia production systems in Honduras). In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaña (Editors), V Central American Symposium on Aquaculture, 18–20 Aug 1999 at San Pedro Sula, Honduras, pp. 254–257. (in Spanish)
- Green, B.W., D.R. Teichert-Coddington, and R.P. Phelps, 1990. Response of tilapia yield and economics to varying rates of organic fertilization and season in two Central American countries. *Aquaculture*, 90:279–290.
- Green, B.W., R.P. Phelps, and H.R. Alvarenga, 1989. The effect of manures and chemical fertilizers on the production of *Oreochromis niloticus* in earthen ponds. *Aquaculture*, 76:37–42.
- Meckenstock, D., D.R. Teichert-Coddington, J.C. Rosas, H. van Es, M.S. Chinnan, and M.M. Murillo, 1991. CRSP Council Honduras concept paper towards a sustainable agriculture in Southern Honduras. Proceedings of the International Sorghum and Millet CRSP Conference, 8–12 Jul 1991, at Corpus Christi, Texas, USA: INTSORMIL Publication No. 92-1, pp. 107–119.
- Rodriguez, R., G. Nuñez, and D. Teichert-Coddington, 1993. Evaluación de dos dietas alimenticias con diferente porcentaje de proteína, bajo dos densidades de siembra época de invierno en Granjas Marinas San Bernardo. II Simposio Centralamericano Sobre Camarón Cultivado, Tegucigalpa, Honduras. Federación de Productores y Exportadores (FPX), San Pedro Sula, Honduras, 267 pp.
- Sherman, C., 1986. Growth of all-female *Tilapia nilotica* in earthen ponds fertilized with chicken litter. CRSP Technical Report (unpubl.), 14 pp. (in Spanish)
- Teichert-Coddington, D.R. and B.W. Green, 1993. Comparison of two techniques for determining community respiration in tropical fish ponds. *Aquaculture*, 114:41–50.
- Teichert-Coddington, D.R. and B.W. Green, 1993. Influence of daylight and incubation interval on water column respiration in tropical fish ponds. *Hydrobiologia*, 250:159–165.
- Teichert-Coddington, D.R. and B.W. Green, 1993. Tilapia yield improvement through maintenance of minimal oxygen concentrations in experimental grow-out ponds in Honduras. *Aquaculture*, 118:63–71.
- Teichert-Coddington, D.R. and B.W. Green, 1993. Usefulness of inorganic nitrogen in organically fertilized tilapia production ponds. Abstracts of World Aquaculture Meeting at Torremolinos, Spain: European Aqua-culture Society Special Publication No. 19, Oostende, Belgium, p. 273.
- Teichert-Coddington, D.R. and B.W. Green, 1993. Yield improvement through maintenance of minimal oxygen concentration in tilapia growout ponds in Honduras. *Aquaculture*, 118:1–2.
- Teichert-Coddington, D.R. and B.W. Green, 1997. Experimental and commercial culture of tilapia in Honduras. In: B.A. Costa-Pierce and J.E. Rakocy (Editors), *Tilapia Aquaculture in the Americas*, Vol. I. World Aquaculture Society, Baton Rouge, Louisiana, pp. 142–162.
- Teichert-Coddington, D.R. and R. Rodriguez, 1994. Relationship of pen-aeid shrimp yields to diet protein level, stocking density and season: a field test on commercial farms of southern Honduras. Abstracts of World Aquaculture '94, New Orleans, Louisiana. World Aquaculture Society, Louisiana State University, Baton Rouge, Louisiana.
- Teichert-Coddington, D.R. and R. Rodriguez, 1995. Semi-intensive commercial growout of *Penaeus vannamei* fed diets containing differing levels of crude protein during wet and dry seasons in Honduras. *Journal of the World Aquaculture Society*, 26(1):72–79.
- Teichert-Coddington, D.R., 1988. Effects of protein diet and sowing density on the production of *Penaeus vannamei* in land tanks. *Rev. Latinoamericana de Acuicultura*, 35:29–44.
- Teichert-Coddington, D.R., 1993. Development of production technologies for semi-intensive fish farming during the past decade in Central America. Proceedings of Symposium on Aquacultural Research in Central America at Heredia, Costa Rica: Programa UNA/LUW Acuicultura, Escuela de Ciencias Biológicas, Heredia, Costa Rica, pp. 71–88.
- Teichert-Coddington, D.R., 1995. Estuarine water quality and sustainable shrimp culture in Honduras. Proceedings of the Special Session on Shrimp Farming, Swimming Through Troubled Water, *Aquaculture '95*: World Aquaculture Society, pp. 144–156.
- Teichert-Coddington, D.R., 1996. Effect of stocking ratio on semi-intensive polyculture of *Colossoma macropomum* and *Oreochromis niloticus* in Honduras, Central America. *Aquaculture*, 143:291–302.
- Teichert-Coddington, D.R., B.W. Green, and R.P. Parkman, 1991. Substitution of chicken litter for feed in production of penaeid shrimp in Honduras. *The Progressive Fish-Culturist*, 53(3):150–156.
- Teichert-Coddington, D.R., B.W. Green, and R.P. Phelps, 1992. Influence of site and season on water quality and tilapia production in Panama and Honduras. *Aquaculture*, 105:297–314.
- Teichert-Coddington, D.R., B.W. Green, N. Matamoros, and R. Rodriguez, 1990. The substitution of chicken litter for feed in the commercial production of penaeid shrimp in Honduras. *Agronomia Mesoamericana*, Vol. 1.
- Teichert-Coddington, D.R., D. Martinez, and C.E. Boyd, 1997. Solubility of selected inorganic fertilizers in brackish water. *Journal of the World Aquaculture Society*, 28(2):205–210.
- Teichert-Coddington, D.R., D. Martinez, E. Ramirez, J. Harvin, W. Toyofuku, R. Zelaya, and B.W. Green, 1997. Semi-intensive shrimp pond management and quality of effluents. In: D.E. Alston, B.W. Green, Teichert-Coddington, D.R., R. Rodriguez, and W. Toyofuku, 1994. Cause of cyclic variation in Honduran shrimp production. *World Aquaculture*, 25(1):57–61.
- 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.

Presentations

- Alvarenga, H.R. and B.W. Green. Produccion y aspectos economicos del cultivo de tilapia en estanques fertilizados con gallinaza. (Production and economic aspects of tilapia culture in ponds fertilized with chicken litter). Presented by H. Alvarenga at the 34th Annual Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at San Jose, Costa Rica, 1988.
- Boyd, C.E. and J.F. Queiroz. Effluent management in pond aquaculture.
- Boyd, C.E. and L. Massaut. Perspectives for sustainable aquaculture through use of better environmental management. IV Congreso Ecuatoriano de Acuicultura, Guayaquil, Ecuador, 1997.
- Boyd, C.E. and M.C. Haws. Good management practices to reduce environmental impacts and improve efficiency of shrimp aquaculture in Latin America. Presented to the V Central American Symposium on Aquaculture at San Pedro Sula, Honduras, 18–20 Aug 1999.

- Boyd, C.E. Codes of conduct and better management practices in shrimp farming. Presented to the Fifth Ecuadorian Aquaculture Conference at Guayaquil, Ecuador, 28–30 Oct, 1999.
- Boyd, C.E. Environmental issues in shrimp farming. Plenary address. Presented to the V Central American Symposium on Aquaculture at San Pedro Sula, Honduras, 18–20 Aug 1999.
- Boyd, C.E. Pond water and soil management procedures to minimize the effects of disease epidemics in shrimp farming. Presented to the Fifth Ecuadorian Aquaculture Conference at Guayaquil, Ecuador, 28–30 Oct, 1999.
- Boyd, C.E. Shrimp farming and the environment. Presented to AAAS Annual Meeting at Philadelphia, Pennsylvania, 12–17 Feb 1998.
- Green, B.W. and H. Alvarenga. Sistemas de producción de tilapia utilizando fertilización orgánica y alimentación. Presented by H. Alvarenga to the Annual Regional Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at San Pedro Sula, Honduras, 1989.
- Green, B.W. and H.R. Alvarenga. Efecto de diferentes tasas de aplicación de gallinaza en la producción de tilapia. (The effect of different rates of chicken litter application on the production of tilapia.) Presented by H. Alvarenga to the 33rd Annual Meeting of the Programa Colaborativo Centroamericana para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at Instituto de Ciencia y Tecnología Agrícola, Guatemala, 30 Mar–4 Apr 1987.
- Green, B.W. and H.R. Alvarenga. Intensive fingerling production of hybrid tilapia *Tilapia nilotica* x *Tilapia honorum* in earthen ponds. Presented by B. Green to the World Aquaculture Society Meeting at Guayaquil, Ecuador, 1987.
- Green, B.W. and L. Lopez. Factibilidad de la producción masiva de alevines machos de *Tilapia nilotica* a través de la inversión hormonal de sexo en Honduras. Presented by L. Lopez to the Annual Regional Meeting of the Programa Cooperativo Centroamericana para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at San Pedro Sula, Honduras, 1989.
- Green, B.W. Mass production of *Oreochromis niloticus* and *Oreochromis aureus* fry in relation to water temperature. Presented to the Fourth International Symposium on Tilapia in Aquaculture at Orlando, Florida, 9–12 Nov 1997.
- Green, B.W. Substitution of organic manure for pelleted feed in tilapia production. Presented to the FAO-EIFAC Symposium on Production Enhancement in Still-Water Pond Culture at Prague, Czechoslovakia, May 1990.
- Green, B.W., D.R. Teichert-Coddington, and L.A. Lopez. Production of *Oreochromis niloticus* fry in earthen ponds for hormonal sex inversion. Presented to the World Aquaculture Society Meeting at Orlando, Florida, May 1992.
- Green, B.W., D.R. Teichert-Coddington, G.H. Ward, and C.E. Boyd. Collaborative research to support sustainable shrimp culture in Honduras: A model program. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
- Green, B.W., H.R. Alvarenga, and R.P. Phelps. The effect of stocking rate on the production of *Tilapia nilotica* in ponds. Presented to the 34th Annual Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at San Jose, Costa Rica, 1988.
- Green, B.W., R.P. Phelps, and H.R. Alvarenga. The effect of nitrogen and phosphorous sources in fertilizers used for the production of *Tilapia nilotica*. Presented to the World Aquaculture Society Meeting at Guayaquil, Ecuador, 1987.
- III Symposium on Nutritional Strategies and Management of Aquaculture Wastes, Vila Real, Portugal, 1997.
- Martinez, D. and D.R. Teichert-Coddington. Solubility of inorganic fertilizers in brackish water. Presented to the Third Central American Shrimp Symposium at Tegucigalpa, Honduras, Apr 1995.
- Martinez, P. Commercial Tilapia Production in Olancho, Honduras: Organization, Costs, and Markets. Agricultural Workers Conference, Tuskegee University, Alabama, December 2002.
- Martinez, P. Commercial Tilapia Production in Olancho, Honduras: Organization, Costs, and Markets. Agricultural Workers Conference, Tuskegee University, Alabama, December 2002.
- Milla, L., D.R. Teichert-Coddington, and D. Meyer. Biological demand of oxygen in shrimp farm water. Presented to the Third Central American Shrimp Symposium, at Tegucigalpa, Honduras, Apr 1995.
- Molnar, J. (Presenter) and E. Trejos-Castillo, 2003. Poster based on M.S. thesis. Association for the Advancement of Science Annual meeting, Denver, Colorado, February 2003.
- Molnar, J. Fingerling Production and Distribution. Presented to farmers and NGO agents in Zamorano, Honduras, December, 2003.
- Molnar, J. Symposium: Aquaculture: Recent Advances in Fish Culture, Breeding, and the Mitigation of Environmental Impact. Presented at the American Association for the Advancement of Science. Seattle, Washington, February, 2004.
- Molnar, J. Tilapia: A Globalized Fish. American Fisheries Society, Quebec, Canada, August 2003.
- Molnar, J. Tilapia: A Globalized Fish. American Fisheries Society, Quebec, Canada, August 2003.
- Molnar, J., Trejos-Castillo, E. 2003. Poster based on M.S. thesis. Association for the Advancement of Science Annual meeting, Denver, Colorado, February 2003.
- Rodriguez, R. and D.R. Teichert-Coddington. Substitution of inorganic fertilization for feeding in the commercial production of *Penaeus vannamei* during the rainy and dry season in Honduras. Presented to the Third Central American Shrimp Symposium at Tegucigalpa, Honduras, Apr 1995.
- Rodriguez, R., O.J. O'Hara, and D.R. Teichert-Coddington. Efecto de la tasa de fertilización inorgánica y calidad de agua sobre el crecimiento y economía en el cultivo semi-intensivo de camarón *Penaeus* spp. en Granja Marinas San Bernardo. Simposio Centroamericano Sobre Camarón Cultivado at Tegucigalpa, Honduras, Apr 1991.
- Teichert-Coddington, D., B. Green, N. Matamoros, and R. Rodriguez. Substitución de alimento por gallinaza en la producción comercial de camarones peneidos en Honduras. Presented to the Annual Regional Meeting of the Programa Cooperativo Centroamericana para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at San Pedro Sula, Honduras, 1989.
- Teichert-Coddington, D.R. and B. Green. Influence of primary productivity, season and site on tilapia production in organically fertilized ponds in two Central American countries. Presented to the FAO-EIFAC Symposium on Production Enhancement in Still-Water Pond Culture at Prague, Czechoslovakia, May 1990.
- Teichert-Coddington, D.R. Characterization of shrimp farm effluents in Honduras and chemical budget of selected nutrients. Presented to the Third Central American Shrimp Symposium at Tegucigalpa, Honduras, Apr 1995.
- Teichert-Coddington, D.R. Florecimiento de algas en el Rio Choluteca. Foro: La industria de la camaricultura buscando asegurar la viabilidad a largo plazo, Choluteca, Honduras, Mar 1994.
- Teichert-Coddington, D.R. Pond management, estuarine water quality, and sustainable shrimp culture in Central America. Presented by Claude Boyd to the Sustainable Aquaculture '95 Conference at Honolulu, Hawaii, Jun 1995.
- Teichert-Coddington, D.R. Problemática detectada en la dinámica del Golfo de Fonseca Hondureño y su repercusión en el cultivo de camarones. Primera Gran Reunión Nacional Camaronera, Choluteca, Honduras, Jan 1994.
- Teichert-Coddington, D.R. Relación entre calidad de agua de esteros y descarga de fincas camaroneras en el sur de Honduras. Encuentro Regional Sobre el Desarrollo Sostenido del Golfo de Fonseca y sus Cuencas at Choluteca, Honduras, May 1994.
- Teichert-Coddington, D.R. Water quality and its management in shrimp ponds. Presented to the Camarón '94 conference at Mazatlan, Mexico, Feb 1994.
- Teichert-Coddington, D.R. Water quality in the shrimp farming estuaries and the "X" Syndrome: Are they related? Segundo Encuentro de Gerentes y Propietarios de la industria de la Camaricultura (Second Conference of Managers and Owners in the Honduran Shrimp Culture Industry) at Choluteca, Honduras, Jan 1995.

- Teichert-Coddington, D.R., B. Green, and M.I. Rodriguez. Efectos de la tasa de alimentacion sobre la producción de tilapia en estanques fertilizados con gallinaza. Presented by M.I. Rodriguez to the Annual Regional Meeting of the Programa Cooperativo Centroamericana para el Mejoramiento de Cultivos Alimenticios (PCCMCA) at San Pedro Sula, Honduras, 1989.
- Teichert-Coddington, D.R., R. Rodriguez, and W. Toyofuku. Causes of cyclical variation in Honduran shrimp production. Poster presented to the World Aquaculture Society Meeting at Torremolinos, Spain, 26–28 May 1993.
- Teichert-Coddington, D.R., W. Toyofuku, J. Harvin and R. Rodriguez. Stocking density effects on survival and production. Presented to the Third Central American Shrimp Symposium at Tegucigalpa, Honduras, Apr 1995.
- 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.
- 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.
- Trejos-Castillo, E., J. Molnar, P. Martinez, E.W. Tollner, B. Verma, G. Pilz, and S. Meyer. Income, Food Security and Poverty Reduction: Case Studies of Small-Scale Aquaculture Producers in Santa Barbara, Honduras. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Zelaya, O., C.E. Boyd, D.R. Teichert-Coddington, and D.B. Rouse. Effects of water circulation on water quality and bottom soil in shrimp ponds. Presented to Aquaculture America 2001, Orlando, Florida, 21–25 Jan 2001.

ESCUELA AGRÍCOLA PANAMERICANA EL ZAMORANO

Theses

- Martínez, J.A., 2000. Socioeconomic characterization of farmers with and without a system of tilapia production in Honduras. B.S. thesis, Escuela Agrícola Panamericana El Zamorano, Honduras. (in Spanish)
- Mejía, G.M., 2000. Study of the production costs for culture of tilapia on small and medium farms in five departments of Honduras. B.S. thesis, Escuela Agrícola Panamericana El Zamorano, Honduras. (in Spanish)
- Molina, J.C., 2000. Study of the actual and potential demand for tilapia in five secondary cities in Honduras. B.S. thesis, Escuela Agrícola Panamericana El Zamorano, Honduras. (in Spanish)
- Quan, Vivian, 2000. Evaluation of the reproduction of tilapia (*Oreochromis niloticus*) in plastic and concrete lined and earthen ponds. B.S. thesis, Escuela Agrícola Panamericana El Zamorano, Honduras. (in Spanish)
- Quispe, F., 2000. Evaluation of the production costs for tilapia fingerlings in Honduras. B.S. thesis, Escuela Agrícola Panamericana El Zamorano, Honduras. (in Spanish)

Publications

- Charris, F., B. Green, and D. Meyer, 1999. Efectividad de cinco métodos para la enumeración de alevines de tilapia (*Oreochromis* sp.). In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaña (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 240–242.
- Meyer, D. and E. Camaño, 1999. Frecuencia de la alimentación y consumo en tilapia (*Oreochromis niloticus*). In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaña (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 262–265.
- Meyer, D. and P. Martinez, 2003. Aquacultura: Manual de Practicas. Zamorano Press. 109 pp.

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

Presentations

- Arias, F., J. Molnar, B. Esquivel, F.M. Quispe, J.A. Martinez, and G.M. Mejia, 2001. Production and marketing strategies used by small- and medium-scale producers in Honduras. Presented to the Sixth Central American Symposium on Aquaculture, Tegucigalpa, Honduras, 22–24 Aug 2001.
- Meyer, D. and P. Martinez, 2003. Aquacultura: Manual de Practicas. Zamorano Press. 109 pp.
- Meyer, D., 2001. Nutrition and feeding of tilapia. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 Aug 2001, pp. 61–70.
- Molnar, J., E. Trejos, P. Martinez, B. Verma, E.W. Tollner, S. Triminio, and D. Meyer, 2002. Advancing aquacultural development through the third sector: Advantages and liabilities of NGO networks for technology transfer in Honduras. Poster presented at the Annual Meeting of the American Association for the Advancement of Science at Boston, Massachusetts, 15 Feb 2002.
- Popma, T. and D. Meyer, 2001. Training and technical assistance in warm-water fish culture. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 Aug 2001, pp. 118–125.
- Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras,
- Tollner, E.W., 2001. Levee pond design model. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 Aug 2001, pp. 116–117.
- Triminio-Meyer, S. and C. Ponciano. Programa de Enseñanza y Proyección Acuicola en Zamorano, Honduras. Presented in The Workshop International Exchange on Aquaculture Extension. Mazatlan, Mexico, June 2004
- Triminio-Meyer, S., D.E. Meyer and J. Molnar. Productores de Alevines de Tilapia en Honduras, Características, Prácticas y Necesidades de Apoyo. Presented in the First Latin American workshop for the Tilapia Sector. Puerto Vallarta, Mexico, June, 2004
- Triminio-Meyer, S., D.E. Meyer, and J. Molnar. Tilapia Fingerling Producers in Honduras: Characteristics, Practices and Needs. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Triminio-Meyer, S., J. Molnar and D.E. Meyer. Opciones de Mercado para productores de Tilapia de Mediana y Pequeña escala en Honduras. Presented in the V Symposium of Aquaculture of Guatemala, October, 2003
- Verma, B.P., D. Meyer, T. Popma, J. Molnar, and E.W. Tollner, 2001. Web-based information delivery system for tilapia for sustainable development of aquaculture in Honduras. Proceedings of the Sixth Central American Symposium on Aquaculture, Annual Meeting of the Asociacion de Acuicultores de Honduras (ANDAH) and the Global Aquaculture Alliance, Tegucigalpa, Honduras, 22–24 Aug 2001, pp. 126–134.

UNIVERSIDAD NACIONAL AUTÓNOMA DE HONDURAS

Theses

- Echeverria, M.A., 1992. Primary production in *Tilapia nilotica* production ponds fertilized with triple superphosphate. B.S. thesis,

- Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (in Spanish)
- Garces, C., 1986. Quantitative analysis of zooplankton in fish ponds fertilized with triple superphosphate during the rainy season. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (in Spanish)
- Gomez, R., 1988. Effect of fertilizer type on the production of male *Tilapia nilotica*. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (in Spanish)
- Hernandez, Carlos, W.N., 1992. Respuesta de fitoplancton y zooplancton a fertilizante orgánico y alimento en estanques piscícolas. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (in Spanish)
- Sherman, C., 1992. All female culture of *Tilapia nilotica* in ponds fertilized with chicken litter. B.S. thesis, Dept. of Biology, Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras. (in Spanish)

UNIVERSITY OF ARKANSAS AT PINE BLUFF

Thesis

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

Publications

- Dasgupta, S. and C.R. Engle, 1999. Non-parametric estimation of returns to investment in Honduras shrimp research. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaña (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 201–203.
- Dasgupta, S. and C.R. Engle, 2000. Non-parametric estimation of returns to investment in Honduras shrimp research. *Aquaculture Economics and Management*, 4(3–4):141–156.
- Engle, C.R. Marketing and Economics. In: C. Webster and C. Lim (Editors). *Tilapia Culture, Nutrition, and Feeding*. CABI Publishers. (in press)
- Fúnez, O., I. Neira, and C. Engle, 2001. Honduras survey: 50% of supermarket to sell tilapia. *Global Aquaculture Advocate*, 4(2):89.
- Fúnez, O., I. Neira, and C. Engle, 2002. Open-air market outlets for tilapia in Honduras. *Global Aquaculture Advocate*, 5(1):88.
- Neira, I., O. Fúnez, and C. Engle, 2001. Honduras survey shows potential for tilapia. *Global Aquaculture Advocate*, 4(1):86.
- Valderrama, D. and C. Engle, 2001. Risk analysis of shrimp farming in Honduras. *Aquaculture Economics and Management*, 5(1–2):49–48.
- Valderrama, D. and C.R. Engle, 1999. Risk analysis of shrimp farming in Honduras. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaña (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 236–239.
- Valderrama, D. and C.R. Engle, 2001. Efectos en la rentabilidad y las estrategias de manejo de las fincas en Honduras, por las tasa de sobrevivencia del camarón blanco. *Panorama Acuicola*, 6(4):40–41.
- Valderrama, D. and C.R. Engle. Economic optimization of shrimp farming in Honduras. *J. World Aquacult. Soc.*, 33(4), pp. 398–409.
- Valderrama, D., and C.R. Engle. Farm-level economic effects of viral diseases on Honduran shrimp farms. *Journal of Applied Aquaculture*. (accepted)

Presentations

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

- Neira, I. and C. Engle, 2001. Markets for tilapia (*Oreochromis* spp.) in Nicaragua: A descriptive analysis of restaurants, supermarkets, and stands in open markets. Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 Aug 2001.
- Neira, I. and C. Engle. The Honduran market for tilapia: Restaurant and supermarket surveys. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
- Neira, I., K. Quagraine, and C. Engle, 2002. Markets for tilapia in Nicaragua: A quantitative analysis of restaurant markets. Annual Research Forum 2002, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas.
- Valderrama, D. A risk programming model for shrimp farming in Honduras. Presented to the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET 2000) at Corvallis, Oregon, 10–13 Jul 2000.
- Valderrama, D. and C.R. Engle, 2001. Optimización económica del cultivo del camarón en Honduras. Sixth Central American Symposium on Aquaculture at Tegucigalpa, Honduras, 22–24 Aug 2001. (in Spanish)
- Valderrama, D. and C.R. Engle, 2002. Economic optimization of shrimp farming in Honduras. *Aquaculture America* 2002, San Diego, California.
- Valderrama, D. and C.R. Engle. Risk analysis of shrimp farming in Honduras. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1–4 Feb 2000.
- Valderrama, D. and C.R. Engle. The effect of survival rates of white shrimp *Litopenaeus vannamei* on net farm income and optimal management strategies of Honduran shrimp farms. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.

UNIVERSITY OF GEORGIA

Publications

- Tollner, E. William; Brahm Verma; Dan Meyer; Suyapa Triminio de Meyer; George Pilz and Joseph Molnar Spreadsheet Tools for Developing Surface Water Supplies for Freshwater Fish Production in Developing Countries.

UNIVERSITY OF TEXAS, AUSTIN

Publication

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

Mexico

THE OHIO STATE UNIVERSITY, COLUMBUS

Publication

- Reed, V., 2003. Effects of 17 α -methyltestosterone and 17 β -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: Peptide and Growth Enhancers. Universidad Juarez Autonoma de Tabasco, Tabasco, Mexico. 27 October, 2003 (Oral Presentation).

- Dabrowski, K. New Developments in Diet Formulations for Larval Fish: Peptide and Growth Enhancers. Universidad Nacional Autónoma de Mexico. 29 October, 2003 (Oral Presentation).
- Rodriguez, G. A., K.J. Lee, W.M. Contreras, and K. Dabrowski. 17 α -Methyltestosterone Detection in Fish Tissue (Tilapia) and Water By a Simplified HPLC Technique Analysis. Presented at the World Aquaculture Society Meeting, Honolulu, Hawaii. 1-5 March, 2004 (Poster presentation).
- Rodriguez, G. and K. Dabrowski. Studies on the Use of Phytochemicals as an Alternate to Methyltestosterone to Produce Monosex Populations in Nile Tilapia (*Oreochromis niloticus*) for Aquaculture. 2004 OARDC Annual Conference, Ohio State University, Wooster, Ohio. 29 April, 2004 (Poster Presentation).
- Rodriguez, G., K.J. Lee, W.M. Contreras, K. Park, and K. Dabrowski. Evaluation of Two Phytochemicals, Genistein and Quercetin as Possible Sex Differentiation-Affecting Agents in *Tilapia nilotica* By Dietary Administration. Presented at the World Aquaculture Society Meeting, Honolulu, Hawaii. 1-5 March, 2004 (Oral Presentation).
- Treadway, K., G. Rodriguez, and K. Dabrowski. Social and Feeding Interactions of Two Cichlid Species, Midas and Nile Tilapia Reared at High Density. Inaugural CFAES Undergraduate Research Forum, College of Food, Agricultural and Environmental Sciences, Columbus, Ohio. 29 April, 2004 (Poster Presentation).

UNIVERSITY OF ARIZONA

Publications

- Fitzsimmons, K. 2003. Produccion y mercado internacional de tilapia. pp:134-150. In: Memorias de la Reunion Nacional de Tilapia. Instituto de la Pesca. Guadalajara, Mexico.
- Fitzsimmons, K. 2003. Tilapia aquaculture in recirculating systems. Aquaculture Magazine 29(2):73-76.
- Fitzsimmons, K. 2003. Tilapia Evolution: Growing industry moves from live fish to value-added products. Global Aquaculture Advocate 6(6):50-52.
- McIntosh, D., K. Fitzsimmons, J. Aguilar and C. Collins 2003. Towards Integrating Olive Production with Inland Shrimp Farming. World Aquaculture 34(1):16-20.
- McIntosh, D. and K. Fitzsimmons. 2003. Characterization of effluent from an inland, low-salinity shrimp farm: What contribution could this water make if used for irrigation? Aquacultural Engineering 27:147-156.

Presentations

- Fitzsimmons, K. Advanced Technologies in Aquaculture: Advantages and Concerns. Presented at AquaBio Brazil and Latin America Chapter of World Aquaculture Society Meeting in Vitoria, Brazil, May, 2004.
- Fitzsimmons, K. International Tilapia Production and Markets. Presented to farmers and government officials in Honolulu, Hawaii, March, 2004.
- Fitzsimmons, K. Opening European Markets to Value-Added Tilapia Products. Presented at a Seafood Business Conference in London, England, November, 2003.
- Fitzsimmons, K. Tilapia Production and Markets. Presented to farmers and government officials in Obregon, Mexico, October, 2003.

UNIVERSIDAD JUAREZ AUTONOMA DE TABASCO

Theses

- Campos-Campos, B. Evaluación de un sistema de filtración continua con Carbono activado para la eliminación de la 17 α -metiltestosterona de sistemas intensivos de reversión sexual de *Oreochromis niloticus*. M.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.

- Chávez-Mendez, A. Masculinización de Crías de Mojarra Paleta, Vieja bifasciata, por Inmersión y Administración Oral Con 17 α -Metiltestosterona y Acetato de Trenbolona. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.
- Contreras-García, M.J. Inversión sexual de las mojarra nativas *Cichlasoma salvini* y *Petenia splendida*, mediante la administración oral de esteroides sintéticos. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.
- Frias-Lopez, M. Evaluacion de la Factibilidad de Produccion de Poblaciones Monosexo de Machos de Tilapia, *Oreochromis niloticus*, Mediante el Empleo de Tamoxifeno y Letrozol. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.
- Hernández-Vera, B.A. Comparación de seis líneas de tilapia (*Oreochromis niloticus*). B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.
- Hernández-Vidal, U., 2002. Tropical Gar (*Atractosteus tropicus*) sex identification and hormonal induced spawn evaluation. M.S. thesis. 83 pp.
- Lara, G.M., 2001. Ictiofauna Asociada a las Escolleras del Puerto Marítimo de Dos Bocas, Paraíso, Tabasco, México. División Académica de Ciencias Biológicas, B.S. thesis, Universidad Juárez Autónoma de Tabasco.
- López-Ramos, I. Comparación del crecimiento de las descendencias de cuatro líneas de tilapia *Oreochromis niloticus* desde la fase de alevín, hasta la etapa de post-madurez. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.
- McDonal Vera, A. Avances en la investigación científica y tecnológica para el cultivo del pejelagarto (*Atractosteus tropicus*) en Tabasco. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.
- Ramon-Zapata, F. Frecuencia de alimentación y su efecto sobre el desarrollo, crecimiento y supervivencia de las larvas de pejelagarto, *Atractosteus tropicus*, en condiciones de laboratorio. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.
- Real-Ehuan, G. Masculinización de crías de mojarra castarrica *Cichlasoma urophthalmus*, mediante la administración de la 17 α -metiltestosterona. B.S. thesis, Universidad Juárez Autónoma de Tabasco, Mexico.
- Zacarías-Sánchez, A., 2003. Effects of feeding schedule on growth and survival of tropical gar (*Atractosteus tropicus*) larvae. Undergraduate thesis. 42 pp.

Publication

- Campos Campos, B., 2002. Filtration System for the Elimination of Methyltestosterone in Tilapia Masculinization Systems. Training pamphlet, independently published, January 2002.
- Campos Campos, B., 2002. Tilapia Fry Production. Training pamphlet, independently published, January 2002.
- Contreras-Sánchez, W.M. Identification of unique genes expressed during sex inversion of Nile tilapia, *Oreochromis niloticus*, by cDNA subtractive hybridization. Gen. Comp. Endocrinol. (in review)
- Hernández-Vidal, U., 2002. Tropical gar (*Atractosteus tropicus*) sex identification and hormonal induced spawn evaluation. M.S. thesis. 83 pp.
- Vidal-López, J.M. Masculinización de crías de la mojarra tenhuayaca *Petenia splendida* (Gunther, 1862), mediante bioencapsulado del esteroide 17 α -metiltestosterona en nauplios de *Artemia salina*.
- 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 truícola. 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.
- Contreras-Sánchez W., C. Shreck, U. Hernandez, and G. Feist. Elimination of Methyltestosterone from Intensive Masculinization Systems Using Activated Charcoal Filters. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Contreras-Sánchez W., C. Shreck, U. Hernandez, and G. Feist. Feminization of the Tropical Gar (*Atractosteus tropicus*) and Masculinization of the Cichlid Castarrica (*Cichlasoma urophthalmus*) Using Steroid-Enriched Artemia Nauplii. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Contreras-Sánchez W., C. Shreck, U. Hernandez, and G. Feist. Reproductive and Growth Performance of Three Lines of Nile Tilapia (*Oreochromis niloticus*) in Tabasco, Mexico. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Contreras-Sánchez W., C. Shreck, U. Hernandez, and G. Feist. Use of Steroid-Enriched Artemia Nauplii for Sex-Reversal: Validation of the Technique Using Nile Tilapia as a Model. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Contreras-Sánchez, W. Advances in Fish Culture at Universidad Juárez Autónoma de Tabasco. 7 October 2003. Audience consisted of government workers.
- Contreras-Sánchez, W. Induced Sex Inversion in Fishes. Seminar presented to public audience at Universidad Juárez Autónoma de Tabasco, 24 September 2003.
- Contreras-Sánchez, W. MT Elimination from Intensive Masculinization Systems. Seminar presented to public audience at Universidad Juárez Autónoma de Tabasco, 29 October 2003.
- Contreras-Sánchez, W., U. Hernández-Vidal, A. Hernández-Franyutti, M.A. Contreras-García, and G. Real-Ehuan. Induced Sex Inversión in Native Fish. Curso-taller Reproducción en peces teleosteos. Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Morelos, Cuernavaca, Mor. México. November 20, 2003. Audience consisted of researchers, professors and students.

Nicaragua

UNIVERSITY OF ARKANSAS AT PINE BLUFF

Thesis

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

Presentations

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

Panama ~ Aguadulce

AUBURN UNIVERSITY

Thesis

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

Publications

- Lovshin, L.L. and N.B. Schwartz, 1999. Evaluation of integrated tilapia culture by resource limited farmers in Panama and Guatemala. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montañó (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 258-261.
- Lovshin, L.L., 2000. Criteria for selecting Nile tilapia and red tilapia for culture. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 49-57.
- Lovshin, L.L., 2000. Evaluation of tilapia culture by resource limited farmers in Panama and Guatemala. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 633-638.
- Teichert-Coddington, D.R. and M. Arrue, 1988. Efectos de dietas de proteínas y densidades de siembra sobre la producción de *Penaues vannamei* en estanques de tierra. (Effects of protein diets and stocking density on production of *Penaues vannamei* cultured in earth ponds.) Revista Latinoamericana de Acuicultura, 35:29-33.

Presentations

- Chavez, H. Estudio trofodinámico de *Penaues vannamei* cultivado en estanques experimentales de aguas salobres. Presented to the First National Scientific Congress at University of Panama, Panama, Dec 1984.
- De Leon, A. El efecto de aplicar fertilizantes inorganicos en la producción de *Penaues vannamei* en estanques. Presented to the Second National Scientific Congress at University of Panama, Panama, Nov 1985.
- Hughes, D.G. and O.M. Garcia A. La producción de semilla de *Tilapia nilotica* en hapas: una comparacion de productividades de clima templada con clima tropical. Presented to the First National Aquaculture Seminar at University Nacional, Heredia, Costa Rica, Jun 1984.
- Hughes, D.G. Prediction of pond productivities: A challenge for aquaculture. Presented to the Pontifical Catholic University of Ecuador at Quito, Ecuador, Nov 1985.
- Hughes, D.G. The marine shrimp culture industry in Panama. Presented to the First Annual Shrimp World Marketing Conference at Acapulco, Mexico, Nov 1984.
- Hughes, D.G., A. Torres, and R.P. Phelps. Production and growth characteristics of *Penaues stylirostris* and *P. vannamei* in monoculture and polyculture in fed and unfed earthen ponds. Presented to the Annual Meeting of the World Mariculture Society at Orlando, Florida, Jan 1985.
- Hughes, D.G., G. de Gomez, E. Lasso de la Vega, R.P. Phelps, and R. Pretto-Malca. Rainy and dry season comparisons in *Penaues vannamei* production ponds in Panama receiving various water exchange rates: Water quality variation. Poster session presented to World Aquaculture Society Meeting at Guayaquil, Ecuador, Jan 1987.
- Kivers, A. Comparacion de dos rangos y dietas alimenticias con alevines de *Tilapia nilotica* en piletas de concreto. Presented to the First National Scientific Congress at University of Panama, Panama, Dec 1984.
- Kivers, A. Comparacion de tres densidades de sembra de alevines de *Tilapia nilotica* en piletas de concreto. Presented to the First National Scientific Congress at University of Panama, Panama, Dec 1984.
- Lasso de la Vega, E. and M. Villareal. Variacion del zooplancton en estanques de cria de camarones blanco durante la estacion seca. Presented to the Second National Scientific Congress at University of Panama, Panama, Nov 1985.
- Lore, D., H. Tunon, and R. Visuetti. Efecto de la aplicacion de abonos organicos, concentrados y pescado fresco (*Dormitator latifrons*) en la producción de *Penaues stylirostris* y *Penaues vannamei*. Presented by H. Tunon to the First National Scientific Congress at University of Panama, Panama, Dec 1984.

- Moreno, J.M. Alimentación de la *Tilapia nilotica* en la etapa de alevinaje. Presented to the First National Scientific Congress at University of Panama, Panama, Dec 1984.
- Moreno, J.M. El uso del andrógeno 17-metil-testosterona en alevinaje de *Tilapia nilotica* para la producción de tilapia monosexuales en Panamá. Presented to the First National Scientific Congress at University of Panama, Panama, Dec 1984.
- Pretto, R., G. Garson, V. Batista, and M. de Leon. Estudio preliminar del policultivo de peneidos con peces nativos de aguas salobres. Presented to the Fifth Symposium of Latin American Aquaculture at Universidad Austral de Chile, Valdivia, Chile, Sep 1983.
- Torres, A. Producción de *Penaeus stylirostris* bajo la influencia del *Penaeus vannamei*, en estanques experimentales de agua salobre con y sin alimentación durante la época seca. Presented to the First National Scientific Congress at University of Panama, Panama, Dec 1984.

UNIVERSITY OF PANAMA

Theses

- Abrego, R., 1985. Uso de andrógenos en alevines de *Tilapia nilotica* para la producción de tilapias monosexuales. B.S. thesis, University of Panama.
- Chavez, H., 1984. Estudio trofodinámico de *Penaeus vannamei* cultivado en estanques experimentales de aguas salobres. B.S. thesis, University of Panama.
- Hernandez de Santamaria, D., 1987. El efecto de dietas experimentales en el crecimiento y sobrevivencia de *Penaeus vannamei* cultivado en estanques. B.S. thesis, University of Panama.
- Lasso de la Vega, E., 1985. Variación del zooplancton en estanques de cría de camarones blanco durante la estación seca. B.S. thesis, University of Panama.
- Lore, D., 1984. Efecto de la aplicación de abonos orgánicos, concentrados y pescado fresco (*Dormitator latifrons*) en la producción de *Penaeus stylirostris* y *Penaeus vannamei*. B.S. thesis, University of Panama.

Panama ~ Gualaca

AUBURN UNIVERSITY

Thesis

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

Publications

- Peralta, M. and D.R. Teichert-Coddington, 1989. Comparative production of *Colossoma macropomum* and *Tilapia nilotica* in Panama. *Journal of the World Aquaculture Society*, 20(4):236-239.
- Teichert-Coddington, D.R. and R.P. Phelps, 1989. Effects of seepage on water quality and productivity of inorganically fertilized tropical ponds. *Journal of Aquaculture in the Tropics*, 4:85-92.
- Teichert-Coddington, D.R., M. Peralta, and R.P. Phelps, 1989. Seepage reduction in tropical fish ponds using chicken litter. *Aquacultural Engineering*, 8:147-154.
- Teichert-Coddington, D.R., N. Stone, and R.P. Phelps, 1988. Hydrology of fish culture ponds in Gualaca, Panama. *Aquacultural Engineering*, 7:309-320.

Presentation

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

UNIVERSITY OF PANAMA

Theses

- Atencio, A., 1987. Phosphorus saturation of acidic soils in tropical fish culture ponds. B.S. thesis, University of Panama.
- Barrios, C.M., 1985. Analysis of water quality in new freshwater ponds at the Freshwater Aquaculture Station in Gualaca. B.S. thesis, University of Panama.
- Friele, M.E.F., 1985. Stomach analyses of *Macrobrachium rosenbergii*, *Tilapia nilotica*, *Colossoma macropomum* and the hybrid *Hypophthalmichthys molitrix* x *Aristichthys nobilis* in polyculture at the Gualaca Freshwater Aquaculture Experiment Station, Panama. B.S. thesis, University of Panama.
- Perez, M.J., 1985. Economic and marketing study of fish and shrimp in polyculture systems in freshwater ponds at Gualaca, Chiriqui Province. B.S. thesis, University of Panama.
- Pimentel, C.A.B., 1984. Effect of liming on new unfertilized ponds at the Gualaca Aquaculture Experiment Station. B.S. thesis, University of Panama.
- Rios, R.A., 1986. Identification and dynamics of zooplankton found in tropical earthen ponds receiving chicken litter at four rates. B.S. thesis, University of Panama.
- Rodriguez, I., 1987. Feeding *Penaeus vannamei* and *Penaeus stylirostris* in nursery ponds. M.S. thesis, University of Panama.
- Serrano, A., 1987. Economics of tilapia production in monoculture or in polyculture with prawns, and utilizing manure or a commercial pellet as the nutrient input in Gualaca, Panama. B.S. thesis, University of Panama.

Peru

AUBURN UNIVERSITY

Presentations

- Molnar, J., F. Alcántara, C.C. Kohler, S. Tello, and M.J. De Jesus. Aquaculture in the Amazon: Sustaining livelihoods, food security, and species in a complex ecological context. Presented to the V Central American Symposium on Aquaculture at San Pedro Sula, Honduras, 18-20 Aug 1999.
- Molnar, J.J., F. Alcántara, and S. Tello. Small-scale aquaculture in the Peruvian Amazon: Marketing practices and strategies. Presented to Aquaculture America 2001 at Orlando, Florida, 21-25 Jan 2001.
- Molnar, J.J., F. Alcántara, and S. Tello. Sustaining livelihoods, ecologies, and rural communities. Presented to the American Association for the Advancement of Science 2000 AAAS Annual Meeting and Science Innovation Exposition at Washington, DC, 17-22 Feb 2000.
- Molnar, J.J., F. Alcántara, and S. Tello. Sustaining small-scale aquaculture in the Peruvian Amazon: Producer perceptions of constraints and opportunities. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1-4 Feb 2000.
- Molnar, J.J., F. Alcántara, and S. Tello. Sustaining small-scale aquaculture in the Peruvian Amazon: Producer perceptions of constraints and opportunities. Presented to World Aquaculture 2000 at Nice, France, 2-6 May 2000.

INSTITUTO DE INVESTIGACIONES DE LA AMAZONIA PERUANA

Publication

- Alcántara, F.B., C.V. Chávez, L.C. Rodríguez, C. Kohler, S. Kohler, W.N. Camargo, M. Colace, and S. Tello. Gamitana (*Colossoma macropomum*) and Paco (*Piaractus brachipomus*) culture in floating cages in the Peruvian Amazon. *World Aquaculture* 34(4):22-24.
- Alcantara, F.B., S.M. Tello, C.V. Chávez, L.C. Rodríguez, C.C. Kohler, S.T. Kohler, and W.N. Camargo. Pond Culture of *Arapaima gigas* in the Peruvian Amazon. *World Aqua.*, 35(1):45-46.

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

Presentations

- Alcántara, F. Performance of *Piaractus brachyomus* and *Colossoma macropomum* stocked in ponds at different densities in Iquitos, Peru. Presented to Development of Aquaculture in the Amazon at Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru, 30 Nov–4 Dec 1999.
- Alcántara, F. Status of aquaculture in the Peruvian Amazon. Presented to Development of Aquaculture in the Amazon at Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru, 30 Nov–4 Dec 1999.
- Alcántara, F.B., C.V. Chávez, L.C. Rodríguez, C.C. Kohler, T.S. Kohler, and W.N. Camargo (presenter). Gamitana (*Colossoma macropomum*) and Paco (*Piaractus brachyomus*) culture in floating cages in the Peruvian Amazon. Aquaculture America 2003, Louisville, Kentucky, February 2003.

SOUTHERN ILLINOIS UNIVERSITY AT CARBONDALE

Publications

- Camargo, W.N., C. Kohler, S. Kohler, M. Rebaza, C. Rebaza, S. Deza, E. Villafana, and C. Alvarez. Fish Culture at the Pucallpa Navy Base in the Peruvian Amazon. Aquanews, 18(4):7-8.
- Camargo, W.N. International Training Courses in Aquaculture and Nutrition of Prominent Amazon Species. Aquanews, 18(4):3.
- De Jesus, M.J. and C.C. Kohler. The commercial fishery of the Peruvian Amazon: Is it sustainable? Fisheries (in revision).
- De Jesus, M.J., C.C. Kohler, and S.T. Kohler, 1998. Sustainable aquaculture in Peru. Aquaculture Magazine, 24(4):23–25.
- Fernandes, J.G.K., R. Lochmann, and F. Alcántara. Apparent digestible energy and nutrient digestibility coefficients of diet ingredients for pacu *Piaractus brachyomus*. Journal of the World Aquaculture Society. (resubmitted)
- Video: Acuicultura en la Amazonia Peruana, experiencia en la carretera Iquitos-Nauta. SWA TV, July 2003. 7 min. Audience consists of general public, over 1,000. (In Spanish)

Presentations

- Alcántara, F., C. Kohler, S.T. Kohler, and M.J. De Jesus. Performance of *Piaractus brachyomus* and *Colossoma macropomum* stocked in ponds at different densities. Presented to the World Aquaculture Society Annual Meeting at Sydney, Australia, 26 Apr–2 May 1999.
- Alcantara, F.B., C.V. Chávez, L.C. Rodríguez, C.C. Kohler, T.S. Kohler, and W.N. Camargo. Gamitana (*Colossoma macropomum*) and Paco (*Piaractus brachyomus*) culture in floating cages in the Peruvian Amazon. Aquaculture America 2003, Louisville, Kentucky, February 2003.
- Camargo, W.N. I Curso de Internacional Nutrición de Peces Tropicales. Seminar presented to public audience in Pucallpa, Peru, 2003.
- Camargo, W.N. III Curso de Internacional Acuicultura con Especies Promisorias de la Amazonia. Seminar presented to public audience in Pucallpa, Peru, 2003.
- Camargo, W.N. Pond Culture of *Arapaima gigas* cuvier in the Peruvian Amazon. World Aquaculture Society Conference, Salvador-Bahía, Brazil, 19–23 May 2003
- Camargo, W.N. Sustainable Small-Scale Aquaculture in the Amazon Region. Seminar presented to public audience in Carbondale, Illinois, March, 2004.
- Chu-Koo, F. Evidence of the seed dispersal role of *Colossoma macropomum* reared in aquaculture in the Peruvian Amazon. International Congress of Ichthyology, Manaus, Brazil, August 2003.

- Chu-Koo, F., C.C. Kohler, W.N. Camargo, F.B. Alcántara, and J. Ríos. Evidence of Seed Dispersal Role of *Colossoma macropomum*, Reared in Aquaculture in the Peruvian Amazon. Aquaculture America 2003, Louisville, Kentucky, February 2003.
- De Jesus, M.J. and C.C. Kohler. Analysis of the commercial fisheries in the Peruvian Amazon. Presented to the Illinois Renewable Natural Resources Conference, Springfield, Illinois, 4–6 Mar 1998.
- Kohler, C., M. De Jesús, S. Kohler, L.B. Campos, and F. Alcántara. Culture of *Colossoma macropomum* in South America. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
- Kohler, C.C., S.T. Kohler, M.J. De Jesus, and F. Alcántara. Use of *Colossoma macropomum* and *Piaractus brachyomus* for sustainable aquaculture in the Peruvian Amazon. Presented to World Aquaculture 2000 at Nice, France, 2–6 May 2000.

THE OHIO STATE UNIVERSITY

Publication

- Dabrowski, Konrad; Jacques Rinchar; Joseph S. Ottobre; Fernando Alcántara; Palmira Padilla; Andrzej Ciereszko; Marcos J. De Jesus and Christopher C. Kohler Effect of Oxygen Saturation in Water on Reproductive Performances of Pacu *Piaractus brachyomus* World Aquaculture Society, 34(4):441-449
- Dabrowski, K., J. Rinchar, J. Ottobre, F. Alcántara, P. Padilla, A. Ciereszko, M. J. De Jesus and C.C. Kohler. 2003. Effect of Oxygen Saturation in Water Provided to Broodstock and Embryos of *Piaractus brachyomus* on Viability of Larvae. J. World. Aquacult. Soc 34:441-449.
- Lee, K.J., K. Dabrowski, J. Rinchar, L. Gomez, Guz, and C. Vilchez. Supplementation of Maca (*Lepidium meyenii*) Tuber Meal in Diet Improves Growth Rate and Survival of Fish. Aquaculture Research. 35:215-223.
- 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.

Presentations

- Dabrowski, K. New developments in diet formulations for larval fish: peptides and growth enhancers. Attended by approximately 60 people from the Institute of Aquaculture, Ministry of Natural Resources (CEPTA, IBAMA), and staff and students from the University of Sao Paulo, Pirassununga. 29 October 2002.
- Dabrowski, K. Peptide Utilization in Larval Fish Diet Formulation: Basic and Applied Aspects. Presented at the World Aquaculture Society Meeting, Honolulu, Hawaii. 1-5 March, 2004 (Oral presentation).
- Dabrowski, K. Tocopherols in aquatic organisms. Special session presented as part of the 2003 Aquaculture America Conference in Louisville, Kentucky, 18–21 February 2003.
- Dabrowski, K., J. Rinchar, F. Alcántara, P. Padilla, A. Ciereszko, and M. De Jesus. Preliminary assessment of gamete quality of *Piaractus brachy-pomus* cultured in ponds in Iquitos, Peru. Presented to Development of Aquaculture in the Amazon at Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru, 30 Nov–4 Dec 1999.
- Dabrowski, K., K. Ware, and M. Tesser. Larval and juvenile rearing of pacu *Piaractus mesopotamicus* using live food and formulated diets (Poster presentation).
- Palacios, M.E., K. Dabrowski, and C.C. Kohler. Growth and Diet Utilization in Pacu (*Piaractus mesopotamicus*) Using Soybean Replacement of Casein Gelatin as a Protein Source. Presented at the World Aquaculture Society Meeting, Honolulu, Hawaii. 1-5 March, 2004 (Oral Presentation).
- Tesser, M., K. Dabrowski, B. Terjesen, J.M. Pizauro, and M.C. Portella. Free- and peptide-based arginine supplementation into arginine-deficient diets for South American fish *Piaractus mesopotamicus*. (Poster Presentation).

Tesser, M., M.C. Portella, and K. Dabrowski. Growth and survival of pacu *Piaractus mesopotamicus* larvae fed formulated diets and live *Artemia* (Oral Presentation).

Publications

- Ostaszewska, T., K. Dabrowski, M. Wegiel, and M.E. Palacios. Growth and Morphological Changes in the Digestive Tract of Rainbow Trout and Paku Due to Casein Protein Replacement With Soybean Protein. Presented at the World Aquaculture Society Meeting, Honolulu, Hawaii. 1-5 March, 2004. (Oral Presentation).
- 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)
- 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*). Oral presentation at Aquamar Internacional, Cancun, Mexico, 3-7 September 2002.
- 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.

UNIVERSIDAD NACIONAL DE LA AMAZONIA PERUANA

Theses

Silva, M., 2004. Reproductive Strategies for the *Cichlasoma Amazonarum* (bujurqui). B.S. thesis, Universidad Nacional de la Amazonia Peruana, Peru.

UNIVERSIDAD NACIONAL MAYOR DE SAN MARCOS

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.

UNIVERSITY OF ARKANSAS AT PINE BLUFF

Publications

Fernandes, J.B.K., R. Lochmann, and F.A. Bocanegra. Apparent Digestible Energy and Nutrient Digestibility Coefficients of Diet Ingredients for pacu (*Piaractus brachipomus*). Journal of World Aquaculture Society 35:237-244.

Presentations

- Lochmann, R. Broodstock Diet Development for Tropical Amazonia Fishes. Presented at III Curso de Internacional Acuicultura con Especies Promisorias de la Amazonia and I Curso de Internacional Nutrición de Peces Tropicales in Pucallpa, Peru, 2003.
- Lochmann, R. Clues to Characid Broodstock Diet Development. Presented at World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Lochmann, R. Fisheries of the Peruvian Amazon. LL Owen Elementary School, Pine Bluff, Arkansas, 15 May 2003.

AFRICA

Egypt

AUBURN UNIVERSITY

Publications

- Green, B. and C.E. Boyd, 1995. Water budgets for fish ponds in the dry tropics. Aquacultural Engineering, 14:347-356.
- Green, B.W. and C.E. Boyd, 1995. Chemical budgets for organically fertilized fish ponds in the dry tropics. Journal of the World Aquaculture Society, 26(3):284-296.
- Munsiri, P., C.E. Boyd, B.W. Green, and B.F. Hajek, 1996. Chemical and physical characteristics of bottom soil profiles in ponds on haplaquents in an arid climate at Abbassa, Egypt. Journal of Aquaculture in the Tropics, 11:319-326.

Presentations

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

CENTRAL LABORATORY FOR AQUACULTURE RESEARCH, ABBASSA, EGYPT

Publications

- Abdalla, A.A.F., C.D. McNabb, and T.R. Batterson, 1996. Ammonia dynamics in fertilized fish ponds stocked with Nile tilapia. The Progressive Fish-Culturist, 58:117-123.
- Green, B., Z. Elnagdy, H. Hebida, and A.R. El Gamal, 1994. Pond management strategies for production of Nile tilapia in Egypt. NARP Harvest No. 2.

Presentations

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

MICHIGAN STATE UNIVERSITY

Publication

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

OREGON STATE UNIVERSITY

Thesis

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

Publications

- Fitzpatrick, M.S., G. Feist, W.L. Gale, C.H. Slater, and C.B. Schreck, 1994. Gonadal sex differentiation in fishes. In: D.D. MacKinlay (Editor), High Performance Fish. Proceedings of an International Fish Physiology Symposium, Fish Physiology Association, Vancouver, BC, pp. 146–149.
- Fitzpatrick, M.S., W.L. Gale, C.H. Slater, and C.B. Schreck, 1995. Gonadal androgen receptors in fishes. In: F.W. Goetz and P. Thomas (Editors), Proceedings of the Fifth International Symposium on Reproductive Physiology of Fish at Austin, Texas, p. 308.
- Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck, 1995. Immersion of Nile tilapia (*Oreochromis niloticus*) in 17 α -methyltestosterone and mestano-lone for the production of all-male populations. In: F.W. Goetz and P. Thomas (Editors), Proceedings of the Fifth International Symposium on Reproductive Physiology of Fish at Austin, Texas, p. 117.
- Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck, 1996. Masculinization of Nile tilapia by short-term immersion in methyl dihydrotestosterone. In: E.M. Donaldson and D.D. MacKinlay (Editors), Aquaculture Biotechnology Symposium. Proceedings of an International Fish Physiology Symposium. Cong. Biol. Fishes, Physiology Section, American Fisheries Society, Vancouver, BC, p. 29.
- Gale, W.L., M.S. Fitzpatrick, M. Lucero, W.M. Contreras-Sánchez, and C.B. Schreck, 1999. Masculinization of Nile tilapia by immersion in androgens. *Aquaculture*, 178:349–357.

Presentations

- Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck. Binding characteristics of a gonadal androgen receptor in Nile tilapia (*Oreochromis niloticus*). Presented to the Western Regional Conference on Comparative Endocrinology at Berkeley, California, 1996.
- Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck. Binding sites for the masculinizing steroid mibolerone in the gonadal tissue of adult tilapia (*Oreochromis niloticus*). Presented to the Western Regional Conference on Comparative Endocrinology at San Diego, California, 1994.
- Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck. Binding sites for the masculinizing steroid mibolerone in the gonadal tissue of adult tilapia (*Oreochromis niloticus*). Presented to the World Aquaculture Society Annual Meeting at San Diego, California, 1–4 Feb 1995.

Kenya**AUBURN UNIVERSITY****Theses**

- Lockhart, M., 1999. Farmer perceptions of constraints on aquaculture development in Central Kenya: Market, household, and resource considerations. M.S. thesis, Auburn University, Alabama.
- Omolo, B.O., 2002. Feed conversion efficiency in channel catfish (*Ictalurus punctatus*) as a function of size. M.S. thesis, Auburn University, Alabama.

Publications

- Osure, G. Evaluation of Growth and Reproductive Performance and Microsatellite Variability of Four Strains of Nile Tilapia, *Oreochromis niloticus*. M.S. thesis, Auburn University.

Presentations

- Liti, D., E. Mac'Were, and K. Veverica. Growth performance and economic benefits of *Oreochromis niloticus* and *Clarias gariepinus* polyculture in fertilized tropical ponds. Poster presented to the Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
- Molnar, J., M. Lockhart, and J. Amadiva. Aquacultural development in central Kenya: Farming system, household, and community

considerations. Poster presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

- Osure, G. Evaluation of growth and reproductive performance of four strains of Nile tilapia, *Oreochromis niloticus*. Aquaculture America 2003, Louisville, Kentucky, 02/03.
- Osure, G. Evaluation of Growth and Reproductive Performance and Microsatellite Variability of Four Strains of Nile Tilapia, *Oreochromis niloticus*. Seminar presented at Auburn University and Wageningen University.
- Osure, G. Evaluation of growth and reproductive performance of four strains of Nile tilapia, *Oreochromis niloticus*. Aquaculture America 2003, Louisville, Kentucky, February 2003.
- Veverica, K., D. Mirera, and G. Matolla. Optimization of phosphorus fertili-zation rate in freshwater tilapia production ponds in Kenya. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
- Veverica, K.L. Commercial tilapia production recommendations and enterprise budgets of East Africa in the absence of formulated feeds. Presented to Lake Victoria 2000 at Jinja, Uganda, 14–19 May 2000.
- Veverica, K.L., B.W. Green, J. Bowman, D.R. Teichert-Coddington, and C.E. Boyd. Optimization of nitrogen fertilization rate in freshwater tilapia production ponds in Honduras and Kenya. Presented to World Aquaculture 2000 at Nice, France, 2–6 May 2000.

MOI UNIVERSITY**Thesis**

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

Publication

- Enos Mac'Were, 2003. Financial analysis of commercial tilapia production from two locally available feeds and a test diet in fertilized ponds. *Aquaculture*. (in review)
- Mac'Were, E. 2003. Financial analysis of commercial tilapia production from two locally available feeds and a test diet in fertilized ponds. *Aquaculture*. (in review)
- Ngugi, C.C., J. Amadiva, K. Veverica, J. Bowman, S. Imende, B. Nyan-datt, and G. Matolla. On Farm Trials in Kenya Change Attitudes of Fish Farmers and Extensionists. *Samaki News*, Vol. 2 July 2003.
- Ngugi, C.C. and J.O. Manyala, 2002. Review of extension service in Kenya, In: *Aquaculture Extension in Africa*.

Presentations

- Muchiri, M. Break-even price and investment costs under different loan schemes for small-scale fish farmers in Kenya. Presented to IIFET 2000 at Corvallis, Oregon, 10–14 Jul 2000.
- Ngugi, C.. Development of a National Fisheries Policy. Seminar presented to government officials in Nairobi, Kenya, 2003.
- Ngugi, C. On Farm Trials; the Kenyan experience, 14 July 2003. Presentation given in Kampala, Uganda. Audience: farmers.
- Ngugi, C. Potential for fish farming in Uganda, 14 July 2003. Presentation given in Kampala, Uganda. Audience: farmers.
- Ngugi, C. Working with fish farmers to develop aquaculture, 14 July 2003. Presentation given in Kampala, Uganda. Audience: farmers.
- Ngugi, C. Yield verification trials in Western Kenya change attitudes of fish farmers and extensionists. Presented at Aquaculture America 2003, Louisville, Kentucky, February 2003.
- Ngugi, C. Yield verification trials in Western Kenya change attitudes of fish farmers and Extensionists. Presented at Aquaculture America 2003, Louisville, Kentucky, February 2003.
- Ngugi, C., J. Macharia, and J. Rasowo. Comparative study of hatching rates of catfish eggs on different substrates. Presented to First

National LVEMP Scientific Conference at Nairobi, Kenya, 15–19 Oct 2001.

Ngugi, C., J. Nzeve, and J.R. Bowman. Growth and survival of African catfish *Clarias gariepinus* larvae fed *Artemia nauplii*, freshwater rotifers, and whole, freeze-dried Cyclops in indoor tanks. *Aquaculture* 2004, March 1-5, 2004. Honolulu, Hawaii.

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

UNIVERSITY OF NAIROBI

Theses

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

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

Presentations

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

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

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

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

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

Rwanda

AUBURN UNIVERSITY

Theses

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

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

Publications

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

Moehl, J.F. and J.J. Molnar, 1996. Institutional requirements for aquacultural development in Africa: Lessons from Rwanda. In: C.

Bailey, S. Jentoft, and P. Sinclair (Editors), *Aquacultural Development: Social Dimensions of an Emerging Industry*, Westview Press, Boulder, CO, USA/Oxford, United Kingdom, pp. 233–248.

Moehl, J.F., K.L. Veverica, B.J. Hanson, and N. Hishamunda, 1988. Development of appropriate pond management techniques for use by Rwandan farmers. In: R.S.V. Pullin, T. Bhukaswan, K. Tonguthai, and J.L. MacLean, (Editors), *The Second International Symposium on Tilapia in Aquaculture*. ICLARM Conference Proceedings 15, Manila, Philippines, pp. 561–568.

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

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

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

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

Presentations

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

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

Newman, J.R., T.J. Popma, and W.K. Seim. Effects of temperature on maximum feed consumption and growth of juvenile Nile tilapia. Poster presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Jan 1996.

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

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

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

UNIVERSITÉ NATIONALE DU RWANDA

Theses

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

- Gatera, A., 1990. Effet du taux d'empoissonnement et du mode de compostage sur la production des poissons en étang. (Effect of stocking rate and composting regime on production of fish in ponds.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Habineza, C., 1986. Analyse de l'effet de la fumure organique (fientes de poules) sur la croissance du *Tilapia nilotica* en étang. (The influence of chicken manure on the growth of *Tilapia nilotica* in ponds.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Hakziyarembe, E., 1984. Etude des effets de l'alimentation sur la croissance des tilapias: essais en bacs sur *T. macrochir* et *T. rendalli*. Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Harwanimbaga, C., 1987. Etude préliminaire des populations planctoniques dans des étangs de Rwasave, Butare, Rwanda. (A preliminary study of the plankton populations in fish ponds at Rwasave, Butare, Rwanda.) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.
- Hatangimbabazi, J.D., 1989. Description des communautés planctoniques des différentes habitats de quelques étangs piscicoles de Rwasave (Butare). (Description of plankton communities in different habitats of fish ponds at Rwasave (Butare).) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.
- Hishamunda, N., 1984. Contribution à l'étude des effets de *Serranochromis macrocephala* Boulenger, sur la prolifération de *Tilapia macrochir* Boulenger, en étangs de pisciculture. (Effects of a predator fish, *Serranochromis macrocephala*, on the proliferation of *Tilapia macrochir* in fish culture ponds.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Isangu, M.M., 1989. L'association porcs-poissons en station: étude de rentabilité financière. (Integrated pig-fish culture: An economic analysis.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Kakuze, A., 1989. Contribution à l'étude du régime alimentaire de *Tilapia nilotica* (L. 1758) des étangs fertilisés de Rwasave (Butare). (A preliminary study of the feeding habits of *T. nilotica* in fertilized ponds at Rwasave, Butare.) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.
- Mbarererehe, F., 1992. Contribution à l'étude de l'influence de la température et de la durée de traitement sur la production des alevins monosexes du *Oreochromis niloticus*. (The influence of temperature and treatment duration on the production of all-male *O. niloticus* fry.) Mémoire présenté en vue de l'obtention du Diplôme d'Ingénieur Technicien A1. Institut Supérieur d'Agriculture et d'Élevage de Busogo, Ruhengeri, Rwanda.
- Mukakarera, C., 1990. Etude hydrobiologique des ruisseaux Uwagatigita et Mbirurume de la forêt naturelle de Nyungwe. (An aquatic biology study of Uwagatigita and Mbirurume streams in the Nyungwe natural forest.) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.
- Munyangaju, A., 1990. Etude des lacs du Bugesera en vue de proposer l'effort de pêche optimale. (A study of the lakes in the Bugesera region in order to propose an optimal fishing effort.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Murangira, J., 1992. Contribution à l'étude de la productivité de quelques graminées fourragères vis à vis trois fréquences de coupe. (Comparative productivity of eight forage grasses at three cutting frequencies.) Rapport de stage, Ecole Agricole et Vétérinaire de Kabutare, Butare, Rwanda.
- Murwanashyaka, J.N., 1989. Alimentation et parasitisme de *Clarias gariepinus* (Burchell, 1822) au Lac Ihema: impact de sa prédation sur l'évolution du stock en haplochromis. (Parasitism and feeding habits of *C. gariepinus* in Lake Ihema: impacts of its predation on haplochromis stocks.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Ndisebuye, A., 1986. Etude des conditions de reproduction de *Tilapia nilotica* en étangs de pisciculture. (A study of the conditions affecting the reproduction of *T. nilotica* in Rwandan fish ponds.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Ngarambe, O., 1986. Etude de l'influence de la fumure organique (fientes de poule) sur la dynamique des éléments fertilisants du sol de quelques étangs piscicoles de Rwasave. (The influence of chicken litter on soil and water fertility in several fish ponds at Rwasave.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Niyitegeka, D., 1990. Bilan d'azote dans les étangs piscicoles enrichis par les fertilisants de différents rapports C:N:P, Rwasave, Butare. (Nitrogen budgets in fish ponds enriched with fertilizers of different C:N:P ratios at Rwasave, Butare.) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.
- Nsengiyumva, D., 1985. Effet de l'alimentation sur la croissance de la carpe herbivore *Ctenopharyngodon idella* Valenciennes. (Growth of the grass carp, *Ctenopharyngodon idella* Valenciennes, in response to feeding.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Nsengiyumva, V., 1989. Production des alevins monosexes de *Tilapia nilotica* Linnaeus par la méthode du "sex-reversal." (Production of *T. nilotica* fingerlings by sex reversal methods.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Rutikanga, P., 1992. Contribution à l'étude des facteurs intervenant dans le taux d'infestation des *O. niloticus* par les Diplostomatidae (maladie des points noirs). (Factors affecting the infestation rate of *Oreochromis niloticus* by diplostomatid cysts (black spot disease).) Rapport de stage, Ecole Agricole et Vétérinaire de Kabutare, Butare, Rwanda.
- Rwalinda, P., 1990. Enrichissement du compost en azote et phosphore et ses effets sur la production du *Tilapia nilotica* (L.). (Enrichment of compost with nitrogen and phosphorus and its effects on the production of *Tilapia nilotica*, L.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Uwera, M., 1987. Une étude des modalités d'échantillonnage des poissons en étangs piscicoles. (A comparative study of methods for sampling fish in ponds.) Mémoire présenté en vue de l'obtention du grade d'Ingénieur Agronome, Université Nationale du Rwanda, Butare, Rwanda.
- Uzabakirho, J.D., 1989. Etude hydrobiologique des lacs Rwanyakizinga, Mihindi, Hago et Kivumba (dépression de l'Akagera, Rwanda). (Hydrobiological study of Lakes Rwanyakizinga, Mihindi, Hago and Kivumba (Akagera River Basin, Rwanda).) Mémoire présenté en vue de l'obtention du grade de Licencié en Biologie Animale, Université Nationale du Rwanda, Butare, Rwanda.

Publication

- Hanson, B.J., J.F. Moehl, K.L. Veverica, F. Rwangano, and M. Van Speybroeck, 1988. Pond culture of tilapia in Rwanda, a high altitude equatorial African country. In: R.S.V. Pullin, T. Bhukaswan, K. Tonguthai, and J.L. MacLean, (Editors), The Second International Symposium on Tilapia in Aquaculture. ICLARM Conference Proceedings 15, Manila, Philippines, pp. 553-559.

Presentations

- Rurangwa, E. and L. Verheust. Fish culture in Rwanda: A high altitude, developing country in central Africa. Presented to the International Aquaculture Conference and Trade Show at Dublin, Ireland, Jun 1991.
- Rurangwa, E. and L. Verheust. *Oreochromis niloticus* culture in Rwanda: Optimal density and feeding ration in earthen ponds. Poster presented to International Aquaculture Conference and Trade Show at Dublin, Ireland, Jun 1991.

OREGON STATE UNIVERSITY

Theses

- Franco, L., 1991. Nile tilapia (*Oreochromis niloticus*) production in tropical microcosms fertilized with rabbit excreta. M.S. thesis, Oregon State University, Corvallis, Oregon.
- Rwangano, F., 1990. Interactions of input types and water quality on the production of *Oreochromis niloticus* (L.) in Rwandan ponds. M.S. thesis, Oregon State University, Corvallis, Oregon.
- Rwangano, F., 1998. Growth and reproduction of *Oreochromis niloticus* (L.) in tropical aquatic microcosms at fluctuating temperature regimes. Ph.D. dissertation, Oregon State University, Corvallis, Oregon.

Publications

- Balakrishnan, R., K. Veverica, and P. Nyirahabimana, 1992. Proceedings of the colloquium on Rwanda women in aquaculture. Kigembe Station, Rwanda. Women in International Development, Oregon State University, Corvallis, Oregon, 11 pp.
- Balakrishnan, R., K. Veverica, and P. Nyirahabimana, 1993. Rwanda women in aquaculture: Context, contributions and constraints. Office of Women in International Development, Oregon State University, Corvallis, Oregon, 39 pp.
- Balakrishnan, R., K. Veverica, P. Nyirahabimana, and R. Rainey, 1992. An approach to integrate gender variable in Rwanda PD/A CRSP. Women in International Development, Oregon State University, Corvallis, Oregon, 28 pp.
- Bowman, J.R. and J.E. Lannan, 1995. Evaluation of soil pH-percent base saturation relationships for use in estimating the lime requirements of earthen aquaculture ponds. Journal of the World Aquaculture Society, 26(2):172-182.
- Curtis, L.R., F.T. Diren, M.D. Hurley, W.K. Seim, and R.A. Tubb, 1991. Disposition and elimination of 17 α -methyltestosterone in Nile tilapia (*Oreochromis niloticus*). Aquaculture, 99:192-201.
- Sikoki, F.D., R.A. Tubb, and L.R. Curtis, 1986. Inhibition of hepatic UDP-glucuronyl transferase (UDP-GT) activity coincident with elevated plasma sex steroid concentrations during gonadal maturation in carp. In: R.S.V. Pullin and T. Bhukaswan (Editors), The Toxicologist, 6(1):553-559.
- Sikoki, F.D., R.A. Tubb, and L.R. Curtis, 1988. Elevation of sex steroids and inhibition of UDP-glucuronyltransferase are out of phase during gonadal maturation in the common carp. Comparative Biochemistry and Physiology, 92(2):267-272.

Presentations

- Balakrishnan, R. and P. Nyirahaimana. Rwanda women's role in integrated aquaculture systems for resource sustainability. Presented to the Farming Systems Research and Extension Symposium: working paper series at Michigan State University, East Lansing, Michigan, 1992.
- Curtis, L., F. Diren, M. Hurley, and R. Tubb. Minimal residue levels after sex reversal of *Tilapia nilotica* by methyltestosterone but persistent alterations in hepatic detoxication systems. Presented to Federation of American Societies for Experimental Biology at Las Vegas, Nevada, Apr 1988.

- Rwangano, F., M. Van Speybroeck, E. Rurangwa, K. Veverica, and B. Han-son. Fingerling production of *Tilapia nilotica* at the Rwasave Fish Culture Station of the National University of Rwanda. Presented to the World Aquaculture Society Meeting at Honolulu, Hawaii, 4-8 Jan 1988.
- Seim, W. Using Eco-region classification to order pond management strategies. U.S. Forest Service Workshop on Warm Water Fish Management at Bend, Oregon, 1993.
- Tubb, R. The reduction of estradiol by liver enzymes in carp and rainbow trout. Presented to Toxicology Meetings, New Orleans, Mar 1986.

UNIVERSITY OF ARKANSAS AT PINE BLUFF

Publications

- Engle, C., M. Brewster, and F. Hitayezu, 1993. An economic analysis of fish production in a subsistence agricultural economy: The case of Rwanda. Journal of Aquaculture in the Tropics, 8:151-165.
- Engle, C.R., 1997. Optimal resource allocation by fish farmers in Rwanda. Journal of Applied Aquaculture, 7(1):1-17.
- Hishamunda, N., C.M. Jolly, and C.R. Engle, 1996. Estimating *Oreochromis niloticus* production function for small-scale fish culture in Rwanda. Journal of Aquaculture in the Tropics, 11:49-57.

Presentation

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

SOUTHEAST ASIA

Indonesia

INSTITUT PERTANIAN BOGOR

Theses

- Etnawati, N., 1987. The effect of *Oreochromis niloticus* Trewavas production by increasing surface area for attached microorganisms. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
- Gartini, T., 1986. Flow rate dependent changes in turbidity and phosphorus in the water conditioning system at Darmaga. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
- Harahat, I.S., 1987. Changes of nitrogen concentration of the Nile tilapia ponds which were fertilized with chicken manure. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
- Haryani, G.S., 1985. The growth rate, mortality and feeding habits of *Tilapia nilotica* (L.). B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
- Litasari, L., 1985. The composition and abundance of macrobenthos in relation to pond productivity. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
- Radiastuti, F., 1986. The balance of nitrogen from an irrigation canal that flows through a water conditioning system in Darmaga. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
- Subyacto, S., 1985. The relationship between chlorophyll a and Secchi disk visibility in tilapia fish ponds at Darmaga, Bogor. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
- Suratman, I.F., 1985. Composition and abundance of zooplankton in *Tilapia nilotica* (L.) fish ponds fertilized with triple superphosphate at Darmaga. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
- Tumbelaka, R., 1986. Primary productivity of aquaculture ponds at Darmaga. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.

- Widjaja, 1985. Flushing rate of experimental *Tilapia nilotica* (L.) ponds at Darmaga and its relationship to some physical and chemical factors of the ponds. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
- Yulianti, S., 1986. Removal of detergents in irrigation canal water by the water conditioning system at Darmaga, Bogor. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.
- Yulisto, 1985. Effect of fish predation on macrobenthos density in aquaculture ponds. B.S. thesis, Faculty of Fisheries, Institut Pertanian Bogor, Indonesia.

MICHIGAN STATE UNIVERSITY

Theses

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

Publications

- Knud-Hansen, C.F., C.D. McNabb, and T.R. Batterson, 1991. Application of limnology for efficient nutrient utilization in tropical pond aquaculture. Proceedings of the International Association of Theoretical and Applied Limnology, 24:2541–2543.
- Knud-Hansen, C.F., T.R. Batterson, and I.S. Harahat, 1988. Nitrate and ammonia depletion in Indonesian aquaculture ponds fertilized with chicken manure [abstract]. Journal of the World Aquaculture Society, 19:42A.
- Knud-Hansen, C.F., T.R. Batterson, C.D. McNabb, I.S. Harahat, K. Sumantadinata, and H.M. Eidman, 1991. Nitrogen input, primary productivity and fish yield in fertilized freshwater ponds in Indonesia. Aquaculture, 94:49–63.
- Knud-Hansen, C.F., T.R. Batterson, C.D. McNabb, Y. Hadiroseyani, D. Dana, and H.M. Eidman, 1990. Hatchery techniques for egg and fry production of *Clarias batrachus* (Linnaeus). Aquaculture, 89:9–19.
- McNabb, C.D., C.F. Knud-Hansen, T.R. Batterson, and K. Jaiyen, 1991. A systematic approach to maximizing nutrient efficient and growth of Nile tilapia (*Oreochromis niloticus*) under semi-intensive pond culture [abstract]. Journal of the World Aquaculture Society, 22:40A.
- McNabb, C.D., K. Sumawidjaja, B.J. Premo, and K. Sumantadinata, 1984. Aquaculture-CRSP Indonesia project report, Cycle I, first 5-month experiment. Michigan State University, East Lansing, Michigan, 107 pp.
- McNabb, C.D., T.R. Batterson, B.J. Premo, C.F. Knud-Hansen, H.M. Eidman, C.K. Lin, K. Jaiyen, J.E. Hanson, and R. Chuenpagdee, 1990. Managing fertilizers for fish yield in tropical ponds in Asia. In: R. Hirano and I. Hanyu (Editors), Proceedings of The Second Asian Fish-eries Forum. Asian Fisheries Society, Manila, Philippines, pp. 169–172.
- McNabb, C.D., T.R. Batterson, H.M. Eidman, and K. Sumantadinata, 1988. Carbon limitation in fertilized fish ponds in Java [abstract]. Journal of the World Aquaculture Society, 19:51A.
- McNabb, C.D., T.R. Batterson, M. Eidman, B.J. Premo, and K. Sumantadinata, 1985. Aquaculture-CRSP Indonesia project report second
- McNabb, C.D., T.R. Batterson, M. Eidman, C.S. Annett, and K. Sumantadinata, 1985. Aquaculture-CRSP Indonesia project report, Cycle II, first 5-month experiment (Jan–Jun 1985). Michigan State University, East Lansing, Michigan, 105 pp.
- Premo, B.J. and K. Sumantadinata, 1984. Laboratory manual of water quality techniques. Julia Press, Bogor, Indonesia, 43 pp.
- Yusoff, F.M. and C.D. McNabb, 1989. Effects of nutrient availability on primary productivity and fish production in fertilized tropical ponds. Aquaculture, 78:303–319.

Presentations

- Batterson, T.R. The problems of water quality for Indonesian fisheries. Presented to the Seminar series of the Bogor Chapter of the Indonesian Fisheries Society at Bogor, Indonesia, 20 Nov 1985.
- Guttman, H. and C.F. Knud-Hansen. Fish pond management by algal assay. Presented to the World Aquaculture Society Meeting at Orlando, Florida, May 1992.
- McNabb, C.D. Application of limnological technology to fish pond management. Presented to the National Institute of Biological Science at Bogor, Indonesia, Dec 1984.
- McNabb, C.D. Carbon limitation in fish culture ponds in Indonesia. Presented as part of the Visiting Scientists Seminar Series, at Lake Biwa Research Center, Shiga University, Otsu, Japan, Mar 1986.
- McNabb, C.D. Limnology of fish ponds in Java. Presented as part of the Visiting Scientists Seminar Series to College of Fisheries and Marine Science, Agricultural University of Malaysia at Serdang, Malaysia, Feb 1986.
- McNabb, C.D., T.R. Batterson, B.J. Premo, and J.R. Craig. Photosynthetically active radiation in tropical and temperate zone habitats. Presented to the 88th Annual Meeting of the Michigan Academy of Science, Arts, and Letters at Grand Rapids, Michigan, Mar 1984.
- Sumantadinata, K. Genetic characteristics of strains of Indonesian carps. Presented to Special Symposium of the Japanese Fisheries Society at Tokyo, Japan, Feb 1985.

Other

- Batterson, T.R. and C.D. McNabb, Jun–Aug 1986. MSU/CIFAD Visiting Scientist Program. Wardana Ismail, Head, Fisheries Research Facilities, Central Research Institute for Fisheries (CRIFI), Agency for Agricultural Research and Development (AARD), Department of Agriculture, Republic of Indonesia, Jakarta. Eight-week program on water quality techniques, and laboratory equipment and design in support of freshwater aquaculture in Indonesia.
- Batterson, T.R., 1985–1987. Indonesia PD/A CRSP data diskettes for Cycles I, II, and III using LOTUS 1-2-3.
- Kinnunen, R.E. and C.D. McNabb, Mar 1986. Collaborative aquaculture research: Institut Pertanian Bogor and Michigan State University. Improvement of pond culture technology and production. Broadcast: National Educational Television, Jakarta, Indonesia, 15 minutes.
- Kinnunen, R.E. and C.D. McNabb, Mar 1986. Water treatment for small pond fisheries. Broadcast: National News Network, Television of the Republic of Indonesia (TVRI), Jakarta, Indonesia, 3 minutes.
- Knud-Hansen, C.F., 23–29 Nov 1986. Workshop on water quality analyses for aquaculture ponds. Invited by Faculty of Fisheries, University of Brawijaya at Malang, East Java, Indonesia.
- McNabb, C.D., H.M. Eidman, P. Suwignjo, D.L. Garling, K. Sumawidjaja, H.C. Lampe, S.M.H. Simandjuntak, R.E. Kinnunen, R.R. Nitibaskara, J. McAlister, T.R. Batterson, and C.F. Knud-Hansen, 1986. A research plan for Faculty of Fisheries, Institut Pertanian Bogor, Bogor, Indonesia. Michigan State University, East Lansing, Michigan. 30 pp. (Written in both English and Bahasa Indonesian.)
- McNabb, C.D., Mar 1986. Fisheries in the tropics. World Food Day National Teleconference. Michigan State University. Response Panel, East Lansing, Michigan.
- National Educational Television and Television of the Republic of Indonesia (TVRI), Jakarta, Indonesia, 1986. Collaborative aquaculture research: Institut Pertanian Bogor and Michigan State University. Improvement of pond culture technology and production. (Videotape, 33 minutes)

The Philippines

CENTRAL LUZON STATE UNIVERSITY

Theses

- Falla, J.I.B., 2002. Hematological characteristics of genetically male tilapia (GMT) strain of Nile tilapia (*Oreochromis niloticus*) under

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

Publications

- Bolivar, R.B. and G.F. Newkirk, 2000. Response to selection for body weight of Nile tilapia (*Oreochromis niloticus*) in different culture environments. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 12–23.
- Bolivar, R.B., E.B.T. Jimenez, and C.L. Brown, 2000. Tilapia feeding strategy to optimize production in ponds. Fisheries and Aquatic Resources Gazette, 2(2):2–3.
- Bolivar, R.B., E.B.T. Jimenez, and C.L. Brown. Large-scale application of an alternate-day feeding strategy for tilapia growout in the Philippines (submitted by invitation). North American Journal of Aquaculture (NAJA)
- Bolivar, R.B., E.B.T. Jimenez, J.R. Sugue, and C.L. Brown. Effect of stocking size on the yield and survival of Nile tilapia (*Oreochromis niloticus* L.) on-grown in ponds. Submitted, International Society for Tilapia Aquaculture (ISTA) for inclusion in proceedings.
- Brown, C.L., R. Bolivar, E.B. T. Jimenez, and J. Szyper, 2000. Timing of the onset of supplemental feeding of Nile tilapia (*Oreochromis niloticus*) in ponds. In: K. Fitzsimmons and J. Carvalho Filho (Editors), Proceedings of the Fifth International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil, pp. 237–240.
- Jimenez, E.B., R.B. Bolivar, and C.L. Brown. 2004. Cost Containment Options in Semi-Intensive Tilapia Culture: Evaluation of Alternate-Day Feeding Strategy (abstract). World Aquaculture Society Book of Abstracts, page 291.

Presentation

- Bolivar, R., 2003. Invited lecturer, Annual Sales Conference, Fish Feed Manufacturers Professional Group, 17 January 2003. Twenty in attendance.
- Bolivar, R.B. Overview of Tilapia Production in the Philippines. Presentation given at the International Technical and Trade Symposium on Tilapia at Hainan, Haikou, China, on 17–22 Apr 2002.
- Bolivar, R.B.. Tilapia Culture in Bangladesh. Presented at Tilapia Culture in Bangladesh: Constraints and Potential. Dhaka, Bangladesh, April, 2004.
- Brown, C.L. Cost Containment Options in Semi-Intensive Tilapia Culture: Evaluation of Alternate-Day Feeding Strategy. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Brown C.L., R. Bolivar, and E.B. Jimenez, 2003. Feeding strategies to optimize tilapia production in ponds. Aquaculture America 2003, Louisville, Kentucky, February 2003.
- Brown, C.L., R. Bolivar, and E.B. Jimenez, 2003. Moderation in feeding: an economic and environmentally friendly approach to tilapia production. Presented at WAS Annual Meeting, Salvador, Brazil, May 2003.

UNIVERSITY OF HAWAII

Publications and Reports

- Brown, C., R. Bolivar, and E.B. Jimenez, 2003. Moderation in feeding: an economic and environmentally friendly approach to tilapia production (abstract). World Aquaculture Society Book of Abstracts, Salvador Brazil. (in press)

- Brown, C.L., 2003. In Memoriam: Milton H. Stetson. General and Comparative Endocrinology, 130:101.
- Carpenter, K.E., A.W. Fast, V.L. Corre, J.W. Woessner, and R.L. Janeo, 1986. The effects of water depth and circulation on the water
- Cato, J.S. and C.L. Brown (Editors), 2003. Marine ornamental species: collection, culture, and conservation. Iowa State University Press, Ames, Iowa. 395 pp.
- Chiu, Y., M.P. Macahilig, and M.A. Sastrillo, 1986. Preliminary studies of factors affecting the feeding rhythm of milkfish (*Chanos chanos* Forskal). Proceedings of the First Asian Fisheries Forum Meeting at Manila, Philippines, 26–31 May 1986, pp. 547–550.
- Corbin, J., J.C. Cato, and C.L. Brown, 2003. Marine ornamentals industry 2001: Priority recommendations for a sustainable future. In: Cato, J. and C.L. Brown (Editors), Marine Ornamental Species: Collection, Culture, and Conservation. Iowa State University Press, Ames, Iowa. pp. 3–10.
- Corre, V.L., K.E. Carpenter, E.J. Pudadera, and R.D. Fortes, 1986. The effects of feeds and fertilizer on the production of *Oreochromis niloticus* in brackish water ponds. University of Hawaii and University of the Philippines in the Visayas. (unpublished paper)
- Fast, A.W., K.E. Carpenter, V.J. Estilo, and H.J. Gonzales, 1988. Effects of water depth and artificial mixing on dynamics of Philippines brackish water shrimp ponds. Aquacultural Engineering, 7:349–361.
- Hopkins, K.D. and D. Pauly, 1993. Instantaneous mortalities and multivariate models: Applications to tilapia culture in saline water. In: M. Prein, G. Hulata and D. Pauly, (Editors), Multivariate methods in aquaculture research: Case studies of tilapias in experimental and commercial systems. ICLARM, Manila, Philippines, pp. 105–111.
- Hopkins, K.D. and J.D. Bowman, 1993. A research methodology for integrated agriculture-aquaculture farming systems. In: J.K. Wang (Editor), Techniques for Modern Aquaculture. Proceedings of an Aquacultural Engineering Conference, 21–23 Jun 1993, at Spokane, Washington. American Society of Agricultural Engineers. St. Joseph, Michigan, pp. 89–98.
- Hopkins, K.D., 1988. Reporting fishpond yields to farmers. Aquabyte, 1(2):6.
- Szyper, J.P., 1996. Comparison of three mixing devices in earthen culture ponds of four different surface areas. Aquacultural Engineering, 15(5):381–396.
- Szyper, J.P., 1996. Observations and model predictions of daily areal primary production in a eutrophic brackish water culture pond. Ecological Modelling International Journal on Ecological Modelling and Systems Ecology, 88:83–92.
- Young, M.J.A., A.W. Fast, and P. Olin, 1989. Induced maturation and spawning of the Chinese catfish (*Clarias fuscus*). Journal of the World Aquaculture Society, 20(1):7–11.
- Zamora, M.N., 2002. Effect of commercial growth promotant on the growth and survival of genetically male Nile tilapia (*Oreochromis niloticus*). Undergraduate thesis, Central Luzon State University, Philippines. 45 pp.

Presentation

- Brown C.L., R. Bolivar (presenter), and E.B. Jimenez, 2003. Feeding strategies to optimize tilapia production in ponds. Aquaculture America 2003, Louisville, Kentucky, February 2003.
- Brown, C. (presenter), R. Bolivar, and E.B. Jimenez, 2003. Moderation in feeding: an economic and environmentally friendly approach to tilapia production. Presented at WAS Annual Meeting, Salvador, Brazil, May 2003.
- Fast, A.W., K.E. Carpenter, F.J. Estilo, and H.J. Gonzales. Effects of water depth on dynamics of Philippines brackish water shrimp ponds. Presented to the World Aquaculture Society Meeting at Guayaquil, Ecuador, Jan 1987.
- Vera Cruz, E., 2003. Use of IGF-I as a molecular growth indicator in the tilapia. Seminar presented at Florida International University on 24 February 2003.

UNIVERSITY OF THE PHILIPPINES IN THE VISAYAS

Thesis

Pahila, I.G., 1986. Sorbed and soil solution phosphorus in relation to the optimum phosphorus level of lab-lab in some brackish water ponds. M.S. thesis, Dept. of Fisheries, University of the Philippines, Visayas, Philippines.

Publications

- Fortes, R.D., V.L. Corre, Jr., and E. Pudadera, 1986. Effects of fertilizers and feeds as nutrient sources on *Oreochromis niloticus* production in Philippine brackish water ponds. Proceedings of the First Asian Fisheries Forum at Manila, Philippines, May 1986, pp. 121–124.
- Minsalan, C.L.O. and Y.N. Chiu, 1986. Effects of teaseed cake on selective elimination of finfish in shrimp ponds. Proceedings of the First Asian Fisheries Forum at Manila, Philippines, May 1986, pp. 79–82.
- Sanares, R.C., S.A. Katase, A.W. Fast, and K.E. Carpenter, 1986. Water quality dynamics in brackish water shrimp ponds with artificial aeration and circulation. Proceedings of the First Asian Fisheries Forum at Manila, Philippines, May 1986, pp. 83–86.
- Ver, L.M.B. and Y.N. Chiu, 1986. The effect of paddlewheel aerators on ammonia and carbon dioxide removal in intensive pond culture. Proceedings of the First Asian Fisheries Forum, Manila, Philippines,

Thailand

ASIAN INSTITUTE OF TECHNOLOGY

Theses

- Ahmed, S., 1995. Assessment of chlorine as a piscicide in freshwater fish culture. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Amechi, M.E.O., 1995. An assessment of by-catch biomass in experimental fish ponds. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Amirullah, Md., 1989. Nutrient release characteristics of duck manure for Nile tilapia production. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Arifin, Z., 1996. Efficacy of liming and uses of liming materials for shrimp pond management. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Athauda, A.R.S.B., 2000. Ultra-sound immersion techniques to improve the efficiency of sex inversion of male tilapia population. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Baouthong, P., 1995. The effect of feeding regime on growth and body composition of shrimp (*Penaeus monodon*). M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Barte, M., 1996. Effect of aeration on water quality and fish growth in intensive culture of Nile tilapia. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Boonsong, S., 1990. Role of zooplankton in feeding juvenile tilapia (*Oreochromis niloticus*). M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Cao, T.B., 1998. Development of pond culture of Thai Nile tilapia (*Oreochromis niloticus* L.) and its marketability in Hanoi, Vietnam. Ph.D. dissertation, Asian Institute of Technology, Bangkok, Thailand.
- Chan, R., 1997. Interactive effect of feeding frequency and time of feeding for tilapia. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Chughtai, M.A., 1995. Effects of water spinach (*Ipomoea aquatica*) on nutrient regime and fish growth. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Guttman, H., 1991. Assessment of nutrient limitation in fertilized fish ponds by algal assay. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Islam, Md.R., 1995. A field survey of the factors involved in the use of ponds for fish culture in Bangladesh, with emphasis on water quality. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Jatuporn, B., 1997. Effect of aeration on water quality and fish production in fertilized ponds. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Long, N.T., 2003. Stocking ratios of hybrid catfish (*Clarias macrocephalus* x *C. gariepinus*) and Nile tilapia (*Oreochromis niloticus*) in an intensive polyculture. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Luong, N.T. Stocking Ratios of Hybrid Catfish (*Clarias macrocephalus* x *C. Gariepinus*) and Nile Tilapia (*Oreochromis niloticus*) in Intensive Polyculture System. M.S. thesis, AIT.
- Mon, A.A., 2000. Use of lotus (*Nelumbo nucifera*) for nutrient retrieval from pond mud. M.S. Thesis, Asian Institute of Technology, Bangkok, Thailand.
- Muthuwan, V., 1991. Nutrient budget and water quality in intensive marine shrimp culture ponds. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Nadtirrom, P., 2001. Comparison of growth performance of different sex genotypes (XX and XY) of Nile tilapia (*Oreochromis niloticus*) and the effect of androgen treatment. M.S. thesis, Asian Institute of Technology, Pathumthani, Thailand.
- Narong, V., 1990. Effects of phytoplankton on nursing walking catfish fry in static and flow-through water systems. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Nguyen, P.H., 1996. Effects of salinity on fertilization for tilapia culture. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Pautong, A.K., 1991. Role of urea in fertilizing fish ponds. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Qifeng, Y., 1991. Nutrient budget and water quality in integrated walking catfish-tilapia culture. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Rachada, M., 1997. Turbidity in fish ponds in northeast Thailand. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Raghunath, B. Shivappa, 1997. Efficacy of probiotics and disinfectant in controlling luminescent bacteria in shrimp postlarvae under normal and stressed conditions. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Rai, S., 1997. Co-culture of walking catfish with Indian major carps. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Rao, V.G.T., 1989. Gonadal development in environmentally induced breeding of walking catfish *Clarias batrachus* (Linnaeus). M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Rungreungwudhikrai, E.O., 1995. Characterization and classification of off-flavour of Nile tilapia. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Ruttanagosrigit, W., 1997. Organic matter dynamics in a closed intensive culture system for black tiger prawn (*Penaeus monodon*). Ph.D. dissertation, Asian Institute of Technology, Bangkok, Thailand.
- Shrestha, M.K., 1989. Impact of attached microorganism biomass on tilapia (*Oreochromis niloticus*) production. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Suresh, A.V., 1990. Influence of stocking density on red tilapia production in a recirculation system. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Thakur, D.P. New Fish Species Studied for Aquaculture Potential by Aquaculture CRSP Researchers. Aquanews, 18(4):1–3.
- Thakur, D.P., 1996. Water quality and nutrient budget in closed intensive shrimp culture systems. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Ungsethaphan, T., 1995. An on-farm trial to investigate feeding strategies for Nile tilapia (*Oreochromis niloticus*) broodfish. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Vuthana, H., 1995. Fish pond turbidity in Cambodia. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Weerasooriya, A.C., 2001. Effects of AquaMats on Nile tilapia (*Oreochromis niloticus*) fry in earthen ponds. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.

- Wirat, J., 1990. The role of sediments in pond fertility. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Xie, J.J., 1995. Alternative methods for maggot production. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Yi, Y., 1997. An integrated rotation culture system for fattening large Nile tilapia (*Oreochromis niloticus*) in cages and nursing small Nile tilapia in open ponds. Ph.D. dissertation, Asian Institute of Technology, Bangkok, Thailand.

Publications

- Bart, A.N., 2001. The use of ultrasound to enhance transport of compound into fish and fish embryos: A review. *Asian Fisheries Science*, 14: 389–397.
- Bart, A.N., A.R.S.B. Athauda, M.S. Fitzpatrick, and W.M. Contreras-Sánchez, 2003. Ultrasound enhanced immersion protocols for masculinization of Nile tilapia, *Oreochromis niloticus*. *Journal of World Aquaculture Society*, 34(2):210–216.
- Bart, A.N., S. Athauda, M. Fitzpatrick, and W. Contreras-Sánchez, 2002. The use of ultrasound to enhance sex reversal in tilapia using immersion protocol. *World Aquaculture Society*. (accepted)
- Cao, T.B., C.K. Lin, and H. Demaine. Evaluation of low-cost supplemental diets for culture of Nile tilapia in North Vietnam: I. Selection of supplemental diets. *Journal of Asian Fisheries Science*. (in revision)
- Cao, T.B., C.K. Lin, and H. Demaine. Evaluation of low-cost supplemental diets for culture of Nile tilapia in North Vietnam: II. Supplemental feeding rates in fertilized ponds. *Journal of Asian Fisheries Science*. (in revision)
- Edwards, P., C.K. Lin, and A. Yakupitiyage, 2000. Semi-intensive pond aquaculture. In: M.C.M. Beveridge and B.J. McAndrew (Editors), *Tilapias: Biology and Exploitation*. Kluwer Academic Publishers, Netherlands, pp. 377–403.
- Giap, D.H., Y. Yi, N.X. Cuong, L.T. Luu, C.K. Lin, J.S. Diana. Application of GIS and Remote Sensing for Assessing Watershed Ponds for Aquaculture Development In Thai Nguyen, Vietnam. *Proceedings of Map Asia 2003* (<http://gisdevelopment.net/application/nrm/water/overview/ma03166.htm>), October, 2003.
- Knud-Hansen, C. and H. Guttman A comparative analysis of the fixed-input, computer modeling, and algal bioassay approaches for identifying pond fertilization requirements for semi-intensive aquaculture *Aquaculture*, 228: 189–214
- Liao, I.C. and C.K. Lin (Editors), 2000. *Proceedings of the First International Symposium on Cage Aquaculture in Asia*. Asian Fisheries Society, Manila, the Philippines. 312 pp.
- Long, N.T., 2003. Stocking ratios of hybrid catfish (*Clarias macrocephalus* x *C. gariepinus*) and Nile tilapia (*Oreochromis niloticus*) in an intensive polyculture. M.S. thesis, Asian Institute of Technology, Bangkok, Thailand.
- Mon, A.A., Y. Yi, and C.K. Lin. Use of lotus (*Nelumbo nucifera*) for nutrient retrieval from fishpond mud. *Aquacultural Engineering*. (in revision)
- Nadtirom, P., Y. Yi, and G.C. Mair. Comparison of growth performance of different sex genotypes (XX and XY) of Nile tilapia (*Oreochromis niloticus* L.) and the effect of androgen treatment. *Aquaculture*. (accepted)
- Yi, Y. and A. Yakupitiyage, 2001. Feeds in small-scale aquaculture. In: IIRR, IDRC, FAO, NACA, and ICLARM, *Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book*. International Institute of Rural Reconstruction, International Development Research Center, Food and Agriculture Organization of the United Nations, Network of Aquaculture Centers in Asia-Pacific, and International Center for Living Aquatic Resources and Management, pp. 263–268.
- Yi, Y. and C.K. Lin, 2000. Analyses of various inputs for pond culture of Nile tilapia (*Oreochromis niloticus*): Profitability and possible environmental impacts. In: K. Fitzsimmons and J. Carvalho Filho (Editors), *Proceedings of the Fifth International Symposium on Tilapia Aquaculture*. Rio de Janeiro, Brazil, pp. 247–257.
- Yi, Y. and C.K. Lin, 2001. Cage-cum-pond—Integrated aquaculture systems recycle wastes. *Global Aquaculture Advocate*, 4(6):65–66.
- Yi, Y. and C. Kwei Lin Minimizing environmental impacts and reuse of pond effluents and mud. *Aquaculture*, 226:57–68
- Yi, Y. and C.K. Lin, 2001. Effects of biomass of caged Nile tilapia (*Oreochromis niloticus*) and aeration on the growth and yields in a cage-cum-pond integrated culture system. *Aquaculture*, 195:253–267.
- Yi, Y. and C.K. Lin, 2001. Low-cost fertilization in inland pond aquaculture. In: IIRR, IDRC, FAO, NACA, and ICLARM, *Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book*. International Institute of Rural Reconstruction, International Development Research Center, Food and Agriculture Organization of the United Nations, Network of Aquaculture Centers in Asia-Pacific, and International Center for Living Aquatic Resources and Management, pp. 250–253.
- Yi, Y., K. Fitzsimmons, and P. Clayden. Stocking Densities of Nile Tilapia in Tilapia-Shrimp Polyculture Under Fixed Feeding Regime. *Proceedings of the 5th National Symposium on Marine Shrimp, BIOTECH, Thailand*, pp. 100–113.
- Yi, Y., C.K. Lin, and J.S. Diana, 2001. Integrating intensive and semi-intensive culture system to utilize feeding waste. In: IIRR, IDRC, FAO, NACA, and ICLARM, *Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book*. International Institute of Rural Reconstruction, International Development Research Center, Food and Agriculture Organization of the United Nations, Network of Aquaculture Centers in Asia-Pacific, and International Center for Living Aquatic Resources and Management, pp. 250–253.
- Yi, Y., C.K. Lin, and J.S. Diana, 2002. Recycling pond mud nutrients in integrated lotus-fish culture. *Aquaculture*, 212(1–4):213–226.
- Yi, Y., C.K. Lin, and J.S. Diana, 2003. Hybrid catfish (*Clarias macrocephalus* x *C. gariepinus*) and Nile tilapia (*Oreochromis niloticus*) culture in an integrated pen-cum-pond system: growth performance and nutrient budgets. *Aquaculture* 217:395–408.
- Yi, Y., C.K. Lin, and J.S. Diana, 2003. Techniques to mitigate clay turbidity in fertilized earthen fish ponds. *Aquacult. Eng.* 27(1). pp. 39–51.
- Yi, Y., C.K. Lin, and J.S. Diana, 2003. Techniques to mitigate clay turbidity in fertilized earthen fish ponds. *Aquacultural Engineering* 27(1): 39–51.
- Yi, Y., C.K. Lin, and J.S. Diana. Comparison of economic returns for various strategies of Nile tilapia (*Oreochromis niloticus*) Pond Culture. *Asian Fisheries Science*. (in review)
- Yi, Y., C.K. Lin, and J.S. Diana. Effects of clay turbidity on fertilization, and analyses of techniques to mitigate turbidity problems. *Aquacult. Eng.* (in revision)
- Yi, Y., C.K. Lin, and J.S. Diana. Optimization of nitrogen fertilization rate and carrying capacity in Nile tilapia (*Oreochromis niloticus*) ponds. *Journal of the World Aquaculture Society*. (in revision)
- Yi, Y., C.K. Lin, and J.S. Diana. Waste recycling in fish pond culture through integrated cage-cum-pond and pen-cum-pond culture systems. In: *Proceedings of the Third World Fisheries Congress*. American Fisheries Association. (in press)
- Yi, Y., C. Kwei Lin and James S. Diana Waste Recycling in Fish Pond Culture through Integrated Culture Systems *American Fisheries Society, Symposium 38*, Bethesda, Maryland, pp. 265–270
- Yi, Y., Potjanee Clayden and Kevin Fitzsimmons Stocking Densities of Nile Tilapia in Tilapia-Shrimp Polyculture Under Fixed Feeding Regime *5th National Symposium on Marine Shrimp, BIOTECH, Thailand*, pp. 100–113

Presentations

- Bart, A. and A. Wahab. Technological Constraints and Future of Tilapia Culture in Bangladesh. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka Bangladesh, April, 2004.
- Bart, A. (presenter) and D.V. Trung. Controlled reproduction of an indigenous herbivorous species, *Spinibarbus denticulatus*, in South-

- east Asia. International Organic Aquaculture Workshop, Minneapolis, Minnesota, July 2003.
- 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. Controlled Reproduction of Indigenous Species to Prevent the Loss of Biodiversity: A Case Study of Herbivorous Species *Spinibarbus denticulatus* in Southeast Asia. Presented at World Aquaculture Society Annual Meeting, Honolulu, Hawaii, March, 2004.
- 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.
- Bart, A. Research proposal writing for external funding in aquaculture and fisheries. 7 day workshop, Rajandrapur, Bangladesh, 25–31 January 2003. Audience included aquaculture and fisheries university faculty from 5 universities.
- Bart, A.N. and A.K. Htin, 2002. Advances in cryopreservation of zebrafish, *Brachydanio rerio*, embryos. Presented to Aquaculture America 2002 at San Diego, California, 27–30 Jan 2002.
- Bart, A.N. Progress towards cryopreservation of fish embryos. Presented to World Aquaculture 2002 at Beijing, China, 23–27 Apr 2002.
- Bart, A.N. Seed production of farmed fish: Critical issues for Asia. Presented to the Ag-Asia 2000 Conference, Bangkok, Thailand, 9–12 Nov 2000.
- Bart, A.N. The use of ultrasound in mass marking of fish population, drug delivery, DNA transfer and cryopreservation of fish embryos. Presented to the International Conference on Advanced Technologies in Fisheries and Marine Sciences at Nagercoli, India, 2–6 Feb 2001.
- Bart, A.N., A.R.S.B. Athauda, M.S. Fitzpatrick, and W.M. Contreras-Sánchez. Ultrasound enhanced masculinization of Nile tilapia in immersion protocol. Presented to World Aquaculture 2002 at Beijing, China, 23–27 Apr 2002.
- Chen, G.Z., Y. Yi, Z.W. Wu, H. Miu, and Q.M. Zhang, 2001. Recent development of integrated rice-fish culture in China. Presented to the Sixth Asian Fisheries Forum at Kaoshiung, Taiwan, 25–30 Nov 2001.
- Clayden, P. Stocking Densities of Nile Tilapia in Tilapia-Shrimp Polyculture Under Fixed Feeding Regime. Presented at Thai National Symposium of Marine Shrimp, Bangkok, Thailand, March, 2004.
- Clayden, P. Tilapia-Shrimp Polyculture Under Fixed Feed Rations at Low Salinity Water. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Derun, Y. Effect of Water Depth on Growth and Survival of *Penaeus monodon* in Hapas in Outdoor Concrete Tanks. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Giap, D.H. Comparison of Larval Performance Between Thai and Vietnamese Freshwater Giant Prawn, *Macrobrachium rosenbergii* (de Man): A Preliminary Study. Presented at the International Symposium of Freshwater Prawns. Kochi, India, August, 2003.
- Giap, D.H. Current Status and Socio-Economic Comparisons of Small-Scale Coastal Shrimp Culture Systems in Northern Vietnam. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Giap, D.H. Effect of Different Fertilization and Feeding Regimes on the Production of Integrated Rice-Prawn (*Macrobrachium rosenbergii*) Culture. Presented at the International Symposium of Freshwater Prawns. Kochi, India, August, 2003.
- Giap, D.H. and N.X. Cuong. Application of GIS and Remote Sensing for Assessing Watershed Ponds for Aquaculture Development in Thai Nguyen Vietnam. Presented at Map Asia 2003. Kuala Lumpur, Malaysia, October 2003.
- Lin, C.K. Recycling Wastewater from Intensive Hybrid Catfish (*Clarias macrocephalus* x *C. gariepinus*) Culture for Semi-Intensive Nile Tilapia (*Oreochromis niloticus*) Culture in Cement Tanks. Presented at First International Symposium On Southeast Asian Water Environment. Asian Institute of Technology, October, 2003.
- Lin, C.K. Tilapia Culture in Thailand. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka, Bangladesh, April, 2004.
- Lin, C.K. and Y. Yi, 2001. Development in integrated aquaculture in Southeast Asia. In: L.M.B. Garcia (Editor), Responsible Aquaculture Development in Southeast Asia. Proceedings of the Seminar-Workshop on Aquaculture Development in Southeast Asia, 12–14 Oct 1999. Southeast Asian Fisheries Development Center (SEAFDEC), Iloilo, Philippines, pp. 77–88.
- Lin, C.K. and Y. Yi. Minimizing environmental impacts and reuse of pond effluents and mud. Special Volume for the Proceedings of AIP Work-shop: Management of Aquaculture Effluents. Aquaculture. (in review)
- Luong, V.C. Development of a Trophic Box Model to Assess Potential of Ecologically Sound Management for Cove Aquaculture Systems in Tri An Reservoir of Vietnam. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Luu, L.T., Y. Yi, C.K. Lin, J.S. Diana, and N.X. Cuong. Assessing watershed ponds for aquaculture development: A case study in Thai Nguyen Province, Vietnam. Presented at the annual meeting of WAG in Beijing, China, 23–27 Apr 2002.
- Nadtirom, P., Y. Yi, and G. Mair. Comparison of growth performance of different sex genotypes (XX and XY) of Nile tilapia (*Oreochromis niloticus* L.) and the effect of androgen treatment. Presented to World Aquaculture 2002 at Beijing, China, 23–27 Apr 2002.
- Phuong, N.T. Environmental Impacts for Cage Culture for Catfish in Vietnam. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Phuong, N.T. Tilapia in Vietnam. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka, Bangladesh, April, 2004.
- Phuong, N.T., Y. Yi, C.K. Lin, and J.S. Diana. Current status of Pangasius catfish cage culture in Vietnam. Presented to World Aquaculture 2002 at Beijing, China, 23–27 Apr 2002.
- Shivakoti, G. and J. Mazumder. Socioeconomic Constraints of Tilapia Production in Bangladesh. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka, Bangladesh, April, 2004.
- Shrestha, M.K. Polyculture of Grass Carp and Nile Tilapia With Napier Grass as the Sole Nutrient Input. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Shrestha, M.K. and Rai, A. Tilapia Culture in Nepal. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka, Bangladesh, April, 2004.
- Wahab, A. On-Farm Trials of Different Fertilization Regimes in Bangladesh. Presented at Asia-Pacific Aquaculture 2003. Bangkok, Thailand, September, 2003.
- Wahab, A. On-station trials of different fertilization regimes used in Bangladesh (10ATR4A). Seminar, BRAC center, Dhaka, Bangladesh, 26 June 2003. Audience consisted of government workers.
- Wahab, M.A., Y. Yi, C.K. Lin, and J.S. Diana. Comparison of effects of different fertilization regimes on fish production, water quality, effluent and economic returns in Bangladesh. Presented to World Aquaculture 2002 at Beijing, China, 23–27 Apr 2002.
- Wu, Z.W. and Y. Yi, 2001. Culture-based reservoir fisheries in China. Presented to Aquaculture America 2002, San Diego, California, 27–30 Jan 2002.
- Wu, Z.W. and Y. Yi, 2001. Fertilization regime and application method in reservoirs. Presented to the Sixth Asian Fisheries Forum at Kaoshiung, Taiwan, 25–30 Nov 2001.
- Wu, Z.W., J.W. Guo, and Y. Yi. Current status and sustainability of cage culture in reservoirs: A case study in China. Presented to the First International Symposium on Cage Aquaculture in Asia at Tungkuang, Taiwan, 2–6 Nov 1999.
- Yi, Y. (presenter), C.K. Lin, and J.S. Diana. Recycling pond mud nutrients in integrated lotus-fish culture. World Aquaculture Society Annual Meeting, Salvador, Brazil, May 2003.
- Yi, Y. (presenter), W. Saelee, P. Nadtirom, A.A. Mon, and K. Fitzsimmons. Tilapia-shrimp polyculture at low salinity water:

- stocking densities of Nile tilapia and feeding strategies. World Aquaculture Society Annual Meeting, Salvador, Brazil, May 2003.
- Yi, Y. Brief introduction of PD/A CRSP activities in the past two decades. Seminar, BRAC center, Dhaka, Bangladesh, 26 June 2003. Audience consisted of government workers.
- Yi, Y. Fertilization strategies for tilapia culture developed by PD/A CRSP. Seminar, BRAC center, Dhaka, Bangladesh, 26 June 2003. Audience consisted of government workers.
- Yi, Y. Integrated Cage-Cum-Pond Aquaculture Systems: Stocking Densities of Caged High Valued Species in Carp Polyculture Ponds. Presented at World Aquaculture Society Annual Meeting, Honolulu, Hawaii, March, 2004.
- Yi, Y. Managing wastes from shrimp ponds. University of Agriculture and Forestry, HCMC, Vietnam, 17 March 2003.
- Yi, Y. Minimizing environmental impacts of aquaculture. Bangladesh Agricultural University, Mymensingh, Bangladesh, 23 March 2003.
- Yi, Y. Minimizing environmental impacts of aquaculture. World Aquaculture Society Annual Meeting, Salvador, Brazil, May 2003.
- Yi, Y. Pond dynamics. Lecture presented at Third Country Training Program on Freshwater Aquaculture (Thailand Department of Fisheries and Japan International Cooperation Agency), 1 July 2003. Audience consisted of trainees from ten South and Southeast Asian countries.
- Yi, Y. Strategies of Fertilization and Supplemental Feeding for Nile Tilapia Culture. Presented at Tilapia Culture in Bangladesh: Constraints and Potentials, Dhaka, Bangladesh, April, 2004.
- Yi, Y., C.K. Lin, and J.S. Diana, 2001. Red tilapia (*Oreochromis* sp.) culture in brackishwater ponds. Presented to the Sixth Asian Fisheries Forum at Kaoshiung, Taiwan, 25–30 Nov 2001.
- Yi, Y., C.K. Lin, and J.S. Diana. Comparison of economic return, nutrient utilization efficiency and environmental impact among different culture systems of Nile tilapia *Oreochromis niloticus*. Presented to Aquaculture America 2001 at Orlando, Florida.

AUBURN UNIVERSITY

Publications

- Boyd, C.E. and P. Munsiri, 1996. Phosphorus adsorption capacity and availability of added phosphorus in soils from aquaculture areas in Thailand. *Journal of the World Aquaculture Society*, 27(2):160–167.
- Boyd, C.E. and P. Munsiri, 1997. Water quality in laboratory soil-water microcosms with soils from different areas of Thailand. *Journal of the World Aquaculture Society*, 28(2):165–170.

Presentation

- Boyd, C.E. Water quality in laboratory soil-water microcosms with soils from different areas of Thailand. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.

CENTRAL LUZON STATE UNIVERSITY

Presentation

- Sevilleja, R. Adoption and economics of tilapia farming technology in the Philippines. Presented to the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET 2000) at Corvallis, Oregon, 10–13 Jul 2000.

MICHIGAN STATE UNIVERSITY

Publications

- Knud-Hansen, C.F. and A.K. Pautong, 1993. On the role of urea in pond fertilization. *Aquaculture*, 114:273–283.
- Knud-Hansen, C.F. and T.R. Batterson, 1994. Effect of fertilization frequency on the production of Nile tilapia (*Oreochromis niloticus*). *Aquaculture*, 123:271–280.

- Knud-Hansen, C.F., 1992. Analyzing standard curves in the chemistry of waters used for aquaculture. *NAGA*, 15:16–19.
- Knud-Hansen, C.F., 1992. Pond history as a source of error in fish culture experiments: a quantitative assessment using covariate analysis. *Aquaculture*, 105:21–36.
- Knud-Hansen, C.F., 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.
- Knud-Hansen, C.F., T.R. Batterson, and C.D. McNabb, 1993. The role of chicken manure in the production of Nile tilapia, *Oreochromis niloticus* (L.). *Aquaculture and Fisheries Management*, 24:483–493.
- McNabb, C.D., T.R. Batterson, C.K. Lin, K. Jaiyen, J.E. Hanson, and R. Chuenpagdee, 1989. Fish yield with nitrogen supplemented organic fertilizers [abstract]. *Journal of the World Aquaculture Society*, 20:56A.
- Shevgoor, L., C.F. Knud-Hansen, and P.E. Edwards, 1994. An assessment of the role of buffalo manure for pond culture of tilapia, part 3: Limiting factors. *Aquaculture*, 126:107–118.
- Shrestha, M.K. and C.F. Knud-Hansen, 1994. Increasing attached microorganism biomass as a management strategy for Nile tilapia (*Oreochromis niloticus*) production. *Aquacultural Engineering*, 13:101–108.

Presentations

- Knud-Hansen, C. 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.
- Knud-Hansen, C. The algal bioassay fertilization strategy: an ecological approach for efficient natural food production in aquaculture ponds. Presented at ISEES 2003 International Organic Aquaculture Workshop, Minneapolis, Minnesota, July 2003.
- Knud-Hansen, C.F. and A.K. Pautong. The role of urea in fishpond fertilization. Presented to the World Aquaculture Society Meeting at Orlando, Florida, May 1992.
- Knud-Hansen, C.F. and C.K. Lin. Strategies for stocking Nile tilapia (*Oreochromis niloticus*) in fertilized ponds. Presented to the Third International Symposium on Tilapia in Aquaculture at Abidjan, Côte d'Ivoire, Africa, Nov 1991.

Other

- Knud-Hansen, C.F. and T.R. Batterson, 1987–1992. Thailand PD/A CRSP data diskettes for Work Plans IV–VI experiments using LOTUS 123.

UNIVERSITY OF HAWAII

Publications

- Hopkins, K.D. and A. Yakupitiyage, 1991. Bias in seine sampling of tilapia. *Journal of the World Aquaculture Society*, 22(4):260–262.
- Hopkins, K.D., 1992. Reporting fish growth: A review of the basics. *Journal of World Aquaculture Society*, 23(3):173–179.
- Hopkins, K.D., M.L. Hopkins, and D. Pauly, 1988. A multivariate model of tilapia growth, applied to seawater tilapia culture in Kuwait. In: R.S.V. Pullin, T. Bhukaswan, K. Tonguthai, and J.L. MacLean (Editors), *The Second International Symposium on Tilapia in Aquaculture*. ICLARM Conference Proceedings 15, Manila, Philippines, pp. 29–39.
- Szyper, J. and K.D. Hopkins, 1996. Effects of pond depth and mechanical mixing on production of *Oreochromis niloticus* in manured earthen ponds. In: R.S.V. Pullin, J. Lazard, M. Legendre, and J.B. Amon Kothias (Editors), *The Third International Symposium on Tilapia in Aquaculture*. ICLARM Conference Proceedings 41, Manila, Philippines, pp. 152–159.

- Szyper, J., J. Rosenfeld, R.H. Piedrahita, and P. Giovannini, 1992. Diel cycles of planktonic respiration rates in briefly incubated water samples from a fertile earthen pond. *Limnology and Oceanography*, 37:1193–1201.
- Szyper, J.P. and C.K. Lin, 1990. Techniques for assessment of stratification and effects of mechanical mixing in tropical fish ponds. *Aquacultural Engineering*, 9:151–165.
- Szyper, J.P. and J.M. Ebeling, 1993. Photosynthesis and community respiration at three depths during a period of stable phytoplankton stock in a eutrophic brackish water culture pond. *Marine Ecology Progress Series*, 94:229–238.
- Szyper, J.P., C.K. Lin, D. Little, S. Setboonsarng, A. Yakupitiyage, P. Edwards, and H. Demaine, 1995. Techniques for efficient and sustainable mass production of tilapia in Thailand. Proceedings, Sustainable Aquaculture 95. Pacific Congress on Marine Science and Technology, pp. 349–356.
- Szyper, J.P., K. Hopkins, and C.K. Lin, 1991. Production of *Oreochromis niloticus* (L.) and ecosystem dynamics in manured ponds of three depths. *Aquaculture and Fisheries Management*, 22:385–396.
- Presentation**
- Emberson, C. and K. Hopkins. Intensive culture of *Penaeus stylirostris* in plastic-lined tanks. Poster presented to the World Aquaculture Society Meeting at San Diego, California, 1–4 Feb 1995.
- THE UNIVERSITY OF MICHIGAN
- Theses**
- Clarke, M., 2003. Shrimp aquaculture brownfields: social, environmental, and economic issues determining rehabilitation options. M.S. thesis, University of Michigan. 95 pp.
- Lin, C.K. and Y. Yi. Minimizing environmental impacts and reuse of pond effluents and mud. Special volume for the Proceedings of AIP Workshop: Management of Aquaculture Effluents. *Aquaculture*. (in revision)
- Tain, F.H., 1999. Impacts of aquaculture extension on small-scale *Oreochromis niloticus* production in northeastern Thailand. M.S. thesis, The University of Michigan, Ann Arbor, Michigan.
- Wirat, J., 1996. Nutritional input of nitrogen in fish ponds through fixation by blue-green algae. Ph.D. dissertation, Asian Institute of Technology, Bangkok, Thailand.
- Publications**
- Buurma, B.J. and J.S. Diana, 1994. The effects of feeding frequency and handling on growth and mortality of cultured walking catfish, *Clarias fuscus*. *Journal of the World Aquaculture Society*, 25:175–182.
- Cao, T.B. and C.K. Lin, 1995. Shrimp culture in Vietnam. *World Aquaculture*, 26:27–33.
- Diana, J., C.K. Lin, and Y. Yi, 1996. Timing of supplemental feeding
- Diana, J.S. and A. Fast, 1989. The effects of water exchange rate and density on yield of the walking catfish, *Clarias fuscus*. *Aquaculture*, 78:267–276.
- Diana, J.S. and C.K. Lin, 1998. The effects of fertilization on growth and production of Nile tilapia in rain-fed ponds. *Journal of the World Aquaculture Society*, 29:405–413.
- Diana, J.S. and D. Ottey, 1983. Biological principles of pond culture: Fish. In: J.E. Lannan, R.O. Smitherman, and G. Tchobanoglous (Editors), *Principles and Practices of Pond Aquaculture: A State of the Art Review*. Oregon State University Press, Corvallis, Oregon, pp. 55–66.
- Diana, J.S., 1993. Conservation and utilization of genetic resources in capture and culture fisheries. In: C.S. Potter, J.I. Cohen, and D. Janczewski (Editors), *Perspectives on Biodiversity: Case Studies of Genetic Resource Conservation and Development*. American Association for the Advancement of Science, Washington, DC, pp. 89–104.
- Diana, J.S., 1995. *Biology and Ecology of Fishes*. Biological Sciences Press, Carmel, Indiana, 441 pp.
- Diana, J.S., C.K. Lin, and K. Jaiyen, 1994. Supplemental feeding of tilapia in fertilized ponds. *Journal of the World Aquaculture Society*, 25:497–506.
- Diana, J.S., C.K. Lin, and P.J. Schneeberger, 1991. Relationships among nutrient inputs, water nutrient concentrations, primary production, and yield of *Oreochromis niloticus* in ponds. *Aquaculture*, 92:323–341.
- Diana, J.S., D.J. Dettweiler, and C.K. Lin, 1991. Effect of Nile tilapia (*Oreochromis niloticus*) on the ecosystem of aquaculture ponds, and its significance to the trophic cascade hypothesis. *Canadian Journal of Fisheries and Aquatic Sciences*, 48(2):183–190.
- Diana, J.S., P.J. Schneeberger, and C.K. Lin, 1988. Relationships between primary production and yield of tilapia in ponds. In: R.S.V. Pullin, T. Bhukaswan, K. Tonguthai, and J.L. MacLean (Editors), *The Second International Symposium on Tilapia in Aquaculture*. ICLARM Conference Proceedings 15, Manila, Philippines, pp. 1–6.
- Diana, J.S., S.L. Kohler, and D.R. Ottey, 1988. A yield model for walking catfish production in aquaculture systems. *Aquaculture*, 71:23–35.
- Edwards, P., C.K. Lin, and A. Yakupitiyage, 2000. Semi-intensive pond aquaculture. In: M.C.M. Beveridge and B.J. McAndrew (Editors), *Tilapias: Biology and Exploitation*. Kluwer Academic Publishers, Dordrecht, the Netherlands, pp. 377–403.
- Lin, C., 1983. Biological principles of pond culture: Phytoplankton and macrophytes. In: J.E. Lannan, R.O. Smitherman, and G. Tchobanoglous (Editors), *Principles and Practices of Pond Aquaculture: A State of the Art Review*. Oregon State University Press, Corvallis, Oregon, pp. 39–43.
- Lin, C.K. and J.S. Diana, 1995. Co-culture of catfish (*Clarias macrocephalus* x *C. gariepinus*) and tilapia (*Oreochromis niloticus*) in ponds. *Aquatic Living Resources*, 8:449–454.
- Lin, C.K. and K. Kaewpaitoon, 2000. An overview of freshwater cage culture in Thailand. In: I.C. Liao and C.K. Lin (Editors), *Proceedings of the First International Symposium on Cage Aquaculture in Asia*. Asian Fisheries Society, Manila, the Philippines, pp. 237–242.
- Lin, C.K. and M. Boonyaratpalin, 1988. An analysis of biological characteristics of *Macrobrachium rosenbergii* in relation to pond production and marketing in Thailand. *Aquaculture*, 74:205–215.
- Lin, C.K. and Y. Yi. Development of integrated aquaculture in Southeast Asia. In: Proceedings of the SEAFDEC Workshop. (in press)
- Lin, C.K. and Y. Yi. Minimizing Environmental Impacts of Freshwater Aquaculture and Reuse of Pond Effluents and Mud. *Aquaculture* 226(1-4):57-68.
- Lin, C.K., 1986. Acidification and reclamation of acid sulfate soil fishponds in Thailand. In: J.L. MacLean, L.B. Dizon, and L.V. Hosillos (Editors), *The First Asian Fisheries Forum*. Asian Fisheries Society, Manila, Philippines, pp. 71–74.
- Lin, C.K., 1986. Nutrient dynamics between inorganic and organic fertilization in tilapia culture ponds. Proceedings of the 24th Kasetsart University Conference on Fisheries, pp. 174–182.
- Lin, C.K., 1989. Occurrence of mass mortality of black tiger prawns in Taiwan. *Thai Fisheries Gazette*, 42:209–216.
- Lin, C.K., 1989. Prawn culture in Taiwan: What went wrong? *World Aquaculture*, 20:19–20.
- Lin, C.K., 1990. Integrated culture of walking catfish (*Clarias macrocephalus*) and tilapia (*Oreochromis niloticus*) in earthen ponds. In: R. Hirano and I. Hanyu (Editors), *Proceedings of the Second Asian Fisheries Forum*. Asian Fisheries Society, Manila, Philippines, pp. 209–212.
- Lin, C.K., J.S. Diana, and Y. Yi. Stocking densities and fertilization regimes for Nile tilapia (*Oreochromis niloticus*) production in ponds with supplemental feeding. *Journal of the World Aquaculture Society*. (in review)
- Lin, C.K., K. Jaiyen, and W. Muthuwana, 1990. Integrated culture of intensive and semi-intensive aquaculture: Concept and example. *Thai Fisheries Gazette*, 43:425–430.

- Lin, C.K., M.K. Shrestha, Y. Yi, and J.S. Diana, 2001. management to minimize the environmental impacts of pond effluent: Harvest draining technique and effluent quality. *Aquacultural Engineering*, 25(2):125-135.
- Lin, C.K., V. Tansakul, and C. Apinpath, 1988. Biological nitrogen fixation as a source of nitrogen input in fishponds. In: R.S.V. Pullin, T. Bhukaswan, K. Tonguthai, and J.L. MacLean (Editors). The Second International Symposium on Tilapia in Aquaculture. ICLARM Conference Proceedings 15, Manila, Philippines, pp. 53-58.
- Liu, K.M. and W.Y.B. Chang, 1992. Bioenergetic modelling of effects of fertilization, stocking density, and spawning on growth of the Nile tilapia, *Oreochromis niloticus* (L.). *Aquaculture and Fisheries Management*, 23:291-301.
- Muthuwana, W., V. Tansakul, and C.K. Lin, 1986. Nutrient dynamics between inorganic and organic fertilized ponds for tilapia culture. Proceedings of the Kasetsart University Agricultural Conference, Jan 1985.
- Nash, G., S. Chinabut, and C. Limsuwan, 1987. Idiopathic muscle necrosis in the freshwater prawn, *Macrobrachium rosenbergii* (de Man), cultured in Thailand. *Journal of Fish Diseases*, 10:109-120.
- Nguyen, M.N. and C.K. Lin, 1996. *Penaeus monodon* seed production in central Vietnam. *World Aquaculture*, 27:6-18.
- Shrestha, M. and C.K. Lin. Recycling of pond mud nutrients to cowpea and taro crops. *Nutrient Cycling in Agri-Ecosystems*. (submitted)
- Shrestha, M.K. and C.K. Lin, 1996. Phosphorus fertilization strategy in fish ponds based on sediment phosphorus saturation level. *Aquaculture*, 142:207-219.
- Suresh, A.V. and C.K. Lin, 1992. Effect of stocking density on water quality and production of red tilapia in a recirculated water system. *Aquaculture Engineering*, 11:1-22.
- Suresh, A.V. and C.K. Lin, 1992. Tilapia culture in saline waters: A review. *Aquaculture*, 106:201-226.
- Tavarutmaneegul, P. and C.K. Lin, 1988. Breeding and rearing of sand goby (*Oxyeleotris marmoratus*, Blk.) fry. *Aquaculture*, 69:299-305.
- Yi, Y. and C.K. Lin, 2000. Integrated cage culture in ponds: Concepts, practice and perspectives. In: I.C. Liao and C.K. Lin (Editors), Proceedings of the First International Symposium on Cage Aquaculture in Asia. Asian Fisheries Society, Manila, the Philippines, pp. 217-224.
- Yi, Y. and C.K. Lin. Analyses for various inputs for pond culture of Nile tilapia (*Oreochromis niloticus*): Profitability and possible environmental impacts. *Aquaculture Economics and Management*. (accepted)
- Yi, Y. and C.K. Lin. Comparative economic analyses for various grow-out strategies of Nile tilapia (*Oreochromis niloticus*) in earthen ponds. *Aquaculture Economics and Management*. (accepted)
- Yi, Y., 1998. A bioenergetics growth model for Nile tilapia (*Oreochromis niloticus*) based on limiting nutrients and fish standing crop in fertilized ponds. *Aquacultural Engineering*, 18:157-173.
- Yi, Y., 1999. Modeling growth of Nile tilapia (*Oreochromis niloticus*) in a cage-cum-pond integrated culture system. *Aquacultural Engineering*, 21:113-133.
- Yi, Y., C.K. Lin, and J.S. Diana, 1996. Influence of Nile tilapia (*Oreochromis niloticus*) stocking density in cages on their growth and yield in cages and in ponds containing the cages. *Aquaculture*, 146:205-215.
- Presentations**
- Alimuzaman, C. and C.K. Lin. Aeration effects on erosion and water circulation in round and rectangular ponds. Presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.
- Diana, J.S. Intergrated Cage-Cum Pond Aquaculture Systems: A Conceptual Model. Presented at World Aquaculture Society Annual Meeting, Honolulu, Hawaii, March, 2004.
- Diana, J.S. and C.K. Lin. Effects of fertilization rate on primary production and yield of tilapia in ponds. Presented to the World Aquaculture Society Meeting at Honolulu, Hawaii, Jan 1988.
- Diana, J.S. and C.K. Lin. Supplemental feeding for production of Nile tilapia *Oreochromis niloticus*. Presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.
- Diana, J.S., C.K. Lin, and D. Dettweiler. Cascading trophic interactions: A test of the hypothesis using tilapia culture data. Presented to the World Aquaculture Society Meeting at Los Angeles, California, Feb 1989.
- Kaewprakaisaengkul, C., C.K. Lin, and Y. Yi. Construction and application of hapa washer. Poster presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10-14 Nov 1998.
- Lin C.K., M.K. Shrestha, J.S. Diana, and D.P. Thakur. Management to minimize the environmental impacts of pond draining: Harvest draining technique and effluent quality, Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10-14 Nov 1998.
- Lin C.K., Y. Yi, and J.S. Diana. Effects of management strategy on nutrient budgets in Nile tilapia (*Oreochromis niloticus*) ponds. Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10-14 Nov 1998.
- Lin, C.K. and J. Szyper. Stratification of temperature and dissolved oxygen in tropical fish ponds. Presented to the World Aquaculture Meeting at Halifax, Jun 1990.
- Lin, C.K. and J.S. Diana. Fertilization effects on pond carrying capacity in extensive culture of tilapia (*Oreochromis niloticus*). Presented to the Second International Symposium on Tilapia in Aquaculture at Bangkok, Thailand, 1987.
- Lin, C.K. and K. Kaewpaitoon. An overview of freshwater cage culture in Thailand. Presented to the First International Symposium on Cage Aquaculture in Asia at Tungkang, Taiwan, 2-6 Nov 1999.
- Lin, C.K. and S. Auworatham. Effects of inorganic and organic fertilizers on zooplankton production in tilapia ponds. Presented to the 25th Kasetsart University Conference at Bangkok, Thailand, 1987.
- Lin, C.K. and S. Kaewchum. Application of bioremediation in intensive culture of black tiger shrimp (*Penaeus monodon*). Presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.
- Lin, C.K. and Y. Yi. Comparative economic analyses for different grow-out strategies of Nile tilapia in earthen ponds. Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10-14 Nov 1998.
- Lin, C.K. and Y. Yi. Development of integrated aquaculture in Southeast Asia. Presented to the Workshop on Responsible Aquaculture Development in Southeast Asia at the Southeast Asian Fisheries Development Center (SEAFDEC), Iloilo, Philippines, 11-15 Oct 1999.
- Lin, C.K. Status of aquaculture and fisheries management in Mekong Delta. Presented to the International Symposium on Mahakum Delta at Jakarta, Indonesia, 4 Apr 2001.
- Lin, C.K., E. Sae-Loaw, and V. Tansakul. Rearing post-larvae of *Macrobrachium rosenbergii* at high stocking density in concrete tanks. Presented to the 25th Kasetsart University Conference at Bangkok, Thailand, 1987.
- Lin, C.K., M. Boonyaratpalin, and Y. Musig. Biological characteristics of *Macrobrachium rosenbergii* (de Man) in relation to pond production and marketing. Presented to the First Asian Fisheries Society Forum at Manila, Philippines, May 1986.
- Lin, C.K., S. Auworatham, and V. Tansakul. Dietary consumption of zooplankton by tilapia in fertilized ponds. Presented to the Thai Fisheries Academy Seminar, 1986.
- Lin, C.K., V. Tansakul, W. Muthuwana, and S. Auworatham. Production and utilization of organic carbon in tilapia culture and ponds. Presented to the Thai Fisheries Academy Seminar, 1986.
- Lin, C.K., W. Muthuwana, V. Tansakul, S. Auworatham, and C. Apinapat. Nutrient dynamics between inorganic and organic fertilized ponds for tilapia culture. Presented to the Thai Fisheries Academy Seminar, 1986.
- Musig, Y., M. Boonyaratpalin, and C.K. Lin. Water quality in *Macrobrachium* growout ponds. Presented to the 25th Kasetsart University Conference at Bangkok, Thailand, 1987.
- Muthuwana, W. and C.K. Lin. Water quality and nutrient budget in intensive shrimp culture ponds. Presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.

- Pant J., P. Promthong, C.K. Lin, and H. Demaine. Fertilization of ponds with inorganic fertilizers: Low cost technologies for small-scale farmers. Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10–14 Nov 1998.
- Tansakul, V., T. Sae-Lee, and E. Sae-Loaw. Acute toxicity and treatment effect of formalin on early larval prawns, *Macrobrachium rosenbergii* (de Man). Presented to the 25th Kasetsart University Conference at Bangkok, Thailand, 1987.
- Yi, Y. A bioenergetics growth model for Nile tilapia (*Oreochromis niloticus*) based on limiting nutrients and fish standing crop in fertilized ponds. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Yi, Y. An integrated cage culture system in earthen ponds: A bioenergetics growth model for Nile tilapia. Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10–14 Nov 1998.
- Yi, Y. and C.K. Lin. An integrated cage culture system in earthen ponds: Stocking densities of caged Nile tilapia (*Oreochromis niloticus*). Presented to the Fourth Asian Fisheries Forum at Beijing, China, Oct 1995.
- Yi, Y. and C.K. Lin. An integrated cage culture system in earthen ponds: biomass of caged Nile tilapia (*Oreochromis niloticus*). Presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.
- Yi, Y. and C.K. Lin. An integrated rotation culture system for fattening large Nile tilapia in cages and nursing small Nile tilapia in open ponds. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
- Yi, Y. and C.K. Lin. Integrated cage culture in ponds: Concepts, practice and perspectives. Presented to the First International Symposium on Cage Aquaculture in Asia at Tungkang, Taiwan, 2–6 Nov 1999.
- Yi, Y., C.K., Lin, J.S. Diana, R.B. Shivappa, and M.A.K. Chowdhury. Management of organic matter and nutrient regeneration in pond bottoms. Presented to the World Aquaculture Society Annual Meeting at Sydney, Australia, 26 Apr–2 May 1999.

Other

- Lin, C.K., 1989. Aquaculture in Thailand and AITs Program. Seminar at Citizens Ambassadors, Bangkok, Thailand, Aug 1989.
- Lin, C.K., 1989. Intensive pond culture of freshwater prawns and marine shrimps in Thailand. Seminar at Auburn University, Alabama, 23 May 1989.
- Lin, C.K., 1989. Overview of current aquaculture in the Orient and the USA. Seminar at United States Agency for International Development, Bangkok, Thailand, 28 Jul 1989.
- Lin, C.K., 1989. The problems of marine shrimp culture in Taiwan. Seminar at Royal Thai Government Department of Fisheries and Shrimp Farmers Association. Bangkok, Thailand, Jul 1989.
- Lin, C.K., 1990. Current status of freshwater prawn and marine shrimp culture in Thailand. Seminar at Great Lakes Fisheries Research Laboratory, Ann Arbor, Michigan.
- Lin, C.K., 1990. Effects of intensive shrimp culture on coastal environment in upper Gulf of Thailand. Seminar at Royal Thai Government Department of Fisheries and Shrimp Farmers Associations, 15–16 Feb 1990.
- Yi, Y. Cage culture in ponds. Seminar presented to the Sichuan Provincial Fisheries Association, Sichuan, China, 9–20 Jun 1999.
- Massaut, L., 1998. Planktonic trophic interactions in catfish and sport-fish ponds in the presence of an omnivorous filter-feeding fish. Ph.D. dissertation, Auburn University, Alabama.
- Rowan, M., 2001. Chemical phosphorus removal from aquaculture pond water and effluent. Ph.D. dissertation, Auburn University, Alabama.
- Sonnenholzner, S., 1999. Chemical and physical properties of shrimp pond sediment in Ecuador and some management strategies for pond preparation. Ph.D. dissertation, Auburn University, Alabama.
- Thunjai, T., 2001. Pond soil pH measurement. M.S. thesis, Auburn University, Alabama.
- 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.
- Warrington, L., 2000. Sex ratio variation and sex determining mechanisms in *Oreochromis niloticus*. M.S. thesis, Auburn University, Alabama.
- Zelaya, O., 2001. Effects of water recycling on water quality and bottom soils in shrimp ponds. M.S. thesis, Auburn University, Alabama.

Publications

- Boyd, C.E. and A. Gross, 1998. Use of probiotics for improving soil and water quality in aquaculture ponds. In: T.W. Flegel (Editor), Advances in Shrimp Biotechnology. BIOTEC, Bangkok, Thailand, pp. 101–106.
- Boyd, C.E. and J.R. Bowman, 1997. Pond bottom soils. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 135–162.
- Boyd, C.E. and L. Massaut, 1999. Risks associated with the use of chemicals in pond aquaculture. Aquacultural Engineering, 20:113–132.
- Boyd, C.E., 1998. Water quality for pond aquaculture. Alabama Agricultural Experiment Station, Research and Development Series 43. Auburn University, Alabama, 37 pp.
- Boyd, C.E., 2000. Water Quality, An Introduction. Kluwer Academic Publishers, Boston, 330 pp.
- Boyd, C.E., 2002. Management of bottom soil condition and pond water and effluent quality. In: C. Lim and C.D. Webster (Editors), Tilapias: Culture, Nutrition, and Feeding. The Haworth Press, Binghamton, New York. (in press)
- Boyd, C.E., 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., C.W. Wood, and T. Thunjai, 2002. Aquaculture pond bottom soil quality management. PD/A CRSP, Corvallis, Oregon, 41 pp.
- Boyd, C.E., M. Boonyaratpalin, and T. Thunjai, 2002. Properties of liming materials. Aquaculture Asia, 7(3):7–8.
- Boyd, C.E., M. Boonyaratpalin, and T. Thunjai, 2002. Properties of liming materials. Aquaculture Asia, 7(3):7–8.
- Boyd, C.E., T. Thunjai, and M. Boonyaratpalin, 2002. Dissolved salts in water for inland, low-salinity shrimp culture. Global Aquaculture Advocate, 5(2).
- Costa-Pierce and J.E. Rakocy (Editors), Tilapia Aquaculture in the Americas, Volume 2. The World Aquaculture Society, Baton Rouge, Louisiana, pp. 34–59.
- Green, B.W., K.L. Veverica, and M.S. Fitzpatrick, 1997. Fry and fingerling production. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 215–244.
- Lovshin, L.L. and N.B. Schwartz, 1999. Evaluation of integrated tilapia culture by resource limited farmers in Panama and Guatemala. In B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaña (Editors), V Central American Symposium on Aquaculture, 18–20 Aug 1999 in San Pedro Sula, Honduras, pp. 258–261.
- Molnar, J., 2000. Sound policies for food security: The role of culture and social organization. Reviews of Agricultural Economics, 21(2):489–498.

Global Activities

AUBURN UNIVERSITY

Theses

- Carpenter, R.H., 2002. Sex determination and inheritance of sex ratio in families of *Oreochromis niloticus*. M.S. thesis, Auburn University, Auburn, Alabama.
- Gross, A., 1999. Nitrogen cycling in aquaculture ponds. Ph.D. dissertation, Auburn University, Alabama.

- Molnar, J., T. Hanson, and L. Lovshin, 1996. Impacts of the Pond Dynamics/Aquaculture Collaborative Support Research Program as a development intervention. *NAGA: The ICLARM Quarterly*, 19(2):31-40.
- Phelps, R.P. and T.J. Popma, 2000. Sex reversal of tilapia. In: B.A. Silapajarn, K. C.E. Boyd, and O. Silapajarn. An Improved Method for Determining the Fineness Value of Agricultural Limestone for Aquaculture. *North American Journal of Aquaculture* 66:113-118.
- Sonnenholzner, S. and C. E. Boyd, 2000. Chemical and physical properties of shrimp pond bottom soils in Ecuador. *Journal of the World Aquaculture Society*, 31:358-375.
- Sonnenholzner, S. and C. E. Boyd, 2000. Vertical gradients of organic matter concentration and respiration rate in pond bottom soils. *Journal of the World Aquaculture Society*, 31:376-380.
- Sonnenholzner, S. and C.E. Boyd, 2000. Managing the accumulation of organic matter deposited on the bottom of shrimp ponds... Do chemical and biological probiotics really work? *World Aquaculture*, 31(3):24-28.
- Sonnenholzner, S. and C.E. Boyd. Aerobic organic matter decomposition in aquaculture pond soils as measured by respiration chambers. *Journal of the World Aquaculture Society*. (in press)
- Sonnenholzner, S. and C.E. Boyd. Decomposition of organic matter as measured by soil respiration in shrimp ponds treated with chemical and biological amendments. *World Aquaculture*. (submitted)
- Teichert-Coddington, D.R., T.J. Popma, and L.L. Lovshin, 1997. Attributes of tropical pond-cultured fish. In: H.S. Egna and C.E. Boyd (Editors), *Dynamics of Pond Aquaculture*. CRC Press, Boca Raton, pp. 183-198.
- Thunjai, T., 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.
- Thunjai T., C.E. Boyd, and M. Boonyaratapalin. Bottom Soil Quality in Tilapia Ponds of Different Age in Thailand. *Aquaculture Research* 35:698-705.
- Thunjai, T., C.E. Boyd, and K. Dube, 2001. Pond soil pH measurement. *Journal of the World Aquaculture Society*, 32(2):141-152.
- Thunjai T., C.E. Boyd, and M. Boonyaratapalin. Quality of Liming Materials Used in Aquaculture in Thailand. *Aquaculture International* 12:161-168.
- Veverica, K.L. and J.J. Molnar, 1997. Developing and extending aquaculture technology for producers. In: H.S. Egna and C.E. Boyd (Editors), *Dynamics of Pond Aquaculture*. CRC Press, Boca Raton, pp. 397-414.
- Wood, C.W. and C.E. Boyd, 2000. Carbon and nitrogen in pond bottom soils. *World Aquaculture Society Special Publication*, 28:754.
- Presentations**
- Boyd, C.E. Aquaculture and the Environment. Seminar presented AAAS meeting in Seattle, Washington, February, 2004.
- Boyd, C.E. Aquaculture and the Environment. Seminar presented to upper level undergraduate students at Rumkhumhaeng University in Bangkok, Thailand, December, 2003.
- 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. Environmental issues in shrimp farming. Presented at the Sustainable Shrimp Farming Conference in Antananarivo, Madagascar, 3 December 2002.
- Boyd, C.E. and C.W. Wood. Conceptual model of aquacultural pond soil development. Presented to the Soil Science Society of America Annual Meeting, Anaheim, California, 25-30 Oct 1997.
- Boyd, C.E. Aquaculture and the environment. Plenary address. Presented to the Western Regional Aquaculture Expo 2000 at Desert Hot Springs, California, 27 Feb-1 Mar 2000.
- Boyd, C.E. Best management practices (BMPs) for pond aquaculture. Presented to Aquaculture America 2001, Orlando, Florida, 21-25 Jan 2001.
- Boyd, C.E. BMPs in aquaculture. Presented to AquaMexico at Culiacan, Mexico, 5-7 Oct 2000.
- Boyd, C.E. BMPs in aquaculture. Presented to the 4th Latin American Aquaculture Congress at Panama City, Panama, 25-28 Oct 2000.
- Boyd, C.E. 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. Effects of pond age on bottom soil quality. WAS Annual Meeting, Salvador, Brazil, May 2003.
- Boyd, C.E. Environmental and sustainability issues in aquaculture. Keynote address presented to Aquaculture America '99 at Tampa, Florida, 27-30 Jan 1999.
- Boyd, C.E. Environmental issues in shrimp farming. Presented at the Sustainable Shrimp Farming Conference in Antananarivo, Madagascar, 3 December 2002.
- Boyd, C.E. Environmental management in aquaculture. Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10-14 Nov 1998.
- Boyd, C.E. Measurement of pH in pond bottom soils. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting, Sydney, Australia, 26 Apr-2 May 1999.
- Boyd, C.E. Overcoming Environmental Barriers to Aquaculture Development. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Boyd, C.E. Phosphorus chemistry in pond soils. Presented to the Boyd, C.E. Pond soil management and shrimp aquaculture. Presented to the First National Symposium on Aquaculture at Penang, Malaysia, 22-24 Nov 1999.
- Boyd, C.E. Quality of Liming Materials Used in Shrimp Farming in Thailand. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Boyd, C.E. Reduction in environmental impact of pond aquaculture through proper site selection, design, and construction. Presented to World Aquaculture 2000 at Nice, France, 2-6 May 2000.
- Boyd, C.E. Substance exchange between pond sediments and water. Presented to the Western Regional Aquaculture Expo 2000 at Desert Hot Springs, California, 27 Feb-1 Mar 2000.
- Boyd, C.E. 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. 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. Use of BMPs in a systems approach to aquaculture. Presented to the Conference on Aquaculture in the Third Millennium at Bangkok, Thailand, 20-25 Feb 2000.
- Boyd, C.E. Water and bottom soil management in pond aquaculture. 6th Conference of the Aquaculture Association of Southern Africa, Stellenbosch, South Africa, 13 September 2002.
- 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.
- Boyd, C.E. Water quality characteristics of overflow from aquaculture ponds. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1-4 Feb 2000.
- Boyd, C.E. Water quality management in pond aquaculture. Presented to the International Aquaculture Conference at Sao Paulo, Brazil, 26-27 Aug 1998.
- 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., A. Gross, and M. Rowan. Laboratory studies of sedimentation as a technique for treating pond effluents. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15-19 Feb 1998.
- Boyd, C.E., J. Clay, and J. Hargreaves. Codes of conduct for improving environmental and social performance in shrimp farming.

- Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
- Hatch, U. Rapid economic evaluation tool. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
- Massaut, L. and C.E. Boyd. Risks associated with use of chemicals in pond aquaculture. Poster presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Molnar, J. Doing development by growing fish: A cross-national analysis of the impacts of aquacultural research. Presented to the Annual Meeting of the Rural Sociological Society, Toronto, Canada, 1997.
- Molnar, J., T. Hanson, and L. Lovshin. Doing science, growing fish, teaching people: Human capital impacts of the PD/A CRSP. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
- Queiroz, J.F. Soil consideration in site selection, pond construction, and pond management. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Silapajarn, K. Particle Size and Reaction of Agricultural Limestone. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Silapajarn, O. Nitrogen and Phosphorus Concentration and Loads in a Stream Receiving Catfish Farm Effluents. Presented at the World Aquaculture Society Annual Conference. Honolulu, Hawaii, March, 2004.
- Smith, E.S. and R.P. Phelps. Effect of feed storage time and storage temperature on growth rate of tilapia fry and efficacy of sex reversal. Presented to the Fourth International Symposium on Tilapia in Aquaculture at Orlando, Florida, 9–12 Nov 1997.
- Sonnenholzner, S. and C.E. Boyd. Chemical and physical properties of shrimp pond bottom soils in Ecuador. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
- Thunjai, T., C.E. Boyd, and W. Wood. Vertical profiles of bulk density, total carbon, total nitrogen, and total phosphorus in pond soil cores. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
- Wood, C.W. Reaction of liming materials in pond bottom soils. WAS Annual Meeting, Salvador, Brazil, May 2003.
- Wood, C.W. Reaction of liming materials in pond bottom soils. World Aquaculture Society Annual Meeting, Salvador, Brazil, May 2003.
- Wood, C.W., C.E. Boyd, and J. Queiroz. Aquaculture pond soil development. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Wood, W. Perspectives on use of best management practices in agriculture. Presented to Aquaculture America 2001, Orlando, Florida, 21–25 Jan 2001.
- World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Other**
- Boyd, C.E. Aquaculture and the environment workshop. Conducted for the Western Australia Fisheries Department, Perth, Australia, 6 May 1999.
- Boyd, C.E. Aquaculture pond soils with emphasis on shrimp culture. Soil Science Graduate Seminar, Texas A&M University, 1997.
- Boyd, C.E. Dissolved oxygen management in ponds workshop. Conducted for the Asociación Nacional de Acuicultores de Honduras, Choluteca, Honduras, 16 Jun 1999.
- Boyd, C.E. Environment management in aquaculture. Conducted for the conference sponsored by Pacific Economic Cooperation Council, Lima, Peru, 1999.
- Boyd, C.E. Farm level indicators and criteria for sustainable shrimp farming. FAO Ad-Hoc Expert Meeting on Indicators and Criteria for Sustainable Shrimp Farming, Rome, Italy, 1998.
- Boyd, C.E. Food safety considerations related to chemical use for water and soil quality enhancement in ponds. FAO/NACA/WHO Study Group on Food Safety Issues Associated with Products of Aquaculture, Bangkok, Thailand, 1997.
- Boyd, C.E. Pond dynamics workshop. Conducted for commercial aquaculturists, Melbourne, Australia, 3 May 1999.
- Boyd, C.E. Shrimp pond fertilization. Three two-hour lectures at Machelle, Perdinalis and Guayaquil, Ecuador, 11–14 Aug 1998.
- Boyd, C.E. Soil and water quality management in shrimp ponds and Water quality management in low-water use systems lectures. Presented to the Regional Shrimp Culture Conference, Panama City, Panama, 1999.
- Boyd, C.E. Water quality in aquaculture workshop. Conducted for commercial aquaculturists, Adelaide, Australia, 4 May 1999.
- Boyd, C.E. Water quality in shrimp ponds workshop. Conducted for shrimp farm employees, Mahajama, Madagascar, 23 May 1999.
- Boyd, C.E. Workshop on pond soil and water quality management. Conducted in Tumbes, Peru, 18–19 Aug 1998.
- Boyd, C.E. Workshop on shrimp pond water quality (2 hr), Chantaburi and Surat Thani, Thailand (total 73 participants) May 1998.
- Boyd, C.E. Workshop on soil management in shrimp ponds (4 days), Guayaquil, Ecuador, (32 participants) Aug 1997.
- Boyd, C.E. Workshop on water and soil quality in shrimp farming (2 days), Mazatlan, Mexico (41 participants) Jan 1998.
- Boyd, C.E. Workshop on water quality (1/2 day), Pietersburg, South Africa (25 participants) Mar 1998.
- Boyd, C.E. Workshop on water quality and pond bottom soils (1/2 day), China, four locations (total of 385 participants) Aug 1997.
- Boyd, C.E. Workshop on water quality in shrimp ponds (3 days), Guayaquil, Ecuador (22 participants) Nov 1997.
- Lovshin, L. Integrated fish culture systems: Do they work? Presented to faculty and students of the Aquaculture Research Unit, University of the North, Pietersburg, South Africa, 20 Apr 1999.
- Molnar, J. (Organizer and Chair). Global shrimp farming, mangroves, and people: finding a sustainable path. 1998 Annual Meeting of the American Association for the Advancement of Science at Philadelphia, Pennsylvania, 12–17 Feb 1998.
- MICHIGAN STATE UNIVERSITY**
- Publication**
- Knud-Hansen, C.F., K.D. Hopkins, and H. Guttman. A comparative analysis of the fixed-input, computer modeling, and algal bioassay approaches for identifying pond fertilization requirements for semi-intensive aquaculture. *Aquaculture*. (in press)
- OREGON STATE UNIVERSITY**
- Theses**
- Bowman, J., 1992. Classification and management of earthen aquaculture ponds, with emphasis on the role of the soil, Ph.D. dissertation, Oregon State University, Corvallis, Oregon.
- Burke, D.A., 1999. An analysis of social relationships at a development site in Kenya. M.A. thesis, Oregon State University, Corvallis, Oregon.
- Contreras-Sánchez, W., 2001. Sex determination in Nile tilapia, *Oreochromis niloticus*: Gene expression, masculinization methods, and environmental effects. Ph.D. dissertation, Oregon State University, Corvallis, Oregon.
- Egna, Hillary S. and Claude E. Boyd Dynamics of Pond Aquaculture CRC Press 1997
- Ernst, D., 2000. AquaFarm[®]: Simulation and decision-support software for aquaculture facility design and management planning. Ph.D. dissertation, Oregon State University, Corvallis, Oregon.
- Hayes, J., 2001. The safe handling of 17 α -methyltestosterone in tilapia aquaculture. M.S. project report, Oregon State University, Corvallis, Oregon.
- Nath, S.S., 1992. Total and available nutrients in manures for pond

- aquaculture. M.S. thesis, Oregon State University, Corvallis, Oregon.
- Nath, S.S., 1996. Development of a decision support system for pond aquaculture. Ph.D. dissertation, Oregon State University, Corvallis, Oregon.

Publications

- Bolte, J., S. Nath, and D. Ernst, 2000. Development of decision support tools for aquaculture: The POND[®] experience. *Aquacultural Engineering*, 23:103–119.
- Contreras-Sánchez, W., M.S. Fitzpatrick, G. Márquez-Couturier, and C.B. Schreck, 1999. Masculinization of the Nile tilapia (*Oreochromis niloticus*) by immersion in synthetic androgens: Timing and efficacy. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaña (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 246–248.
- Contreras-Sánchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck, 1998. Masculinization of Nile tilapia (*Oreochromis niloticus*) by single immersion in 17 α -methylidihydrotestosterone and trenbolone acetate. In: K. Fitzsimmons (Editor), Tilapia Aquaculture: Proceedings from the Fourth International Symposium on Tilapia in Aquaculture. NRAES, Ithaca, New York, pp. 783–790.
- Contreras-Sánchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck. Masculinization of Nile tilapia with steroids: Alternate treatments and environmental effects. In: Proceedings of the Sixth International Symposium on Reproductive Physiology of Fish, Bergen, Norway, 4–9 Jul 1999. (submitted)
- Contreras-Sánchez, W.S., M. Fitzpatrick, R.H. Milston, and C.B. Schreck, 2000. Masculinization of Nile tilapia: Alternate treatments and environmental effects. In: B. Norberg, O.S. Kjesbu, G.L. Taranger, E. Andersson, and S.O. Stefansson (Editors), Proceedings of the Sixth International Symposium on the Reproductive Physiology of Fish. Institute of Marine Research and University of Bergen, Bergen, Norway, pp. 250–252.
- Egna, H.S. and C.E. Boyd (Editors), 1997. Dynamics of Pond Aquaculture. CRC Press, Boca Raton, 437 pp.
- Egna, H.S., 1989. Fish pond management guidelines: A CRSP goal. Science and Technology Agricultural Reporter, US Agency for International Development, Washington, DC.
- Egna, H.S., 1990. The PD / A CRSP. In: Global Research for Sustainable Food Production. The CRSP Council, USAID, Washington, DC, pp. 28–32.
- Egna, H.S., 1991. Collaboration, aquaculture style. BIFADEC Briefs. Board for International Food and Agriculture Development and Economic Cooperation, USAID, Washington, DC, Vol. XV, No. 6, 8 pp.
- Egna, H.S., 1993. Introduced technologies and changes in food consumption in Rwanda. Proceedings of the Oregon Academy of Sciences, vol. XXIX.
- Egna, H.S., 1994. Monitoring water quality in tropical freshwater fishponds: General applications of aircraft and satellite imagery. *Fisheries Management and Ecology*, 1(3):165–178.
- Egna, H.S., 1995. Psychological distress as a factor in environmental impact assessment: Some methods and ideas for quantifying this intangible intangible. *Environmental Impact Assessment Review*, 12:115–137.
- Egna, H.S., 1997. History of the PD / A Collaborative Research Support Program. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 19–52.
- Egna, H.S., 1999. Environment, aquaculture, and food policy nexus: Case study of two USAID aquaculture projects in Rwanda. In: D.L. Soden and B.S. Steel (Editors), Handbook of Global Environmental Policy and Administration. Marcel Dekker, Inc., New York, pp. 281–314.
- Egna, H.S., C.E. Boyd, and D.A. Burke, 1997. Introduction. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 1–18.
- Ernst, D.H., J.P. Bolte, and D. Lowes, 1997. PD / A CRSP Central Database: An information resource for pond-based aquaculture. In: K. Fitzsimmons (Editor), Tilapia Aquaculture: Proceedings from the Fourth International Symposium on Tilapia in Aquaculture. NRAES, Ithaca, New York, pp. 683–700.
- Ernst, D.H., J.P. Bolte, and S. Nath, 2000. AquaFarm: Simulation and decision-support software for aquaculture facility design and management planning. *Aquacultural Engineering*, 23:121–179.
- Fitzpatrick, M., W. Contreras-Sánchez, R.H. Milston, and C.B. Schreck, 1999. Fate of masculinizing agent methyltestosterone in the pond environment. In: B.W. Green, H.C. Clifford, M. McNamara, and G.M. Montaña (Editors), V Central American Symposium on Aquaculture. San Pedro Sula, Honduras, pp. 249–250.
- Gale, W.L., M. Fitzpatrick, M. Lucero, W. Contreras-Sánchez, and C.B. Schreck, 1999. Masculinization of Nile tilapia (*Oreochromis niloticus*) by immersion in androgens. *Aquaculture*, 178(1999): 349–357.
- Kapetsky, J.M. and S.S. Nath, 1997. A strategic assessment of the potential for freshwater fish farming in Latin America. FAO COP-ESCAL Technical Paper, No. 10, FAO, Rome, 128 pp.
- Lannan, J.E., 1990. Farming and ranching an aquatic system. *Food Reviews International*, 6:293–298.
- Lannan, J.E., G.A.E. Gall, J.E. Thorpe, C.E. Nash, and B.A. Ballachey, 1989. Genetic resource management of fish. *Genome*, 31:798–804.
- Losta, R.T. To sit quietly on a winter's eve, busy sounds muted by the falling snow. To nestle into a warm blanket engrossed in the words before me, hearing only the soft rustle of the pages as I turn them and the crackle of the fire dancing in the fireplace. To savor hot coffee gentle thoughts and solitude.
- Nath, S., J.P. Bolte, L.G. Ross, and J. Aguilar-Manjarrez, 2000. Applications of geographic information systems (GIS) for spatial decision support in aquaculture. *Aquacultural Engineering*, 23:233–278.
- Seim, W.K., C.E. Boyd, and J.S. Diana, 1997. Environmental considerations. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press, Boca Raton, pp. 163–182.
- Yohe, J.M., P. Barnes-McConnell, H. Egna, J. Rowntree, J. Oxley, R.G. Han-son, D. Cummins, and A. Kirksey, 1991. The CRSPs: 1978 to 1990. In: Toward Sustainability—A Plan for Collaborative Research on Agriculture and Natural Resource Management. National Academy Press, Washington, DC, 36 pp.
- Yohe, J.M., P. Barnes-McConnell, H. Egna, J. Rowntree, J. Oxley, R.G. Hanson, D. Cummins, and A. Kirksey, 1995. The CRSPs: International CRSPs. In: J.F. Leslie and R.A. Frederiksen (Editors), Disease Analysis through Genetics and Biotechnology. Iowa State University Press, Ames, Iowa, 321 pp.

Presentations

- Bolte, J. and S. Nath. POND[®]: A decision tool for warmwater aquaculture. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
- Bolte, J., D. Lowes, and S. Nath. Geographic Information System technologies for aquaculture decision support. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Bolte, J.P., S.S. Nath, P. Darakjian, and J.M. Kapetsky. Regional-scale analysis of aquaculture development potential. Poster presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Feb 1996.
- Contreras-Sánchez, W.M., M.S. Fitzpatrick, and C.B. Schreck. Masculinization of Nile tilapia (*Oreochromis niloticus*) by immersion in trenbolone acetate. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1–4 Feb 2000.
- Contreras-Sánchez, W.M., M.S. Fitzpatrick, M. Alonso, C.B. Schreck, and J.C. Leong. Identification of unique genes induced by trenbolone acetate during sex inversion of Nile tilapia (*Oreochromis niloticus*). Presented to the Eleventh Western Regional Conference on Comparative Endocrinology at Corvallis, Oregon, 24–25 Mar 2000.
- Contreras-Sánchez, W.M., M.S. Fitzpatrick, M. Alonso, C.B. Schreck, and J.C. Leong. Identification of unique genes expressed during sex inversion of Nile tilapia (*Oreochromis niloticus*) induced by short immersions in the synthetic steroid trenbolone acetate. Presented to Fourth International Symposium on Fish Endocrinology

- at Seattle, Washington, 31 Jul–3 Aug 2000.
- Contreras-Sánchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck. Masculinization of Nile tilapia with steroids: Alternate treatments and environmental effects. Presented to 6th International Symposium on Reproductive Physiology of Fish at Bergen, Norway, 4–9 Jul 1999.
- Contreras-Sánchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck. Masculinization of Nile tilapia with steroids: Alternate treatments and environmental effects. Presented to the Gilbert Ichthyological Society Meeting at Newport, Oregon, 18 Oct 1999.
- Craven, C. and H.S. Egna. The PD/A CRSP: Strengthening linkages and developing technologies for sustainable aquaculture in the United States and worldwide. Poster presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
- Craven, C. and H.S. Egna. The PD/A CRSP–developed technologies: Domestic rewards and returns. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1–4 Feb 2000.
- Crawford, T.W., Jr., J.M. Yohe, B. Gebrekidan, J.H. Williams, C.L. Neely, P.W. Barnes-McConnell, H.S. Egna, and M.W. Demment. CRSPs: Vital Links. Poster presented to American Society of Agronomy Annual Meeting at Minneapolis, Minnesota, 5–9 Nov 2000.
- Egna, H. International aquaculture: Research. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
- Egna, H.S. and C. Craven. The PD/A CRSP and best management practices for small-scale warmwater aquaculture. Presented to Aquaculture America 2001 at Orlando, Florida, 21–25 Jan 2001.
- Egna, H.S., C. Craven, and D. Burke. The PD/A CRSP–Developed Technologies: Domestic Rewards and Returns. Poster presented to Aquaculture America 2000, at New Orleans, Louisiana, 1–4 Feb 2000.
- Egna, H.S., C.K. Lin, and D.Z. Clair. The PD/A CRSP: Developing technologies and networks for sustainable aquaculture and rural development. Presented to Joint FAO/NACA Expert Consultation on Sustainable Aquaculture for Rural Development at Chiang Rai, Thailand, Mar 1999.
- Egna, H.S., J.M. Baker, and D.A. Burke. The PD/A CRSP: Contributions to International Aquaculture. Poster presented to the Annual Meetings of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Baltimore, Maryland, 19 Oct 1998.
- Egna, H.S., M. Niles, and C. Boyd. Research Priorities and Highlights: An Overview of the PD/A CRSP. Presented to the Western Regional Aquaculture Expo 2000 at Desert Hot Springs, California, 27 Feb–1 Mar 2000.
- Ernst, D.H. Computer tools for aquaculture management and design. Lecture presented to the Western Regional Aquaculture Expo at Sacramento, California, 1996.
- Ernst, D.H., J.P. Bolte, and S.S. Nath. Application of decision support software for aquaculture facility design. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
- Ernst, D.H., S.S. Nath, and J.P. Bolte. Software for design and management of aquaculture facilities. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Fitzpatrick, M.S., W.M. Contreras-Sánchez, and C.B. Schreck. Methyltestosterone persists in the environment after use for masculinizing Nile tilapia. Presented to Aquaculture America 2000 at New Orleans, Louisiana, 1–4 Feb 2000.
- J.M. Yohe, J.M., P. Barnes-McConnell, D.C. Cummins, H.S. Egna, H.J. Hor-tik, and W.P. Warren. Introduction, Historical Development, and Over-view of the CRSPs. Presented to the Annual Meetings of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America at Baltimore, Maryland, 19 Oct 1998.
- Kapetsky, J.M., S. Nath, and J.P. Bolte. A fish farming GIS for Latin America. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
- Nath, S. Planning, design, and management tools for aquaculture. Presented to National Aquaculture Extension Conference at Annapolis, Maryland, 9–10 Apr 1997.
- Nath, S., J.P. Bolte, and D.H. Ernst. A fish bioenergetics model for pond aquaculture. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
- Nath, S.S., J.P. Bolte, and D.H. Ernst. Decision support for pond aquaculture planning and management. Presented to Sustainable Aquaculture '95 at Honolulu, Hawaii, 11–14 Jun 1995.
- Nath, S.S., J.P. Bolte, and D.H. Ernst. Simulation models and economic optimization techniques for pond aquaculture. Poster presentation to the World Aquaculture Society Meeting, Bangkok, Thailand, Feb 1996.

SOUTHERN ILLINOIS UNIVERSITY AT CARBONDALE

Publication

- Kelly, A.M. and C.C. Kohler, 1997. Climate, site, and pond design. In: H.S. Egna and C.E. Boyd (Editors), *Dynamics of Pond Aquaculture*. CRC Press, Boca Raton, pp. 109–134.

UNIVERSITY OF ARIZONA

Presentations

- Fitzsimmons, K. Aquaculture CRSP Contributions to Sustainable Aquaculture. Presented to farmers and government officials in Honolulu, Hawaii, March, 2004.
- 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.
- Fitzsimmons, K. Tilapia Aquaculture in Africa. Presented to government officials and visitors from World Fish Center at AID Headquarters in Washington D.C., April, 2004

UNIVERSITY OF ARKANSAS AT PINE BLUFF

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.
- Engle, C.R., R. Balakrishnan, T.R. Hanson, and J.J. Molnar, 1997. Economic considerations. In: H.S. Egna and C.E. Boyd (Editors), *Dynamics of Pond Aquaculture*. CRC Press, Boca Raton, pp. 377–396.
- 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. Quagraine, 2002. Potential restaurant

- markets for farm-raised tilapia in Nicaragua. *Aquaculture Economics and Management*. (accepted)
- Perschbacher, P. and R. Lochmann, 1999. Effects of feeding pelleted versus non-pelleted defatted rice bran on Nile tilapia *Oreochromis niloticus* production and water quality in ponds. *Asian Fisheries Science*, 12(1999):49–55.
- 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)

Presentation

- Engle, C.R. Teaching aquaculture economics. Presented to the World Aqua-culture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.

UNIVERSITY OF CALIFORNIA, DAVIS

Theses

- Culberson, S.D., 1993. Simplified model for prediction of temperature and dissolved oxygen in aquaculture ponds using reduced data inputs. M.S. thesis, University of California, Davis, California.
- Giovannini, P., 1994. Water quality dynamics in aquaculture ponds: an investigation of photosynthetic production and efficiency variations. Ph.D. dissertation, University of California, Davis, California.
- Jamu, D., 1998. Modeling organic matter and nitrogen dynamics in integrated aquaculture/agriculture systems: Effects of cycling pathways on nitrogen retention and system productivity. Ph.D. dissertation, University of California, Davis, California.

Publications

- Culberson, S.D. and R.H. Piedrahita, 1993. Model for predicting dissolved oxygen levels in stratified ponds using reduced data inputs. In: Jaw-Kai Wang (Editor), *Techniques for Modern Aquaculture*. Proceedings of an Aquacultural Engineering Conference, 21–23 Jun 1993, at Spokane, Washington. American Society of Agricultural Engineers, pp. 543–552.
- Culberson, S.D. and R.H. Piedrahita, 1996. Aquaculture pond ecosystem model: temperature and dissolved oxygen prediction—mechanism and application. *Ecological Modeling*, 89:231–258.
- Eikebrokk, B., R.H. Piedrahita, and Y. Ulgenes, 1995. Rates of fish waste production and effluent discharge from a recirculating system (Biofish) under commercial conditions. *Aquaculture Research*, 26:589–599.
- Giovannini, P. and R.H. Piedrahita, 1988. Analysis and modeling of dissolved oxygen in warm water aquaculture ponds. *American Society of Agricultural Engineers*, 88-5004, 30 pp.
- Giovannini, P. and R.H. Piedrahita, 1989. Analysis and modeling of diel pond dynamics: measuring phytoplankton light adaptation and saturation. *American Society of Agricultural Engineers*, 89-7556, 29 pp.
- Giovannini, P. and R.H. Piedrahita, 1990. Measuring primary production efficiency in aquacultural ponds. *American Society of Agricultural Engineers*, 90-7034, 24 pp.
- Giovannini, P. and R.H. Piedrahita, 1991. Engineering of non-fed pond systems. Proceedings of WAS/ASAE sessions at World Aquaculture Society Meeting at San Juan, Puerto Rico, 16–20 Jun 1991. American Society of Agricultural Engineers, Saint Joseph, Michigan.
- Giovannini, P., and R.H. Piedrahita, 1994. Modeling photosynthetic production optimization for aquaculture ponds. *Aquacultural Engineering*, 13:83–100.
- Grace, G. and R.H. Piedrahita, 1989. Carbon dioxide removal in
- Grace, G. and R.H. Piedrahita, 1993. Carbon dioxide control with a

- packed column aerator. In: Jaw-Kai Wang (Editor), *Techniques for Modern Aquaculture*. Proceedings of an Aquacultural Engineering Conference, 21–23 Jun 1993, at Spokane, Washington. American Society of Agricultural Engineers, pp. 496–505.
- Grace, G. and R.H. Piedrahita, 1994. Carbon dioxide control. In: M. Timmons and T.M. Losordo (Editors), *Engineering Design and Management of Aquaculture Water Reuse Systems*. Developments in Aquaculture and Fisheries Science, 27:209–234.
- Jamu, D.M., Z. Lu, and R.H. Piedrahita, 1998. Secchi disk visibility and chlorophyll a relationships in aquaculture ponds. In: M.B. Timmons and T. Losordo (Editors), *Advances in Aquacultural Engineering: Proceedings from the Aquacultural Engineering Society (AES) Technical Sessions at the Fourth International Symposium on Tilapia in Aquaculture*. NRAES, Ithaca, New York, pp. 159–162.
- Jamu, D.M., Z. Lu, and R.H. Piedrahita, 1999. Relationship between Secchi disk visibility and chlorophyll a in aquaculture ponds. *Aquaculture*, 170(1999):205–214.
- Losordo, T.M. and R.H. Piedrahita, 1991. Modeling temperature variation and thermal stratification in shallow aquaculture ponds. *Ecological Modelling*, 54:189–226.
- Lu, Z. and R.H. Piedrahita, 1993. Nitrifying characteristics of a high rate packed column. In: J.-K. Wang (Editor), *Techniques for Modern Aquaculture*. Proceedings of an Aquacultural Engineering Conference, 21–23 Jun 1993, at Spokane, Washington. American Society of Agricultural Engineers, pp. 345–351.
- Lu, Z., R.H. Piedrahita, and C. Dos Santos Neto, 1999. Generation of daily and hourly solar radiation values for modeling water quality in aquaculture ponds. *Transactions of the American Society of Agricultural Engineers*, 41:1853–1859.
- packed column aerators. *American Society of Agricultural Engineers*, 89-7011, 21 pp.
- Piedrahita, R.H. and A. Seland, 1995. Calculation of pH in fresh and sea water aquaculture systems. *Aquacultural Engineering*, 14:331–346.
- Piedrahita, R.H. and D.E. Brune, 1989. Aquacultural engineering: Aquatic habitat commands innovative thrusts. *Agricultural Engineering*, 70(1):30–32.
- Piedrahita, R.H. and J.K. Wang, 1988. Engineering in aquaculture, an overview. Proceedings of the Joint U.S. India International Symposium on Aquaculture Research Needs for the Year 2000 at New Delhi, India.
- Piedrahita, R.H. and P. Giovannini, 1991. Fertilized non-fed pond systems. *Aquaculture Systems Engineering*. Proceedings of WAS/ASAE sessions at World Aquaculture Society Meeting at San Juan, Puerto Rico, 16–20 Jun 1991. American Society of Agricultural Engineers, Saint Joseph, Michigan, pp. 1–14.
- Piedrahita, R.H., 1989. Simulation of short-term management actions to prevent oxygen depletion in ponds. *American Society of Agricultural Engineers*, 89-7555, 20 pp.
- Piedrahita, R.H., 1990. Aquaculture: Engineering and construction. In: Y.H. Hui (Editor), *Wiley Encyclopedia of Food Science and Technology*. Wiley and Sons, New York, pp. 117–126.
- Piedrahita, R.H., 1990. Calibration and validation of TAP, an aquaculture pond water quality model. *Aquacultural Engineering*, 9:75–96.
- Piedrahita, R.H., 1990. Detritus-based aquaculture systems. *Food Reviews International*, 6(3):317–331.
- Piedrahita, R.H., 1991. Engineering aspects of warmwater hatchery design. Proceedings of WAS/ASAE sessions at World Aquaculture Society Meeting at San Juan, Puerto Rico, 16–20 Jun 1991. American Society of Agricultural Engineers, Saint Joseph, Michigan, pp. 85–100.
- Piedrahita, R.H., 1991. Modeling water quality in aquaculture ecosystems. In: D.E. Brune and J.R. Tomasso (Editors), *Aquaculture and Water Quality*, World Aquaculture Society, Baton Rouge, Louisiana, pp. 322–362.
- Piedrahita, R.H., 1991. Simulation of short-term management actions to prevent oxygen depletion in ponds. *Journal of the World Aquaculture Society*, 22(3):157–166.

Piedrahita, R.H., S.S. Nath, J. Bolte, S.D. Culberson, P. Giovannini, and D.H. Ernst, 1997. Computer applications in pond aquaculture—Modeling and decision support systems. In: H.S. Egna and C.E. Boyd (Editors), *Dynamics of Pond Aquaculture*. CRC Press, Boca Raton, pp. 289–324.

Presentations

- Batterson, T. and R.H. Piedrahita. Current trends, interests and concerns related to aquacultural wastes and their treatment in the United States. Proceedings of the European Inland Fisheries Advisory Commission (EIFAC)/Food and Agriculture Organization (FAO) Workshop on Economics of Waste Water Management at Stirling, Scotland, Jun 1994.
- Brune, D.E., C.M. Drcho, and R.H. Piedrahita. Pond oxygen dynamics: Design and management strategies. Presented to Aquaculture '92 International Conference at Orlando, Florida, 21–25 May 1992.
- Culberson, S.D. and R.H. Piedrahita. Modification of stratified temperature and dissolved oxygen model to accommodate reduced data inputs: Identifying critical requirements. Presented to Aquaculture '92 International Conference at Orlando, Florida, 21–25 May 1992.
- Jamu, D.M. and R.H. Piedrahita. A nitrogen and organic matter cycling model for an integrated aquaculture-crop system. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
- Lu, Z. and R.H. Piedrahita. Modeling of temperature and dissolved oxygen in stratified aquaculture ponds using stochastic weather variables. Presented to the World Aquaculture Society Annual Meeting at Seattle, Washington, Feb 1997.
- Lu, Z. and R.H. Piedrahita. The probability distributions of temperature and dissolved oxygen in stratified fish ponds under stochastic input weather variables. Presented to Aquaculture America '99 at Tampa, Florida, 27–30 Jan 1999.
- Piedrahita, R.H. and G. Grace. Carbon dioxide removal for intensive aquaculture. Presented to the Workshop on Recirculating Aquaculture Systems at Baton Rouge, Louisiana, Sep 1991.
- Piedrahita, R.H. and G. Grace. Removal of carbon dioxide and intensive aquaculture systems. Presented to the World Aquaculture Society Meeting at Halifax, Nova Scotia, Jun 1990.
- Piedrahita, R.H. Managing environmental impacts in aquaculture. Presented to the United States-Japan Natural Resources (UJRN) Aquaculture Panel at Kyoto, Japan, Nov 1992.
- Piedrahita, R.H., Z. Lu, and D. Jamu. Dissolved oxygen modeling in tropical aquaculture ponds under the PD/A CRSP. Presented to the World Aquaculture Society Meeting, Bangkok, Thailand, Jan 1996.
- Whitman, M.H. and R.H. Piedrahita. Water quality requirements of Pacific oysters (*Crassostrea gigas*) in holding systems. Presented to the World Aquaculture Society Meeting at Los Angeles, Feb 1989.

Other

Piedrahita, R.H. Aquacultural Engineering, a five-day course at the Universidad Autonoma de Baja California, Ensenada, Baja California, 23–28 Nov 1997.

UNIVERSITY OF GEORGIA

Presentations

- Nath, S. Geographic Information System technologies for aquaculture decision support. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Nath, S.S., B.P. Verma, G. Rosenberg, and D. Nute. Integrated, multi-perspective approaches to decision support: Case study in Honduras. Presented to the 1998 Institute of Biological Engineering Meeting at Orlando, Florida, 10–12 Jul 1998.

UNIVERSITY OF HAWAII

Presentation

Szyper, J.P., R.H. Piedrahita, and P. Giovannini. Requirements for maximizing bloom stability and net oxygen production in earthen ponds. Poster presented to the World Aquaculture Society Meeting at Torremolinos, Spain, 26–28 May 1993.

UNIVERSITY OF MICHIGAN

Publications

- Diana, J.S., 1997. Feeding strategies. In: H. Egna and C. Boyd (Editors), *Dynamics of Pond Aquaculture*. CRC Press, Boca Raton, pp. 245–262.
- Diana, J.S., J.P. Szyper, T.R. Batterson, C.E. Boyd, and R.H. Piedrahita, 1997. Water quality in ponds. In: H.S. Egna and C.E. Boyd (Editors), *Dynamics of Pond Aquaculture*, CRC Press, Boca Raton, pp. 53–71.
- Lin, C.K., D. Teichert-Coddington, B. Green, and K. Veverica, 1997. Fertilization regimes. In: H.S. Egna and C.E. Boyd (Editors), *Dynamics of Pond Aquaculture*. CRC Press, Boca Raton, pp. 73–108.
- Springborn, R.R., A.L. Jensen, and W.Y.B. Chang, 1994. A variable growth rate modification of Von Bertalanffy's equation for aquaculture. *Aquaculture and Fisheries Management*, 25:259–267.
- Springborn, R.R., A.L. Jensen, W.Y.B. Chang, and C. Engle, 1992. Optimum harvest time in aquaculture: An application of economic principles to a Nile tilapia, *Oreochromis niloticus* (L.), growth model. *Aquaculture and Fisheries Management*, 23:639–647.

UNIVERSITY OF OKLAHOMA

Publication

Rubinshtein, I., S. Rothbard, and W.L. Shelton, 1997. The relationship between the embryological age, cytokinesis-1 and the timing of ploidy manipulation in fish. *Israeli Journal of Aquaculture/Bamidgeh*, 49:99–110.

Presentation

Shelton, W. and R. Phelps. Sex manipulation in *Oreochromis niloticus*. Presented to Aquaculture America '99 at Tampa, Florida, 27–30 Jan 1999.

UNIVERSITY OF TEXAS

Publication

Ward, G.H., 1996. A strategic approach to carrying-capacity analysis for aquaculture on estuaries. In: United States/Japan Natural Resource Panel on Aquaculture, United States-Japan Cooperative Program in Natural Resources. Sea Grant, Texas A&M University, 24:71–84.

OTHER

Publications

- Aguilar-Manjarrez, J. and S. Nath, 1998. A Strategic Reassessment of Fish Farming Potential in Africa. CIFA Technical Paper, No. 32. FAO, Rome, 170 pp.
- Kapetsky, J.M. and S.S. Nath, 1997. A Strategic Assessment of the Potential for Freshwater Fish Farming in Latin America. COPESCAL Technical Paper, No. 10. FAO, Rome, 124 pp.
- Nath, S.S. and J.P. Bolte, 1998. A water budget model for pond aquaculture. *Aquacultural Engineering*, 18(3):175–188.

Aquaculture CRSP Publications

NOTICES OF PUBLICATION AND RESEARCH REPORTS

- 87-1 Hopkins, K.D., J.E. Lannan, and J.R. Bowman. A data base management system for research in pond dynamics.
- 87-2 Nash, G., S. Chinabut, and C. Limsuwan. Idiopathic muscle necrosis in the freshwater prawn, *Macrobrachium rosenbergii* de Man, cultured in Thailand.
- 87-3 Tavarutmaneegul, P. and C.K. Lin. Breeding and rearing of sand goby (*Oxyeleotris marmoratus*, Blk.) fry.
- 88-4 Lin, C.K. Acidification and reclamation of acid sulfate soil fishponds in Thailand.
- 88-5 Ver, L.M.B. and Y.N. Chiu. The effect of paddlewheel aerators on ammonia and carbon dioxide removal in intensive pond culture.
- 88-6 Carpenter, K.E., A.W. Fast, V.L. Corre, J.W. Woessner, and R.L. Janeo. The effects of water depth and circulation on the water quality and production of *Penaeus monodon* in earthen ponds.
- 88-7 Sanares, R.C., S.A. Katase, A.W. Fast, and K.E. Carpenter. Water quality dynamics in brackish water shrimp ponds with artificial aeration and circulation.
- 88-8 Batterson, T.R., C.D. McNabb, C.F. Knud-Hansen, H.M. Eidman, and K. Sumatadinata. Effect of chicken manure additions on fish production in ponds in West Java, Indonesia.
- 88-9 Teichert-Coddington, D.R., N. Stone, and R.P. Phelps. Hydrology of fish culture ponds in Galuca, Panama.
- 88-10 Sikoki, F.D., R.A. Tubbs, and L.R. Curtis. Elevation of sex steroids and inhibition of UDP-glucuronyltransferase are out of phase during gonadal maturation in the common carp.
- 88-11 Minsalan, C.L.O. and Y.N. Chiu. Effects of teaseed cake on selective elimination of finfish in shrimp ponds.
- 88-12 Fortes, R.D., V.L. Corre, Jr., and E. Pudadera. Effects of fertilizers and feeds as nutrient sources on *Oreochromis niloticus* production in Philippine brackish water ponds.
- 89-13 Fast, A.W., K.E. Carpenter, V.J. Estilo, and H.J. Gonzales. Effects of water depth and artificial mixing on dynamics of Philippines brackish water shrimp ponds.
- 89-14 Chang, W.Y.B. and H. Ouyang. Dynamics of dissolved oxygen and vertical circulation in fish ponds.
- 89-15 Green, B.W., R.P. Phelps, and H.R. Alvarenga. The effect of manures and chemical fertilizers on the production of *Oreochromis niloticus* in earthen ponds.
- 89-16 Lin, C.K. and M. Boonyaratpalin. An analysis of biological characteristics of *Macrobrachium rosenbergii* (de Man) in relation to pond production and marketing in Thailand.
- 89-17 Chang, W.Y.B. Estimates of hypolimnetic oxygen deficits in ponds.
- 89-18 Diana, J.S. and A.W. Fast. The effects of water exchange rate and density on yield of the walking catfish, *Clarias fuscus*.
- 89-19 Diana, J.S., P.J. Schneeberger, and C.K. Lin. Relationships between primary production and yield of tilapia in ponds.
- 89-20 Lin, C.K., V. Tansakul, and C. Apinpath. Biological nitrogen fixation as a source of nitrogen input in fishponds.
- 89-21 Teichert-Coddington, David R. and Ronald P. Phelps. Effects of seepage on water quality and productivity of inorganically fertilized tropical ponds.
- 90-22 Chang, W.Y.B. Integrated lake farming for fish and environmental management in large shallow Chinese lakes: A review.
- 90-23 Hopkins, K.D., M.L. Hopkins, and D. Pauley. A multivariate model of tilapia growth, applied to seawater tilapia culture in Kuwait.
- 90-24 Hopkins, K.D. Reporting fishpond yields to farmers.
- 90-25 Peralta, M. and D. Teichert-Coddington. Comparative production of *Colossoma macropomum* and *Tilapia nilotica* in Panama.
- 90-26 Teichert-Coddington, D.R., B.W. Green, N. Matamoros, and R. Rodriguez. The substitution of chicken litter for feed in the commercial production of penaeid shrimp in Honduras.
- 90-27 Green, B.W. and L.A. Lopez. Implementing the large-scale production of young males of *Tilapia nilotica* using hormonal sex inversion in Honduras.
- 90-28 Hanson, B.J., J.F. Moehl, Jr., K.L. Veverica, F. Rwangano, and M. Van Speybroek. Pond culture of tilapia in Rwanda, a high altitude equatorial African country.
- 90-29 Knud-Hansen, C.F., T.R. Batterson, and C.D. McNabb. Hatchery techniques for egg and fry production of *Clarias batrachus* (L.).
- 91-30 Green, B.W., D.R. Teichert-Coddington, and R.P. Phelps. Response of tilapia yield and economics to varying rates of organic fertilization and season in two Central American countries.
- 91-31 Szyper, J.P. and C.K. Lin. Techniques for assessment of stratification and effects of mechanical mixing in tropical fish ponds.
- 91-32 Knud-Hansen, C.F., T.R. Batterson, C.D. McNabb, I.S. Harahat, K. Sumatadinata, and H.M. Eidman. Nitrogen input, primary productivity and fish yield in fertilized freshwater ponds in Indonesia.
- 91-33 Piedrahita, R.H. Calibration and validation of TAP, an aquaculture pond water quality model.
- 91-34 Piedrahita, R.H. Modeling water quality in aquaculture ecosystems.
- 91-35 Piedrahita, R.H. Engineering aspects of warmwater hatchery design.
- 91-36 Piedrahita, R.H. and P. Giovannini. Fertilized non-fed pond systems.
- 91-37 McNabb, C.D., T.R. Batterson, B.J. Premo, C.F. Knud-Hansen, H.M. Eidman, C.K. Lin, K. Jaiyen, J.E. Hanson, and R. Chuenpagdee. Managing fertilizers for fish yield in tropical ponds in Asia.
- 91-38 Green, B.W. and H.R. Alvarenga. The effect of different application rates of chicken litter on tilapia production.
- 91-39 Alvarenga, H.R. and B.W. Green. Production and economic aspects of tilapia cultivation in ponds fertilized with chicken litter.
- 92-40 Szyper, J.P., K.D. Hopkins, and C.K. Lin. Production of *Oreochromis niloticus* (L.) and ecosystem dynamics in manured ponds of three depths.
- 92-41 Piedrahita, R.H. Simulation of short-term management actions to prevent oxygen depletion in ponds.
- 92-42 Teichert-Coddington, D.R., B.W. Green, and R.W. Parkman. Substitution of chicken litter for feed in production of penaeid shrimp in Honduras.
- 92-43 Knud-Hansen, C.F., C.D. McNabb, and T.R. Batterson. Application of limnology for efficient nutrient utilization in tropical pond aquaculture.
- 92-44 Hopkins, K. and A. Yakupitiyage. Bias in seine sampling of tilapia.
- 92-45 Engle, C.R. and M. Skladany. The economic benefit of chicken manure utilization in fish production in Thailand.
- 92-46 Green, B.W. Substitution of organic manure for pelleted feed in tilapia production.
- 92-47 Green, B.W., and D.R. Teichert-Coddington. Comparison of two samplers used with an automated data acquisition system in whole-pond, community metabolism studies.
- 92-48 Liu, K.M. and W.Y.B. Chang. Bioenergetic modeling of effects of fertilization, stocking density, and spawning on growth of the Nile tilapia, *Oreochromis niloticus* (L.).
- 93-49 Teichert-Coddington, D.R., B.W. Green, and R.P. Phelps. Influence of site and season on water quality and tilapia production in Panama and Honduras.
- 93-50 Suresh, A.V. and C.K. Lin. Tilapia culture in saline waters: A review.
- 93-51 Knud-Hansen, C.F. Analyzing standard curves in the chemistry of waters used for aquaculture.
- 93-52 Szyper, J.P., J.Z. Rosenfeld, R.H. Piedrahita, and P. Giovannini. Diel cycles of planktonic respiration rates in briefly incubated water samples from a fertile earthen pond.
- 93-53 This report is a duplicate of an earlier number.

- 93-54 Lin, C.K., K. Jaiyen, and W. Muthuwana. Integration of intensive and semi-intensive aquaculture: Concept and example.
- 93-55 Szyper, J.P. and J.M. Ebeling. Photosynthesis and community respiration at three depths during a period of stable phytoplankton stock in a eutrophic brackish water culture pond.
- 93-56 Knud-Hansen, C.F., T.R. Batterson, and C.D. McNabb. The role of chicken manure in the production of Nile tilapia, *Oreochromis niloticus* (L.).
- 93-57 Boyd, C.E. and D. Teichert-Coddington. Relationship between wind speed and reaeration in small aquaculture ponds.
- 93-58 Teichert-Coddington, D.R. and B.W. Green. Influence of daylight and incubation interval on water column respiration in tropical fish ponds.
- 93-59 Knud-Hansen, C.F. and A.K. Pautong. On the role of urea in pond fertilization.
- 94-60 Shrestha, M.K. and C.F. Knud-Hansen. Increasing attached microorganism biomass as a management strategy for Nile tilapia (*Oreochromis niloticus*) production.
- 94-61 Springborn, R.R., A.L. Jensen, W.Y.B. Chang, and C. Engle. Optimum harvest time in aquaculture: An application of economic principles to a Nile tilapia, *Oreochromis niloticus* (L.), growth model.
- 94-62 Hopkins, K.D. and D. Pauly. Instantaneous mortalities and multivariate models: Applications to tilapia culture in saline water.
- 94-63 Green, B.W. and D.R. Teichert-Coddington. Production of *Oreochromis niloticus* fry for hormonal sex reversal in relation to water temperature.
- 94-64 Engle, C.R., M. Brewster, and F. Hitayezu. An economic analysis of fish production in a subsistence agricultural economy: The case of Rwanda.
- 94-65 Knud-Hansen, C.F. and T.R. Batterson. Effect of fertilization frequency on the production of Nile tilapia (*Oreochromis niloticus*).
- 94-66 Teichert-Coddington, D.R., R. Rodriguez, and W. Toyofuku. Cause of cyclic variation in Honduran shrimp production.
- 94-67 Springborn, R.R., A.L. Jensen, and W.Y.B. Chang. A variable growth rate modification of von Bertalanffy's equation for aquaculture.
- 94-68 Diana, J.S., D.J. Dettweiler, and C.K. Lin. Effect of Nile tilapia (*Oreochromis niloticus*) on the ecosystem of aquaculture ponds, and its significance to the trophic cascade hypothesis.
- 94-69 Ayub, M., C.E. Boyd, and D. Teichert-Coddington. Effects of urea application, aeration, and drying on total carbon concentrations in pond bottom soils.
- 94-70 Boyd, C.E. and D. Teichert-Coddington. Pond bottom soil respiration during fallow and culture periods in heavily-fertilized tropical fish ponds.
- 94-71 Hopkins, K.D. Reporting fish growth: A review of the basics.
- 94-72 Hopkins, K.D. and J.D. Bowman. A research methodology for integrated agriculture-aquaculture farming systems.
- 94-73 Diana, J.S. and K. Jaiyen. Supplemental feeding of tilapia in fertilized ponds.
- 94-74 Knud-Hansen, C.F. Pond history as a source of error in fish culture experiments: A quantitative assessment using covariate analysis.
- 94-75 Green, B. and D. Teichert-Coddington. Growth of control and androgen-treated Nile tilapia, *Oreochromis niloticus* (L.), during treatment, nursery and growout phases in tropical fish ponds.
- 94-76 Teichert-Coddington, D. and B. Green. Comparison of two techniques for determining community respiration in tropical fish ponds.
- 94-77 Teichert-Coddington, D. and B. Green. Tilapia yield improvement through maintenance of minimal oxygen concentrations in experimental growout ponds in Honduras.
- 94-78 Teichert-Coddington, D., M. Peralta, and R.P. Phelps. Seepage reduction in tropical fish ponds using chicken litter.
- 95-79 Giovannini, P. and R.H. Piedrahita. Modeling photosynthetic production optimization for aquaculture ponds.
- 95-80 Culberson, S.D. and R.H. Piedrahita. Model for predicting dissolved oxygen levels in stratified ponds using reduced data inputs.
- 95-81 Culberson, S.D. and R.H. Piedrahita. Modification of stratified temperature model to accommodate reduced data inputs: Identifying critical requirements.
- 95-82 Teichert-Coddington, D. Development of production technologies for semi-intensive fish farming during the past decade in Central America.
- 95-83 Teichert-Coddington, D. Effects of protein diet and sowing density on the production of *Penaeus vannamei* in land tanks.
- 95-84 Szyper, J.P., C.K. Lin, D. Little, S. Setboonsarng, A. Yakupitiyage, P. Edwards, and H. Demaine. Techniques for efficient and sustainable mass production of tilapia in Thailand.
- 95-85 Egna, H.S. Psychological distress as a factor in environmental impact assessment: Some methods and ideas for quantifying this intangible intangible.
- 95-86 Bowman, J.R. and J.E. Lannan. Evaluation of soil pH-percent base saturation relationships for use in estimating the lime requirements of earthen aquaculture ponds.
- 96-87 Green, B.W. and C.E. Boyd. Water budgets for fish ponds in the dry tropics.
- 96-88 Green, B.W. and C.E. Boyd. Chemical budgets for organically fertilized fish ponds in the dry tropics.
- 96-89 Teichert-Coddington, D.R. and R. Rodriguez. Semi-intensive commercial grow-out of *Penaeus vannamei* feed diets containing differing levels of crude protein during wet and dry seasons in Honduras.
- 96-90 Boyd, C.E. and D. Teichert-Coddington. Dry matter, ash, and elemental composition of pond-cultured *Penaeus vannamei* and *P. stylirostris*.
- 95-91 Green, B.W., Z.E. Nagdy, H. Hebicha, I. Shaker, D.A.R. Kenawy, and A.R.E. Gamal. Evaluation of Nile tilapia production systems in Egypt.
- 96-92 Egna, H.S. Monitoring water quality for tropical freshwater fisheries and aquaculture: A review of aircraft and satellite imagery applications.
- 96-93 Lin, C.K. and J.S. Diana. Co-culture of catfish (*Clarias macrocephalus* x *C. gariepinus*) and tilapia (*Oreochromis niloticus*) in ponds.
- 96-94 Lin, C.K. *Clarias* and tilapia interaction in polyculture.
- 96-95 Abdalla, A.A.F. and C.D. McNabb. Ammonia dynamics in fertilized fish ponds stocked with Nile tilapia.
- 96-96 Boyd, C.E. and P. Munsiri. Phosphorus adsorption capacity and availability of added phosphorus in soils from aquaculture areas in Thailand.
- 96-97 Teichert-Coddington, D.R. Effect of stocking ratio on semi-intensive polyculture of *Colossoma macropomum* and *Oreochromis niloticus* in Honduras, Central America.
- 96-98 Munsiri, P. and B.F. Hajek. Texture and chemical composition of soils from shrimp ponds near Choluteca, Honduras.
- 97-99 Moehl, J.F. and J.J. Molnar. Institutional requirements for aquacultural development in Africa: Lessons from Rwanda.
- 97-100 Hishamunda, N., C.M. Jolly, and C.R. Engle. Estimating *Oreochromis niloticus* production function for small-scale fish culture in Rwanda.
- 97-101 Shrestha, M.K. and C.K. Lin. Phosphorus fertilization strategy in fish ponds based on sediment phosphorus saturation level.
- 97-102 Green, B.W. Polyculture of tilapia with marine shrimp.
- 97-103 Diana, J.S., C.K. Lin, and Y. Yi. Timing of supplemental feeding for tilapia production.
- 97-104 Engle, C.R. Optimal resource allocation by fish farmers in Rwanda.
- 97-105 Szyper, J.P. Observations and model predictions of daily areal primary production in a eutrophic brackish water culture pond.
- 97-106 Szyper, J.P. Comparison of three mixing devices in earthen culture ponds of four different surface areas.
- 97-107 Green, B.W. Inclusion of tilapia as a diversification strategy for penaeid shrimp culture.

- 97-108 Teichert-Coddington, D., J. Harvin, and D. Martinez. Semi-intensive shrimp pond management and quality of effluents.
- 97-109 Veverica, K. The PD/A CRSP-sponsored proceedings of the third conference on the culture of tilapias at high elevations in Africa.
- 97-110 Yohe, J.M., P.B. McConnell, H.S. Egna, J. Rowntree, J. Oxley, R.G. Hanson, D. Cummins, and A. Kirksey. The CRSPs: International CRSPs.
- 97-111 Teichert-Coddington, D. and D. Martinez de Pinel. Solubility of selected inorganic fertilizers in brackish water.
- 97-112 Boyd, C. Water quality in laboratory soil-water microcosms with soils from different areas of Thailand.
- 97-113 Shrestha, M. and C.K. Lin. Determination of phosphorus saturation level in relation to clay content in formulated pond muds.
- 97-115 Yi, Y., C.K. Lin, and J.S. Diana. Influence of Nile tilapia (*Oreochromis niloticus*) stocking density in cages on their growth and yield in cages and in ponds containing the cages.
- 97-116 Munsiri, P., C.E. Boyd, B.W. Green, and B.F. Hajek. Chemical and physical characteristics of bottom soil profiles in ponds on haplaquents in an arid climate at Abbassa, Egypt.
- 97-117 Ward, G.H. Water effluent and quality, with special emphasis on finfish and shrimp aquaculture.
- 97-118 Green, B.W., M.P. Micheletti, and C.A. Lara. A collaborative project to monitor the water quality of estuaries in the shrimp producing regions of Honduras.
- 98-119 Ernst, D.H., J.P. Bolte, D. Lowes, and S.S. Nath. PD/A CRSP Central Database: A standardized information resource for pond aquaculture.
- 98-120 Jamu, D.M., Z. Lu, and R. Piedrahita. Secchi disk visibility and chlorophyll a relationship in aquaculture ponds.
- 98-121 Contreras-Sánchez, W., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck. Masculinization of Nile tilapia (*Oreochromis niloticus*) by single immersion in 17 α -methylidihydrotestosterone and trenbolone acetate.
- 98-122 Kapetsky, J.M. and S.S. Nath. A strategic assessment of the potential for freshwater fish farming in Latin America.
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- 98-124 Hishamunda, N., M. Thomas, D. Brown, C. Engle, and C. Jolly. Small-scale fish farming in Rwanda: Economic characteristics.
- 98-124a Hishamunda, N., M. Thomas, D. Brown, C. Engle, and C. Jolly. Small-scale fish farming in Rwanda: Data report.
- 98-125 Abdalla, A.A.F. and C.D. McNabb. Acute and sublethal growth effects of un-ionized ammonia to Nile tilapia *Oreochromis niloticus*.
- 98-126 Nath, S.S. and J.P. Bolte. A water budget model for pond aquaculture.
- 98-127 Aguilar-Manjarrez, J. and S.S. Nath. A strategic reassessment of fish farming potential in Africa.
- 98-128 Yi, Y. A bioenergetics growth model for Nile tilapia (*Oreochromis niloticus*) based on limiting nutrients and fish standing crop in fertilized ponds.
- 99-129 Veverica, K.L., N. Hishamunda, and P. Nyirahabimana. Aquaculture extension in Rwanda.
- 99-130 Boyd, C.E. and B.W. Green. Dry matter, ash, and elemental composition of pond-cultured tilapia (*Oreochromis aureus* and *O. niloticus*).
- 99-131 Diana, J.S. and C.K. Lin. The effects of fertilization and water management on growth and production of Nile tilapia in deep ponds during the dry season.
- 99-132 Jamu, D.M., Z. Lu, and R.H. Piedrahita. Relationship between Secchi disk visibility and chlorophyll a in aquaculture ponds.
- 99-133 Gale, W.L., M.S. Fitzpatrick, M. Lucero, W.M. Contreras-Sánchez, and C.B. Schreck. Masculinization of Nile tilapia (*Oreochromis niloticus*) by immersion in androgens.
- 99-134 Boyd, C.E. and L. Massaut. Risks associated with the use of chemicals in pond aquaculture.
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- 99-136 Boyd, C.E. and M.C. Haws, 1999. Good management practices (GMPs) to reduce environmental impacts and improve efficiency of shrimp aquaculture in Latin America.
- 99-137 Ward, G.W., B.W. Green, and D.R. Teichert-Coddington. Estimation of carrying capacity for shrimp aquaculture in the eastern estuaries of the Gulf of Fonseca.
- 99-138 Dasgupta, S. and C.R. Engle. Non-parametric estimation of returns to investment in Honduras shrimp research.
- 99-139 Valderrama, D. and C.R. Engle. Risk analysis of shrimp farming in Honduras.
- 99-140 Contreras-Sánchez, W.M., M.S. Fitzpatrick, G. Márquez-Couturier, and C.B. Schreck. Masculinization of Nile tilapia (*Oreochromis niloticus*) by immersion in synthetic androgens: Timing and efficacy.
- 99-141 Fitzpatrick, M., W.M. Contreras-Sánchez, R.H. Milston, C.B. Schreck. Fate of the masculinizing agent methyltestosterone in the pond environment.
- 99-142 Green, B.W. Sistemas de producción de tilapia en Honduras (Tilapia production systems in Honduras).
- 99-143 Lovshin, L.L. and N.B. Schwartz. Evaluation of integrated tilapia culture by resource limited farmers in Panama and Guatemala.
- 99-144 Green, B.W., D.R. Teichert-Coddington, C.E. Boyd, J.M. Wigglesworth, H. Corrales, D. Martínez, and E. Ramírez. Efecto del recambio de agua en la producción semi-intensiva de *Penaeus vannamei* (Effect of water exchange on semi-intensive production of *Penaeus vannamei*).
- 99-145 Yi, Y. Modeling growth of Nile tilapia (*Oreochromis niloticus*) in a cage-cum-pond integrated culture system.
- 00-146 Perschbacher, P. and R. Lochmann. Effects of feeding pelleted versus non-pelleted defatted rice bran on Nile tilapia *Oreochromis niloticus* production and water quality in ponds.
- 00-147 Molnar, J.J. Sound policies for food security: The role of culture and social organization.
- 00-148 Yi, Y. and C.K. Lin. Integrated cage culture in ponds: Concepts, practice and perspectives.
- 00-149 Lin, C.K. and K. Kaewpaitoon. An overview of freshwater cage culture in Thailand.
- 00-150 Ward, Jr., G.H. Effects of shrimp farming on the hydrography and water quality of El Pedregal and San Bernardo estuaries, Gulf of Fonseca, Honduras.
- 00-151 Sonnenholzner, S. and C.E. Boyd. Chemical and physical properties of shrimp pond bottom soils in Ecuador.
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- 00-153 Bolte, J., S. Nath, and D. Ernst. Development of decision support tools for aquaculture: The POND[®] experience.
- 00-154 Ernst, D.H., J.P. Bolte, and S. Nath. AquaFarm: Simulation and decision support for aquaculture facility design and management planning.
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- 00-156 Bolivar, R.B. and G.F. Newkirk. Response to selection for body weight on Nile tilapia (*Oreochromis niloticus*) in different culture environments.
- 00-157 Lovshin, L.L. Criteria for selecting Nile tilapia and red tilapia for culture.
- 00-158 Brown, C.L., R.B. Bolivar, E.B.T. Jimenez, and J. Szyper. Timing of the onset of supplemental feeding of Nile tilapia (*Oreochromis niloticus*) in ponds.
- 00-159 Yi, Y. and C.K. Lin. Analysis of various inputs for pond culture of Nile tilapia (*Oreochromis niloticus*): Profitability and potential environmental impacts.
- 00-160 Verma, B., E.W. Tollner, J. Renew, T. Popma, J.L. Molnar, and D. Meyer. Concurrent design of hillside ponds for tilapia production.

- 00-161 McKeon, C., E. Glenn, C.P. Gerba, and K. Fitzsimmons. Microbiological hazards of tilapia culture systems.
- 00-162 Verdegem, M.C.J., A.A. van Dam, A.A. Cabarcas-Nuñez, and L. Oprea. Bio-energetic modeling of growth and waste production of Nile tilapia (*Oreochromis niloticus* L.) in recirculation systems.
- 00-163 Jamu, D. A pilot study on the spatial and temporal soil moisture and distribution in integrated crop-fish-wetland and crop-wetland agroecosystems in Zomba-East, Malawi.
- 00-164 Lovshin, L.L. Evaluation of tilapia culture by resource limited farmers in Panama and Guatemala.
- 01-165 Contreras-Sánchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck. Masculinization of Nile tilapia with steroids: Alternate treatments and environmental effects.
- 01-166 Sonnenholzner, S. and C.E. Boyd. Managing the accumulation of organic matter deposited on the bottom of shrimp ponds... Do chemical and biological probiotics really work?
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- 01-168 Yi, Y. and C.K. Lin. Effects of biomass of caged Nile tilapia (*Oreochromis niloticus*) and aeration on the growth and yields in an integrated cage-cum-pond system.
- 01-169 Thunjai, T., C.E. Boyd, and K. Dube. Pond soil pH measurement.
- 01-170 Dasgupta, S. and C.R. Engle. Nonparametric estimation of returns to investment in Honduras shrimp research.
- 01-171 Valderrama, D. and C.R. Engle. Risk analysis of shrimp farming in Honduras.
- 01-172 Lin, C.K., M.K. Shrestha, and Y. Yi. Management to minimize the environmental impacts of pond effluent: Harvest draining techniques and effluent quality.
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- 01-174 Phelps, R.P. Sex reversal: The directed control of gonadal development in tilapia.
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- 02-179 Meyer, D.E. Technology for successful small-scale tilapia culture.
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- 02-181 Tollner, E.W. Levee pond design model.
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- 02-183 Verma, B.P., D.E. Meyer, T.J. Popma, J.J. Molnar, and E. W. Tollner. Web-based information delivery system for tilapia for sustainable development of aquaculture in Honduras.
- 02-184 Corrales, H.L., C.A. Lara, J.E. Heerin, J.M. Wigglesworth, and B.W. Green. A sustainable shrimp aquaculture system from Honduras.
- 02-185 Yi, Y., and C.K. Lin. Recycling Pond Mud Nutrients in Integrated Lotus-Fish Culture.
- 03-186 Green, B.W., Z.E. Nagdy, and H. Hebicha. Evaluation of Nile Tilapia Pond Management Strategies in Egypt.
- 03-187 Yi, Y., and C.K. Lin. Techniques to Mitigate Clay Turbidity Problems in Fertilized Earthen Fish Ponds.
- 03-188 Yi, Y., and C.K. Lin. 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 Fúnez, O., I. Neira, and C. Engle. Potential for Supermarket Outlets for Tilapia in Honduras.
- 03-190 Engle, C.R., and I. Neira. Potential for Supermarket Outlets for Tilapia in Nicaragua.
- 03-191 Monestime, D., I. Neira, O. Fúnez, and C.R. Engle. Potential for Restaurant Markets for Tilapia in Honduras.
- 03-192 Neira, I., and C. Engle. Potential for Restaurant Markets for Tilapia in Nicaragua.
- 03-193 Fúnez, O., I. Neira, and C. Engle. Potential for Open-Air Fish Market Outlets for Tilapia in Honduras.
- 03-194 Engle, C.R., and I. Neira. Potential for Open-Air Fish Market Outlets for Tilapia in Nicaragua.
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DATA REPORTS BY PD / A CRSP RESEARCHERS

- Batterson, T.R., C.D. McNabb, C.F. Knud-Hansen, H.M. Eidman, and K. Sumantadinata, 1989. Data Report, Vol. 3, No. 3, Indonesia: Cycle III of the Global Experiment. PD / A CRSP, Oregon State University, Corvallis, Oregon, 135 pp.
- Bowman, J. and D. Clair, 1996. Data Report, Volume 1, Second Edition, General Reference: PD / A CRSP Site Descriptions. PD / A CRSP, Oregon State University, Corvallis, Oregon, 74 pp.
- Carpenter, K.E., A.W. Fast, J. Carreon, and R. Juliano, 1991. Data Report, Vol. 4, No. 3, Philippines: Cycle III of the Global Experiment. PD / A CRSP, Oregon State University, Corvallis, Oregon, 257 pp.
- Carpenter, K.E., J. Woessner, R.D. Fortes, A. Fast, and P. Helfrich, 1991. Data Report, Vol. 4, No. 2, Philippines: Cycle II of the Global Experiment. PD / A CRSP, Oregon State University, Corvallis, Oregon, 501 pp.
- Diana, J.S., C.K. Lin, T. Bhukaswan, and V. Sirsuwanatach, 1987. Data Report, Vol. 2, No. 1, Thailand: Cycle I of the Global Experiment.
- Diana, J.S., C.K. Lin, T. Bhukaswan, V. Sirsuwanatach, and B.J. Buurma, 1990. Data Report, Vol. 2, No. 2, Thailand: Cycle II of the Global Experiment. PD / A CRSP, Oregon State University, Corvallis, Oregon, 54 pp.
- Diana, J.S., C.K. Lin, T. Bhukaswan, V. Sirsuwanatach, and B.J. Buurma, 1991. Data Report, Vol. 2, No. 3, Thailand: Cycle III of the Global Experiment. PD / A CRSP, Oregon State University, Cor-

- vallis, Oregon, 86 pp.
- Egna, H.S., N. Brown, and M. Leslie (Editors), 1989. Data Report, Vol. 1, General Reference: Site Descriptions, Materials and Methods for the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 84 pp.
- Green, B.W., H.R. Alvarenga, R.P. Phelps, and J. Espinoza, 1989. Data Report, Vol. 6, No. 3, Honduras: Cycle III of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 114 pp.
- Green, B.W., H.R. Alvarenga, R.P. Phelps, and J. Espinoza, 1990. Data Report, Vol. 6, No. 1, Honduras: Cycle I of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 94 pp.
- Green, B.W., H.R. Alvarenga, R.P. Phelps, and J. Espinoza, 1990. Data Report, Vol. 6, No. 2, Honduras: Cycle II of the Global Experiment.
- Hanson, B., V. Ndoreyaho, F. Rwangano, R. Tubb, and W.K. Seim, 1991. Data Report, Vol. 5, No. 2, Rwanda: Cycle III of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 102 pp.
- Hanson, B., V. Ndoreyaho, R. Tubb, F. Rwangano, and W.K. Seim, 1989. Data Report, Vol. 5, No. 1, Rwanda: Cycle I of The Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 62 pp.
- Hughes, D., A.T. Diaz, R.P. Phelps, and R.P. Malca, 1991. Data Report,
- Hughes, D., R.P. Phelps, and R.P. Malca, 1991. Data Report, Vol. 8, No. 2, Aguadulce, Panama: Cycle II of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 143 pp.
- Hughes, D., R.P. Phelps, and R.P. Malca, 1991. Data Report, Vol. 8, No. 3, Aguadulce, Panama: Cycle III of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 230 pp.
- McNabb, C.D., T.R. Batterson, B.J. Premo, H.M. Eidman, and K. Sumantadinata, 1991. Data Report, Vol. 3, No. 2, Indonesia: Cycle II of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 49 pp.
- McNabb, C.D., T.R. Batterson, B.J. Premo, H.M. Eidman, and K. Sumantadinata, 1988. Data Report, Vol. 3, No. 1, Indonesia: Cycle I of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 67 pp.
- PD/A CRSP, Oregon State University, Corvallis, Oregon, 47 pp.
- PD/A CRSP, Oregon State University, Corvallis, Oregon, 94 pp.
- Teichert-Coddington, D.R., M. Peralta, R.P. Phelps, and R.P. Malca, 1991. Data Report, Vol. 7, No. 1, Gualaca, Panama: Cycle I of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 97 pp.
- Teichert-Coddington, D.R., M. Peralta, R.P. Phelps, and R.P. Malca, 1991. Data Report, Vol. 7, No. 2, Gualaca, Panama: Cycle III of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 56 pp.
- Vol. 8, No. 1, Aguadulce, Panama: Cycle I of The Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 122 pp.
- Woessner, J., R.D. Fortes, and V. Corre, Jr., 1991. Data Report, Vol. 4, No. 1, Philippines: Cycle I of the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 141 pp.

CRSP WORK PLANS

- PD/A CRSP, 1983. CRSP Work Plan: First Experimental Cycle. PD/A CRSP, Oregon State University, Corvallis, Oregon, 99 pp.
- PD/A CRSP, 1984. CRSP Work Plan: Second Experimental Cycle. PD/A CRSP, Oregon State University, Corvallis, Oregon, 143 pp.
- PD/A CRSP, 1985. CRSP Work Plan: Third Experimental Cycle. PD/A CRSP, Oregon State University, Corvallis, Oregon, 128 pp.
- PD/A CRSP, 1989. Revised CRSP Work Plan: Fourth Experimental Cycle. PD/A CRSP, Oregon State University, Corvallis, Oregon, 39 pp.
- PD/A CRSP, 1989. Fifth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 151 pp.
- PD/A CRSP, 1991. Sixth Work Plan. PD/A CRSP, Oregon State Uni-

- versity, Corvallis, Oregon, 71 pp.
- PD/A CRSP, 1993. Revised Seventh Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 85 pp.
- PD/A CRSP, 1996. Interim Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 47 pp.
- PD/A CRSP, 1997. Eighth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 171 pp.
- PD/A CRSP, 1998. Addendum to the Eighth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 31 pp.
- PD/A CRSP, 1999. Second Addendum to the Eighth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 18 pp.
- PD/A CRSP, 2000. Third Addendum to the Eighth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 5 pp.
- PD/A CRSP, 1999. Ninth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 92 pp.
- PD/A CRSP, 2000. Addendum to the Ninth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 41 pp.
- PD/A CRSP, 2001. Tenth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 148 pp.
- PD/A CRSP, 2002. Second Addendum to the Ninth Work Plan. PD/A CRSP, Oregon State University, Corvallis, Oregon, 15 pp.
- Aquaculture CRSP 2003. Eleventh Work Plan, Part I. Aquaculture CRSP, Oregon State University, Corvallis, Oregon, 121 pp.

CRSP ADMINISTRATIVE REPORTS

- PD/A CRSP, 1983. First Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 29 pp.
- PD/A CRSP, 1984. Second Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 35 pp.
- PD/A CRSP, 1985. Third Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 37 pp.
- PD/A CRSP, 1986. Fourth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 28 pp.
- PD/A CRSP, 1988. Fifth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 49 pp.
- Egna, H.S. and H. Horton (Editors), 1989. Sixth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 91 pp.
- Egna, H.S., J. Bowman, and M. McNamara (Editors), 1990. Seventh Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 114 pp.
- Egna, H.S., J. Bowman, and M. McNamara (Editors), 1991. Eighth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 166 pp.
- Egna, H.S., M. McNamara, and N. Weidner (Editors), 1992. Ninth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 172 pp.
- Egna, H.S., M. McNamara, J. Bowman, and N. Astin (Editors), 1993. Tenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 275 pp.
- Egna, H.S. and M. McNamara (Editors), 1994. Eleventh Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 80 pp.
- Egna, H.S., J. Bowman, B. Goetze and N. Weidner (Editors), 1994. Eleventh Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 178 pp.
- Egna, H.S., M. McNamara, and N. Weidner (Editors), 1995. Twelfth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 95 pp.
- Egna, H.S., J. Bowman, B. Goetze, and N. Weidner (Editors), 1995. Twelfth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 209 pp.
- Goetze, B., H. Berkman, and H. Egna (Editors), 1995. Egypt Project Final Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 30 pp.
- McNamara, M., H. Egna, B. Goetze, B. Herbison, and D. Clair (Editors), 1996. Thirteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 96 pp.
- Egna, H.S., B. Goetze, D. Burke, M. McNamara, and D. Clair (Edi-

- tors), 1996. Thirteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 206 pp.
- Clair, D., B. Goetze, D. Burke, M. McNamara, and H. Egna (Editors), 1997. Fourteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 94 pp.
- Burke, D., B. Goetze, D. Clair, and H. Egna (Editors), 1997. Fourteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 192 pp.
- Clair, D., B. Goetze, D. Burke, J. Baker, and H. Egna (Editors), 1998. Fifteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 113 pp.
- Burke, D., J. Baker, B. Goetze, D. Clair, and H. Egna (Editors), 1998. Fifteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 187 pp.
- Clair, D., D. Burke, K. McElwee, M. Niles, and H. Egna, 1999. Sixteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 100 pp.
- McElwee, K., D. Burke, M. Niles, and H. Egna (Editors), 1999. Sixteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 189 pp.
- Clair, D., K. McElwee, D. Burke, M. Niles, and H. Egna (Editors), 1999. Seventeenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 124 pp.
- McElwee, K., D. Burke, M. Niles, X. Cummings, and H. Egna (Editors), 2000. Seventeenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 178 pp.
- Clair, D., K. McElwee, A. Gupta, D. Burke, and H. Egna (Editors), 2001. Eighteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 118 pp.
- Gupta, A., K. McElwee, D. Burke, J. Burreight, X. Cummings, and H. Egna (Editors), 2001. Eighteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 163 pp.
- Clair, D., J. Burreight, K. McElwee, M. Nidiffer, S. Sempier, and H. Egna (Editors), 2002. Nineteenth Annual Administrative Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 116 pp.
- McElwee, K., K. Lewis, M. Nidiffer, and P. Buitrago (Editors), 2002. Nineteenth Annual Technical Report. PD/A CRSP, Oregon State University, Corvallis, Oregon, 163 pp.
- Clair, D., K. Lewis, M. Olson, I. Courter, and H. Egna (Editors), 2003. Twentieth Annual Administrative Report. Aquaculture CRSP, Oregon State University, Corvallis, Oregon 94 pp.
- Clair, D., J. Burreight, R. Harris, I. Courter, and H. Egna (Editors), 2004. Twenty-first Annual Administrative Report. Aquaculture CRSP, Oregon State University, Corvallis, Oregon.
- Harris, R., I. Courter, and H. Egna (Editors), 2004. Twenty-first Annual Technical Report. Aquaculture CRSP, Oregon State University, Corvallis, Oregon, 315 pp.
- Boyd, C.E., 1998. Pond water aeration systems. *Aquacultural Engineering*, 18:9–40.
- Boyd, C.E., 1999. Aquaculture sustainability and environmental issues. *World Aquaculture*, 30(2):10–13 and 71–72.
- Boyd, C.E., 1999. Codes of practice for responsible shrimp farming. Global Aquaculture Alliance, St. Louis, Missouri. 42 pp.
- Brune, D.E. and R.H. Piedrahita, 1982. Operation of a retained biomass nitrification system for treating aquaculture water for reuse. Proceedings of the First International Conference on Fixed-Film Biological Processes, pp. 845–869.
- Cato, J.S. and C.L. Brown (Editors), 2003. Marine ornamental species: collection, culture, and conservation. Iowa State University Press, Ames, IA. 395 pp.
- Chang, W.Y., 1987. Large lakes of China. *J. Great Lakes Res.*, 13(3):235–249.
- Chang, W.Y.B. and H. Ouyang, 1988. Dynamics of dissolved oxygen and vertical circulation in fish ponds. *Aquaculture*, 74:263–276.
- Chang, W.Y.B. and R. Rossmann, 1988. Changes in the abundance of blue-green algae related to nutrient loadings in the nearshore of Lake Michigan. *Hydrobiologia*, 157:271–278.
- Chang, W.Y.B., 1986. Aquaculture research in China. *China Exchange News, CSCPRC, National Academy of Sciences*, 14(2):13–16.
- Chang, W.Y.B., 1986. Practical methods for treating fish during oxygen stress in ponds. *Aquaculture Magazine*, 13(4):20–22.
- Chang, W.Y.B., 1986. Vertical oxygen dynamics of shallow tropical impoundments in the Pearl River Delta, China. *Tran. Amer. Phys. Union*, 66(51):13–1.
- Chang, W.Y.B., 1987. A historical center of fish culture in China: Lake Tai/ Yangtze River Delta. *Aquaculture Magazine*, 13:39–42.
- Chang, W.Y.B., 1987. Fish culture in China. *Fisheries*, 12(3):11–15.
- Chang, W.Y.B., 1989. Estimates of hypolimnetic oxygen deficits in ponds. *Aquaculture and Fisheries Management*, 20:167–172.
- Chang, W.Y.B., 1989. Integrated lake farming for fish and environmental management in large shallow Chinese lakes: A review. *Aquaculture and Fisheries Management*, 20:441–452.
- Chang, W.Y.B., J. Diana, and W. Chapoehuk, 1983. Strengthening of Southeast Asian Aquaculture Institutions. Workshop Report to Agency for International Development.
- Corbin, J., J.C. Cato, and C.L. Brown, 2003. Marine ornamentals industry 2001: Priority recommendations for a sustainable future. In: Cato, J. and C.L. Brown (Editors), *Marine Ornamental Species: Collection, Culture, and Conservation*. Iowa State University Press, Ames, IA. pp. 3–10.
- Ebeling, J.M. and R.H. Piedrahita, 1985. Microcomputer-based data acquisition system for aquaculture use. *American Society of Agriculture Engineers*, 85-5014, 9 pp.
- Fitzsimmons, K., 2000. Future trends for tilapia aquaculture in the Americas. In: B.A. Costa-Pierce and J.E. Rakocy (Editors), *Tilapia Aquaculture in the Americas, Volume 2*. World Aquaculture Society and American Tilapia Association, Baton Rouge, Louisiana.
- Fitzsimmons, K., 2000. Tilapia aquaculture in Mexico. In: B.A. Costa-Pierce and J.E. Rakocy (Editors), *Tilapia Aquaculture in the Americas, Vol. 2*. World Aquaculture Society and American Tilapia Association, Baton Rouge, Louisiana, pp. 171–183.
- Fridley, R.B., R.H. Piedrahita, and T.M. Losordo, 1988. Challenges in aquacultural engineering. *Agricultural Engineering*, 69(4):12–15.
- Gross, A., C.E. Boyd, and C.W. Wood, 1999. Ammonia volatilization from freshwater ponds. *Journal of Environmental Quality*, 28:793–797.
- Gross, A., C.E. Boyd, and J. Seo, 1999. Evaluation of the ultraviolet spectrophotometric method for the measurement of total nitrogen in water. *Journal of the World Aquaculture Society*, 30:388–393.
- Hopkins, K.D., J.E. Lannan, and J.R. Bowman, 1988. Managing a data base for pond research data—the CRSP experience. *Aquabyte*, 1(1):3–4.
- Jamu, D., 2000. A pilot study on the spatial and temporal soil moisture. Liu, K.M. and W.Y.B. Chang, 1992. Bioenergetic modeling of effects

Other Work by CRSP Researchers

Publications

- Boyd, C.E. and A. Gross, 1999. Biochemical oxygen demand in channel cat-fish pond waters. *Journal of the World Aquaculture Society*, 30:349–356.
- Boyd, C.E. and C.S. Tucker, 1998. *Pond Aquaculture Water Quality Management*. Kluwer Academic Publishers, Boston, Massachusetts, 700 pp.
- Boyd, C.E. and H.R. Schmittou, 1999. Achievement of sustainable aquaculture through environmental management. *Aquaculture Economics and Management*, 3(1):59–70.
- Boyd, C.E. and J.W. Clay, 1998. Shrimp aquaculture and the environment. *Scientific American*, Jun 1998, 278(6):42–49.
- Boyd, C.E., 1998. Mechanical aeration in pond aquaculture, In: Proceedings Second International Symposium on Aeration Technology, American Society of Mechanical Engineers, Washington, DC, pp. 1–6.

- of fertilization, stocking density, and spawning on growth of the Nile tilapia, *Oreochromis niloticus* (L.). *Aquaculture and Fisheries Management*, 23:291–301.
- Losordo, T.M. and R.H. Piedrahita, 1988. Modeling vertical water quality profiles in aquaculture ponds, review and evaluation. *Proceedings of the Conference Aquacultural Engineering: Technologies for the Future at Stirling, Scotland. I. Cheme Symposium Series No. 111: EFCE Publications Series No. 66, Rugby, United Kingdom*, pp. 313–327.
- Losordo, T.M. and R.H. Piedrahita, 1988. Simulating aquacultural pond thermal stratification with a spreadsheet model. *American Society of Agricultural Engineers*, 88-5003, 38 pp.
- Losordo, T.M., J.M. Ebeling, and R.H. Piedrahita, 1986. Stratification measurement techniques in aquaculture ponds. *American Society of Agricultural Engineers*, 86-5047, 14 pp.
- Losordo, T.M., R.H. Piedrahita, and J.M. Ebeling, 1988. An automated water quality acquisition system for use in aquaculture ponds. *Aquacultural Engineering*, 7:265–278.
- McKeon, C., E. Glenn, C.P. Gerba, and K. Fitzsimmons, 2001. Microbiological hazards of tilapia culture systems. In: K. Fitzsimmons and J. Carvalho Filho (Editors), *Proceedings of the Fifth International Symposium on Tilapia Aquaculture*. Rio de Janeiro, Brazil, pp. 479–485.
- Nile tilapia (*Oreochromis niloticus*) in recirculation systems. In: K. Fitzsimmons and J. Carvalho Filho (Editors), *Proceedings of the Fifth International Symposium on Tilapia Aquaculture*. Rio de Janeiro, Brazil, pp. 368–381.
- Piedrahita, R.H. and D.E. Brune, 1989. *Aquacultural Engineering: Aquatic habitat commands innovative thrusts*. *Agricultural Engineering*, 70(1):30–32.
- Piedrahita, R.H. and G. Tchobanoglous, 1987. The use of human wastes and sewage in aquaculture. In: D.J.W. Moriarty and R.S.V. Pullin (Editors), *Detritus and microbial ecology in aquaculture: ICLARM Conference Proceedings 14, Manila, Philippines*, pp. 336–352.
- Piedrahita, R.H., 1987. Sensitivity analysis for an aquaculture pond model. In: J.G. Balchen (Editor), *Automation and Data Processing in Aquaculture*. IFAC Proc. Ser. No. 9, *Proceedings of the IFAC Symposium, Trondheim, Norway*, 18–21 Aug 1986, pp. 119–123.
- Piedrahita, R.H., 1988. Introduction to computer modeling of aquaculture pond ecosystems. *Aquaculture and Fisheries Management*, 19:1–12.
- Piedrahita, R.H., D.E. Brune, G. Tchobanoglous, and G.T. Orlob, 1984. A general model of the aquaculture pond ecosystem. *Journal of the World Mariculture Society*, 14:355–366.
- Piedrahita, R.H., G. Tchobanoglous, and B. Moore, 1987. Effect of organic matter addition to fish culture systems. *Transactions of American Society of Agricultural Engineers*, 30(1):233–237.
- Piedrahita, R.H., J.M. Ebeling, and T.M. Losordo, 1987. Use of data acquisition systems in aquaculture. In: J.G. Balchen (Editor), *Automation and Data Processing in Aquaculture*. IFAC Proc. Ser. No. 9, *Proceedings of the IFAC Symposium, Trondheim, Norway*, 18–21 Aug 1986, pp. 259–262.
- Potts, A.C. and C.E. Boyd, 1998. Chlorination of channel catfish ponds. *Journal of the World Aquaculture Society*, 29:432–440.
- Rodriguez, F. and T. Popma. Tilapia aquaculture in Colombia. In: B.A. Costa-Pierce and J.E. Rakocy, (Editors), *Tilapia Aquaculture in the Americas, Volume 2*. World Aquaculture Society, Baton Rouge, Louisiana, pp. 141–150.
- Smith, D.W. and R.H. Piedrahita, 1988. The relation between phytoplankton and dissolved oxygen concentration in fish ponds. *Aquaculture*, 68:249–265.
- Teichert-Coddington, D.R. and R.O. Smitherman, 1988. Lack of response by Tilapia nilotica to mass selection for rapid early growth. *Transactions of the American Fisheries Society*, 117:297–300.
- Teichert-Coddington, D.R., L.L. Behrends, and R.O. Smitherman, 1990. Effects of manuring regime and stocking rate on primary production and yield of tilapia using liquid swine manure. *Aquaculture*, 88:61–68.
- ture and distribution in integrated crop-fish-wetland and crop-wetland agroecosystems in Zomba-East, Malawi. In: K. Fitzsimmons and J. Carvalho Filho (Editors), *Proceedings of the Fifth International Symposium on Tilapia Aquaculture*. Rio de Janeiro, Brazil, pp. 582–587.
- Verdegem, M.C.J., A.A. van Dam, A.A. Cabarcas-Nuñez and L. Oprea (2000) Bio-energetic modelling of growth and waste production of Nile tilapia (*Oreochromis niloticus* L.) in recirculation systems, pp. 368–381 In: *Proceedings of the 5th International Symposium on Tilapia in Aquaculture*, 3-7 September 2000, Brazil.

Presentations

- Bowman, J. Soil pH and liming: A review of acidity/alkalinity management practices in aquaculture. Presented to the World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Boyd, C. E. Soil and water quality management in shrimp farming. Presented to Aquaculture Brazil '98 at Recife, Brazil. 1998.
- Boyd, C.E. Control of suspended solids in effluents from coastal aquaculture ponds. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting, Sydney, Australia, 26 Apr–2 May 1999.
- Boyd, C.E. Promoting environmentally responsible aquaculture to meet world food needs. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting at Sydney, Australia, 26 Apr–2 May 1999.
- Boyd, C.E. Shrimp farming and the environment. Presented to the IV Ecuadorian Symposium on Aquaculture, Guayaquil, Ecuador.
- Boyd, C.E. Use of probiotics in aquaculture. Presented to Fifth Asian Aquaculture Conference, Chiang Mai, Thailand, 1998.
- Boyd, C.E. Water quality in channel catfish farming. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting, Sydney, Australia, 26 Apr–2 May 1999.
- Boyd, C.E.. The Global Aquaculture Alliance Codes of Practice. Aquaculture '99, World Aquaculture Society Annual Meeting, Sydney, Australia, 26 Apr–2 May 1999.
- Brown, C. Ontogeny of digestive enzymes in marine larvae: Dietary and hormone effects. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting at Sydney, Australia, 26 Apr–2 May 1999.
- Brown, J.J., E.P. Glenn, and K.M. Fitzsimmons. Forage crop production on highly saline aquaculture effluent. Presented to Aquaculture '98, World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Chang, W. China integrated aquaculture: An efficient ecological system. Presented to the Limnology & Oceanography 1987 Annual Meeting.
- Chang, W. The world's highest lake: Tibetan Lakes. Presented to 30th Conference of the International Association for Great Lakes Research, 1987.
- Chang, W.Y.B. Large lakes in China. Presented to 29th Conference of the International Association for Great Lakes Research, 26–29 May 1986.
- Diana, J.S., D. Clapp, P. Hudson, and G. Regal. Movements of brown trout in the AuSable River, Michigan. Presented to the American Fisheries Society meeting at Dearborn, Michigan, Aug 1996.
- Fitzsimmons, K. and B.C. Posadas. Consumer demand for tilapia products in the U.S. and the effects on local markets in exporting countries. Presented to the Fourth International Symposium on Tilapia in Aquaculture at Orlando, Florida, 9–12 Nov 1997.
- Fitzsimmons, K. High school students and aquaculture projects. Presented to Aquaculture America '99 at Tampa, Florida, 27–30 Jan 1999.
- Lin, C.K. and C. Limsuwan. Management strategies and approaches for water quality improvement in shrimp farming. Presented to the American Association for the Advancement of Science at

- Philadelphia, Pennsylvania, 12–17 Feb 1998.
- Lin, C.K. Inland marine shrimp culture and its legislative, environmental and socio-economic implications in Thailand. Presented to Aquaculture '99, World Aquaculture Society Annual Meeting at Sydney, Australia, 26 Apr–2 May 1999.
- Lin, C.K., J.B. Hambrey, and J. Szyper. Environmental impact assessment for a shrimp farm project in Tanzania: A case study. Presented to Aquaculture '98, World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Lin, C.K., W. Ruttanagosrigit, D. Thakur, and P. Wanuchsoontorn. Organic matter and nutrients in sludge of closed ponds for intensive shrimp culture. Presented to Aquaculture '98, World Aquaculture Society Annual Meeting at Las Vegas, Nevada, 15–19 Feb 1998.
- Muthuwan, V. and C.K. Lin. Green water recirculating system for intensive culture of marine shrimp (*Penaeus monodon*). Presented to the Fifth Asian Fisheries Forum at Chiang Mai, Thailand, 10–14 Nov 1998.
- Phelps, R.P., K.L. Veverica, R.S. Weyers, and J.J. Duffy. Induced spawning of the red snapper, *Lutjanus campechanus*, using three different hormone treatments. Poster presented to the World Aquaculture Society Meeting at Bangkok, Thailand, Jan 1996.



APPENDIX 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
- Brooklyn College, New York
- 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 Adiestramiento 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 Tecnologia (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 (DIGEP-ESCA), 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
- Kasetsart University, Thailand
- 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 Investigación y Transferencia de Tecnología Agropecuaria para los Tropicos (PROCI-TROPICS), 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 Paulo, Brazil
- Secretaría de Agricultura y Ganadería, Honduras
- 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 California, Davis
- University of Cantho, Vietnam
- University of Delaware
- University of Fisheries, Nha Trang, Vietnam
- University of Nairobi, Kenya
- University of Oklahoma
- University of Stirling, United Kingdom
- University of Texas at Austin
- 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
- WorldFish (ICLARM)
- 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

ACIAR	Australian Center for International Agricultural Research	LHRHa	Luteinizing hormone-releasing hormone analog
ADR	Adoption/Diffusion Research	LIFD	Low-income food-deficit
AIT	Asian Institute of Technology	ME	Management Entity
AMR	Administrative Management Review	MEAR	Marketing and Economic Analysis Research
ANDAH	Asociación Nacional de Acuicultores de Honduras	MOU	Memorandum of Understanding
ASF	Animal source foods	MRC	Mekong River Commission
ASMR	Aquaculture Systems Modeling Research	MSU	Michigan State University
ATR	Appropriate Technology Research	MT	17 α -methyltestosterone
AU	Auburn University	NAR	Net annualized revenue
BAU	Bangladesh Aquacultural University	NASULGC	National Association of State Universities and Land-Grant Colleges
BOD	Biochemical oxygen demand	NAU	National Agriculture University
BOD	Board of Directors	NGO	Nongovernmental organization
BRAC	Bangladesh Rural Advancement Committee	NSR	New Aquaculture Systems/New Species Research
CF	Condition factor	OhSU	The Ohio State University
CFS	China Society of Fisheries	OSU	Oregon State University
CIAT	Centro Internacional de Agricultura Tropical	OSURF	Ohio State University Research Foundation
CIFAD	Consortium for International Fisheries and Aquaculture Development	PD/A CRSP	Pond Dynamics/Aquaculture CRSP
CLSU	Central Luzon State University	PDF	Portable Document Format
CONACYT	Consejo Nacional de Ciencia y Tecnología (National Council for Science and Technology)	PDR	Pond Dynamics Research
CRSP	Collaborative Research Support Program	PDVR	Product Diversification Research
DBT	Database Task Force	PMO	Program Management Office
DIGEPESCA	General Directorate of Fisheries and Aquaculture	PPEC	Proposal Planning Executive Committee
DO	Dissolved oxygen	PRR	Rural Reconstruction Program
E2	Estradiol	RCR	Reproduction Control Research
EdOp Net	Educational Opportunities Network	RFP	Request for Proposals
EEP	External Evaluation Panel	SIUC	Southern Illinois University at Carbondale
ER	Effluents and Pollution Research	SMILE	Science and Math Investigative Learning Experiences Program
FFR	Feeds and Fertilizers Research	SRP	Soluble reactive phosphorus
FIU	Florida International University	TA	Trenbolone acetate
FONDEPES	Fondo Nacional de Desarrollo Pesquero (National Fund for Fishing Development)	TAN	Total ammonia nitrogen
FSR	Food Security Research	TC	Technical Committee
GAFY	Gross annualized fish yield	TIPS	Tilapia Integration to Prawn Culture System
GIFT	Genetically Improved Farmed Tilapia	TN	Total nitrogen
GIS	Geographic Information System	TP	Total phosphorus
GISR	GIS: Planning, Policy, and Global Data Analysis Research	TS	Total solids
HSI	Hepatosomatic index	TSP	Triple superphosphate
HTML	Hypertext Markup Language	TSS	Total suspended solids
IAAS	Institute of Agriculture and Animal Science	UAPB	University of Arkansas at Pine Bluff
ICLARM	International Center for Living Aquatic Resources Management	UCD	University of California, Davis
IIAP	Instituto de Investigaciones de la Amazonia Peruana (Research Institute of the Peruvian Amazon)	UG	University of Georgia
IIFET	International Institute of Fisheries Economics and Trade	UH	University of Hawaii
IGF-1	Insulin-like growth factor 1	UJAT	Universidad Juárez Autónoma de Tabasco
IMNC	Information Management and Networking Component	UM	The University of Michigan
INPA	Instituto Nacional de Pesquisas da Amazonia	UO	University of Oklahoma
JCARD	Joint Committee on Agricultural Research and Development	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

