AQUAFISH CRSP
FOURTH ANNUAL REPORT
1 October 2009 to 30 September 2010

Aquaculture & Fisheries
Collaborative Research Support Program

Management Entity
Oregon State University
418 Snell Hall ◆ Corvallis, Oregon 97331-1643 ◆ USA
aquafish@oregonstate.edu

AQUAFISH CRSP FOURTH ANNUAL REPORT

Program activities are funded in part by the United States Agency for International Development (USAID) under CA/LWA No. EPP-A -00-06-00012-00 and by participating US and Host Country institutions.

Disclaimers
The contents of this document do not necessarily represent an official position or policy of the United States Agency for International Development (USAID). Mention of trade names or commercial products in this report does not constitute endorsement or recommendation for use on the part of USAID or the AquaFish Collaborative Research Support Program (CRSP). The accuracy, reliability, and originality of work presented in this report are the responsibility of the individual authors.

Acknowledgments
The Management Entity of the AquaFish CRSP gratefully acknowledges the contributions of CRSP researchers and the support provided by participating US and Host Country institutions.

Cover Photo
Photo by Hillary Egna: Taken in Ghana, August 2010

This publication may be cited as:
AquaFish Collaborative Research Support Program. October 2010. Fourth Annual Report. AquaFish CRSP, Oregon State University, Corvallis, Oregon, 238 pp.

AquaFish CRSP Management Entity
Oregon State University
418 Snell Hall ◆ Corvallis, Oregon 97331-1643 ◆ USA

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... **i**

I. INTRODUCTION **1**

II. PROGRAM HIGHLIGHTS **2**

III. FISHELLANEOUS **6**

IV. RESEARCH & TECHNOLOGY TRANSFER ACCOMPLISHMENTS **19**

V. OVERVIEW OF RESEARCH PROGRAM STRUCTURE **29**

VI. CORE RESEARCH PROJECT REPORTS **35**

LEAD US UNIVERSITY: AUBURN UNIVERSITY
HYDROLOGY, WATER HARVESTING, AND WATERSHED MANAGEMENT FOR FOOD SECURITY, INCOME, AND HEALTH: SMALL IMPOUNDMENTS FOR AQUACULTURE AND OTHER COMMUNITY USES *36*

LEAD US UNIVERSITY: NORTH CAROLINA STATE UNIVERSITY
IMPROVED COST EFFECTIVENESS AND SUSTAINABILITY OF AQUACULTURE IN THE PHILIPPINES AND INDONESIA *45*

LEAD US UNIVERSITY: PURDUE UNIVERSITY
IMPROVING COMPETITIVENESS OF AFRICAN AQUACULTURE THROUGH CAPACITY BUILDING, IMPROVED TECHNOLOGY, AND MANAGEMENT OF SUPPLY CHAIN AND NATURAL RESOURCES *55*

LEAD US UNIVERSITY: UNIVERSITY OF ARIZONA
DEVELOPING SUSTAINABLE AQUACULTURE FOR COASTAL AND TILAPIA SYSTEMS IN THE AMERICAS *60*

LEAD US UNIVERSITY: UNIVERSITY OF CONNECTICUT
DEVELOPMENT OF ALTERNATIVES TO THE USE OF FRESHWATER LOW VALUE FISH FOR AQUACULTURE IN THE LOWER MEKONG BASIN OF CAMBODIA AND VIETNAM: IMPLICATIONS FOR LIVELIHOODS, PRODUCTION AND MARKETS *65*

LEAD US UNIVERSITY: UNIVERSITY OF HAWAI'I AT HILO
HUMAN HEALTH AND AQUACULTURE: HEALTH BENEFITS THROUGH IMPROVING AQUACULTURE SANITATION AND BEST MANAGEMENT PRACTICES *73*

LEAD US UNIVERSITY: UNIVERSITY OF MICHIGAN
IMPROVING SUSTAINABILITY AND REDUCING ENVIRONMENTAL IMPACTS OF AQUACULTURE SYSTEMS IN CHINA, AND SOUTH AND SOUTHEAST ASIA *80*

LEAD US UNIVERSITY: OREGON STATE UNIVERSITY
ASSESSING THE IMPACTS OF CRSP RESEARCH: HUMAN CAPITAL, RESEARCH DISCOVERY, AND TECHNOLOGY ADOPTION *89*

VII. MALI ASSOCIATE AWARD PROJECT **93**

VIII. CAPACITY BUILDING **114**

SHORT-TERM TRAINING *114*

LONG-TERM TRAINING *116*

OUTCOMES AND IMPACTS OF AQUAFISH CAPACITY BUILDING EFFORTS *119*

CRSP CO-SPONSORED CONFERENCES AND EVENTS *121*
IX. SYNTHESIS **131**
DEVELOPMENT THEMES ADVISORY PANELS (DTAP) *131*
REGIONAL CENTERS OF EXCELLENCE (RCE) *135*
SYNTHESIS PROJECT *148*
X. MONITORING & EVALUATION **150**
DTAP INDICATORS *150*
KEY DEVELOPMENT TARGETS: INDICATORS & BENCHMARKS *151*
USAID IMPACT REPORTING USAID IMPACT REPORTING *163*
XI. LESSONS LEARNED **166**
APPENDIX 1. PROGRAM PARTICIPANTS **169**
APPENDIX 2. LINKAGES **175**
APPENDIX 3. LEVERAGED FUNDING **178**
APPENDIX 4: MONITORING & EVALUATION TABLES **179**
APPENDIX 5. ACRONYMS **225**
APPENDIX 6. LIST OF PEER REVIEWED JOURNAL PUBLICATIONS **230**

EXECUTIVE SUMMARY

The Fourth Annual Report for the AquaFish CRSP covers FY2010 activities and accomplishments in 16 countries in Africa, Asia, and Latin America. During this reporting period, Host Country investigators representing 29 institutions and their US partners at 16 universities undertook a collaborative program focused on improving the livelihoods of the rural poor and building institutional capacity through training of students and stakeholders at all levels from rural fish farmers to government policy makers. The eight core research projects initiated 50 new investigations under *Implementation Plan 2009–2011*. These investigations cover all of the ten AquaFish CRSP topic areas in the categories of *Integrated Production Systems* and *People, Livelihoods, and Ecosystems Relationships*.

Among the FY2010 research accomplishments are significant advances in sustainable feed technologies, domestication of indigenous fish species, and improved waste management systems. For example, at Can Tho University in Vietnam, researchers developed a pelleted feed with a lower fishmeal content for farmed snakehead, a high-value freshwater fish. This new feed represents a significant step toward resolving the conflict between poor people who depend on small fish from the Mekong River Basin for their food and snakehead farmers whose competitive need for a fishmeal source is threatening the sustainability of the fishery. At the Autonomous Juarez University of Tabasco in Mexico, researchers made advancements on two fronts. One research team succeeded in getting snook, a popular native food fish, to spawn in captivity and developed a customized diet that ensures survival of young fish to the next growth stage. Overcoming these initial hurdles is a promising step toward domestication. Snook aquaculture will open new income opportunities for smallholders along Mexico's gulf coast. Hatcheries and fish farmers who use methyltestosterone (MT) to produce all-male tilapia fingerling populations for fish stocking are close to having a simple, cost-effective technology for removing residual hormone from treatment water. Researchers identified bacteria species that consume MT residue and are finalizing their experimental work in preparation for commercial scale-up. For the USAID/Mali Associate Award, farmer-to-farmer contacts following rice-fish demonstrations and pond culture trainings have led to multiplier effects with respect to the adoption of new technologies and the numbers of farmers benefitting from project interventions.

Since program inception in October 2006, AquaFish CRSP has supported 273 students in long-term academic training. Women represent 48% of this student population. For FY2010, 196 students were enrolled in undergraduate and graduate programs in Host Country and US institutions. During the the past year, 25 short-term trainings held in 11 Host Countries reached 694 stakeholders, raising the total number of trainees since program inception to 3,106. For rural smallholders, these trainings covered a range of topics including production and processing best practices for fish and shellfish, value-added processing, marketing, and sustainable feed technologies. Several production and processing workshops specifically involved women. Addressing the need for institutional capacity building, five train-the-trainer workshops were conducted for researchers, extensionists, hatchery managers, and farmer trainers.

The AquaFish CRSP program continues to look outward by building linkages among Host Countries through the activities of its Regional Centers for Excellence (RCE), which expanded with the opening of an RCE for West Africa. Taking an internal focus, AquaFish CRSP initiated an Impact Assessment Project to build a framework by which to examine core research project progress through methodologies developed for assessing research discoveries and impacts of technology adoption.

I. INTRODUCTION

The mission of the Aquaculture & Fisheries Collaborative Research Support Program (AquaFish CRSP) is to enrich livelihoods and promote health by cultivating international multidisciplinary partnerships that advance science, research, education, and outreach in aquatic resources. The United States Agency for International Development (USAID) looks at the AquaFish CRSP to "develop more comprehensive, sustainable, ecological and socially compatible, and economically viable aquaculture systems and innovative fisheries management systems in developing countries that contribute to poverty alleviation and food security."

This report describes the activities and accomplishments of the AquaFish CRSP from 1 October 2009 to 30 September 2010. USAID funds the AquaFish CRSP under authority of the Foreign Assistance Act of 1961 (PL 87-195), as amended. Significant funding is also provided by the participating US and Host Country institutions. The AquaFish CRSP is a partner of USAID's Economic Growth, Agriculture, and Trade (EGAT) Bureau's Office of Agriculture.

AquaFish 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 first USAID award, which was received on 30 September 2006, the CRSP is guided by the concepts and direction set down in the *Program Description*, which is funded under USAID CA/LWA No. EPP-A-00-06-00012-00. This award authorizes program activities from 30 September 2006 to 29 September 2011.

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 technical and programmatic activities at OSU are carried out by a Management Team (MT: Director and staff), which is supported in the task of program administration by advisory bodies. Management team personnel and advisory group membership during the reporting period appear in Appendix 1.

The AquaFish CRSP diverges from the previous Aquaculture CRSP in both organization and theme. Organizationally, this CRSP is a Cooperative Agreement, with a Leader with Associates (LWA) term of reference, whereas the Aquaculture CRSP was a grant. The LWA is a mechanism for allowing additional USAID funding to complement core activities. Core activities are funded by EGAT's Office of Agriculture originally at $8.9 million over 5 years, but amended in September 2009 to $12.82 million for additional work in technology transfer, outreach, impact assessment, and communications.

Associate Award activities under the Lead totaled $750,000 since 2007, or $250,000 during this reporting period. The AquaFish CRSP ME is wrapping up an Associate Award focusing on aquaculture and fisheries in Mali which was due to expire on 30 September 2010 but which received a three-month no-cost extension. On the last days of this reporting period, the ME received another Associate Award (AA). This new $1.1million AA is from EGAT for scaling up technologies as part of the US Government Feed the Future initiative. Thematically, the new AquaFish CRSP focuses on aquaculture with its core funds, and on both aquaculture and fisheries with its Associate Awards. The themes echo much of the sustainable aquaculture emphasis of the Aquaculture CRSP, since that earlier CRSP incorporated a farsighted and mindful approach.

II. PROGRAM HIGHLIGHTS

In Fiscal Year 2010, AquaFish CRSP managed eight core research projects and two program-wide projects operating at 16 US universities, 29 HC institutions and in 16 countries. Below are programmatic comments and highlights for Fiscal Year 2010.

- At the beginning of this FY, in September 2009, the ME was awarded additional funding to its core award raising the ceiling from $8.9 million to $12.82 million. The additional funding came in response to an RFA in August 2009, which CRSP Director, Dr. Hillary Egna, applied for with a full proposal, including a technical application and cost proposal for $3.92 million.

- FY 2010 was the first year of programming for increased funding from USAID with the objectives of: 1) promoting the extension of CRSP technologies through extension, commercialization, and partnership; and 2) assessing the impact and communicate the importance of CRSP research. Work conducted under this included:
  - A project designed to assess AquaFish CRSP discoveries, technology adoption, and impacts.
  - A project employing a journalistic approach for preparing stories to illustrate successes and sustainable practices of AquaFish CRSP.
  - Support for "add-on" investigations proposed by the current US Lead Institutions to advance USAID's stated objectives for this additional funding.

- No-cost extensions (NCE) were granted to the six original core research projects for extending their work under the *Implementation Plan 2007-2009* from 30 September 2009 through 31 December 2009 for five projects and through 31 March 2010 for one other. NCEs were requested due to delays stemming from natural disasters and political events that included flooding and the Swine flu pandemic in Mexico and political unrest in Kenya.

- After review by an external NSF-style peer-review panel held in September 2009, proposals for 2009-2011 continuation work from the six existing US lead institutions were approved and subawards extended through 29 September 2011. Work being conducted under *Implementation Plan 2009-2011* now includes a total of eight lead research projects involving 16 countries, 16 US universities, and over 29 HC institutions.

- The Management Team published the *Implementation Plan 2009-2011* (April 2010), *Aquanews* (quarterly) and *EdOPNet* (monthly). The Management Team updated the *Site Descriptions (07-09)*; wrote an *Annual Work Plan* (a new report required for the additional September 2009 funding); and published two volumes of final investigation reports.
  - *AquaFish Collaborative Research Support Program (September 2010). Technical Reports: Investigations 2007-2009: Volume 1*
  - *AquaFish Collaborative Research Support Program. (September 2010)Technical Reports: Investigations 2007-2009: Volume 2*

  The Management Team also published updated AquaFish CRSP Brochures (February 2010) and posters for the following meetings and events:
  - Reifke, Lisa, James Bowman, and Hillary Egna. *Promoting Sustainable Aquaculture and Fisheries Through*

Capacity Building: A Synopsis of Short- and Long-Term Training Conducted Under the AquaFish CRSP. Aquaculture 2010, San Diego, CA, March 2010.

- Evans, Ford, Stephanie Ichien, Laura Morrison, and Hillary Egna. *Mitigating the negative environmental impacts of aquaculture practices.* Aquaculture 2010, San Diego, CA, March 2010.
- Evans, Ford, Stephanie Ichien, and Hillary Egna. *AquaFish CRSP: Advancing research, education, and outreach in aquatic resources through international partnerships.* Aquaculture 2010, San Diego, CA, March 2010.
- Bowman, James, Lisa Reifke, Héry Coulibaly, Charles Ngugi, Yang Yi, Liu Liping, Nancy Gitonga, Peter Nzungi, and Hillary Egna *Towards The Development of Sustainable Freshwater Aquaculture and Fisheries Management in Mali: Collaborative Work Under the AquaFish CRSP*. Aquaculture 2010, San Diego, CA, March 2010.
- The AquaFish CRSP Management Team. *AquaFish Collaborative Support Program.* Oregon State University Earth Day, Corvallis, OR, April 2010.
- The AquaFish CRSP Management Team. *AquaFish Collaborative Support Program.* Oregon State University Day, Corvallis, OR, September 2010.
- Egna, Hillary and Stephanie Ichien. *Poverty Alleviation in Developing Countries Through Sustainable Solutions in Aquaculture and Fisheries*. IIFET 2010, Montpellier, France, July 2010.

All publications are available for download from the AquaFish website (http://aquafishcrsp.oregonstate.edu).

- The AquaFish CRSP MT organized and facilitated the AquaFish CRSP Annual Meeting, held this year in San Diego, California, prior to the World Aquaculture Society's "Aquaculture 2010" conference (March 2010). US and HC personnel were in attendance as well as external evaluators from World Wildlife Fund and University of Tasmania to assess program output. Meeting highlights include:
  - AquaFish CRSP Director Hillary Egna chaired the Aquaculture 2010 technical session *Optimizing Small-Scale Aquaculture for the Poor*: *A Session in Honor of Yang Yi*, a long-time CRSP participant who passed in away in July 2009. The full-day technical session included 27 presentations focusing primarily on CRSP research in Asia, Africa and Latin America.
  - AquaFish CRSP Director Hillary Egna presented the Outstanding Achievement Award to Jim Diana (University of Michigan) during the plenary session of Aquaculture 2010, honoring his accomplishments and contributions to aquaculture.
  - The *SOU-CRSP Yang Yi Travel Award* was established during FY 2010 to support excellent young scientists from one of the Asian partner institutions to present research at professional aquaculture conferences. This year's recipient was Zexia Gao, who used the award to attend the AquaFish CRSP Annual Meeting and Aquaculture 2010.
  - AquaFish CRSP US Lead PIs, Drs. Kevin Fitzsimmons and Jim Diana, presented the AquaFish CRSP award for best student poster at the Aquaculture 2010 student reception.

- In FY 2010, AquaFish CRSP continued to support IIFET (International Institute of Fisheries, Economics & Trade), through the Developing Country Aquaculture Economics Best Student Paper Prize and the Aquaculture Economics Professional Travel Award presented at the IIFET 2010 conference in Montpellier, France. AquaFish Director, Dr. Hillary Egna, presented the best student paper to Jayasekhar Somasekharan (India) and three awards to Giap Nguyen (Vietnam), Taiwo Ejiola Mafimisebi (Nigeria), and Indah Susilowati (Indonesia).

- The Library Donation Project, administered by the AquaFish CRSP MT, continued in FY 2010, shipping boxes of scientific references,

textbooks, and journals donated to Host Country libraries in Kenya and Mexico.

- The AquaFish CRSP secure website for the MT and project partners made great leaps forward in the past year. Existing databases, such as short-term and long-term training have been updated with features including multiple viewing options, uploading of documents, and connectivity to more user-friendly online reporting forms. New features for FY2010 include:
  - An online travel database, allowing for more efficient tracking and reporting of authorized trips
  - An interactive photo gallery allowing CRSP participants to upload and edit photos
  - A multi-media page, providing a platform to help distribute photo, print, and video media
  - SUA (Single User Accounts) allowing for various levels of secure access to the AquaFish CRSP website
  - Online outreach via Facebook
  - The ability to view AquaFish field sites via Google Earth

- AquaFish CRSP continued to provide leverage, establish research, ties and help facilitate linkages between ongoing AquaFish CRSP projects and former Aquaculture CRSP researchers. Through their FY2010 Quarterly, Annual and Regional Centers of Excellence Reports, current AquaFish core research projects have reported over $440,000 in leveraged support (i.e. non-AquaFish CRSP funds that were acquired as a consequence of CRSP funding). This leveraged support is in addition to US non-Federal cost share and Host Country Institution match. For additional details, see Appendix 3.

- The AquaFish CRSP Director continued to explore avenues to promote SARNISSA (Sustainable Aquaculture Research Network in Sub-Saharan Africa) and continue its role as a highly successful social networking tool for the aquaculture industry across Africa - currently reaching over 1,500 registered members.

- As a member of the steering committee of the CRSP Council, the AquaFish CRSP Director continued to interact with other CRSP's on a variety of topics through several conference calls during this fiscal year. The AquaFish CRSP Director and Research Projects Manager also attended the joint USAID/CRSP Directors Meeting held in September 2010 in Washington DC via conference call.

- The AquaFish CRSP Director and Capacity Building Coordinator participated in a conference call with the Long-Term Agricultural Training Assessment Team (Under USAID contract) to provide CRSP insight to identify the most effective features of long-term U.S. training programs that build African institutional capacity in agriculture.

- As in previous years, the Regional Centers of Excellence (RCE) continued to build linkages and promote networking opportunities. This year, the Africa RCE was divided to include one RCE focusing on Eastern and Southern Africa (RCE Lead Coordinator: Charles Ngugi) and a second new RCE focusing on West Africa (RCE Lead Coordinator: Hery Coulibaly). The division was necessary to provide adequate coverage for these large and very active regions. Highlights of RCE activities are included below (excluding the newly formed West Africa RCE as it had not started until August 2010).
  - In Asia, Lead Coordinator Dr. Remedios Bolivar (Central Luzon State University in the Philippines) has continued to promote international and regional networking by visiting commercial fish farms and initiating contact with Mindanao State University to foster future collaborative partnerships. Networking was also facilitated by Dr. Bolivar's attendance at a regional meeting on Tilapia culture in the Philippines, which was also attended by the Asia Regional Coordinators of The WorldFish Center.

  - Dr. Bolivar also expanded linkages by communicating with individuals that support the role of women in aquaculture

and fisheries in Asia, including the Gender and Development (GAD) Officers at the local-level (at CLSU) and at the national-level through the Bureau of Fisheries and Aquatic Resources in the Philippines.

- RCE Lead Coordinator, Dr. Charles Ngugi (Kenyatta University in Kenya) has continued to strengthen CRSP networks throughout Africa, including work with the Sustainable Aquaculture Research Network in Sub-Saharan Africa (SARNISSA) and the Aquaculture Network for Africa (ANAF). Dr. Ngugi attended the ANAF annual meeting in Jinja, Uganda, at the beginning of July, which was organized by the FAO.

- Dr. Ngugi has maintained excellent working relations with NGOs, such as Women in the Fishing Industry Programme (WIFIP), a not-for-profit organization, based in Western Kenya, working on educating women and other vulnerable groups in the fishing industry.

- During this reporting period, Dr. Ngugi has initiated contact with and visited several feed manufacturers to assist fish farmers source quality feeds. One manufacturer, Ugachick in Uganda, is currently supplying extruded feed to the fish farming industry and another, Sigma Feeds, has plans to start producing extruded feeds at their Nairobi facility. A third feed producer, Unga Feed Factory in Nakuru, Kenya, was visited to encourage diversifying into fish feeds.

- In Latin America and the Caribbean (LAC), RCE Lead Coordinator Dr. Wilfrido Contreras-Sanchez (Universidad Juárez Autónoma de Tabasco) continues to support small- and medium-size fish farms in the region, and has also expanded collaborations to include larger farms. The RCE Lead Coordinator is communicating with a large-scale commercial farm, Acuagranja Dos Lagos, Mexico, to facilitate transfer of technology for tilapia production as well as the production of native fish for restocking efforts.

- The LAC RCE has strengthened linkages with non-profit organizations such as Fundacion Vigas which is interested in the development and commercialization of marine species, as well as linkages with governmental funding organizations, such as Fundacion Produce which recently approved two collaborative projects between UJAT and a commercial fish farm.

- The ME continues to administer the “Mali Project” Associate Award (AA) for aquaculture and fisheries work in Mali, West Africa. This project, funded for three years by the USAID Mission in Mali, began 1 October 2007 and runs through 30 September 2010. During this reporting year, the project made great strides, including running eight short-term training courses for 122 participants, beginning on-farm fish culture trials with six participating farmers and rice-fish culture demonstrations with four participating farmers, and conducting the first-ever frame survey of Lake Sélingué.

- During FY 2010, the AquaFish CRSP held 25 short-term training events with 694 trainees and supported long-term training for 273 students from 22 countries at US and Host Country Universities.

- In August 2010, the AquaFish CRSP Director, Dr. Hillary Egna, responded to a an RFAA (request for Associate Award Application from USAID/EGAT to “scale-up the dissemination and commercialization of improved agricultural technologies and/or management practices”. On 28 September 2010, the AquaFish CRSP ME at OSU was awarded a 3-year, $1.1 million Associate Award to “Enhance the profitability of small aquaculture farm operations in Ghana, Kenya, and Tanzania.” This was the culmination of over six months of work with numerous revisions and additional analyses, starting from a call for “concept papers” in March 2010.

III. FISHELLANEOUS

Successes throughout all the projects can be seen in the achievements of the AquaFish CRSP researchers and their students. The following Aquanews clippings offer a view into the people and projects of the CRSP during this reporting period.

AQUANEWS CLIPPINGS
CORE RESEARCH PROJECTS

AUBURN UNIVERSITY

The Role of Fish Producer Organizations for Developing Commercial Fish Farmers in Uganda

(Volume 25, Number 1/ Summer 2010)

In the words of a Ugandan fish farmer, the news is out: "Households with land and water can earn good incomes through fish farming." Many Ugandans have joined fish producer organizations in hopes of improving their household food security and incomes. Fish producer organizations have a crucial role to play in developing a commercial fish farming sector, linking people to each other and to valuable resources. In the Ugandan aquaculture context, fish producer organizations are stores of technical information, experience, and relationships with fingerling producers, feed sources, extension staff, funding agencies, and other networks.

Uganda is well poised to increase its aquaculture productivity and develop a thriving commercial aquaculture sector. All of the necessary factors (i.e., availability of quality fingerlings, formulated feeds, quality technical information, affordable long-term investment capital, access to land and water resources, and a favorable governance climate) are currently present or are being strengthened. Besides the factors listed, another important element of commercial aquaculture development is strong fish producer organizations, which is the focus of this study.

According to the aquaculture development literature, the long list of beneficial roles for fish producer organizations include: influencing policy and regulations, providing technical services, facilitating market access, providing extension services, developing and encouraging adherence to codes of conduct or better management practices, extending credit to member farmers, and facilitating knowledge-sharing. All of these activities contribute to the development of commercial fish farming sector.

Despite enthusiasm for fish producer organizations in Uganda, no framework or set of guidelines exists for creating effective fish producer organizations. In fact, many fish producer organizations are described as ineffective or short-lived. Emily Stutzman Jones, a Masters student in Rural Sociology at Auburn University, under the direction of Dr. Joseph Molnar, collaborated with AquaFish CRSP host country investigators to identify key elements inherent in successful fish producer organizations.

We examined four fish producer organizations in Uganda with the goal of understanding the characteristics of fish farmer organizations with productive member farmers. The host country investigators, Gertrude Atukunda and John Walakira, worked extensively with fish farmer organizations through their professional roles at Uganda's National Fisheries Resources Research Institute (NaFIRRI). We used qualitative social science research methods including semi-structured interviews and participant observation.

Producer organizations were selected in diverse areas of the country: one in northern Uganda, one in central Uganda, and two in western Uganda. Each focuses on tilapia production, although one

also raises African catfish. Two of the producer organizations practice lake cage culture, one on Lake Victoria and one in western Uganda. One producer organization produces and sells fingerlings. One is involved exclusively in pond culture.

These four producer organizations are similar in some important ways. Each organization is formed based on the advice of a government official and with the goal of accessing government or NGO funding. Most importantly, all producer organizations operate under government organized umbrella groups.

With all four programs, the nature and focus of the umbrella organization has important effects on the member group. In one case, the umbrella organization focuses on poverty alleviation, and operates a variety of income-generating projects for their members. Their activities include handicraft production, roadside food vendors, and fish farming. To this umbrella organization, fish farming is viewed as a project, not as a business.

In another case, the umbrella organization focuses on environmental conservation. Their projects include beekeeping, animal husbandry, improving stoves, environmental education, and fish farming. Here, too, fish farming is viewed as one of many projects, and not as a commercial activity. These two fish producer organizations received the most donor funding. With donor funding comes donor requirements, which include serving the disabled, providing HIV/AIDS education, and caring for orphans. While these are laudable efforts, they can distract from the focus on developing commercial fish farmers.

In a third case, the umbrella group is a national fish farmers' cooperative society, and their member groups are fish farmer organizations. Compared to the umbrella groups with a variety of activities, the producer organization that operates under the fish farmer-focused umbrella group is the most productive. They also receive the least donor assistance of any of the four groups. Also, through a national fish farmer cooperative society, the local fish producer organizations have access to aquaculture-specific information and resources.

Although conclusions about these four case studies cannot be extended to all fish farmer organizations in Uganda, our study identifies some key characteristics of strong leaders within these organizations in the Ugandan context. For example, strong leaders have already achieved success as fish farmers, putting them in a position to serve as mentors for beginning fish farmers. Also, as successful fish farmers, they are less likely to see leading a fish producer organization as a financial end in itself. Additionally, strong leaders value good technical training. Ironically, the leaders of the least productive fish farmer organizations feel that their training is sufficient, focusing instead on their needs for financial assistance. On the other hand, the leaders of the most productive fish producer organizations stress their need for more technical training.

Development professionals urge fish farmers to form or join organizations. Our research suggests that not all fish farmer organizations serve the interest of developing commercial fish farmers. Specifically, fish farmer organizations belonging to umbrella organizations specializing in aquaculture are more effective at increasing member fish farmers' production than umbrella organizations with diverse activities and wide-ranging goals.

Photo in Uganda courtesy of Joseph Molnar

NORTH CAROLINA STATE UNIVERSITY

Feed Reduction Strategies and Alternative Feeds Effective in Reducing the Costs of Pond-Cultured Tilapia in the Philippines

(Volume 25, Number 1/Spring 2010)

Feed constitutes 60-80% of total variable costs for producing tilapia. Therefore, any strategies that prove effective in limiting the quantity of feed used for fish growout and the cost of formulated feeds could reduce overall feed costs, improving the efficiency of tilapia culture and the subsequent incomes of farmers. Investigators at Central Luzon State University (CLSU) in the Philippines and North Carolina State University (NCSU) show that feeding reduction protocols and the replacement of costly fishmeal in formulated diets are effective in decreasing overall costs in the semi-intensive pond culture of tilapia in the Philippines.

Earlier CRSP work at CLSU showed that 1) delaying the onset of supplemental feeding to either 45-days or 75-days in fertilized ponds reduces the amount of feed consumed without any negative impact on the production of marketable tilapia, 2) feeding at a sub-satiation level of 67% did not reduce measurable production of marketable fish relative to fish fed at 100% satiation level, and 3) feeding only on alternate days saved approximately half of feed cost without a significant reduction in growth, survival, or market yield of Nile tilapia in growout ponds. The first of a series of studies led by Remedios Bolivar of CLSU and Russell Borski of NCSU, and their students and collaborators, tested the utility of combining delayed and reduced feeding strategies to evaluate if production costs of tilapia for farmers in the Philippines could be further reduced. They examined a feeding management strategy that incorporated an initial period of 60 days delayed feeding, followed by 30 day alternate day feeding, and then 67% satiation feeding. They compared the growth and yield of fish on the combined delayed-reduced feeding protocol to that of fish fed daily at prescribed levels. The study lasted 120-days and was done on the farms of local tilapia growers in the Central Luzon region. Each farm allocated two ponds, one each for the delayed-reduced and the normal feeding protocol. Ponds were fertilized weekly to provide supplemental planktonic feed. Fish raised on the delayed-reduced feeding protocol showed lower growth rates and survivorship and overall harvest size then fish fed daily at full prescribed levels. Approximately 55% less feed was applied to animals on the combined delayed-reduced feeding regimen relative to those fed on a traditional full daily feeding schedule. Overall, they found that the combined delayed and reduced ration feeding method is less effective at improving the cost-effectiveness of tilapia farming than when used individually.

In a second on-farm growout trial, they evaluated if a 50% reduction in daily ration level might prove an additional option for reducing costs of tilapia production, over and above that observed previously with 67% satiation feeding. Production variables were measured in tilapia fed daily at 50% subsatiation versus those on a full daily ration. Fish on the reduced ration level had growth and survival rates, and final harvest size that did not differ significantly from fish fed a full daily ration over 120 days. Fish on the reduced ration also consumed 56% less feed and had 100% improved feed conversion relative to fish fed full ration. Hence, it took substantially less feed to produce marketable fish when tilapia are raised on half the normal feed ration. A basic cost-benefit analysis indicates the net return of fish on the reduced ration level was approximately $1375/hectare compared with $14/hectare for tilapia on the typical full daily ration. Collectively, these results show that farmers have the potential to dramatically improve incomes while reducing nutrient loading in pond waters.

The cost of commercial fish feeds is rising sharply as the market demand increases to supply the growing aquaculture industry and the availability

of fishmeal declines. About 20% of feed costs are attributable to fishmeal, which constitutes 7-10% of the feed formulation. Much of the fishmeal used for tilapia in the Philippines is imported, and costs are expected to rise in the future as global supplies become constrained by increasing demands and declines in commercial bait fisheries.

Because tilapia are omnivorous fish, which naturally feed on plankton, diatoms, small crustaceans, algae, higher plants and detritus, they do not require fish in their diet and they are an ideal group of species to recycle food by-products into high quality food protein for humans. Therefore, CLSU and NCSU investigators conducted a series of studies to evaluate the utility of other protein sources; namely, fermented mechanically deboned meat poultry byproduct, yeast extract protein, and poultry by-product meal in replacing fishmeal. They found that substitution of fishmeal with these ingredients was as effective as standard diets containing fishmeal in the growout of tilapia in tanks.

A critical element to subsequent investigations was to formulate diets to replace fishmeal that incorporate ingredients widely available in the Philippines. To this end, studies were conducted in cooperation with Santeh Feeds Corporation in the Philippines to evaluate the efficacy of diets formulated with pork by-product meal as a replacement for fishmeal and that also included cassava meal, copra meal, coconut oil, rice bran, and local fish oils produced in the Philippines. In testing the diets, they also used an alternate-day feeding scheme whereby fish were fed every other day rather than daily. This reduced feeding strategy previously was shown to produce fish of comparable yields as those fed daily, but at half the feed cost. An evaluation of the least-cost formulated diet containing 0% fishmeal showed it to be as effective as the standard diet containing 6% fishmeal on the growth performance and production characteristics of tilapia during a 120-day growout in experimental ponds at CLSU. A marginal budget analysis showed an 8% improved return on fish fed the cheaper diet lacking fishmeal. This along with the alternate-day feeding strategy has the potential to reduce overall feed costs for growing marketable size tilapia by > 60%.

Collectively, the series of studies discussed here show that reduced feeding strategies and substitution of diets containing fishmeal with cheaper and more sustainable sources of protein are effective options for reducing the costs without negatively impacting the production of tilapia. Future work at CLSU and NCSU will continue to harness the input and cooperation of farmers and local feed manufacturers to further the development practical strategies and technologies that yield additional cost savings for small scale farmers in the Philippines and other regions of the world. Complimentary outreach activities, including the development of Tilapia Podcast modules is underway to extend cost containment strategies to the tilapia farming community.

PURDUE UNIVERSITY

The Bidii Fish Farmers Association: A Success Story of Fish Farming Clusters in Kenya

(Volume 25, Number 1/ Spring 2010)

Aquaculture in Kenya is mainly comprised of small-scale farmers practicing extensive fish farming in earthen ponds. To help address the challenges of inefficiencies in production and marketing that these farmers face, the USAID office in Kenya initiated a program for fish farmers in 2006 aimed at providing business development services (BDS) that would lead to new aquaculture enterprises and new markets for fish farmers. The Kenya BDS program focused on training small-scale farmers by providing technical advice and information transfer.

In 2007, AquaFish CRSP partnered with the Kenya BDS program to help farmers come together into clusters for the production of catfish fingerlings as baitfish for the Lake Victoria fisheries, and to assist with market integration of

cluster farmers with baitfish markets. The program began with the formation of four fish farmer clusters located in districts around Lake Victoria in Kenya's Western Province— Bidii Fish farmers (Vihiga cluster), Bukhayo Self Help Group (Mundika cluster), Funyula North Fish farmers (Funyula cluster), and the Tumainin Self Help Group (Matayos cluster).

Today, the Bidii Fish farmers Cluster has become a model that is motivating the formation of other fish farmers groups. George Ambuli, Bidii Chairman, explained that the beginning was not easy. "The group started off with 10 individual fish farmers as members," he said. "Each member owns their own ponds but the group coordinates production and sells collectively. They also started off interested in exchanging ideas on fish rearing."

With guidance from Moi University and the Ministry of Fisheries and funding from AquaFish CRSP, the group decided on their name, developed a constitution, and established a leadership structure. The group then registered with the Kenya Ministry of Gender, Sports, Culture, & Social Services.

Ambuli recalled the group's venture into the baitfish business in 2007. "The first three attempts to culture catfish failed with 100 percent losses due to poor management skills and improper feed. This resulted in the withdrawal of three members. However, knowing there was a need for baitfish by fishermen on Lake Victoria, the remaining seven pledged to continue learning fish propagation."

AquaFish CRSP activities through Moi University focused on technical assistance with hands-on experiences with catfish propagation and hatchery techniques. After a series of training programs, fish farmers in the Bidii Cluster improved their farming skills and started realizing 10 percent survival of catfish fingerlings. By early 2008, survival had improved to 25 percent. By May of 2008, the cluster had established a marketing link with baitfish dealers and was consistently supplying catfish fingerlings.

The Bidii Cluster has grown to 25 fish farmers, including nine women. Its wholesale price of fingerlings ranges from KSh (Kenya Shilling) 3.50 to KSh 5.00 per piece, depending on fingerling size. Besides selling to baitfish dealers and farmers, the Bidii Cluster also sells to other catfish farmers for stocking their ponds. The group's governance structure provides for three executive officers: chair, secretary, and treasurer. The revenue sharing arrangement developed by the group requires that 80 percent of revenue be returned to the members while 20 percent is kept by the group for administrative and other promotional expenses. The group currently has two bank accounts, and their future plans include developing a well-equipped hatchery as well as owning a feed mill. Feed supply is a major challenge to the aquaculture industry.

The success of the Bidii Cluster has drawn attention and financial support from the Women in Fishing Industry Project (WIFIP) based along the shores of Lake Victoria, Kenya. "WIFIP helps women fish traders to identify income generating activities," said Jennipher Kere, executive director. The project seeks to engage women in aquaculture by providing additional household income and supporting them during the annual fishing ban on Lake Victoria, when income is at its lowest.

WIFIP has solicited the help of the Bidii Cluster farmers to train women in fishpond construction and catfish breeding. According to Daniel Juma Ebole, secretary of the Bidii Cluster, the group receives KSh3,000 each day to train women's groups and other fish farming clusters.

The Bidii Cluster has trained six groups since 2008: the St. Vincent Cluster, the Todo Cluster, the Visiki Cluster, and three other fish farmer groups in the Kisumu and Vihiga Districts. At a June 2009 workshop on marketing and supply-chain development, AquaFish CRSP presented the Bidii Cluster with an award recognizing their exemplary commitment to fish farming and assistance to other fish farming groups.

UNIVERSITY OF HAWAI'I HILO

Safe and Healthy Seafood from Sinaloa Mexico

(Volume 25, Number 1/ Spring 2010)

The University of Hawaii, Hilo led AquaFish CRSP project has been working in Mexico for the last three years to build capacity among aquaculture producers, processors, and vendors to improve seafood safety during all stages of production and marketing. Aquaculture production in the States of Sinaloa and Nayarit, Mexico, consists largely of shrimp, tilapia, and bivalve shellfish in coastal areas. Expanding bivalve and tilapia production have been prioritized by the Mexican National and Sinaloa State governments as a means of diversifying aquaculture, which is now dominated by shrimp culture. Research done under the former ACRSP in 2006 suggested that seafood safety and quality were problematic for nearly all aquaculture and seafood products at all stages of production and marketing. Large-scale shrimp culture was one exception, as shrimp is produced mainly for export and is thus subject to strict safety standards and inspections. Other products were mainly affected by the general lack of awareness of producers and vendors as to specific techniques to maintain hygienic standards, although most people are aware of the need to handle and select seafood carefully. The cultural preference of coastal residents in Mexico to consume seafood raw, pickled, or lightly cooked highlights the importance of food safety standards. Most Mexicans are keenly aware of the need for special attention to seafood safety. For example, an ACRSP marketing survey conducted in 2007 by Drs. Fong (University of Alaska, Fisheries Technology Industry Center) and Cordero (CIAD) revealed that oyster consumers placed a high priority on knowing the origin of oysters and water quality of the growing grounds. Members of the CRSP team has also been leading the way in identifying emerging risks to seafood, such as the spread of gnathosomiasis, a worm-like parasite carried by freshwater and brackish water fish which causes illness and death. Drs. Silvia Paz, Marcela Vergara, and Magdalena Uribe have studied this parasite and its fish hosts, and have conducted outreach to affected coastal communities which to prevent further spread. One issue is the increasing popularity of using freshwater fish for sushi and ceviche, which can spread the disease. As fish culture grows, prevention becomes more critical. The Center for Food and Development Research (CIAD) in Mazatlan has produced a series of best management practices manuals for shrimp, bivalves, catfish, and tilapia. Dr. Omar Calvario will be leading upcoming work with an intensive series of workshops for producers and vendors in best management practices related to seafood and hygiene using the manuals as a part of the course content. Shellfish sanitation has been a key theme in the CRSP project since the beginning, and headway has been made in raising awareness of the need for, and components of, shellfish sanitation programs among a wide variety of stakeholders. Again, this is important due to the tradition of consuming bivalve shellfish raw and because of their susceptibility to post-harvest contamination.

Promotion of seafood and aquaculture products consumption is also important— the average Mexican consumes only about 12 kilograms of seafood per year, with most of this consumption is by coastal residents. Aquaculture can help provide some of the protein needs in areas, which still have food security issues, including many coastal areas. For example, a typical toddler would only need one ounce of fish or shellfish to meet his or her daily protein requirements.

Sinaloa is famous for its fresh seafood dishes, which are among the most exquisite examples of Mexican cuisine. Many dishes involve combinations of fresh or raw seafood, raw vegetables, and delicious, easy-to-prepare sauces. Many of the sauces also include citrus juice, which increases vitamin content and helps lower fat consumption. It is worth noting that Sinaloa is not only a source of fish, shellfish, fruit, and vegetables for Mexico, but supplies much of the

U.S. and Canada, making food safety of all products an international issue. The recipes presented below are quick to make and represent the very best examples of fresh Mexican cooking. The University of Hawaii AquaFish CRSP project would particularly like to thank Restaurant Mariscos Pavi owners, Roberto Villaverde and Thelma Payan Villaverde, who prepared the dishes shown in the photographs and are sharing their recipes with the Aquanews CRSP readers.

Bivalve Relay & Depuration in Nicaragua

(Volume 25, Number 2/ Summer 2010)

The University of Hawaii at Hilo project on bivalve aquaculture development and shellfish sanitation in Latin America builds on six years of CRSP work. Bivalves are a heavily utilized resource throughout the region, with some of the more marginalized groups of the population heavily dependent upon them for income and food. Bivalve aquaculture thrives in some areas of Latin America, but its potential has generally not been reached. This situation, compounded by the decline of many of the bivalve fisheries and the resulting ecological and economic impacts, leaves the sector in need of more effective resource management and innovation. With an emphasis on native species, this AquaFish CRSP project focuses both on the development of bivalve aquaculture and fisheries management recommendations, primarily emphasizing improvements in shellfish sanitation.

Bivalves such as clams, oysters and cockles are healthy foods high in protein, vitamins and minerals and low in fat, demonstrating their potential for aquaculture. However, without proper sanitation their consumption can pose health dangers if they are taken from contaminated waters. Most bivalves are filter feeders and can accumulate and concentrate potentially lethal impurities such as bacteria, viruses, toxins, and heavy metals. Thus, good water quality is essential to producing a healthy, safe bivalve product.

Residents of poor coastal communities who rely on shellfish are particularly vulnerable to shellfish-borne diseases since they often lack even basic sanitary accommodations. Improving shellfish sanitation through a variety of approaches is important locally as well as regionally and nationally since shellfish are often marketed or exported out of local areas. The optimal way to improve shellfish sanitation is to improve water quality in shellfish growing areas. Often, this approach is not feasible in the short-term since it may require expensive infrastructure, such as wastewater treatment systems or minimally adequate latrines for entire villages or towns.

One method to improve shellfish sanitation is by “relay and depuration,” which involves moving shellfish from contaminated waters to a clean-water area for a predetermined time period. By filtering clean water, shellfish can reduce the concentration of bacterial pathogens in their tissues to safe levels. Using fecal coliform bacteria as an indicator, researchers are able to track bacterial concentrations to determine when acceptable levels are reached. A more costly version of “relay and depuration” uses land-based depuration plants, usually consisting of raceways or tanks of treated water for the depuration process. It should be noted that depuration methods are only effective for lowering bacterial concentrations, whereas viral contamination is better addressed with sound shellfish harvesting controls based on sanitation and shoreline surveys.

In Nicaragua, the primary species of concern are black cockles (e.g. Anadara similis, A. tuberculosa and A. grandis), which are collected from Pacific Coast mangroves by mostly poor women and children. Anadara similis is the most heavily collected species, but little information exists regarding depuration rates. Water quality monitoring from 2007- 2008 showed that of three coastal estuaries where intensive cockle gathering takes place, only the Aserradores Estuary had sufficiently clean waters throughout the year to be considered as a candidate site for depuration trials.

Due to the limited knowledge about depuration rates for A. similis, a series of laboratory trials were conducted. Before depuration, cockles used in these

trials initially had high levels of E. coli and fecal coliforms (>330 MPN/g), low levels of Vibrio parahaemolyticus (<1.0x103 UFC/g) and undetectable levels of Salmonella. Within 24 hours, both E. coli and fecal coliform levels reduced to <20 MPN/g, within acceptable limits, indicating that field trials might also be successful. Concurrently, water quality monitoring was conducted in the Aserradores Estuary to find locations that could function as depuration sites. Cockles were then placed in one of these sites with water and tissues sampled over a 72-hour period. Similar to the laboratory results, E. coli and fecal coliform levels reduced to <20 MPN/g in 24 hours. These trials demonstrate that relay and depuration can successfully be used with cockles in the Aserradores Estuary.

The success with relay and depuration in Nicaragua has helped the Central American University, the AquaFish CRSP partner in this work, in obtaining a major grant from the European Union to continue the work. Next steps include the use of a solar-powered, land-based depuration plant to be tested and operated by a local cooperative. This work can also potentially serve as a model for other Latin American countries that have similar problems in their coastal areas where communities depend on bivalve fisheries and aquaculture.

UNIVERSITY OF MICHIGAN

Evaluating the Effects of Invasive Species Introduced into Major Reservoirs in China and Vietnam

(Volume 25, Number 2/ Summer 2010)

One of the main concerns with aquaculture in Asia is the release of invasive species. Potentially devastating to native ecosystems, this is particularly an issue when cage culture of exotic fishes is done in reservoirs. These stores of water are created by obstructing natural river flow with dams or other embankments. Over time, lacustrine fish populations replace the former riverine species in these artificial lakes. Further alteration to the systems occur when non-native fish species are introduced through aquaculture practices managing for commercial fisheries.

Managers in Thailand and China have stocked many non-native species in an attempt to improve fishing in reservoirs, although there has been little effort to monitor the impacts of these introductions. AquaFish CRSP researchers in China and Vietnam, under The University of Michigan project, have taken on the task of documenting the influence of aquaculture on native species. Recording these influences is made difficult, however, by the many changes occurring simultaneously in these aquatic ecosystems.

Recently, AquaFish CRSP research teams at Huazhong Agricultural University and Nong Lam University have undertaken comparative investigations in a major reservoir in each respective country to document the nature of fishing on these reservoirs, to evaluate the importance of these non-native species in the fishery, and to evaluate changes in the fish community as a result of these introductions.

Tri An Reservoir, Vietnam

In Vietnam, tilapia were introduced into the Tri An Reservoir as a means to improve the fish caught by the Dong Nai Fishery Company. There were multiple introductions into in the region during the period between 1951 and 1997 for culture in ponds, cages, and rice fields. Populations were established in Tri An Reservoir and became an important commercial fish. While there has been no stocking of tilapia in the reservoir since 2000, their populations remain abundant indicating successful natural reproduction. Over the past ten years, there has been large-scale stocking of other herbivorous fish such as silver carp, bighead carp, and common carp. The intentional introduction of these non-native cultured fish has contributed to changes in the biodiversity of the reservoir.

As a result of fish stocking and other changes, there has been a significant increase in catch-per-unit effort of all species combined over the last 15 years. These data indicate increasing harvest and potentially increasing fish production since 1993. While tilapia were a large component of the fish collected for this study, they have not been an important component of the fishery harvest. The fish catch by the top five fishing gears took 81.7% of the total catch in the reservoir (about 3,124 tons per year), but did not take many tilapia. This is in spite of the fact that tilapia represented the second most abundant species taken by experimental seines in 2008. This suggests that better gear could be used for harvesting tilapia more effectively considering tilapia are the more valuable fish species in this reservoir.

Original data showed that there were 109 fish species in Tri An Reservoir, but the efforts of the research team and that of the commercial fishery collected only twenty and forty different species, respectively, in 2008. It is unclear whether biodiversity has decreased within the reservoir, or if these additional species are more difficult to collect and not important in the commercial fishery. What is clear is that the overall catch per unit effort has increased over recent years, in spite of increasing fishing effort, which is an indication of improvements in the fish community. There is little evidence that tilapia have damaged other fish populations within this region.

Zhanghe Reservoir, China

A very different story emerges from Zhanghe Reservoir in China. Once again, there has been a long history of introducing fish species into the area, both through aquaculture and intentional stocking. In 1992, the Taihu icefish (*Neosalanx taihuensis*) was introduced into Zhanghe Reservoir. This was done because the fish were declining in abundance in natural water bodies and was an important fish for harvest. Researchers from Huazhong Agricultural University set out to evaluate the current status and the historical trends in the icefish in Zhanghe Reservoir. The Taihu icefish was abundant in early years, but has not been recorded as caught since 2006 (Figure 1). The most common fish taken in Zhanghe Reservoir were silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), and three different species of culter (*Culter spp*.) (Figure 2). Even after extensive sampling efforts for this study, only 55 grams of icefish were taken during our collections.

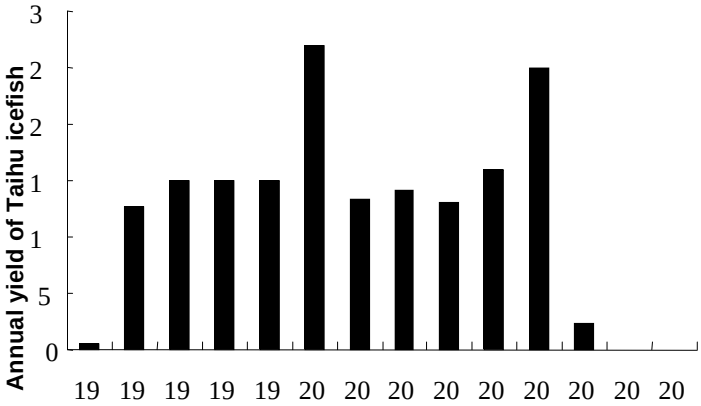


figure 1. Annual yield (t) of Taihu icefish (*Neosalanx taihuensis*) in Zhanghe Reservoir, China, 1995-2008.

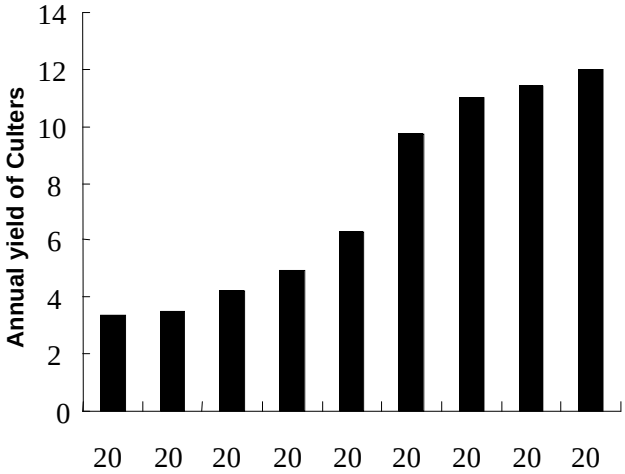


Figure 2. Annual yield (t) culters in Zhanghe Reservoir, China 2000-2008.

The overall impacts appear to be a series of top-down changes, driven by predation in the reservoir. The various culters consumed a variety of fish, particularly Taihu icefish, which was the most important prey item by mass (34.4%) and by number (39.5%). Originally, the culters were held in control by the yellowcheek (*Elopichthys bambusa*), another larger carnivorous fish that was also of value to the commercial fishery. As the

yellowcheek declined in abundance, the yield of culters increased.

Thus, changes in Zhanghe Reservoir appear to be related more to trophic interactions between species within the reservoir than to stocking and commercial fishing. Over fishing on yellowcheek resulted in a decline in their population, an increase in top-mouth culters (their prey fish), and a decline in the icefish (prey to the culters). This trophic cascade appears to be mediated by commercial fishing and has been the major cause of changes within the reservoir. Once again, in this case, the Taihu icefish was an important commercial fish, and stocking was the main means of introduction, although the population maintained itself by natural reproduction after stocking in 1992. However, the harvest has declined dramatically as a result of other predatory interactions among species in the reservoir.

For these cases, both biotic interactions and human perturbations have influenced the fish communities of these unnatural reservoir systems within each country. Since there is concern about biodiversity preservation, we have held a series of workshops to extend information on the trends and conditions of each reservoir to local fisheries. AquaFish CRSP has developed appropriate techniques for evaluating changes in fish community structure and relating it to human perturbations of the ecosystem. Building the capacity of research for field-based evaluations of natural fish communities has been an important component of the CRSP and has had strong influences on commercial fishing and on fishery regulations within Vietnam and China. This research capacity will be important to each country as well.

AQUANEWS CLIPPING
MALI ASSOCIATE AWARD

Rice-Fish Culture in Mali

(Volume 25, Number 1/Spring 2010)

Rice-fish culture, which can be traced as far back as 2,000 years ago in China, is still practiced today throughout Asia. The rice-fish system is an integration of fish culture and paddy-based rice production, often (but not always) in irrigated areas. Each system is a modification of an existing rice field to accommodate the additional requirements of a crop of fish. Due to the potential of rice-fish culture to provide new opportunities to farmers and improve local diets, the AquaFish CRSP Mali project is transferring rice-fish techniques from China to selected areas in Mali, including the Baguineda irrigation scheme near the capital city of Bamako. The addition of fish to the rice fields not only provides a new source of income and nutrition for farmers and their communities, but it can also benefit rice production through the reduction of weeds, improved insect control, loosening of the soil, and direct fertilization from fish excreta.

In June 2009, the process of converting two rice fields in the Baguineda irrigation area for rice-fish culture began with the modification of the fields to provide a sump and access channels for the fish. After a five-month culture period, the farmers harvested both rice and fish by November 2009. A combination of tilapia and Clarias catfish provided a total of over 140 kg of fish between the two sites. Net profits of the rice-fish systems summed to CFA 150,210. Rice alone produced CFA 73,760 and fish produced CFA 76,450. Budget analyses show that using the whole area solely for rice production would have resulted in a net CFA 89,490, demonstrating that the addition of fish to the field produced CFA 60,720 extra income for the farmers. The experience of these two farmers generated interest among other farmers in the Baguineda area; some are already modifying their systems so they can add fish during the next rice production cycle.

AQUANEWS CLIPPINGS
AQUAFISH CRSP GRADUATE STUDENTS

Borlaug Leap Fellows Attend World Food Prize 2010
(Volume 25, Number 2/ Summer 2010: Goings-on in the Pond)

Two AquaFish CRSP graduate students, having received the Borlaug LEAP Fellowship, will participate in the World Food Prize 2010 this fall. The Prize acknowledges improvements in global food security drawing on what can be accomplished in the future. Nhuong Van Tran (Vietnam) and Rafael Martinez-Garcia (Mexico) were rewarded LEAP Fellowships for demonstrating strong promise as leaders in agriculture related fields.

SOU-CRSP Yang Yi Young Scientist Travel Fund
(Volume 25, Number 1/Spring 2010)

The Yang Yi Travel Award was established this year in memory of Dr. Yang Yi (1963-2009) with the SOU-CRSP Yang Yi Young Scientist Travel Fund. The award is expected to support excellent young scientists from one of the Asian partner institutions to present their research at the World Aquaculture Society conferences. Zexia Gao from Huazong Agricultural University was awarded the first award.

ZEXIA GAO
(Volume 25, Number 1/Spring 2010)

The first winner of the SOU-CRSP Yang Yi Young Scientist Travel Fund Award, Zexia Gao had the opportunity to travel from China to the US to attend the AquaFish CRSP Annual Meeting and Aquaculture 2010 conference in San Diego, California this March. At the conference, Zexia presented at the Finfish Genetics Session on her research with yellow cheek carp and had the chance to interact with aquaculture researchers from around the world.

Zexia is currently a PhD candidate in a joint education program with Huazhong Agricultural University (HAU) and the Ohio State University (OhSU). Her dissertation, “Analysis on sex determination mechanism and sex-related DNA markers in bluegill sunfish (Lepomis macrochirus),” will potentially improve our understanding of the underlying basis for sex determination of monosex male populations of bluegill. Working under her two major professors, Weiman Wang from HAU and Han-Ping Wang from OhSU, Zexia hopes to complete her degree in September 2011.

Exposed to aquaculture at an early age, Zexia grew up in Sichuan, China where her father was a fish farmer. As fish became a central part of her life, Zexia developed a love for seafood and a fascination with biology, ecology, and fish behavior. Her interest in the natural world led her to HAU’s notable Life Sciences Department, where she completed her undergraduate degree in aquaculture in June 2007.

Zexia has been involved in AquaFish CRSP work in China over the last two years. Her first CRSP investigation experience, “Assessing the

effectiveness of current waste management practices for intensive freshwater aquaculture in China" ended in 2009. With waste management as one of the major issues under the AquaFish CRSP topic area, "Mitigating Negative Environmental Impacts", this project produced information about proper stocking densities and suitable waste mitigation techniques. It also included a social aspect in which a series of interviews and questionnaires revealed that Chinese tilapia and carp farmers appear to realize the importance of water quality and environmental impacts. Zexia sees this awareness as an indication of a positive step toward the development of a more sustainable aquaculture industry in China.

Zexia has been involved with two of the more recent AquaFish CRSP projects in China. Continuing with the theme of mitigating negative environmental impacts in the waste management project, she is now working on an investigation that is comparing water quality parameters during the grow-out phase of traditional and improved cages in order to estimate a carrying capacity for commercial aquaculture cages in deep water lakes in China. Another investigation is more related to Zexia's own PhD work in fish genetics. This project is studying the impacts of the rapid invasion of red swamp crayfish (Procambarus clarkii) in China through changes in the population genetic structure.

With the rapid growth of China's aquaculture industry in recent years, Zexia recognizes the need for the development of cleaner and more efficient practices. While China contributes a high percentage of the global fish supply, the aquaculture industry faces a multitude of challenges. Zexia is encouraged by new developments in Chinese legislation regarding water quality, and hopes that the Chinese aquaculture industry can someday produce a more sustainable seafood product.

In her two years working with AquaFish CRSP, Zexia values the international connections that she has made. Her experience working with researchers from around the world has provided her the opportunity to learn about the different aquaculture issues in other countries. This exposure to diverse research questions has been her most enjoyable experience with AquaFish CRSP. Once she finishes her PhD, Zexia hopes to continue her career as an aquaculture researcher.

GIFTY ANANE-TAABEAH

(Volume 25, Number 2/Summer 2010)

Gifty Anane-Taabeah has been working with AquaFish CRSP at Virginia Polytechnic Institute and State University (Virginia Tech) since 2009 under the guidance of her major professor, Dr. Emmanuel Frimpong. In 2008, Gifty received her Bachelor of Science degree in Natural Resource Management from Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi, Ghana southeast of her hometown of Berekum in the Brong Ahafo Region. At Virginia Tech, she is currently working to complete her Masters of Science degree in Fisheries Science with the hopes of gaining the experience and knowledge necessary to one day influence the management of fisheries and aquatic resources in Ghana.

Gifty's research, "Harnessing Opportunities and Overcoming Constraints to Widespread Adoption of Cage Aquaculture in Ghana," is part of the AquaFish CRSP Project with Purdue University, "Improving Competitiveness of African Aquaculture Through Capacity Building, Improved Technology, and Management of Supply Chain and Natural Resources." The Purdue Project has established long-standing partnerships in Ghana, providing Gifty with a history of AquaFish CRSP research there and a comprehensive baseline for her work.

Gifty will analyze data from the Ghanaian community through interviews and questionnaires about the constraints and opportunities of adopting cage aquaculture. Once the data are compiled and evaluated, Gifty and the research team hopes to provide recommendations for an aquaculture policy review in Ghana.

Gifty first realized the importance of aquaculture during her undergraduate work at KNUST and has since made aquaculture a part of her life. In Ghana, she has seen the industry grow over the past decade. "However", she says, "the contribution of aquaculture to total fish production in Ghana [remains] insignificant".

Gifty identifies several obstacles preventing aquaculture from continuing to progress, including the lack of inexpensive locally manufactured feeds and lack of quality seed. She hopes her graduate research at Virginia Tech will "provide a platform to influence decisions in management and fisheries of aquatic resources in Ghana". She adds, "This [research] should help speed up the adoption rate of cage aquaculture in Ghana and ultimately increase the fish production for local consumption".

Through her work at Virginia Tech and with AquaFish CRSP, Gifty plans to gain a comprehensive understanding of the theoretical and practical aspects of fisheries science to support her long-term goal of a career in fisheries and aquaculture research. "I enjoy working with different people both in workshops and field work", Gifty says about her work with the CRSP. "I hope to combine my research with training other students in my research area".

IV. RESEARCH & TECHNOLOGY TRANSFER ACCOMPLISHMENTS

During FY2010, AquaFish CRSP researchers have continued to make advances in development and transfer of new technologies and practices to improve the lives of the rural poor. The CRSP work has also led to significant achievements in marketing and trade, aquatic product development, and policy assessments relating to natural resources management and expanision of domestic and export markets. The following highlights briefly summarize illustrative accomplishments in investigations from the *Implementation Plans 2007–2009* and *2009–2011*.

TOPIC AREAS: INTEGRATED PRODUCTION SYSTEMS

Production System Design & Best Management Alternatives (BMA)

On-farm polyculture trials in Nepal with the indigenous fish sahar (*Tor putitora*) and Nile tilapia (*Oreochromis niloticus*) showed that sahar to tilapia stocking ratios between 1:33–1:16 optimize tilapia growth. Participating farmers (13 women; 3 men) in the on-farm trials joined researchers and fisheries personnel in a follow-up December 2009 training on the adoption of this new technology. Sahar, a popular food and game fish for Bangladesh, India, Nepal, and Pakistan, is under threat from overfishing and habitat loss. As a predatory fish in polyculture with tilapia, sahar offers the advantage of controlling tilapia recruitment in aquaculture ponds. Thus, polyculture with sahar can offer a better economical choice for small-scale, resource-poor Nepalese farmers who are currently using a relatively low production, mixed-sex tilapia monoculture system. Culturing sahar may also help decrease fishing pressures on wild stocks. As a next step in this work, researchers are now testing a semi-intensive polyculture system with carps (common, silver, bighead, grass, rohu, naini/mrigal, and Bhakur/Catla), tilapia, and sahar. In addition to on-farm trials, this investigation will assess nutrient recovery, conduct a cost-benefit analysis, and evaluate performance at the small-farm level. 07BMA02UM/09BMA03UM

In Uganda, a tilapia cage-culture trial on Lake Victoria for promoting small-scale fish farming is designed as a working enterprise model that will recruit other farmers to this new technology. Members of the Jinja United Group Initiative for Poverty Alleviation & Economic Development (JUGIPAED) are participating in the project. Currently, the livelihood of fishers is threatened due to reduced fish catches caused by overfishing and depleted fish stocks in the lake. Local fishers and farmers who adopt the cage culture technology will have an alternative income opportunity.
Another element of this investigation has examined what leads to the success or failure of producer organizations. In case studies of four producer organizations, CRSP researchers have found that fish farmer groups belonging to umbrella organizations specializing in aquaculture are more effective at increasing their production than those operating with diverse activities and wide-ranging goals. With respect to donors, the investigators have concluded that producer groups tend to model a donor's short-term project goals. Over time, this phenomenon can inhibit development of a viable market-driven aquaculture sector. CRSP investigators recommend that leaders of fish farmer groups demand reforms in the financial incentive structure of government and donor institutions to better serve all of their common interests for improved opportunities in the aquaculture sector. — 09BMA01AU

- In Uganda, over 150 participants attended the 3rd Annual Fish Farmers Symposium & Trade Fair — *Dealing with the Challenges of Building an Aquaculture Industry* — held in January 2010. The event was organized in partnership with the Walimi Fish Farmers Cooperative Society. Topics included challenges associated with (1) accessing inputs, return on investment, and quality of service delivery; (2) markets, marketing, and market information; and (3) current support services and their accessibility for the aquaculture private sector. — 09BMA02AU

- In work on pond-based recirculating systems for shrimp (*Litopeneaus vannamei*), CRSP researchers are evaluating water quality parameters, filtering mechanisms for improving water quality, and the overall production performance between recirculating and closed, non-recirculating shrimp culture ponds. Findings to date indicate that overly high stocking densities in ponds without water exchange may be the cause of poor water quality conditions — such as lower pH and higher chemical oxygen demand — that can negatively affect appetite and thereby jeopardize shrimp growth. — 09BMA04UM

- Under eutrophic conditions in aquaculture ponds, blooms of the toxin-producing cyanobacteria *Microcystis aeruginosa* can develop. Buildup of this blue-green algae degrades water quality and causes harmful levels of microcystin toxin to develop. The toxin is a secondary metabolite that can be lethal to aquatic animals. When the toxin accumulates in fish and shellfish tissue, it also affects its the food quality and safety for human consumption. Previous CRSP work identified chitosan clay as a cost-effective and environmentally benign control measure to remove the blue-green algae from ponds. Current work focuses on controlling microcystins in indoor recirculating culture systems for shrimp. The red swamp crayfish (*Procambarus clarkii*) is being used as a test species in experiments to identify the lethal mechanisms of the microcystin toxin. Recent work has established that the toxin lowers survival rate of juvenile crayfish and adversely affects the disease immunity of adult crayfish, leading to poor grow-out in culture systems. — 07HHI01UM/09BMA05UM

Sustainable Feed Technology (SFT)

- A three-day "Basics of Aquaculture" workshop held in August 2010 began an AquaFish CRSP project to help an indigenous Amerindian population living in an isolated area of rural Guyana to develop small-scale aquaculture. Trainees were introduced to topics dealing with a range of basic production topics for the local native fish species pacu and hassar: pond construction and maintenance, fish production techniques, capture and feeding of broodstocks, preparation of local ingredients for fish feed, and formulation and manufacture of feed. Harvest, processing, and marketing of farmed fish to nearby domestic, and even international, markets were also covered. The 40 fishers and farmers, among them 13 women, who attended the workshop included representatives from surrounding villages. As CRSP trainees, they will serve as trainers for their villages. — 09SFT03UA

- For small-scale, rural tilapia farmers in the Philippines, feed is the most costly component, representing 60-80% of the total production cost. Reducing this cost requires either application of less feed or use of lower cost feeds. Building on the findings of the earlier reduced feeding experiments, CRSP researchers have now established that farmers can reduce production costs if they switch from a 100% daily feeding schedule to one of the following regimes: 67% subsatiation, 50% subsatiation, or 100% alternate-day feeding. — 07SFT02NC/09SFT04NC

Indigenous Species Development (IND)

- As part of an integrated effort to better manage the Lower Mekong Basin fishery for both snakehead and small-value fish, CRSP researchers have successfully developed feed formulations that reduce fishmeal content (07SFT01UC/09SFT01UC). These feeds are currently being tested in on-farm trials. This effort addresses the competing interests for low-value fish, and comprises 59 small-sized fish species used as a significant food source by the rural poor of Cambodia and Vietnam. The low-value

fish also suit the fishmeal needs of the growing aquaculture industry for farmed snakehead, a high-value native fish that is in decline in the Mekong River due to overfishing and broodstock capture. Taking a sustainable approach through aquaculture, CRSP researchers are developing a snakehead hatchery at the Freshwater Aquaculture Research & Development Center in Cambodia to provide a domesticated seed source. Spawning experiments and pellet feed formulation trials for larvae are underway. A companion study in Vietnam is investigating parasitic, fungal, and bacterial diseases of snakehead, which will need to be addressed in aquaculture conditions. — 09IND02UC

- Chame (*Dormitator latifrons*), a fish low on the trophic chain, is a popular food fish for poor communities throughout the Latin American region. Its use as a source for fishmeal and the dependence on wild-caught juveniles for aquaculture are depleting native supplies. CRSP researchers are working on developing techniques for controlled reproduction in captivity, which will open sources for domesticated broodstock. In recent experimental work, a breakthrough has been reached with the first successful spawning and rearing of chame. This accomplishment is a significant step towards fully domesticating the species. — 09IND03UH

- The native cichlid breeding program in Mexico continues the successes of work under the *Implementation Plan 2007–2009* with the spawning of F_1 and F_2 stocks of tenguayaca (*Petenia splendida*) and castarrica (*Cichlasoma urophthalmus*). Researchers are currently designing a pedigreed breeding program to better guide the selective breeding processes. A major producer has expressed a preliminary interest in large-scale commercial production, which promises the successful entry of these species into local aquaculture. —07IND02UA/09IND05UA

- In earlier work, CRSP researchers have been successful in inducing spawning in native species of common snook and fat snook. However, survival of the young fish has proved to be a major hurdle due to the need for a customized diet that mimcs what is available in the wild. Researchers have overcome this hurdle with the development of a mix of natural feeds and formulated diets that the larvae and fry can successfully consume to survive into the next growth stages. Work will now focus on obtaining broodstock from both wild-caught and hatchery-reared snook juveniles from which to develop domesticated lines for aquaculture. — 09IND01UA/09IND05UA

- In developing appropriate technical guidelines for seed production and pond culture of native fish in Ghana, CRSP researchers are taking a step-wise approach. The ultimate goal is to establish the groundwork that will inform decision-making and policy related to mass production of farmed fish and market development. As an initial step in this process, a two-day workshop in advanced experimental design, data management, and analysis was held in July 2010 for master's level CRSP students, project staff, and fisheries officers of the Ghanaian Ministry of Agriculture Fisheries Directorate. This training has helped to expand their research capacity in experimental aquaculture, which will be essential to their contributions dealing with indigenous species development in Ghana. — 09IND06PU

TELLING THE AQUAFISH STORY

Press Release by Tiffany Woods, Oregon State University

Hooking up snooks

Researchers are trying to bolster stocks of the lucrative snook, but getting the fish to 'do it' and then getting their kids to eat is no easy catch.

JALAPITA, Mexico – The facility is part fertility clinic, part singles bar. It's tucked away on the beach in the sleepy village of Jalapita on Mexico's gulf coast amid coconut trees that stretch for miles. Under a blue sky, swimming pools bubble like hot tubs as palm fronds rustle in the warm breeze and tropical birds chatter. In one pool, four glistening, slender bodies eye each other across the water, their libidos artificially primed to put them in the mood.

This is where snooks come to hook up.

The fish are part of an experiment that aims to boost their population. Scientists at the Autonomous Juarez University of Tabasco in Mexico are trying to use these wild fish as a broodstock to crank out juveniles in captivity. The university aims to sell young snooks to fishermen-turned-fish farmers as a way to relieve fishing pressure on wild stocks. It also hopes to sell them to the government to release into coastal lagoons and rivers.

"We need to increase the population in the wild. They're overfished. There has also been a lot of habitat degradation from cutting down mangroves and from oil refineries and wells," says Kevin Fitzsimmons, a professor at the University of Arizona and former president of the World Aquaculture Society.

He's one of the participants in the snook project, which also involves Texas Tech University. The work is partially funded by the U.S. Agency for International Development through its AquaFish Collaborative Research Support Program, which is headquartered at Oregon State University.

This funny-named fish, known as *robalo* in Spanish, is the most expensive fish sold in Mexico City, according to the country's National Commission on Aquaculture and Fishing. Fishermen in Mexico earned more than $25 million for landing about 8,000 metric tons of snooks in 2008, making it the country's eighth most important aquatic product in terms of value, the commission reported.

Various species of snooks inhabit coastal waters, estuaries and lagoons from Florida to Brazil. A widespread one is the aptly named common snook, a silvery, streamlined, snouted carnivore with a dark lateral pinstripe and a bulldoggish underbite. These acrobatic fighters, which can reach 4 feet and 50 pounds, are highly prized by sport anglers. Fishermen in Florida and Texas used to catch snooks until those states banned commercial captures in 1957 and 1987, respectively, to protect the population.

"In Texas there's anecdotal evidence that they're making a comeback. Sport fishermen are finding them more often and in places where they didn't find them before," says Reynaldo Patino, the leader of the Texas Cooperative Fish and Wildlife Research Unit at Texas Tech University and one of the researchers involved in the project.

Efforts to influence what snooks do when no one is looking is complicated by their sexual plasticity. They're protandric hermaphrodites, meaning they can change from males into females. So far, researchers have had some success in getting them to breed in captivity, but getting their kids to eat has been a real head-scratcher.

"It's a challenge," says Wilfrido Contreras Sanchez, the lead investigator and the director of biological sciences at the university in Tabasco that's conducting the research. "Not much is known about snooks. There are still many questions."

To help answer those questions, he began

Continued on page 23

Continued from page 22

contracting fishermen in Jalapita in 2006 to catch two species of snooks: fat and common.

Researchers later injected some and implanted others with different doses of a hormone to induce spawning. They wanted to know which treatment and which dosage produced the most mature eggs and resulted in the highest rates of fertilization, hatching and larval survival. None of the injected fish released its eggs, and only some of the fish with the implanted hormonal pellets did.

Maria de Jesus Contreras Garcia, a graduate student helping conduct the research, suspects that stress, which can adversely affect reproduction, may be to blame. Human contact may have frazzled the fish because researchers injected the hormone into each of them on three different occasions, she says. They handled the fish with implants only once.

On one occasion, Contreras Garcia wanted to know how much time would pass between implantation and spawning so she and a colleague chaperoned three fish for 24 hours. They slept in a hammock and sofa bed in a makeshift house on the beach and set an alarm to sound every hour so they could alternate shifts. With flashlight in hand, she'd groggily lumber to the holding tank and scan the water for eggs. No luck.

Others did though. Almost all of the eggs hatched. But the tiny fish, still in their larval stage, lived for just eight days and were only about as long as the thickness of three stacked dimes. Autopsies revealed empty bellies. The food they were given, although microscopic, was too big for their small mouths, Contreras Sanchez says.

He thinks they might survive if fed the same diet that recently hatched wild snooks around Jalapita feast on. He plans to hire local fishermen to collect microscopic animal and plant plankton as well as snook larvae from nearby spawning grounds. Researchers will dissect their wee stomachs to see if the grub inside is the same as the collected plankton. They then hope to customize a recipe for a locavore diet that they can duplicate in mass quantities in the lab.

They'll also inspect snooks' stomachs, intestines and pancreases to identify enzymes that help digest their food. Certain enzymes break down certain substances, so if they can indentify the enzymes, they'll know what to feed the fish, Contreras Sanchez said. Additionally, they're continuing to refine their work with hormonal injections and implants to see if they get better results. And they've added a third species to their research, the Mexican snook.

About a mile up the road from the research facility, fisherman Ramon Dominguez Sanchez is eager for results. He's eating a mango from a tree in his dirt yard as two women scrub clothes by hand. A few feet away, one of his sons sits under the hood of a truck and replaces the fuel filter. It smells of gas.

The broad-shouldered, thick-necked, flip-flop-wearing Dominguez is the president of a fishing cooperative in Jalapita that would like to buy young snooks from the university, rear them and sell them. The sooner the co-op can do this the better because harvests, at least for him, are declining, says Dominguez, 54, who has been hauling in nets for 40 years. During the previous week he pulled in about $10 worth of fish but there wasn't a snook in the bunch, he says. So Dominguez wants to see the research succeed.

Perhaps it's this pressure to perform that's causing some of the snooks not to cooperate. Back at the beachside research station, the two couples that were checking each other out in the pool have lost interest. Apparently, they're just not that into each other. Researchers vow to keep trying though. Sometimes love just needs time.

Quality Seedstock Development (QSD)

- In the Philippines, demand for tilapia seed is expected to triple in the coming years. Currently, seed production is estimated to be over 1.2 billion annually. To meet the growing demand for quality tilapia seed, production improvements are essential. Preliminary work has focused on the relationship between broodstock age and seed production in the GIFT strain of Nile tilapia, which is the major strain farmed in the Philippines. Recent results show that broodstock ranging in age from eight months to two years can be used for tilapia seed production with no significant loss in final growout yield. For tilapia farmers this work promises technology improvements that will guarantee them improved seed quality at affordable prices. — 09QSD01NC

- CRSP investigators have substantially contributed to a new aquaculture industry in Kenya that has opened income opportunities for farmers and fish traders while offering a sustainable solution to a threatened native fishery on Lake Victoria. The farmers are now successfully raising juvenile catfish, selling them to local traders who in turn sell them to fishers as bait for catching Nile perch. These farmed catfish fingerlings are helping to protect the lake's native catfish, whose populations are being depleted by the Nile perch fishers who have been collecting juvenile catfish for baitfish. There are now six well-established farmed baitfish traders on Lake Victoria. Adoption of CRSP's cluster enterprise model by local farmers is also continuing. A post-production training held in November 2010 updated baitfish farmers, traders, and fisheries officers on techniques for preparing a marketing plan and finance management. — 07QSD02PU

- In August 2010, CRSP investigators led an interactive multi-day workshop at Universidad Juárez Autónoma de Tabasco on the basics of an Integrated Aquaculture Agriculture System (aquaponics) for researchers and service personnel. The workshop included a field trip to the isolated village of Guerrero located in the mountains of southern Tabasco, where attendees teamed up with the Lacadon Village Farmer's Cooperative to work on the CRSP aquaponics demonstration project, which has recently been started there. CRSP investigators advised farmers on water and nutrient delivery, drainage, sun angles, shade problems and harvest plans. A second workshop held in September for farmers, hatchery managers, and university personnel focused on hatchery management and use of bioflocs for shrimp and fish hatcheries. — 09QSD02AU

TOPIC AREAS: PEOPLE, LIVELIHOODS, & ECOSYSTEM INTERRELATIONSHIPS

Human Health Impacts of Aquaculture (HHI)

- A synthesis report on the black cockle (*Anadara* spp.) co-management and bivalve sanitation work prepared by AquaFish CRSP investigators has been submitted to Nicaraguan government agencies and research partners. The Ministry of the Environment is currently reviewing the recommendation for a community-based no-take zone alternative to the current closed season regulation, which has proven ineffective. In March 2010, CRSP held two workshops for cockle collectors from the Aserradores Estuary region, who are mostly women. These trainings provide these rural women with essential skills for safe collecting and developing income-generating opportunities. One workshop dealt with food safety and quality and the other with requirements for commercialization and export of cockles. — 07HHI05UH/09HHI01UH

Food Safety & Value-Added Product Development (FSV)

- The rural poor of Cambodia and Vietnam process small-value fish into prahoc, a fermented fish paste

that forms a major portion of their diets and a key source of protein. Following traditional fermentation practices, women take fresh-caught fish and process it into fish paste. Prahoc is used in the home and provides a source of income when sold in local and regional markets. Quality varies and the short shelf life poses health and safety concerns. To address these issues and also provide women processors with better income opportunities, CRSP researchers are conducting workshops and meetings to teach best practices for food improved quality and food safety as well as value-added product development. Safety guidelines, packaging, and labeling standards for prahoc have also been finalized. In Cambodia's Siem Reap Province, CRSP has also helped organize the Women's Fermented Fish Paste Association, a significant first step towards furthering the economic interests of women processors. — 07FSV01UC/09FSV01UC

Technology Adoption & Policy Development (TAP)

- AquaFish CRSP researchers have developed five English-language podcasts on tilapia aquaculture for download from websites hosted by the CLSU (Central Luzon State University) computer center, North Carolina State University, and AquaFish CRSP at Oregon State University. The four most recent podcasts describe feeding technologies that will reduce fishmeal usage and lower feed costs for Filipino farmers. Two of these have been translated into Tagalog, the primary Filipino language — alternate day feeding strategy and daily feed ration. These podcasts are an easily obtainable outreach tool with up-to-date information on tilapia production techniques that have improved farmers income. — 07TAP02NC/09TAP02NC

- CRSP investigators are coordinating the participation of 30 Cambodian snakehead farmers selected for a feed technology adoption pilot to test the pelleted feed formulation developed in the sustainable feed technology investigations (07SFT01UC/09SFT01UC). Participating farmers, attended an orientation workshop in June 2010 where they were introduced to the new feed technology and recordkeeping methods for the study. Farmers are required to keep daily records on feed amounts and fish mortality and monthly records on fish growth rate and size. CRSP graduate students and technicians will assist farmers in data collection and recordkeeping. With the initial startup phase completed, farmers are set to begin the pilot study which will provide them with a beneficial experience in good production practices and give researchers the opportunity to test the new feed formulation on farms. — 09TAP03UC

Marketing, Economic Risk Assessment & Trade (MER)

- AquaFish CRSP researchers have completed one phase of their evaluation of supply chain opportunities for tilapia farmers in the Philippines. To respond to current constraints on market expansion, they have recommended the following improvement measures: (1) establish government certification of feed quality and standardized fish weights; (2) focus on production of a larger standardized fish size for urban marketing outlets; (3) develop private hatcheries; (4) address production inefficiencies related to fish mortality due to extreme water temperatures and down times of 1–2 months. — 07MER04NC/09MER03NC

Watershed & Integrated Coastal Zone Management (WIZ)

- A baseline study of the pond aquaculture-environmental interaction in the Ashanti and Brong Ahafo regions of Ghana is the first of its kind for the humid forest zone of sub-Saharan Africa. It will serve as an important reference for policy makers and regulators involved with the development of sustainable aquaculture in the region. Findings show that current aquaculture activities are not adversely affecting receiving stream water quality or the fish and macroinvertebrate biota. While a majority of the fish farms already have some environmentally friendly management practices in place, a CRSP training held in November 2009 introduced farmers to the concept of Best Management Practices (BMPs). The training concentrated on proper effluent control to maintain healthy rivers and other receiving waters and management practices for feeding, nutrients, and

biodiversity. With this information, farmers have improved capacity for adhering to sustainable practices that will protect their local water systems. — 07WIZ01PU

- In Uganda, CRSP researchers are developing an integrated suite of software approaches for modeling surface catchment sustainability. This set of decision tools will aid local researchers and extensionists in their efforts to assess water availability for aquaculture and other competing uses as well as locate impoundments to protect wetlands and promote diversity. The integral capacity building component of this work is underway. A July 2010 training for university and extension personnel on hydrology and aquaculture pond siting and construction issues is an important step in the development of a watershed and basin assessment center at Makerere University. In bringing these personnel together under the training umbrella, CRSP investigators also are helping to build the networking structure essential for ensuring a cooperative approach for community water supply management and natural resource conservation. — 09WIZ02AU

Mitigating Negative Environmental Impacts (MNE)

- AquaFish CRSP has initiated a series of workshops to train poor Filipino women in milkfish post-harvest techniques. These trainings target women residing in six coastal communities located in Guimaras and Iloilo, which are major area for milkfish. The focus is on providing skills development in processing and value-adding that improve income opportunities. In the two workshops held in April 2010, participating women were given practical training in milkfish deboning and marinade preparation. They also learned marketing techniques for selling these value-added products. Business opportunities that develop may be stand-alone or part of an integrated milkfish production system. For setting up a business, CRSP investigators are assisting women trainees to link up with a microfinance company. — 09MNE02NC

- With the competing interests of aquaculture expansion versus natural resource conservation, AquaFish CRSP is organizing a 2011 symposium to examine issues that drive the debate: *Evaluating the Relationship Between Semi-Intensive Aquaculture and Natural Biodiversity*. Organizers have put together a roster of invited experts who will speak on a wide range of topics including invasive species effects, effluents and eutrophication, antibiotic effects, environmental performance, use of aquaculture feeds, and social and economic impacts. — 09MNE06UM

Photo in Vietnam courtesy of Jim Diana

TELLING THE AQUAFISH STORY

Press Release by Tiffany Woods, Oregon State University

Bacteria on steroids: A new way to make water at tilapia farms safer?

VILLAHERMOSA, Mexico – It's no secret that baseball stars, bodybuilders and cyclists have used steroids. Now it turns out that even bacteria get juiced.

Researchers in Mexico have found that three common species of bacteria have voracious appetites for methyltestosterone (MT), a potentially harmful steroid that fish farmers use to change the sex of tilapia. The discovery may eventually result in a safer environment for farm workers and nearby residents and wildlife. It has global implications given that tilapia is raised in more than 100 countries, according to the U.N. Food and Agriculture Organization.

Tilapia producers add methyltestosterone to the powdered food they dish out to large tanks of tiny tilapias called fry every day for three to four weeks to turn them into males. They want males because they grow faster than females and because having only one gender prevents reproduction. (Breeding makes the farmers' operation less cost-efficient.) The young tilapias swallow the steroid but then excrete it back into the water through their feces and urine.

Fish biologist Wilfrido Contreras Sanchez worries that MT residue might endanger the health of workers who wade into the water to scoop up juvenile fish. Also, many tilapia producers discharge the hormone-laced water from the tanks into streams, rivers and lagoons where it might harm other fish and amphibians, said Contreras, who heads the biological sciences division at the Autonomous Juarez University of Tabasco where the bacterial research was conducted. Additionally, the health of local residents who swim in or wash clothes in these bodies of water might be at risk, he said.

Contreras said little is known about how the use of MT in aquaculture might affect humans or wildlife. MT is an androgen and is prescribed to stimulate puberty in slow-developing adolescent boys and to treat breast cancer. The U.S. Food and Drug Administration has said that prolonged use of high doses of androgens has been associated with the development of liver cancer and that androgens may increase elderly people's chances of developing prostate cancer. High doses in women can lead to deeper voices, facial hair, acne and irregular menstrual cycles, the FDA said.

Contreras hopes that the bacteria he studied will eliminate potential hazards if added in sufficient amounts to the water filters in the tanks where the tiny tilapias dine on MT. They're naturally present in all fish culture systems (particularly in the filters) but not in large enough quantities to degrade the hormone, he said.

In lab tests, he and fellow researchers found that *Pseudomonas fluorescens*, which spoils milk, and *Bacillus ceresus*, the culprit of food poisonings, each removed 99 percent of the hormone after 20 days in flasks. Another species, *P. aeruginosa*, which can cause rashes, pneumonia, bladder infections and swimmer's ear and can even break down crude oil, devoured 97 percent of the hormone after 16 days in flasks.

Because the single-celled *P. aeruginosa* had multiplied rapidly in the lab, researchers selected it for the next leg of the experiment. They added billions of the bacteria to filters that used gravel and special plastic balls to clean the water of three 8,000-liter concrete tanks. The filters were inside plastic drums that stood on the edge of the tanks. Each tank held 5,700 young tilapias that were fed MT daily (The fish ate the MT before it was pumped into the bacteria-smothered water filters on the other end of the tanks).
The trial showed a trend toward lower levels of MT over time in the tanks where bacteria had been added versus the control tanks without bacteria, Contreras said.

Continued on page 28

Continued from page 27

He and his team plan to conduct more experiments to fine tune how many bacteria use, what species or combination of species to use and how long to let them feast, Contreras said. If the kinks are worked out, the university hopes to grow mass quantities of whatever bacteria are finally selected and then sell the microorganisms to tilapia producers in the form of a concentrate, he said.

MT aside, the researchers uncovered something unexpected in their experiment. The fish in the tanks with *P. aeruginosa* weighed more than those in tanks without the bacteria. Some species of bacteria in aquaculture systems enhance growth, and *P. aeruginosa* may be one of them, Contreras said. Also, lab tests found no diseases in the kidneys, livers or spleens of fish raised in tanks with the bacteria. Because the bacteria are already ubiquitous and may be eaten by tilapias, Contreras doubts that they would cause any health problems, like infections, in people or fish.

The research was funded by Oregon State University, the University of Arizona, the Autonomous Juarez University of Tabasco, and the U.S. Agency for International Development through its AquaFish Collaborative Research Support Program.

V. OVERVIEW OF RESEARCH PROGRAM STRUCTURE

AquaFish CRSP is managed in a manner to achieve maximum program impacts, particularly for small-scale farmers and fishers, in Host Countries and more broadly. CRSP program objectives address the need for world-class research, capacity building, and information dissemination. Specifically, the AquaFish CRSP strives to:

- Develop sustainable end-user level aquaculture and fisheries systems to increase productivity, enhance international trade opportunities, and contribute to responsible aquatic resource management;
- Enhance local capacity in aquaculture and aquatic resource management to ensure long-term program impacts at the community and national levels;
- Foster wide dissemination of research results and technologies to local stakeholders at all levels, including end-users, researchers, and government officials; and
- Increase Host Country capacity and productivity to contribute to national food security, income generation, and market access.

The overall research context for the projects described in this *Annual Report* is poverty alleviation and food security improvement through sustainable aquaculture development and aquatic resources management. Discovery of new information forms the core of projects. Projects also include institutional strengthening, outreach, and capacity building activities such as training, formal education, workshops, extension, and conference organizing to support the scientific research being conducted.

Projects focus on one USAID-eligible country within a region, but have activities in nearby countries within the same region. All projects received USAID country-level concurrence prior to award.

GLOBAL AQUAFISH CRSP PROJECT THEMES (GOALS)

A. Improved Health and Nutrition, Food Quality, and Food Safety
B. Income Generation for Small-Scale Fish Farmers and Fishers
C. Environmental Management for Sustainable Aquatic Resources Use
D. Enhanced Trade Opportunities for Global Fishery Markets

Each project has one AquaFish CRSP theme as its primary focus, but addresses all four themes in an integrated systems approach. The global themes of the CRSP are cross-cutting and address several specific USAID policy documents and guidelines.

AQUAFISH CORE RESEARCH PROJECTS STATS

Under the *Implementation Plan 2009-2011*, 50 investigations have been initiated with a distribution by Systems Approach of 24 for *Integrated Production Systems* and 26 for *People, Livelihoods, & Ecosystem Interrelationships*. Projects include 16 countries, 16 US Universities and 29 HC institutions in formal funded partnerships.

Table V-1. AquaFish Core Research Project Investiations by Systems Approach and Topic Areas (2009-2011)

SYSTEMS APPROACH	TOPIC AREA	NUMBER OF INVESTIGATIONS
Integrated Production Systems		
	Indigenous Species Development (IND)	6
	Quality Seedstock Development (QSD)	5
	Sustainable Feed Technology (SFT)	6
	Production System Design & Best Management Alternatives (BMA)	7
People, Livelihoods, & Ecosystem Interrelationships		
	Human Health Impact of Aquaculture (HHI)	2
	Technology Adoption & Policy Development (TAP)	7
	Marketing, Economic Risk Assessment, & Trade (MER)	4
	Mitigating Negative Environmental Impacts (MNE)	7
	Watershed & Integrated Coastal Zone Management (WIZ)	3
	Food Safety & Value-Added Product Development (FSV)	3
	Total	50

AQUAFISH CRSP TOPIC AREAS

Core projects have work plans (investigations) organized around a number of specific areas of inquiry called Topic Areas. Current projects contain between five and eight investigations. Projects focus on more than one topic area in describing aquaculture research that will improve diets, generate income for smallholders, manage environments for future generations, and enhance trade opportunities.

A systems approach requires that each CRSP project integrate topic areas from both *Integrated Production Systems* and *People, Livelihoods and Ecosystem Interrelationships.* USAID also encourages the CRSP to address biodiversity conservation and non-GMO biotechnology solutions to critical issues in aquaculture. Each overall project describes a comprehensive development approach to a problem.

Projects were formed around *core program components*, as identified by USAID:

- a systems approach
- social, economic, and environmental sustainability
- capacity building and institution strengthening
- outreach, dissemination, and adoption
- gender integration

Topic Areas pertain to aquaculture and the nexus between aquaculture and fisheries. Some of the following topic areas overlap and are interconnected. Investigations in this *Implementation Plan* identify a single topic area that best describes each individual investigation. The text under each topic area is

provided for illustrative purposes and is not prescriptive. Fisheries-only issues were not funded with core EGAT funds per guidance from USAID.

TOPIC AREAS: INTEGRATED PRODUCTION SYSTEMS

- **Production System Design & Best Management Alternatives (BMA)**
  Aquaculture is an agricultural activity with specific input demands. Systems should be designed to improve efficiency and/or integrate aquaculture inputs and outputs with other agricultural and non-agricultural production systems. Systems should be designed so as to limit negative environmental impacts. CRSP research should benefit smallholder or low- to semi-intensive producers, and focus on low-trophic species for aquaculture development. Research on soil-water dynamics and natural productivity to lessen feed needs were fundamental to the Aquaculture CRSP; critical new areas of research may be continued. Interventions for disease and predation prevention must adopt an integrated pest management (IPM) approach and be careful to consider consumer acceptance and environmental risk of selected treatments.

- **Sustainable Feed Technology (SFT)**
  Methods of increasing the range of available ingredients and improving the technology available to manufacture and deliver feeds are an important research theme. Better information about fish nutrition can lead to the development of less expensive and more efficient feeds. Investigations on successful adoption, extension, and best practices for efficient feed strategies that reduce the "ecological footprint" of a species under cultivation are encouraged. Feed research that lessens reliance on fishmeal/proteins/oils and lowers feed conversion ratios is desired, as is research on feeds (ingredients, sources, regimes, formulations) that result in high quality and safe aquaculture products with healthy nutrition profiles.

- **Indigenous Species Development (IND)**
  Domestication of indigenous species may contribute positively to the development of local communities as well as protect ecosystems. At the same time, the development of new native species for aquaculture must be approached in a responsible manner that diminishes the chance for negative environmental, technical, and social impacts. Research that investigates relevant policies and practices is encouraged while exotic species development and transfer of non-native fishes are not encouraged. A focus on biodiversity conservation, and biodiversity hotspots, as related to the development of new native species for aquaculture is of great interest. Aquaculture can be a means to enhance and restock small-scale capture and wild fisheries resources (Aquaculture-Fisheries Nexus Topic Area). Augmentation of bait fisheries through aquaculture to support capture fisheries is an area of interest, provided there are no net negative environmental effects.

- **Quality Seedstock Development (QSD)**
  Procuring reliable supplies of high quality seed for stocking local and remote sites is critical to continued development of the industry, and especially of smallholder private farms. A better understanding of the factors that contribute to stable seedstock quality, availability, and quantity for aquaculture enterprises is essential. Genetic improvement (e.g., selective breeding) that does not involve GMOs may be needed for certain species that are internationally traded. All genetic improvement strategies need to be cognizant of marketplace pressures and trends, including consumer acceptance and environmental impacts.

TOPIC AREAS: PEOPLE, LIVELIHOODS, & ECOSYSTEM INTERRELATIONSHIPS

- **Human Health Impacts of Aquaculture (HHI)**
  Aquaculture can be a crucial source of protein and micronutrients for improved human health,

growth, and development. Research on the intrinsic food quality of various farmed fish for human consumption is needed—this might include science-based studies of positive and negative effects of consuming certain farmed fishes. Patterns of fish consumption are not well understood for many subpopulations. Human health can be negatively impacted by aquaculture if it serves as a direct or indirect vector for human diseases. There is interest in better understanding the interconnectedness of aquaculture production and water/vector-borne illnesses such as malaria, schistosomiasis, and Buruli ulcer and human health crises such as HIV/AIDS and avian flu.

- **Food Safety & Value-Added Product Development (FSV)**
  Ensuring high quality, safe, and nutritious fish products for local consumers and the competitive international marketplace is a primary research goal. Efforts that focus on reducing microbial contamination, HACCP controls and hazards associated with seafood processing, value-added processing, post-processing, and by-product/waste development are of interest. Consumers and producers alike will benefit from research that contributes to the development of standards and practices that protect fish products from spoilage, adulteration, mishandling, and off-flavors. Certification, traceability, product integrity and other efforts to improve fish products for consumer acceptance and international markets are desired. Gender integration is important to consider as women are strongly represented in the processing and marketing sectors. (Aquaculture-Fisheries Nexus Topic Area)

- **Technology Adoption & Policy Development (TAP)**
  Developing appropriate technology and providing technology-related information to end-users is a high priority. The program encourages research that results in a better understanding of factors and practices that set the stage for near-term technology implementation and that contribute to the development of successful extension tools and methods. Areas of inquiry can include institutional efforts to improve extension related to aquaculture and aquatic resources management; science-based policy recommendations targeting poor subpopulations within a project area, or more broadly (for example, national aquaculture strategies); methods of improving access to fish of vulnerable populations including children (e.g., school-based aquaculture programs); science-based strategies for integrating aquaculture with other water uses to improve wellbeing, such as linkages with clean drinking water and improved sanitation. Policy initiatives that link aquaculture to various water uses to improve human health are needed. Additionally, social and cultural analyses regarding the impacts of fish farming may yield critical information for informing policy development.

- **Marketing, Economic Risk Assessment & Trade (MER)**
  Aquaculture is a rapidly growing industry and its risks and impacts on livelihoods need to be assessed. Significant researchable issues in this arena include cost, price, and risk relationships; domestic market and distribution needs and trends; the relationships between aquaculture and women/underrepresented groups; the availability of financial resources for small farms; and the effects of subsidies, taxes, and other regulations. Understanding constraints across value chains in local, regional, and international markets is of interest, especially as constraints affect competitiveness, market demand, and how to link producers to specific markets. **(**Aquaculture-Fisheries Nexus Topic Area)

- **Watershed & Integrated Coastal Zone Management (WIZ)**
  Aquaculture development that makes wise use of natural resources is at the core of the CRSP. Research that yields a better understanding of aquaculture as one competing part of an integrated water use system is of great interest. The range of research possibilities is broad—from investigations that quantify water availability and quality to those that look into the social context of water and aquaculture, including land and water rights, national and regional policies (or the lack thereof), traditional versus industrial uses, and the like. Water quality issues are of increasing concern as

multiple resource use conflicts increase under trends toward scarcity or uneven supply and access, especially for freshwater. Ecoregional analysis is also of interest to explore spatial differences in the capacities and potentials of ecosystems in response to disturbances. Innovative research on maximizing water and soil quality and productivity of overall watersheds is of interest. Pollution is a huge concern, as over 50% of people in developing countries are exposed to polluted water sources. Additionally, aquatic organisms cannot adequately grow and reproduce in polluted waters, and aquaculture may not only be receiving polluted waters, but adding to the burden. Rapid urbanization has further harmed coastal ecosystems, and with small-scale fisheries and aquaculture operations in the nearshore, integrated management strategies for coastal areas are also important. (Aquaculture-Fisheries Nexus Topic Area)

- **Mitigating Negative Environmental Impacts (MNE)**
  With the rapid growth in aquaculture production, environmental externalities are of increasing concern. Determining the scope and mitigating or eliminating negative environmental impacts of aquaculture—such as poor management practices and the effects of industrial aquaculture—is a primary research goal of this program. A focus on biodiversity conservation, especially in biodiversity "hotspot" areas, as related to emerging or existing fish farms is of great interest. Therefore, research on the impacts of farmed fish on wild fish populations, and research on other potential negative impacts of farmed fish or aquaculture operations is needed, along with scenarios and options for mitigation. **(**Aquaculture-Fisheries Nexus Topic Area)

ENVIRONMENTAL COMPLIANCE

The following USAID environmental restrictions apply to the projects and the overall program:

- Biotechnical investigations will be conducted primarily on research stations in Host Countries.
- Research protocols, policies, and practices will be established prior to implementation to ensure that potential environmental impacts are strictly controlled.
- All training programs and outreach materials intended to promote the adoption of CRSP-generated research findings will incorporate the appropriate environmental recommendations.
- All sub-awards must comply with environmental standards.
- CRSP Projects will not procure, use, or recommend the use of pesticides of any kind. This includes but is not limited to algaecides, herbicides, fungicides, piscicides, parasiticides, and protozoacides.
- CRSP Projects will not use or procure genetically modified organisms (GMO).
- CRSP Projects will not use, or recommend for use, any species that are non-endemic to a country or not already well established in its local waters, or that are non-endemic and well established but are the subject of an invasive species control effort.

TERMINOLOGY FOR INVESTIGATIONS

Investigations that generate new information form the core of projects. Each investigation is clearly identified as an experiment, study, or activity, based on the following definitions:

Experiment	A scientifically sound investigation that addresses a testable hypothesis. An experiment implies collection of new data by controlled manipulation and observation.
Study	A study may or may not be less technical or rigorous than an experiment and may state a hypothesis if appropriate. Studies include surveys, focus groups, database examinations, most modeling work, and collection of technical data that

do not involve controlled manipulation (e.g., collection and analysis of soil samples from sites without having experiments of hypothesized effect before collection).

Activity — An activity requires staff time and possibly materials but does not generate new information like an experiment or a study. Conference organization, training sessions, workshops, outreach, and transformation and dissemination of information are examples of activities.

Investigations provide a transparent means for evaluating different types of work under the CRSP, be they quantitative, empirical, biologically-based, qualitative, policy-based, or informal. Each project was required to include at least one experiment or study. Projects were also required to include outreach activities such as training, formal education, extension, and conference organizing to supplement the scientific research being proposed.

GENERAL RESEARCH PRIORITIES

All core projects address the following general research priorities:

- Priority Ecosystems
  Freshwater and brackish water ecosystems for aquaculture and aquaculture-fishery nexus topic areas. Marine ecosystems are also included in the aquaculture-fishery nexus topic areas.

- Priority Species
  Low-trophic level fishes; domesticated freshwater fishes; non-finfishes (e.g., bivalves, seaweeds); aquatic organisms used in polycultures and integrated systems; native species. Food fishes are a priority but species used for non-food purposes (e.g., ornamental, pharmaceutical) may also be included as a priority if they are a vital part of an integrated approach towards food security and poverty alleviation.

- Target Groups
  Aquaculture farms (small- to medium-scale, subsistence and commercial) and aquaculture intermediaries, policy makers, and others in host countries.

- Key Partners
  University, government, non-government, and private sector

VI. CORE RESEARCH PROJECT REPORTS

Annual reports submitted by each project cover the period from 1 October 2009 to 30 September 2010. Six of the core research projects negotiated no-cost extensions (NCE) that extended their work under the Implementation Plan 2007-2009 from 30 September 2009 through 31 December 2009 for five projects (North Carolina State University, Purdue University, University of Connecticut–Avery Point, University of Hawai'i at Hilo, and University of Michigan) and through 31 March 2010 for one other (University of Arizona).

All 2007-2009 investigations were successfully completed. Full final investigation reports were published by the Management Office in two volumes under the title, *Technical Reports: Investigations 2007-2009* and are available at aquafishcrsp.oregonstate.edu/publications.php. Due to their length and detail, they are not printed in this annual report.

Implementation Plan 200-2011 reports are printed as submitted by Lead Projects with subsequent addition by the MNE of project summaries, which were drawn from project proposals.

Photo in Mexico by Tiffany Woods:

LEAD US UNIVERSITY: AUBURN UNIVERSITY

HYDROLOGY, WATER HARVESTING, AND WATERSHED MANAGEMENT FOR FOOD SECURITY, INCOME, AND HEALTH: SMALL IMPOUNDMENTS FOR AQUACULTURE AND OTHER COMMUNITY USES

PROJECT SUMMARY

Our vision is to provide research results that increase the knowledge base on water resource uses that work in the African context. The studies identify best practices in water use, enterprise development, and fish culture and contribute a legacy of trained individuals capable of leading and guiding aquacultural development as part of watershed management. Four studies address a broad range of water management, production, credit, and extension issues in Uganda and South Africa with intent and potential to extend findings and training to other countries. In Uganda, we build on a three-year intensive USAID-funded effort to build an aquaculture industry that brings to the project an extensive network of contacts and institutional knowledge. We have a strong network of women scientists and extension professionals as Host Country Partners. Some host country partners have a sustained record of meaningful impact in the aquacultural sector in their own and neighboring countries whereas others are new to aquaculture by bring other disciplines and approaches to the broader context of watershed management.

Much research on small-holder aquaculture in developing nations has focused on integration of aquaculture with other activities on small farms. Our approach was to consider how to integrate aquaculture into watershed management schemes that focus on capturing overland flow in one or more small impoundments for multiple use, e.g., community water supply, aquaculture, livestock watering, small-scale irrigation, etc. We acknowledge the fundamental resilience that women lend to small-scale aquaculture through their labor, vigilance, and interest in the activity.

The project uses climatic and hydrological variables, as well as topographic and geologic features to develop a procedure for identifying sites where such schemes could be installed. This project provides basic data on precipitation, evaporation from water surfaces, temperature, and evapotranspiration needed in modeling and engineering efforts, complemented by case studies of water use and management for fish farming. Other work refines hydrologic models and proposes appropriate layout and engineering guidelines for designing and constructing small impoundments and water conveyance systems. In addition, watershed management practices for protecting the quality and quantity of the water source are delineated. The other components consider how aquaculture could be interwoven with other uses in environmentally and socially sound ways. Finally, there is a component dedicated to considerations of how stakeholders could organize themselves to guide multiple land uses and land owners, to develop reasonable procedures for allocating water for different uses, and to optimize benefits to surrounding communities.

We draw our broader view of small-holder aquacultural development from the FAO Limbé Declaration that asserts a number of principled conclusions (Moehl et al. 2005). The statement concludes that aquaculture development in sub-Saharan Africa (SSA) is at a crossroads. Burgeoning population growth and declining natural sources of fish make it imperative that aquaculture contributes as substantially to continental fish supply as possible. The region is the only one in the world where per capita fish consumption is declining and is projected to decline further. Reasons for this situation include civil conflict, weak management structures, low levels of investment in rural economies, and lack of economic

growth. At the same time, however, new opportunities exist that brighten the prospects for aquaculture development. In particular, we see women as key practitioners of small-scale aquaculture as a source of income and food security for rural households.

The FAO document asserts that small- and medium-scale commercial enterprises are the most efficacious engines of economic growth (Moehl et al. 2005). Researchers at the International Food Policy Research Institute found that "... even small increments to rural incomes that are widely distributed can make large net additions to growth and improve food security." The CGIAR has identified interventions that lead to improved incomes at the level of the rural farmer and resource manager as "having a larger impact on countrywide income than increases in any other sector." To increase the benefits accruing from aquaculture, development planners should consider how to move from the current situation of dominance of small-holder artisanal/large-scale commercial investors, to one where there are many small- and medium-scale commercial investors, without losing the benefits currently being generated by aquaculture.

The project addresses a number of constraints to the development of aquaculture, which includes basic insights into water availability and hydrological context, seed and feed production, as well as inefficient extension and outreach. Such considerations are vital for protecting wetlands and promoting biodiversity. It addresses women directly and recognizes their role in sustaining small-scale aquaculture. We endeavor to clarify how public/private partnerships between investors and knowledge delivery structures can facilitate sectoral growth by providing farmers with the highest quality of technological, managerial and marketing information available (Moehl et al. 2005).

While appreciating the need to address major constraints identified (water, seed, feed, extension), there is a need to examine other areas, such as market development, access to capital and other policy issues (Moehl et al. 2005). There is a clear need for cost-effective financial and institutional arrangements that can complement government and donor resources to deliver a limited number of critical research, advisory and technical services to high-potential farmers.

Aquaculture can provide high quality food for rural and urban consumers, generate employment and general commercial activities in otherwise impoverished local economies, make sense in the land and water context, and contribute to national wealth through increased revenue from markets and trade. The growth and expansion of fish farming must take account of the soil and water systems that provide a sustainable context for this productive enterprise. Our vision is to provide research results and visible examples that increase the knowledge base on developmental production paths that work in the African context, that guides aquaculture development in ways that protect wetlands and enhance biodiversity, that identify best practices based on successful experiences, and to contribute to a legacy of trained men and women capable of leading and guiding aquacultural development in the long term. The insights and approaches developed in Africa also have parallels and implications for problems confronting communities and watersheds in the U.S. (Boyd et al. in press). The next step for this project if future funding became available would be to expand the geographic scope of the project in Uganda, enhance training for Ugandan farmers and technical personnel, and conduct research to ameliorate the malleable constraints to aquacultural development. Our exit strategy is to leave behind a trained cadre of business sensitive technical personnel with functioning feed suppliers who can work with capable farmers to advance the aquaculture industry in Uganda.

Literature Cited

Moehl, J., M. Halwart, and R. Brummett. 2005. Report of the FAO-WorldFish Center Workshop on Small-scale Aquaculture in Sub-Saharan Africa: Revisiting the Aquaculture Target Group Paradigm. Limbé, Cameroon, 23-26 March 2004. CIFA Occasional Paper. No. 25. Rome, FAO. 2005. 54p. Retrieved 14 January,

2009: http://www.fao.org/docrep/008/a0038e/a0038e04.htm#TopOfPage Boyd, C. E., S. Soongsawang, E. W. Shell, and S. Fowler. In press. Small impoundment complexes as a possible method to increase water supply in Alabama. Proceedings of the 2009 Georgia Water Resources Conference, University of Georgia, Athens, Georgia, USA.

PROJECT PERSONNEL

Alabama A&M
James **Bukenya**- US Co-PI

Auburn University
Joseph **Molnar**- US Lead PI
Claude **Boyd**- US Investigator
Karen **Veverica**- US Investigator

Gulu University, Uganda
Nelly **Isyagi**- HC Co-PI
Alfonse **Opio**- HC Investigator

University of Georgia
Bill **Tollner**- US Co-PI

Makerere University, Uganda
Levi **Kasisira**- HC Lead PI
Peter **Mulumba**- HC Investigator
Monica Karuhanga **Berahu**- HC Investigator
Theodora **Hyuha**- HC Investigator

NaFIRRI, Uganda
Gertrude **Atakunda**- HC Co-PI
John **Walakira**- HC Investigator

Stellenbosch University, South Africa
Khalid **Salie**- HC Co-PI

INVESTIGATION PROGRESS REPORTS

Printed as submitted by Joseph Molnar, US Lead PI

09WIZ01AU - Effects of Watershed-Water Quality-Aquaculture Interactions on Quanitity and Quality of Water from Small Catchments in South Africa and Uganda

Progress. Start-up for the study in South Africa was slow because of administrative issues related to transferring the first increment of funding to Stellenbosch University. The US PI visited Stellenbosch University in February 2010 and assisted in locating suitable ponds for the study. Twelve sites were visited and several ponds were tentatively selected as possibilities for the research. The South African researchers then interviewed farmers and examined the conditions for monitoring at each pond. After considerable effort, six sites were identified as being suitable for both the hydrologic and water quality aspects of the study. These sites were grouped to allow a trout-culture pond and a control pond (no aquaculture) in the same general vicinity (Table 1). The ponds ranged in size from 7 to 23.7 ha, and all ponds were in farmland areas. The watershed areas were delineated and agricultural practices on the watersheds recorded. A weather station nearest each of the three groups of trout production/control pond pairs was identified and weather data is being obtained at regular intervals.

Weather data including maximum and minimum daily temperature, total daily rainfall, total daily class A pan evaporation, minimum and maximum daily relative humidity, and daily wind run are being accumulated. It will be possible to obtain daily values for all of the variables. Hydrologic measurements, primarily water depth in ponds, began in mid September 2010. Thus, this part of the study has not progressed enough to report any findings.

Water quality data have been collected twice in 2010 from the ponds for trout culture as part of another investigation. However, water quality monitoring in the control ponds was initiated in September 2010. Therefore, no evaluation of effects on water quality of trout culture can be made in this report.

Dr. William Tollner recently visited Stellenbosch University and traveled to the pond sites. He felt that hydrologic data from the Cape Olive pond (Table 1, Location 3*) would be the most useful for his hydrologic monitoring effort in Uganda.

Table VI-1. Site selected for hydrologic and water quality studies. A trout production pond (*) and a control pond (**) were paired at three locations.

Location/pond	Circumference (km)	Surface area (ha)	Coordinates	Land use
1 Bluegum*	1.98	16.8	34° 1′ 55.07″S 18° 55′ 54.49″E	Farmland
Rooiland**	2.24	23.7	34° 4′ 52.14″S 18° 54′ 38.72″S	Farmland
2 Mountain Vineyards*	1.37	8.0	33° 52′ 24.88″S 18° 57′ 20.43″E	Farmland
Normandi*	1.5	11.8	33° 53′ 12.97″S 18° 59′ 5.77″S	Farmland
3 Cape Olive	1.16	7.0	33° 42′ 26.19″S 19° 2′ 1.23″E	Farmland
Ashanti	2.0	13.8	33° 43′ 35.42″S 19° 1′ 52.21″E	Farmland

09WIZ02AU - Surface Catchment Development and Sustainability Evaluation for Multipurpose Water Supply for Meeting Aquaculture and Other Water Needs

At Makerere University, topographical, soils and Geomorphology maps of Uganda were acquired from Uganda lands and surveys Department with Arcview 3.2a software for preliminary remote sensing and data analyses. Field visits to small-scale and progressive fish farmers to identify best water management and construction practices as well as water-related constraints of production. Each visit involved GPS coordinate data collection for sites of existing fish ponds in Wakiso, Kampala, Jinja and Mpigi districts. Water management was identified as one of the key problems facing existing ponds and was attributed to pond construction methods that allow: (i) high seepage rates, (ii) Sediment inflow into the ponds with limited runoff micro-catchment control, (iii) High evaporation rates during some seasons of the year, (iv) improper positioning of inlet and outlets to the ponds, (v) improper leveling of the ponds. Amongst the good water quality practices identified included use of Interceptor drains and riparian zones created around the ponds and micro-watershed. The BMPs identified will be used in the community training workshop to be done in the next project phase. A journal article entitled “Aquaculture pond construction guidelines for sustainable micro-watershed development in Uganda” is being prepared and will be

submitted next year. We secured additional EPA pond construction fund and finalization of the Makerere University Sub-contract with UGA has been done. Model pond construction will commence in November, 2010 and data on the different construction methods will be collected. Water quality testing for the two sites at MUARIK and AEATREC has been accomplished but the water quantity and quality modeling is yet to be completed. Evaluation of good water management practices in terms of wetland impacts will be studied in the model pond site after construction. Hydrological modeling of the MUARIK site-stream is being conducted by an undergraduate B.S. Agricultural Engineering student as a final year design project. The student is using HEC-RAS model to define the stream hydrology and simulate riverside developments of introducing a reservoir and a fish pond before the pond construction. Soil, climate, vegetation cover, watershed and pond characteristics data inputs from the two sites are being collected for use in the spreadsheet screening tool for catchment suitability screening. SPAW model synthesis and adaptation to Uganda data is yet to be done.

At the Univeristy of Georgia, E.W.Tollner, Herbert Ssegane and Karen Veverica published Geospatial Modeling of Site Suitability for Pond Based Tilapia and Clarias Farming in Uganda. The study set out to implement geospatial modeling of site suitability for Tilapia and Clarias farming for Uganda. Seven criteria of water requirement, water temperature, soil texture, terrain slope, potential farm gate sales, availability of farm inputs, and access to local and regional markets were analyzed. The crisp and fuzzy approaches of criterion classification were implemented and the results compared. The weighted linear aggregation method was used to generate the overall suitability maps. There was a statistically significant difference between suitability values generated by crisp and fuzzy approaches. For both the crisp and the fuzzy approaches, over 99 % of the land was classified as moderately suitable or as suitable. However, the distributions of the suitable and moderately suitable classifications varied between the two approaches. The differences were more dominant in the Northeastern part of the country and areas around the shores of the major Lakes. For the same location, the fuzzy method gave slightly higher suitability values at the lower extreme (unsuitable) and gave slightly lower suitability values at the upper extreme (very suitable). Overall, the crisp method classified 59,203 ha (0.34 %) as very suitable for Tilapia and Clarias farming compared to 230 ha (0 %) by the fuzzy method. Simultaneously, the crisp method gave 10,794 ha (0.06) as unsuitable compared to 7,150 ha (0.04 %) by the fuzzy method. Of the 138 fish ponds with operational pond status, the crisp method classified 71 % as suitable while 29 % as moderately suitable while the fuzzy method classified 71.7 % as suitable while 28.3 % as moderately suitable.

09BMA01AU - Evaluation and Improvement of Production Technology in Uganda: Case Studies of Small-Holder Cage Culture in Watershed Reservoirs and as an Alternative Livelihood for Fishers

Progress. The project started with outlining funding opportunities for the identified farmer groups. A number of opportunities were looked at. Given that the farmer groups still operate on small scale, the most feasible ones included government input donations to farmers and borrowing inputs such feed and fingerlings from supplies. The borrowed inputs would be paid back with no interest after fish sales at the end of the production cycle. Various groups across the country were studied in order to identify those that qualified to partner with the project. A series of criteria were developed and used to select the farmers. The criteria included:[1] Registration status of the group with the local government in the area and or with a farmer association; [2] Evidence of financial resources and their sources [3] Fish production and financial records.

One farmer group “Jinja United Group Initiative for Poverty Alleviation and Economic Development (JUGIPAED)” qualified to participate in the project. The group comprises small scale farmers and they have already obtained permits for cage culture, outside Jinja, within about 5 km of where the Nile River exits Lake Victoria. A Memorandum of Understanding (MoU) has been signed between the group and the project to guide the project activities. The MoU spells out roles of each partner. There is another group in the vicinity and involved in cage culture with support from the National Agricultural Advisory Services (NAADS) that the project will study for comparison purposes. Efforts to identify a group in Northern

Uganda were not fruitful given that most of the groups had been newly formed and not in operation. Others were already in partnership with the USAID funded LEAD project.

Work done so far with the group: [1] Detailed description of the group; [2] Survey of the Kirinya area of Lake Victoria. The survey measured water quality parameters. Interviews were conducted with the community around and the Kirinya government prison officials to understand social issues and accessibility arrangements. The prison officials promised total support to the cage culture trails including availing space for. [3] Site selection on Lake Victoria putting up a storage shade. [4] Developing production and financial management plan with the group [5] Recommending the group for feed loan support from UgaChick company. Finalised feed procurement arrangement by farmer group (farmer group will provide all the feed throughout the trial). Floating feed produced by Ugandan based company Ugachick Ltd will be used. [6] Procurement of cage materials and making cages; [7] Booking Tilapia fingerlings to stock the cages. (The group was not in position to raise fingerlings as was originally planned); [8] Finalised site accessibility arrangement with Kirinya Uganda government prison [9] Two students were identified for internship to assist farmer group in record keeping

Case Study Results. Four pond groups were identified as exemplifying a range of focus and commitment to aquaculture production. The results were analyzed and presented in Emily Stutzman Jones M.S. thesis. Though patterns of distorted incentive systems and piecemeal donor seeking were established by donor behavior, the effects damage the viability of producer organizations and undermine their ability to accomplish the goal of becoming profitable commercial fish farmers. Each donor comes that donor's own aims, which may or may not align with the umbrella group's goals. In fact, government or donor goals may serve to hinder member fish farmers from focusing on production, profitability, and long-term organizational viability. Donor and governments' requirements certainly threaten fish producer organization leadership development, as this pattern of goal displacement and distortion obstructs leaders from defining, working towards, and achieving goals and forming an organizational identity. In the current method of operations, leaders of donor-driven fish producer organizations simply follow the dictates of donor organizations, dictates which change with the creation and completion of an endless stream of short-term projects conducted by an alphabet soup of donor organizations. Additionally, fish producer organizations model the donor's short term project orientation. For fish producer organizations in Uganda to support a market-driven, thriving aquaculture sector sustained over time, producer organization leaders must recognize that current government and donor financial incentives are not serving their interests as commercializing fish farmers, and avoid them while demanding that these structures be reformed to serve the intended purposes of governments, donors, and fish farmers.

09MER01AU - Market Assessment and Profitability Analysis of Aquaculture Enterprises in Uganda

Data Collection. The first step in assessing aquaculture firm-level production costs, management practices, and marketing arrangements, is to identify the number, size, and location of existing aquaculture producers and processors and the current markets they serve. List of current fish farmers and processors in the study area (central region) were developed in collaboration with NaFIRRI, WAFICO and UFPEA. While the administration of the fish processor survey is still on-going, the administration of the fish farmers' survey has been completed. The final farmers' survey questionnaire was administered to 200 farmers using direct personal interviews at farmers' residences at appointed times or at the farmer's convenience. The exercise started on 14th June, 2010 and ended on July 15th 2010. The interviews, lasting about two hours, solicited information on number of years in the aquaculture business, allied industries, type of operation, species reared, product forms, marketing strategies and income from aquaculture enterprise.

Data Analysis and Results. Data from questionnaire interviews were coded and entered into a database system using Microsoft Excel software. A statistical method – SPSS (Statistical Package for Social Science) was used to analyze the data, producing descriptive statistics. Two-way and three-way frequency tables were generated. Main findings:

- Only 36 percent (n=72) of the farmers interviewed had fish farming as their main source of income. The other 64 percent (n=128) farms had a wide range of other livelihood activities
- Although some of the farmers interviewed had been involved with fish farming for many generations, there appeared to be an increasing number of people who were starting to practice aquaculture.
- Farms visited were generally established from between 1980 and 2010, with 3 main periods of development identified [1996-2000 (n=38), 2001-2005 (n=83) and 2006-2009 (n=57)]. Over 70 percent of the farms surveyed started in the past 10 years (2000-2009).
- Although many farmers regarded it as source of income, it is not regarded as important as other sources of income, rather one that could be used sporadically.
- More farms cultured tilapia and catfish compared with any other fish species. When asked to indicate the species grown for their last harvest, the majority (82 percent) reported tilapia.
- Most farmers (24 percent) harvested their fish for family consumption as well as for local markets (70 percent).
- The majority (61 percent) of the farms solicited additional labor (1 to 5 people) during harvest and most of this additional help was paid labor.
- The average smallest market fish size harvest ranged between 0-500 grams and the average largest market fish size was 500-1000 grams and this appeared to be related to the species that they farmed the size of the pond used and the market purpose of their harvest.
- Over 35 percent of the farms surveyed categorized their fish harvest to be of good quality while 21 percent categorized their harvest as poor quality.
- The majority (72 percent) of the farms rented their harvesting net
- The majority of farms fed their fish with maize bran (47 percent) followed by Ugachic feed (24 percent), but a proportion also used crop leaves and pellets.
- Nearly all of the farmers interviewed cultured fish in ponds rather than cages.
- A high number of farmers (64 percent) owned between 1 or 2 ponds
- The day-to-day management of the ponds on 57 percent of the surveyed farms was under family labor.
- The most common pond size was 100 to 200m^2.
- Farmers obtained their fry/fingerlings from a variety of different sources with the most common source of fish seed being from Kajjansi fisheries institute (58 percent) followed by Mpigi and Umoja fish farm.
- The stocking density of fingerlings ranged from 100 fish to 9050 fish with most farmers stocking at between 351-550 fish.
- Only 45 percent of the farms surveyed made a profit from the last completed harvest.
- The majority of the farms (60 percent) sold their fish fresh.
- Over 90 percent of the farms surveyed used personal funds to finance their production.
- The majority of the farms (76 percent) are not associated with any organization.
- Only 48 percent of the farms kept some form of written records related to their fish farming activities, relating mainly to production costs.
- Only 10% of farmers claimed to contact the extension officers with most farmers relying on their own experience or advice from other farmers.
- Generally, farms involved in small-scale fish farming stocked and harvested their fish ponds throughout the year.

- The length of the production cycle (from stocking to harvest) ranged from 8 to 9 month for the majority of the farms surveyed.

09BMA02AU - Training and Outreach in Uganda and Surrounding Nations

Progress. The training and outreach component successfully organised the Third Annual Fish Farmers Symposium and Trade Fair in partnership with the Walimi Fish Farmers Cooperative Society (WAFICOS) in January 2010. The theme of the Third Annual Fish Farmers Symposium and Trade Fair was "Dealing with the Challenges of Building an Aquaculture Industry". The specific areas discussed were:

1. Challenges Faced in Accessing Inputs the Consequent Implications on Returns to Investment and Quality of Service Delivery.
2. Markets, Marketing and Market Information.
3. Current Support Services to the Aquaculture Private-Sector and Factors Affecting their Accessibility.

An optional one-day field tour to various aquaculture-related establishments that included farms and feed and fish-net manufacturing plants. There were a total of about 158 paid in participants to the symposium. The proceedings of the third symposium have been compiled into a CD that is being distributed locally in Uganda. The proceedings are also being distributed by the US team and also been uploaded on the SARNISSA website. The SARNISSA website is a source of aquaculture information for more than 1000 practitioners (farmers, policy makers, suppliers, etc) from in Sub-Saharan Africa. The SARNISSA link www.sarnissa.org. An article about the third symposium was also written for Aquanews.

Technical Support. Study 2: Assistance was provided in the organization for the seminars to be presented by Herbert Ssegane and Bill Tollner. This included developing the structure of the seminars, wrote the invitation letters, prepared the invitation lists as well as provided contacts of key people to be invited to the local team. The presentations of the seminars were compiled into a CD. In addition assistance was provided to the engineering team in planning and organizing local visits to Gulu and around Kampala. This included a fish farmer who had just obtained a loan to start constructing ponds. Input from his farm will feed independently into study 2 and 4. GIS readings of other fish farms that were taken under a previous GIS assessment study conducted by Nelly Isyagi and Maurice Ssebisubi were made available to the engineering team to augment the data collected by the Uganda team. The additional data will help enhance the calibration of the impoundment citing and water catchments models.

Study 3: on the evaluation of cage culture production involved linking the local investigators with farmers who had undertaken cage culture and sourcing inputs as well as their costs for constructing cages. Mr. Borel of Tende Innovation farm kindly offered to give second hand cages at a reduced costs as well as the material for making floats for the cage. Assistance was also provided to the Kajjansi team in sourcing stock. Training material on cage culture for training the proposed farmers group has been compiled.

Study 4: Linked the local investigators to WAFICOS who in turn provided the Market and Profitability assessment team with the list of farmers in the association as well as their contacts. A significant proportion of the farmers interviewed for this study were members of WAFICOS. Assistance was also provided in the review of the questionnaire before its use in the field to ensure that the information collected would encompass the essential economic factors affecting aquaculture enterprises in Uganda. In addition, sourced a research assistant (Mr. Mbulameri who previously worked as an assistant in the USAID FISH Project) with experience in aquaculture to participate in the team conducting the interviews for the study. His participation has had a positive impact on the aquaculture data collected by the team.

Nelly Isyagi also participated the FAO ANAF meeting that was held between the 26th to 28th June, 2010 in Jinja with Joseph Molnar, the lead PI who gave a presentation on the CRSP-Uganda project.

The date of the 'Fourth Fish Farmers Symposium and Trade Fair' has been fixed for the 12th to 14th January, 2011 at Uganda Manufacturers Associations Hall. The theme for the 2011 'Fourth Fish Farmers Symposium and Trade Fair' is 'Viable Fish Farming'.

Presentations & Publications

Table VI-1. Presentations

Title	Author(s)	Type	Event	Location
NEW DIRECTIONS IN AQUACULTURE DEVELOPMENT IN UGANDA: DEMONSTRATION AND TRAINING TO ADVANCE A NASC ENT INDUSTRY	Joseph Molnar	Oral	WAS	San Diego
WATER USE EFFICIENCY IN AQUACULTURE	Claude Boyd	Oral	WAS	San Diego
PROSPECTS OF AQUACULTURE ENTERPRISES IN POVERTY REDUCTION IN UGANDA	Theodora Huhya	Oral	WAS	San Diego
AQUACULTURE POND CONSTRUCTION GUIDELINES FOR SUSTAINABLE MICRO-WATERSHED DEVELOPMENT IN UGANDA	Levi Kisasira	Oral	WAS	San Diego
INTEGRATED FISH AND HALOPHYTE PRODUCTION: EFFECTS OF SALINITY ON GROWTH AND OSMOTIC ADJUSTMENT OF Salicornia bigelovii AND Allenrolfea occidentalis	Khalid Sallie	Oral	WAS	San Diego
UNDERSTANDING THE ROLE OF FISH PRODUCER ORGANIZATIONS AS INTERMEDIARIES FOR AQUACULTURAL DEVELOPMENT IN UGANDA	Emily Stutzman Jones and Joseph J. Molnar	Oral	Rural Sociolgical Society	Atlanta

LEAD US UNIVERSITY: NORTH CAROLINA STATE UNIVERSITY

IMPROVED COST EFFECTIVENESS AND SUSTAINABILITY OF AQUACULTURE IN THE PHILIPPINES AND INDONESIA

PROJECT SUMMARY

Aquaculture in the Philippines and Indonesia is a high food security priority particularly in the light of the countries' rapidly growing populations and their continued dependence on fish protein. The incomes from family farming, however, are generally poor with 43% of small-scale tilapia farmers in Central Luzon, Philippines falling below the poverty line. The difficult socioeconomic conditions are even more pronounced for fishers in coastal regions where traditional livelihoods have been lost, and many seek transition to milkfish farming, but with some uncertainty. In Indonesia, a tsunami eliminated shrimp-farms, and the livelihoods of entire communities continue to rebuild. In this project we develop and implement strategies that will improve the cost effectiveness, sustainability and income opportunities of farming fish in the Philippines and Indonesia and the subsequent livelihood of their people. A cluster of integrated investigations assess key areas of research and outreach that form a natural extension of the activities and accomplishments of the first phase of our AquaFish CRSP. We continue to develop methods to reduce farming costs for tilapia and milkfish, conduct an extensive supply-chain analyses to specifically address the marketing opportunities and constraints of expanding tilapia products to reach more lucrative retail supermarkets, assess the utility of integrative/polyculture systems to reduce environmental impacts of farming fish while providing additional products for market and home consumption, develop a series of short Tilapia Podcasts designed for disseminating current culture practices and cost-saving strategies to the farming community of Central Luzon, and provide training on the harvest and processing of seaweeds in the Philippines and Aceh region of Indonesia. The research and outreach activities planned incorporate specialists from Central Luzon State University (CLSU) the Southeast Asian Fisheries Development Center (SEAFDEC), Ujung Batee Aquaculture Center, North Carolina State University (NCSU), University of Arizona, and the United States Department of Commerce, their collaborators and the farming communities of the host countries. Nine workshops are planned, as are a community-based training program and the involvement of over 30 students.

Tilapia and milkfish are the two most prominent finfish cultured in the Philippines. They are low trophic species whose culture is expanding rapidly both in inland and coastal regions and in a more intensive fashion. Feed is clearly one of the most costly aspects of fish farming, representing as much as 80% of total production costs for tilapia and 60-70% for milkfish. Feed wastage and the escalating cost of fishmeal in commercial diets contribute to this problem; sources are rapidly declining and demand remains high. The project aims to improve management strategies and will deliver more cost-effective formulations to reduce feed usage and costs. Controlling costs is a requisite to increasing income for small-scale farmers, while also preserving the biodiversity of bait fisheries. Limiting nutrient load from feed wastage will also help mitigate the environmental imprint of fish farming and promote its sustainability. A series of studies reduce feed costs for tilapia farmers that incorporates a combination of sub-satiation feeding; decreases in feed formulation costs through reductions in crude protein, amino acid supplementation, and replacement of fishmeal with lower cost protein sources; and use of a cheaper manufacturing process that uses pellet rather than extrusion processing. This aspect of our work features a unique synergy between a Filipino feed company, CLSU and NCSU researchers, and Luzon farmers in the Philippines.

Additional studies to reduce ration levels and integrate seaweeds and sea cucumber in the culture of milkfish limit feed inputs and reduce the ecological imprint of milkfish culture clusters in coastal regions near where fish kills have been reported. Integrated milkfish culture systems may not only improve water and sediment quality, but will benefit farmers' incomes through the delivery of additional marketable seafood products. SEAFDEC will introduce the integrated system to the farming communities, through season-long training programs using their cages as a demonstration facility. The SEAFDEC training staff and several of the seaweed farmers recruited for this project will be women, which will foster and expand the role of women in traditionally, male-dominated fish farming. Additionally, the seasonal training program will incorporate a workshop on the processing and production of value added milkfish products geared toward women that should allow for improvements in household incomes.

The need for improved-quality tilapia seed is expected to triple over the next decade. To enhance reliability and production of high quality seed and limit the risks of entry of new farmers, we will undertake studies to establish practical methods for selecting broodstock with high fecundity that can be used by hatcheries in the Philippines and elsewhere. We will utilize appetite, eye color, and social behavior patterns in tilapia to select broodstock with low susceptibility to stress and higher yield of robust fry. This investigation should provide practical technologies for selecting individuals for breeding programs as well as for pairings to improve seed production. We will also evaluate the density-dependent stress and growth response of tilapia, and quantify hormones mediating the responses in hapa and tank enclosures frequently used by a growing number of farmers that intensively culture tilapia in the Philippines and USA. These studies build upon our current effort to develop suitable biomarkers of growth and stress that can be used to optimize conditions for tilapia culture, toward addressing the USAID priority of establishing suitable biotechnologies for the advancement of aquaculture.

There is currently a strong desire to expand tilapia culture in the Philippines to meet the growing demand for fish products in the domestic retail supermarket and fast-food chains. Toward this goal we are evaluating and developing an efficient tilapia supply chain to foster the development of viable fast food and supermarket purchases of tilapia from small-scale producers. We anticipate that this work will facilitate development of domestic tilapia markets that can expand tilapia farming, increase sales, improve farm incomes, and increase small farmer participation.

In Indonesia and the Philippines, the polyculture of seaweeds in shrimp and fish ponds has proven to be popular in several coastal communities based on our initial work in the first phase of the AquaFish CRSP project. In phase I (IP 2007-2009) we provided training on seaweed polyculture and several farming communities embraced this new practice, but wish to learn more about how to handle and process the seaweed produced. We will conduct a series of workshops in communities of Aceh, Indonesia and the Philippines to assist farmers on management, harvest and processing of seaweeds. We will assist farmers on how to process their raw seaweed into more valuable semiprocessed forms for sale to commercial agar buyers and for use in making candy and desserts for local markets, the latter providing an option for home businesses, especially those operated by women.

Finally, we will further develop Tilapia Podcasting, following our successful launch of the first podcast at CLSU. This emerging technology is a powerful approach to information distribution that has been met with considerable enthusiasm in the Philippines and the tilapia community. Following its recent link to a trackable server at NCSU we found the Podcast was uploaded over 100 times in the past month, alone. In the proposed studies we will train a CLSU student and produce 8 short tilapia-related podcasts with information on tilapia culture methodology, new production technology, cost-saving feeding practices, etc. These podcasts will be laid out on a CLSU, AquaFish CRSP, and NCSU website where they will be fully accessible by Central Luzon farmers and the worldwide tilapia community.

The long-range goals of our work will be to continue to tackle the excessive production costs associated with commercial feeds in finfish aquaculture. We anticipate continuation of refinements of feed strategies and formulations for tilapia and milkfish that should directly benefit farmers and their capacity to improve incomes, including the production of value added "organic" products that might include algal enrichment with omega-3 fatty acids. We also anticipate developing additional culture systems and methods to reduce environmental impacts of fish farming, possibly including integrative culture systems using bivalves and water reuse technologies to limit nutrient outflow in waterways. The retail and export market demand for tilapia and milkfish continue to grow, and we hope to develop the requirements and recommendations needed for small farmers to sell products to domestic retail, and eventually export markets. This endeavor has only begun, but may show the strongest promise for increasing incomes of farmers. Other areas of research might include enhanced selective breeding of tilapia for all-male production and production of superior culture traits. Because of the wide popularity of tilapia we anticipate the management strategies applied to its production in the Philippines will be applicable to addressing similar constraints in other underdeveloped countries in Africa, Asia, and Central/South America. Our contributions - because of continued publication in respectable international journals and our podcasting efforts - are likely to reach far beyond the Southeast Asian region. We feel, once the management strategies and research capabilities for sustaining and expanding aquaculture are established that our mission will have been completed.

PROJECT PERSONNEL

Central Luzon State University, Philippines
Remedios B. **Bolivar**- HC Lead PI
Wilfred **Jamandre**- HC Investigator
Emmanuel M. **Vera Cruz**- HC Investigator

Institute of Fish Processing Technology, College of Fisheries, University of the Philippines at the Visayas
Rose T. **Mueda**- HC Collaborator

North Carolina State University
Russell **Borski**- US Lead PI
Peter R. **Ferket**- US Investigator
Upton **Hatch**- US Investigator
Charles R. **Stark**- US Investigator

SEAFDEC-AQD, **Philippines**
Evelyn Grace T. **De Jesus-Ayson**- HC Co-PI
Felix G. **Ayson**- HC Investigator
Nelson **Golez**- HC Investigator
Anicia **Hurtado**- HC Investigator
Maria Rovilla **Luhan**- HC Investigator

Ujung Batee Aquaculture Center, Banda Aceh, Indonesia
Hassan **Hasanuddin**- HC Co-PI
Coco **Kokarkin**- HC Investigator

University of Arizona
Kevin **Fitzsimmons**- US Co-PI

US Department of Commerce-NOAA
Christopher **Brown**- US Co-PI

INVESTIGATION PROGRESS REPORTS

Printed as submitted by Russell Borski, US Lead PI

09SFT04NC - Feeding and Feed Formulation Strategies to Reduce Production Costs of Tilapia Culture

A growout trial was initiated to evaluate the effect of high and lower crude protein in commercial feeds with or without pond fertilization on performance of Nile tilapia. However, a delay in receiving formulated feeds from our industry cooperator, Santeh feed company of the Philippines, following the initial stocking of fingerlings in ponds precluded our completing the study. Nonetheless, we improvised by conducting a supplementary study with the stocked fish that evaluated the effects of a combined feed reduction on growout of tilapia using commercial feed in fertilized ponds. Our previous work shows that 67% subsatiation feeding produces growth rates identical to that of fish fed daily at full feeding levels and

significantly improves production efficiency of tilapia growout in the Philippines. We also show that alternate day full feeding and 50% daily subsatiation feeding strategies further reduce costs of tilapia growout, although the total biomass of fish is was lower than that of fish fed daily at full ration. Therefore, we tested a combined feeding strategy to evaluate whether a 67% subsatiation feeding combined with alternate day or 50% reduced feeding could reduce costs with little impact on total biomass produced. The treatments were as follows: Treatment I – 67% daily feeding until harvest; Treatment II - 67% daily feeding for 60 days, 50% daily feeding until harvest; and Treatment III - 67% daily feeding for 60 days, 100% alternate day feeding until harvest. Over a 120-day culture period the growth of fish and other production parameters (final body size, growth rate, feed conversion) were similar among the 3 treatment groups. However, total biomass at harvest was highest in treatment I fish. This difference is due to the higher survival rates in treatment I (46.9%) than in treatment II (29.3%) and treatment III (27.7%), although survivorship was generally low among all groups likely due to the high temperatures experienced over the culture period. Overall, this study shows that it is more profitable to grow fish using the daily 67% subsatiation feeding strategy alone than that, which incorporates this combined with 100% alternate day or daily 50% subsatiation feeding. Clearly, when used alone 67% subsatiation, 50% subsatiation and 100% alternate-day feeding are all effective in reducing production costs of tilapia compared with the recommended typical 100% daily feeding schedule.

For a second study, we have initiated the formulations of low (26%) and high (31%) protein diets with and without fishmeal to ascertain if a more sustainable and less costly diet could be used in combination with subsatiation feeding in further reducing the costs of culturing tilapia in ponds.

09QSD01NC - Nile Tilapia Broodstock Selection, Seed Quality and Density-Dependent Growth in the Philippines

The first study aims to investigate whether the outcomes of competition for social dominance among Nile tilapia (*Oreochromis niloticus*) individuals can be predicted by evaluating the duration of appetite inhibition after transfer to isolation. In addition, it also investigates if eye color pattern (ECP) is related to the duration of behavioral stress response such as appetite inhibition. The concept is to enable the selection of those broodstock that show dominance and hence will have and convey reproductive advantages. Physical and behavioral markers such as eye color pattern (ECP) and appetite, respectively, are features that could be easily assessed by hatchery operators in selecting the best mating pairs for seed production.

Fifty-four all male tilapia of similar sizes, were individually weighed and isolated at random and introduced to aquaria (1 fish per aquarium) for ten days. The time before first acceptance of food during the first day of isolation was monitored for each fish. Feeding behavior during the entire isolation period was quantified by assigning corresponding scores for a particular feeding behavior as follows: 0 score, fish does not react or eat the feed; 1 score, fish eat only pellets that are directly put in front of them and do not move to consume feed; 2 score, fish moves to consume food, but comes back to its original aquaria location between each feeding; and 3 score, fish continuously consume all food pellets in the aquarium. These data (i.e. weight and duration of inhibition of feeding) were used for the assignment of the opposing fish, in which the two opposing fish had similar weights and one of the opponent fish had longer period of appetite suppression than the other. During the isolation period, the ECP of the fish was also measured (based on Volpato et al., 2003). The fish were fed, once a day, at 1% of the body weight. Immediately after the isolation period the fish were paired and introduced to a new aquarium, to ensure that there is no familiarity with home location. The period from time of the introduction of the fish up to the time of first agonistic attack, the total number of agonistic attacks during the interaction, the duration of social interaction before establishment of social status, and changes in ECPs was monitored and recorded. After establishment of social rank the pair of fish were stocked in one aquarium separated by a divider. Twenty-four hours after the establishment of social hierarchy, the ECPs and individual body

weight of the fish were measured. Every morning the division of the aquarium was removed for ten minutes and the social interaction of the fish was observed. After the interaction, all fish were then fed to satiation once daily and after 14 days of pairing, ECP and body weight of each fish were measured. Ten dominant and subordinate fish were collected for quantification of hepatic IGF-I according to our previously described methods. Total RNA from the liver of 20 sample fish was purified, DNAse treated to remove any possible genomic DNA contamination and quanitified and quantified for future IGF-I mRNA analyses.

The remaining dominant and subordinate groups were each divided into three and are being cultured in net enclosures for two and a half months to evaluate the growth performance. Eye color pattern, and duration of social interaction and social response are being assessed using linear regression and Pearson correlation coefficient.

A second study to assess the effect of broodfish potential social condition on seed production of Nile tilapia (wet season) has been designed and initiated.

For the fourth study that evaluates density-dependent effects on growth and stress response, assays for plasma cortisol and tissue glucocorticoid (cortisol) receptor abundance were established and validated for tilapia species.

09TAP02NC - Internet-Based Podcasting: Extension Modules for Farming Tilapia in the Philippines

We proposed to further develop Tilapia Podcasting, following our successful launch of the first podcast at Central Luzon State University (CLSU). This emerging technology is a powerful approach to information distribution that has been met with considerable enthusiasm in the Philippines and the tilapia community. To this end, we have completed the production of several new podcast modules on tilapia culture. A North Carolina State University (NCSU) undergraduate, Katrina Jiamachello (a Caldwell Scholar) and a CLSU graduate student (Roberto Sayco) were trained in podcasting at North Carolina State University over a twelve-week period. We produced 6 extension podcasts that conveyed feeding practices demonstrated to reduce costs for growout of Nile tilapia. Four of the podcasts are produced in the English language and two others were modified and translated into Tagalog, the primary Filippino language. The podcasts include the following subjects:

1) Alternate-day feeding strategy for reducing costs of Nile tilapia growout in the Philippines (English)
2) Pag-aaral sa pagpapakain na may isang araw na pagitan upang mapababa ang gastos sa pagpapalaki ng tilapia sa Pilipinas (tagalog) (English translation: Alternate-day feeding strategy for reducing costs of Nile tilapia growout in the Philippines)
3) A 67% subsatiation feeding strategy for reducing costs of Nile tilapia Growout in the Philippines (english)
4) Evaluation of 50% daily feed ration levels versus full daily feed ration on on-farm growout of Nile tilapia in earthen ponds (english)
5) Pag-aaral sa araw-araw na pagpapakain gamit ang kalahati at buong rasyon ng pakain sa tilapia (tagalog). (English translation: Evaluation of 50% daily feed ration levels versus full daily feed ration on on-farm growout of Nile tilapia in earthen ponds)
6) Delayed onset of supplemental feeding reduces the cost for growout of Nile tilapia in ponds.

The podcasts produced were configured with photographic images depicting tilapia culture in the Philippines, in order to maintain a high level of familiarity and comfort for the farmers in that area. We also provided figures, tables and graphs of experimental outlines, growout data and cost-benefit analyses so podcast users could see the methodology and advantages of different feeding practices in reducing production costs of tilapia culture in earthen ponds. The podcasts have been sent out for review and will

be uploaded shortly to the CLSU Fisheries and Aquaculture and AquaFish CRSP websites, as well as at the NCSU iTunesU site where hits, downloads, and other data for podcasts will be collected. These websites will allow the international research, extension, and farming communities full access of information that directly benefit the tilapia aquaculture industry in the Philippines and other regions of the world.

09MER03NC - Improving Supply Chain Opportunities for Tilapia in the Philippines

Tilapia culture has been well established in the Philippines as a viable agricultural enterprise and is readily available in local fish markets and grocery stores in a wide variety of product forms. The project goal is to investigate opportunities for further industry expansion. From the marketing side, identify and analyze new opportunities; and from the production side, use the experience of research and extension professionals to recommend potential adjustments to best management practices (BMP's) that will facilitate market expansion.

Drs. Wilfred Jamandre and Upton Hatch initiated data collection and interviews in early 2010 and Hatch traveled in-country in August, 2010. Information was collected through interviews and focused group discussion on marketing and production technologies, arrangement, requirements and performance. Jamandre and Cruz (MS student) plan to complete data collection in winter 2011. Upon completion of data collection, Hatch will return to CLSU to work with Jamandre and Cruz to complete data analysis. Study results will provide the basis for Cruz's MS thesis and Hatch will serve as Cruz's co-advisor with Jamandre.

At project midpoint, Jamandre and Hatch have identified several issues that constrain the expansion of tilapia culture that they will investigate further and discuss with tilapia research, extension and government professionals. These observations focus on market improvements, expansion of private specialized hatcheries, and research priorities on brackish water, pond efficiencies, and larger fish size.

Several marketing refinements have been noted: saturate national market first and establish government certification of feed quality and standardized weights. The next stage should focus on provision of larger fish size, standardized, high quality fish for large urban marketing outlets. Movement of fish through the supply chain nodes of Pampanga, Daguyan, Batangus, Baguio and Munoz appears to reflect market maturity and continues to develop along expected lines. Feed content is often not clearly specified on the bag; consequently, many farmers have no confidence in feed quality. Similar complaints related to standardization of weight of fish that were being sold at pond bank were frequently expressed.

In most successful aquaculture industries worldwide, development of specialized private hatcheries is a key step in its evolution toward expanded commercial viability. Benefits from these operations range from more efficient use of improved genetic strains and pond resource to greater ability to expand market opportunities.

Future directions in tilapia research, extension and government priorities should focus on brackish water, larger size, and pond management efficiency. Competition of freshwater resources for aquaculutre and human use should convince researchers and government officials that a portion of the research portfolio should be directed at improvements in brackish water systems. It is clear that larger individual fish size is a primary characteristic highly valued by consumers and supply chain buyers for super markets. BMP's for the several market supply chains identified in the project would be a useful addition to extension information for farmers. That is, different BMP's based on targeted market should be developed.

There are definite times during the year when supply is less dependable for the supply chain. Explanations have centered on market reasons related to periods just after high demand and price market

windows and production constraints related to fish kills caused by extreme water temperatures. Interviews with producers tended to indicate that 1-2 months of down time was common. CLSU extension specialists should investigate the reasons for these non-productive periods and work with researchers to address this inefficiency.

09MNE02NC - Ration Reduction, Integrated Multitrophic Aquaculture (milkfish-seaweed-sea cucumber) and Value-Added Products to Improve Incomes and Reduce the Ecological Footprint of Milkfish Culture in the Philippines

We have shown in previous experiments that reductions in the daily feeding rate from 10% to 7.5% of fish biomass during the initial phase of culture, followed by prescribed reductions in rate to 4% of body weight towards harvest, produces milkfish of comparable body size, but with less feed input. Likewise we showed in tanks and brackishwater ponds that feeding milkfish at the initial reduced feeding rate of 7.5% body weight on alternate days rather than daily saves almost 50% on feed costs with minimal effect on growth, survival or total biomass at harvest. Therefore, we tested the effects of alternate day versus daily feeding at the reduced feeding rate of 7.5% on production of milkfish in marine cages, the fastest growing component milkfish culture in the Philippines. Results show that survival rate and total biomass at harvest were comparable between the two treatments. Further, feed consumption, feed cost and FCR were higher in daily fed fish compared to alternate day fed ones. Levels of water and sediment quality indicators (sulphide, phosphorus and ammonia) were also lower in production areas using lower feed inputs and these parameters were closely related to the intensity of aquaculture activity. These results indicate that the twin objectives of lowering production cost by lowering feed inputs and reducing the environmental footprint of milkfish aquaculture are attainable.

From these results, milkfish production trials will be conducted integrating culture of seaweeds and sea cucumber as additional crops that would bring supplemental income to farmers while simultaneously lowering the environmental impacts of milkfish farming with the idea that seaweeds will absorb some of the dissolved nutrients while sea cucumber will partially clean up the sediments. A preliminary experiment was conducted to test the feasibility of integrated culture of milkfish and sea cucumber. However, sea cucumbers were preyed on by parrotfish and other predators in the area. Currently, fish are being conditioned for the next experiment on integrated culture of milkfish, seaweeds and sea cucumber using a different design i.e. culturing the sea cucumbers inside (bottom) of the milkfish cage. A parallel experiment will also be conducted in brackishwater ponds.

As another component to this investigation we have made arrangements for integrating capacity building on integrated culture in an ongoing season-long milkfish culture training for 4 fishers organizations from different coastal villages in Guimaras, Philippines.

Additional activities have targeted participation of women toward improvement of household livelihoods centered on milkfish culture. Through a series of workshops, women from two coastal villages in Tigbauan, Iloilo and 4 coastal communities in Guimaras were trained on milkfish postharvest procedures like deboning in order for them to make value added milkfish products and get better prices for milkfish. This could be a stand-alone business opportunity or could be linked as a downstream activity in an integrated milkfish production system. To this end, women from the Guimaras communities also are being assisted in setting up a small business by linking up with a microfinance company as a development partner.

Other activities include co-organizing the FAO Experts Workshop on Onfarm Feeds and Feeding for Aquaculture, which was held last 13-15 September. The workshop highlighted case studies on feeding practices for tilapia, carps, catfishes, and white shrimp in the Philippines, Thailand, Vietnam and other

countries in the Mekong area, Indonesia, China, Bangladesh and India and Africa focusing mostly on small-scale and small-holder aquaculture.

09FSV02NC - Demonstration of Sustainable Seaweed Culture and Processing in Aceh, Indonesia and the Philippines - Opportunities for Women to Improve Household Welfare

Visits to Aceh were made in early April 2010 to meet with Indonesian partners, Hasanuddin and Coco, to review project progress and plans. Farm sites were visited and seaweed production with demonstration farmers was discussed. Several demonstration racks were constructed for the communities of Aceh to promote the proper harvest and drying of seaweed.

Upton Hatch from North Carolina State and Sidrotun Naim (Graduate student from Arizona) met in Banda Aceh to conduct interviews with farmers and Ujung Batee staff to evaluate the impacts of seaweed culture as part of the integrated polyculture system promoted to the former shrimp farmers in the region. The evaluation and results are part of the submitted trip report and recommendations include some of the activities outlined in this investigation. Overall, the report concludes that seaweed polyculture has an excellent opportunity to be incorporated into and provide several important benefits to the existing aquaculture system. However, some marketing and production constraints need to be addressed before the potential can be fully realized. This includes additional training on handling and drying seaweeds. Training workshops regarding proper harvesting, handling, and drying of red seaweeds for the region are currently being planned and implemented. An additional recommendation is that financial support for purchase of drying racks for farmers who have had successful harvests using seaweed polyculture system would be useful. Although demonstration-drying racks for seaweed have been built through this project, additional, larger units will be required to produce the quantities of seaweed needed for wholesale distribution. Other recommendations suggest: 1) market opportunities be improved through establishment of certification process and facilitation of selling seaweed through forward contracting between farmer and production plant; 2) support for applied research and extension on understanding the relationship between white spot virus and other crops in polyculture system (tilapia, milkfish, and seaweed); and, 3) support for applied research and extension on understanding the relationship between odor and crops in polyculture system (tilapia, shrimp, milkfish, and seaweed).

Naim also delivered textbooks for Hasanuddin needed for his Master's degree program at University in Banda Aceh.

Photo in Band Aceh courtesy of Russell Borski

PRESENTATIONS & PUBLICATIONS

Table VI-2. Presentations

Title	Author(s)	Type	Event	Location
North Carolina Aquaculture – Research Update	Borski, R.J., Daniels, H., Hinshaw, J., Losordo, T., and Sullivan, C.	Oral	North Carolina Aquaculture Development Conference Annual Meeting	Atlantic Beach, NC USA
Genomic Enablement of Aquaculture: Graduate Research, Education, and Training	Borski, R.J., Sullivan, C.V., and Noga, E.G.	Oral	International Symposium on Aquaculture and Fisheries Education	Pathumthani (Bangkok), Thailand
AquaFish Project Mini-Updates: Improved cost effectiveness and sustainability of aquaculture in the Philippines and Indonesia.	Borski, R.J., Bolivar, R., Vera Cruz, E., Jamandre, W., Bolivar, H., DeJesus-Ayson, E.G., Hurtado, A., Golez, N., Hasanuddin, H., Fitzsimmons, K., Brown, C.	Oral	Annual Meeting of the Aquaculture and Fisheries (AquaFish) Cooperative Research Support Program	San Diego, CA USA
Growth performance of Nile Tilapia, *Oreochromis niloticus* L., in ponds in the Philippines using combined feed reduction strategies.	Borski, R.J., Bolivar, R., Jimenez, E.B., Sayco, R., and Argueza, R.	Oral	Aquaculture 2010	San Diego, CA USA
Salinity regulation of prolactin cell proliferation and apoptosis in the euryhaline tilapia, *Oreochromis mossambicus*.	Borski, R.J. and Strom, C.	Oral	Aquaculture 2010	San Diego, CA USA
Effect of age of broodfish on the grow-out performance of Nile Tilapia, *Oreochromis niloticus* L., fingerlings in earthen ponds.	Bolivar, R., Jimenez, E.B., Sayco, R., Argueza, R., Bolivar, H., Dadag, L., and Borski, R.J.	Oral	Aquaculture 2010	San Diego, CA USA
Endocrine dynamics of metabolic and growth-regulatory hormones during compensatory growth in a teleost model, the hybrid striped bass.	Won, E.G., Picha, M.E., Strom, C., and Borski, R.J.	Oral	Aquaculture 2010	San Diego, CA USA
Catch-up growth: Hormones and Mechanisms	Borski, R.J.	Oral	Seminar	Stony Brook University, Stony Brook, NY USA

Table VI-3. Publications

Picha, M.E., Strom, C.N., Riley, L.G., Walker, A.A., Won, E.T. Johnstone, W.M. and Borski, R.J. (2009). Plasma ghrelin and growth hormone regulation in response to metabolic state in hybrid striped bass: Effects of feeding, ghrelin and insulin-like growth factor-I on *in vivo* and *in vitro* GH secretion. General and Comparative Endocrinology. 161:365-372.

Picha, M.E., McGinty, A.S., Gross, K., Hedgpeth, V.S., Siopes, T.D., and Borski, R.J. Supra-elevated circulating and muscle insulin-like growth factor-I gene expression during complete catch-up growth in Hybrid Striped Bass (*Morone chrysops* X *Morone saxatilis*) with temperature and feeding manipulation (in review)

Turano, M.J., Picha, M.E., Daniels, H.V., Sullivan, C.V. Jackson L.F., and Borski R.J Regulation of plasma growth hormone and pituitary growth hormone gene expression and content during catabolism and compensatory growth in a teleost fish, the hybrid striped bass, *Morone chrysops* x *M. saxitilis* (in review)

Strom, C.N, Patisaul, H.B., Mozdziak, P.E., and Borski, R.J. Salinity Regulation of Lactotroph Cell Proliferation and Apoptosis in the Euryhaline Teleost, the Tilapia (*Oreochromis mossambicus*). (in review)

Jamandre, W.E., Hatch, L.U., Bolivar, R.B., and Borski, R.J. (2010) Market opportunities for tilapia and their implications on production systems in the Philippines. Journal of Agriculture. In press.

Newspaper article on milkfish culture in the Philippines. Title: Research helps bangus industry grow. Sarian, Z.B. ed. Agriculture section of the Manila Bulletin. September 2, 2010

Killerich, P., Tipsmark, C.K., Borski, R.J., Madsen, S.S. Differential effects of cortisol and 11-deoxycorticosterone on ion-transport protein mRNA levels in gills of two euryhaline teleosts, Mossambique tilapia (Oreochromis mossambiccus) and striped bass (Morone saxatilis). Accepted with Revision.

LEAD US UNIVERSITY: PURDUE UNIVERSITY

IMPROVING COMPETITIVENESS OF AFRICAN AQUACULTURE THROUGH CAPACITY BUILDING, IMPROVED TECHNOLOGY, AND MANAGEMENT OF SUPPLY CHAIN AND NATURAL RESOURCES

PROJECT SUMMARY

The overall goal of this continuation project is to develop physical and human capacity for the aquaculture industry in sub-Sahara Africa through new and better technology of fish production, better management of the natural resources, development of indigenous species, and responding appropriately to market demands for fish products. Results from the various investigations will help to vitalize rural aquaculture entrepreneurship by providing capacity and opening up a larger market for rural aquaculture producers. They will also help to provide additional employment and income generation that will create demand for other products and thus support the growth of other rural economic activities.

Individual investigations included in this project build on and add value to currently funded AquaFish CRSP studies. In Kenya, past CRSP research studies suggests a strong production focus, leaving many fish consumer and marketing questions unanswered. Therefore, an investigation is included to consumer preferences and developing linkages between fish consumers and production with the development of a Farmed Fish Market Information System in Kenya. A second study in Kenya looks at fish feeding efficiencies to enhance productivity in open ponds. The integrated system being examined will allow open pond water to utilize cage wastes as fertilizers, generating natural food in the pond. This is an environmentally friendly technology that permits less waste nutrients to be released to the public water systems.

In Tanzania, we are building on the current nutrition study by developing fish feeding strategies for local protein sources in Tanzania. The current research has revealed that Leucaena leucocephala leaf meal and Moringa oleifera leaf meal can replace up to 25% of soymeal as protein sources and still obtain good growth. Therefore, an experiment will be conducted to test the effects of different diets and feeding regimes on growth performance of Nile tilapia. In addition, there will be an investigation to compare the performance (growth rate, survival, feed conversion ratio and mature body size) of five different strains of Nile tilapia (Oreochromis niloticus) that has proliferated the industry. There is a need for bio-prospecting for various species of tilapia to identify the species better suited for aquaculture in Tanzania.

In Ghana, cage culture is becoming popular with several multi-million investments into the technology in the Volta Lake. Many small scale farmers are looking into the technology of cage aquaculture. The only species being farmed in these cages is tilapia. There is concern about the market price and the viability of small-scale tilapia producers given the trends towards industry type tilapia production. Therefore, one study will look at the opportunities and challenges to the adoption of cage culture as an alternative production system in Ghana, while a second study examines the development of alternative species with emphasis on indigenes to provide guarantees against potential biodiversity degradation that could result from unbridled spread of aquaculture species. Numerous opportunities exist for the development of new species and expansion of the variety of production systems in Ghana to provide a safety net and access to new markets for small-scale aquaculture producers.

PROJECT PERSONNEL

Kenyatta University, Kenya
Charles C. **Ngugi**- HC Lead PI

Kwame Nkrumah University of Science & Technology, **Ghana**
Stephen **Amisah**- HC Co-PI
Selina Naana **Egyir**- Research Assistant
Nana Akwasi **Osei**- Research Assistant
Richard **Pendleton**- Research Assistant
Afua Serwaah Akoto **Prempeh**- Research Assistant
Nelson **Agbo**- Host Country Investigator

Ministry of Fisheries Development, Kenya
Judith **Amadiva**- HC Co-PI
Sammy **Macharia**- HC Investigator

Ministry of Natural Resources & Tourism, Aquaculture Division, Tanzania
Kajitanus **Osewe**- HC Collaborator

Moi University, Kenya
Julius **Manyala**- HC Co-PI

Purdue University
Kwamena **Quagrainie**- US Lead PI
Jennifer **Dennis**- US Investigator

Sokoine University of Agriculture, Tanzania
Sebastian **Chenyambuga**- HC Co-PI
Nazael **Madalla**- HC Investigator
Berno V. **Mnembuka**- HC Investigator

University of Arkansas at Pine Bluff
Rebecca **Lochmann**- US Co-PI

Virginia Polytechnic Institute & State University
Emmanuel **Frimpong**- US Co-PI

Women in Fishing Industry Project, Kenya
Jennifer **Atieno**- HC Collaborator

INVESTIGATION PROGRESS REPORTS

Printed as submitted by Kwamena Quagrainie, US Lead PI

09MER02PU - Value Chain Development for Tilapia and Catfish Products: Opportunities for Women Participation

Data collection for the first component of this study involving consumer preferences is completed. Over 1,600 responses have been obtained from fish consumers in Kenya, Tanzania and Ghana. The survey instrument solicited information on consumers' socio-demographic features, general fish consumption partterns, specific consumption of tilapia and catfish, and a choice experiment specifically for tilapia products. The data is currently being analyzed.

The second component of this study involving women participation in the fish value has started with a review of the relevant literature. The study will provide information on strategic challenges that the Kenyan aquaculture industry faces, with a focus on value addition and value capture opportunities in farmed tilapia and catfish in a bid to determine the necessary strategic opportunities and value addition options along the fish marketing chain for women.

09SFT02PU - Assessment of Integrated Pond-Cage System for the Production of Nile Tilapia to Improve the Livelihood of Small-Scale Fish Farmers in Kenya

The study is in progress. Cages have been stocked with fish and the first sampling and recording of data will be done in October.

09SFT05PU - Development of Feeding Strategies for Moringa oleifera and Leucaena leucocephala as Protein Sources in Tilapia Diets

Work has begun on this project. Feed materials are being gathered and prepared for the feeding trials. A student recruited at University of Arkansas at Pine Bluff is currently working out some logistics related to feeding and stripping of fish, obtaining fish yield, and the maximum number of times fish can be stripped

per week without stressing the fish. Fish are being sorted, sexing larger fish to prepare for the digestbility trials on Moringa oleifera and Leucaena leucocephala.

09QSD04PU - Performance Evaluation of Different Tilapia Strains and Species in Tanzania
Various institutions have been contacted about sourcing different strains of tilapia. Production facilities at Sokoine University are currently being prepared for the study. A student has been identified to work on this investigation.

09TAP04PU - Harnessing Opportunities and Overcoming Constraints to Widespread Adoption of Cage Aquaculture in Ghana
About 90% of targeted questionnaire surveys and in-person interviews have been completed. Participants have included both current and potential cage fish farmers, regional fisheries officers in the Eastern and Volta regions, officials of the head office of the Fisheries Commission, the Aquaculture Development Research Center of the Water Research Institute, and heads of financial institutions. The return rate of responses to questionnaires was very high but we are still expecting about 10% of the distributed questionnaires. We had the most difficulty obtaining the needed data from financial institutions. One surprising observation of the summer field work was a higher level of cage culture activities on the Volta Lake than had been anticipated. It appeared many farmers had entered the cage culture industry in the past two to three years. Sustainability of the small-scale cage culture industry, especially as related to knowledge of technology, affordability of high quality feeds, and the water-quality of the lake environment are emerging questions.

09IND06PU - Development and Diversification of Species for Aquaculture in Ghana
Literature has been reviewed on the ecological and life history of the species (*Heterotis niloticus*, *Chrysichthys nigrodigitatus*, and *Parachanna obscura*) and also their native distribution. A survey has also been conducted to obtain information (anecdotal) from fish farmers, in the Ashanti and Eastern regions (where most fish farmers can be found), who have the species on their farms and fishermen who are mainly the suppliers of parent stock or fingerlings from the natural waters. Juveniles of the three fish species have been acquired and are being held in happas before the experiments. *H.niloticus* (220 fingerlings) and *C. nigrodigitatus* (200 fingerlings) were obtained from farms in Akuse and WRI-ARDEC.

H. Niloticus and *C. nigrodigitatus* were fed a formulated feed and a commercial feed (Ranan fish feed) and the acceptance was good. Feed intake will be assessed during the growth trial. Digestibility of the experimental diets will be conducted after the growth trial. Proximate analysis of feed ingredients has been done and feed formulation and preparation are in progress.

Training in advanced experimental design, data management, and analysis for master's level students associated with AquaFish, project staff, and fisheries officers of the Ministry of Agriculture Fisheries Directorate was conducted in July 28-30.

09TAP07PU - Effects of ACRSP and AquaFish CRSP Initiatives and Activities on Aquaculture Development in Kenya
This study has not begun. A student is currently being recruited to work on the study.

09QSD05PU - Training Program in Propagation and Hatchery Management of tilapia (Oreochromis niloticus) and catfish (Clarias gariepinus) in Ghana
Four planning meetings have taken place in Ghana involving all the project personnel. The two training venues have been identified and tentative dates set for the training. The first training will be held in December at the Water Research Institute's aquaculture facility at Akosombo, Ghana. The second training will be held in May/June at Kwame Nkrumah University of Science and Technology aquaculture facility

in Kumasi, Ghana. The training is currently being publicized through the various aquaculture associations. Project personnel have begun registering attendees.

PRESENTATIONS & PUBLICATIONS

Table VI-4. Presentations

Title	Author(s)	Type	Event	Location
USE OF Moringa oleifera AND Leucaena leucocephala TO IMPROVE COST EFFICIENCIES IN TILAPIA Oreochromis niloticus FEED	Sebastian W. Chenyambuga, Margaret M. Kibodya, Berno V. Mnembuka, Kajitanus O. Osewe, Rebecca Lochmann and Kwamena Quagrainie	Oral	Aquaculture 2010	San Diego, California
FISH AND MACROINVERTEBRATE ASSEMBLAGES IN RECEIVING STREAMS IN THE VICINITY OF EARTHEN PONDS IN GHANA	Yaw Ansah, Emmanuel Frimpong, Steve Amisah and Gifty Anane-Taabeah	Oral	Aquaculture 2010	San Diego, California
RELATIONSHIP AMONG MANAGEMENT PRACTICES, POND WATER QUALITY, AND RECEIVING STREAM INTEGRITY IN CENTRAL GHANA	Emmanuel Frimpong, Steve Amisah and Yaw Ansah	Oral	Aquaculture 2010	San Diego, California
POTENTIAL EFFLUENT QUALITY AND MICROBIAL LEVELS IN EARTHEN PONDS AND RECEIVING STREAMS OF CENTRAL GHANA	Yaw Ansah, Emmanuel Frimpong and Steve Amisah	Oral	Aquaculture 2010	San Diego, California
MARKETING FARMED FISH IN KENYA: OPPORTUNITIES AND CHALLENGES	Charles C. Ngugi and Judith M. Amadiva	Oral	Aquaculture 2010	San Diego, California
EFFICIENT POND DESIGN STRATEGIES FOR A VARIETY OF ENVIRONMENTS	Charles C. Ngugi and Kwamena Quagrainie	Oral	Aquaculture 2010	San Diego, California
HETEROGENEOUS PREFERENCES AND CONSUMER PURCHASE BEHAVIOR IN THE NORTH CENTRAL LIVE FISH MARKET	Kwamena Quagrainie	Oral	Aquaculture 2010	San Diego, California

Table VI-5. Publications

Quagrainie, K.K., C.C. Ngugi, and S. Amisah. “Analysis of the use of credit facilities by small-scale fish farmers in Kenya.” *Aquaculture International*, Published online at http://www.springerlink.com/content/32052u1u36436471/

Quagrainie, K.K., S. Amisah, and C.C. Ngugi. “Aquaculture Information Sources for Small-Scale Fish Farmers: The Case of Ghana.” *Aquaculture Research*, Vol. 40, 2009: 1516-1522.

Amisah, S., D. Adjei-Boateng, K. A. Obirikorang and K.K. Quagrainie. “Effects of clam size on heavy metal accumulation in whole soft tissues of Galatea paradoxa (born, 1778) from the Volta estuary, Ghana.” *International Journal of Fisheries and Aquaculture*, 1(2) 2009: 014-021.

Amisah, S. A.B. Gyampoh, P. Sarfo-Mensah, and K.K. Quagrainie. "Livelihood trends in Response to Climate Change in Forest Fringe Communities of the Offin Basin in Ghana." *J. Appl. Sci. Environ. Manage*. 13(2) 2009: 5 – 15.

Adjei-Boateng, D., S. Amisah, and K.K. Quagrainie. "Bacteriological contamination of the freshwater clam (Galatea paradoxa/born 1778) from the Volta estuary, Ghana." *African Journal of Microbiology Research*, 3(7) 2009: 396-399.

Chepkirui-Boit, V., Ngugi, C.C., Bowman,J., Oyoo-Okoth, E., Rasowo, J., Mugo-Bundi,J. and Cherop, L. Growth performance, survival, feed utilization and nutrient utilization of African catfish (*Clarias gariepinus*) larvae co-fed *Artemia* and a micro-diet containing freshwater atyid shrimp(*Caridina nilotica*) during weaning. Aquaculture Nutrition 2010: 1-8

LEAD US UNIVERSITY: UNIVERSITY OF ARIZONA

DEVELOPING SUSTAINABLE AQUACULTURE FOR COASTAL AND TILAPIA SYSTEMS IN THE AMERICAS

PROJECT SUMMARY

The aquaculture industry in Central and South America is dominated by shrimp and tilapia culture. While these industries have generated thousands of jobs, millions of dollars of exports and improved household nutrition, we feel that great strides can be made to make aquaculture more sustainable and profitable in the region. We believe that through the use of polyculture, domestication of native species, and integration of aquaculture with agriculture, aquaculture can produce fewer environmental externalities while at the same time improving production efficiencies and increasing profits.

The team from Mexico, Guyana and the University of Arizona feel that we have made solid progress in the first phase to address these issues and expect to build upon these successes. We believe that we can further expand our outreach to additional audiences, further improve the skills of those we have worked with in the first phase, and conduct additional trials to develop more cost effective diets, improve environmental sustainability of aquaculture in Mexico and Guyana, and raise the profile of the AquaFish CRSP and US-AID as critical supporters of sustainable aquaculture in these countries.

In the first phase of the Developing Sustainable Aquaculture for Coastal and Tilapia Systems in the Americas project our group had several notable achievements. Advances were reported on the reproductive biology of the snook. With captive broodstocks and induced spawning, we hope to eventually have the capability of stock enhancement and replenishing the overfished stocks of snook in the Gulf of Mexico. The advances in husbandry of two native cichlids, the Tenhuayaca (P. splendida) and Castarrica (C. urophthalmus), are equally impressive. The potential that both of these fishes could be restocked and domesticated as food fish are well on the way to fruition with captive spawning and transfer of the techniques to the private sector. The problem of hormone residues escaping from hatcheries using methyltestosterone, was addressed with directed bacterial degradation and through the use of titanium dioxide. In Guyana, a number for locally available ingredients were examined for use in fish diets. The proximate and mineral analyses allowed us to develop cost-effective practical diets for use on local farms. The experimental diets are now being tested with replicated trials of fingerlings and adult fish.

The outreach portion of the project has been equally successful. The Eighth International Symposium on Tilapia in Aquaculture had over 500 participants and the Ninth ISTA to be held in Shanghai China should have over 1000 participants, including many of our AquaFish colleagues. The number of training sessions, workshops, field days, conference sessions and presentations and symposia completed exceeded our expectations and we hope to further that success. An intern program between Mexican universities and US tilapia farmers proved to be especially useful for almost a dozen interns and the US and Mexican tilapia farms. We expect to also direct our workshops and training efforts to serve women to increase their participation in aquaculture and preparation of healthy seafood.

Our project addresses several critical issues of special concern to aquaculture producers in Mexico and Guyana. One is the use of locally produced protein sources for the replacement of fishmeal in tilapia, pacu and shrimp diets. Another is the management of YY supermale and GIFT strain tilapia stocks. In both cases the project will assist by providing nucleus breeding centers and support for pedigreed

selective breeding programs. We will also evaluate these strains with others already available to local growers.

The integrated aquaculture and agriculture (hydroponics, vegetables, and field crop culture) research has garnered enormous interest. Several groups have requested collaborations ranging from small farmer cooperatives, to government agencies (INIFAP, EPA), NGO's (Farmer to Farmer, Partners of the Americas), the Peanut CRSP, and even the investment firm Goldman Sachs. Integrated aquaculture-agriculture may be one of the most long lasting contributions of the project. Demonstration and research result supported outreach could help the Western Hemisphere aquaculture producers develop an industrial version of the small-scale integrated fish, rice, and vegetable production common across eastern and southern Asia. This could contribute to a quantum step forward in productivity and sustainability, vastly improving the quantity, quality, and profitability of both crops and seafood. Increased farm efficiency and training in handling of aquaculture products should improve household nutrition, income and overall welfare. These improvements in the welfare of the rural poor will help both the residents of the host country and reduce the need for citizens of the host countries to migrate to other countries in search of improved circumstances.

PROJECT PERSONNEL

Delaware State University
Dennis **Mcintosh**- US Collaborator

Department of Fisheries, Guyana
Pamila **Ramotar**- HC Co-PI
Vivek **Joshi**- HC Investigator

Shanghai Ocean University, China
TingTing **Zhou**- HC Collaborator
Liping **Liu**- HC Collaborator

Texas Tech University-Lubbock
Reynaldo **Patino**- US Co-PI

University of Guyana
Lawrence **Lewis**- HC Collaborator

Fish Farmacy
Jason D. **Licamele**- US Collaborator

Universidad Autonoma de Tamaulipas, Mexico
Pablo **Gonzalez-Alanis**- HC Co-PI
Mauricio A. **Ondarza**- HC Investigator

Universidad Juarez Autonoma de Tabasco, Mexico
Wilfrido **Contreras-Sanchez**- HC Lead PI
Alfonso **Alvarez-Gonzalez**- HC Investigator
Mario FER**nandez-Perez**- HC Investigator
Arlette **Hernandez Franyutti**- HC Investigator
Ulises **Hernandez-Vidal**- HC Investigator
Gabriel **Marquez Couturier**- HC Investigator
Rosa Martha **Padron-Lopez**- HC Investigator
Salomon **Paramo Delgadillo**- HC Investigator

University of Arizona
Kevin **Fitzsimmons**- US Lead PI
Edward **Glenn**- US Investigator

Shrimp Improvements Systems
Traci **Holstein**- US Collaborator

INVESTIGATION PROGRESS REPORTS

Printed as submitted by Kevin Fitzsimmons, US Lead PI

09TAP01UA - Aquaculture & Fisheries CRSP Sponsorship of the Ninth International Symposium on Tilapia in Aquaculture to be held in Shanghai, China

Fitzsimmons traveled to Shanghai in June 2010 to meet with other conference organizers at the Shanghai Ocean University. We outlined the program, visited the conference hotels, developed the plans for the trade show, discussed the printing options, reviewed the websites, and toured the meeting rooms and trade show space. Fitzsimmons also met with Liping Liu in Phuket Thailand on Sept 22 and 23 to futher

discuss the ISTA 9 plans. Fitz also developed plans for Intervet SP to join the conference as a Gold Sponsor with a $10,000 contribution.

The call for papers has been prepared and will be distributed at conferences in Kuala Lumpur and China in October and November.

09SFT03UA - Expansion of Tilapia and Indigenous Fish Aquaculture in Guyana: Opportunities for Women

Ramotar came to visit Arizona in March 2010 to discuss project progress and to observe facilities and practices at University of Arizona. She also visited the campus and bagan application proceedures for MS program at Arizona.

In August Fitzsimmons and Licamele traveled to Guyana to meet with Aquaculture staff at the Ministry of Agriculture and discuss project progress. Fitzsimmons also presented a guest lecture at the University of Guyana and prepared an MOU between University of Guyana and University of Arizona. One faculty member has since requested to spend his sabbatical at Arizona.

A three day workshop was then held at Bina Hill, near Annai, in Region 9. This workshop was directed towards the indigenous AmerIndian community in the inland region of Guyana. The workshop focused on production of native species and included capture and feeding of broodstocks, pond construction and maintenance, preparation of local ingredients for a fish diet, formulation and manufacture of ingredients into a diet. We also discussed harvest, processing and marketing of the locally grown fish to nearby, domestic, and even interantional markets. Representatives from many villages were invited and hosted to attend the workshops. The representatives will serve as trainers to extend the information with their respective village members.

The final two days were spent trying to develop processing, shipping and international markets for farmed fish and shrimp from Guyana to seafood markets in Trinidad and Florida.

Have also continued working with Pamila to get her accepted into Master's program at University of Arizona with tentative start date of 4 Jan 2011.

09QSD02UA - Sustainable Integrated Tilapia Aquaculture: Aquaponics and Evaluation of Fingerling Quality in Tabasco, Mexico

A demonstration project has been started in the village of Guerrero. The village is in the mountains of southern Tabasco and cannot be reached by road. Two suspension walking bridges are used to get all materials to the community. An integrated fish and vegetable project is expected to improve nutrition and wlefare for several of the families in the village. Fish tanks and plumbing have already been walked in and assembled on site.

Two workshops with farm visits were conducted in August and Sept of 2010. The first workshop, led by Dr. Dennis McIntosh from Delaware State and Kevin Fitzsimmons, from Arizona. focused on integrated aquaculture agriculture. The primary goals were to describe the benefits and sustainability of using aquaculture effluents to irrigate and fertilize grain and vegetable crops. Aspects of plant nutrition, soil science, water chemistry, fish nutrition, fish husbandry, harvest techniques and marketing were covered. The demonstration project in the village of Guerero was visited on August 14. The fish tanks and plumbing were examined and the suggested garden site was paced off and surveyed. Dicsussions focused on water and nutrient delivery, drainage, sun angles, shade problems and harvest plans.

A second workshop was held Sept 6-9 at UJAT for farmers, hatchery managers and university staff and students. The focus was on hatchery management and use of bioflocs for shrimp and fish hatcheries.

Traci Holstein, recent graduate from University of Arizona led the workshop. Traci and a colleague from her new position at Shrimp Improvement Systems in Florida met with hatchery staff to discuss biofloc proceedures and economic and husbandry benefits. Due to heavy rains and flooding she was not able to visit the demonstration farm site.

Dr. Ed Glenn served on the graduate committees of Kyle Vanderlugt and Rafael Martinez who both worked on this investigation.

09IND05UA - Consolidation of Native Species Aquaculture in Southeastern Mexico: Continuation of a Selective Breeding Program for Native Cichlids and Snook Reproduction in Captivity

Native cichlid breeding program has continued to make progress with continued spawning of F1 and F2 stocks. A pedigreed breeding program is being designed to better guide the selective breeding processes. Interest from the Regal Springs Farm in Chiapas suggests that a major commercial producer may be interested in producing the fish on a very large scale with royalities to be returned to UJAT.

The snook have resumed spawning over the summer and we have succeeded in rearing some of the fry to juvenile stage. A mix of natural feeds and formulated diets were finially successful in getting the fish through larval and fry stages. The hatchery facilities have been further upgraded and the UJAT administration has purchased additional adjoining lands for future expansion.

Dr. Edward Glenn served on the graduate commitee for Rafael Martinez who was invloved with some of this research.

PRESENTATIONS & PUBLICATIONS

Table VI-6. Presentations

Title	Author(s)	Type	Event	Location
GLOBAL TILAPIA PRODUCTION: SUSTAINABLE SOURCE OF SEAFOOD	Kevin Fitzsimmons	Oral	Cowen and Associates	New York, NY
POSITIVE EFFECTS OF DIETS SUPPLEMENTED WITH NUTRAFITO PLUSTM ON THE GROWTH OF PACIFIC WHITE SHRIMP Litopenaeus vannamei: A REVIEW	Mario Hernandez-Acosta*, Rodrigo Otero, Kevin Fitzsimmons	Oral	WAS 2010	San Diego
COMPARATIVE ANALYSIS BETWEEN POLYCULTURE AND MONOCULTURE SYSTEMS TO MEASURE THE EFFECT OF TILAPIA FISH (Oreochromis niloticus) ON THE PRODUCTION OF SHRIMP (Litopenaeus vannamei) IN A WATER RECIRCULATION SYSTEM	Hernandez and Fitzsimmons	Oral	WAS 2010	San Diego
THE POTENTIAL OF ANTIBACTERIAL ACTIVITY AND GREEN WATER PRODUCED BY GENETICALLY SUPERMALE INDONESIAN TILAPIA IN REDUCING VIBRIO ATTACK AND STIMULATING IMMUNE SYSTEM OF SHRIMP	Sidrotun Naim	Oral	WAS 2010	San Diego
UTILIZATION OF LOCAL FEED INGREDIENTS FOR FRESHWATER AQUACULTURE	Kevin Fitzsimmons	Oral	WAS 2010	San Diego
TILAPIA: 2009 STATE OF THE INDUSTRY REPORT	Fitzsimmons, Naim, Alghanim	Oral	WAS 2010	San Diego

EFFICACY OF GROWSTONE AS A FILTER MEDIA FOR AQUACULTURE APPLICATIONS	Tekie Anday and Kaolin Young	Oral	WAS 2010	San Diego
EFFECTS OF SALINITY ON GROWTH AND SURVIVAL OF GIFT TILAPIA Oreochromis niloticus AND RED HYBRID TILAPIA Oreochromis niloticus x Orechromis	Rafael Martinez-Garcia*, Raul Ponzoni , Nguyen Nguyen Hong , Khairul Rizal Abu Bakar , Stephen Nelson and Kevin Fitzsimmons	Oral	WAS 2010	San Diego
TILAPIA: THE AQUATIC CHICKEN AND ITS ROLE LEADING THE AQUACULTURE INDUSTRY	Fitzsimmons	Oral	AllTech	Lexington KY

Table VI-7. Publications

Allen, G., Fielder, S., Fitzsimmons, K., Applebaum, S., and Raizada, S. 2009. Chapter 36. Inland saline aquaculture. pp. 1119-1147. In: Burnell, G. and Allen, G. (eds). *New Technologies in Aquaculture*. CRC Press and Woodhead Publishing.

Stevenson, K., Fitzsimmons, K. and G. 2010. Integration of aquaculture and arid lands agriculture for water reuse and reduced fertilizer dependency. Experimental Agriculture 46:1-18.

Yuan, D. Yi, Y. Yakupitiyage, A., Fitzimmons, K. and Diana, J. 2010. Effects of addition of red tilapia (*Oreochromis spp.)* at different densities and sizes on production, water quality and nutrient recovery of intensive culture of white shrimp (*Litopenaeus vannamei*) in cement tanks. Aquaculture 298: 226–238.

Young, K. 2009. Omega-6 (n-6) and omega-3 (n-3) fatty acids in tilapia and human health: a review. International Journal of Food Sciences and Nutrition 60(S5): 203-211.

Allen, G., Fielder, S., Fitzsimmons, K., Applebaum, S., and Raizada, S. 2009. Chapter 36. Inland saline aquaculture. pp. 1119-1147. In: Burnell, G. and Allen, G. (eds). *New Technologies in Aquaculture*. CRC Press and Woodhead Publishing.

Licamele, J. and Fitzsimmons, K. 2009. Aquaculture In Guyana - Tilapia, Pacu, Shrimp Raised With Plant Crops. Global Aquaculture Advocate 12(2):83-84.

Fitzsimmons, K. Alghanim, K., and Naim, S. 2009. Tilapia Production, Market Report - Production, Consumption Increase Despite Economic Downturn. Global Aquaculture Advocate 12(2):67-70.

Fitzsimmons, K. 2010. Tilapia update 2010. The Practical Asian Aquaculture 1(2):32-34.

LEAD US UNIVERSITY: UNIVERSITY OF CONNECTICUT

DEVELOPMENT OF ALTERNATIVES TO THE USE OF FRESHWATER LOW VALUE FISH FOR AQUACULTURE IN THE LOWER MEKONG BASIN OF CAMBODIA AND VIETNAM: IMPLICATIONS FOR LIVELIHOODS, PRODUCTION AND MARKETS

PROJECT SUMMARY

In the Mekong region, many capture fisheries resources have been largely overexploited and, as a result, development of aquaculture has been encouraged to provide the protein, income, employment and export earnings for some countries. Such a development trend implies that sufficient feed for aquaculture production will be available. One source of feed is low value/trash fish (Low value/trash is defined as fish that have a low commercial value by virtue of their low quality, small size or low consumer preference). There is increasing demand and trade in the lower Mekong region of Cambodia and Vietnam for low value/trash fish for (1) local consumption (e.g. fresh, dried); (2) direct feed (e.g. livestock, high value species aquaculture); (3) fish meal production (e.g. poultry, aquaculture); and (4) value-added products (e.g. fish sauce).

The price of low value/trash fish has tripled since 2001 and it is predicted to continue to rise as aquaculture expands (FAO-APFIC 2005). The use of artificial fish based feeds and/or fresh fish resources have further increased pressure on wild fish stocks. Inevitably, a dangerous spiral has evolved where the demand for low value/trash fish for aquaculture feed has supported increased fishing pressure on already degraded resources. It is predicted that as aquaculture grows in the region, it will be difficult to meet the demand for low value/trash fish. There is a general concern that the rapid expansion of aquaculture may ultimately be constrained by the dependence on low value/trash fish and fish meal, popularly referred to as the "fish meal trap". The Asia-Pacific countries may need to increase imports of fish meal from the global market for the aquaculture industry, or replace these with other feed materials. There is a need to address the increasing demand for low value/trash fish by aquaculture by improving feeds for aquaculture through changing over from direct feeding to pellet feeding and reduction of fish meal content by substitution of suitable ingredients in pellets.

There is also increasing conflict between the use of low value/trash fish for feed and for human consumption. In some cases, such feeds are comprised of fish species traditionally used as cheap food for people and this allocation of fish resources to aquaculture may result in negative impacts of food security and livelihoods. It is the economics of the different uses of low value/trash fish in different localities that direct the fish one way or the other. There are also trade-offs between direct food benefit and the indirect employment and income generation opportunities afforded by feeding to aquaculture. It has been argued that it would be more efficient and ethical to divert more of the limited supply to human food, using value-added products. Proponents of this suggest that using low value/trash fish as food for domestic consumers is more appropriate than supplying fish meal plants for an export, income oriented aquaculture industry, producing highvalue commodities. On the other hand, food security can also be increased by improving the income generation abilities of poor people, and it can be argued that the large volume of people employed in both fishing and aquaculture has a beneficial effect. This raises some important questions regarding the social, economic and ecological costs and benefits of aquaculture, its sustainability and future trends.

The focus of this project is equally on the aquaculture of carnivorous fish and the management of lower value/trash fish. Investigations 4, 5, and 6 address the uses and bioecological characteristics of low value/trash fish. Investigations 1, 2, and 3 address alternative feeds for freshwater aquaculture and feed technology adoption.

The vision of this project is for sustainable freshwater aquaculture development in the Lower Mekong basin region of Cambodia and Vietnam, taking into consideration the balancing of social, economic and environmental/natural resource needs and implications. This vision takes into account that the main driver of this project is the continued expansion of aquaculture and its dependency on capture fisheries for low value/trash fish for feed. It also takes into account that: capture and culture fisheries continue to play an important role in the food security, poverty alleviation and economies of both countries; the strong interdependency between capture fisheries and aquaculture; management of these two sub-sectors cannot be carried out in isolation of each other; there is increasing intra-regional trade; and there is increasing competition and conflict between the use of low value/trash fish for feed and human consumption. This project will address this issue through six separate but complementary investigations on the management of low value/trash fish fisheries; development of alternative feeds and feeding strategies; outreach and feed technology adoption; market and trade development; and value-added product development.

To date, the project has made considerable progress in accomplishing the objectives set forth in the first phase. Developed weaning methods so that small, hatchery-reared snakehead can be quickly adapted to pelleted diets. Determined that Channa striata snakehead survive as well on pelleted diets in which up to 50% of the fish meal has been replaced by soybean meal as they do on pelleted diets made purely of fish meal. Development of best practice compared between traditional product and modern product of fermented fish product, then determine the issues related to low value fish processing practice and value added product development, market and trade to recommend policies and strategies to address the identified problems and issues in order to ensure high quality, safe and nutrition low value fish products for local and international trade, and to support value-added product development. Information was collected about issues on snakehead farming in the region. Market research has revealed a range of markets in the region for the processed products from low value fish.

The work undertaken through this activity will be sustained after the life of the project by the partners in Cambodia and Vietnam and through partnerships developed with other regional organizations such as the Network of Aquaculture Centers in Asia (NACA), the Southeast Asian Fisheries Development Center-Aquaculture (SEAFDEC-AQD), and the WorldFish Center. Additional funding to continue the work started through this project has been or will be secured through such sources as Australia Center for International Agricultural Research (ACIAR), International Development Research Center (IDRC), US Agency for International Development country missions, and funds from each country. Future activities associated with the project are the development of feed and feeding strategies for other fish species, further on-farm trials of feed formulations, policy and technology for trade and value-added product development for low value/trash fish, development of farm made feeds, improved management strategies for capture fisheries, and policy development for sustainable aquaculture and capture fisheries. The project has allowed strong partnerships to be developed between IFREDI and Cantho University researchers which are expected to continue in the future. The exchange of information and knowledge is ongoing and will continue.

PROJECT PERSONNEL

Can Tho University, Vietnam
Tran Thi Thanh **Hien**- HC Co-PI
Sinh **Le Xuan**- HC Investigator

IFReDI, Cambodia
Nam **So**- HC Lead PI
Navy **Hap**- HC Investigator
Sochivi **Kao**- HC Investigator
Somany **Prum**- HC Investigator

University of Connecticut-Avery Point
Robert S. **Pomeroy**- US Lead PI
Sylvain **De Guise**- US Investigator
Tessa **Getchis**- US Investigator

University of Rhode Island
David A. **Bengtson**- US Co-PI
Chong M. **Lee**- US Investigator

INVESTIGATION PROGRESS REPORTS

Printed as submitted by Robert Pomeroy, US Lead PI

09SFT01UC - Alternative feeds for freshwater aquaculture species in Vietnam.

The objective of the investigation is the development of cost-effective alternative feeds for carnivorous freshwater species to replace or reduce the dependence on low value/trash fish.

Activities Completed during this Period:

1. Reviewed related literatures**:** Review of all relevant literature regarding the situation of using feed for snakehead culture in the Lower Mekong Basin and snakehead requirements. The review was aimed to use the knowledge on existing aquaculture technology to transform into the printed media for dissemination to the project sites.
2. Orientation within team members**:** A team of 3 members has been established in CTU – Vietnam to internalize team members to make them aware of the project document and to understand the requirements needing to be accomplished by the members in the process of project implementation.
3. Consultation meeting between investigations**:** This investigation is implemented along with investigation 2 and 3 in both IFReDI and CTU. The consultation is made with different team members from two investigations in CTU (1 & 5) and with those in IFReDI (2 & 3) for synchronization of the preparation and implementation of related activities. The consultation is also to establish a link of each investigation in terms of its activities, planning, and implementation. The consultation was conducted to inform the team members of the rules, policies, and procedures of AquaFish.

Three experiments of the Investigation 1 have been finished. In addition, 7 students in CAF who were partially funded by this investigation were graduated and 10 are studying.. More than 50 farmers in Mekong Delta raised snakehead fish by formulated feed were suggestion.

09IND02UC - Sustainable snakehead aquaculture development in the Lower Mekong River Basin of Cambodia and Vietnam

January – March 2010

In Cambodia:

- Selected research assistants who will be responsible for snakehead domestication breeding and weaning snakehead with formulated diets at Freshwater Aquaculture Research and Development Center (FARDeC), and they will receive training on snakehead domestication breeding and weaning, and snakehead feed nutrition and formulation at CTU.
- Discussed with these research assistants to draft a plan for snakehead domestication breeding and weaning, with different kinds of diets (live feed, low value fish feed and formulated diets from different plant proteins.

- Set up a hatchery at FARDeC for domestication breeding of snakehead, including broodstock ponds, nursing/weaning ponds, and live feed production ponds/tanks.
- Consulted with provincial fisheries officers and fishers in Kampong Chhnang, Pursat and Battambang provinces to inform and make them understanding the objectives, expected outputs and activities of this investigation, and to buy good quality and adult/matured snakehead broodstock in order to develop snakehead broodstock at FARDeC.
- Consulted with CTU in Vietnam researchers to make them understanding objectives, expected outputs and main activities to be accomplished in Vietnam, and to arrange training and technology transfer from CTU to IFReDI and FARDeC researchers on snakehead
- Domestication breeding and weaning, and snakehead feed nutrition and formulated diets at CTU.

In Vietnam:

- Selected researcher assistants to work on the (1) training and technology transfer on snakehead domestication breeding and weaning,and snakehead feed nutriiton and formulation, (2) water quality, and (3) snakehead fish diseases.
- Prepared a plan for the above traning and technology transfer at CTU to transfer the above knowledge and technology from CTU to FARDeC and IFReDI.
- Conducted water samples for water quality analsysis (e.g. temperature, pH, DO, NH4 , NH3,
- NO2, NO3…) from three snakehead earthern ponds in each of the three provinces in the Mekong Delta: Can Tho, Dong Thap and An Giang provinces.
- Conducted fish disease surveys and collected samples for disease study (e.g. parasites, fungi and bacteria diseases) from three snakehead earthern ponds in each of the three provinces in the Mekong Delta: Can Tho, Dong Thap and An Giang provinces.

April - June 2010
In Cambodia (IFReDI)

- Developed a snakehead hatchery, including major facilities such as broodstock ponds, nursery ponds, breeding cement tanks, hatching tanks and moina production cement tanks at Freshwater Aquaculture Research and Development Center (FARDeC).
- 30 pairs (60 individuals) of mature broodstock of murrel snakehead (*Channa striata*) were collected and bought from Tonle Sap Lake and stocked in broodstock ponds at FARDeC for inducing spawning in July 2010.

In Vietnam (CTU)

- Organized an on-the-site training course on snakehead breeding and weaning, including hatchery set up, broodstock development, feed formulation, and feed strategies for FARDeC staff/Project assistants (14-26 June 2010).
- Water quality analysis: water quality parameters including temperature, pH, DO, NH4 , NH?3, NO2, and NO3 were sampled 5 times from each of 6 snakehead earthen ponds in Dong Thap (3 ponds) and An Giang (3 ponds) provinces. The sampling was conducted every month. Water quality analysis is on-going at CTU laboratory.
- Snakehead diseases study: Fish tissues were sampled from each of the six snakehead earthen ponds in Dong Thap and An Giang provinces for studying parasite, fungi, and bacterial diseases. The sampling was conducted every month. Laboratory analysis is on-going at CTU.

July - September 2010
In Cambodia (IFReDI)

- The CTU researchers Dr. Bui Minh Tam and Mr. Nguyen Hong Quyet Thang to visit FARDeC in Cambodia to assist FARDeC researchers in setting up snakehead hatchery and inducing snakehead spawning experiments.

- The CTU researchers Dr. Tran Thi Thanh Hien and Mr. Nguyen Hoang Duc Trung to visit FARDeC in Cambodia to assist FARDeC researchers to set up snakehead weaning facilities and equipment, and weaning experiments.
- The first domestication breeding of murrel snakehead *(Channa striata*) was conducted at Freshwater Aquaculture Research and Development Center
- The 3-day old fish larvae were fed with *Moina* for 5 days
- The 8-day old larvae were fed with *Moina* replaced 70% per day by freshwater small-sized fish for 3 days, and then 100% freshwater small-sized fish were fed until day 20th
- The 28-day fry were fed with freshwater small-sized fish replaced by 5%, 10%, 15%, 20%,…, 95% and 100% pellet feed (Protein 41%) each for 3 days.
- Larvae were stocked in 50-L tanks with stocking density of 5 fish/L. The fish were fed to satiation by hand twice daily. The remaining feed and faeces were siphoned out before feeding.
- Daily records were kept on mortality, food consumption and water quality, such as temperature, pH and dissolved oxygen. Larvae were weighed and measured at biweekly intervals.

In Vietnam (CTU)

- Water quality analysis: water quality parameters including temperature, pH, DO, NH4 , NH?3, NO2, and NO3 were sampled 5 times from each of 6 snakehead earthen ponds in Dong Thap (3 ponds) and An Giang (3 ponds) provinces. The sampling was conducted every month. Water quality analysis is on-going at CTU laboratory.
- Snakehead diseases study: Fish tissues were sampled from each of the six snakehead earthen ponds in Dong Thap and An Giang provinces for studying parasite, fungi, and bacterial diseases. The sampling was conducted every month. Laboratory analysis is on-going at CTU.

09TAP03UC - Development of alternatives to the use of freshwater low value fish for aquaculture in the Lower Mekong Basin of Cambodia and Vietnam: implications for livelihoods, production and market.

- Organized consultation meeting with district fisheries authority and commune council members on snakehead fish farmers selection criteria for experimental group.
- Selected 30 poor household snakehead fish farmers (12 females and 18 male) for experimental group for new feed technology adoption pilot.
- Coordinate with Investigation 1 to conducted training on “Home Made Feed” and “Formulated Feed” of new developed CRSP Feed Technology and “Record Keeping Method” for the 30 selected snakehead fish culture farmers in Lvea Em District, Kandal Province, Cambodia on June 27, 2010. Training materials translated into Khmer language for the trainees.
- All Trainees were given a notebook for record keeping of their fish culture data such as: pond size, number of fingerlings, date of stocking fingerling, fingerling size, price of fingerling, number of fish death after stock, method of feeding, type of feed, and amount of feed.
- To follow up the record with fish farmers, one staff was involved and one 3rd year fisheries student (bachelor) was engaged to carry out the research topic on “Effectiveness and Adoption level of CRSP Home Made Feed for Snakehead Fish in Cambodia.

09FSV01UC - Maximizing the utilization of low value or small-size fish for human consumption by improving food safety and value added product development (fermented fish paste) through the promotion of women's fish processing groups/associations in Cambodia.

- Review the result from the first phase complied with desktop survey to better understand of fermented fish paste best practice processing in Cambodia and fermented fish processing guideline from other countries (from 01-31/01/2010)
- ***Field Observation***, focus group discussion, and key informant interview and observation using some guide question to the processors to study the processing practices on the processing plant/chain and

areas of fermented fish paste product and to identify problems and issues related to food safety, processing, and value-added product development (from 01/02 to 30/04/2010).

- ***Organize the Women Fermented Fish Paste Group/Association*** (from 01/02 to 30/04/2010).
- ***Identified and analyzed the composition of nutrition fact, microbiological and chemical hazard of the products*** through getting simples from the women processor group and then send it to the accreditation laboratory to check and analysis it (from 01-31/05/2010).
- **Conduced *Consultation workshop/meetings with processors***, who are primarily women, on the best practice of fermented fish paste product quality and safety guideline, packaging, and labeling standard (from 01/06 to 30/09/2010).
- ***Revising and finalizing guideline, packaging and labeling standard*** of *prahoc* product (from 01/10/ 2010 to 30/02/2011).
  - Completed literature review
  - Conducted field observation and key informant interview
  - Selected and organized women fermented fish paste group in Siem Reap Province.
  - Conducted site visit monthly to see how is the process of the women group work in order to check of their product quality and safety through the primary testing of their product by sending the samples to both national and international laboratories to analyze the biological, chemical and physical on product for food quality and safety to human consumption before applying the guideline, packaging, and labeling standard for their product.
  - Produced the first draft of the fish paste product guideline and consult with the relevant stakeholders through the workshop on last 14 June 2010 in the Apsara Angkor Hotel in Siem Reap province.

Participant of the workshop are representative from the Central Fisheries Administration (all department and institution under), all 24 Provincial Fisheries Cantonment, processors, traders, consumers, local authority and representative from the ministry of Mine industry and Energy (MIME), Ministry of Commerce (MoC), Ministry of Public Health (MOH) and Ministry of Agriculture Forestry and Fisheries with all representative from all department under).

Objective of this workshop are 1) to consult with the relevant stakeholders on the Fish Paste Guideline in order to develop it as a formal one to improve quality, safety, and market of the product in Cambodia. 2). to identify the SWOT analysis in order to develop the strategic development plan for the women association.

- Revising and reviewing the guideline, packaging and labeling standard for fish paste product and processing through the recommendation of the participants from the national consultation workshop had been conducted last June in order to finalize by next year 2011.

09MER04UC - Value chain analysis of snakehead fish in the Lower Mekong Basin of Cambodia and Vietnam

The value chain analysis of snakehead fish in LMB consists of the follows:

- ***A function analysis:*** in this analysis the number, type and function of actors will be determined. The approach focuses questions on the inputs and outputs of production as well as the mechanisms by which value chain actors maintain control production. Focus not only those directly involved in the value chain, but also those within a broader network, providing economic, policy and social support to actors. The data is then presented in 'chain maps' illustrating the main export and domestic channels, proportional outputs and description of the key functions.
- ***A map of the material and financial flows from input suppliers to market:*** This approach calculates the main expenses and net profit margins of production for the actors and consolidated the expenses and margins from the rest of the chain. The analysis emphasizes the percentage value added to the fish at each transaction in the value chain, calculated as the selling price minuses buying price, not taking into account fixed or variable costs of each actor. For grow-out farmers,

total cost include the cost of buying fingerlings and the added costs involved in the growing cycle. All the costs and added value will be computed per kg of fresh fish equivalent.

- A set of recommendations to support development of a policy framework addressing aquaculture/capture fisheries interactions, the sustainable development of snakeheads in the lower Mekong basin, and human food security issues.

Conclusions

The data collection of the Investigation 1 was finished in September, and data analysis was completed in November while the country reports have been prepared in December. The final country reports and the final combined report of Investigation 1 are expected to be submitted in August 2011. A total of 4 master students and 06 bachelor students in CAF who were partially funded by this Investigation were graduated. 2 master students and 5 bachelor students will be funded for their theses in 2011. Two publications were released.

For continuing the 2nd phase of Investigation #1, the money should be transferred as soon as possible in association with the correction of contract in which the salaries of Dr Sinh was not included.

09MNE04UC - Developing Management Recommendations for Freshwater Small-Sized/Low Value Fish in the Lower Mekong Region of Cambodia and Vietnam

This investigation will start on 1 January 2011.

PRESENTATIONS & PUBLICATIONS

Table VI-8. Presentations

Title	Author(s)	Type	Event	Location
REPLACEMENT OF FISH MEAL BY SOYBEAN MEAL WITH ALPHA-GALACTOSIDASE IN DIETS FOR SNAKEHEAD Channa striata	Tran Thi Thanh Hien, Ly Vu Minh, Nguyen Hoang Duc Trung, Chong M. Lee, David A. Bengtson	Oral	Aquaculture 2010	San Diego, CA, USA
MARKET CHANNEL AND TRADE OF FISH PASTE FROM SMALL-SIZED FISH IN CAMBODIA	Nam So*, Sophea Un, Sy Vann Leng, Robert Pomeroy	Oral	World Aquaculture Society 2010	San Diego, CA, USA
SMALL-SIZED FISH PASTE PRODUCTION TECHNOLOGY IN CAMBODIA'S MEKONG RIVER BASIN	Nam So*, Chakriya Norng, Sy Vann Leng, Robert Pomeroy	Oral	World Aquaculture Society 2010	San Diego, CA, USA
ROLE OF FISHING ACTIVITIES TO THE HOUSEHOLDS IN FLOODED AREAS OF THE MEKONG DELTA	Huynh Van Hien, Le Xuan Sinh & Nguyen Duy Can	Oral	National Workshop of students and research in Aquaculture & Fisheries	Cantho University, Cantho City
ROLE OF FISHING ACTIVITIES TO THE HOUSEHOLDS IN FLOODED AREAS OF THE MEKONG DELTA	Huynh Van Hien	Oral	National workshop of Students & Research, 2010	Cantho City, Vietnam

Table VI-9. Publications

So, N (2009). Snakehead Aquaculture in the Mekong Delta, Vietnam. *Cambodia Fisheries Magazine: No.* 13.

Le Xuan Sinh & Do Minh Chung (2010). Current situation and challenges for snakehead farming

(Channa micropeltes AND *Channa striatus)* in the Mekong Delta. Journal of Agriculture & Rural Development (in Vietnamese, Accepted, May 2010).

So Nam (2009). Snakehead Aquaculture in the Mekong Delta, Vietnam. Brief Communication. Cambodia Fisheries Magazine No. 13. Fisheries Administration, Phnom Penh, Cambodia

Un Sophea, Pomeroy Robert, So Nam and Chhany Kongkea. Market Channel and Trade of Fermented Small-Sized Fish Paste in Cambodia. Accepted by International Society of Environmental and Rural Development (ISERD)

So Nam, Norng Chakriya, Leng Sy Vann & Pomeroy Robert. Small-Sized Fish Paste Production Technology In Cambodia's Mekong River Basin. Submitted.

Huynh Van Hien, Le Xuan Sinh & Nguyen Duy Can (2010). Role of fishing activities to the households in flooded areas of the Mekong Delta. Scientific magazine of Can Tho University, Special issues, June 2010 (in Vietnamese, published).

Tran Thi Be, Tran Thi Thanh Hien, 2010. Replacement of fish meal protein with soybean meal protein with or without phytase supplemetion in diets for snakehead (*Channa striata*). Scientific Journal of Can Tho University (published)

Tran Thi Thanh Hien, Le Quoc Toan, Tran Thi Be, Nguyen Hoang Duc Trung. 2010. Replacing fish meal by soybean meal in giant snakehead *(Channa micropeltes)* diets. Scientific Journal of Can Tho University (submitted, accepted)

Un S, Pomeroy R, So N & Chhay K (2010). Market Channel and Trade of Fermented Small-Sized Fish Paste in Cambodia. *IJERD – International Journal of Environmental and Rural Development 1–1:* 145-151

Le Xuan Sinh, 2010. Aquaculture Economics. Text book for undergraduate and master students in Aquaculture & Fisheries. Cantho University Publication.

LEAD US UNIVERSITY: UNIVERSITY OF HAWAI'I AT HILO

HUMAN HEALTH AND AQUACULTURE: HEALTH BENEFITS THROUGH IMPROVING AQUACULTURE SANITATION AND BEST MANAGEMENT PRACTICES

PROJECT SUMMARY

The project's research, training and outreach activities will add components of aquaculture research, development and training to existing integrated coastal zone management programs for three large estuarine complexes in Mexico and Nicaragua. Design of the research activities is based on extensive prior needs assessments, which include feasibility studies, management plans and previous research findings. The overall goal is to increase capacity to implement best management practices in aquaculture sanitation as a means to improve human health through disease prevention and product quality and safety. Improving food security through multiple strategies is also a theme for this work. These efforts aim to develop bivalve culture as a means of increasing utilization of indigenous species, which are low on the food chain, have low technology requirements and have high value. Bivalves also provide valuable ecological services and require improved management of their fisheries throughout Latin America and the Carribbean. For this continuation of current efforts, we have chosen to focus on continuing research to determine the effectiveness of a community-based co-management effort for the black cockle fishery in Nicaragua, which may serve as a model for the other troubled bivalve fisheries in Latin America. Additionally, efforts to develop native bivalve species for culture will continue through developing hatchery methods and continuing extension to oyster farming groups in two Mexican States. The members of these groups are largely women, or extended families. Additionally, we will continue work sponsored by the ACRSP and the USAID SUCCESS project to develop a native fish species ("chame", Dormitator latifrons) found throughout LAC that holds tremendous potential for aquaculture. Expected outcomes include: 1) information critical to decision-making and planning for coastal communities and economic development; 2) increased capacity for extension agents and researchers to work in bivalve culture, fisheries management and shellfish sanitation; 3) improved extension services benefiting coastal communities; 4) developing the basis for shellfish sanitation plans and classification of shellfish growing waters; 5) improved food quality and safety for shellfish and other aquaculture products; 6) improved prices and markets for products; and 7) reduction in the incidence of food-borne illnesses related to aquaculture. Issues of basic food security are also addressed through development of native species that are suited for aquaculture by poor, coastal residents.

Improving the health and well being of stakeholders is the fundamental justification for aquaculture development. Aquaculture can affect human health through a wide variety of direct and indirect causal pathways, including but not limited to: the relationship with environmental quality; use of natural resources (e.g. water, land, inputs); consumption of safe, high protein food products; increased household revenues to improve food security; and involvement of women, youth and marginalized groups.

The ways in which users and resources are affected by and affect aquaculture are complex, not completely understood, and are dynamic in nature. Workers in this area must constantly update their knowledge and understanding of the processes involved, new technology and the changing socioeconomic framework. CRSP stakeholder and expert panel meetings of the Africa, Asia and Latin America/Caribbean regions (2002) reveal two critical trends; 1) research and development of new aquaculture technology has been effective in laying the informational basis for development of

subsistence aquaculture; and 2) the ability of researchers and extension agents to transfer and implement the outcomes of research and development has not kept pace with the rate of technological innovation nor the rapidly changing socioeconomic milieu of most developing nations and their communities. It is not uncommon for technology transfer to lag technology development in any economic sector, but an opportunity exists to significantly strengthen the collective CRSP and associated stakeholders' ability for technology transfer in human health themes.

Similar issues affect the on-going, community-based coastal management efforts on the Pacific Coasts of Mexico and Nicaragua. There are three on-going coastal management initiatives in these countries that this work will support through carrying out specific recommendations in each area's management plan related to aquaculture, fisheries and development of alternative livelihoods. The coastal management initiatives that this work will support are located at: 1) Santa Maria Bay, Sinaloa, Mexico; 2) Boca de Camichin, Nayarit, Mexico; and 3) Aserradores Estuary, a part of the Estero Real Protected Area and RAMSAR site. This work is also linked to work conducted as part of the USAID SUCCESS program, EU fisheries management programs and other international initiatives.

We are using to use support from CRSP to build on current coastal and aquaculture management efforts to: 1) continue an emphasis on bivalve culture, sanitation and co-management as a means to diversify aquaculture and improve food security; 2) research aquaculture methods and fisheries dynamics for a new fish species with high potential; 3) provide extension support to communities to assure adoption of technologies and best management practices developed during Phase I of this project; and 4) improve access to key information for decision-making and planning through publications, outreach, extension and exchanges.

Two types of aquaculture have been selected for their potential to diversify aquaculture; those that have direct impact on food security and minimal impacts on the environment. Firstly, since becoming part of the CRSP network in 2003, efforts have focused on promoting culture of native species of bivalves as a sustainable form of aquaculture with low technology requirements and minimal environmental impacts. The health aspects of aquaculture and links with the environment have also been researched, particularly shellfish sanitation. To date, accomplishments in this area have included the classification of shellfish growing grounds, development of depuration and relaying methods, increased culture of the native oyster species and transfer of culture technologies. The current work will solidify accomplishments and continue to advance in certain key areas, including developing hatchery methods to assure the supply of larvae, now the major constraint to future progress by community groups culturing shellfish. Secondly, in the theme of developing native species which can substitute for introduced species and which offer potential to directly supply food for poor, rural people with minimal impacts, the CRSP and SUCCESS projects have been working to develop the chame fish (Dormitator latifrons), which is found along the entire Pacific Coast of the Americas, from California to northern Peru. The chame is euryhaline and omnivorous, and has the habit of ingesting detritus. This fish was once abundant in many areas and with the exception of certain indigenous groups, has been largely distained despite its high quality flesh. Trials in Ecuador under the SUCCESS program demonstrated that it could be successfully cultured using low protein locally sourced feeds and have rapid growth rates. Researchers in Mexico will undertake research to determine the nutritional requirements of fingerlings, methods to induce spawning and assess the population dynamics of the wild populations.

This work aims to further current efforts to develop indigenous species in Mexico and Central America focusing on bivalves such as clams, oysters and scallops as a low-impact alternative to shrimp aquaculture and to more directly benefit poor coastal communities. A thriving bivalve fishery and aquaculture industry in Mexico and Nicaragua that yields safe, high quality products will create jobs, improve food security and reduce the incidence of shellfish-borne illnesses. Development of the chame fish will add an easily-cultured native species to the array of possibilities for small scale fish culture along the Pacific

Coast of Latin America. Training and extension in general food safety and quality for all aquaculture products will build capacity among producers and vendors to reduce risks and improve the value of their products. Additionally, this work will contribute to improving national capacity in Mexico and Nicaragua by training professionals (including one graduate student) to increase their knowledge in these fields. Findings will be disseminated globally through peer-reviewed publications, accessible website material and presentations at international meetings.

SUCCESS is the global Sustainable Coastal Communities and Ecosystems program of EGAT/USAID, working since 2004 on site-specific (Nicaragua, Ecuador, East Africa) and global activities related to natural resources management and alternative livelihoods. The University of Hawaii Hilo and the University of Rhode Island were the lead partners. SUCCESS, along with CRSP, sponsored the initial work on bivalve sanitation and co-management, as well as the development of chame.

PROJECT PERSONNEL

CIAD, Mexico
Omar **Calvario Martinez**- HC Co-PI

CIDEA-UCA, Nicaragua
Carlos **Rivas Leclair**- HC Co-PI
Nelvia **Hernandez Del Socorro**- HC Investigator
Erik Jose **Sandoval Palacios**- HC Investigator
Juan Ramon **Bravo**- HC Investigator

Louisiana State University
John **Supan**- US Co-PI

Ohio State University
Konrad **Dabrowski**- US Co-PI

University of Hawaii at Hilo
Maria **Haws**- US Lead PI

Universidad Autonoma de Sinaloa-Culiacan, Mexico
Eladio **Gaxiola Camacho**- HC Lead PI
Lorena Irma **Camacho**- HC Investigator

Universidad Autonoma de Sinaloa-Mazatlan, Mexico
Guillermo **Rodriguez Dominguez**- HC Co-PI
Olga **Zamudio Armenta**- HC Investigator
Gustavo **Rodriguez Montes De Oca**- HC Investigator
Jose Cristobal **Roman Reyes**- HC Investigator

University of Alaska
Quentin **Fong**- US Collaborator

INVESTIGATION PROGRESS REPORTS

Printed as submitted by Maria Haws, US Lead PI

09IND01UH - Developing hatchery methods for the mangrove oyster, Crassostrea corteziensis for the Pacific Coast of Mexico

The native "Pleasure Oyster" *Crassostrea corteziensis*, is the preferred oyster species on the Pacific Coast of Mexico. For the last 30 years, it has been largely cultured in the State of Nayarit, with most production coming from the Boca de Camichin Estuary. Most of this seed is obtained through collection of wild spat. Although normally this is a preferred method, being less costly and easier than hatchery production, the need for a hatchery has become clear. Justification for a hatchery is the following: 1) storms and hurricanes often make spat collection impossible and affect farming; 2) the recent finding that Perkinsus marinus is present on the Pacific Coast has led authorities to prohibit movement of adult oysters and spat which prevents increasing the geographic range in which C. corteziensis could be culture; and 3) there is a need for more research and development for this species, which requires a reliable source of larvae and spat, thus necessitating a hatchery. The other oyster species cultured along the Pacific Coast of Mexico is the Pacific Oyster (C. gigas) which is cultured in the States of Sinaloa and Sonora, as well as on the Baja Peninsula. The CRSP work aims to promote culture of the native species and to reduce

reliability on foreign seed sources. Much of the C. gigas seed used for Mexican farms comes from U.S. companies based in the Northwest, which are suffering from drastic declines in production as a result of ocean acidification.

The CRSP work entails establishing a small research and training hatchery at the Marine Science Center (FACIMAR), located in Mazatlan, Sinaloa. The lead researcher on this project is Olga Zamudio Armenta, a specialist in bivalves and algae culture. Drs. Maria Haws (UHH) and John Supan (LSU) traveled to Mazatlan in January 2010 to assist with biosassys, hatchery design and set-up. They were accompanied by Roberto Quintana (UHH Hatchery Manager) and David Nisbet (Owner and Operator of Goosepoint Oyster, Inc). The latter assisted with the design aspects. The team also visited Bahia Santa Maria and Altata in Sinaloa to work with producer groups on grow-out details which influence hatcher and nursery operations. The team also provided training to the UAS personnel in spawning methods and microalgae production.

After the initial version, Olga Zamudio continued to set-up the hatchery and began to train CRSP students and personnel. Hatchery, nursery and microalgae laboratory set-up work continued. Work experimenting with maturation of broodstock also continued. Some delays in this work were encountered as new administrators at FACIMAR delayed signing of the new MOU, which delayed transfer of funds. UAS continued working on this investigation as much as possible given the delays in funding. The MOU has now been signed so that transfer of funds can move forward.

09IND03UH - Stock assessment of "Chame" Dormitator latifrons in Nayarit and South of Sinaloa México

This work has been delayed due to the delays in signing the MOU between UHH and UAS. Funds could not be transferred due to this delay. The MOU has now been signed and funds will be transferred. Meanwhile, HC Co-PI Guillermo Rodriguez has completed planning for this work and will begin executing it as soon as funds have been transferred. The CRSP students for this work have also been selected.

09IND04UH - Induced spawning and larval rearing of the "chame" Dormitator latifrons in laboratory conditions

Objective 1: Induced spawning and spermiation using synthetic analogues of luteinizing hormone releasing hormone (LHRHa)

A total of 29 spawns were achieved using several delivery techniques for synthetic analogs of the hormone LHRHa. A preliminary trial with 9 females, 3 per treatment (mean weight 146g) treated with either Desgly10-Ala6 LHRHa injected at 20 µg/kg as priming dosage and 40 µg/kg as resolving dose, 2 injections of Ovaprim® at 0.5 ml/kg or a single implant of 75 µg (Ovaplant®), showed a 100% success as oocyte final maturation and releasing agents within 72 hours after treatments in the Ovaprim® and Ovaplant® treated females.

Thereafter a second experiment was conducted with 12 females divided into the following groups: control group (0.5 ml/kg 0.9% saline solution), Desgly10-Ala6 LHRHa injected at 40 µg/kg as priming dosage and 80 µg/kg as resolving dose, 2 injections of Ovaprim® at 0.5 ml/kg or a single implant 75 µg (Ovaplant®), using 1 year captive and newly collected females in all groups showed a 100% success ratio within 24 hours for the ovaplant group and 100% spawning ratio for the LHRHa and Ovaprim groups within 48-72 hours. Only one natural spawn was observed for all females either within the experiment and for all collected fish. Obtained spawns allowed determining oocyte size as 300 µm and a relative fecundity of 80,000 to 100,000 cells per gram. Apparently, only partial spawns were recorded for all 29 spawns within both trials, as well as other females induced with Ovaplant® for further larvae production. With regards to males, all LHRHa delivery treatments were effective to induce spermiation in volumes from 0.5 to 10 ml per male (Desgly10-Ala6 LHRHa injected at 40 µg/kg, Ovaprim® at 0.5 ml/kg or a

single implant 75 µg (Ovaplant®); however several males released sperm naturally up to 1 ml throughout the reproductive season. Obtained data indicates that sperm activation time is close to 4 minutes, and overall concentration is within the range of 1 to 2X109 cells per milliliter. No spermatocrit values were recorded as chame sperm viscosity probed to high in undiluted sperm.

Objective 2. Effect of water salinity on fertilization, egg incubation and hatching success.
As optimal salinity values, both for fertilization and egg incubation, our results indicate that there is no sperm activation above 5‰ of salinity; similar data were recorded for optimal incubation salinity as no hatching was observed above the same salinity value. Therefore all fertilization and incubation trials were conducted in 1 µm filtered, UV sterilized fresh water. Extensive data has been recorded on incubation time at 26-28°C as14 hours, hatching size of larvae (1-1.2 mm), time for yolk absorption (26-32 hours post fertilization hpf) and eye and mouth appearance time (30-40 hpf).

Objective 3: Effect of water salinity, food type and availability on larval survival and growth after yolk sack absorption.
Several feeding trial have been conducted. First experiment consisted of several types of dry food along with a mixture of 50-80,000 cell/ml of *Chlorella* and *Scenedesmus* as freshwater phytoplankton and 50µm filtrated water (5-10 ml/day) from a rotifers *Brachionus rotundiformis* rearing tank; such feeds were as follows: micropowder *Spirulina* <20 µm (Mackay Marine®), algamac 3000, brewer´s yeast, microparticulate MPz < 70µm (Mackay Marine®) and Epicin G2 (probiotic) as bacterial and biofilm promoter with four replicates per dietary treatment and a larval density of 0.5 larvae per ml. Larvae from this experiment survived for 6 days post fertilization, with 100% mortality afterwards.
A second trial was conducted, using a combination of two of the above mentioned feeds, all including mixture of 50-80,000 cell/ml of *Chlorella* and *Scenedesmus* as freshwater phytoplankton, 50µm filtrated water (5-10 ml/day) from a rotifers *Brachionus rotundiformis* rearing tank and 5 mg/l twice a day of Epicin G2 (probiotic) as bacterial and biofilm promoter as base diet and etiher a mixture of Algamac 3000 (1 mg/l) plus brewer´s yeast (3 mg/l), Algamac 3000 (1 mg/l) plus micropowder *Spirulina* <20 µm (Mackay Marine®) (3 mg/l) or brewer´s yeast (3 mg/l) plus micropowder *Spirulina* <20 µm (Mackay Marine®) (3 mg/l) with four replicates per feeding treatment at a larval density of 0.25 larvae per ml. Similar results were observed in terms of 0% survival at 120 hours after yolk sack absorption. For this experiment, several larvae (n=10-15) per experimental unit were collected and processed for gut content with a solution of 1% potassium hydroxide, finding no evidence of food intake and/or intestinal content within two hours after first feeding of the day 96 hours after yolk sack absorption.

A third and fourth trials were conducted in rearing tanks with a promoted biofloc and biofilm using shade cloth strips as substrate; tanks were maturated for a 8d period tank with continuous adding of a mixture of 50-80,000 cell/ml of *Chlorella* and *Scenedesmus* as freshwater phytoplankton and Epicin G2 plus honey as carbon source to promote bacterial growth and biofilm. In both trials the presence of at least two large sized protozoans (still under taxonomical identification) terminated all larvae within 48 hours after tank was stocked with aprox. 5000 larvae in four 45 L tanks (rearing density 0.1 larvae/ml).

At this moment a fifth and sixth feeding experiments are underway, using a mixture of 50-80,000 cell/ml of *Chlorella* and *Scenedesmus* as freshwater phytoplankton and Epicin G2 (5 mg/l) twice a day, experiment #5 includes different volumes of 35 µm filtrated Green-water originated in 250 L tanks tilapia (*Oreochromis* sp), as well as etiher a mixture of Algamac 3000 (1 mg/l) plus brewer´s yeast (3 mg/l), Algamac 3000 (1 mg/l) plus micropowder *Spirulina* <20 µm (Mackay Marine®) (3 mg/l) or brewer´s yeast (3 mg/l) plus micropowder *Spirulina* <20 µm (Mackay Marine®) (3 mg/l) with four replicates per feeding treatment at a larval density of 0.25 larvae per ml. Experiment #6 includes a gradual increase of water salinity 2.5 ‰ per day, increasing rearing salinity one replicate per feeding treatment at the time using the same feeding treatments described above, with the only exception that all replicates are

inoculated equal amounts of 35 µm filtrated Green-water, having as pending results, checking for larval survival at 120 h after yolk sack absorption, gut content and sizing.

09HHI01UH - Co-management and bivalve sanitation for black cockles (Anadara spp.) in Nicaragua
A synthesis report on the cockle co-management and bivalve sanitation work from March 2006-March 2010 was completed in Spanish. This report was submitted to government agencies and partners. The Ministry of the Environment is reviewing the report as part of their efforts to determine whether the use of community-based no-take zones can be adopted as a legal alternative to the current closed season, which is largely ineffective. Meanwhile, maintenance was conducted for the cockle no-take zones (i.e. the areas had their boundary markers replaced). CIDEA/UCA personnel continued outreach to the community to foster continued compliance with the no-take areas. Overall this effort is going well with continued strong support from the community. Cockle populations will be sampled in the upcoming quarter.

CIDEA/UCA personnel also met several times with the Aserradores community members to make progress on cockle sanitation and to structure the adminstrative committee for the Depuration Center. Although community members continue to use the open water area for depuration, CIDEA/UCA has additional funding from the EU to install a solar electric depuration plant for the community. This is viewed as a model for other areas of Nicaragua and MExico where remote communities cannot use relay and depuration methods since water areas close enough to monitor are too contaminated and where lack of electrical power makes standard depuration plants impossible. This work, if successful, may help the situation at Boca de Camichin, Mexico, where open water depuration was shown not to be feasible in the previous CRSP work.

CIDEA/UCA personnel are also working on replicating the successful no-take cockle zones in other communities. An agreement was recently signed with the Foundation of Friends of Rio San Juan (FUNDAR) in southern Nicaragua) to replicate the no-take zones. Work will proceed with FUNDAR, the Autonomous University of Leon, LIDER Foundation, the Ministry of the Environment, Ministry of Forestry, the Mesoamerican Biological Network and Conservation Chapter of Nicaragua to organize an event called, "Forum for the defense of mangrove ecosystems, guaranteeing the biodiversity and food security of the ancient cockle collecting communities". This event is intended as a planning workshop to develop joint strategies to protect biodiversity and offer alternative livelihoods. This event is scheduled for Oct. 21 and 28, 2010.

Training was also conducted:

1) workshop for Aserradores cockle collectors, "Requirements for food safety and quality". March 19, 2010.
2) workshop for Aserradores cockle collectors, "Requirements for commercialization and export". March 27, 2010.

Visits were also made to sixteen communities where cockle collection is a major livelihood to document the socioeconomic condition of these communities and to conduct outreach on the use of no-take zones for cockle fisheries management.

09HHI02UH - Capacity building in aquaculture, fisheries management and coastal management for coastal women. Workshop: Opportunities for Coastal Women in Fisheries, Aquaculture and Coastal Management
Planning for this activity is underway. The workshops are expected to be held in May and June 2010.

PRESENTATIONS & PUBLICATIONS

Table VI-10. Presentations

Title	Author(s)	Type	Event	Location
CONCENTRATION OF ORGANIC MATERIAL IN OYSTER (Crassostrea corteziensis) GROWING WATERS AT BOCA DE CAMICHIN, NAYARIT, MEXICO	Haws, M.C., G. Rodríguez-Domínguez, O. Calvario Martinez, L.E. Corona Osuna and E. Gaxiola-Camacho	Oral	World Aquaculture Society Meetings	San Diego, CA
DEVELOPMENT OF THE PACIFIC FAT SLEEPER Dormitator latifrons FOR DIVERSIFICATION OF AQUACULTURE IN LATIN AMERICA	Gustavo A. Rodriguez M. de O., Maria C. Haws, Guillermo Rodriguez D., Eladio Gaxiola C., Alejandra Medina J., Rafael Elao, Guerdy Guevara, Francisca Cotera	Oral	World Aquaculture Society Meetings	San Diego, CA

Table VI-11. Publications

Haws, M.C., B. Crawford, S.C. Ellis, N. Jiddawi, A. Mmochi, E. Gaxiola-Camacho, G. Rodriguez-Dominguez, G. Rodriguez, J. Francis, C. Rivas-LeClair, A. Saborio-Coze, N. Hernandez, E. Sandoval, K. Dabrowski, M.C. Portella and M. Jaroszewska. 2010. Aquaculture research and development as an entry-point and contributor to natural resources and coastal management. Coastal Management Journal. (submitted)

Crawford, B.C., M.D. Herrera, N. Hernandez, C. Rivas-LeClair, N. Jiddawi, M. Semba, M.C. Haws. 2010. Small Scale Fisheries Management: Lessons from Cockle Harvesters in Nicaragua and Tanzania. Coastal Zone Management Journal. 38:3, 195-215.

LEAD US UNIVERSITY: UNIVERSITY OF MICHIGAN

IMPROVING SUSTAINABILITY AND REDUCING ENVIRONMENTAL IMPACTS OF AQUACULTURE SYSTEMS IN CHINA, AND SOUTH AND SOUTHEAST ASIA

PROJECT SUMMARY

This project contains a collaboratively defined series of studies with host country counterparts in China, Nepal, Thailand, Bangladesh, and Vietnam. The experiments listed were defined largely by the host country scientists, in consultation with their university and government colleagues in each country. The priority of each experiment or study is exemplified by the fact that of all possible studies to be done, each investigator believed this was the most important one, currently.

Investigation #1 (09BMA03UM) is the next step of our continuing work in Nepal. We have done experiments testing various species combinations in polyculture, and this experiment adds tilapia and sahar, a highly valued local fish, to the mix. It intends to use sahar as a biological control to limit natural reproduction of tilapia, producing a cash crop of its own as well as allowing for tilapia culture without extensive hatchery systems to produce sex-reversed fish.

Investigation #2 (09BMA04UM) tries to use recirculating technology from indoor shrimp systems to improve water quality and reduce the effects of effluents and solid waste from outdoor pond systems on the local environment. Shrimp culture is very important to China for internal food uses as well as export. However, water quality is equally important, given the difficult state of many natural waters there. This system, if successful, should create a cost effective way for small scale farmers to adopt recirculating technology without a large investment in water treatment systems. It is also related to Investigation #5 (09BMA05UM).

Investigation #3 (09QSD03UM) returns the AFCRSP to Bangladesh with work on prawn culture in Bangladesh, this time using polyculture of prawns with mola, an important indigenous fish. Prawns are quite valuable and can produce high economic value, but most farmers rely on their ponds for household consumption as well. Adding mola to prawn ponds should provide a food resource for the household along with a cash crop, and allow small scale farmers to benefit nutritionally as well as economically. This study is also related to Investigation #7 (09BMA06UM).

Investigation #4 (09MNE01UM) continues our work on invasive species, this time looking at the invasion dynamics of red swamp crayfish in China. This species has caused problems in many areas, because it is often introduced by aquaculture systems but escapes and becomes a damaging invasive species. This study will apply genetic techniques, along with population dynamic studies, to evaluate the extent, sources, and routes of invasion of the crayfish in China. This study relates to Investigation #8 (09MNE05UM) as well.

Investigation #5 (09BMA05UM) is another study on improving shrimp aquaculture systems, this time using indoor recirculating technology in China. The study will conduct experiments in a commercial indoor recirculating system, and look at various water treatment options as well as existing technology to determine their effects on water quality and shrimp production. In addition, this study will continue our work on microcystins in pond aquaculture by evaluating a number of natural shrimp ponds and other

systems for the existence of microcystins in algae blooms, and the limnological characteristics associated with these blooms. It is similar in nature to Investigation #3 (09QSD03UM).

Investigation #6 (09MNE03UM) continues the work from the last work plan on life cycle assessment of shrimp production in China. This study applies other techniques, including mass balance models, economic analyses, and best management practices to evaluate the environmental effects of various culture options, and in doing this to assess the likely outcome of some practices from an ecological, social, and economic perspective. It has some related elements to Investigations #3 and #5.

Investigation #7 (09BMA06UM) continues work from our earlier surveys in Thailand, Bangladesh, and Vietnam on prawn culture systems. This study is a workshop to inform practitioners in Thailand on various management practices used in the country, the economic analyses of their success, and other aspects of aquaculture practice for prawns. It will also encourage exchange of information from participants, especially farmers, in an attempt to better educate each other on sustainability of prawn culture.

Investigation #8 (09MNE05UM) will refocus our work on biodiversity in reservoirs and the effects of introduced species on native fauna. Our studies to date have been on larger reservoirs with numerous introductions and large fisheries. While these systems are interesting, they are very difficult to evaluate quantitatively. This study will use surveys of a number of small irrigation reservoirs, as well as local studies on several of these reservoirs, in an effort to better define the effects of introduced fishes on the native fauna.

Finally, investigation #9 (09MNE06UM) will convene a symposium to review the interactions between semi-intensive aquaculture and biodiversity. Participants will include CRSP scientists as well as other recognized experts in this field. The effects of aquaculture on biodiversity is controversial, and needs better resolution and broader analysis in order to gain a better perspective on what aquaculture should do to minimize these deleterious effects. This symposium will focus on semi-intensive aquaculture to deal more effectively with the CRSP mission as well as utilize our experiences in research, and also to help understand the factors involved in small-scale fish farming.

Overall, these nine investigations span a wide variety of university participants, countries, subjects, and methodologies. This breadth is very important to the aquaculture community as well as to the vitality of our research group. We believe that these studies will help provide further information to fine tune aquaculture systems throughout the world, and will result in considerable improvement in aquaculture practice as well as published literature to expand the impact beyond the boundaries of this region.

Photo in Vietnam courtesy of Jim Diana

PROJECT PERSONNEL

Bangladesh Agricultural University
Mohammed Abdul **Wahab**- HC Co-PI

Hainan University, China
Qiuming **Lai**- HC Co-PI

Huazhong Agricultural University, China
Weimin **Wang**- HC Co-PI
Zexia **Gao**- HC Investigator

Institute of Agriculture & Animal Science, Nepal
Madhav K. **Shrestha**- HC Co-PI

Network of Aquaculture Centres in Asia-Pacific
Yuan **Derun**- HC Co-PI

Shanghai Ocean University, China
Liping **Liu**- HC Lead PI
Min **Jiang**- HC Investigator
Dai **Xilin**- HC Investigator

University of Michigan
James S. **Diana**- US Lead PI

World Wildlife Fund in Asia
Flavio **Corsin**- US Collaborator

Wuhan University, China
Biyu **Song**- HC Co-PI

Nong Lam University, Vietnam
Hung **Le Thanh**- HC Co-PI
Hoa **Nguyen Phu**- HC Investigator
Luong **Vu Cam**- HC Investigator

INVESTIGATION PROGRESS REPORTS

Printed as submitted by James Diana, US Lead PI

09BMA03UM - Incorporation of tilapia (*Oreochromis niloticus*) and Sahar (*Tor putitora*) into the existing carp polyculture system for household nutrition and local sales in Nepal

Two experiments were proposed for this study. The first was on station at Institute of Agriculture and Animal Science (IAAS), Rampur, and the second on farm experiment at farmers' ponds. The first experiment is ongoing at IAAS Aquaculture farm. Twelve earthen ponds averaging 130 m^2 size (115-152 m^2) are being used for this experiment. The experiment includes four treatments with three replications: carp polyculture (7000 fish/ha) (Treatment-1, control); carps (7000 fish/ha) tilapia (3000 fish/ha) (Treatment-2); carps (7000 fish/ha) tilapia (3000 fish/ha) Sahar (500 fish/ha) (Treatment-3); carps (7000 fish/ha) tilapia (3000 fish/ha) Sahar (1000 fish/ha) (Treatment-4). Species combinations for carp polyculture is 30% silver carp, 20% bighead carp, 25% common carp, and 5% grass carp, whereas rohu and naini were 10% each. The fingerlings were stocked in ponds on 17 July 2010. Ponds are fertilized weekly. Locally made pellet feed of about 20% CP is prepared from rice bran, maize flour, mustard oilcake, and soybean oilcake at 2:2:1:1 and is offered on alternate days at the rate of 2% total fish body weight between 9-10 am. About 10-20 % of the fish were sampled on 16 August for growth sampling. Feed requirement for the second month was calculated on the basis of average weight calculated during growth check. This experiment continues as planned.

09BMA04UM - Study on the effectiveness of a pond-based recirculating system for shrimp culture

From March 2010 to present, two 0.3-ha earthen ponds have been selected as treatments for pond-based recirculating systems of shrimp culture in the Haoshideng shrimp farm. Two separate ponds with the same size of 0.3 ha have been used as controls. Water is not recirculated in the control ponds, but exchanged at a fixed rate throughout the culture period. Stocking density in each pond is 1,000,000 PL/ha. For comparison of water quality and production performance in recirculating and closed, non-recirculating shrimp culture ponds, water quality in each pond has been recorded biweekly. Water quality analyses include total suspended solids, total ammonia nitrogen, total nitrogen (TN), total phosphorus (TP), COD, nitrite, active phosphorus, total bacteria density, and Vibrio density, following standard

methods. Dissolved oxygen, pH, temperature, and salinity have also been measured. The number and weight of seeds, feed, and the amount of water exchange have also been recorded.

The shrimp were harvested in July 2010 and the experimental data is currently being analyzed. By comparing the shrimp growth rate in treatment ponds and control ponds, we found that shrimp grow slower in the treatment ponds, mainly due to poor water quality. Without water exchange, treatment ponds have higher particle organic matter and COD values, but lower pH value and dissolved oxygen concentration, which may negatively affect the appetite of shrimp and jeopardize shrimp growth. A possible explanation is that the stocking density of shrimp in the treatment ponds is too high. Based on this experiment, we plan to repeat the experiment at reduced stocking densities next year.

09QSD03UM - Development of polyculture technology for giant freshwater prawns (*Macrobrachium rosenbergii*) and mola (*Amblypharyngodon mola*)

An experiment has been carried out since July 2010 to identify the effects of the addition of mola at different densities to giant freshwater prawn production and to compare the growth and production performance between all male and female giant freshwater prawn culture. There are five treatments (numbered sequentially): all male prawn 1mola/m2, all male prawn 1.5 mola/m2, all male prawn 2 mola/m2, all male prawn alone, and all female. Prawn stocking densities were 3 juveniles m-2 in all treatments. Major water quality parameters are being measured fortnightly, and fish are weighed monthly. The water quality parameters were within the suitable range for prawn and mola culture during 60 days of observation. All male freshwater prawn showed better weight gain (7.69g) than all female prawn (3.73g) and all male prawn with 1.5/m2 mola (T2) demonstrated better growth than prawn with 1 and 2 mola/m2. The research is in progress.

09MNE01UM - Invasion of the red swamp crayfish (*Procambarus clarkii*) in China: genetic analysis of the invasion and the impacts evaluation

Two experiments comprise this study. The first involved collections of samples of red swamp crayfish. Collections in 38 sampling sites from Chongqing, Anhui, Hubei, Hunan, Jiangsu, Jiangxi, Shanghai, and Zhejiang provinces have been completed. In order to better evaluate and understand the sources, extent, and routes of this crayfish in China, collections are also being done in the natural range for this species, including Louisiana, Texas, Florida, California, Kentucky, Pennsylvania, as well as in Saitamaken, Japan, which will serve as an outgroup for the genetic analysis.

The second experiment is an evaluation of genetic structures of different red swamp crayfish populations. DNA extractions have been conducted. Microsatellites and *Cyt b* are being used as markers. A total of 34 microsatellite primers have been synthesized. Results of polymorphism analysis of these microsatellites have shown that 21 microsatellites are polymorphic. Continued experimentation will focus on obtaining genotypes and Cyt b sequences and performing software analysis to evaluate the sources, extent, and routes of red swamp crayfish in China.

09BMA05UM - Development of indoor recirculating culture systems for intensive shrimp production in China

Litopenaeus vannamei culture in the Shanghai area started more than 20 days later than previous years because of bad weather and low temperature. A lab was established in an experimental farm so researchers could track the aquaculture process more precisely. Indoor experiments have been delayed because construction of the greenhouses is still in progress, so outdoor ponds with four different water management systems have been investigated first.

Ponds with the size of 50m (L) ×11m (W) ×1.5m (H) were used for the experiments. Water quality was analyzed biweekly. Different water quality conditions were observed in ponds with different treatment models. Water quality in model 1 ponds was the worst with the lowest DO, variable pH, and the highest

COD, nitrite and ammonia values. An algae bloom occurred in one model 1 pond. Models 2, 3, and 4 were much better with lower concentrations of COD, NO2-N, and NH3-N, higher and stable DO, and stable pH which provided an appropriate environment for shrimp. The water quality analysis will continue until harvest season, and then food quality, including flavor of shrimp, will be monitored for each different model.

Microcystis aeruginosa is found world-wide in fresh, brackish and marine water environments and its blooms occur especially in eutrophic freshwater bodies. Its metabolites, namely microcystins, are the most common and dangerous group of cyanotoxins and have been proven to cause damage to aquatic animals. In our research, larvae of crayfish Procambarus clarkii were exposed to different concentration of Microcystis aeruginosa (1.0×106 cells/ml, 5.0×106 cells/ml, 1.0×107 cells/ml, and 2.0×107 cells/ml) to investigate the algae's impact on survival and hepatopancreas ultrastructure of the crayfish. At the same time, adult crayfish were exposed to different concentrations of Microcystis aeruginosa(1.0×106 cells/ml?5.0×106 cells/ml and 1.0×107 cells/ml) and total hemocyte counts density (THCs), content of hemocyanin in the serum, superoxide dismutase (SOD), peroxidase (POD), phenol oxidase (PO) and Na /K -ATPase in the gill filaments were determined. The results showed that: (1) Microcystis aeruginosa can significantly reduce the survival rate of crayfish larvae. When algae cells reached 5.0×106 cells/ml, the survival rate was only 68.33%, which was significantly lower than the control group($p<0.05$. Additionally, the 1.0×107 cells/ml group had significantly lower survival (61.67%) than the control group after 19 days ($p<0.05$). (2) The hepatopancreas of larval crayfish became darkened and hepatopancreas cells were observed to be damaged under transmission electron microscopy. (3) THCs of the adult crayfish increased significantly and stayed at high levels after being exposed for one day. The content of hemocyanin was not significantly affected at the beginning but decreased after 5d($p<0.05$). The activity of T-SOD in serum was inhibited after one day, and was activated to a high level on the fifth day. The activity of POD and PO showed fluctuation trends. The activity of Na /K -ATP in gills dropped significantly after one day($p<0.01$), then increased and stayed at a high level. The results indicated that Microcystis aeruginosa had a negative impact on the survival of juvenile crayfish and affected immunity of adult crayfish, which may cause poor grow-out of crayfish in culture systems.

09MNE03UM - Integrating environmental impacts, productivity, and profitability of shrimp aquaculture at the farm-scale as means to support good aquaculture practices and eco-certification

The case study was conducted in Hainan Island, China to optimize shrimp aquaculture systems in terms of environmental sustainability, economic viability, and social acceptability. There were three components in this study, including mass balance modeling, economic analysis, and social analysis. Data were collected at shrimp farms on Hainan Island during the summer and early fall of 2010 and analysis is ongoing.

For mass balance modeling, one intensive shrimp farm with 6 ponds (about 0.33ha/pond) and one semi-intensive shrimp farm with 6 ponds (1 ha/pond) were selected. Water quality, shrimp growth, and farm management of each farm were monitored biweekly throughout the entire culture cycle (about 90 days), from early April to July. Shrimp post-larvae (PL) were stocked at the density of 150 PL/m2 in intensive ponds and 30 PL/m2 in semi-intensive ponds. Commercial feed was applied as the main source of nutrients for each farm. Average FCR was 1.6 in intensive ponds and 0.95 in semi-intensive ponds. Three models of N, P, and C will be developed to evaluate nutrient dynamic changes in the ponds over time. Differential equations for N, P, and C dynamics will be formulated based on mass balance and nutrient sources, and sinks. The models will be used to evaluate the impact of variation in water exchange rate (0-100%) and stocking density (0-200 m-2) on water quality by predicting the concentrations of N, P, and C metabolites, and phytoplankton in the water column. This analysis is expected to be completed by winter 2011.

For economic analysis, two sets of questionnaires regarding cost, benefit, and disease risk were developed for shrimp monoculture and polyculture. There were mainly three types of shrimp farming in Hainan Island, including intensive, semi-intensive, and polyculture. To better understand the differences of each type, they were further divided into the groups Intensive Commercial, Intensive Family, Semi-intensive Family, and Polyculture of Shrimp and Grouper. Ten farms of each type at different scales were selected and interviewed in late August 2010. This economic analysis will assess production costs and system profitability under different management strategies to determine how stocking density, farm size, and disease may affect profitability. This analysis is expected to be finished by winter 2011.

For social analysis, another two sets of questionnaires regarding farmers' quality of life and the potentials of treating farm effluents were developed for shrimp farmers and other villagers around shrimp farms. Fifty shrimp farmers and 50 other villagers were randomly selected and interviewed in August 2010. This sub-study will examine if quality of life of farmers is improved by shrimp aquaculture, and probe farmers' attitudes on effluent treatment. This analysis is expected to be finished by winter 2011.

09BMA06UM - Identifying best practices to improve the giant river prawn industry in Thailand
This workshop is planned for the summer of 2011, so no substantial progress has been made to date. Preparation for the workshop is under way, including gathering background papers, identifying participants, and finalizing schedule.

09MNE05UM - The impact of fish stocking on wild fish populations, fish production and the ecosystem of irrigation reservoirs in South Vietnam
We have selected eight irrigation reservoirs in two provinces for survey and data collection. Also, three master's students have been selected to carry out their theses in the project.

Southeast Vietnam is characterized by uphill geography. To support agriculture in this area, more than 50 small reservoirs (from 10 to 50 ha) and about 10 medium reservoirs (200-400 ha) were built for irrigation. We will estimate the degree and extent of damages on fisheries and biodiversity of indigenous fish species due to the introduction of cultured fish species in 8 small reservoirs. These reservoirs include 3 without stocked fish (Bau Um, Suoi Lai, and Hung Phu Revervoirs in Binh Phuoc Province) and 5 with aquaculture practices (Dong Xoai, Sa Cat Reservoirs in Binh Phuoc Province, and Cau Moi, Da Ton and Gia Ui Reservoirs in Dong Nai Province). The reservoirs' areas of Bau Um, Suoi Lai, Hung Phu, Dong Xoai, Sa Cat, Cau Moi, Da Ton, and Gia Ui are 60, 30, 18, 450, 45, 320, 350, and 320 ha, respectively. Bimonthly surveys were carried out in Dong Nai Province since July 2010 and Binh Phuoc Province since August 2010 to estimate the total catch and fish species composition at studied reservoirs. In addition, bi-monthly field sampling was also carried out at Cau Moi Reservoir since July 2010 and Bau Um Reservoir since August 2010 to measuring water quality and to estimate the biomass (in dry weight) of natural food chains including phytoplankton, zooplankton, benthos, detritus, terrestrial plants, and main fish species groups. At the end of the sampling year in August 2011, Ecopath 5.0 models will be constructed to evaluate the stocking rate and fisheries carrying capacity for each reservoir. Since the studied reservoirs vary in characteristics such as area, fish species composition, fish stocking, hydrology, morphology, physico-chemical conditions, and management regimes, we will have to adapt the field sampling and surveys at each reservoir to take these differences into account.

09MNE06UM - Evaluating the relationship between semi-intensive aquaculture and natural biodiversity
The effects of aquaculture on biodiversity have been the subject of much recent debate, but most of this debate focuses on two particular aquaculture systems: shrimp and salmon. However, these are not among the most common species grown in aquaculture, nor the most common systems used. Many aquaculture systems use semi-intensive culture to produce fish at a lower level of intensity and using more natural systems, often in ponds or other containers. Semi-intensive aquaculture has a very different potential impact

than intensive aquaculture, and the specific impact in this area has not been well defined. The role of intensification in aquaculture and agriculture is the subject of much debate today, so this is a good time to consider the relationships between lower intensity aquaculture and biodiversity as a part of that debate. This symposium is proposed to provide evaluation of the main impacts of semi-intensive aquaculture on biodiversity, and to seek means of reducing these impacts of aquaculture expansion on natural communities. Planned speakers include: Jim Diana – Overview, Director, Michigan Sea Grant, Professor, School of Natural Resources and Environment, University of Michigan. Gabrielle Canonico Hyde – Effects of Invasive Species, Regional Coordinator, NOAA's Integrated Ocean Observing System (IOOS) Program. Mark Peterson – Effects of Invasive Species, Professor, Dept. of Coastal Sciences, Fisheries Ecology, University of Southern Mississippi. Todd Slack – Effects of Invasive Species, Curator, Mississippi Museum of Natural Science. Claude Boyd – Effluents and Eutrophication, Professor, Auburn University. Melba Bondad-*Reantaso – Diseases and Parasite, Fisheries Department, FAO.* Felipe C. Cabello – Effects of antibiotics, Professor, New York Medical College. Ling Cao – Environmental Performance, Ph.D. student, School of Natural Resources and Environment, University of Michigan. Marc Verdegem – Environmental Performance, Senior Lecturer and Study coordinator, Animal Sciences, Aquaculture and Fisheries, WU. Albert Tacon – Use of Feeds, Technical Director, Aquatic Farms Ltd. Konrad Dabrowski – Use of Feeds, Professor, School of Environment and Natural Resources, The Ohio State University. Robert Pomeroy – Social and Economic, Impacts, Professor, Connecticut Sea Grant Extension. Richard Pollnac – Social and economic impacts (not confirmed yet), Professor Emeritus, University of Rhode Island.

09WIZ03UM - Improved cages for fish culture commercialization in deep water lakes

Eutrophication and concomitant algal blooms are a frequent occurrence in China. Nutrients released from aquaculture operations are a contributing factor to eutrophication in freshwaters. This study assessed the impacts of improved commercial freshwater aquaculture cages designed to reduce nutrient waste inputs into the water column. The study took place on Longtan Reservoir in southern Guizhou Province, China. These experimental cages feature a sediment collector under the cages, which allows for the removal of feces and waste feed from the water column. The new cages were stocked with catfish (*Ictalarus punctatus*) and also feature an outer cage stocked with bighead carp (*Hypophthalmichthys nobilis),* common carp (*Cyprinus carpio*), and tilapia (*Oreochromis niloticus*) that feed off plankton in the water column and improve water quality around the cages. A phosphorus mass balance model was created to quantify the nutrient releases from aquaculture cages. The experiment began in June 2010 and data collection will continue until October 2010. Fish weight and length were measured once a month to establish growth rates. Fish carcasses, feces, and fish feed were analyzed to determine the percent phosphorus of these components for the model. The sedimentation rates were also measured by sampling the sediment from the sediment collector. Water chemistry data was also collected: NO_3, NO_2, TN, TP, TSS, pH, Chl-a, NH_4, temperature, and Secchi depth. Samples were collected inside each cage, and 1 m outside the cages at depths of 0.5, 5, and 15 m. Additional samples were collected 1 km upstream and downstream of the cages, as well as in the bay where the cages are located. These samples were used to determine the background levels of phosphorus in the reservoir, independent of the experimental cages. An additional digestibility experiment will be conducted at the University of Michigan in fall 2010. Using fish feed from China, the fraction of digestible phosphorus will be determined for the feed and used in the mass balance model. The fish will be harvested in October 2010 and data will be input into the model and final results created in winter 2011.

PRESENTATIONS & PUBLICATIONS

Table VI-12. Presentations

Title	Author(s)	Type	Event	Location
ADVANCES IN OPTIMIZING POND CULTURE SYSTEMS	James S. Diana, Yang Yi	Oral	WAS 2010	San Diego, CA, USA
DR. YANG YI: A MEMORIAL	James S. Diana, C. Kwei Lin	Oral	WAS 2010	San Diego, CA, USA
LESSONS FROM ASIA FOR RICE-FISH CULTURE IN MALI IN WEST AFRICA	Liping Liu, Derun Yuan, James H. Bowman, Yang Yi, Héry Coulibaly, Hillary Egna	Oral	WAS 2010	San Diego, CA, USA
EFFECT OF THE Microcystis aeruginosa ON THE WATER FLEA Daphnia magna AND THE RED SWAMP CRAYFISH Procambarus clarkia	Liping Liu, Kang Li, Taoying Chen, Yang Yi, James S. Diana	Oral	WAS 2010	San Diego, CA, USA
Nitrogen and phosphorus budget in intensive pond culture of Litopenaeus vannamei in Hainan, China	Lai Qiuming	Oral	WAS 2010	San Diego, CA. USA
LIFE CYCLE ASSESSMENT OF SHRIMP FARMING IN CHINA TO SUPPORT MORE ENVIRONMENTALLY SUSTAINABLE AQUACULTURE	Ling Cao, James S. Diana	Oral	WAS 2010	San Diego, CA, USA
ELIMINATING MICROCYSTINS-PRODUCING ALGA Microsystis aeruginosa BY USING CHITOSAN AND PAC MODIFIED CLAYS	Biyu Song, Yang Yi, James S. Diana	Oral	WAS 2010	San Diego, CA, USA
PREY FORAGING HABITS OF MARBLE GOBY (Oxyeleotris marmoratus) FINGERLINGS TO DIFFERENT PREY TYPES	Nguyen Phu Hoa, Yang Yi	Oral	WAS 2010	San Diego, CA, USA
INVESTIGATING ECOSYSTEM-LEVEL IMPACTS OF SHRIMP FARM EUTROPHICATION IN THAILAND THROUGH STABLE ISOTOPE RATIO ANALYSIS, AND AN EVALUATION OF ECO-CERTIFICATION'S POTENTIAL TO SUPPORT RELATED BEST MANAGEMENT PRACTICES	Sarah Kempke, James Diana, Dhirendra Prasad Thakur	Poster	WAS 2010	San Diego, CA, USA
POLYCULTURE OF SAHAR Tor putitora WITH MIXED-SEX NILE TILAPA Oreochromis niloticus	Madhav Shrestha, Ravi Sharma, Kamala Gharti, Yang Yi, James Diana	Oral	WAS 2010	San Diego, CA, USA
GENETIC DIVERSITY, POPULATION STRUCTURE, AND PHYLOGENETICS OF YELLOWCHEEK CARP Elopichthys bambusa AS REVEALED BY MICROSATELLITES MARKERS AND CYTOCHROME B SEQUENCES	Zexia Gao, Khalid Abbas, Weimin Wang	Oral	WAS 2010	San Diego, CA, USA
EFFECTS OF DIFFERENT FEEDING METHODS ON PERFORMANCES OF INTENSIVE POLYCULTURE OF WHITE SHRIMP Litopenaeus vannamei AND RED TILAPIA Oreochromis spp.	Derun Yuan, Amararatne Yakupitiyage, Yang Yi, James S. Diana	Oral	WAS 2010	San Diego, CA, USA

Table VI-13. Publications

Cao X., and Wang, W. 2010. Anatomical and histological characteristics of the intestine in the topmouth culter (*Culter alburnus*). Anatomia, Histologia, Embryologia. AHE-06-09-OA-094.R2.

Cao, X., and Wang, W. 2010. Haematological and biochemical characteristics of two aquacultured carnivorous cyprinids, topmouth culter (*Culter alburnus*) and yellowcheek carp (*Elopichthys bambusa*). Aquaculture Research. 10.1111/j.1365-109.2009.02421.x.

Ling, Z. Jinliang, L., and Qiuming, L. 2010. Studies on embryonic development, morphological development and feed changeover of *Epinephelus lanceolatus* larva. Chinese agricultural science bulletin, Vol.26 No.1(Serial No.199).

Yu Gending, Jiang min, Xing bin, Dai Xilin, Gu Deping, Hu Weiguo. 2010. Relevance analysis of organic pollutants parameters in pinds of Litopenaeus vannamei culturing. Freshwater Fisheries, 2010, 40(2): 67-69. (In Chinese)

Liping Liu, Taoying Chen, Kang Li, Xilin Dai,Yi Yang, James S. Diana. 2010. Effects of *Microcystis aeruginosa* on the life history of water flea *Daphnia magna*. submitted to Toxicon.

LIU Liping, LI Kang, YUE Yaling, YAN Jun, YANG Yi, James S. Diana. 2010. The Dangers of Microcystins in Aquatic Systems, and Progress of Research into their Detection and Elimination. submitted to World Aquaculture.

Xiaoyun Zhou, Khalid Abbas, Mingyun Li, Libao Fang, Su Li, Weimin Wang. 2010. Comparative studies on survival and growth performance among diploid, triploid and tetraploid dojo loach *Misgurnus anguillicaudatus*. Aquaculture International 18:349–359

LEAD US UNIVERSITY: OREGON STATE UNIVERSITY

ASSESSING THE IMPACTS OF CRSP RESEARCH: HUMAN CAPITAL, RESEARCH DISCOVERY, AND TECHNOLOGY ADOPTION

PROJECT SUMMARY

This project characterizes and assesses AquaFish CRSP's Phase II (2009 - 2011) investigations. The assessments will include the investigations' Phase I (2007 - 2009) histories to the degree that work from Phase I is being materially carried forward into Phase II. The present proposal is to be distinguished from the AquaFish CRSP Synthesis Project presently underway (Evaluating AquaFish Accomplishments in a Systems Framework), in which preliminary assessments of the CRSP's 38 Phase I (2007 - 2009) investigations are being conducted by topic category: Integrated Production Systems; Human Health, Food Safety, and Value-Added; Technology and Policy Adoption; Marketing, Trade, and Risk Assessment; and Watershed, Coastal Management, and Environmental Impact Mitigation.

The Synthesis Project focuses, like the present project, on a central problem encountered when assessing CRSP and many other agricultural research projects: the wide variety of - and complex systems relationships among - CRSP investigations and consequent problems in characterizing and assessing the investigations as a whole. Investigation heterogeneity in the AquaFish CRSP is manifold. It includes the variety of investigation goals (human capital formation, research, outreach), the variety of outcomes (aquaculture profitability, human health, ecosystem quality), and the variety of their technological and cultural settings. Such variety complicates issues already present in CRSP program assessment, in particular the ever-present data and conceptual difficulties in distinguishing CRSP program influences from other factors affecting a fish farm setting.

AquaFish CRSP assessment faces the additional challenge that the structure for collecting project-specific assessment data, and resources to support such collection, have not been built into the CRSP investigation workplans and must be added after the investigations have been partially completed. Opportunities for collecting some relevant baseline (pre-project) data thus are lost, and resources for gathering other data are unavailable. Because situations of this nature are often unavoidable, an effective assessment plan must take into account the data that will feasibly be available. See, for example, the recent review of assessment methods at CGIAR centers (CGIAR Science Council 2009), and CGIAR current impact assessments of scientific and policy-oriented research (CGIAR Science Council 2008). The current synthesis project has succeeded in: (a) conducting a detailed examination of AquaFish CRSP project- and investigation-level settings, objectives, and goals; (b) provided assistance with DTAP terminology definitions; (c) assembling a list of the quantifiable study inputs and outputs of each AquaFish CRSP project and investigation; and (d) conducting a review of the literature on probability elicitation and Bayes probability updating, useful for developing the methods we will use to elicit investigations' probabilistic output information; (e) opening communication with the AquaFish PIs in order to assemble investigations' input data.

Besides deepening our analysis of AquaFish CRSP's inputs and outputs (Investigation # 1, 09BMA07OR), we will assess the economic, environmental, and gender impacts of those study outputs (Investigation #2, 09TAP05OR). The Tradeoff Analysis and Minimum-Data methodologies already have been developed as part of the Soil Management CRSP that ended in 2007. They have been widely applied

and disseminated. Further details are available at www.tradeoffs.montana.edu. We also plan (Investigation #3) to hold a planning meeting in which HC participators will discuss data and methods of evaluating research productivity and project impact assessment.

Besides introducing the work described under Investigations #2 (09TAP05OR) and #3 (09TAP06OR), Investigation #1 (09BMA07OR) will add to current synthesis project in two ways: (a) it will allow attention to the CRSP's 2009 - 2011 activities, while the synthesis project can address its 2007 - 2009 activities; (b) this project includes development of seven investigation case studies, one for each of the AquaFish projects.

This project is part of the investigators' career interest in science and technology assessment, project impact, and economic development. We plan to conduct follow-up research on project input-output relationships and impact evaluation in developing countries, possibly with support from the Bill and Melinda Gates Foundation. Our focus will be on constructing assessment methods that are economically rigorous but capable of implementation in low-data and heterogeneous settings.

PROJECT PERSONNEL

Oregon State University
Steve **Buccola**- US Lead PI

Montana State University
John **Antle**- US Co-PI
Roberto **Valdivia**- US Investigator

INVESTIGATION PROGRESS REPORTS

Printed as submitted by Steve Buccola, US Lead PI

09BMA07OR - Assessment of AquaFish CRSP Discoveries

FY 2010 accomplishments were:

1. Our one-day First Annual Project Meeting for host-country investigators was held in conjunction with the 2010 AquaFish Annual Meeting in San Diego on 1 March 2010. Thirty-one AquaFish host country investigators and 12 non-host-country (US PIs, AquaFish and USAID staff, and visitors) individuals attended. The meeting focused on methods of research discovery and impact assessment. Discovery methods included procedures for measuring research accomplishment, expressed in terms of the difference between the study's prior expectations and subsequent findings. Although the example problems were drawn from the 2007 - 2009 investigations -- which are specific to our Synthesis project -- they were helpful for sharpening understanding for the present project as well, which covers only the 2009 - 2011 investigations.

2. A four-page questionnaire allowing specification of each research investigation's inputs and study conditions was drawn up and circulated among AquaFish investigators for comment. The questionnaire has now been distributed among host country investigators and the filling-out process begun.

3. Similarly, a Bayesian-based questionnaire was formulated to enumerate each investigation's treatments, settings, and information outputs. It was sent to US and HC investigators for comment, revised several times, and is now final form. It was slated for further testing at our October 4 - 7, 2010 Project Meeting (see Investigation #3 report). We have decided not to employ scoring rules in prior-probability elicitation.

4. Once the relevant host country investigator(s) have completed the input and output questionnaire for each research-type 2009 - 2011 AquaFish investigation, we will pool the input and output data

to estimate a quantitative model of the factors affecting research success. [The Synthesis Project will cover the 2007 – 2009 investigations, employing the same model.] Development of the structure of that model, and identification of the types and sources of data in the output and input questionnaires necessary to estimate it, occupied a substantial portion of our FY 2010 effort. Those questions are now solved and we are ready for estimation once the data are assembled.

5. The wide variety of AquaFish research investigations makes it difficult to pool their output and input data into a single quantitative framework. We demonstrated our questionnaires' flexibilities in accommodating that inter-investigation variety by testing them with host-country investigators in all seven AquaFish projects. The tests included both controlled-experiment and statistical-survey studies.

6. A similar difficulty arises in determining how to assemble the data itself. AquaFish projects are conducted in 14 countries and differ in research variety and geographic complexity. A significant part of our work this year was to develop an administrative structure for data collection that accommodates those varied circumstances. That structure is now in place. A contact individual in each of the seven projects, responsible for delivering the completed input and output questionnaire data, has been tentatively identified. We are ready to contract with these individuals to deliver the data by March 1, 2010.

7. Focus on the above issues has left inadequate time to meet the case-study deadlines stated in our proposal. Most of the work toward assembling a case study for each AquaFish project is therefore being postponed to the latter half of FY 2011.

8. Work toward these goals was facilitated by Steve Buccola's visit to project sites in China, Vietnam, and Philippines from August 23 through September 15, 2010. The project site visits were especially helpful in gathering background information for the case studies planned under this project.

09TAP05OR-Assessment of AquaFish CRSP Technology Adoption and Impact

All items in the FY 2010 work plan were accomplished as planned.

1. A one-day First Annual Project Meeting for host-country investigators was held in conjunction with the 2010 AquaFish Annual Meeting in San Diego on 1 March 2010. Thirty-one AquaFish host country investigators and twelve non-host-country (US PIs, AquaFish and USAID staff, and visitors) individuals attended. The meeting focused on methods of research discovery and impact assessment (IA). A PowerPoint presentation on IA was made, and was also made available on the Tradeoff Project web site (www.tradeoffs.oregonstate.edu). Meetings were held with investigators from each project to discuss potential IA activities for their projects.

2. The TOA-MD software was adapted for use with agriculture-aquaculture systems. Documentation was updated. An application to an aquaculture system in Malawi was developed and used to test the software.

3. AquaFish projects were reviewed in preparation for the project meeting held October 4-7 in Seattle. At this project meeting, participating investigators were provided further details on data needed for IA, the TOA-MD software and documentation, and a working example of IA analysis. Plans were made for investigator collaborations to implement the IA.

4. A paper on the IA methodology was prepared and submitted to the American Journal of Agricultural Economics for publication. It was in revision for publication as of October 2010.

09TAP06OR- Project Planning Meeting on AquaFish Technology Discovery and Impact Assessment
Preparations were made for the October 4 – 7, 2010, "Assessing the Impacts of CRSP Research" Project Meeting in Seattle, WA. Preparations included:

1. In conjunction with the US and HC PIs in each project, identifying which host-country researchers would attend the Meeting.

2. Identifying a Meeting site in Seattle, and working with the hotel staff to provide meeting arrangements and accommodations.

3. Assisting prospective attendees with travel and visa arrangements.

4. Developing (or in certain cases adapting) research procedures and materials for host-country attendees to use during the Meeting.

5. Formulating a four-day agenda providing for break-out as well as plenary sessions.

VII. MALI ASSOCIATE AWARD PROJECT

Aquatic Resource Use and Conservation for Sustainable Freshwater Aquaculture and Fisheries in Mali

Mali Project Third Annual Report

October 1, 2009 – September 30, 2010
Cooperative Agreement # 688-A-00-07-00044-00
Leader with Associates Award EPP-A-00-06-00012-00

INTRODUCTION

The *Mali Project*, "Aquatic Resource Use and Conservation for Sustainable Freshwater Aquaculture and Fisheries in Mali," operates through an award received from USAID/Mali under the "Leader with Associates" (LWA) award that established the AquaFish CRSP in 2006. The project had a planned span of three years (1 October 2007 through 30 September 2010), but was approved for a 3-month no-cost extension (NCE) at the end of the fourth quarter (on September 15, 2010). The NCE will allow the project to complete a final training and a final report.

The overall goal of the project is improving the productivity and income of producers in targeted areas of Mali through facilitation of access to technologies and building the capacity of stakeholders involved in freshwater fish farming and capture fisheries management. It is working in three thematic areas to:

- Facilitate access and adoption of improved aquaculture production technologies in targeted areas to increase and diversify the incomes of farmers,
- Build the capacity of the Government of Mali to develop and disseminate relevant technologies,
- Identify appropriate strategies for the implementation of integrated rice and fish farming in target areas,
- Help develop an appropriate fisheries management plan to ensure long-term viability and sustainability of capture fisheries in the target area, and
- Help establish linkages useful for further development of aquaculture and fisheries in Mali.

The Mali Project's Three Thematic Areas: The Project's three-pronged approach towards facilitating the development of sustainable aquaculture and good fisheries management in Mali is being applied through work in these thematic areas:

- *Pond Culture—Advancing Sustainable Freshwater Aquaculture Practices and Technologies* (Theme Leaders Charles Ngugi, Héry Coulibaly, and Mr. Boureima Traoré)
- *Rice-Fish—Promoting Sustainable Rice-Fish Aquaculture in Irrigated Systems* (Theme Leaders Liu Liping, Héry Coulibaly, and Mr. Alassane dit Sandy Touré)
- *Fisheries Planning—Building Community and Consensus towards a Fisheries Management Plan* (Theme Leaders Mrs. Nancy Gitonga, Héry Coulibaly, and Mr. Soumaila Diarra)

Theme I is working to identify, develop, and promote appropriate pond culture systems for implementation in Mali. Theme II is working to introduce appropriate adaptations of proven rice-fish systems, based on experience in China, into irrigated systems of the Niger River delta in Mali, and Theme III is seeking to involve local stakeholders in the process of developing sound fisheries management plans (co-management), working initially at Lake Sélingué.

South-South Approach: The *Mali Project* takes a South-South approach to development, by bringing the scientific expertise and practical experience of CRSP partners from host countries with more fully developed aquaculture industries to bear on the three primary theme areas of the project.

PRIMARY COLLABORATING INSTITUTIONS AND PERSONNEL:

AquaFish CRSP, Oregon State University, Corvallis, Oregon, USA
(Lead US Institution)
Hillary Egna, Principal Investigator
James Bowman, Project Coordinator
Dwight Brimley, Business Manager

Direction Nationale de la Pêche, Ministère de l'Élevage et de la Pêche, Bamako, Mali
(Lead Mali Institution)
Héry Coulibaly, Principal Investigator and Theme Leader for Themes I, II, & III (Pond Culture, Rice-Fish, & Fisheries Management), Direction Nationale de la Pêche
Boureima Traore, Collaborator, Theme I
Madi M. Keita, Collaborator for Theme II
Alassane dit Sandy Touré, Collaborator for Theme II
Soumaila Diarra, Collaborator for Theme III

Ministère de l'Élevage et de la Pêche, Bamako, Mali
Mme Diallo Madeleine BA, Minister

Kenyatta University, Kenya (Theme I Lead Institution)
Charles Ngugi, Theme Leader, Theme I

Shanghai Ocean University, Shanghai, China (Theme II Lead Institution)
Liping Liu, Theme Leader, Theme II

FishAfrica, Nairobi, Kenya (Theme III Lead Institution)
Nancy Gitonga, Theme Leader, Theme III

OTHER COLLABORATORS

Network of Aquaculture Centres in Asia-Pacific (NACA)
Derun Yuan, Assistant Theme Leader, Theme II

Fisheries Department, Government of Kenya, Nairobi, Kenya
Peter Nzungi, Frame Survey collaborator, Theme III

Mwea Aquafish Farm, Kenya
Charles Ngugi, Theme Leader, Theme I
James Mugo, Assistant Trainer, Theme I

PROGRESS MADE AND RESULTS ACHIEVED

Pond Culture

Workshops

Charles Ngugi travelled to Bamako on 10 January 2010, to lead two workshops supporting On-Farm Trials conducted under the Pond Culture theme. The first was a one-day workshop held to evaluate the success of technologies and practices adopted by farmers in the first set of On-Farm Trials, which had been run from July 2009 to January 2010, and the second was another one-day workshop to set up the second set of On-Farm Trials, which ran from January to June, 2010).

Farmer's registration and training for the On-Farm Trials Evaluation Workshop took place on Monday 11 January 2010. Farmers selected for participation in the evaluation workshop included those that were involved in the first On-Farm Trials plus an additional three farmers. During the evaluation, it was noted that stocking of the ponds, which had been scheduled for 15 July through 31 July 2009, had been delayed because the irrigation canal whose water the farmers depend on for filling their ponds was under repair. However, DNP staff reported that 6 farmers were able to successfully stock their ponds in time and harvesting began in early January 2010. All farmers who were in the first On-Farm Trials had harvested their fish by February 2010.

Charles again traveled to Bamako on 9 May 2010, to conduct two more workshops. The first was a one-day workshop on 10 May for DNP technical staff to train them on how to conduct a third set of on-farm trials. The second was the postponed workshop on record keeping, business plan development, and marketing of farmed fish, using models developed under AquaFish programs in Kenya and Ghana but modified and translated for the Mali project. A wrap-up meeting was held at the end of the workshop on Friday 14 May to talk about the third set of on-farm trials and future projections of Theme 1.

On-Farm Trials

Two sets of *On-Farm Trials* were planned as part of the project's *Pond Culture* theme during the course of the project. The first set of trials was begun in mid-July 2009, and ran until mid-January 2010. Ponds involved in the trials were monitored and sampled monthly by DNP personnel and our student participant Ahmadou Nouh Sow, from the Institut Polytechnique Rural de Formation et de Recherche Appliquée (IPR/IFRA) (Rural Polytechnic Institute for Training & Applied research), Katibougou. Sampling for growth was done periodically through the trial period and harvesting took place in January and February. Sample and harvest data were summarized for the evaluation carried out at the Bamako workshop in January. Presentation of the harvest data was done by Boureima Traore, with other technical staff also providing input on data that they had presented to the DNP. Production from these trials ranged from 1,352 kg to 9,090 kg for one crop that took 6 months which translates into 2,704 to 18,180 kg/ha/yr. Records presented during this workshop were from six farmers who were among the 15 farmers initially selected for the trials. The results show that for these 6 farmers there has been a tremendous increase in production per unit area, moving up from the 1,500 kg/ha/yr estimated at the beginning of this project to a high of 9,090 kg/ha/6 months recorded during the trials (extrapolated this would be just over 18,000 kg/ha/yr).

During the first set of on-farm trials, Mamadou Kane, a dedicated DNP extension officer who had been trained in Kenya last year, died and so his farmers experienced a setback in their trials.

The second set of *On-Farm Trials* was initiated in January 2010, with stocking of the ponds occurring in February. Sampling for fish growth was scheduled for approximately one-month intervals in March, April, May, and June. Following the May workshops in Bamako, Charles Ngugi, Boureima Traore, and other DNP staff visited two of the participating sites—the Jigiya Association ponds in Kayo-Somono and Mofa Fofana's farm near Baguineda—to assess fish stocking and growth. It was observed that the pond

sizes in this set of on-farm trials ranged from 49.50 m^2 to 6,300 m^2. At Kayo, where fish were stocked on February 24th, sampling revealed average lengths of 15 to 16 cm and weights of over 80 g. At Mofa Fofana's farm the fish had been stocked in January, including 5000 catfish in a 320 m^2 pond and about 5 MT of fish in a tilapia pond. Catfish sampled ranged from 28 to 33 cm, tilapia ranged from 15 to 23 cm. In June a fourth sampling of the ponds in this set of trials was carried out and all ponds were harvested. Evaluation of the results of this second set of trials and preparations for a third set were ongoing as of the end of this reporting period.

This pond near Bamako was selected for the second set of *On-Farm Trials* and stocked with African catfish (*Clarias gariepinus*).

One of the larger fish sampled from Mafa Fofana's rearing tanks near Baguineda.

Spin-off Activities

Since his training under this project, both in Mali and in Kenya, Mr. Seydou Toé was not only instrumental in the construction of the hatchery at the Sotuba training center, but has also constructed a small hatchery facility at his own farm in Banco and begun producing catfish fingerlings for sale. To date he has sold all the fingerlings he has produced. Mr. Toe has also conducted a number of other trainings around the country, starting with the training of 10 young people in Bougouni (approximately 160 km south of Bamako) in the techniques of pond construction and management in early November. Other trainings he has done include the following:

- Training of 40 producers in pond construction in Ségou in January 2010
- Training of 35 producers in pond management in Sanankoroba in February 2010_
- Training of 5 leading producers in pond construction in Gao in May of 2010.

Additional information about Mr. Toe is provided under "SUCCESS STORIES" later in this report.

Pond construction in Bougouni (Seydou Toé).

Pond construction in Gao (Seydou Toé).

Following the wrap-up of the first set of *On-Farm Trials* in January, the Malian and Kenyan theme leaders decided to set up and run a third set of trials. These trials were started near the end of the planned project period (August/September 2010), but will be monitored and evaluated beyond the project period by DNP staff. Ponds for those trials were selected in June.

The DNP reported that two new Koulikoro farmers took up fish farming during the fourth quarter of the year.

A new fish pond in Koulikoro (Tandiacoro).

Tilapia raised at the Tandiacoro farm.

African catfish raised at the Tandiacoro farm.

Rice-Fish Culture

Workshops

Three rice-fish related workshops were held during this reporting year. Two of these were held in November and the third in January. Theme leader Liping Liu, along with Yuan Derun and Sun Tao, visited Mali in November to conduct two workshops as well as to harvest the four Baguineda area Rice-Fish Demonstration plots that were set up in July 2009.

The first workshop, "Workshop on Appropriate Aquaculture Post-harvest Technologies," was held in Baguineda on 13-14 November. There were 24 participants in this workshop, including fishers, fish farmers, fish traders/marketers, processors, government officers responsible for aquatic food quality and safety, and researchers. The objectives of the workshop were to examine the current status of post-harvest processing practices, review the technologies available, identify constraints and problems in post-harvest processing, and recommend appropriate technologies for small post-harvest businesses. Yuan Derun reviewed aquaculture post-harvest technology and its roles in aquaculture development, poverty alleviation, food security, safety and aquaculture trade, and this was followed by Sun Tao's presentation covering the details of post-harvest technologies, including cooling, drying and salting, and smoking fish. Alassane Touré reviewed current practices of aquaculture post-harvest processing in Mali. After that, Liu Liping introduced live fish and fish larvae transportation techniques. All the participants then discussed issues and constraints of rice-fish culture in Mali. The experts gave useful technical solutions to the workshop attendees.

The second workshop, "Workshop on Training and Extension Capacity for Rice-Fish Culture," followed immediately after the first on 16-20 November. There were 27 participants in this workshop (including 7 government officials), which aimed to build training and extension capacity for government extension officers, university teachers, and others working to develop rice-fish culture techniques. The topics covered history, relevance, status, and development trends of rice-fish culture, and rice-fish culture systems (including physical structure and construction, fish component, species choices, seed production, grow-out in rice fields, and feeds and feeding). Training and extension methods were also presented to help build training and extension capacity.

The third short-course was a four-day stakeholder workshop on "Best Aquaculture Practices (BMPs) and Aquaculture Policy in Mali," organized by the DNP for approximately 20 participants, including fishers, fish farmers, middlemen, fish traders, government officers responsible for aquatic food quality and safety, and researchers from 31 January to 3 February 2010. The objective of the workshop was to generate recommendations regarding development and implementation of BMPs for Mali aquaculture through careful review of the current status of aquaculture practices and policies in Mali, critical examination of the existing guidelines and standards, and consultation with multiple stakeholders and experts. The workshop was led by Theme leaders Liping Liu (Shanghai Ocean University) and Alassane Touré (Direction Nationale de la Pêche), with assistance from Tang Jianye (SOU). The workshop covered international principles for responsible aquaculture practice, aquaculture status, practice and future development trends in Mali, current policy and regulations on aquaculture in Mali, code of quality and safety management for aquaculture in China, guidelines for drug use in aquaculture, tolerance for residue of drugs in seafood, integrated pest management, and tilapia culture and practices. It was followed by group discussion and brainstorming on aquaculture in Mali. Jeff Dorsey, who works in the Niono area and had contacted us during the previous quarter, attended the workshop and talked about rice-fish culture in Mali. Finally, a French translation of a document on fisheries standards in use in China, *Le standard industriel de la poissonnerie dans la République populaire de Chine*, was discussed and recommended for submission to the DNP as a reference for work in Mali. That document was included in our report for the 2nd quarter.

Rice-Fish Demonstrations

As reported earlier, four *Rice-Fish Demonstrations* had been started during the previous reporting year during the month of July. On 19 November 2009, the fish were harvested from the first rice field, that of Mamadou Samake. Mr. Samake's harvest was observed by the participants of the Theme II training workshop and Mrs. Diallo Madeleine BA, Minister of the Ministère de l'Élevage et de la Pêche. More than 106 kg of fish were harvested from a field of approximately 840 m^2 (0.176 ha) in area. The harvest of 106 kg extrapolates to just over 1260 kg per hectare. This result was very appealing to Mr. Samake because of the additional income he was able to receive by selling the fish. His results have also generated a great deal of interest among other rice producers in the Baguineda area, a large number of whom began to make plans for going into rice-fish culture after the water supply was restored. All four demonstration sites were harvested between November 19th and 22nd. Students Fadima Keita and Bocary Diarra continued to assist with the rice-fish demonstrations right through the harvests.

Spin-Off Activities

After seeing rice farmer Mamadou Samake's success in last year's *Rice-Fish Demonstrations*, at least 21 new Baguineda-area rice farmers chose to adapt their rice fields for fish production during this year's rice production season. This is a 5X increase over the four farmers who volunteered to participate in our first set of rice-fish demonstrations. Several new designs for the layout of fish sump and access channels in the fields are being tried, and DNP technical officers have been monitoring the preparation and stocking of their fields, and with assistance from the OPIB, rice was planted into all of these fields in late June and July. Fish were then stocked and harvesting is planned for December 2010 and January 2011. CRSP trainee Alhassane Toure "Sandy" continues to be a leader for the DNP in this work. The rice-fish farmers of the Baguineda area have also formed a cooperative to better organize themselves for sharing and spreading this new technology.

Two additional farmers in the Mopti area have also taken up this technology, bringing the total of new farmers for this year to 23.

The DNP has been collaborating with other organizations, such as the IICEM and the Farmer-to-Farmer Program, to share information and set up training and demonstrations in areas such as Mopti. Trainees were producers, technical staff in Mopti and NGOs who are involved in the Tombouctou and Gao regions.

Fisheries Planning

Lake Sélingué Frame Survey

Last year (FY 09) a Frame Survey of Lake Sélingué was carried out by the Fisheries Planning team from 16-19 February, subsequent to holding two short training sessions for those who would be assisting with the survey (supervisors and enumerators). A database system was developed for storing and managing the survey data in early April 2009, and a report on the survey results (*Report on Lake Sélingué Frame Survey of February 2009*) was submitted to the DNP in May.

For maximum benefit to stakeholders and to Mali, and with co-management of the lake to conserve its fishery resources as the goal, the results and implications of the Frame Survey needed to be shared and discussed with all stakeholders. Two stakeholders' workshops had thus been planned as a part of overall Theme III activities, and these workshops were conducted in FY 10.

Stakeholders' Workshops

The two stakeholders' workshops conducted this year included one in Bamako for the DNP fisheries management team and another at the ODRS offices in Sélingué for Lake Sélingué fishers. A PowerPoint

presentation for reporting on the Frame Survey at these workshops was prepared by the workshop leader in Kenya prior to traveling to Mali in May 2010. This presentation touched on the Lake Sélingué fisheries database and how it operates, the results of the 2009 Frame Survey, and recommendations for the sustainable management of the resources of the lake, based on the survey results. The agenda for the stakeholders' workshops was drawn up through e-mail consultations between Frame Survey expert Peter Nzungi, Theme III leader Nancy Gitonga, and DNP Director Héry Coulibaly.

Stakeholders Workshop for the DNP Fisheries Management Team
Two days (May 10th and 11th 2010) were given to the stakeholders' workshop for the DNP fisheries management team held at the DNP offices. During the two days the Frame Survey expert presented the results of the Frame Survey, the Lake Sélingué fisheries database and how it operates, and draft recommendations on sustainable management of the resources of the lake based on the Frame Survey results for discussion. This was done through an interpreter. Lively discussions ensued and the participants were happy with the results. They came up with several other recommendations which were included in the final survey report.

Stakeholders Workshop for Lake Sélingué Fishers
Another two days (12-13 May 2010) were given for the stakeholders workshop held at the ODRS offices in Sélingué for Lake Sélingué Fishers. During the workshop the Frame Survey expert presented the results of the Frame Survey and draft recommendations on sustainable management of the resources of the lake based on the Frame Survey results as well as additional ones suggested by DNP management. Again this was done through an interpreter. Just like the meeting with the DNP fisheries management team, a lively discussion followed the presentations and again the participants of this workshop were happy with the results. They also came up with several other recommendations which have been included in the final report. There were 33 participants in this second workshop.

Preparation and Dissemination of Final Frame Survey Report
After the stakeholders' workshops in May, the Frame Survey expert returned to Kenya and immediately began preparing the final Lake Sélingué Frame Survey report, which was submitted to the CRSP project coordinator James Bowman, DNP Director Héry Coulibaly, and Theme III leader Nancy Gitonga. In the report, the Frame Survey expert incorporated the views and recommendations obtained from the participants in the two stakeholders' workshops. The recommendations in the report are expected to facilitate "Sustainable Utilization and Development of Lake Sélingué Fisheries Resources"

Lake Fisheries Co-Management Training
On evaluation of the activities conducted under this project through FY 09, DNP Director Héry Coulibaly requested that we not hold a third Pond Culture training session in Kenya as planned, but focus those resources on additional Fisheries Planning training instead. At the team leaders meeting following the AquaFish CRSP Annual Meeting in San Diego, it was agreed that it would be in the best interest of the project and of fisheries development in Mali to respond favorably to the DNP director's request, and USAID agreed the project could substitute the refocused training.

The focus of this new training was on how fisheries management, and specifically co-management, has been successfully applied at Lake Victoria, Kenya. The training, conducted out of Kisumu, on the shore of Lake Victoria, thus took the form of a study tour, looking at 1) fisheries co-management, 2) monitoring, control, and surveillance systems, and 3) the formation and roles of Beach Management Units at Lake Victoria, Kenya. Through the addition of two extra days, it was also possible to expand the training in Nairobi to include the use of computer software for data storage, management, and analysis.

The DNP, FishAfrica, and the OSU Management Office put considerable effort into planning this revised training course during the 3rd and 4th quarters of the year, with dates for the training eventually set for 27

September through 3.October to maximize the benefits of this effort for Mali, four participants were sent rather than two. The four participants departed Mali on 26 September, arriving in Kenya on 27 September, and returned to Mali on 4 October. The results of this study tour will be presented in a workshop to Sélingué, and the documentation collected in Kenya will be used to develop guidelines for the wise use of the fisheries resources of Lake Sélingué. A full report on the training and its initial impacts will be included in the final report.

Other Project Activities

Activities of the Direction Nationale de la Pêche (DNP)
The DNP has been very active this year, participating in all work plan activities but also conducting follow-up/complementary activities for the three project themes and carrying out some supplemental new activities. Examples of follow-up work related to our themes are the initiation of a third set of *On-Farm Trials* (Pond Culture) and providing advice to Baguineda farmers leading to at least 21 new rice farmers investing in rice-fish technology during the present crop season (Rice-Fish). In addition, the DNP has engaged a local studio to videotape many of the field and classroom events that have occurred this year and will be producing several short videos to promote the aquaculture and fisheries activities that we have been involved in. The DNP has also taken responsibility for getting "signage" in place at our sites to show USAID sponsorship of our work. The Project Management Office assisted the DNP by creating the design for the signs using appropriate logos.

Mali Project Meeting, Annual AquaFish CRSP Meeting, and the World Aquaculture Society's "Aquaculture 2010" Conference; San Diego, California, February 27 - March 5
Project team members in attendance at the Annual Meeting of the AquaFish CRSP and the *"Aquaculture 2010"* conference (World Aquaculture Society) in San Diego, California, from 1-5 March 2010, took the opportunity to meet to discuss project issues. DNP Director Héry Coulibaly was joined by Theme Leaders Nancy Gitonga, Liu Liping, and Charles Ngugi, and by Oregon State University PIs Hillary Egna and Jim Bowman for this meeting. USAID/Mali's AOTR Gaoussou Traore was unable to attend the meeting due to a schedule conflict, although CRSP AOTR Harry Rea attended. This was a very productive meeting, involving the DNP Director, all three of the theme leaders, and the OSU PIs. It provided an opportunity for the team to thoroughly review progress made and to plan for the remainder of the project period, adjust the activity schedules of the three theme areas, and discuss potential activities for the future. And as reported above, an important part of the discussion focused on the idea of converting and replacing a *Pond Culture* workshop with one focused on *Fisheries Planning*.

At this meeting CRSP Director Hillary Egna invited Héry Coulibaly to serve as leader for the CRSP West Africa Regional Center of Excellence (RCE). This will further connect Mali into the CRSP framework while providing a way for Héry to bring his own networks in as well. In the entire AquaFish CRSP membership of 300 participants, there are only 4 RCE leaders, including Héry, so his role as RCE leader will be an important one. This recognition and role is projected beyond the life of the current Mali Project.

This also provided us with another opportunity to interact with participants in the wider AquaFish CRSP, both from the US and from participating Host Countries. Participation in the *Aquaculture 2010* conference brought all of us once again into contact with the global aquaculture community, providing examples and models of what aquaculture can and does do in other countries and regions.

Participation in USAID/Mali All-Partners Meetings
December 2009
The purpose of this meeting was to provide a venue for USAID/Mali/AEG to describe the components of its economic growth portfolio to its partners and for the partners to share what they are doing with each

other. DNP Director Héry Coulibaly represented the project at these meetings, making a presentation in which he outlined the project's three theme areas and highlighted the activities undertaken and results achieved to date. No other project team members were able to attend this meeting due to schedule conflicts at the time.

June 2010
In this meeting USAID/Mali/AEG sought input from its partners to help it prioritize potential economic growth programs for support under the *Feed the Future* initiative, with the Government of Mali's *National Priority Investment Plan* for 2011-2015 as the starting point. It also provided opportunity for brainstorming with regard to scaling up those program areas considered to be most important for Mali's economic growth. Participants were asked to take a broad view with regard to commodity prioritization and not to favor their own areas of interest. Boureima Traore (DNP) and Jim Bowman (OSU) attended this meeting on behalf of the project team. This two day meeting provided a great opportunity to meet representatives of the many other USAID/Mali partners and to learn about other value chains and their importance to the Malian economy; unfortunately there was not much time for in-depth discussions with those other partners.

OSU Management Office Activities
In preparation for the December 2009 All-Partners Meeting in Mali, the Management Office prepared a brochure and a fact sheet about the project along with PowerPoint material for the presentation made at the meeting by Héry Coulibaly. We have also been developing a Mali Page on the AquaFish website, where project documents such as MOUs, subcontracts, and quarterly and annual reports are posted and where team members can log in and record indicator data such as numbers of short-term training events held and numbers of participants attending. We have prepared and submitted four quarterly reports (the first three have been translated to French and the fourth is being translated) and submitted annual indicator reports both in the USAID/Mali Excel format and through the GFSR M&E system (http://gfsr.synisys.com/de/). We set up at least five conference calls between Héry Coulibaly (DNP), Gaoussou Traore, Karen Ramsey, and Yacouba Santara (USAID/Mali), and Jim Bowman (OSU), and have had numerous SKYPE discussions with Héry Coulibaly.

As in the previous year the OSU Management Office prepared a poster about the Mali Project for display at the *Aquaculture 2010* conference. This poster covered the goals of our project, the approaches taken to achieve those goals, and progress made through January. Two French-language copies of the posters were also prepared and these were sent back to Mali with Héry Coulibaly. The French version was updated in May and five copies were printed and taken to Mali by Jim Bowman when he visited for the USAID All-Partners Meeting in June.

Amendments to OSU's subcontracts with the Direction Nationale de la Pêche (DNP), Shanghai Ocean University (SOU), and FishAfrica (FA) were finalized and became effective in December 2009, providing funding for Year 3 activities for these partners. Three additional amendments were later agreed on due to budget adjustments that needed to be made for the new fisheries planning workshop in Kenya.

Jim Bowman visited Mali in November 2009 and in June 2010, and Hillary Egna visited in August 2010. Both were able to visit some of the *On-Farm Trials* and *Rice-Fish Demonstrations* sites and the ponds of several farmers and farmer associations. Each also visited the Practical Aquaculture Training Center of Molodo (Niono, Segou area); the Office de Developpement Rural de Sélingué (ODRS), the ODRS hatchery, and the Carriere fish landing beach in Sélingué; and the hatchery and ponds of the Practical Training Center for Breeding at Sotuba. Both also had several opportunities to meet with the project's DNP and USAID partners, as reported in quarterly reports throughout the year. For his November 2009 trip to Mali Jim Bowman was fortunate to be able to pass through Kenya for an opportunity to meet with Theme Leaders Nancy Gitonga and Charles Ngugi to discuss project progress and problems, activity

schedules, and indicator reporting. The meeting was hosted by Nancy Gitonga in her office at OAU headquarters in Nairobi.

The Management Office was intensively involved in planning and coordinating arrangements for the Lake Victoria co-management workshop, including the preparation of supplemental subcontract amendments for the DNP and FishAfrica, the two subcontracting institutions most closely involved in this training.

The Management Office requested a three-month no-cost extension (NCE) for the project and developed and submitted two proposals for future collaborative work to be led by the AquaFish CRSP. The request for an NCE was subsequently granted by USAID/Mali, extending our operating time through December 31, 2010. No feedback on the proposals has been officially received although there is indication of possible interest in continuation beyond the current project end date.

Summary of Training Efforts

Short-Term Training

The Mali Aquaculture and Fisheries Project utilizes on-farm trials, field demonstrations, and short-term training to test, adapt, and transfer appropriate aquaculture and fisheries technologies to its targeted audiences in the three theme areas. Training activities reach a wide audience of participants, including fishers, fish farmers, middlemen, fish traders, processors, government officers, and researchers. Most of the project's short-term training events have occurred in Mali, but some training has also been carried out in third countries, specifically China and Kenya. During FY 10, nine short-term training activities were conducted in Mali and one course was conducted in Kenya, as summarized in Table VII-1.

Theme II leaders awarded certificates to the participants attending the November 2009 Workshop on Post-harvest Technologies in Baguineda.

Farmers and Technical staff visited Ibrahim Mare in Kalaban Coro during the Theme I *On-Farm Trials* workshop held in January 2010 in Bamako.

Long-Term Training

Although long-term training is not a major component of this project, three students from the Institut Polytechnique Rural de Formation et de Recherche Appliquée (IPR/IFRA) (Rural Polytechnic Institute for Training & Applied research), Katibougou, continued to receive partial support for participation in project activities this year. The students are Ahmadou Nouh Sow, who is associated with Theme I (Pond Culture) activities, and Fadima Keita and Bocary Diarra, both of whom are associated with Theme II (Rice-Fish) activities. Ahmadou Nouh Sow has been involved in monthly monitoring and sampling of the Theme I On-Farm Trials and Theme I workshop participation and Fadima Keita and Bocary Diarra were involved in monitoring and harvesting the Theme II Rice-Fish Demonstrations and participation in Theme II workshops.

Table VII-1. Workshops conducted by the AquaFish CRSP Mali Project during fiscal year 2010.Two or more workshops were conducted under each of the projects three thematic areas, Pond Culture, Rice-fish Culture, and Fisheries Planning.

Event Name	Theme	Date	Location	# of trainees	# of women
Workshop on Appropriate Aquaculture Post-harvest Technologies	Rice-Fish	13-14 November 2009	Baguineda	24	9
Workshop on Training and Extension Capacity for Rice-Fish Culture	Rice-Fish	16-20 November 2009	Baguineda	27	0
Post-on-farm trials: 1st evaluation workshop for supervisors and participating farmers	Pond Culture	11 January 2010	Bamako	14	2
Pre-on-farm trials workshop for supervisors	Pond Culture	12 January 2010	Bamako	6	1
Best Aquaculture Practices (BMPs) and Aquaculture Policy in Mali	Rice-Fish	31 January -3 February 2010	Baguineda	18	2
2nd On-farm trials evaluation workshop	Pond Culture	10 May 2010	Bamako	6	1
Stakeholders workshop for the DNP fisheries management team	Fisheries Planning	10 -11 May 2010	Bamako	12	0
Training on record keeping, enterprise budget, business planning in aquaculture and marketing of farmed fish	Pond Culture	11-14 May 2010	Bamako	14	3
Stakeholders workshop for fishers of Lake Sélingué at the ODRS offices in Sélingué	Fisheries Planning	12 -13 May 2010	Sélingué	33	3
Training course in Kenya on lake fisheries co-management	Fisheries Planning	27 September - 3 October, 2010	Lake Victoria, Kenya	4	0
TOTAL: 10 short-term events				**158**	**21**

The involvement of women in the trainings continues to be a challenge. Some of this is due to role distinctions inherent in Mali culture but some could be due to less entrenched reasons. The Management Office is gearing up for enhancing outreach towards women beneficiaries, possibly with additional funds dedicated to women's involvement in the next project. Given the de novo nature of aquaculture in Mali, there could be lower barriers for women entrants but land and water rights, access to resources (info, credit, inputs), and perceptions of risk (vs. known low-risk outputs from labor) conspire almost everywhere in Africa to keep women from profiting. However, in Mali our experience with involving women was more segmented than in our other Africa activities. Fundamentally two years is inadequate time to bring in underrepresented groups, but with more time, funds, and up-front dedication, we think we can make a difference.

Summary of Project Activities at Year's End

Year 1: October 1 2007 through September 30 2008

- ✓ ***Nov 2007 to Dec 2008:*** In Mali, ALL: Planning design & review with Mali counterparts
- ✓ ***May to September, 2008:*** Theme II: Planning for Rice-Fish Demonstration and Workshop on Training and Extension Capacity for Rice-Fish Culture
- ✓ ***September 2008:*** In China, Theme II: Training on Rice Fish Culture plus Capacity Building for Effective Skills Transfer
- ✓ ***Continuous:*** ALL: monitoring, evaluating, and impact reporting

Year 2: October 1 2008 through September 30 2009

- ✓ ***Feb2-6, 2009:*** In Mali, Theme I: Mali Pond Culture Workshop #1
- ✓ ***Feb 9-13, 2009:*** In Mali, Theme III: Frame Survey Training
- ✓ ***Feb 16-20, 2009:*** Frame Survey, Lake Sélingué (two Theme III activities end-to-end)
- ✓ ***Apr 6-17, 2009:*** In Kenya, Theme I: Kenya Pond Culture Workshops #1+2[1]
- ✓ ***Jun 21-Jul 3, 2009:*** In Mali, Theme I: Mali Pond Culture Workshop #2
- ✓ ***Jul 15, 2009:*** In Mali, Theme I: Start of Pond Culture On-Farm Trials #1 (immediately following the Pond Culture Workshop)
- ✓ ***Jun 26-Jul 15, 2009:*** In Mali, Theme II: Rice-fish demonstration set-up, first rice crop (at beginning of rice season)
- ✓ ***Continuous:*** ALL: monitoring, evaluating, and impact reporting

Year 3: October 1 2009 through September 30 2010

- ✓ ***Nov 12-14, 2009:*** In Mali, Theme II: Workshop on Appropriate Aquaculture Post Harvest Technologies
- ✓ ***Nov 16-20, 2009:*** In Mali, Theme II: Workshop on Training and Extension Capacity Building for Rice-Fish Culture (just before harvest)
- ✓ ***Jan 9-12, 2010:*** In Mali, Theme I: Set up and start Pond Culture On-Farm Trials #2
- ✓ ***Feb 1-4, 2010:*** In Mali, Theme II: Workshop on BMPs - the Issues and Challenges
- ✓ ***May 10, 2010:*** In Mali, Theme I: Evaluation and Wrap-Up, On-Farm Trials #1
- ✓ ***May 10, 2010:*** In Mali, Theme III: Stakeholders Workshop #1
- ✓ ***May 11-14, 2010:*** In Mali, Theme I: Mali Pond Culture Workshop #3
- ✓ ***May 12, 2010:*** In Mali, Theme III: Stakeholders' Workshop #2
- ➡ ***Sep 27-Oct 4, 2010:*** In Kenya, Theme III: Lake Management Training, Lake Victoria[2]
- ➡ ***September to December 2010:*** ALL: Final Reporting; Lessons Learned

Key:

Theme I - Pond Culture
Theme II - Rice-Fish
Theme III - Fisheries Planning
All

- ✓ Items already completed
- ➡ In progress as of September 30, 2010

[1] Two of the original three sessions (planned for 2 trainees each) combined into a single session with 4 trainees.
[2] The third pond culture training session was converted to this fisheries planning course at Lake Victoria.

Progress towards Impact Indicator Targets

Significant progress was made this year with respect to project impact indicators and targets, as shown in Table 2 (next page). The table consists of two sections, one for the five indicators required in the Work Plan and another for additional indicators that are being tracked to the extent possible. Note that we have exceeded our targets for some indicators.

Table VII-2. Impact indicators being tracked under the AquaFish CRSP Mali Project.

Required Indicators:

Indicator	***Project Target***	***Results end of FY 2009***	***Results in FY 2010***	***New Total***
New technologies under field testing	*12*	*2*[1]	*2*[3]	*2*
New technologies made available	*4*	*6*	*2*	*8*
Individuals receiving short-term training[4]	*155 (79/76)*	*124 (116/8)*	*158 (137/21)*	*282 (253/29)*
Farmers who adopted new practices[2]	*16 (8/8)*	*17 (17/0)*	*26 (24/2)*	*43 (41/2)*
Fish processors who adopted new practices[5]	*4 (2/2)*	*0*	*0*	*0*

Optional Indicators:

Indicator	***Project Target***	***Results end of FY 2009***	***Results in FY 2010***	***New Total***
Number of Malians who attend international aquaculture meetings[2]	*3*	*4 (4/0)*	*1 (1/0)*	*5 (5/0)*
Number of students trained or mentored in Mali[2]	*3*	*3 (2/1)*	*0 (0/0)*	*3 (2/1)*
Number of participants trained outside of Mali[2]	*8*	*6 (5/1)*[2]	*4 (4/0)*	*10 (9/1)*[2]
Additional aquaculture production area resulting from project efforts (either number of additional ponds or rice paddies or additional area in hectares)	*1.4 ha*	*Not yet determined*	*Over 200 new ponds and 27 rice-fish paddies*	*Over 200 new ponds and 27 rice-fish paddies*
Estimated increase in fish productivity in ponds or rice-fish systems in targeted areas (kg/ha/yr or percent)	*1500 kg/ha/yr*	*Not yet determined*	*2,700 to 18,000 kg/ha/yr*[6]	*2,700 to 18,000 kg/ha/yr*[4]
Estimated increase in income for fish farmers in targeted areas (CFA/ha/yr or percent)	*Not yet determined*	*Not yet determined*	*180 to 1,200%*[4]	*180 to 1,200%*[4]
Number of extension publications developed	*10*	*12*	*10*[7]	*22*[5]
Number of frame surveys conducted for lake fisheries	*1*	*1*	*0*	*1*

3 Previously reported as 4 technologies; now re-defined as 2: Pond Culture and Rice-Fish Culture.

4 The total number of individuals is followed in parentheses by the number of men/number of women. For example, an entry of 9 (5/4) would indicate a total of nine individuals, of which 5 were men and 4 were women.

5 Impacts related to processors are not expected to be apparent until late 2010.

6 In ponds of farmers participating in the first set of Theme I On-Farm Trials.

7 Includes PowerPoint teaching modules.

SUCCESS STORIES

Increases in Fishpond Productivity

One of the major goals of the project is to help fish farmers improve their practices to increase productivity. Results coming out of our *On-Farm Trials* this year show exactly the kind of increases we are looking for. Among the ponds of the six farmers who completed these trials, production ranged from 1,352 to 9,090 kg for a six-month crop cycle, which extrapolates to between 2,704 and 18,180 kg/ha/yr. This is a 2- to 11-fold increase in production per unit area over the 1,500 kg/ha/yr baseline estimated at the beginning of this project, and it shows the positive effect that occurs when farmers apply improved management practices provided to them through training and education.

Fish Farmer Seydou Toé

We reported on Mr. Toé's initial successes in last year's report, but his story continues to be remarkable. Mr. Toé is an agricultural producer who has been practicing fish culture since 2006. His farm, operated in partnership with his brother Richard Toé, is at the edge of an arm of the Niger River in Banco, approximately 30 km southwest of Bamako. Seydou speaks neither French nor English, but speaks Bambara and writes N'Ko. He is a founding member of the Association des Pisciculteurs et Aquaculteurs du Mali (APAM) and has participated in four of this project's training courses.

With respect to fish farming, prior to the beginning of this project, Seydou had been having problems related to poor construction of his ponds, lack of good feeds for the fish, lack of pond management information, and limited access to fingerlings. Some of his pond construction issues were related to high soil permeability, resulting in poor water retention in the ponds.

With respect to the activities of the USAID/AquaFish CRSP *Mali Project*, Seydou was selected by APAM to participate in the Theme I (Pond Culture) training workshops in Bamako and Sagana, Kenya, in February and April 2009, respectively. In these workshops he learned about pond construction and management and the propagation of *Clarias* (African catfish), including spawning, hatching, and the care of catfish fry in the hatchery.

On their return from the Kenya training course, Seydou and his fellow trainees constructed and tested a hatchery at the Centre de Formation Pratique en Elevage at Sotuba. This hatchery has been used in subsequent training sessions to hatch catfish eggs that are produced during courses on *Clarias* breeding and continues to be operated by APAM to produce *Clarias* fry.

The team members who were trained in the artificial propagation of *Clarias* (African catfish) at Sagana Aquaculture Centre in Kenya; from left to right: Rokia Coulibaly, Mamadou Kane, Seydou Toé, and Bouréima Traore

Seydou Toé explaining the construction and operation of the *Clarias* (catfish) hatchery that he now uses at his farm in Banco.

Using locally available materials, Seydou also built a hatchery at his own farm in Banco. This year he continued to produce catfish fingerlings and market them to other farmers. His fingerling sales serve as an important source of income, enabling him to meet the various expenses of fish pond operation. He has also acquired additional land, with better soils for pond construction, where he plans to expand his fish farming operation.

In addition to the improvements he has made in his own fish farming work, Seydou is in high demand throughout Mali as a pond construction trainer. The fact that people are willing to pay him for his services is an indication that farmers see fish culture as a sustainable enterprise and understand that positive economic benefits can be gained from it.

The training Seydou has received under the AquaFish CRSP Mali Project, financed by USAID/Mali, has enabled him to identify good sites for pond construction, improve pond management at his farm, and produce fingerlings for sale to other fish farmers. Seydou now also contributes to the dissemination of the information he has received and technologies he has learned by training and advising other producers.

Catfish Fry Producer Rokia Coulibaly

New this year is the successful installation of another new catfish hatching system by another of the trainees who went to Kenya in 2009. Rokia Coulibaly completed a hatchery installation in June of this year and hatched her first batch of catfish larvae in July. The significance of the innovation of these simple hatching systems is that they are inexpensive, easy to construct, and easy to operate, so that many farmers or suppliers should be able to put them into operation. With many of them in operation around the country, catfish fingerlings should become much more readily available in close proximity to farmers who want to produce catfish.

Rokia shows her newly completed catfish hatching system

Above, Rokia Coulibaly is using a hapa net and shading by banana leaves to nurse and protect newly-hatched catfis larvae.

.

Rice-Fish Farming in Baguineda

Last year we reported on the success of rice-fish farmer Mr. Mamadou Samake in the Baguineda irrigation area. At that time he was one of the first rice farmers to try growing fish in a rice field, through his participation in the project's *Rice-Fish Demonstrations*. More than 106 kg of fish were harvested from his field at the end of demonstration period, which was very appealing to him because of the extra income that was generated.

The significance of that initial success this year is in the multiplier effect it has had among other rice farmers in Mali, especially in the Baguineda irrigation area, but elsewhere in the country as well. As an example, at least 21 new rice farmers in the Baguineda area modified their fields for rice-fish farming this year. In anticipation of the re-opening of the irrigation system, the new fields were modified in May and June, rice was transplanted in June, and the fish were stocked in July. New farmers are using not only the original design used by Mr. Samake, but are also trying out new field configurations. We eagerly await the results of these new undertakings in terms of fish production, income generation, and the comparative performance of the new field designs that are being tested.

Mme Diallo Madeleine BA, Minister of the Ministry of Livestock and Fisheries, visiting the farm of Mamadou Samake on harvest day.

Over 100 kg of fish were harvested from the rice-fish field of Mamadou Samake in November 2009.

One of the new rice-fish field designs, seen in early August, after rice transplantation and over a month of cultivation.

Another of the new rice-fish field designs, seen well after rice transplantation and significant rice growth.

Capacity Building for Fisheries Management

Last year the project conducted a *Frame Survey* of Lake Sélingué to provide baseline information about its fisheries from which the impact of management measures can be evaluated and improved management plans can be formulated. The survey provided information on the number of fish landing sites; the facilities available at the fish landing sites to service the sector, including accessibility to the landing sites;

the service providers, especially fishermen cooperatives/associations; the number of fishers; the number and types of fishing canoes and their modes of propulsion; the types and sizes of fishing gear used on the lake and the mode of operation for gillnets. This allowed the *Fisheries Planning* team to develop recommendations on best approaches for managing the lake based on the information gathered.

This year Lake Sélingué stakeholders participated in two workshops to consider the implications of last year's Frame Survey and to begin to work together on plans for future management of the lake. In addition, four Malian stakeholders participated in a study tour of Lake Victoria, Kenya, where they visited fishing communities and members of Beach Management Units (BMUs), learning about Kenya's experiences in co-management of fisheries resources and how management responsibilities are shared among the three nations bordering the lake (Kenya, Tanzania, and Uganda). Through completion of Lake Sélingué's frame survey, the formulation of management recommendations, participation in stakeholders' workshops, and exposure to how fisheries co-management is practiced in a major African lake, Lake Sélingué stakeholders are ready to develop a new management plan for the lake. In addition, Malians now have the capacity to conduct regular frame surveys at Lake Sélingué or other important Malian water bodies, analyze the results, and design good management strategies for those bodies of water.

Trainings in China and Kenya

Some of our best successes have had their beginnings in trainings conducted outside of Mali, for example, the *Rice-Fish* training conducted in Shanghai, China, and the *Pond Culture* training conducted in Kenya.

Participants Alassane Toure ("Sandy") and Tieman Traoré, who were trained at Shanghai Ocean University, China, in 2008, returned to share what they had learned there with farmers and OPIB officials in the Baguineda irrigation area. They were directly involved in setting up the four rice-fish demonstration sites in Baguineda in 2009. The success of rice farmers who participated in those demonstrations, particularly Samake, in turn generated so much interest among other Baguineda area rice farmers that at least 21 new farmers adapted their fields for fish production this year.

Likewise, participants who were trained at Sagana Aquaculture Centre, Kenya, in 2009 returned to construct hatchery facilities at public and private locations, train others in how to build and operate these facilities, and begin producing catfish (*Clarias*) fry and fingerlings on their own. Soon after their return the returnees constructed a catfish hatchery at Sotuba training center and two of them, Seydou Toé and Rokia Coulibaly, have constructed their own catfish egg hatching facilities on their own property. Seydou Toe has independently been involved in training of other farmers.

This past month four new participants went to Kenya for training in lake co-management and related topics at Lake Victoria. Initial reactions to the training are very positive and we expect to see good results in terms of the application of what they learned in Kenya to lake management in Mali, initially at Lake Sélingué but ultimately at other lakes and reservoirs as well.

The successes of these external training activities have occurred in spite of the language differences that exist, demonstrating again the value of the active, hands-on approach to training we have used and the extent to which language barriers can be overcome when trainees and trainers alike are excited about the subject matter and believe that they can overcome language differences to communicate effectively and achieve good results.

PROBLEMS ENCOUNTERED

Arrangements for some of the travel undertaken during this year were somewhat difficult, due to problems such as the long and complicated processes for getting visas for many countries these days and

the need to meet "Fly America" requirements while keeping travel as straightforward as possible. In addition, in at least one case we found that confirmed reservations had at the last minute been cancelled without warning, requiring us to quickly make alternate flight arrangements that resulted in higher fares, incurred penalties, and required more time for travelers to reach their destinations.

Wire transfers between the US and our partners have frequently taken much longer than hoped and expected. This may be due to the current economic atmosphere and the reactions of banking systems to it. We find that wire transfers tend not to go directly from our bank to theirs, but instead often have to wend their way through clearing houses and other banks, sometimes taking two to three weeks to arrive at the recipient bank. This has been problematic in cases where we needed to quickly get funds from OSU to our partners.

The distances between partners continued to make communications a bit difficult. This year we again benefited from having an opportunity to meet face-to-face during the conferences in San Diego in March. Several of us, including our DNP colleagues, have also been able to use SKYPE for discussions, and this does allow for much better communication than do email messages and regular telephone calls.

LESSONS LEARNED

Coordinating a collaborative effort that includes partners from three countries in addition to the host country requires a considerable extra amount of time, effort, and patience. As mentioned above, the simple physical separation makes communication more difficult, meaning that more time is usually required to reach consensus on important decisions or to receive and compile information for reports. When all of the partners are already involved in high-level programs of their own and one or more of them may be traveling at any particular time, it becomes even more difficult to make timely decisions and keep the collective activities moving ahead on schedule. This lesson became apparent to us early in the project but may not have been brought out in previous reports.

Tools such as *On-Farm Trials*, *Rice-Fish Demonstrations*, and *Stakeholders' Workshops* are extremely effective in sharing critical information and providing the kind of hands-on, practical experience that is needed for good learning. In our project we have found that participants in these activities were very enthusiastic, actively engaged, and excited about the material at the end of each activity.

More timely information and feedback from USAID regarding project extensions is required. Until mid-August, we were actually planning a closedown on 30 September. The university and partner agreements were ending and contract officers were beginning layoffs and closedown procedures. While we definitely appreciate the no-cost extension that was granted, it came at the 11th hour and caused higher transaction costs and extra work related to partner arrangements such as MOUs and subcontracts. This is likely to occur again in November, as we come up on the extended project end date. The organizations involved are large and complex and require greater lead time for actions such as responding to RFPs and negotiating MOUs and subcontracts.

If a new project is desired by USAID, planning for it would have benefitted from starting in early summer, at the time of the June workshop. The in-person communications that could have occurred at that time, as well as the resulting increase in planning time, would have been far more conducive to putting together a solid project in a timely manner. Without the guidelines provided by an RFA, developing plans for future work competes unfavorably with onerous daily demands.

OUTCOMES AND IMPACTS

Notable impacts realized this year have included:

- *Success of farmers* like Seydou Toé: Seydou Toé's story continues to be one of real success. Seydou participated in training events both as a trainee and as an assistant to trainers, and has since greatly improved his own fish farming efforts. He has constructed his own simple catfish hatchery and is now producing catfish fingerlings for sale, has purchased new land for expansion of his fish farming enterprise, and is actively engaged in training other farmers in pond construction. He serves as the best kind of model for promoting fish farming in Mali, a model that can potentially have an enormous multiplier effect.

- *Improved management of pre-existing fishponds*: Following their training experiences, many farmers have returned home to apply their new knowledge to improve their pond management and productivity. Farmers who have participated in our *On-Farm Trials* have increased production to levels as high as 2,700-18,000 kg/ha/yr, as compared with the pre-project productivity estimate of approximately 1,500 kg/ha/yr.

- *Construction of new ponds*: Following participation in training sessions trainees have also gone home to construct new ponds based on what they learned about selecting suitable pond sites and using appropriate construction methods. This year the project team is reporting that over 200 new fish ponds have been built.

- *Application of simple methods for catfish propagation and hatchery management*: In 2009 a new hatchery was designed and installed at the *Sotuba Centre de Formation Pratique en Elevage* by participants returning from training in Sagana, Kenya. This year a second person trained in catfish propagation in Kenya, Rokia Coulibaly, has installed a small hatchery at her own property (Seydou Toé had installed one the previous year).

- *Expansion of fish farming by the Jigiya Association*: The Jigiya ("Hope") Association, an 11-member group that was formed last year in Kayo (near Koulikoro) and participated in the first set of *On-Farm Trials*, has built two additional ponds and acquired additional land for further growth.

- *Increased government capability in lake fisheries management:* This year Lake Sélingué stakeholders participated in two workshops to consider the implications of last year's Frame Survey and to begin to work together on plans for future management of the lake. In addition, four Malian stakeholders participated in a study tour of Lake Victoria, Kenya, where they observed the successful application of fishery co-management techniques that they and other stakeholders will adapt to the Lake Sélingué situation. That the stakeholders understand the results of the Frame Survey and are buying in to the recommendations made to date is illustrated by the fact that for the first time ever no citations for harmful fishing practices were given to Carriere fishers by the fishing authorities.

- *Expansion of rice-fish culture*: The farmer-to-farmer effect was clearly seen in the Baguineda area this year, where based on the experience of the four farmers who participated in last year's rice-fish demonstrations, at least 21 new farmers adapted their rice fields and stocked fish this year. At least two other farmers have started rice-fish farming in the Mopti area, and the DNP has been providing support to other organizations who wish to support this technology in other areas.

SUMMARY

The Mali Project has made great strides again this year, completing ten short-term training activities involving 158 participants, complementing last year's Lake Sélingué Frame Survey with 2 stakeholders' workshops and a lake co-management study tour in Kenya, catalyzing the diffusion of rice-fish technologies within Mali, and conducting *On-Farm Trials* in fish farmers' ponds. Following their experiences in our training courses, participants have gone on to renovate poorly constructed fish ponds, build new ponds, correctly apply improved management practices to their fish ponds, begin small-scale fingerling production, and become involved in training others. The results of our first set of *On-Farm Trials* showed productivity of 2,700-18,000 kg/ha/yr in ponds that completed the trials, as compared with our baseline estimate of 1,500 kg/ha/yr at the beginning of the project. There continues to be great potential making significant contributions to aquaculture and fisheries development in Mali and the region, and we hope to continue to be a part of that effort.

VIII. CAPACITY BUILDING

Training supported by AquaFish CRSP takes a number of forms, with perhaps the most important being short-term (non-degree) courses and long-term (degree) programs. Short-term training most frequently occurs as seminars, workshops, and short-courses scheduled for periods between half a day to two or three weeks. Trainings focus on specific topics for stakeholders, which are integral to the project objectives. Long-term training encompasses academic programs for a BS, MS, or PhD degree at an accredited university located either in a Host Country or the US as well as high school and certificate programs.

SHORT-TERM TRAINING

During FY10, 25 short-term AquaFish CRSP training sessions for 694 trainees were run under eight core research projects[8]. Of these, 11 training sessions were held in the Asian region (6 in Cambodia, 2 in the Philippines, 2 in Vietnam, and 1 in Nepal), 8 were held in Latin America and the Caribbean (5 in Mexico, 2 in Nicaragua, and 1 in Guyana), and 6 were held in Africa (2 in Ghana, 2 in Tanzania, 1 in Kenya, and 1 in Uganda). Of the 694 trainees, 229 were trained in Cambodia, 113 in Mexico, 78 in Ghana, 61 in Nicaragua, 41 in Nepal, 40 in Guyana, 34 in Vietnam, 30 in Kenya, 30 in Tanzania, 28 in the Philippines, and 10 in Uganda (Figure VIII-1). See Table VIII-5 at the end of this section for a full listing of trainings.

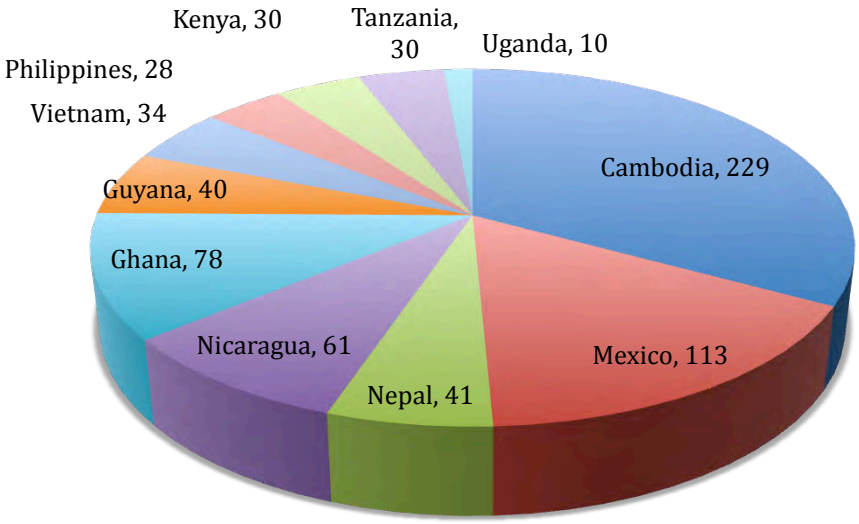


Figure VIII-1. Numbers of participants in AquaFish CRSP short-term training events in FY10, by country.

[8] Data in this report (short- and long-term) reflect the best information to date (i.e., data drawn from FY10 project reports received as of October 15, 2010).

Gender Distribution in Short-Term Training

Of the 694 trainees, 275 (39.6%) were women and 419 (60.4%) were men. Table VIII-1 shows the gender distribution on a country basis.

Table VIII-1. Numbers and percentages of women trainees participating in FY10 AquaFish CRSP short-term trainings.

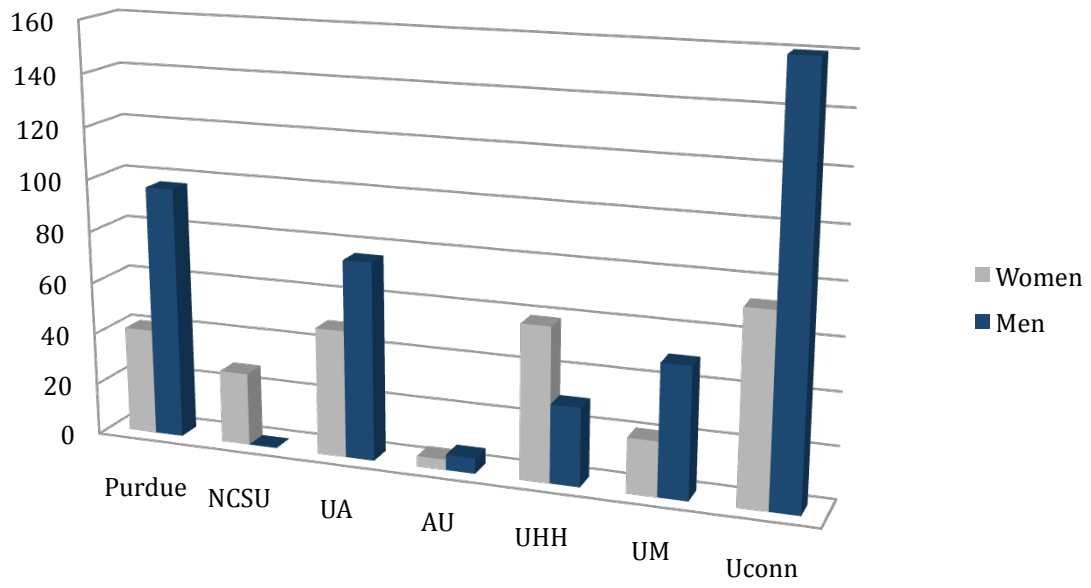
Country	Trainee Total	Number of Women	% Women
Cambodia	229	73	31.9
Ghana	**78**	**21**	**26.9**
Guyana	**40**	**13**	**32.5**
Kenya	**30**	**8**	**26.7**
Mexico	**113**	**42**	**37.2**
Nicaragua	**61**	**53**	**86.9**
Nepal	**41**	**16**	**39**
Philippines	**28**	**28**	**100**
Tanzania	**30**	**12**	**40**
Uganda	**10**	**4**	**40**
Vietnam	**34**	**5**	**14.7**
Total	**694**	**275**	**39.6**

At least one-third of all trainees were women in Mexico (37.2%), Nicaragua (86.9%), Nepal (39%), the Philippines (100%), Tanzania (40%), and Uganda (40%). All of those trained in the Philippines were women, reflecting that these trainings were focused specifically on the female heads of households in the communities where they were held. Lower percentages of women trained in events in Kenya (26.7%) and Vietnam (14.7%) largely reflect that fish farming and fishing activities—the main focus of training events held in these countries—are traditionally undertaken by men, whereas women are typically involved in post-harvest activities such as processing and marketing. The composition of participants in training courses on pond construction, pond management, hatchery management, or fishery surveys would thus tend to include more men than women.

On a project basis, Purdue held 5 short-term training events with 138 participants (29.7% women), North Carolina State University held 1 event with 28 participants (100% women), University of Arizona held 4 events with 125 participants (39.2% women), Auburn University held 1 training with 10 participants (40% women), University of Hawaii Hilo held 2 with 89 participants (66.3% women), University of Michigan held 2 events with 71 participants (29.6% women), and University of Connecticut held 7 training events with a total of 233 trainees (31.3% women) (Figure VIII-2).

Photo in Uganda courtesy of Joseph Molnar

Photo in Mexico courtesy of Maria Haws



I
events in FY10, by project.

Short-Term Training for Participants from IEHA Countries

There were 110 IEHA-country nationals who received training this year, representing 15.9% of all short-term trainees. Trainings occurred in Ghana (2 courses, 77 IEHA participants), Kenya (1 course, 29 IEHA participants), and Uganda (1 course, 4 IEHA participants). Three training sessions were held by Purdue University and one was held by the Auburn University project.

LONG-TERM TRAINING

Since the inception of the AquaFish CRSP, a total of 273 degree students have been supported, including 143 men and 130 women (52.4 and 47.6 % respectively), for an almost 50:50 balance[9]. In FY10, the AquaFish CRSP supported the long-term training programs of 196 degree program students, including 109 men and 87 women (55.6% and 44.4% respectively). These students represent 22 countries[10], including Brazil, Cambodia, China, Ecuador, Eritrea, Ghana, Guyana, Indonesia, Ivory Coast, Kenya, Mexico, Micronesia, Nepal, Nicaragua, Nigeria, the Philippines, Samoa, South Africa, Tanzania, Uganda, the U.S., and Vietnam. The distribution of these students by nationality is as shown in Table VIII-2. For a full listing of FY10 students, see Table VI-5 at the end of this section.

[9] Students are reported for the eight core projects under the *2009–2011 Implementation Plan*, and the Program Management Office.

Table VIII-2. Numbers and percentages of long-term students supported by the AquaFish CRSP in FY10, by nationality.

Nationality	Number of Students	Percent of Total	Number of Men	% Men	Number of Women	% Women
Mexico	35	17.9	23	65.7	12	34.3
China	29	14.8	13	44.8	16	55.2
USA	27	13.8	13	48.1	14	51.9
Vietnam	24	12.3	16	66.7	8	33.3
Philippines	21	10.7	7	33.3	14	66.7
Kenya	13	6.6	6	46.2	7	53.8
Nicaragua	10	5.1	5	50	5	50
Ghana	9	4.6	6	66.7	3	33.3
Cambodia	5	2.6	4	80	1	20
Tanzania	5	2.6	3	60	2	40
Nepal	4	2	3	75	1	25
Uganda	2	1	2	100	0	0
Guyana	2	1	2	100	0	0
Ecuador	2	1	2	100	0	0
Micronesia	1	0.5	1	100	0	0
Ivory Coast	1	0.5	0	0	1	100
Indonesia	1	0.5	0	0	1	100
Samoa	1	0.5	0	0	1	100
Nigeria	1	0.5	1	100	0	0
Eritrea	1	0.5	1	100	0	0
South Africa	1	0.5	0	0	1	100
Brazil	1	0.5	1	100	0	0
Total	**196**	**100**	**109**	**55.6**	**87**	**44.4**

On a regional basis, 84 of the program's long-term students (42.9%) are from Asia and the Pacific, 50 (25.5%) are from Latin America and the Caribbean, 33 (16.8%) are from Africa, and 29 (14.8%) are from the US and Pacific Islands. On a project basis, 31 (15.8%) are engaged under the North Carolina State University lead project, 30 (15.3%) under the Purdue University lead project, 25 (12.8%) under the University of Arizona lead project, 38 (19.4%) under the University of Michigan lead project, 23 (11.7%) are through the University of Connecticut lead project, 40 (20.4%) under the University of Hawaii at Hilo project, 2 (1%) under the Auburn University Project, 1 (0.5%) student under the OSU/MSU project, and 6 (3.1%) under the Program Management Office at Oregon State.

Degrees Sought by AquaFish CRSP Students

Student enrollment in degree programs currently supported under the AquaFish program are shown in Figure VIII-3: 73 students are seeking bachelor's degrees (37.3%), 98 students are seeking master's degrees (50%), and 21 students are seeking doctorates (10.7%). There are also 4 students seeking "other" degrees, which may include high school diplomas or certificates (2%).

Gender Distribution of Long-Term AquaFish CRSP Students

Overall the program supported the education of 87 women and 109 men during FY10, for a close-to 50% ratio (44.4% and 55.6%, respectively).

Among students seeking BS degrees, 42 are men (57.5%) and 31 are women (42.5%); among MS candidates, 52 (53.1%) are men and 46 (46.9%) are women; and among those seeking PhD's, 12 (57.1%) are men and 9 (42.9%) are women. Of the 4 students classified as "other" (high school or certificate students), 3 are men (75%) and 1 (25%) is a woman (Figure VIII-3).

Among the 84 long-term students from Asia, 43 (51.2%) were men and 41 (48.8%) were women. In Latin America and the Caribbean, 33 (66%) of the 50 students were men and 17 (34%) were women; in Africa 19 of the 33 were men (57.6%) and 14 (42.4%) were women, and among the 29 US and Pacific Islands students, 14 (48.3%) were men and 15 (51.7%) were women.

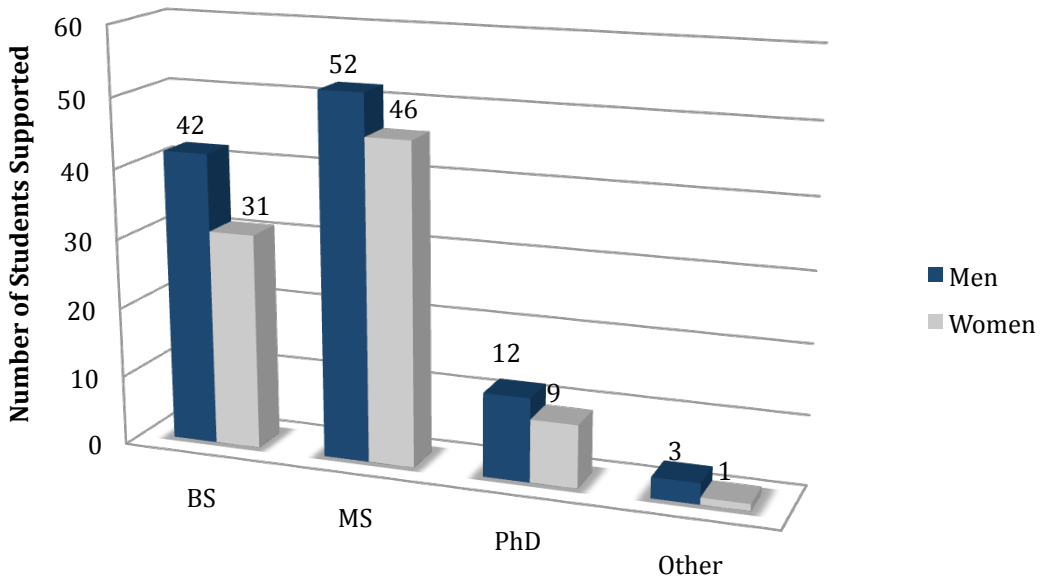


Figure VIII-3. Numbers of all AquaFish CRSP students seeking BS, MS, PhD, and "other" degrees supported during FY10, disaggregated by gender. Students classified as "other" are seeking high school diplomas, certificate students or post-docs.

With respect to students supported through each of the AquaFish projects, 17 of 31 students (54.8%) sponsored through the NCSU project are women, 14 of 30 students (46.7%) supported by the Purdue project are women, 6 of 25 students (24%) supported through the University of Arizona project are women, 8 of 23 students (34.8%) through the University of Connecticut project are women, 18 of 40 (45.0%) of those supported through the University of Hawaii at Hilo project are women, 17 of 38 (44.7%) of those sponsored through the University of Michigan project are women, 1 of 2 students (50%) supported through the Auburn University project is a woman, the 1 student under the Montana State project is a woman, and 5 of the 6 (83.3%) supported through the Oregon State University Program Management Office are women (Table VIII-3).

Table VIII-3. Numbers and percentages of long-term training participants who are women in AquaFish CRSP core projects and the Program Management Office.

US Lead Institution	Total Students	Number of Women	% Women
North Carolina State University	31	17	54.8
Purdue University	**30**	**14**	**46.7**
University of Arizona	**25**	**6**	**24**
University of Connecticut–Avery Point	**23**	**8**	**34.8**
University of Hawaii at Hilo	**40**	**18**	**45.0**
University of Michigan	**38**	**17**	**44.7**
Auburn University	**2**	**1**	**50**
Oregon State /Montana State	**1**	**1**	**100**
Program Management Office (OSU)	**6**	**5**	**83.3**
Total	**196**	**87**	**44.4**

Long-Term Training in IEHA Countries

Of the 33 students from African countries (19.5% of all long-term trainees), 25 (75.8%) were from IEHA countries (Kenya, Ghana, Uganda, and Nigeria). Among these 25 students, 15 (60%) were women and 10 (40%) were men. Additionally, 8 (32%) are seeking BS degrees, of which 3 (37.5%) are women and 5 (62.5%) are men, 14 (56%) are seeking MS degrees, of which 7 (50%) are women and 7 (50%) are men, and 3 (12%) are seeking PhD degrees, of which 3 are men (100%).

New Long-Term Students in FY09

This year 74 new CRSP-supported students were enrolled, all of whom were taken on by the eight core research projects. Of these 74 students, 45 were male (60.8%) and 29 were women (39.2%). Of these new students, there were 17 (23%) from Mexico, 11 from Vietnam (14.9%), 4 from Kenya (5.4%), 4 from the US (5.4%), 6 from Nicaragua (8.1%), 6 from China (8.1%), 2 from Guyana (2.7%), 11 from the Philippines (14.9%), 3 from Cambodia (4.1%), 2 from Nepal (2.7%), 2 from Uganda (2.7%), and 1 each from South Africa (1.4%), Ghana (1.4%), Brazil (1.4%), Somoa (1.4 %), Nigeria (1.4%), and Eritrea (1.4%). Eight (10.8%) of the new students were from IEHA countries. Thirteen new students were supported by the North Carolina State University project, 7 by the Purdue Project, 5 by the University of Arizona, 9 by the University of Connecticut-Avery Point, 27 by the University of Hawaii at Hilo, 12 by the University of Michigan project, and 1 by the Auburn project.

Long-Term Programs Completed in FY09

AquaFish CRSP-supported training for 20 students was completed during the reporting year. These students included 10 women (50%) and 10 men (50%). See table VIII-5 for details.

OUTCOMES AND IMPACTS OF AQUAFISH CAPACITY BUILDING EFFORTS

In its core research projects, the AquaFish CRSP has achieved a number of notable accomplishments in its capacity building efforts:

- Each of the eight core projects has fully developed the partnerships needed for collaborative work on capacity building. The three RCEs have also established additional linkages and partnerships with regional and international organizations and institutions.

- As of the end of this reporting year, a cumulative total of 273 long-term students have enrolled in long-term training programs since program inception. For FY10, 196 long-term students received CRSP support through the core projects and the Management Office. The majority of these FY10 students are Host Country nationals (161) studying in their home countries or the US. Of the 161 host country national students, 71 (44.1%) are women and 90 (55.9%) are men.

- Overall when combining all country data, the CRSP is nearly to the long-term training 50% target of women students. For this reporting period, women represent 44.4% of the cumulative student enrollment (87 women/196 total students). Adjusting the data for HC-only students, the gender ratios are similar with a cumulative enrollment of 44.1% for women.

- The gender data reflect the challenges of bringing women into aquaculture, particularly in countries such as Kenya and Mali where they have traditionally been involved mainly with post-harvest activities. The increasing role of women graduates in academic, entrepreneurial, and governmental positions as well as their visibility in trainings and through community and regional involvement is helping to influence the enrollment of women students in degree programs.

- Each of the eight core projects has a gender inclusivity strategy and a gender focused investigation for the *Implementation Plan 2009-2011*. This will help to improve opportunies for women in locations where women's participation in training activities has been lower.

- Short-term trainings are designed to integrate stakeholders at all levels, thereby removing barriers such as those between farmers/fishers and extension agents/fisheries officers. Trainings are also designed to empower trainees to "train" their counterparts. Some examples of the 25 short-term training events conducted by the core projects during FY10 are as follows:

    - 09QSD02UA (Mexico): The primary goals of this workshop on integrated aquaculture/agriculture were to describe the benefits and sustainability of using aquaculture effluents to irrigate and fertilize grain and vegetable crops. Aspects of plant nutrition, soil science, water chemistry, fish nutrition, fish husbandry, harvest techniques, and marketing were covered and a demonstration project in the village of Guerero was visited. The fish tanks and plumbing were examined and the suggested garden site was paced off and surveyed. Discussions focused on water and nutrient delivery, drainage, sun angles, shade problems, and harvest plans.

    - 09IND02UC (Vietnam): An on-site training course on snakehead breeding and weaning, including hatchery set up, broodstock development, feed formulation, and feed strategies for FARDeC staff/project assistants took place in Vietnam.

    - 09MNE02NC (Philippines): Through a series of workshops, women from two coastal villages in Tigbauan, Iloilo, and four coastal communities in Guimaras were trained on milkfish postharvest procedures such as de-boning. The workshops provided instructions on how to make value-added milkfish products in order to get better prices for the fish. This could be a stand-alone business opportunity or could be linked as a downstream activity in an integrated milkfish production system. To this end, women from the Guimaras communities also are being assisted in setting up a small business by linking up with a microfinance company as a development partner.

    - 09SFT03UA (Guyana): A three-day workshop was held at Bina Hill, near Annai, in Region 9. This workshop was directed towards the indigenous Amerindian community in the inland

region of Guyana, focusing on production of native species. The workshop included capture and feeding of broodstock, pond construction and maintenance, preparation of local ingredients for a fish diet, and formulation and manufacture of ingredients into a diet. Harvest, processing, and marketing of the locally grown fish to local, domestic, and even international markets were also discussed. The final two days of the workshop were spent discussing processing, shipping, and international markets for farmed fish and shrimp from Guyana to seafood markets in Trinidad and Florida. Representatives from many villages, who will serve as trainers to extend the information to their respective village members, were invited to attend the workshops.

CRSP CO-SPONSORED CONFERENCES AND EVENTS

The AquaFish CRSP continues to sponsor international and regional conferences and events at various aquaculture, fisheries, and aquatic resource management meetings. These conferences are of the utmost importance for the development of professional careers and for fostering long-term relationships based upon credible scientific capabilities, both among and between developed and developing countries. They provide a platform for sharing ideas, networking with world-class scientists, and publishing research findings. Students attending these conferences are able to stay connected and current in their field even after returning to their home countries to continue their professional careers. These efforts also increase the visibility of the program and represent an important component of the overall AquaFish CRSP dissemination strategy.

Several CRSP co-sponsored conferences, symposia, and meetings were organized and conducted during the reporting period. These targeted the international research community, bringing together researchers with common interests in aquaculture development for the poor, building the aquaculture industry in Africa, economics of fisheries and aquatic resources, and aquaculture and fisheries education. Highlights of these activities follow:

- The AquaFish CRSP ME organized and facilitated the AquaFish CRSP Annual Meeting, held in San Diego, CA, prior to the World Aquaculture Society's "Aquaculture 2010" conference (March 2010). US and Host Country partners, external evaluators, and AquaFish ME staff were in attendance. The meeting provided an opportunity to share research highlights, exchange ideas for regional integration of projects, discuss gender equality and training, and cover other AquaFish business.

- A full-day session at Aquaculture 2010, in San Diego, California, USA on 1-5 March 2010 brought together 26 presentations covering Asia, Africa, and South and Central America. The session's topic "Optimizing small-scale aquaculture for the poor: In Honor of Yang Yi" naturally drew presentations on CRSP research, but also drew good presentations on other international efforts. A capacity audience (approximately 100 scientists) came away with an indication of the breadth of aquaculture research and development underway in poorer countries. The session was organized by the CRSP Director.

- The Auburn University's CRSP project organized the Third Annual Fish Farmers Symposium and Trade Fair in partnership with the Walimi Fish Farmers Cooperative Society (WAFICOS) in Kampala, Uganda in January 2010. The theme was "Dealing with the Challenges of Building an Aquaculture Industry." An optional one-day field tour to aquaculture-related establishments included farms, feed mills and fish-net manufacturing plants. There were a total of about 158 participants to the symposium. The proceedings have been compiled into a CD that is being distributed locally in Uganda. The proceedings have been uploaded on the SARNISSA website (www.sarnissa.org) and on the AquaFish CRSP website.— 09BMA02AU

- The AquaFish CRSP co-sponsored this year's International Institute of Fisheries Economics & Trade (IIFET) conference, *"Economics of fish resources and aquatic ecosystems: balancing uses, balancing costs,"* held on 13-16 July 2010 in Montpellier, France. The conference brought together participants to focus on the theme of the multi-functionality of fisheries and aquatic ecosystems, with particular emphasis on the developing world.

- The International Symposium on Aquaculture and Fisheries Education (ISAFE) held in Bangkok, Thailand on 27-30 November 2009 was co-sponsored by the AquaFish CRSP. The symposium brought together educators and scientists around the theme of, "The Future of Aquaculture and Fisheries Education," to discuss emerging needs for aquaculture and fisheries education and to promote collaboration.

CRSP Co-Sponsored Events Underway

- AquaFish CRSP is also co-sponsoring TILAPIA 2010 in Kuala Lumpur, Malaysia on October 27-29, 2010 as of present date. This year's three-day event attracted a global audience of tilapia experts, from fish farmers and processors to importers/exporters and government officials to address issues of relevance to the industry, such as industry situation and outlook, production and processing, markets and marketing, and technological developments and related issues. In total, the conference attracted 240 delegates from 34 countries.

- The AquaFish CRSP ME will organize and facilitate the AquaFish CRSP Annual Meeting in Shanghai, China, prior to the 9AFAF conference (April 2011).

- The AquaFish CRSP is co-sponsoring the 9th Asian Fisheries and Aquaculture Forum (9AFAF) of the Asian Fisheries Society (AFS) to be held on 21-25 April 2011 in Shanghai, China. Additionally, the Director of AquaFish CRSP will serve on the scientific committee at this forum. This international forum will bring together leading aquaculture and fisheries scientists and key commercial stakeholders from all over the world to discuss important issues pertaining to sustainable aquatic resource production, utilization, and management in the Asia-Pacific.

- The AquaFish will co-sponsor the Ninth International Symposium on Tilapia in Aquaculture (9ISTA) on 22-25 April 2011. This will be the ninth of the highly successful series of symposia that have brought together tilapia biologists to review the latest discoveries in tilapia nutrition, physiology, reproductive biology, genetics, ecology, improvements in production systems, and other fields related to tilapia and their use in aquaculture. The symposium will have a special emphasis on best management practices, quality control, new product forms, international trade, and opening new markets for farmed tilapia products. ISTA 9 will be held in conjunction with the 9th Asian Fisheries and Aquaculture Forum and Fourth ISSESR.

- The International Institute of Fisheries Economics & Trade (IIFET) will hold its sixteenth biennial conference in Dar es Salaam, Tanzania in 2012. This event will bring together economists, fisheries managers, industry members, and representatives of international organizations to develop new areas of collaboration, understanding, and exchange on the economics of fisheries management, aquaculture development, seafood trade and related topics.

Table VIII-4. FY10 Short-term trainings for the eight core research projects

Project	Event Name	Investigation Code	Country	Start Date	End Date	Trainees Total	Trainees Women
NCSU	Women Training on Post-harvest (Value Addition) and Marketing of Milkfish1	09MNE02NC	Philippines	2010-4-16	2010-04-16	13	13
NCSU	Women Training on Post-harvest (Value Addition) and Marketing of Milkfish2	09MNE02NC	Philippines	2010-4-29	2010-04-29	15	15
UM	Sahar-Tilapia Polyculture Farmers Workshop	07BMA02UM	Nepal	2009-12-18	2009-12-18	41	16
UM	Alien-Indigenous Species Workshop-Vietnam2	07MNE03UM	Vietnam	2009-12-24	2009-12-24	30	5
UA	Native Gar and Cichlids Training	07IND02UA	Mexico	2009-10-06	2009-10-08	15	5
UA	Basic aquaculture workshop for the rural poor 1	09SFT03UA	Guyana	2010-08-05	2010-08-08	40	13
UA	Workshop for hatchery managers and Bioflocs	09QSD01UA	Mexico	2010-09-06	2010-09-10	35	17
UA	Integrated Aquaculture-Agriculture	09QSD01UA	Mexico	2010-08-13	2010-08-18	35	14
UHH	Mollusc Production BMPs Workshop-1	07BMA04UH	Mexico	2009-11-21	2009-11-21	15	3
UHH	Mollusc Production BMPs Workshop-2	07BMA04UH	Mexico	2009-12-05	2009-12-05	13	3
UHH	Requirements for commercialization and export of black cockles	09HHI01UH	Nicaragua	2010-03-27	2010-03-27	33	28
UHH	Requirements for food quality and safety in cockles	09HHI01UH	Nicaragua	2010-03-19	2010-03-19	28	25
AU	Watershed Workshop	09WIZ02AU	Uganda	2010-07-06	2010-07-07	10	4
UConn	Stakeholder Review Workshop	07TAP01UC	Cambodia	2009-12-04	2009-12-04	35	7
UConn	Final National Workshop	07MNE01UC	Cambodia	2009-12-28	2009-12-28	31	6
UConn	Alternative Feeds Workshop	07SFT01UC	Cambodia	2009-12-08	2009-12-08	30	5
UConn	Fish Feed Technology	07TAP01UC	Cambodia	2010-06-27	2010-06-27	30	12
UConn	On-site training on Snakehead breeding and weaning	09IND02UC	Vietnam	2010-06-14	2010-06-26	4	0
UConn	Log book/ fish measurement training	09TAP03UC	Cambodia	2010-06-26	2010-06-26	30	12
UConn	workshop/meeting with fermented fish paste processors	09FSV01UC	Cambodia	2010-06-14	2010-06-14	73	31
Purdue	Plant-Based Feed Farmers Training	07SFT06PU	Tanzania	2009-11-25	2009-11-26	15	6
Purdue	Post-Production Farmer's Workshop	07QSD02PU	Kenya	2009-11-09	2009-11-09	30	8
Purdue	Aquaculture and Environment workshop	07WIZ01PU	Ghana	2009-11-24	2009-11-25	56	8
Purdue	Farmer & Extension Training	07MER03PU	Tanzania	2009-11-25	2009-11-26	15	6
Purdue	Experimental design and analysis workshop	09IND06PU	Ghana	2010-7-28	2010-7-30	22	13
					Total FY10 Trainees	**694**	**275**

IX. SYNTHESIS

Oregon State University's vision for the AquaFish CRSP brings together highly creative and knowledgeable people in functional advisory groups. Advisory groups provide linkages to the broad global community engaged in aquaculture and fisheries development issues. This innovative structure evolved from past ACRSP structure, as originally envisioned by BIFAD (Board for International Food & Agricultural Development). A flexible structure allows a common organizational framework to emerge across all CRSPs as they are re-competed and re-organized. Commonalities can lead to cost-saving standardization and facilitated management by USAID, as well as amplification of benefits across focal areas and themes. Technical advisory groups (RCE and DTAP) have responsibility for synthesizing information across regions and themes. A Synthesis Project has responsibility for providing metadata analysis and broad evaluative syntheses.

DEVELOPMENT THEMES ADVISORY PANELS (DTAP)

DTAP provides technical advice on emerging issues and gaps in the portfolio from a thematic perspective. The four panels are aligned with the four themes in the AquaFish CRSP Program Description. Lead Coordinators of the thematic panels assist the ME in integrating cross-cutting needs identified by USAID, but add additional emphases on conserving biodiversity, preventing further degradation of aquatic ecosystem health, reducing poverty among small-scale farmers and fishers, maintaining and restoring capture fisheries productivity developing IPM strategies, improving soil-and-water quality, and developing biotechnology approaches cautiously. The DTAP can recommend policies for technical hot-topics, e.g., certification for organic standards, biotechnology applications, and toxics standards for fish consumption.

The following reports cover progress to date on accomplishments that are measured by the DTAP thematic impact indicators. Investigation reports on DTAP Indicators are included in *Monitoring & Evaluation* (Appendix 4, Tables 1 to 8).

DTAP A: Improved Health and Nutrition, Food Quality, and Food Safety of Fishery Products

Submitted by Maria Haws (University of Hawai'i at Hilo), DTAP A Lead Coordinator

Up to 50% of the world's seafood supply may be lost or decreased in value due to poor production and post-harvest practices. Aquaculture now accounts for at least 50% of the world's aquatic products supplies. There is also a strong relationship between environmental quality, aquaculture practices, and product quality and safety. Additionally, some of the world's most vulnerable demographic segments are particularly dependent upon aquaculture and fisheries for food. These same groups are also the most vulnerable to food borne illnesses and economic losses when products are affected by decomposition or contamination or harbor pathogens. Improving the quality, safety, and availability of aquaculture products is crucial for food security, assuring that aquatic products are produced in a sustainable and safe manner, and increasing economic benefits to all stakeholders.

Several of the CRSP projects have made significant advances towards addressing specific issues related to this theme. Utilization of by-catch and low-value fisheries products is a global issue, particularly when considered in the context of aquaculture, which depends on fishmeal or whole, low-value fish as feed, particularly for carnivorous species. The University of Connecticut-led project in Vietnam and Cambodia has made significant advances in researching the dynamics of the use of low-value fish and developing integrated aquaculture and fishery management plans to prevent overexploitation of this fishery as well as

processing practices to ensure improved quality and safety of fish paste and fish sauce products made from these fish. This work not only improves the long-term sustainability of the Mekong River Basin aquaculture and fisheries, but also provides economic benefits for a wide range of stakeholders.

Steady progress is being made on other fronts related to food quality and safety. In Mexico and Nicaragua, CRSP researchers continue to develop native species of oysters and cockles, which is linked to improvements in shellfish sanitation, bivalve fisheries management, and increased use of native species as opposed to introduced species. This year also saw a break through in the first spawning and rearing of the "chame" fish (*Dormitator latifrons*), a fish low on the trophic chain that is a popular eating fish for poor communities throughout LAC. Additional progress is being made in improving shrimp and prawn culture by the University of Michigan-led project. Good aquaculture practices and eco-certification of shrimp are being supported in China; food safety and quality are key outcomes of this work. Development of polyculture technology for giant freshwater prawns (*Macrobrachium rosenbergii*) and mola (*Amblypharyngodon mola*), an indigenous fish is a target in Bangladesh. North Carolina State University is working to improve seaweed culture and production of seaweed products in Indonesia and the Philippines and to train women processors of milkfish (*Chanos chanos*) in value-added deboning and marinating techniques. Strengthening local capability to produce high quality, local seaweed, agar products, and processed milkfish products provides healthy foods, as well as increasing direct revenues to farmers and processors, particularly women.

DTAP B: Income Generation for Small-Scale Fishers and Farmers

Submitted by Kwamena Quagrainie (Purdue University), DTAP B Lead Coordinator

AquaFish CRSP FY2010 project work involved improvements in technology, production practices, and management targeted at rural communities. The objective was to enhance the production of fish and shellfish through access to production practices and technologies that help fish farmers and rural communities with limited resources to maximize productivity and quality of life. The technologies developed or introduced related to the whole value chain, from input supply to post harvest technologies.

One focus area was the adoption of and improvements in cage aquaculture technology. Cage aquaculture in ponds, lakes and reservoirs for fish production is an alternative fish production technology that provides economic opportunities for limited resource farmers, landless men and women in rural communities. The advantages of cage aquaculture include low capital outlay, use of existing water bodies, and scalable production from subsistence level to commercial ventures. The projects also addressed technological efficiencies relating to feed utilization. Adoption of this technology would enhance the level of investments and economic growth in rural economies.

Another focus area involved innovative technologies and production practices to diversify fish production, reduce income variability, and minimize production risks through integrated production systems and polyculture systems. The projects introduced high-valued fish species into existing culture systems as well as domesticating native species for commercial production to supplement farm income. Integration of production systems helped to decrease fishing pressure on natural water systems. Adoption of polyculture practices and integrated systems ensured sustainable aquaculture systems throughout the developing world. An example of diversification of systems was the integration of pond-based recirculating aquaculture system (RAS) and pond-based cage systems with solid waste removal and water quality controls. Aquaponics technology integrating fish production with agricultural production for effective utilization of pond wastes was another example of technologies introduced.

On the lower end of the value chain involving input supply, technologies were introduced on manufacturing specifications for fish feed that ensure pellet durability and water stability. Feeding strategies that can lower costs by reducing feed amount and replacing fishmeal with more sustainable protein sources were also being tested. Feed costs account for a significant portion of the cost of production. Thus, minimizing feed wastage through new feed technologies ensures efficient feed

utilization.

Post-harvest technologies are essential parts of adding value to farm production to enhance income levels and economic growth in rural economies. New post-harvest technologies focused on seaweed and milkfish processing. For seaweed, poor fish farmers were trained in improved drying methods using racks. Women were taught value-added processing techniques for using agar to making candy and desserts and for deboning and marinating milkfish.

DTAP C: Environmental Management for Sustainable Aquatic Resources Use

Submitted by Jim Diana (University of Michigan), DTAP C Lead Coordinator

The AquaFish CRSP has two goals that relate to sustainable resource use. The first goal is to develop sustainable end user aquaculture and fisheries systems to increase productivity, enhance trade, and contribute to responsible resource management. The second goal is to increase Host Country capacity and productivity and contribute to national food security income generation and market access. Many of the projects in the AquaFish CRSP have substantially addressed these goals.

Several of our research projects have focused on control of effluent and solid waste emanating from fish culture systems. We have evaluated performance of pond-based recirculating aquaculture systems in outdoor and indoor systems. Both are targeted on systems using zero exchange to eliminate effluent discharge. Both remain experimental, but activities in this area are focused on improved techniques for effluent retention. Similarly, projects evaluating integrated polyculture for milkfish will reduce the waste load and improve feeding efficiency, since integrated polyculture utilizes natural as well as artificial feeds and combinations of species to improve nutrient retention. An aquaponics system is also being tested to reduce the ecological footprint by utilizing nutrients from tilapia tanks to grow vegetables. An improved cage project focuses both on recapturing wastes from cage culture utilizing a sediment trap and utilization of waste feed and fecal matter by filter-feeding fish surrounding the cages. Finally, evaluation of many different culture techniques is being conducted in a project determining good practices in eco-certification of shrimp culture by comparing different culture systems in terms of their most effective energy use, nutrient dynamics, and effluent quality. All of these projects are focused on the improved control of solid and dissolved matter resulting from aquaculture systems. Over 200 hectare equivalents of fish farming systems have been improved by these various interventions.

Another major area of environmental management has to do with the use of native species in culture systems. Development of sahar polyculture techniques will not only improve tilapia production but will also produce sahar for both restocking of natural waters as well as for harvesting as an income-generating crop. The production of oyster seed in a hatchery system will eliminate collection of seed from the wild and therefore enhance wild reproduction of native oysters. Farmed snakehead production should relieve pressure on wild snakehead populations. The selective breeding of cichlids and snook will enhance their use in aquaculture and reduce the threat on wild stocks by seed collection. Development of integrated management plan for aquaculture and capture fisheries in the Mekong River Basin will protect the small indigenous species fishery on which the rural poor depend for food while protecting the overall biodiversity of the regional fisheries. Evaluating effects of stocked fish in reservoirs will help to understand their impact on indigenous species and define an appropriate role for stocking in these reservoirs in the future. Similarly, knowledge of the expansion of red swamp crayfish will give a better model of the threats that aquaculture and invasive species pose to native fauna in China and elsewhere.

The AquaFish CRSP has had a substantial portfolio of research in environmental performance. This research is positively affecting local citizens through workshops provided to extend the results of our techniques, and through publications that promote more sustainable aquaculture systems to be used in aquaculture extension.

DTAP D: Enhanced Trade Opportunities for Global Fishery Markets

Submitted by Robert Pomeroy (University of Connecticut–Avery Point), DTAP D Lead Coordinator

In FY2010, development of new domestic and international markets for aquatic products has progressed for six aquatic products — sahar, tilapia, snakehead, fish paste, shrimp, and prawn. In Nepal, sahar (*Tor putitora*) is being tested in a polyculture system and should result soon in a farmed product being available for sale. In the Philippines, an analysis of supply chain efficiency for tilapia for domestic and international markets has led to new market opportunities and recommendations for best management practices for tilapia, which will favorably impact the supply chain. In China, research on the evaluation of shrimp impacts and practices should aid in the eco-certification of shrimp cultured under best practices and lead to market development. In Bangladesh, work on prawn culture has led to the development of prawn from monosex-male polyculture systems (prawn-mola) that should open up export markets. Work on chame (*Dormitator latifrons*) spawning and larval rearing in Mexico, will lead to market development of fingerlings of this important native species. In Cambodia's Mekong River Basin, small-sized fish are processed into a fish paste product called *prahok*. Analysis of processing practices has led to recommended best management practices. As processors adopt these new practices, markets for fermented fish paste will expand both in Cambodia and in other countries in the region.

In Cambodia, snakehead aquaculture of has been banned by the government due to decreasing stocks from capture of the fish from the wild and to the over-exploitation of small-size fish for feed. Work is underway to develop a snakehead hatchery, including major facilities for broodstock ponds, nursery ponds, breeding cement tanks, hatching tanks, and moina production at the Freshwater Aquaculture Research & Development Center (FARDeC: Cambodia). Success has been achieved in breeding indigenous species of snakehead at FARDeC. If the breeding program is successful and establishes a fingerling supply, and in combination with the new snakehead feed that the project has developed, a request will be made to government to allow snakehead aquaculture. This step would lead to the opening of new markets for farmed snakehead from Cambodia. In Vietnam where snakehead aquaculture is currently allowed, a value chain analysis is underway to identify solutions for expanding markets for farmed snakehead both domestically and internationally.

Work continues on the development of a number of new aquatic products for human consumption:

- In Bangladesh, work on best management practices for giant river prawn culture in a monosex-male polyculture system (prawn-mola) will lead to prawn being available for export markets and mola available for household consumption.
- In Cambodia, locally farmed snakehead may become available for human consumption for the first time in years if the breeding research can successfully initiate a snakehead fingerling program, and in combination with the new CRSP snakehead feed, lead the Cambodian government to agree to allow to lift the ban on snakehead aquaculture.
- In China, work to support good aquaculture practices and certification of shrimp aquaculture is leading the way toward eco-certified shrimp.
- In Nepal, sahar (*Tor putitora*) is being tested in a polyculture system and will result soon in a new farmed product which will reduce fishing pressures on wild sahar.
- In The Philippines, an integrated multitrophic polyculture (milkfish-seaweed-sea cucumber) system will lead to a more sustainable source of milkfish along with new seaweed and sea cucumber products.
- In Mexico and Nicaragua, the development of native oyster (Mexico) and black cockle (Nicaragua), hatchery-produced seed sources will lead to a more reliable flow of these shellfish products available for market.
- In Mexico, current work on chame (*Dormitator latifrons*) spawning and larval rearing will lead to the potential development of a farmed chame product that will be an important food source for the poor.
- In Cambodia, development of best management practices for processed fermented fish paste

and fish sauce made from small-size fish will improve food quality and safety, leading to increased product value and income potential for the small-scale processors.
- In The Philippines and Indonesia, the demonstration of and training on sustainable seaweed culture will lead to more valuable processed seaweed products such as candy and desserts made from agar.
- In The Philippines, CRSP training in value-adding techniques (deboning and marinating milkfish) for women processors will raise their income potential while making these value-added products available to markets.

REGIONAL CENTERS OF EXCELLENCE (RCE)

RCEs provide technical advice on emerging issues and gaps in the portfolio from a regional perspective. Centers will develop useful materials for Missions, other regional stakeholders and end-users, and gauge opportunities for collaboration based on regional or national needs. Three centers have been formed and each coordinates activities within a specified region: Asia, Africa, and Latin America and the Caribbean (LAC). The center for Africa will also coordinate, synthesize, and report on activities related to IEHA goals. Additional RCEs may be added depending on the portfolio of projects funded through Associate Awards. Lead Coordinators (one for each center) will take an active role in integrating Associate Award partners into the portfolio and in assisting in the management of any Associate Awards that fall under its purview. Lead coordinators will also assist the ME in cases where a screening process is required in advance of an Initial Environmental Examination.

RCE–Africa Annual Report

by Charles Ngugi (Moi University, Kenya), Lead Coordinator

Introduction

The Regional Center of Excellence (RCE-Africa) continued to perform its role in building community among all CRSP participants; identify potential additional partnerships with the public and private sector, NGOs, USAID, and others; and bridge the knowledge gap from local-regional perspectives to global development outcomes.

RCE has facilitated Networking with global scientists interested in African aquaculture through SARNISSA, WAS, NEPAD and ANAF meetings and conferences. Specific approaches included:
- Personal contacts/relationships;
- HC PI networking in each respective country;
- AquaFish CRSP matchmaking;
- Collaborative research and institutional linkage.

Rural Community Benefits Stemming from RCE activities: CRSP has brought new technologies to rural communities and helped to build support structure for aquaculture extension. Farmers adopting CRSP technologies and management practices designed for their local conditions in Ghana, Kenya, Mali, Uganda and Tanzania have already begun to experience dramatic fish yield increase. In Kenya, for example, AquaFish has contributed to increased production from 1,100 metric tons in 2006 to 4,500 metric tons reported in 2007. Through our continued effort we envisage that pond fish production will rise to over 7,500 metric tons in 2009. In Mali production per unit area has risen from 1,500 metric tons to over 6,500 metric tons per hectare per year. RCE involvement goes beyond the usual project activities and leverage on additional work that helps to raise awareness and foster collaborations among host country professionals, policy makers and extension agents among other key stakeholders.

The RCE has also been instrumental in setting up forward working interpretations to facilitate various aquaculture tasks in the region particularly collaborating with ANAF on special programs for aquaculture development in Africa. Through the RCE, AquaFish CRSP has supported the setting up of the ANAF regional office in Jinja. The RCE has also been a key player in ANAF by attending and participating in

ANAF annual meetings, most recently the meeting held in Jinja, Uganda in June 2010.

Activities supporting involvement of women

The RCE has made every effort to address gender integration within the planned scope of work through training and involvement in project implementation. Presently, we factor in procedures for monitoring and evaluating gender integration in AquaFish projects in the region; I relay this information to all host country PIs within the region.

Women generally play a major role in the production, processing and marketing of fish and fish products in Africa. This realization has brought about a growing concern about gender issues in aquaculture with governments and developing organizations focusing attention on improving the condition of women, especially those in the rural and semi-urban areas. One of the broad strategies of CRSP activities is to implement intervention strategies that assist and improve the lives of women relating to equality and empowerment. A better integration of women is in value chain of marketed fish products leading to improved economic wellbeing and help overcome inequalities and poverty for women.

In our endeavour to accomplish this realization, CRSP work in Kenya and Tanzania has established excellent working relationships with private operations and NGOs such as Women in the Fishing Industry Programme (WIFIP) working in the areas of fisheries, aquaculture and the environment. WIFIP is a not-for-profit, non-Governmental organization working towards empowerment of marginalized communities with a focus on women. WIFIP is based in Western, Kenya and has been working on education and training of women and other vulnerable groups in the fishing industry for the last eight years. The key program interventions focus on socio–economic and sustainable development through development and delivery of contextually distance-learning programmes particularly packaged as educational radio and audio programs. Their collaboration has contributed to the successful innovations of ACRSP and AquaFish CRSP work and in Kenya. It has resulted in the government funding construction of over 35,000 fish ponds in 160 constituencies throughout the country.

We will continue and extend these partnerships such as Women in the Fishing Industry Programme (WIFIP) by involving women in our activities through workshops and training. We anticipate that some activities will focus solely upon gender-related issues in the context of aquaculture and fisheries development. HC PIs are reminded that they need to consider effects of specific activities on gender and ensure that any possible negative effects are mitigated. We have therefore made deliberate attempts to promote the equal participation of women in formal and informal education and training opportunities provided through the AquaFish CRSP in the region.

Photo in Kenya by Kwanena Quagrainie

Assessment of opportunities and gaps in technology
by Charles Ngugi

Technology transfer is frequently more efficient if end-users can see firsthand the results of novel technologies and management strategies. In its simplest form, a technology gap is where the motivation of innovators and consumers are out of synch. Resulting from this, the consumer adoption of technology lags behind the availability of innovations. Through Collaborative research in Aquaculture, CRSP has endeavored to work with all stakeholders in Africa. In the region, aquaculture has been promoted through interrelated programs in education, training research and outreach. In recognition of the need for technical skills in the region, there has been a major support of education at all levels.

The present approach to aquaculture in Africa has been to assist member countries to investigate aspects of aquaculture development, and to test and demonstrate methods and approaches that are socially and economically viable, as well as technically feasible. The program's results have been prominent, especially with the outputs in extension methodology development and application in Nigeria, Ghana, Kenya, Mali, Malawi Uganda, Tanzania and Zambia, among a host of other countries in Africa.

Aquaculture was introduced to a large part of the African Continent five decades ago as an innovation that would improve the economic and nutritional well-being of producers. An example is the former Belgian Congo where fish ponds were built in mining areas to produce high protein to feed miners. Fish ponds were foreseen as an ideal component of integrated farming systems, a fish crop grown using by-products from the home and farm. Indeed, from Kenya to Sierra Leone thousands of ponds were built, many only to be abandoned after a few years of meager production. "Failures of some of the ill-conceived programs during the early part of the century have continued to remain a major constraint in convincing the farmers and investors of the economic viability of aquaculture. Insufficient appreciation of the basic requirements of an effective aquaculture development program and consequent inadequacy of governmental support activities, have handicapped the orderly and rapid development of the industry. Ineffective or non-existent policies combined with inadequate infrastructure, poor extension support and unavailability of inputs (including seed, feed and credit) are cited as major problem areas.

Fingerling production is major challenge with several important dimensions: quantity of seed produced, quality of seed produced, cost of seed produced and means of seed distribution to farmers. A recurring weakness, which places sustainability of aquaculture in jeopardy, is the fact that rural freshwater aquaculture in most African countries is still dependent upon government support for seed. Hundreds of fish stations have been built across the continent mainly with donor support (examples exist in Nigeria, Ghana, Kenya, Cameroon, Côte d'Ivoire, Uganda, Tanzania, Zambia and Malawi). Some of these government stations are large and old, while others are small units of only a few hundred square meters. However, regardless of size, they impose demands on government. In today's Aquaculture climate and the need to develop sustainable technologies, the validity of these government run stations must be reassessed.

It can be argued that fingerling and food fish supplies should come from the private sector because private farms make the best demonstrations. Thus, with a more channeled vision, theses stations should be seen as being justified only for training and research.

Poor quality seed means disappointing harvests and abandonment of the fish pond by farmers. Although a wide variety of fish have been tried in culture environments, the most common pond-raised fish in the region are tilapias (i.e. various fish from the genera *Oreochromis* and Tilapia), common carp (*Cyprinus carpio*) and catfishes (i.e. *Clarias*, *Heterobranchus* or their hybrid). Initially both the carp and catfish were victims of the scarcity syndrome, both requiring extraordinary hatchery techniques. Fortunately, today it is now possible to produce *Clarias* seed

Continued on page 138

Continued from page 137

using farmer-friendly techniques. Carp in Cameroon and Rwanda are spawning naturally while *Clarias* fingerlings are being produced by farmers in Kenya, Uganda and Mali.

In spite of this, tilapia remains the most frequently cultured fish, and the fish about which more complaints are made with respect to small harvest size, stunting, etc. To attempt to address this problem, a variety of techniques have been used in countries around the Region, including Ghana, Côte d'Ivoire and Zambia, to raise all male tilapia, which grow to a larger size (than females). Hand sexing to obtain an all-male stock is the most user-friendly method. In Some countries such as Kenya, Ghana, Nigeria and Uganda, sex reversal using methyl-testosterone is employed, but this requires access to the hormone and slightly higher technology.

In view of the lack of reliable supplies of fish feeds especially extruded or floating pellets, most small-scale semi-intensive systems have relied upon natural food (e.g., zoo- and phytoplankton) production enhanced with fertilization (most often organic fertilizers) and supplemented by farm and household by-products (e.g. kitchen wastes, etc.). Such systems have demonstrated their productivity when farmers use an adequate variety of inputs in sufficient quantity. However, the promotion of semi-intensive systems does not directly address the issue of feed. In numerous countries formulation of more complete fish feeds has been attempted. Currently countries such as Kenya (Sigma Feeds) and Uganda (Ugachick) have witnessed feed companies setting up extruders. More commercially produced feeds are available in some countries (e.g. Nigeria, South Africa, Côte d'Ivoire and Zimbabwe) but these require the country's agricultural sector to produce large quantities of by-products that can be available for feed fabrication. However, many countries in Africa do not have such supplies available. Yet, as one looks to the future, the current aquaculture forecasts mean that more and more countries should provide opportunities for more fish feed production at an affordable price.

The increase in the value of fish combined with increased production on both global and regional scales implies a continued sustained demand for fish and fish products. This is quite expected, particularly for Africa where population growth rate far exceeds the rate of food production implying that aquaculture still has the potential for further development of aquaculture. In the recent past, the accelerating pace of growth of aquaculture in sub-Saharan Africa has received much positive appraisal because of the potential of the industry to contribute to development and food security by providing jobs (for the youth) and supplementing wild fish protein. In Kenya for example, the government has recognized aquaculture as a sub-sector with great potential to contribute towards the national economy. It is for this reason that the Government of Kenya under the Economic Stimulus Programme (ESP) developed an aquaculture support program to fast track development of the sub-sector. The first phase got a huge allocation of Ksh 1.1 billion (($14.7m) for the Kenya aquaculture support program in the 2009-2010, followed by a second phase in 2010-2011 financial years were with an allocation of Ksh. 2.7 billion ($35m). Similar attentions although at different scale of funding are occurring in Malawi, Ghana, Uganda, and Mali among a host of other African countries.

Leveraged activities
In Mali USAID mission funded an Associate Award project on "Aquatic Resource use and Conservation for Sustainable Fresh water Aquaculture and Fisheries," which partnered with Kenya in a south-south approach to rapid development and use of technology. In Kenya, we have worked with the USAID Mission through the Kenya Business Development Services (KBDS) and recent discussions on future collaboration were held during the visit by Dr. Kwamena Quagrainie in June 2009 and a second visit April 15, 2010 at the USAID mission offices in Gigiri, Nairobi, Kenya.

Developed Proposals Submitted for Research and Leverage:

- Kenya and South Africa linked with Brazil to write a proposal in August 2008. Funds for this project have been released and activities have begun. The RCE coordinator was invited to give a key note address at the annual aquaculture conference in Brazil
- Research-into-Use Programme- Call for 'Best Bets' Concept Notes: Agricultural Development in East and Central Africa. We have received funding for a pilot project on Setting up Aquashop in western Kenya.
- Basic Research to facilitate Expansion of Aquaculture in Developing (BREAD) regions of Brazil and Kenya using indigenous and local resources was submitted as a proposal to NSF/Gates Foundation
- ASARECA: a proposal for enhancing a fish farmer–led enterprise for sustainable productivity and livelihoods in East Africa was submitted but was not funded

RCE Contacts in Ghana, Kenya, Mali, Uganda and Tanzania
The Lead Coordinator has established links and contacts with senior government officers in these countries:

- In Ghana: we are working with FAO Africa Representative John Moehl on information exchange.
- In Kenya: we are in close collaboration with The Ministry of Fisheries Development and have been invited to several meetings to discuss the Aquaculture stimulus programme and the Aquaculture development plan
- In Tanzania: the Assistant Director of Fisheries member of ANAF attended the meeting in Jinja and I linked him to FAO and SARNISSA
- In Uganda: we have established linkage with the Kajanssi Research Centre and the Uganda Commissioner for Fisheries who attended the ANAF meeting in Jinja.

Involvement in Regional Meetings
Regional Meeting: Aquaculture Network for Africa (ANAF) meeting (Jinja, Uganda)
Charles attended an ANAF meeting organized by John Moehl in Jinja at the beginning of July, which was planned to discuss and see whether SARNISSA and ANAF could merge into one overall network. There have been a number of African aquaculture, fisheries, policy level, etc. networks set up over the last 3-5 years with some progressing further than others in terms of impacts and results whilst there has also been a certain level of replication in what each was trying to achieve. William Leschen had been having discussions with John Moehl since inviting him and Sloans Chimatiro to our SARNISSA annual meeting in Malawi in Feb 2010 (the RCE attended) where the idea of a merger was first broached. After a fairly lively discussion, at the Jinja meeting, we came to an agreement that ANAF and SARNISSA should try to merge into one overall network. During the negotiations on this, we both agreed that SARNISSA should keep its own identity and brand — within terms of IT, information sharing, the websites, the discussion fora, the cross over between French- and English-speaking SSA aquaculture, etc. SARNISSA would retain all of these roles whilst ANAF would work more within a policy-level role as it has done in the past and also going on to develop a training education-based programme.

More Specifically ANAF would focus on prioritized areas addressing the greatest perceived needs within SSA development such as fish farm management, training, outreach, seed production and hatchery management, collaboration with local institution in developing university and college curricula in order to give students more of the skills required for working in commercial or sustainable aquaculture – rather

than going on to work for the government in research or administration. In the same vein assist in developing on farm internship programmes, and identifying and strengthening in SSA context "Centres of Excellence" for specific areas e.g. fish genetics, fish propagation, reproduction, nutrition, aquatic animal health etc.

Networking

1. Quarterly Networking visits held in Bunda, Malawi

Charles attended the SARNISSA Stakeholders Workshop held on 10-11 February 2009 in Lilongwe, Malawi. The objective of the annual SARNISSA Stakeholders Workshop was to build research coalitions among public research and private sector producers to develop fundable programs of action research around key technological problems facing the aquaculture sector in sub-Saharan Africa. This was the second workshop having had the first such workshop, in Cameroon in 2008, which established partnerships to work on feeds in West Africa, periurban aquaculture production systems in the DR Congo and women's freshwater prawn farming in Cameroon.

Each of these teams has evolved since the 2008 Yaoundé, Cameroon meeting through cross-site visits and teambuilding exercises and is currently developing research grant proposals. The Lilongwe meeting brought together stakeholders from Eastern and Southern Africa to develop similar programs of work. The major output was a group of concept notes for funding to regional, collaborative, public-private research partnerships. In addition, SARNISSA is developed a sustainability plan that would build it firmly into the evolving institutional framework within the sub-Region.

We also discussed collaboration with NEPAD and ANAF and how these might engage with SARNISSA. A second important output of the meeting was developing a framework for further consideration, development and presentation to the Committee for the Inland Fisheries and Aquaculture of Africa (CIFAA) in their next meeting. During this meeting, we appreciated with pride SARNISSA's Achievements, outputs, challenges and way forward into the final year. We reviewed and discussed performance of each work package and also monitoring of project impacts. Charles as RCE Lead Coordinator plays a key role in SARNISSA and provides a vital link with AquaFish CRSP.

2. Fostering Linkages and Collaboration

Host Country decision makers were engaged so that aquaculture and fisheries policies would incorporate relevant research findings. Charles received invitations to participate in local stakeholder meetings and provided input on research directions while also accessing up-to-date information on research and outreach activities from government agencies and other stakeholders. Within this period, the RCE helped HC PIs establish linkages with, USAID country Missions, (such as in Ghana, Mali, Uganda and Kenya), FAO mission and region offices, NEPAD/COMESA, ANAF, and SARNISSA among other stakeholders.

The RCE has through SARNISSA established contacts with over 1,500 stakeholders who are enrolled members of SARNISSA. The partners within SARNISSA are pleased with what has been achieved over the last two years – we can still do much more – and in retrospect and analyses put this down to essentially having very clear and specific objectives – and associated activities – right from the proposal stage of the project – clearly knowing what we wanted to do. As William Leschen put it, we wished to create an information sharing network with materials and information relevant to African users, a community of individual members from a wide stakeholder base, and then to encourage and bring about sharing and potential collaborations between the different members towards positive change in African aquaculture.

3. Meeting with Feed Manufacturers

In April 2009, I visited Ugachick Factory in Uganda and held discussion with the owner on the possibilities of Ugachick supplying extruded feed to Kenya fish farmers. This new extrusion line began in July 2008 when the first equipment order was placed. Installation began in April 2009 and was completed along with several other feed mill additions by November 2009. A small trial was run in November but

the real testing began in January. Following more recent data on input quality, the formulation was altered and commercial production began towards the end of January 2010. Farmers have already begun purchasing the feed. Ugachick feed is now available to Kenya farmers and is being distributed by the Ministry of Fisheries Development under the Economic Stimulus programme. Inquiries for sales can be sent to: ugachick@infocom.co.ug

In November 2009, Karen Veverica and I visited Sigma Feed factory located in Nairobi to assess the potential for supply of extruded feeds that Sigma planned to sell to fish farmers in Kenya.

In yet another attempt to assist fish farmers source quality feeds and enhance pond fish growth performance, I visited Unga Feed Factory in Nakuru in June 2010. I had a discussion with management regarding need for the company to diversify into fish feed production. They informed me that in 1980s through 1990s they were producing trout pellets but due to reduced demand, they stopped producing fish feeds. They assured me however that they would consider holding a discussion with the Minister for Fisheries development so as to explore possibilities of making extruded feeds for the economic stimulus programme.

4. RCE Linkage with DFID/ Farm Africa RIU Project

Research-into- Use (RIUP) is a DFID funded programme aimed at catalysing agricultural innovation as a follow-up to DFID's £220m investment in the Renewable Natural Resources Research Strategy (RNRRS). It represents a shift in emphasis away from generating new knowledge and towards ensuring that existing research with potential is promoted and scaled up successfully to achieve lasting development impact.

The implementing team is comprised of representatives from Natural Resources International Limited (England), Farm Africa (UK), University of Stirling (Scotland), Kenyatta University (CRSP), and Imani Development (East Africa). This team is collaborating with Ministry of Fisheries Development and Women in Fishing Industry (WIFIP).

The Aquaculture Research into Use project aims to build services by sharing the Best Practice and by supporting policy. This is an initiative that will build aquaculture development services through Aqua Shops. It is intended for the Aquashops to be hubs for commercial and small-scale fish farmers to conveniently access aquaculture inputs, technical support and links to markets. The initiative will also share best practices in aquaculture through the development and provision of packages of information essential to profitable and sustainable aquaculture enterprises. It proposes to build a business in Western Kenya that refines and actively replicates this Aqua Shop model and develops a wide network of franchised outlets delivering a range of affordable, quality-assured products and services to farmers interested to expand their livelihood options to include fish farming.

5. The Kenya Farmers Helpline

Recently, a donor-funded extensive research study was carried out which aimed at establishing the availability of information sources for Small Holder Farmers (SHFs) in Kenya and how the information is accessed. Findings from the study show that the farmers have a range of sources but which are not readily available and not always dependable. As a result of these findings, KenCall leveraged its technical and customer service management expertise to launch the revolutionary Kenya Farmers' Helpline – Huduma Kwa Wakulima, a unique and innovative service that aims to provide agricultural and horticultural information, advice and support over the phone to small holder farmers who are living on or around the subsistence level.

KenCall is a new concept in Kenya. It is the largest contact center operating globally and providing call center and Business Process Outsourcing (BPO) services to organizations worldwide. KenCall offers unrivalled experience in customer care, telesales, technical support, customer acquisition, web chat services and BPO. Its business is built upon world-class technology infrastructure and operations.

USAID Mission Visits

1. First visit with the USAID Mission in Nairobi
We had the first USAID mission visit in June 2010. During this visit attended by Kwamena Quagrainie (US PI – also referred to as DTAP), John Bower on a consultancy with USAID Washington and Charles Ngugi met and discussed AquaFish CRSP involvement in Africa. We briefed the USAID mission on the projects that were being implemented and also thanked them for finding time to review CRSP proposals sent to them for comments.

Since then, we have made an attempt to inform USAID personnel in Kenya and Mali on the option to receive AquaFish CRSP publications, including *Aquanews*, Annual Administrative and Technical Reports, manuals, fact sheets, etc. to keep the Mission properly informed of AquaFish CRSP activities. The AquaFish USAID personnel were also invited to participate in planning and assessment meetings to remain completely informed of progress and constraints facing the Project.

2. Second visit with the USAID Mission in Nairobi
During my second visit, I was accompanied by Mrs Nancy Gitonga of African Union (AU) on 15 April 2010. We held a very successful meeting with Mr. Phares Ratego. The meeting discussions are summarized below:

AU-IBAR and Fisheries
Mrs. Gitonga gave a brief summary of the reason for the meeting, which was basically to establish collaboration mechanisms with USAID to expedite aquaculture development in Africa.

The Strategic Partnership for Sustainable Investment Fund (SPFIF) project is housed by AU-IBAR, which is an AUC regional office that deals with annual resources issues in Africa. The SPFIF project development included elaborate stakeholders' consultation process. As a partnership initiative the SPFIF is designed to facilitate sustainable fisheries management in the large marine ecosystems. The project through the RAC Secretariat thus endeavors to forge collaborators and partnerships with institutions and programmes and therefore the main reason for this meeting is to discuss on fisheries areas for collaboration between AU and USAID.

It is important to note that the AU has very little information on donor-funded projects that occur in Africa because the reporting of the projects' progress and outcomes is direct to donors. This needs to change and the process can be expedited through development of a collaboration mechanism, coordinated by AUC.

It is important to develop synergies in aquaculture and therefore due to the role that the CRSP has played in the continent, through USAID funding, AU envisaged that there is need for projects' coordination and information sharing. Fortunately, the RCE provides a very good avenue for aquaculture networks and information sharing.

Some information was given on the ongoing Economic Stimulus Package where Kenya government is giving 1.1 billion Kenya Shillings for aquaculture development. It is a good step forward towards development of aquaculture for government of Kenya to recognize sub-sector and give it so much prominence as one of the areas that can expedite economic development. This development is based on the confidence that the sub-sector can perform well with proper inputs and marketing systems.

Mr. Phares Ratego gave a brief insight on the USAID activity planning processes:
The USAID mission develops strategies that state what they want to do for economic growth through selected sectors. This is long term and general. An operational plan for the year with specific allocated and locked in the activities. This process usually takes place in March for the following year's activities.

This, he explained makes it difficult for the mission to have any extra resources for any other activity not included in the operational plan. He however, agreed that the mission should provide some level of oversight but this is impeded by shortage of staff. It is important that AquaFish CRSP and the African Union continue to engage with USAID through sharing information especially on activities of other projects funded by USAID.

Mr. Ratego informed us that USAID-Kenya has developed a food security programme targeting staple food. They are promoting what they term as orphan food crops of which fish is included.

Meeting recommendations:

- AquaFish CRSP to share ongoing Aquaculture projects information with USAID-Kenya – Action Prof. Ngugi;
- Establish a collaboration mechanism RCE/AU-IBAR/USAID – Kenya – Action: All
- Organize for a meeting between Head of AU-IBAR Animal Resources Production unit and the Head of Agriculture, Business and Environment, USAID-Kenya office. Action: Mrs. Gitonga and Mr. Ratego
- Involvement of RCEs in aquaculture development initiatives – Action: AU-IBAR and NEPAD (Mrs. Gitonga to initiate)

RCE–Asia Annual Report

by Remedios Bolivar
(Central Luzon State University, Philippines), Lead Coordinator

Activities supporting women's involvement

Efforts have been made through phone calls, emails, websites, etc. to gather information regarding the identification of activities that support women's involvement in aquaculture and fisheries in Asia. The following are some of the information gathered.

At CLSU, there is a Gender and Development (GAD) Coordinator has been assigned. Accomplishments of the coordinator related to activities that support women's involvement in aquaculture and fisheries include the following:

- Served as trainer in Smoked Tilapia Processing on February 16, 2010 at Curva, Science City of Muñoz, Nueva Ecija, Philippines. This was attended by members of a women's group in the Science City of Muñoz, Nueva Ecija, Philippines called "Kababaihan ng Lungsod Agham ng Munoz (KLAM).

- A livelihood training on Fish Value-Adding was conducted on February 13, 2009 for fishermen and their housewives at Poblacion East and West, Pantabangan, Nueva Ecija, Philippines. As a result, assorted fish species caught from Pantabangan Reservoir are processed into tinapa (smoked fish), buro (fermented fish with rice) and bagoong (fermented fish sauce) as additional source of income.

- A similar training was conducted to housewives of tilapia caretakers at Puyat Fish Farm, Gapan City, Nueva Ecija, Philippines and this resulted to the processing of small-sized tilapia during harvest into bagoong for food and as source of income.

- A tilapia cooking contest was participated by CLSU students. There were 20 registered participants to this contest and first place was garnered by a male participant.

Assessment of opportunities and gaps in technology
By Remedios Bolivar

Aquaculture is a dynamic industry needing the concerted efforts of various stakeholders from the private sector, public and academic institutions in the areas of human resource development, sustainable aquaculture and the dissemination of technologies. Regional and national organizations that are involved in aquaculture should strategize in addressing the foregoing concerns in order to make this sector a sustainable domain for increased food production with so much concern in insuring the protection of the integrity of the environment and the safety of aquaculture products for the growing population in the region.

Some of these opportunities for collaboration are as follows:

Human resource development: Professional practitioners of aquaculture should have gained their competencies from their pursuit of the fisheries education program that are geared towards meeting the requirements of the industry with strong acumen in the business aspect of aquaculture. Agriculture and Fisheries (Agri-fisheries business) is now considered as one of the top generators of employment in the country unseating the nursing profession. To capitalize on this, development of the fisheries curriculum programs in the region should do benchmarking of each program to standardize the curriculum, if it conforms with the international standards.

Sustainable aquaculture: A regional network should be in place to assess the present aquaculture practices in the region with the end view of insuring sustainable aquaculture for the present and future generation. Efforts must be made in dealing with present issues such as climate change, the growing interest to organically produced aquaculture products and genetically engineered organisms in relation to sustainable aquaculture.

Dissemination of technologies: The transfer of technology in most countries in the region is still wanting or may be considered as the weak link in the continuous development of aquaculture. Development of new modalities in the transfer of technology specific to aquaculture must be one of the priorities.

On the national level, the Bureau of Fisheries and Aquatic Resources (BFAR) under the Department of Agriculture (DA), a Gender and Development (GAD) Focal System was reconstituted through a Fisheries Office Order No. 24, Series of 2010. This is being chaired by Atty. Benjamin F.S. Tabios, Jr. with Ms. Mildred M. Buazon as Vice-Chairperson. There are seven (7) members and two persons as members/secretariat. The functions and responsibilities of this focal system are to provide directions in the GAD mainstreaming initiatives of BFAR; conceptualize and implement specific programs and projects pursuant to GAD; formulate the GAD Strategic Plan of the Bureau; review the Bureau's annual GAD plan and budget including its Regional Offices, National Centers and National Training Centers; conduct periodic monitoring/assessment of GAD activities and accomplishments; monitoring and control GAD budget utilization; prepare and submit reports to the DA-GAD Focal System; formulate and implement programs, projects and activities in the areas of sexual harassment, violence against women and discrimination in the work place, trainings/seminars, human resources procedures, policies, systems and programs, health and wellness, environmental protection/sustainability, and GAD budget; coordinate the participation of the Bureau in GAD-related activities; and represent the Bureau in GAD-related activities/fora/meetings.

The Secretariat will assist the chair in the conduct of GAD meetings; prepares the consolidated GAD Plan and Budget and Accomplishment Reports; coordinates with the different offices regarding gender programs, trainings and other similar activities.

The Southeast Asian Development Center (SEAFDEC) in Tigbauan, Iloilo, Philippines also initiated women's participation in aquaculture by conducting training workshops on "Post-harvest and Marketing of Milkfish. Traditionally, women's participation in milkfish culture has been limited so one approach to enhance women's role and visibility in the industry is to get involved in the postharvest and marketing activities including value addition. Two training workshops conducted in this area were organized by Dr. Evelyn Grace de Jesus-Ayson, the Head of the Research Division of SEAFDEC. The first training was held on April 16, 2010 and participated in by 13 women, while there were 15 participants in the second training workshop which was composed mostly of housewives with no regular employment, 3 unemployed single women and one student. The trainings were conducted in Barangay Buyuan and Barangay Parara, Tigbauan, Iloilo, Philippines. Iloilo is in Region VI of the Philippines and includes the province of Iloilo, a major milkfish producing area in the country. The one-day training workshop included lectures in the morning on Harvest and Post-Harvest Handling Techniques and Market Potential and Marketing Techniques of Economically Important Marine Fish. In the afternoon, the participants did practical activity on milkfish deboning and preparation of marinades.

Networking

To add new partners and linkage to AquaFish CRSP, one private farm was visited on June 21, 2010 (ZH Aqua Farm) owned by Mr. Vic Zafra. A short profile of the farm is provided as follows:

The farm is located in Zone 4, Brgy. Sto. Tomas, San Jose City, Nueva Ecija, Philippines and is managed by the owner, Mr. Vic Zafra. The farm includes a facility for fingerlings production and dispersal, conditioning and breeding ponds as well as ponds for grow-out production.

ZH Aqua Farm is a farm utilizing the BFAR GET-EXCEL strain of tilapia in producing fingerlings. Its operation includes production of sex-reversed and mixed-sex fingerlings. They prepare their hormone-treated feeds for the sex-reversal of tilapia. The farm has been providing tilapia fingerlings for the local tilapia farmers within the province and also has its clients in the nearby provinces.

The farm is also involved in several partnerships with private and government institutions in conducting experiments, and field trials using the facility of the farm. In 2008, they conducted a feeding experiment with the American Soybean Association. The farm also currently maintains about 100 stocks of *Pangasius hypopthalmus* catfish in one of the ponds.

Another institution I am considering for establishing a linkage is the Mindanao State University – Maquindanao (MSU-Maguindanao). Mr. Ramjie Odin, a former MS student here at CLSU and who is now back to work at MSU as a faculty member, visited CLSU on June 9, 2010.

For some details about MSU, the university aims to become a Center of Excellence not only in teacher education, science and technology but also in tourism, sports, arts, humanities and social sciences. It hopes to contribute to the goals of urban and countryside development through peace, unity and understanding among Christians and Muslims. It aspires to transform itself into a premier supra regional university in Mindanao.

Part of my discussion with Mr. Odin is the conduct of the thesis by his undergraduate students at MSU on tilapia feeding strategies in cages in lakes. I see it as a good opportunity to establish linkage with MSU in the future.

RCE–LAC Annual Report

by Wilfrido Contreras-Sánchez
(Universidad Juárez Autónoma de Tabasco, Mexico), Lead Coordinator

Activities supporting the involvement of women

- A three-month workshop (Global warming, Aquaculture and Gender) is being organized at UJAT. We expect students, professors and aquaculture producers to participate in this meeting. The main speaker – Laura Vidal—is just finishing the structure of the workshop and we will initiate communication to recruit participants. We expect this workshop to be conducted around September – December 2010.
- Several women have been involved as technicians, graduate and undergraduate students in all activities of our projects.
- With the Vigas Foundation project we are promoting to considerer strong women involvement in all projects.

Summary of Associate Awards and/or other leveraged activities

- UJAT just purchased a 1.5 hectare property in Jalapita ($16,260 USD) where a Marine facility will be built to support snook research.

- Fundación Produce –a governmental funding institution- recently approved two projects for a collaborative effort between UJAT and the "El Pucté" Farm one will focus on the implementation of the technological package for tropical gar culture at the farm and the second will evaluate the performance of the Nile tilapia line produced at the farm. The grant obtained totals $60,000 USD.

- The Biological Division Direction at UJAT just initiated the rebuilding of the entire aquaculture laboratory. A live-food production laboratory, seven offices, a meeting room, bathrooms, a storage room and one extension office will be created from this investment. The Division will invest approximately $120,000 USD.

Networking

- Three meetings were conducted in Mexico City and one in Villahermosa with personnel from Fundación Vigas (information is provided above).
- Two meetings were conducted with the manager of the "El Pucté" farm to define strategies and write proposals for "Fundación Produce" (information is provided above), proposals were accepted and funding is expected soon.
- Two meetings and one visit were conducted with personnel from "Acuagranja Dos Lagos" farm. Agreements are to be signed soon.

Assessment of opportunities and gaps in technology
By Wilfrido Contreras

Our activities have mostly focused on supporting small and medium size farmers in the region; however, we have initiated communication with a large-scale tilapia farm (Acuagranja Dos Lagos; Regal Springs Mexico) located in the limits between Tabasco and Chiapas. Our intention is to create stronger bonds with large tilapia producers in the region. Dos Lagos is currently producing 20-30 tons of whole tilapia/week using floating cages in a hydropower dam reservoir (Peñitas). Recently, they built a hatchery to produce their own fry starting with one million fry per month. They are very interested in our production techniques for the native cichlid tenhuayaca (*Petenia splendida)* since they have an agreement with the fishermen of the reservoir for re-stocking *Petenia*. *Petenia* represents a very important fishery in the reservoir and is potentially overexploited. Directives from Dos Lagos have agreed on developing social projects in the area. Therefore, we will help with the technology transfer to their facilities. They may hire Rosa Aurora Pérez (a graduate student from our laboratory) to start up the project. They also have interest in initiating agreements with our laboratory for specific investigations regarding tilapia feeds for their operations. Two meetings have occurred so far and the international director visited our facilities, we expect to have agreements signed soon.

We have also initiated collaboration with Fundación Vigas, which is a nonprofit organization that promotes productive projects for socially and economically marginalized communities in México. This group is looking for opportunities in technology cooperation from either public or private institutions; they are interested in the joint development of marine species cultivation technology for commercial purposes in the South Pacific Coast of our country. The communities where this venture will be launched are located in the State of Oaxaca, Southern México. This state is divided into 12 different regions and 570 counties; it has 93,952 km^2 which represents 4.7 % of the national land. It is the third poorest State in México, 71.9% of the population earns less than $5.3 US dollars per day, only 10% of the population does not have problems related to malnutrition, 21.5% of the population cannot read, and 60.5% live in rural areas. Approximately 50,000 people from Oaxaca migrate to the United States every year, looking for job opportunities. Oaxaca is among the seven Mexican States that contributes the most to migration from Mexico into the US.

The first stage of the project is planned to be settled in the “Costa Chica” region, in the county of Pinotepa Nacional. Pinotepa Nacional is the major city in the surroundings (98° 03’ west, 16° 20’ North at 200 meters above the sea level) it has 24,347 habitants; the nearest airport is located in Puerto Escondido (210 kilometers away from this city). The target communities are descendants of African slaves that where brought during the Spanish colony, after their liberation they migrated to this region. Its main economic activity is artisan fishery, which solves their alimentary needs, but only reports a monthly income per capita of approximately $314 Mexican pesos (23.2 USD; 0.77 USD/day). The tropical lagoons in which they fish have very important mangrove ecosystems. Over-exploitation has strongly affected the environmental balance and the fishing production has constantly fallen in the last decade generating social problems like poverty and migration. In 2020 a population decrease of about 19,901 Afro-Mexicans is expected for this region.

UJAT´s participation in their projects is looking at aquaculture as a way to support regional development. Fundación Vigas is planning on investing together with several partners in a sustainable aquaculture project involving native and introduced species. Snooks, Amberjacks and oysters represent the first options to explore. We are planning on developing several studies to evaluate potential projects in the Corralero Lagoon. Undergraduate and graduate theses projects may be incorporated and funding for students are expected from Fundación Vigas. Three meetings have been conducted in Mexico City and one in Villahermosa in order to build a strong project to be presented to the stakeholders. So far, the project aims at building a marine hatchery, an aquaculture park and a marketing office.

SYNTHESIS PROJECT

The overall Synthesis Projectat the ME includes a research component, begun in Fall 2008, and a program support component. During this reporting period, the research component has begun its metadata analysis, which will lead to recommendations for minimum dataset sizes to reduce duplication and streamline data collection. The Annual Report that follows for this research component covers the period 1 October 2009 to 30 September 2010.

Annual Report: Evaluating AquaFish Accomplishments in a Systems Framework

Printed as Submitted by Steven Buccola (Oregon State University)

FY 2010 accomplishments were:

- Our one-day First Annual Workshop for host-country investigators was held in conjunction with the 2010 AquaFish Annual Meeting in San Diego on 1 March 2010. Thirty-one AquaFish host country investigators and 12 non-host-country individuals (US PIs, AquaFish and USAID staff, and visitors) attended. The workshop was dedicated to the theory and methods of research discovery and impact assessment. Discovery methods included procedures for measuring research accomplishments, defined as the difference between the study's prior expectations and its subsequent findings. Emphasis was placed on examining the discoveries of the 2007-2009 AquaFish investigations, which are the purview of the present Synthesis Project. Impact assessment focused on the probabilities that the findings will be adopted in specified environments. Attendees worked on example problems to sharpen understanding.

- A four-page questionnaire that will enumerate each research investigation's inputs and study conditions was drawn up and circulated among AquaFish investigators for comment. The questionnaire has now been distributed among host country investigators.

- Similarly, a Bayesian-based questionnaire was formulated to enumerate each research investigation's treatments, settings, and information outputs. It was sent to US and HC investigators for comment, was revised several times, and has been shown effective. The questionnaire was slated for further testing at our October 4 - 7, 2010 Project Meeting in Seattle (see Investigation #3 of the OSU/MSU Project).

- Once the relevant host country investigator(s) have completed the input and output questionnaire for each research-type 2007 – 2009 AquaFish investigation, we will pool the input and output data in those years to develop a quantitative characterization of the factors affecting research success. [Note that the present Synthesis project will examine the 2007 – 2009 investigations and the OSU/MSU Project will examine the 2009 – 2011 ones, each with the same analytical model.] Development of the structure of that model, and identification of the types and sources of data in the output and input questionnaires needed to estimate it, occupied a substantial portion of our FY 2010 effort. Those questions are now solved and we are ready to estimate once the data are assembled.

- The wide variety of AquaFish investigations makes it difficult to pool their output and input data into a single quantitative framework. We demonstrated our questionnaires' flexibilities in accommodating that inter-investigation variety by testing them against host-country investigators in all seven AquaFish projects. The tests included both controlled-experiment and statistical-survey studies conducted during the 2007 - 2009 period, for which this Synthesis Project is responsible.

- A similar difficulty arises in determining how to assemble the data itself. The 2007 - 2009 AquaFish projects were spread over 12 countries and differed in both research variety and geographic complexity. A significant part of our work this year was to develop an administrative

structure for data collection that accommodates each project's circumstances. That structure is now in place. A contact individual in each of the seven projects, responsible for delivering the completed input and output questionnaire data for the 2007 - 2009 period, has been tentatively identified. We are ready to contract with these individuals to deliver the data by March 1, 2010.

- Work toward these goals was facilitated by Steve Buccola's visit to project sites in China, Vietnam, and Philippines from August 23 through September 15, 2010.

- Preparations were made for the 4 – 7 October 2010 Project Meeting in Seattle, WA. Fourteen host-country researchers, two from each of the seven AquaFish projects, will attend.

X. MONITORING & EVALUATION

The Monitoring and Evaluation (M&E) Plan was formalized in the *AquaFish CRSP 2nd Annual Report.* It functions under two sets of internal impact indicators — (1) theme-driven DTAP indicators .and (2) key development target indicators tied to the USAID research, capacity building, information dissemination, IEHA (President's Initiative to End Hunger In Africa), and gender integration targets for the CRSPs. Tables 9 to 13 in Appendix 4 cross reference these internal AquaFish CRSP indicators to the applicable FY 2010 EGAT and FTF (Feed the Future Initiative) indicators under which AquaFish CRSP reports[11].

DTAP INDICATORS

The DTAP indicators are tied to the four AquaFish CRSP global themes. They were developed by the MT in consultation with the US and HC Lead PIs in the May 2007 *Pre-Synthesis & Orientation Meeting* and updated in May 2008 at the Annual Meeting and in June 2009 by the DTAP B Lead Coordinator. The current set of DTAP indicators under which core research projects reported in FY 2010 are listed below.

DTAP A: Improved Health and Nutrition, Food Quality, and Food Safety of Fishery Products
A-01: Number of aquaculture products developed to improve food safety or quality

DTAP B: Income Generation for Small-Scale Fishers and Farmers
B-01: Number of new technologies developed
B-02: Number of institutions with access to technological practices
B-03: Number of (people) trained in use of technological practices

DTAP C: Environmental Management for Sustainable Aquatic Resources Use
C-01: Number of management practices developed or adopted to improve natural resource management
C-02: Number of hectares under improved natural resource management
C-03: Number of management practices developed to support biodiversity
C-04: Number of people trained in practices that promote soil conservation and/or improved water quality

DTAP D: Enhanced Trade Opportunities for Global Fishery Markets
D-01: Number of new markets for aquatic products
D-02: Number of aquatic products available for human food consumption

Tables 1– 8 in Appendix 4 compile the DTAP reports submitted by each of the seven AquaFish CRSP core research projects, which were actively engaged in research during FY 2010. Since short-term training data were collected under a separate internal reporting mechanism, FY 2010 reports for indicators B-03 and C-04 are included in the short-term training compilation (Appendix 4, Table 5).

The FY 2010 actuals reported here encompass metrics for continued accomplishments associated with investigations initiated under the *Implementation Plan 2007–2009* and metrics for new work that began on 1 January 2010 under the *Implementation Plan 2009–2011*.

[11] Indicators for the USAID Economic Growth & Trade program form the EG 5.2 (Agriculture Sector Productivity) set under which AquaFish CRSP reports. This set also includes indicators relating specifically to the FTF initiative.

KEY DEVELOPMENT TARGETS: INDICATORS & BENCHMARKS

AquaFish CRSP measures achievements in meeting key development targets through a set of internal indicators and benchmarks. The benchmarks provide a means to explore measures of performance different from those measured by the DTAP or USAID indicator metrics. The targets tracked below are consistent with those approved in the Program Description of the USAID CA/LWA for this CRSP.[12] Year 1 Benchmarks cover 2006–2007. Benchmarks for Years 2–5 are appended and show progress through this reporting period, which is Year 4.

This conceptual framework helps ensure that targets and benchmarks are adequately addressed across the AquaFish CRSP global portfolio. This facilitates feedback and continuous learning in order to improve processes and outcomes. We report on the four key development targets of research, capacity, information dissemination, and IEHA. As the fifth target, gender ensures strong programmatic commitment toward gender inclusion through plans implemented at both the project and program level. Gender is both integrated into the four other targets and highlighted independently.

Benchmarks for Year 1 have been fully met. Most benchmarks for the Years 2-5 have also been fully met below are illustrative examples of the accomplishments associated with each benchmark.

Research Target

Produce sustainable end-user aquaculture and fisheries research results that increase productivity, enhance international trade opportunities, and contribute to responsible aquatic resource management.

Program-wide Research Indicators

(1) Developed and adopted innovative technologies that increase profitability and environmental stewardship in aquaculture and fisheries.
(2) Addressed biodiversity conservation issues to ameliorate threats to biodiversity and developed technologies and strategies to protect biodiversity habitat and populations.
(3) Continuously funded research projects that meet the expectations of external peer-review panels.
(4) Conducted appropriate biotechnology research to develop technologies that increase farm productivity.
(5) Engaged local stakeholders in research design, implementation, and results reporting through active participation in stakeholder meetings.
(6) Published AquaFish CRSP research in regional, national, and international peer-reviewed journals."

Year 1 Benchmarks. Status: Successfully completed

(a) Request for Proposals approved by USAID and widely advertised, and submitted proposals externally peer-reviewed.
RFP process through proposal finalist selection was completed on 31 March 2007.

(b) Favorably reviewed proposals have activities initiated.
Project work began in May 2007 with attendance at the Presynthesis & Orientation Meeting, formation of the advisory technical panels, and training on indicators, IEE, gender, and POP (Program Operating Procedures).

Years 2–5 Benchmarks:

(a) 1 innovative aquaculture and fisheries technology or strategy developed and disseminated throughout each region:

[12] The Targets and Benchmarks were again approved as part of the AquaFish CRSP M&E Plan in 2008.

The following examples of technologies and strategies are illustrative of project achievements that have more than met this benchmark:

Africa***:*** *Kenyan farmers participating in Purdue University's group marketing and supply chain project (07QSD02PU/07MER02PU) are currently marketing their farmed baitfish in six markets along the shores of Lake Victoria. One highly successful group marketing cooperative, the Vihiga (Bidii) Fish Farmers Group is promoting the market cluster model and has taken the initiative to train other fish farmers in this marketing strategy. It has also partnered with the Women in Fishing Industry Project, a local Lake Victoria NGO that helps women identify income generating opportunities, to train women to become baitfish farmers.*

Cage culture technology is in the process of transfer in Uganda. Farmers are part of a trial that offers them a new livelihood with tilapia cage culture on Lake Victoria where overfishing has threatened their ability to earn a livelihood (09BMA01AU). This hands-on training project is preparing them in culture and business techniques that will ensure their success as farmers and models to others who wish to adopt this new technology.

Asia***:*** *As a result of the multifaceted approach of the University of Michigan project in China and Vietnam, there are significant achievements in developing technologies and strategies for sustainable environmental management of various components of aquaculture and fisheries systems. In these studies, stakeholders have been actively engaged in the research through on-farm trials, surveys to assess the status of fish populations in the reservoirs and assess the impact of alien fish stocking on wild fish populations (07MNE03UM/09MNE05UM), and surveys relating to aquaculture practices. For pond aquaculture, two new technologies are under transfer: (1) effluent reduction measures for pond aquaculture (07MNE04UM) and (2) an environmentally benign treatment to remove toxin-producing, blue-green algae blooms (07HHI01UM).*

On the basis of detailed assessments, AquaFish CRSP researchers have (1) recommended adoption of management plans to eliminate stocking of icefish (China) and tilapia (Vietnam) to protect the native fish biodiversity in three freshwater reservoirs (07MNE03UM), (2) determined the ecological footprint of shrimp farming for domestic and international markets (07MNE05UM), and shared the chitosan clay control technology with other aquaculture researchers (07HHI01UM). Dissemination of this work is taking place in trainings and through networking of AquaFish CRSP researchers (07MNE07UM).

New sustainable feed technology work has promising benefits for tilapia fish farmers in the Philippines and for snakehead farmers in the Mekong River Basin. Filipino farmers can save on feed costs with reduced feeding strategies — a 45-day delayed supplemental feeding, alternate day feeding, or daily subsatiation feeding at 67% (07SFT02NC). Transfer of this technology is taking place through trainings and podcasts (09TAP02NC). Vietnamese researchers have developed a reduced fishmeal pelleted feed for snakehead (07SFT01UC) that is currently undergoing on-farm trials (09TAP03UC) with selected Cambodian and Vietnamese farmers who will serve as models for other farmers as the adoption process progresses.

Latin America- Caribbean :*Based on AquaFish CRSP recommendations developed from carrying capacity studies in the Boca Camichin Estuary, the Mexican government has imposed a ban on new oyster farms to control water quality and aquatic diseases. By including oyster producers in the monitoring work, AquaFish CRSP researchers developed an effective community-based collaboration with rural stakeholders. Community meetings with the oyster producers were designed to train them in culture and sanitation techniques for improved oysters safe for human consumption (07WIZ02UH).*

Researchers in Mexico have successfully developed a sustainable control measure to eliminate methyltestosterone (MT) residue from hatchery treatment water (07MNE96UA). In the use of MT to sex reverse young fingerlings, disposal of contaminated water has become a significant problem for

hatcheries and large farms that use the male hormone to create monosex tilapia fingerlings. This new MT-elimination technology makes use of bacteria that have been experimentally shown to degrade the MT residue that builds up in treatment water. They are inoculated onto the biofilter component of the treatment tank's water filtration system and feed on the MT residue that they capture from water as it is filtered through. One added advantage of the bacteria is their proven probiotic contribution towards improving fish productivity. A commercial scale-up trial is being set up with a private hatchery partner under a proposed add-on investigation (09MNE07UA).

(b) AquaFish CRSP activities remain locally appropriate by receiving regular input through the Regional Centers of Excellence and Development Theme Advisory Panels.

The RCEs have been active in establishing regional linkages with NGOs, governmental and academic institutions, and stakeholder groups. These linkages are serving to promote information exchanges and technology sharing among researchers, policymakers, government officers, and local stakeholders. They also are establishing strong regional networking links that enable regular information sharing and promote regional capacity building. RCE emphasis on empowering students and funding their participation in trainings and conference attendance is further strengthening the long-term training goals of the core research projects. These activities have helped the MT and project leaders in assessing needs for research and activities under the continuation plans.

The DTAP Lead Coordinators have played an instrumental role in evaluating work plan changes under the Implementation Plan 2007–2009. They have also provided substantive feedback to the MT through the DTAP impact reporting, which has guided the MT reviews of the continuation plans (Implementation Plan 2009-2011) and add-on investigations.

(c) Measured increases in farm productivity, farmer incomes, market access, and export value achieved following adoption of AquaFish CRSP recommendations and technologies.

Training and outreach for technologies and management recommendations are improving the aquaculture and fisheries economic sectors for various levels of stakeholders. Stakeholders have participated in research activities (University of Hawaii, University of Michigan, and University of Arizona projects), provided input into the development of management practices and policy recommendations (North Carolina State University, Purdue University, University of Connecticut, and University of Michigan projects), participated in regional events where they can interact with other stakeholders and service sector personnel (Auburn University and University of Hawaii projects), and actively trained fellow stakeholders (Purdue University project).

The following examples illustrate project achievements that are leading to measured increases for stakeholders in productivity, incomes, market access, and product export value:

<u>Farm/Fishery Productivity</u>

- *adoption of practices to mitigate pollution of receiving waters from aquaculture pond effluents in China (07MNE04UM) and Ghana (07WIZ01PU)*
- *adoption of management practices or improved technologies: catfish fingerling aquaculture (07QSD02PU), tilapia-catfish polyculture (07MER03PU), tilapia-sahar polyculture (07BMA02UM), seaweed-fish-mollusc-shrimp polyculture and soft-shell mud crab aquaculture (07MNE02NC), and Nile tilapia seedstock (07QSD01NC)*
- *implementation of management plans to control alien species introduction in three freshwater reservoirs in Vietnam and China as a step to maintain sustainable fisheries (07MNE03UM/09MNE05UM)*
- *improved implementation of management plans to control carrying capacity of an estuary for oyster production (07WIZ02UH) and to the freshwater fishery for small-sized fish in the Lower Mekong River Basin (07MNE01UC/09MNE04UC)*
- *improved production efficiency through on-farm trials of an integrated pond-cage system with tilapia and catfish for small-scale fish farmers in Kenya (09SFT02PU)*

- *improved production capabilities for small-scale Uganda farmers undertaking cage culture on Lake Victoria (09BMA01AU)*
- *establishment of sahar-tilapia-carp polyculture in Nepal will open income opportunities for women producers (07BMA02UM/09BMA03UM)*

Also, see the DTAP C-02 reports showing number of hectares under improved natural resource management (Appendix 4: Table 5).

Farmer Income*: Farmers, processors, and vendors benefiting from improved productivity as listed above will see increases in income. Similarly, farmers and processors of aquatic products who adopt the new technologies and practices promoted in CRSP research and trainings will benefit from improved income opportunities:*

- *sustainable feed technologies will lower a major contributor to production costs and thereby improve profit margins for farmers — (1) locally available protein replacement for fishmeal: 07SFT01UC/09SFT01UC; 07SFT04UA/07SFT05UA/09SFT03UA; 07SFT06PU/09SFT05PU) and (2) feed reduction strategies: 07SFT02NC/09STF04NC; 07SFT03NC*

- *new aquatic products will open production and market opportunities — (1) products with improved health and safety: producers and vendors of native cockles (07HHI05UH/09HHI01UH) and oysters (07IND03UH/07IND04UH/09IND01UH) can improve their income opportunities when hatchery-raised seed becomes available to support expanding production interest — particularly among coastal women — and demand for depurated products develops in local shellfish markets; (2) new aquatic species available for aquaculture: research success with breeding snook and native cichlids in captivity will open the way for new aquaculture opportunities for native fish species in Latin America (snook and native cichlids (07IND01UH/07IND02UA/09IND05UA) and chame (09IND03UH); (3) new products for small-holder farmers and processors: trainings in seaweed polyculture systems and processing techniques address sustainable production methods and open new income opportuntities for coastal communities in the Philippines and Indonesia (07MNE02NC/09FSV02NC); research on an integrated multitrophic milkfish-seaweed-sea cucumber aquaculture system and processing trainings will open income opportunities for Filipino farmers and women processors of value-added milkfish products (09MNE02UC).*

Market Access*: Baitfish farmers are now successfully selling at six well-established market locations along the shores of Lake Victoria (07QSD02PU/07MER02PU). Ghanaian farmers who adopt the supply chain/group marketing model will have more opportunities in urban markets (07MER02PU). A market for depurated cockles is beginning to grow as demand for this "safer" aquatic shellfish product spreads by word-of-mouth (07HHI05UH). Market opportunities for women are expanding through trainings in value-added product processing and marketing (09MER02PU; 09FSV01UC; 09FSV02NC; 09MNE02NC; 09HHI02UH)*

Export Value*: Tilapia farmers in the Philippines who adjust production to meet the specific requirements of export markets will have expanded income opportunities (07MER04NC/09MER03NC). Markets for processed fish products in Cambodia and Vietnam will expand as women processors adopt best management practices for the improved safety and quality in the production of fermented fish paste and fish sauce (07FSV01UC/09FSV01UC).*

(d) Threats to biodiversity resulting from aquaculture activities ameliorated and biologically significant areas positively impacted.

A management recommendation to eliminate alien species introductions in three freshwater reservoirs in China and Nepal will protect the biodiversity of native species in the reservoirs and help

ensure a sustainable native fishery (07MNE03UM/09MNE05UM). In Kenya, the successful development of catfish-baitfish aquaculture offers an alternative source of baitfish to Nile perch fishers on Lake Victoria, thereby protecting the threatened wild catfish fishery (07QSD02PU). Development of cage culture aquaculture by small-scale Ugandan farmers will both offer new income opportunities and help to address overfishing in Lake Victoria where wild fish stocks are declining (09BMA01AU). Success in development of snook aquaculture will help relieve pressures on the wild fishery of this important native Latin American species (07IND01UA/09IND05UA).

Several sustainable feed technology investigations target reduction of fishmeal in aquaculture feed as both a cost-savings measure and sustainable practice to reduce pressures on wild-caught fish used for fishmeal (07SFT01UC/09SFT01UC; 07SFT02NC/09STF04NC; 07SFT03NC; 07SFT06PU/09SFT05PU; 07SFT04UA/07SFT05UA/09SFT03UA). The move away from fishmeal serves to protect local and international wild-caught fisheries that have been supplying fishmeal inputs (e.g., small, low-value fishery in the Mekong River).

The Director and US Lead PI Jim Diana are currently planning a symposium entitled "Effects of Aquaculture on Biodiversity" to be held in 2011. The Symposium is intended to highlight the benefits of aquaculture for protecting and improving biodiversity as well as biodiversity issues associated with aquaculture systems. (See UM Project Report)

(e) Cost-effective biotechnology appropriate for use in developing countries developed.

Innovative biotechnologies will bring cost efficiencies to methyltestosterone (MT) residue control and fish growth performance monitoring which will translate to improved productivity in aquaculture systems. The development of an MT-elimination system based on bacterial degradation (07MNE06UA) will help tilapia hatcheries address a major environmental impact issue associated with masculinization systems. Commercial testing of this technology at a large Mexican hatchery will take place in FY2011 under a proposed add-on investigation (09MNE07UA). The IGF-1 assay developed and tested on tilapia (07SFT02NC) and milkfish (07SFT03NC) is serving as a simple tool for measuring fish growth performance in the field.

(f) Continuous academic output of AquaFish CRSP data as publications within recognized journals and presentations provided at regional, national, and international forums.

AquaFish CRSP researchers have published over 35 scientific articles since the start of the program and have submitted a significant number of articles for peer-review publication. They have also presented their work in a wide array of international, national, and regional conferences and symposia, taught academic seminars, and participated in professional workshops and meetings.

Capacity Building Target

Focus AquaFish CRSP investments on building local capacity in aquaculture and aquatic resource management and ensuring long-term program impacts at local and national levels through strategic informal and formal training opportunities. Integrate items related to gender.

Capacity Building Indicators – Regional

(1) Forged professional and managerial relationships between US and Host Country researchers and institutions.
(2) Established track record of successful formal long-term training of Host Country and US students and researchers.
(3) Delivered relevant short-term training opportunities that provide positive Host Country societal benefits beyond the life of the AquaFish CRSP.
(4) Identified gender issues in aquaculture and fisheries and adopted gender program-wide integration policies."

Year 1 Benchmarks. Status: Successfully Completed

(a) An additional year of the highly successful Host Country Principal Investigator Exchange Project continued to exchange information on cichlid aquaculture to additional countries including two IEHA countries.

Phase II exchange visits to South Africa and Ghana (October 2007), Vietnam (December 2007), and Vietnam (February 2008) were conducted and the HCPI project was successfully completed in the previous reporting period.

(b) The jointly funded NOAA Sea Grant Technical Assistance program continued

The Director and Jim Murray, Deputy Director of NOAA/Sea Grant discussed model cases in Korea and finalized the exchange visit for Paul Olin, Director of the California Sea Grant Extension Program. Three Lead US PIs (James Diana, Maria Haws, and Robert Pomeroy) actively engaged in management of their regional Sea Grant Programs, and have networked CRSP efforts into Sea Grant on a regional basis.

(c) Gender integration strategies adopted within all sub-awards

All six projects adopted a strategy consistent with the CRSP integrated approach; USAID (Julie Swanson) reviewed all six projects and met with PIs during the May 2007 orientation meeting.

(d) Regional Centers of Excellence established to reflect the AquaFish CRSP regions for research activities (i.e., Asia, Africa, and Latin America and the Caribbean)

Three RCEs were established and the Director appointed, with USAID consultation, Lead Coordinators at the May 2007 orientation meeting.

(e) Formal Memoranda of Understanding adopted between all US and Host Country partners

MOUs and/or Subcontracts are completed for all projects that began in Year 1 with the exception of University of Arizona's MOUs and subcontracts that are still in process.

Years 2-5 Benchmarks:

(a) Partnerships strengthened among US and Host Country universities, NGOs, NARS, and USAID Missions through Associate Awards.

Partnerships are fully developed for each of the seven core projects. An additional RCE has been added for Africa giving a more comprehensive regional coverage — RCE-West Africa and RCE-East & Southern Africa — and enabling the Lead Coordinators to focus more directly on their specific regional issues. The RCEs continue to build linkages and partnerships with USAID Missions and with regional and international organizations and institutions. The three-year Associate Award with the USAID Mission in Mali (1 October 2007– 30 September 2010) for an aquaculture and fisheries project in Mali has concluded and will continue under a three-month no-cost extension. A new USAID Feed the Future Associate Award for work to be conducted in Ghana, Kenya, and Tanzania will begin in FY2011.

(b) At least 100 degree students enrolled through formal long-term training opportunities in US, Host Country, and Regional universities.

Since program inception, 273 students have been enrolled in long-term training. For FY2010, 196 degree students from 22 countries are enrolled in long-term academic programs associated with core research projects and the Management Office. Of these, 161 students are Host Country nationals.

(c) Equal numbers of women and men trained through short- and long-term training opportunities.

Short-Term Training*: The total number of individuals receiving training since program inception is*

3,016. (Of these, gender data were available for 2,897 trainees. Women comprised a total of 1030 or 35.6% of the 2,897 trainees.)

Long-Term Training*: Of the 273 students receiving long-term or degree training, 130 (47.6%) are women.*

(d) Numerous train-the-trainer workshops convened to provide Host Countries with highly skilled extension specialists

Short-term trainings are designed to integrate stakeholders at all levels, thereby removing barriers between farmers/fishers and extension agents/fisheries officers, etc. An additional component of trainings is the empowerment of trainees to "train" their counterparts. Successes of this integrated approach are exemplified by the catfish farmer trainings in Kenya (07QSD02PU), feed formulation trainings in Guyana (07SFT05UA), as well as shellfish sanitation workshops (07HHI03UH, 07HHI04UH). Other trainings specifically designed as Train-the-Trainer include the following:

- *07BMA05UH: intensive training and internship on bivalve culture and sanitation*
- *07IND01UA: international workshop on snook biology for professionals*
- *07MNE06UA: technical workshop for extensionists and students on MT elimination*
- *07MNE07UM: project level workshop on aquaculture, human health, and the environment*
- *07TAP01UC: farmers training of trainer workshop on alternative feed for snakehead aquaculture*
- *09IND02UC: On-site training on snakehead breeding and weaning*
- *09IND06PU: Experimental design and analysis for aquaculture training*
- *09QSD02UA: Workshop for hatchery managers and bioflocs*
- *09SFT03UA: Basic aquaculture and aquaponics for the rural poor (training local farmer trainers)*
- *09WIZ02AU: Watershed workshop for researchers and extensionists*

(e) Biotechnology and biodiversity training activities conducted as identified.

Examples illustrating training activities that focused on biotechnology and biodiversity are listed below.

Biotechnology short-term trainings:
MT elimination (07MNE06UA): 2 workshops
Biotechnology of marine algae (07BMA03UA): 1 workshop

Biodiversity short-term trainings:
Seaweed-fish-mollusc-shrimp polyculture trainings (07MNE02NC): 8 workshops
Tilapia-sahar polyculture (07BMA02UM): 1 workshop
Alien species introductions (07MNE03UM): 3 workshops
Native cichlid farmer trainings (07IND02UA): 3 workshops
Native oyster culture trainings (07IND03UH): 1 workshop

Information Dissemination Target

Disseminate AquaFish CRSP research results to foster broad application of results among local stakeholders within governmental and non-governmental organizations, as well as for end-users.

Information Dissemination Indicators – Regional

(1) Successful diffusion of AquaFish CRSP research results and technologies between countries within a region having comparable social and environmental conditions.
(2) Increased awareness of local stakeholder constraints and opportunities related to responsible aquaculture and fisheries management.

(3) Applicable extension activities associated with each research project conducted to ensure wide dissemination of research results
(4) AquaFish CRSP results and technologies for farm operations adopted and policies for responsible aquatic resource management created.
(5) Applicable technologies developed and adopted by the US and other countries' aquaculture and fisheries sectors."

Year 1 Benchmarks. Status: Successfully Completed

(a) Dissemination efforts have continued through *Aquanews*, EdOp Net, and a new searchable online publication database.

Publication services continued uninterrupted during the transition from the former ACRSP into the first year of AquaFish CRSP: quarterly issues of Aquanews (Vol. 22, Nos. 1-3; Vol. 23, No.1); 12 monthly issues of EdOp Net; CRSP Notices of Publication for 22 peer-reviewed research reports by CRSP researchers.

(b) The importance of extension evident through integration of at least one outreach activity within each funded project.

The RFP institutionalizes the integration of research and outreach by requiring proposals to contain at least one outreach investigation and to include an Outreach and Dissemination Plan. Proposals were revised as necessary to include one or more outreach activities prior to being approved as core projects.

(c) Research adoption encouraged by prioritizing the use of on- and off-farm trials to conduct research.

On- and off-farm trials and other types of field trials were included as appropriate within each project to promote research adoption as follows:

- *07BMA02UM: tilapia-sahar stocking density trial in collaboration with the Rural Integration Development Society*
- *07HHI01UM: on-farm microcystin controls and consultation with farmer cooperators*
- *07HHI02UA: aquaculture effluent-irrigation trial with farmer cooperator*
- *07HHI05UH: test marketing of depurated black cockle*
- *07IND01UA: farm trials to assess tranferability of experimental snook aquaculture*
- *07IND03UH: women's oyster cooperatives involved with spat collection*
- *07IND04UH: active participation by community members in oyster depuration trials*
- *07MER03PU: on-farm trials using small-scale farmers' ponds*
- *07SFT05UA: on-farm trial of experimental diets using local ingredients.*

Years 2-5 Benchmarks:

(a) Intra- and inter-regional diffusion of AquaFish CRSP results and technologies accomplished.

On a regional basis, short-term trainings and workshops are successfully transferring research results, management practices, technologies, and recommendations to the various levels of stakeholders from rural farmers to stakeholders. Professional-level workshops and CRSP-sponsored conferences (e.g., Workshop on Marine Algae, ISTA8, Workshop on Aquaculture, Human Health and Environment, Annual Fish Farmers Symposium & Trade Show) have served as vehicles for the diffusion of results and technologies beyond the areas targeted by AquaFish CRSP investigations. Through their promotion of linkages and collaborative networks, the RCEs have also actively contributed to inter-regional diffusion.

(b) Training manuals with local and regional scopes published following completion of AquaFish CRSP research projects.

Outreach materials with local and regional scope that are currently available include the following:

- *(07TAP02NC and 09TAP02NC) Tilapia Podcasts*
- *(07MNE04UM) BMPs for Effluent Control in Aquaculture transferred in trainings*
- *(07QSD02PU) Fact Sheets on Pond Production: Pond Fertilization, Pond Liming, Feeding, Stocking & Harvesting*
- *(07MER02PU) Extension Brochure: Marketing Strategies for Smallholder Fish Farmers in Sub-Saharan Africa*
- *(07MER02PU) Extension Manual: Forming an Effective Fish Farmers' Cooperative in Sub-Saharan Africa*
- *(07SFT06PU) Manual for Hand Sexing of Tilapia*
- *(07WIZ01PU) BMPs for pond aquaculture transferred in training*

(c) At least 30 workshops convened over the course of the 5-year AquaFish CRSP.

Since inception, 96 workshop/trainings have been held across the seven core projects.

IEHA Country Involvement Target

Expand AquaFish CRSP science and technology efforts in IEHA Host Countries to increase local capacity and productivity thereby contributing to national food security, income generation, and market access.

IEHA Indicators – Within each participating IEHA Host Country

(1) Development and adoption of innovative technologies that increase profitability and environmental stewardship in the context of aquaculture and fisheries.
(2) Students enrolled in formal long-term training programs within Host Country, Regional, and US universities;
(3) Increased awareness of stakeholder constraints and opportunities related to responsible aquaculture and fisheries management.
(4) Applicable extension activities associated with each research project conducted to ensure wide dissemination of research results.
(5) AquaFish CRSP results and technologies adopted for farm operations and policies for responsible aquatic resource management created.
(6) Increased farm income and local economic growth through enhanced market access in project areas."

Year 1 Benchmarks. Status: Successfully Completed

(a) Formal strategy initiated to maximize locally appropriate results in participating IHEA Host Countries.

The Purdue University IEHA project is designed to improve competitiveness by empowering small holders and developing local economies and markets through capacity building, improved technology, and management of supply chain and natural resources.

(b) Sites selected and formal connections established with suitable research institutions and government departments within each IHEA Host Country.

The Purdue University IEHA project is currently negotiating MOUs and establishing linkages.

(c) The Africa Regional Center of Excellence has representation from IEHA countries to design research and outreach activities.

The RCE Lead Coordinator has established initial linkages within IEHA countries.

Years 2-5 Benchmarks:

(a) Formal linkages, collaborative research, and outreach activities fostered between US universities and IEHA site institutions.

The Purdue University project which conducts research in the two IEHA countries of Ghana and Kenya has formally partnered with Moi University (Kenya), Kenyatta University (Kenya), Kwame Nkrumah University of Science & Technology (Ghana), and Virginia Polytechnic Institute & State University (US). These linkages encompass collaborative research on seven investigations under Implementation Plans 2007–2009 and 2009–2011. To date, outreach activities in Kenya and Ghana have included nine farmer trainings and production of (1) Fact Sheets covering stocking and harvesting, feeding, pond liming, and pond fertilization, (2) BMPs for Pond Aquaculture, (3) an Extension Brochure "Marketing Strategies for Smallholder Fish Farmers in Sub-Saharan Africa" and an Extension Manual, "Forming an Effective Fish Farmers' Cooperative in Sub-Saharan Africa."

The Auburn University project, which conducts research in Uganda, has formerly partnered with three Ugandan institutions — Gulu University, Makerere University, Uganda National Fisheries Resources Research Institute — and Alabama A&M University (US), University of Georgia (US), and Stellenbosch University (South Africa).

In August 2010, the RCE-Africa was expanded to encompass two centers that will be better able to serve the specific regional and geographic needs of West versus East and Southern Africa. Through these two RCEs as well as other efforts by CRSP researchers, collaborations and linkages have been developed with FAO, African Union, SARNISSA, NEPAD, ANAF, FishAfrica, local NGOs (e.g., Women in Fishing Industry Project – Kenya), government agencies (e.g., Uganda Commission for Fisheries), regional agencies (Lake Victoria Fisheries Organization) and the USAID Missions in Ghana, Kenya, Uganda, and Mali. Collaborative research has also been pursued by the RCE-East & Southern Africa through other funding sources.

(b) Long-term research projects addressed specific needs of each IEHA Host Country.

Bringing Kenyan farmers into a successful farming enterprise to raise catfish fingerlings for sale as baitfish for Nile perch fishers has addressed needs of several stakeholders: fish farmers for whom the group marketing clusters will ensure a viable business enterprise; baitfish traders who can depend on a steady supply of farmed fish to sell to fishers; rural communities along the shores of Lake Victoria whose livelihoods and food security depend on a sustainable catfish fishery that will be protected from overexploitation with the availability of farmed catfish fingerlings. Current investigations under the Implementation Plan 2009-2011 address specific needs of stakeholders by expanding income-earning opportunities for Kenyan women through training in value-chain development for tilapia and catfish products and for farmers through on-farm trials of and an integrated pond-cage system for catfish and tilapia that promises to maximize aquaculture efficiencies

Development of BMPs for aquaculture farmers in Ghana will help ensure cost-effective production practices that will reduce feed waste and effluent output from ponds into receiving waters. With improved production methods, Ghanaian farmers can improve their income. CRSP researchers are also working towards improving aquaculture opportunities for Ghanaian farmers through a collaborative effort with the government to set standards for cage culture on Lake Volta and by conducting research to expand the number of fish candidates for culture.

The Auburn University project in Uganda places a strong focus on farmer training on the individual and community levels through the annual Fish Farmers Symposium & Trade Show and the small-

holder cage culture study on Lake Victoria. These trainings are designed to expand production and job opportunities for stakeholders. Interregional exchanges between Uganda and Kenya encompassed in the Farmer-to-Farmer Study Tour and the Kenyan baitfish investigation offer opportunities for stakeholders to learn and benefit from each other's experiences.

(c) Diffusion of knowledge facilitated between separate research projects ongoing within each IEHA Host Country.

Kenyan farmers visited fish farm facilities in Uganda in a collaborative training conducted in FY09 (07QSD02PU). Kenyan researchers are serving as partners on the Associate Award Project in Mali, benefiting that project with their expertise that has been built over the long term through CRSP research activities. In Uganda, the Annual Fish Farmers Symposium & Trade Show affords a national opportunity for Uganda farmers to network and exchange knowledge while also benefitting from the event's extension and outreach programs. The Farmer-to-Farmer Study tour for Ugandan and Kenyan farmers affords opportunities for inter-regional exchanges.

Also, the HCPI Phase II Project involved Ghanaian and Kenyan researchers in a regional exchange in Africa.

(d) A measured increase in farm productivity, farmer incomes, market access, and export value has followed adoption of AquaFish CRSP recommendations and technologies in project areas.

The following example illustrates the multi-faceted achievements of AquaFish CRSP work.

Catfish farmers who have adopted baitfish culture practices and become members of group marketing clusters have improved pond productivity by following AquaFish CRSP management practices. Their total production of catfish fingerlings has reached 250,000 fry/fingerlings since 2006, when production was virtually non-existent. Since CRSP's initiation of this farmed baitfish program, survival rate of fingerlings has increased from less than 10% to 50% representing an increase in productivity of 400%. Six (6) new baitfish market centers have been opened along Lake Victoria, and baitfish farmers have recorded about 50% increase in sales. Most baitfish farmers have recorded about 65% increase in farm income from baitfish production. (07QSD02PU/02MER02PU).

Gender Integration Strategy

The AquaFish CRSP is dedicated to improving gender inclusiveness in the Aquaculture and Fisheries sectors, and in the CRSP arena. Gender Integration is implicit and interwoven into in the above "target" benchmarks and indicators requested by USAID in its 2006 RFA. Additional explicit guidance, in the form of an improvement plan, was established for CRSP operations.

Year 1 Initiatives. Status: Successfully Completed

(a) Require that all funded projects address gender inclusiveness within their planned scope-of-work.

The RFP requires that all projects have a strategy for integrating and addressing gender (a Gender Strategy). Strategies for gender inclusiveness have been incorporated into revisions to the proposals.

(b) Seek out USAID review of projects' gender inclusiveness plans and respond by improving plans prior to project implementation.

The ME submitted revised proposals with gender inclusiveness plans to USAID in June 2007. Proposal revisions addressed USAID suggestions prior to receiving funding, and prior to implementation.

Years 2–5 Initiatives:

(a) Collect disaggregated gender data from individual research and outreach projects funded by the CRSP.

Data for short-term and long-term training activities are disaggregated and are covered in the Capacity Building sections of this and the Second and Third Annual Reports.

(b) Analyze disaggregated data on an annual basis to gauge gender inclusiveness success and take appropriate action as indicated through data analysis.

Since program inception, the analysis has shown that long-term training participants comprise 52.4% men and 47.6% women. In FY2010, the long-term trainees were 44.4% women and 55.6% men. The short-term training participants in FY2010 comprised 39.6% women and 60.4% men. In order to improve opportunities for women's participation in short-term training events, each of the core projects has a gender inclusivity strategy and a gender focused investigation under the Implementation Plan 2009-2011. The gender-focused investigations are as follows:

- *Demonstration of Sustainable Seaweed Culture and Processing in Aceh, Indonesia and the Philippines - Opportunities for Women to Improve Household Welfare (09SFV02NC)*
- *Value Chain Development for Tilapia and Catfish Products: Opportunities for Women Participation (09MER02PU)*
- *Expansion of Tilapia and Indigenous Fish Aquaculture in Guyana: Opportunities for Women (09SFT03UA)*
- *Maximizing the Utilization of Low Value or Small-sized Fish for Human Consumption by Improving Food Safety and value-Added Product Development (Fermented fish paste) through the Promotion of Women's Fish Processing Groups/Associations in Cambodia (09FSV01UC)*
- *Capacity building in aquaculture, fisheries management and coastal management for coastal women. Workshop: Opportunities for Coastal Women in Fisheries, Aquaculture and Coastal Management (09HHI02UH)*
- *Incorporation of tilapia (Oreochromis niloticus) and Sahar (Tor putitora) into the existing carp polyculture system for household nutrition and local sales in Nepal (09BMA03UM)*

(c) Involve field projects in monitoring and evaluating gender integration as the program progresses with time. Evaluate the effects of specific projects on gender and ensure that any possible negative effects due to gender bias are mitigated.

Disaggregated gender data are currently reported for all long- and short-term trainings as well as for field trials. Gender of all US and HC staff is also currently reported. Each core project has a gender integration strategy that outlines steps to increase the number of, and mitigate bias against, female participation. Work under continuation plans (2009-2011) includes at least one activity focusing specifically on gender issues.

(d) Focus one component of a lessons learned and synthesis assessment specifically on the social context and impact of CRSP research and outreach activities on the lives of women.

The second RFP (May 2009) specifically requires new projects to design and implement an activity focusing on women as follows:

<u>Technical Considerations for Award of a CRSP Project</u> *(p. 6, Items 3 & 5):*

3. Proposals must include at least one experiment or study. Proposals <u>must</u> also include at least one outreach activity that focuses on women.

5. Investigations must integrate gender to the extent possible to meet program targets. Overall, proposals will include a gender inclusiveness strategy(RFP website: Gender Inclusivity Strategy). The existing strategy can be revised or resubmitted if it is still

applicable to the work proposed. If resubmitting the gender strategy from 2007-09, additional details for incorporating gender will need to be apparent in the new investigations.

(e) Tailor specific extension and technical services related to sustainable aquaculture and aquatic resource management to women producers.

Examples illustrating completed activities tailored specifically for women stakeholders are listed below.

- *Community-level shellfish culture and sanitation trainings: collaboration with women's producer organizations/cooperatives (07HHI04UH, 07IND03UH) and focus on women participating in community trainings (07HH05UH, 07IND04UH, 07WIZ02UH)*
- *Tilapia-Sahar polyculture: collaboration with RIDS-Nepal to include 50% women in the farmer training (07BMA02UM)*
- *Women processors: assessments of utilization and processing practices for small, low-value fish from the Mekong River fishery include a specific focus on the role of women (07FSV01UC)*
- *Women's Cooperative: collaborative assistance of the Trafalgar Women's Cooperative in the feed formulation trainings associated with the sustainable feed studies in Guyana (07SFT04UA/07SFT05UA)*
- *Women's Training on post-harvest processing and value-added product development: 2 workshops (09MNE02NC)*
- *Requirements for food quality and safety in cockles (09HHI01UH)*

(f) Engage extension specialists sensitive to diversity issues and access to resources of underrepresented groups and women will be included as an integral part of their delivery team to ensure women farmers and fishers feel welcome in CRSP training opportunities.

Each core project has a gender integration strategy that outlines steps to increase the number of women participating in short-term trainings and enrolling in long-term degree programs: (1) female researchers and students are being given positions as workshop presenters to establish connections with women trainees, (2) constraints limiting attendance in workshops are being addressed (e.g., more flexibility in workshop location and scheduling), (3) extension specialists are being trained to be more gender sensitive, (4) women are being invited to participate in on-farm trials, (5) women's producer cooperatives have been actively sought out to collaborate with AquaFish CRSP researchers, and (6) research focus and strategy are taking into account women's roles as food providers and preparers as well as their key positions in production and marketing.

(g) Promote the participation of women in formal and informal education and training opportunities provided through the CRSP. The CRSP has set a 50% benchmark for training women in formal and informal education. In addition, the 50% benchmark applies to attracting and retaining women scientists and administrators in all CRSP activities, as project researchers, advisory group members, and managers.

Projects are committed to promoting the participation of women at all levels from target populations to top-level researchers. Women are well represented in CRSP management, Advisory Groups, and in the group of Principal Investigators and collaborators. Women are the focus of stand-alone studies, which are included in the portfolio to reflect a gendered perspective.

USAID IMPACT REPORTING USAID IMPACT REPORTING

AquaFish CRSP reports under USAID's various impact reporting frameworks to achieve outcomes that have meaning for stakeholders, including Missions, HC decision makers, and end-users. The indicator reports filed with USAID for this reporting year (FY 2010) are presented in this section.

USAID-EGAT Indicator Reporting

For this reporting period, AquaFish CRSP only reported under USAID-EGAT 5.2 Agriculture Sector Productivity indicators (Table X-1). Tables 15 to 17 in Appendix 4 provide supporting data for the technologies, practices, products, and markets reported under the technology indicators — 5.2-H(8), 5.2-I (9), and 5.2-J (10).[13]

Table X-1. AquaFish CRSP FY 2010 USAID-EGAT Indicator Report as submitted on 1 November 2010

4.5.2 Agriculture Sector Productivity	**FY 2010 Targets**	**FY 2010 Results**	**FY 2011 Targets**
5.2 -J (10): Number of new technologies or management practices under research as a result of USG assistance.	58	55	34
5.2-H (8): Number of new technologies or management practices made available for transfer as a result of USG assistance.	24	24	31
5.2-I (9): Number of new technologies or management practices being field tested as a result of USG assistance.	21	20	19
5.2-B (2): Number of additional hectares under improved technologies or management practices as a result of USG assistance.	2,774	2,676	3,473
5.2-E (5): Number of farmers, processors, and others who have adopted new technologies or management practices as a result of USG assistance - Female	–	–[a]	–[a]
5.2-E (5): Number of farmers, processors, and others who have adopted new technologies or management practices as a result of USG assistance - Male	–	–[a]	–[a]
5.2-M (13): Number of rural households benefiting directly from USG interventions - Female Headed Household	–	–[b]	–[b]
5.2-M (13): Number of rural households benefiting directly from USG interventions - Male Headed Household	–	–[b]	–[b]
5.2-K (11): Number of producers organizations receiving USG assistance	10[§]	10	10
5.2-K (11): Number of water users associations receiving USG assistance		0	0
5.2-K (11): Number of trade and business associations receiving USG assistance		0	0
5.2-K (11): Number of community-based organizations (CBOs) receiving USG assistance		1	1
5.2_New: Number of producers organizations who have adopted new technologies or management practices as a result of USG assistance.	–	–[b]	–[b]
5.2_New: Number of water user associations who have adopted new technologies or management practices as a result of USG assistance.	–	–[b]	–[b]
5.2_New: Number of trade and business associations who have adopted new technologies or management practices as a result of USG assistance.	–	–[b]	–[b]
5.2_New: Number of community-based organizations (CBO) who have adopted new technologies or mangement practices as a result of USG assistance.	–	–[b]	–[b]

[13] Metrics are based on the best available data at the time of the 31 October 2010 reporting date.

Table X-1. AquaFish CRSP FY 2010 USAID-EGAT Indicator Report as submitted on 1 November 2010

4.5.2 Agriculture Sector Productivity	**FY 2010 Targets**	**FY 2010 Results**	**FY 2011 Targets**
Number of agriculture-related firms benefiting directly from USG supported interventions.	10	9	9
Number of women's organizations/associations assisted as a result of USG interventions.	6	5	5
5.2-L (12): Number of public-private partnerships formed as a result of USG assistance.	21	19	0
5.2-G (7): Number of individuals who have received USG supported short-term agricultural sector productivity or food security training — Female	500	275	500
5.2-G (7): Number of individuals who have received USG supported short-term agricultural sector productivity or food security training — Male	500	419	500
5.2-F (6): Number of individuals who have received USG supported long-term agricultural sector productivity or food security training — Female	75	87	75
5.2-F (6): Number of individuals who have received USG supported long-term agricultural sector productivity or food security training — Male	75	109	75
5.2_New: Value of new private sector investment in the agriculture sector or food chain leveraged by FTF implementation.	–	–[c]	–[c]
FTF-IR4: Number of jobs attributed to FTF implementation (disagregated by gender, ag vs non-ag)	–	–[c]	–[c]

[a]Will not be able to report due to lack of mechanism for collecting actual "adoption" by stakeholders.
[b]For FY 2009, AquaFish CRSP reported a FY 2010 target of 1000 rural households for EG 5.2-19 (now revised as EG 5.2-M(13). The FY 2010 target was an estimate of households based on training attendance. There is no mechanism for collecting head of household data or for determining household status. On the advice of the AOTR (as per his comments at the AquaFish CRSP FY 2010 Annual Meeting regarding the difficulties in reporting on this indicator), AquaFish CRSP will not report on 5.2-M(13).
[c]Will not be able to report because indicator focus was not encompassed in prior year's approved workplans.
[§]Target set in FY 2009 indicator report as an aggregated value.

XI. LESSONS LEARNED

The lessons learned that are presented below are from an overall program perspective. Lessons learned from the Mali Associate Award are included here to the extent that they affect AquaFish CRSP program management. The annual report for the Mali Associate award presents lessons learned specific to that project.

- In the past three years, USAID has done a laudable job of providing incremental annual funding to the CRSP on a timely basis. Cost applications and technical applications are reviewed and negotiated each September, and extensions have arrived at OSU near the annual closedown date of 29 September each year. Funds have not been cut at the last moment or delayed, as was customary in the previous CRSP. To harken back, up until 2006 or so, CRSPs fought USAID every year for funds that were committed to them but were being withheld for opaque reasons. Now, there is greater transparency. The process through APLU and Congress, with the guidance of Dr. Tag Demment, has surely helped. In addition, USAIDs' contracting officers, along with those who work with them such as the AOTRs, have made noticeable improvements in delivery, and they have done so with courtesy and care. We recognize and appreciate them for their diligence.

  We look forward to receiving more on-time extensions, especially as we wrap up our final year with an end date of 29 September 2011. On the horizon looms trouble, however, as delays in USAID's 4th Year Evaluation are mounting. This USAID Evaluation was to have been completed in the last fiscal year. It has not yet started. The concern is that the Evaluation was the vehicle by which our CRSP would be invited to apply for another 5 years. Many have called CRSPs 5 + 5-year programs. Doing a paper-only review is an option the CRSP Council has discussed and which USAID might wish to consider as it would surely expedite the process. As most AOTRs know, the RFP and competition process through MOU and subcontracting to initial implementation takes 6 to 12 months, or longer if all new subcontracts and MOUs are required. The lesson learned from many past CRSP renewals is that we are coming up on a period of critical significance when losses in projects, valued researchers, momentum, and investment mounts with every day a decision is not made. From a programming perspective, knowing USAID's intentions, or alternate plans, by January 2011 is of utmost importance.

- AquaFish CRSP's US Lead Universities typically extend CRSP funding to collaborating HC Institutions through cost-reimbursement contracts. The AquaFish CRSP ME is exploring the use of fixed-price contractual agreements between US Lead Institutions and HC Institutions as a reimbursement method to directly link payment to receipt of deliverables and/or performance. Under this system, HC Institutions receive payment upon timely receipt of predetermined deliverables or meeting predetermined performance benchmarks. Further, as stated in the FAR 16.2, fixed-price contracts provide "maximum incentive for the contractor to control costs and perform effectively and imposes a minimum administrative burden upon the contracting parties." All HC partners would still be held to the same standards, rules, and regulations currently enforced by AquaFish CRSP and USAID.

- Contractual agreements between the ME and US Lead Universities require annual reports to be submitted by US Lead PIs on or before 15 October for each preceding fiscal year. This deadline allows the US and HC researchers to conduct work throughout the entire fiscal year for which they are reporting. The AquaFish CRSP collects, analyzes, and verifies data from these reports to

generate its own annual report (due to USAID on 31 October) and USAID indicator reports (due 1 November). With increased burden placed upon the ME to report on an ever-expanding list of indicators, we have learned that requiring US Lead PIs to submit annual reports on 15 October does not provide sufficient time for the ME to meet USAID's due dates for the AquaFish CRSP Annual Report or for USAID indicator reporting. Under future contractual agreements with US Lead Institutions, we may require annual reports to be submitted to the ME earlier thereby allowing us to better meet USAID deadlines, with the unfortunate consequence of reducing the amount of time available for PIs to perform their work.

- The combined sets of internal DTAP and USAID EGAT indicators serve as valuable tools for quantifying accomplishments. However, as it currently operates, the USAID indicator component does not work as smoothly as it should nor does it offer recognizable benefits to the CRSP investigators who are the principal data gatherers. Last minute changes in USAID indicators and the associated rushed data gathering, such as is the case with the FY 2010 set (announced on 21 October 2010), do not promise robust metrics. The changing annual landscape of USAID indicators also threatens consistency in comparative assessments of results across years. Host Country and US investigators enthusiastically support impact assessment but are less sure of the value of indicators because the reporting process strikes them as inconsistent and with no tangible returns for their efforts. Unfortunately, the USAID indicator process seems out of balance by primarily emphasizing indicators as data to justify funding at the agency level. CRSP investigators have an equal need for the same data with which they can assess progress and accomplishments and also draw upon to guide next steps in their research and development approaches. From the perspective of what indicators should be, but unfortunately are not, the lessons learned are that indicator reporting should be an integrated process that is tied directly into the CRSP investigation workplans with pre-approved indicators that apply through the duration of the investigation and offer metrics that are useful both for USAID and the investigators who are working to improve aquaculture and fisheries systems in their countries. The CRSPs own DTAP metrics and benchmarks, which are an internal set of indicators, provide better feedback to the CRSP on performance and serve as more useful predictive tools for assessing project impacts.

- Coordinating a collaborative effort that includes partners from three countries in addition to the host country—as is the case in our Mali Associate Award Project— requires a considerable amount of extra time, effort, and patience. Although at times burdensome, the Mali Associate Award provides the AquaFish CRSP with an opportunity to contribute to aquaculture and fisheries development through a greater West African presence. Administration of the Mali Associate Award, however, has continued to incur higher-than-anticipated costs for the ME this year. Many project tasks, although similar to those necessary to run the core AquaFish CRSP program, must be handled independently and thus require extra resources and effort to complete. The additional unique reporting requirements of our Mali AA are an excellent example of this. In future planning for AAs, we will need to keep this in mind and adjust estimates of the time and funding needed to successfully manage an AA.

- Increasing Management Office staffing to administer extra projects and assimilating such projects more completely into the overall AquaFish program are two ways to improve the management of AAs in the future. The consensus among AquaFish CRSP management and advisory groups at the 2009 Annual Meeting was that we should consider treating future Associate Awards more similarly to core research projects, adhering to technical peer-review, organizational, and reporting (i.e., DTAP) requirements. With the new FTF AA, already we have heeded this lesson by requiring all tasks to: be written as "investigations" that undergo external peer-review; add to the DTAP metrics; and conform with core CRSP guidelines. With the Mali AA this was impossible due to the last minute nature of the 2007 RFA. Integration and alignment require extra planning time. Quick turnaround task-order type RFAs don't typically allow for this. Another method for promoting integration tool of Associate Award personnel is for them to provide service on core

CRSP advisory groups. The CRSP Director appointed the Mali PI as the CRSP West Africa RCE Leader on the core program. This is not only a distinction for Mali but will help with Mali project sustainability as the AA draws to an end this Fall 2010. Synchronizing the smaller AAs into the core requires considerable coordination and stresses both units as there are real differences in timeframes, deliverables, reporting, and networks. These alignment issues can only be reduced if the AAs do not have independent technical or performance reporting requirements, if adequate funding is given to the ME for coordination, if time is allotted up front for coordination among units, and if the awarding unit at USAID understands that the project will be fitting into a CRSP organization which operates under a University system that has its own sets of rules and cultural norms.

- The CRSP Council has discussed the use of associate awards to fund activities that are consistent with the Leader Award but are administratively burdensome. The Council wishes that USAID would fund the core mission of the CRSPs at a full level of $3m or more per year, rather than through smaller contract-like awards. Two reasons for this are that CRSPs' cohesiveness has been degraded through the years through an erosion of funding ($2m of funding received when PDA CRSP started in 1982 is the same as $4.5m today). The other is that associate awards are essentially independent projects that have independent reporting requirements plus added reporting requirements within the Leader award. Last year saw three new AAs awarded to CRSPs and attributed to the new FTF initiative. Our AquaFish CRSP received one of these awards, after an approximate investment of well over 200 person-hrs from concept paper to USAID award, an inarguably inefficient process. While we don't want to appear ungrateful, the cost to the Leader Award was high, and we wonder if there is a better way to accomplish the same outcome. These three AAs – the other two went to the Pulse CRSP and INTSORMIL -- came about because there was approximately $5m remaining from last year's (FY10) CRSP commitment from Congress. USAIDs motivation for strategic short-term activities underlies many of these new awards, including last year's $3.92M award. The benefits of the additional resources get offset by: additional transactions costs to each CRSP, parasitizing core resources (or leveraging off oneself), and dissolution of researchers' time to band-aid pressing issues of the day at the expense of longer term discoveries. Most worrisome is that piecemeal funding of CRSPs could signal a redirection away from the time-tested successful CRSP model -- capacity building hand-in-hand with discovery. If USAID is considering doing away with LWAs, CRSPs would encourage a more streamlined effort possibly involving adding funds to the core. In any case, CRSPs would welcome being consulted if changes are made to the LWA.

- Meeting matching requirements for CRSP has become a challenge for almost every US university. In the CRSP model, cost share is a fundamental dimension of all programs as it helps stretch limited federal dollars with State and other non-federal sources of funds, and leverages experienced faculty and resources from the US university community. Of the participating US lead universities, none are currently exceeding their cost share requirements as was customary in the past. At cost-sharing rates of 35% for US universities in the CRSP including the management entity, all US universities are being tested in meeting their minimum commitments. A combination of factors contributes to the current situation, with the present shortfalls in almost all State economies leading the reasons. Most CRSP US universities are funded through State dollars, and with greater accountability of professors' salaries being demanded by the States, less is truly available for external programs. It is our understanding that the auditable portion of US university cost-share, specified under 22CFR226 and other directives, does not include in-kind contributions from non-US sources, specifically from host countries. Host country match is anyway optional, and requested for strengthening institutions, especially those charging overhead. The CRSP will continue to monitor and evaluate its cost share status into early 2011, with the intention of being able to request advance permission, if necessary, from USAID to retire a portion of cost share obligations that are unreachable in the current timeframe under the current poor economic environment.

APPENDIX 1. PROGRAM PARTICIPANTS

Management Team Staff

Oregon State University, Corvallis, Oregon USA

Hillary Egna	Director
Ford Evans	Research Projects Manager
Jim Bowman	Capacity-Building Coordinator (0.25 FTE)
Dwight Brimley	Accountant (through July 2010)
Patty Heublein	Office Specialist (through January 2010)
Cindi Claflin	Office Specialist (from April 2010)
Lisa Reifke	Training & Gender Coordinator (from April 2010)

United States Agency for International Development

Washington, DC USA

Harry Rea	Agreement Officer's Technical Representative

Advisory Bodies

External Program Advisory Council

Christine Crawford	University of Tasmania, Australia
Jason Clay/Aaron McNevin	World Wildlife Fund, Washington, DC
Nathanael Hishamunda	FAO, Rome, Italy

Ex-Officio Members

Harry Rea	USAID
Hillary Egna	Oregon State University

Development Themes Advisory Panel: Lead Coordinators

Maria Haws	DTAP A	University of Hawai'i at Hilo
Kwamena Quagrainie	DTAP B	Purdue University
James Diana	DTAP C	University of Michigan
Robert Pomeroy	DTAP D	University of Connecticut–Avery Point

Regional Centers of Excellence: Lead Coordinators

Charles Ngugi	East & Southern Africa	Kenyatta University, Kenya
Héry Coulibaly	West Africa	Direction Nationale de la Pêche, Mali (From Aug. 2010)
Remedios Bolivar	Asia	Central Luzon State University, Philippines
Wilfrido Contreras-Sanchez	LAC	Universidad Juárez Autónoma de Tabasco, Mexico

Core Research Project Researchers

Auburn University

Participants	Status	Country
		USA
Joseph Molnar	US Lead PI	Auburn University
Claude E. Boyd	US Investigator	Auburn University
Karen Veverica	US Investigator	Auburn University
James O. Bukenya	US Co-PI	Alabama A&M University
E. William Tollner	US Co-PI	University of Georgia
		Uganda
Levi Kasisira	HC Lead PI	Makerere University
Theodora Hyuha	HC Investigator	Makerere University
Monica Karuhanga Beraho	HC Investigator	Makerere University
Peter Mulumba	HC Investigator	Makerere University
Nelly Isyagi	HC Co-PI	Gulu University
Alfonse Opio	HC Investigator	Gulu University
Gertrude Atukunda	HC Co-PI	National Fisheries Resources Research Institute
E. John Walakira	HC Investigator	National Fisheries Resources Research Institute
		South Africa
Khalid Salie	HC Co-PI	Stellenbosch University

North Carolina State University

Participants	Status	Country
		USA
Russell Borski	US Lead PI	North Carolina State University
Peter R. Ferket	US Investigator	North Carolina State University
Upton Hatch	US Investigator	North Carolina State University
Charles R. Stark	US Investigator	North Carolina State University
Kevin Fitzsimmons	US Co-PI	University of Arizona
Christopher Brown	US Co-PI	US Department of Commerce-NOAA
		Philippines
Remedios B. Bolivar	HC Lead PI	Central Luzon State University
Wilfred Jamandre	HC Investigator	Central Luzon State University
Emmanuel M. Vera Cruz	HC Investigator	Central Luzon State University
Evelyn Grace T. de Jesus-Ayson	HC Co-PI	SEAFDEC-AQD
Maria Rovilla J. Luhan	HC Investigator	SEAFDEC-AQD

North Carolina State University (cont)

Participants	Status	Country
Rose T. Mueda	HC Collaborator	University of the Philippines at the Visayas
		Indonesia
Hassan Hasanuddin	HC Co-PI	Ujung Batee Aquaculture Center, Banda Aceh
Coco Kokarkin	HC Investigator	Ujung Batee Aquaculture Center, Banda Aceh

Oregon State University

Participants	Status	Country
		USA
Steven Buccola	US Lead PI	Oregon State University
Rolf Fare	US Investigator	Oregon State University
John Antle	US Co-PI	Montana State University
Roberto Valdivia	US Investigator	Montana State University

Purdue University

Participants	Status	Country
		USA
Kwamena Quagrainie	US Lead PI	Purdue University
Jennifer Dennis	US Investigator	Purdue University
Rebecca Lochmann	US Co-PI	University of Arkansas at Pine Bluff
Emmanuel Frimpong	US Co-PI	Virginia Polytechnic Institute & State University
		Kenya
Charles Ngugi	HC Lead PI	Kenyatta University
Judith Amadiva	HC Co-PI	Ministry of Fisheries Development
Sammy Macharia	HC Investigator	Ministry of Fisheries Development
Julius Manyala	HC Co-PI	Moi University
Jennifer Atieno	HC Collaborator	Women in Fishing Industry Project
		Ghana
Stephen Amisah	HC Co-PI	Kwame Nkrumah University of Science & Technology
Nelson Agbo	HC Investigator	Kwame Nkrumah University of Science & Technology
		Tanzania
Sebastian Chenyambuga	HC Co-PI	Sokoine University of Agriculture
Berno V. Mnembuka	HC Investigator	Sokoine University of Agriculture

Purdue University (cont)

Participants	Status	Country
		Tanzania (cont)
Nazael Madalla	HC Investigator	Sokoine University of Agriculture

University of Arizona

Participants	Status	Country
		USA
Kevin M. Fitzsimmons	US Lead PI	University of Arizona
Reynaldo Patiño	US Co-PI	Texas Tech University-Lubbock
Dennis McIntosh	US Collaborator	Delaware State University
Jason D. Licamele	US Collaborator	Fish Farmacy
Traci Holstein	US Collaborator	Shrimp Improvement Systems
Edward Glenn	US Investigator	University of Arizona
		Mexico
Wilfrido Contreras-Sánchez	HC Lead PI	Universidad Juárez Autónoma de Tabasco
Carlos Alfonso Alvarez-González	HC Investigator	Universidad Juárez Autónoma de Tabasco
Mario Fernández-Pérez	HC Investigator	Universidad Juárez Autónoma de Tabasco
Arlette Hernández-Franyutti	HC Investigator	Universidad Juárez Autónoma de Tabasco
Ulises Hernández-Vidal	HC Investigator	Universidad Juárez Autónoma de Tabasco
Gabriel Marquez Couturier	HC Investigator	Universidad Juárez Autónoma de Tabasco
Rosa Martha Padron-Lopez	HC Investigator	Universidad Juárez Autónoma de Tabasco
Salomon Paramo Delgadillo	HC Investigator	Universidad Juárez Autónoma de Tabasco
Pablo Gonzales Alanis	HC Co-PI	Universidad Autónoma de Tamaulipas
Mauricio A. Ondarza	HC Investigator	Universidad Autónoma de Tamaulipas
		Guyana
Pamila Ramotar	HC Co-PI	Department of Fisheries
Vivek Joshi	HC Investigator	Department of Fisheries
Lawrence Lewis	HC Collaborator	University of Guyana

University of Connecticut–Avery Point

Participants	Status	Country
		USA
Robert S. Pomeroy	US Lead PI	University of Connecticut-Avery Point
Sylvain De Guise	US Investigator	University of Connecticut-Avery Point
Tessa Getchis	US Investigator	University of Connecticut-Avery Point
David A. Bengtson	US Co-PI	University of Rhode Island

University of Connecticut–Avery Point (cont)

Participants	Status	Country
Chong M. Lee	US Investigator	University of Rhode Island
		Cambodia
So Nam	HC Lead PI	IFReDI
Hap Navy	HC Investigator	IFReDI
Kao Sochivi	HC Investigator	IFReDI
Prum Somany	HC Investigator	IFReDI
		Vietnam
Tran Thi Thanh Hien	HC Co-PI	Can Tho University
Le Xuan Sinh	HC Investigator	Can Tho University

University of Hawai'i at Hilo

Participants	Status	Country
		USA
Maria Haws	US Lead PI	University of Hawai'i at Hilo
Kevin Hopkins	US Investigator	University of Hawai'i at Hilo
Konrad Dabrowski	US Co-PI	Ohio State University
John Supan	US Co-PI	Louisiana State University
David Nisbet	US Collaborator	Goosepoint Oyster Inc
Quentin Fong	US Collaborator	University of Alaska
		Mexico
Eladio Gaxiola Camacho	HC Lead PI	Universidad Autónoma de Sinaloa-Culiacán
Omar Calvario Martínez	HC Co-PI	CIAD
Lorena Irma Camacho	HC Investigator	Universidad Autónoma de Sinaloa-Culiacán
Guillermo Rodriguez Domínguez	HC Co-PI	Universidad Autónoma de Sinaloa-Mazatlán
Gustavo Rodriguez Montes de Oca	HC Investigator	Universidad Autónoma de Sinaloa-Mazatlán
Olga Olivia Zamudio Armenta	HC Investigator	Universidad Autónoma de Sinaloa-Mazatlán
Jose Cristobal Roman Reyes	HC Investigator	Universidad Autónoma de Sinaloa-Mazatlán
		Nicaragua
Carlos José Rivas Leclair	HC Co-PI	CIDEA-UCA

University of Hawai'i at Hilo (cont)

Participants	Status	Country
Nelvia Hernandez del Socorro	HC Investigator	CIDEA-UCA
Erik José Sandoval Palacios	HC Investigator	CIDEA-UCA

University of Michigan

Participants	Status	Country
		USA
James S. Diana	US Lead PI	University of Michigan
		Bangladesh
Mohammed Abdul Wahab	HC Co-PI	Bangladesh Agricultural University
		China
Liu Liping	HC Lead PI	Shanghai Ocean University
Jiang Min	HC Investigator	Shanghai Ocean University
Dai Xilin	HC Investigator	Shanghai Ocean University
Lai Qiuming	HC Co-PI	Hainan University
Wang Weimin	HC Co-PI	Huazhong Agricultural University
Gao Xexia	HC Investigator	Huazhong Agricultural University
Song Biyu	HC Co-PI	Wuhan University
		Nepal
Madhav K. Shrestha	HC Co-PI	Institute of Agriculture & Animal Science
		Thailand
Derun Yuan	HC Co-PI	Network of Aquaculture Centres in Asia-Pacific
		Vietnam
Le Thanh Hung	HC Co-PI	Nong Lam University
Nguyen Phu Hoa	HC Investigator	Nong Lam University
Vu Cam Luong	HC Investigator	Nong Lam University

Oregon State University Research Support Projects

Participants	Project
Laura Morrison	Synthesis Project
Steve Buccola	Synthesis Project
Peg Herring	Journalism Project
Jeff Hino	Journalism Project
Tiffany Woods	Journalism Project

APPENDIX 2. LINKAGES

Institutions, NGOs, and organizations listed below participate as partners in the AquaFish CRSP research projects.

Symbols indicate the following:

*US and Host Country PI affiliations and direct funding recipients through subcontracts and MOUs. Entities with affiliations based on financial support via travel reimbursement or personal services agreements, or other shorter term funding arrangements are not included in this group.

† Linkage through the Mali Associate Award Project.

US Partners

Alabama A&M University*
American Soybean Association
Cornell University
Delaware State University
Department of Commerce, NOAA
Fisheries Industry Technology Center–University of Alaska
Fish Farmacy (Arizona)
Florida International University
Goosepoint Oyster Inc (Washington)
Louisiana State University*
National Oceanic & Atmospheric Administration–International Sea Grant
North Carolina State University*
Oregon State University*
Oxfam America
Pacific Aquaculture & Coastal Resources Center–University of Hawaii at Hilo*
Pacific Shellfish Growers Association
Purdue University*
Shrimp Improvement Systems (Florida)
Sustainable Management of Watershed CRSP
Texas A&M University
Texas Parks & Wildlife Department
Texas Tech University*
University of Arizona*
University of Arkansas at Pine Bluff*
University of Connecticut–Avery Point*
University of Georgia*
University of Hawaii at Hilo*
University of Michigan*
University of Rhode Island*
University of Rhode Island–Coastal Resources Center
University of Texas
US-Mexico Aquaculture TIES Program
U.S. Department of Commerce (Milford, CT)
U.S. Food & Drug Administration
Virginia Polytechnic Institute & State University*
World Wildlife Fund*

International Partners

Aquaculture without Frontiers (USA) Australian Centre for International Agricultural Research
International Development Research Centre (Canada)
Lake Victoria Environmental Management Project (Kenya, Tanzania, Uganda)
Network of Aquaculture Centers in Asia (Thailand)
United Animal Feed Producers
United Cooperative of Fishermen
United Nations Food & Agriculture Organization (Italy)
United Nations Food & Agriculture Organization, Regional Office (Ghana)
United Nations Food & Agriculture Organization in Asia-Pacific (Cambodia)
USAID Farmer-to-Farmer Program, Guyana
USAID GTIS Programme (Guyana)
USAID SUCCESS Program (USA)
US-Mexico Aquaculture TIES Program
World Aquaculture Society (USA)
WorldFish Center (Malaysia)

Australia

Australian Centre for International Agricultural Research

Bangladesh
Bangladesh Agricultural University

Brazil
Centro de Acüicultura, UNESP

Cambodia
Department of Fisheries, Mekong River Commission, Aquaculture/Fisheries Projects
Department of Fisheries, Post-Harvest Technologies & Quality Control of Fisheries Administration
Fisheries Administration
Freshwater Aquaculture Research & Development Center
Inland Aquaculture Extension & Productivity Improvement Project
Inland Fisheries Research & Development Institute (IFReDI)*****
Prek Leap National School of Agriculture (PLNSA)

China
China Aquatic Products Processing & Marketing Association
Hainan University*****
Haoshideng Shrimp Farm
Huazhong Agricultural University*****
Huiting Reservoir Fisheries Management Company
Shanghai Ocean University*****† (formerly Shanghai Fisheries University)
Sichuan Aquacultural Engineering Research & Technology Research Center†
Tongwei Co. Ltd
Wuhan University*
Zhanghe Reservoir Fisheries Management Company

Costa Rica
University of Costa Rica

Ecuador
Ecocostas

Egypt
Academy of Scientific Research & Egyptian Universities
Central Administration of Agricultural Foreign Relations
Central Laboratory for Aquaculture Research
Egyptian Society of Agribusiness
Ministry of Agriculture & Land Reclamation

Ghana
Anna Regina Fish Culture Station
Fisheries Department, Ministry of Food & Agriculture
Kwame Nkrumah University of Science & Technology*****
Ministry of Agriculture Fisheries Directorate
Maharaja Oil Mill
Mon Repos Aquaculture Center
National Aquaculture Association of Guyana
Trafalgar Union Women's Cooperative
Von Better Aquaculture
Water & Sewerage Company

Guatemala
San Carlos University

Guyana
Department of Fisheries
Maharaja Oil Mill
Mon Repos Aquaculture Center*****
National Aquaculture Association of Guyana
USAID/GTIS Programme–Guyana
Von Better Aquaculture

Honduras
Zamorano University

Indonesia
Ujung Batee Aquaculture Center, Banda Aceh*****
Indonesian Department of Fisheries
Ladong Fisheries College

Kenya
Department of Fisheries†
Fish Africa*†
Kenya Business Development Services
Kenya Marine & Fisheries Research Institute
Kenyatta University*†
Moi University*†
National Investment Center
Sagana Aquaculture Centre
Women in Fishing Industry Project (WIFIP)

Lebanon
American University of Beirut

Mali
Direction Nationale de la Pêche†

Mexico
Cooperativa Pesquera San Ramon
Comite Estatal de Sanidad Acuicola de Sinaloa
Federation of Shrimp Cooperatives
Instituto Sinaloense de Acuacultura Instituto Nacional de Investigaciones Forestales y Agropecuarias
Mariano Matamoros Hatchery
Research Center for Food & Development (CIAD) *****
Secretariat of Agricultural Development for the State of Tabasco
Sinaloa Institute for Aquaculture
Sinaloa State Fisheries Department
State Committee for Aquaculture Sanitation of Sinaloa (CESASIN)
Universidad Autónoma de Tamaulipas*****
Universidad Autónoma de Sinaloa–Culiacán*****
Universidad Autónoma de Sinaloa–Mazatlán*****

Universidad Juárez Autónoma de Tabasco*****

Women's Oyster Culture Cooperatives of Nayarit
Women's Oyster Culture Cooperatives of Puerto Penasco

Nepal

Institute of Agriculture & Animal Science*****
Rural Integrated Development Society

Nicaragua

Center for Research of Aquatic Ecosystems-Central American University (CIDEA-UCA)*****
Nicaraguan Ministry of the Environment

Philippines

Bureau of Fisheries and Aquatic Resources (BFAR)*****
Central Luzon State University*****
Department of Agriculture
Genetically Improved Farmed Tilapia (GIFT) Foundation International, Inc
Southeast Asian Fisheries Development Center (SEAFDEC) AQD*****
University of the Philippines at the Visayas (Institute of Fish Processing Technology)

South Africa

Department of Water Affairs & Forestry (DWAF)
University of Stellenbosch*
Water Research Commission (WRC)

Tanzania

Kingorwila National Fish Center
Mbegani Fisheries Development Centre
Ministry of Natural Resources & Tourism, Aquaculture Development Division***** Nyegezi Fisheries Institute
Sokoine University of Agriculture*****
Tanzania Fisheries Research Institute
University of Dar-es-Salaam

Thailand

C NN Aquaculture & Supply Company, Bangkok
Department of Fisheries
Network of Aquaculture Centres in Asia-Pacific (NACA)†

Uganda

Blessed Investment Fish Farm
Gulu University*
Jinja United Group Initiative for Poverty Alleviation & Economic Development (JUGIPAED)
Lake Victoria Fisheries Organization (Kenya, Tanzania, Uganda)
Makerere University*
Namuyenge Mixed Farmers Ltd
National Fisheries Resources Research Institute (NaFiRRI)*
Source of the Nile (SoN) Fish Farm
Walimi Fish Cooperative Society Ltd

United Kingdom

UK Department for International Development

Venezuela

BIOTECMAR

Vietnam

Can Tho University*****
Dong Nai Fisheries Company
University of Agriculture & Forestry*

APPENDIX 3. LEVERAGED FUNDING

This table presents estimated fiscal Year 2010 funding from non-AquaFish CRSP leveraging. Leveraged funding is indicated below as reported through Quarterly, Annual, and Regional Centers of Excellence (RCE) Reports. Funding sources include grants, training, travel support, equipment, facilities, and other forms of provided services and supplies. Leveraged support is in addition to US non-Federal cost share and Host Country institution match.

US Lead Institution	Reported for Quarter Ending or RCE report	Amount ($)	Funding Source
University of Arizona			
	June 2010	$1,200	All Tech
	FY 2010 RCE Report	$16,260	Universidad Juàrez Autònoma de Tabasco
	FY 2010 RCE Report	$60,000	Fundacion Produce
	FY 2010 RCE Report	$120,000	Universidad Juàrez Autònoma de Tabasco
University of Michigan			
	June 2010	$16,055	Aquaculture Without Frontiers – UK
North Carolina State University			
	June 2010	$211,612	United States Department of Agriculture
Purdue University			
	September 2010	$10,000	PEO International Women's Peace Scholarship Program scholarship
Auburn University			
	March 2010	$2,000	Auburn University (Travel)
	June 2010	$4,500	Alabama Agricultural Land Grant Alliance
Total		**$441,627**	

APPENDIX 4: MONITORING & EVALUATION TABLES

Table 1. AquaFish Investigation Indicator Reports for DTAP A-01: Number of aquaculture products developed to improve food safety or quality

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	A01 Report Text
09FSV01UC Fish Paste Product Development	1	1	Improved fermented fish paste products with improved quality and safety under research and development (See D-01 and D-02)
09FSV02NC Seaweed Processing	1	1	Seaweed products with improved quality: (1) candy/desserts made from agar (See D-02)
09IND01UH Native Oyster Hatchery	1	1	Hatchery seed of native oyster for shellfish with improved health and safety See D-02
09IND03UH Chame Spawning & Larval Rearing	1	1	Development of chame product with improved quality and safety associated with spawning/larval rearing technologies See D-02
09MNE03UM Good Practices & Eco-Certification	0	1	Eco-certified shrimp with improved health and safety
09QSD03UM Prawn-Mola Polyculture	0	1	Prawns are commonly eaten and exported from Bangladesh, but the development of mola culture will add a new product to the market that addresses nutritional needs of smallholders.

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B-01 Report Text
07MER03PU Tilapia-Catfish Predation Culture	4	0	Training for small-farmers in production and management practices: (1) Pond preparation and construction (2) Fish management practices (3) Hand-sexing (4) polyculture of tilapia and catfish
07QSD02PU Catfish-Baitfish Farming	2	0	Post-production training in marketing: (1) Marketing plan for baitfish farm clusters (2) Finance management
07WIZ01PU Ghana water quality	3	0	Management practices to minimize waste and contamination of receiving waters from pond effluent and non-native species: (1) Effluent Management (2) Feeding and nutrients (3) Prevention of farm fish escape
07IND02UA Native Cichlid Culture	1	0	Farmer training in biology and culture technology for tropical gar and native cichlids
07BMA02UM Sahar-tilapia polyculture	1	0	Tilapia-sahar polyculture system with sahar density at 0.125 fish per square meter under adoption by cooperators.

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B-01 Report Text
07BMA04UH Shellfish BMPs	2	0	Training in BMPs to improve shellfish production and sanitation for farmers and vendors: (1) Oyster culture methods (2) shellfish sanitation
07HHI05UH Nicaragua: Depurated Cockles	1	0	Market for depurated cockles building due to spread by word-of-mouth of improved quality and safety with depurated product
07TAP01UC Feed Technology Adoption	2	0	Farmer Training: (1) sustainable feed alternatives for snakehead (2) sustainable fish feeding practices
09BMA01AU Cage Culture	1	1	Cage Culture for Small-Holder Farmers (For Practices under this technology, see C-01 and C-03)
09BMA03UM Sahar Polyculture	1	1	On farm development of polyculture technology for sahar-tilapia-carp for best ratio of predator to prey in economic and ecological terms. (For practices, see C-01 and C-03)

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B-01 Report Text
09BMA04UM Pond-Based RAS	1	1	Pond-based RAS system for shrimp with solid waste removal and water quality controls (For practices, see C-01 and C-03)
09BMA05UM Indoor RAS	2	2	Indoor RAS for shrimp: control of water quality and micro-organisms (e.g., cyanobacteria) Floc-based aquaculture system (For practices, see C-01 and C-03)
09FSV02NC Seaweed Processing	1	2	(1) Improved seaweed drying method using racks - completed. (2) Value-added seaweed processing for agar to make candy/desserts (3) Value-added processing for industrial grade agar and carrageenan
09IND01UH Native Oyster Hatchery	1	1	Larviculture of native oyster (For products, see A-01 and D-02)
09IND02UC Snakehead Aquaculture	1	1	Snakehead Domestication: induced spawning in captivity (For practices, see C-01 & C-03)

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B-01 Report Text
09IND03UH Chame Spawning & Larval Rearing	1	1	Indigenous species development of Chame for aquaculture: (1) Spawning technology successfully tested (2) Larval rearing technology (under development)
09IND04UH Chame Stock Assessment	0	1	Indigenous species development of Chame: Management Technology: (1) Age-determination technology (See C-01 for practices)
09IND05UA Cichlids & Snook	5	5	Native Species Aquaculture Technologies -- experimental protocols for: 1. Selective Breeding of Cichlid broodstock 2. Establishing Fat snook and common snook broodstock lineages from wild and hatchery raised juveniles 3. snook spawning in captivity 4. identify native plankton as feed during early snook development 5. determine gene expression of enzymatic activity in different snook life stages
09IND06PU New Species for Aquaculture	3	3	Investigation of aquaculture potential of 3 native African species in Ghana: *Heterotis niloticus*, *Chrysichthys maurus*, and *Parachanna obsucura* and farmer training in new species culture

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B-01 Report Text
09MNE02NC Milkfish Feed Inputs	2	2	Improved Ecological Footprint Technologies for Milkfish: (1) integrated, multitrophic aquaculture of milkfish-seaweed-sea cucumber in cages and pens (2) Alternate day feeding at an initial reduced feed ration (7.5 - 4% body weight) (3) Value-added processing of milkfish (deboning and marination) training for women
09QSD01NC Tilapia Seedstock Development	5	5	Tilapia Broodstock & Seed Production Technologies: 1. Social and physiological responses to stress as potential indicators for broodstock selection 2. Broodstock social condition effects on seed production - 3. social condition effects on fingerling growout performance 4. Stocking density effects on growth and stress responses 5. IGF-I and cortisol tests as growth indicator (under testing)
09QSD02UA Aquaponics &Tilapia	3	3	Aquaponics technology and Tilapia strain selection technologies: 1. Aquaponics-aquaculture for control of pond wastes 2. Enterprise model for cost-benefits 3. Tilapia strain evaluation protocol
09QSD03UM Prawn-Mola Polyculture	1	1	Small-scale prawn-mola polyculture for market (prawn) and home consumption (mola) See C-01 for practices

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B-01 Report Text
09QSD04PU Tilapia Performance	0	1	Aquaculture technology for new, improved tilapia species for small-scale aquaculture production:
09SFT01UC Alternative Feed	3	3	Snakehead pelleted feed trials: 1.C. micropeltes: Survival and growth 2. C. striata: Survival and growth 3.Replacement of fishmeal from marine vs. freshwater fish trials for Cambodia farmers (Companion to 09TAP03UC)
09SFT02PU Pond-Cage System	1	1	Integrated pond-cage technology for small-scale tilapia farmers to reduce feed cost and manage pond waste
09SFT03UA Guyana Aquaculture	2	3	Aquaculture Technologies 1. Integrated inland farming-aquaculture for small-scale farmers and women 2. YY Tilapia for regional hatchery program 3. Standardized aquaculture feed with local ingredients to reduce fishmeal

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B-01 Report Text
09SFT04NC Tilapia Feed Strategies	4	4	Tilapia Least-Cost Feed Formulation Technology and Feed Reduction Strategies: 1. Feed reduction strategy 2.Formulation Strategies: reduce fishmeal component by replacing with agricultural by-product protein sources 3.Protein Level: effect on grow-out performance 4. Manufacturing Specifications: pellet durability and water stability
09SFT05PU Leaf Meal Feeding Strategies	3	3	Sustainable Feed Technology studies using lower-cost, locally available ingredients: 1. Plant-based protein substitutes in feed 2. Feeding regime 3. Digestibility test with Chromium (III) oxide marker
09TAP02NC Tilapia Podcasts	1	1	4 Extension podcasts modules for international community of tilapia farmers and extension and research community
09TAP03UC Alternatives for Low-Value Fish	1	1	Snakehead feed adoption pilot with on-farm trials in Vietnam and Cambodia
09TAP04PU Cage Culture in Ghana	1	1	Assessment of Cage Culture technology: strategy to remove constraints
09WIZ01AU Multiple Water Use	1	1	Rural watershed management for multiple uses--cage culture and non-aquacultural applications
09WIZ02AU Water Management	1	1	Software approaches for water management for multiple uses

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B-01 Report Text
09WIZ03UM Fish Cage Culture	1	1	Deep water cage production model with polyculture fish system: under performance evaluation

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B02 Report Text
09BMA01AU Cage Culture	3	3	**Producer Group** Jinja United Group Initiative for Poverty Alleviation and Economic Development (JUGIPAED) **Agricultural Firm** UgaChick Company **Institutions & NGOs** National Agricultural Advisory Services
09BMA02AU Training & Outreach	1	1	**Producers** Walimi Fish Farmers Cooperative Society (WAFICOS)

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B02 Report Text
09BMA03UM Sahar Polyculture	2	2	**Women's Organizations** Rural Integrated Development Society (NGO) - Nepal (RIDS) Women in Aquaculture
09BMA04UM Pond-Based RAS	4	4	**Institutions & NGOs** Hainan University, Shanghai Ocean University, and University of Michigan **Agricultural Firm** Haoshideng shrimp farm
09BMA05UM Indoor RAS	3	3	**Agricultural Firm** Blue sea Aquaculture Development Company **Institutions & NGOs** Shanghai Ocean University, and University of Michigan
09BMA06UM Prawn Best Practices	4	4	**Institutions & NGOs** Department of Fisheries (Tahiland), Network of Aquaculture Centres in Asia, Shanghai Ocean University, and University of Michigan

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B02 Report Text
09FSV01UC Fish Paste Product Development	30	30	**Govt** Central Fisheries Administration 24 Provincial Fisheries Cantonment, Ministry of Mine industry and Energy (MIME), Ministry of Commerce (MoC), Ministry of Public Health (MOH) and Ministry of Agriculture Forestry and Fisheries **Women's Organizations** Women Fermented Fish Paste Group/Association
09HHI01UH Black Cockle Management	8	8	**Govt** Ministry of the Environment Ministry of the Environment Ministry of Forestry, **Women's Organization** Fishers & women's group in Aserradores estuary **Institutions & NGOs** Autonomous University of Leon, LIDER Foundation, Mesoamerican Biological Network & Conservation Chapter of Nicaragua Foundation of Friends of Rio San Juan (FUNDAR) in southern Nicaragua)
09IND01UH Native Oyster Hatchery	2	2	**Institutions & NGOs** Marine Science Center, (FACIMAR), (Mazatlan, Sinaloa)

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B02 Report Text
09IND02UC Snakehead Aquaculture	4	4	**Govt** Ministry of Agriculture, Forestry& Fisheries of Cambodia Fisheries Administration Department of Aquaculture Development **Institutions & NGOs** Freshwater Aquaculture Research and Development Center (FARDeC)
09IND03UH Chame Spawning & Larval Rearing	1	2	**Institutions & NGOs** Ecocostas (Ecuador) FACIMAR-UAS (Facultad de Ciencias del Mar Universidad Autonoma de Sinaloa)
09IND04UH Chame Spawning & Larval Rearing	3	3	**Producer Orgs** Fishers groups in Nayarit and Sinaloa (2) **Ag Firm** Mariano Matamoros Hatchery
09IND06PU New Species Development	5	10	**Govt, Institutions & NGOs** Fisheries Commission, Water Research Institute, KNUST, University of Ghana, University of Cape Coast, Savannah Agricultural Research Institute, University for Development Studies **Producer Orgs** Fish Farmers Association

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B02 Report Text
09MER02PU Value Chain	3	3	**Govt, Institutions & NGOs** Moi University, Kenyan Marine Fisheries Institute, Ministry of Fisheries Development
09MER04UC Value-Chain Analysis	25	25	**Govt, Institutions & NGOs** Government fisheries department, research centers, extension, NGOs, and private sector
09MNE01UM Red Swamp Crayfish	1	3	**Govt, Institutions & NGOs** Huazhong Agricultural University, Shanghai Ocean University, and University of Michigan
09MNE02NC Milkfish Feed Inputs	6	6	**Producers Organizations:** 4 fishers organizations from different coastal villages in Guimaras, Philippines 2 Communities (Buyuan, Pararanorte), 28 women (all women)
09MNE03UM Good Practices & Eco-Certification	2	3	**Govt, Institutions & NGOs** Shanghai Ocean University, Hainan University, and University of Michigan
09MNE04UC Management Recommendations	25	25	**Govt, Institutions & NGOs** Research centers, government fisheries department, non-government organizations, and inter-governmental organizations

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B02 Report Text
09QSD02UA Aquaponics &Tilapia	6	6	**Producers Org** Lacadon Village Farmers Cooperative **Govt, Institutions & NGOs** UAT, UJAT, WorldFish **Ag Firms:** Mariano Matamoros Hatchery Commercial Tilapia Farm
09QSD03UM Prawn-Mola Polyculture	1	3	**Govt, Institutions & NGOs** Huazhong Agricultural University, Shanghai Ocean University, and University of Michigan **NGOs** Caritas (NGO - to help with training women in production techniques)
09QSD04PU Tilapia Performance	4	4	**Govt, Institutions & NGOs** Sokoine University of Agriculture, Tanzania Fisheries Research Institute, Ministry of Livestock and Fisheries Development, **Producers Organizations:** Farmers Association
09SFT01UC Alternative Feed	20	20	**Govt, Institutions & NGOs** Research centers, government fisheries department, non-government organizations, and inter-governmental organizations

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B02 Report Text
09SFT02PU Pond-Cage System	4	4	**Govt, Institutions & NGOs** Moi University, Kenyan Marine Fisheries Institute, Ministry of Fisheries Development **Women's Orgs** Women in Fishing Industry Project
09SFT03UA Guyana Aquaculture	4	4	**Govt, Institutions & NGOs** (1) Ministry of Agriculture-Fisheries Office (GOVT) (2) University of Guyana (EDUC/RES) (3) National Aquaculture Association of Guyana (NGO) (4) GTIS (GOVT) **Women's Organization** Trafalgar Union Women's Cooperative **Ag Firm** Maharaja Oil & Feed Mill
09SFT04NC Tilapia Feed Formulation and Feed Reduction Strategies	3R	8	**Govt, Institutions & NGOs** Central Luzon State University, North Carolina State University, **Agricultural Firm** Santeh Feed Company in Philippines
09SFT05PU Leaf Meal Feeding Strategies	4	10	**Govt, Institutions & NGOs** Sokoine University of Agriculture, Tanzania Fisheries Research Institute, Ministry of Livestock and Fisheries Development,

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B02 Report Text
09TAP01UA ISTA 9	2	6	**Govt, Institutions & NGOs** Shanghai Ocean University (EDU/RES) Asian Fisheries Society (EDU Professional Org)
09TAP02NC Tilapia Podcasts	9	9	**Govt, Institutions & NGOs** BBAP/Ujung Batee - Government, Univ Arizona - Education, North Carolina State University - Education, Aquaculture without Frontiers - NGO, SEAFDEC AQD - Government, ACIAR - Government, **Communities:** 3 communities in Aceh, Indonesia
09TAP03UC Alternatives for Low-Value Fish	40	40	**Govt, Institutions & NGOs** Research centers, government fisheries department, non-government organizations, and inter-governmental organizations
09TAP03UC Alternatives for Low-Value Fish	3	3	**Communities**: Farmer adoption (farmers in three Vietnam provinces adopted use of feed) (3)

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	B02 Report Text
09TAP04PU Cage Culture in Ghana	5	15	**Govt, Institutions & NGOs** Fisheries Commission, Water Research Institute, , KNUST, University of Ghana, University of Cape Coast, Savannah Agricultural Research Institute, University for Development Studies and financial institutions **Communities** Fish Farmers
09WIZ01AU Multiple Water Use	2	2	**Govt, Institutions & NGOs** Department of Water Affairs & Forestry Water Research Commission
09WIZ02AU Water Management	1	1	**Water Users** Sustainable Management of Watershed (SUMAWA) CRSP
09WIZ03UM Fish Cage Culture	7	7	**Govt, Institutions & NGOs** Huazhong Agricultural University, Wuhan University, Luo Dian Spark Eco Aquaculture Company, Guizhou Normal University, Shanghai Ocean University, and University of Michigan **Agricultural Firms** Tongwei Corporation

Table 4. AquaFish Investigation Indicator Reports for DTAP C-01: Number of management practices developed or adopted to improve natural resource management

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C01 Report Text
09BMA01AU Cage Culture	2	2	Cage Culture in Lake Victoria for Small-Holder Farmers: (1) Production and (2) Enterprise techniques to improve resource management (For technology, see B-01)
09BMA03UM Sahar Polyculture	0	0	On farm development of polyculture technology for sahar-tilapia-carp being tested for the best ratio of predator to prey in economic terms and ecological terms. On farm testing may also result in adoption by the participating farms.
09BMA04UM Pond-Based RAS	0	0	Improved resource management with pond-based RAS system for shrimp with solid waste and water quality controls
09BMA05UM Indoor RAS	0	0	Improved resource management with indoor RAS and a Floc-based aquaculture system for shrimp
09BMA06UM Prawn Best Practices	0	1	Management practices for giant river prawn aquaculture to be developed and transferred at the workshop

Table 4. AquaFish Investigation Indicator Reports for DTAP C-01: Number of management practices developed or adopted to improve natural resource management

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C01 Report Text
09FSV01UC Fish Paste Product Development	2	2	Best Practices and Standards for Fish Paste Products: 1. Quality & Safety Processing Guidelines 2. Packaging & Labeling Standards (Develop the prahoc quality and safety guidelines, standardize packaging and labeling for fish paste)
09HHI01UH Black Cockle Management	1	1	Assessment of no-take zone management practice to regulate sanitation of black cockles:
09IND02UC Snakehead Aquaculture	1	1	BMPs for snakehead farming: Feeding strategy to maintain water quality (See B-01 for technology)
09IND04UH Chame Stock Assessment	1	1	Assessment of chame fishery on Mexican Pacific Coast for development of management recommendations for currently unregulated fishery (See B-01 for technology)
09MNE01UM Red Swamp Crayfish	1	1	Model to characterize invasive spread of red swamp crayfish in China.
09MNE02NC Milkfish Feed Inputs	0	0	Feed strategy and integrated polyculture will reduce waste load on environment and feed costs

Table 4. AquaFish Investigation Indicator Reports for DTAP C-01: Number of management practices developed or adopted to improve natural resource management

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C01 Report Text
09MNE03UM Good Practices & Eco-Certification	0	1	Best technology/practices for shrimp production to improve environmental performance based on testing of 3 culture management systems: (1) moderate density stocking vs (2) high density stocking in flushed ponds and (3) outdoor recirculating ponds.
09MNE04UC Management Recommendations	1	1	Recommendations for managing integrated aquaculture and capture fisheries of small-sized, low-value fishery
09MNE05UM Fish Stocking in Reservoirs	0	0	Evaluating the impacts of stocked fish on wild fish may result in the elimination of stocking in small reservoirs, which would improve the environment for natural biodiversity.
09QSD02UA Aquaponics &Tilapia	0	0	Aquaponics-aquaculture system will reduce ecological footprint of waste control by utilizing effluent from tilapia tanks to grow vegetables, beans and corn
09QSD03UM Prawn-Mola Polyculture	3	3	Small-scale prawn-mola polyculture: testing 3 different practices to determine the best returns for one practice in economic and ecological terms 1. Growth & Production performance based on gender ratios 2. Stocking density 3. Grading & size selective harvest See B-01 for technology

Table 4. AquaFish Investigation Indicator Reports for DTAP C-01: Number of management practices developed or adopted to improve natural resource management

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C01 Report Text
09SFT02PU Pond-Cage System	0	0	Integrated pond-cage technology for small-scale tilapia farmers reduces feed cost and waste management
09WIZ03UM Fish Cage Culture	0	0	Deep water cage production model with polyculture fish system: Reduction of ecological footprint by reduction of nutrient and sediment loading in receiving waters:

Table 5. AquaFish Investigation Indicator Reports for DTAP C-02: Number of hectares under improved natural resource management

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C02 Report Text
09BMA03UM Sahar Polyculture	0	10	Based on Average farm size in Nepal of 0.5, and an adoption by 20 trainees, 10 ha will be under improved management practices in FY11.
09BMA04UM Pond-Based RAS	0	60	Based an the average farm size of 3 ha and adoption by 20 trainees, 60 ha will be under improved management practices in FY11.

Table 5. AquaFish Investigation Indicator Reports for DTAP C-02: Number of hectares under improved natural resource management

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C02 Report Text
09BMA05UM Indoor RAS	0	40	Based on an average farm size of 1 ha and adoption by 40 trainees, 40 ha will be under improved management practices with the floc culture system in FY11
09BMA06UM Prawn Best Practices	0	120	Based on the average farm size in Thailand of 3 ha and 40 trainees, 120 ha will be under improved management practices for prawns in FY11.
09FSV02NC Seaweed Processing	10	30	Estimate that 10 ha of farms are using drying racks and will increase in FY11
09IND01UH Native Oyster Hatchery	0	15	Estimate of 15 hectares of oyster farms using hatchery seed.
09TAP03UC Snakehead Aquaculture	0	20	Estimate of 20 hectares of snakehead farms using CRSP snakehead feed practices provided government approves a new policy to allow snakehead aquaculture
09IND04UH Chame Stock Assessment	0	15	Wild-caught fisheries under improved resource management

Table 5. AquaFish Investigation Indicator Reports for DTAP C-02: Number of hectares under improved natural resource management

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C02 Report Text
09MNE02NC Milkfish Feed Inputs	0	10	Estimate of improved hectares through adoption of reduced feed Inputs for milkfish production and integrated milkfish culture
09MNE03UM Good Practices & Eco-Certification	0	6	Estimate of 100 fact sheets being distributed for government and private farms, with about 20% adoption for 6 ha of improved farms
09MNE04UC Management Recommendations	0	50	Fishery under improved management of freshwater small-sized/low value fish in the Lower Mekong region due to recommendations
09QSD02UA Aquaponics &Tilapia	2	2	FY10: hectares for aquaponic-aquaculture trials FY11: hectares under improved management practices
09QSD04PU Tilapia Performance	0	5	Farms using improved tilapia culture practices
09SFT01UC Alternative Feed	5	30	Farms utilizing sustainable feed practices
09SFT02PU Pond-Cage System	0	50	Farms using integrated pond-cage system

Table 5. AquaFish Investigation Indicator Reports for DTAP C-02: Number of hectares under improved natural resource management

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C02 Report Text
09SFT03UA Guyana Aquaculture	2	5	Maharaja Hatchery and ponds, Annai and Bina Hill projects
09SFT04NC Feed Strategies	2180	2900	Farms using up to 3 different alternate feeding strategies to reduce costs of Nile tilapia culture. Estimate of 15% the first year and an additional 5% of total hectares of tilapia pond culture in a portion of Central Luzon Philippines
09SFT05PU Leaf Meal Feeding Strategies	0	5	Farms using leaf-meal based feeds and feeding strategy
09WIZ03UM Fish Cage Culture	10	100	Conservative estimate that about 100 ha of reservoir will be in the area of improved deep-water cages
07HHI04UH Regional workshop	365	0	Oyster famers adopting shellfish culture and sanitation practices: Bahia Santa Maria 120 ha Boca de Camichin 195 ha Altata 50 ha
07MNE02NC Sustainable coastal aquaculture	3	0	Farms using seaweed polyculture to grow shrimp or fish
07MNE04UM Waste Mgmnt Practices	40	0	Better waste management for marine and freshwater aquaculture systems in China. Practices include use of settling ponds, co-culture of seaweeds, use of polyculture, and filtration.

Table 5. AquaFish Investigation Indicator Reports for DTAP C-02: Number of hectares under improved natural resource management

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C02 Report Text
07MNE06UA MT Elimination	2	0	Hectare estimate for hatcheries/farmers using MT elimination technology in aquaculture masculinization systems, including hectare estimate for farmers who procure all-male fingerlings from producers who use MT elimination technologies
07QSD02PU Catfish-Baitfish Farming	4	0	Estimate of additional ponds being used for catfish fingerling production.
07SFT06PU Locally available feed for tilapia	2	0	2 hectare estimate for farmer trainees who will adopt alternative plant protein feed for tilapia and any other feeding strategies for minimizing adverse effects on water quality
07WIZ01PU Ghana water quality	51	0	51 hectare estimate for farmers who will adopt BMPs for controlling aquaculture effluent

Table 6. AquaFish Investigation Indicator Reports for DTAP C-03: Number of management practices developed to support biodiversity

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C03 Report Text
09BMA01AU Cage Culture	0	0	Cage Culture in Lake Victoria for Small-Holder Farmers will reduce pressure on wild fish populations. See B-01 and C-01

Table 6. AquaFish Investigation Indicator Reports for DTAP C-03: Number of management practices developed to support biodiversity

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C03 Report Text
09BMA03UM Sahar Polyculture	0	0	Sahar polyculture technology/practices will reduce pressure on wild populations
09BMA06UM Prawn Best Practices	0	0	Practices are likely to reduce eutrophication from pond effluent, which would be a new management practice to protect wild diversity
09HHI01UH Black Cockle Management	0	0	Management practices to protect native black cockle fishery
09IND01UH Native Oyster Hatchery	0	0	Hatchery seed for culture of native oyster will protect wild populations
09IND02UC Snakehead Aquaculture	0	0	Farmed Snakehead will relieve pressures on wild snakehead populations
09IND03UH Chame Spawning & Larval Rearing	0	0	Captive breeding technology will protect wild populations by reducing wild fingerling capture

Table 6. AquaFish Investigation Indicator Reports for DTAP C-03: Number of management practices developed to support biodiversity

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C03 Report Text
09IND04UH Chame Stock Assessment	0	0	Assessment of chame fishery on Mexican Pacific Coast for development of management recommendations for currently unregulated fishery will help reduce pressure on wild populations
09IND05UA Cichlids & Snook	0	0	Native Species Selective Breeding technology for native cichlids and snook will reduce threat on wild stocks
09MER04UC Value-Chain Analysis	1	1	Recommendations to reduce pressure on wild-caught small-value fish by using feed alternatives for snakehead aquaculture
09MNE04UC Management Recommendations	0	0	Recommendations for managing integrated aquaculture and capture fisheries of small-sized, low-value fishery to protect biodiversity of fishery in Mekong River Basin
09MNE05UM Fish Stocking in Reservoirs	1	1	Evaluating the impacts of stocked fish on wild fish may result in the elimination of stocking in small reservoirs, which would improve the environment for natural biodiversity.
09QSD04PU Tilapia Performance	0	0	Management practices for best tilapia species for aquaculture for small-scale producers will lessens threat on wild fisheries
09SFT01UC Alternative Feed	0	0	Snakehead feeding practice with alternative feeds to lower pressure on small-sized fishery in Mekong River Basin

Table 6. AquaFish Investigation Indicator Reports for DTAP C-03: Number of management practices developed to support biodiversity

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	C03 Report Text
09SFT03UA Guyana Aquaculture	0	0	Feed formulation with fishmeal reduction practice reduces threat to wild fisheries
09SFT04NC Tilapia Feed Strategies	0	0	Feed Technologies: Formulated a Nile tilapia diet containing locally available ingredients that is effective at replacing fishmeal for culture in the Philippines
09SFT05PU Leaf Meal Feeding Strategies	0	0	Alternative protein sources for fishmeal reduces threat on wild fisheries
09WIZ03UM Fish Cage Culture	0	0	Deep water cage production model with polyculture fish system: reduction of nutrient and sediment loading in receiving waters, which would improve the situation for natural biodiversity in the reservoirs

Table 7. AquaFish Investigation Indicator Reports for DTAP D-01: Number of new markets for aquatic products

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	D01 Report Text
09MER03NC Tilapia Supply Chain	2	2	Analysis of supply chain efficiency with recommendations to lead toward tilapia market development and growth (1) domestic markets (2) export markets

Table 7. AquaFish Investigation Indicator Reports for DTAP D-01: Number of new markets for aquatic products

09MER04UC Value-Chain Analysis	2	2	Value-Chain analysis to identify solutions for development of snakehead aquaculture and market opportunities for snakehead and small-value fish: (1) domestic markets and (2) export markets
09QSD03UM Prawn-Mola Polyculture	0	1	Development of prawn from monosex-male polyculture systems should open up export markets for prawns in Bangladesh

Table 8. AquaFish Investigation Indicator Reports for DTAP D-02: Number of aquatic products available for human food consumption

Investigation Code	**FY10 DTAP Actual**	**FY11 DTAP Target**	**D02 Report Text**
09BMA03UM Sahar Polyculture	1	1	Farmed sahar
09BMA06UM Prawn Best Practices	2	2	Giant River Prawn (if improved product due to adoption of Best Practices) Mola for household consumption
09FSV01UC Fish Paste Product Development	1	1	Processed fish paste products with improved quality and safety (See A-01 and D-01)

Table 8. AquaFish Investigation Indicator Reports for DTAP D-02: Number of aquatic products available for human food consumption

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	D02 Report Text
09BMA03UM Sahar Polyculture	1	1	Farmed sahar
09FSV02NC Seaweed Processing	1	1	New seaweed products (human and non-human uses): (1) candy/desserts made from agar (2) industrial grade agar and carrageenan raw product (non-human consumption) See A-01
09IND01UH Native Oyster Hatchery	0	1	Hatchery seed of native oyster for shellfish with improved health and safety (non-human consumption) See A-01
09IND02UC Snakehead Aquaculture	1	1	Farmed snakehead (will depend on approval of new government policy to allow snakehead aquaculture)
09IND03UH Chame Spawning& Larval Rearing	1	1	Development of chame product with improved quality and safety associated with spawning/larval rearing technologies See A-01

Table 8. AquaFish Investigation Indicator Reports for DTAP D-02: Number of aquatic products available for human food consumption

Investigation Code	FY10 DTAP Actual	FY11 DTAP Target	D02 Report Text
09BMA03UM Sahar Polyculture	1	1	Farmed sahar
09MNE02NC Milkfish Feed Inputs	3	2	Products of integrated milkfish polyculture: (1) Value-added milkfish product: deboned and marinated milkfish products (2) seaweed (3) sea cucumber
09MNE03UM Good Practices & Eco-Certification	0	1	Eco-certified shrimp
09QSD03UM Prawn-Mola Polyculture	0	2	Prawn from all male monosex prawn culture for export Mola for household consumption

USAID – DTAP INDICATORS CROSS-REFERENCING

The AquaFish CRSP DTAP and Key Development Target Indicators are specifically tailored for assessing program-specific achievements, impacts, targets, and benchmarks. Tables 9 to 13 cross-reference these program indicators with USAID's broader, more general EG and FTF Indicators listed below:

Agriculture Program Element Indicators (EG 5.2 Agriculture Sector Productivity)

- **5.2-J(10):** Number of new technologies or management practices under research as a result of USG assistance.
- **5.2-I(9):** Number of new technologies or management practices being field tested as a result of USG assistance.
- **5.2-H(8):** Number of new technologies or management practices made available for transfer as a result of USG assistance.
- **5.2-E(5):** Number of farmers, processors, and others who have adopted new technologies or management practices as a result of USG assistance — Female.
- **5.2-E(5):** Number of farmers, processors, and others who have adopted new technologies or management practices as a result of USG assistance — Male.
- **5.2-B(2):** Number of additional hectares under improved technologies or management practices as a result of USG assistance.
- **5.2-M(13):** Number of rural households benefiting directly from USG interventions — Female.
- **5.2-M(13):** Number of rural households benefiting directly from USG interventions — Male.
- **5.2-K(11):** Number of producers organizations receiving USG assistance
- **5.2-K(11):** Number of water users associations receiving USG assistance
- **5.2-K(11):** Number of trade and business associations receiving USG assistance.
- **5.2-K(11):** Number of community-based organizations (CBOs) receiving USG assistance.
- **5.2_New:** Number of producers organizations who have adopted new technologies or management practices as a result of USG assistance.
- **5.2_New:** Number of water users associations who have adopted new technologies or management practices as a result of USG assistance.
- **5.2_New:** Number of trade and business associations who have adopted new technologies or management practices as a result of USG assistance.
- **5.2_New:** Number of community-based organizations (CBOs) who have adopted new technologies or management practices as a result of USG assistance.
- technologies or management practices as a result of USG assistance
- **5.2- :** Number of agriculture-related firms benefiting directly from USG supported interventions (formerly 5.2-22).

- **5.2- :** Number of women's organizations/associations assisted as a result of USG interventions (formerly 5.2-28).

- **5.2-L(12):** Number of public-private partnerships formed as a result of USG assistance.

- **5.2-G(7):** Number of individuals who have received USG supported short-term agricultural sector productivity or food security training – Female.

- **5.2-G(7):** Number of individuals who have received USG supported short-term agricultural sector productivity or food security training – Male.

- **5.2-F(6)**: Number of individuals who have received USG supported long-term agricultural sector productivity or food security training – Female.

- **5.2-F(6)**: Number of individuals who have received USG supported long-term agricultural sector productivity or food security training –Male.

- **New**: Value of new private sector investment in the agriculture sector or food chain leveraged by FTF implementation.

- **FTF-IR4**: Number of jobs attributed to FTF implementation (disaggregated by gender, ag vs non-ag).

Cross-Referencing

AquaFish CRSP and USAID's EG and FTF indicators[14] do not have a one-to-one correspondence. In most cases, the USAID indicators apply only in part and usually form a mixed combination for a given AquaFish CRSP program indicator.

The following USAID FY 2010 indicators, which were just recently issued on 21 October 2010 and for which there are no corresponding AquaFish CRSP indicators, are not included in the cross-referencing:

5.2-E(5): Number of farmers, processors, and others who have adopted new technologies or management practices as a result of USG assistance — Female & Male.

5.2_New: Number of producers organizations, water user associations, trade and business associations, and community–based organizations (CBOs) who have adopted new technologies or management practices as a result of USG assistance.
New: Value of new private sector investment in the agriculture sector or food chain leveraged by FTF implementation.

FTF-IR4: Number of jobs attributed to FTF implementation (disaggregated by gender, ag vs non-ag).

[14] USAID indicators for which there is no number assignment under the new FTF system are listed here with their FY 2009 indicator number assignment (i.e., 5.2-21 and 5.2-28).

Tables 9 to 13 illustrate (1) how the AquaFish CRSP indicators are an extension of USAID's indicator set and (2) how general features of the USAID set can be encompassed within a specific AquaFish CRSP indicator. Where there is no correspondence between the two indicator sets, the USAID indicator cell is marked "NA" (Not Applicable).

Table 9 AquaFish CRSP Development Themes

USAID EG 5.2 Indicators[15]	AquaFish CRSP Impact Indicators
5.2-J (10) 5.2 -I (9) 5.2-H (8)	**DTAP A**: **Improved Health and Nutrition, Food Quality, and Food Safety of Fishery Products** *A-01: Number of aquaculture products developed to improve food safety or quality*
5.2-J (10) 5.2 -I (9) 5.2-H (8) 5.2-M (13) 5.2-K (11) 5.2-21 5.2-L (12) 5.2-G (7) 5.2-F (6) 5.2-28	**DTAP B: Income Generation for Small-Scale Fishers and Farmers** *B-01: Number of new technologies developed* *B-02: Number of institutions with access to technological practices*[16] *B-03: Number of (people) trained in use of technological practices*
5.2-J (10) 5.2-I (9) 5.2-H (8) 5.2-B (2) 5.2-K (11) 5.2-21 5.2-G (7) 5.2-F (6) 5.2-28	**DTAP C: Environmental Management for Sustainable Aquatic Resources Use** *C-01: Number of management practices developed or adopted to improve natural resource management* *C-02: Number of hectares under improved natural resource management* *C-03: Number of management practices developed to support biodiversity* *C-04: Number of people trained in practices that promote soil conservation and/or improved water quality*
5.2-J (10) 5.2-I (9) 5.2-H (8)	**DTAP D: Enhanced Trade Opportunities for Global Fishery Markets** *D-01: Number of new markets for aquatic products* *D-02: Number of aquatic products available for human food consumption*

Table 10. AquaFish CRSP Research Targets

USAIDEG 5.2 Indicators	AquaFish CRSP Research Indicators
5.2-J (10) 5.2-I (9) 5.2-H (8) 5.2-M (13) 5.2-K (11) 5.2-21 5.2-L (12) 5.2-G (7)	(1) Developed and adopted innovative technologies that increase profitability and environmental stewardship in aquaculture and fisheries.

[15] Cross referencing for the AquaFish CRSP DTAP indicators is at the thematic level.

[16] To broaden the reporting capability, the term "institution" in DTAP B-02 was defined to include two categories: (1) organizations of all types, e.g., public entities, NGOs, cooperatives, businesses; and (2) rural communities.

Table 10. AquaFish CRSP Research Targets

USAIDEG 5.2 Indicators	AquaFish CRSP Research Indicators
5.2-F (6) 5.2-28	
NA	(2) Addressed biodiversity conservation issues to ameliorate threats to biodiversity and developed technologies and strategies to protect biodiversity habitat and populations.
NA	(3) Continuously funded research projects that meet the expectations of external peer-review panels.
5.2-J (10)	(4) Conducted appropriate biotechnology research to develop technologies that increase farm productivity.
5.2-M (13) 5.2-K (11) 5.2-21 5.2-L (12) 5.2-28	(5) Engaged local stakeholders in research design, implementation, and results reporting through their active participation in stakeholder meetings.
NA	(6) Published AquaFish CRSP research in regional, national, and international peer-reviewed journals.

Table 11. AquaFish Capacity Building Targets

USAIDEG 5.2 Indicators	AquaFish CRSP Capacity Building Indicators
5.2-J (10) 5.2-I (9) 5.2-L (12)	(1) Forged professional and managerial relationships between US and Host Country researchers and institutions
5.2-F (6)	(2) Established track record of successful formal long-term training of Host Country and US students and researchers.
5.2-H (8) 5.2-M (13) 5.2-K (11) 5.2-21 5.2-L (12) 5.2-G (7) 5.2-28	(3) Delivered relevant short-term training opportunities that provide positive Host Country societal benefits beyond the life of the AquaFish CRSP.
5.2-28	(4) Identified gender issues in aquaculture and fisheries and adopted program-wide, gender-integration policies.

Table 12. AquaFish CRSP Information Dissemination Targets

USAIDEG 5.2 Indicators	AquaFish CRSP Information Dissemination Indicators
NA	(1) Successful diffusion of AquaFish CRSP research results and technologies between countries within a region having comparable social and environmental conditions.

Table 12. AquaFish CRSP Information Dissemination Targets

USAIDEG 5.2 Indicators	AquaFish CRSP Information Dissemination Indicators
NA	(2) Increased awareness of local stakeholder constraints and opportunities related to responsible aquaculture and fisheries management.
5.2-H (8) 5.2-G (7)	(3) Applicable extension activities within each research project conducted to ensure wide dissemination of research results.
5.2-H (8) 5.2-G (7)	(4) Adoption of AquaFish CRSP results and technologies for farm operations and policies created for responsible aquatic resource management.
5.2 -J (10) 5.2-I (9) 5.2-H (8) 5.2-M (13) 5.2-K (11) 5.2-21 5.2-L (12) 5.2-G (7) 5.2-28	(5) Applicable technologies developed and adopted by the US and other countries' aquaculture and fisheries sectors.

Table 13. IEHA Country Involvement Targets

USAID EG 5.2 & IEHA Indicators	AquaFish CRSP IEHA Indicators
5.2 -J (10) 5.2-I (9) 5.2-H (8) 5.2-M (13) 5.2-K (11) 5.2-21 5.2-L (12) 5.2-G (7) 5.2-28	(1) Development and adoption of innovative technologies that increase profitability and environmental stewardship in the context of aquaculture and fisheries.
5.2-F (6)	(2) Students enrolled in formal long-term training programs within Host Country, regional, and US universities.
NA	(3) Increased awareness of stakeholder constraints and opportunities related to responsible aquaculture and fisheries management.
5.2-H (8) 5.2-G (7)	(4) Applicable extension activities associated with each research project conducted to ensure wide dissemination of research results.
5.2-H (8) 5.2-L (12) 5.2-G (7)	(5) AquaFish CRSP results and technologies adopted for farm operations and policies for responsible aquatic resource management created.
NA	(6) Increased farm income and local economic growth through enhanced market access in project areas.

Table 14: Supporting documentation for AquaFish CRSP FY 2010 Report on USAID-EGAT Indicator 5.2 -J (10): Number of new technologies or management practices under research as a result of USG assistance.

Investigation Code	5.2 -J (10) Technology	Tech Total	5.2 -J (10) Practice	Prac Total	5.2 -J (10) Product/Market	Prod Total	All Total
09BMA03UM	On farm development of polyculture technology for sahar-tilapia-carp for best ratio of predator to prey in economic and ecological terms.	1			Farmed sahar	1	
09BMA04UM	Pond-based RAS system for shrimp with solid waste removal and water quality controls	1					
09BMA05UM	Indoor RAS for shrimp : control of water quality and micro-organisms (e.g., cyanobacteria)	1					
09FSV01UC			Best Practices and Standards for Fish Paste Products: 1. Quality & Safety Processing Guidelines 2. Packaging & Labeling Standards (Develop the prahoc quality and safety guidelines, standardize packaging and labeling for fish paste)	2			
09IND01UH	Larviculture of native oyster				Hatchery seed of native oyster for shellfish with improved health and safety	1	
09IND02UC	Snakehead Domestication: induced spawning in captivity	1	BMPs for snakehead farming: Feeding strategy to maintain water quality	1	Farmed snakehead (will depend on approval of new government policy to allow snakehead aquaculture)	1	
09IND03UH					Development of chame product with improved quality and safety associated with spawning/larval rearing technologies	1	
09IND04UH			Assessment of chame fishery on Mexican Pacific Coast for development of management recommendations for currently unregulated fishery	1			
09IND05UA	Native Species Aquaculture Technologies -- experimental	5					

Table 14: Supporting documentation for AquaFish CRSP FY 2010 Report on USAID-EGAT Indicator 5.2 -J (10): Number of new technologies or management practices under research as a result of USG assistance.

Investigation Code	5.2 -J (10) Technology	Tech Total	5.2 -J (10) Practice	Prac Total	5.2 -J (10) Product/Market	Prod Total	All Total
	protocols for: 1. Selective Breeding of Cichlid broodstock 2. Establlshing Fat snook and common snook broodstock lineages from wild and hatchery raised juveniles 3. snook spawning in captivity 4. identify native plankton as feed during early sook development 5. determine gene expression of enzymatic activity in different snook life stages						
09IND06PU	Investigation of aquaculture potential of 3 native African species in Ghana: Heterotis niloticus, Chrysichthys maurus, and Parachanna obsucura and farmer training in new species culture	1					
09MER03NC					Analysis of supply chain efficiency with recommendations to lead toward tilapia market development and growth (1) domestic markets (2) export markets	2	
09MER04UC			Recommendations to reduce pressure on wild-caught small-value fish by using feed alternatives for snakehead aquaculture	1	Value-Chain analysis to identify solutions for development of snakehead aquaculture and market opportunities for snakehead and small-value fish: (1) domestic markets and (2) export markets	2	

Table 14: Supporting documentation for AquaFish CRSP FY 2010 Report on USAID-EGAT Indicator 5.2 -J (10): Number of new technologies or management practices under research as a result of USG assistance.

Investigation Code	5.2 -J (10) Technology	Tech Total	5.2 -J (10) Practice	Prac Total	5.2 -J (10) Product/Market	Prod Total	All Total
09MNE01UM			Model to characterize invasive spread of red swamp crayfish in China.	1			
09MNE02NC	Improved Ecological Footprint Technologies for Milkfish: (1) integrated, multitrophic aquaculture of milkfish-seaweed-sea cucumber in cages and pens (2) Alternate day feeding at an initial reduced feed ration (7.5 - 4% body weight)	2					
09MNE04UC			Recommendations for managing integrated aquaculture and capture fisheries of small-sized, low-value fishery	1			
09MNE05UM			Evaluating the impacts of stocked fish on wild fish may result in the elimination of stocking in small reservoirs, which would improve the environment for natural biodiversity.	1			
09QSD01NC	Tilapia Broodstock & Seed Production Technologies: 1. Social and physiological responses to stress as potential indicators for broodstock selection 2. Broodstock social condition effects on seed production - 3. social condition effects on fingerling growout performance 4. Stocking density effects on growth and stress responses	4					

Table 14: Supporting documentation for AquaFish CRSP FY 2010 Report on USAID-EGAT Indicator 5.2 -J (10): Number of new technologies or management practices under research as a result of USG assistance.

Investigation Code	5.2 -J (10) Technology	Tech Total	5.2 -J (10) Practice	Prac Total	5.2 -J (10) Product/Market	Prod Total	All Total
09QSD02UA	Aquaponics technology and Tilapia strain selection technologies: 1. Enterprise model for cost-benefits 2. Tilapia strain evaluation protocol	2					
09QSD03UM	Small-scale prawn-mola polyculture for market (prawn) and home consumption (mola)	1	Small-scale prawn-mola polyculture: testing 3 different practices to determine the best returns for one practice in economic and ecological terms 1. Growth & Production performance based on gender ratios 2. Stocking density 3. Grading & size selective Harvest	3	Product: Prawn from all male monosex prawn culture and Mola for household consumption Market: Development of prawn from monosex-male polyculture systems should open up export markets for prawns in Bangladesh	3	
09SFT01UC	Snakehead pelleted feed trials: 1.C. micropeltes: Survival and growth 2. C. striata: Survival and growth 3.Replacement of fishmeal from marine vs. freshwater fish trials for Cambodia farmers	3					
09SFT02PU	Integrated pond-cage technology for small-scale tilapia farmers to reduce feed cost and manage pond waste	1					

Table 14: Supporting documentation for AquaFish CRSP FY 2010 Report on USAID-EGAT Indicator 5.2 -J (10): Number of new technologies or management practices under research as a result of USG assistance.

Investigation Code	5.2 -J (10) Technology	Tech Total	5.2 -J (10) Practice	Prac Total	5.2 -J (10) Product/Market	Prod Total	All Total
09SFT03UA	YY Tilapia for regional hatchery program	1					
09SFT04NC	Tilapia Least-Cost Feed Formulation Technology and Feed Reduction Strategies: 1. Feed reduction strategy 2.Protein Level: effect on grow-out performance 3. Manufacturing Specifications: pellet durability and water stablility	3					
09SFT05PU	Sustainable Feed Technology studies using lower-cost, locally available ingredients: 1. Plant-based protein substitutes in feed 2. Feeding regime 3. Digestibility test with Chromium (III) oxide marker	3					
09WIZ02AU	Software approaches for water management for multiple uses	1					
09WIZ03UM	Deep water cage production model with polyculture fish system: under performance evaluation	1					
Total Technologies under development		33	Total Practices under development	11	Total Products/Markets under development	11	55

Table 15: Supporting documentation for AquaFish CRSP FY 2010 Report on USAID-EGAT Indicator 5.2-I (9): Number of new technologies or management practices being field-tested as a result of USG assistance.

Code	5.2-I (9): Technology	TechTotal	5.2-I (9): Practice	Prac Total	5.2-I (9): Product/Market	Prod Total	All Total
09BMA01AU	Cage Culture for Small-Holder Farmers	1	Cage Culture in Lake Victoria for Small-Holder Farmers: (1) Production and (2) Enterprise techniques to improve resource management	2			
09BMA03UM	On farm development of polyculture technology for sahar-tilapia-carp for best ratio of predator to prey in economic and ecological terms.	1					
09BMA04UM	Pond-based RAS system for shrimp with solid waste removal and water quality controls	1					
09BMA05UM	Indoor RAS for shrimp : control of water quality and micro-organisms (e.g., cyanobacteria) Floc-based aquaculture system	1					
09FSV01UC			Best Practices and Standards for Fish Paste Products: 1. Quality & Safety Processing Guidelines 2. Packaging & Labeling Standards (Develop the prahoc quality and safety guidelines, standardize packaging and labeling for fish paste)	2			
09FSV02NC					New seaweed products (human and non-human uses): candy/desserts made from agar	1	

Table 15: Supporting documentation for AquaFish CRSP FY 2010 Report on USAID-EGAT Indicator 5.2-I (9): Number of new technologies or management practices being field-tested as a result of USG assistance.

Code	5.2-I (9): Technology	TechTotal	5.2-I (9): Practice	Prac Total	5.2-I (9): Product/Market	Prod Total	All Total
					agar and carrageenan raw product		
09HHI01UH			Assessment of no-take zone management practice to regulate sanitation of black cockles:	1			
09IND01UH					Hatchery seed of native oyster for shellfish with improved health and safety (	1	
09IND03UH	Indigenous species development of Chame for aquaculture: Spawning technology successfully tested	1					
09MNE02NC					Products of integrated milkfish polyculture: (1) seaweed (2) sea cucumber	2	
09QSD01NC	Tilapia Broodstock & Seed Production Technologies: IGF-I and cortisol tests as growth indicator	1					
09QSD02UA	Aquaponics-aquaculture for control of pond wastes	1					
09SFT04NC	Formulation Strategies: reduce fishmeal component by replacing with agricultural by-product protein sources	1					
09TAP03UC	Snakehead feed adoption pilot with on-farm trials in Vietnam and Cambodia	1					

Table 15: Supporting documentation for AquaFish CRSP FY 2010 Report on USAID-EGAT Indicator 5.2-I (9): Number of new technologies or management practices being field-tested as a result of USG assistance.

Code	5.2-I (9): Technology	TechTotal	5.2-I (9): Practice	Prac Total	5.2-I (9): Product/Market	Prod Total	All Total
09WIZ02AU	Software approaches for water management for multiple uses	1					
09WIZ03UM	Deep water cage production model with polyculture fish system: under performance evaluation	1					
Total Technologies under field testing		11	Total Practices under field testing	5	Total Products under field testing	4	**20**

Table 16: Supporting documentation for AquaFish CRSP FY 2010 Report on USAID-EGAT Indicator 5.2-H (8): Number of new technologies or management practices made available for transfer as a result of USG assistance.

Code	5.2-H (8):Technology	Tech Total	5.2-H (8): Practice	Prac Total	5.2-H (8): Products & Markets	Prod Total	All Total
07BMA02UM	Tilapia-sahar polyculture system with sahar density at 0.125 fish per square meter under adoption by cooperators.	1					
07BMA04UH			Training in BMPs to improve shellfish production and sanitation for farmers and vendors: (1) Oyster culture methods (2) shellfish sanitation	2			
07HHI05UH					Market for depurated cockles building due to spreach by word-of-mouth of improved quality and safety with depurated product	1	
07IND02UA	Farmer training in biology and culture technology for tropical gar and native cichilids	1					
07MER03PU			Training for small-farmers in production and management practices: (1) Pond preparation and construction (2) Fish management practices (3) Hand-sexing (4) polyculture of tilapia and catfish	4			
07QSD02PU					Post-production training in marketing: (1) Marketing plan for baitfish farm clusters (2) Finance management	2	
07TAP01UC			Farmer Training: (1) sustainable feed alternatives for snakehead (2) sustainable fish feeding practices	2			
07WIZ01PU			Management practices to minimize waste and contamination of receiving waters from pond effluent and non-native species: (1) Effluent Management (2) Feeding and nutrients (3) Prevention of farm fish escape	3			

Table 16: Supporting documentation for AquaFish CRSP FY 2010 Report on USAID-EGAT Indicator 5.2-H (8): Number of new technologies or management practices made available for transfer as a result of USG assistance.

Code	5.2-H (8):Technology	Tech Total	5.2-H (8): Practice	Prac Total	5.2-H (8): Products & Markets	Prod Total	All Total
09FSV01UC			Best Practices and Standards for Fish Paste Products: 1. Quality & Safety Processing Guidelines 2. Packaging & Labeling Standards (Develop the prahoc quality and safety guidelines, standardize packaging and labeling for fish paste)	2	Processed fish paste products with improved quality and safety	1	
09FSV02NC	Improved seaweed drying method using racks	1			Value-added milkfish product: deboned and marinated milkfish products	1	
09MNE02NC							
09SFT03UA	Aquaculture Technologies 1. Integrated inland farming-aquaculture for small-scale farmers and women 2. Standardardized aquaculture feed with local ingredients to reduce fishmeal	2					
09TAP02NC	4 Extension podcasts modules for international community of tilapia farmers and extension and research community	1					
Total Technologies under transfer		6	Total Practices under transfer	13	Total Products/Markets under transfer	5	**2006.224**

APPENDIX 5. ACRONYMS

ACIAR	Australian Centre for International Agricultural Research
ACRSP	Pond Dynamics/Aquaculture CRSP
AFCRSP	Aquaculture & Fisheries CRSP
AIT	Asian Institute of Technology, Thailand
ANAF	Aquaculture Network for Africa
AOP	Advanced Oxidation Process
APEC	Asia-Pacific Economic Cooperation
AQD	Southeast Asian Fisheries Development Center/Aquaculture Department, Philippines
AquaFish	Aquaculture & Fisheries CRSP
ASEAN	Association of Southeast Asian Nations
ATA	American Tilapia Association
AwF	Aquaculture without Frontiers, USA
BAU	Bangladesh Agricultural University
BFAR	Bureau of Fisheries & Aquatic Resources, Philippines
BIOTECMAR	Cultivos & Biotecnologíca Marina C.A., Venezuela
BMA	Production System Design & Best Management Alternatives
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
BSE	Bovine Spongiform Encephalopathy
BW	Brackish Water
CBA	Cost Benefit Analysis
cDNA	complementary DNA (Deoxyribonucleic acid)
CESASIN	Comite Estatal de Sanidad Acuicola de Sinaloa (Sinaloa State Committee for Aquaculture Sanitation), Mexico
CETRA	Centro de Transferencia Tecnológica para la Acuacultura (Center for Aquaculture Technology Transfer), Mexico
CFU	Colony Forming Units
CG	Compensatory Growth
CGIAR	Consultative Group on International Agricultural Research
CI	Conservation International, Mexico
CIAD	Centro de Investigación de Alimentos y Desarrollo (Research Center for Food & Development), Mexico
CIDEA-UCA	Centro de Investigación de Ecosistemas Acuáticos de la Universidad Centroamericana (Center for Research on Aquatic Ecosystems-Central American University), Nicaragua
CIFAD	Consortium for International Fisheries & Aquaculture Development
CIMMYT	International Wheat & Maize Improvement Center, Mexico
CLAR	Central Laboratory for Aquaculture Research, Egypt
CLSU	Central Luzon State University, Philippines
COD	Chemical Oxygen Demand
COMESA	Common Market for Eastern and Southern Africa
CP	Crude Protein
CRC/URI	Coastal Resources Center/University of Rhode Island
CRSP	Collaborative Research Support Program

CTU	Can Tho University, Vietnam
DA-BFAR	Department of Agriculture–Bureau of Fisheries & Aquatic Resources, Philippines
DASP	Department of Animal Sciences & Production, SUA
DFID	Department for International Development (England)
DO	Dissolved Oxygen
DOF	Department of Fisheries
DWAF	Department of Water Affairs & Forestry (South Africa)
EC	E. coli
ECP	Eye Color Pattern
EGAT	Bureau for Economic Growth, Agriculture, & Trade (USAID)
EPA	US Environmental Protection Agency
EPT	Ephemeroptera, Pleocoptera & Trichoptera
EU	European Union
FAC	Freshwater Aquaculture Center, Central Luzon State University, Philippines
FACIMAR	Facultad de Ciencias del Mar Universidad Autónoma de Sinaloa
FAO	Food & Agriculture Organization, United Nations
FAQ	Frequently Asked Questions
FARDeC	Freshwater Aquaculture Research & Development Center
FCR	Food (Feed) Conversion Ratio
FD	Department of Fisheries, Kenya
FDA	US Food & Drug Administration
FDAP	Fisheries Development Action Plan, Cambodia
FiA	Fisheries Administration, Cambodia
FISH	The FISH Project (Fisheries Improved for Sustainable Harvest), Philippines
FIU	Florida International University
FSV	Food Safety & Value-Added Product Development
GESAMP	Joint Group of Experts in the Scientific Aspects of Marine Environmental Protection, FAO
GIFT	Genetically Improved Farmed Tilapia
GIFT	Genetically Improved Farmed Tilapia Foundation International Inc., Philippines
GIS	Geographic Information System
GLM	Generalized Linear Model
GMO	Genetically Modified Organism
GnRHa	Gonadotropin Releasing Hormone Analogue
GOP	Government of Philippines
GTIS	Guyana Trade & Investment Support Project
HACCP	Hazard Analysis & Critical Point Control
HC	Host Country
HCPI	Host Country Principal Investigator
HHI	Human Health Impacts of Aquaculture
HIV/AIDS	Human Immuno Virus/Acquired Immune Deficiency Syndrome
HPLC	High Performance Liquid Chromatography
HSD	Hepatosomatic Index
IAAS	Institute of Agriculture & Animal Science, Nepal
IARC	International Agricultural Research Center(s), CGIAR
ICLARM	International Center for Living Aquatic Resources Management (= The WorldFish Center), Malaysia
IDRC	International Development Research Centre, Canada
IEHA	Presidential Initiative to End Hunger in Africa, USA
IFREDI	Inland Fisheries Research & Development Institute, Cambodia
IGF-I	Insulin-like Growth Factor-I

IGO	Inter Governmental Organization
IPM	Integrated Pest Management
ISA	Sinaloa Institute for Aquaculture, Mexico
ISD	Indigenous Species Development
ISSC	Interstate Shellfish Sanitation Conference
ISTA	International Symposium on Tilapia in Aquaculture
JUGIPAED	Jinja United Group Initiative for Poverty Alleviation & Economic Development
KBDS	Kenya Business Development Services, USAID
KNUST	Kwame Nkrumah University of Science & Technology, Ghana
KSh	Kenya Shillings
LAC	Latin America & Caribbean Regions
LC/MS	Liquid Chromatography/Mass Spectrometry
LCA	Life Cycle Assessment
LCCA	Life Cycle Cost Analysis
LHRHa	Luteinizing Hormone-Releasing Hormone analogue
LMB	Lower Mekong Basin
LST	Lauryl Sulfate Tryptose
LSU	Louisiana State University
MAFF	Ministry of Agriculture, Forestry and Fisheries
MARENA	Nicaraguan Ministry of the Environment
MC	Microcystins
ME	Management Entity
MER	Marketing, Economic Risk Assessment & Trade
MOU	Memorandum of Understanding
MRC	Mekong River Commission
mRNA	messenger RNA (Ribonucleic Acid)
MSU	Michigan State University
MT	17α-Methyltestosterone
NAAG	National Aquaculture Association of Guyana
NACA	Network of Aquaculture Centers in Asia, Thailand
NaFIRRI	National Fisheries Resources Research Institute (Uganda)
NARS	National Agricultural Research System (of Host Countries)
NB	Nota Bene, note well
NCSU	North Carolina State University
NE	Mitigating Negative Environmental Impacts
NEPAD	New Partnership for Africa's Development
NGO	Nongovernmental organization
NIC	National Investment Center
NL	Notochordal
NO_2-N	Nitrite Nitrogen
NOAA	National Oceanographic & Atmospheric Administration, USA
NPRS	National Poverty Reduction Strategy, Cambodia
NSF	National Science Foundation, USA
NSSP	National Shellfish Sanitation Program
OSU	Oregon State University
PACRC	Pacific Aquaculture & Coastal Resources Center/University of Hawai’i at Hilo
PD/ACRSP	Pond Dynamics/Aquaculture CRSP
PDF	Portable Document Format
PDI	Pellet Durability Index
PI	Principal Investigator
PO	Phenyl Oxidase

POD	Peroxidase
PRCA	Participatory Rural Communication Appraisal
QSD	Quality Seedstock Development
RFA	Request for Assistance
RFP	Request for Proposals
RIA	Radioimmunoassay
RIDS-Nepal	Rural Integrated Development Society-Nepal
RRA	Rapid Rural Appraisal
SARNISSA	Sustainable Aquaculture Research Network in Sub Saharan Africa
SEAFDEC/	
SEDPIII	Third Five-Year Socioeconomic Development Plan, Cambodia
SEMARNAT	Secretariat of Natural Resources, Mexico
SFT	Sustainable Feed Technology
SGR	Specific Growth Rate
SL	Standard Length
SO	Superoxide Dismutase
SOU	Shanghai Ocean University, China
SPE	Solid Phase Extraction
SPSS	Statistical Package for Social Science
SR	Sex Reversed
SS	Salmonella-Shigella
SUA	Sokoine University of Agriculture, Tanzania
SUCCESS	Sustainable Coastal Communities & Ecosystems (EGAT/USAID)
SUMAWA	Sustainable Management of Watershed CRSP
TAN	Total Ammonia Nitrogen
TAP	Technology Adoption & Policy Development
THC	Total Hemocyte Counts
TIES	Training, Internships, Education & Scholarships Program (USAID-Mexico)
TN	Total nitrogen
TNC	The Nature Conservancy, USA
TOC	Total Organic Carbon
TP	Total phosphorus
TSS	Total suspended solids
TTU	Texas Tech University, Lubbock
UA	University of Arizona
UAPB	University of Arkansas, Pine Bluff
UAS	Universidad Autónoma de Sinaloa (Autonomous University of Sinaloa), Mexico
UAT	Universidad Autónoma de Tamaulipas (Autonomous University of Tamaulipas), Mexico
UBAC	Ujung Batee Aquaculture Center, Banda Aceh, Indonesia
UCA	Universidad Centroamericana (Central American University), Nicaragua
UG	University of Georgia
UHH	University of Hawai'i at Hilo
UJAT	Universidad Juárez Autónoma de Tabasco (Autonomous University of Juarez, Tabasco), Mexico
UJAT-CPSR	Cooperativa Pesquera San Ramón (San Ramón Fisheries Cooperative), Mexico
UM	The University of Michigan
URI	University of Rhode Island
US	United States
USA	United States of America
USAID	United States Agency for International Development
USEPA	US Environmental Protection Agency, USA

USG	United States Government
UV	Ultraviolet
VT	Virginia Polytechnic Institute & State University
WAFICO	Walimi Fish Cooperative Society Ltd
WAS	World Aquaculture Society
WIFIP	Women in Fishing Industry Project
WIZ	Watershed & Integrated Coastal Zone Management
WRC	Water Research Commission (South Africa)
WWF	World Wildlife Fund, USA
XLD	Xylose Lysine Desoxycholate

APPENDIX 6. LIST OF PEER REVIEWED JOURNAL PUBLICATIONS

The following peer-reviewed articles by current AquaFish CRSP investigators on their CRSP-sponsored research. Some of the publications before 2009 may be attributable in part to the Aquaculture CRSP. In the period from 2006-2008, the Aquaculture CRSP was also operational on a no-cost extension.

Morrison, C.M., K. Fitzsimmons, and J.R. Wright Jr. 2006. Atlas of Tilapia Histology. The World Aquaculture Society, Baton Rouge, USA. 96 pp. 619–644.

Adjei-Boateng, D., S. Amisah, and K.K. Quagrainie. 2009. "Bacteriological contamination of the freshwater clam (Galatea paradoxa/born 1778) from the Volta estuary, Ghana." African Journal of Microbiology Research, 3(7) 2009: 396-399.

Ahmad, S.A.S., A. N. Bart, Y. Yang, J. E Rakocy, and J. S Diana. 2009. The effect of the introduction of Nile tilapia (Oreochromis niloticus, L.) on small indigenous fish species (mola, Amblypharyngodon mola, Hamilton; chela, Chela cachius, Hamilton; punti, Puntius sophore, Hamilton). Aquaculture Research, 1-9, DOI:10.1111/j.1365-2109.2009.02372.x.

Alrubaian, J., S. Lecaude, J. Barba, L. Szynskie, N. Jacobs, D. Bauer, I. Kaminer, B. Bagrosky, R.M. Dores, and C. Brown. 2006. Trends in the Evolution of the Prodynorphin Gene in Teleosts: Cloning of Eel and Tilapia Prodynorphin cDNAs. Peptides 27:797-804.

Amisah, S. A.B. Gyampoh, P. Sarfo-Mensah, and K.K. Quagrainie. 2009. "Livelihood trends in Response to Climate Change in Forest Fringe Communities of the Offin Basin in Ghana." J. Appl. Sci. Environ. Manage. 13(2) 2009: 5 – 15.

Amisah, S., D. Adjei-Boateng, K. A. Obirikorang and K.K. Quagrainie. 2009. "Effects of clam size on heavy metal accumulation in whole soft tissues of Galatea paradoxa (born, 1778) from the Volta estuary, Ghana." International Journal of Fisheries and Aquaculture, 1(2) 2009: 014-021.

Arslan, M. Effects of different dietary lipid sources on the survival, growth and fatty acid composition of South American catfish (Pseudoplatystoma fasciatum), surubim, juveniles. Journal of the World Aquaculture society 39(1):51-61, 2008.

Arslan, M., K. Dabrowski, and M. C. Portella. 2009. Growth, fat content and fatty acid profile of South American catfish, surubim (Pseudoplatystoma fasciatum) juveniles fed live, commercial and formulated diets, Journal Applied Ichthyology 25: 73-78.

Asaduzzaman, Md., M.A. Wahab, Y. Yi, J.S. Diana and C.K. Lin. 2006. Bangladesh Prawn-Farming Survey Reports Industry Evolution. Global Aquaculture Advocate, November/December 2006, pp. 41-43.

Avalos-Hernández, N., C.A. Alvarez-González, R. Civera-Cerecedo, E. Goytortua-Bores and G. Dávalos. 2007. Sustitución de Harina de Pescdo con Harina de Cerdo en Alimentos Practicos para Juveniles

de la Tilapia del Nilo Oreochromis niloticus. In Wilfrido M. Contreras-Sanchez and Kevin Fitzsimmons (eds.), Proceedings for the 7th International Symposium on Tilapia in Aquaculture (ISTA7), Vera Cruz, Mexico, 6-8 September 2006, p. 123

Bolivar, R.B. and E.B.T. Jimenez. 2006. Alternate-day feeding strategy for Nile tilapia grow out in the Philippines: Marginal cost-revenue analysis. North American Journal of Aquaculture, 68:192–197.

Bolivar, R.B., H. L. Bolivar, R. M.V. Sayco, E.B.T. Jimenez, R.L.B. Argueza, L.B. Dadag, A.G. Taduan, and R.J. Borski. 2008 Growth evaluation, sex conversion rate and percent survival of Nile tilapia (Oreocrhromis niloticus L.) fingerlings in earthen ponds. In H. Elghobashy (ed), From the Pharaohs to the Future: Proceedings of the 8th International Symposium on Tilapia Aquaculture, Cairo, Egypt, October 12–14, 2008. Vol 1: 403-413.

Borski, R.J., Sullivan, C.V., and E.G Noga. 2010. Genomic Enablement of Aquaculture: Graduate Research, Education, and Training. In Proceedings of 1st International Symposium on Aquaculture & Fisheries Education, Pathumthani, Thailand, 27–30 November 2009.

Bowman, J., A. Bart, R. Bolivar, W. Contreras-Sanchez, N. Gitonga, D. Meyer and Hillary Egna. 2008. A Comparison of Tilapia Culture Technologies: Linking Research and Outreach Results across Geographic Regions. World Aquaculture 39(2):39-44.

Boyd, Claude E.. 2006. Management of Bottom Soil condition and Pond Water and Effluent Quality. C. Lim and C.D. Webster (Editors). Tilapia: Biology, Culture, and Nutrition. Food Products Press, Binghamton, pp. 449–448.

Brown C.L. Microbrewing Science: A Primer on Yeast Culture for Classic Brewing.

Cao, L., W. Wang, C. Yang, Y. Yang, J. Diana, A. Yakupitiyage, and D. Li. 2007. Application of microbial phytase in fish feed. Enzyme and Microbial Technology 40 (2007) 497-507.

Cao, L., W. Wang, Y. Yang, C. Yang, S. Xiong, and J.S. Diana. 2007. Environmental impact of aquaculture and countermeasures to aquaculture pollution in China. Environmental Science & Pollution Research 14:453-462.

Cao, L., W.M. Wang, A. Yakupitiyage, D.R. Yuan, and J.S. Diana. 2008. Effects of pretreatment with microbial phytase on phosphorous utilization and growth performance of Nile tilapia (Oreochromis niloticus). Aquaculture Nutrition 14:99-109.

Cao, L., Y. Chengtai, W. Wang, Y. Yang, K. Abbas, B. Yan, H. Wang, L. Su, Y. Sun, and H. Wang. 2007. Comparative and evolutionary analysis in natural diploid and tetraploid weather loach Misgurnus anguillicaudatus based on cytochrome b sequence data in central China. Environmental Biology of Fishes DOI: 10.1007/s10641-007-9283-9, 09/20/07.

Carole R. Engle. 2006. Marketing and Economics. C. Lim and C.D. Webster (Editors). Tilapia: Biology, Culture, and Nutrition. Food Products Press, Binghamton, pp.

Chepkirui-Boit, V., C.C. Ngugi, J. Bowman, E. Oyoo-Okoth, J. Rasowo, J. Mugo-Bundi, and L. Cherop, L. 2010. Growth performance, survival, feed utilization and nutrient utilization of African catfish (Clarias gariepinus) larvae co-fed Artemia and a micro-diet containing freshwater atyid shrimp (Caridina nilotica) during weaning. Aquaculture Nutrition 2010: 1-8 (doi: 10.1111/j.1365-2095.2009.00737.x)

Contreras Sanchez, W.F. and K. Fitzsimmons (eds.). 2007. Proceedings of the 7th International Symposium on Tilapia in Aquaculture. Vera Cruz, Mexico, 6-8 September 2006. American Tilapia Association and Aquaculture CRSP. 389 pp.

Contreras-García, M. de J., W. M. Contreras-Sánchez, A. Mcdonal-Vera, U . Hernández-Vidal, C. A. Álvarez-González, S. Páramo-Delgadillo, and J.M.Vidal López 2010. Variación reproductiva en hembras silvestres de chucumite Centropomus parallelus mediante el empleo del diámetro de ovocitos como indicador de maduracion. Universidad y Ciencia. [submitted]

Dabrowski, K., M. Arslan, J. Rinchard, and M.E. Palacios. 2008. Growth, maturation, induced spawning, and production of the first generation of South American Catfish (Pseudoplatystoma sp.) in the North America. Journal of the World Aquaculture Society 39:174-183.

Derun, Y., Y. Yang, A. Yakupitiyage, K. Fitzimmons, and J. Diana. 2010. Effects of addition of red tilapia (Oreochromis spp.) at different densities and sizes on production, water quality and nutrient recovery of intensive culture of white shrimp (Litopenaeus vannamei) in cement tanks. Aquaculture 298: 226–238.

Diana, J.S. 2009. Aquaculture Production and Biodiversity Conservation. Bioscience 59: 27-38.

Diana, J.S., F. Tain, V. Schwantes, and M. Clarke. 2009. Outreach Assessment Studies Examine Aquaculture Links To Thai Communities. Global Aquaculture Advocate 12(6):10-12.

Fitzsimmons, K. 2006. Harvest, Handling, and Processing. C. Lim and C.D. Webster (Editors). Tilapia: Biology, Culture, and Nutrition. Food Products Press, Binghamton, pp. 607-618.

Fitzsimmons, K. 2006. Prospect and Potential for Global Production. . C. Lim and C.D. Webster (Editors). Tilapia: Biology, Culture, and Nutrition. Food Products Press, Binghamton, pp. 51–72.

Fitzsimmons, K. 2008. Aquaculture Restoration in the Tsunami Zone, Aceh Province, Indonesia. World Aquaculture, 39(1): 41-43,66 (March 2008).

Fitzsimmons, K. 2008. Food Safety, Quality Control in Tilapia. Global Aquaculture Advocate, January/February 2008, pp. 42-44.

Fitzsimmons, K. 2010. Tilapia update 2010. The Practical Asian Aquaculture 1(2):32-34.

Fitzsimmons, K. Alghanim, K., and Naim, S. 2009. Tilapia Production, Market Report – Production, Consumption Increase Despite Economic Downturn. Global Aquaculture Advocate 12(2):67-70.

Fitzsimmons, K. and P. Gonzalez. 2007. Future Expansion of Global Supplies and Markets for Tilapia Products-2006. In Wilfrido M. Contreras-Sanchez and Kevin Fitzsimmons (eds.), Proceedings for the 7th International Symposium on Tilapia in Aquaculture (ISTA7), Vera Cruz, Mexico, 6-8 September 2006, p. 312.

Fitzsimmons, K., 2008. Aquaculture restoration in the tsunami zone, Aceh Province, Indonesia, World Aquaculture, 39(1): 41-43,66. March 2008

Gao, Z., W. Wang, K. Abbas, X. Zhou, Y. Yang., J.S. Diana, H. Wang., H. Wang, Y. Li, and Y. Sun. 2007. Haematological characterization of loach Misgurnus anguillicaudatus: Comparison among

diploid, triploid and tetraploid specimens. Comparative Biochemistry and Physiology, Part A 147 (2007) 1001-1008

Gending, Jiang min, Xing bin, Dai Xilin, Gu Deping, Hu Weiguo. 2010. Relevance analysis of organic pollutants parameters in ponds of Litopenaeus vannamei culturing. Freshwater Fisheries 40(2): 67-69. [in Chinese]

Haws, M.C., B. Crawford, S.C. Ellis, N. Jiddawi, A. Mmochi, E. Gaxiola-Camacho, G. Rodriguez-Dominguez, G. Rodriguez, J. Francis, C. Rivas-LeClair, A. Saborio-Coze, N. Hernandez, E. Sandoval, K. Dabrowski, M.C. Portella, and M. Jaroszewska. 2010. Aquaculture research and development as an entry-point and contributor to natural resources and coastal management. Coastal Management Journal 38:238–261.

Hernandez-Vidal. 2007. Growth Performance of a Genetically Improved Line of Nile Tilapia under Tropical Conditions in Tabasco, Mexico. In Wilfrido M. Contreras-Sanchez and Kevin Fitzsimmons (eds.), Proceedings for the 7th International Symposium on Tilapia in Aquaculture (ISTA7), Vera Cruz, Mexico, 6-8 September 2006, pp. 229-230.

Huynh, V. H., S. Le Xuan, D.C. Nguyen. 2010. Role of fishing activities to the households in flooded areas of the Mekong Delta. Scientific Magazine of Can Tho University, Special issue, June 2010 [in Vietnamese].

Jamandre, W.E., L.U. Hatch, R. B. Bolivar, and R.J. Borski. 2010. Market opportunities for tilapia and their implications on production systems in the Philippines. Journal of Agriculture [in press].

Jaroszewska, M., K. Dabrowski, and G. Rodriguez. 2009. Development of testis and digestive tract in longnose gar (Lepisosteus osseus) at the onset of exogenous feeding of larvae and in juveniles. Aquaculture Research, pp. 1-12, doi:10.1111/j.1365-2109.2009.02442.x.

Jimenez-Martínez, L.D., C. A. Alvarez-González, W. M. Contreras-Sánchez, G. Marquez-Couturier, L. Arias-Rodríguez, and J. A. Almeida-Madrigal. 2009 Evaluation of Larval Growth and Survival in Mexican Mojarra, Cichlasoma urophthalmus, and Bay Snook, Petenia splendida, Under Different Initial Stocking Densities. Journal of the World Aquaculture Society 40: 753-761.

Kaliba, A.R., C.C. Ngugi, J. Mackambo, and K.K. Quagrainie. 2007. Economic Profitability of Nile Tilapia (Oreochromis niloticus L.) Production in Kenya. Aquaculture Research 38:1129-1136.

Kaliba, A.R., K.K. Quagrainie, K.O. Osewe, E. Senkondo, B. Mnembuka, and S. Amisah. 2007. Potential effects of aquaculture promotion on poverty reduction in Sub-Saharan Africa. Aquaculture International 15:445-459

Kaliba, A.R., K.O. Osewe, E.M. Senkondo, B.V. Mnembuka, and K.K. Quagrainie. 2006. Economic Analysis of Nile Tilapia (Oreochromis niloticus) Production in Tanzania. Journal of the World Aquaculture Society 37(4):464-473.

Kaliba, A.R., S. Amisah, L. Kumah, and K.K. Quagrainie. 2007. Economic Analysis of Nile Tilapia Production in Ghana. Quarterly Journal of International Agriculture, Vol. 46(2): 105-117.

Le Xuan, S. 2010. Aquaculture Economics. Textbook for undergraduate and master students in Aquaculture & Fisheries. Can Tho University Publication.

Le Xuan, S. and C. Do Minh. 2010. Current situation and challenges for snakehead farming (Channa Micropeltes and Channa striatus) in the Mekong Delta. Journal of Agriculture & Rural Development [in Vietnamese, Accepted].

Leyva, C. and C.R. Engle. 2008. Optimizing tilapia (Oreochromis sp.) marketing strategies in Nicaragua: a mixed-integer transshipment model analysis. Journal of the World Aquaculture Society 39(3):339-351, 2008.

Leyva, C. and C.R. Engle. 2008. Optimizing tilapia, Oreochromis sp., marketing strategies in Nicaragua: A mixed-integer transshipment model analysis. Journal of World Aquaculture Society, 39:339-351.

Leyva, C.M., C.R. Engle, and Y.-S. Wui. 2006. A Mixed-integer Transshipment Model for Tilapia (Oreochromis sp.) Marketing in Honduras. Aquaculture Economics and Management 10:245-264.

Lian, P., C.M. Lee, and D.A. Bengtson. 2008. Development of a Squid-hydrolysate-based Larval Diet and its Feeding Performance on Summer Flounder, Paralichthys dentatus, Larvae. Journal of the World Aquaculture Society 39:196-204

Licamele, J. and K. Fitzsimmons. 2009. Aquaculture In Guyana – Tilapia, Pacu, Shrimp Raised With Plant Crops. Global Aquaculture Advocate 12(2):83-84.

Lim, C. and C. D. Webster. 2006. Tilapia: Biology, Culture, and Nutrition (Introduction). C. Lim and C.D. Webster (Editors). Tilapia: Biology, Culture, and Nutrition. Food Products Press, Binghamton, 705

Lim, C., M. Yildirim-Aksoy, T. Welker, and K. Veverica. 2006. Effect of Feeding Duration of Sodium Chloride-Containing Diets on Growth Performance and Some Osmoregulatory Parameters of Nile Tilapia, Oreochromis niloticus, After Transfer to Water of Different Salinities. Journal of Applied Aquaculture 18(4):1-17.

Liu, L., C. Taoying, L. Kang, D. Xilin, Y. Yang, and J. S. Diana. 2010. Effects of Microcystis aeruginosa on the life history of water flea Daphnia magna. [submitted to Toxicon].

Liu, L., K. Li, Y. Yue, J. Yan, Y. Yang, and J. S. Diana. 2010. The Dangers of Microcystins in Aquatic Systems and Progress of Research into their Detection and Elimination. [Submitted to World Aquaculture].

López-Ramírez, G., C.A. Cuenca-Soria, C.A. Alvarez-González, D. Tovar-Ramírez, J. L. Ortiz-Galindo, N. Perales-García, G. Márquez-Couturier, L. Arias-Rodríguez, J.R. Indy1, W.M. Contreras-Sánchez, E. Gisbert, F.J. Moyano. 2010. Development of digestive enzymes in larvae of Mayan cichlid Cichlasoma urophthalmus. Fish Physiology & Biochemistry Journal [accepted]

Mac'Were, E.O., C.C. Ngugi, and K.L. Veverica. 2006. Yields and Economic Benefits of Tilapia (Oreochromis niloticus) and catfish (Clarias gariepinus) polyculture in ponds using locally available feeds. Journal of East African Natural Resources Management, (1)(2):1-13.

Madriaga, L.B. and R. B. Bolivar. 2007. Sugarcane Bagasse as Periphyton Substrate in the Culture of Nile Tilapia (Oreochromis niloticus) in Fertilized Ponds. In Wilfrido M. Contreras-Sanchez and Kevin Fitzsimmons (eds.), Proceedings for the 7th International Symposium on Tilapia in Aquaculture (ISTA7), Vera Cruz, Mexico, 6-8 September 2006, p. 124.

Martínez-Cordero, F.J., Q. S.W. Fong, and M. C. Haws. 2009. Marketing extension and outreach in Sinaloa, Mexico: A preliminary analysis of preferences for oysters. Marine Resource Economics, 24:89-95

Molnar, J.J., L.Carrillo, F. Damian, C. Savaria, D. Meyer, S. Meyer and E.W. Tollner. 2007. Exploring the Potential for Aquacultural Development to Promote Food Security Among Indigenous People in Guatemala. In Wilfrido M. Contreras-Sanchez and Kevin Fitzsimmons (eds.), Proceedings for the 7th International Symposium on Tilapia in Aquaculture (ISTA7), Vera Cruz, Mexico, 6-8 September 2006, pp. 297-298.

Neira, I., C. R. Engle, and C. Ngugi, 2009, Economic and Risk Analysis of Tilapia Production in Kenya, Journal of Applied Aquaculture 21:1-23.

Ostaszewska, T., K. Dabrowski, A. Wegner, and M. Krawiec. 2008 The Effects of Feeding on Muscle Growth Dynamics and the Proliferation of Myogenic Progenitor Cells during Pike Perch Development (Sander lucioperca). Journal of the World Aquaculture Society 39:184-195.

Osure, G.O., and R.P. Phelps. Evaluation of reproductive performance and early growth of four strains of Nile tilapia (Oreochromis niloticus, L.) with different histories of domestication. Aquaculture 253(1-4):485-494

Palacios, M.E., K. Dabrowski, M.A.G. Abiado, K.-J. Lee, and C.C. Kohler. 2006. Effects of Diets Formulated with Native Peruvian Plants on Growth and Feeding Efficiency of Red Pacu (Piaractus brachypomus) Juveniles. Journal of the World Aquaculture Society, 37:246–255.

Park, K. H., G. A. Rodriguez-Montes de Oca, P. Bonello, K.-J. Lee, and K. Dabrowski. 2008. Determination of quercetin concentrations in fish tissues after feeding quercetin-containing diets. Aquaculture International. 17:537–544.

Park, K.H., B.F. Terjesen, M. B. Tesser, M.C. Portella and K. Dabrowski. α-Lipoic acid-enrichment partially reverses tissue ascorbic acid depletion in pacu (Piaractus mesopotamicus) fed vitamin C-devoid diets.

Park, K.H., G.A. Rodriguez-Montes de Oca, P. Bonello, K.-J. Lee, and K. Dabrowski. Determination of quercetin concentrations in fish tissues after feeding quercetin-containing diets.

Phoryou, Ahaiku. 2010. Small fish, trash fish/ Salted to paste/ Cambodian Cheese.

Picha, M.E., M.J. Turano, B.R. Beckman, and R. J. Borski. 2008. Endocrine Biomarkers of Growth and Applications to Aquaculture: A Minireview of Growth Hormone, Insulin-Like Growth Factor (IGF)-I, and IGF-Binding Proteins as Potential Growth Indicators in Fish. North American Journal of Aquaculture 70:196-211.

Picha, M.E., Strom, C.N., Riley, L.G., Walker, A.A., Won, E.T. Johnstone, W.M. and Borski, R.J. (2009). Plasma ghrelin and growth hormone regulation in response to metabolic state in hybrid striped bass: Effects of feeding, ghrelin and insulin-like growth factor-I on in vivo and in vitro GH secretion. General and Comparative Endocrinology. 161:365-372.

Portella, M.C. and C.C. Ngugi. 2008. Aqüicultura na África: O Projeto Interegional de Intercâmbio de Tecnologia sobre Produção de Tilápias e outros Ciclídeos. Panorama da Aqüicultura 105:50-55.

Quagrainie, K.K., C.C. Ngugi, and S. Amisah 2010. Analysis of the use of credit facilities by small-scale fish farmers in Kenya. Aquaculture International, 18:393-402.

Quagrainie, K.K., C.C. Ngugi, and S. Amisah. 2010. Analysis of the use of credit facilities by small-scale fish farmers in Kenya. Aquaculture International. 18:393-402.

Quagrainie, K.K., S. Amisah, and C.C. Ngugi. 2009. Aquaculture Information Sources for Small-Scale Fish Farmers: The Case of Ghana. Aquaculture Research 40: 1516-1522.

Rai, S., Y. Yang, M.A. Wahab, A. Bart, and J.S. Diana. 2008. Comparison of rice straw and bamboo stick substrates in periphyton-based carp polyculture systems. Aquaculture Research 39(5):464-473.

Rasowo, J., O.E. Okoth, and C.C. Ngugi. 2007. Effects of formaldehyde, sodium chloride, potassium permanganate and hydrogen peroxide on hatch rate of African catfish Clarias gariepinus eggs. Aquaculture 269:271-277.

Schwantes, V.S., J. S. Diana, and Y. Yang. 2009. Social, economic, and production characteristics of freshwater prawn Macrobrachium rosenbergii culture in Thailand. Aquaculture 287:120-127.

So, N. 2009. Snakehead Aquaculture in the Mekong Delta, Vietnam Brief Communication. Cambodia Fisheries Magazine No. 13. Fisheries Administration, Phnom Penh, Cambodia

So, N., C. Norng , S.V. Leng, and R. Pomeroy. 2010.. Small-sized fish paste production technology in Cambodia's Mekong River Basin [Submitted].

Ssegane, H., E.W.Tollner, and K. Veverica. 2010. Geospatial Modeling of Site Suitability for Pond-Based Tilapia and Clarias (Catfish) Farming in Uganda [Submitted to World Aquaculture].

Tain, F.H. and J.S. Diana. 2007. Impacts of extension practice: Lessons from small farm-based aquaculture for Nile tilapia in northeast Thailand. Society & Natural Resources 20(7):583-595.

Tollner, E. W. , Daniel Meyer, Suyapa Triminio-Meyer, Joseph J. Molnar. 2008. Spreadsheet tool for computing levee pond excavation costs for developing countries, Aquacultural Engineering Volume 39:122-126.

Tran Thi Thanh, H., T. Le Quoc, B.Tran Thi, T. Nguyen Hoang Duc. 2010. Replacing fish meal by soybean meal in giant snakehead (Channa micropeltes) diets. Scientific Journal of Can Tho University [accepted]

Tran Thi, B. and H. Tran Thi Thanh. 2010. Replacement of fish meal protein with soybean meal protein with or without phytase supplementation in diets for snakehead (Channa striata). Scientific Journal of Can Tho University [in Vietnamese].

Trattner, S., J. Pickova, K.H. Park, J. Rinchard, and K. Dabrowski. 2007. Effects of alpha-lipoic and ascorbic acid on the muscle and fatty acids and antioxidant profile of the South American pacu Piaractus mesopotamicus. Aquaculture, 273(1):158-164.

Triminio Meyer, S.A., J.J. Molnar, D. Meyer, D. E., and W.E. Tollner. 2007. Tilapia Fingerling Production in Honduras. Journal of Applied Aquaculture19(2):1-27.

Trung, D.V. and Amrit Bart. 2006. A preliminary study on the maturation and reproduction of Spinibarbus denticulatus (Oshima, 1926), and indigenous species of Northern Vietnam. Asian Fisheries Science. Vol.19: 349-362.

Tsadik, G.G., and A.N. Bart. 2007. Characterization and comparison of variations in reproductive performance of Chitralada strain Nile reproductive performance of Chitralada strain Nile tilapia, Oreochromis niloticus. Aquaculture Research 38:1066-1073.

Tsadik, G.G., and A.N. Bart. 2007. Effects of feeding, stocking density and water-flow rate on fecundity, spawning frequency and egg quality of Nile tilapia, Oreochromis niloticus (L.). Aquaculture 272:380-388.

Un S., R. Pomeroy, N. So, and K. Chhany. 2010. Market Channel and Trade of Fermented Small-Sized Fish Paste in Cambodia. International Society of Environmental & Rural Development (ISERD) 1–1: 145-151

Un, S, R. Pomeroy, N. So, and K. Chhany. 2010. Market Channel and Trade of Fermented Small-Sized Fish Paste in Cambodia. International Society of Environmental & Rural Development (ISERD) [accepted]

Uscanga-Martínez, A., C. A. Álvarez-González, W. M. Contreras-Sánchez, G. Márquez-Couturier, R. Civera-Cerecedo, A. Hernández-Llamas, H. Nolasco-Soria, E. Goytortúa-Bores, and F. Javier Moyano. 2010. Effect of dietary protein level on growth and body composition in Masculinized and Non-Masculinized Juveniles of Bay Snook Petenia splendida. Journal of the World Aquaculture Society [submitted]

Vera Cruz, E.M. and C. L. Brown. 2007. The influence of social status on the rate of growth, eye color pattern and Insulin-like Growth Factor-I gene expression in Nile tilapia, Oreochromis niloticus. Hormones and Behavior 51(4):611-619

Vera Cruz, E.M. and C.L. Brown. 2009. Influence of the photoperiod on growth rate and insulin-like growth factor-I gene expression in Nile Tilapia (Oreochromis niloticus). Journal of Fish Biology 75:130-141.

Vera Cruz, E.M., and C.L. Brown, J.A. Luckenbach, M.E. Picha, R.J. Borski, and R. Bolivar. PCR-cloning of Nile Tilapia, Oreochromis niloticus L., Insulin-like Growth Factor-I and its Possible use as an Instantaneous Growth Indicator. Aquaculture 251:585-595.

Vidal-López J. M., C.A Álvarez-González., W.M. Contreras-Sánchez , and U. Hernández-Vidal. 2009. Masculinization of the native cichlid Tenhuayaca, Petenia splendida (Günther, 1862), using Artemia nauplii as a vehicle of the steroid 17-α methyltestosterone. Hidrobiológica 19 (3): 211-216 [in Spanish].

Watanabe, Wade O., Kevin Fitzsimmons, Yang Yi. 2006. Farming Tilapia in Saline Waters. C. Lim and C.D. Webster (Editors). Tilapia: Biology, Culture, and Nutrition. Food Products Press, Binghamton, pp. 347–448.

Wudtisin, I. and C.E. Boyd. 2006. Physical and chemical characteristics of sediments in catfish, freshwater prawn and carp ponds in Thailand Aquaculture Research, 37: 202 – 1214, 2006.

Xiaoyun Zhou, Khalid Abbas, Mingyun Li, Libao Fang, Su Li, Weimin Wang. 2010. Comparative studies on survival and growth performance among diploid, triploid and tetraploid dojo loach Misgurnus anguillicaudatus. Aquaculture International 18:349–359

Yang, Y. and J. Diana. 2008. Strategies for Nile tilapia pond culture. In H. Elghobashy, K. Fitzsimmons, A. S. Diab, Proceedings of the 8th International Symposium on Tilapia in Aquaculture, Cairo, Egypt, 12-14 October 2008, pp. 11–22.

Yi, Yang and J.S. Diana. 2008. Strategies for Nile Tilapia (Oreochromis niloticus) Pond Culture. Proceedings of the 8th International symposium on Tilapia in Aquaculture, Cairo, Egypt, 12-14 October 2008.

Youji Wang, Menghong Hu, Ling Cao, Yi Yang and Weimin Wang. 2008. Effects of daphnia (Moina micrura) plus chlorella (Chlorella pyrenoidosa) or microparticle diets on growth and survival of larval loach (Misgurnus anguillicaudatus). Aquaculture International 16:361-368.

Young, K. 2009. Omega-6 (n-6) and omega-3 (n-3) fatty acids in tilapia and human health: a review. International Journal of Food Sciences and Nutrition 60(S5): 203-211.

Yuan, D. Yi, Y. Yakupitiyage, A., Fitzimmons, K. and Diana, J. 2010. Effects of addition of red tilapia (Oreochromis spp.) at different densities and sizes on production, water quality and nutrient recovery of intensive culture of white shrimp (Litopenaeus vannamei) in cement tanks. Aquaculture 298: 226

Zexia, G., W. Wang, Y. Yang, K. Abbas, L. Dapeng, Z. Guiwei, and J.S.Diana. 2007. Morphological studies of peripheral blood cells of the Chinese sturgeon, Acipenser sinensis. Fish Physiology and Bio-Chemistry 33(3):213-222