AQUAFISH CRSP
FIFTH ANNUAL REPORT
1 October 2010 to 29 September 2011

Aquaculture & Fisheries
Collaborative Research Support Program
Management Entity
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USAID FROM THE AMERICAN PEOPLE

Oregon State University OSU

AQUAFISH COLLABORATIVE RESEARCH SUPPORT PROGRAM

AQUAFISH CRSP FIFTH ANNUAL REPORT

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This report covers the period from 1 October 2010 to 29 September 2011, which we refer to interchangeably as FY11 and reporting year (30 Sep 2010 to 29 Sep 2011), with the understanding that there is a one-day divergence between this reporting period and the Federal Fiscal Year, and that this work does not use FY11 federal funding.

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Dedication:
To our friends and colleagues in Thailand who are suffering from the worst floods of over a century: Our hearts go out to you for a speedy recovery. We are ready to help in whatever way possible.

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EXECUTIVE SUMMARY

The Fifth Annual Report for the AquaFish CRSP covers activities and accomplishments in 16 countries in Africa, Asia, and Latin America from 1 October 2010 through 29 September 2011. During this reporting period, Host Country investigators representing 31 institutions and their US partners at 17 universities conducted collaborative efforts focused on improving the livelihoods of the rural poor and building institutional capacity through training students and stakeholders at all levels -- from rural fish farmers to government policy makers. The eight core research projects consist of 54 investigations under *Implementation Plan 2009–2011.* These investigations cover all ten AquaFish CRSP topic areas in the categories of *Integrated Production Systems* and *People, Livelihoods, and Ecosystems Relationships*.

FY2011 saw the continued adoption of CRSP research innovations by private and government sectors. In Banda Aceh, Indonesia polyculture of seaweed with shrimp, tilapia, and milkfish has been introduced by CRSP researchers along with hands-on training targeting end-users. Prior to CRSP involvement there was no seaweed polyculture in Banda Aceh and now it is estimated that approximately 200 farmers have incorporated seaweed in their culture systems. In the Philippines, CRSP research has demonstrated that reduced feeding strategies can decrease feed costs by as much as 50% without lowering yield. These techniques have been widely adopted thanks to innovative outreach tools such as podcasts and videos posted to YouTube. In Nicaragua CRSP researchers studied the feasibility of communities and local governments co-managing stocks of black cockles, a source of animal protein for coastal communities and employment in a fishery where women make up a large fraction of the workforce. CRSP found that a management system based on no-take areas was much more effective than the traditional management technique that relied on a 4-month closure of the fishing season. Due to the success of no-take areas, the Nicaraguan government is now adopting this management system in two additional coastal communities.

AquaFish CRSP completed the successful USAID/Mali Associate Award for aquaculture and fisheries work in Mali, West Africa. This project, originally funded for three years by the USAID Mission in Mali, began 1 October 2007 and continued via a no-cost extension, through 31 December 2010. The successes of this project have led to multiplier effects with respect to the adoption of new technologies and the numbers of farmers benefitting from project interventions. This fiscal year also saw the implementation of a $1.1 million USAID/BFS Associate Award, “Enhancing the profitability of small aquaculture farm operations in Ghana, Kenya, and Tanzania,” which focuses on Feed the Future (FtF) initiative development goals, including scaling up innovations from previous CRSP project successes and accelerating best management practice (BMP) adoption rates.

Efforts to communicate successes of AquaFish CRSP, and CRSPs in general, continued in this reporting year. The CRSP Council Knowledge and Data Management Project, a CRSP-wide effort to combine the wealth of information accumulated by all CRSPs into a single information clearinghouse and database, was officially launched in Spring 2011. Cultural Practice, LLC, was selected to perform the work and was awarded the initial subcontract through Oregon State University in July 2011. The AquaFish ME continued to support OSU journalists in producing press releases, articles, and videos highlighting AquaFish CRSP accomplishments, which, along with internally produced Success Stories, are publically available on the AquaFish webpage.

Since program inception in October 2006, AquaFish CRSP has supported 320 students in long-term academic training. Women represent 48% of this student population. For FY2011, 188 students were enrolled in undergraduate and graduate programs in Host Country and US institutions. During the past year, 60 short-term trainings held in 12 countries reached 1,758 people, raising the total number of trainees since program inception to 6,103. 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.

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 2010 to 29 September 2011. 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. Originally with USAID's Economic Growth, Agriculture, and Trade (EGAT) Bureau's Office of Agriculture, AquaFish now operates under the newly formed Bureau of Food Security.

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, students, and stakeholders. 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. A no-cost extension, granted 8 September 2011, extended the end date of the current Award from 29 September 2011 to 29 September 2012.

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 former 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 were originally funded by EGAT's Office of Agriculture at $8.9 million over 5 years, and amended in September 2009 to $12.82 million for additional work in technology transfer, outreach, impact assessment, and communications. Significant restructuring at USAID now places AquaFish under the newly formed Bureau of Food Security, the lead USAID Bureau for the whole-of-government Feed the Future initiative.

Two Associate Awards have been received under the Leader Award since 2007, totaling $1,850,000. In FY 2011, the AquaFish CRSP ME completed an Associate Award focusing on aquaculture and fisheries in Mali, which ended on 31 December, after receiving a three-month no-cost extension. On the last days of the previous reporting period, the ME received a second Associate Award. This new $1.1million Associate Award, originally funded under EGAT, will scale up technologies as part of the US Government Feed the Future initiative. Thematically, the 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

During this reporting year (1 Oct 2010 to 29 Sep 2011), AquaFish CRSP managed eight core research projects and three program-wide projects operating at 17 US universities and 31 HC institutions in 16 countries. Below are programmatic highlights for this past year.

- During this reporting period, AquaFish CRSP held 60 short-term training events with 1758 trainees and supported long-term training for 188 students from 22 countries at US and Host Country Universities.

- 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 FY2011 Quarterly, Annual, and Regional Centers of Excellence Reports, current AquaFish core research projects have reported over US$68 million in leveraged support. This leveraged support is in addition to US non-Federal cost share and Host Country Institution match. For additional details, see Appendix 3.

- Four subcontracts to current US Lead Institutions were amended for "add-on" investigations to advance USAID's stated goals of: 1) promoting the extension of CRSP technologies through extension, commercialization, and partnership; and 2) assessing the impact and communicating the importance of CRSP research.

- Cultural Practice, LLC was awarded a subcontract through Oregon State University in July 2011 to fund the initial work on the "CRSP Council Knowledge and Data Management Project" which is a CRSP-wide effort intended to combine the wealth of information accumulated by all CRSPs into a single information clearinghouse.

- In June 2011, the ME requested a one-year, no-cost extension to the OSU Leader Award from USAID in order to allow students to complete degree programs, allow completion of work for which funds have already been committed, and to facilitate a smooth transition from the current 5-year award and any future 5-year award. The amendment, signed by USAID on September 8, 2011, extends the Leader Award completion date from 29 September 2011 to 29 September 2012.

- Oregon State University granted no-cost extensions (NCE) to seven core research projects to complete work delayed by weather (such as typhoon and flooding), on-the-ground logistical constraints (such as delays in acquiring materials and supplies) and other unforeseen circumstances.

- On 28 September 2010, the AquaFish CRSP ME at OSU was awarded a 3-year, $1.1 million Associate Award from USAID/BFS to "Enhance the profitability of small aquaculture farm operations in Ghana, Kenya, and Tanzania." Proposals submitted in response to an Invitation to Participate have been reviewed and subcontracts are in place with two US universities: Purdue University and Virginia Tech. The project is focusing on profitability analysis and best practices in effluent and nutrient management. Outreach activities have been initiated in Ghana, Tanzania, and Kenya.

- AquaFish CRSP completed its Associate Award (AA) for aquaculture and fisheries work in Mali. This project, "Aquatic Resource Use and Conservation for Sustainable Freshwater Aquaculture and Fisheries in Mali", funded for three years by the USAID Mission in Mali, began 1 October 2007 and continued via a no-cost-extension, through 31 December 2010. The highly successful project included 20 short-term training courses for 358 participants, three sets of on-farm trials demonstrating both improved pond culture practices and rice-fish culture techniques, and the first-ever frame survey of Lake Sélingué. After trials using CRSP rice-fish technology in model farms showed promising results, 20-fold increases in local adoption rates followed. The no-cost

extension into FY2011 allowed the project to complete proposed work, including a final fisheries planning training activity.

- The AquaFish Director was invited by the Association of Public and Land-grant Universities (APLU), in coordination with USAID and USDA, to participate in planning meetings to discuss the whole-of-government Feed the Future initiative research strategy in January 2011 at Purdue University. Dr. Egna provided additional input via a follow-up meeting in June 2011 in Washington DC., numerous conference calls, and online reporting.

- As a member of the steering committee of the CRSP Council, the AquaFish CRSP Director continued to interact frequently with other CRSP's on a variety of topics. This year's CRSP Council Meeting was held in Kampala, Uganda, an FtF focus country common to most CRSPs. In attendance were US and African partners including the US Ambassador to Uganda.

- The CRSP Director assisted in preliminary efforts to develop and coordinate an online graduate-level fishery management certificate program at Oregon State University specifically designed for African stakeholders.

- Boamah Yaw Ansah, a recent AquaFish CRSP graduate student and PhD candidate at the Virginia Polytechnic Institute & State University, was selected as a Fellow for the Borlaug Leadership Enhancement in Agriculture Program (LEAP) for his outstanding leadership potential as demonstrated by his work on freshwater pond aquaculture in collaboration with Purdue University and the University of Arkansas at Pine Bluff. Mr. Ansah follows in a long line of AquaFish CRSP student successes and is the 4th LEAP Fellow to be selected from this CRSP (2006-2011).

- The Management Team produced the Fourth Annual Report (October 2010), an addendum to the *Implementation Plan 2009-2011* (March 2011), *Aquanews* (quarterly), and *EdOPNet* (monthly). The Management Team also updated the *Site Descriptions (2007-2011)*, wrote an *Annual Work Plan for FY2011*, and compiled *Final Technical Reports for Implementation Plan 2007-2009* (October 2010).

- In addition to updating the AquaFish program brochure (December 2010), the Management Team also published three new regional brochures focusing on AquaFish work in Africa, Latin America/Caribbean, and Asia (March 2011).

- Journalists from the ME at Oregon State University continued to report on project successes globally. In addition to a trip to Asia, the ME generated press releases, videos, and features on a range of topics, including native cichlid aquaculture in Mexico, baitfish farming in Kenya, the effects of Kenya's Economic Stimulus Program on that country's growing aquaculture sector, and the continued impacts that CRSP work has had in Honduras. Press releases, stories, and videos are available at http://aquafishcrsp.oregonstate.edu/news_events.php.

- AquaFish CRSP was active in reaching out to various stakeholder groups and was well represented at local, regional and international conferences during FY 2011. Posters and presentations included:
  - F. Evans, J. Bowman, L. Reifke, and H. Egna. *Promoting sustainable aquaculture and fisheries development through capacity building: A synopsis of short- and long-term training conducted by the Aquafish CRSP*. The 9th International Symposium on Tilapia in Aquaculture, Shanghai, China, April 2011.
  - S. Ichien and H. Egna. *Addressing the goals and objectives of the Feed The Future Initiative: Enhancing the profitability of small aquaculture operations in Ghana, Kenya, and Tanzania.* The 9th International Symposium on Tilapia in Aquaculture, Shanghai, China, April 2011.
  - S. Ichien, F. Evans, and H. Egna. *Mitigating the negative environmental impacts of aquaculture practices: Developing sustainable feed technologies*. The 9th International Symposium on Tilapia in Aquaculture, Shanghai, China, April 2011.
  - AquaFish CRSP Management Team. *AquaFish Collaborative Research Support Program (Overview)*. Oregon State University Earth Week Community Fair, Oregon, USA, April 2011.
  - H. Egna. *Recent developments in setting research priorities for international agriculture: The "Feed the Future" Initiative*,

Exploring World Agriculture Course, OSU, May 2011
- H Egna. *Challenges facing aquaculture development and what the AquaFish CRSP is doing about them*. Triad OSU Faculty Club, Oregon, May 2011.
- S. Ichien and H. Egna. *Investigating the relationship between rural aquaculture development and biodiversity.* World Aquaculture 2011, Natal, Brazil, June 2011.
- S. Ichien and H. Egna. *Developing and improving the culture of indigenous species.* World Aquaculture 2011, Natal, Brazil, June 2011.
- S. Ichien, L. Reifke, C. Stephen, F. Evans, J. Bowman, and H. Egna. *Supporting the development of sustainable aquaculture and fisheries through capacity building and gender integration.* World Aquaculture 2011, Natal, Brazil, June 2011.
- S. Ichien, L. Morrison, and H. Egna. *Improving livelihoods in Africa through advances in aquaculture productivity and watershed management.* CRSP Council Meeting, Uganda, June 2011.
- S. Ichien, L. Morrison, and H. Egna. *Hydrology, water harvesting, and watershed management for food security, income, and health in Uganda: Small impoundments for aquaculture and other community uses*. CRSP Council Meeting, Uganda, June 2011.
- H. Egna, L. Reifke, and N. Gitonga. *Challenges of Including Gender Dimensions in Biotechnological Research Projects.* Special GAF3 Issue of *Asian Fisheries Science (AFS)* journal, June 2011
- S. Ichien, C. Stephen, and H. Egna. *Addressing the impacts of semi-intensive aquaculture on biodiversity: Developing and improving the culture of indigenous species*. American Fisheries Society Annual Meeting, Seattle, WA, September 2011.
- F. Evans, S. Ichien, and H. Egna. *Developing sustainable shellfish and algal production systems to increase food security in Latin America and Asia*. American Fisheries Society Annual Meeting, Seattle, WA, September 2011.

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

- The AquaFish CRSP management team organized and facilitated the AquaFish CRSP Annual Meeting, held this year in Shanghai, China, in April 2011, in conjunction with the 9th Asian Fisheries and Aquaculture Forum (9AFAF) Annual Meeting, the 9th International Symposium on Tilapia Aquaculture (ISTA9), and the 3rd Global Symposium on Gender in Aquaculture & Fisheries (GAF3). Meeting highlights include:
  - The CRSP Annual Business Meeting, which was attended by over 63 program participants, included programmatic and project updates as well as a mid-day working session focused on advancing the productivity frontier of global aquaculture.
  - AquaFish Director Dr. Hillary Egna, organized and chaired a special session to discuss the prospects for new research on air breathing fishes. The meeting included over 20 participants and ten presentations that outlined research needs for six groups of air breathing fishes.
  - AquaFish Director Egna organized and chaired a special project-level coordination meeting for training activities planned by CRSP in African during 2011.
  - With past SOU President, Dr. Egna presented the Shanghai Ocean University (SOU)-CRSP Yang Yi Young Scientist Travel Fund Award to Pandit Narayan Prasad, from the Institute of Agriculture and Animal Science in Rampur, Chitwan, Nepal. The SOU-CRSP Yang Yi Travel Award was established in 2009 to support excellent young scientists from one of the Asian partner institutions to present research at professional aquaculture conferences.
  - Sk. Ahmad- Al- Nahid (Swan) from Bangladesh Agricultural University received the CRSP-ISTA travel award to participate in and present at the 9th International Symposium on Tilapia Aquaculture and the 2011 AquaFish CRSP Annual Meeting.
  - AquaFish CRSP Director Egna organized and chaired the 9ISTA all-day technical session "Accelerating Aquaculture Development in Poorer Countries," which contained a total of 19 presentations.
  - AquaFish CRSP Director Egna presented a talk at the 3rd Global Symposium on Gender in Aquaculture and Fisheries Symposium (GAF3) titled "Challenges of including gender dimensions in biotechnological

research projects." Dr. Egna was subsequently invited to the FAO Special Workshop on the Future Direction for Gender in Aquaculture and Fisheries Action, Research and Development.
  - AquaFish Director Egna organized and chaired the 9AFAF session titled, "Marketing and Globalization," emceed by assistant chair, Dr. Kwamena Quagrainie.
  - AquaFish CRSP sponsored a large booth in the exhibit and trade show hall to display CRSP posters, photos, publications and other outreach materials.

- The AquaFish CRSP Director met with project management and other interested stakeholders 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. Additional discussions have been held with interested stakeholders from FAO and ANAF.

- In FY 2011, AquaFish CRSP continued to collaborate with the International Institute of Fisheries, Economics & Trade (IIFET) to promote and support their biennial conference.

- The Regional Centers of Excellence (RCE) continued to build linkages and promote networking opportunities. RCE Lead Coordinators (and region) include: Charles Ngugi (East and South Africa), Hery Coulibaly (West Africa), Remedios Bolivar (Asia), and Wilfrido Contreras (Latin America/Caribbean).

- The AquaFish CRSP Management Team continued to administer the Library Donation Project in FY 2011, shipping boxes of scientific references, textbooks, and journals donated to Host Country libraries. Our Library Donation Project began in 1999—akin to Libraries without Frontiers-- to help strengthen HC libraries in Africa, Asia, and Latin America.

- Further advancements were made to the AquaFish CRSP website to enhance functionality for project partners and the general public. New features for FY 2011 include:
  - A page dedicated to gender issues in aquaculture highlighting AquaFish CRSP efforts in gender equity
  - A document upload feature on each project reporting page designed to facilitate online reporting and submission of deliverables
  - A web-based project performance tracking system linking multiple data bases to allow the Management Team and investigators to monitor project progress
  - Six new Success Stories and one 4-page Activity Brief are now linked directly to AquaFish homepage
  - Development of a page dedicated to AquaFish CRSP efforts to promote outreach and capacity building.

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

Women in Science and Engineering: Q&A with Gertrude Atukunda

(Volume 25, Number 2/Fall 2010)

Gertrude Atukunda is a project leader for the AquaFish CRSP in her native country, Uganda, and a Research Officer in socio-economics with the Kajjansi Aquaculture Research and Development Centre (KARDC). The mandate of KARDC is to develop technologies and generate information through aquaculture research for improved aquaculture fish production, and to guide stakeholders in the planning, investment, and development of aquaculture. Her responsibilities center on designing and carrying out aquaculture socioeconomic studies among fisher communities. These studies investigate the contribution of fisheries—both capture and aquaculture—on livelihoods, economic viability, adoption of aquaculture technologies, markets, and marketing.

Gertrude Atukunda (left) with two young women scientists (Photo courtesy of Gertrude Atukunda)

Atukunda knows first hand that measures of inequality persist throughout the world. Women's roles in Uganda's aquaculture industry—although evident in its success —is largely invisible. "Women battle with demonstrating that they can perform as well or even better than men, despite domestic demands and obligations", says Atukunda. "This is because… men are still the majority in leadership positions. They tend to perceive women as not able to perform well in certain aspects, especially due to negative perceptions about their reproductive roles".

"Once a woman manages to complete education, there is no discrimination, per se, because employment opportunities are equal for both men and women", she remarks. She herself received a Bachelors of Science Degree in Sociology from Makerere University, in Kampala, Uganda, and went on to get her Masters of Arts in Development Studies at Uganda Martyrs University Nkozi. Still, she adds, women tend to get overworked because they are less assertive, and therefore readily agree to take on duties that put more demands on their time. "For example", she adds, "maternity leave is a big toll on office work, especially if the position of the individual is so specialized and not easily substitutable".

As a representative woman in her field who has experienced these challenges, Atukunda was invited as a special guest to Auburn University for a gathering sponsored by the WISE Institute (Women in Science and Engineering Institute) for female graduate students in STEM (science, technology, engineering, and

mathematics). This assembly allowed for informal discussions about the opportunities and the challenges women face in these disciplines. The gathering was held on 12 October 2010, just days after she spoke at Auburn University's seminar for "Socioeconomic Aspects of Aquaculture Development in Uganda". Aquanews got in touch with Atukunda over email to gain her perspective on the role of women in her field of study, the challenges women still face in Uganda and worldwide, and where women can go from here.

Q You just left the US after having spent a week traveling between Seattle, Washington and Auburn, Alabama. Overall, how was your experience on this trip?

A The trip was very inspirational. I felt honored for having been identified to attend the CRSP project meeting, in addition to meeting my research collaborators at Auburn University. I liked the opportunities that were availed to me to speak on two occasions (the seminar where I presented a paper and discussion group of which I was the guest speaker). Both opportunities made me feel special not just as a research scientist who was representing the project I am working on but also as a woman. I was re-energized to continue seeking excellence in my career. I was also inspired to further my work in promoting the education of disadvantaged girls through charity work, which I am involved in outside my official duties.

Q What are some of the biggest challenges faced by women in your field in Uganda?

A The main challenges faced by women in the science field stem from their reproductive roles which sometimes demand time that officially is meant for office and related field work. Responsibilities in the laboratory and field often require working beyond office hours. Some of the work also includes overseeing experiments that require 24-hour monitoring, and writing proposals, reports, and papers for publication. In order to make personal career accomplishments, most colleagues have often used time after official working hours to succeed in writing.

Women also tend to be reluctant to take up long-term training courses that keep them away from their homes. This is because once they have a family (husband and children) they are sensitive and careful about consequences that may arise when they are away from their families. In addition, society does not expect a woman to be away from her marital home, which, however, seems to be normal for a man.

Our culture is still strongly embedded with gender stereotyping and misconceptions about the potential role of women in the professional sphere. Although the situation is changing, women are continually under-represented in the science field. This situation sends the wrong signal that the field is not actually for women.

Q How might this compare to challenges faced on a global scale?

A Globally, women face the same challenges but the magnitude differs across continents. Gender stereotyping, which places women in disadvantaged positions, tend to be more prevalent in developing countries than in the developed ones. For example, women are largely responsible for the domestic work in their homes. Therefore, women in the professional sphere must resort to employing house helpers who are usually uneducated girls or school dropouts, a situation that further puts women at a disadvantage.

Q How have women's roles in science and engineering changed since you first got involved?

A Most of the few women in the science field have become very successful and acted as role models to other women and young girls. There have been efforts to recognize women scientists through rewards in appreciation of their achievements. These rewards have been in the form of grants to further their careers and leadership promotion roles that increase their visibility and self esteem.

Q What more do you feel needs to happen to help women succeed in these fields of study?

A First, we must continue to create awareness among households in order to promote education of girls, and increase professional training opportunities for women so that they can compete favorably with male counterparts. This can be achieved by increasing availability of funding opportunities that focus on empowering women scientists—post graduate, short course, and project proposal funding. Increasingly, these efforts have led to attitude change. For example, at the Aquaculture Research and Development Centre, the ratio of female to male employment at the level of scientist (minimum of Masters Degree) has over time shifted from 1: 2 in 1999 to 1:1 in 2010. Specific efforts to mentor young scientists can

also greatly help women in their fields of study. Also, young scientists should have opportunities for interacting on a professional level. Competitive research and writing grants coupled with meetings where young scientists can share results and learn from each other should be made available. Women should be given opportunities and encouraged to take up long-term career development courses in their earlier lives, before they get too engrossed in the social demands of the marital home.

An Overview of the Fourth Fish Farmers Symposium and Trade Fair in Uganda
(Volume 26, Number 2/Spring 2011)

Over the last 5 years, the Walimi Fish Farmers Cooperative Society (WAFICOS) has developed a tradition of holding annual symposia and trade fairs as a platform for experience sharing and exposure to new developments among farmers and stakeholders. The last two symposia were conducted in collaboration with AquaFish CRSP. Additional support for the 2011 symposium was obtained from the USAID Livelihoods and Enterprises for Agricultural Development (LEAD) and the National Agricultural Research Organization (NARO). The symposia are becoming more of a major forum through which farmers and key players in the farmed fish value chain – input suppliers, fish processors, researchers and trainers, and private service providers – can network and discuss issues that affected the sector the previous year.

In the previous year, 2010, the viability of fish farming enterprises was greatly challenged. The supply of commercial feed was seriously affected as the main fish feed producer, Ugachick Poultry Breeders Limited, was installing a steam extruder to produce steam extruded fish pellet. The only establishment that could produce good quality formulated fish feed was the Source of Nile Limited, whose capacity was grossly inadequate as the facilities were primarily to cater for its own needs and were not mechanized. Source of Nile Limited is the largest tilapia hatchery and cage farm in Uganda. Consequently, the only alternative for farmers was to produce their own feed on farm. Furthermore, the costs of feed ingredients – and consequently feed on the whole – shot-up by more than 50%. The low supply of feed also affected levels of seed production, which resulted in several ponds not being stocked on schedule.

Being able to produce feed consistent in quality was a major challenge for fish farmers particularly for those who had expanded their operations given the availability and performance of Ugachick's initial sinking feed pellet. Yields and quality of farmed product subsequently declined and became inconsistent. Several farmers had their fish turned away from fish processing plants as well as farmers engaged in the business of smoking fish because of the high variability in size and high degree of fattiness in the farmed product. So in addition to declining yields, farmed fish became less marketable. Several previously profitable operations suffered significant losses.

The major issues discussed at the 2011 symposium covered: Production Planning and Management; Fish Feeds and Feeding; Value Addition and Marketing of Farmed Fish; and Current Support Services to the Aquaculture Private-Sector. The sessions were lively, particularly the open session titled "When I sold my fish at a loss and at a profit" where farmers shared experiences.

The trade fair ran concurrently with the symposium. This year the technologies showcased included a range of farmed fish products and inputs for sale. Several farmed fish by-products were prepared and displayed for sale. All the fish brought to the symposium this year was sold and there was demand for more from participants as well as passers-by who had come to the trade fair.

Three optional one-day field tours were also conducted that focused on demonstrating Best Management Practices in the production and marketing of catfish and tilapia fingerlings and table fish. Post-harvest handling, filleting, smoking and packaging were among the key aspects demonstrated.

The 2011 symposium attracted a total of 150 persons. Fifty-one percent of participants this year were farmers, 19% researchers and trainers and 12% technical advisors. Two fish farmers attended from Kenya. This year a South African Company, Deep Blue Aquatic Systems, displayed live fish holding systems.

Participants viewed the symposium as a great success. Mr. Paul Ssebinyansi, the WAFICOS chairman, commented, "The presentations have been relevant and have addressed farmers' issues, challenges and experiences."

UNIVERSITY OF CONNECTICUT

Transforming Local Practices for Feeding Snakehead Fish in Aquaculture in Vietnam

(Volume 26, Number 1/Winter 2011)

Snakehead culture is a growing industry in Vietnam, with two species in production: the giant snakehead (*Channa micropeltes*), produced primarily in cages, and the snakehead murrel (*Channa striata*), produced primarily in ponds. As is still the case with some small-scale catfish production in Vietnam, the preferred aquaculture feed for snakehead has been small fish (also known as low-value fish or trash fish) taken mostly from the Mekong River. In Cambodia, such reliance on small fish as feed has resulted in a ban on snakehead culture. One of the goals of the Aquafish CRSP project "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" has been to reduce or eliminate the use of small fish as feed for the snakehead industry. One part of this project, the investigation entitled "Alternative feeds for freshwater aquaculture species in Vietnam" specifically studies ways to raise snakehead on formulated pellet feed In the first part of this project, there were several significant findings. First, researchers at Can Tho University found that the small fish used as feed for snakehead culture in Vietnam represented 33 species, many of which were commercially important species in their juvenile stages. Second, they determined the optimum weaning protocol to train snakehead in the hatchery to eat pellets, rather than live feeds, at a young age. This was critical because if snakehead are raised too long on live feeds, they will not want to switch to pellets and will have to be fed small fish. Finally, in the major part of the project, we conducted several experiments to test various pellet diets on snakehead. These included diets in which a significant portion of the fish meal was replaced by soybean meal with added amino acids, taurine and phytase, as well as local products like cassava meal and rice bran as a protein source. Phase One of this project ended with a small-scale field trial in which snakehead were raised on three diets: small fish only, a fish-meal based pellet diet, and fish-meal plus plant protein pellet diet. After six months of rearing, the fish were prepared as filets for a blind taste test by Can Tho University (CTU) students. The very positive result from this taste test was that students could not distinguish any significant differences among the filets from fish fed the three diets.

Armed with the results of both lab studies on survival and growth of the fish reared on pellets and the taste test, Dr. Hien was able to recruit a local feed mill to produce the AquaFish CRSP diets and more than 50 farmers in Dongthap and An Giang provinces to use those diets in rearing snakehead. She and her students collaborated with local fisheries departments in the provinces to set up technology transfer sessions for fisheries technicians and farmers, both at CTU and in the local areas. In these sessions they shared results of their on-farm trials and discussed the production of pellet feed by the cooperating feed mill. In addition, Dr. Le Xuan Sinh explained the harmful effects of using small fish as feed in snakehead culture, both

Feeding snakehead in Vietnam (Photo courtesy of Bob Pomeroy)

economically and ecologically. Every month, CTU and feed mill staff visit the farmers to collect data on water quality, fish growth, fish health, etc., to monitor the results of this phase of the work, as well as to provide guidance to the farmers on snakehead culture.

One of the problems with snakehead culture in Cambodia is that there are no snakehead hatcheries, as there are in Vietnam. Any snakehead used in aquaculture in Cambodia would be collected from natural waters like the Mekong River or Tonle Sap as juveniles past the age at which they can be transitioned to formulated feed. Thus, two needs must be met for snakehead culture to be instituted in Cambodia: a) provision of hatchery-reared juveniles trained to eat formulated diets, and b) the pellet diets to feed them so that farmers do not use small fish. In Phase Two of the project, Cambodian fishery biologists spent time in Vietnam learning hatchery production techniques and have begun small-scale hatchery production of snakehead in a government hatchery in Cambodia.

NORTH CAROLINA STATE UNIVERSTIY

New Milkfish Culture Feeding Alternatives to Reduce Production Costs and Improve Income for Fish Farmers in the Philippines

(Volume 26, Number 2/Spring 2011)

Milkfish, the national fish o f the Philippines, is the most important foodfish produced from aquaculture there, constituting a large portion of the staple diet of most Filipinos. Locally known as bangus, milkfish are an ideal culture fish because they are fast-growing, omnivorous, hardy, disease resistant, and also euryhaline , denoted by their ability to live in both freshwater and full-strength seawater. Traditionally, they are cultured in brackish water and freshwater ponds or freshwater pens. Average annual production for brackish water ponds is around 820 kg/ha and from freshwater pens around 3600 kg/ha. Recently, milkfish culture in freshwater and marine cages has increased because of higher demand and greater productivity. However, feed constitutes more than half of the total variable costs for producing milkfish. Therefore, strategies that limit the quantity of feed used for grow-out could reduce over all feed costs, improve production efficiency, and increase farmers' incomes.

CRSP Investigations at the Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC AQD) in the Philippines collaborated with AquaFish researchers at North Carolina State University (NCSU) to demonstrate that feeding on alternate days results in comparable production as feeding stocks every day and thus is effective in reducing overall costs in the culture of milkfish in the Philippines. These findings were the result of several feed trials conducted to compare the effects of two distinct feeding regimes on the growth performance and production cost of milkfish stocked in both brackish water ponds and marine cages.

For growth trials in brackish water ponds, four pond compartments with an area of 700m^2 were stocked with milkfish fingerlings at a stocking density of 0.5 fish/m2. Stocks in two ponds were fed daily with normal ration while fish in the other two cages were fed the normal ration but on alternate days only. Two runs were conducted and the data are summarized in Table 1.

The marine cage trial used hatchery produced milkfish fry grown in brackish water nursery ponds. Milkfish fingerlings were randomly stocked in 6 unit 75m^3 cages at a density of 35 fish/m3. As in the pond trials, stocks in 3 control cages were fed daily with normal daily ration while fish in 3 replicate experiment cages were fed on alternate days. Feeding rations were adjusted every two weeks based on the average body weight of the fish during the last sampling. The fish were cultured for 4 months. The data are summarized in Table 2.

The most remarkable results of the pond and marine cage culture trials are the significant reduction in feed inputs and improvement in feed conversion ratio (FCR), which is the amount of feed it takes to grow fish to a

certain biomass. The improved FCR of fish fed on alternate days yielded comparable harvested biomass of milkfish but with substantially less feed input compared with fish fed daily (Tables 1 & 2). For the pond trials, savings in feed cost of 56.54 ± 4.60 percent were realized whereas in the marine cage trials, expenditures on feed inputs were on average 31.74 ± 0.50 percent lower in alternate day fed stocks than the daily fed stocks.

As the aquaculture industry continues to expand, the cost of commercial fish feeds will continue to increase as the market demand increases and the availability of fishmeal declines. Our studies show that feeding on alternate days is an effective strategy for reducing the cost of production as well as negative environmental impact but does not affect the production of milkfish. Future work at SEAFDEC AQD and NCSU will continue to look at strategies that will improve production efficiency of milkfish, enhance income of farmers and advance integrative culture techniques that reduce the environmental impact of fish culture. Similar strategies can also be tested and applied in the culture of other economically valuable fish species. SEAFDEC AQD and NCSU are partnering with the Philippine Bureau of Fisheries & Aquatic Resources for a wider dissemination of the feeding strategy for milkfish among farmers especially in the Philippines. With the growing interest in milkfish culture in the Association of Southeast Asian Nations (ASEAN) member countries, SEAFDEC AQD can likewise collaborate with relevant institutions to disseminate the AquaFish CRSP-generated technologies throughout the region.

Table 1. Production characteristics of milkfish in brackish water ponds

Parameter	**Treatment A** (Fed daily, control)	**Treatment B** (Fed on alternate days)
Initial ABW (g)	72.12 ± 6.04	66.30 ± 2.23
Final ABW (g)	324.31 ± 17.13	275.79 ± 19.52
Survival Rate (%)	83.93 ± 6.85	92.62 ± 3.82
Actual Biomass Harvested (kg)	99.01 ± 10.16	94.48 ± 4.14
Total Food Consumed (kg)	326.59 ± 8.01	140.87 ± 11.95
Total Feed Cost (PhP)	8818.0 ± 216.33	3803.54 ± 322.57
Savings on Feed Cost (PhP)		5014.51 ± 528.67
Savings on Feed Cost (%)		56.54 ± 4.60
FCR	3.41 ± 0.37	1.50 ± 0.14

Table 2. Production characteristics of milkfish in floating marine cages

Parameter	**Treatment A** (Fed daily, control)	**Treatment B** (Fed on alternate days)
Initial ABW (g)	29.55 ± 6.02	31.76 ± 6.15
Final ABW (g)	185.13 ± 17.43	140.5 ± 33.91
Culture Period (days)	135 ± 12.66	170.33 ± 5.55
Survival Rate (%)	83.12 ± 1.27	88.69 ± 3.65
Actual Biomass Harvested (kg)	629.67 ± 6.01	615 ± 42.36
Total Feed Consumed (kg)	2015.13 ± 36.76	1374.79 ± 10.14
Total Feed Cost (PhP)	54,408.42 + 993.56	37,119.24 ± 274.26
Total Savings on Feed Cost (PhP)		17,289.18 ± 788.88
Savings on Feed Cost (%)		31.74 ± 0.50
FCR	3.2 ± 0.06	2.25 ± 0.15

FCR: Feed Conversion Ratio ABW: Average Body Weight

Feeding milkfish in the Philippines (Photo courtesy of Evelyn Grace De Jesus-Ayson)

AQUANEWS CLIPPING
MALI ASSOCIATE AWARD

AquaFish CRSP Mali Project Reflections: Three years, Three Themes, Many Achievements
(Volume 26, Number 1/Winter 2011)

After just over three years of focused aquaculture and fisheries progress, the CRSP's Mali Project wrapped up its work on 31 December 2010. This project, "Aquatic Resource Use and Conservation for Sustainable Freshwater Aquaculture and Fisheries in Mali", was funded by USAID's Mali Mission under an Associate Award, with the objective of providing access to improved technologies for Malian farmers, fishers, government and non-government technical staff, and other stakeholders along the fishery products value chain. Through appropriate technological applications with a focus on management, the project aimed to advance sustainable freshwater aquaculture practices, promote rice-fish culture techniques, and facilitate the development of community-based management plans for Mali's fisheries.

To achieve these goals, the project took a South-South approach, collaborating with partners in other AquaFish CRSP host-countries to transfer their most successful practices to Mali and adapt them to local conditions. The project was divided into three themes and headed by AquaFish collaborators and Host Country PIs, emphasizing capacity building opportunities and sustainable solutions for maximizing benefits to the people of Mali. Nancy Gitonga of FishAfrica, headquartered in Nairobi, Kenya, provided leadership for the fisheries management planning effort; Yang Yi and Liu Liping of Shanghai Ocean University in Shanghai, China, took the lead for the rice-fish culture component; and Charles Ngugi of Moi University and Kenyatta University, in Kenya, guided the work of the pond culture activities.

With the objective of providing improved technologies to our selected target audiences, a total of 20 workshops, which attracted a total of 358 participants, were conducted across the projects three themes over three years. These workshops covered a wide-range of aquaculture and fisheries topics, including pond site selection, pond construction, pond management, up-to-date techniques for rice-fish culture, fish transportation, catfish propagation and care of fry, best management practices, post-harvest technologies, and lake survey techniques. They also included three stakeholders' workshops to discuss the results of the Lake Sélingué frame survey that has prompted planning for co-management of that lake.


Malian farmer usng a cast net as part of workshop activities (photo by Jim Bowman)

Field tests and demonstrations complemented the workshop activities with guided hands-on experience to farmers. The pond culture team conducted two sets of on-farm trials and the rice-fish team coordinated and supervised a set of rice-fish demonstration plots. Through the application of improved management practices and supervision by project leaders, farmers participating in the on-farm trials realized yields of up to 9000 kg/ha in a six-month period (18,000 kg/ ha/yr), a substantial increase over the estimated average productivity of ponds at the beginning of the project (1500 kg/ha/yr). In the rice-fish demonstrations, after approximately four months of culture, one farmer harvested 115 kg of fish from a rice paddy just 840 m2 in area (equivalent to 1369 kg/ha), substantially contributing to the family income.

The fisheries planning component accomplished the first ever frame survey of Lake Sélingué, preceded by two workshops to train those who would be conducting the survey. This not only produced a valuable baseline dataset for evaluating the fishing capacity of the lake, but also resulted in the creation of a cadre of individuals trained in survey techniques so that they now have the capacity to conduct future surveys.

Highlights of the project's successes include:
Technicians of Mali's National Fisheries Directorate have been trained in pond culture, rice-fish culture, and lake survey techniques and can now apply them to future development activities in the country. Following their training, several trainees have taken lead roles in transferring their new-found knowledge to other Malians.

One of the initial pond culture trainees has been instrumental in setting up catfish hatching systems in at least three locations and is now producing and selling catfish fingerlings on his own. In addition, he has himself become a trainer, leading at least four pond-construction training sessions for 90 people in Bougouni, Segou, Sanankoroba, and Gao during the final year of the project. Over 120 people have visited his farm seeking fish farming advice and 16 of these have started to build ponds of their own.


Researchers observing zooplankton (Photo By Liu Luping)

After observing the results of the project's rice-fish demonstrations, at least 22 new farmers in the Baguineda area decided to modify their fields to include fish during the 2010 growing season. With assistance from government technicians, rice farmers in other parts of Mali are also taking up rice-fish culture.

The work of the AquaFish CRSP Mali Project has thus set the stage for further development of the aquaculture and fisheries sectors in Mali. Fish farmers have received previously unavailable technical information that will enable them to expand aquaculture production as well as increase their productivity per unit area. Fishers in Lake Sélingué have been brought into the management planning process, and the technical staff of the Direction Nationale de la Pêche now has the skills needed for conducting additional frame surveys in the future, whether at Lake Sélingué or elsewhere. Rice farmers in Baguineda and other areas have seen how irrigated rice fields can be modified to accommodate a crop of fish, and many of them are now doing this. Both rice farmers and fish farmers have learned how to produce more fish in their respective areas, thus bringing in added food and income to support their families.

AQUANEWS CLIPPINGS
AQUAFISH CRSP GRADUATE STUDENTS

Graduate Student Profile: Gladys Kuria
(Volume 25, Number 2/Fall 2010)

While it was a fond taste of fish that initially got Gladys Kuria fired up about aquaculture, press further and she'll tell you there is much to love about the industry. In her native home of Kenya, for instance, aquaculture has been known to generate jobs, provide food security, and improve nutrition. Her interest in science propelled Gladys to earn her undergraduate degree in Fisheries and Aquatic Science at Moi University in 2009. She is continuing on to pursue a masters degree with a concentration in aquaculture at Moi University under the guidance of her major professor, Dr. Charles Ngugi. Not only is this university known for its competence in teaching, the Cheploilel Campus at Moi University is the only university in Kenya that offers a masters program in aquaculture.

Her thesis work investigates the effects of stocking density on growth, survival and yield performance of Nile tilapia (*Oreochromis niloticus*) in an integrated cage-cum-pond culture system. This system integrates cage culture with semi-intensive pond culture where an artificial diet is fed only in the cages. Any feed that passes through the cage mesh that would otherwise be deemed "wasted" in turn serves as a source of food for the fish in the open ponds. Feed waste contributes to economic loss and nutrient loading in aquaculture systems, greatly challenging the success of small-scale commercial fish farming. Feed "recycling" in this system effectively addresses this problem by increasing the efficiency of food utilization.

The study is being conducted at Mwea Aqua Fish Farm (MAFF) in nine 1m2 cages within a 1300m2 earthen pond and stocked with hand-sexed male tilapia fingerlings (approximately 65 g) from the MAFF hatchery. The pond is stocked with 4 fish per m2, and the cages have been randomly allotted three treatments with three stocking densities of 50, 75, and 100 fish per m3. The study is currently underway with daily water quality testing and monthly fish growth monitoring. The intended outcome of this research is to identify opportunities to improve fish yield in culture systems that are economically feasible for the farmers. Gladys has the unique opportunity of directly applying her research methods to improve current operations run by small-scale fish farmers in Kenya. Says Kuria, "They are expected to adopt the finding to increase fish yield, generate more income, and in the long run improve their livelihood."

Having worked with AquaFish CRSP for over a year, Kuria identifies working with and training local farmers who are participating in the on-farm trials as some of the most enjoyable experiences in her work with the CRSP. "I am interested in community development", Kuria adds, "giving back to the community through extension services and helping farmers to write proposals that could provide funding for various activities that would be of help to them." Kuria plans to continue her studies in a PhD program, which will prepare her for a career in researching and lecturing on topics in aquaculture. In addition to one day becoming a professor in aquaculture, she ultimately dreams of establishing a fish farm of her own.

"The poor perception of aquaculture in Kenya's recent past has made it difficult to promote its development, as most potential investors are not convinced that aquaculture can be a profitable enterprise", states Kuria. "However, the government is recognizing that the subsector can play a key role in poverty alleviation of rural populations". Kuria is particularly thankful to the CRSP for supporting aquaculture in Kenya through research and funding of various projects, and for providing many students with the opportunity to get involved in this burgeoning field. Says Kuria, "They have given many students from developing countries—including me—a remarkable chance to further their studies"

Graduate Student Profile: Alejandro Macdonal-Vera
(Volume 26, Number 1/Winter 2011)

Alejandro Macdonal-Vera has strong ties with Universidad Juarez Autonoma de Tabasco (UJAT). Not only is he a former AquaFish supported graduate student at the university, where he completed his Masters degree in Environmental Science, but UJAT is also where he hopes to one day establish himself as a fulltime professor. Judging by Alejando's dedication to projects that stand to improve the economy of rural aquaculture producers in the region, this seems like a natural fit.

The university upholds the mission to "prepare professionals with broad expertise in their area of study to fulfill the needs of Tabasco and the country at large." It was here that Alejando— Alex to friends and colleagues – discovered a rich diversity of aquaculture studies and the regional application of related research activities. He completed his Masters degree, evaluating the polyculture of red tilapia and shrimp in the Southeast State of Sinaloa, and continues to be plugged in to both the socioeconomic and conservation aspects of aquaculture development in his native home of Mexico.

There is no doubting Alex's expertise in the field of aquaculture. To date, he has amassed a total of 13 years in the industry, and has contributed his skills in a range of investigations. Under the guidance of his major professor, AquaFish CRSP Host Country Principal Investigator Dr. Wildfrido Contreras Sanchez, Alex is currently working on two investigations in collaboration with AquaFish CRSP, the first of which is an investigation of selective breeding programs for native cichlid and snook aquaculture. This project is a continuation of the earlier breeding program initiated in 2007 using wild castarrica (*Rocio octofasciata*) and tenhuayaca (*Petenia splendida*) broodstock, from which the first generation of selected native fish was obtained. Alex has been involved in the successful sex-reversal and breeding of these native cichlids, as well as in the progress leading to induced spawning and reproduction of snook species. Continuing the selective breeding programs of these species will provide cultivators – primarily poor farmers – with native fish seed stock that exhibit better growth characteristics, promoting conservation of an economically important natural resource.

Alex is also involved in an investigation on sustainable integrated aquaponics and the evaluation of fingerling quality in Tabasco, Mexico. Continuing research will focus on improvements in the production of juvenile tilapia for growers. A comparative experiment on growth performance and cost of production of several strains of tilapia will provide farmers with unbiased information from which they can make decisions on purchasing economically viable fingerings. Alex and the AquaFish team at UJAT are also developing a method to eliminate methyl-testosterone used in masculinization systems for tilapia sex-reversal (see Aquanews Fall 2010).

"I have enjoyed sharing my knowledge and experience with producers about management technique of diverse culture species," Alejandro says about his work with the CRSP. He is pleased to see new methodologies developed from his research subsequently implemented by producers in the region. It is his hope that his research will provide quality fingerlings to producers, and help repopulate native water bodies with economically important snook and native cichlids.

Graduate Student Profile: Boamah Yaw Ansah
(Volume 26, Number 2/Spring 2011)

Having grown up in Apam, Ghana, Boamah Yaw Ansah is witness to the early stages of aquaculture in his home country, which is largely comprised of small-scale, semi-intensive operations in earthen ponds. Fisheries constitutes an important sector in Ghana's national economic development, but depletion of resources has made it difficult for commercial fishing to meet the demands of Ghana alone. Fish production from aquaculture is expected to help, but its contribution to the national economy has not been disaggregated and its relative importance is generally unrecognized.

Within the last decade or so, there has been a growing enthusiasm about fish farming on Ghana's Volta Lake. "Aquaculture is still in the nascent stages in Ghana," says Ansah. "However, the huge potential of the industry in the country is obvious, considering the deficit in fish production demand." Ansah hears that potential knocking loudly on Ghana's door, and he wants to open it up and let it flourish. It seems fitting, considering aquaculture had the same effect on Ansah himself. Ansah's first love was water quality management. After getting involved in an internship with the Water Resources Commission (WRC), he chose to study Fisheries and Watershed Management at the Kwame Nkrumah University of Science and Technology (KNUST) in Ghana. Before long Ansah discovered that aquaculture studies effectively merged his interest of watershed management and low impact ecosystem services with his growing interest in food security. To Ansah, it seemed possible that aquaculture could address these critical issues affecting his home country. Ansah went on to get his Master's degree at Virginia Polytechnic Institute & State University with funding support from AquaFish CRSP and KNUST, which he completed in 2010. In February 2011, he recieved the Norman E. Borlaug Leadership Enhancement in Agriculture Program (LEAP) Fellowship.

Today, Ansah is as passionate as ever about the potential of aquaculture in Ghana. He is now working towards his PhD in Fisheries and Wildlife Conservation at Virginia Tech with his major professor Dr. Emmanuel Frimpong on a project titled "Enhancing profitability of small-scale aquaculture farm operations through resource management and environmental best management practices." This is a new "Feed the Future" (FtF) project with Purdue University under a collaboration between Dr. Kwamena Quagrainie at Purdue and Dr. Hillary Egna at Oregon State University. In addition to Ghana, this project also involves work in Kenya and Tanzania. Two examples of Best Management Practices (BMPs) considered for tilapia production in Ghana are water re-use and utilization of floating feeds. Part of this FtF project aims to assess the impacts of these two aquaculture BMPs on water quality, farm profitability, and social welfare among Ghanaian fish farmers. Data will be obtained from bi-weekly measurement of fish growth rates and water quality at cooperating farms throughout Ghana. Field work, Ansah says, is one of his favorite components of the work. "The most enjoyable experience is returning to Ghana every summer and travelling through local communities."

But what influences the adoption of BMPs among fish farmers? Innovation Diffusion is a type of decision making that occurs through a series of communication channels over a period of time among members of a similar social system. New innovations or practices can be rejected at any point throughout the five stages of adoption, defined as knowledge, persuasion, decision, implementation, and confirmation. Ansah has identified three different techniques that facilitate diffusion of new innovations or practices among fish farmers: demonstrations, workshops, and farmer-to-farmer training. His dissertation will investigate the relative effectiveness of these Innovation Diffusion Techniques, and assess the impact that BMP adoption has on the supply of ecosystem services.

To date, farmers have been selected to participate in the study and farm demonstrations have commenced. The first three regional workshops are scheduled to begin in July, at which time surveys will be administered before, during, and after to ascertain the status quo proportion of farmers using the BMPs. Ansah hopes that the results will be applicable to the entire sub-Saharan African region, where the cultivation of tilapia in

earthen ponds is ubiquitous. But its immediate utility in Ghana is certainly tenable. “This study will provide important data for Ghana’s forthcoming fisheries and aquaculture policy document,” says Ansah. “Effective Innovation Diffusion Techniques will also be available, which will guide future extension efforts on BMP adoption and adaptation to local conditions.” But as Ansah proclaims, it’s not only about increasing production. “Aquaculture ought to prevent environmental impacts – commonly water quality issues – that have pervaded aquaculture adoption in the past,” he states. Adoption of BMPs could be just the ticket that Ghana needs to realize aquaculture’s full potential in the country.

Learning & Sharing Through Multimedia: Victor Motari
(Volume 26, Number1/Winter 2011)

Growing up in Nairobi, Kenya, Victor Motari has an acute sense of the role that the fish industry has in Kenya. Despite being aware of the present challenges that fish farmers face, his perspective on the issues of aquaculture is infused with an overwhelming sense of optimism. In fact, given his breadth of knowledge and experience in the field, it’s surprising to learn that Motari is only just completing his undergraduate degree at Kenyatta University.

Victor first got involved in AquaFish in 2009 when, at the university, he met AquaFish Host Country Principal Investigator Dr. Charles Ngugi who saw great potential in the young student. Since then, Victor has gotten broad exposure to the many aquaculture activities going on in and around his home of Nairobi. Under Dr. Ngugi’s guidance, Victor has participated in value chain development for catfish and tilapia production, as well as the assessment of integrated pond-cage systems for the production of Nile tilapia for improved livelihood of small-scale fish farmers in Kenya. His involvement has been instrumental in documenting aquaculture activities throughout Kenya, ranging from on-farm trials and workshops to the bustle of field and market activity. In the process, Victor has observed the many challenges faced by small-scale farmers including the adoption of best management practices and availability of quality seed and fish feed. But it’s the success stories – such as that of catfish bait producers and tilapia farmers in central and western provinces – that sustain his optimism. “I have learned that the various challenges present in aquaculture are not insurmountable but can be overcome by embracing new and better alternatives, knowledge, innovations, skills and technologies,” he remarks.

Indeed, there seems to be no limit to what Victor has learned in the process. “I have been able to participate in regional projects from which I’ve learned a lot more about the technologies applied in aquaculture systems in different regions,” says Victor. This exposure has allowed him to interact with fish farmers on the ground, an experience that has proven educational, enjoyable, and motivational. “I have found so much joy in community development,” he adds. “I am always excited to hear stories of how the local fish farmers are prospering and earning better income.”

Victor first got involved in these projects because he wanted to see more young people and women take up aquaculture with the seriousness he believes it deserves, and because, as he says, learning and sharing is exciting and more fulfilling when it results in empowering other to improve their livelihoods. “I was impressed by the enthusiasm of the women who attended a training in Mumias, Kenya, in November 2010,” he states. “It goes to show that the support for tools of development is never in vain but a worthwhile investment since women, too, are more than willing to adopt them.”

So where does he want to go from here? You can bet his future will involve continuing his work with aquaculture and perhaps even one day starting his own fish farm. When asked if he’ll be continuing his studies, Victor responds: “Certainly, yes!”

We are proud of Victor’s accomplishments and look forward to seeing him progress towards his goals. To view Victor Motari’s videos hosted by Youtube and Vimeo, please visit Aquanews on the CRSP website.

IV. RESEARCH & TECHNOLOGY TRANSFER ACCOMPLISHMENTS

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

TOPIC AREAS: INTEGRATED PRODUCTION SYSTEMS

Production System Design & Best Management Alternatives (BMA)

- A tilapia cage-culture trial for promoting small-scale fish farming on Lake Victoria is designed as a working enterprise model that will recruit other farmers to this new technology. Members of Uganda's 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. A key aspect of the CRSP work has been to illustrate cage culture as a profitable venture. CRSP investigators provided technical assistance and "partnered" with JUGIPAED on a combined cost-share/research basis. This dual purpose approach offered a hands-on experience to the participating farmers with CRSP mentoring in a successful business model. At the conclusion of the trial, fish yield data showed farmers that the cage culture model is be profitable. — 09BMA01AU

- In Uganda, just under 300 participants attended the 3rd and 4th Annual Fish Farmers Symposium & Trade Fair held in January 2010 and 2011. The events were organized in partnership with the Walimi Fish Farmers Cooperative Society. Topics reflected the requests and interests of event attendees: (1) accessing inputs, return on investment, and quality of service delivery; (2) markets, marketing, and market information; (3) current support services and their accessibility for the aquaculture private sector; (4) feeds and feeding guidelines; (5) enterprise budgets; (6) farmer-based value-addition; and (7) financing. Study tour visits to farms and other associated businesses were introduced by CRSP and have proven a successful outreach tool for information exchange. The popularity of these tours is evidenced in their growth from one tour in 2010 to four tours in 2011, including one offered to Kenyan farmers. Participants have enthusiastically acknowledged the success of this multifaceted annual event as a forum for information exchange, networking, and working out practical solutions to current production challenges. — 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 indicate that overly high stocking densities in ponds without water exchange may be the cause of poor water quality conditions (e.g., lower pH and higher biochemical oxygen demand) that can negatively affect appetite and thereby jeopardize shrimp growth. For ponds with recirculating systems and no water exchange, data show that water quality is stable and shrimp growth normal. From this work, CRSP investigators have established that a pond-based, recirculating system for shrimp is a successful management approach for controlling solid waste and water quality. — 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 (MC) toxin to develop. The toxin is a secondary metabolite that can be lethal to aquatic animals. When accumulated in fish and shellfish tissue, the toxin also affects the food product's quality and safety for human consumption. Current work focuses on controlling MC in indoor recirculating culture systems for shrimp. The red swamp crayfish (*Procambarus clarkii*) and the freshwater prawn *Macrobrachium rosenbergii* are being used as test species in experiments to identify the lethal mechanisms of the MC toxin. For the crayfish, the toxin from MC exposure lowers the survival rate of juvenile crayfish and adversely affects the disease immunity of adult crayfish, leading to poor grow-out in culture systems. In the case of prawns, no accumulation of MC toxin in tissues was found. Thus, further studies are required to identify the mechanism of the toxin's lethal effect on juvenile prawns. These results point to MC's complexities and the need for continued studies to characterize its mode of action in different aquatic organisms. This information will prove especially critical for developing MC control methods for intensive shrimp production systems. —09BMA05UM

- In 2006, a CRSP evaluation of prawn farm practices in Thailand identified the negative environmental impacts of pond effluents and overfeeding. To follow-up, CRSP researchers at The University of Michigan partnered with the Network of Aquaculture Centres in Asia-Pacific this past year to present a workshop for farmers and managers to review the current status of prawn farming and educate them on how to minimize environmental impacts from farming practices. Surprisingly, they found that farmers had already voluntarily changed their practices in response to the 2006 evaluation. The intensive monoculture system used by 96% of prawn farmers in 2005 had been reversed with polyculture now practiced by an estimated 80% of farmers. Best practices based on an integrated prawn-shrimp culture and lower stocking density of prawns have allowed farmers to retain and reuse their pond water rather than discharge it. This and other substantial cultural changes as well as voluntary adoption of better environmental performance methods illustrates the strength of the CRSP approach. In this example, CRSP focused in on the root cause of problem and provided farmers with the information and tools that they then successfully adopted and transferred among themselves. — 09BMA06UM

Sustainable Feed Technology (SFT)

- Building on their innovative development of a pelleted feed for snakehead, Vietnamese researchers took the next step by taking the experimental feed to the farm to test in the real-world aquaculture environment of small snakehead farms. A native high-value carnivorous fish, farmed snakehead is traditionally raised on a diet of small-sized fish from freshwater or marine sources. Researchers have found that growth of cultured snakehead on pelleted feed with a lowered fishmeal content of 30% to 50% is equivalent to that on an all-fish diet. Also, pelleted feed can be used to replace up to 50% of the snakehead's overall fish consumption. The successful farm trials verify the benefits of formulated feed both for its reduced impact on capture of fish resources and the cost savings it will bring farmers. —09SFT01UC

- In Kenya, training of three groups of small-scale commercial farmers in a cage-cum-pond system for tilapia has provided them with a cost-effective approach for managing feed costs and lowering the levels of pond waste that reaches public water systems. In this two-crop system—originally developed by CRSP researchers in Asoa—the caged fish are fed with commercial feeds while the pond fish feed on the natural foods generated by the fertilizing effects of the cage wastes. In the research stage, CRSP investigators established cage stocking density parameters that will guide farmers in their stocking decisions. While the lowest density (50 fish/m^3) led to better growth, low FCR, and higher survival rates, these factors would need to be balanced against potential lower yield. In preparation for on-farm trials, farmers were comprehensively trained in cage management and production practices. A smaller, select group of farmers was trained in cage construction. These trainees then transferred their newly acquired knowledge to their respective groups to construct six cages for the on-farm trial at their farm sites. A post-trial workshop afforded the farmers an opportunity to evaluate their experiences and challenges with the integrated cage culture technology. In addition to introducing an environmentally

friendly culture system to a new group of farmers, this CRSP work is leading the way for community-wide diffusion as other farmers adopt this technology on the basis of the success of the first adopters. – – 09SFT02PU

- CRSP trainings for small-holder farmers in rural northern and southern Guyana have successfully transferred sustainable feed and production technologies. These trainings have targeted individual farmers, small communities, women farmers, a feed mill, and tilapia hatchery. Three workshops were held in an isolated area in southern Guyana to help communities develop small-scale aquaculture, including their own feed production and marketing structure. A demonstration farm that integrates aquaculture with vegetable growing has been set up as a working model for the surrounding communities. The CRSP trainees will serve as trainers for their villages. The 16 women members of the Trafalgar Women's Cooperative have benefitted from women-focused trainings in aquaculture production basics, tilapia biology, and sustainable feed formulation and feeding regimes. Working together, CRSP investigators have guided these stakeholders towards successful adoption of technologies and practices that will ensure an improved livelihood from aquaculture. Now the potential for a US export market for tilapia and brackish water shrimp exists. — 09SFT03UA

- For small-scale, rural tilapia farmers in the Philippines, feed is the most costly component, representing 60-80% of total production costs. Reducing this cost requires either application of less feed or use of lower cost feeds. Building on the findings of earlier alternate day 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 for supplemental feeds: (1) a delayed supplemental feeding of 45–75 days, (2) 50% or 67% subsatiation feeding, or (3) alternate-day feeding at the 100% satiation level. Research has also shown that tilapia grown on a low crude protein-amino acid supplemented diet with 0% fishmeal brings a 10% cost savings on feed. A recent training on these feeding strategies, which was attended by over 60 tilapia farmers, feed manufacturers, representatives of local and regional Filipino government agencies, and university students, was featured on a local news channel: http://www.youtube.com/watch?v=5cM-T5N3Iwk&feature=related. Farmers are already adopting these new technologies and increasing their profits. Diffusion of the technology by example, through podcasts, and through the media will broaden the population of Filipino as well as international stakeholders who can benefit from these CRSP technologies. — 09SFT04NC/09SFT06NC

Milkfish culture in the Philippines. (Photo courtesy of Evelyn Grace de Jesus-Ayson)

Telling the AquaFish Story
Press Release by Jeff Hino, Oregon State University

With U.S. help, Kenya aims to boost economy via fish farming

Aquaculture is helping jump-start Kenya's struggling economy, thanks in part to an international program led by Oregon State University.

Kenya is in the midst of rebirth: The East African nation signed a new constitution in August, and has launched an economic stimulus program that includes a novel $16 million effort to increase fish farm production from 1,000 tons in 2008 to 15,000 tons in 2012.

The initiative comes as natural fish stocks in Lake Victoria are declining from overfishing and demand for fish is increasing. Government officials are counting on fishponds - which will be home to millions of tilapia, catfish and ornamental fish - to supply a more sustainable source of protein and income.

A key partner in the efforts is the Aquaculture & Fisheries Collaborative Research Support Program, known as AquaFish CRSP. It's funded by the U.S. Agency for International Development (USAID) and is headquartered at OSU. The program works with developing countries to improve the livelihoods of the rural poor while growing their aquatic product industry. Other projects include researching beneficial bacteria for tilapia ponds in Mexico and evaluating the effects of invasive species in China and Vietnam.

"It's less about fish than about poverty reduction," said OSU's Hillary Egna, the director of AquaFish CRSP. "We work with people who work with the poor, and we help them build capacity for small-scale economic development."

AquaFish CRSP has been helping improve Kenyan aquaculture since 1997. One beneficiary is George Ambuli, the CRSP-trained chairman of a fish-farming cooperative in a small village near Lake Victoria.

"I'm proud to say that fish farming has made me what I am today," he said. "I eat fish, I have a cell phone in my pocket, and I am paying the school fees for my 9-year-old daughter, all with my fish money."

The aquaculture component of the stimulus package was created in late 2009. The program aims to increase the country's fishponds from 7,500 to 48,000. "Fish production in Kenya was a very small industry prior to this cooperative research program," said Kwamena Quagrainie, a lead U.S.-based researcher for CRSP's projects in Africa. "CRSP started with research to understand the whole fish production industry, including pond construction, management and the varieties of fish species that can be produced."

The initiative is expected to benefit some of the country's poorest farmers, as well as two traditionally underprivileged groups: women and youth. Though fishponds continue to be owned almost exclusively by men, women are increasingly involved in all phases of fish farming, including feeding, fertilization and predator control. Kenya's vastly underemployed youth, meanwhile, are finding jobs and gaining skills in pond construction.

But the huge growth in fish farming has presented some cultural and economic challenges. The demand for fingerlings to stock the fast-growing number of fishponds has skyrocketed from 1 million to 28 million in less than a year, forcing the government to lean heavily on private industry. Officials plan to upgrade more than 30 of the nation's hatcheries to help meet demand.

Another obstacle is a sudden need for programs to train new fish farmers how to manage their ponds and market their fish. On top of that, farmers who have built their own ponds without stimulus funding are looking to the government for guidance and training. The government is working to meet these demands as it phases out its involvement over the next 18 months.

As Kenya's aquaculture program expands, fisheries officials plan to put additional marketing structures into place. Outreach efforts include encouraging farmers to improve their income by including value-added activities like gutting, scaling and drying fish for market. The government is building 80 small refrigeration centers around the country, which will help farmers sell fish beyond neighborhood markets. Although perception persists that farmed fish are not as good as captured fish, Fisheries Director Godfrey Monor is confident that in time, half of the fish consumed in Kenya will be farm-grown.

Indigenous Species Development (IND)

- Chame (*Dormitator latifrons*), a fish low on the trophic chain, is a popular aquatic food 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 developing techniques for controlled reproduction in captivity, which will open sources for domesticated broodstock. In ongoing experimental work, a breakthrough has been reached with the first successful spawning and rearing of chame. Research is currently focusing on identification of a successful feeding regime and salinity conditions for optimal larval growth. These research accomplishments represent significant steps towards the development of broodstock to supply chame aquaculture. — 09IND03UH

- As part of an integrated effort to better manage the Lower Mekong Basin fishery for both snakehead and small-sized 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 of aquaculture for small-sized fish from the inland fisheries for livestock and fish feed versus their use as a significant food source for the rural poor. Farmed snakehead has been under a ban in Cambodia since 2005 due to fish population declines in the Mekong River from over collection of snakehead seed and loss of species diversity with overfishing of small-sized fish used as snakehead feed. Taking a sustainable approach, CRSP researchers are building the framework for snakehead aquaculture with new technologies that will ease the resource conflicts and, in conjunction with management plans, ensure a viable fishery in the lower Mekong River Basin. A snakehead hatchery at the Freshwater Aquaculture Research & Development Center in Cambodia is operational and making progress in establishing the protocols for raising snakehead from seed. This represents a significant accomplishment for developing Cambodian snakehead broodstocks as well as development of programs to reduce diseases associated with import of Vietnamese broodstocks and to address illegal snakehead imports. In a companion study at Can Tho University in Vietnam, CRSP researchers working on snakehead diseases, which pose a serious problem in its aquaculture, have prepared and disseminated an "Atlas of Pathogenic Agents in Snakehead" to farmers in three Vietnamese provinces. — 09IND02UC

- Bringing native fish species into aquaculture is the focus of experimental work by CRSP researchers at the Universidad Juárez Autónoma de Tabasco (Mexico). Building on work undertaken in the *Implementation Plan 2007–2009* (07IND01UA/07IND02UA), the current goal is to develop broodstock lines and feeding protocols for the larval to adult fish life-cycle stages. While snook will spawn in captivity, survival of the larvae is still problematic. Efforts emphasize finding the right live feed for the larvae, which will ensure their survival. For the native cichlid species, tenguayaca and castarrica, the selection process for creating broodstock lines has moved to the F_2 generation. Although still in the experimental stage, this work is representative of the scientific success that CRSP has engendered at the institutional level in HC partner countries. In another aspect of the successful CRSP model, bringing native species into "local" aquaculture is an important step in self-sufficiency, implementing workable approaches to reduce pressures on the often-overfished wild-caught fisheries, and addressing cultural food preferences by bringing traditionally favored food fish into aquaculture. — 09IND05UA

- The potential introduction of several native species into Ghanaian aquaculture has been investigated—Claroteid catfish (*Chrysichthys nigrodigitatus*), African Bony-Tongue (*Heterotis niloticus*), and (*Parachanna obscura*) African snakehead. Work focused on the nutritional requirements of *Chrysichthys* and *Heterotis*. A market survey of snakehead established that aquaculture would be a useful step in ensuring a consistent supply of this popular fish while protecting its wild populations. An information brochure on the three species is being distributed as an educational resource. This work is also part of a larger analysis of aquaculture in Ghana to identify constraints on and opportunities for its development. Efforts to date are initial steps toward diversification of Ghanaian aquaculture, which will open new market and income opportunities along the value chain. — 09IND06PU

Telling the AquaFish Story
Press Release by Tiffany Woods, Oregon State University

Researchers aim to boost production of two native fish species in Mexico

Rafael Fernandez Guzman raises tilapia out in the lush, green Mexican countryside. It's a place where cows graze and the roads are lined with stands selling tortillas, papayas, potted plants, bananas and roasted chickens.

The straw hat-wearing, cell phone-carrying former cattle rancher farms the fish in rectangular, excavated earthen ponds roughly the size of basketball courts not far from the city of Villahermosa. His customers drive up and buy them fresh from the water, still breathing and flopping. He sold 120 metric tons of tilapia in 2009, the equivalent of 230,000 fish, he says.

Now he wants to branch into popular native species like Mayan cichlids and bay snooks (they're not actually related to snooks) because customers regularly ask for them, he says. The problem is, though, that he's not sure if these fish would be as lucrative as tilapia. He wouldn't stray from tilapia, he says, unless he could earn a profit margin of at least 25 percent.

Researchers at the Autonomous Juarez University of Tabasco in Villahermosa are trying to make sure that he can. Through systematic breeding, they're working to develop improved broodstocks of Mayan cichlids and bay snooks that would produce fast-growing, meaty fish that are consistent in size and quality and could compete economically with tilapia when raised in farmed conditions. The university aims to sell the juveniles, known as fingerlings, to fish farmers in southeastern Mexico.

Production of these species in captivity is also necessary because environmental degradation and overfishing have reduced their populations, says Kevin Fitzsimmons, a professor at the University of Arizona and a former president of the World Aquaculture Society.

He's one of the participants in the project, which is partially funded by the U.S. Agency for International Development through its AquaFish Collaborative Research Support Program headquartered at Oregon State University. Hillary Egna, the program's director, initiated the project.

For nearly a decade, the university in Villahermosa has been breeding and raising these native cichlids in captivity and selling them to the state of Tabasco and local governments for repopulation efforts, but this is its first attempt to improve the genetics of farmed stocks, says Wilfrido Contreras Sanchez, the lead Mexican researcher on the project.

The omnivorous Mayan cichlid, known locally as castarrica, is native to the fresh and brackish waters of Central America and southeastern Mexico. It has black vertical bands on its sides and is just the right size to fit on a dinner plate. The carnivorous bay snook, also known as tenguayaca or giant cichlid, has a line of large black spots on its sides, inhabits fresh waters in southeastern Mexico and Central America and grows slightly bigger than the Mayan cichlid.

Researchers chose these two species because they have been overexploited, they fetch higher prices than tilapia in local markets, consumers like them, and fish farmers want to raise native species because of their popularity, Contreras says.

The challenge, however, is to produce fish that grow fast enough to compete with the quick-growing tilapia, a popular, easy-to-raise, non-native farmed cichlid that is ready for market after six months in grow-out ponds. The reason for wanting to speed up their growth is simple: The longer fish take to reach market sizes, the more money producers have to spend on feeding them.

Contreras doubts that these native species could ever grow as fast as tilapia. But, he says, if the time were shortened even just partially, the economics might work out in the end because of their more lucrative price. At local fish markets, one kilogram (2.2 pounds) of tilapia sells for around 40 pesos (about $3.40) but bay snooks and Mayan cichlids command at least twice that.

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Libido Rivera Lopez knows about the economics. The wiry, soft-spoken fish farmer and other members of a cooperative in the community of Cucuyulapa took a stab at raising Mayan cichlids but threw in the towel because the fish took too long to reach a marketable size. They went back to their trusty tilapia.

But if the researchers' work is successful, Rivera might have a second chance. At one of the university's campuses near Villahermosa, the project is in full swing. Dozens of mesh cages holding Mayan cichlids and bay snooks float in two earthen ponds. The fish are the offspring of nearly 200 wild progenitors that underwent a rigorous physical exam, including blood cell counts, before being deemed healthy enough to be parent material. Once the blood work was done, the fish consummated their relationships in nuptial tanks and spawned hundreds of thousands of small fry.

Researchers have been gradually weeding out the slow-growing offspring. It's tedious, repetitive, slimy, sweaty, wet work. The kind you give to students – like Enrique Hernandez Gonzalez. The biology undergraduate is up to his waist in the pond water, dragging the cages to shore and scooping Mayan cichlids into a bucket. Standing in the sweltering humidity under a tree, graduate student Beatriz Adriana Hernandez Vera then weighs and measures their flopping, slippery bodies as Rosa Aurora Perez Perez, also a graduate student, records the data on a clipboard. Thousands of squirming fish have passed through their hands since the selection process started in 2009.

They'll keep an elite group of the largest and heaviest ones. They'll then breed those lucky few, cull their undersized offspring, breed the survivors, discard the lightweights and voilà, several crosses later, they'll have the final crème de la crème parent stock: 880 hearty Mayan cichlids and 960 robust bay snooks, with both groups equally split by gender. They'll be maintained as broodstock to supply a steady stream of fingerlings to fish farmers. One day, those offspring just might end up at Rafael Fernandez's fish farm.

Quality Seedstock Development (QSD)

- To improve the quality of tilapia seed production, CRSP research is focusing on the relationship between broodstock age and seed production in the GIFT strain of Nile tilapia, the major strain farmed in the Philippines. 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 grow out yield. To establish a measure of fecundity and grow out performance, CRSP researchers are testing for IGF-I gene expression. Results will enable them to establish protocols for broodstock selection and seed production. Ultimately, farmers will benefit with improved production efficiencies as this research is translated into an applied technology and set of production practices that lead to higher seed quality and growth performance guidelines. — 09QSD01NC

- CRSP has set up three integrated aquaculture–agriculture demonstration units for tilapia culture in southeastern Mexico (Tabasco). Two units are located in indigenous communities that had earlier partnered with the former Aquaculture CRSP as part of a community-based aquaculture project. The third educational unit was set up at the Universidad Juárez Autónomo de Tabasco. The training component is multifaceted, beginning with a training of trainers. These trainees then worked with farmers in the Chol community of Cartidad Guerrero (Lacadon Village Farmer's Cooperative) to set up the on-farm demonstration site. An additional demonstration was also set up in the Chontal community in Oxiacaque, Nacajuca County. Farmers were trained in water and nutrient delivery, drainage, sun angles, shade problems, and harvest plans. — 09QSD02UA

- Training farmers and potential farmers in the basic techniques of aquaculture, thereby providing them with essential knowledge and skills, often leads to a ripple effect in information diffusion and technology transfer. In Ghana, two CRSP trainings dealing with basic production practices to raise Nile tilapia and African catfish, from propagation through grow-out, offer such an example. Over 60 small- to medium-

scale farmers attended the trainings. Their enthusiasm and interest was strongly in evidence with their requests for a regular schedule of trainings to reach new farmers and to cover areas not included in the Ashanti and Eastern regional focus of the CRSP trainings. — 09QSD05PU

TOPIC AREAS: PEOPLE, LIVELIHOODS, & ECOSYSTEM INTERRELATIONSHIPS

Human Health Impacts of Aquaculture (HHI)

- In the Aserradores Estuary of Nicaragua, 66 families have participated in the CRSP community-based co-management program for the native black cockle (*Anadara* spp.) fishery. This program offers a more effective management system to the traditional seasonal ban from April to July. CRSP has worked closely with these families, involving them in monitoring activities and management of the boundary markers for the no-take areas. To date, CRSP's accomplishments at the community level can be measured by the success of the community partners and cockle collector cooperatives in managing healthy cockle populations under the no-take area model. Other evidence of success is in the steps the Nicaraguan government has taken to test the community co-management approach in two other estuarine communities dependent on cockles. —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 provides 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 have developed processing standards for food quality and safety. As CRSP researchers make progress in educating women processors in the importance of following standards, they are also turning their attention to meeting international standards that will open export markets. In addition to disseminating information in workshops, they are meeting with government policymakers and making use of mass media to raise public awareness. — 09FSV01UC

- Coastal shrimp farmers in the Philippines and Banda Aceh, Indonesia have adopted a new polyculture technique with shrimp and seaweed that they learned in CRSP trainings. CRSP researchers addressed the difficulties that farmers were having in properly drying seaweed with a special training to instruct them in drying techniques to keep the seaweed uncontaminated with sand and snail shells. In other CRSP trainings, local women were taught how to process the seaweed and prepare value-added food such as seaweed-flavored chips, seaweed pickles, and agar candies. As seaweed culture develops within these poor coastal communities and markets expand for the raw and processed seaweed, men and women have improved income opportunities. —09FSV02NC

Technology Adoption & Policy Development (TAP)

- Since Ghana's aquaculture industry is currently below its potential to contribute to the country's local food economy, first steps in building it require an assessment of the constraints on its growth. A predominantly land-based industry of small-holder farmers, farmed fish is estimated at only 1% of local fish production. Cage culture is considered a technology that can help boost production provided the barriers to expanded growth are addressed. Based on a comprehensive evaluation that identified lack of capital and technical knowledge as major constraints, CRSP researchers have recommended several immediate remedial steps to stimulate the needed growth: A guaranteed loan program for farmers, subsidized feed costs for smallholders similar to those available in agricultural production, and a more specialized aquaculture extension program patterned after the successful agricultural model. These

efforts are at the heart of the CRSP approach to capacity building — taking a fundamental approach to build the infrastructure that will bring farmers into aquaculture and ensure their success through access to technical knowhow and equitable loan financing. — 09TAP04PU

Marketing, Economic Risk Assessment & Trade (MER)

- With the evaluation of the tilapia supply chain in the Philippines completed, CRSP researchers developed the following recommendations for an improved and sustainable supply chain of farmed tilapia: (1) better quality broodstocks and improved technology transfer; (2) promotion of niche market opportunities for farmers and consumers; (3) incentives for small farms to participate in supply chains; (4) establishing an accreditation program to improve quality assurance in the feed, hatchery, and processing sectors; (5) providing capital to improve facilities and cost efficiencies in the entire supply chain. Implementation of these recommendations will open new opportunities for small-holder tilapia farmers to enter into the supermarket and fast food markets. — 09MER03NC

- As part of the multifaceted approach for developing recommendations for managing the lower Mekong River Basin fisheries for small-sized fish and establishing sustainable snakehead aquaculture, CRSP researchers conducted a value-chain analysis of wild-caught versus farmed snakehead in Vietnam and Cambodia. In Vietnam, data show that wholesalers reap about 90% of the total profits in the system whereas farmers take in only about 6% profit. While retailers make the greatest profit per kilogram of fish, they account for a small percentage of total profits due to the small number of fish that each retailer sells. Coupled with other aspects of CRSP work on snakehead feed technology and hatchery production, this information will guide policymakers in decision making to develop an interregional snakehead aquaculture industry that takes the roles and economic viability of major stakeholders into account. — 09MER04UC

Watershed & Integrated Coastal Zone Management (WIZ)

- A study of small-watershed impoundments in South Africa was undertaken to assess the feasibility of applying this model to a multipurpose aquaculture-agriculture-household pond system in rural Uganda. Water quality issues and water levels are the primary areas of concern. The clogging effects of phytoplankton buildup in irrigation pipes and eutrophication effects on household uses of water present challenges. On the positive side, the impoundment system would have the beneficial effects of improving local wetland systems and their associated biodiversity while providing rural sources of water for consumption and food production. This initial analysis suggests feasibility of adapting the model to Uganda's needs once guidelines are developed for pond site selection, design, construction, and operation. — 09WIZ01AU

- In Uganda, CRSP researchers have developed a set of site suitability maps for selecting the location of earthen aquaculture ponds to better capture and manage water. These maps incorporate the following site selection criteria: water requirement, water temperature, soil texture, slope gradient, potential for farm-gate sales, access to local and regional markets, and availability of farm inputs. Major wetland areas are designated as protected sites on the maps. In another component of this work, researchers and extensionists were trained at a CRSP workshop at Makerere University in techniques for advising local farmers in their site selections. This new technology offers a more sustainable approach for community water supply management and natural resource conservation for rural Uganda fish farmers. — 09WIZ02AU

Mitigating Negative Environmental Impacts (MNE)

- As a concluding step in evaluating the resource conflicts in the lower Mekong River Basin over the use of the small-sized/low-value fish as food for human consumption versus its use as food for livestock and farmed fish, CRSP researchers held high-level stakeholder consultations in Cambodia and Vietnam. These meetings were structured as forums for dialogue among the concerned parties in the government, NGOs, research and academic institutions, and private sector. The fundamental problem in management of this major fishery is that demand is outstripping supply. This situation is further complicated by the

needs of the poor pitted against two growing industrial sectors. In preparing recommendations based on a comprehensive analysis of these competing interests, CRSP researchers were seeking input on the diverse perspectives of these stakeholders. The challenge in managing the fishery will be in how food security is viewed and addressed. For the poor domestic consumer, their food security will depend on a stable fishery on which they can rely for a steady source of small-sized fish. For industry, food security can be viewed through expanded income-generating opportunities as the fishing and aquaculture industries grow. Input from these high-level meetings combined with the data collected from four years of multidisciplinary studies will be further analyzed to develop recommendations to sustainably conserve the biodiversity of this major Mekong River Basin fishery. — 09MNE04UC

- Addressing the competing interests of aquaculture expansion versus natural resource conservation, AquaFish CRSP organized and led a symposium at the September 2011 American Fisheries Society meeting in Seattle, Washington entitled *"The Effects of Semi-Intensive Aquaculture on Biodiversity In Nearshore and Inland Waters*." The 12 invited international experts spoke on a wide range of topics that drive the debate between the benefits and drawbacks of aquaculture relative to natural biodiversity. Symposium topics covered invasive species effects, effluents and eutrophication, antibiotic effects, environmental performance, use of aquaculture feeds, and social and economic impacts. The proceedings will be published in a peer-reviewed journal. — 09MNE06UM/Capacity Building Initiatives in Host Countries (ME)

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*, 54 investigations have been initiated with a distribution by Systems Approach of 27 for *Integrated Production Systems* and 27 for *People, Livelihoods, & Ecosystem Interrelationships*. Projects include 16 countries, 17 US Universities and 31 HC institutions in formal funded partnerships.

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

SYSTEMS APPROACH	TOPIC AREA	NUMBER OF INVESTIGATIONS
Integrated Production Systems		
	Indigenous Species Development (IND)	8
	Quality Seedstock Development (QSD)	5
	Sustainable Feed Technology (SFT)	7
	Production System Design & Best Management Alternatives (BMA)	7
People, Livelihoods, & Ecosystem Interrelationships		
	Human Health Impact of Aquaculture (HHI)	2
	Technology Adoption & Policy Development (TAP)	8
	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	54

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.

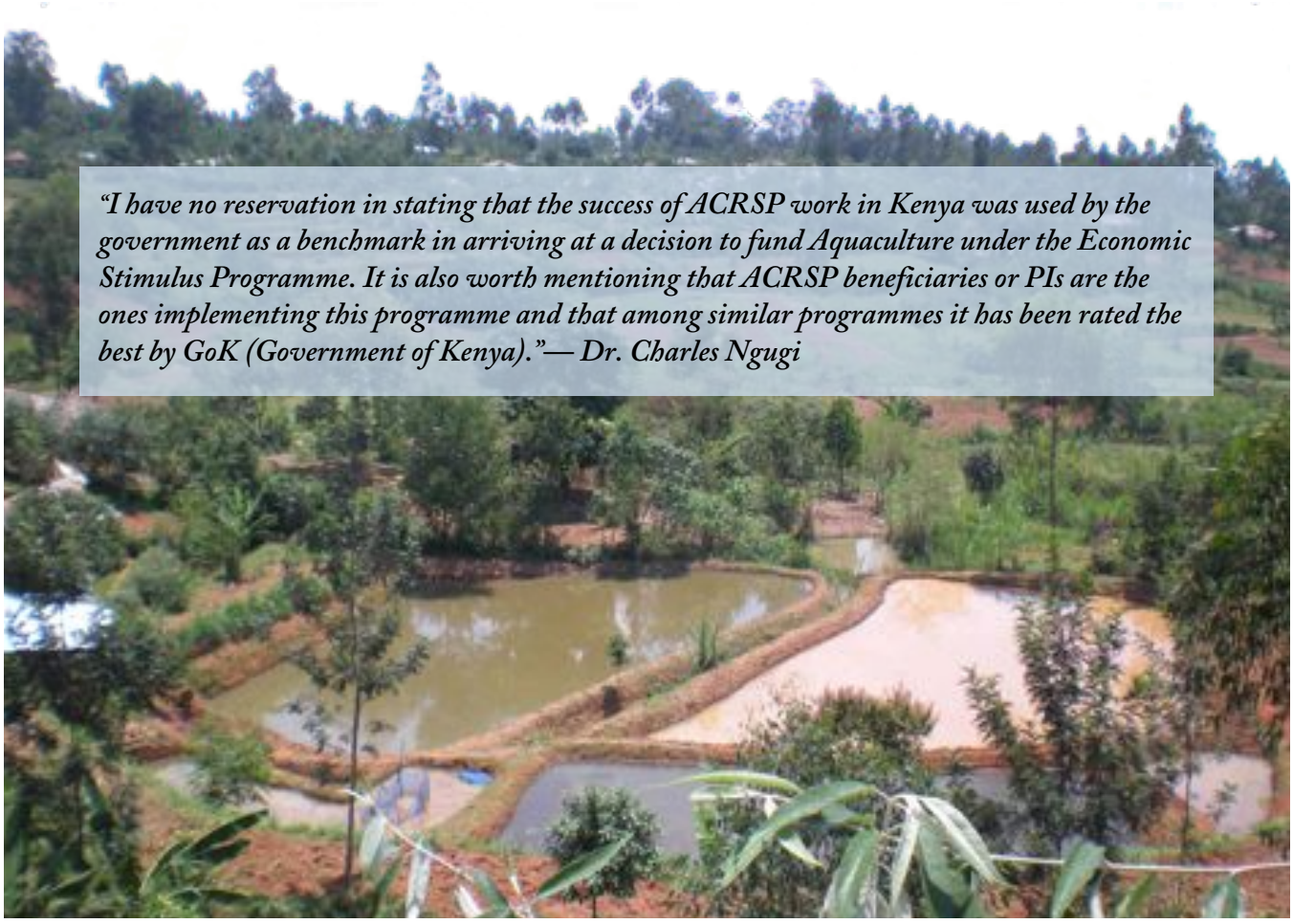
- Target Groups
  Aquaculture farms (small- to medium-scale, subsistence and commercial) and aquaculture intermediaries, policy makers, and others in host countries.

- 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 2010 to 29 September 2011. All 2009-20011 investigations are complete as of the 29 September 2011 deadline, with the exception of one or two investigations in each of the 7 core research projects. Final investigation reports are available from the ME and the AquaFish CRSP website. Due to their length and detail they are not printed in this annual report.

2009-2011 Annual Project Reports are printed as submitted by project personnel with the subsequent addition by the ME of project summaries, which were drawn from project proposals.



Cluster ponds in Kenya (Photo by Ford Evans)

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

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PROJECT PERSONNEL

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Karen **Veverica** - US Investigator

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INVESTIGATION PROGRESS REPORTS

Printed as submitted by Joesph 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

The study reveals that water level declines caused by water withdrawal for irrigation could negatively impact aquaculture in multipurpose impoundments. Aquaculture activities in such impoundments might increase plankton production and the planktonic particles could clog irrigation systems. Changes in water quality caused by aquaculture might also negatively impact use of water for domestic purposes. Nevertheless, these effects could be mitigated, and small impoundments seem to be an excellent way of increasing water supply in rural areas. Construction of small impoundments would convert land to aquatic habitat, but overall, the effort probably would increase local ecosystem complexity and be beneficial to biodiversity.

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

Fish farming in Uganda is predominantly practiced by poor people in villages for subsistence with 80 % of the ponds about 100 m². Many of the ponds are just dug in swampy/wetland areas or micro-watershed concentrated storm runoff areas without proper planning or guidelines that take into considerations the ecological and environmental impacts. This has led to drying up of ponds and massive encroachment on wetlands and riparian buffers. Also, on the national coverage, there was no detailed map of Uganda depicting areas that are suitable for inland fish farming while accounting for the need to control encroachment on wetlands and riparian buffers. The project goal was to develop strategies to better employ water capture in Uganda by modeling for surface catchment and site evaluation in the presence of potential surface water runoff. The specific objectives included: (1) use of geographic information systems (GIS) and remote sensing (RS) to develop an aquaculture site suitability map for Uganda; (2) develop guidelines on site selection of ponds to ensure reliable water supply and sustainable ecological existence within the micro-watershed; and (3) construction of pilot pond for demonstration and future instruction purposes. The approach for the physical research began with remote sensing and GIS assessment of site suitability for Uganda with emphasis on soils, topography, climate, access to farm inputs and access to markets. Working with host country personnel, sites were identified for the preliminary screening analysis based on GIS analysis and the spreadsheet tool. Potential sites were further analyzed using infiltration or seepage pits. The major suitability study findings related to the crisp and fuzzy suitability maps developed for Uganda. For both the crisp and the fuzzy approaches, over 98 % of the land was classified as either suitable or as moderately suitable. Overall, the crisp method classified 16,322 hectares (0.09 %) as very suitable compared to zero hectares (0 %) by the fuzzy method. Simultaneously, the crisp method gave 297,344 hectares (1.96 %) as unsuitable compared to 168,592 hectares (0.96 %) by the fuzzy method. Of the 138 surveyed fish ponds that were

operational, 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. Key concerns regarding pond construction were side slope stabilization and levee compaction. These were extensively emphasized during the host country workshop. For the compaction, farmers expressed interest in a simple manually operated tool that can easily be transported to any site. The second challenge expressed by visited farmers was excess water during the wet months and drying up of ponds during the dry months.

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
Aquaculture development commentary supports the formation of fish farmer associations or producer organizations as avenues for cultivating small- and medium-scale commercial farmers. However, little is known about the types of associations that facilitate commercialization. This research presents four qualitative case studies, based on semi-structured interviews, profiling existing associations of commercial fish farmers in Uganda. We conclude that the umbrella organizations under which local fish farmer associations vertically align themselves have important implications for fish farmer production. Aquaculture-specific umbrella organizations contribute to the success of local member associations more than general umbrella organizations do. Successful fish farmer associations accept government assistance only when it directly improves their fish farm operations. Other farmer groups seemed to wait for direct subsidization. Training fish farmers, providing quality information, cost sharing, and advocating for the aquaculture sector, not donor seeking, are the top priorities in productive fish farmer associations. Part I of this report summarizes the four case studies; Part II summarizes the results of the cage culture trials.

09MER01AU - Market Assessment and Profitability Analysis of Aquaculture Enterprises in Uganda
By focusing on aquaculture technology for smallholder farmers, this project conducted market assessments and profitability analysis of smallholder aquaculture enterprises in Uganda. Aquaculture farm-level production costs, management practices, and marketing arrangements were assessed by documenting the number, size, and location of existing aquaculture producers and processors and the current markets they serve. The risk-return tradeoffs associated with a given aquaculture enterprise were quantified in isolation and in conjunction with alternative enterprises using enterprise budgets and portfolio analysis frameworks. Fish marketing and credit issues in the country were identified using secondary data and literature reviews. Information on marketing and credit flows was gathered using a combination of face-to-face interviews/survey questionnaires and purposeful selection of respondents. This report presents a summary of the activities accomplished that relate to profitability analysis of aquaculture enterprises, fish marketing, credit for fish marketing and production, and economic modeling for fisheries marketing development.

09BMA02AU - Training and Outreach in Uganda and Surrounding Nations
Research, extension and education can contribute greatly to enhancing aquacultural production in a sustainable way and to reducing poverty, but achievements have generally fallen short of expectations in Africa (Sanginga et al. 2008). Farmers trust the experience and knowledge of others who are in situations similar to their own. Their desire to meet and talk with each other has spurred the formation of groups and networks to foster informal gatherings and more formal mechanisms of association to facilitate peer-to-peer learning. Such learning groups are most effective when they have a targeted membership like fish farmers. If member perspectives are too diverse, then participants tend to become disenchanted because the results do not apply to their situations (Barrett and Ewert 1998).

09TAP08AU - Training Trainers for Long Term and Sustained Impact of Pond Aquaculture in Africa
A training-of-trainers program was held on the Auburn University, Department of Fisheries and Allied Aquacultures research facilities in July 2011. Trainers from Uganda, Tanzania, Ghana, Kenya, and Nigeria participated in an intensive program of instruction and hand-on practical application of course principles. The participants also enrolled in the Certification for Aquaculture Professionals (CAP) program, a distance learning mechanism for advancing skills and understanding. Each participant completed two extension bulletins or “fact sheets” for use in their home country. The participants will have access to the Auburn

University library and a wealth of aquaculture-related research and extension information located in the Department of Fisheries and Allied Aquacultures. Additional trainings will be led by the graduates in their home countries, beginning with Ghana in September.

09IND07AU - Prospects and Potential of the African Lungfish (Protopterus Spp): An Alternative Source of Fishing and Fish Farming Livelihoods in Uganda and Kenya.
Culture of resilient species to drought and stressed water quality conditions may be a significant part of the future of African aquaculture. Air breathing fishes potentially have a role in low-management culture systems because dissolved oxygen is not a limiting factor. The African lungfish (*Protopterus* spp) is advantageous because it is an indigenous fish with good quality flesh, an air-breather and a biocontrol agent against schistosome vector snails. Little is known about indigenous practices of culture, harvest, and marketing of *Protopterus* spp from farm ponds and water bodies.

This study assessed the status and potential of lungfish aquaculture in Uganda in seven districts in Kampala, Wakiso, Kumi, Busia, Soroti, Pallisa and Jinja. Semi-structured interviews were conducted with key stakeholders; fish farmers, fisher folk communities, Fisheries officers, scientists, fish traders, and consumers. Socio-economic conditions (prices, demand, and public perceptions) that shape the culture of African lungfish were also assessed.

African lungfish wild stocks in Uganda are continuously being reduced while no clear or sustainable mitigation measures/policies are being addressed to replenish the plummeted stocks. Lungfish is highly valued in major tribes of eastern of Uganda but gradually accepted in the central region. Majority of lungfish is consumed fresh but smoked products are also preferred. Its food and 'medicinal' value is gradually substituting Tilapia and Nile perch markets, among the rural and densely populated communities. Cultural (traditional and religious) beliefs are main factors that continue to deter some consumers from eating lungfish. However, preliminary findings in this study reveal women not only derive their livelihoods from lungfish trade but also consume it.

Efforts to culture the African lungfish in captivity are described. Most fish farmers' accidently grow lungfish that escape into their ponds during flood periods. Likewise, the fisher folk/traders have applied indigenous knowledge to domesticate the lungfish caught from the wild in hand-dug holes and in concrete tanks. Otherwise, there are no statistics or records that show fish farmers involved in culturing African lungfish in Uganda. However, lack of proven technologies has deterred the culture of this high-value fish, and, yet there is interest. National scientific research is currently focusing on its fishery and not its aquaculture. Lungfish farming, therefore, will not only diversify farmed fish products in Uganda but will eventually reduce pressure on the declining stocks from the wild.

Future studies will explore factors that determine lungfish productivity and profitability in different culture systems (tanks, ponds and cages), while addressing its handling procedures. Furthermore, socio-economic conditions shaping the culture of African lungfish will be re-examined/reviewed. Production of lungfish fingerlings will be pursued after obtaining scientific knowledge generated from this study.

PRESENTATIONS & PUBLICATIONS

Presentations

Title	Author(s)	Type	Event	Location
Aquaculture Development In Uganda	John Walakira	Oral	World Aquaculture Society	New Orleans
Fish Health Management	Nelly Isyagi and John Walakira	Oral	Training Conference for Uganda Fish Farmers	Umoja, Kakiri, Uganda
Geospatial Modeling Of Site Suitability For Pond Based Tilapia and Clarias Farming In Uganda	H. Ssegane, E.W.Tollner, and K. Veverica	Oral	9AFAF	Shanghai
GIS and Aquaculture Planning	Herbert Ssegane	Oral	Departmental Seminar	Makerere University
Harvesting and Marketing	John Walakira	Oral	Training Conference for Uganda Fish Farmers	Umoja, Kakiri, Uganda
Market Assessment and Profitability Analysis of Aquaculture Enterprises In Uganda	T. Hyuha	Oral	International Academy of African Business Development	Edmonton, Alberta
Overcoming Institutional Barriers To Aquacutural Development In Subsaharan Africa: New Initiatives To Ensure Sustainable Food Systems	J. Molnar	Oral	9AFAF	Shanghai
Overview of Aquaculture in Uganda	John Walakira and Gertrude Atukunda	Oral	Departmental Seminar	Makerere University
Pond Construction	Nelly Isyagi	Oral	Departmental Seminar	Makerere University
Profitability Analysis of Aquaculture For Small Scale Farmers in Central Uganda	T. Hyuha	Oral	9AFAF	Shanghai
The Relationship of Aquaculture Production to Renewable Freshwater	Claude Boyd	Oral	9AFAF	Shanghai
Watersheds and Fish Pond Siting and Construction	William Tollner	Oral	Departmental Seminar	Makerere University
Women in Aquaculture Development in Uganda	Gertrude Atukunda	Oral	International Center for Aquaculture and Aquatic Environments	Auburn University

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.

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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

Our previous work established that elimination of fishmeal from a 31% crude protein tilapia diet formulated with locally available ingredients and in the Philippines produces fish of similar size as animals on a 6% fishmeal diet, but at an 8% cost savings. A pond study to test feed formulation strategies that eliminates dietary inclusion of fishmeal with alternate day feeding strategy improves the rate of return on pond-cultured tilapia by almost 60%. We then tested if lowering the protein content in feeds from 31% to 26% could provide additional cost savings using a 67% subsatiation feeding protocol. Sex-reversed fingerlings were stocked in 500 m^2 earthen ponds at a density of 4 pcs m^{-2}. Ponds are treated weekly with inorganic fertilizer (28 kg N and 5.6 kg P). Fish were fed daily at 2% ABW (approximately 67% subsatiation) with dietary treatments consisting of a factorial arrangement of 2 levels of crude protein (31% and 26% CP amino acids) and 2 dietary inclusion levels of fishmeal (0% and 6%) in place of alternative food by-products proteins

commonly found in the Philippines. The 26% CP content contained amino acids equivalent to that of the 31% CP diet. Diets were formulated and produced in collaboration with the Santeh feed company in the Philippines. The costs for diets in Filipino pesos are as follows: P30.75/kg for the 31% CP with fishmeal, P29.65/kg for 31% CP with 0% fishmeal, P29.00/kg for the 26% CP amino acids with fishmeal, and P27.20/kg for the 26% CP amino acids with 0% fishmeal. There was no difference in growth rate, yield or survival of tilapia grown on the different diets. However, survival was low among all groups (20%) likely due to bird predation and perhaps other factors observed throughout the area. Nevertheless, almost a 10% cost savings on feed can be achieved with fish grown on the low crude protein, amino acid supplemented diet with 0% fishmeal relative to animals grown on the typical 31% CP diets containing fishmeal. This along with 67% subsatiation feedings has the potential for dramatically enhancing profits for farmers.

Pellet quality for animal feeds is critical for maximum feed efficiency and nutrient utilization as it greatly improves handling characteristics, reduces feed wastage, and encourages feed intake resulting in better growth rate. Although most tilapia feeds are extruded because of superior pellet durability and water stability, feed costs can be significantly reduced if the feed can be manufactured into durable compressed pellets that can withstand commercial tilapia production conditions. Therefore, additional studies were undertaken to evaluate the efficacy of different types of pellet binder feed additives on the durability and water stability of pelleted tilapia feed. A 26% crude protein tilapia basal diet (containing ~34% corn, 25% soybean meal, 22% rice bran, 10% poultry by-product meal, 5% distillers dried grains with solubles, 0.5% poultry fat, and amino acids, vitamins and minerals making up the balance) was ground through a #4 hammer mill screen (400 micron geometrical mean particle size. In experiment 1, 50 kg of the basal diet was split into 4 kg batches. Three commercial pellet binders and one “No Binder” control were prepared in triplicate and arranged in three randomized blocks of consecutive processing runs through a small experimental pellet mill with 40 psi steam at ~80C with a 3.7 mm X 18 mm die. Feed additive pellet binders and inclusion levels tested were urea-formaldehyde (UF), 0.2%, bone gelatin (BG), 0.1%, and wheat gluten (WG), 2%. These same experimental treatments were tested in experiment 2 using a commercial-sized pellet mill equipped with a 4 mm X 45 mm die), with the addition of two additional treatments: 0.2% UF 2% WG and 0.2% UF 0.1% BG. In both experiments, pellet durability (PDI) was assessed using the Holmen Pellet Tester (HPT) for 60 or 90 seconds, and pellet water stability (PWS) was evaluated by the percentage of the dried pellet remaining after immersion in 24 C deionized water for 10 minutes. In experiment 1, PDI exceeded 97% for all experimental treatments, without effect of pellet binder. However, the UF, BG, and WG increased ($P < 0.001$) PWS by 37.3%, 5.7%, and 19.7%, respectively, over the no binder control (yielding 50.1% PWS). In experiment 2, the UF, BG, and UF BF binders significantly increased ($P < 0.05$) PDI by 1.6%, 2.0%, and 2.2%, respectively, over the no binder control (91.5% NYPT PDI. In contrast, UF, BG, and UF BG increased ($P < 0.001$) PWS by 10%, 7%, and 15%, respectively over the no binder control and WG binder treatments (averaging 68% PWS. In both experiments, the addition of 0.2% UF was found to be the most effective pellet binder, and the combination of 0.2% UF 0.1% BG resulted in the best water stability of pelleted tilapia feed. We have subsequently formulated diets in cooperation with Santeh Feed Company in the Philippines to test fishmeal-free, sinking pelleted versus floating extruded tilapia feed at 31 and 26% crude protein using 0.2% UF 0.1% BG as pellet binder. The diets are currently being tested on growout of tilapia fed on alternate days in ponds.

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

A study assessing the duration of appetite inhibition (DAI) as a predictor of social dominance and subordinance (or social stress) that could be used in broodstock selection was completed. Clear establishment of dominance hierarchy was observed in 24 of the 25 pairs. From the 24 dominants, 17 (70.83%) of them have shorter DAI during isolation compared to that of their conspecifics. This indicates that tilapia with shorter DAI during the isolation had a greater possibility to win the fight for social dominance and therefore, dominance can be predicted using the DAI of the fish during isolation. Reduced growth rate of both dominant and subordinate fish, a well-described physiological end result of social stress, were observed one day after the social interaction. The greater weight losses in subordinate fish compared to dominant fish during and after the establishment of social hierarchy were mainly attributed to behavioral differences such

as appetite rather than to differences in physical activities. These results were written up as a manuscript for the 9th International Symposium of Tilapia Aquaculture to be presented in Shanghai, China.

We subsequently evaluated the effect of broodfish social condition on seed production of Nile tilapia in hapas was conducted. Social groups of broodstock representing Low Stress Response (LSR) breeders and High Stress Response (HSR) breeders (based on feeding response) were bred in hapas installed in ponds. The LSRHSR♂♀ group was composed of one LSR male, three LSR females, one HSR male, and three HSR females and served as the control. The LSR♂♀ had both LSR male and female breeders, HSR♂♀ have HSR male and female breeders, while the LSR♂HSR♀ and HSR♂LSR♀ consisted of LSR males and HSR females; and HSR males and LSR females, respectively. Total egg production in the LSRHSR♂♀ group (5144.00) was comparable to that in the LSR♂♀ (4016.66) but significantly higher (P).

An additional study evaluated the effect of social condition of broodfish on grow-out performance of Nile tilapia fingerlings is on-going. Two social groups of broodstock representing Low Stress Response and High Stress Response individuals were bred in hapas installed in ponds. Eggs and fry were collected. Eggs were incubated in artificial units to swim up fry stage. First-feeding fry were sex reversed for 21 days. Sex-reversed fingerlings were stocked in ponds and growth and survival rates are being monitored.

A study assessing the effect of stocking density-related stress on biological markers such as insulin-like growth factor-1 (IGF-1), growth parameters, survival rates, and cholecystic profiles for 30 days during nursery phase of Nile tilapia was completed. The experiment had a total of 8,000 fish distributed in four treatments [T1 - 250 fish/m3 (control, low density mixed-sex), T2 - 250 fish/m3 (sex-reversed), T3 - 500 fish/m3 (sex-reversed), and T4 - 1,000 fish/m3 (sex-reversed)]. The IGF-1 mRNA gene expression was highest in T2 (31.59 ng/µl) and lowest in T3 (14.44 ng/µl). Differences in the levels of the biological markers indicated varying responses of the different treatments to the effect of stocking density-related stress. The highest average weight attained at harvest was demonstrated by the control group (T1, low density, mixed-sex, 8.13 g) while the lowest average weight was exhibited by the group with the highest density (T4, 4.65 g) ($P<0.01$). The specific growth rate (SGR) of 1.64% was noted in low density, sex-reversed group (T2) while SGR for Treatments 1, 3 and 4 were 0.35%, 0.26% and -0.12%, respectively. The highest survival rate of 87.60% was observed in T1 while the lowest survival rate of 61.10% was observed in T4. The highest ratio of gall bladder to liver weight, was recorded in T4 with 43.31% while T1 had the lowest value of 26.45%. The overall effect of density as a stressor showed that low density group responded well in terms of growth, SGR, survival and IGF-1 mRNA gene expressions compared the fish reared and confined at high densities.

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 (English)

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 were reviewed and uploaded 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 can 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.

Three additional podcasts on cost containment strategies for milkfish production have been produced at Central Luzon State University and SEAFDEC. This included a production in English, one in Tagolog the primary Filipino language, and the third in Ilonggo, the primary local dialect found in the Iloilo region of the Philippines where milkfish aquaculture predominates. Following some revisions these podcasts will soon be uploaded.

09MER03NC - Improving Supply Chain Opportunities for Tilapia in the Philippines
This study was designed to evaluate and develop an efficient tilapia supply chain to foster the development of viable fast food and supermarket purchases of tilapia from small-scale producers; with the following specific objectives: Phase 1 – Evaluation: (1) Develop tilapia supply chain maps for each market level, i.e., producer, wholesale, restaurant, supermarket, fast food stores, etc., to identify specific activities and services, key players, logistical issues, external influences, and flow of product, information and payment among market levels. (2) Analyze tilapia supply chain performance for efficiency, flexibility and overall responsiveness. (3) Identify areas for improvement in supply chain (i.e. behavioral, institutional and process). (4) Provide recommendations to improve the tilapia industry, in general and specific supply chain items. Phase 2 - Development Undertaking: (1) Design specific improvement measures based on the identified areas of improvement from Phase 1: (2) Test the improvement measures in the market place, then assess and refine the improvement measures: (3) Design and implement measures to ensure the sustainability of the improved supply chain of tilapia.

The country's tilapia industry supply chain is composed of the following parts: the hatchery and nursery farms which are responsible for the introduction of improved brood stocks to commercial or backyard fish farms which in turn responsible in providing improved quality tilapia fishes for the end-users such as consumers and institutional buyers. The institutional buyers could be further decomposed into processors, consolidators or traders, supermarkets, specialty shops, food chains, restaurants, bars and canteens, among others.

The provinces of Pampanga, Batangas and Laguna are the major tilapia sources while the cities of Metro Manila, Angeles and Baguio are the major demand centers. Dagupan City, Pangasinan being known as "bangus" or milkfish capital is a major transshipment point of tilapia and other seafood for the Northern Luzon provinces including Cagayan Valley and the Cordillera Administrative Regions. In addition to the major supply center, Camarines Sur in Bicol Region, is becoming a key source of tilapia fries. The product flow of tilapia fries from the hatchery to the nursery farms generally follows a continuous 18-day cycle while tilapia fingerlings from nursery to commercial or backyard farms follows thirty to forty five-day cycle

depending on fish sizes required by the customers. Direct buying and selling, wholesaling, and retailing at central markets through agents and "consignacion" are the most common marketing operations of the tilapia industry. Consumers generally prefer whole live fish with size ranging from 250 – 300 grams per fish (or 4-5 pieces per kilogram) but the requirements of institutional buyers are more varied depending on their customers' preferences. Filleted tilapia requires about 2-3 pieces per kg or equivalent to 450 – 750 grams per fish. Grilled and barbequed tilapia are now becoming more popular recipes in the major demand centers.

The major concerns of hatcheries and nurseries are the high cost of outbound logistics, which is exacerbated by high competitive pressures of inferior quality but inexpensive stocks (e.g., non-sex reversed) and high levels of mortality due to environmental and cultural factors.

The fish farms' major concerns include; expensive but low quality feeds (at times mislabeled) and other inputs, very low fish recovery and longer culture period to reach larger fishes. Their transaction costs include the cost of waiting for buyers, delays in delivery, in-transit mortality, toll fees or "goodwill" as well as shrinkage losses. In addition, the lack of cold storage and transport vehicles equipped with tanks and aerators or refrigeration facilities delimits them from taking market opportunities. Interestingly, many farmers adopt a "circuitous" production technique to take advantage of markets preference of tilapia with darker skin.

The major concerns of processors are too few farms that could provide regular supply of the desired quality and volume of tilapia, the lack of capital for market expansion, and competition with cheaper imported counterparts.

The concerns of traders including "consignacion", suppliers or consolidators are: (a) meeting the product quality and quantity orders on schedule, (b) high logistics and transaction costs of consolidating and distributing fishes from sources to destinations and (c) absence of product grades and standards.

The following are some recommendations to address the various issues and concerns of the various chain players: (1) encourage the establishment of more nursery farms for better quality brood stocks while intensifying technology transfer to farmers for better health and management of tilapia (2) conduct market promotion activities highlighting the various niche opportunities of tilapia among growers and consumers (3) motivate the participation of small farmers in supply chains by setting up an incentive scheme through a mix of patronage refund and profit sharing (4) institutionalize an accreditation program for feed manufacturers, hatcheries, processors and the like to improve the quality assurance of products and services (5) provide capital windows to improve facilities and reduce logistics and transaction costs in the entire supply chains of tilapia.

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

Although aquaculture is an important and increasingly intensive industry in the Philippines the concept of Integrated Multi-Trophic Aquaculture (IMTA) has not been systematically or widely practiced in aquaculture production. Although polyculture or integrated aquaculture has been practiced to some extent, the complementary trophic roles of various aquatic organisms in recycling nutrients and energy during the production cycle to contain the solid and liquid waste that pollute the aquatic environment has not been fully explored or utilized. Extensive aquaculture system where stocking density is low and the cultured species are totally dependent on the natural productivity of the culture environment for growth and sustenance is undoubtedly a sustainable practice but volume of harvest is low. On the other hand, intensive/semi-intensive aquaculture of a single species (monoculture) where stocking density is very high and relies heavily on high feed inputs, like in intensive shrimp culture, is not sustainable because of the release of enormous amounts of nutrient-rich wastes that pollute the coastal environment. Applying IMTA in intensive aquaculture systems will lessen its negative impact to the environment and with proper adjustments in the stocking density and feed inputs, will make the practice sustainable. The potential is high for the application of IMTA in tropical

aquaculture production systems to address two important global targets: increase aquaculture productivity for food security and protection of the aquatic culture environment.

The concept of IMTA is being applied and tested in the current work on milkfish. For the trials in brackishwater ponds, six pond compartments with an area of 700 m^2 were stocked with milkfish fingerlings at a stocking density of 0.5 fish/m^2. Three ponds were stocked with sea cucumber at a density of 0.2 individuals/m^2. The seaweed *Gracilaria bailinae* is used as biofilter. Preliminary experiments were conducted and showed that high mortalities occur when sea cucumbers are stocked directly into the pond, with total mortality recorded within 1 week. Culture of sea cucumber in cages set in ponds where milkfish are stocked was tested as an alternative. Survival of sea cucumber was very good (78-86%). The presence of sea cucumber or the sea cucumber cages likewise did not have any effect on the growth of milkfish in both weight and length. The seaweeds *Gracilaria bailinae* grown in canals between ponds initially showed good growth but later died off after alternating days of intense heat followed by days of heavy rains which lowered the salinity in the pond below 25 ppt.

For the trial in marine cages, the seaweed *Kappaphycus alvarezii* is used as biofilter. Milkfish fingerlings were randomly stocked in 6 units 5x5x3m cages at a density of 35 fish/m^3. Sea cucumbers were stocked under three of the cages. However, 100% mortality was observed during the 1st sampling (2 weeks). Dr. MJHL Lebata-Ramos of SEAFDEC AQD did trials on sulfide tolerance of sea cucumbers and her results show that sea cucumbers cannot withstand the high sulfide environment under cages especially if the site has been used for mariculture operations for some time or as sulfide builds up with increasing biomass of stocks and hence increasing intensity of feeding. Other alternative species were also tested including the windowpane oyster (*Placuna placenta*) and the mangrove clam (*Anodontia philippiana*) and results show that the mangrove clam may be the most suitable for marine cages because they have the ability to reduce sulfide. On the other hand, sea cucumbers seem to thrive in shallower marine pens thus co-culture of milkfish in pens will also be tried. *Kappaphycus alvarezii* grown in cages (by MRJ Luhan) adjacent to the milkfish cages initially showed good growth but later showed signs of ice-ice disease and exhibited stunting after alternating days of intense heat followed by days of heavy rains.

Results of the alternate day feeding strategy to reduce production costs of milkfish have been disseminated in various local, national and regional fora through lectures in seminar workshops, training programs and conferences. Two workshops entitled “Small-scale Aquaculture and Livelihood Venture: Culture of Milkfish and Seaweed Culture” and “Small-scale Aquaculture and Livelihood Ventures: Cage Culture of Milkfish and Other Marine Fishes” was conducted in the Philippines in January and February 2011 for fish farmers in Pandan, Antique and Roxas City, Capiz in the Philippines. The incorporation of *Kappaphychus* seaweed as a potential polyculture species and supplemental source of income in milkfish culture was introduced. Alternate feeding methods to enhance production efficiency of milkfish and of culturing other high value marine finfish was also described. In 3-4 May 2011, EG de Jesus-Ayson gave a lecture on marine fish culture in the light of environmental degradation and climate change incorporating results of the current milkfish project as well as results of work done in tilapia under the CRSP program during the Seminar Workshop on Fisheries and Aquaculture and Climate Change organized by the Bureau of Fisheries and Aquatic Resources Regional Office 2 in Tuguegarao, Cagayan as part of the activities lined up in celebration of Farmers’ and Fisherfolks’ month. F.G. Ayson likewise gave a lecture on breeding and seed production for aquaculture in relation to climate change in the same forum. Participants included 150 farmers, fisherfolks and local government officials. Similar lectures were also incorporated in the training course for trainers on marine fish hatchery and culture organized by SEAFDEC AQD for technical staff of all 7 Regional Fisheries Training Centers of the Bureau of Fisheries and Aquatic Resources held from 09 May to 24 June 2011. There were 21 participants in the course. Aside from the RFTC technical staff, there were also private participants from Iran (1) and the Philippines (1). Same lectures were included as well in the curriculum for the regular training course on marine fish hatchery and culture offered by SEAFDEC AQD annually with this year’s course running from 20 June to 27 July 2011, with 11 participants from ASEAN member countries.

The alternate day feeding strategy for milkfish and tilapia were likewise included in the thematic paper on Maintaining the Integrity of the Environment Through Responsible Aquaculture and Adaptation to Climate Change presented by EG de Jesus-Ayson during the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2020 - Fish for the People 2020: Adaptation to a Changing Environment (Session on Sustainable Aquaculture Development) held in Bangkok, Thailand from 13-17 June 2011 with over 500 participants from 29 countries.

During the months of April and May, 2011, on-the job trainees (OJTs) from various State Colleges and Universities (especially from Mindanao) assigned at the SEAFDEC AQD Marine Fish Hatchery and the Igang Marine Station assisted during samplings and were given informal lectures related to the project. They are as follows: Majella Alarcon, Cherry Lyn Elechicon, TJ Manalo, Girly Olangoy, Rethzel Seberias and Girlie Villanueva (Iloilo State College of Fisheries), Alvin Doroteo (University of Antique-Tibiao Campus) Renato Diaz, Jr. and Brillo Portevilla (Capiz State University), Mechell Advincula, Sitti Amina Hashim and Recil Palosero (Zamboanga State College of Marine Science and Technology), Carlos Angeles, Anwar Lingga and Yusof Saidali (Mindanao State University-Marawi Campus), and Junaldin Ibnosali (Mindanao State University-Tawi-tawi Campus).

From 27 June to 01 July 2011, A team from SEAFDEC AQD and Taytay sa Kauswagan, Inc. (meaning Bridge to Development, TSKI is a microfinance and developmental institution) including EG de Jesus-Ayson assessed the Panabo Mariculture Park in Davao del Norte as part of the project in a cluster of Mariculture Parks in the Davao Gulf Region (Region XI) managed by the Regional Fisheries Training Center XI. The project examines the technological, environmental, socio-economic and financial components of the operations of the mariculture parks. Consultation with the investors, farmers, technicians, local government officials and BFAR and RFTC personnel revealed 3 major constraints to production – reliable source and consistent supply of good quality fingerlings, prohibitive cost of feeds, and marketing. To help address the issue on feed costs, RFTC XI Director Andrew Ventura announced that RFTC will set up demo production cages using alternate day feeding strategies. Another development is the use of fermented milkfish by-products from processing/value adding activities as replacement for fishmeal being tried by one enterprising farmer/investor, which is reportedly 30% cheaper than commercial feeds and results in comparable, if not better growth and survival. E.G. Ayson informed the group of the study being conducted by R. Bolivar in CLSU in collaboration with R. Borski and his team in NCSU using fermented chicken as protein source.

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

A series of workshops were held in July 2011 to further demonstrate seaweed culture and more imporantly demonstrate drying and handling procedures. Each of the local shrimp farmers has a less than one-hectare ponds (tambak) that they operate as the main source of income for the family. Most of the farmers have adopted the polyculture of *Gracilaria* seaweed in the ponds as we had recommended last summer. Many of the ponds have luxuriant growth of seaweed and improved survival and growth of the shrimp. However, their initial attempts to sell the seaweed to professional buyers had failed. The farmers had pulled the seaweed from the ponds and were drying it on the pond banks. The seaweed was contaminated with sand and snail shells and the bottoms of the piles was decomposing rather than drying properly.

A major portion of the July 25 presentations prepared by Maria Luhan and Evelyn G. de Jesus- Ayson included the reasons that the seaweed for processing had to be dried properly and kept uncontaminated. They also described how to build sturdy tables of local materials for drying large quantities of seaweed and how the product would be further processed to make pharmaceutical grade agar.

On July 26 we held a second workshop. In this workshop, Maria and Evelyn focused on home uses of *Gracilaria* and other seaweeds. They provided several recipes and then we broke the workshop into three groups and had the groups each prepare a different product. The first group took finely chopped fresh *Gracilaria*, mixed it with wheat based flour and seasonings with a little water. A small ball of dough was

then flattened through a tortilla type press. The resulting chip was then deep fried in oil to make a seaweed flavored chip. The second group lightly cooked the seaweed (blanched) and then prepared a casserole style meal with onions, carrots, potatoes, tomatoes, and some local vegetables we did not recognize. The third group boiled their seaweed and then strained it through tightly twisted cheesecloth and collected the raw agar. The agar is then frozen and thawed and allowed to separate. This partly processed agar is commonly used for cooking as a thickener or as the main ingredient in several kinds of candy.

On July 28 a third workshop was held in Medan, with the team from Ujung Batee, several of the farmers and a seaweed buyer, Mr. Zarkasyi Bin Ismail, Dr. Hatch and Maria and Evelyn. The workshop centered on values of products and on additional contributions from the seaweed buyer. The conclusions were that the buyer would loan money to the farmers to build four additional tables, beyond the two tables AquaFish CRSP had sponsored. The farmers would repay the loan in quarters taken from their first four shipments of dried seaweed. The intent is to supply 600 MT per month from the Sigli farmers at a price of 3,500 rupiahs per kg.

Overall the mission was very productive. The farmers are on the verge of having a significant new revenue stream that comes entirely from a by-product of improving pond water quality. Evelyn and Maria had a great rapport with the women of Sigli. The women of the community have a new highly nutritious aquatic vegetable to prepare in several recipes. And they understand how to process the seaweed to generate agar for use as a thickening agent in cooking or as a base for making candies and desserts.

Workshops on “Small-scale Aquaculture and Livelihood Ventures: Seaweed Culture” was conducted in February 2011 in Roxas City in the province of Capiz on Panay Island in the Philippines. Training in seaweed culture, seaweed processing for production of agar, and methods for pickling seaweed as a value-added nutritional product and income source was provided.

09SFT06NC - Impact Assessment of CRSP Activities in the Philippines and Indonesia

AquaFish CRSP in the Philippines and Indonesia has developed and implemented strategies that will improve the cost effectiveness, sustainability and income opportunities of tilapia and milkfish culture as well as shrimp/finfish-seaweed polyculture in the Philippines and Indonesia. In the Philippines, research at the Freshwater Aquaculture Center at Central Luzon University has demonstrated that reduced feeding strategies - delayed onset, alternate day, and/or sub-satiation – can decrease feeding by as much as 50% without impacting yield. In Indonesia, polyculture of seaweed with shrimp, tilapia and milkfish has been introduced with new training programs at the Ujung Batee Science Center in Banda Aceh. The objective of the CRSP Impact Assessment is to promote additional training and to assess the impact of technologies and management practices aimed at improving incomes for small-scale aquaculture farmers in the Philippines and Indonesia. The focus of the assessment is improvement of tilapia production and marketing in the Philippines and initial introduction of seaweed culture into existing shrimp, tilapia and milkfish aquaculture systems in Indonesia

In July-August 2011, Dr. Upton Hatch of North Carolina State University (NCSU) traveled to Central Luzon State University (CLSU) in Munoz, Philippines to work with Dr Remedios Bolivar and to Ujung Batee Science Center (UBSC) in Banda Aceh, Indonesia to collaborate with Dr. Coco Kokarkin.

The assessment is nearing completion with data collection in progress. At CLSU, a survey team was assembled including Hatch, Bolivar and several students and technicians. Hatch developed an initial draft instrument using similar surveys and their instruments along with survey team field experience. The instrument was revised to decrease interview time, to improve respondent understanding of questions, and to facilitate completion of survey form by interviewers. Revision process was initiated with goal of having survey instrument field pre-tested prior to Hatch departure, enabling survey team to collect data in his absence. A field pre-test was conducted at 2 farms in CLSU vicinity and 4 pond sites in Papangas – major

Philippine tilapia production area. Final revisions were made using pre-test results and survey was started in August and completion of data collection is anticipated in October.

A workshop was also conducted at the Carabao Center/CLSU in the Science City of Munoz in Central Luzon to disseminate and provide additional training on reduced feeding strategies and feed technologies that are effective in reducing tilapia production costs and improving incomes for farmers. Drs. Bolivar of CLSU and Borski and Ferket of NCSU led the workshop. It was well attended with over sixty individuals including farmers, feed manufacturers, representatives of local and regional government agencies, students, the CLSU president, project personnel, and the press. The workshop was featured by a local news channel and videos are provided through YouTube (http://www.youtube.com/watch?v=5cM-T5N3Iwk&feature=related).

At UBSC, the challenges are quite different because of the introduction of a new polyculture production system that had not been used previously. That is, the Philippine effort involves a production system that is well established and an important source of income and protein. In contrast, there was no seaweed polyculture in Banda Aceh prior to CRSP project. Although still in its infancy, substantial progress has occurred in implementing seaweed into shrimp and fish culture systems. It is estimated that around 200 farmers have incorporated seaweed in their culture systems. However, little if any has been sold. Marketing is a clear constraint.

Hatch, Kevin Fitzsimmons, Maria Luhan, Evelyn deJesus-Ayson, Coco Kokarian and Hasanuddin met with seaweed farmer representatives to discuss their interest and ability to meet production requirements of seaweed buyers and processors. The research team also met with seaweed buyer/processor to discuss his interest in working with small farmers in Aceh and get details on production requirements. The success of these meetings led to a larger meeting with seaweed farmers and the buyer to discuss their interest and ability to finalize an agreement. Buyer asserted his experience working with small farmers and expressed his commitment to work with them. He agreed to provide a loan to build drying racks – materials and labor, to supplement the initial ones built by the CRSP project. Small farmers agreed to have 15 MT of clean, dry seaweed available for buyer's truck on a consistent basis, at least one per month. Small farmers selected a collector to be interface with buyer. Two workshops were conducted on drying and processing seaweed that is essential for farmers' success in marketing their seaweed.

PRESENTATIONS & PUBLICATIONS

Presentations

Title	Author(s)	Type	Event	Location
Brackishwater Polyculture of Tilapia With Milkfish In Aceh, Indonesia	Hasanuddin and Rimmer	Oral	ISTA9	Shanghai, China
Characterization of Leptin and Its Putative Receptor (lepr) in Euryhaline Tilapia: A Novel Link Between Energy Status and Osmoregulatory Function?	David A. Baltzegar, Emily S. Brune, William M. Johnstone III, and Russell J. Borski	Oral	North American Society of Comparative Endocrinology	Ann Arbor, Michigan
Completed and On-going Research and Development Projects	Remedios Bolivar	Oral	23rd Annual Agency In-house Review	Research, Extension and Training, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines
Culture Of Marine Fish	Eveln Grace De Jesus-Ayson	Oral	Seminar Workshop on Fisheries and Aquaculture	Tuguegarao, Philippines

			and Climate Change	
Duration Of Appetite Inhibition Predicts Social Dominance In The Nile Tilapia, *Oreochromis Niloticus* L.	Vera Cruz, E.M. Valdez, M.B., Bolívar, R.B., and Borski, R.J.	Oral	ISTA 9	Shanghai, China
Fishmeal-free Diets Improve The Cost Effectiveness Of Culturing Nile Tilapia (*Oreochromis niloticus*, L.) In Ponds Under An Alternate Day Feeding Strategy	Borski, R.J., Bolivar, R.B., Jimenez, E.B.T., Sayco, R.M.V., Arueza, R.L.B., Stark, C.R., and Ferket, P.R.	Oral	ISTA 9	Shanghai, China
Identification Of A Putative Plasma Membrane Glucocorticoid Receptor In The Mozambique Tilapia (*Oreochromis mossambicus*)	William M. Johnstone III, Rebecca A. Alyea, Kathryn A. Mills, Peter Thomas, and Russell J. Borski	Poster	North American Society of Comparative Endocrinology	Ann Arbor, Michigan
Improving The Supply Chain Of Tilapia Industry In The Philippines.	Jamandre, W.E., Hatch, U., Bolivar, R.B., and Borski, R.J.	Oral	ISTA 9	Shanghai, China
Leptin Stimulates Hepatic Growth Hormone Receptor Expression: Possible Role In Enhancing Gh-mediated Anabolic Processes In Fish	Russell J. Borski, Eugene T. Won, and David A. Baltzegar	Oral	North American Society of Comparative Endocrinology	Ann Arbor, Michigan
Maintaining the Integrity of The Environment Through Responsible Aquaculture and Adapting to Climate Change	EG De Jesus-Ayson and WG Gallaro	Oral	ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2020 (Fish for the People 2020: Adaptation to a Changing Environment)	Bangkok, Thailand
Marine Fish Culture	EG De Jesus-Ayson	Oral	Training for Trainors on Marine Fish Hatchery and Culture (for BFAR RFTC)	Iloilo, Philippines
Marine Fish Culture	EG De Jesus-Ayson	Oral	Training Course for Marine Fish Hatchery and Culture (regular training course for participants from ASEAN member countries)	Iloilo, Philippines
North Carolina Aquaculture – Research Update	Borski, R.J., Daniels, H., Hinshaw, J., Losordo, T., and Sullivan, C.V.	Oral	2011 NC Aquaculture Development Conference	Atlantic Beach, NC

Overview of Aquafish CRSP Project and Tilapia Grow-out, Pond Fertilization and Feeding Strategies	Remedios Bolivar	Oral		Freshwater Aquaculture Center, CLSU, Science City of Muñoz, Nueva Ecija, Philippines
Preliminary Study on Microbial Activity Associated with Tilapia Culture Against Vibrio Harveyi	Sidrotun Naim	Poster	ISTA 9	Shanghai China
SEAFDEC AQD R&D Initiatives On Sea Cucumber	Evelyn Grace T. De Jesus-Ayson	Oral	Japan International Research Center for Agricultural Sciences (JIRCAS) Project Meeting	Tsukuba, Japan
SEAFDEC AQD R&D Opportunities For Aquaculture Ventures And Livelihood Options	Evelyn Grace T. De Jesus-Ayson	Oral	Joint SEAFDEC AQD-BFAR Regional Fisheries Training Centers Worshop for Technology Dissemination	Tigbauan, Iloilo, Philippines
SEAFDEC AQD R&D : Status And Plans For 2011	Evelyn Grace T. De Jesus-Ayson	Oral	Meeting of SEAFDEC AQD Technical Advisory Committee	Quezon City, Philippines
SEAFDEC AQD R&D : Status And Plans For 2011	Evelyn Grace T. De Jesus-Ayson	Oral	Meeting of the SEAFDEC Program Committee	Bangkok, Thailand
Supplemental Feeding Of Nile Tilapia (*Oreochromis niloticus* L.) In Fertilized Ponds Using Combined Feed Reduction Strategies	Sayco, R.M.V., Bolivar, R.B., Jimenez, E.B.T., and Borski, R.J.	Oral	ISTA 9	Shanghai, China
Tilapia Grow-out, Pond Fertilization And Feeding Strategies	Remedios Bolivar	Oral	Lecture	Freshwater Aquaculture Center, CLSU, Science City of Muñoz, Nueva Ecija, Philippines

Publications

Bolivar, R.B., Jimenez, E.B.T., Sayco, R.M.V., and Borski, R.J. 2011. Supplemental Feeding of Nile Tilapia (*Oreochromis Niloticus* L.) in Fertilized Ponds using Combined Feed Reduction Strategies. p 268-274. In Liping L. and and Fitzsimmons K. (eds.). Proceedings of the Ninth International Symposium on Tilapia in Aquaculture. April 21-24. Shanghai, China. 407 p

Borski, R.J., Bolivar, R.B., Jimenez, E.B.T., Sayco, R.M.V., Arueza, R.L.B., Stark, C.R., and Ferket, P.R. 2011. Fishmeal-free diets improve the cost effectiveness of culturing Nile tilapia (*Oreochromis niloticus*, L.) in ponds under an alternate day feeding strategy. p 95-101. In Liping L. and and Fitzsimmons K. (eds.). Proceedings of the Ninth International Symposium on Tilapia in Aquaculture. April 21-24. Shanghai, China. 407 p

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Vera Cruz, E.M. Valdez, M.B., Bolívar, R.B., and Borski, R.J. 2011. Duration of appetite inhibition predicts social dominance in the Nile tilapia, Oreochromis niloticus L. p. 86-94. In Liping L. and and Fitzsimmons K. (eds.). Proceedings of the Ninth International Symposium on Tilapia in Aquaculture. April 21-24. Shanghai, China. 407 p

Developing feeding strategies at CLSU in the Philippines (Photo by Peg Herring)

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 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.

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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

This investigation consisted of two parts: 1) A consumer preference study and 2) value chain analysis. Analyses of the preferences of consumers in urban Ghana and Kenya for farmed tilapia and catfish suggest that consumers have issues with farmed tilapia and catfish relating to availability and healthiness. However, Ghanaian consumers generally prefer smoked tilapia and catfish while Kenyan consumers prefer fresh and fried forms of tilapia and catfish. Taste, color, smell and nutritional value are very important to consumers and positively affected the preferences of consumers for farmed fish in both countries. Consumers in both countries also prefer large size tilapia and consumers' willingness to pay for farmed tilapia in both countries is influenced by age, education, household size, household monthly income, and urban residence.

The value chain analysis related to the African Catfish and Nile Tilapia value chain in Kenya. The actors identified included; 1) input suppliers- for sole input suppliers such as aquaculture and greenhouse construction equipment suppliers and harvest equipment suppliers, 2) fish farmer/Input supplier- for female fish farmers who also provide fingerlings and fry and thereby act as hatcheries, 3) female fish farmers, and 4) fish marketers- this includes wholesalers, traders and processors because there were negligible numbers that were exclusively either group.

A total of 12 input suppliers, 8 input supplier/fish farmers, 60 female fish farmers, and 98 fish marketers were surveyed. The key survey findings were that:

1. Most fish farmers are small scale and/or only just starting and did not have previous harvest information or financial information and sell directly to consumers at the farm-gate. Most of the information gathered on fish marketing is based on wild caught fish but provide insights on opportunities for farmed fish and for women.
2. Nairobi had the most diversity in terms of fish products- fresh, fried, dried, smoked, etc. Eldoret consumers were not appreciably fresh fish consumers and mostly processed fish products.
3. Kisumu region had the most fish farmers and the best fish market- in terms of facilities. Eldoret had only one small room in the market but it was very well organized.

4. The input suppliers for construction and harvest equipment were not exclusively aquaculture suppliers and only supplied these inputs because they were inputs that had other functions. This includes even the recently established aquashops.
5. Although women form the majority of fish marketers and labor suppliers, their numbers are increasing as farmers.
6. The government Economic Stimulus Program is the major program that has contributed to the increase in the number of ponds constructed
7. There are 6 government accredited aquaculture equipment suppliers and 6 recently established aquashops.
8. The main opportunities for women are as fish farmers that also act as a hatchery and provide fingerlings and fry as this allows for income generation to tide them over before the harvest is ready.
9. Although access to larger markets is recommended in the long run, at their current small scale, sale to neighbors and the local community is advisable as it eliminates transport costs and the transaction costs of marketing.
10. Women could also increase their welfare by entering the chain as fish marketers but this is not yet viable for farmed fish as they are not yet entering the formal markets

The main problems experienced were that:

1. The microfinance providers were unwilling to be interviewed due to protocol, i.e. "they are large corporations and there are channels to go through from head office right down" and intellectual property rights, i.e. "researchers often give information they have provided to their competitors".
2. Other input suppliers, mainly, although a few other supply chain actors also expressed an unwillingness to provide financial data as they felt this was proprietary information.
3. Empirical analysis of the data collected is ongoing.

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

There are several aquaculture systems in use in developing nations, among them being pond culture, cage culture but most recent is the integrated cage-cum-pond culture. The system is environmentally friendly because less waste nutrients are released to the public water systems.

This study investigated varying stocking density for rearing *O. niloticus* in cage-cum-pond fish culture in a 1,300m^2 earthen pond using 9 cages of 1m^3 each. Hand sexed male *O. niloticus* fingerlings were stocked in the cages and the open pond water respectively. Prior to stocking, the pond was fertilized with 20kgN ha^{-1} wk^{-1} and 5kg P ha^{-1} wk^{-1}1 using Urea and Di-ammonium phosphate. Cages were stocked at varying densities of 50, 75 and 100 fish m^{-3}. Fish in cages were fed with commercial floating feeds containing 17.60% crude protein reared for 180 days. Water quality parameters were also monitored during the entire study period.

Results showed that fish stocked at the low stocking density (50 fish m^{-3}) had better growth, low FCR and higher survival rate as compared to the other two treatments. The largest fish in cages weighed 590g while the smallest fish was 180g. The low stocking density had the lowest yield. This information will be useful to small scale fish farmers who will benefit from two crops in one pond.

Part of this investigation involved training farmers after the research work on cage-cum-pond culture. Three groups of farmers were identified: Ruiru Youth for Development and Environment Conservation (RYDEC) group from Thika; Rugita Youth Development group (RYDG) from Kikuyu; and Karunda Whiteland Youth Dvelopment Group (KWYDG) from Nyeri. These youth groups utilize Twiga, Rungiri and Gathathi-ini dams respectively in fish farming. A pre-trial workshop introduced the farmers to cage. Farmers were taught on importance of cage culture, cage construction, site selection for placement of the cages, feeding, record keeping, and stocking densities among other cage management practices. They were also introduced to pond management practices. A follow-up more intensive training was conducted where two farmers from each group attended. The farmers constructed cage frames and also learnt how to make a complete cage. After the

training, farmers were given materials for cage construction and use on their respective sites. Each group constructed six cages.

A post-trial workshop for the three groups of farmers was held to assess progress in cage farming, their experiences in fish farming and the challenges they were facing. Farmers were given a chance to ask questions and discuss the impacts they have had on the community around them. It was reported that in addition to cage farming on the dam, RYDEC and RYDG groups have started other activities in the dam. For example, in Twiga dam, RYDEC practice sport fishing, capture fishing of dam fish as well as kayaking. In Rungiri dam, RYDG practices sport fishing and growing of cucumber. This group has had a great impact on the community as some have shown interest in fish farming. Some members of the group have dug ponds. The group is also planning to start fishing in the dam.

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

The digestibility trial is completed and all diets and fecal samples have been analyzed for proximate composition. Additional samples have been sent to another lab for chromic oxide analysis. We expect to be able to calculate the digestibility coefficients by the end of September.

The feeding trial is in progress. The initial fish weights suggest that some groups have quadrupled their weight since the study began. The 30% *moringa* diet seems to be lagging behind the others (fish from subsamples are smaller), and there are no other differences among diets (which include a soybean meal control, 2 diets with 15- or 30% Leucaena in place of soy, and 2 diets with 15- or 30% *Moringa* in place of soy). The trial will run for a minimum of one more month. Water quality is being analyzed routinely (including chlorophyll a analysis). In addition, the protocol to measure proteolytic enzyme activity in these fish at the end of the trial has been set up and tested.

09QSD04PU - Performance Evaluation of Different Tilapia Strains and Species in Tanzania

Growth performances of Niletilapia (*Oreochromis niloticus)*, Jipe tilapia (*Oreochromis jipe*), Wami tilapia (*Oreochromis urolepis hornorum) and Ruvuma tilapia (Oreochromis ruvumae)* were studied. The study was undertaken on-station in ponds at Sokoine University of Agriculture and on-farm at Changa and Kibwaya villages, Mkuyuni division, Morogoro rural district in ponds of small-scale fish farmers.

Niletilapia (*Oreochromis niloticus*) fingerlings were collected from Kingolwira National Fisheries Research Centre. The fingerlings of *Oreochromis jipe*, *Oreochromis urolepis hornorum and Oreochromis ruvumae* were collected from Lake Jipe Mwanga district, river Wami at Dakawa sub town and river Ruvuma at Litapwasi village, respectively. The fingerlings were collected from their respective sources and stored separately in concrete tanks at Sokoine University of Agriculture prior to the start of the experiment**.**

The experiment was conducted for 90 days. For on–station experiment, two ponds each with four hapas of 6 m^2 surface area and one meter depth each were used. Stoking density was 2 fish per m^2 in each hapa. All Fish in happas were supplemented daily with concentrate comprised of soybean meal and maize bran. Body weights of fish were measured at the start of the experiment and then monthly for 90 days by using an electrical weighing scale. Similarly body length and width were measured at the beginning and then at monthly intervals by using a measuring board with a ruler. Water quality parameters were measured weekly by using YSI 55 instrument for temperature and DO; water pH, nitrate, nitrite by using JBL Easy Test strips and water transparency by using secchi disk.

For on–farm trials, a total of six farmers from Changa and Kibwaya villages participated in the experiment. Each species of tilapia was distributed to two different farmers and body measurements (weight, length and width) of fish and water quality parameters were taken at the start of the experiment and then monthly.

The experiments are completed and the results are being analyzed.

09TAP04PU - Harnessing Opportunities and Overcoming Constraints to Widespread Adoption of Cage Aquaculture in Ghana

This study was conducted to identify why the overall contribution of the aquaculture industry to local fish production in Ghana is low (< 1%) although cage aquaculture has a potential to increase production. A total of 106 questionnaires was administered to six respondent groups (current cage fish farmers, potential adopters of cage aquaculture, farmers who have abandoned cage aquaculture, Fisheries Commission, regional and district fisheries officers, and financial institutions) to obtain insight into the constraints in cage aquaculture as well as opportunities that can be exploited to promote cage aquaculture adoption. For the purpose of this study, potential adopters are individuals who have fish-related livelihoods including fishermen, pond-based fish farmers and fish traders. We also interviewed key informants in relevant government institutions.

Preliminary results indicate that lack of funds and lack of government extension services are the main constraints in cage aquaculture in Ghana. Lack of funds manifests in farmers' inability to afford quality floating feed and could explain low production levels of current cage farmers, although most (95%) suggested they could market their fish if they increased production. Lack of funds also accounted for the inability of potential adopters and farmers who have abandoned cage aquaculture to start or continue cage aquaculture respectively. Major opportunities identified include 1) a high interest among potential adopters (97%) to start cage aquaculture and farmers who have abandoned cage aquaculture (100%) to resume if constraints are removed, 2) development of a feed production plant in Ghana by a private enterprise, 3) willingness of some financial institutions to provide loans for cage farmers, and 4) a number of government initiatives to promote cage aquaculture. Our preliminary recommendations are that the Fisheries Commission should work with the financial institutions to help determine farmers' ability to repay loans and guarantee loans made by the financial institutions. Also, there is a need for a more specialized aquaculture extension service accessible to farmers to help with technical issues built on the model of agricultural extension services in Ghana.

09IND06PU - Development and Diversification of Species for Aquaculture in Ghana

There is lack of technical information on the culture of 'non-traditional' species such as the African bony-tongue *Heterotis niloticus*, Claroteid catfish *Chrysichthys nigrodigitatus* and the African snakehead *Parachanna obscura*, which are among the most highly valued species in West African inland fisheries. In Ghana, there is scanty knowledge on the ecology and biology, especially the dietary requirements under culture conditions for these species. To consider the species for development, it is important to verify their life-history, trophic, and other ecological traits that could be exploited for commercial seed production and fast grow-out in ponds and cages. Documentation of such information will provide basis for further studies on the species for development inGhana. The study, therefore, was designed to gather information from literature, fish farmers, vendors, and fishers and to conduct experiments to determine the nutritional requirements of the African bony-tongue, Claroteid catfish, and the African snakehead.

The study has documented information on several aspects of the culture and nutritional requirements for the three indigenous fishes. It has been determined that the dietary protein requirements for juvenile African bony-tongue and the Claroteid catfish are 30-35% and 35-40% respectively. These findings were the result of several feed trials conducted to compare the effects of varying crude protein (CP) levels ranging from 25% to 45% using fish meal/soybean meal as protein sources in a ratio of 2:1 in practical diets. The Claroteid catfish were reared in tanks and African bony-tongue were reared in hapas.

A workshop was held on the culture of the new indigenous species, which received overwhelming attendance by over 100 farmers, an indication that farmers' interest in the production of these species remains high. Farmers were so intrigued by the preliminary findings that some started requesting for the experimental diets to feed their fish.

The findings are preliminary and additional work is on-going for these species.

09TAP07PU - Effects of ACRSP and AquaFish CRSP Initiatives and Activities on Aquaculture Development in Kenya

This study sought to assess the impact of ACRSP and AquaFish CRSP activities in Kenya using stochastic frontier production functions. Particularly, the study compares the technical efficiency of fish farms adopting and those not-adopting ACRSP practices and technologies and also identified factors affecting technical efficiency. The study also calculated the cost and benefits analysis of fish farming in Kenya.

The stochastic frontier production function specification permits output to be specified as a function of controllable factors of production, random noise and a technical inefficiency term. Data for this study was collected in the months of June and July 2011 in Kenya. A sample of 297 farmers were randomly sampled in 10 counties (Busia-60; Kakamega-62; Kiambu-21; Kiriinyaga-22; Kisumu-1 ; Muranga-20; Nyandarua-1; Nyeri-28; Ol Kalou -1; Siaya-33; Trans Nzoia-18; Vihiga-30;). All farmers were used for the general statistics but only 118 were used for the production and efficiency model since those had complete production data. To make a comparative analysis of the ACRSP and non-ACRSP trained farmers a dummy was created for the sample of respondents that has participated in the ACRSP activities and the variable included in the inefficiency model.

Preliminary analyses suggest most farmers are aged between 30 to 60 years with the mean range of between 40 and 50 years. Most farmers are educated up to secondary level. The range of farm income is from Kshs 5000 to 10, 000 while the non-farm income is mostly below 5,000. The average farm size is 3.8 acres and the average number of people living in each household is about 8 persons. For the stochastic production model, the average output of fish per hectare is 8,675.64 kg with a high standard deviation implying that there is a big disparity in the production output of fish in Kenya. The output revenue also shows similar trends. The output revenue per hectare is Kshs 2.93 million with a standard deviation of 23.2 million The input variable show smaller standard deviation in comparison to output and output revenues. The average number of seed per hectare is 27, 891.53 with a standard deviation of 11, 885.99. The average feed weight per ha is 75.94 with a standard deviation of 74.66 and the labor hour per day per hectare is 46.49 with a standard deviation of 44.57. Other variable are used for the inefficiency model.

The maximum likelihood estimates of the Cobb-Douglas stochastic frontier model and those in the inefficiency model show all slope coefficients of the stochastic frontier had the expected signs and are highly significant. Output elasticity of inputs was highest for seed (1.24) followed by labor (0.15) and feed (0.13). The test statistics for inefficiency model have not been carried out yet but several variables seem to be associated with the technical inefficiency. These include “awareness to ACRSP activities”, pond size, gender, age, household income, number of people in the household and presence of children below the age 15years. These results are very preliminary and detailed results will be reported in the final technical report.

09QSD05PU - Training Program in Propagation and Hatchery Management of tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*) in Ghana

Increasing government support for aquaculture development in Ghana has the potential to create new jobs and improve food security among poor households. Unfortunately, technical know-how and skills in fingerling production is fairly restricted and most fish farmers lack the basic skills required for a successful fish production regime. Training programmes in fish propagation and hatchery management of Tilapia (*Oreochromis niloticus)* and Catfish *Clarias gariepinus* were conducted in Ghana at two separate locations in the Eastern and Ashanti regions. The training targeted small to medium scale fish farmers and potential fish farmers to provide them with technical knowledge and skills to enhance sustainable production of Tilapia and catfish fingerlings from hatchery stage to maturity. Over 60 fish farmers were trained in hatchery management and propagation of tilapia and catfish. It is anticipated that the skills acquired would enhance capacity of farmers and result in sustainable production of tilapia and catfish fingerlings to cope with the rising demand for fingerlings for commercial fish farming.

PRESENTATIONS & PUBLICATIONS

Presentations

Title	Author(s)	Type	Event	Location
Aquatic Research For Development	Charles Ngugi	Oral	KMFRI Annual Science Conference	Naivasha, Kenya
Comparative Growth Performance Of Nile Tilapia (*Oreochromis niloticus*) Grown Under Mixed-sex, Monosex And Polyculture Systems In Small-scale Ponds In Tanzania	Sebastian W. Chenyambuga, Joshua Buru, Berno V. Mnembuka, Nazael Madalla, Rebecca Lochmann and Kwamena Quagrainie	Oral	9th Asian Fisheries & Aquaculture Forum	Shanghai, China
Constraints and Opportunities in Cage	Gifty Anane-Taabeah, Emmanuel A. Frimpong, Stephen Amisah	Oral	9th Asian Fisheries & Aquaculture Forum	Shanghai, China
Consumer Preference For Farmed Tilapia and Catfish in Ghana and Kenya	Francis Darko	Oral	Aquaculture America 2011	New Orleans, LA, USA
Effects Of Stocking Density On The Growth, Survival And Yield Performance Of Nile Tilapia (*Oreochromis niloticus*, Linn. 1858) In An Integrated Cage-cum-pond Culture System	Charles C. Ngugi, Gladys Kuria, Kwamena Quagrainie, and Sammy Macharia	Oral	9th Asian Fisheries & Aquaculture Forum	Shanghai, China
Farmed vs Wild-caught Tilapia: A Study Of Consumer Preferences In Ghana	Kwamena Quagrainie, Francis A Darko, Nicole Olynk, Jennifer Dennis and Otto Doering	Oral		Shanghai, China
Kenya Aquaculture Suitability Assessment	Sammy K. Macaria, Charles C. Ngugi, Kwamena Quagrainie, Brian Wamubeyi, Harrison Ong'anda	Oral	9th Asian Fisheries & Aquaculture Forum	Shanghai, China
Value Chain Development For Tilapia And Catfish Products: Opportunities For Female Participation In Kenya	Leah Ndanga	Poster	Aquaculture America 2011	New Orleans, LA, USA

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

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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

All bills paid and extra copies of ISTA 9 proceedings have been sent and received at University of Arizona. Some copies of the proceedings have been donated to contributor of papers who could not attend. We have also donated copies of the proceedings to some libraries (California Sea Grant and CP Prima in Jakarta) and some developing country aquaculture farmers.

Scientists in Israel have requested to host ISTA 10 in Jerusalem in 2013 and colleagues in Indonesia are requesting government support to host ISTA 11 in Indonesia in 2015. The success of the ISTA 9 in China has already translated into ongoing interest and support for future meetings. The AquaFish CRSP role will be crucial to future success as the CRSP is one of the most ijmportant supporters and outreach entities for small scale sustainable aquaculture in developing countries. There is plenty of support and investment in high priced products for international trade. Howver, the interest in working with the rural poor to utiize native or domesticated aquatic animals and plants for local markets is limited to a dedicated few.

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

Our AquaFish CRSP work in Guyana is split between the northern watersheds whih drain to the coastal areas to the east and west of the capital Georgetown. In the eastern area, Regions 4 and 5, we have worked with a number of individual farmers rearing tilapia and pacu and with one women's cooperative rearing tilapia and hassar, a local armored catfish. The farms are all arrayed along the coastal highway and use their fish primarily for direct consumption and local sales, as well as some sales to the major population center of Georgetown.

In Regions 4 and 5 we have worked with most of the individual farmers including those growing tilapia, pacu and shrimp, a feed mill producing fish feed and one tilapia hatchery. The tilapia farmers are using both Mozambique tilapia imported years ago and improved selections of Nile tilapia donated by Swansea University in Wales with support from the British DFID. We have great hopes for these farmers and have started test shipments of tilapia to Florida.

The Trafalgar Union Women's Cooperative is one of the largest farms in Region 5. This cooperative of 16 women have pooled their resources and been provided with a low cost lease on 12.5 hectares of federal land. We have conducted three workshops for the women. One at the national aquaculture center at Mon Repos, one at the Maharaja Feed Mill and a third at the Trafalgar Union Farm. The first workshop included basics of aquaculture and tilapia biology. The second covered basic fish nutrition, feed formulations, feed manufacturing, and on farm feed handling and distribution.

Our second area of interest is in the Rupununi Basin in the southern portion of Guyana. The people are essentially subsistence farmers utilizing solar panels or diesel generators for household electrical power. Our focus in the southern watersheds was to develop, describe and demonstrate a simple integrated farming system utilizing native fishes and vegetable crops grown in the area. We organized our workshops and visits with the Fisheries Office staff in Georgetown before flying by small plane to the airstrip at Annai. We held our first workshops to describe the system to the community members and to gather their input and suggestions as to how to improve the concept. We also visited several ponds that had previously been built in the area. All of these ponds were poorly designed and essentially unusable.

Therefore we recommended a simple small pond system coupled with production of local vegetables. With the lack of reliable electricity we purchased a solar panel with battery for the pump to be used during irrigation periods.

After the prior workshop and discussions with the local association of farmers, we determined to put the demonstration farm at the Rock View Lodge. The proprietor, Colin Edwards, has started the pond construction and planted the garden. He has the solar panel and battery apparatus ready to install when the fish are stocked. The current plan is to stock with native pacu fingerlings from a hatchery across the border in Brazil, in September 2011.

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

Introduction

Fingerling quality has become a significant concern among tilapia farmers in Southeastern Mexico during recent years. The problem goes to the basics, since several fingerling vendors are introducing fish at a lower price; however, there is no evidence that farmers are buying good quality fish, neither the effectiveness of the masculinization treatment used. Members of the Association of Tilapia Producers of Tabasco have expressed their concern to the personnel of the Tropical Aquaculture Laboratory (UJAT) regarding bad quality fingerlings. This low-quality product is mainly perceived as low growth and low survival. There are also concerns that the "purity" of the line sold is not trustable.

Objectives

1. To build three demonstration aquaculture – agriculture units in indigenous communities.
2. To evaluate the success of local farmers adopting multi-use concepts to grow fish and plant crops.
3. To provide an enterprise model documenting the cost – benefits of the integrated system.
4. To compare at least five different tilapia strains used in Southeastern Mexico.
5. To provide a protocol for tilapia strain evaluation based on growth and economic variables.
6. To provide objective information for farmers to help decide which strains produce best results.

Methods and materials

Demonstration and Evaluation of an Integrated Aquaculture – Agriculture System for Indigenous Farmers in Tabasco, Mexico

Two workshops were held at UJAT. The first workshop by Drs. Kevin Fitzsimmons, Dennis McIntosh & Rafael Martinez-Garcia on Integrated aquaculture agriculture systems. The second workshop by Tracy Holstein on biofloc systems.

Three integrated aquaculture agriculture systems in two indigenous communities and one educational and demonstrative site were built. An integrated aquaculture agriculture system was developed in an indigenous chol community at Caridad Guerrero, Tacotalpa county in Tabasco. The effluents of 1500 Tilapias feed 2 twice per day with ratio of 5% biomass of Tilapia feed contained in a 12 m^3 geomembrane tank were used to irrigate habanero peppers twice per day, grown from seedlings in three agricultural beds (10 x 15m), with a 3% slope for capture effluents for analysis. Sampling of Tilapia and habanero were made each month, total length and weight were taken for the Tilapia and length for habanero pepper, total product harvest were done weighting the total production (fruit) of each plant

The second site was developed at a chontal indigenous community in Oxiacaque, Nacajuca county. Except for the agricultural unit measures (5 x 10m) most of the procedure was conducted as described for Caridad Guerrero.

The third site an educational and demonstrative system was built at UJAT, all procedure was conducted as in Caridad Guerrero.

Tilapia and habanero seedlings were transfer to the sites at different times. Data for biomass crop production will be analyzed in order to obtain media for each case. Analysis of water quality was performed monthly, measuring Nitrites, Nitrates & Ammonia to calculate total Nitrogen.

A social economic evaluation is being performed at Caridad Guerrero, based on qualitative statistics with surveys and interviews.

Evaluation of Different Tilapia Strains used in Southeastern Mexico and Incorporation of a Pure GIFT Line as Reference to Determine Quality of Tilapia Fingerlings.
Fingerlings were purchased anonymously (*Oreochromis niloticus*: "GIFT", "YY super males", "Chitralada", "Rocky Mountain", "Stirling", " Pucté" and Tabasco line) from different hatcheries and/or retailers. Tilapia sizes were from 0.3 to 0.7 g. Initial weight and total lenght among the lines was used as covariables in order to avoid statistical bias. Monthly samples were made in order to evaluate growth in weight and length. 1000 Tilapias were placed randomly in mosquito-mesh hapas for a month, at the end of this period all fish were count in order to evaluate survival and Tilapias were transfer to ½" mesh hapas. Tilapias were feed three times per day with a ratio of 5% total biomass. Feed ratio was adjusted each month. Water exchange was done at 10% ratio weekly. 2000 Tilapias were used to evaluate possible infections for most common bacterial pathogens (*Streptococcus, Trichodina, Columnaris,* or *Aeromonas*), ich disease (*Ichthyophthirius multifilis*) and parasites, samples were taken and analyzed by the personnel of the Aquatic Sanitation Laboratory (UJAT).

Statistical analysis
The experimental design contemplated for this experiment was a randomly blocked design. Three factors were considered (length, weight and date of initiation). The response variables (Length and Weight) will be tested to determine if the assumptions for parametric analysis are met; if so, contrasts will be performed using ANOVA, otherwise data will be transformed to meet the requirements. Total biomass will be compared using an ANOVA test and Survival results will be compared among treatments by Chi square test using contingency tables.

Results
Demonstration and Evaluation of an Integrated Aquaculture – Agriculture System for Indigenous Farmers in Tabasco, Mexico
A total of 80 participants assisted to the Integrated aquaculture agriculture and bioflocs workshops, participants were; professors, students, local farmers, and extension government agents.

In Caridad Guerrero habanero harvest is carrying out in some early productive plants, the rest are flowering and some still growing, Tilapia reached a media of 45 g. Nitrogen analysis showed high retention from soil matrix and plants. Oxiacaque system is showing excellent progress, habanero plants reached 18 cm and Tilapia 34 g. At UJAT Tilapia achieve 20g and habanero plants 16 cm. Nitrogen analyses were carried out at Caridad Guerrero and Oxiacaque, where high amount of nitrogen (around 70%) was retained by soil matrix and uptake by plants. Due to problems with soil compaction, some of the slope was lost and capture of effluents was not precise at the demonstrative site.

Two surveys and one interview was carried out to 80% (100 families) of the population in Caridad Guerrero in order to achieve data for the social economic analysis and describe the impact of the project at the community.

Evaluation of Different Tilapia Strains used in Southeastern Mexico and Incorporation of a Pure GIFT Line as Reference to Determine Quality of Tilapia Fingerlings.
Seven lines were bought available in the region: "GIFT", "super males YY", "Chitralada", "Rocky Mountain", "Stirling", "Pucté" and "Tabasco line".Tilapias (1000 per hapa) were placed in mosquito mesh for a month. At the beginning Tilapia were sampled in order to determine differences in length and weight among the lines. At the end of the first month a sampling was conducted in order to evaluate growth. Fish were counted and placed in a ½" mesh hapas. Parasites analysis was carried out, finding infections by *Monogenea and tricodina* in 4 of the 5 lines. Bacterial infections were found by *Pseudomonas fluorescens, Aeromonas hydrophila, Aeromonas sobri, Plesiomonas shigelloides, Plesiomonas shigelloides, Aeromonas sobria, Moraxella spp, Pseudomonas putida, Burkholderia cepacia, Photobacterium damselae* and *Pseudomonas aeruginosa* in skin, liver, kidney and spleen.

Universidad Autonoma de Tamaulipas Aspect _ Food Safety Study Of Leafy Greens Irrigated With Tilapia Farm Effluents.

Status of The Project.

The project studied the presence or absence of pathogens in water and leafy greens plants in indoors systems and outdoors systems. In the case of presence of pathogens, if they can be removed by UV light system.

- The research is concluded and the data analysis as well.
- Field (outdoor production) systems continue using water from fish effluents to irrigate different crops operated by the land owners .
- Indoors system (CUAUTLI Facilities) still in use for academic and research purposes, teaching tilapia culture techniques; masculinization, health management, diets, etc.

Academic Products.

- From Spring semester (2011), 73 undergraduate students registered for aquaponics course and successfully completed the 3 unit (hours) class and 3 units (hours) laboratory (per week) at the CUAUTLI facilities.
- 6 undergraduate students devoted to voluntary work in the fish facilities.
- 2 undergraduate students are working on the data analysis and thesis.
- Several videos from indoors and outdoors project facilities were produced and available on You Tube.
- Study program for Aquaponics for graduate program in UAT, starting in January.
- Participation in SEMARNAT workshop on Green house effect - climate change on aquaculture.
- Participation in the Center for Climate Strategy Workshop.

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

Selective Breeding Program for Tenhuayaca (Petenia splendida) and Castarrica, (Cichlasoma urophthalmus) using Total Length and Condition Factor. Reproduction trials were conducted at UJAT and progeny testing trials were performed at the "Mariano Matamoros" Hatchery, Teapa, Tabasco, Mexico. Groups of broodstock were kept at UJAT as a backup.

This study was composed of two groups of broodstock for fry production and growth comparisons for each species: A) Control group (Fingerlings produced from wild broodstock collected from Tabasco and Chiapas); B) F1 CRSP line (A&F CRSP project)

The first group of broodstock for fry production and growth comparisons were obtained from the wild broodstock collected from Tabasco and Chiapas and currently used in the laboratory of Aquaculture. Females selection were based on the best total length measurements, and males selection were performed using individuals with the best condition factor. Each selected broodstock group was placed in 2.5m-diameter tanks. Each tank contained 9 females and 2 males/tank, fish were stocked at a sex ratio of 3:1 (female:male) in five spawning tanks. Fry used for grow-out trials was collected from spawning tanks and stocked in grow-out hapas at a density of 1000 fish/m2. To eliminate age variability, fish stocked in a single pond had a maximum difference of seven days of age. Fish were grown for two months in these hapas.

Five hundred fingerlings were collected from the grow-out hapas and moved into three 2 x 1 x 1.2 floating cages with one-inch mesh size. This procedure was repeated five times to assure five groups of fry. Fish were grown for three more months. After three months of growth; fish were collected and measured. All fish were divided in three groups using weight as the selection variable: 1) Fry which were 33% above the median value, 2) fry which were 33% around the median value, and 3) fry which were 33% below the median value. Group 1 was reserved for follow-up studies, and group 2 was used for line selection. All fish in group 3 were discarded. From group 2 (of each replicate), fish were stocked in 1,000 m^2 earthen ponds and grown-out for 3 months. At the end of the grow-out phase, 900 females and 100 males with the highest length were selected and placed (separated by sex) in 1,000 m^2 earthen ponds. After three months of growth, fish were selected to

produce the F_2 generation. Males were selected based on highest condition factor, and females were selected based on highest length.

Snook aquaculture

Experiment 1. To obtain broodstock from wild and hatchery-reared snook juveniles.
Snooks were submitted to a feeding scheme and fasting in each feed transition: the first 14 days were feed with live feed (*Cichlasoma urophthalmus* and *Oreochromis niloticus*) ad libitum; at days 15 and 16 fish were submitted to fasted; from day 17 to 18 fish were feed ad libitum with hold fresh fish; from day 19 to 20 were fasted and from day 21 to 22 were feed ad libitum with pieces of fresh fish. From day 23 to 24 were fasted and finally from day 25 and onwards were submitted to a semi-wet diet two or three times per day.

The diet used was designed in order to substitute live feed from the diet of the wild juveniles, this diet was based on fish meal, grounded fish filet, shrimp meal, fish oil, soy lecithin, vitamins and minerals premix, vitamin C, unflavored gelatin, soy milk and sorghum flour which have been used in similar researches (Sánchez et al. 2007; Amaral et al. 2009; Cerqueira and Tsuzuki, 2009).

Experiment 2. To evaluate spawning of Mexican snook in captivity.
Centropomus poeyi wild organisms were collected during the natural spawning season of this specie (June - September). Initially fish were maintained at the Marine Aquaculture Station in 25 m^3quarantine tanks.

Experiment 3. To identify native plankton used as feeds during early development of snooks
Phyto- and zooplankton was collected from the common snook spawning zones closed to the Gonzalez river mouth. Sampling was made with plankton nets of 20, 64 and 120 µm for 10 minutes with a boat at low speed. Samples were fixed with formol at 4% and were analyzed with a microscope.

RESULTS

Experiment 1
151 fish were captured and kept without food for 72 hours, Adaptation to fresh water was attained satisfactorily. After this adaptation period, fish were offered a semi-wet diet, which was accepted by most of the fish. To date we have five lots of *C. undecimalis* composed of 83 separated by size weighing between 60.11 and 258.02 g and averaging between 20.47 to 34.08 cm in length. These fish have easily adapted to captivity and are the first batch of fish adapted to captivity from the juvenile stage that will be used as broodstock in the future. The lot of fish from spawning in captivity was not obtained. Even though the induction of spawning was successful, and larvae were obtained fish did not survive beyond 15 days.

Experiment 2. Adult fish obtained from the wild were cannulated during the beginning of the spawning season obtaining negative results. Despite this, we decided to initiate induction of maturation using 100 and 200 ug/fish implants. After 29 hours of implantation fish from both treatments spawned. After five days of hatching, 25,000 larvae were transported to our live-feed laboratory where they are fed the rotifer *Brachionus plicatilis* and the microalgae *Nannochloropsis oculata* and *Tetracelmis chuii*. Egg and larvae samples are currently under analysis.

Experiment 3. Phyto and zooplankton were collected from snook spawning grounds. Samples were fixed and currently under analysis. The most abundant groups of plankton identified so far are copepods, rotifers chaetognaths, brachyur, polichets, ostracods, nematods, fish eggs, and dinoflagellates. We have observed significant changes in the monthly composition of the zooplankton. Diatoms are the most important group of phytoplankton.

09MNE07UA - Reaching the Farms Through AquaFish CRSP Technology Transfer: Elimination of MT from Intensive Masculinization Systems Using Bacterial Degradation

The project continued to make progress with our research on the bioflocs and biofilter bacterial films continuing. We have isolated the bacteria that provide the higest level of degradation of the MT. We

have also cultured the bacteria to increase the populations that could be used as inoculum for biofilters at the commercial hatcheries using MT for sex reversal. However, the delivery of the baceria inoculum to the hatcheries has been delayed. Due to the severe floods, the hatcheries at the commercial farms were damaged and have been unable to start their recirculation systems that utilize the biofilters. The repairs have been continuing in recent months and we expect to be able to complete the work before December.

PRESENTATIONS & PUBLICATIONS

Presentations

Title	Author(s)	Type	Event	Location
Advances In Fat Snook *Centropomus Parallelus* Reproduction In Captivity, Tabasco, Mexico	Wilfrido Contreras-Sanchez, María De Jesús Contreras-García, Ulises Hernández-Vidal, Alejandro Mcdonal-Vera, Reynaldo Patiño	Oral	Aquaculture America	New Orleans, LA
Development Of Sustainable Aquaculture Practices In Tabasco, Mexico Using Novel Iaa Technology	Martinez-Garcia, R., Cifuentes-Alonso, M., Estrada Botello, M., Lopez Torres, A., Contreras-Garcia, M. De Jesus, Macdonal-Vera, A., Gonzalez-Arevalo, E., Contreras-Sanchez, W. and Fitzsimmons, K.	Oral	ISTA 9	Shanghai, China
Growth Of The Tropical Gar *Atractosteus Tropicus* During The First Year Of Age Is Not Related To Sex	Wilfrido Contreras-Sanchez, Gabriel Márquez-Couturier, Maria De Jesus Contreras-García, Cesar Jesús Vázquez-Navarrete	Oral	Aquaculture America	New Orleans
Sex Inversion Of The Native Cichlid *Petenia Splendida* Using Oral Administration Of 17a-methyltestosterone	Wilfrido Contreras Sánchez, Maria DeJesus Contreras-Garcia, Alejandro Mcdonal-Vera	Oral	Aquaculture America	New Orleans, LA
The Effects Of Plankton On Tilapia Growing Using Organic And Inorganic Fertilizers and What Causes Phytoplankton Bloom To "crash".	Pamila Ramotar	Poster	ISTA 9	Shanghai, China
Tilapia 2011 - Swimming Against The Tide: Increased Consumption In A Down Market	Fitzsimmons, Martinez, Naim, Ramotar	Oral	Aquaculture America	New Orleans, LA
Tilapia Update 2010	Ramotar, Fitzsimmons, Naim	Oral	WAS 2011	Natal Brazil
Why Tilapia Is Becoming The Most Important Food Fish On The Planet	Fitzsimmons, Martinez and Gonzalez	Oral	ISTA 9	Shanghai, China

Publications

Al-Ghanem, K., Alam, A., Al-Hafedh, Y., and Fitzsimmons, K. 2011. Tilapia Aquaculture in Saudi Arabia - Farming with seaweed may improve economic, environmental sustainability. Global Aquaculture Advocate (3):26-27.

Gonzalez-Alanis,Pablo*, J.I. Gutierrez-Olguin, H. Ezqueda-Palacios, H.H. Gojon-Baez, G. Aguirre-Guzman, F.M. Guzman-Saenz, K.M. Fitzsimmons, 2011. Food Safety Study of Leafy Greens Irrigated with Tilapia Farm Effluents in Tamaulipas.

Fitzsimmons, K., Martinez-Garcia, R., Gonzalez-Alanis, P. 2011. Why tilapia is becoming the most important food fish on the planet. Pp. 8-16. In: Lui Liping and Fitzsimmons, K. 2011. Better Science, Better Fish, Better Life - Proceedings of the Ninth International Symposium on Tilapia in Aquaculture. American Tilapia Association and Department of Agriculture, Shanghai, China. ISBN: 978-1-888807-19-6. 450pp.

Lui Liping and Fitzsimmons, K. 2011. Better Science, Better Fish, Better Life - Proceedings of the Ninth International Symposium on Tilapia in Aquaculture. American Tilapia Association and Department of Agriculture, Shanghai, China. ISBN: 978-1-888807-19-6. 450pp.

Martinez-Garcia, R., Cifuentes-Alonso, M., Estrada Botello, M., Lopez Torres, A., Contreras-Garcia, M. de Jesus, Macdonal-Vera, A., Gonzalez-Arevalo, E., Contreras-Sanchez, W. and Fitzsimmons, K. 2011. Development of sustainable aquaculture practices in Tabasco, Mexico using novel IAA Technology. In: Lui Liping and Fitzsimmons, K. 2011. Better Science, Better Fish, Better Life - Proceedings of the Ninth International Symposium on Tilapia in Aquaculture. American Tilapia Association and Department of Agriculture, Shanghai, China. ISBN: 978-1-888807-19-6. 450pp.

Padrón-López, R.M., L. Vázquez-Cruz, U. Hernández-Vidal, W. M. Contreras-Sánchez and K. Fitzsimmons. 2011. Potential Use Of Bacterial Degradation To Eliminate Methyltestosterone From Intesive Tilapia Masculinization Systems. In: Lui Liping and Fitzsimmons, K. 2011. Better Science, Better Fish, Better Life - Proceedings of the Ninth International Symposium on Tilapia in Aquaculture. American Tilapia Association and Department of Agriculture, Shanghai, China. ISBN: 978-1-888807-19-6. 450pp.

Bay snook fishermen in Mexico (Photo by Tiffany Woods)

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

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Robert S. **Pomeroy** - US Lead Project PI
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David A. **Bengtson** - US Co-PI
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INVESTIGATION PROGRESS REPORTS

Printed as submitted by Robert Pomeroy, US Lead PI

07TAP01UC - Feed Technology Adoption and Policy Development for Fisheries Management.

- Conducted training on fish feed technology to 30 selected snakehead fish farmers to train them on how to make CRSP home made feed by mixing trash fish and rice bran and cassava mill to reduce the use of trash fish by 20-40 % for snakehead farmers for farmers adoption pilot.
- Conducted workshop on Information/communication Monitoring and Evaluation to 41 participants from different stakeholders such as target snakehead fish farmers, local fisheries officers, and researchers.
- Conducted seminar on Impact Assessment to fisheries officers, researchers, local authorities, fish farmers, as well as policy makers to understand the impact of using trash fish for snakehead culture and how to reduce the utilzation of trash fish by substitute with the rice bran and cassava mill 20-40% with the CRSP formulation of home made feed.

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.

Activity research 2011:

- Evaluate the chemical composition of marine trashfish
- Pilot trails on weaning method using formulated feeds for snakehead larvae
- Grow-out of *Channa striata* on desmonstration farms
- Second laboratory feeding experiment: Replacement frashwater trash fish by rice bran and cassava meal in diet for snake head.
- Trial on farm for *Channa micropeltes* at AnGiang.
- Investigating on status of using commercial pellet in fed cultured snakehead fish (*Channa striata*) in An Giang and Dong Thap provinces

Up to the end of Sep, 2011, experiments and survey were finished. The experimental data processed and draft final report was finished.

All experiments and trial onfarm of the Investigation 1 have been finished. In addition, 6 students in CAF who were partially funded by this investigation were graduated and 1 PhD students are studying.The results confirmed that trash fish can be replaced by formulated feed for snakehead culture. Using trash fish or formulated feed for snakehead culture was significant difference in profit of AnGiang provinces. The snakehead *Channa striata* effectively used trash-fish from freshwater comparing trash-fish from marine. Formulated pellet contributed to reduce the feed cost in snakehead culturing. Moreover, farmer could utilize available local rice bran and freshwater trash-fish through the diet which is 70% freshwater trash-fish and 30% rice bran. In addition, farmer could also use diets MTF RB CM 60:20:20 or MTF RB 50:50 for snakehead culturing. Pond culture in culture snakehead was popular in Mekong Delta, showing the highest proportion (85.4%) of farmers. The lowest percentage was hapas sytem with 2.4%. Pellet feed using for feeding cultured snakehead was probably a sustainable system than using of trash fish basing on survival, FCR value and return on equity.

The success of this investigation has been due to sound scientific research at Can Tho University followed by feeding trials on actual farms and extension of those results to farmers and feed manufacturers.

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

Cambodia aquaculture represents about 10% of the total fisheries production, while the Mekong delta in Vietnam more than 50%. Aquaculture of these carnivorous and omnivorous fish species is highly dependent on inland fisheries of small-sized fish species for sourcing key dietary nutrient inputs. It is estimated that

approx. 50,000 ton of freshwater small-sized fish is used for the above aquaculture development in Cambodia. The recent study by IFReDI revealed that approx. 200 small-sized fish species were used as feed for aquaculture development in the Lower Mekong basin of Cambodia and Vietnam. The government of Cambodia put a ban on snakehead farming in May 2005 and the reasons for this was the potential negative impacts on wild fish populations from wasteful snakehead seed collection and on other fish species diversity, and also potential negative effects on poor consumer groups from decreased availability of small-sized/low valued fish. the ban does not only result in positive impacts on poor consumer groups from increased availability of freshwater small-sized fish in Cambodia, but also providing negative effects on livelihood of tens of thousands of snakehead farmers who depend on this livelihood for generating household income. Aquaculture of this domesticated snakehead fish has commonly and wisely been practiced, and recently intensified by using freshwater and marine small-sized fish as direct feed. The snakehead aquaculture production increased from 30,000 ton in 2009 to 40,000 ton in 2010. As a result, environmental issue and outbreak of fish disease are the biggest problems, which cause high fish mortality due to poor water quality, and cause decreased income of hundred thousands of snakehead farmers in the Mekong Delta in Vietnam. To find better solution this Investigation is set up with three specific objectives: (1) To domesticate wild snakehead (*Channa striata*) to address the snakehead banning issue in Cambodia in order to lift the ban on snakehead culture in Cambodia; (2) To study environment impacts, fish diseases and biosecurity of snakehead farming in Vietnam; and (3) To provide recommendations for policy and best practices development of snakehead farming.

Overall the project is progressing according to the schedule of activities. The first results of this Investigation include (1) the wild broodstock of striped snakehead *Channa striata* successfully developed at the Freshwater Aquaculture Research and Development Center, Cambodia; (2) breeding and hatching techniques developed; weaning technique, with formulated diets available; (4) F_1 broodstock available; water quality of snakehead farms (temperature, pH, DO, NH^4, NH^3, NO^2, and NO^3) in three main provinces of the Mekong Delta in Vietnam analyzed; and pathogenic agents (fungi, bacteria and virus) in snakehead identified.

In Cambodia (IFReDI)

- Up to 31 December 2010, the first generation of murrel snakehead (*Channa striata*) reared in hapas in an earthen pond at FARDeC were 158 days old.
- They are fed with 100% pellet (crud protein 35%). There were fed 2 times per day
- The size of the snakehead is ranging from 13 to 20 cm or 25 from 30 g
- The age of the fish is 158 days old (5.3 months old)
- 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.
- Total number left is 251.
- Up to 31 March 2011, the first generation of murrel snakehead (*Channa striata*) reared in hapas in an earthen pond at Freshwater Aquaculture Research and Development Center (FARDeC) were 248 days old.
- They are fed with 100% pellet (crud protein 35%). They were fed 2 times per day
- The size of the snakehead is ranging from 200 to 400 g
- The age of the fish is 248 days old (about 8 months old)
- 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.
- Total number left is 201.
- Arranged and facilitated Peg and Bob's visits to the project sites of Tonle Sap Lake provinces of Kandal, Kampong Chnang, Battambang and Siem Reap regarding fisheries, aquaculture, and fish processing.
- Up to 31 August 2011, the first generation of murrel snakehead (*Channa striata*) reared in hapas in an earthen pond at Freshwater Aquaculture Research and Development Center (FARDeC) were 400 days old.
- They are fed with 100% pellet (crud protein 35%). There were fed 2 times per day
- The size of the snakehead is ranging from 210 to 400 g (Avg. 261 g) or 184-354 cm (Avg. 287 cm)

- 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.
- Total number left is 200.
- Experiments on hormone injection set up to assess (1) effects of different dosages of HCG to spawning performances of female and male breeders; and (2) effects of different injecting methods to spawning performances of female and male breeders.
- Experiments on larvae rearing and weaning with different feeds first moina, then small-sized fish and gradually replaced by pelleted feed of different crud proteins (50%, 45%, 40% & 35%).
- Organized a project meeting at Preah Sihanouk province (29 July– 1 August 2011) for AquaFish CRSP project staff in Cambodia and Vietnam to discuss the progress of each investigation and set up plan, how and who for completing (1). Trip reports for the trips completed in July, August and September; (2). LT & ST training updates for July; (3). Attachment III reports: AquaNews article, outreach document, lesson learnt, successful story/policy paper, and quantifiable benefit statement; (4) 2011 annual report, including LT & ST training updates; and (5) Final technical report.

In Vietnam (CTU)

- Water quality analysis: water quality parameters including temperature, pH, DO, NH^4, NH^3, $NO^{2,}$ and NO^3 were sampled 5 times from each of 6 snakehead earthen ponds in Dong Thap (3 ponds), An Giang (3 ponds) as well as in Can Tho city. 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 Can Tho, 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.
- Atlas of Pathogenic Agents in Snakehead was prepared and disseminated to fish farmers in Dong Thap, An Giang and Can Tho provinces.
- Data analysis and report writing is on-going.

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.

- 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 and 28, 2010 respectively. 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."
- make final report

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.

In this time, after we revised and finalized the 2nd draft of the Fish Paste (Prahoc) Product Technology Development; GMP/GHP code of practice; and Product Standard Development include with the labeling and packaging of products with a good supporting from some experts, FAO in Rome, Italy to consult and help to finalized through conducted one dissemination consultation workshop on August 9, 2011 at Angor Era Hotal, Siem Reap province. The workshop were presided over by H.E. Dr. Nao Thouk, Delegate of the Royal Government of Cambodia in charge of Director general of Fisheries Administration and follow by H.E. Ping Sivlay, Director General (President) of Institute of Standard of Cambodia (ISC), then by H.E. Mao Sovuthy, Vice Governor of Siem Reap province, and last by the expert from the Codex allimentarious with

other representative participants from the all National and sub-national level of Government Authorities such as: 1) Fisheries Administration; 2) from the Directors and Deputy Director or representative staff of the Department of Agriculture Industrial, Department of Agriculture Legislation of Ministry of Agriculture, Forestry and Fisheries; 3) from the Director General, Deputy Director General of ISC and Director of the Certification Department and Director of Standard Department with the International Standard Expert from ISC of Ministry of Industry, Mine and Energy (MIME); 4) some other relevant agencies involving in food safety are the Deputy Director of Food and Drug Department of Ministry of Health; Senior Officer from the Ministry of Commerce (MOC); some provincial authority senior staff and together with the Fermented Fish Paste processors and traders totally around one hundred participants. This workshop objectives were: to disseminate and provided awareness, and consult of the Final Draft of the *Fermented Fish Paste product technology, GMP/GHP code of practice, and product standard development to the stakeholders and the national and international expert.* The workshop even was also disseminate the information through the 3 national mass media (TV) to provide more awareness raising to all public people that now in Cambodia we already started improved our Fermented Fish Paste (Prahoc) quality, safety and market through developing a Product Technology, GMP/GHP Code of Practice, and Product Standard.

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

All surveys and data analysis of the Investigation 5 have been finished. 4 master students and 13 bachelor students graduated while 2 master students and 3 bachelor students are continuing their theses. The success of this investigation is based on a sound scientific research at Can Though University and IFReDI supported by CRSP funds and technical advices from Dr Robert Pomeroy, as well as the collaboration from all groups of chain actors and sector managers.

1. Reviewed related literatures**:** Review of all relevant literature regarding the situation of snakehead value chain in Lower Mekong Basin of Cambodia and Vietnam. Available information related to reproduction, grow-out, trading, processing and sector management of snakeheads in the study sites were collected and reviewed.
2. Orientation within team members**:** A Vietnamese team of 6 members were established in CTU – Vietnam, and another team in Cambodia included 5 members in IFReDI. A set of different forms for data collection were developed by Vietnamese team in CTU and then translated into English for use in Cambodia. These teams conducted all activities for data collection, analysis and report writing.
3. Consultation meeting between investigations**:** This investigation is implemented along with investigations 1& 2 in both IFReDI and CTU. The consultation was made with different team members from two investigations in CTU (1 & 5) and with those in IFReDI (1 & 2) for synchronization of the preparation and implementation of related activities within the same CRSP project. The consultation was 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 CRSP project.

Trip to Shanghai in China**:** The objective of the trip was to attend the AquaFish CRSP Meeting and Asian Fisheries Forum No.9 in 2011. The aims were to discuss the activities related to the remaining tasks including all types of reports for Phase 2 of AquaFish-CRSP project, and to discuss the activities related to training courses on Impact Assessment in Cantho University in April 2011.

Trip to Cambodia**:** To present the results of value chain analysis of cultured snakeheads inVietnam and captured snakeheads inCambodia. To develop AquaNews with Prof. David Bengston and Hap Navy; to develop policy briefs with Hap Navy; to discuss the activities related to all types of reports for AquaFish CRSP project, and the remaining tasks with Prof. David Bengston and other Cambodian and Vietnamese members.

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

There is an increasing conflict between the use of small-sized/low value fish for animals/fish and for human consumption. Supplies of small-sized/low value fish are finite, and as indicated by a recent increase in price, i.e. demand is outstripping supply. 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, etc. Proponents of this suggest small-sized/low value fish as food for poor domestic consumers is more appropriate than supplying fish meal plants for an export income oriented aquaculture industry, producing high value 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 number of people employed in both fishing and aquaculture has this beneficial effect, via income generation, rather than direct food supply.

Significant data and information on the problem, issue, status of stocks, utilization, supply and demand trends and impacts have been collected from other investigations of this project. This has provided a solid foundation for developing management plans and interventions. A series of stakeholder consultations with all relevant government and non-government organizations, research and academic institutions, and the private sector in both Cambodia and Vietnam have been conducted to obtain additional information and to validate findings and recommendations. A desk policy analysis and management recommendation was conducted. A re-analysis of all this data and information and the development of fisheries management recommendations to conserve the biodiversity of freshwater small-sized/ low value fish species in the Lower Mekong region are on-going. Overall the project is progressing according to the schedule of activities.

- Collection, review and analysis of Phase 1 data and information from investigations 07MER01UC (Sinh and Navy), 07MNE01UC (So Nam & Leng Sy Vann), 07SFT01UC (Hien) and 07FSV01UC (So Nam), including the problems, issues, status of stocks, utilization, supply and demand trends and impacts.
- Conducted consultations with (1) provincial government fisheries officers in Kampong Cham, Prey Veng, Kandal, Phnom Penh, Kampong Chnang, Battambang and Siem Reap provinces in Cambodia, (2) non-government staff: WWF, CI, FAO, FACT, CEPA, JICA, DANIDA, IUCN, WCS and MRC, (3) Royal University of Agriculture and Prek Leap National School of Agriculture, and (4) fishing lot owners in order to collect additional information and data and to validate research findings and recommendation for freshwater small-sized fish management in the Cambodia Mekong River basin.
- Started collecting and compiled significant data and information
- Initially re-analyzed all this data and information and (2) initially developed fisheries recommendations to manage the biodiversity of freshwater small-sized fish species in the Lower Mekong region.
- Initially re-analyzed all this data and information and (2) initially developed fisheries recommendations to manage the biodiversity of freshwater small-sized fish species in the Lower Mekong region.
- Conducted training workshop on “Importance and Use of freshwater small-sized fish in the Lower Mekong basin of Cambodia and Vietnam, and policy management development and dialogue for freshwater small-sized fish in the Lower Mekong of Cambodia” on 11-12 May 2011 at Inland Fisheries Research and Development Institute (IFReDI), Phnom Penh, Cambodia.
- Conducted training workshop on “Importance and Use of freshwater small-sized fish in the Lower Mekong basin of Cambodia and Vietnam, and policy management development and dialogue for freshwater small-sized fish in the Lower Mekong of Vietnam” on 8 July 2011 at Can Tho University, Vietnam
- Collection, review and analysis of Phase 2 initial data and information from investigations 09SFT01UC (Hien), 09IND02UC (So Nam), 09TAP03UC (Somany), 09FSV01UC (Sochivi) and 09MER04UC (Sinh)

09FSV03UC - Assessing the Impacts of Sustainable Freshwater Aquaculture Development and Small-Sized/Low-Value Fisheries Management in the Lower Mekong Basin region of Cambodia and Vietnam
The objective of this study is to assess the impact of the investigations in the AquaFish CRSP project "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" on both the private and public sectors of Cambodia and Vietnam. To date, two trainings on impact assessment were conducted by Dr. Boris Bravo-Ureta of the Department of Agricultural and Resource Economics of the University of Connecticut on 28-29 April in Cantho, Vietnam and 3-4 May in Phnom Penh, Cambodia. The focus of the trainings were on methods for conducting agricultural impact assessments, specifically adoption studies and economic studies, to be utilized in the actual impact assessment of the investigations in the larger research project. The training resulted in an understanding of the methods by the participants and a workplan to undertake impact assessment of the investigations in the project. Following the workshop in Cambodia, students and scientists have been assigned to two investigations (09IND02UC and 09MER04UC) of the project to undertake impact assessment. Impact assessment reports are being prepared and presented. In Vietnam, students and faculty of Cantho University are undertaking an impact assessment of investigation 09SFT01UC. This investigation has been given an extension until 31 December 2011.

Cambodia component
Fisheries and aquaculture research generates many types of outputs. These include technologies embodied in a physical object (e.g., improved feed), management tools and practices, information, and improved human resources. Impact assessment is a process of measuring whether or not research has produced its intended effect—that of meeting development objectives, such as increases in production and income and improvements in the sustainability of production systems. Impact assessment to be undertaken in this investigation is of two types: ex- post and concurrent. The ex-post assessment refers to the evaluation made upon the completion of a project to determine achievements and to estimate the impact of research. Four components determine the adoption of a technology: technology traits (e.g. duration, quality, etc.), policy environment (e.g. price support, procurement, etc.), institutional arrangements (e.g. seed supply sector, credit availability, etc.), and infrastructure (e.g. markets, roads, power, clean water, processing facilities, etc.). Through this investigation, students, researchers, scientists and government fisheries officers and officials have been trained in methods to undertake both ex-post and concurrent assessments by Professor Boris E. Bravo-Ureta from University of Connecticut and then Dr. So Nam from IFReDI. Students and scientists have been assigned to two investigations (09IND02UC and 09MER04UC) of the project to undertake impact assessment. Impact assessment reports is being prepared and presented.

- Conducted training workshops on "Assessment of impacts of the ban on snakehead aquaculture in Cambodia" for provincial government officers: Kampong Cham (3-4 January 2011), Prey Veng (6-7 January 2011), Kandal (10-11 January 2011), Phnom Penh (13-14 January 2011), Kampong Chnang (14-15 Feb 2011), Battambang (17-18 Feb 2011) and Siem Reap (24-25 February 2011).
- Organized a training workshop on "Impact Evaluation of Development Project" on 3-4 May at Inland Fisheries Research and Development Institute (Phnom Penh) for students, faculty staff, researchers, scientists, and government fisheries officers and officials.
- Conducted training workshops on "Assessment of impacts of the ban on snakehead aquaculture in Cambodia" and "Impact Evaluation of Development Project" for provincial government officers in Pursat, Kampong Chnang, and Kampong Thom provinces in Cambodia from 5-14 June 2011
- Reviewed compiled and analyzed AquaFish CRSP phase 1 data and information for preparing input and output questionnaires for control experiment and survey studies of all phase 1 investigations to assess research recovery study in cooperation with by Prof. Buccola.
- Completed input and output questionnaire for control experiments and survey studies of all AquaFish CRSP Phase 1 investigations.
- Prepared a brief document describing the baseline system currently being used by farmers in the areas of Cambodia where the snakehead system is being studied (System 1 in the model terminology), and also describing the system using improved practices for snakehead production (System 2 in the model terminology) in cooperation with by John Antle.

- Using survey data collected from farms using System 1, and using data collected from farms using System 2, and other appropriate data, calculated the statistics needed to parameterize the TOA-MD model for systems 1 and 2. Prepared a brief document providing documentation of the survey and other data used. This has implications for impact assessment of snakehead culture in Cambodia, in cooperation with Prof. John Antle.
- Conducted training workshops on "Assessment of impacts of the ban on snakehead aquaculture in Cambodia" and "Impact Evaluation of Development Project" for provincial government officers in Phnom Penh, Kandal, Kampong Cham and Prey Veng from 20-22 July 2011.

Vietnam Component

In Vietnam, students and faculty of Cantho University are undertaking an impact assessment of investigation 09SFT01UC. Assistance has been provided by a MS graduate student, Mr. Justin Grimm-Greenblatt, who spent June and July 2011 at Cantho University helping to collect and analyze data for the impact assessment.

PRESENTATIONS & PUBLICATIONS

Presentations

Title	Author(s)	Type	Event	Location
Assessing Fish Abundance And Impacts Of Deep Pools In The Mekong River, Tonle Sap River And Tributaries Of Tonle Sap Lake, Cambodia	Chan Sokheng, Putrea Solyda & So Nam	Poster	Asian Fisheries and Aquaculture Forum	April 2011 Shanghai, China
Fisheries Resources Management In Cambodia	Chheng Phen & So Nam	Oral		22 April 2011 Shanghai, China
Larval Fish Species Diversity And Abundance In The Mekong And Tonle Sap	Chea Tharith & So Nam	Oral	Asian Fisheries and Aquaculture Forum	22 April 2011 Shanghai, China
Larval Fish Species Diversity And Abundance In The Mekong And Tonle Sap Rivers Near Phnom Penh, Cambodia	Chea Tharith & So Nam	Oral	Asian Fisheries and Aquaculture Forum	22 April 2011 Shanghai, China
Monitoring Fish Abundance And Diversity By Using Local Fishers In The Major Rivers Of Cambodia	Putrea Solyda & So Nam	Oral	Asian Fisheries and Aquaculture Forum	23 April 2011 Shanghai, China
Presentation On "Summary Of Investigations: Development Of Alternatives To The Use Of Freshwater Low Value Fish For Aquaculture In The Lower Mekong River Basin Of Cambodia And Vietnam"	So Nam & Le Xuan Sinh	Oral	AquaFish Project Meeting on Assessing the Impacts of CRSP Research: Human Capital, Research Discovery, and Technology Impact Assessment	Seattle, Washington
Production And Marketing Of Fish Paste (prahoc), A Staple Food In Cambodia	So Nam	Oral	Asian Fisheries and Aquaculture Forum	23 April 2011 Shanghai, China
Progress And Updates Of Investigation # 2 09IND02UC & # 6 09MNE04UC	So Nam	Oral	Cambodia & Vietnam Project Final Meeting	Preah Sihanouk Province, Cambodia

Sustainable Snakehead (C*hanna striata*) Aquaculture Development In Cambodia	So Nam	Oral	AquaFish CRSP Air breathing fish Meeting	18 April 2011 Shanghai, China

Publications

Huynh Cong Minh (2010): Investigation of bacteria pathogen on snakehead fish with red spot disease. *B.Sc. thesis*. University of Can Though, Vietnam

Lu Tri Tai (2010): A studies on common pathogen agents on snakehead fish (*Channa striata*) in intensive pond. *M.Sc. thesis*. University of Can Tho, Vietnam

Pham Minh Duc and Nguyen Thi Thuy Hang (2011). Preliminary study lower fungi (*Achlya* sp.) infection on fingerling of snakehead fish (*Channa striata*) cultured in dong thap province. *National Journal of Agriculture and Rural Development (18 June 2011)*

Sann Long (2011). Semi-artificial breeding of the murrel snakehead (*Channa striata*) in Cambodia. *BS.C. thesis*. Inland Fisheries Research and Development Institute and Royal University of Agriculture, Phnom Penh, Cambodia.

Tran Thi Thanh Hien, Ngo Minh Dung, Bui Minh Tam (2011). Weaning methods for artificial food in rearing snakehead murrel (*Channa striata*) larvae. Proceedings of the 4 th Aquaculture and fisheries Conference. Agricultural publisher.

Technical Paper on: "Fermented Fish Paste (Prahoc) Product Technology Development, GMP/GHP Code of Practice, and Product Standard Development. **Dr. Kao Sochivi**, Deputy Director General of Fisheries Administration in charge of: Department of Fisheries Post-Harvest, Technology and Quality (DFPTQ)- Inland Fisheries Research and Development Institute (IFReDI)- Focal Point for Climate Change in Fisheries- One Village One Fisheries Product/Service (FOVOP)- Vice Chief of Women Association; **Mr. Chan Sopha**, Deputy Director General of Institute of Standard of Cambodia, MIME; **Mr. Som No**, Deputy Director of Certification of ISC, MIME; **Mr. Nouv Buntha**, Senoir Officer of Department of Fisheries Post-Harvest Technology and Quality

Visiting a snakehead broodstock facility in Vietnam (Photo by Le Xuan Sinh)

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 Hawai'i 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

University of Hawai'i at Hilo
Maria **Haws** - US Lead Project PI
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William **Steiner** - US Investigator
Sharon **Ziegler-Chong** - US Investigator

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Omar **Calvario Martinez** - HC Co-PI

CIDEA-UCA, Nicaragua
Osejo **Baca** - HC Investigator
Eufrecia Cristina **Balladares** - HC Investigator
Juan Ramon **Bravo** - HC Investigator
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Nelvia **Hernandez del Socorro** - HC Investigator
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Miguel Angel **Sanchez Rodriguez** - HC Investigator
Olga **Zamudio Armenta** - 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

During 2011, hatchery and microalgae laboratory facilities were set-up at the marine sciences research facilty of UAS in Mazatlan, Sinaloa. These facilities will extremely useful not only for production of eye-larvae, but also for student training and research by faculty. Broodstock were obtained from different sources in Sinaloa and Nayarit. Conditioning methods were tested and a combination of a microalgae diet and corn/rice flour proved to be the most successful in producing ripe broodstock. A small collection of broodstock has also been established in the ocean near the marine laboratory. Microalgae culture has been successfully established in sufficient volume and quality for larval feeds. Two spawns from *Crassostrea corteziensis* were conducted in 2011, and larval rearing has proceeded to the third week. Unfortunately larvae have not survived beyond this point to the metamorphosis stage, but a third spawn is presently being conducted. Review and diagnosis of the past spawns suggests that hygene may be responsible for causing contamination by protozoans resulting in larval mortality. Three students are conducting their thesis research as part of this investigation.

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

The stock assessment study for *Dormitator latifrons* ("chame") began in January 2011. Initial reconnaissance was conducted in January and February to locate populations of chame and to assess where they are being fished. Sampling has been conducted on a monthly basis since January in the states of Sinaloa and Nayarit. Size and weight are recorded, and gonads, scales and otoliths are taken monthly. To date, 270 samples have been processed and analyzed. Preliminary data will be reported in september in lieu of the final technical report as this study requires a year long period of sampling, which will be completed in December 2011. The final technical report will be issued in January 2012. Three UAS students are involved in this work.

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

Reproduction of Pacific fat sleeper "chame" (*Dormitator latifrons*) under captive conditions has been achieved by the use of gonadotropin releasing hormones either by injection or implantation. Work continues related to the manipulation of temperature, salinity and the use gonadotropins (Carp pituitary extract and human chorionic gonadotropin). Results indicate that females produce 50-80000 oocytes per gram of spawn, with fertilization only at low salinities (0-5 ppt) as conditions for sperm activation and there is no hatching above 12 ppt as incubation conditions. At present, a series of experiments with different sources of live and artificial feeds in combination with different salinity gradients are been carried out to elucidate the conditions for optimal larval fish growth and survival.

09HHI01UH - Co-management and bivalve sanitation for black cockles (*Anadara* spp.) in Nicaragua

This investigation has been nearly completed. To date, regular monitoring of population densities and cockles sizes have been monitored at four no-take areas, four adjacent areas and six points in the Aserradores Estuary that were originally established for baseline data collection in 2006. The final monitoring is being conducted on August 30 and 31, with the data analysis to follow and to be included in the final technical report. The community and cockle collectors continue to support the no-take areas and have been highly successful in excluding cockles collectors from the immediate community and intruders. They also work with researchers to conduct the monitoring and to re-install boundary markers on the no-take areas as required. The boundary markers were most recently re-installed in July 2011.

CIDEA also continues to work with the Aserradores community, other coastal communities and government agencies such as MARENA (Ministry of the Environment and Natural Resources), the Muncipality, the University of Nicaragua in Leon, the Project "Mangrove Corridor", the NGO's "Leader" and "FUNDAR" and representatives of the cockle collector cooperatives and individual cockle collectors to present the successful outcomes of the community-managed no-take areas to other communities. The government is now testing this system in two other communities as a possible alternative to the current management methods which is a 4 month closed season. Research has shown that the closed season is highly ineffective, and in fact, the months of April-July when the season is closed, have high volumes of cockle harvest (coinciding with seasonal increases in demand).

CIDEA is also continues to work on related issues such as improving cockle sanitation. CIDEA personnel worked with INPESCA (the fisheries agency), FUNDAR and others to conduct a survey of the cockle resource and utilization along the entire Nicaraguan coast. Most recently, the final consultation process for development of the National Strategy to Support the Cockle Sector was completed with participation by CIDEA.

09HHI02UH - Capacity building in aquaculture, fisheries management and coastal management for coastal women. Workshop: Opportunities for Coastal Women in Fisheries, Aquaculture and Coastal Management

The first of two regional workshops was held in Nicaragua on July 26-27, 2011 was held in Chinandega. Ninety three particpants attended, including 24 from El Salvador representing women's cockle collecting

cooperatives. Ms. Lorena Camacho (Sociologist) from the Mexico team attended to present the Mexico experiences with shellfish sanitation, management and research. The event was widely publicized in local newspapers. A video has been made of the event including instructional material on sanitation. This has been distributed widely in the cockle collecting communities.

The workshop in Mexico was held in early September 2011.

09IND08UH - Effects of environmental conditions on gills and gas bladder development in bimodal-breathers, gar (*Lepisosteus sp*.), pirarucu (*Arapaima gigas*) and bowfin (*Amia calva*).
Subcontracts are currently pending final signatures. No results to report.

PRESENTATIONS & PUBLICATIONS

Presentations

Title	Author(s)	Type	Event	Location
Applying Good Management Practices In Aquaculture	Nelvia Hernandez	Oral	MAGFOR meeting	Chinandega, Nicaragua
Bacteriological Quality In Shellfish Waters And Tissues (Anadara Spp.)	UCA Team	Oral	8th Scientific Conference of the Central Nicaraguan University- "Incentivizing science and technology for development during changing times"	Managua, Nicaragua
Contributions by CIDEA	Nelvia Hernandez, Erick Sandoval, Juan Ramon Bravo	Oral	Definitions of indicators of the national system of quality under the trade support program PACE-BID/2244BL-NI	Managua, Nicaragua
Contributions By CIDEA	Nelvia Hernandez, Erick Sandoval, Juan Ramon Bravo	Oral	Revision of the regulation ISO 17021 "Evaluation of the compliance and requirements for the institutions that conduct auditing and certification for developing systems"	Managua, Nicaragua
Governance For Sustainable Resource Use In Coastal Ecosystems	UCA Team	Oral	First Departmental Forum on Sovereignty and Food Security	Managua, Nicaragua
Governance For Sustainable Uses In Coastal Ecosystems	Nelvia Hernandez	Oral	Friends of the San Juan River Foundation	San Juan, Nicaragua
Improvement Of Growth And Survival In Hatchery-produced Larvae Of Pacific Fat Sleeper Dormitator Latifrons	Armando García-ortega, Gustavo Rodríguez-montes De Oca, José Roman-reyes, Guillermo Rodríguez-dominguez, Maria Haws	Oral	CRSP Airbreathing Fishes	Shanghai, China

National Representation On Mollusk Fishing and Management	Uca Team	Oral	Regional conference on the fishing and management of mollusks	San Salvador, El Salvador
Preliminary Evaluation Of Lhrha For Use In The Reproduction Of Puyeque *Dormitator latifrons*	Gustavo Rodriguez	Oral	17th National Science and Technology Week Workshop	Mazatlan, Mexico
Production Of Larval Puyeque *Dormitator latifrons*	Gustavo Rodriguez	Oral	Scientific, Technical and Social Research at UAS	Culiacan, Mexico

Publications

Haws, M.C. and P. Pascua. (submitted July 26, 2011). Abundance of *Ruditapes philippinarum* (Adam and Reeve) and *Tellina (Quidnipagus) palatum* (Iredale, 1929) at two sites in Kāne`ohe Bay, O`ahu, Hawai`i. Aquaculture Research. *Note: although this work was not directly funded by CRSP, one of the students partially funded by CRSP was inspired by her CRSP participation to assist with this research.*

Haws, M.C., E. Sandoval, N. Hernandez, L. Arias, E. Balladares, J. Bravo, C. Rivas, M. Montserrat and G. Laeiva. (Submitted August 18, 2011). Depuration of black cockles (*Anadara similis* and *A. tuberculosa*) in the field and laboratory to reduce the incidence of shellfish-borne diseases in Latin America. Journal of the World Aquaculture Society.

Haws, M., E. Sandoval, N. Hernandez, J.R. Bravo and C. Rivas. (submitted Sept. 6, 2011). Marketing channels and value-added opportunities for black cockles (*Anadara tuberculosa* and *A. similis*) in Nicaragua. Marine Resource Economics.

Rodriguez-Montes de Oca, G.A., E.A. Medina Hernandez, J. Velasquez Sandoval, V.V. Lopez Lopez, K. Dabrowski and M.C. Haws. (submitted June 2011). Advances on Chame (*Dormitator latifrons*) larvae production for aquaculture. Revista Columbiana de Cienca Pecuaria.

Cockles in Nicaragua (Photo by Nelvia Hernandez)

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.

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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 in this study. The first one is on station at the Institute of Agriculture and Animal Science (IAAS), Rampur; and the second is an on-farm experiment at farmers' ponds. Experiment 1 has 4 treatments with 3 replicates and was conducted in 12 earthen ponds of 100 m^2 size at IAAS, Rampur, Chitwan. Experiment 1 began on 15 July 2010, but there was a problem of flooding in four ponds during early September. At the same time, two ponds had problems with theft. All ponds were drained and checked for fish remaining in the ponds in mid October. After evaluating the number of fish present in ponds, we decided to terminate the experiment. The experiment has been restarted and fingerlings of all proposed species (six species of carps, tilapia, and sahar) were stocked on 25February 2011. Regular water quality parameters and growth sampling are ongoing. The experiment was completed on August 25, 2011. The second experiment (on-farm) will be conducted in farmers' ponds and will be started in September 2011, since it depends on the results of the first experiment.

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

From 29 March 2010, two 0.3-ha earthen ponds were used for the pond-based recirculating system of shrimp culture at Haoshideng shrimp farm. Another two ponds were used as a control group. Water in the control group was not recirculated, but was exchanged as needed throughout the growing period. A total of 300,000 post-larval whiteleg shrimp were stocked in each pond. For comparison of water quality parameters in recirculating and closed, non-recirculating shrimp culture ponds, water quality in each pond was analyzed biweekly. For comparison of overall production performance, we recorded the amount of feed eaten and the body weight of shrimp biweekly.

The shrimp from experimental ponds were harvested 18 July 2010. Results indicated that the suspended organic particles were removed effectively from the drum filter and foam separator. Comparing the water quality of inlet and outlet, the water recirculating system reduced chemical oxygen demand (COD) by 3.5%-7.2%, total ammonia nitrogen by 12.05%-19.60%, and dissolved oxygen was increased by 29.3%-48.7%. By comparing the shrimp growth rate in treatment ponds and control ponds, we found that shrimp grow a little slower, but the survival rate and the production was somewhat higher in the treatment ponds. Although there was no water exchange in treatment ponds, water quality was stable and shrimp growth normal.

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

This project was slow in starting, mainly due to problems getting the funds transferred from Shanghai Ocean University to Bangladesh Agricultural University. Research in both on-station and on-farm has been planned and the on-station experiment is underway. The best treatment of the first experiment will be used as control and some four more treatments will be tried. The protocol for this year's research is being prepared. The starting time of this year's research was 1 May 2011, and harvests for the on-station experiment will be in August 2011.

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. One is a collection of samples of red swamp crayfish. Collections in 38 sampling sites from Chongqin, Anhui, Hubei, Hunan, Jiangsu, Jiangxi, Shanghai, and Zhejiang provinces have been performed. So far, collections have basically been completed in China. In order to better evaluate and understand the sources, extent, and routes of this crayfish in China, six sampling sites including Louisiana, Texas, Florida, California, Kentucky, and Pennsylvania (USA) and one site from Saitamaken, Japan have been chosen, and the collection works are almost completed.

The second experiment is an evaluation of genetic structures of different red swamp crayfish populations. DNA extractions have been conducted. Two kinds of markers, microsatellites (SSR) and D-loop, are used in this study. A total of 34 microsatellite primers have been synthesized. Results of polymorphism analysis of these microsatellites have shown that 21 microsatellites are polymorphic. SSR genotyping of all the crayfish sampled have been obtained. D-loop sequencing has been performed. The red swamp crayfish invasion in China appears to have originated in the Shanghai area and expanded in China in a form that indicates aquaculture systems aided in the dispersal.

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

For shrimp research during this quarter, we prepared for *Litopenaeus vannamei* culture by importing 6.2 million post-larvae from Hainan on June 17 and June 19to the shrimp nursery in ponds in a greenhouse. Salinity of water was decreased from 25‰ to fresh water. The larvae were transferred to 40 ponds around June 27, and harvest will occur in September 2011.

For microcystins research during this quarter, juvenile shrimp were exposed to different densities of *Microcystis aeruginosa*, and the survival rates were analyzed according to *Microcystis* density and exposure time. The enzyme activity, phagocytosis ratio, and phagocytosis index of the haemocytes of *Litopenaeus vannamei* exposing to standard microcystin-LR are under testing. However, due to the low survival rate of the shrimp *Litopenaeus vannamei* under laboratory systems, we chose prawn *Macrobrachium rosenbergii and* crayfish *Procambarus clarkii* as substitutes for *Microcystis* exposure.

Three independent experiments were conducted to investigate the impacts of *M. aeruginosa* on the survival, growth of *M. rosenbergii*. (1) Juvenile prawns *M.rosenbergii* (10.33±1.44mm in body length) were exposed to different concentrations of *M. aerugrinosa* (0, 1×10^6, 5×10^6, 10×10^6, 20×10^6, 30×10^6cell/ml). The results showed that *M. aeruginosa* had a negative effect on the survival of the juvenile shrimp and the LD50s of *M. aeruginosa* at 144 and 168h were 36.08×10^6 and 28.81×10^6 cell/ml, respectively. (2) When exposed to *M. aeruginosa* at 0, 2×10^6, 10×10^6cell/ml for 80d, growth rate of prawns in cultures at 2×10^6 and 10×10^6cell/ml were slower compared to the control ($P<0.05$). (3) *M.rosenbergii* were stocked to different concentrations of *M. aerugrinosa* for 28d and tissues from the prawns (hepatopancreas, muscle, eyestalk, heart, stomach, intestine and gill) were sampled and evaluated using the HPLC/MS method for the accumulation of microcystins. The result showed no accumulation of MCs in those tissues, which indicated that toxic MCs were not the cause of death for shrimp. Further studies are needed to investigate the mechanisms of lethal effect of *M. aeruginosa* on juvenile prawn *M.rosenbergii*.

Larvae of crayfish *Procambarus clarkii* were also exposed to different concentrations of *M. aeruginosa* to investigate their impacts on survival and hepatopancreas ultrastructure of the crayfish. At the same time, adult crayfish were exposed to different concentrations of *Microcystis aeruginosa* and the 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 filament were detected. The results indicated that *Microcystis aeruginosa* has a negative impact on the survival of juvenile crayfish and affects immunity of adult crayfish, which may cause decline in their production.

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

For the mass balance-modeling component, one intensive shrimp farm with 6 ponds (about 5 mu/pond, 1 mu=667 m^2) and one semi-intensive shrimp farm with 6 ponds (15 mu/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 a density of 100,000 PL/mu in intensive ponds and 20,000 PL/mu in semi-intensive ponds. Commercial feed was used as the main source of nutrients for each farm. Average feed conversion ratio (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 pond over time. Differential equations for N, P, and C dynamics will be formulated based on mass balance and nutrient rates. 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. Related data (biweekly records of water quality parameters and management) were collected in November 2010, and analysis is expected to be completed by fall 2011.

For the economic performance component, 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 on Hainan Island, including intensive, semi-intensive, and polyculture. To better understand the differences of each type, they were further divided into four groups: intensive commercial, intensive family, semi-intensive family, and polyculture of shrimp and grouper. Fifteen farms of each type at different scales were selected, and interviews were conducted from late August-November 2010. This economic analysis will assess production costs and system profitability under different management strategies to determine how stocking density, farm size, and disease affects profitability. This analysis is expected to be finished in summer 2011.

For the social analysis component, another two sets of questionnaires regarding farmers' quality of life and the potential 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 from August-November 2010. This component will examine if the quality of life for farmers has improved since shrimp aquaculture began, and explore farmers' attitudes on effluent treatment. This analysis is also expected to be completed by summer 2011.

09BMA06UM - Identifying best practices to improve the giant river prawn industry in Thailand
In 2005, the University of Michigan project conducted surveys of prawn farming in Thailand, with intent to understand the environmental impact (Schwantes et al. 2009). The end results showed that prawn farming was lucrative for farmers, but there were major concerns about eutrophication of water sources, overuse of feed, and other environmental impacts symptomatic of over-intensity of prawn production. As a follow-up to that evaluation, this August, we brought together a group of managers and farmers and planned to review the status of prawn farming and educate them on how to minimize the environmental impacts from farming practices. As the workshop progressed, we were surprised to find that prawn farming had changed dramatically over the past six years. The typical prawn farmer had significantly reduced stocking density, tended to use no exchange water systems for production, and reduced total yield while achieving a higher standard product from the grow-out systems. As a result, the concerns about eutrophication and overfeeding had largely disappeared over that six-year period.

To our surprise, prawn farmers in Thailand had willingly changed their practices to a very substantial degree. In 2005, 96% of all farmers practiced intensive monoculture. While we were unable to conduct a similar survey with statistical methodology in the 2011 workshop, reports at the workshop indicated that 80% of farmers today used polyculture instead. The common polyculture was with *Macrobrachium* (about 6 pieces per square meter) and white shrimp *Litopenaeus vannamei* (about 12 pieces per square meter) in fresh water. This is in comparison with monoculture of prawns, which was done at about 40 pieces per square meter; so effectively, the overall density had decreased by at least one-half. Similarly, in 2005, feeds were often handmade and were of low quality with many fine particles, while in polyculture, commercial feeds were used, which are controlled more regularly. Feeding rates are now evaluated using feeding trays. Water exchange in 2005 was about 60% per pond per week, while currently, water is exchanged at a much lower rate, and most of that water is retained. These changes have occurred in part because of the adoption of the

GAP standards for shrimp and applying them to prawns, and in part because of the move by the Thai Department of Fisheries to help farmers become more environmentally aware, as well as more profitable. In the new aquaculture system, most farmers rely on freshwater culture of white shrimp at low density for their basic income, and then the culture of prawn at even lower densities of prawns for supplementing their income because of the high market value.

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, four master's students have been selected to carry out their thesis during the project. The reservoirs include three without stocked fish (Bau Um, Suoi Lai, and Hung Phu Reservoirs in Binh Phuoc Province) and five with aquaculture practices (Dong Xoai and Sa Cat Reservoirs in Binh Phuoc Province, and Cau Moi, Da Ton, and Gia Ui Reservoirs in Dong Nai Province). The surveys have been conducted since August 2010 to estimate the total catch and fish species composition at studied reservoirs. Bi-monthly field sampling has also been carried out at Cau Moi Reservoir since July 2010 and Bau Um Reservoir since August 2010 to measure water quality and estimate the biomass (in dry weight) of natural food chains, including phytoplankton, zooplankton, benthos, detritus, terrestrial plants, and the main fish species groups. Sampling was completed on 19 June 2011. Analysis of data and samples should take another three weeks. Ecopath 5.0 and SWAT models will be used to evaluate the stocking rate and fisheries carrying capacity for each reservoir and the impact of environment to aquaculture.

09MNE06UM - Evaluating the relationship between semi-intensive aquaculture and natural biodiversity

The symposium is scheduled for September 2011 at the annual American Fisheries Society meeting in Seattle. We have commitments from 12 speakers, all abstracts for the talks have been submitted, and the draft manuscripts are due August 1. We also have a commitment from the North American Journal of Aquaculture to publish the proceedings.

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

This study assessed the impacts of improved commercial freshwater aquaculture cages designed to reduce nutrient waste inputs into the 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 *Ictalurus punctatus* and also feature an outer cage stocked with bighead carp *Hypophthalmichthys nobilis,* common carp *Cyprinus carpio*, and tilapia *Oreochromis niloticus* that feed off the plankton in the water column and improve water quality around the cages. The experiment began in May 2010, and data collection continued until December 2010. Fish weight and length were measured monthly to establish growth rates. Fish carcasses, feces, and fish feed were analyzed to determine the percent phosphorus. 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. Phytoplankton and zooplankton were also monitored in Longtan Reservoir. Water samples were collected inside each cage and 1m outside the cages at depths of 0.5, 5, and 15m. Additional samples were collected 1km upstream and downstream of the cages, as well as in the bay in which the cages are located. These samples were used to determine the background levels of phosphorus in the reservoir, independent of the experimental cages. The fish were harvested in December 2010, and data will be input into a mass balance model and final results created in 2011.

There were 122 species of phytoplankton, which belonged to 49 genera and 7 phyla. The most dominant species of phytoplankton in the reservoir were *Cyclotella comensis, Cyclotella stelligera, Navicula exigua, Scendesmus bjjuga, Trionema minus, Merismopedia tenuissima, Crptomonas ovate, Chlorella minimum, Crucigenia rectangularis*. Also there were 92 species of zooplankton including 26 Protozoans, 43 Rotifers, 14 Cladocerans and 9 Copepods. The predominant species were mainly *Keratella cochlearis, Brachionus falcatus, Dicranophorus caudatus, Bosmina coregoni*, and *Paracyclops fimbriatus*.

There were no significant differences between the surface and bottom water quality in cages. Water temperature ranged from 19.5 to 30.7°C, pH from 7.99 to 8.80, and DO from 4.76 to 8.71 mg/L from June to December 2010. Ammonia (NH^4-N) and nitrite (NO^2-N) accounted for a small proportion of the total inorganic nitrogen (TIN),while nitrate (NO3-N) accounted for not only the main part of TIN, but also a major component of total nitrogen (TN). The experimental cage improved FCR and reduced the amount of food residue. During the growth period, 2.7 t dry weight of waste was collected, which inhibited water eutrophication. The feces collected contained 2.93% crude protein, 0.29%TP, and 0.47% TN. There were no significant differences among water quality of traditional or experimental cages.

Longtan Reservoir was phosphorus limited. The content of chlorophyll a showed a significantly positive correlation with TN. There were no significant differences in TN and TP between water from experimental cage and the reservoir.

09SFT07UM - Sustainable feed and improved stocking densities for gar (*Atractosteus* spp.) culture. Two experiments were proposed for this study. The first experiment investigates multiple treatments of fish-meal substitution (using animal by-products in place of fish meal at 0, 25, 50, 75, 100% substitution) in feed for two species of *Atractosteus* gars, the Cuban gar (*A. tristoechus*) and tropical gar (*A. tropicus*). The experiment using Cuban gars would take place at the University of Michigan (U-M), United States, and the experiment using tropical gars at Universidad Juarez Autonoma de Tabasco (UJAT) in Tabasco, Mexico. The second experiment investigates improved stocking densities of tropical gars and would take place in Tabasco only. Stocking density treatments will be 25, 50, and 100 fish/m^3.

Cuban gars (~13-15 cm) were acquired through multiple shipments during March-June 2011 and were pellet-trained for experimental trials from June-August 2011. An initial feeding trial using live feed (fathead minnows, *Pimephales promelas*) was run for 52 days to establish a baseline for growth rate at 0% fishmeal substitution. The pilot study used 4 replicates each with 3 gars in experimental aquaria. Individuals fed ad libitum on live fish increased in weight by 440% over the experimental period. Cuban gars (N = 45) are currently prepared for experimental trials at U-M that will begin in 1-2 weeks upon arrival of appropriate experimental feed from UJAT.

Aquacultured tropical gars were acquired by UJAT and pellet trained for feeding experiments. We are currently awaiting funds to arrive (from U-M to UJAT) for production of the appropriate feed to be used in both Cuban gar and tropical gar experiments. Upon receipt of funds, feeding trials will commence on both species at their respective locations. Improved stocking density experiments will also begin at UJAT upon receipt of funds.

PRESENTATIONS & PUBLICATIONS

Presentations

Title	Author(s)	Type	Event	Location
Aquaculture and Fisheries Education in Nepal	Madhav Shrestha	Oral	9th Asian Fisheries Forum	Shanghai, China
Growth Assessment of Asaila Schizothorax Plagiostomus Under Captive Conditions	Madhav Shrestha	Oral	9th Asian Fisheries Forum	Shanghai, China
Impacts of the Introduction of Alien Tilapias (*oreochromis* Spp.) on the Fisheries and Biodiversity Of Indigenous Species in Tri An Reservoir, Vietnam	Le Thanh Hung	Oral	9th Asian Fisheries Forum	Shanghai, China
Status and Sustainability Analysis of the Tilapia Aquaculture in China	Liu Liping	Oral	9th Asian Fisheries Forum	Shanghai, China
The Application of Water Recirculating Systems in Intensive Shrimp Culture	Lai Qiuming	Oral	9th Asian Fisheries Forum	Shanghai, China

The Shrimp Farming Situation and Culture Technique in China.	Lai Qiuming	Oral	Tropical Ocean Industry Development for Developing Countries	Hainan, China

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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 Project PI

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

*Currently at OSU

INVESTIGATION PROGRESS REPORTS

Printed as submitted by Steve Buccola, US Lead PI

09BMA07OR - Assessment of AquaFish CRSP Discoveries Annual Report, FY 2011

This Investigation #1 of the AquaFish Research Discovery and Impact Assessment Project is closely connected with the associated study under the AquaFish Synthesis Project. The latter focuses on a quantitative assessment of 2007 – 2009 AquaFish research and training investigations. The present investigation focuses instead on a quantitative assessment of 2009 – 20011 AquaFish research and on training investigations, and on developing a brief case study for each of the seven AquaFish projects. In both the Synthesis Project and Investigation #1, the quantitative assessment follows the same models and procedures.

Quantitative assessment of AquaFish research investigations employs a statistical model of the manner in which research inputs such as money, human capital, infrastructure, and management affect research output – that is the amount of knowledge gained from the research. A Bayesian approach is used to measure knowledge output: the knowledge produced from a given experimental treatment or survey question is the difference between the expected utility of employing *pre*-research information when making a management or marketing decision, and the expected utility of employing *post*-research information in that decision. The Bayesian theory behind this approach, including an examination of the loss functions that it utilizes, is provided in the project proposal.

1. The springboard for Investigation #1's activities this year was the October 4 – 7 Project Meeting in Seattle, at which: (i) our seven main host-country AquaFish collaborators for the quantitative-modeling parts of the Investigation were identified; (ii) bugs were eliminated in the research Input and Output questionnaires developed for eliciting the research inputs and outputs; and (iii) an administrative structure was formulated through which the contractors would obtain, and forward to us, the necessary data from the key AquaFish individuals directly responsible for conducting and completing the research investigations.

   Personal services contracts were drawn up with these seven individuals, one in each of AquaFish's seven projects. The contracts, which stipulateed each contractor's deliverables, reporting schedule, and compensation, were reviewed and implemented though the CRSP Management Office. The seven contractors are, by U.S. project university: Steve Amisah (Purdue), Gertrude Atukunda (Auburn), Remedios Bolivar (North Carolina State), Wilfrido Contreras (Arizona), Gao Zexia (Michigan), Eladio Gaxiola (Hawai'i), and So Nam (Connecticut).

2. The early part of FY 2011 was devoted mostly to improving aspects of the quantitative model. Research outcomes such as feed conversion rates were normalized on their mean to enable comparability across the twenty-five 2009 - 2011 research investigations. To construct the relevant loss functions, a format was drawn up for numerical integration of an outcome observation's density functions. Simulations of likely data structures confirmed the superior properties of these improvements.
3. Much of the Investigation #1 effort this year consisted in collecting the Input and Output data discussed in item No. 1 above. The Input questionnaire elicits data on each investigation's human capital (FTE by educational level); travel distances, transportation modes, and road conditions from station to work sites; FTEs and human capital of such study collaborators as fish farmers and traders; and other factors hypothesized to influence the investigation's knowledge outputs. For statistical-survey-type studies, the Output questionnaire elicits the principal survey questions asked in the survey, the scientist's prior probabilities of alternative answers to those questions, and the means and standard deviations of the subsequent survey answers themselves. For experiment-type investigations, the Output questionnaire elicits information about each experimental treatment and each type of treatment outcome (mortality rate, feed conversion, growth rate, etc.) in each investigation. It then elicits, for each such observation, the scientist's prior probabilities of alternative outcomes and the subsequent ANOVA means and standard deviations, along with allied information on sample size and experimental equipment.
4. The AquaFish individual responsible for completing the research investigation's Input and Output questionnaire, and forwarding it to us by way of the Personal Services contractor in that project, was the one identified as the key researcher in that investigation. About half of our work this year was in collecting these research input and output data from the key AquaFish individuals. We examined the data as it arrived, often asking for clarifications or re-workings of parts of it. Relationships between output and input data also were compared across investigations to check for approximate consistency.
5. Some of the quantitative data were collected in the course of the workshop conducted by this project on 18 April 2011 in conjunction with the AquaFish's Shanghai Annual Meeting. Our personal-service contractors and several other key AquaFish individuals attended. Following a brief overview of quantitative modeling issues, the ¾-day workshop consisted entirely of one-on-one conversations with these individuals on data-development problems. By the end of that workshop, we had collected in good order approximately one-third of the data potentially available from the 2009 – 2011 investigations and all the data from the 2007 – 2009 investigations. Unfortunately, little additional 2009 – 2011 data had arrived by 25 August 2011. This partly may be due to vacation schedules, but partly because many 2009 – 2011 AquaFish research studies had not yet been completed by late August. Renewed efforts to collect the remaining 2009 – 2011 data were initiated in mid-August.
6. The Phase 2009 – 2011 data so far collected, along with the now fully-collected 2007 – 2009 data, were used to develop preliminary estimates of research input-output relationships. The estimates were used to provide an early look at coefficient signs and robustness, allowing adjustments in how certain input variables are modeled. Within-investigation sample variation in input variables was initially found to be inadequate. This was solved by identifying new control variables, such as categories of investigation outcomes, that vary within investigations. Substantial progress also was made in solving problems connected with the right-skewness of the Bayesian knowledge measure's density function when quadratic loss functions are employed. Two solutions were to: (i) use log transformations of the quadratic-loss-based knowledge measure; and (ii) use a knowledge measure based on mean-absolute-difference forms of the loss function. Our estimates of research input-output relationships are correspondingly improving.
7. Analysis also has proceeded of the input-output relationships in AquaFish's training-type investigations. Most of the data for such analysis has been obtained from AquaFish proposals and quarterly and annual reports. These data are far sparser than those from AquaFish's research-type investigations. They consist primarily of the number of individuals trained and the number of hours per trainee; some information on the type of trainee and the distance the trainers had to travel to the

training site; and of AquaFish, U.S. institution, and Host-Country institution expenditures. On most of these variables, only one observation is available per investigation, even when several workshops had been held during the two-year period. Given that data poverty, we have elected to use non-parametric methods of input-output analysis for the training-type investigations. Approximately one-half the necessary data had been collected by 25 August 2011, and preparations were being made to conduct the non-parametric analysis.

8. The case-study analyses also are well underway. The seven investigations targeted for a case study have been identified in consultation with the US PI, host-country PIs, and key investigation individuals. A template and approximate length has been drawn up for each case study. Much of the information demanded by the template have been collected from the investigation's proposal and from its subsequent quarterly and annual reports. For the remaining information, a questionnaire has been developed and is now being sent for enumeration to the investigation's key individual.

09TAP05OR-Assessment of AquaFish CRSP Technology Adoption and Impact

Impact assessments were further developed for three projects: Cambodia (collaborator, So Nam), China (collaborator, Zexia Gao), and Vietnam (collaborator, Le Xuan Sinh). According to the personal service contracts set up in late 2010, these collaborators were to deliver Task 1 (description of systems to be evaluated, March 1) and data for the base systems (April 1). Zexia Gao delivered the results from Tasks 1 and 2 on schedule; reports from Nam and Sinh were not received on schedule despite reminders that their reports were overdue. Le Xuan Sinh delivered the Task 1 report and some data on April 15, too late to be reviewed by Antle or Valdivia before the April 18 project meeting; So Nam did not deliver Task 1 but provided some data on April 15, but with inadequate documentation and too late to be reviewed by Antle or Valdivia before the Shanghai project meeting on April 18.

At the April 18 project, the following activities were carried out:

a. Impact assessment methods were reviewed, and investigators were asked if any new data were available that could be used for IA studies. None were identified.
b. Data provided by Gao, So Nam and Sinh were reviewed and discussed. Key points were:
   -- China
      i. Define components of variable, fixed cost
      ii. Identify variables for environmental indicator(s)
      iii. Define size of populations (area) in each stratum
      iv. Need to re-construct statistics for the model
   -- Vietnam
      v. Need more observations on farms without/with pellet feeding
      vi. Need non-aquaculture income data
      vii. Define size of populations (area) in each stratum
   -- Cambodia
      viii. Need to re-construct statistics for model based on small, large farm stratification
      ix. Define size of populations (area) in each stratum
c. We discussed the need to identify a journal for publication of each of the case studies, prepare an outline, identify parts for members of the team to complete.
d. Unfortunately, at the end of the meeting, both So Nam and Sinh indicated that they did not have any time available to do any more work on data preparation. Antle indicated that a relatively small amount of time would be needed to carry out additional statistical analysis that was needed, and offered to do the work with them in Shanghai. However, they both indicated that they did not have the data with them and that it would not be possible to do any further work for the Impact Assessment project.
e. Gao agreed to provide more information about issues identified with the data she had provided before the April 18 meeting. Subsequently, Gao provided several new versions of data, but upon reviewing these data, Antle and Valdivia determined that there were apparent definitional problems and inconsistencies with the data. With the assistance of OSU graduate student Lin Qin, many additional attempts were made to rectify the data problems. After many further interactions with Gao during May,

June and July, it was not possible to obtain data that were adequate to carry out the impact assessment. In late July, the IA team were able to review the original survey data and ascertain that the survey methods were fatally flawed; most notably, many of the responses were erroneous, and the Chinese collaborators were not able to explain inconsistencies in the data. Further details are provided in the Final Report of this Investigation.

1. A paper was prepared for the 9AFAF conference in Shanghai on impact assessment methods for aquaculture systems, and was submitted February 1, 2011. The paper was presented at the conference in April in Shanghai, and is available on-line at tradeoffs.oregonstate.edu along with the PPT presentation.
2. Antle and Valdivia investigated methods for linking the TOA-MD model with DREAM. At the April 18 meeting, Antle and Valdivia discussed data requirements for market equilibrium analysis with the collaborators from Cambodia, China and Vietnam. OSU Graduate student Xiaojuan Jheng reviewed methods for market surplus analysis using the DREAM model, and searched for possible data to implement market surplus analysis for the Chinese provinces where TOA-MD analysis was planned. Gao was unable to provide any information. Jheng carried out a literature and data search but did not identify any suitable data.

09TAP06OR- Project Planning Meeting on AquaFish Technology Discovery and Impact Assessment
A Project Meeting of AquaFish host-country investigators interested in participating in the "Assessing the Impacts of CRSP Research" Project was held October 4 – 7, 2010 in Seattle, Washington. The objectives of the Meeting were to review procedures for research discovery and impact assessment, begin applying those procedures to AquaFish investigations, and make plans for completing the assessments by the end of the 2009 – 2011 AquaFish cycle. The Meeting was designed to tie in with our San Diego Workshop held on 1 March 2010, and our planned concluding Workshop in Shanghai in April 2011.

Each AquaFish project was represented by two host-country investigators. Host-country participants were, by U.S. university project:
University of Arizona: Wilfrido Contreras, Pablo Gonzalez
North Carolina State University: Evelyn Ayson, Remedios Bolivar
University of Michigan: Zexia Gao, Vu Cam Luong
University of Hawai'i: Eladio Gaxiola, Erick Sandoval
Auburn University: Gertrude Atakunda, Khalid Salie
University of Connecticut: So Nam, Le Xuan Sinh
Purdue University: Steve Amisah, Sebastian Chenyambuga

Other AquaFish guests also attending: Kwamena Quagrainie (US PI, Purdue Project), Emanuel Frimpong (collaborator, Purdue Project), and Laura Morrison and Lisa Reifke of the AquaFish Synthesis staff.

Meeting leaders were John Antle and Steve Buccola. Lin Qin assisted with the research discovery topics and Roberto Valdivia with impact assessment topics. Roberto Valdivia (Montana State University) handled administrative arrangements.

Day One focused on: (a) the principles of research discovery assessment, emphasizing Bayesian statistical methods and careful specification of each experimental or survey treatment, and (b) the principles of impact assessment, focusing on the expected profitability of the new technology in specified settings and the importance in profitability assessment of accurately depicting the decision maker's economic situation. Representatives of the seven AquaFish projects also reported on their ongoing studies.

On Days Two and Three, research discovery assessments and plans for future work were conducted in break-out meetings between Buccola and Qin and each project-level pair of investigators. Laura Morrison and Lisa Reifke participated in these break-out meetings. Simultaneously, attendees conducted research impact

assessments by developing preliminary characterizations of a decision maker's economic environment and applying minimum-data (TOA-MD) software to estimate the probabilities of new-technology adoption in that environment. On Day Four, plans were drawn up with individual AquaFish projects to continue this work into FY 2011.

PRESENTATIONS & PUBLICATIONS

Presentations

Title	Author(s)	Type	Event	Location
Methods for Assessing Environmental and Social Impacts of Aquaculture Technologies: Adoption of Integrated Agriculture-aquaculture in Malawi	John Antle and Roberto Valdivia	Oral	9AFAF-9ISTA	Shanghai, China
What Influences the Success Of Aquacultural Research Projects?	S. Buccola, L. Qin, and R. Fare	Oral	9AFAF - 9ISTA	Shanghai, China

AquaFish CRSP participants learning about stocking densities in hapas, Ghana (Photo courtesy of Kwamena Quagrainie)

VII. ASSOCIATE AWARDS

USAID Leader-with-Associate (LWA) awards allow for the provision of additional, non-core funding to carry out activities that fit within the broader program description of the Leader Agreement. Such additional funding comes in the form of an "Associate Award," which might be provided by a USAID mission or by USAID/Washington. In the case of the AquaFish CRSP, two such awards have been received since program inception. The first of these was an award given by the USAID/Mali Mission for aquaculture and fisheries work in Mali, and the second was an award given by USAID/Washington for work being conducted in Ghana, Kenya, and Tanzania, all of which are named as focus countries under the Feed the Future (FtF) initiative.

LEAD US UNIVERSITY: OREGON STATE UNIVERSITY

ENHANCING THE PROFITABILITY OF SMALL AQUACULTURE OPERATIONS IN GHANA, KENYA, AND TANZANIA

FIRST ANNUAL REPORT
October 1, 2010 – September 30, 2011

Associate Award Number AID-OAA-LA-10-00006
Leader with Associates Award EPP-A-00-06-00012-00

The full annual report can be found online at the CRSP website.

EXECUTIVE SUMMARY

The First Annual Report for the AquaFish CRSP Strategic Investment in Rapid Technology Dissemination (SIRTD) Program Associate Award "Enhancing the profitability of small aquaculture farm operations in Ghana, Kenya, and Tanzania" covers activities and accomplishments from October 1 2010, through September 30, 2011. During this reporting period, US and Host Country investigators conducted collaborative activities focused on SIRTD and FtF development goals, including scaling up innovations from previous CRSP project successes and accelerating best management practice (BMP) adoption rates.

The origins of this Associate Award date back to March 2010, when USAID/EGAT contacted the ten CSRP Directors requesting short concept notes to move existing CRSP research towards adaptation and dissemination at a scale that will result in greater impact and visibility. The Director of AquaFish CRSP, Dr. Hillary Egna, in consultation with partnering US Project PIs, submitted two concept notes for consideration. On April 9, 2010, USAID informed Dr. Egna that the concept note for "Enhancing profitability of small aquaculture farm operations in Ghana, Kenya, and Tanzania" was highly ranked and to submit a more detailed pre-proposal addressing reviewer comments. On April 19, 2010, Dr. Egna submitted the pre-proposal and through July, she then revised the pre-proposal several times in response to changing instructions from USAID to address reviewer comments. On August 12, 2010, Dr. Egna received a formal Request for Associate Award Application (RFAAA) under the Aquaculture & Fisheries CRSP Leader Award from USAID through the EGAT/AG Strategic Investment in Rapid Technology Dissemination (SIRTD) Program. AquaFish was one of only three CRSPs to receive a RFAAA. On September 6, 2010, Dr. Egna submitted a full proposal in response to the RFAAA, including expanded sections on environmental impacts and gender inclusivity. Anticipating the need to expedite work under this Associate Award, and in

furtherance of research and development discussions among select and previously interested colleagues, Dr. Egna sent an Invitation to Participate to Dr. Kwamena Quagrainie (Purdue University), and Dr. Emmanuel Frimpong (Virginia Polytechnic Institute and State University), inviting them to submit proposals for work under the Associate Award. On September 28, 2010, the AquaFish CRSP ME at OSU was awarded a 3-year, $1.1 million from USAID for the Associate Award "Enhancing the profitability of small aquaculture farm operations in Ghana, Kenya, and Tanzania." Proposals submitted to AquaFish from Drs. Quagrainie and Frimpong were externally peer-reviewed that fall 2010 and subcontracts put in place with Purdue University and Virginia Polytechnic Institute and State University in spring 2011.

The focus of this Associate Award is technology adoption involving best management of inputs for fish production to provide economic, environmental, and agronomic efficiency of aquaculture in sub-Saharan Africa. Target technologies being focused on include *effluent management practices* and *nutrient management practices*, using the lens of *profitability analysis*. This project focuses on Ghana for initial scale-up but with the sub-Saharan African region as a whole in mind. As a further step in scaling up innovations from previous ACRSP and AquaFish project successes and accelerating BMP adoption rates in Ghana, Kenya, and Tanzania, three innovation diffusion techniques are being simultaneously deployed: 1) Central Media (series of workshops at the regional level and extension follow-ups), 2) Demonstrations (BMPs at work on farms of selected farmers), and 3) Lateral Diffusion (farmer-to-farmer extension of BMPs).

During this first annual reporting period CRSP BMPs have been extended through both on-site demonstration ponds and short-term training workshops. In Ghana, six farms are currently demonstrating the use of CRSP BMPs. Two short-term training events were held at Kwame Nkrumah University of Science and Technology, Ghana, and included a training-of-trainers targeting extension personnel and a BMP workshop targeting farmers. A total of 168 FtF focus country nationals have received training.

During this reporting period efforts were made to coordinate activities conducted under this Associate Award and existing core AquaFish CRSP projects. A face-to-face meeting occurred immediately prior to the 2011 AquaFish CRSP Annual Meeting in April 2011, allowing project researchers from Oregon State University, Virginia Polytechnic Institute and State University, Purdue University, Kwame Nkrumah University of Science and Technology, Kenya Ministry of Fisheries Development, and Sokoine University of Agriculture, to discuss and coordinate SIRTD Project activities with other activities planned under CRSP core projects in Africa.

INTRODUCTION

Feed the Future (FtF) is a new US Government initiative to reduce poverty and hunger around the globe, recognizing that agriculture and rural development have long been neglected in international aid programs and renewing a commitment to strive towards sustainable global food security through reinvestment in these areas. USAID has recognized the severe impact poverty has on livelihoods, health, and ecosystems and has endeavored to align its strategies and goals within the FtF initiative.

Oregon State University's AquaFish CRSP has responded with a project that addresses FtF goals and helps reduce gnawing development problems that contribute to keeping the poor poor. This project*, Enhancing the Profitability of Small Aquaculture Operations in Ghana, Kenya, and Tanzania,* is framed around USAID and FtF objectives by investing in strong, evidence-based efforts. The project shares the FtF aim of accelerating progress toward meeting the poverty and hunger Millennium Development Goals, as measured by reducing the prevalence of poverty and reducing the incidence of underweight children. Our project is working towards these goals by accelerating inclusive agriculture sector growth through improved agricultural productivity, expanded markets and trade, and increased economic resilience in vulnerable rural communities. Improvements in nutritional status are expected to result from increased access to diverse and high quality foods. The ability to access and utilize food must remain stable and sustained over time. Paying attention to cross cutting themes such as gender, environment (climate change), and natural resources management can result in improved nutrition for all family members.

The AquaFish CRSP FtF project works in three of the focus countries identified by FtF: Ghana, Kenya, and Tanzania. Feed the Future's overarching goal is "to sustainably reduce global hunger and poverty by tackling their root causes and employing proven strategies for achieving large scale and lasting impact." We are focusing on small-scale agricultural producers, high quality seed, and best management practices, working with private sector partners to expand commercially sustainable agro-input industries and dealer networks, including small enterprises and seed production training to improve quality management. Increased access to inputs will be coupled with strategies to help ensure their safe and sustainable use. Our technologies will be refined and tailored to local conditions by supporting national research institutes and building local research capacities, including training local researchers and technicians. If gender inequalities inhibit demand, then these inequalities will be addressed. Our aim is to provide women with equal access to affordable inputs and improved techniques and technology.

The project additionally supports FtF objectives in the area of *Expanding Markets and Trade*, through the development and dissemination of market information for producers and enterprise owners, including activities that focus on equitable access for women. Greater access to market information can increase the ability of small-scale agricultural producers to participate in formal and higher-value markets. By improving post-harvest market infrastructure, our project aims to make markets work better for women and men agricultural producers and to extend the availability of nutritious foods. Through the reach of the project, our results will also aid FtF's objective of *Improving Nutritional Status* (FtF GUIDE, section 3.3.2), by improving diet quality and diversity through the addition of animal source protein and micronutrients commonly found in fish.

This project has primary focus locations in Ghana and Kenya to leverage work done by the AquaFish CRSP, and to consolidate adoption of the technology and ensure measurable impact. In addition to the intensive efforts in Ghana and Kenya, a pilot workshop will be held in Tanzania. The project began on 1 October, 2010, and will continue through 30 September, 2013.

Resource Management Practice

Working regionally across Africa with Best Management Practices (BMPs) holds the promise of strengthening regional coordination and can add value to activities at the country level. This includes harmonization of laws and regulations governing the release of varieties and trade in fish inputs (e.g., seed), developing more efficient supply chains for feeds, fertilizers, and other inputs, facilitating efficient dissemination of best practices and knowledge for similar agro-ecological conditions, and encouraging shared approaches to help producers adapt to the effects of global climate change.

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 and supplementing wild fish protein. Questions, however, are being raised about how long it will be before the industry comes under scrutiny for its environmental practices and the need for regulations. BMPs in aquaculture are now widely recognized as a more viable alternative to conventional industrial waste treatment methods, and their widespread adoption will help forestall imposition of prohibitive regulations on smallholder fish farms.

The adoption of BMPs in fish production requires strategies that integrate profitability and efficiency in the fish farming enterprise. Production options that consider both profitability and other efficiency issues were studied by Purdue University under the previous ACRSP where decision support tools were developed for assessing farm profitability. The tools involved financial spreadsheets that incorporated enterprise budgeting. Methods for farm-level reporting led to improved record keeping—important documentation for securing loans from banks. This is mainstream CRSP "soft" technology that can incorporate farm costs associated with adoption of BMPs and evaluation of profitability.

In November 2009, CRSP held a two-day national workshop in Ghana attended by 60 participants including fish farmers, fisheries commission officials, extension officers, regulators, and researchers. The workshop was held in the local language and also served as a "test drive" of one of several methods that could be used together to disseminate BMP guidelines and facilitate adoption. There was great enthusiasm among farmers with many interested in setting aside demonstration ponds for AquaFish-funded studies. These workshops thus accomplished: 1) training of extension officers who could follow up with farmers implementing BMPs in a sustained outreach program; 2) reaching a core group of farmers who may continue to spread the BMP ideas to other farmers; and 3) convincing regulators that the aquaculture industry has an active program of examining its environmental practices and continually working on improving these practices, thereby reducing costs of creating a formal regulatory process. A formal regulatory process for fish farms in Ghana does not currently exist in any standardized form. Establishing such a process is time consuming and faces challenges due to the difficulty of monitoring, corruption, and creating unintended costs to small farmers.

Target Technologies

The focus of this project is technology adoption involving best management of inputs for fish production to provide economic, environmental, and agronomic efficiency in aquaculture in sub-Saharan Africa. Target technologies being focused on in this work include *effluent management practices*, *nutrient management practices*, and *profitability analysis*.

Effluent Management Practices

Effluent management practices include guidelines on pond operation, settling ponds and vegetation ditches, draining to wetlands, top-releases for partial drainage, and water re-use (by holding or re-circulating to other ponds). Specifically, issues to be addressed include frequency of drainage, installation of drain outlets, and water level maintenance. Of these practices, emphasis will be placed on water re-use to provide the most environmental benefit because intentional drainage, which accounts for most effluent output, can be avoided altogether for many years. In areas facing water scarcity, such as baitfish farming in Arkansas, USA, farmers have successfully adapted harvesting methods that involve little or no draining. A new crop is then stocked in the "old water." This technology is clearly viable for most tilapia and catfish farms in Africa. Even where water is not in short supply, the technology produces environmental benefits because of reduced effluents. Problems anticipated for those adopting water reuse is that some existing ponds are too deep or have non-uniform bottoms. Some of these could be retrofitted with variable-depth overflow standpipes that keep water at desired and safe depths. Size of fingerlings at stocking in old water usually needs to be adjusted upward to account for the fact that old water is a more hostile environment for fingerlings initially because predators may remain in the water. Some benefits to farmers of reusing water include retaining nutrients from previous production that can still be incorporated into the biomass of the new crop. New and expanding farms that anticipate adopting water reuse would need to construct ponds with relatively shallow and uniform bottoms.

Nutrient Management Practices

Nutrient management practices include guidelines relating to fertilizing and feeding regimes that avoid wastes or, in worse cases, result in deteriorated water that threaten the health or condition of the fish. Avoidance of feed wastes is input cost-saving and translates directly into farm profitability. It is a better practice to regulate fertilization by packing fertilizer into ponds in slow-release sacs that can be removed from the pond when water attains the desired level of plankton bloom. Remaining fertilizer can be dried and saved for future use. Feeding is best regulated by observing how much the fish are eating and then adjusting the amount of feed accordingly. This is possible only when extruded (floating) feeds are used as opposed to pelleted (sinking) feed. Feed that is not eaten functions very much like fertilizer and can cause highly eutrophic water conditions that both reduce yields and escalate the cost of operations. Thus, pelleted feeds often result in high waste loads and lower feed conversion ratios (FCR: = weight of feed fed/fish weight gain). Pelleted feeds are however more common and relatively cheap in Ghana wherever any formulated feed is available at all. Farmers who cannot afford formulated feed use a variety of local agro-industrial wastes, all of which are expected to produce even poorer feed conversion ratios than pelleted feeds. The BMP recommendation for feeding is to use floating feeds.

Profitability Analysis

Appropriate stocking and feeding regimes can reduce the cost of production through reduced aeration, better water quality, higher survival, reduced use of medication and chemicals, and improved feed conversions. These parameters account for over 75% of the cost of fish production and consequently profitability. Previous ACRSP work in Ghana that measured performance indicators and profitability in Nile Tilapia, *Oreochromis niloticus*, using measures of variable costs, fixed costs, owned inputs, yield and revenues showed that the economic profitability of integrating economic, social, and environmental objectives in the Ashanti Region achieved a break-even production of 904 kg/acre and a break-even price of $0.99/kg. The Brong-Ahafo region had a break-even production of 877 kg and a break-even price ($1.25/kg), indicating better performance for farmers in the Ashanti region. Incorporating BMPs into this analysis could increase profitability by at least 20%. The decision tool to be used enhances and delivers a financial decision support system that can assist prospective, new, and existing fish farmers who want to adopt BMPs to assess and select production scenarios and profitability relationships for their farm enterprises. The tool provides financial spreadsheet templates for fish farmers to develop their own financial profiles and determine benchmarks that serve as bases for investment decisions, comparisons, and/or improvements to the farm enterprise.

Outreach and Diffusion Techniques

This project focuses on Ghana for initial scale-up but with the sub-Saharan African region as a whole in mind. Targeted regions for deploying BMPs are Ghana, Kenya and Tanzania. As a further step in scaling up innovations from previous ACRSP and AquaFish project successes and accelerating BMP adoption rates in Ghana, Kenya, and Tanzania, three innovation diffusion techniques will be simultaneously deployed: 1) Central Media (series of workshops at the regional level and extension follow-ups), 2) Demonstrations (BMPs at work on farms of selected farmers), and 3) Lateral Diffusion (farmer-to-farmer extension of BMPs).

Central Media (workshops)

This is a series of workshops at the national or regional level that targets as many farmers as possible to expand first exposure to BMPs. These workshops include regional extension officers (i.e., a train-the-trainer model) who are expected to follow up adopters and liaise between these adopters and researchers to provide advice and sustain adoptions. Communications media are being developed in local languages. In Ghana, the Western, Ashanti, and Brong-Ahafo regions are being targeted, where there are 2,869 fish farmers and about 4,500 farm ponds. In Kenya, we are targeting about 600 fish farmers, and in Tanzania, the target is about 100 fish farmers. We will hold three regional workshops in Ghana, each of which will target 100 farmers. We will also hold three national workshops for Kenya and Tanzania, each of which will target 50-100 farmers.

BMP Demonstrations (BMPs at work on farms of selected farmers)

Demonstrations are used both to take advantage of their positive effects in the diffusion process and also to provide the data needed to estimate the economic benefits of selected components of BMPs for monitoring and evaluation of the intervention. The demonstration effect has been identified as one of the principal variables that explain diffusion of innovations. We envisage BMPs at work on farms to be a crucial ingredient to show skeptical farmers what benefits can be achieved with BMPs. In the Ashanti and Brong-Ahafo regions of Ghana, AquaFish CRSP projects have already established working relationships with many farmers. We have identified farmers whose farms are accessible to researchers and who have the highest potential to reach out with new ideas to other farmers. In Kenya and Tanzania, we will leverage existing work with lead farmers to demonstrate focal BMP schemes. Through agreement with farmers, we will select two ponds each from ten farms and put these ponds under each of the two focal BMP management schemes (i.e., water re-use and nutrient management). Accurate data will be collected on these ponds, including stocking densities, fertilization rates, feeding rates, monthly water quality, yields, and FCRs. These ponds will be managed by AquaFish-supported graduate students and fisheries extension officers with the cooperation of the farmers. Ponds will be visited during workshops to show farmers the benefits of BMPs. In addition, data collected from these ponds will be contrasted with data from similar ponds under “regular”

management from the same farms. These data will be used for *with-versus-without* analysis of the benefits and cost of BMP implementation.

Lateral Diffusion (farmer-to-farmer extension of BMPs)
Through regional workshops and demonstrations we will be establishing a business enterprise network in each country. One vital function of these networks is farmer-to-farmer extension of BMPs. Under the innovation diffusion model, farmers exposed and trained in workshops constitute nodes in a network. These farmers can spread information to other farmers who, in their estimation, are likely to be interested in their new ideas. These new farmers also become nodes and propagate their own networks, thereby laterally transmitting knowledge without the direct involvement of the central media.

Gender Integration and Analysis
The AquaFish CRSP is dedicated to improving gender inclusiveness in the aquaculture and fisheries sectors across the spectrum of CRSP projects and activities. FtF requires that we develop approaches to target both men and women with agricultural interventions. This includes investments in sustainable labor-saving technologies so that shifts in the gender division of labor and products do not systematically disadvantage one sex over the other. Where water, fuel, and labor constraints increase the domestic chore burden on women and girls and prevent women from expanding agricultural production, labor-saving technologies might be introduced to mitigate this effect. Involving and recognizing both the men and women producers within the household in agricultural programs can be more sustainable than focusing only on the head-of-household (FtF Guide, May 2010).

Following guidance from USAID, we considered the following for our SIRTD project:

> "a. How will the different roles and status of women and men within the community, political sphere, workplace, and household (for example, roles in decision-making and different access to and control over resources and services) affect the work to be undertaken?
> "b**.** How will the anticipated results of the work affect women and men differently?"

The purpose of the first question is to ensure that: 1) the differences in the roles and status of women and men are examined; and 2) any inequalities or differences that will impede achieving program or project goals are addressed in the planned work design. The second question calls for another level of analysis in which:

> 1) The anticipated programming results are examined regarding the possible different effects on women and men; and
> 2) The design is adjusted as necessary to ensure equitable and sustainable program or project impact. For example, programming for women's income generation may have the unintended consequence of domestic violence as access to resources shifts between men and women. This potential negative effect could be mitigated by engaging men to anticipate change and be more supportive of their partners.

This project recognizes that providing for equal opportunities for women's involvement is necessary because such a directed involvement of women is one of the keys to advancing economic and social development not only in aquaculture but for a holistic household and family economy. Women play a major role in the production, processing and marketing of agricultural products in Ghana, Kenya and Tanzania, but agricultural information and production resources are not reaching and benefiting them in the food value chain. The project's intent is therefore to ensure that no one is excluded from participating in the training or educational activities and opportunities conducted on the basis of gender. Further, where women are members of the larger populations under consideration (i.e., Fisheries Officers who serve as aquaculture extension officers, fish farmers, fish traders, consumers, program personnel, students, etc), we are actively recruiting women to participate in these activities. Qualified women graduate students from host countries have been selected for long-term training, and efforts are being made, when selecting workshop and short-term training participants, to seek a 50:50 gender ratio or to design women-only workshops should we find low enrollment of women due to logistical, cultural, or subject matter concerns.

Initiation of Subawards to Partnering Institutions
In preparation for the Associated Award in support of the Strategic Investment in Rapid Technology Dissemination (SIRTD), the ME sent an Invitation to Participate to eligible partners at Purdue University and at Virginia Polytechnic Institute and State University. Proposals containing a scope of work and budget were received from both institutions on 30 September 2010. In order to maintain quality standards associated with all CRSP-affiliated work, the investigations underwent a peer review in accordance with the established NSF-style process adopted by AquaFish CRSP. Reviewer critiques and programmatic comments from the ME were returned to both proponents by November 2010. Requests were submitted to OSU's Office of Sponsored Programs in mid-February 2011 to initiate subcontracts. Subcontracts were fully executed in by mid-June 2011.

COLLABORATING INSTITUTIONS AND PERSONNEL

AquaFish CRSP, Oregon State University
Hillary Egna, Principal Investigator

Purdue University
Kwamena Quagrainie, US Co-PI

Virginia Polytechnic Institute and State University
Emmanuel Frimpong, US Co-PI

Kwame Nkrumah University of Science and Technology, Ghana
Steve Amisah, HC Co-PI

Ministry of Fisheries Development, Kenya
Sammy Macharia, HC Co-PI (from July 2011)
Charles Ngugi, HC Investigator (was HC Co-PI thru July 2011)
Judith Amadiva, HC Investigator

Ministry of Natural Resources and Tourism, Tanzania
Kajitanus Osewe, HC Co-PI

Sokoine University of Agriculture, Tanzania
Sebastian Chenyambuga, HC Co-PI

PROGRESS MADE AND RESULTS ACHIEVED

Enhancing the Profitability of Small Aquaculture Operations in Kenya and Tanzania
Demonstration farm sites have been identified and selected in Kenya and farmers are currently being recruited for participation in the workshops. The manager of Mwea Aqua Fish Farm, one of the key demonstration farms in Kenya, was sent to Ghana in July 2011 to visit a demonstration farm that is in operation there and to participate in the first farmers' BMP training workshop held in Ghana. Workshop materials are being developed and discussions have been held between the Kenya and Ghana project teams regarding the sharing of workshop materials for use in the three countries involved in the overall FtF project.

Due to recent personnel movements in Kenya, it became necessary to negotiate a new Kenya lead institution and transfer HC PI responsibilities accordingly. The Ministry of Fisheries Development is replacing Kenyatta University as the lead HC institution for this project, with Sammy Macharia, Aquaculture Scientist in the Ministry, taking up HC PI duties. Charles Ngugi, who has taken a new position as Fisheries Secretary advisor in the Ministry, will continue to assist in the role of HC Co-PI. A new subcontract between Purdue University and the Kenya Ministry of Fisheries Development was signed and put into place in late August 2011.

Enhancing the Profitability of Small Aquaculture Operations in Ghana
Six on-farm demonstrations of the use of BMPs in production ponds are underway. The first production cycle on three farms (1 in Ashanti, 1 in Brong Ahafo, and 1 in Western Region) is about 75% completed and the other 3 (2 in Ashanti, and 1 in Western) were started in August 2011. None of the farms examined in the Central Region met the criteria for inclusion in demonstrations. However, the Western Region demonstrations will also serve the Central Region.

In addition to the six demonstrations begun, two workshops have been conducted. The first was a training-of-trainers workshop, needed to prepare extension personnel for their roles in the farmer training sessions to follow, and the second was the first BMP workshop for farmers. The training-of-trainers workshop was conducted at Kwame Nkrumah University of Science and Technology (KNUST) on 11 January 2011, and covered topics such as the criteria for selecting farms for the BMP demonstrations, experimental design for on-farm demonstrations, expectations from participants, and water quality kit demonstrations. The first farmers' workshop on BMPs was conducted at Kumasi, on 12-15 July 2011. The concept of BMPs was introduced to the farmers and was followed by a discussion of the pros and cons of using them in pond aquaculture. A BMP survey questionnaire was introduced and the participants were guided through the completion of its baseline section. Attendance at this first BMP workshop, with 155 trainees, exceeded the target by 50%. The first workshop put to test the utility of the on-farm demonstrations as an integral part of outreach activities. The demonstration component of the workshop proved vital for communicating the differences that the choice of feeds can make on fish growth. As the demonstrations advance over time, it is expected that noticeable differences will also be observed between ponds operated under the water reuse BMP and ponds not operated under this BMP.

Approximately 150 baseline BMP knowledge and adoption surveys have been completed. This is also in excess of the original target, which was 100. A subsample of the respondents will be surveyed by phone in December 2011 to begin to monitor evolving attitudes about BMPs and estimate the initial rate of self-reported adoptions of BMPs.

Short-Term Training under the FtF Project

In this first year of the SIRTD (FtF) Associate Award, two short-term training events were held, with a total of 168 FtF-country nationals receiving training. Of these, 25 were women (14.9%) and 143were men (85.1%). Future trainings will be designed to increase access of women to information. These two events were held at KNUST, Kumasi, Ghana.

Project-Level Coordination Meeting at the 2011 AquaFish CRSP Annual Meeting

Prior to the 2011 AquaFish CRSP Annual Meeting in April 2011, the project's principal investigators from OSU, VT, Purdue, KNUST, Kenya Fisheries, and Sokoine met to discuss and coordinate FtF Project activities with other CRSP activities planned under CRSP core projects in Africa. It was agreed that, where possible, short-term training events and other activities would be conducted "back-to-back" for efficiency and so that trainees would have opportunities for participation in more than one event.

Peer-review of BMP fact sheets

In November 2010, the MT initiated a technical review of three BMP handouts (Virginia Tech University) and one husbandry manual (Purdue University). These BMP handouts encompass a range of topics including effluent management, nutrient management, biodiversity conservation, and manual sexing of fish. Critiques from two technical reviewers were returned to the authors in December 2010.

PROBLEMS ENCOUNTERED

Oregon State University recently restructured several of its administrative offices, including creating several Business Centers to decentralize financial and HR administrative duties. There has also been considerable personnel turnover in key positions both in the Business Centers and within central University offices such as the Office of Sponsored Programs. The AquaFish MT has experienced numerous administrative problems stemming from the restructuring and the new, inexperienced staff hired to perform essential OSU administrative support roles. One problem that we encountered during this fiscal year that pertains directly to this Associate Award was a 4-month delay in initiating subawards for Purdue University and Virginia Tech. The delay primarily resulted from uncertainty at OSU about donor authorization required to transfer a minor amount ($73) among direct cost line items. After considerable back-and-forth between OSU's Office of Sponsored Programs and Office of Post Award Administration, an email was sent from OSU to USAID

asking permission to make the budget change. USAID replied indicating that no donor permission was necessary to make the requested change. The experience highlighted communication and staffing shortfalls in OSU's newly restructured administrative offices. OSU has learned from this experience and we are hopeful that University support will be provided in a more efficient and timely manner on future subaward actions.

LESSONS LEARNED

There is a visible benefit of AquaFish programs to KNUST, both in terms of growth in the aquaculture and fisheries programs (in areas such as student enrollment and student engagement in research and development activities) and development of the research skills and output of faculty. These benefits are not clearly captured in the current metrics being used in project impact assessment by USAID. This project has clearly benefitted from the cumulative effect of previous AquaFish-sponsored projects in Ghana.

The AquaFish-sponsored training programs are well patronized and playing a crucial role in extension and farmer-to-farmer networking in Ghana. Extension services for fish farming are weak to non-existent in many parts of the country. This is antithetical to the increasing interest in aquaculture marked by the influx of new farmers. Many workshop attendees come wanting to learn everything, even the most basic skills they should be learning through basic extension services. One remarkable experience during this year's BMP workshop was when Nana Siaw, an experienced farmer whose farm is being used as one of the demonstration farms in Ashanti, gave a demonstration of how to sex tilapia to sort males from females. The number of farmers who enthusiastically observed the demonstration and admitted they didn't know how to do this was staggering. Obviously, no farmer can truly raise tilapia profitably if they can't separate the sexes, since quality control for the production and supply of all-male tilapia fingerlings in Ghana is still questionable. The role of demonstrations is promising as a means of improving aquaculture extension in Ghana, if more of these can be established strategically in a coordinated national effort.

SUCCESS STORIES

Yaw Ansah, a CRSP PhD student under PI Frimpomg at VT, through his participation in this project, was awarded a 2011 Borlaug LEAP Fellowship in the amount of $19,660, covering part of his international travels and field activities in Ghana. This fellowship has also leveraged significant in-kind support through collaboration with the International Water Management Institute (IWMI), represented by Dr. Regarssa Namara in Accra, Ghana. Dr. Namara provided valuable input in the development of the BMP survey instrument and the IWMI provided office space and access to the rich CGIAR library in Ghana during Yaw Ansah's 6-week visit to Ghana this summer.

The first BMP training session in Ghana, held 12-15 July for 155 participants, drew public attention in Ghana, as evidenced by the appearance of an article entitled "Fish farmers recount prospects of aquaculture for job creation" in the on-line news service Myjoyonline.Com (http://myjoyonline.com/) on 7/22/2011. The article acknowledges the three-year AquaFish CRSP FtF project and Dr. Emmanuel Frimpong's role in the project and training course. Frimpong is quoted as saying "Our intervention is identifying the constraints that make aquaculture not so profitable. The lure of it that it is profitable obviously is out there because a lot of people get into it before they realize that it's hard to run fish farming for profit. So our interventions are targeted at helping farmers eliminate the sources of non-profitability and the threat to a sustained growth down the road."

PRESENTATIONS AND PUBLICATIONS

Ichien, S., C. Stephen, and H. Egna. 2011. Addressing the goals and objectives of the Feed the Future Initiative: Enhancing the profitability of small aquaculture operations in Ghana, Kenya, and Tanzania (poster). The Ninth International Symposium on Tilapia in Aquaculture, Shanghai, China, April 2011.

Frimpong, Emmanuel, Yaw Ansah, and Stephen Amisah. 2010. Effluent Best Management Practices. (Fact sheet).

Frimpong, Emmanuel, Yaw Ansah, and Stephen Amisah. 2010. Feeding and Nutrients Best Management Practices. (Fact sheet).

Frimpong, Emmanuel, Yaw Ansah, and Stephen Amisah. 2010. Biodiversity Best Management Practices. (Fact sheet).

Egna, Hillary S. 2011. AquaFish CRSP Project-Level Coordination Meeting: Training Activities Planned in Africa. (Meeting) Shanghai, China.

AquaFish CRSP participants, Drs. Padi and Attipoe attend the propagation and hatchery workshop in Ghana. (Photo courtesy of Kwamena Quagrainie)

LEAD US UNIVERSITY: OREGON STATE UNIVERSITY

AQUATIC RESOURCE USE AND CONSERVATION FOR SUSTAINABLE FRESHWATER AQUACULTURE AND FISHERIES IN MALI

FINAL REPORT SUMMARY
October 1, 2007 – December 31, 2010

Cooperative Agreement # 688-A-00-07-00044-00
Leader with Associates Award EPP-A-00-06-00012-00

The full final report can be found online at the CRSP website.

INTRODUCTION

The Mali Project spanned a period of 39 months, including a three-month no-cost extension, beginning on 1 October 2007 and ending on 31 December 2010. Annual reports for the project were included in the previous three AquaFish CRSP annual reports, and a full final report was delivered to USAID/Mali on 9 March 2011. We present here the Executive Summary from the final report, which is available for viewing in its entirety on the *Publications* page of the AquaFish CRSP website (http://aquafishcrsp.oregonstate.edu/publications.php).

EXECUTIVE SUMMARY

Introduction

The AquaFish CRSP *Mali Project*, "Aquatic Resource Use and Conservation for Sustainable Freshwater Aquaculture and Fisheries in Mali," was funded through an award received from USAID/Mali under the "Leader with Associates" (LWA) award that established the AquaFish CRSP in 2006. The project spanned a period of 39 months (1 October 2007 through 31 December 2010), including a 3-month no-cost extension approved on 15 September 2010. The no-cost extension allowed the project to complete a final fisheries planning training activity and prepare this final report.

The overall goal of the Mali Project has been to increase the productivity and income of fish producers (farmers and fishers) in targeted areas of Mali. To achieve this, the project has focused its efforts on these three thematic areas:

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

More specific goals of the project have been 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
- Help establish linkages useful for further development of aquaculture and fisheries in Mali

The Mali Project has taken 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 in Mali.

Collaborating Institutions

The primary institutions involved in this project have included the following:

- AquaFish CRSP, Oregon State University, Corvallis, Oregon, USA (Lead US Institution)
- Direction Nationale de la Pêche, Bamako, Mali (Lead Mali Institution)
- Ministère de l'Élevage et de la Pêche, Bamako, Mali
- Moi University, Kenya (Theme I Lead Institution through 2009)
- Kenyatta University, Kenya (Theme I Lead Institution beginning 2010)
- Shanghai Ocean University, Shanghai, China (Theme II Lead Institution)
- FishAfrica, Nairobi, Kenya (Theme III Lead Institution)

Results Achieved

In keeping with the project's primary goal of making improved technologies available to our selected target audiences, a total of 20 workshops were conducted across our three theme areas during the thirty-nine month project period. These workshops covered a wide-range of aquaculture and fisheries topics, including pond site selection, pond construction, pond management, up-to-date techniques for rice-fish culture, fish transportation, catfish propagation and care of fry, best management practices, post-harvest technologies, and lake survey techniques, and also included 3 stakeholders workshops to discuss the results of the Lake Sélingué frame survey (see below) and begin developing a plan for co-management of that lake. A total of 358 participants took part in these workshops.

Field testing and demonstrations were also conducted to complement workshop activities and provide guided, hands-on experience to farmers. Two sets of on-farm trials were conducted by the pond culture team and one set of rice-fish demonstration plots were set up and run under the supervision of the rice-fish team. Through the application of improved management practices and supervision by project leaders, farmers participating in the on-farm trials realized yields of up to 9000 kg/ha in a six-month period (18,000 kg/ha/yr), a substantial increase over the estimated average productivity of ponds at the beginning of the project (1500 kg/ha/yr). In the rice-fish demonstrations, after approximately four months of culture one farmer harvested 115 kg of fish from a rice paddy just 840 m^2 in area (equivalent to 1369 kg/ha), bringing in welcome additional income for the family.

Several activities not specified in the work plan were catalyzed by this project and are worth noting. Upon completion of the first and second sets of on-farm trials, it was decided to run a third set, beginning near the original end-date of the project and to be completed after the project end-date under the supervision of DNP technical staff. One of our pond culture trainees, who speaks neither French nor English, has been instrumental in setting up catfish hatching systems in at least three locations and is now producing catfish fingerlings and selling them to other farmers. In addition, he has himself become a trainer, having led at least four pond construction training sessions for 90 people in Bougouni, Segou, Sanankoroba, and Gao during the final year of the project. He is also in demand as a consultant, having received over 120 people seeking fish farming advice at his farm, with 16 of these having started to build ponds of their own. After observing the results of the project's rice-fish demonstrations, at least 22 new farmers in the Baguineda area decided to modify their fields to include fish during the 2010 growing season.

Our fisheries planning activities included conducting the first ever frame survey of Lake Sélingué, preceded by two workshops to train those who would be conducting the survey. This not only produced a valuable baseline dataset for evaluating the fishing capacity of the lake, but also resulted in the creation of a cadre of individuals trained in the survey techniques used, so that they now have the capacity to conduct future surveys on this lake or others. Following analysis of the survey data, two stakeholders' workshops were held to discuss the results of the survey and the implications of those results for future fishery management. The project's final fisheries planning activities were a study tour for four Malians conducted at Lake Victoria,

Kenya, to observe how co-management (participation of both government and local stakeholders in developing and carrying out management plans), is being successfully practiced at this lake, followed by a final workshop with Lake Sélingué stakeholders to discuss the findings of the Lake Victoria study tour and continue the management planning process for the lake.

Summary

The work of the AquaFish CRSP Mali Project has thus set the stage for further development of the aquaculture and fisheries sectors in Mali. Fish farmers have received previously unavailable technical information that will enable them to expand the area under aquaculture production as well as increase their productivity per unit area. Fishers in Lake Sélingué have been brought into the management planning process, and technical staff of the Direction Nationale de la Pêche now have the skills needed for conducting additional frame surveys in the future, whether at Lake Sélingué or elsewhere. Rice farmers in Baguineda and other areas have seen how irrigated rice fields can be modified to accommodate a crop of fish, which many of them are now doing. Both rice farmers and fish farmers have learned how to produce more fish in their respective areas, thus bringing in added food and income to support their families.

Pond culture workshop in Mali (Photo by Jim Bowman)

VIII. CAPACITY BUILDING

One of the AquaFish CRSP's primary goals is to strengthen human and institutional capacities both in our collaborating Host Countries and in the US. We achieve this largely through short-term (non-degree) and long-term (degree) programs, but also by mentoring students, staff, and other participants and providing them with opportunities for capacity development through participation in conferences, symposia, and other meetings regionally and internationally. Short-term training most frequently occurs as seminars, workshops, and short-courses scheduled for periods of half a day to two or three weeks in host countries. These training sessions focus on specific topics that are integral to project objectives. Long-term training encompasses academic programs leading to BS, MS, or PhD degrees at accredited institutions either in the Host Country, the US, or a third country, as well as other programs leading to certificates of completion or high school diplomas.

SHORT-TERM TRAINING

During FY11, AquaFish CRSP core research projects conducted 60 short-term training sessions in which 1758 participants were trained[1]. As compared with FY10, this reflects an increase of approximately 2.4x in terms of the number of events held and the number of participants trained. A full listing of these trainings is provided in Table VIII-4 at the end of this section. A country breakdown of these events is shown in Figure VIII-1.

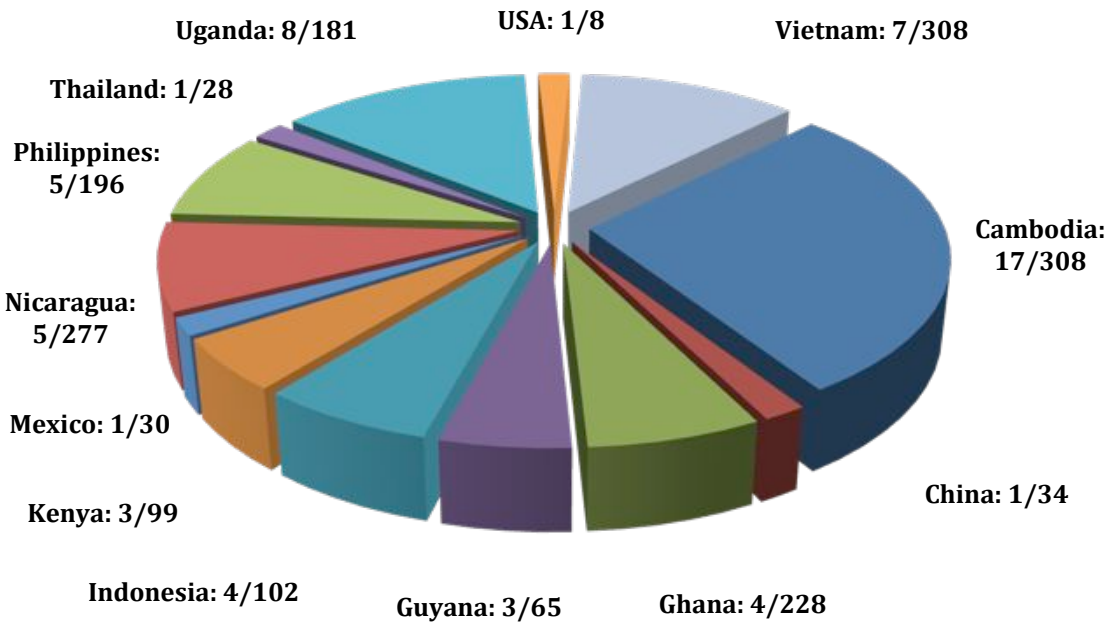

Figure VIII-1. Numbers of events and participants in AquaFish CRSP short-term training events in FY11, by country where held.

[1] Data provided in this report reflect the best information available to date (i.e. data drawn from FY11 training databases and project reports received as of September 15, 2011).

Gender Distribution in Short-Term Training

Of the 1758 participants trained this year, 658 (37.4%) were women and 1100 (62.6%) were men. Table VIII-1 shows the gender distribution by country.

Table VIII-1. Numbers and percentages of women trainees participating in FY11 AquaFish CRSP short-term trainings, by countries where events were held.

Country	Trainee Total	Number of Women	% Women
Cambodia	308	103	33.4
China	34	3	8.8
Ghana	228	30	13.2
Guyana	65	28	43.1
Indonesia	102	50	49.0
Kenya	99	37	37.4
Mexico	30	27	90.0
Nicaragua	277	180	65.0
Philippines	196	74	37.8
Thailand	28	14	50.0
Uganda	181	54	29.8
USA	8	4	50.0
Vietnam	202	54	26.7
Total	**1758**	**658**	**37.4**

Lower percentages of women trained in short-term events in some countries continue to reflect the types of aquaculture or fisheries activities in which training was provided and the extent to which women or men have traditionally been involved in those activities. Higher percentages of women trainees in some countries (e.g., Mexico—90% women trainees; Nicaragua—65% women trainees) reflect concerted efforts in the respective projects to focus trainings on activities or skills in which women have traditionally been involved or to include more women in trainings in which men have traditionally been the main participants.

The gender distribution of FY11 short-term trainees in each of the 7 core research projects is shown in Figure VIII-2.

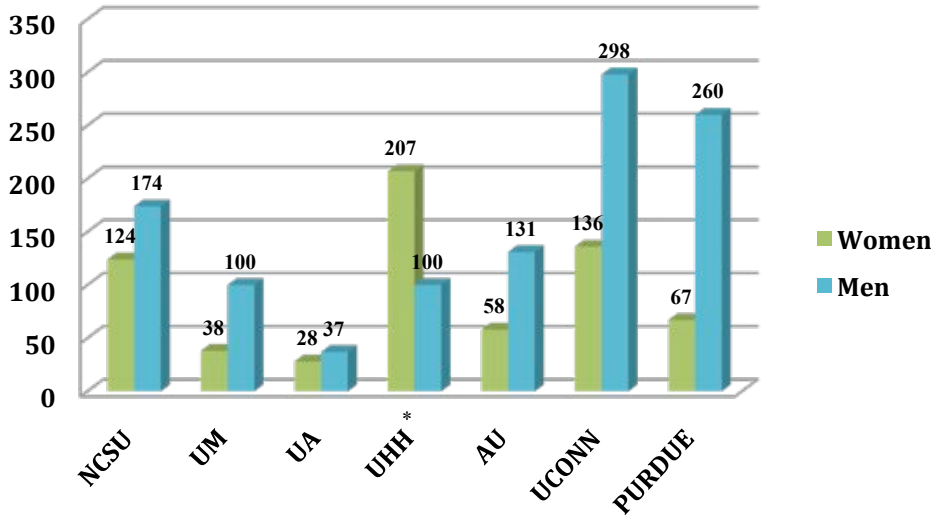

Figure VIII-2. Numbers of women and men trainees in AquaFish CRSP FY11 short-term training events, by core project. *UHH is the only core research project led by a wmoan

Short-Term Training for Participants from IEHA Countries

This year 510 IEHA-country nationals received training under AquaFish CRSP core projects, representing 29.0% of all short-term trainees. Trainings of IEHA participants occurred in Ghana (4 events, 228 IEHA participants), Kenya (3 events, 99 IEHA participants), and Uganda (9 events, 183 IEHA participants). Seven of these events were held by Purdue University project and nine were held by the Auburn University project.

LONG-TERM TRAINING

Since the AquaFish CRSP's inception in late 2006, a total of 320 degree students have received program support, including 166 men and 154 women (51.9 and 48.1 % respectively), for an almost 50:50 balance. During this fiscal year, the AquaFish CRSP supported the long-term training programs of 188 long-term students, including 101 men and 87 women (53.7% and 46.3% respectively), from 22 countries. The distribution of these students by nationality is shown in Figure VIII-3 and Table VIII-2. Most students receive partial funding from CRSP, which is heavily leveraged. Students from non-CRSP Host Countris are typically funded by extrernal sources, but become part of the CRSP effort through shared roles and resources at universities with Lead CRSP researchers. For a full listing of students supported during FY11, see Table VIII-5 at the end of this section.

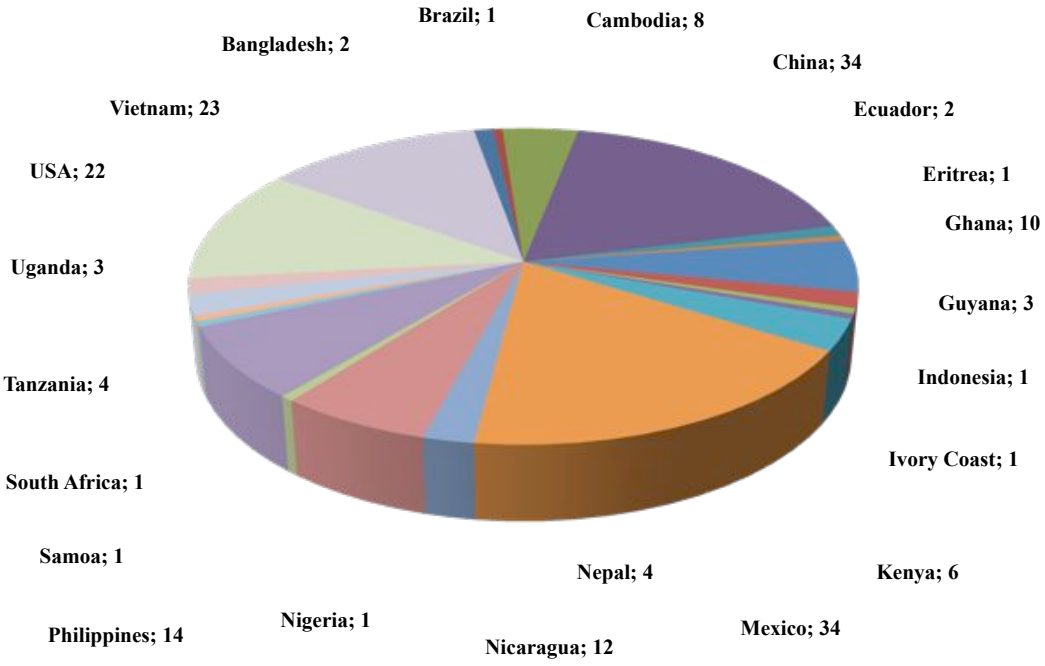

Figure VIII-3. Numbers of students supported by the AquaFish CRSP in FY11, by nationality.

Table VIII-2. Number, percentage, and gender of long-term students supported by the AquaFish CRSP in FY11, by nationality.

Nationality	Number of Students	Percent of All Students	Number of Men	% Men	Number of Women	% Women
China	34	18.1	14	41.2	20	58.8
Mexico	34	18.1	22	64.7	12	35.3
Vietnam	23	12.2	18	78.3	5	21.7
USA	22	11.7	9	40.9	13	59.1
Philippines	14	7.4	4	28.6	10	71.4
Nicaragua	12	6.4	6	50.0	6	50.0
Ghana	10	5.3	5	50.0	5	50.0
Cambodia	8	4.3	5	62.5	3	37.5
Kenya	6	3.2	3	50.0	3	50.0
Nepal	4	2.1	2	50.0	2	50.0
Tanzania	4	2.1	2	50.0	2	50.0
Guyana	3	1.6	2	66.7	1	33.3
Uganda	3	1.6	3	100.0	0	0.0
Bangladesh	2	1.1	1	50.0	1	50.0
Ecuador	2	1.1	2	100.0	0	0.0
Brazil	1	0.5	1	100.0	0	0.0
Eritrea	1	0.5	1	100.0	0	0.0
Indonesia	1	0.5	0	0.0	1	100.0
Ivory Coast	1	0.5	0	0.0	1	100.0
Nigeria	1	0.5	1	100.0	0	0.0
Samoa	1	0.5	0	0.0	1	100.0
South Africa	1	0.5	0	0.0	1	100.0
Total	**188**	**100.0**	**101**	**53.7**	**87**	**46.3**

The distribution of these students by core AquaFish CRSP project is shown in Table VIII-3.

Degrees Sought by AquaFish CRSP Students

Student enrollment in various types of long-term training programs supported under the AquaFish CRSP program during FY11 is shown in Figure VIII-4. Seventy-eight students were seeking bachelor's degrees (41.5%), 86 students were seeking master's degrees (45.7%), and 21 students were seeking doctorates (11.2%). Three students (1.6%) were pursuing "other" programs, including 2 certificates and 1 post-doc program.

The Training Program in Propogation and Hatchery Management of tilapia in Ghana. (Photo Courtesy of Kwamena Quagrainie)

Students at CanTho University test formulated feeds developed by CRSP researchers. (Photo by Peg Herring)

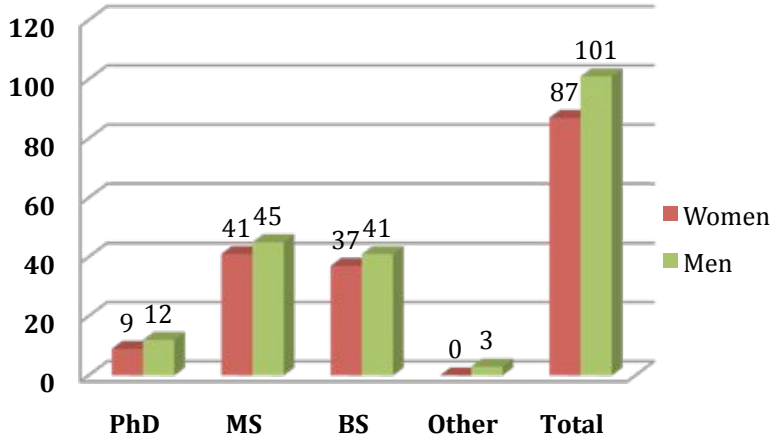

Figure VIII-4. Numbers of AquaFish CRSP students seeking BS, MS, PhD, and "other" degrees during FY11, disaggregated by gender. Students classified as "other" were seeking certificates of completion at an agriculture school or were in a post-doc program.

Gender Distribution of Long-Term AquaFish CRSP Students

Overall the program supported the education of 87 women 46.3% and 101 men 53.7% during FY11, resulting in a ratio that remains, as in previous years, close to 50:50. The numbers and percentages of women students supported by each of the AquaFish CRSP projects and the Program Management Office during FY11 are shown in Table VIII-3.

Table VIII-3. Numbers and percentages of women in long-term training programs in AquaFish CRSP during FY11.

US Lead Subcontracting Partner Institution	Total Students	# of Women	% Women
North Carolina State University	**23**	**14**	**60.9**
Purdue University	**23**	**12**	**52.2**
University of Arizona	**17**	**3**	**17.6**
University of Connecticut–Avery Point	**21**	**7**	**33.3**
University of Hawai'i at Hilo	**46**	**22**	**47.8**
University of Michigan	**46**	**21**	**45.7**
Auburn University	**3**	**1**	**33.3**
Oregon State University /Montana State Univestiy	**3**	**2**	**66.7**
Program Management Office (OSU)	**6**	**5**	**83.3**
Total	**188**	**87**	**46.3**

Long-Term Training in IEHA Countries

Twenty of the long-term trainees who received AquaFish CRSP support during this year were from IEHA countries (Kenya, Ghana, Uganda, and Nigeria). Among these 20 students, 8 (40%) are women and 12 (60%) are men. Among these students, 4 (20%) were seeking BS degrees, of which 2 (50%) are women and 2 (50%) are men, 14 (70%) were seeking MS degrees, of which 6 (30%) are women and 8 (70%) are men, and 2 (10%), both men (100%), were seeking PhD degrees.

Long-Term Programs Ended in FY11

Fifty-three students completed AquaFish CRSP-supported degree training during the reporting year. These students included 23 women (43.4%) and 30 men (56.6%). Seven IEHA students (2 women and 5 men) were among those finishing. Completions included 6 PhD, 29 MS, and 18 BS programs at institutions in 12 countries.

OUTCOMES AND IMPACTS OF AQUAFISH CAPACITY BUILDING EFFORTS

The AquaFish CRSP has achieved a number of notable accomplishments in its capacity building efforts:

- As of the end of this reporting year, a cumulative total of 320 long-term students have enrolled in long-term training programs since program inception. During FY11, 188 long-term students received CRSP support through the core projects and the Management Office. The majority of these FY11 students (166 students, 88.3% of all students) were Host Country nationals studying in their home countries or the US.
- Overall, the AquaFish CRSP has reached its target of including 50% women in its long-term training efforts. For this reporting period, women represented 46.3% of the cumulative student enrollment (87 women/188 total students). Adjusting the data for HC-only students, the gender ratios are similar, with an enrollment of 44.6% women.
- The gender data reflect the challenges of bringing women into aquaculture, particularly in countries where they have traditionally been involved mainly in 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 seven core projects has a gender inclusivity strategy and a gender-focused investigation for the *2009-2011 Implementation Plan*. This is helping to improve opportunities for women in situations 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 from among the 60 short-term training events conducted during FY11 are as follows:
  - ⇒ In Uganda, the CRSP project led by Auburn University co-sponsored the 4th Annual Fish Farmers Symposium & Trade Fair held in Kampala from 11-13 January 2011. The event was organized in partnership with WAFICOS—the Walimi Fish Farmers Cooperative Society. Attendees included stakeholders at all levels: farmers, prospective farmers, service providers, fisheries officers, students, and researchers. Presentations, which reflected the requests of event attendees, covered topics focusing on operating fish ponds and farms as businesses, feeds and feeding of fish, and farmer's experiences both in making profits and selling fish at a loss. Study tours to farms and related businesses offered participants opportunities to observe successful aquaculture operations in situ. The multifaceted nature of this annual event serves as a forum where stakeholders at all levels can learn from each other as they share information, network, and work out practical solutions to current production challenges. (CRSP Investigation Code 09BMA02AU)
  - ⇒ In the Philippines, a workshop on reduced feeding strategies ("Workshop on Tilapia Feeding Strategies and Feed Manufacturing: Meeting Global Challenges") was organized by the North Carolina State University project and attended by over 60 tilapia farmers, feed manufacturers, representatives of local and regional Filipino government agencies, and university students. Since feed costs are the highest single production cost farmers face, strategies that reduce the amount of feed used without significantly reducing production improve their profit potential. CRSP researchers have developed several such strategies and produced four English-language podcasts, as well as two in Tagalog (the native Philippine language), as outreach tools to educate farmers on these cost-saving feeding technologies. The project used this training event as a way to broaden the audience of stakeholders who have access to this information and encourage its further diffusion by the fisheries officers, government officials, and feed company owners who attended. The event, held at Central Luzon State University on 11-12 August 2011, was also featured on a local news channel. The news

video is available on YouTube and the podcasts can be downloaded from iTunes. (CRSP Investigation Codes 09SFT04NC and 09SFT06NC)

⇒ In Ghana, a workshop on "Propagation and Hatchery Management of the Nile Tilapia (*Oreochromis niloticus*) and African Catfish, (*Clarias gariepinus*), in Ghana," organized by the CRSP's Purdue University project and its partne Virginia Polytechnic Institute and State University, was held at Akosombo on 14-16 December 2010. This training focused specifically on practices for small- and medium-scale Ghanaian farmers to follow to successfully produce Nile tilapia and African catfish fingerlings, the starting point for all aquaculture grow-out operations. The goal of the CRSP organizers was to provide farmers and prospective farmers with essential knowledge and skills in basic techniques of aquaculture, to better enable farmers to become successful producers and models for their communities. The request by participants for a regular schedule of trainings to reach new farmers and to expand beyond the current regional focus shows both the popularity of the CRSP trainings and signs that the farmers themselves are enthusiastically promoting diffusion. (CRSP Investigation Code 09QSD05PU)

⇒ The University of Connecticut project incorporated a comprehensive impact assessment component to evaluate the combined accomplishments of its CRSP work in the lower Mekong River Basin in Cambodia and Vietnam. To train the cooperating local fisheries officers and other associated government officials, the project held 13 workshops dealing with data collection and assessment methods. The data collected by these teams of CRSP researchers and local cooperators will be used to assess the project impacts of CRSP work in the areas of 1) sustainable approaches to snakehead aquaculture and its value chain, 2) sustainable management of the aquaculture-capture fisheries interactions, 3) management recommendations for protecting the small-sized fishery, and 4) standards for fish paste processing. Bringing in local cooperators is helping with the diffusion of information about CRSP activities in the region and the new technologies and policies that will develop as a result of this work. (CRSP Investigation Code 09FSV03UC)

⇒ In the Aserradores Estuary of Nicaragua, 66 families have participated in the CRSP community-based co-management project for the native black cockle (*Anadara* spp.) fishery. The no-take zone approach for maintaining sustainable shellfish populations and safe-to-consume cockles offers a more effective management system than the traditional four-month seasonal ban. CRSP's community focus and partnership with the 66 families to monitor and manage no-take areas has proven a successful capacity building endeavor. On 21-22 October 2010, the University of Hawaii at Hilo project organized the "Forum for Defense of the Mangrove Ecosystem to Assure Biodiversity and Food Security for the Cockle Collecting Communities" at the University of Nicaragua-Leon to promote this model and the underlying ecological issues within a larger community of stakeholders. There were over 100 attendees from coastal communities, government, businesses, and academic institutions. These stakeholders will be instrumental partners in spreading information about the workable solutions embodied in the community management approach, which will ensure both food security for the coastal communities and the ecological well-being of the mangroves. Diffusion among stakeholders is already in evidence. The success of the collaborative CRSP community model has prompted the Nicaraguan government to test the community co-management approach in two other coastal communities. (CRSP Investigation Code 09HHI01UH)

⇒ In Thailand, the University of Michigan partnered with the Network of Aquaculture Centres in Asia-Pacific (NACA) to present a workshop for farmers and managers to review the current status of prawn farming and educate them on how to minimize the environmental impacts from farming practices ("Identifying Best Practices for Giant River Prawn Industry"). This workshop was held from 8-10 August 2011. Attendees represented a cross-section of stakeholders that included fisheries officers, government officials, prawn farmers, and hatchery owners. Following a 2006 CRSP evaluation that identified major environmental problems with the intensive prawn monoculture system, farmers have already willingly changed their production practices. Polyculture is now practiced by an estimated 80% of farmers, a dramatic change from 2005, when 96% of prawn farmers practiced monoculture. Best practices based on integrated culture with shrimp and lower density of prawns has allowed farmers to retain and reuse their water rather than discharge it. This and other substantial culture changes as well as voluntary adoption of better environmental performance

methods illustrates the strength of the CRSP development approach. These changes in practices occurred as a consequence of the diffusion that stakeholders initiated and then promoted as they adopted CRSP best practices. (CRSP Investigation Code 09BMA06UM)

⇒ The third in a series of CRSP trainings for small-holder farmers in rural Guyana was conducted by the University of Arizona-led project on 12 November 2010. This training series on sustainable feed and production technologies targeted individual farmers, small communities, women farmers, a feed mill, and a tilapia hatchery. The workshops were designed to help communities develop self-sustaining, small-scale aquaculture systems that include their own feed production and marketing structures. CRSP also set up community demonstration farms that integrate aquaculture with vegetable growing. These demonstration farms now serve as working models for surrounding communities. Through the trainings and demonstration farms, CRSP is promoting community-to-community diffusion starting with the first adopters who in turn train others through their example in successfully using CRSP aquaculture technologies. (CRSP Investigation Code 09SFT03UA)

CRSP CO-SPONSORED CONFERENCES AND EVENTS

International and regional conferences offer CRSP participants access to technical information on aquaculture and fisheries topics as well as opportunities to meet other professionals who are conducting research, training students, or carrying out extension activities. When possible, 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. This is also true for students whose training is being supported by the CRSP, so this support includes, where possible, attendance of our students at these conferences so they can present the results of their CRSP research and establish connections that will help them continue their professional careers after they return home. CRSP efforts in this area 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 co-sponsored the 9th Asian Fisheries and Aquaculture Forum (9AFAF) of the Asian Fisheries Society (AFS) held on 21-25 April, 2011, in Shanghai, China. The CRSP Director served on the scientific committee of this forum, which brought 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 CRSP co-sponsored the Ninth International Symposium on Tilapia in Aquaculture (ISTA 9), held 22-25 April, 2011, in Shanghai, China. This was the ninth of the highly successful series of symposia that brings together tilapia scientists and culturists 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 had a special emphasis on best management practices, quality control, new product forms, international trade, and opening new markets for farmed tilapia products. ISTA 9 was held in conjunction with the 9th Asian Fisheries and Aquaculture Forum (9AFAF) and Fourth ISSESR.
- As part of AquaFish CRSP involvement in and support of the 9AFAF and ISTA9 conferences in Shanghai in April 2011, the CRSP Director organized and chaired a full-day session on *Accelerating Aquaculture Development in Poorer Countries*, bringing together 18 presentations covering research and

outreach efforts in Asia, Africa, and South and Central America. A capacity audience came away with an indication of the breadth of aquaculture research and development underway in poorer countries.

- The CRSP is co-sponsoring the International Institute of Fisheries Economics and Trade (IIFET) 2012 Conference in Tanzania on 16-20 July, which will enable African researchers to participate in state of the art conversations about aquaculture, trade, and economics.
- The AquaFish CRSP co-sponsored *TILAPIA 2010* in Kuala Lumpur, Malaysia on 27-29 October, 2010. This 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 CRSP organized and chaired a symposium on *The Effects of Semi-Intensive Aquaculture on Biodiversity In Nearshore and Inland Waters*, held during the 2011 AFS conference ("New Frontiers in Fisheries Management and Ecology: Leading the Way in a Changing World") in Seattle, USA, from 4-8 September, 2011. This session, held on 8 September, included 13 presentations by professionals both in and outside of the CRSP, and was co-chaired by Director Hillary Egna and long-time CRSP Lead PI Dr. James Diana of the University of Michigan.

Table VIII-4. Short-term trainings conducted in FY11.

Project	Event Name	Investigation Code	Country	Start Date	End Date	# of Trainees	% Women
NCSU	Tilapia Feeding Strategies and Feed Manufacturing	09SFT04NC	Philippines	2011-01-18	2011-01-19	47	31.9
NCSU	Culture of Seaweeds & Milkfish	09MNE02NC	Philippines	2011-01-26	2011-01-27	28	25.0
NCSU	Cage Culture of Milkfish & Other Marine Fishes	09MNE02NC	Philippines	2011/02/21	2011-02-21	27	22.2
NCSU	Seaweed Culture	09FSV02NC	Philippines	2011-02-22	2011-02-22	28	71.4
NCSU	Seaweed Harvest/Processing-Aceh 1	09FSV02NC	Indonesia	2011-07-24	2011-07-25	29	10.3
NCSU	Candy/Dessert Workshop 1	09FSV02NC	Indonesia	2011-07-26	2011-07-26	45	95.6
NCSU	Nutrition & Seaweed Handling	09FSV02NC	Indonesia	2011-07-27	2011-07-27	21	19.0
NCSU	Processing Methods Workshop 1	09FSV02NC	Indonesia	2011-07-28	2011-07-28	7	0.0
NCSU	Workshop on Tilapia Feeding Strategies and Feed Manufacturing: Meeting Global Challenges	09SFT06NC	Philippines	2011-08-11	2011-08-12	66	39.4
UM	Invasive Species Impacts in Reservoirs 1	09MNE05UM	Vietnam	2011-07-29	2011-07-29	42	33.3
UM	Invasive Species Impacts in Reservoirs 2	09MNE05UM	Vietnam	2011-08-01	2011-08-01	34	20.6
UM	Water Quality Management Training for Farmers	09BMA05UM	China	2011-08-08	2011-08-08	34	8.8
UM	Identifying Best Practices for Giant River Prawn Industry	09BMA06UM	Thailand	2011-08-08	2011-08-10	28	50.0
UA	Aquaculture for Rural Poor-3	09SFT03UA	Guyana	2010-11-12	2010-11-12	43	46.5
UA	Rockview Lodge Workshop	09SFT03UA	Guyana	2011-06-15	2011-06-16	9	0.0
UA	Trafalgar Union Workshop	09SFT03UA	Guyana	2011-06-20	2011-06-20	13	61.5
UHH	Forum on Mangrove Ecosystem Biodiversity & Food Security	09HHI01UH	Nicaragua	2010-10-21	2010-10-22	64	59.4

Table VIII-4. Short-term trainings conducted in FY11.

UHH	Community Meeting on Cockle Population Monitoring	09HHI01UH	Nicaragua	2010-10-30	2010-10-30	25	48.0
UHH	Community Meeting: Population Monitoring	09HHI01UH	Nicaragua	2010-11-03	2010-11-04	45	91.1
UHH	Sign Re-installation for Black Cockles Management	09HHI01UH	Nicaragua	2010-11-19	2010-11-19	16	75.0
UHH	Regional Workshop for Women 2	09HHI02UH	Nicaragua	2011-07-26	2011-07-27	127	60.6
UHH	Regional Workshop for Women 1	09HHI02UH	Mexico	2011-09-03	2011-09-04	30	90.0
AU	Student Data Collectors Training	09BMA01AU	Uganda	2010-10-01	2010-10-01	5	40.0
AU	Cage Culture Farmer Training 1	09BMA01AU	Uganda	2011-01-01	2011-01-01	10	40.0
AU	2011 Fish Farmers Symposium	09BMA02AU	Uganda	2011-01-11	2011-01-13	115	31.3
AU	2011 Study Tour 1	09BMA02AU	Uganda	2011-01-14	2011-01-14	10	20.0
AU	2011 Study Tour 2	09BMA02AU	Uganda	2011-01-14	2011-01-14	11	18.2
AU	2011 Study Tour 3	09BMA02AU	Uganda	2011-01-14	2011-01-14	9	11.1
AU	Kenyans Study Tour	09BMA02AU	Uganda	2011-01-31	2011-02-04	11	27.3
AU	Cage Culture Farmer Training 2	09BMA01AU	Uganda	2011-03-01	2011-03-01	10	40.0
AU	CAP Training at AU	09TAP08AU	USA	2011-07-26	2011-08-26	8	50.0
UConn	Practical Feed for Snakehead	09SFT01UC	Vietnam	2010-11-04	2010-11-04	34	14.7
UConn	Impact Assessment trainings-Cambodia 1	09FSV03UC	Cambodia	2011-01-03	2011-02-04	15	33.3
UConn	Impact Assessment Training-Cambodia 2	09FSV03UC	Cambodia	2011-01-06	2011-01-07	9	44.4
UConn	Impact Assessment Trainings-Cambodia 3	09FSV03UC	Cambodia	2011-01-10	2011-01-11	14	35.7
UConn	Impact Assessment Trainings-Cambodia 4	09FSV03UC	Cambodia	2011-01-13	2011-01-14	8	37.5
UConn	Impact Assessment Trainings-Cambodia 5	09FSV03UC	Cambodia	2011-02-14	2011-02-15	9	33.3
UConn	Impact Assessment Trainings-Cambodia 6	09FSV03UC	Cambodia	2011-02-17	2011-02-18	10	30.0
UConn	Impact Assessment Trainings-Cambodia 7	09FSV03UC	Cambodia	2011-02-24	2011-02-25	11	45.5
UConn	Value Chain Analysis-Cambodia 1	09MER04UC	Cambodia	2011-03-27	2011-03-29	7	57.1
UConn	Value Chain Analysis- Vietnam 1	09MER04UC	Vietnam	2011-03-27	2011-03-27	6	50.0
UConn	Impact Assessment Methodologies-Vietnam	09FSV03UC	Vietnam	2011-04-28	2011-04-29	53	26.4
UConn	Value Chain Analysis-Vietnam 2	09MER04UC	Vietnam	2011-04-28	2011-04-28	6	50.0
UConn	Impact Assessment Methodologies-Cambodia	09FSV03UC	Cambodia	2011-05-03	2011-05-04	49	20.4
UConn	Management Recommendations for small-sized fishery-Cambodia	09MNE04UC	Cambodia	2011-05-11	2011-05-12	37	24.3
UConn	Value Chain Analysis-Cambodia 2	09MER04UC	Cambodia	2011-05-23	2011-05-24	7	57.1
UConn	Impact Assessment Trainings-Cambodia 8	09FSV03UC	Cambodia	2011-06-05	2011-06-07	9	33.3
UConn	Impact Assessment Trainings-Cambodia 9	09FSV03UC	Cambodia	2011-06-09	2011-06-11	9	33.3
UConn	Impact Assessment Trainings -	09FSV03UC	Cambodia	2011-06-12	2011-06-14	8	50.0

Table VIII-4. Short-term trainings conducted in FY11.

	Cambodia 10						
UConn	Impact Assessment Seminar	07TAP01UC	Cambodia	2011-06-27	2011-06-27	41	43.9
UConn	Information/Communication Monitoring & Evaluation Workshop	07TAP01UC	Cambodia	2011-06-28	2011-06-28	41	43.9
UConn	Management recommendations for small-sized fishery-Vietnam	09MNE04UC	Vietnam	2011-07-08	2011-07-08	27	29.6
UConn	Assessment impact trainings-Cambodia	09FSV03UC	Cambodia	2011-07-20	2011-07-22	24	8.3
PU	Pre-On-Farm Trial workshop	09SFT02PU	Kenya	2010-10-16	2010-10-16	39	28.2
PU	Value Chain Opportunities for Women	09MER02PU	Kenya	2010-11-24	2010-11-26	19	78.9
PU	Training Program at WRI-ARDEC	09QSD05PU	Ghana	2010-12-14	2010-12-16	25	16.0
PU	Cage culture workshop	09TAP04PU	Ghana	2011-02-24	2011-02-26	13	15.4
PU	Post On-Farm Trial workshop	09SFT02PU	Kenya	2011-07-08	2011-07-08	41	26.8
PU	Training Program at PAC - Propagation and Hatchery Management of the Nile Tilapia	09QSD05PU	Ghana	2011-07-12	2011-07-13	39	12.8
PU	Indigenous Species Culture	09IND06PU	Ghana	2011-07-14	2011-07-14	151	12.6
					Totals:	**1758**	**37.4**

AquaFish CRSP graduate student, Glayd Kuria sets up cages in Kenya (Photo courtesy of Kwamena Quagrainie)

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 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 mentioned in the Program Description. Lead Coordinators of the thematic panels assist the ME in integrating cross-cutting needs identified by USAID, but adding 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 using biotechnology approaches cautiously. The Lead Coordinators are also responsible for writing annual reports, assisting the Director in evaluating workplan changes, performing assessments, and working together to provide quality information for thematic synthesis and lessons learned reporting. 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

Undernourishment is a worldwide problem among the poor. It affects all ages and plays a major role in perpetuating poverty. During FY2011, AquaFish CRSP projects in Africa, Asia, and LAC have focused directly and indirectly on alleviating this problem through a broad spectrum of activities and research that have introduced new technologies and species for small-holder aquaculture, trained stakeholders in food safety and quality standards for aquatic products, opened new income-generating opportunities along the value-chain, and helped protect fisheries through sustainable management plans.

In Cambodia, CRSP researchers have taken a multi-faceted approach for resolving the competing uses of the small-sized, low-value fish of the lower Mekong River Basin for fishmeal to feed farmed fish and livestock versus for human consumption by the rural poor living within the river system. CRSP management recommendations that have been developed for submission to the Cambodian government establish a policy

framework that will reestablish fish stocks while supporting food security and poverty alleviation. CRSP has also trained poor women in food safety and quality guidelines to use when they produce prahoc, a traditional fish paste made from these small-sized fish, which serves as a primary protein source in the diet of the Cambodian poor. In the Philippines and Indonesia, CRSP trainings that largely target poor women are opening new income-generating opportunities for preparing value-added processed milkfish products, pickled seaweed, and candy and desserts made from the agar that they extract from seaweed. Food safety and quality is an underlying emphasis in these trainings. CRSP has also trained farmers in proper techniques for raising and drying seaweed as a quality product that will be used for human consumption. In China, CRSP researchers have developed best practices for pond-raised shrimp, which will lead to eco-certification, a product status that ensures food safety and quality.

CRSP has introduced sustainable polyculture systems where they can offer both income generating opportunities and food security to small-holder fish farmers. In Bangladesh, polyculture of giant freshwater prawns (*Macrobrachium rosenbergii*) with the small indigenous fish known as mola (*Amblypharyngodon mola*) is an innovative approach that provides families with a continuous source of food with no adverse effect on the prawn cash crop that will be harvested for export markets. In Nepal, the focus is on increased production and improved aquaculture productivity by incorporating tilapia and the native fish sahar (*Tor putitora*) into carp polyculture. With trainings that also bring women into aquaculture and emphasize household nutrition, the benefits will extend beyond improved income from the cost-efficiencies of the polyculture system.

In Mexico and Nicaragua, CRSP researchers have been working with local estuarine communities along the Pacific Coast to train them in basic techniques for shellfish sanitation. In Mexico, CRSP researchers have set up a hatchery at the Universidad Autónoma de Sinaloa where they are developing methods for producing seed of the native oyster *Crassostrea corteziensis*, which will supply the region's developing fishery for this species. The hatchery is also serving in a dual role as a training and research facility for students and faculty. Once fully operating, it will provide poor fishers who have been trained in shellfish sanitation methods with a reliable source of spat. In Nicaragua, members of 66 families have collaborated with CRSP researchers to learn a system of no-take areas in the Asseradores Estuary by which to sustainably manage the cockle fishery (*Anadara* spp.) and ensure the safety and quality of cockles they collect for food and market. In other ongoing CRSP-supported work, development of breeding technology for chame (*Dormitator latifrons*) is moving towards a farmed source of fingerlings, which currently must be obtained from the wild. This technology will ensure a more sustainable chame aquaculture and the associated food security it will provide. It will also help alleviate pressures on the wild fishery which has also suffered from overfishing for use as fishmeal. Rural stakeholders will benefit in having a farmed source of this native fish, which has been a traditional food of the poor.

DTAP B: Income Generation for Small-Scale Fishers and Farmers

Submitted by Kwamena Quagrainie (Purdue University) Lead Coordinator

Improvements in technology, production practices, and natural resources management enhance the production of fish and shellfish in rural communities. AquaFish CRSP activities focused on a number of technological practices across the various regions.

In Africa, diversification in production practices was introduced to offer small-scale fish farmers opportunities to enhance revenues from aquaculture. Improved cage aquaculture technologies in ponds, lakes, and reservoirs for fish production were introduced in Kenya and Uganda as complementary technologies to fish production from traditional ponds and wild-caught fisheries. This integration of production systems helped to decrease fishing pressure on natural fisheries. The technologies provided additional economic opportunities and incomes for limited resource farmers and landless men and women in rural communities. In Ghana however, where cage aquaculture has seen increased adoption, efforts were targeted at strategies for removing constraints to cage aquaculture adoption. Other diversification opportunities were the integration of pond-based recirculating aquaculture systems with solid waste removal

and water quality controls (China) and aquaponics technologies (Mexico and Guyana) for integrated agriculture-aquaculture systems in rural areas.

Across all regions, diversification also related to technologies to minimize production risks through integrated production systems and polyculture systems. The program introduced high-valued fish species into existing culture systems as well as domesticated native species for commercial production to supplement farm income. Examples included on-farm development of polyculture technology for optimal sahar-tilapia-carp production for best economic returns in Nepal, the integrated multitrophic polyculture of milkfish-seaweed-sea cucumber in the Philippines for nutrient recycling and expanded production capacity, a cage-cum-pond system in Kenya with tilapia and catfish for feeding reduction and waste control. Other work focused on bringing native species into aquaculture: snakehead in Cambodia, chame, native cichlids, and snook in Mexico, and African bony-tongue, Claloteid catfish, African snakehead in Ghana. Some technological practices adopted included induced spawning, management of early life stages, identification of nutritional requirements, and optimal feeding strategies.

Other new technologies related to feed formulation, reduced feeding strategies, lowered fishmeal content in feed, processing of fish waste, seaweed drying rack system, value-added processing, packaging technologies, and labeling standardization. Farmers benefited from the lower production costs from improved production efficiencies, and new income opportunities. Women benefited the most from the adoption of post-harvest technologies.

New information technologies were introduced under AquaFish CRSP activities. For example, a pilot Farmed Fish Marketing Information System (FFMIS) that taps into existing market information systems in Kenya to allow timely access to markets was tested by selected cluster farmers. Software approaches for water management under multiple uses were tested in Uganda. Podcasts dealing with reduced feeding strategies for small-scale tilapia farmers are being disseminated through electronic media and the internet.

DTAP C: Environmental Management for Sustainable Aquatic Resources Use

Submitted by Jim Diana (University of Michigan) 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.

One focus of the AquaFish CRSP related to environmental management has been on the reduction of effluent and solid waste emanating from fish culture systems. Studies on pond-based recirculating aquaculture systems in China have shown that effluent release can be completely eliminated by management using suspended flocs and bio-nets to grow periphyton. Similarly, seaweed co-culture systems in Banda Aceh and the Philippines have resulted in substantial removal of nitrogen and phosphorus from receiving waters in aquaculture systems. In addition, a number of improved feeding practices have been evaluated, which would allow for more efficient use of nutrients applied and therefore less effluent in the water drained from these systems. For example, studies in the Philippines have shown that alternate-day feeding of milkfish and integration of milkfish with other species are substantially improving food conversion efficiency. Similarly, studies on aquaponic systems in Mexico indicate that tilapia in the systems can be fed efficiently and the waste can be used to grow vegetable crops for even better nutrient retention. Reduced feeding strategies have also been applied to tilapia in the Philippines, with significant success in changing local practices. Snakehead aquaculture in Vietnam has also been improved by the development of pelleted feed with lower fishmeal content.. These steps not only improve effluent management, but also reduce the pressure on native fish resources in the area used for fishmeal.

An excellent end result of effluent control was the workshop conducted on prawn culture in Thailand. A previous CRSP study had shown that effluents from ponds and overfeeding were creating environmental damages from prawn culture. During the workshop, best practices by local farmers showed that integrated culture with shrimp and lower density culture of prawns allowed farmers to retain and reuse their water rather than discharge it. There have been substantial changes in the prawn culture methods in Thailand as a result of the earlier study and adoption of better environmental performance methods.

Another area of environmental performance involves water use and water management. We have developed management practices for building ponds and managing watersheds in ways that reduce loss of water from the aquaculture system and also improve aquaculture performance.

A third focus of the AquaFish CRSP has been on the use of native species. In Nepal, polyculture of sahar with other carp species has resulted in improved management, new crops, and reduced pressure on wild sahar populations. In addition, a proportion of the sahar produced are being restocked into natural waters to re-establish sahar populations. Similar studies in Ghana have focused on farming native African species and reducing the pressure on wild fish stocks. In Central America, sustainable management of native oyster and black cockles fisheries will result in improved livelihoods for communities in Pacific coast estuaries which depend on these shellfish for food and sale to local markets. Similarly, the development of a chame fishery management in the region will reduce pressure on wild fish stocks as will the development of snook aquaculture.

A fourth focus of the AquaFish CRSP in environmental performance involves enhancement of natural fish populations. The understanding of the small-size, low-value fish in the lower Mekong region of Cambodia has provided many management recommendations for improving the fishery while reducing the pressure on fish stocks. Coupled with this are changes in feed practices from lowered fishmeal in feed pellets for snakehead, which will help to reduce fishing pressures on the small-size fish species which form a primary protein source for the rural poor living in the Mekong River Basin. Development of hatchery management methods in Mexico will provide oyster farms with a reliable, sustainable source of spat. Development of no-take zones in the black cockle fishery in Central America resulted in significant production improvement in the fishery, as well as conservation of natural cockle communities. Studies in Vietnam evaluating the effects of stocked fish on the wild fish populations have resulted in reductions on stocking in many small reservoirs, which improves the situation for the native fish species present.

The AquaFish CRSP has had a significant portfolio in improving environmental performance for sustainable aquatic resources use. Our estimates are conservative but show that an additional 3,500 hectares of land have been placed under improved management practices, with newly developed practices focused on biodiversity and on improved natural resources management. Extension of this information through workshops, pamphlets, and fact sheets has resulted in much more spread of the information than estimated above, but it is impossible for us to accurately quantify how extensively these practices have influenced current aquaculture farmers throughout the host countries.

DTAP D: Enhanced Trade Opportunities for Global Fishery Markets

Submitted by Robert Pomeroy (University of Connecticut–Avery Point) Lead Coordinator

In FY2011, the development of new domestic and international markets for aquatic products continues to progress. In Uganda, a market assessment for aquaculture products found that (1) information on the supply and demand for fish products is limited, (2) small-scale fish farmers located relatively close to markets have the widest range of marketing opportunities, (3) fish farmers who are not close to roads or who produce unreliable quantities and variable quality products are facing high transaction costs of marketing their product and decreasing net returns to production, and (4) significant on-farm labor and access to input markets are important factors leading to negative net returns to fish farming. 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. A value chain analysis for snakehead and small-size fish in Cambodia and Vietnam found that small-size fish caught in the Mekong River Basin are used for feed (45%), household consumption (21%), sold to traders (15%), and direct sale in local markets (15%). Overfishing for small-size fish has negative impacts on wild fish stocks, reduction in food supply, and depletion of juveniles. Market analysis revealed that there is a range of markets in the region for the processed products from small-size fish. In Cambodia, small size fish are important for poor people as fish paste, smoked fish, and fermented fish and are used for household consumption the whole year round. The project has worked to develop best processing practices to improve and ensure food safety and quality of fermented small-size fish paste (*prahok*) products for local consumers and the competitive markets in Cambodia and to develop a women's fish processing group/association. The project has also conducted a market channel and trade analysis of fermented small-sized fish paste in Cambodia identifying both domestic and international markets. In Vietnam, ten significant value chains were identified, with the two most prominent being "Fish farmers – Wholesalers – Retailers – End consumers in the Mekong Delta (MKD)," and "Fish farmers – Wholesalers – Wholesalers in Ho Chi Minh City". In Cambodia, 11 significant value chains were identified, with 25% of the wild-caught snakehead going from fishers to end users. An examination of profits throughout the whole Vietnamese value chain indicates that wholesalers reap about 90% of the total profits in the system, based on a profit per kg of 1200 VDN (USD 0.06) and the large volume (728 kg) that each processor handles. Farmers, on the other hand, make only about 6% of the profit in the system, based on a profit per kg of 4400 VDN (USD 0.23) and production of a small amount (about 14 tons) per farm. Retailers make the greatest profit per kg (7500 - 9700 VDN, USD 0.39-0.51), but also account for a small percentage of total profits in the system due to the small number of kg that each retailer handles. In Guyana, efforts are underway to develop an international market for brackishwater shrimp, a new product for the country.

A number of aquatic products available for human food consumption are under development or available in the market. 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 integrated multitrophic polyculture (milkfish-seaweed-sea cucumber) system is leading to a more sustainable source of milkfish along with new deboned and marinated milkfish products and development of seaweed and sea cucumber production. In China, research on the evaluation of shrimp impacts and practices should aid in the eco-certification of shrimp to minimize negative impacts and increase consumer confidence in aquaculture production. Mass balance models, economic performance, and social analysis work will lead to government regulatory and environmental mitigation efforts as well as transfer of best practices to farmers. In Bangladesh, work on polyculture systems will lead to production of four products: prawn for export and mola and carp for household consumption. . Work to bring chame (*Dormitator latifrons*) into aquaculture will open up new markets in Mexico and elsewhere in LAC for this important fish, which is a traditional food fish for the poor as well as a source for fishmeal. In Thailand, a workshop on giant river prawns, an important local product, will expand prawn production knowledge. In Cambodia, analysis of processing practices has led to recommended best management practices for *prahok*. As processors adopt these new practices, markets for fermented fish paste will expand both in Cambodia and in other countries in the region. In Mexico, hatchery seed production of native oysters will ensure a sustainable production system for the poor farmers and communities who depend on them for food and income. In the Philippines and Indonesia, trainings on sustainable seaweed culture and value-added processing is leading to new products for human and non-human uses such as candy and desserts made from agar, pickled seaweed, industrial grade agar and carrageenan raw product. 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. A snakehead hatchery has been developed, 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.

REGIONAL CENTERS OF EXCELLENCE (RCE)

The Regional Centers of Excellence (RCEs) provide technical advice on emerging issues and gaps in the portfolio from a regional perspective. Centers develop useful materials for Missions, other regional stakeholders and end-users, and gauge opportunities for collaboration based on regional or national needs. Four centers have been formed and each coordinates activities within a specified region: Asia, East and Southern Africa, West Africa, and Latin America and the Caribbean (LAC). The centers for Africa 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) take active roles in integrating Associate Award partners into the portfolio and assist in the management of Associate Awards that fall under their purview. Lead Coordinators also assist the Director in cases where a screening process is required in advance of an Initial Environmental Examination.

RCE–East and Southern Africa Annual Report

Charles Ngugi, Lead Coordinator
(Ministry of Fisheries Development, Kenya)

The East Africa Regional Center of Excellence (RCE) continued to perform its role in building community among all CRSP participants; identifying potential additional partnerships with the public and private sectors, NGOs, USAID, and others; and bridging the knowledge gap from local/regional perspectives to global development outcomes. During this reporting period, RCE facilitated networking with African scientists through SARNISSA, WAS, NEPAD, and ANAF meetings, conferences, and exchange fora. Specific approaches included:

- Fostering personal contacts/relationships
- Networking with AquaFish CRSP HC PIs in Kenya, Uganda and Tanzania
- Farmer to farmer exchange programmes
- Reviewing regional proposals
- Establishing collaborative research and institutional linkages

The RCE organized three fish farmers' workshops at the Mwea Aquafish Farm and ran two on-farm trials on pond/cage tilapia culture. RCE facilitated regional networking by developing posters, aquaculture fact sheets, and teaching modules in collaboration with University of Stirling under the DFID-funded Research into Use programme through the Aqua Shops pilot projects in Western Kenya. In addition, the RCE office initiated a collaborative meeting between AquaFish Director and SARNISSA Coordinator that culminated in AquaFish supporting some of SARNISSA's activities and developing a stronger linkage.

The RCE's present approach to promoting aquaculture in Africa has been to assist member countries in investigating aspects of aquaculture development and to test and demonstrate methods and approaches that are socially and economically viable as well as technically feasible. The programme'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. Major problem areas observed in the region include the following:

- Ineffective or non-existent policies
- Inadequate infrastructure
- Poor extension support
- Unavailability of inputs (including seed, feed, and credit)

Through collaborative research in aquaculture, CRSP has endeavoured to work with all stakeholders in Africa. In the region, aquaculture has been promoted through interrelated programmes in education, training,

research, and outreach. In recognition of the need for technical skills in the region, there has been major support to education at all levels. This year the RCE supported undergraduate and graduate student education through sponsorship or partial funding to travel to the field and undertake various aquaculture activities. More specifically the RCE office supported Victor Motari to shoot, edit, and upload aquaculture videos on YouTube as part of information exchange.

Charles has established links and contacts with senior officers in government and in international organizations 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.
- From Tanzania, the Assistant Director of Fisheries, a member of ANAF, attended the ANAF meeting in Jinja (Uganda) and I linked him to FAO and SARNISSA.
- In Uganda we have established a linkage with Kajanssi Research Centre and the Uganda Commissioner for Fisheries, who attended the ANAF meeting in Jinja.

In keeping with AquaFish CRSP policy, the RCE has made every effort to encourage gender integration in project implementation, and has endeavored to ensure that equal numbers of men and women are included in all AquaFish CRSP activities. Within the present AquaFish CRSP in Kenya for example, women have been included in training on the production of catfish as bait fish for Lake Victoria fisheries, in several workshops, and in a study tour to Uganda fish farms. More than 40% of the students educated through formal training opportunities are women; the two graduate students on the Kenya project are both women, and the RCE does play a role in the selection and mentoring of these students. The two students have received full funding including registration and accommodation to attend the Aquaculture Association of Southern Africa (AASA) conference to be held in Malawi this September (2011).

Charles also organized an e-workshop for farmers in Kisumu and Kirinyaga in March, 2011, in which farmers were introduced to the use of the internet as a source of aquaculture literature and information. The objective of this annual SARNISSA Stakeholders Workshop was to build research coalitions among fish farmers who plan on using the internet to source aquaculture information on production and marketing. This regional RCE plays a key role in SARNISSA and provides a vital link with the AquaFish CRSP. The RCE has through SARNISSA established contacts with over 1,800 stakeholders who are enrolled members of SARNISSA. This has provided individuals with something they need and can benefit from.

The RCE has made every effort to source leverage funds from USAID missions, EU, CIDA, DFID, and government ministries, among others, in support of aquaculture development for the region. Currently there are FAO/ TCP aquaculture projects going on in Uganda, Kenya, and Ghana. The most recent undertaking has been the FAO support in Ghana. The "Aquaculture Investments for Poverty Reduction in the Volta Basin: Creating Opportunities for Low-Income African Fish Farmers through Improved Management of Tilapia Genetic Resources – Regional Project GCP/RAF/417/SPA". The USAID funding in Uganda, World Fish Center funding in Malawi, NEPAD/Comesa project at Bunda College in Malawi, Leader with Associate Award in Mali, EU-SARNISSA funding for Cameroon, Malawi, and Kenya, DFID Aqua Shop projects in Kenya are among a host of other projects in the region.

Efforts to encourage commercial fish feed production in the region have continued this year. Ugachick feed (ugachick@infocom.co.ug) is now available to Kenya farmers and is being distributed by the Ministry of Fisheries Development under the Economic Stimulus Programme.

RCE–West Africa Annual Report

Héry Coulibaly, Lead Coordinator
(Technical Advisor, Permanent Assembly of the Chambers of Agriculture, Mali)

The West Africa Regional Center of Excellence is the newest of the regional centers, being set up in 2010. Dr. Héry Coulibaly, who served at the time as the HC Principal Investigator for the Mali Associate award, was selected to serve as its Lead Coordinator. The Mali Project has been completed and Dr. Coulibaly has since moved on to become Technical Advisor to the Permanent Assembly of the Chambers of Agriculture, Government of Mali, but continues in his role as Lead Coordinator.

From 12 - 14 October, 2010, the West Africa Lead Coordinator participated in a regional workshop entitled *Securing Sustainable Small-Scale Fisheries: Bringing together responsible fisheries and social development-Regional Workshops (AFRICA)*, held in Maputo, Mozambique. The workshop was organized by the FAO Committee on Fisheries (COFI) and included representatives from Burkina Faso, Cameroun, Congo, Ivory Coast, Gambia, Chad, Guinea, Morocco, Mali, Mozambique, Mauritania, Mauritius, Nigeria, Sierra Leone, Tanzania, Togo, and COREP—the Regional Fisheries Committee for the Gulf of Guinea. Detailed reviews of the aquaculture situations in Mauritania, Burkina Faso, Congo, and Togo were presented and a COREP representative gave a regional overview. Some constraints to aquacultural development mentioned in the presentations included:

- Lack of water, especially in the Sahelian parts of the region
- Lack of integration of aquaculture development with agricultural development
- Lack of taking public perceptions of aquaculture into account in planning
- Lack of national strategies for aquaculture development
- Lack of technological knowledge/insufficient training
- Inadequate staffing, especially senior officers
- Lack of aquacultural research experience among responsible institutions, especially with regard to rice-fish culture
- Insufficient supplies of tilapia fingerlings
- Poorly developed post-harvest handling systems
- Competition between aquaculture and animal husbandry for the use of available local feed ingredients
- Lack of locally produced fish feeds
- Unavailability of financing (loans) to begin fish farming operations

Tilapias are the main species of fish farmed in the region, although some farmers also produce African catfish (*Clarias*).

Women's roles in much of the region are on the post-harvest side, i.e., trading, processing, and marketing. However, in some areas they also participate in pond harvesting.

In Mali, the construction of a central fish market (with financing from Japan) will make it possible for 60 women wholesalers to market fish with better equipment and under improved hygienic conditions. Japanese financing also provided for the construction of fish markets for fish saleswomen in Koulikoro, Kangaba, and Kati. Three other fish markets that have been built—in Kayes, Bafoulabé, and Mahina—will benefit commercial fish women. These were built within the framework of the *Senegal River Basin Multi-purpose Water Resources Development Project*, with financing from the *International Development Association* (IDA). Three market-gardening perimeters are already arranged within the framework of the same project for the women of fishermen to enable them to produce vegetables during closed fishing periods. Two additional fish markets will be built (in Tombouctou and in Gao) for the fish saleswomen within the framework of the *Development Project of the Water Resources and of Durable Management of the Ecosystems of the Basin of the River Niger* (PDREGDE) of the ABN, also with financing from the IDA, and another project to develop marketing space for women is being planned.

During the sustainable small-scale fisheries workshop mentioned above, contacts were made with representatives from Burkina Faso, Congo, Mauritania, Togo, and COREP.

In Mali, the construction of a private 80-pond aquaculture farm was begun in the Baguineda area in February 2011, and another new farm project is underway near Sanankoroba (10 ponds, 1000 m^2 each). Another farm for the intensive production of *Clarias* is planned for Kéniorokoba, and Mrs. Sérébara Fatoumata Sidibé and her women's organization constructed two ponds in Yanfolila. In Segou, rice-fish culture is being tested in up to 60 plots in the administrative area of the *Office du Niger*. Fish Farmer Seydou Toé, considered to be one of the success stories of the AquaFish CRSP Mali Project, continues to produce *Clarias* fingerlings for sale and is looking into new ways of producing tilapia fingerlings. He continues to use the team he formed to build ponds for private individuals. The Koulikoro and Bamako Regional Offices of the DNP continue to support private individuals in the realization of their ponds.

RCE–Asia Annual Report

Remedios Bolivar, Lead Coordinator
(Central Luzon State University, Philippines)

The intensification of aquaculture operations in the region has resulted in high feeding rates, which hasten the build-up of organic matter in bodies of water used for aquaculture and are detrimental to the ecosystem. Proof of this is recent tilapia and milkfish kills in the Philippines. While aquaculture offers an array of opportunities for income generation and job creation in the region, there are gaps that need to be resolved to sustain the continuous growth of aquaculture:

1) Markets – marketing of some aquaculture products should be looked into in order to encourage stakeholders to invest in aquaculture. A new market niche must be established in aquaculture production.
2) Technologies –technologies appropriate for each region must be identified. No technology is universally applicable, just as there is no universal fish for culture.
3) Technology transfer – a strategy for technology dissemination is an essential ingredient to increase production in aquaculture. Regional and inter-regional cooperation provides the basic mechanism for technology transfer.
4) Training and extension – most countries in the region lack effective training and extension mechanisms, so the establishment of effective training and extension services is of special significance.
5) Applied research – research areas that will have direct effects on the needs of the fish farmers must be given priority. Examples are the following:
    a. Development of aquaculture technologies that are appropriate for countryside development
    b. Entrepreneurship in aquaculture
    c. Development of competitiveness of the aquaculture industry
    d. Enhancement of capability building in emerging technologies

While aquaculture operations are dominated by men, there is now a growing trend in the participation of women in the aquaculture industry. Women have proved to be competent in adopting new aquaculture technologies, but their role is very much restricted and often ignored. In the Philippines, women are well represented in many fisheries organizations, even occupying key positions. A handful of women operate tilapia hatchery businesses as well as grow-out operations. In rural areas, women are engaged in fish processing such as fish smoking and drying, which become a part of their livelihood. In the academe (aquaculture and fisheries), women have established their niches as effective and competent professors/mentors and researchers/scientists. In light of this bright development, some issues need to be addressed:

1) Training of women in the various aspects of aquaculture operations
2) Protection of women working in fisheries in far-flung areas

3) Establishment of cooperatives involved in aquaculture post-harvest related activities, which will encourage women to go into such endeavours
4) Initiate programs to empower women in fisheries undertakings

A collaborative research project was undertaken with the Mindanao State University – Maquindanao (MSU-Maguindanao), where a study entitled "Cage Culture of Nile Tilapia (*Oreochromis niloticus*) Using Different Feeding Strategies" was conducted. As a result of this collaboration, the university gave an equity counterpart amounting to $1190 for the purchase of water quality monitoring devices like dissolved oxygen meter, ammonia kit, etc. Likewise, the attendance of Mr. Ramjie Odin, of MSU-Maguindanao, at the *9th Asian Fisheries and Aquaculture Forum* and his presentation of a paper at the ISTA 9 symposium was partly supported by MSU-Maguindanao by covering his domestic travel (airfare and accommodation) while processing his Chinese visa in Manila.

An Information Brief about the AquaFish CRSP as well as the Regional Center of Excellence – Asia was developed and uploaded to the CRSP website.

The RCE– Asia served as a bronze sponsor in the *Tilapia 2010 Third International Technical and Trade Conference and Exposition on Tilapia*, held in Kuala Lumpur, Malaysia, from 27-29 October, 2010.

RCE–Asia Annual Report

Yuan Derun, Lead Coordinator
(Network of Aquaculture Centres in Asian-Pacific (NACA), Thailand)

Notable developments in Asian aquaculture

Aquaculture in Asia has been growing fast in last three decades. Production increased from 6.2 million tons in 1980 to 66.7 million tons in 2009 accounting for 91% of the world total. Asian aquaculture is dominated by small scale farms, defined as those owned or leased, managed or operated by farm families. Several cyprinids and tilapia which feed on low levels of food chains were among top ten most produced species with production accounting for 75% of Asian total in 2009 (FAO, 2011).

Some notable developments in last decade include: (1) shift of intensive shrimp culture from *P. monodon* to *L. vannamei* in traditional shrimp producing countries such as Thailand, Indonesia, Vietnam, and Philippines, and fast expansion of white shrimp culture in China, (2) scale-up of production and successful establishment of export markets of striped catfish in Vietnam, (3) aquaculture certification and improvement of product traceability and (4) development and adoption of BMPs.

Asian aquaculture are facing some emerging challenges, including (1) voluntary or compulsory compliance with increasingly stringent aquatic food safety and quality requirements and environmental regulations, (2) increasing production cost due to increase of prices of raw materials, (3) imbalance of profit distribution along value chains and economic viability, (4) climate change impacts, and (5) erroneous public perceptions in relation to aquaculture production process, food safety and biodiversity.

In immediate future, low-cost production for fish feeding on low levels of food chains such as carps and tilapia will still dominate aquaculture sector, white shrimp culture will continue to prevail with high possibility of return of *P. monodon* culture, and striped catfish culture is likely to sustain. New development may focus on (1) improvement of productivity, profitability, economic viability of small farming systems, (2) improvement of aquaculture certification schemes and product traceability, (3) enhance of small scale farmer education and development of farming clusters, and (4) institutional intervention and furthering communications and dialog among stakeholders to sustain ethical aquaculture trade. Fast growth and expansion may be seen at (1) culture-based fisheries, (5) use of small static water bodies for cage culture, and (3) marine culture.

Aquaculture CRSP and AquaFish CRSP in development process
Observations in my travels in the region in 2010 – 2011 strongly suggested that CRSP research has benefited majority of small scale farmers in Asia with its innovative and applicable research results and played a significant role in accelerating growth of aquaculture sector. It is well recognized as one of most sustainable research projects with great positive impacts on aquaculture by researchers, university teachers and students, government officers and development agencies. Impacts of CRSP can be felt on almost all aspects of regional aquaculture development including improvement of current aquaculture systems, new system development, food quality and safety, environment protection, and conservation of biodiversity. For example, decade-long research by Aquaculture CRSP led to establishment of pond fertilization theories and practical procedures for aquaculture, and application by aquaculture farmers has resulted in improvement in productivity of Asian traditional integrated systems, polyculture, and semi-intensive based monoculture. A series of culture technologies developed by CRSP for tilapia have also contributed remarkably to fast increase of tilapia production witnessed in last two decades.

CRSP communication nods in Asia
One of the most important achievements of CRSP is its communication network in the region established through various project activities including collaborative research, support to formal degree education, conferences, CRSP annual meetings, extension workshops, seminars and others. The network is the primary driving force to disseminate CRSP research results and spread CRSP influence in the region.
The communication nods in Asia may be categorized into three groups, (1) CRSP researchers and associates who have been directly involved in CRSP projects, (2) teachers and alumni of higher education institutions and researchers from research institutes which have served as CRSP country hosts, (3) some government officers, extension workers, NGO staff members and some individuals from private sectors who have been directly or indirectly involved in CRSP activities. These CRSP communication nods will likely continue to play roles in maintaining CRSP appearance and extending CRSP influence in the region.

New connections through NACA
NACA as an intergovernmental organization has a rather extensive communication network consisting of policy, research, education and development agencies in its 18 member states and governments. These include but not limited to government fisheries and aquaculture departments, government fisheries and aquaculture stations/centers, collaborative research institutes and universities. Contacts to these institutions, agencies or individuals are made through various channels including (1) NACA's two annual events - the Governing Council meeting and the Technical Advisory Committee meeting, (2) research and development projects, (3) NACA's communication program and (4) NACA's training and education program.
Linkage between NACA and CRSP and their collaborative activity to organize a workshop on giant freshwater prawn BMPs were reported to NACA's 21st and 22nd Governing Council and the Technical Advisory Committee.

RCE–LAC Annual Report

Wilfrido Contreras-Sánchez, Lead Coordinator
(Universidad Juárez Autónoma de Tabasco, Mexico)

Regional Assessment
Opportunities for collaboration have been approached both at the national and the international levels. At the national scale, several strategies have been pursued and turned out to be effective. As RCE I have taken advantage of established networks in Mexico (Panorama Acuicola and the Association of Mexican Tilapia Producers). A newly developed webpage (www.tilapiamexicana.com) has been frequently used to answer tilapia related questions as well as for helping farmers to establish contacts with hatcheries.

The RCE has been contacted by Mr. Hector Sada, co-owner and representative of Comercio Agrícola S.A. a company dedicated to the production and commercialization of organic agricultural products (mainly vegetables). They requested a proposal for integrated agriculture-aquaculture production. Our proposal focused on the production of tilapia and the use of the effluents to irrigate cotton and/or bell peppers. We also proposed in-situ training and the personal services of our recently graduated MC Rosa Aurora Perez-

Perez. We are waiting for a response from the company to execute this project.

In Brazil, Maria C. Portella taught a course on Neotropical Fish Larviculture for 12 graduate students from the Federal University of the Semi-Arid Region, in Mossoro, Rio Grande do Norte state. The northeastern region is the poorest region in Brazil and water resources in this area are limited. Precipitation is low and many years ago the government constructed several reservoirs for multipurpose use. Mostly they are used for human and animal consumption and irrigation. The establishment of sustainable fish culture in these brackish water lagoons is a challenge and this course was part of our contribution, sharing knowledge and transferring technology.

At the international level, two approaches have been taken: 1) Through established international networks where UJAT is a member (The International Network for Lepisosteid Research and the International Network for Snook Biology and Conservation) and 2) through the WAS Latin American and Caribbean Chapter, where Maria Celia Portella was recently named President and Alfonso Alvarez named Treasurer. In both cases, communication with researchers and farmers has been very successful. AquaFish-related research has been presented in network meetings (Gar network and WAS meetings). As a result of this, we have been writing proposals and exchanging students with researchers from Nicholls State University. We were also contacted by Dr. Richard Kline, Assistant Professor from the Biological Sciences Department at University of Texas at Brownsville, requesting participation of researchers in the Gulf of Mexico regarding the status of the Red Snapper populations and fishery. In the same order of ideas, Rocky Ward, from West Texas A&M University, requested our participation in a research proposal to investigate the status of Atlantic sharpnose shark populations in the Gulf of Mexico. In both cases, we are waiting for results from the evaluators.

Maria Celia Portella has established communications with South American researchers and received invitations to teach a graduate course on Native Fish Larviculture in at the Universidad Nacional de la Amazonia Peruana, Iquitos, Peru and participate as lecturer in two meetings in Colombia, one national (Jornada de Acuicultura, Nov 25, 2011) and another international (V Congreso Colombiano de Acuicultura y Congreso de la Sociedad Latinoamericana de Acuicultura-SLA 2011, Nov 10, 2011.

Constraints to Development in the Region

Constraints to aquaculture development in the region include the following:

- Lack of mid- to long-term planning
- Lack of government investment
- Poor communications between researchers and producers
- Lack of good quality extension agents
- Resistance to change in production methods
- Cost of fish production is high (driven mainly by feed prices)
- Lack of sanitation and certification processes for shellfish products
- Fingerling production is concentrated in a few hands
- MT use is limited because it is either banned or unavailable
- Aquaculture pollution is becoming a growing issue, generating restrictions

Research Priorities

We see the following as priorities for research in the near future:

1) Low-cost production systems/species
2) Evaluation of sustainability in aquacultural processes
3) Environmental studies in two directions:
    a. Impacts of aquacultural practices
    b. Vulnerability and risk assessment
4) Marketing
5) Evaluations of the status of key fishery populations and the impacts of fishing pressure
6) Effects of environmental and climate changes on fish populations
7) Research on sustainable fisheries

8) Basic biology and ecology of fish species used
9) Impacts of species introductions on native species

We have continued supporting involvement of women using different strategies such as: 1) by hiring undergraduate and graduate students in our research projects, 2) submitting projects where women groups are responsible of small aquaculture facilities, and 3) promoting meetings to encourage women in aquaculture at the national and the international level.

In Tabasco we have submitted a proposal to the state government to support gar and tilapia culture where women are responsible for the production of the fish. If this project is successful we plan to promote it at the national and the international level using our contacts. Our experiences indicate that small aquaculture production units where women are in charge, provide better results (a gar hatchery in Boca de Chilapa, Tabasco). At UJAT we recently started a Women in Science program, which has a main goal of promoting the involvement of women in research projects. At the biology school we are promoting involvement of women in aquaculture under this program.

Maria Celia also works to stimulate the participation of women in science. Currently she advises eight graduate students in Aquaculture (7 PhD and 1 MS), and six of them are women. Maria Celia also mentored the Session "Women in Aquaculture" during the WAS 2011 Conference in Natal, Brazil. In this session, women scientists from Latin America (Brazil and Chile) and several other countries (India, Portugal, Australia, and Norway) highlighted their leadership roles and responsibilities in aquaculture, sharing their personal experiences and giving their impressions on the role of women in the field.

One challenge for the coming years will be to increase the participation of women as members of the Cooperative of Fish Farmers in Santa Fe do Sul, Brazil. Maria Celia and Wilfrido Contreras lead a project supported by the CNPq (National Council for Scientific and Technological Development, Brazil) to carry out in situ experiments and give technical support for the members of this Cooperative.

In Mexico, three on-farm projects related to AquaFish CRSP activities have been accepted for support. They are:

1. Snook Hatchery and Live Feed Facilities. Supported by INAPESCA-Mexico ($160,000 USD). The hatchery will be built at UJAT´s Marine Research Station located in Jalapita, Tabasco, and a Juvenile grow-out facility will be built at "El Pucté" farm located in Emiliano Zapata, Tabasco.
2. Tropical Gar Hatchery. Supported by INAPESCA-Mexico ($80,000 USD). The hatchery will be built at "Blanco del Grijalva" Farm. UJAT will provide technical support.
3. Common snook juvenile grow-out experiment. Supported by INAPESCA-Mexico ($65,000 USD). Hatcheries will be built to conduct these experiments in two places—at the "San Ramón" fishing cooperative in Jalapita, Tabasco, and at "Blanco del Grijalva" Farm. UJAT will provide technical support.

In Brazil, Maria Celia has been able to obtain approval for four projects with the CNPq, one project with FAPESP (Sao Paulo Research Foundation, Brazil), and one project with FINEP (The Brazilian Innovation Agency – Research and Project Financing), as described below:

- Project I: ProAfrica/CNPq, "Increasing Productivity and Sustainability of Fish Culture in Africa Through Training, Education and Collaborative Research With Brazil." (R$55,000, or US$34,800).
- Project II: Technology and Sustainability of Tilapia Production in Familiar System/CNPq (R$150,000, or US$ 95,000).
- Project III: Fellowship to Rodrigo Takata to spend 10 months at Ohio State University, Columbus, OH for the completion of his PhD degree. CNPq Sandwich Fellow. $1200/month * 10 months (= US $12,000), plus tickets (airfare) US$ 3,000.00 = US$ 15,000.00.
- Project IV: Production of Microencapsulated Diets to Feed Fish Larvae/CNPq. (R$136,000, or US$85,000)

- Project V: Fellowship for Caroline Nebo follows her PhD Degree in Animal Sciences, UNESP, Brazil. FAPESP. Project title: Morphology and Expression of genes related to muscle growth and atrophy of Nile tilapia submitted to feed restriction and re-feeding. ($1200/month, for 36 months, total $43,200).
- Project VI: Renovation, expansion, and installation of a recirculating system in the Laboratory of Nutrition of Aquatic Organisms at the Aquaculture Center/FINEP. (R$1,500.000, or US$ 937,000).

A document has been prepared and sent to Missions in Mexico and Central America. It provides information regarding RCE roles and commitments and a brief explanation of CRSP involvement in the region. This document will be expanded by Maria Celia Portella and submitted in South American Missions. Communication with the USAID mission in Mexico has not been very successful. USAID reduced its personnel in Mexico considerably and only one person has been in charge of all environmental programs since early 2007. However, personnel from the US embassy visited UJAT recently and invited Wilfrido Contreras to give a talk in an annual reunion (September 20, 2011) with American investors working in Mexico. Two topics will be discussed—the role that universities can play serving as business facilitators through service projects and the role of UJAT in AquaFish CRSP activities. No other missions have been contacted in Central or South America.

Maria Celia was recently elected president of the Latin American Chapter of the World Aquaculture Society. We have been planning different activities to expand networking of the RCE. Our immediate plan is to have a Latin American meeting in Mexico in 2012. In the last WAS meeting Maria was actively contacting Latin American and Caribbean representatives with the intention of organizing an agenda in the near future.

SYNTHESIS PROJECT

The overall Synthesis Project at the ME that began in Fall 2008 includes a research component and a program support component. The Annual Report that follows for this research component covers the period 1 October 2010 to 29 September 2011.

Annual Progress Report

Printed as submitted by Steve Buccola, US Lead PI

Evaluating AquaFish Accomplishments in a Systems Framework

This Research Discovery aspect of the AquaFish Synthesis Project is closely connected with the associated study under Investigation #1 of the Research Discovery and Impact Assessment Project. The latter focuses on a quantitative assessment of the 2009 – 2011 AquaFish research and training investigations and on developing a brief case study for each of the seven AquaFish projects. The present Synthesis study focuses instead on a quantitative assessment of the 2007 – 2009 AquaFish research investigations. In both the Synthesis Project and Investigation #1, quantitative assessment follows the same models and procedures.

Quantitative assessment of AquaFish research investigations employs a statistical model of the manner in which research inputs such as money, human capital, infrastructure, and management affect research output – that is the amount of knowledge gained from the research. A Bayesian approach is used to measure knowledge output: the knowledge produced from a given experimental treatment or survey question is the difference between the expected utility of employing *pre*-research information when making a management or marketing decision, and the expected utility of employing *post*-research information in that decision. The Bayesian theory behind this approach, including an examination of the loss functions that it utilizes, is provided in the project proposal.

The springboard for our Synthesis activities this year was the October 4 – 7 Project Meeting in Seattle, at which: (i) our seven main host-country AquaFish collaborators for the quantitative-modeling parts of the Investigation were identified; (ii) bugs were eliminated in the research Input and Output questionnaires developed for eliciting the research inputs and outputs; and (iii) an administrative structure was formulated through which the contractors would obtain, and forward to us, the necessary data from the key AquaFish individuals directly responsible for conducting and completing the research investigations.

Personal services contracts were drawn up with these seven individuals, one in each of AquaFish's seven projects. The contracts stipulate each contractor's deliverables, reporting schedule, and compensation. The seven contractors are, by U.S. project university: Steve Amisah (Purdue), Gertrude Atukunda (Auburn), Remedios Bolivar (North Carolina State), Wilfrido Contreras (Arizona), Gao Zexia (Michigan), Eladio Gaxiola (Hawai'i), and So Nam (Connecticut).

The early part of FY 2011 was devoted mostly to improving aspects of the quantitative model. Research outcomes such as feed conversion rates were normalized on their mean to enable comparability across the twenty-eight 2007 - 2009 research investigations. To construct the relevant loss functions, a format was drawn up for numerical integration of an outcome observation's density functions. Simulations of likely data structures confirmed the superior properties of these improvements.

Much of the Synthesis effort this year consisted in collecting the Input and Output data discussed in item No. 1 above. The Input questionnaire elicits data on each investigation's human capital (FTE by educational level); travel distances, transportation modes, and road conditions from station to work sites; FTEs and human capital of such study collaborators as fish farmers and traders; and other factors hypothesized to influence the investigation's knowledge outputs. For statistical-survey-type studies, the Output questionnaire elicits the principal survey questions asked in the survey, the scientist's prior probabilities of alternative answers to those questions, and the means and standard deviations of the subsequent survey answers themselves. For experiment-type investigations, the Output questionnaire elicits information about each experimental treatment and each type of treatment outcome (mortality rate, feed conversion, growth rate, etc.) in each investigation. It then elicits, for each such observation, the scientist's prior probabilities of alternative outcomes and the subsequent ANOVA means and standard deviations, along with allied information on sample size and experimental equipment.

The AquaFish individual responsible for completing the research investigation's Input and Output questionnaire, and forwarding it to us by way of the Personal Services contractor in that project, was the one identified as the key researcher in that investigation. About half of our work this year was in collecting these research input and output data from the key AquaFish individuals. We examined the data as it arrived, often asking for clarifications or re-workings of parts of it. Relationships between output and input data also were compared across investigations to check for approximate consistency.

Some of the quantitative data were collected in the course of the workshop conducted by this project on 18 April 2011 in conjunction with the AquaFish Shanghai Annual Meeting. Our personal-service contractors and several other key AquaFish individuals attended. Following a brief overview of quantitative modeling issues, the ¾-day workshop consisted entirely of one-on-one conversations with these individuals on data-development problems. By the end of that workshop, we had collected in good order all the data from the 2007 – 2009 investigations.

The now fully-collected 2007 – 2009 data were used to develop preliminary estimates of research input-output relationships. These estimates were used to provide an early look at coefficient signs and robustness, allowing adjustments in how certain input variables are modeled. Within-investigation sample variation in input variables was initially found to be inadequate. The inadequacy was solved by identifying new control variables, such as categories of investigation outcomes, that vary within investigations. Substantial progress also was made in solving problems connected with the right-skewness of the Bayesian knowledge measure's

density function when quadratic loss functions are employed. Two solutions were to: (i) use log transformations of the quadratic-loss-based knowledge measure; and (ii) use a knowledge measure based on mean-absolute-difference forms of the loss function. Our estimates of research input-output relationships are correspondingly improving.

CRSP KNOWLEDGE AND DATA MANAGEMENT (KDM) PROJECT

Cultural Practice, LLC was awarded a subcontract through Oregon State University to fund initial work on the "CRSP Council Knowledge and Data Management Project," a CRSP-wide effort to combine the wealth of information accumulated by all CRSPs into a single information clearinghouse/database. The project and project budget start date was March 31, 2010, although the subaward was fully executed in July 2011.

Funding for this project was secured by the AquaFish CRSP Director in response to an RFA from USAID. The award was granted in September 2009, with the stated objectives of: 1) promoting the extension of CRSP technologies through extension, commercialization, and partnership; and 2) assessing the impact and communicating the importance of CRSP research.

The objectives of the CRSP Knowledge and Data Management Project are to inventory the materials the CRSPs have produced, consolidate information about the results generated, analyze available information across several different themes, and produce a series of products for outreach and dissemination to a wide audience of stakeholders in the development community, including but not limited to USAID. The Knowledge Data Management Project features three activities: 1) Knowledge Management and Database Development; 2) Synthesis and Analysis; and 3) Outreach and Dissemination.

Annual Progress Report

Knowledge Management Website/Database. After pursuing a relationship with QED LLC which currently holds the knowledge management contract for USAID's Bureau for Food Security, it was decided to move forward independently with the design of the all-CRSP website. A contract was set-up with Openbox9 to design and create a CRSP website. Meetings were held with Creative Director Michael Shafer, Senior Designer Nathan Fussner and Database Programmer Joe Tan. The KDM project team conducted a survey of CRSP Directors and other CRSP staff to gather input on the website function/design. In coordination with the KDM project team, Openbox9 developed a sitemap proposal and homepage concepts for review and approval. A draft version of the site will be available for review by the CRSP Directors at the World Food Prize.

Development of a comprehensive database of current CRSP information continues. The Project team is collecting and organizing both hard copy and electronic CRSP materials for inclusion in a web-based resource center. Work was initiated on a training database and a partner/collaborator database. All databases under development will be accessed through a web-based platform.

Collation, Review and Synthesis. Research was initiated on a human and institutional capacity building cross-CRSP thematic report. Lack of consistent reporting across CRSPs and differing definitions within categories have presented challenges. The KDM project is developing a framework for reporting and standard definitions of terms for use by the CRSPs. Staff have reviewed other cumulative training reports by some CRSPs and have also conducted a desktop review of literature on training and capacity building efforts in development.

Outreach and Dissemination. An exhibit booth was secured for the World Food Prize, October 12 – 14, 2011 in Des Moines, Iowa. Outreach materials were written and developed for distribution at both the WFP and BIFAD meeting. Deliverables include brochures and flyers on the following topics: the CRSP Approach, Title XII and the CRSPs, the CRSP Digest Project, Feed the Future and the CRSPs, CRSPs Partners, and Human/Institutional Capacity Building. Success stories that were already written were reprinted for the event. A "Learning from Success" banner was designed for the exhibit. Preparation was also made for presentations at the CRSP Directors meeting and the public BIFAD meeting to be held prior to the World Food Prize.

A strategic plan for events and CRSP informational sessions was developed for the coming year. Events planned include participation in the winter BIFAD meeting, a conference in Washington DC and follow-up seminars at USAID or other appropriate venue.

Project Management. Caitlin Nordehn and Franklin Holley were hired to assist the project. Nordehn has been hired as a research associate and will be assisting with developing the web-based library, data entry, and will provide staff support. Holley, a part-time research associate, is a former Global Livestock CRSP employee and has been hired to assist with research, writing, and database management.

Cooperative Funding. During this recent quarter, cooperative funding mechanisms were developed by Director Dr. Egna and agreed upon by all ten CRSPs (Nutirtion CRSP will count as one CRSP for this project). Each CRSP will contribute $25,000 per year to this project to fully fund all project objectives.

To date agreements are currently being processed or negotiated with each CRSP

X. MONITORING & EVALUATION

A Monitoring and Evaluation (M&E) Plan was formalized at the start of the AquaFish CRSP in 2006, and reused in subsequent years. 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 2011 USIAD Performance Indicators under which AquaFish CRSP reports[2].

DTAP INDICATORS

The DTAP indicators are tied to the four AquaFish CRSP global themes. They were developed by the Director 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 2011 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 2011. Since short-term training data were collected under a separate internal reporting mechanism, FY 2011 reports for indicators B-03 and C-04 are included in the short-term training compilation (Appendix 4, Table 5).

The FY 2011 actuals reported here encompass metrics for continued accomplishments associated with investigations initiated under the *Implementation Plan 2009–2011*.

[2] AquaFish CRSP reports under the EG 4.5.2 Agriculture Sector Productivity set of indicators as revised by USAID in October 2010 to align with the Feed the Future initiative.

KEY DEVELOPMENT TARGETS: INDICATORS & BENCHMARKS

AquaFish CRSP measures achievements in meeting key development targets through a set of internal indicators. The benchmarks provide a means to explore measures of performance different from those measured by the more quantitative DTAP or USAID indicator metrics. The Targets and Benchmarks tracked below are consistent with those approved in the Program Description of the USAID CA/LWA for this CRSP.[3] Year 1 Benchmarks cover 2006–2007. Benchmarks for Years 2–5 are appended and completed to 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 for facilitating 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 strategy 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 and reports contain illustrative examples of the associated project accomplishments.

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 (refers to p.13 under Technical Approach in the CA/LWA Program Description):

(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:
The following examples of technologies and strategies are illustrative of project achievements that have more than met this benchmark:

[3] The Targets and Benchmarks were again approved as part of the AquaFish CRSP M&E Plan in 2008.

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 (as of FY10 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 and Kenya. Ugandan farmers are part of a trial that offers them a new livelihood with tilapia cage culture on Lake Victoria where the effects of overfishing has threatened their ability to earn a livelihood (09BMA01AU). This hands-on training project is preparing them in production and business techniques that will ensure their success as farmers and models to others who wish to adopt this new technology. Three groups of Kenyan farmers have been trained in a cage-cum-pond tilapia culture system including hands-on experience in constructing cages. These farmers have taken this technology back to their communities where it will help bring others to fish farming (09SFT02PU).

Asia: *As a result of the multifaceted approach of the University of Michigan project work in China and Vietnam, there are significant achievements in transferring technologies and strategies for sustainable environmental management of various components of aquaculture and fisheries systems. With information from an assessment of the impacts of alien fish stocking on wild fish populations in reservoirs, CRSP researchers in Vietnam are developing environmental management plans for stocking rate and fisheries carrying capacity, which will guide the sustainable approach to protecting the biodiversity of wild fisheries management and aquaculture in reservoir systems (07MNE03UM/09MNE05UM). 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) that develop in aquaculture ponds.*

New sustainable feed technology work has promising benefits for fish farmers in the Philippines, Cambodia, and Vietnam (lower Mekong River Basin). Filipino tilapia farmers can save on feed costs with reduced feeding strategies — a delayed supplemental feeding by 45–75 days, alternate- day feeding, or daily subsatiation feeding at 50% or 67% (07SFT02NC/09SFT04NC). Transfer of this technology is taking place through trainings and podcasts (09TAP02NC/ 09SFT06NC) and is also being trialed in milkfish aquaculture systems (09MNE03NC). CRSP researchers have developed a pelleted feed for snakehead with reduced fishmeal content (07SFT01UC/09SFT01UC) that has undergone successful on-farm trials (09TAP03UC) with selected Vietnamese farmers. Farmers who adopt this new sustainable feed technology will realize cost reductions with the lower cost feed that is formulated with local protein sources such as rich bran to replace a portion of the higher priced fishmeal. This new pelleted feed is one component of a sustainable solution being developed for re-opening snakehead aquaculture in Cambodia where it is currently banned due to the overfishing of small-sized fish from the lower Mekong River for use as livestock and fish feed.

Latin America: *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. Through community meetings, local oyster producers have learned culture and sanitation techniques that will improve harvests of oysters safe for human consumption (07WIZ02UH). Similarly in Nicaragua, CRSP investigators have trained communities that depend on the cockle fishery in Aserradores Estuary in the no-take zone management approach that will ensure a healthy shellfish population balance and improved sanitation of the harvested cockles (07HHI05UH/09HHI01UH). This successful model is now*

being transferred among communities and is being tested by the Nicaraguan government in two other communities as a possible alternative to the current closed season management technique that has proven unsuccessful.

Researchers in Mexico have successfully developed a sustainable control measure to eliminate methyltestosterone (MT) residue from hatchery treatment water (07MNE06UA). 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 where they 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 underway with a private hatchery partner (09MNE07UA). Farmers and hatchery managers have also been trained in the beneficial probiotic effects of bacteria when used as bioflocs in aquaculture.

(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, including opportunities for student training and exchanges. 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 and in add-on investigations.

The DTAP Lead Coordinators have played an instrumental role in evaluating work plan changes under the Implementation Plan 2007–2009 and new investigation approaches in add-on investigations under the Implementation Plan 2009–2011. They have also provided substantive feedback to the MT through the DTAP impact reporting and overview of research accomplishments (Lead Coordinator Reports), which has guided the MT reviews of the continuation plans, add-on investigations, and other research activities.

(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 Arizona, University of Connecticut – Avery Point, University of Hawai'i at Hilo, University of Michigan, and 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 Hawai'i projects), and actively trained fellow stakeholders (Purdue University and University of Arizona projects).

The following examples illustrate project achievements that are leading to measured increases for stakeholders in productivity, incomes, market access, and product export value:

Farm/Fishery Productivity

- *adoption of practices to mitigate pollution of receiving waters from aquaculture pond effluents (China: 07MNE04UM; Ghana: 07WIZ01PU) and methyltestosterone residues (Mexico: 07MNE06UA/09MNE07UA).*
- *adoption of management practices or technologies to improve production efficiencies and/or lower costs: catfish fingerling aquaculture (07QSD02PU), tilapia-catfish polyculture (07MER03PU); an integrated cage-cum-pond culture system 09SFT02PU), Nile tilapia seedstock (07QSD01NC/09QSD01NC), and tilapia aquaculture (07SFT02NC/09SFT04NC).*
- *implementation of management plans to control alien species introduction in freshwater reservoirs in Vietnam and China as a step to maintain sustainable aquaculture and wild fisheries (07MNE03UM/09MNE05UM)*
- *improved implementation of fishery management plans to control carrying capacity (native oysters: 07WIZ02UH); to maintain sustainable production outputs (black cockles: 07HHI05UH/09HHI01UH); to protect the freshwater fishery for small-sized fish in the Lower Mekong River Basin from overfishing for animal and fish feed uses (07MNE01UC/09MNE04UC); and to sustainably manage aquacultural water use and quality in watersheds and wetland areas of Uganda (09WIZ01AU/09WIZ02AU).*
- *improved production capabilities and business stability for small-scale farmers undertaking cage culture on Lake Victoria in Uganda (09BMA01AU)*
- *opened income opportunities with new aquaculture species and culture systems: tilapia-sahar polyculture for women in Nepal (07BMA02UM/09BMA03UM); seaweed-fish-mollusc-shrimp polyculture and soft-shell mud crab aquaculture for shrimp farmers in the Philippines and (Banda Aceh, Indonesia (07MNE02NC/09FSV02NC)*

Also, see the DTAP C-02 reports showing number of hectares under improved natural resource management in FY2011 (Appendix 4, Table 5).

***Farmer Income**: Farmers, processors, and vendors benefiting from improved productivity of aquatic products as listed above will see increases in income. Improved income opportunities include the following:*

- *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)*
  2. ***feeding reduction strategies**: 07SFT02NC/09STF04NC; 07SFT03NC/09MNE02NC*

- *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, native cichlids, and chame 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 have opened new income opportuntities for coastal communities in the Philippines and Indonesia — 200 farmers have incorporated seaweed into their culture systems (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) and value chain opportunities (09MER01PU).

***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). An export market for sales of brackishwater shrimp to the US will open a new product opportunity for Guyanese aquaculture (09SFT03UA). Markets for processed fish products in Cambodia will expand as women processors adopt best management practices for 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.

Management recommendations to control alien species introductions in freshwater reservoirs as well as the effects of associated aquaculture systems will protect native species diversity in the reservoirs and help ensure a sustainable wild fishery in Vietnam and China (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 that serves as an important food source for the rural poor (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). A multifaceted research effort is underway to assess the current status of wild chame stocks native to Mexico (09IND04UH)and to develop the techniques for captive breeding as a first step toward chame aquaculture (09IND03UH). Stock assessments will lead to management guidelines to protect this important native fishery in the coastal LAC countries of the Pacific Rim while aquaculture will provide a sustainable source for the competing interests of human food and fishmeal industries. A no-take management zone approach adopted by communities in the Aserradores Estuary along the Pacific Coast of Nicaragua will help preserve the sustainable production status of the native black cockle fishery, which serves as an important food and income source for the poor (09HHI01UH).

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 to the animal feed industry (e.g., small, low-value fishery in the Mekong River).

The Director and US Lead Project PI Jim Diana (University of Michigan) organized and led a symposium entitled "The Effects of Semi-Intensive Aquaculture on Biodiversity In Nearshore and Inland Waters" at the September 2011 American Fisheries Society meeting in Seattle, Washington. The presentations by 12 invited speakers from the international aquaculture community and an open-discussion forum highlighted the status of a range of issues from the benefits of aquaculture for

protecting and improving biodiversity to biodiversity challenges associated with aquaculture systems. (See Chapter VI, University of Michigan Project Report for additional details)

(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 hormone-based masculinization systems. Commercial testing of this technology at a large Mexican hatchery is underway (09MNE07UA). Tests for IGF-I gene expression are in use as tools for measuring fish growth performance and stress responses in work to establish protocols for broodstock selection and seed production that will improve this aspect of production efficiencies (07SFT02NC/07SFT03NC /09QSD01NC).

(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 52 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 (refers to p.13under Technical Approach in the CA/LWA Program Description):
(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 concluded on 31 December 2010. A new USAID Feed the Future Associate Award was initiated in FY2011 for a three-year project in Ghana, Kenya, and Tanzania to promote adoption of innovations and Best Management Practices that will improve production and economic efficiencies of small-holder producers.

(b) At least 100 degree students enrolled through formal long-term training opportunities in US, Host Country, and Regional universities.
Since program inception, 320 students have been enrolled in long-term training. For FY2011, 188 degree students from 22 countries are enrolled in long-term academic programs associated with core research projects and the Management Office. Of these, 166 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 6103. (Of these, gender data were available for 6044 trainees. Women comprised a total of 2004 or 33.2% of the 6044 trainees.)*

***Long-Term Training**: Of the 320 students receiving long-term or degree training, 154 (48.1%) 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 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), shellfish sanitation workshops (07HHI03UH, 07HHI04UH) and shellfish management trainings (09HHI02UH/09HHI01UH).

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 (4 trainings)*

- *07IND02UA: tropical fish culture for students*
- *07MNE06UA: technical workshop for extensionists and students on MT elimination (2 trainings)*
- *07TAP01UC: farmers training of trainer workshop on alternative feed for snakehead aquaculture*

- *09IND02UC: on-site training on snakehead breeding and weaning for researchers*
- *09IND06PU: experimental design and analysis for aquaculture*
- *09QSD02UA: integrated aquaculture-agriculture for a rural farmer's cooperative (training of student trainers)*
- *09SFT03UA: basic aquaculture and aquaponics for the rural poor (training local farmer as community trainers) (2 trainings)*
- *09TAP08AU: Certification of Aquaculture Professionals training at Auburn University for eight African candidates from Ghana, Kenya, Tanzania, and Uganda.*
- *09WIZ02AU: watershed workshop for researchers and extensionists*

The University of Connecticut (09FSV03UC) has incorporated a comprehensive impact assessment component into its project to evaluate the combined accomplishments of AquaFish CRSP work. Thirteen trainings were held in FY2011 to prepare project and collaborating government personnel in uniform data collection and assessment methods for the following activities:

- *Sustainable approaches to snakehead aquaculture and its value chain*
- *Policy framework for sustainably managing the aquaculture-capture fisheries interactions*
- *Management recommendations for protecting the small-sized fishery in the lower Mekong River Basin*
- *Standards for fish paste processing*

(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/09MNE07UA): 4 workshops
Biotechnology of marine algae (07BMA03UA): 1 workshop

Biodiversity short-term trainings:
Seaweed-fish-mollusc-shrimp polyculture and seaweed harvest/processing trainings (07MNE02NC/09FSV02NC): 10 workshops
Tilapia-sahar polyculture (07BMA02UM): 1 workshop
Alien species introductions (07MNE03UM/09MNE05UM): 5 workshops
Native cichlid farmer trainings (07IND02UA): 3 workshops
Native oyster culture trainings (07IND03UH): 1 workshop
Native black cockle management trainings (09HHI01UH): 4 workshops

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 (refers to pp.13-14under Technical Approach in the CA/LWA Program Description):

(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:

- 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 policymakers. Professional-level workshops and CRSP-sponsored conferences (e.g., Workshop on Marine Algae, ISTA8 and ISTA9, Workshop on Aquaculture, Human Health and Environment, the Fish Farmers Symposium & Trade Show (2010 and 2011), AFS Symposium: The Effects of Semi-Intensive Aquaculture on Biodiversity In Nearshore and Inland Waters) 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.

- 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 printed materials and podcasts:

- *07TAP02NC: Tilapia podcast (1 in English) — Book reviews*
- *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*

- *09IND06PU: Indigenous Species Brochure*
- *09MNE02NC: Milkfish Processing*
- *09OSD05PU: Fish Life Cycle & Reproductive Strategies*
- *09TAP02NC: Tilapia podcasts (4 in English and 2 in Tagalog) — Reduced Feeding Strategies*
- *09TAP04PU: Information Sheet on Constraints and Opportunities for Cage Culture in Ghana*

- At least 30 workshops convened over the course of the 5-year AquaFish CRSP.
  Since inception, 162 workshop/trainings have been held across the eight core research 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 (refers to p.14under Technical Approach in the CA/LWA Program Description):

(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), Water Research Institute-Aquaculture Research Development Center (Ghana), Fisheries Directorate (Ghana), and Virginia Polytechnic Institute & State University (US). These linkages encompass collaborative research on nine investigations under Implementation Plans 2007–2009 and 2009–2011. To date, outreach activities in Kenya and Ghana have included 17 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," (4) a farmer brochure "The Life Cycle and Reproductive Strategies of the Nile Tilapia (Oreochromis niloticus)," (5) information brochure "Indigenous Species for Aquaculture Development in Ghana," and (6) an information sheet on "Constraints and Opportunities in Cage Aquaculture in Ghana."

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). To date, outreach activities in Uganda include 11 trainings as well as a US-based short course at Auburn University (Certification of Aquaculture Professionals) for six IEHA students, two each from Ghana, Kenya, and Uganda. Five study tours conducted in 2010 (1 study tour) and 2011 (4 study tours) as outreach activities of the Fish Farmers Symposium offered participants the opportunity for information exchange with proprietors and workers at fish farms and associated businesses in the growing aquaculture sector of Uganda.

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: (1) expanding income-earning opportunities for women fish traders to other components of the fish value chain, including aquaculture; (2) helping small-holder farmers to maximize aquaculture efficiencies and income generation with an integrated pond-cage system for catfish and tilapia.

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 training in improved fish production and propagation methods, Ghanaian farmers and hatchery managers can improve cost efficiencies. 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, concentrating on native species.

The Auburn University project in Uganda places a strong focus on farmer training at the local and regional 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 farmer 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. In the area of water quality and water management in aquaculture, strategies have been developed to help guide farmers in pond siting and water usage that will best utilize water resources, ensure stable water supplies, and maintain ecosystem complexity and promote biodiversity.

(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) and participated in both the 2011 Fish Farmers Symposium & Trade Fair and six-day study tour of Ugandan fish farms and associated enterprises. Kenyan researchers served 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 provides 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 tours mentioned above for Ugandan and Kenyan farmers afforded opportunities for local and inter-regional exchanges.

The HCPI Phase II Project (FY2008) 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 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; FY2009 data).

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 by the CRSP Director for CRSP operations following input from USAID.

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, Third, and Fourth 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 51.9% men and 48.1% women. In FY2011, the long-term trainees were 46.3% women and 53.7% men. The short-term training participants in FY2011 comprised 37.4% women and 62.6% men with an overall four-year gender distribution of 33.2% women and 66.8% men (FY2008-FY2011). 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)*

In the Auburn University Project, gender integration is a feature at all levels of the project with a significant role taken by women investigators (Nelly Isyagi, Monica Karuhanga Berahu, Theodora Hyuha, and Gertrude Atukunda) and an overall emphasis on engendering the training and mentoring of women into all sectors of the aquaculture economy.

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 the Implementation Plan 2009-2011 includes at least one activity in each project focusing specifically on gender issues as listed above.

(c) 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:

Technical Considerations for Award of a CRSP Project *(p. 6, Items 3 & 5):*

3. Proposals must include at least one experiment or study. Proposals must 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.***

(d) 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, 09HHI01UH, 09HHI02UH)*
- *Tilapia-Sahar polyculture: collaboration with RIDS-Nepal to include 50% women in the farmer training (07BMA02UM/09BMA03UM)*
- *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/09FSV01UC)*
- *Women's Cooperative: collaborative assistance of the Trafalgar Women's Cooperative in the feed formulation trainings associated with the sustainable feed studies in Guyana and their assistance in developing small-scale aquaculture in poor rural areas (07SFT04UA/07SFT05UA/09SFT03UA)*
- *Women's Training on post-harvest processing and value-added product development (09MNE02NC/09FSC02NC)*
- *Targeted trainings for women: Requirements for food quality and safety in cockles, no-take zone management and monitoring, ecosystem management (09HHI01UH)*
- *Shellfish sanitation standards: trainings for women in Nicaragua and Mexico (09HHI02UH)*
- *Value-chain opportunities for women: collaboration with the Women in Fishing Industry Project to train women fish traders working in the Lake Victoria region in other income-generating opportunities along the fish value chain (e.g., aquaculture) (09MER02PU)*

(e) 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.

(f) 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

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 2011) are presented in this section.

USAID-EG Indicator Reporting

For this reporting period, AquaFish CRSP only reported under USAID-EG 4.5.2 Agriculture Sector Productivity indicators (Table X-1). Tables 14 to 16 in Appendix 4 provide supporting data for the technologies, practices, products, and markets reported under the technology indicators — 4.5.2-H(8), 4.5.2-I (9), and 4.5.2-J (10).[4]

Table X-1. AquaFish CRSP FY 2011 USAID-EG Indicator Report

4.5.2 Agriculture Sector Productivity	FY 2011 Targets	FY 2011 Results
5.2 -J (10): Number of new technologies or management practices under research as a result of USG assistance.	34	35
5.2-H (8): Number of new technologies or management practices made available for transfer as a result of USG assistance.	31	31
5.2-I (9): Number of new technologies or management practices being field tested as a result of USG assistance.	19	18
5.2-B (2): Number of additional hectares under improved technologies or management practices as a result of USG assistance.	3,473	3,575
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
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

[4] Metrics are based on the best available data at the time of the 29 September 2011 reporting date.

Table X-1. AquaFish CRSP FY 2011 USAID-EG Indicator Report

4.5.2 Agriculture Sector Productivity	FY 2011 Targets	FY 2011 Results
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]
Number of agriculture-related firms benefiting directly from USG supported interventions.	9	9
Number of women's organizations/associations assisted as a result of USG interventions.	5	5
5.2-L (12): Number of public-private partnerships formed as a result of USG assistance.	0	0
5.2-G (7): Number of individuals who have received USG supported short-term agricultural sector productivity or food security training — Female	500	658
5.2-G (7): Number of individuals who have received USG supported short-term agricultural sector productivity or food security training — Male	500	1,758
5.2-F (6): Number of individuals who have received USG supported long-term agricultural sector productivity or food security training — Female	75	101
5.2-F (6): Number of individuals who have received USG supported long-term agricultural sector productivity or food security training — Male	75	87
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]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.

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.

- *Third-Country Training* can provide exceptionally good benefits for stakeholders in developing areas. In-person observations of successes (and sometimes failures) in other countries, complemented with face-to-face discussions with practitioners in those countries, often provides a far better educational experience than reading reports or listening to conference presentations from afar. This truth has been demonstrated in several AquaFish CRSP projects. One example comes from the Mali AA project, in which outstanding contributions to aquaculture and fisheries development efforts were made by Malians after receiving CRSP-sponsored training in China and Kenya. On their return to Mali, participants were instrumental in developing rice-fish culture demonstrations and constructing simple catfish hatchery facilities, in serving as leaders in subsequent trainings of farmers and extension personnel, and in providing support to other agencies working in these development areas in Mali. Their contributions proved to be significant factors in the successes achieved by the project and are expected to continue to play a role in the future development of the aquaculture and fisheries sectors in Mali. Another example comes from a study tour for Kenyan farmers conducted in Uganda as part of the Fish Farmers Symposium annual event. During a six-day tour they visited hatcheries and farms producing tilapia and catfish, held discussions with WAFICOS (Walimi Fish Farmers Cooperative Society) leaders, and visited Ugachick Poultry Breeders, Ltd., which produces fish feeds for distribution in Uganda and Kenya. The benefits to the participants were real and many, perhaps best summed up in the words of Suzanne Njeri, team leader for the group:

  > "The tour was an exposure and eye opener for us. Undoubtedly, we each greatly benefitted from the tour and were greatly impressed by the fish farming developments in Uganda. The techniques adopted for increasing fish production, quality fish feeds, good water management practices, and cage farming were some of the aspects that we found very useful."
  >
  > "We will also do our best to start a forum like WAFICOS in Kenya and keep networking with you all. It is our prayer that such exchange visits will continue and that farmers from both countries will get more opportunities like this!"

- Most lessons learned are dry recollections, well after the fact. This lesson is different in that it is still in progress, and more of an acknowledgement of a wrong that could be righted if acted upon quickly enough. This lesson is that had USAID done their 4th year evaluation of our CRSP on time, and had we been invited to submit an extension proposal before USAID's new policies and cuts began taking shape, we could have secured another 5 years to do the meaningful work we can do and have been doing. In a perfect world, the timeline would have looked like this: completion of the 4th year evaluation report before Oct 2010; submission of the proposal by Spring 2011; review and approval of the extension proposal by July 2011; notice of award in early August 2011. As it turned out, none of those deadlines were met. Without a 4th year evaluation, we could not submit an unsolicited proposal. As a seasoned Director I began writing a proposal, but USAID could not provide guidance on funding level, format, criteria for selection, alignment with FtF and myriad other important details. Also, our CA/LWA states that the 4th year evaluation is the gate that one passes through to

submit a proposal. Without an open gate, there is nowhere to pass a proposal through. Time does not stand still, so during our 4th year and into our last year, USAID's BFS was reorganizing several times and USAID was dutifully at work to reform its operational processes. *USAID Forward* took shape and on Aug 24th the USAID Administrator released a general notice that could curtail our CRSPs ability to move forward expeditiously. I am concerned that we are not grandfathered in to the rules in place during our extension-review period. The CRSP Council, BIFAD and good souls within USAID will be making the case that research and CRSPs really should be an exemption to the new ADS303 policy. But no matter. USAID will not be able to extend us with funding at the end of our current 5-year award. As of 29 Sep 2011, we will be running on fumes. The silver lining? We have a no-cost extension and a few investigations and students to finish up. And I will still be working to submit a proposal to someone who may be in a position to listen and make decisions.

- In June 2011, Oregon State University, through its expanded authority, notified USAID that the termination date of AquaFish CRSP would be extended through 29 September 2012 (i.e. a one-year no-cost extension). The extension was justified in order to allow students to complete degree programs, to allow completion of work for which funds were already committed, and to facilitate a smooth transition from the current 5-year award and any future 5-year award. The modification extending the award was agreed upon by all parties and fully executed on 8 September 2011. By exercising expanded authority the ME ensured that subcontracts with US Institutions and their sub-subcontracts, including those in Host Countries, did not lapse. The cost of re-establishing severed contractual relationships in the US and abroad incurs obvious administrative costs associated with preparing and reviewing the actual documentation. Perhaps more importantly, however, is the cost associated with time lost on the ground, where breaks in contracts could lead to pay/personnel redistribution (e.g. PIs and other skilled people leaving) and resource redistribution (e.g. lab and field research space). People and resources reassigned to non-CRSP projects may become unavailable for CRSP work once contractual ties are mended. Lost to many originating contracts officers and administrators is the fact that downstream subcontracts will seldom be extended until the upstream parent award is extended. Any delayed action from the funding source is magnified by the time the terminal subaward is amended. It may take many months before any extension is authorized at Host Country Institutions. Interestingly, this lag-time is often underappreciated at every step in the process – everyone mistakenly thinks that they have until the contract termination date to get their amendments processed. Lesson learned: early action by OSU, invoking its expanded authority, allowed the necessary time to maintain the contractual integrity of this CRSP, from USAID through Host Country institutions.

- Several years ago, AquaFish CRSP transitioned the on-line project reporting process to a new largely automated, web-based, on-line system. With the underlying framework in place and tested, the new online report system was in place in 2009. Built on a network of relational databases, the new reporting format serves as the data entry point for project progress and administrative information. The customized report forms are accessible on a secure webpage unique to each project. Investigators access the page via a secure login and can make use of a number of on-line reporting features (e.g., training and trip databases), review the status of project work (e.g., workshops completed), or view project contractual documents (e.g., subcontract). From the management office end, on-line reporting looked like a simple, easy-to-use system that would save time on both sides. We assumed that computer knowhow and the robustness of the internet would ensure the smooth functioning of the online reporting system. But, we have been faced with a number of interesting, and often unforeseen, challenges that have stood in the way of realizing a system that works well for all. One of the fundamental problems is with browser choice. While the online system was designed following W3C web standards, the on-line form will malfunction in cases where Microsoft's Internet Explorer (IE) design wavers from the W3C. Much time has been spent on adjusting the form's underlying design to compensate for IE browser issues that prevent users from successfully inputting text and data. For dealing with this problem, we have reached the conclusion that the best approach on both sides is to advise CRSP investigators to use other browsers (e.g., Firefox, Safari) when

completing the form. What we have also re-discovered is that the simplicity of worldwide email communication and internet access belies a situation in the developing world that is far more complicated and technologically hampered. For a variety of reasons, the login system has proved a stumbling block for many HC investigators. Computer access time, slow connections, institutional policies on cookies, misunderstanding instructions, etc. all have contributed to frustrating experiences for HC investigators in completing the form and for the management office in dealing with "lost" reports, missing information, and repeated efforts to solve problems from thousands of miles away with only a short email message (e.g., "I could not save entries to the Section 9") to go by. At this point, management's efforts continue to be focused on refining the reporting process and improving the reliability of the on-line form for all users, no matter their location or technological difficulties.

- USAID funds a diverse portfolio of CRSPs, eleven in all, covering researchable priorities for crops and animals and the systems they are grown in around the world. All CRSPs are organized to reduce poverty, hunger and environmental degradation in various regions, commodities, and systems. In order to get work done on the ground, however, CRSPs differentiate into focus areas around fish, fisheries products, aquatic ecosystems, livestock, dry grains, pulses, peanuts, sorghum, millet, vegetables, fruits, natural resources management, markets, nutrition, integrated pest management, and so on. Our CRSP focuses on aquaculture and fisheries in following the CRSP mission of achieving outcomes by improving incomes, feeding vulnerable populations, enhancing food security, and conserving precious natural resources. Last year, two important steps were taken to bring these eleven CRSPs together.
  - The first was to combine the wealth of information CRSPs have accumulated over the years in an information clearinghouse. AquaFish CRSP led the way in contracting with a private sector company— Cultural Practice, LLC— in a new CRSP Council Knowledge Management Project. The KM project will operate most effectively at $200k per year, and recommended contributions are $25k per year per CRSP. The AquaFish CRSP Director pressed her fellow directors to buy into the project, which is designed to showcase work from all CRSPs. Some CRSPs, including AquaFish CRSP, received prior approval from USAID for funding such an activity, but others, especially newer CRSPs, were less able to free up funds. Indeed the newer CRSPs were not even aware of the CRSP Council when they got their awards from USAID. Thus, the AquaFish CRSP Director created a staged contribution plan to allow CRSPs to buy in when funds become available according to each CRSPs own timeline. Additionally, each ME University has a different mode of contracting with different rules and rates, so AquaFish determined it was best to allow CP, LLC to contract individually. CRSPs can buy in to certain elements of the KM Project (usually for contractual reasons) or into pooled contributions for work across all elements. With help from the KM project leader, Dr. Deborah Rubin of Cultural Practice LLP, as of early September 2011 already nine CRSPs have contracted or are in negotiation with CP, LLC. By the end of this reporting period, the KM Project will have designed a website that it has begun populating with CRSP data, and developed various synthesis materials for engaging a broad community of interest. We look forward to the success of this very much needed activity.
  - The second step in aggregating efforts across CRSPs occurred in July 2011 when the CRSP Council held its first-ever "Council-USAID Partners Meeting" overseas. Because Uganda hosts nine CRSPs, it proved a practical place to convene the CRSPs along with their USAID Washington partners in a face-to-face meeting with USAID and CRSP counterparts in Africa. The Steering Committee of the Council met in the morning, after which our USAID/Washington partners joined in to discuss alignment with FtF and other USAID priorities. The second day's meeting highlighted themes from each CRSP through posters and summaries of CRSP work in Uganda. The USAID/Uganda Mission Director, staff, and representatives from other USAID offices in the region showed interest in our cumulative capacity building successes. An unexpected but rewarding visit by the US Ambassador to Uganda, Jerry P. Lanier, topped off the second day's meeting, which was followed the final day by visits to CRSP sites in Uganda. Connections between CRSPs were strengthened, with Aquafish CRSP making plans to work with

other CRSPs on the ground to share technologies and leverage investments (i.e., horticulture field cooler for fish, dry grains in fish feeds to reduce aflatoxin, Makerere University Agriculture Dean involvement in AquaFish CRSP). Although planning this meeting was difficult, with a brave staff member (Ben Hassankhani) from Pulses CRSP stepping in last minute, the meeting was a huge success. The Council might consider having another overseas Council-USAID meeting perhaps in West Africa within the next two years.

For many years, USAID has asked CRSPs to work more closely and effectively together. Past Inter-CRSP research projects have not created the desired synergies, which is no surprise given their non-overlapping scientific foci; the CGIAR centers also experience this problem. Researchers galvanize around issues of common interest. Yet with these two examples above, we are now seeing true milestones being met in CRSPs working better together where they can. The CRSP meeting overseas and the KM project are but two steps our eleven CRSPs have taken to create synergies. Cross-CRSP connections among researchers on the ground, administrators in the MEs, and evaluation experts in the private sector are changing the landscape in which all CRSPs operate.

APPENDIX 1. PROGRAM PARTICIPANTS

Management Team Staff

Oregon State University, Corvallis, Oregon USA

Hillary Egna	Director & Lead Principal Investigator
Ford Evans	Research Projects Manager
Jim Bowman	Outreach and Capacity Building Coordinator; Mali Project Associate Award Coordinator
Laura Morrison	Synthesis and Reporting Coordinator
Shawn Hayward	Web Manager
Cindi Claflin	Office Specialist
Stephanie Ichien	Research Program Assistant (Part-time, from January 2011)
Claire Schrodt	Research Program Assistant (Part-time, from November 2010)

United States Agency for International Development

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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
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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
Remedios Bolivar	Asia	Central Luzon State University, Philippines
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Core Research Project Researchers

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University of Connecticut–Avery Point

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Central Projects

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Deborah Rubin

Deborah Caro

Susan Johnson

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Peg Herring

Jeff Hino

Tiffany Woods

International Institute for Fisheries Economics and Trade (IIFET)

Ann Shriver

APPENDIX 2. LINKAGES

Institutions, NGOs, and organizations listed below participate or participated as partners in the AquaFish CRSP research projects between 2006-2011.

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 Associate Award Projects.

US Partners

Alabama A&M University*
American Soybean Association
Auburn University*
Cornell University
Cultural Practice, LLC
Delaware State University
Fisheries Industry Technology Center– University of Alaska
Fish Farmacy (Arizona)
Florida International University
Goosepoint Oyster Inc (Washington)
Louisiana State University*
Montana 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 Hawai'i 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 Hawai'i 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-NOAA (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)
International Water Management Institute (IWMI) of the Consultative Group on International Agriculture Development (CGIAR)†
Lake Victoria Environmental Management Project (Kenya, Tanzania, Uganda)
Network of Aquaculture Centers in Asia (Thailand)
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

Aquaculture Center, Jaboticabal
Centro de Acüicultura, UNESP
Sao Paolo State University

Cambodia

Cambodia Molecular Genetic Group, Health Scientific Research Centre University Health Sciences

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
Fisheries Department, Ministry of Food & Agriculture
Kwame Nkrumah University of Science & Technology*†
Ministry of Agriculture Fisheries Directorate
Trafalgar Union Women's Cooperative
Water & Sewerage Company
Water Research Institute's Aquaculture Research Development Center

Guatemala
San Carlos University

Guyana
Anna Regina Fish Culture Station
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†
FishAfrica*†
Kenya Business Development Services
Kenya Marine & Fisheries Research Institute
Kenyatta University*†
Ministry of Fisheries Development
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†
Ministry of Livestock and Fisheries (Ministère de l'Èlevage et de la Pêche)
Rural Polytechnic Institute for Training & Applied Research
The Permanaent Assembly of Chambers of Agriculture (APCAM)
University of Bamako
USAID/Mali

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
Mindanao State University
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
Lake Victoria Fisheries Organization
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 2011 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, RCE report, or by HCPI	Amount ($)	Funding Source
University of Arizona			
	March 2011	$10,000	Intervet Schering Plough
	April 2011	$60,000	National Council for Science and Technology
	April 2011	$672,300	Universidad Juàrez Autònoma de Tabasco
	April 2011	$41,200	National Institute for Aquaculture & Fisheries
	June 2011	$10,000	Intervet Schering Plough
	June 2011	$15,000	Guyana Trade and Investment Support
University of Michigan			
	April 2011	$11,696	Shanghai Ocean University
	April 2011	$1,400	Shanghai Ocean University
	April 2011	$27,000	Shanghai Agriculture Administration
	August 2011	$34,500	National Natural Science Foundation of China
	2008	$21,900	Shanghai Municipal Science and Tech. Commission [5]
	2009	$11,700	Shanghai Municipal Education Commission [6]
North Carolina State University			
	March 2011	$93,608	North Carolina Sea Grant
Purdue University			
	April 2011	$302,000	Kwame Nkrumah University of Science and Tech.
	April 2011	$66,000,000	Kenyan Government [7]
University of Connecticut			
	April 2011	$5,000	Mekong River Commission (MRC) and Nagao Natural Environment Foundation (NEF)
	April 2011	$10,000	Nagao Natural Environment Foundation and Cambodian Government
	April 2011	$36,000	Inland Fisheries Research & Development Institute (IFReDI)

[5] Prior year funding of 150,000 Yuan reported August 2011. Converted using 9/30/08 exchange rate of 6.8431.

[6] Prior year funding of 80,000 Yuan reported August 2011. Converted using 9/30/09 exchange rate of 6.8262.

[7] Kenya Economic Stimulus Program. This leveraged funding is split across two years ($16 million in year one and $50 million in year two) and was obtained through Aquaculture and AquaFish CRSP activities dating back to 1997.

US Lead Institution	Reported for Quarter Ending, RCE report, or by HCPI	Amount ($)	Funding Source
University of Hawai'i at Hilo			
	April 2011	$73,200	University of Hawai'i at Hilo
	September 2011	$10,000	CIDEA Foundation
Auburn University			
	December 2010	$4,000	USAID National Agricultural Development Project
	March 2011	$9,602	US Environmental Protection Agency
	June 2011	$4,000	Alabama Land Grant Alliance
Regional Centers of Excellence			
	April 2011	$144,800	The Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) National Council for Science and Technological Development
	September 2011	$85,000	The Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) National Council for Science and Technological Development
	September 2011	$160,000	Instituto Nacional de Pesca (INAPESCA)
	September 2011	$80,000	Instituto Nacional de Pesca (INAPESCA)
	September 2011	$65,000	Instituto Nacional de Pesca (INAPESCA)
	September 2011	$43,200	Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) Foundation for Research Support of the State of São Paulo
	September 2011	$937,000	Financiadora de Estudos e Projects (FINEP) Research and Projects Financing
	September 2011	$1,190	Mindanao State University
	Total	**$68,980,296**	

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	FY11 DTAP Target	FY11 DTAP Actual	A01 Report Text
09BMA03UM Sahar Polyculture	1	1	Farmed sahar (local indigenous fish) raised in polyculture is under development and on-farm testing. Availability of farmed sahar will provide improved nutrition to local households.
09FSV01UC Fish Paste Product Development	1	1	Improved fermented fish paste products with improved quality and safety under research and development
09FSV02NC Seaweed Processing	2	2	Seaweed products with improved quality: (1) candy/desserts made from agar (2) pickled seaweed
09IND01UH Native Oyster Hatchery	1	1	Hatchery seed of native oyster for shellfish with improved health and safety
09IND03UH Chame Spawning & Larval Rearing	1	1	Development of chame product with improved quality and safety associated with spawning/larval rearing technologies
09MNE03UM Good Practices & Eco-Certification	1	1	Eco-certified shrimp with improved health and safety: in progress, but we expect that at least one of our studied methods will improve food quality by reducing needs for chemical control

Table 1. AquaFish Investigation Indicator Reports for DTAP A-01: Number of aquaculture products developed to improve food safety or quality.

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	A01 Report Text
09QSD03UM Prawn-Mola Polyculture	1	2	The development of mola culture as part of a freshwater prawn polyculture system will add a new product to the market that addresses nutritional needs of smallholders. (The prawnswill be raised for the export market.)

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-01 Report Text
09BMA01AU Cage Culture	1	2	1. Cage Culture trial for Small-Holder Farmers -- 2 cages 2. Developed demand feeding practices using automatic feed in South Africa
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.
09BMA04UM Pond-Based RAS	1	1	Pond-based RAS (Recirculating Aquaculture System) system for shrimp with solid waste removal and water quality controls
09BMA05UM Indoor RAS	2	2	Indoor RAS (Recirculating Aquaculture System) for shrimp: control of water quality and micro-organisms (e.g., cyanobacteria) Floc-based aquaculture system
09FSV01UC Fish Paste Product Development	2	2	Under transfer, Best Practices and Standards for processing Fish Paste Products: 1. Quality & Safety Processing Guidelines 2. Packaging & Labeling Standards
09FSV02NC Seaweed Processing	1	2	(1) Improved seaweed drying method using racks - completed. (2) Value-added seaweed processing for agar to make candy/desserts; value-added processing for industrial grade agar and carrageenan

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-01 Report Text
09IND01UH Native Oyster Hatchery	1	1	Larviculture of native oyster
09IND02UC Snakehead Aquaculture	1	1	Snakehead for Aquaculture: induced spawning in captivity
09IND03UH Chame Spawning & Larval Rearing	2	2	Indigenous species development of Chame for aquaculture: 1. Spawning technology successfully tested 2. Larval rearing technology (under development) (For practices, see C-03)
09IND04UH Chame Stock Assessment	1	1	Indigenous species development of Chame: Management Technology: Age-determination technology
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

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-01 Report Text
09IND06PU New Species for Aquaculture	3	3	Aquaculture of 3 native African species in Ghana: *Heterotis niloticus*, *Chrysichthys maurus*, and *Parachanna obsucura* 1. Testing optimal protein levels in feed for *Heterotis niloticus* 2. Testing optimal protein levels in feed for *Chrysichthys maurus* 3. Acertaining life history and growth performance of *Parachanna obsucura*
09MNE01UM Red Swamp Crayfish	1	1	Model to characterize invasive spread of red swamp crayfish in China. Model is being tested
09MNE02NC Milkfish Feed Inputs	3	4	Improved Ecological Footprint Technologies for Milkfish: 1. On-farm demos of integrated, multitrophic aquaculture of milkfish-seaweed-sea cucumber in cages and pens 2. Alternate day feeding 3. Initial reduced feed ration (7.5 - 4% body weight) 4. Value-added processing of milkfish (deboning and marination) training for women
09MNE07UA MT Elimination Tecnnology Transfer	1	4	MT Elimination Technologies for transfer in on-farm trials: 1. Reducing MT dose for masculinization of tilapia fry 2. Charcoal filtration of MT treatment water 3.MT elimination with bioflocs of MT-degrading bacteria 4. Probiotic use of bacteria to foster MT-treated fish growth & survival
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)

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-01 Report Text
09QSD02UA Aquaponics &Tilapia	3	3	Aquaponics 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 and carp species)
09QSD04PU Tilapia Performance	3	4	Aquaculture technology for 4 improved tilapia species for small-scale aquaculture production: 1) Testing growth performance of Nile tilapia (*Oreochromis niloticus*) 2) Testing growth performance of Wami tilapia (*Oreochromis hornorum*) 3) Testing growth performance of Jipe perege (*Oreochromis jipe*) 4) Testing growth performance of Ruvuma perege (*Oreochromis placidus ruvumae*
09QSD05PU Propagation & Hatchery Mgmnt Training	4	5	1) Sex reversal to produce all-male tilapia 2) Production of broodstock catfish through pituitry extracts and injection 3) Safe transportation of fingerlings from hatchery to production units 4) Water quality monitoring in the hatchery 5) Preparation of hormonal feed for test reversal in juvenile fish
09SFT01UC Alternative Feed	3	3	Snakehead pelleted feed trials: 1. *Channa micropeltes*: Survival and growth 2. *C. striata*: Survival and growth 3. Trials for Cambodia farmers-Replacement of fishmeal from marine vs. freshwater fish (Companion to 09TAP03UC)

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-01 Report Text
09SFT02PU Pond-Cage System	1	9	Integrated pond-cage technology for small-scale tilapia farmers to reduce feed cost and manage pond waste 1) Pond Design and construction 2) Pond culture including fish pond management 3) Rice and fish culture integration 4) Catfish hatchery design and construction 5) Catfish breeding and propagation 6) Fish feed formulation 7) Tilapia fingerling transportation 8) Catfish fingerling feeding and growth 9) Fish value addition- marketing strategy (fresh, smoked, frozen, filleted, sun dried or deep fried)
09SFT03UA Guyana Aquaculture	3	3	Aquaculture Technologies 1) Integrated inland farming-aquaculture for small-scale farmers and women 2). Standardized aquaculture feed with local ingredients to reduce fishmeal 3) Brackish water shrimp production
09SFT04NC Tilapia Feed Strategies	5	8	Tilapia Least-Cost Feed Formulation Technology and Feed Reduction Strategies: 1. Feed reduction strategies = 4 (delayed onset; alternate day; 67% and 50% subsatiation (counted as 4 different feeding strategies) 2.Formulation Strategy: reduce fishmeal component by replacing with agricultural by-product protein sources;2/3 (already demonstrated through research and being transferred and also conducting workshop training with feed manufacturers) 3.Formulation Strategy: reduced crude protein (26% from 31%) in normal fishmeal tilapia diet 4.Formulation Strategy: reduced crude protein (26% from 31%) and fishmeal free tilapia diet 5. Manufacturing Specification: pellet durability and water stability

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-01 Report Text
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
09SFT06NC Impact Assessment	0	4	Transfer of aquaculture technologies to small-scale farmers: 1. Feed reduction strategies for tilapia 2.Alternative feed practices for milkfish 3. Value-added processing for milkfish 4. integrative culture systems for milkfish
09TAP02NC Tilapia Podcasts	1	1	Extension podcast technology: modules on tilapia reduced feeding regimes (09SFT04NC) for international community of tilapia farmers and extension and research community; uploaded so anyone can access technologies developed and shown in podcasts
09TAP03UC Alternatives for Low-Value Fish	1	1	Snakehead feed adoption pilot with on-farm trials in Vietnam and Cambodia: Farmer adoption in three Vietnam provinces. Technology transfer via outreach for the pelleted feed developed in 09SFT01UC
09TAP04PU Cage Culture in Ghana	1	1	Assessment of Cage Culture technology: strategy to remove constraints. New trainees learned to build cages and adopt cage aquaculture technology
09WIZ01AU Multiple Water Use	1	2	Rural watershed management for multiple uses--cage culture and non-aquacultural applications: 1. Developed methodology for trout farming in irrigation reservoirs in South Africa (under development) 2. Developed floating garden technique for producing vegetables in floating styrofoam containers placed near trout cages

Table 2. AquaFish Investigation Indicator Reports for DTAP B-01: Number of new technologies developed

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-01 Report Text
09WIZ02AU Water Management	1	1	Software approaches for water management for multiple uses
09WIZ03UM Fish Cage Culture	1	2	1.Deep water cage production model with polyculture fish system under performance evaluation 2. Development of a mass balance model for phosphorus in cage culture systems.

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-02 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

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-02 Report Text
09BMA02AU Training & Outreach	1	1	**Producers Assn** Walimi Fish Farmers Cooperative Society (WAFICOS)
09BMA03UM Sahar Polyculture	2	2	**Women's Organizations** Rural Integrated Development Society (NGO) - Nepal (RIDS) Women in Aquaculture
09BMA04UM Pond-Based RAS	1	1	**Agricultural Firm** Haoshideng shrimp farm
09BMA05UM Indoor RAS	1	1	**Agricultural Firm** Blue sea Aquaculture Development Company
09BMA06UM Prawn Best Practices	1	1	**Institutions & NGOs** Department of Fisheries (Thailand)
09FSV01UC Fish Paste Product Development	6	6	**Govt** Central Fisheries Administration; Ministry of Mine industry and Energy (MIME), Ministry of Commerce (MoC), Ministry of Public Health (MOH); Ministry of Agriculture Forestry and Fisheries **Women's Organizations** Women Fermented Fish Paste Group/Association
09FSV03UC Assessing Impacts	3	3	**Govt** Provincial fisheries departments in AnGiang province; Dong Thap provinces; Prey Veng provinces

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-02 Report Text
09HHI01UH Black Cockle Management	7	7	**Govt** Ministry of the Environment; Ministry of Forestry, **CBO** Aserradores estuary community group representing 66 families **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)
09HHI02UH Workshop for Coastal Women	2	5	**Govt** Sinaloa State Aquaculture Sanitation Committee (CESASIN); Nayarit State Aquaculture Sanitation Committee (CESANAY) **Producers Group, Women's Organization & CBO** Oyster growing cooperative from Boca de Camichin (Mexico); Women's oyster growing cooperative at Bahia Santa Maria (Mexico); Nicaraguan Community groups
09IND01UH Native Oyster Hatchery	2	2	**Govt** Sinaloa State Aquaculture Sanitation Committee (CESASIN); Nayarit State Aquaculture Sanitation Committee (CESANAY) **Producers Group, Women's Organization** Women's oyster growing cooperative at Bahia Santa Maria; Oyster growing cooperative from Boca de Camichin
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)

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-02 Report Text
09IND03UH Chame Spawning & Larval Rearing	2	3	**NGOs** Ecocostas (NGO-Ecuador) **Govt** Sinaloa State Aquaculture Sanitation Committee (CESASIN); Nayarit State Aquaculture Sanitation Committee (CESANAY)
09IND04UH Chame Spawning & Larval Rearing	3	2	**Govt** Sinaloa State Aquaculture Sanitation Committee (CESASIN) (State Government); Nayarit State Aquaculture Sanitation Committee (CESANAY) (State Government)
09IND05UA Cichlid/Snook Selective Breeding	2	2	**Govt** Mariano Matamoros Hatchery **Cooperative** Cooperativa Pesquera San Ramon
09IND06PU New Species Development	5	7	**Govt, Institutions & NGOs** Water Research Institute, Fisheries Commission, University of Cape Coast, Savannah Agricultural Research Institute, University of Ghana, University for Development Studies, International Water Management Institute
09MER01AU Aquaculture Enterprises	1	1	**Producer Group** Walimi Fish Farmers Cooperative Society (WAFICOS)
09MER02PU Value Chain	1	2	**Govt & NGOs** Women in Fishing Industry Project (WIFIP) Ministry of Fisheries Development

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-02 Report Text
09MER04UC Value-Chain Analysis	10	11	**Govt, Institutions & NGOs** Ministry of Agriculture and Rural Development (Vietnam), Vietnam: Provincial fisheries departments of An Giang, Dong Thap, Cantho and Vinh Long provinces Fisheries Administration (Cambodia), Cambodia: Provinces of Kandal, Prey Veng, Kampong Chhnang, Siem Reap, Battambang
09MNE02NC Milkfish Feed Inputs	4	18	**Producers Organizations:** 4 fishers organizations from different coastal villages in Guimaras; **Microfinance/development Institute:** Taytay sa Kauswagan, Inc.; **Private/Public Group:** Panabo Mariculture Park; **Government:** 7 Regional Fisheries Training Center of the Bureau of Fisheries and Aquatic Resources **Academic**: 1.Mindanao State University-Tawi-tawi Campus, Zamboanga State College of Marine Science and Technology; University of Philippines-Visayas; Iloilo State College of Fisheries; Mindanao State University-Marawi Campus
09MNE04UC Management Recommendations	11	11	**Govt, Institutions & NGOs -** Ministry of Agriculture and Rural Development (Vietnam), Vietnam: Provincial fisheries departments of An Giang, Dong Thap, Cantho and Vinh Long provinces Fisheries Administration (Cambodia), Cambodia: Provinces of Kandal, Prey Veng, Kampong Chhnang, Siem Reap, Battambang
09MNE07UA MT Elimination Tecnnology Transfer	1	1	**Ag Firms:** Pucte del Usumacinta (fish farm)

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-02 Report Text
09QSD01NC Tilapia Seedstock Development	2	2	**Research Entity:** GIFT Foundation International; Genomar; **Government:** Bureau of Fisheries and Aquatic Resources
09QSD02UA Aquaponics &Tilapia	6	6	**Govt & NGOs** Mariano Matamoros Hatchery (Govt); SAGARPA: Secretaria de Agricultura Ganaderia, Recursos naturales y Pesca. (GOVT); DIF: Desarrollo integral de la familia (GOVT: Youth at Risk program); WorldFish (NGO) **Ag Firms:** Commercial Tilapia Farm
09QSD03UM Prawn-Mola Polyculture	1	1	**NGOs** Caritas (NGO - to help with training women in production techniques)
09QSD04PU Tilapia Performance	4	3	**Govt, Institutions & NGOs** Tanzania Fisheries Research Institute, Ministry of Livestock and Fisheries Development, Kingolwira Fish Farming Centre
09SFT01UC Alternative Feed	20	20	**Govt, Institutions & NGOs** Staff at research centers and government fisheries departments in An Giang and Dong Thap provinces, WWF-Vietnam
09SFT02PU Pond-Cage System	1	1	**Govt, Institutions & NGOs** Kenyan Marine Fisheries Institute

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-02 Report Text
09SFT03UA Guyana Aquaculture	4	5	**Govt, Institutions & NGOs** University of Guyana (EDUC/RES); National Aquaculture Association of Guyana (NGO); GTIS (GOVT) **Women's Organization** Trafalgar Union Women's Cooperative **Ag Firm** Maharaja Oil & Feed Mill
09SFT04NC Tilapia Feed Formulation and Feed Reduction Strategies	1	4	**Agricultural Firm:** Santeh Feed Company in Philippines; Cargill (US)- Philippines; Feed World **Research Entity:** GIFT Foundation International
09SFT05PU Leaf Meal Feeding Strategies	3	3	**Govt, Institutions & NGOs**Tanzania Fisheries Research Institute, Ministry of Livestock and Fisheries Development; Kingolwira Fish Farming Centre **Ag Business** International Tanfeeds Ltd
09TAP01UA ISTA 9	6	6	**Govt, Institutions & NGOs** Asian Fisheries Society (EDU Professional Org); China Aquatic Products Processing and Marketing Association (GOV); Tilapia International Foundation (NGO), Office of Rural Affairs - Shanghai Municipal Agricultural Commission (GOV); Global Times (Press)
09TAP03UC Alternatives for Low-Value Fish	3	3	**Govt, Institutions & NGOs** Staff of research centers and government fisheries department in An Giang and Dong Thap provinces and WWF-Vietnam (NGO)

Table 3. AquaFish Investigation Indicator Reports for DTAP B-02: Number of institutions with access to technological practices

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	B-02 Report Text
09TAP04PU Cage Culture in Ghana	15	12	**Govt, Institutions & NGOs** Ministry of Agriculture-Fisheries Directorate; FAO REgional Office; Water Research Institute; Fisheries Commission; University of Cape Coast; Savannah Agricultural Research Institute; University of Ghana; University for Development Studies
09TAP08AU Training Trainers	2	2	Seminars on pond construction focused at trainers and service providers. Attendance was registered from the 1. Universityof Agricultural Engineering, Busitema, 2. The Fisheries Training Institute
09WIZ01AU Multiple Water Use	2	2	**Institutions & NGOs** 1.Water Research Comm'n (DWAF-South Africa) 2. Department of Water Affairs & Forestry (DWAF-South Africa)
09WIZ02AU Water Management	1	2	**NGOs** Sustainable Management of Watershed (SUMAWA)
09WIZ03UM Fish Cage Culture	3	3	**Govt, Institutions & NGOs** Guizhou Normal University **Agricultural Firms** Tongwei Corporation Luo Dian Spark Eco Aquaculture Company,

Table 4. AquaFish Investigation Indicator Reports for DTAP C-01: Number of management practices developed or adopted to improve natural resource management

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	C01 Report Text
09BMA01AU Cage Culture	2	2	Cage culture practices for small-holder farming in Lake Victoria: 1. Set of Practices for farming trout in cages 2. Set of Practices for harvest and post-harvest handling of fish.
09BMA06UM Prawn Best Practices	0	1	Set of current management practices and practices for giant river prawn aquaculture to improve water quality and production
09HHI01UH Black Cockle Management	1	1	Assessment of no-take zone management practice to regulate sanitation of black cockles and improve fishery in production and cockle size: community-managed no-take zones have been demonstrated to be successful the methods are now being trialed in 2 additional communities
09IND02UC Snakehead Aquaculture	1	1	BMPs for snakehead farming: Feeding practices designed to maintain water quality and developed for use by researchers in current experimental stage to bring snakehead into aquaculture using a pelleted alternative feeding system.
09IND04UH Chame Stock Assessment	1	1	Assessment of chame fishery on Mexican Pacific Coast for development of management recommendations for currently unregulated fishery
09MNE01UM Red Swamp Crayfish	1	1	Model to characterize invasive spread of red swamp crayfish in China will lead to improved resource management.
09MNE03UM Good Practices & Eco-Certification	0	3	Best 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.

Table 4. AquaFish Investigation Indicator Reports for DTAP C-01: Number of management practices developed or adopted to improve natural resource management

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	C01 Report Text
09MNE04UC Management Recommendations	1	1	Recommendations for managing capture fisheries of small-sized, low-value fishery through use of formulated snakehead feed in aquaculture
09MNE05UM Fish Stocking in Reservoirs	1	1	By food web modeling, strategies for management practices on natural food web interactions will be better known, thus improving natural resources management.
09QSD03UM Prawn-Mola Polyculture	3	3	Small-scale prawn-mola polyculture: testing 3 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
09SFT02PU Pond-Cage System	5	6	Management practices for integrated cage cum pond polyculture system: 1. Management of fish in Static ponds 2. Cage –cum – Pond practices 3. Pond fertilization and water quality maintenance 4. Feeding fish with live feed 5. Transport of fish in cans, polythene bags and aeration 6. Integrating rice, livestock with fish
09WIZ01AU Aquaculture Interactions	2	2	Watershed management practices for managing water harvesting and land use pattern as part of model development. 1. Construct ponds on former cropland to avoid destruction of fynbos vegetation. 2. Do not construct ponds on wetlands.

Table 4. AquaFish Investigation Indicator Reports for DTAP C-01: Number of management practices developed or adopted to improve natural resource management

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	C01 Report Text
09WIZ02AU Water Management	2	2	Best management practices (including software tools) for pond construction and water management to protect wetlands and water quality. 1. Evaluate soil in construction area to avoid high water loss through seepage. 2. Make ponds as deep as possible to reduce land area and minimize surface area; storage volume ratio to reduce evaporation loss.
09WIZ03UM Fish Cage Culture	0	1	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	FY11 DTAP Target	FY11 DTAP Actual	C02 Report Text
09BMA03UM Sahar Polyculture	10	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	60	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	FY11 DTAP Target	FY11 DTAP Actual	C02 Report Text
09FSV02NC Seaweed Processing	30	5	Estimate that 10 ha of farms are using drying racks and will increase in FY11
09HHI01UH Black Cockle Management	0	27	Management practices to protect native black cockle fishery Total ha of mangroves in Aserradores that is partially protected by community vigilance: 2,628 ha
09MNE02NC Milkfish Feed Inputs	10	10	Estimate of improved hectares through adoption of reduced feed inputs for milkfish production and integrated milkfish culture with testing underway at a mariculture park.
09MNE03UM Good Practices & Eco-Certification	6	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	50	50	Fishery under improved management of freshwater small-sized/low value fish in the Lower Mekong region due to CRSP recommendations
09QSD02UA Aquaponics &Tilapia	2	1	Hectares under improved management practices
09QSD04PU Tilapia Performance	2	2	Farms using improved tilapia culture practices
09QSD05PU Propagation & Hatchery Mgmnt Training	25	25	Farms/hatcheries using hatchery management technologies/practices (Approximately 50 trainees with an average farm size of 0.5ha)

Table 5. AquaFish Investigation Indicator Reports for DTAP C-02: Number of hectares under improved natural resource management

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	C02 Report Text
09SFT01UC Alternative Feed	30	30	Farms utilizing sustainable feed practices
09SFT02PU Pond-Cage System	8	8	Farms using integrated pond-cage system in 3 reservoirs (2ha, 3ha, and 3ha) total 8 hectares
09SFT03UA Guyana Aquaculture	5	4	Maharaja Hatchery and ponds, Annai and Bina Hill projects
09SFT04NC Feed Strategies	2900	3200	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	5	5	Farms using leaf-meal based feeds and feeding strategy
09WIZ01AU Aquaculture Interactions	0	32	Hectares under CRSP best management practices developed for pond construction:
09WIZ03UM Fish Cage Culture	10	100	Conservative estimate that about 100 ha of reservoir will be in the area of improved deep-water cages

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
09MNE05UM Fish Stocking in Reservoirs	0	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.
09WIZ02AU Water Management	1	1	Best management practice (including software tools) to by-pass water downstream to protect stream biodiversity

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
09MER01AU Aquaculture Enterprises	1	1	Market assessment for aquaculture products to improve market structure and producer access
09MER02PU Value Chain Development	1	1	Farmed Fish Marketing Information System (FFMIS) technology under development for use by fish farmers
09MER03NC Tilapia Supply Chain	2	2	Supply chain efficiency analysis with recommendations to lead toward tilapia market development and growth: export and domestic markets
09MER04UC Value-Chain Analysis	2	2	Value-chain analysis to develop aquaculture and market opportunities for snakehead and small-value fish: export and domestic markets
09MNE03UM Good Practices & Eco-Certification	0	1	Eco-certified shrimp as market-based tool to minimize negative environmental impacts

Table 8. AquaFish Investigation Indicator Reports for DTAP D-02: Number of aquatic products available for human food consumption

Investigation Code	FY11 DTAP Target	FY11 DTAP Actual	D02 Report Text
09BMA03UM Sahar Polyculture	1	1	Farmed sahar (local indigenous fish) raised in polyculture
09FSV01UC Fish Paste Product Development	1	1	Processed fish paste products with improved quality and safety
09FSV02NC Seaweed Processing	1	4	New seaweed products (human and non-human uses): 1. Candy/desserts made from agar 2. Pickled seaweed 3. Industrial grade agar 4. Carrageenan raw product
09IND01UH Native Oyster Hatchery	0	1	Hatchery seed of native oyster for shellfish with improved health and safety for oyster production
09QSD03UM Prawn-Mola Polyculture	0	2	Polyculture system under development to produce 2 products: 1. Prawn from all male monosex prawn culture for export. 2. Fish for household consumption: Mola and two carp species (catla and silver carp)
09SFT03UA Guyana Aquaculture	1	1	Brackish water shrimp species being farmed is new in aquaculture and new to export market

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 Agriculture Sector Productivity Indicators listed below:

Agriculture Program Element Indicators (EG 4.5.2 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.
- **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 Agriculture Sector Productivity indicators[8] 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).

[8] USAID indicators for which a new number was not assigned in USAID's October 2010 indicator revision are listed here by their original EG 4.5.2 indicator number assignments (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[9]	**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*[10] *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) 5.2-F (6)	(1) Developed and adopted innovative technologies that increase profitability and environmental stewardship in aquaculture and fisheries.

[9] Cross referencing for the AquaFish CRSP DTAP indicators is at the thematic level.

[10] 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
5.2-28	
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 2011 Report on USAID EG Agriculture Sector Productivity 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					Farmed sahar	1	
09BMA05UM	Indoor RAS with bioflocs for shrimp: controls water quality and micro-organisms (e.g., cyanobacteria)	1					
09IND01UH	Larviculture of native oyster	1			Hatchery seed of native oyster for shellfish with improved health and safety	1	
09IND02UC	Snakehead in Aquaculture: induced spawning in captivity	1	BMPs for feeding strategies used by researchers to maintain water quality in current experimental stage to bring snakehead into aquaculture using a pelleted alternative feeding system.	1			
09IND03UH	Larval rearing technology for chame	1					
09IND04UH	Age-determination technology for chame for use in stock assessment	1					
09IND05UA	Captive breeding technologies for (1) bringing native cichlids into aquaculture and (2) establishing snook lineages	2					
09IND06PU	Investigation of aquaculture potential of native African species in Ghana: Heterotis niloticus, *Chrysichthys maurus,* and *Parachanna obsucura*	1					
09MER01AU					Market assessment for aquaculture products to improve market structure and producer access	1	

Table 14: Supporting documentation for AquaFish CRSP FY 2011 Report on USAID EG Agriculture Sector Productivity 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
09MER02PU					Farmed Fish Marketing Information System (FFMIS) technology under development for use by fish farmers	1	
09MER03NC					Supply chain efficiency analysis with recommendations to lead toward tilapia export/domestic market development and growth	1	
09MER04UC					Value-chain analysis to develop aquaculture and export/domestic market opportunities for snakehead and small-value fish	1	
09MNE02NC	Integrated, multitrophic aquaculture of milkfish-seaweed-sea cucumber in cages and pens to mitigate environmental impacts	1					
09MNE03UM			Set of best practices for shrimp production to improve environmental performance under three culture management systems: (1) moderate density stocking, (2) high density stocking in flushed ponds, (3) outdoor recirculating ponds.	1	Eco-certified shrimp as market-based tool to minimize negative environmental impacts	1	
09MNE04UC			Recommendations for managing integrated aquaculture and capture fisheries of small-sized, low-value fishery	1			
09MNE05UM			Using food web modeling, develop natural resource management practices to manage stocked fish and their effects on wild fish in reservoirs	1			

Table 14: Supporting documentation for AquaFish CRSP FY 2011 Report on USAID EG Agriculture Sector Productivity 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
09QSD01NC	Broodstock and seed production technology: social condition effects on stress responses in tilapia	1					
09QSD02UA	Tilapia strain evaluation protocol	1					
09QSD03UM	Small-scale prawn-mola polyculture technology to produce for market (prawn) and home consumption (fish)	1			Fish for household consumption (mola, catla and silver carp) and prawns for export	2	
09QSD04PU	Improved native tilapia species for small-scale aquaculture	1					
09SFT03UA					Brackish water shrimp new to aquaculture and available to market	1	
09SFT05PU	Sustainable feed technology studies using lower-cost, locally available leaf meals as protein substitute	1					
09WIZ01AU	Rural watershed management for multiple uses--cage culture and non-aquacultural applications	1	Watershed management practices to control water harvesting and land use patterns as part of model development	1			
09WIZ02AU	Software tools for multi-use water management	1	Management practices for pond construction and water management to protect wetlands and water quality.	1			
09WIZ03UM	Mass balance model for deep-water cage polyculture of fish	1	Practice to reduce sediment outputs from deeep-water cages	1			
Total Technologies under development		**17**	**Total Practices under development**	**8**	**Total Products/Markets under development**	**10**	**35**

Table 15: Supporting documentation for AquaFish CRSP FY 2011 Report on USAID EG Agriculture Sector Productivity 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	Tech Total	5.2-I (9): Practice	Prac Total	5.2-I (9): Product/Market	Prod Total	All Total
09BMA04UM	Pond-based RAS system for shrimp with solid waste removal and water quality controls	1					
09FSV02NC	Improved seaweed drying racks	1			Non-food grade agar extracted from seaweed grown in polyculture-	1	
09MNE01UM	Model to characterize invasive spread of red swamp crayfish in China.	1					
09MNE02NC	Reduced feeding strategy: alternate day feeding at an initial reduced feed ration (7.5 - 4% body weight)	1					
O9MNE07UA	MT elimination technologies for transfer in on-farm trials: 1. Reduced MT dose 2. MT elimination using charcoal filtration and MT-degrading bacteria bioflocs with probiotic effects on MT-treated fish growth & survival	2					
09QSD01NC	Tilapia Broodstock & Seed Production Technologies: 1. IGF-I and cortisol tests as growth indicator 2. Social condition and stocking density effects as stress indicators for production and performance	2					

Table 15: Supporting documentation for AquaFish CRSP FY 2011 Report on USAID EG Agriculture Sector Productivity 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	Tech Total	5.2-I (9): Practice	Prac Total	5.2-I (9): Product/Market	Prod Total	All Total
09SFT01UC	Snakehead pelleted feed trials: 1. Snakehead survival and growth using pelleted feeds 2. Replacement of fishmeal from marine vs. freshwater fish	2					
09SFT02PU	Integrated pond-cage technology for small-scale tilapia farmers to reduce feed cost and manage pond waste	1	Management practices for integrated cage cum pond polyculture system: 1. Feeding and fertilization practices to reduce feed cost and waste 2. Pond management and integration with agriculture (rice, livestock) 3. fish transport	3			
09SFT03UA	Standardized aquaculture feed with local ingredients to reduce fishmeal	1					
09SFT04NC	Protein formulation technology: reduced fishmeal, reduced crude protein, or fishmeal-free diets for tilapia	1					
09WIZ03UM	Deep water cage production model for fish polyculture	1					
Total Technologies under field testing		**14**	**Total Practices under field testing**	**3**	**Total Products/Markets under field testing**	**1**	**18**

Table 16: Supporting documentation for AquaFish CRSP FY 2011 Report on USAID EG Agriculture Sector Productivity 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
09BMA01AU	Demand feeding technology	1	Practices for cage culture: 1. Trout production in cages 2. Harvest and post-harvest handling of farmed fish	2			
09BMA03UM	Polyculture technology for sahar-tilapia-carp for best ratio of predator to prey in economic and ecological terms.	1					
09BMA04UM	Improved resource management with pond-based RAS system for shrimp with solid waste removal and water quality controls	1					
09BMA06UM			Set of management practices for giant river prawn aquaculture to improve water quality and production	1			
09FSV01UC			Best practices and standards for Fish paste products 1. Quality and safety processing guidelines 2. Packaging and labeling Standards	2	Improved processed fish paste products following standards for quality and safety	1	
09FSV02NC	Value-added processing technology for food-grade agar to make candy and desserts	1			Processed seaweed products for food or non-food products: 1. Candy and desserts from agar 2. Pickled seaweed 3. Carrageenan raw product	3	
09HHI01UH			Community-managed no-take zones for black cockles trialed in 2 new locations	1			
09MNE02NC	Value-added processing technology for milkfish	1					

Table 16: Supporting documentation for AquaFish CRSP FY 2011 Report on USAID EG Agriculture Sector Productivity 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
09MNE04UC			Recommendations for managing capture fisheries of small-sized, low-value fishery through use of formulated snakehead feed in aquaculture	1			
09QSD02UA	Aquaponics-agriculture technology for control of pond wastes, utilizing effluent from tilapia tanks to grow vegetables, beans and corn	1					
09QSD05PU	Propagation and hatchery management technologies: 1.Sex reversal to produce all-male tilapia 2.Production of broodstock catfish through pituitry extracts and injection 3. Safe transportation of fingerlings from hatchery to production units 4. Water quality monitoring in the hatchery 5. Preparation of hormonal feed for test reversal in juvenile fish	5					
09SFT03UA	Standardized reduced fishmeal feed formulation technology	1			Farmed brackish water shrimp is new product in production in Guyana	1	
09SFT04NC	Alternative Feeding Strategies for Tilapia Set of cost-cutting, reduced feeding strategies for tilapia (alternate day, delayed feeding, reduced ration) Three formulation strategies for	4					

Table 16: Supporting documentation for AquaFish CRSP FY 2011 Report on USAID EG Agriculture Sector Productivity 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
	(reduced fishmeal, reduced crude protein, or fishmeal-free diets using locally sourced products thereby relieving pressure on wild fisheries						
09TAP02NC	Extension podcasts modules for international community of tilapia farmers and extension and research community	1					
09TAP03UC	Farmer adoption of pelleted feed for snakehead in Vietnam	1					
09TAP04PU	Farmer adoption of cage culture technology	1					
Total Technologies under transfer		**21**	**Total Practices under transfer**	**5**	**Total Products/Markets under transfer**	**5**	**31**

APPENDIX 5. ACRONYMS

ABW	Average Body Weight
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	Aquaculture Department and SEAFDEC, 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
BFS	Bureau of Food Security (USAID)
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
CP, LLC	Cultural Practic, Limited Liability Company
CPSR	Cooperativa Pesquera San Ramón (San Ramón Fisheries Cooperative), Mexico
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
FtF	Feed the Future (USAID)
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, Cambodia
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
IWMI	International Water Management Institute
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
LEAP	Leadership Enhancement in Agriculture Program
LHRHa	Luteinizing Hormone-Releasing Hormone analogue
LLC	Limited liability company
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
MNE	Mitigating Negative Environmental Impacts
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
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	South East Asian Fisheries Development Center
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
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
WAFICOS	Walimi Fish Cooperative Society Ltd, Uganda
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 operational on a no-cost extension.

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