

FEED THE FUTURE INNOVATION LAB FOR COLLABORATIVE  
RESEARCH ON AQUACULTURE & FISHERIES  
(AQUAFISH INNOVATION LAB)

# SEVENTH ANNUAL REPORT

1 October 2012 to 30 September 2013



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**AQUAFISH**  
INNOVATION LAB



## AQUAFISH INNOVATION LAB SEVENTH ANNUAL REPORT: 2012-2013

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This report covers the period from 1 October 2012 to 30 September 2013. This document serves as the Annual Report for FY13 activities.

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### Cover Photos:

**Front cover center:** Women and children in Prey Veng Province, Cambodia, learn about the nutritional benefits of fish. Photo by Bunthang Touch.

**Front cover left:** A woman fish cleaner prepares small fish for processing in the Tonle Sap, Cambodia. Photo by Peg Herring.

**Front cover right:** An AquaFish researcher conducts a feed demonstration in Ghana. Photo courtesy of AquaFish Innovation Lab.

**Back cover:** Women and children after pond harvest in Nepal. Photo by Hare Ram Devkota.

**Bottom silhouette:** Fishermen returning from a trip in Mali. Photo courtesy of Jim Bowman.

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Pond Aquaculture, Nepal. Photo courtesy of University of Michigan.

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## EXECUTIVE SUMMARY

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The Seventh Annual Report describes AquaFish activities and accomplishments from 1 October 2012 to 30 September 2013 (FY13) as the program moved from Phase I (initially funded from 2006-2011) to Phase II (2013-2018). This reporting period was largely transitional. AquaFish had been operating on significantly reduced funding with a looming termination date, when the extension was awarded midway through the year. Since FY11, the program experienced a 70% cut from normal funding levels and consequently was forced to reduce staff and project activities while waiting for a decision from Washington regarding the program's future. Two highly commendable major external reviews completed in Summer 2012 – the Board for International Food & Agricultural Development (BIFAD) and USDA-USAID – fed into the USAID determinations to continue AquaFish. Two subsequent internal USAID review processes were passed in late Fall 2012 – Board for Acquisition and Assistance Reform (BAAR) review and USAID Administrator's approval – and AquaFish was invited to apply for an extension on 21 December 2012. After experiencing multiple delays and cuts, AquaFish was revived on 31 March 2013 with a five-year extension through 29 March 2018. The transition was both arduous and complicated; it is mostly a result of careful management and the continued dedication of our research partners that AquaFish has been able to reassemble for another five years.

AquaFish's strategy for the lengthy two-year transition period involved preserving a presence in existing US Government Feed the Future (FTF) host countries in the event of a possible extension. In order to accomplish this, Management took a disproportionately large cut and non-FTF host countries were phased out. That all former partners later opted into the broader (unfunded) AquaFish network, and that they remain eager to participate using their own resources, speaks volumes about AquaFish's graceful exit strategy. Management also wisely preserved subcontractual relations with partners; thus, seven Phase I projects continued through most of FY13. Strategic continuity among partners and principal FTF host countries allowed AquaFish to respond rapidly to USAID's approval of Phase II. Five reconfigured subcontracts have been continued for work in the following FTF countries: Ghana, Tanzania, Kenya, Uganda, Bangladesh, Nepal, Vietnam, and Cambodia.

In FY13, AquaFish researchers continued work in Asia, Africa, and Latin America, wrapping up the last subset of over 100 investigations under Phase I. Phase I began in 2006 and involved 33 Host Country (HC) and 17 US partner institutions in 20 countries. During the FY11-13 transition period, Management funded anticipatory bridging activities from Phase I to Phase II. These included value chain assessments (VCA), experimental pond unit assessments (EPUA), and the development of air breathing fishes (ABFs) for aquaculture. These investigations served as a means for AquaFish projects to sustain relationships and develop the HC capacity for moving into Phase II.

On 31 March 2013, AquaFish officially moved into Phase II under the new USAID-approved name *Feed the Future Innovation Lab for Collaborative Research on Aquaculture & Fisheries* or *AquaFish Innovation Lab* for short. Phase II addresses the programmatic goals of AquaFish in accordance with the FTF Initiative to:

- Improve sustainable aquaculture productivity;
- Address natural resources management and biodiversity with targeted programs that protect native fisheries and the integrity of local and regional water systems;
- Improve health and nutrition especially of women and children; and

- Advance market development by linking small producers to markets, developing producer organizations, and training rural stakeholders in food safety and quality standards.

This fiscal year also saw the continued progress on the Associate Award *Enhancing the profitability of small aquaculture farm operations in Ghana, Kenya, and Tanzania*, which focuses on the FTF initiative including scaling up innovations from previous CRSP successes for accelerating best management practices (BMP) adoption rates.



Man throwing a net in Mali. Photo courtesy of Jim Bowman.





## I. INTRODUCTION

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The AquaFish mission 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 AquaFish 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.”

The Seventh Annual Report (first annual report under Phase II) describes program activities and accomplishments from 1 October 2012 to 30 September 2013. AquaFish is funded by the United States Agency for International Development (USAID) under the authority of the Foreign Assistance Act of 1961 (PL 87-195) as amended, and with major contributions from participating US and Host Country institutions. Originally housed in USAID’s Economic Growth, Agriculture, and Trade (EGAT) Bureau’s Office of Agriculture, AquaFish now falls under the Bureau of Food Security (BFS), which was formed in November 2010.

This reporting year brought on many changes for AquaFish, as the program transitioned from Phase I to Phase II. After about a year and a half of operating in limbo, AquaFish received the green light to continue when USAID awarded Dr. Hillary Egna of Oregon State University (OSU) a five-year extension that began on 31 March 2013. Significant changes within USAID along with two external reviews and two subsequent internal USAID reviews throughout 2012, prompted a number of adjustments. The most visible difference is in the program name, which USAID changed to Feed the Future Innovation Lab for Collaborative Research on Aquaculture & Fisheries, or AquaFish Innovation Lab for short. This name change was mandated by USAID for all of the Collaborative Research Support Programs (CRSPs), which are collectively referred to as Collaborative Research Innovation Labs. AquaFish was also asked to consolidate projects and focus research more intentionally on fewer species and in fewer countries in only Asia and Africa. As a result, many of the non-FTF focus countries phased out of the AquaFish research portfolio in Phase II, including all of Latin America and the Caribbean.

When it was conceived in 2006, AquaFish was envisioned as a long-term research program. The second five-year phase continues the program’s mission to improve livelihoods and promote health through collaborative research in aquaculture and fisheries through four interrelated themes (Phase II changes shown in italics):

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

During Phase I, AquaFish researchers completed over 100 investigations in 20 Countries with 33 Host Country and 17 US partners under Implementation Plan (IP) 2007-2009, IP 2009-2011, and three subsequent IP 2009-2011 Addenda. With an original close down date of 29 September 2011, external delays in receiving a formal program extension led to a 70% funding reduction from previous years’ base levels.

The Phase II approval bisected the reporting year, marking FY13 as the end of a two-year transitional period for closing down ongoing work from Phase I while gearing up for new projects to move forward into Phase II. In FY13, seven core research projects completed a handful of investigations under Phase I, which are covered in this Seventh Annual Report. These investigations focused on maintaining relationships and establishing foundations for Phase II (which was anticipatory for much of FY13) under three areas: air-breathing fishes (ABF), experimental pond unit assessment (EPUA), and value chain assessment (VCA).

In Phase II of AquaFish, the program is building on successes of previous CRSP efforts, strengthening longstanding collaborative partnerships, and forging new ones. Phase II research is focusing on improving the sustainability of aquaculture through the development and transfer of innovative technologies that address key elements:

- The health and nutrition needs of our target communities, particularly women and children;
- Natural resource management, climate change, and biodiversity issues with targeted activities that protect native fisheries and the integrity of local and regional water systems; and
- Market development by linking small producers to markets and training rural stakeholders in food safety and food quality standards.

As part of the new Feed the Future Food Security Innovation Center, AquaFish operates under the Program for Research on Nutritious and Safe Foods, which “addresses undernutrition, especially in women and children, by increasing the availability and access to nutrient dense foods through research on horticulture crops, livestock, fish and dairy, food safety threats such as mycotoxins and other contaminants and on household nutrition and food utilization” (R. Bertram, 7 December 2012).

AquaFish is now establishing new projects while also building on a long history and a strong foundation of fruitful work. Since inception in 2006, the AquaFish CRSP conducted research in or partnered with Brazil, Bangladesh, Cambodia, China, Ghana, Guyana, Honduras, Indonesia, Kenya, Mali, Mexico, Nepal, Nicaragua, Philippines, South Africa, Tanzania, Thailand, Uganda, and Vietnam in over 100 investigations. Strong relationships enabled the AquaFish CRSP to leverage nearly 7 dollars of extramural support for every dollar committed by USAID. Scholarly output has been significant through the publication of over 150 peer-reviewed journal articles. AquaFish CRSP research and outreach activities have resulted in 9,983 hectares under improved technologies or management practices. A capacity building effort has to date supported 351 degree-students, of whom 48% are women. All of these students are now part of an international network of aquaculture scientists and professionals, ensuring the long-term success of in-country accomplishments. Over 7,600 individuals have benefitted from 245 short-term training events on a variety of topics offered by the AquaFish CRSP around the world.

The AquaFish Innovation Lab will continue to operate in the same manner as the previous CRSP whereby OSU serves as the Lead US Institution and partners with other institutions in the US and internationally. As AquaFish continues to build on the interconnected network of researchers worldwide, program participants will collectively work to fulfill the overall program mission. Bringing together resources from US and Host Country institutions, AquaFish strives to (1) strengthen the capacities of its participating institutions, (2) increase the efficiency of aquaculture in environmentally and socially acceptable ways, and (3) disseminate research results to a broad audience.

Phase II of AquaFish officially began on 31 March 2013. Five continuing but reconfigured projects from Phase I responded to an RFP for work in Asia and Africa. Continuing project principal investigators submitted proposals in early May and have progressed through an NSF-style external peer-review process along with a programmatic review involving USAID, the Nutrition Innovation Lab, and the AquaFish Management Team.



Two Associate Awards have been received under the AquaFish Leader Award since 2007. The first Associate Award from USAID/Mali, focusing on aquaculture and fisheries in Mali, ended in December 2010 and the second began in 2010. This second Associate Award, which is part of the BFS/USAID Strategic Investment in Rapid Technology Dissemination (SIRTD) Program, is called *Enhancing the Profitability of Small Aquaculture Operations in Ghana, Kenya, and Tanzania*. Late in this reporting year, the SIRTD Associate Award received a no-cost extension to 30 September 2014. Thematically, AquaFish focuses on aquaculture with its core funds, and on both aquaculture and fisheries with its Associate Awards. Collectively, the AquaFish leader award and the associate awards continue to conduct research and develop human and institutional capacity in select host countries towards the overall mission of enriching livelihoods and promoting health.

Although this reporting year started with a very uncertain future, and significantly reduced staffing, the Management Team continued to work toward AquaFish goals by organizing and attending project meetings and scientific conferences, conducting site visits, and managing seven core research projects and the SIRTD Associate Award. The much-anticipated invitation for program continuation came on 21 December 2012 from USAID and set many changes in motion. The proposal process for Phase II took three months, including a review, comment, and revision period. Once the five-year extension was in place, the AquaFish Management Team began Phase II within one week by releasing a restricted RFP for Phase II research projects, and then conducting peer-reviews and programmatic reviews to ensure quality and alignment. In addition to setting up the framework to initiate new projects, the Project Management Office (PMO) hired new management team members to re-staff to full operational levels. The AquaFish Management Team released an open RFP for work in Burma on 1 May, as requested by USAID. Proposals were submitted in response to the Burma RFP on 19 July 2013 and were assessed for alignment with the broader AquaFish research portfolio. The PMO coordinated two orientation workshops for project participants: the Africa Regional Workshop in Ghana and the AquaFish Phase II Orientation Workshop in Washington, DC. With these collective activities well underway, Phase II is getting off to a strong and promising start.



## II. PROGRAM HIGHLIGHTS

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During this reporting year (1 October 2012 to 30 September 2013), Oregon State University continued to serve as the Management Entity (ME) of AquaFish, with technical, programmatic, and fiscal responsibility for the performance of the program. The AquaFish Management Team, led by Director and Lead Principal Investigator Dr. Hillary Egna, accomplished a variety of technical and programmatic activities at OSU. Below are programmatic highlights for this past reporting year.

- AquaFish Director, Dr. Hillary Egna, participated in three CRSP Council meetings in FY13, and eight Council conference calls. The first Council meeting, attended by Dr. Egna, was held in October 2012 in Des Moines, Iowa in conjunction with the World Food Prize. The second was held in March 2013 in Tanzania called *Examining Opportunities for Linkages in Collaborative Research, Technology Dissemination, and Human and Institutional Capacity Development*. HC-PI, Sebastian Chenyambuga from Sokoine University of Agriculture, represented AquaFish at the event. The third Council meeting was held in Accra, Ghana in July 2013 and included several USAID Missions in Africa as well as USAID Washington. The Council meeting followed the *Feed the Future Collaborative Research Innovation Labs and Partners Workshop*, which Drs. Egna, Quagrainie (PU) and Frimpong (VT) attended. Both of these meetings immediately followed the inaugural Africa Regional Meeting highlighted later in this section.
- Seven US Lead Institutions received a no-cost extension (NCE), extending the end date of their subawards for student support, transitional research, and Phase I project completion. Two of the seven projects were closed this fiscal year (University of Arizona and University of Hawai'i at Hilo). The other five projects were extended for continuity into Phase II.
- On 21 December 2012, AquaFish received a Request for Application (RFA) from USAID for a five-year extension of the leader award.
  - On 2 February 2013, Director Egna submitted a proposal for a five-year extension. USAID reviewed the proposal and returned it with comments on 5 March 2013. The Director responded to comments on 10 March 2013, and to several subsequent review questions by the Office of Acquisition and Assistance (OAA) through 27 March 2013; she submitted a revised final proposal and additional materials on 20 March 2013.
  - USAID/OAA approved the proposal on 27 March 2013, extending the Leader Award end-date to 29 March 2018 and raising total estimated budget from \$14.72 million to \$34.42 million. The extension award was announced on 29 March 2013 after a 48-hour embargo period, and began on 31 March.
- From the beginning of FY11 through half of FY13, AquaFish operated at 30% of previous base levels. The Management Team reduced staff in FY12. With Phase II, AquaFish has hired new team members, nearly returning to historic staffing levels.
- This period covers a transitional year that began with two arduous external reviews that had been completed in Summer 2012 and were circulating and informing decision makers in Fall 2012. The external BIFAD review was released as a report during the Council meeting in Iowa in October 2012; the CRSP Council commented upon it, later to receive a reply from BIFAD. The CRSP name change

concept was not mentioned in the BIFAD report. Along with the BIFAD review, program-specific external reviews organized by USDA using USAID funds focused on four CRSPs: AquaFish, Pulse, Peanut, and INTSORMIL. The BIFAD and USDA-USAID external reviews formed the basis of subsequent internal reviews at USAID for the first half of FY13. Internal reviews included the BAAR which considered competitive contracting issues for Acquisitions and Assistance under procurement regulations, and an evaluation process at the highest levels of USAID. Administrator Shah's approval was sought and received prior to AquaFish receiving its RFA on 21 December 2012. AquaFish's lengthy transition surpassed the timeframe of the other CRSPs under review, except INTSORMIL, and presented significant challenges for management and researchers. Sustaining morale, fighting inertia, and maintaining readiness in the face of huge budget cuts, staff reductions, project attrition, and mixed messages from government were challenges that AquaFish met with grace, but would prefer to never again have to deal with in the future.

- On 23 September 2013, AquaFish received a one-year no-cost extension from USAID/OAA for the Associate Award entitled *Enhancing the Profitability of Small Aquaculture Farm Operations in Ghana, Kenya, and Tanzania*. In FY13, the Associate Award continued focusing on profitability analysis and best practices in effluent and nutrient management through outreach activities in Ghana, Tanzania, and Kenya. To date this project has held 10 workshops, involving 512 trainees, including one workshop focusing on women in commercial aquaculture.
- In February 2013, Drs. Ford Evans and Hillary Egna of OSU organized and chaired a successful session at the *Aquaculture 2013* conference in Nashville, Tennessee entitled, *Sustainable Shellfish Aquaculture in Developing Countries*. This session generated much interest and contained topics that will be a focus of work in Phase II.
- The AquaFish Management Team was active in reaching out to various stakeholder groups during FY13. Posters, presentations, outreach materials, and proceedings included:
  - AquaFish Collaborative Research Support Program. (Egna, Hillary S., ed.). 2013. *Feed the Future Innovation Lab for Collaborative Research on Aquaculture & Fisheries*. [Brochure] AquaFish CRSP, Oregon State University, Corvallis, Oregon. 2 pp.
  - Edwards, Paris, Hillary Egna, Stephanie Ichien and Jenna Borberg. 2013. *Compendium of Tilapia Publications*. AquaFish Innovation Lab, OR, 30 pp.
  - Egna, Hillary and Stephanie Ichien. 2013. *Aquaculture Best Management Practices on Non-Fed Pond Systems*. AquaFish Innovation Lab, OR, 1 pp.
  - Egna, Hillary and Stephanie Ichien. 2013. *AquaFish Innovation Lab—West Africa*. Feed the Future Collaborative Research Innovation Labs and Partners Workshop, Ghana, 8-9 July 2013. 1 pp.
  - Egna, Hillary and Stephanie Ichien. 2013. *AquaFish Innovation Lab—East Africa*. Feed the Future Collaborative Research Innovation Labs and Partners Workshop, Tanzania, March 2013. 1 pp.
  - Egna, Hillary, Paris Edwards, and Ford Evans. 2013. *Improvements to Human Health and Nutrition Through Shellfish Aquaculture*. [Poster] Asian-Pacific Aquaculture 2013, Ho Chi Minh City, Vietnam, 10-13 December 2013.
  - Egna, Hillary, Paris Edwards, and Stephanie Ichien. 2013. *Building Capacity and Developing Technology to Alleviate Poverty through Sustainable Aquaculture Development—AquaFish Research In Asia*. [Poster-submitted] Asian-Pacific Aquaculture 2013, Ho Chi Minh City, Vietnam, 10-13 December 2013.
  - Egna, Hillary. 2012. *Aquaculture trends and strategic partnerships*. [invited speaker] Kenya Department of Fisheries. July 2012.
  - Egna, Hillary. 2012. Keynote Speaker of Workshop on Value Chain Analysis with WIOMSA. [invited speaker] Tanzania. July 2012.

- Egna, Hillary. 2013. *Library Donation Program*. [invited presentation] Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. July 2013.
- Egna, Hillary. 2013. *Two rules of thumb for every fish culturist*. [invited presentation] BMP Workshop, Western Region School of Mines, Tarkwa, Ghana. July 2013.
- Egna, Hillary and Stephanie Ichien. 2013. *The Promise of Air-Breathing Fishes for Developing Sustainable Aquaculture in a Climate Changing Future*. AIARD Annual Conference, Washington DC, 2-4 June 2013. 1 pp
- Evans, Ford and Hillary Egna. 2013. *Using bivalve aquaculture to improve food security and livelihoods in developing countries*. [Poster] Aquaculture 2013, Nashville, Tennessee, 21-25 February 2013.
- Ichien, Stephanie and Hillary Egna. 2013. *Exploring Opportunities for the Culture of Indigenous Air Breathing Fish for Climate Change Adaptation*. [Poster] Aquaculture 2013, Nashville, Tennessee, 21-25 February 2013.
- Ichien, Stephanie, Hillary Egna, and Meryl Williams. (eds.). 2012. *Proceedings for the IIFET Special Session on Markets and Value Chains for Small Aquaculture & Fisheries Enterprises with a Focus on Gender*. AquaFish Collaborative Research Support Program, Oregon State University, Corvallis, Oregon, pp. 209.
- Ichien, Stephanie, Paris Edwards, Caleb Price, and Hillary Egna. 2013. *Optimizing Small-Scale Tilapia Culture for Improved Health and Income Generation in Developing Countries*. [Poster] 10<sup>th</sup> International Symposium on Tilapia in Aquaculture (ISTA10), Jerusalem, Israel, 6-10 October 2013.
- Ichien, Stephanie, Paris Edwards, Caleb Price, and Hillary Egna. 2013. *Building Human and Institutional Capacity in Developing Countries to Provide Equal Opportunities for Women and Men for Enhancing Sustainable Aquaculture*. [Poster] 10<sup>th</sup> International Symposium on Tilapia in Aquaculture (ISTA10), Jerusalem, Israel, 6-10 October 2013.
- In addition to the above listed research publications, the Management Team at Oregon State University produced the Sixth Annual Report/Final Report (October 2012), addenda to the Implementation Plan, the 2013 Annual Work Plan (June 2013), a newsletter (*Aquanews*), and 12 monthly employment opportunity newsletters (*EdOPNet*). All publications are available for download from the AquaFish website ([www.aquafish.oregonstate.edu](http://www.aquafish.oregonstate.edu)).
  - In FY13, the AquaFish Management Team conducted three site visits to close down Phase I projects (Mexico and Guyana) and lay the groundwork for Phase II (Nepal). In Mexico and Guyana, AquaFish Management personnel met with project participants and evaluated research facilities as a way of assessing outcomes and defining possible future linkages for the AquaFish Regional Centers of Excellence. During the Nepal site visit, AquaFish Management personnel met with USAID Mission representatives and Nutrition Innovation Lab researchers to coordinate in-country activities. The Nepal site visit focused on meetings with AquaFish researchers and students at the Agriculture and Forestry University (formerly the Institute of Agriculture & Animal Science- IAAS) and new Phase II partners in the National Agriculture Research Center (NARC) and the Directorate of Fisheries Development.
  - AquaFish hosted an inaugural Africa Regional Meeting at the KNUST in Kumasi, Ghana from 5-9 July 2013. The meeting was chaired by Dr. Hillary Egna, and organized by Dr. Steve Amisah (KNUST), Dr. Kwamena Quagraine (US Lead Project PI), and Hillary Egna. Local coordination in Ghana was superb, owing to the wonderful support of KNUST faculty and staff including Dr. Nelson Agbo (HC Co-PI) and others. During the first day of the meeting, Dr. Egna described the new Phase II AquaFish Innovation Lab and discussed proposed AquaFish projects in Africa with participants from the Purdue and Auburn University projects. Further topics included developing synergies and regional collaboration with other groups working in Africa, and break-out sessions on capacity

building, technology development, impact assessment, outreach, and gender integration. The last two days of the Regional Meeting included field trips to an aquaculture cage farm in the Eastern Region, to the Aquaculture Research Development Center, and to the Ranaan feed facility.

- On 23-24 September 2013, Dr. Hillary Egna organized and led an Orientation Workshop in Washington, DC for the five AquaFish Phase II core research projects. Representing each of the projects, the five US Lead Project PIs and the five Host Country Project PIs from Cambodia, Nepal, Bangladesh, Ghana, and Uganda attended the workshop. Individuals from USAID and BFS were invited to make presentations on the Innovation Labs in BFS, Monitoring & Evaluation, Human and Institutional Capacity Development (HICD), Gender, Nutrition, and the USAID Environmental Strategy. In addition to the invited speakers, other attendees from USAID included Joyce Turk, Harry Rea, and Shivaun Leonard. On both mornings of 23 and 24 September, two business meetings were held for project PIs and management to cover administrative details for Phase II.
- The reporting year saw changes within USAID for all the CRSPs (renamed Innovation Labs in late March 2013) including reorganization of BFS to include: a research office led by Saharah Moon Chapotin and an HICD office led by Susan Owens; a coordinator hired for integrating the various Agreement Officer's Representatives (AORs) involved with CRSPs (Carole Levin), and; the creation of the Food Security Innovation Center with its seven new programs. AquaFish was placed in the program on nutritious foods. AquaFish saw additional changes with the retirement of USAID AOR Harry Rea on 31 December 2012. Harry Rea served AquaFish and its predecessor CRSPs well for many years and is dearly missed. In January 2012, Joyce Turk was assigned AquaFish in addition to her AOR duties for two other CRSPs, and Harry Rea was retained for part-time, on-call work. Shivaun Leonard was hired in response to the GS-13 advertisement released by BFS in Winter 2013. She came on board in time for the Ghana workshop in early July 2012, and as of the end of FY13 continues to serve in a consultant position while her US government paperwork goes through the clearance process. Her AOR certification is not expected to occur until Spring 2014 at the earliest. These changes have been disruptive, however, Management and the AOR triumvirate are working through challenges as they arise and expect smoother operations ahead.
- Director Egna nominated two longtime CRSP Director colleagues for prestigious awards. Dr. John Yohe (INTSORMIL CRSP Director) received a Distinguished Service award from the CRSP Council in recognition of his 35 years of outstanding leadership and service to the CRSPs. Director Egna revived this award and undertook efforts to create the ceremony; the last Council award recipient was Dr. Pat Barnes-McConnell of the former Bean/Cowpea CRSP. The award was presented to Dr. Yohe by the CRSP Council, with USAID/BFS and BIFAD leadership present, on 15 October 2012 in Des Moines, Iowa. Later in the year, Director Egna teamed with Amanda Crump of the Horticulture CRSP to nominate Dr. Jonathan (Tim) Williams (Peanut CRSP Director) and Dr. John Yohe for special awards from the Association for International Agriculture and Rural Development (AIARD), which were presented to both Directors at the June conference in Washington DC. Both Directors retired in 2013. They are remembered for their dedication in championing the CRSPs as highly successful USG vehicles for interwoven capacity building and agricultural research development.
- The Regional Centers of Excellence (RCE) continued to build linkages and promote networking opportunities. RCE Lead Coordinators include: Charles Ngugi and Héry Coulibaly (Africa), Remedios Bolivar and Yuan Derun (Asia), Maria Celia-Portella and Wilfrido Contreras-Sánchez (Latin America/Caribbean).
- The AquaFish CRSP Management Team continued to administer the Library Donation Project in FY13, shipping boxes of scientific literature, textbooks, and journals donated to Host Country

libraries. The AquaFish Library Donation Project began in 1999 - akin to Libraries without Frontiers - to help strengthen HC libraries in Africa, Asia, and Latin America.

- AquaFish has continued to innovate around social media and the internet as a means to collect, synthesize, and share information. The Management Team developed and maintains a number of databases, an online management information system, and other services to promote interaction with the wider community of practice. Website traffic through the AquaFish site ([www.aquafish.oregonstate.edu](http://www.aquafish.oregonstate.edu)) increased by 1,870 unique visitors in FY13.
- In this nearly terminal year -- now more aptly called transitional year -- AquaFish avoided sinking into obscurity by maintaining its visibility at key professional conferences. AquaFish continued to sponsor international conferences and symposia on aquaculture and fisheries in an effort to encourage information sharing and to build connections between researchers with the common interests in aquaculture development.
  - The Walimi Fish Farmers Cooperative Society (WAFICOS) held its Sixth Annual Fish Farmer's Symposium and Trade Show in Kampala, Uganda, on 23-25 January 2013.
  - The Asian Fisheries Society's Tenth Asian Fisheries and Aquaculture Forum (10AFAF) was held in Yeosu, South Korea, on 30 April-4 May 2013.
  - The Fourth Global Symposium on Gender in Aquaculture Fisheries (GAF4) was held in conjunction with 10AFAF in Yeosu, South Korea, on 30 April - 4 May 2013. On day one of the symposium, Dr. Hillary Egna chaired the first session on capabilities and vulnerabilities with respect to changes in aquaculture and fisheries sectors.
  - AquaFish is a Gold Sponsor for the Tenth International Symposium on Tilapia in Aquaculture (ISTA10), which is scheduled to take place on 6-10 October 2013 in Jerusalem, Israel. AquaFish sponsorship includes support for promising young scientists from poorer countries to attend ISTA10, and for best presentation awards.
- Two ongoing award programs focus on providing opportunities for students and young professionals from developing countries to attend professional conferences important for career development. One program is the *Yang Yi Travel Award*, and the other is for the *International Symposium on Tilapia in Aquaculture*. In addition, the AquaFish Director has created and supported intermittent professional development opportunities and recognition awards for students and young professionals at other professional symposia including the Institute of International Fisheries Economics and Trade (IIFET), Gender in Aquaculture and Fisheries (GAF), and World Aquaculture Society (WAS). Not including OSU, over 80 students and young professionals have benefitted from these opportunities over the life of these awards.
  - The Third Shanghai Ocean University-AquaFish Yang Yi Young Scientists Travel Award was presented to two excellent young scientists from China, Dr. Youji Wang and Ms. Dongmei Zhu, during the opening ceremony of 10AFAF in Yeosu, South Korea, on 30 April 2013. A website for the award is under development by the Management Team for utilization by Shanghai Ocean University (SOU).
- Akuffo Amankwah was awarded a Borlaug LEAP Fellowship in April 2013. Pursuing his PhD at Purdue University under the mentorship of AquaFish US-PI, Dr. Kwamena Quagrainie, Akuffo has been involved with the AquaFish Strategic Investment in Rapid Technology Dissemination (SIRTD) Associate Award, entitled *Feed the Future: Enhancing the Profitability of Small Aquaculture Operations in Ghana, Kenya, and Tanzania*. Akuffo joins a growing group of successful AquaFish LEAP fellows and is the fifth AquaFish student to receive the Borlaug Leap Fellowship since 2006.



- AquaFish continues to support curriculum development at host country universities. Two notable successes occurred at the Juarez Autonomous University of Tabasco (UJAT) in Mexico and Kwame Nkrumah University of Science and Technology (KNUST) in Ghana.
- AquaFish Director, Dr. Hillary Egna, received the World Aquaculture Society (WAS) Honorary Life Award in Nashville in February 2013. The first woman to receive the honor since its inception in 1963, Dr. Egna was nominated by WAS members for her significant contributions to the field of aquaculture. Additionally, Dr. Egna received the Merit Award from the Asian Fisheries Society at 10AFAF in Yeosu Korea on 30 April 2013 in recognition of her contributions to aquaculture and development.
- In FY13, AquaFish accomplishments have been highlighted in a number of media outlets including the following:
  - Chapotin, Saharah Moon. 2013. *The value of research to feed the future*. The Guardian. 4 September 2013. [www.theguardian.com/global-development-professionals-network/us-news-blog/2013/sep/04/usaid-feed-the-future-research?view=mobile](http://www.theguardian.com/global-development-professionals-network/us-news-blog/2013/sep/04/usaid-feed-the-future-research?view=mobile)
  - Hargreaves, John. 2013. *Aquaculture 2013 in Nashville*. World Aquaculture Vol 44, No 2, Page 20.
  - United States Agency for International Development: Water Office. 2012. *Fishing for the Future*. Global Waters: Water and Fish for a Hungry Planet. Vol. III. Issue III. 8-13 pp. August 2012.
  - Feed the Future: Science & Technology in Agriculture. 21 August 2012. *From Best Practices to Best Outcomes in Ghana*. The Feed the Future Monthly Newsletter. Issue 12. Page 6.
  - Sullistianti, Endah. 2012. *Science for Life: Profile of Indonesian Student: Sidrotun Naim*. [video] <http://vimeo.com/36843301>. 15 February 2012.



Participants of the 2013 AquaFish Africa Regional Meeting at KNUST, Kumasi, Ghana. Photo by Steve Amisah.





### III. RESEARCH ACCOMPLISHMENTS

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During FY13, AquaFish researchers continued to make advances despite being in limbo for six months while USAID determined whether the program would be invited to continue. The following summaries highlight several research accomplishments from the work completed this fiscal year (funded in previous years), primarily resulting from the VCA, EPUA, and ABF research under each of the topic-area categories: *Integrated Production Systems* and *People, Livelihoods, & Ecosystem Interactions*.

#### INTEGRATED PRODUCTION SYSTEMS

- AquaFish research increased the profitability of tilapia growth in Cambodia and Nepal by identifying cost effective practices for pond management. Two projects improved understanding of environmental and feeding effects on tilapia aquaculture practices through investigating alternative feed strategies, pond characterization, and production evaluation. This research reinforces earlier CRSP results and proves useful for first-time fish farmers entering the industry. (09BMA12US and 09BMA14UM)
- An EPUA project in Ghana led to the enhancement of two research and development facilities. Kwame Nkrumah University of Science and Technology (KNUST) experimental fish farm and the Pilot Aquaculture Center (PAC) of the Fisheries Commission were improved to provide high-quality facilities for the study of pond and environmental soil and water dynamics. In addition, capacity building and outreach events facilitated training and communication among farmers and fisheries officers, which created opportunities for positive and effective working relationships within the industry. Under this investigation, project participants leveraged ongoing AquaFish work. (09BMA10PU)
- Researchers from Universidad Juarez Autonoma de Tabasco (UJAT) in Mexico and the University of Michigan improved culture practices for gar (*Atractosteus* spp.), a unique air breathing fish, to make it more sustainable and accessible for small-scale fish farmers. Increased gar productivity and more sustainable practices have the potential to enhance the income opportunities for small-scale farmers as gar are a highly sought after fish for food, the ornamental trade, and for supplementing natural populations. This collaborative research project revealed that closed or recirculating filtration systems and different salinity conditions did not affect growth or survival for Cuban or tropical gar, providing an opportunity to improve growing conditions with different salinities while reducing water and energy use. (09IND11UM)

#### PEOPLE, LIVELIHOODS, & ECOSYSTEM INTERACTIONS

- AquaFish training events with coastal shrimp farmers in the Philippines and Banda Aceh, Indonesia, led to the adoption of a new polyculture technique with shrimp and seaweed. Researchers helped farmers overcome challenges with properly drying seaweed by leading a special training on drying techniques. Local women were also 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 raw and processed seaweed, men and women who have been trained in seaweed drying and processing will have improved income opportunities. (09FSV02NC)

- A workshop held at Universidad Juarez Autonoma de Tabasco (UJAT), Mexico, increased knowledge about the value chain model for tilapia. Twenty-three workshop participants identified weaknesses in the system in order to develop improvements that can yield best returns on investment. Participants included producers, fingerling suppliers, feed suppliers, traders, academics, students, and technicians. Understanding the roles that each group plays in the same system and how they affect one another underscored the importance of collaboration to increase efficiency and profitability. (09MER08UA)
- Research in the Lower Mekong Basin highlighted the need for collaboration between industry and management authorities to develop and implement import and export laws and regulations. Results were informed by a value chain analysis of small-sized, freshwater fish that was conducted to learn general information and concerns within the industry. The assessment was informed by a broad range of stakeholder groups (fishers, fish farmers, traders, exporters, processors, and consumers) through conducting a questionnaire that involved 10 districts, 19 communes, and 38 villages. (09MER09UC)



Carp in a net. Photo by James Lannan.



## IV. OVERVIEW OF RESEARCH PROGRAM STRUCTURE

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AquaFish is managed to achieve maximum program impacts, particularly for small-scale farmers and fishers, in Host Countries and more broadly. AquaFish program objectives address the need for world-class research, capacity building, and information dissemination. Specifically, AquaFish 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 through research and technology development forms the core of projects. Projects also integrate institutional strengthening, outreach, and capacity building through activities such as training, formal education, workshops, extension, and conferences to support the scientific research being conducted.

Projects focus on one or two USAID-eligible countries within a region, and may include activities in nearby countries within the same region. All projects received USAID country-level concurrence prior to award.

### GLOBAL AQUAFISH PROJECT THEMES FOR PHASE II (GOALS)

- A. Improved Human 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 focuses on one primary AquaFish theme and integrates all four themes to achieve a systems approach. The global themes of AquaFish are cross-cutting and address several specific USAID policy documents and guidelines.

### AQUAFISH CORE RESEARCH PROJECTS

Core projects have work plans (investigations) organized around ten 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 AquaFish project integrates topic areas (listed below and described later in this section) from the following two categories:

*Integrated Production Systems*

- Production System Design & Best Management Alternatives (BMA)
- Sustainable Feed Technology (SFT)
- Climate Change Adaptation: Indigenous Species Development (IND)
- Quality Seedstock Development (QSD)

*People, Livelihoods, and Ecosystem Interrelationships*

- Human Nutrition and Human Health Impacts of Aquaculture (HHI)
- Food Safety, Post Harvest, and Value-Added Product Development (FSV)
- Policy Development (PDV)
- Marketing, Economic Risk Assessment, and Trade (MER)
- Watershed and Integrated Coastal Zone Management (WIZ)
- Mitigating Negative Environmental Impacts (MNE)

**Research Project Statistics**

AquaFish has achieved a systems approach balance for Phase I and Phase II projects combined, with 51% of investigations categorized as *Integrated Production Systems* and 49% as *People, Livelihoods, and Ecosystem Interrelationships* (Table IV-1).

Table IV-1. AquaFish core research project investigations by Systems Approach and Topic Areas for Phase I and Phase II. \* Investigations listed under 2009-2013 include Phase I projects under Implementation Plan 2009-2011 as well as those conducted under the three Addenda described in the Introduction.

Systems Approach	Topic Area	Number of Investigations				Percent of Total
		2007-2009	2009-2013*	2013-2015	Total	
Integrated Production Systems						
	BMA	4	13	6	23	17%
	SFT	6	7	8	21	15%
	IND	4	10	4	18	13%
	QSD	2	5	2	9	7%
	<b>SubTotal</b>	<b>16</b>	<b>35</b>	<b>20</b>	<b>71</b>	<b>51%</b>
People, Livelihoods, and Ecosystem Interrelationships						
	HHI	5	2	4	11	8%
	FSV	1	3	0	4	3%
	PDV	3	8	1	12	9%
	MER	4	10	5	19	14%
	WIZ	2	3	1	6	4%
	MNE	7	7	1	15	11%
	<b>SubTotal</b>	<b>22</b>	<b>33</b>	<b>12</b>	<b>67</b>	<b>49%</b>
<b>TOTAL</b>		<b>38</b>	<b>68</b>	<b>32</b>	<b>138</b>	



During Phase I, 106 investigations were initiated with 51 addressing *Integrated Production Systems* and 55 addressing *People, Livelihoods, and Ecosystem Interrelationships*. A total of 20 countries, 17 US Universities, and 33 HC institutions were included in formal funded partnerships. Phase II core projects include 32 proposed investigations with 21 addressing *Integrated Production Systems* and 12 addressing *People, Livelihoods, and Ecosystem Interrelationships*. A total of 10 countries, 11 US Universities, and 20 HC institutions are involved in formal funded partnerships.

USAID also encourages AquaFish 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: A systems approach; social, economic, and environmental sustainability; capacity building and institution strengthening; outreach, dissemination, and adoption; and gender integration.

### AQUAFISH TOPIC AREAS

Topic Areas pertain to aquaculture and the nexus between aquaculture and fisheries. Some of the following topic areas overlap and are interconnected. Each Phase I and Phase II investigation identifies a single topic area that best describes it. The text under each topic area is provided for illustrative purposes and is not prescriptive.

#### **Integrated Production Systems**

- **Production System Design & Best Management Alternatives (BMA)**  
Aquaculture is an agricultural activity with specific input demands. Systems need to be designed to improve efficiency and/or integrate aquaculture inputs and outputs with other agricultural and non-agricultural production systems. AquaFish research must benefit smallholder or low- to semi-intensive producers, and should focus on low-trophic species for aquaculture development. Design systems to limit negative environmental impacts, to improve overall fish health, and optimize carrying capacity. 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. Innovative research is encouraged on: recirculating and aquaponics systems for supplying aquatic products to denser marketplaces in urban and peri-urban areas; integrated systems using shellfish, seaweeds, or other plants and animals; and new solutions for aeration, cold storage, and pond operations involving solar or other novel energy sources.
- **Sustainable Feed Technology and Nutrient Input Systems (SFT)**  
Methods of increasing the range of available ingredients and improving the technology available to manufacture and deliver feeds are a critical 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. Research on soil-water dynamics and natural productivity to lessen feed needs were fundamental to the PD/A and ACRSPs; critical new areas of research may be continued, along with outreach to poor farmers using low-cost, no/low-feed technologies. 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. Complex pond dynamics technologies need to be simplified for use by new farmers; improved applications of pond dynamics technologies for driving non-fed plankton-driven systems is applicable where access to feeds is expensive or unreliable.

- **Climate Change Adaptation: Indigenous Species Development (IND)**

Aquaculture, like agriculture and other human activities, will feel the effects of long-term climate change. Among the myriad challenges, ocean acidification and sea level rise will affect the world's coastal aquaculture operations, much of which occurs in poorer countries. Temperature changes will test the resiliency of domesticated varieties. Research challenges involve understanding the adaptive range of these species, and developing cultivation techniques for new species, such as air-breathing fishes. The shifting distribution of global freshwater supplies will pose challenges for the aquaculture industry, small farmers, and the marketplace. Genomics tools may be used to characterize candidate air-breathing species already being evaluated through previous CRSP research. 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, economic, 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 native species for aquaculture is of great interest. Aquaculture, done sensitively, can be a means to enhance and restock small-scale capture and wild fisheries resources. (Aquaculture-Fisheries Nexus Topic Area)

- **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 small-holder 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 genetically modified organisms (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. Augmentation of bait fisheries through aquaculture to support capture fisheries is an area of interest, provided there are no net negative environmental effects.

### **People, Livelihoods, and Ecosystem Interrelationships**

- **Human Nutrition and 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. Focus on vulnerable populations, women and children, and underserved populations, and assess how any given technology will affect or improve the welfare of these groups. Research or field-testing with schools and nutrition centers is encouraged. (Aquaculture-Fisheries Nexus Topic Area)

- **Food Safety, Post Harvest, and 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 (Hazard Analysis and Critical Control Point) 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. Processing waste can claim up to 70% by weight of finfish depending on the species and manner processed, and post harvest losses can claim around 30%. Partnering with other groups and co-developing outreach techniques to reduce post harvest losses can significantly contribute to the amount of fish available for consumption; thus, contributing to the nutrition goals of USAID's Feed the Future Initiative. 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, and throughout much of the value chains. (Aquaculture-Fisheries Nexus Topic Area)

- **Policy Development (PDV)**

Policy initiatives that link aquaculture to various water uses to improve human health are needed. 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. Additionally, social and cultural analyses regarding the impacts of fish farming may yield critical information for informing policy development.

- **Marketing, Economic Risk Assessment, and 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 AquaFish program. 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 AquaFish-generated research findings will incorporate the appropriate environmental recommendations.
- All sub-awards must comply with environmental standards.
- AquaFish Projects will not procure, use, or recommend the use of pesticides of any kind. This includes but is not limited to algacides, herbicides, fungicides, piscicides, parasiticides, and protozoacides.
- AquaFish Projects will not use or procure GMOs.
- AquaFish 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 AquaFish, be they quantitative, empirical, biologically-based, qualitative, policy-based, or informal. Each project is required to include at least one experiment or study, and at least one outreach activity that focuses on women and/or girls.

### **GENERAL RESEARCH PRIORITIES**

All core projects address the following general research priorities:

- **Priority Ecosystems**  
Inland and coastal ecosystems for aquaculture and 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, and 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**  
Universities, HC and US government, non-government organizations, private sector, CGIAR, and the USAID Food Security Innovation Center.



## **V-A. CORE RESEARCH PROJECT REPORTS – PHASE I**

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Annual reports submitted by each Phase I core research project Lead PI include the period from 1 October 2012 to 31 March 2013. In this reporting period, AquaFish concluded fifteen transitional investigations in host countries for Phase I core research projects (FY10-2012 funds) in the following three research areas described below: Experimental Pond Unit Assessment, Value Chain Analysis, and studies of Air Breathing Fishes. The results of this work served as a foundation for Phase II. All personnel listed are reflective of the duration of IP 2009-2011 Addendum 3 projects. No new work was funded in FY13.

### **EXPERIMENTAL POND UNIT ASSESSMENT (EPUA): TOPIC AREA - BMA**

As a global-style research project, the EPUA investigations were designed to develop a baseline set of physical, chemical, and biological characteristics of aquaculture ponds and build the human and institutional capacity at each AquaFish experimental site in the host country. The experimental framework draws upon methods formulated under the former Pond Dynamics/Aquaculture CRSP. The overall goal of this experimental approach was to establish a uniform research approach for basic work needed to develop small-scale aquaculture. The information produced from these experiments will help to develop methodology for customizing country-specific management practices for any given pond aquaculture system and provide recommendations for fish farmers to use in designing and constructing small-scale pond aquaculture operations in developing countries across the globe.

### **VALUE CHAIN ANALYSIS (VCA): TOPIC AREA - MER**

AquaFish researchers use the VCA tool to describe and evaluate existing value chains related to delivering an aquaculture product from farmers to local markets. Researchers conduct VCAs to identify the distribution of benefits in a value chain for a particular aquaculture product, improve local efficiency, increase participation of small-scale farmers in markets, and add value to existing fish products. In fish value chains, women tend to occupy the middle and interactions differ. Gender has been found to be an important factor in terms of access to investment, trade goods and information. Collectively, these analyses can help to derive greater value from existing products and generate more income for fish farmers. As part of this research component, AquaFish organized a VCA symposium with sessions focusing on gender value chains for fellow AquaFish researchers in July 2012. This symposium was held in connection with a professional conference, and the three special sessions included: markets and value chains for small aquaculture enterprise, looking at fish supply chains with a gender lens, and overcoming gender inequalities in fish supply chains to inform policy and action.

### **AIR BREATHING FISHES (ABF): TOPIC AREA - IND**

Air-breathing fishes are considered excellent candidate species for aquaculture due to their rapid growth potential, adaptability to high densities, and high tolerance of low water quality conditions. AquaFish researchers conducted investigations to evaluate the aquaculture potential of indigenous air-breathing fishes. Though this process varies between sites and among species, there are several key steps to determine the feasibility of culturing an ABF species. These include testing and streamlining reliable artificial propagation and hatchery methods for the species, exploring the socio-economic and environmental aspects of utilizing the species, and evaluating the prospective use and management of the species among local smallholder fish farmers.

Final investigation reports are available from the AquaFish Management Team (MT) and the AquaFish website. Due to the length and detail of these reports, only the abstracts are printed in this annual report. Reports are printed as submitted by Lead Projects with subsequent addition of project summaries (drawn from project proposals) by the MT.



Man repairing a cichlid culture cage in Honduras. Photo by Tiffany Woods.

## LEAD US UNIVERSITY: NORTH CAROLINA STATE UNIVERSITY

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

#### **Project Summary**

The North Carolina State University project took a multifaceted approach with a unifying objective to improve cost efficiencies and livelihoods for stakeholders throughout the production chain in the Philippines and Banda Aceh, Indonesia. Notable accomplishments include: (1) reduced feeding strategies for small-scale tilapia and milkfish farmers in the Philippines making aquaculture a more profitable enterprise through significantly reduced feed costs; (2) improved hatchery technologies for enhanced tilapia seed quality; (3) production of podcasts that serve as an extension tool to convey reliable evidence-based production information to tilapia farmers; (4) targeted training events on seaweed production and processing that open income opportunities for coastal farmers and women processors in Banda Aceh; and (5) guidelines from market analyses that will help fish farmers structure their production for more lucrative export markets.

#### **Project Personnel**

##### **North Carolina State University, USA**

Russell **Borski** - US Lead Project PI

Harry **Daniels** - US Investigator

Upton **Hatch** –US Investigator

##### **Ujung Batee Aquaculture Center, Indonesia**

Hasan **Hasanuddin** – HC Investigator

Coco **Kokarkin** – HC Investigator

##### **Bangladesh Agricultural University, Bangladesh**

Md. Abdul **Wahab** – HC Investigator

##### **Central Luzon State University, Philippines**

Remedios **Bolivar** – HC Lead Project PI

Wilfred **Jamandre** – HC Investigator

#### **Investigation Progress Report**

##### **Experimental Pond Unit Assessment in Bangladesh (09BMA09NC)**

The purpose of this study was to assess production and water quality parameters in: 1) two freshwater prawn-farming systems in Southwest Bangladesh, and 2) tilapia-carp polyculture ponds in Mymensingh region of Bangladesh. An exploratory survey was conducted to characterize two major prawn farming systems, a modified pond system where rice fields are permanently converted to year-round prawn production and gher (pond) systems where prawn is integrated with rice culture. Factorial analysis was run to identify the main ecological processes affecting water quality in the ponds. Factors 1, 2 and 3 accounted for 37%, 16%, and 13%, respectively, of the overall variability of the data. The first factor (Factor 1) showed the combined effects of rain and liming on water quality of ponds (ghers), which were elevated at the start of the experiment and then gradually declined by the end. The second factor (Factor 2) showed the opposite effects of decomposition and photosynthesis on water oxygen and ammonia content. The third factor (Factor 3) showed positive correlations among chlorophyll, pH, and dissolved oxygen.

Phytoplankton biomass and oxygen production were higher in prawn-only ponds than in gher where rice was previously cultured. Mean value ( $\pm$  SD) of soil pH, organic carbon (%), total phosphorus (ppm), and total nitrogen (%) were 7.1 ( $\pm$  0.30), 1.6 ( $\pm$  0.3), 15.80 ( $\pm$  4.8), and 0.15 ( $\pm$  0.02) respectively, in modified pond systems, and 6.5 ( $\pm$  0.64), 2.5 ( $\pm$  1.25), 11.94 ( $\pm$  3.9), and 0.23 ( $\pm$  0.11) in gher systems. The mean production of prawn in modified pond and gher culture systems was 407.5 ( $\pm$  15.55) and 335 ( $\pm$  19.15) kg/ha, respectively. Although the prawn production in gher systems was significantly lower ( $p < 0.05$ ), the overall agricultural production, socio-economic, and sustainability benefits may be greater for the gher system since it integrates both rice and prawn production. Potential replenishment of nutrients in bottom mud with prawn culture may also allow for enhanced utilization by rice crops.

This investigation evaluated water quality and production of Nile tilapia (*Oreochromis niloticus*) polycultured with silver carp (*Hypophthalmichthys molitrix*) in ponds at the Bangladesh Agricultural University under treatments of fertilization alone (T1), fertilization combined with feeding daily at 50% ration (T2), and feeding alone daily at 100% ration (T3). The fish species were stocked in 12 ponds in a completely randomized block design allocated to the three treatments. The range of water quality parameters was as follows: water temperature 30-34.8°C (air temperature was 28-32°C), transparency 19-65 cm, pH 6.79-10.86, dissolved oxygen 1.75-8.48 mg/l, total alkalinity 8-152 mg/l, phosphate-phosphorus 0.08-3.0 mg/l, nitrate-nitrogen 0.00-0.51 mg/l, nitrite-nitrogen 0.00-0.26 mg/l, ammonia-nitrogen 0.14-1.57 mg/l, TDS 25.6-109 mg/l, conductivity 55-203 Sc/m and chlorophyll-*a* 2-250 µg/l. Temperature, dissolved oxygen, alkalinity, nitrite-nitrogen, phosphate-phosphorus and chlorophyll-*a* did not vary significantly among the treatments. However, transparency, TDS, and conductivity were reduced in T1 versus other treatments. The pH, nitrate-nitrogen, and ammonia-nitrogen content of water were marginally significant among treatments. The mean harvesting weight of tilapia was significantly lower in T1 (fertilization alone) than in T2 (fertilization plus 50% supplementary feeds) and T3 (only feeds) treatment, while the mean harvesting weight of silver carp did not differ among treatments. Specific growth rate (SGR) for tilapia was highest in T2 and T3 and elevated in silver carp in T1 versus the T2/T3 treatments. The feed conversion ratio (FCR) for tilapia was not significant between T2 and T3. The FCR for tilapia alone or when combined with silver carps was lower or better in T2 than in the T3 treatment. The gross and net production performances of tilapia were considerably higher in T2 and T3 as compared with T1, and did not vary significantly for silver carp among treatments. The combined net production of two species was significantly higher in T2 (4227 kg/ha) and T3 (3845 kg/ha) than in T1 (1567 kg/ha).

#### **Value Chain Analysis of seaweed in Aceh, Indonesia (09MER06NC)**

This study analyzed the value chain of seaweeds (particularly *Gracilaria*) for Banda Aceh, Indonesia including the roles of key players, logistical issues, external influences, and transaction flows among market levels. The study identified areas for improvement and provided recommendations for the Indonesian seaweed industry, in general and the Banda Aceh seaweed farmers, in particular. Key players of the seaweeds industry are the seaweed farmers, collectors (or assemblers), interregional shippers/traders, provincial/regional processors and exporters. Jakarta, Sulawesi and Surabaya are the major transshipment points of tradeable seaweed products either in dried or derivative forms. Dried seaweeds (about 80%) are exported for further processing into agar and carrageenan and imported back to meet its domestic demand for food, pharmaceutical, industrial and energy sectors. Domestic demand for seaweed derivatives is fast growing in many seaweed raw material sources such as Indonesia, Philippines and other Southeast Asian countries, thus putting downward pressure on the availability of raw material supply in the global markets.

The technological advances of the seaweed derivatives market (downstream subsector) had clearly outpaced those in the upstream subsector including the reliability and quality of planting materials, cultural and post-production practices of dried seaweeds, among others. Hence, the mismatch of information on grades and standards is one of the major reasons for disparities of growth among the key players in the seaweed industry.

Because of the geographic locations and state of marketing infrastructures in rural Indonesia, the major problems of the seaweed industry are the very weak linkages of the raw material subsector to the seaweed derivatives and end-user subsectors. These problems include high logistics and transaction costs across the value chain, lack of seaweed laboratories and nurseries, lack of postharvest technologies and facilities at the farm level, and irregular supply of desired quality and volume of dried seaweed. The levels of public and private investment in research and extension coupled by the geographic distribution of seaweed farming communities should require a shift in business and/or marketing strategies. The

traditional marketing modes should now be replaced by more strategic ones like the value (or supply) chain management schemes, joint ventures and/or other coordinating mechanisms.

Some recommendations to address the issues and concerns are: encourage the establishment of more seaweed laboratories, nurseries or multiplier farms; establish more cluster-based post-harvest facilities; institutionalize an accreditation program for seaweed derivatives processors and manufacturers of end products, etc.; and provide capital windows to improve facilities and enhance the entire management of value chains of the seaweed industry.



## LEAD US UNIVERSITY: UNIVERSITY OF CONNECTICUT AT AVERY POINT

### ***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**

The University of Connecticut at Avery Point project was an integrated program that addressed the issues surrounding the increasing competition and conflict over the use of small-size fish for aquaculture feed and for human consumption in the lower Mekong River basin region of Cambodia and Vietnam. The primary controversy is over the sustainable aquaculture production of the popular freshwater snakehead (*Channa micropeltes* and *C. striata*) balanced with the management of the small size fisheries resources. Notable accomplishments include: (1) developing and transferring a pelleted snakehead feed with up to 50% of the fishmeal from small-size fish replaced with a soybean/cassava/rice bran protein formulation; (2) recommendations for improved management strategies for small-size fisheries have been submitted to the respective governments of Cambodia and Vietnam; (3) working with rural processors, who are mostly women to adopt best processing practices to improve food safety of the fish paste and other value-added products made from small-size fish; (4) making significant steps towards snakehead aquaculture, which is currently banned in Cambodia, by developing breeding stock of snakehead and conducting a baseline system analysis to establish the groundwork for a sustainable system that is well integrated with the Mekong River management to protect the small size fishery from overexploitation.

#### **Project Personnel**

##### **University of Connecticut at Avery Point, USA**

Robert S. Pomeroy - US Lead Project PI

##### **Freshwater Aquaculture Research and Development Center, Cambodia**

Nen Phanna - HC Investigator

##### **Inland Fisheries Research & Development Institute, Cambodia**

So Nam - HC Lead Project PI

Hap Navy – HC Investigator

##### **Can Tho University, Vietnam**

Vu Ngoc Ut - HC Investigator

Le Xuan Sinh – HC Investigator

#### **Investigation Progress Report**

##### **Experimental Pond Unit Assessment in Cambodia (09BMA12UC)**

In Cambodia, fish provide a main source of protein and essential nutrients of daily diet for millions of people, especially for the poor households in rural areas; and also contribute to the national economy. It contributes more than 75% of people's animal protein intake. The national fish consumption rate is in average of 23-31kg/capita/year. Fish consumption and export are mainly supplied by fish catches from inland waters. The aquaculture sector has been promoted in Cambodia due to the dramatic decline of wild fish catch caused by illegal and overfishing, and the increased demand for fish in response to rapid population growth.

Eighty percent of aquaculture production comes from cages and pens in Tonle Sap Great Lake, Tonle Sap, Mekong and Bassac River systems; and the commercial species cultured in cages include the river catfish *Pangasianodon hypophthalmus* and giant snakehead *Channa micropeltes*. Raising fish in ponds and paddy fields is less developed in Cambodia, contributing about 15-20% of total aquaculture production. Since 2005 small-scale aquaculture has been jointly promoted and supported by the government, NGOs and international agencies (e.g., JICA, PADEK, AIT, etc.) for the poor and in the areas far away from natural water bodies which lack fish consumption. The small-scale cultures are mainly in ponds, rice fields and integrated fish farming with livestock and vegetables. The main species cultured in those systems, particularly in pond, include Tilapia, Chinese carp, Indian carp and some

indigenous species (e.g., silver barb, walking catfish, river catfish). Currently, pond culture has increased in number and may play an important role in aquaculture development throughout the country in the future. Pond characteristics, physical, chemical and biological factors, interact in pond ecosystem as well as the organisms being culture. Water quality in fish ponds is a major factor determining the production of fish. Evaporation and seepage contribute to the water losses from the pond, resulting in higher densities of fish in the pond which can lead to various water quality problems causing stress to fish or direct mortality and lowering the production per cycle. The study of pond characterization, water quality, nutrient cycling, and water use in pond aquaculture have been done in many parts of the world. For example, in the neighboring countries like Thailand and Vietnam, many researches and studies in the field of aquaculture have been done and their aquaculture sectors have rapidly developed. So far Cambodia's aquaculture is less developed because a lack of research and study have been conducted due to the lack of experts in this field. So, it is necessary to conduct a research on physical, chemical and biological characteristics of aquaculture ponds during grow-out since it may contribute to aquaculture development in Cambodia.

The purpose of this experiment was to evaluate ponds in Southern Cambodia for their physical, chemical, and biological characteristics during a grow-out period from June to October 2012.

#### **Value Chain Analysis of freshwater small-sized fish in Cambodia (09MER09UC)**

There is increasing demand and trade in the Lower Mekong Basin (LMB) of Cambodia for small-sized fish for human consumption (fresh and processed), and fish and animal feed. Significantly, pond and cage culture and crocodile farming in Cambodia are dependent on freshwater small-sized fish used for feed. Therefore, there is also conflict between the use of small-sized fish for feed and for human consumption. In some cases, such feed consists of fish species traditionally used as cheap food for people. This allocation of fish resources to aquaculture and animal feed may result in negative impacts on food security, employment and income generation. Small-sized fish represent from 60 to 100% of the total feed used for fish culture and animal raising depending upon feeding strategies adopted by various farmers. It is the economics of the different uses of small-sized 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 for 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 small-sized fish as food for domestic consumers is more appropriate than supplying fish meal plants for export, income oriented aquaculture industry, or 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 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.

To date, there has been no comprehensive study of the marketing system for small-sized fish in the LMB. The small-sized fish industry for food and feed in the LMB of Cambodia has spontaneously developed without any comprehensive analysis of the markets for the products, particularly the lack of information on the stakeholders and marketing practices. Therefore, there is a need to conduct a study covering all of the aspects of value chain for small-sized fish in the LMB. The results of this study will be useful for development of policy recommendations for upgrading current harvesting and management of freshwater small-sized fish species in the LMB in order for sustainable utilization of this limited resource. Moreover, this study will be vital for further development of the small-sized fish industry in order to stabilize and sustain the contribution of the small-sized fish to food security, job creation and marketing in the LMB.

**Presentations and Publications**

Sinh, L.X., H. Navy, and R.S. Pomeroy. 2012. Value chains of captured and cultured snakeheads (*Channa micropeltes* & *Channa striatus*) in the Lower Mekong Basin of Cambodia and Vietnam. Presentation at the Sixteenth Biennial Conference of IIFET, July 17, 2012 in Dar es Salaam, Tanzania.

**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 Purdue University project focused on enhancing production capacity, aquatic resource management in regional freshwater systems, and supply chain management to ensure the long-term beneficial impacts of aquaculture to rural communities in Ghana, Kenya, and Tanzania. The integrated approach in addressing the needs of stakeholders along the value chain has led to significant successes in adoption. Notable accomplishments have been realized in all areas of the project: (1) With feed costs as one the major constraints to aquaculture development in Africa, researchers in Tanzania developed a new tilapia feed formulation that improves farmer profitability by that replacing costly soybean meal with leaf meals derived from local leguminous tree species; (2) With AquaFish training, local Kenyan farmers have successfully adopted a new aquaculture enterprise that raises catfish fingerlings to sell as bait to the longline fishing industry on Lake Victoria. The move to aquaculture protects the declining natural populations of catfish in the lake and also has provided women baitfish traders who have entered the fish farming sector a new income source. Training in supply chain management has enabled the development of new market opportunities for foodfish producers in Kenya and Ghana as well as new markets for baitfish producers in Kenya. Farmers have acquired knowledge about the environmental effects of their activities and are therefore implementing broadly focused environmental BMPs on their farms, especially in Ghana. Studies that analyzed consumer preferences for farmed fish have provided valuable information for the development of consumer-driven aquaculture production in Ghana and Kenya.

**Project Personnel****Purdue University, USA**

Kwamena **Quagrainie** - US Lead Project PI  
 Jennifer **Dennis** – HC Investigator

**Virginia Polytechnic Institute & State University, USA**

Emmanuel A. **Frimpong** – US Investigator

**Kwame Nkrumah University of Science & Technology, Ghana**

Stephen **Amisah** – HC Lead Project PI  
 Nelson W. **Agbo** - HC Investigator  
 Gifty **Anane-Taabeah** – HC Investigator

**Investigation Progress Report****Experimental Pond Unit Assessment in Ghana (09BMA10PU)**

This investigation involved an experimental pond unit assessment of two facilities used in AquaFish research in Ghana. The facilities are the KNUST farm and the Pilot Aquaculture Center (PAC) of the Fisheries Commission. The project took place from July to October 2012 and involved physical, chemical, and biological characterization of 10 ponds of which 8 were stocked with *Oreochromis niloticus* at 2 m<sup>2</sup> and 2 were not stocked. Overall, most of the variables originally planned for measurement were successfully completed and the project played a vital role in institutional and individual capacity building.

**Assessment of Tilapia Value Chain in Ghana (09MER07PU)**

The performance of farmed tilapia value chain in Ghana can be used to achieve sustainable food production and poverty alleviation through improvements in market access and competitiveness. The study was conducted to assess the value chain of farmed tilapia in Ghana; specifically, characterize the current farmed tilapia value chain, analyze the performance, identify areas of improvement, and provide recommendations for strategic improvement of the value chain. Data was collected from a survey conducted in 2012. Key actors in the tilapia value chain in Ghana were identified, and information was obtained on their activities and roles, the flow of products and information, costs and margins, and

external influences. The key chain actors identified were input suppliers (brood stock developers and hatcheries, feed suppliers, pond and cage constructors, and net suppliers); producers (pond and cage grow-out farmers); processors; marketers (distributors and retailers); and food services (restaurants, food vendors, etc.). A Benefit-Cost Analysis was used to assess the performance of input suppliers, fish farmers, marketers, and food services. The results revealed that all chain participants had a benefit-cost ratio higher than 1 except fish farmers, suggesting that fish farming is less profitable compared with the other value chain activities. Input suppliers appeared to make the most profit. The study also used Factor Evaluation Matrix to compare the competitiveness of the different value chain participants in terms of the traditional five marketing factors, i.e., product, place, price, promotion and procurement (process). Input suppliers also had the highest self-evaluation performance in terms of Porters' 5 Forces framework and had the strongest sector in the value chain. The success of input suppliers in the value chain may be attributed to their efficiency in terms of having well defined payment transaction with customers, having persistent relationships with customers, and keeping good records of costs and revenues. Other chain actors could form strong persistent linkages among themselves to improve the relationships among actors and ensure efficiency in the value chain. Fish farmers could also prioritize record keeping of costs and revenues to enable them to track their performance in terms of profit margins. To ensure quality products and services are supplied along the chain, the Fisheries Directorate of Ghana should consider setting and enforcing quality standards along the chain, especially for hatcheries and processors.

### **Presentations and Publications**

- Darko, F.A., Quagraine, K.K., and Chenyambuga, S. Consumer Preference for Farmed Tilapia in Tanzania: A Choice Experiment Approach Aquaculture. *Aquaculture. In review.*
- Darko, F.A., Quagraine, K.K., Dennis, J.H., Olynk, N., and Doering, O. Consumer Preference for Farmed Tilapia in Ghana and Kenya: A Stated Preference Approach. *Marine Resource Economics. In review.*
- Darko, F.A., Quagraine, K.K., Dennis, J.H., Olynk, N., and Doering, O. Correlates of Preference for Tilapia and catfish in Ghana and Kenya. *Food Policy. In review.*
- Kasiga, T., and R. Lochmann. Nutrient Digestibility of Reduced-Soybean-Meal Diets Containing Moringa or Leucaena Leaf Meals for Nile tilapia, *Oreochromis niloticus*. *Journal of the World Aquaculture Society. In review.*
- Ndanga, L.Z.B., Quagraine, K.K., and Dennis, J.H. Economically Feasible Options for Increased Women Participation in Kenyan Aquaculture Value Chain. *Aquaculture. In review.*
- Ndanga, L.Z.B., Quagraine, K.K., Ngugi, C.C., and Amadiva, J. An Application of Porter's Framework to Assess Aquaculture Value Chain in Kenya. *African Journal of Food, Agriculture, Nutrition and Development. In review.*

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

The University of Michigan project focused on south and southeast Asia where about 90% of world aquaculture production occurs. With the broad aquaculture experience in this region, AquaFish researchers are in a unique position to develop innovative solutions for the environmental problems that have been identified with aquaculture. Notable accomplishments include: (1) managing water quality in shrimp culture with recirculating systems; (2) developing an improved cage culture system that reduces solid and dissolved waste transport into receiving waters; (3) developing polyculture systems, using indigenous species which increase nutrient utilization, reduce effluent effects, and offer a farmed source of a threatened species; (4) assessing the effects of invasive species on native fish communities as a first step to developing sustainable management plans; (5) developing detection and control techniques to prevent toxic microcystins from entering the food chain.

**Project Personnel****University of Michigan**James **Diana** - US Lead Project PISolomon **David** - US Investigator**Agriculture and Forestry University (Formerly  
Institute of Agriculture & Animal Science),  
Nepal**Madhav **Shrestha** - HC Lead Project PI**Universidad Juarez Autónoma de Tabasco,  
Mexico**Wilfrido M. **Contreras-Sánchez** – HC  
Investigator**Investigation Progress Report****Experimental Pond Unit Assessment in Southern Nepal (09BMA14UM)**

This pond characterization experiment had goals to evaluate ponds in Nepal for their physical, chemical, and biological characteristics during a grow-out; and to evaluate production characteristics of Nile tilapia (*Oreochromis niloticus*) in these ponds. Twelve earthen ponds were used with treatments including 4 control ponds receiving fertilization alone, 4 fully fed ponds with feed applied at 3% bw, and 4 combined ponds with both feed at 1.5% and fertilizer applied. All ponds were stocked a week after fertilization with sex-reversed Nile tilapia at 2 fish/m<sup>2</sup>. Fertilizer was applied each week at 4 kg N and 1 kg P per hectare for fertilization treatments. Locally available feeds were used to feed twice daily in the morning and afternoon. Fish were stocked on 9 February 2013 and the experiment is ongoing. Fish growth in fertilized with half feeding ponds gave highest growth, followed by full feeding then fertilizer. Treatments that included fertilizer had higher pH, higher dissolved oxygen, lower Secchi disk, higher chlorophyll-a, higher total Kjeldahl nitrogen, higher total phosphorus, lower alkalinity, higher ammonium, higher soluble reactive phosphorus, and higher nitrite-N compared to only fed ponds. Fertilization with feeding produced the best growth conditions and best water quality consistently.

**Development of sustainable feeds, improved stocking densities, and salinity management in closed recirculating systems for gar (*Attractosteus spp.*) culture (09IND11UM)**

The purpose of this study was to determine success of closed and recirculating filtration systems on water quality and growth of tropical and Cubangars, and to determine the effect of salinity on growth (treatments 0, 10, and 15 ppt salinity). Fish were divided into treatment groups. For the system experiment, treatments were a control in a recirculating system, and closed systems for a second treatment with aquarium filtration systems. For the salinity experiments, treatments were 0-15 ppt salinity. Fish length and weight were measured at beginning and end of experiments (tropicalgars also measured every

15 days), and were fed *ad libitum* with trout feed (tropical gars) or commercial pellet feed (Cuban gars). In all experiments, ammonia, nitrite, nitrate, and pH were measured weekly, and temperature daily. The various salinity treatments and recirculating or filtered systems resulted in no significant differences in growth for any treatment. Water quality was generally similar among all treatments as well. Overall, this experiment indicates that tropical and Cuban gars are tolerant of a range of conditions and could be reared using a variety of systems without any loss of yield. Since the various systems have different costs of maintenance and operation, this wide ranging tolerance of rearing conditions allows gar to be reared more efficiently in systems to suit local conditions.

### **Value Chain Analysis of carp polyculture systems in Southern Nepal (09MER11UM)**

The objectives of this study were to develop a Value Chain Map of carp polyculture in the Chitwan District of Nepal, and to identify areas for improvement and further research of the Nepal aquaculture sector. This study primarily covered the Chitwan District. Interviews were performed in July 2012 with 3 hatchery and nursery owners, 31 fish farmers, and 10 market sellers, including the majority of sellers at local markets. Small-Scale Farmers (n = 22) were those who produced 100 kg or less of fish per year and did not sell any fish to markets, while Commercial Farmers (n = 9) produced greater than 100 kg fish per year and sold fish to markets. Among Small-Scale Farmers, 55% of all fish produced was consumed by the farmer's family, while 45% was sold to neighboring households. Among Commercial Farmers, 46% of fish produced was sold to local markets, 32% kept for home consumption, and 22% sold to neighboring households. Local Market Sellers prepared and sold the fish in the market, purchased it directly from the farmer, and transported it by way of bicycle or motorbike.

In this study, small-scale farmers were found to be largely content with the production of fish for home consumption. However, 20 of the 22 farmers also wanted to increase the size of their existing pond or build additional ponds in order to produce more fish to sell. All nine commercial farmers interviewed also desired to increase production and ship fish to distant markets, such as those in Kathmandu. There is high demand for fish in Kathmandu, and a preference for fresher, Nepali-raised fish. Among the private hatchery, private nursery, and government hatchery personnel interviewed in this study, only the latter reported to have a successful, self-sustaining business. In order to maintain a Chitwan-run, prosperous aquaculture sector, improvements must be made through training of private hatchery owners by government hatchery personnel. Currently, the government hatchery aims to help local fish farmers by raising and selling fingerlings at a price lower than that of the private hatcheries, which creates incentive for farmers not to purchase fingerlings from private sellers. Additionally, the government hatchery was reported to raise over 1000 kg of full-grown fish every year, which it also sold to consumers at a lower price than fish sold at local markets, again out-competing local fish farmers.

### **Presentations and Publications**

- Cao, L., J.S. Diana, and G.A. Keoleian. 2013. Role of life cycle assessment in sustainable aquaculture. *Reviews in Aquaculture* (online) 4:1–11.
- Diana, J.S. 2012. Is lower intensity aquaculture a valuable means of producing food? An evaluation of its effects on near-shore and inland waters. *Reviews in Aquaculture* 4:234-245.
- Diana, J.S. 2012. Some principles of pond fertilization for Nile tilapia using organic and inorganic inputs. Pages 163-177 in C.C. Mischke, editor. *Pond Fertilization: Impacts of Nutrient Input on Aquaculture Production*. John Wiley and Sons, Inc., New York.
- Diana, J.S., H.S. Egna, T. Chopin, M.S. Peterson, L. Cao, R. Pomeroy, M. Verdegem, W.T. Slack, M.G. Bondad-Reantaso, and F. Cabello. 2013. Responsible aquaculture in 2050: Valuing local conditions and human innovations will be key to success. *BioScience* 63:255-262.



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

The University of Arizona project built on an earlier OSU project and addressed the development of sustainable aquaculture systems to feed the growing populations of developing countries in the Americas while protecting fragile coastal ecosystems. Through its program of investigations and workshops as well as student scholarships and international conferences designed to address the issues of developing world researchers, it focused on innovation and outreach to introduce aquaculture to new communities and farmers, train stakeholders in improved production practices, and offer new technologies and indigenous fish species for a more sustainable aquaculture sector. Notable accomplishments in Mexico included: (1) developing broodstock lines of native fish species that will be used both for restoration efforts of important fisheries and for farming, thereby opening new income opportunities in the Mexico and the surrounding region; (2) developing multi-trophic production systems by applying aquaculture effluents to vegetable production (aquaponics and field plots) and seaweeds; (3) developing and transferring an innovative, cost-effective technology to remove residual hormone from sex-reversal treatments of tilapia from aquaculture water; (4) bringing basic sustainable aquaculture and aquaponics technologies to poor communities to open new opportunities for food production and income generation; and (5) developing lower cost fish feed formulations by replacing fish meal with local protein sources from plant residues and animal by-products.

**Project Personnel****University of Arizona, USA**

Kevin Fitzsimmons – US Lead Project PI

**University of Eldoret (formerly Chepkoile University College), Kenya**

Julius Manyala – HC Investigator

**Universidad Juárez Autónoma de Tabasco, Mexico**

Wilfrido M. Contreras-Sánchez – HC Lead Project PI

Rafael Martinez Garcia –HC Investigator

**Investigation Progress Report****Experimental Pond Unit Assessment in Kenya (09BMA11UA)**

Measurements of DO, temperature, conductivity, pH, hardness, TDS, total phosphates, bicarbonates and ammonia were undertaken from 11 February 2013 to 28 February 2013 as a preliminary assessment of the pond units under three fertilizer-feed regimes. The ponds were stocked with all male-tilapia. The experiments are aimed at assessing pond productivity under different management regimes and to facilitate the design of production systems and Best Management Practices (BMP). The preliminary observations show that temperature increases during the day closely track the increase in the amount of dissolved oxygen in the ponds and that both fertilization and feeding enhance primary productivity. Both TDS and conductivity have been shown to be more elevated in fertilized-feed ponds as compared to only fed or fertilized ponds. The preliminary results of the study reinforce CRSP green water technologies indicating that pond characterization can be done using water quality parameters for enhancing production and implementing BMP.

**Value Chain Analysis in Southern Mexico (09MER08UA)**

Tilapia has become one of the most popular food fishes in Mexico. They are frequently used to replace overharvested fish stocks from both freshwater and marine systems. Farm production is occurring in ponds, tanks and in raceway systems, with several domesticated strains. Farmed tilapias are currently sold in several different forms including live, frozen, and fresh on ice. They are also marketed in some value-added forms included scaled and gutted, headed and gutted, and as fresh and frozen fillets.

The tilapia industry in Mexico contributes 7.6% of the total aquaculture products in the nation and has grown by a considerable amount in the Southwest region over the last 10 years. As tilapia become a more important sector of the seafood industry across the country, an in-depth study of the value chain stands to benefit stakeholders from producers, through harvesters, shippers, processors, wholesale and retail and the eventual consumers.

The value chain has been used as an analytical tool for the aquaculture industry. It is used to describe the various steps in the pathway from farm to consumer and to determine the competitive advantages that certain stakeholders may have during these steps and processes. It may also identify where additional efficiencies may be gained in the production, processing, transportation and retailing aspects.

The results of the study reveal that the supply chain for tilapia in the region is relatively simple. It is based on inputs from providers of fingerlings, suppliers to grow-out producers, then to traders and retailers. Tilapia products are not subject to any fillet processing and in some cases the product is even sold fresh/live, not even gutted or headed. A small amount of the product is taken out of the region by traders, but most of it is sold within the region. In addition to a detailed analysis of the key customers and product forms, major players and activities, major routes of products, and payment flow in the value chain, the study produced recommendations to address the concerns of chain players. These include:

1. Encourage the establishment of high quality reliable hatchery-nursery facilities that can provide different or bigger sizes of fingerlings to shorten grow-out cycle.
2. Conduct market promotion activities that highlight the various niche opportunities for tilapia among growers and consumers (added value, market small sizes in new niches, specialty shops).
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. Provide capital windows to improve facilities and reduce logistics and transaction costs in the entire supply chain of tilapia.

Dr. Wilfred Jamandre, AquaFish HC-PI at Central Luzon State University in the Philippines, was recruited to participate in a workshop for this investigation because of his experience conducting tilapia value-chain analysis. The workshop, held at Universidad Juárez Autónoma de Tabasco in Mexico, brought together 23 participants, including producers, fingerling suppliers, feed suppliers, traders, students, professors and technicians. The workshop was effective at confirming data collected previously about the value chain, and stimulated collaboration between different players in the value chain who had not considered the benefits of improving the value chain. This is great example of the unique synergies that are created when AquaFish investigators from different projects and host countries combine their varying expertise to collaborate on aquaculture research.

## 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 University of Hawai'i at Hilo project focuses on poor women and children in the coastal Latin American region who are highly dependent upon natural resources extraction, often in the form of bivalve shellfish and other mangrove resources. The accomplishments of this work include (1) improving food security and reduction of food-borne diseases through improved fisheries management, small-scale aquaculture and improved food sanitation practices; (2) ecological and fisheries studies providing information critical to decision-making and planning for coastal communities and economic development; (3) increased capacity for extension agents and researchers to work in bivalve culture, fisheries management and shellfish sanitation; (3) community-based co-management of resources and small shellfish growing businesses.; (4) development of the basis for shellfish sanitation plans and classification of shellfish growing waters to reduce the risk of shellfish consumption and open the door to exports; and (5) considerable advances have been made in developing a new, native fish for aquaculture (*Dormitator latifrons*), which offers potential as a low-cost, low-tech aquaculture species for Latin America.

#### **Project Personnel**

##### **University of Hawai'i at Hilo**

Maria **Haws** - US Lead Project PI

Armando **Garcia-Ortega** - US Investigator

##### **North Carolina State University, USA**

Mike **Frinsko** – US Investigator

##### **Universidad Autónoma de Sinaloa – Culiacán, Mexico**

Eladio Gaxiola **Camacho** – HC Lead Project PI

##### **Universidad Autónoma de Sinaloa – Mazatlán, Mexico**

Guillermo Rodriguez **Dominguez** - HC Investigator

Gustavo Rodriguez Oca **de Montes** – HC  
Investigator

##### **CIDEA-UCA, Nicaragua**

Nelvia **Hernandez** - HC Investigator

Erik José **Sandoval Palacios** - HC Investigator

Wendel Carl **Selexza** – HC Investigator

Juan Ramón **Bravo** - HC Investigator

Eufresia Cristina **Balladares** - HC Investigator

Maria Christina **Espinoza** – HC Investigator

Wilber **Herrera** – HC Investigator

Gleyman Aristides **Cruz** – HC Investigator

Leticia **Guadamuz** – HC Investigator

#### **Investigation Progress Report**

##### **Experimental Pond Unit Assessment in Nicaragua (09BMA13UH)**

Nicaragua has rich freshwater and marine resources with high potential for aquaculture. It also has two large freshwater lakes, Lake Managua and Nicaragua, which traditionally had rich fisheries, although these have suffered drastic declines. Tilapia was introduced in Nicaragua in the 1950's and has become the primary freshwater fish species, including for cage aquaculture in the two large lakes, as well as in polyculture with marine shrimp. Unfortunately Nicaragua has not been able to emulate the success of its Central American neighbors, Honduras, Costa Rica and Panama, which have developed major tilapia producing and exporting industries. Although many factors can be blamed for this lack of development, two factors which can be addressed are the lack of institutional capacity for research and development, as well as the lack of experience with tilapia culture under local conditions. This work is intended to begin strengthening the ability of the Central American University (UCA) to improve its capacity for research and demonstration for freshwater fish aquaculture.

### **Developing feeds for larval *Dormitator latifrons* (chame) (09IND10UH)**

The Pacific Fat Sleeper (*Dormitator latifrons*) is a facultative air breathing fish found extensively along the Pacific coast of Latin America. It is a fisheries target in many areas of Latin America and has been traditionally cultured on a limited basis in Ecuador. It has greater potential as a fisheries and aquaculture species, despite being relatively unknown throughout its range. Like most air breathing fish species, further development for aquaculture is important given the need for increasing the supply of high protein food, particularly in the face of growing climate change impacts, where air breathing fish have numerous advantages. The chame has additional advantages including high quality flesh, fast growth rate and it is low on the food chain. Simple culture methods similar to those used for tilapia are adequate to produce harvest-size fish in six months. The main obstacle is the difficulty in spawning and rearing this species under hatchery conditions. While progress has been made with past AquaFish work for induction of spawning, the early stages of rearing larvae is problematic and remains largely unresolved, although key biological information has been obtained. The current effort will test three additional strategies to find feeds that are small enough to be ingested by the small larval fish and which are nutritionally adequate.

AquaFish sponsored research on the species' population dynamics in Mexico has also yielded key information leading to an improved understanding of the basic life history traits of this species and implications for fisheries management. The status of *D. latifrons* populations is highly variable throughout its geographic distribution, ranging from local extinctions to high abundance. Recent research in Mexico suggests that the species may be threatened by a variety of stressors such as habitat destruction, impedance on migratory routes and intentional and unintentional destruction as bycatch or as "pest" species. The Mexico populations may be going down the same road as the Ecuador stocks which have suffered significant declines. There is concern that as other fish stocks are diminished, and as demand for *D. latifrons* increases in Mexico or elsewhere, further declines may occur. Hence there is a need for outreach, consideration of regulations and preventing destruction of key wetland habitats.

### **Value Chain Analysis for black cockles (*Anadara tuberculosa* and *A. similis*) (09MER10UH)**

Previous AquaFish sponsored research produced a preliminary value chain analysis for the black cockle in Nicaragua. The black cockle (*Anadara* sp.) is an important fisheries and aquaculture product through Latin America, and also in Africa and Asia. The preliminary value chain analysis provided useful information for cockle management. One short fall however, was the lack of adequate resources to collect data on all aspects of cockle marketing, and some cost and price data was also difficult to collect. Hence, more in-depth and updated information would be valuable at this point in time. Additionally, although the preliminary study was not comprehensive, the findings along with other research results indicated that two key points exist in the value chain that would improve benefits to the fishers and community-based consolidators/vendors. These are the depuration and certification of black cockles. Methods were developed by which cockles can be depurated and product safety assured in less than three days. Both field and laboratory depuration trials were conducted. While both were effective, the water quality conditions in most estuaries where collectors work are too variable to guarantee that depuration can always be conducted. Hence, UCA has built a small, solar-powered depuration center in the community of Aserradores which can be easily operated by local producers once they are trained. The Nicaraguan government inspectors have advised, however, that the center will not comply with established HACCP requirement unless minor modifications are made. Additionally, dialogues with the Nicaraguan government have indicated that the depurated product can be certified and previous market studies suggest that certified product may yield a higher volume of sales and potentially higher prices. It was also found that there is a high level of interest in value-added products made from cockles, which might further increase the value to vendors. CIDEA will incorporate value-added experiences from El Salvador and Mexico for the development and testing of value-added cockle products.

**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**

The Auburn University project addressed the inefficiencies that constrain the development of aquaculture in Uganda and South Africa by building a knowledge base with research results and visible examples that work in the African context. Notable accomplishments include: (1) developing a suite of software approaches to assess water availability and promote wetland protection in communities with competing aquaculture and other water usage needs; (2) working with small-scale farmers to guide their adoption of cage aquaculture as a new income-generating enterprise; (3) assessing the commercial potential for small-scale aquaculture enterprises and availability of local markets; and (4) establishing a successful model for an annual farmers symposium that serves as a national training activity that offers networking opportunities and a forum for information exchange and technology transfer.

**Project Personnel****Auburn University**Joseph **Molnar** – US Lead Project PIClaude **Boyd** – US InvestigatorRon **Phelps** – US InvestigatorJeff **Terhune** – US InvestigatorKaren **Veverica** – US Investigator**Kenyatta University, Kenya**Charles C. **Ngugi** – HC Investigator**Network of Aquaculture Centres in Asia-Pacific, Thailand**Yuan **Derun** – HC Investigator**Investigation Progress Report****Training trainers for long term and sustained impact of pond aquaculture in Africa (09TAP08AU)***No progress report submitted*



## **V-B. RESEARCH PROJECT STARTUP REPORTS – PHASE II**

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On 31 March 2013, AquaFish officially started Phase II under the new name Feed the Future Innovation Lab for Collaborative Research on Aquaculture & Fisheries (abbreviated to AquaFish Innovation Lab). Upon initiation of Phase II, AquaFish invited proposals for continuing research in Asia and Africa through 2015.

Lead Project Principal Investigators from five US universities submitted proposals for continuing research for the 2013-2015 implementation period: the University of Michigan, North Carolina State University, and the University of Connecticut in Asia, and Purdue University and Auburn University in Africa.

Phase II project reports are summarized from full-length proposals, with components printed as submitted by Lead Projects. Research activities had just commenced at the time this report was published. Full proposal Implementation Plans are available from the Management Team and the AquaFish website.



Family-scale aquaculture at floating houses on the Mekong River, Vietnam. Photo by Peg Herring.

**LEAD US UNIVERSITY: NORTH CAROLINA STATE UNIVERSITY*****ENHANCING AQUACULTURE PRODUCTION EFFICIENCY, SUSTAINABILITY AND ADAPTIVE MEASURES TO CLIMATE CHANGE IMPACTS IN BANGLADESH*****Project Summary**

Bangladesh is one of the most densely populated country in the world, with 40% of the population living in abject poverty. Fifty percent of women are malnourished, with over 40% of children under the age of five showing moderate to severe stunting. Finfish are an important source of nutrition, comprising great than 60% of the dietary protein for most people. Accordingly, aquaculture in Bangladesh is considered a high food security priority for enhancing dietary nutrition and improving the economic livelihoods for its poorest citizens. Aquaculture production in Bangladesh faces significant problems which directly threaten the lives and economic livelihoods of local farmers, including: limited production of nutrient-rich foods available for direct consumption, poor productivity and high mortality rates in marine shrimp (cash crop), excessive and costly feed inputs leading to poor economic return, poor pond management leading to low water quality and environmental degradation, limited diversification of aquaculture products, and a poor understanding of the value chain for seafood products. This project will address these problems, including those centered in the high priority regions of Southwest Bangladesh.

Feed is the most costly aspect of fish farming, representing over half of the total production cost for tilapia, and is even higher in the farming of indigenous, air-breathing fishes (Shing and Koi) currently produced by monoculture. This project will incorporate reduced-feeding protocols, in combination with polyculture production of popular Indian carp species, into current practices of tilapia, Shing, and Koi farming. Technologies promoting a more cost-effective and sustainable method of Shing/Koi farming, fishes rich in iron and other minerals, will contribute toward alleviating malnutrition common in rural women and young children, such as iron-deficient anemia. This project will also investigate novel metagenomic approaches to identify gut microbial communities linked to enhanced feed conversion of tilapia, to lay the framework toward development of probiotic supplements for improving fish growth.

This project will also examine Best Management Practices for shrimp farming as well as assess the potential for farming *Pangasius catfish* in brackish (hyposaline) waters in regions traditionally reliant solely upon shrimp farming. This project will also test a novel polyculture/land-farming strategy, whereby Mola (*Amblypharyngodon mola*), a small indigenous fish with high vitamin A content, is cultured with prawns and pond muds are used as fertilizer to grow fresh vegetables on unflooded gher-dykes. Currently, 38% of rural children in Bangladesh suffer from chronic vitamin A deficiency. For many women-led households in coastal Bangladesh, the sale of mudcrab (*Scylla serrata*) constitute their sole economic livelihood. Currently, the economics of mud-crab culture are not understood, and local communities and government support may advance the production and marketing methods through better participation. This project will conduct a value chain analysis on mud-crab farming by women in coastal Bangladesh to identify how this industry can be further developed for their benefit.

**Project Personnel****North Carolina State University, USA**Russell **Borski** - US Lead Project PIUpton **Hatch** - US InvestigatorHarry **Daniels**, US Investigator**Southeast Asian Development Center –  
Aquaculture, Philippines**Emilia **Quinitio** - HC Co-PI**Khulna University, Bangladesh**Sk. Barlur **Rahaman** – HC Investigator**WorldFish - South Asia, Bangladesh**Manjurul **Karim** – HC Collaborator**Bangladesh Agricultural University, Bangladesh**Md. Abdul **Wahab** - HC Lead Project PIShahroz Mahean **Haque** - HC InvestigatorSadika **Haque** – HC Investigator**Central Luzon State University, Philippines**Wilfred **Jamandre** – HC Co-PI**Sushilan NGO, Bangladesh**Sattyandanda **Biswas** – HC Investigator**University of Dhaka, Bangladesh**Abu Torab M.A. **Rahim** – HC Investigator**Hajee Mohammad Danesh Science Technology  
University, Bangladesh**Ashraful **Islam** – HC Investigator**List of Investigations****Economic and environmental benefits of reduced feed inputs in the polyculture of tilapia and major  
Indian carps (13SFT04NC)**

Sustainable Feed Technology and Nutrient Input Systems / Experiment

**Pulsed feeding strategies to improve growth performance, gastrointestinal nutrient absorption  
efficiency, and establishment of beneficial gut flora in tilapia pond culture (13SFT05NC)**

Sustainable Feed Technology and Nutrient Input Systems / Experiment

**Novel approach for the semi-intensive polyculture of indigenous air-breathing fish with carps for  
increasing income and dietary nutrition while reducing negative environmental impacts  
(13MNE01NC)**

Mitigating Negative Environmental Impacts / Experiment

**The culture potential of *Pangasius* catfish in brackish (hyposaline) waters of the greater Barisal  
regions in Southern Bangladesh (13BMA02NC)**

Production System Design and Best Management Alternatives / Experiment

**Integrated *Mola* fish and gher/freshwater prawn farming with dyke cropping to increase household  
nutrition and earnings for rural farmers in Southwest Bangladesh (13HHI03NC)**

Human Nutrition and Human Health Impacts of Aquaculture / Experiment

**Production of nutrient-rich small fish *Mola* and freshwater prawn using integrated cage-pong/carp  
polyculture for Northwest Bangladesh (13BMA03NC)**

Production System Design and Best Management Alternatives / Experiment

**Improving nutritional status and livelihood for marginalized women households in Southwest  
Bangladesh through aquaculture and value chain analysis (13MER04NC)**

Marketing, Economic Risk Assessment, and Trade / Activity



**LEAD US UNIVERSITY: UNIVERSITY OF CONNECTICUT AT AVERY POINT*****IMPROVING FOOD SECURITY, HOUSEHOLD NUTRITION, AND TRADE THROUGH SUSTAINABLE  
AQUACULTURE AND AQUATIC RESOURCE MANAGEMENT IN CAMBODIA AND VIETNAM*****Project Summary**

This project focuses on poverty alleviation and food security improvement through sustainable aquaculture development and aquatic resources management in Cambodia and Vietnam; especially in the context of climate and non-climate drivers of change. The work undertaken through this project will be sustained after the life of the project by the partners in Cambodia and Vietnam and with a number of partner organizations and projects.

In Cambodia, freshwater aquaculture production has increased rapidly over the last two decades, with an annual average growth rate of about 20%. In 2010, aquaculture represented 12 % of total inland fisheries production. In Vietnam, the annual growth of aquaculture has been about 10-13 % during the last decade. The Mekong Delta region of Vietnam often contributes about 55-60% of the total aquatic production and more than 60% of total aquatic production for export of the whole country. Any adverse impacts to the fisheries and aquaculture sector in the region will therefore have implications for the region's economic development, for poverty reduction, and for global as well as regional food security. Importantly, it must be recognized that these two countries are highly vulnerable to climate change because of their low capacity to respond and adapt. Climate change is likely to have negative impacts on capture fisheries systems already stressed by overexploitation and pollution and also likely to impact the productivity and viability of aquaculture operations.

Past studies of AquaFish CRSP produced a number of outcomes, including development of a plant based feed for snakehead fish, recommendations to government and the private sector for a sustainable snakehead aquaculture industry, value-added products from small-sized/low value fish such as fish paste and fish sauce, extension/outreach technologies, recommendations for improvements in the marketing system for both capture and culture fish in the region, and recommended policies to improve management of small-sized/low value fish in the Mekong area. These outcomes have impacted or are impacting both the private and public sectors through improvements in technologies, commercialization of new products, sustainable aquatic resource management practices, and policies for aquaculture and capture fisheries. For example, the snakehead feed developed by the project is now being made commercially in Vietnam and 10,000 farmers are using it. The vision of this project is poverty alleviation and food security improvement through sustainable aquaculture development and aquatic resources management in Cambodia and Vietnam; especially in the context of climate and non-climate drivers of change. This vision takes into account the need to address under-nutrition, especially in women and children, by increasing the availability and access to nutrient dense foods through research on fish.

This project will address this issue through six separate but complementary investigations on fish value chains, development of feeds and feeding strategies and processed products, sustainable snakehead aquaculture systems, estimating carrying capacity for aquaculture, food and nutrition security vulnerability of women, and policy and outreach. The work undertaken through this project will be sustained after the life of the project by the partners in Cambodia and Vietnam and with a number of partner organizations and projects including the WorldFish Center – Cambodia office, Integrated Pest Management CRSP, Cambodia HARVEST project, the Network of Aquaculture Centers in Asia (NACA), Mekong River Commission, and the Southeast Asian Fisheries Development Center-Aquaculture (SEAFDEC-AQD). The research to be undertaken through this project has been identified as high priority by the Cambodian government. It is expected that the government, through IFREDI and FiA, will continue to fund these research areas and seek additional donor funding.

**Project Personnel****University of Connecticut at Avery Point, USA**Robert **Pomeroy** - US Lead Project PISylvain **De Guise** – US Co-PI**University of Rhode Island, USA**David **Bengston** - US Co-PI**Can Tho University, Vietnam**Tran Thi Thanh **Hien** – HC Co-PITran Ngoc **Hai** – HC Co-PI**Inland Fisheries Research and Development Institute, Cambodia**So **Nam** – HC Lead Project PIPrum **Somany** – HC InvestigatorHap **Navy** – HC InvestigatorChheng **Phen** – HC InvestigatorTouch **Bunthang** – HC InvestigatorNem **Phanna** – HC Investigator**List of Investigations****Impacts of climate change on fish value chains in the Lower Mekong Basin of Cambodia and Vietnam (13MER03UC)**

Marketing, Economic Risk Assessment, and Trade / Study

**Alternative feeds and processing for freshwater aquaculture species (13SFT03UC)**

Sustainable Feed Technology and Nutrient Input Systems / Experiment

**Sustainable snakehead aquaculture development in the Lower Mekong River Basin of Cambodia (13IND02UC)**

Climate Change Adaptation: Indigenous Species Development / Experiment

**Estimating carrying capacity for aquaculture in Cambodia (13WIZ01UC)**

Watershed and Integrated Coastal Zone Management / Study

**Enhancing food security and household nutrition of women and children with a focus on nutrient dense commonly consumed fish from capture fish and aquaculture in Cambodia (13HHI02UC)**

Human Nutrition and Human Health Impacts of Aquaculture / Study

**Policy recommendations to address the impacts of climate and non-climate drivers of change on fisheries and aquaculture in the Lower Mekong Basin of Cambodia and Vietnam (13PDV01UC)**

Policy Development / Activity

**LEAD US UNIVERSITY: PURDUE UNIVERSITY*****AQUACULTURE DEVELOPMENT AND THE IMPACT ON FOOD SUPPLY, NUTRITION AND HEALTH IN GHANA AND TANZANIA*****Project Summary**

African governments acknowledge in National Development Plans that urgent poverty reduction measures are needed to achieve the UN Millennium Development Goals, with governments most focusing on national poverty eradication strategies and improvements in food nutrition and security. Fish has always been an important part of the diet of the people of the continent but until recently fish has been largely harvested from the wild. Total fish output in some African nations such as Nigeria and Egypt continue to grow at accelerating rates and fish cultivation has become part of many rural agricultural enterprises. This has been encouraged by expansion of NGO developmental activities on aquaculture, improved aquaculture production technologies, recognition of over exploitation of natural fisheries, and increased nutritional requirement of a rapidly growing population. These factors combine to make aquaculture an economically attractive agricultural production alternative in sub-Saharan Africa.

Previous AquaFish CRSP work has focused on a broad range of issues targeting poverty reduction and increased productivity. In Tanzania, for example, lower costs feed alternatives were identified from leguminous tree species to replace the more costly soybean meal used in tilapia diets. Through training in hatchery techniques and management, Kenya farmers now have an additional aquaculture enterprise of raising catfish fingerlings and selling as bait to the longline fishing industry on Lake Victoria. Traders in baitfish from natural catches are now engaged in fish farming that has enabled year-round supply of baitfish. Training in supply chain management has enabled the development of new market opportunities for foodfish producers in Kenya and Ghana as well as new markets for baitfish producers in Kenya. Farmers have acquired knowledge about the environmental effects of their activities and are therefore implementing broadly focused environmental BMPs on their farms, especially in Ghana and Kenya. Studies that analyzed tilapia value chain provided valuable information needed for the improvement of tilapia trade through market intelligence. Similarly, consumer preference studies for farmed fish provided information for the development of consumer-driven aquaculture production in Ghana and Kenya.

The vision of this project is to build on previous work to enhance the profitability of the aquaculture industry in sub-Saharan Africa through physical and human capacity development; enhanced market information sharing and trading; improved nutritional qualities of fish and consequently human nutrition; growth of a whole chain of activities from farm to the consumer; better management of native fish and shellfish species. Results from the various investigations will help to achieve the goals of improving human nutrition, efficiency in the value chain, increased incomes for producers and traders of aquaculture products, diversified production systems, enhanced nutrient, and reduction in postharvest losses through efficient market information sharing mechanisms.

This project involves knowledge generation and physical and human capacity development. Student participation in research activities is designed to create a framework such that all additional materials and investment by this project are viewed as part of quality improvement of the Aquaculture Sciences program. Involvement of students means involving a set of other faculties such as graduate committee members. This will facilitate joint planning and management of the additional equipment and investments and also create continuity, as other students outside the program will continue to use the additional facilities.

**Project Personnel****Purdue University, USA**Kwamena **Quagrainie** - US Lead Project PI**University of Arkansas at Pine Bluff, USA**Rebecca **Lochmann** – US Co-PI**Kwame Nkrumah University of Science and Technology, Ghana**Stephen **Amisah** – HC Lead Project PINelson **Agbo** – HC InvestigatorRegina **Edziye** – HC InvestigatorGifty **Anane-Taabeah** - HC Investigator**University of Dar es Salaam, Tanzania**Narriman **Jiddawi** – HC Co-PI**Western Indian Ocean Marine Sciences Association, Tanzania**Julius **Francis** – HC Co-PI**Virginia Polytechnic Institute & State University, USA**Emmanuel A. **Frimpong** - US Co-PI**University of Hawai'i at Hilo, USA**Maria **Haws** – US Co-PI**University for Development Studies – Nyankpala Campus, Ghana**Akwas **Ampofo-Yeboah** - HC Investigator**Sokoine University of Agriculture, Tanzania**Sebastian **Chenyambuga** – HC Co-PINazeel **Madalla** - HC InvestigatorElibariki Emmanuel **Msuya** - HC Investigator**List of Investigations****Assessing the nutritional impact of aquaculture policy in fish farming districts in Tanzania and Ghana (13HHI01PU)**

Human Nutrition and Human Health Impacts of Aquaculture / Study

**Development of a cell-phone based seafood market information system (SMIS) in Ghana:****Application to tilapia (13MER01PU)**

Marketing, Economic Risk Assessment, and Trade / Study

**Value chain analysis of farmed Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) in Tanzania (13MER02PU)**

Marketing, Economic Risk Assessment, and Trade / Study

**Spat collection and nursery methods for shellfish culture by women (13QSD01PU)**

Quality Seedstock Development / Experiment

**Coastal women's shellfish aquaculture development workshop (13BMA01PU)**

Production System Design and Best Management Alternatives / Activity

**Identifying local strains of *Oreochromis niloticus* that are adapted to future climate conditions (13IND01PU)**

Climate Change Adaptation: Indigenous Species Development / Experiment

**Evaluation of invertebrates as protein sources in Nile tilapia (*Oreochromis niloticus*) diets (13SFT01PU)**

Sustainable Feed Technology and Nutrient Input Systems / Experiment

**Enhancing the nutritional value of tilapia for human health (13SFT02PU)**

Sustainable Feed Technology and Nutrient Input Systems / Experiment

**LEAD US UNIVERSITY: UNIVERSITY OF MICHIGAN*****DEVELOPMENT OF MORE EFFICIENT AND ENVIRONMENTALLY SUSTAINABLE AQUACULTURE SYSTEMS FOR NEPAL*****Project Summary**

Nepal is a poor country; most residents are at best educated at the level of primary schooling, and many are undernourished or even malnourished. As a result of this poverty, most planning documents produced by the government, as well as outside organizations, concentrate on human health and nutrition as the main focus for future development of aquaculture. This focus is long standing. In 1976, Rana and Rajbanshi developed a National Plan for Development of Aquaculture in Nepal, which focused on increasing production of household ponds and other systems that would provide nutrition to poor households as the main concept. Subsequent plans in Nepal, including the Fisheries Perspective Plan, the Strategic Vision of Aquaculture Research, and evaluations by FAO all maintain nutrition for poor families as the main focus. Throughout the poorer countries of Asia, small indigenous species of fish (SIS) are promoted as a means to provide health benefits for poor consumers. The benefits of their consumption include increased intake of calcium and vitamins (such as vitamin A) because the fish are generally consumed whole. In addition, these fish, when cultured or captured, are generally consumed in the home rather than sent to market, so they provide direct nutrition. While SIS can be caught from natural waters, they have not been well incorporated into aquaculture production systems. For example, the polyculture systems, which are the mainstay of commercial aquaculture in Nepal, largely use 5-7 carp species, all targeted on large carp species sold to market. While SIS could be incorporated into these polyculture systems — possibly without any loss of yield for the large carp species — this has seldom been done, and there is no research basis to indicate whether such incorporation would be helpful or damaging to overall production. Over the first two years of this grant, our project will focus on this incorporation of SIS into polyculture systems to determine if it is a viable means to increase food production for poorer households.

Since the 1970's aquaculture development in Nepal has focused on utilizing marginal agricultural lands, such as ghols (flooded areas with marginal agricultural potential), to serve as aquaculture sites for poor households. As a result of outreach conducted in the Terai (the low elevation plains area of Nepal), numerous household ponds have been built in these marginal agricultural areas, and the management of those ponds with cages has been promoted as a means to substantially improve nutrition of poor households. Such outreach to extend aquaculture into ghols has been promoted in all of the aquaculture plans for Nepal, and yet the success of these systems and their effects on household nutrition remain uncertain. This is the project's second main focus; to evaluate the success of household ponds in increasing fish consumption by women and children in poor households, and to then determine if this increased consumption leads to improvements in health as measured by World Health Organization standards of nutritional status for children.

A third area of focus for this project is the enhanced production of native species, particularly sahar, a cool water species indigenous to Nepal. Again, all of the aquaculture planning documents described above had a focus on fish production in colder regions of the country. While these plans generally called for trout culture, sahar may be a more successful alternative because it is a native species, valued by local inhabitants, and important as a target of restoration. This project will incorporate sahar in on-farm trials, as well as to expand sahar seed production to other regions of the country. In addition to sahar, this project will work to establish aquaculture systems for another indigenous species, the stinging catfish.

**Project Personnel****University of Michigan, USA**James **Diana** - US Lead Project PI**Fisheries Research Center, NARC, Nepal**Jay Dev **Bista**, - HC Co-PI**Directorate of Fisheries Development, Nepal**Rama Nanda **Mishra** – HC Co-PI**Agriculture and Forestry University, Nepal**Madhav **Shrestha** - HC Lead Project PINarayan P. **Pandit** - HC InvestigatorSunila **Rai** - HC InvestigatorDilip K. **Jha** - HC InvestigatorC.N.R. **Yadav** - HC Investigator**List of Investigations****Reproduction and seed production of sahar (*Tor putitora*) in Chitwan, Nepal (13QSDXXUM)**

Quality Seedstock Development / Study

**Production of periphyton to enhance yield in polyculture ponds with carps and small indigenous species (13SFTXXUM)**

Sustainable Feed Technology and Nutrient Input Systems / Experiment

**Household fish ponds in Nepal: Their impact on fish consumption and health of women and children; and their constraints determined by value chain analysis (13HHIXXUM)**

Human Nutrition And Human Health Impacts Of Aquaculture / Study

**Two small indigenous species to improve sustainability in typical polyculture systems in Nepal (13INDXXUM)**

Climate Change Adaptation: Indigenous Species Development / Experiment

**Demonstrating the value of tilapia and sahar production in polyculture ponds using government farm and on-farm trials (13BMAXXUM)**

Production System Design and Best Management Alternatives / Experiment

**Establishing school ponds for fish farming and education to improve health and nutrition of women and children in rural Nepal (13HHIXXUM)**

Human Nutrition and Human Health Impacts of Aquaculture / Activity

**LEAD US UNIVERSITY: AUBURN UNIVERSITY*****AQUACULTURE DEVELOPMENT IN KENYA AND UGANDA: ADVANCING COST-EFFECTIVE TECHNOLOGY, MARKET ASSESSMENT, AND END-USER ENGAGEMENT*****Project Summary**

This project endeavors to solve or clarify some bottleneck or unknown dimension that limits the advance of fish culture in Uganda and Kenya. Whether it be the reproductive control and managed grow out of a new species such as lungfish, the established practice of tilapia culture under diverse and changing local circumstance, or new insights on how to reach and engage fish farmers with practical information through their cellphones, this project is committed to practical, tangible results.

Ensuring the supply of quality fingerlings for local farms is a fundamental task in both Uganda and Kenya. Training, research, and outreach focused on growing a spatially balanced distribution of seedstock producer clusters will foster the development of the tilapia industry. Readily available quality fingerlings will facilitate producer motivation for timely restocking for increased production and enhance availability of supply. Developing and stimulating the network of fingerling producers also will foster peer-to-peer technical support, market development, and other forms of mutual support.

Aquaculture development is building in Uganda as at least one large commercial farm is using cage culture to produce daily truckloads of tilapia destined for export to Congo. The medium and small-scale sector is advancing through the endeavors of project-developed and supported Annual Fish Farmer Conference and Trade Show that has become a focal event for the industry. Project-trained trainers continue to hold events and work with producers throughout the country. Tilapia remains a readily marketed and popular consumer item, particularly in locales away from Lake Victoria and other large water bodies. Yet serious deficiencies in production practice, value chain development, and species alternative remain. Research is needed to demonstrate and clarify optimal timing and strategies for producing tilapia and clarius for food and baitfish. New cell-phone based systems for market development, management guidance, and seedstock coordination present real possibilities for augmenting the value captured by producers in the marketing chain. New species, particularly lungfish, offer the advantages of known consumer acceptability associated with a popular indigenous species, yet can only be expanded through research that unlocks the reproductive process to foster seedstock development for the species and identifies viable cage culture production regimes.

In Kenya, national policies have promoted fish culture through the subsidized distribution of fingerlings and the coordination of feed supplies. The government has also promoted creation of thousands of small farm ponds so that many new farmers have access to ponds and need technical guidance. This project will contribute to capacity building of university and extension to train these new farmers.

The graduate students that will conduct research and organize practical activities such as training events and guidance conferences will learn from these experiences as well and contribute to the advance of the industry. The project seeks to support a small subset of individuals for U.S. training, but also supports graduate students at the Host Country institutions who will engage in studies, trials, and training events in ways that will advance their projects but also build each nation's human capacity for aquacultural development.



**Project Personnel****Auburn University, USA**Joseph **Molnar** - US Lead Project PIClaude **Boyd** – US Co-PI**National Fisheries Resources Research Institute –  
NARO, Uganda**John **Walakira** – HC Co-PI**Ministry of Fisheries Development, Kenya**Charles **Ngugi** – HC Co-PI**University of Arizona, USA**Kevin **Fitzsimmons** - US Co-PI**Alabama A&M University, USA**James **Bukenya** – US Co-PI**Makerere University, Uganda**Theodora **Huhya** – HC Lead Project PI**University of Eldoret, Kenya**Julius **Manyala** – HC Co-PI**List of Investigations****Development of low-cost captive breeding and hatching technologies for the African lungfish (*Protopterus* spp) to improve livelihoods, nutrition and income for vulnerable communities in Uganda (13INDXXAU)**

Climate Change Adaptation: Indigenous Species Development / Study

**New approaches to inform, motivate, and advance small and medium-scale fish farmers: building industry networks through cell phone networks, training, and market participation (13BMAXXAU)**

Production System Design and Best Management Alternatives / Study

**Assessment of market opportunities for small-scale fishers and farmers in central Uganda (13MERXXAU)**

Marketing, Economic Risk Assessment, and Trade / Study

**Assessment of growth performance of monosex Nile tilapia (*Oreochromis niloticus*) using low cost supplemental feeds in cages and training fish farmers on best management practices in Kenya (13SFTXXAU)**

Sustainable Feed Technology and Nutrient Input Systems / Activity

**Formulation and manufacture of practical feeds for Western Kenya (13SFTXXAU)**

Sustainable Feed Technology and Nutrient Input Systems / Study

**Development of low-cost aquaponics systems for Kenya (13BMAXXAU)**

Production System Design and Best Management Alternatives / Activity



## VI. ASSOCIATE AWARDS

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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 AquaFish, two such awards have been received since program inception. The first of these was a competitive award from the USAID/Mali Mission for aquaculture and fisheries work in Mali that ended in 2010, and the second award, still underway, was a competitive award from EGAT/USAID, Washington for work being conducted in Ghana, Kenya, and Tanzania.

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**LEAD US UNIVERSITY: OREGON STATE UNIVERSITY**

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

THIRD ANNUAL REPORT  
1 October 2012 – 30 September 2013

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

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

### **Collaborating Institutions and Personnel**

**AquaFish, Oregon State University, USA**  
Hillary Egna, Principal Investigator

**Purdue University, USA**  
Kwamena Quagrainie, US Co-PI

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

**Kwame Nkrumah University of Science and Technology, Ghana**  
Steve Amisah, HC Co-PI  
Gifty Anane-Taabeah, HC Investigator

**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  
Nazael Madalla, HC Investigator

## **Introduction**

Feed the Future (FTF) is a United States Government initiative designed to reduce poverty and hunger. Recognizing that agriculture and rural development have long been neglected in international aid programs and the severe impact that poverty has on livelihoods, health, and ecosystems, FTF renews a USAID commitment to reinvest in activities that lead to sustainable food security globally. To align its strategies and goals with those of the FTF initiative, USAID issued a Request for Assistance (RFA) under the Strategic Investment in Rapid Technology Dissemination program within EGAT for work in this crucial area in 2010.

Oregon State University's AquaFish responded to USAID's RFA with a project that addresses FTF goals and helps reduce gnawing development problems that contribute to keeping the poor poor. This project, titled *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 towards meeting the poverty and hunger goals of the UN's Millennium Campaign. The project is working towards these goals by helping to increase agricultural productivity, expand markets and trade, and increase 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 resource management can result in improved nutrition for all family members.

This AquaFish Associate Award works in three 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." The project focuses on small-scale aquaculture producers, the production of high quality seed, and the adoption of best management practices (BMPs). Project participants are working with private sector partners to expand commercially sustainable agro-input industries and dealer networks, including small enterprises. Increased access to inputs is being coupled with strategies to help ensure their safe and sustainable use. AquaFish technologies are being refined and tailored to local conditions by supporting national research institutes and building local research capacities, including training local researchers and technicians. Gender inequalities inhibiting women's access to information, inputs, or technology are addressed and anticipated. The aim is to provide women with equal access to affordable inputs and improved technologies.

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, this project aims to make markets work better for both women and men agricultural producers and to extend the availability of nutritious foods. Through the reach of the project, results are also aiding 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 foods and micronutrients commonly found in fish.

This project has primary focus locations in Ghana and Kenya to leverage work done by AquaFish, to consolidate adoption of technologies, and to ensure measurable impact. In addition to the intensive efforts in these two countries, associated activities are planned for Tanzania.

On 23 September 2013, a no-cost extension (NCE) was fully executed for this Associate Award, extending the award end date from 30 September 2013 to 30 September 2014. This extension allows project participants to complete field work in Tanzania and Kenya, and enable the completion of reports,

enhanced communication materials, student degree work, and translations associated with project activities in Kenya, Tanzania, and Ghana.



AquaFish trainers lead a workshop in Ghana, January 2013 (Photo courtesy of Emmanuel Frimpong)

### **Background**

The accelerating pace of aquaculture growth in sub-Saharan Africa has received much positive attention because of the potential of the industry to contribute to development and food security by providing jobs and supplementing wild fish protein. Questions are being raised, however, 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 aquaculture production methods, and their widespread adoption can help forestall the 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 these issues were studied by the PD/A and Aquaculture CRSPs, where decision support tools were developed for assessing farm profitability. The tools utilized financial spreadsheets that incorporated enterprise budgeting. Methods for farm-level record keeping led to improved understanding of the costs and returns associated with fish farming, documentation that is important 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, AquaFish held a two-day 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 trial run of one of several methods that could be used together to disseminate BMP guidelines and facilitate adoption. Farmers participating in the workshop showed great enthusiasm for the concepts presented, with many expressing interest in setting aside ponds for AquaFish demonstrations and 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 are expected to 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.

In the first three years of the project (FY11-FY13), nine short-term training events were held, five in Ghana, three in Kenya, and one in Tanzania. Of the 718 trainees in those nine events, 178 (25%) were women and 540 (75%) were men, with an increase in women's involvement to 37% in the third year as compared to the 16 % in the first year. On a country basis, 132 trainees attended the course in Kenya, including 27 women (26%), and 545 people were trained in Ghana, including 140 women (25%). Tanzania had 41 attendees, with 11 women (26%) and 30 men (73%). Efforts were made to increase women's involvement in BMP trainings and demonstrations, as traditionally far fewer women are involved in aquaculture production compared to men (e.g., the percentage of women attending short-term training far exceeds the percentage of women fish farmers (<10%). Part of this effort included a training program specifically for women in commercial aquaculture.

Six sites were used for BMP demonstrations in Ghana in the first year. The first three were started in FY11, with one each in the Ashanti, Brong Ahafo, and Western regions. The second set of six included two in the Ashanti Region and one in the Western region. After all six of these demonstrations were completed in FY12, five more were started in May 2012, using 20 ponds on five farms in the Ashanti and Brong Ahafo regions. None of the six demonstration farms in Ghana are owned exclusively by women, but some of the businesses are considered family owned and operated. Demonstration sites for Kenya were not scheduled to begin until FY12. Seven farms in three regions (Rift Valley, Western, and Central) are participating in the demonstrations. The first cycle has been completed and the second cycle is underway. In contrast to Ghana, two of the seven participating farms are owned by women and one of the seven is dually owned by a man and a woman.

### **Target Technologies**

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

### **Effluent Management Practices**

Improved effluent management practices include guidelines on pond operation, management of 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 include frequency of drainage, installation of drain outlets, and water level maintenance. Of these practices, emphasis is being 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 longer periods of time than has been traditionally practiced. In areas facing water scarcity, such as baitfish farming in Arkansas, USA, farmers have successfully adapted harvesting methods that involve little or no draining. 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 and more easily treated effluents. Some benefits to farmers of reusing water include retaining nutrients from previous production that can be incorporated into the biomass of the new crop.

### **Nutrient Management Practices**

Better nutrient management practices include fertilizing and feeding regimes that reduce waste and prevent water quality deterioration that threatens fish health. A better practice is to regulate pond water fertility by applying fertilizers to ponds in slow-release sacs that can be removed from the pond when the desired plankton concentration is reached. Avoiding excessive feeding saves on input costs and translates

directly into farm profitability. Feed that is not eaten often functions like an expensive fertilizer and can lead to highly eutrophic water conditions that both reduce yields and escalate the cost of operations. Feeding is best regulated by observing how much feed the fish are consuming and adjusting the amount offered accordingly. This is more easily done when extruded (floating) feeds are used as opposed to pelleted (sinking) feeds. The use of pelleted feeds often results in high waste loads and lower feed conversion ratios ( $FCR = \text{weight of feed fed} / \text{fish weight gain}$ ).

### **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. Previous work conducted under the Aquaculture Collaborative Research Support Program (ACRSP) measured performance indicators and the profitability of Nile tilapia (*Oreochromis niloticus*) production in Ghana. Initial profitability analyses that included variable costs, fixed costs, owned inputs, yield, and revenues showed that the integration of economic, social, and environmental objectives into aquaculture production indicated that the inclusion of BMPs could result in increased profits. A financial decision support tool has been developed to assist existing and prospective fish farmers considering the adoption of BMPs to assess and select production scenarios and profitability relationships for their farm enterprises. The tool consists of financial spreadsheet templates that fish farmers will be able to populate with data to develop their own financial profiles and determine benchmarks that serve as bases for investment decisions, comparisons, and/or improvements to the farm enterprise. This tool was presented to farmers in the third year of the project (FY13).

### **Outreach and Diffusion Techniques**

Three innovation diffusion techniques are being simultaneously deployed: 1) Central Media (series of workshops at the regional level), 2) Demonstrations (BMPs demonstrated at selected farms), and 3) Lateral Diffusion (farmer-to-farmer extension of BMPs).

#### **Central Media (workshops)**

This is a series of workshops at national or regional levels in which we are targeting 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 with adopters and liaise between these adopters and researchers to provide reliable 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 an estimated 2,869 fish farmers with about 4,500 farm ponds. In Kenya, we are targeting about 600 fish farmers, and the target for Tanzania is about 100 fish farmers. During FY13, the project organized and held three workshops—two in Ghana involving 252 participants and one in Tanzania that involved 41 participants.

#### **BMP Demonstrations (BMPs demonstrated at selected farms)**

The demonstration effect has been identified as one of the principal variables that explain diffusion of innovations. Demonstrations are used both to take advantage of their positive effects in the diffusion process and to provide the data needed to estimate the economic benefits of selected components of BMPs for monitoring and evaluation of the intervention. On-farm BMP demonstrations are crucial for showing skeptical farmers the benefits that can be achieved with BMPs. In the Ashanti and Brong-Ahafo regions of Ghana, AquaFish projects had already established working relationships with many farmers prior to the beginning of this project. Farmers whose farms were accessible to researchers and had the highest potential for the diffusion of new ideas to other farmers were selected as demonstration sites. In Kenya, the two focal BMP management schemes (i.e., water re-use and nutrient management) are being demonstrated in three regions: Rift Valley Region, Western Region, and Central Region. Accurate data are being collected from these demonstrations, including stocking densities, fertilization rates, feeding

rates, monthly water quality, yields, and FCRs. These ponds are being managed by AquaFish-supported graduate students and fisheries extension officers with the cooperation of the farmers. Ponds are visited during workshops to show farmers the benefits of BMPs. In addition, data collected from these ponds are being compared with data from ponds under “regular” management within the same farms. These data will be used for with-versus-without analysis of the benefits and costs of BMP implementation.

**Lateral Diffusion** (farmer-to-farmer extension of BMPs)

Through regional workshops and demonstrations, participants are 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 social network. These farmers spread information to other farmers and become nodes, propagating their own networks, thereby laterally transmitting knowledge without the direct involvement of extension personnel.

**Gender Integration and Analysis**

AquaFish is dedicated to improving gender inclusiveness in the aquaculture and fisheries sectors across the spectrum of AquaFish projects and activities. FTF requires that agricultural interventions involve both men and women. These include investments in sustainable labor-saving technologies so that shifts in the gender division of labor and products do not systematically disadvantage one gender 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).

This project recognizes that providing 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 equally. 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 (e.g., Fisheries Officers who serve as aquaculture extension officers, fish farmers, fish traders and processors, consumers, program personnel, students, etc.), the project 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 participants for short-term training, to invite all known women fish farm proprietors and wife-and-husband joint owners of fish ponds/farms.



## **PROGRESS MADE AND RESULTS ACHIEVED**

This Associate Award has the broad objectives of scaling up innovations from previous CRSP and AquaFish successes, and accelerating BMP adoption rates in Ghana, Kenya, and Tanzania. Progress made and results achieved for the two subcontracting US Lead Institutions (Purdue University and Virginia Polytechnic Institute and State University) are presented separately below.

### ***ENHANCING THE PROFITABILITY OF SMALL AQUACULTURE OPERATIONS IN KENYA AND TANZANIA (10BMA01PU)***

Purdue University (USA), Ministry of Fisheries Development (Kenya), Kenyatta University (Kenya), Moi University (Kenya), Sokoine University of Agriculture (Tanzania), and Ministry of Natural Resources and Tourism (Tanzania), with Oregon State University.

#### **Investigation Objectives**

The specific objectives of this investigation are to:

- A. Provide information on BMP adoption in Kenya and Tanzania
- B. Quantify adoption of BMPs in Kenya
- C. Quantify production and financial efficiencies for BMPs adopters versus non-adopters in Kenya
- D. Assess economic benefits of adopting BMPs in Kenya

#### **Investigation Progress**

Because of the collaborative activities that AquaFish has with the Kenya Ministry of Fisheries Development and the efforts of this Associate Award, BMPs have become part of the Kenya government's fisheries extension curriculum. Fish farmers are adopting the use of commercial floating feed and reusing pond water instead of draining ponds every year.

The graduate student working on this project, Akuffo Amankwah at Purdue University, secured a Norman E. Borlaug Leadership Enhancement in Agriculture Program (LEAP) fellowship to collect more data. He will be traveling to Kenya and Ghana in Spring 2014 for data collection.

### ***ENHANCING THE PROFITABILITY OF SMALL AQUACULTURE OPERATIONS IN GHANA (10BMA02VT)***

Virginia Polytechnic Institute and State University (USA) and Kwame Nkrumah University of Science and Technology (Ghana) with Oregon State University

#### **Investigation Objectives**

The specific objectives of this project are to:

- A. Widely disseminate information on readily adaptable BMPs in Ghana, Kenya, and Tanzania
- B. Quantify adoption of selected BMPs in Ghana
- C. Quantify production and financial efficiencies for adoption of selected BMPs in Ghana
- D. Assess economic benefits of adopting the Selected BMPs in Ghana

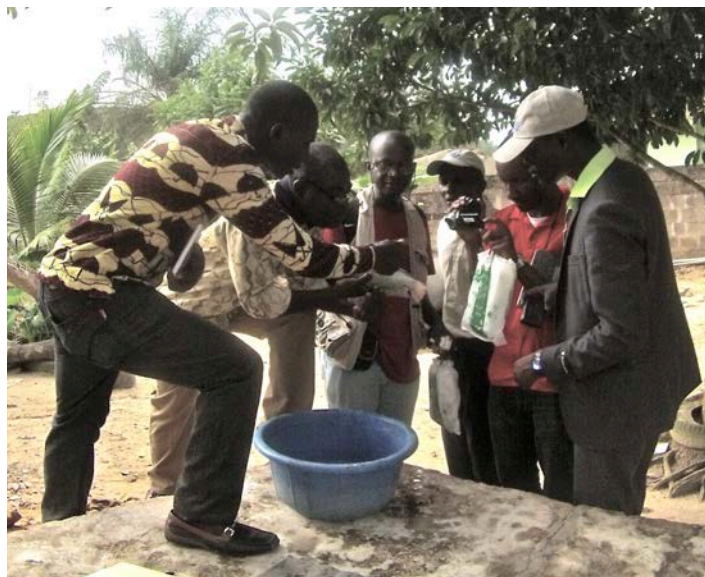
#### **Investigation Progress**

One new workshop was conducted in the reporting period. This year's workshop and training was conducted in Tarkwa in the Western region and was attended by farmers from all three study regions. This was the third regional BMP workshop that was attended by 171 participants, including trainers. Dr. Emmanuel Frimpong led the program and Dr. Hillary Egna chaired. The second round of demonstration experiments involving 5 farms and 20 ponds was completed in November-December 2012.

Approximately 550 surveys have been administered, including three baseline and three follow-up surveys. These surveys included approximately 350 farmers from all the study regions (Ashanti, Western, and Brong Ahafo regions). The final follow-up survey was completed in August 2013 and marks the end of active data collection for this project in Ghana. Analysis of the data is currently ongoing at Virginia Tech.

The first and second round of demonstrations are complete and extensive surveys have been conducted to document the adoption of water reuse and the use of formulated feeds. Demonstrations showed marked improvement in the second round over the first round after some basic management problems were identified and corrected. Changes in protocol that were approved for the second round included the use of a different hatchery with better sex-reversal rates for tilapia *Oreochromis niloticus*, reduced tilapia stocking density to 2/m<sup>2</sup>, and stocking of 20% catfish *Clarias gariepinus* before the possible onset of unwanted reproduction in ponds. Average tilapia growth approached 350g in 5 months, which is about double what was observed in the first round of demonstrations. In addition, some farms performed exceptionally well, averaging almost 400g in 5 months (stocking at 10g fish), implying that better management practices could further improve productivity on the average farm. Reused water did not result in significantly smaller fish, which translates to significant environmental benefits as long as the cost of recycling water is kept lower than the cost of filling ponds with new water. The commercially available formulated floating feed resulted in much larger sizes of tilapia, compared to the farm-made sinking feed. Ongoing economic analysis will answer the question of whether the floating feed is more profitable. The preliminary analysis already indicates better water quality in floating feed ponds.

Preliminary analysis of the survey data indicate that certain characteristics of farmers predict adoption of BMPs, including their geographic location, labor availability, and participation in the AquaFish training programs or frequency of interaction with extension personnel.



AquaFish workshop participants (left) and workshop coordinators (right) in Ghana, July 2013. (Photos by Hillary Egna).



### **SHORT-TERM TRAINING**

In this third year of the Associate Award, three short-term training events were held (2 in Ghana and 1 in Tanzania), with a total of 293 host country nationals receiving training (252 in Ghana and 41 in Tanzania). For the two training events in Ghana, 96 women (38%) and 156 men (62%) were trained. In Tanzania, 11 women and 30 men were trained (27 and 73%, respectively). Although SIRTHD project work continued in Kenya during FY13, all short-term training in Kenya was completed by FY12. In Ghana, two training events took place: one was the third in a series of pond aquaculture BMP workshops, while the other focused on training women on commercial-scale aquaculture practices (79 of the 87 attendees were women).

Over the life of the SIRTHD Associate Award project (2011-2013) a dedicated effort has led to an increase in the number of women participating in AquaFish trainings from 16% in 2011 to 37% in 2013. The underrepresentation of women in aquaculture poses a potential challenge to involvement in trainings; however, AquaFish continues to work towards the goal of involving equal numbers of men and women. The increase in women's participation in this Associate Award over time is an indication of these efforts.

### **LONG-TERM TRAINING**

Twelve students were supported under the SIRTHD project during this reporting year, including seven women (58%) and five men (42%). Seven of these students are Ghanaians (four women and three men), and three are Kenyans (two women and one man). Among the seven Ghanaians, two are pursuing PhDs, and five are pursuing Master's degrees. In Kenya, all five of the students are working on MS degrees.

Supported Host Country students are enrolled in universities in Kenya (Kenyatta University, Moi University, and University of Nairobi), Ghana (Kwame Nkrumah University of Science and Technology), and the United States (Purdue University and Virginia Polytechnic Institute and State University).

### **PROJECT-LEVEL COORDINATION**

In July 2013, Dr. Hillary Egna (AquaFish Director and PI for the Associate Award) traveled to Ghana to meet with key Associate Award partners and to attend the third Ghana BMP Training Workshop. From 2-5 July, Dr. Egna chaired a workshop on Pond Aquaculture BMPs at the Faculty of Engineering at Kwame Nkrumah University of Science and Technology (KNUST) in Tarkwa, Ghana. The first day of the workshop was moderated by Dr. Regina Edziyie and Dr. Nelson Agbo from KNUST and involved presentations on BMP, break-out sessions discussing the pros and cons of BMPs, pond construction and maintenance, and aquaculture basics. The second day focused largely on developing business skills and a fish marketing seminar, and concluded with a tour of a fish farm led by Dr. Steven Amisah from KNUST.

Immediately following the BMP workshop, AquaFish hosted an inaugural Africa Regional Meeting at the KNUST Engineering guest House in Kumasi, Ghana, from 5-9 July 2013. The meeting was chaired and organized by Hillary Egna. Local organizers were Steve Amisah, Kwamena Quagraine, Nelson Agbo (HC Co-PI), and other KNUST faculty. This provided the Associate Award participants a chance to coordinate with leader award activities and to provide an update to the other AquaFish teams in Africa.

### MONITORING & EVALUATION

AquaFish operates under USAID's Feed the Future Monitoring System (FTFMS) to achieve outcomes that have meaning for multiple stakeholders. The FTFMS indicator targets and results for FY13-FY14 as requested by USAID in accordance with FTFMS for this Associate Award are presented in Table VI-1.

Table VI-1. AquaFish SIRTID Associate Award Feed the Future Monitoring System indicator targets and results for FY13 and preliminary targets for FY14.

Indicator Number	Indicator	2013 Target	2013 Actual	2014 Target
4.5.2(2)	Number of hectares under improved technologies or management practices as a result of USG assistance			
	Total	434	392	392
	Continuing	189	189	392
	New	245	203	0
4.5.2(6)	Number of individuals who have received USG supported long-term agricultural sector productivity or food security training			
	Total	12	12	2
	Female	7	7	1
	Male	5	5	1
4.5.2(7)	Number of individuals who have received USG supported short-term agricultural sector productivity or food security training			
	Total	165	206	40
	Female	52	63	20
	Male	143	143	20
4.5.2(11)	Number of food security private enterprises (for profit), producers organizations, water users associations, women's groups, trade and business associations, and community-based organizations (CBOs) receiving USG assistance			
	Total	8	8	2
	New	0	0	0
	Continuing	8	8	2
4.5.2(39)	Number of new technologies or management practices in one of the following phases of development: (Phase I/II/III)			
	Total	6	6	3
	Phase 1 Number of new technologies or management practices under research as a result of USG assistance	0	0	0
	Phase 2 Number of new technologies or management practices under field testing as a result of USG assistance	3	3	1
	Phase 3 Number of new technologies or management practices made available for transfer as a result of USG assistance	3	3	2

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- Ansah, Y. B., Frimpong, E. A., Amisah, S., Adjei-Boateng, D. 2012. Effects of Two Aquaculture Best Management Practices on Tilapia Growth. Virginia Tech Graduate Research Symposium, Blacksburg, Virginia. March 28, 2012.
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## VII. CAPACITY BUILDING

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Capacity building is central to the work conducted by AquaFish and participating Host Country and US institutions. The bulk of the AquaFish human capacity building effort is achieved through short-term (non-degree) and long-term (degree) programs. These efforts help develop professional-level skills and abilities for trainees in aquaculture and aquatic resource management. Short-term trainings most frequently occur as seminars, workshops, field demonstrations, and short-courses scheduled for periods of half a day to two or three weeks. These training sessions focus on specific topics, often linked to innovative methodologies and technologies developed by AquaFish researchers in response to needs on the ground. 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.

The capacity building efforts of AquaFish help to benefit stakeholders in the US and participating Host Countries through the transfer of knowledge and technology in aquaculture and aquatic resource management. Each core project conducted by an AquaFish Lead Partner Institution is designed to address country-specific development gaps related to national and local food security, income generation, market access, sustainable resource management, and gender equality. This overall effort is one of the crosscutting elements of the program as a whole, and is a fundamental component towards addressing the AquaFish mission.

### SHORT-TERM TRAINING

During FY13, one short-term training was carried out under the core research projects, reaching 14 trainees. Additionally, two short-term training sessions were carried out by the AquaFish Associate Award project. The shortage of short-term training data available for FY13 reflects the unique situation of the program.<sup>1</sup> Phase I projects were closing down, having completed most short-term trainings in earlier years, and Phase II projects were just getting underway at the end of the fiscal year. From 2006-2013, including the Associate Award projects (SIRTD and Mali), 245 training events occurred in 20 countries with 7,601 participants (Figure VII-1).<sup>1</sup> For core research projects (not including SIRTD or Mali), 6,099 people were trained. During Phase II continuing projects will carry out short-term trainings under the 2013-2015 Implementation Plan.

As Phase I projects came to a close over the last two reporting periods, 21 total events were conducted, reaching 862 trainees, 33% of whom were women for FY12 and FY13 including trainings associated with SIRTD projects. Short-term training data for FY12 was not pulled out as a subset in the previous year's Final Report and is therefore included in this report. Core research projects carried out 15 of the 21 trainings, with the remaining six carried out by Associate Award projects (527 trainees, 28% women).

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<sup>1</sup> Data provided in this report reflect the best information available as of the date of analysis (data are drawn from FY13 training databases and project reports received as of 9 September 2013).



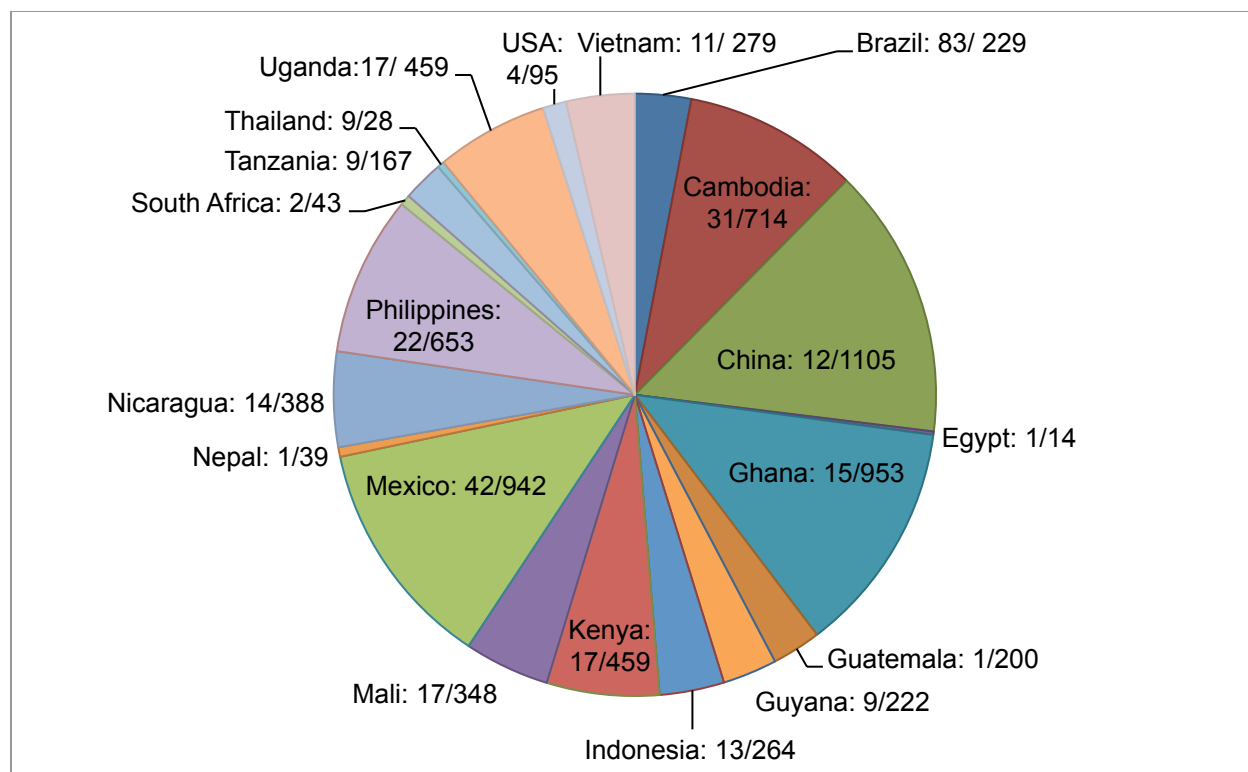


Figure VII-1. Numbers of events and participants in AquaFish Phase I short-term trainings, by country from 2006-2013. AquaFish Associate Award data are included in this figure.

### **Gender Distribution of Short-Term Trainings**

For all Phase I trainings (from 2007 through March 2013), 33% of the total 7,601 short-term trainees were women. The gender distribution by country for Phase I short-term trainees is shown in Table VII-1. Higher percentages of female trainees in some countries (e.g., 50% in Guyana and Thailand and 59% in Nicaragua) reflect efforts in the respective projects to focus trainings on activities or skills in which women have traditionally been involved, or a concerted effort to include more women in trainings that have traditionally involved male participants, and also that in these countries, historically men were more engaged in the fisheries and aquaculture sector. Lower percentages of women trained in Phase I short-term events in some countries may indicate that the types of aquaculture and fisheries trainings were skewed toward traditionally male-dominant activities. Moving forward, Phase II core projects include at least one activity specifically designed for women as a deliberate way of involving more women in AquaFish short-term trainings.

The total number and proportion of female short-term trainees increased appreciably during Phase I between the 2007-2009 and 2009-2011 Implementation Plans (Figure VII-2). Under the 2007-2009 Implementation Plan, there were 989 female short-term trainees (32% of total trainees), and this number increased to 1,102 female trainees (39% of total trainees) under the 2009-2011 Implementation Plan. During the last two years of Phase I (2011-2013), the proportion of women participants increased to 43% of total trainees through 13 additional short-term trainings that reached 291 people. Phase II requirements increase trainings for women and should therefore help to continue the upward trend of women's participation in short-term trainings.

Table VII-1. Numbers and percentages of women trainees participating in AquaFish short-term trainings (2006 to 2013), by country where events were held. AquaFish Associate Award data are included.

<b>Country</b>	<b>Trainee Total</b>	<b>Number of Women</b>	<b>% Women</b>
Brazil	229	83	36%
Cambodia	714	226	32%
China	1105	334	30%
Egypt	14	1	7%
Ghana	953	214	22%
Guatemala	200	40	20%
Guyana	222	112	50%
Indonesia	264	72	27%
Kenya	459	118	26%
Mal	348	33	9%
Mexico	942	405	43%
Nepal	39	17	44%
Nicaragua	388	277	59%
Philippines	653	299	46%
South Africa	43	12	28%
Tanzania	167	48	29%
Thailand	28	14	50%
Uganda	459	128	28%
USA	95	6	6%
Vietnam	279	68	24%
<b>Total</b>	<b>7601</b>	<b>2507</b>	<b>34%</b>

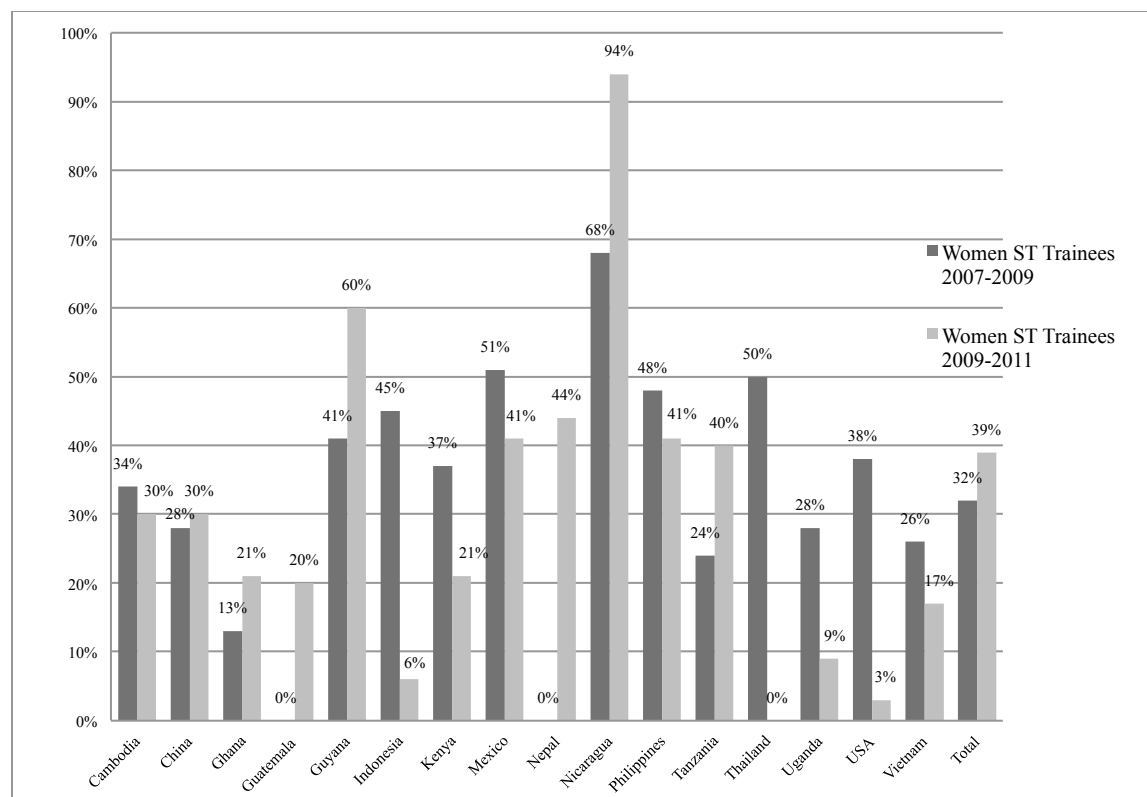


Figure VII-2. Percent of women short-term (ST) trainees for the 2007-2009 and 2009-2011 Implementation Plans by Host Country. \* Zeros represent Implementation Plans under which no trainings were conducted.

### LONG-TERM TRAINING

From late 2006 to 31 March 2013, a total of 351 degree-seeking students received program support, including 183 men and 168 women (52% and 48% respectively), for an almost 50:50 balance. During the 2013 fiscal year, AquaFish supported the long-term training of 51 students, including 25 men and 26 women (49% and 51%, respectively), from 14 countries. The distribution of these students by nationality is shown in Figure VII-3 and Table VII-2. Most students receive partial funding from AquaFish, which is heavily leveraged, adding great value to the program. Students from non-AquaFish Host Countries are typically funded by external sources, but become part of the AquaFish effort through shared roles and resources at universities with Lead AquaFish researchers.

#### Long-Term Degrees Supported During FY13

Of the 51 students enrolled in long-term training programs during FY13, 28 students were seeking bachelor's degrees (55%), 17 students were seeking master's degrees (33%), 5 students were seeking doctorates (10%), and one student was a post-doc (2%) (Figure VII-4). Over half of the enrolled BS students were women (57%), nearly half of the MS students were women (47%), and 40% of the PhD students were women.

Eight long-term students completed their training in FY13: four students from Cambodia, two from the USA, one from Tanzania, and one from Uganda. Five students completed Bachelors degrees and three completed Masters degrees. Of the eight students, three were women.

Under Phase II, AquaFish has initiated support for 11 long-term students in FY13, including two MS students in the USA (one man and one woman) and one woman PhD student in Ghana. Note that under

Phase II USAID asked for AquaFish to consolidate activities in fewer countries; as a result, numbers of long-term students are expected to decline at least temporarily.

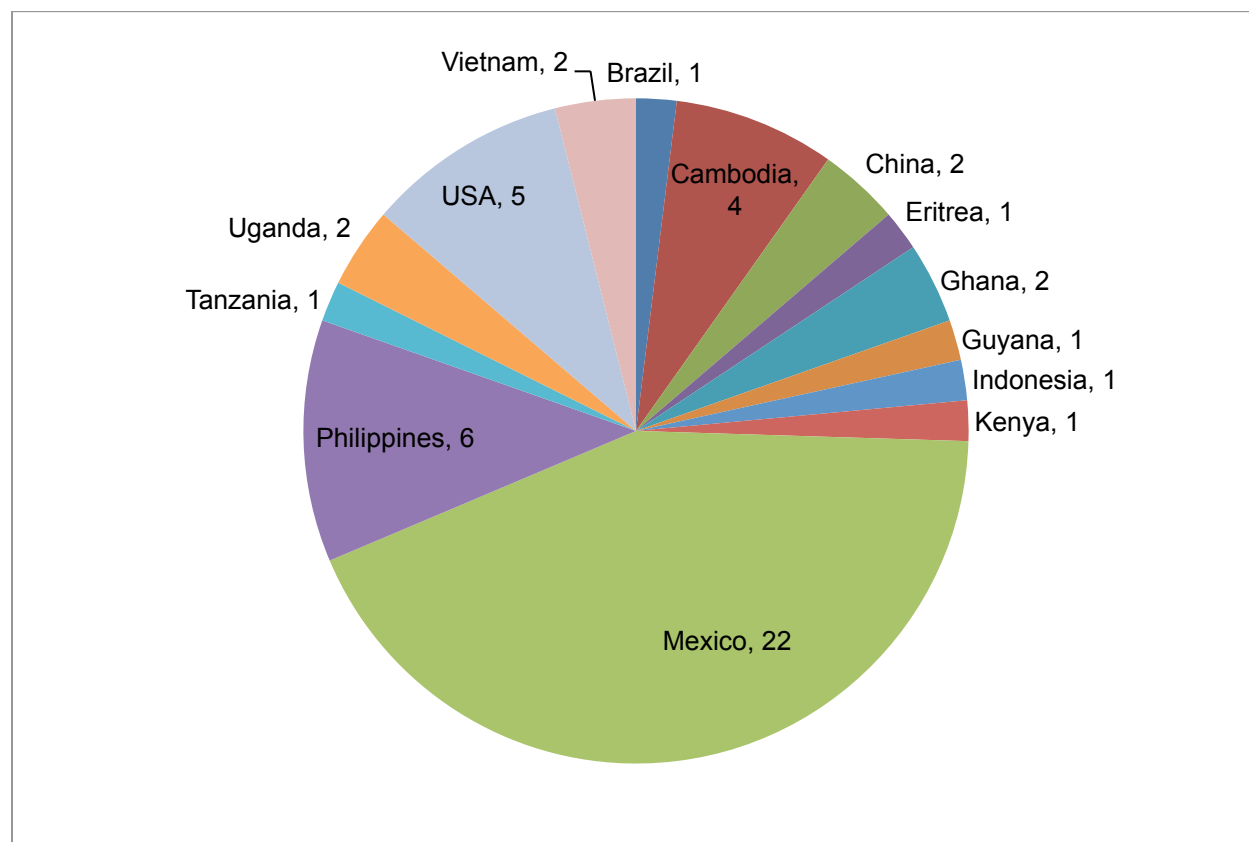


Figure VII-3. Number of students in FY13 by nationality (total = 51).

Table VII-2. Number, percentage, and gender of long-term students supported by AquaFish in FY13.

Nationality	Trainee Total	Number of Women	% Women
Brazil	1	0	0%
Cambodia	4	2	50%
China	2	0	0%
Eritrea	1	0	0%
Ghana	2	2	100%
Guyana	1	1	100%
Indonesia	1	1	100%
Kenya	1	0	0%
Mexico	22	11	50%
Philippines	6	5	83%
Tanzania	1	0	0%
Uganda	2	0	0%
USA	5	3	60%
Vietnam	2	1	50%
<b>Total</b>	<b>51</b>	<b>26</b>	<b>51%</b>

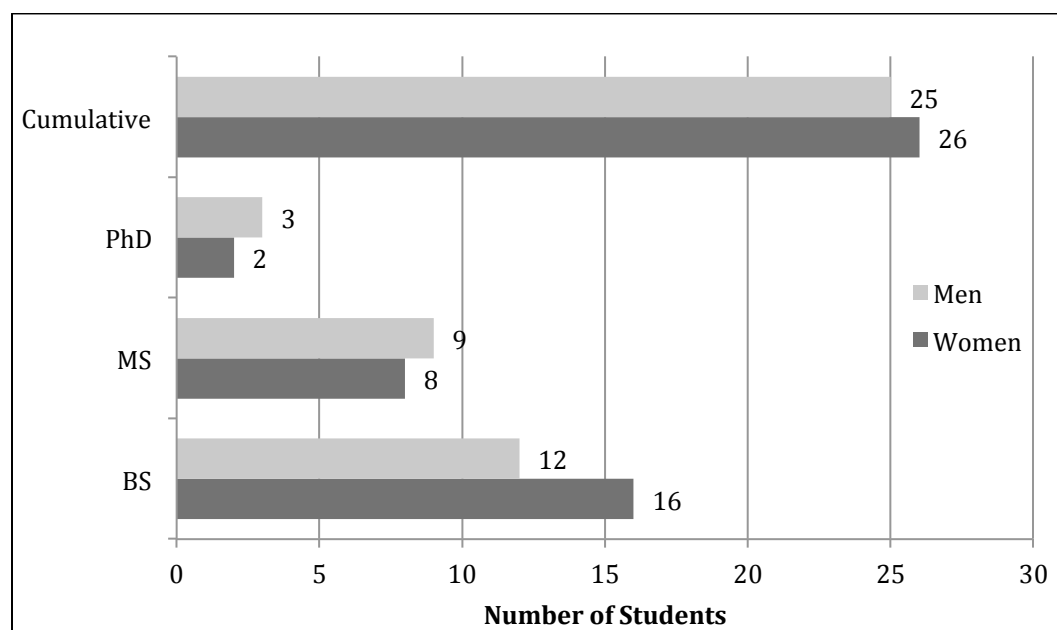


Figure VII-4. Number of men and women students in FY13 by degree sought.

#### **Long-Term Degrees Supported During Phase I**

For all of Phase I, 351 long-term degrees were supported by AquaFish, with 160 seeking bachelor's degrees, 143 seeking master's degrees, and 36 seeking doctorates (Figure VII-5). Women represented 48%, 50%, and 44% of the total bachelors, masters, and doctorate degrees, respectively. Table VII-3 shows the nationality of all long-term students during Phase I, and the percentage of women for each country.

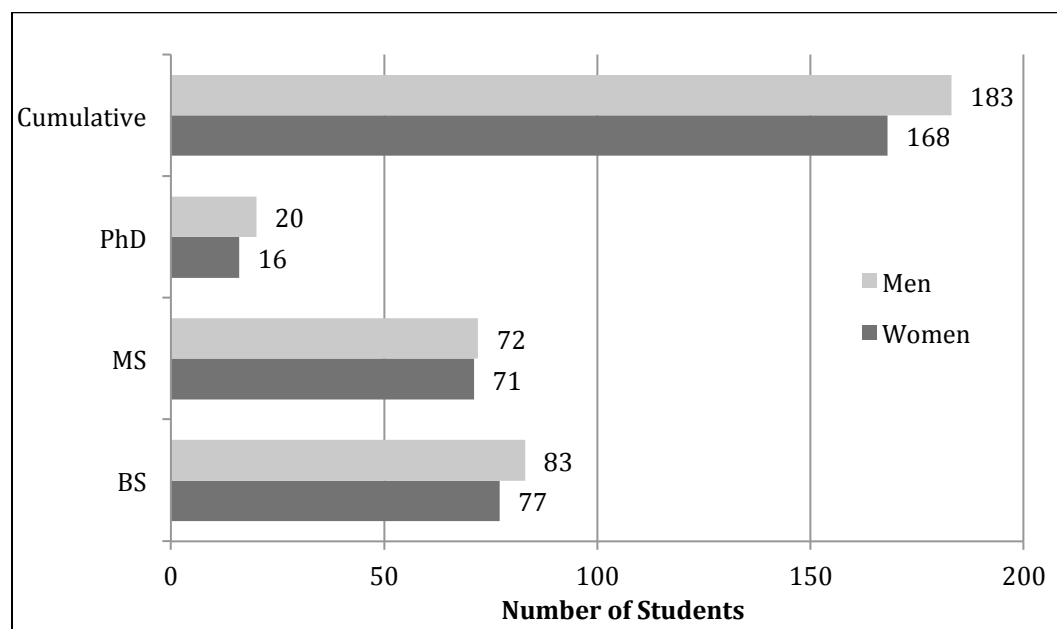


Figure VII-5. Number of men and women students in Phase I (2006-2013) by degree sought.

Table VII-3. Number, percentage, and gender of long-term students supported by AquaFish in Phase I (2006-2013).

<b>Nationality</b>	<b>Trainee Total</b>	<b># of Women</b>	<b>% Women</b>
Bangladesh	1	1	100%
Brazil	1	0	0%
Cambodia	21	11	52%
China	41	23	56%
Ecuador	2	0	0%
El Salvador	1	0	0%
Eritrea	1	0	0%
Ghana	23	12	52%
Guyana	4	2	50%
India	1	0	0%
Indonesia	1	1	100%
Ivory Coast	1	1	100%
Kenya	21	10	48%
Mali	3	1	33%
Mexico	51	19	37%
Micronesia	1	0	0%
Nepal	7	3	43%
Nicaragua	14	7	50%
Nigeria	1	0	0%
Other	1	0	0%
Philippines	48	31	65%
Samoa	1	1	100%
South Africa	1	1	100%
Tanzania	8	3	38%
Uganda	5	0	0%
USA	45	26	58%
Vietnam	46	15	33%
<b>Total</b>	<b>351</b>	<b>168</b>	<b>48%</b>

### OUTCOMES AND IMPACTS OF AQUAFISH CAPACITY BUILDING EFFORTS

AquaFish has a long history of capacity building in aquaculture and fisheries in the US and developing countries. Professional development is achieved through funding young faculty, supporting travel to conferences and symposiums, and creating opportunities for network building and collaborative work. Improvement of aquaculture practices on the ground is achieved through innovative technologies and curriculum and course development designed to transfer scientific advancements to aquaculture individual practitioners, communities, researchers, and policy makers. Examples of outcomes and impacts of these efforts for FY13 are listed below.

- The Yang Yi Young Scientist Travel Award was given to Dr. Youji Wang and Ms. Dongmei Zhu at the 10<sup>th</sup> Asian Fisheries and Aquaculture Forum. The award was established in association with Shanghai Ocean University in honor of Professor Yang Yi who passed away in 2010. The award was created in remembrance of Professor Yang Yi, a longtime CRSP researcher, to support young

scientists in aquaculture and fisheries attending international professional conferences. The selection process began in 2012, when the selection committee nominated six candidates from Bangladesh, Thailand, Malaysia, and China. Dr. Wang and Ms. Zhu were selected as recipients of this year's award by selection committee vote. To date, this honor has been awarded to two other students in previous years: Zexia Gao from China (2010) and Narayan Prasad Pandit from Nepal (2011).

- AquaFish MS student, Akkuffo Amankwah, received a Borlaug Leadership Enhancement in Agriculture Program (LEAP) fellowship in April 2013. The Borlaug LEAP provides support for thesis research conducted by graduate students from developing countries, and recognizes students who demonstrate strong scientific and leadership promise. Pursuing his PhD at Purdue University under the mentorship of AquaFish US PI, Dr. Kwamena Quagraine, Akuffo has been involved with the AquaFish Strategic Investment in Rapid Technology Dissemination (SIRTD) Associate Award Project, entitled *Feed the Future: Enhancing the Profitability of Small Aquaculture Operations in Ghana, Kenya, and Tanzania*.
- AquaFish capacity building efforts in Ghana have played a role in strengthening existing curriculum and creating a new program at Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi. AquaFish supported the development of eight aquaculture courses by four faculty in the College of Agriculture and Natural Resources at KNUST from 2007-2013. Dr. Steve Amisah, AquaFish HC-PI, was recently named the Dean of Faculty in this College. A newly formed BSc degree in Fisheries and Water Resources Management within this College resulted from AquaFish's long-term support, and Dr. Nelson Agbo, AquaFish HC Investigator, was named the Head of the Department. Admission to the newly formed BSc in Aquaculture and Water Resources Management Program, an applied program aimed at aquaculture as a business, began Fall 2013. Twenty students enrolled in the first year, and 50 applied for admission in the second year. The creation and growth of this new program and are an indication of the progress being made in the aquaculture and fisheries sectors of Ghana. A new MS/MPhil degree in Aquaculture Business Management is now under review by the National Accreditation Board of Ghana for subsequent implementation in September 2014.
- John Walakira of Uganda (Auburn University) won the SARNISSA-ASAKUA Fish Health Competition for his work on fish diseases. Mr. Walakira is a long-term trainee pursuing a PhD with full support of AquaFish. His current work explores the prospects of farming lungfish to increase income generation and nutrition for small-scale farmers in Uganda. John is an active mentor of other young scientists and contributes to training farmers on the ground in innovative fish farming methods and techniques.
- AquaFish Director, Dr. Hillary Egna, was recognized by the Asian Fisheries Society (AFS) at the 10th Asian Fisheries and Aquaculture Forum (10AFAF) with the Merit Award from the Society in recognition of her scientific achievements and her contributions to development in AFS. Additionally, in recognition of her impact on the field of aquaculture, Dr. Egna was presented the Honorary Life Award by the World Aquaculture Society (WAS) at the triennial meeting in Nashville, Tennessee on 22 February 2013. Dr. Egna is the first woman to receive the award in its 50 year history and was nominated by WAS members for her "longstanding and significant contribution" to the field of aquaculture.
- An AquaFish workshop on Value Chain Analysis for Aquatic Products included thirty-two AquaFish participants in Stonetown, Zanzibar, in September 2012. Organized by the Management Office at OSU and the University of Connecticut AquaFish Project under Dr. Bob Pomeroy, the workshop was facilitated by the Western Indian Ocean Marine Science Association (WIOMSA). The primary objectives of the workshop were to provide participants with an understanding of value chain analysis (VCA) and organizational analysis methods and to discuss the objectives, approaches, and methods being undertaken by the seven Phase I core AquaFish research projects. Strategically held in the days leading up to IIFET 2012 Tanzania, the workshop convened in time

for participants to attend the conference on 17-20 July 2012. This Phase I capacity building event was not reported on during FY12 and is therefore documented in the FY13 report.

- At UJAT in Mexico, over 12 years, AquaFish supported eight key faculty members and the development of courses in Experimental Design, Culture of Aquatic Organisms, Fish Nutrition, Tilapia Aquaculture, and Limnology. Key faculty incorporated the new courses into curriculum revisions for the BS in Biology, BS in Aquaculture Engineering, and the MSc in Environmental Sciences degrees. AquaFish also helped strengthen the infrastructure of the Tropical Aquaculture Laboratory of the Biological Sciences Division, the Aquaculture Laboratory of the Agricultural Sciences Division, and the Marine Aquaculture Station. Research for theses is conducted at these facilities, which are also used for teaching workshops and laboratory classes in support of the above-mentioned degrees.

### AQUAFISH CO-SPONSORED CONFERENCES AND EVENTS

International and regional conferences offer AquaFish participants access to technical information on aquaculture and fisheries topics, as well as opportunities to meet other professionals who are conducting research, training students, and carrying out extension activities on a global stage. When possible, AquaFish 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 AquaFish. Whenever possible, students are sponsored to attend conferences, present the results of their AquaFish research, and establish connections that will help them continue their professional careers after they return to their home countries. AquaFish efforts in this area also increase the visibility of the program and represent an important component of the overall AquaFish dissemination strategy.

Several AquaFish co-sponsored conferences, symposia, and meetings were organized and conducted during the FY13 reporting period. Highlights of these activities include:

- **The Tenth International Symposium on Tilapia in Aquaculture (ISTA10)** was co-sponsored by AquaFish in Jerusalem 6-10 October 2012. AquaFish director, Dr. Hillary Egna, served as chair and also co-chaired the awards selection committee. This event brought together tilapia biologists and culturists who review the newest innovations in nutrition, physiology, genetics, and other aspects of tilapia production. The proceedings included several original contributions from AquaFish CRSP researchers in the field of tilapia.
- **The Sixteenth Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET)** was held in Dar es Salaam, Tanzania, 16-20 July 2012. This AquaFish co-sponsored conference was well attended with participants representing 53 countries. The conference focused on revealing the hidden possibilities of fisheries in all areas of the world, with particular emphasis on Africa and other developing regions. AquaFish Director, Dr. Hillary Egna, organized and chaired the main conference session, and co-chaired a special session with Dr. Meryl Williams, collectively focusing on fish value chains with an emphasis on gender integration. *NB: This event occurred in FY2102, but it was not reported in the AquaFish FY12 Annual Report.*
- **The Sixth Annual Fish Farmers Symposium and Trade Fair of the Walimi Fish Farmers Cooperative Society (WAFICOS)** was held 23-25 January 2013 in Kampala, Uganda. This AquaFish co-sponsored symposium and trade fair attracted fish farmers, researchers, technical advisors, students, and policy makers from the whole region. The theme of the symposium was *Play your part in sustainable commercial aquaculture and fisheries management*, with a focus on



addressing bottlenecks in the emerging aquaculture value chain in the region. The goal was to promote market growth and positive relationships. Several AquaFish partners presented, notably AquaFish supported-student and Co-PI John Walakira, who shared novel work on the culture of the African lungfish (*Protopterus spp.*).

- **The Fourth Gender in Aquaculture and Fisheries (GAF4)** event at the Tenth Asian Fisheries and Aquaculture Forum in Yeosu, South Korea, was co-sponsored by AquaFish 30 April – 4 May 2013. On the first day of the symposium, Dr. Hillary Egna, Director of the AquaFish Innovation Lab, chaired Session One (titled *Gendered Change*) with Co-Chair Dr. Kyoko Kusakabe. The session focused on the capabilities and vulnerabilities with respect to changes in the aquaculture and fisheries sector (environmental, social, cultural, and economic).
- **The Africa Regional Orientation Meeting** was held 8-9 July 2013. AquaFish Innovation Lab co-sponsored a workshop for Scaling Agricultural Technologies and Developing Collaborative Partnerships to Prioritize Research for Development in Accra, Ghana. This workshop involved several other Innovation Lab programs, the Bureau of Food Security from USAID, and officers from the mission in Ghana to discuss potential synergies between Innovation Labs and USAID missions in designing and creating greater value in extension and capacity building efforts. Participants also reviewed the status of the innovation labs and plans moving forward into current funding cycles.



Women in Cambodia weaving fish onto skewers for smoking. Photo by Peg Herring.

### AQUAFISH STUDENT PROFILES



#### CECILIA MUTHONI

Cecilia is currently working on an MSc in Aquaculture at Moi University in Eldoret Kenya, having completed a BSc in Fisheries and Aquatic Sciences there in 2009. It was when she was in high school that Cecilia first gained an interest in aquaculture after hearing of the advances being made in China and Norway. Of particular interest to her was the opportunity to use fish farming and fishing as an economic activity, which is apparent in her thesis on *Consumer Preferences of Wild and Cultured Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) in Selected Urban Centers of Kenya* and in the CRSP work she is helping with to improve the productivity for fish farmers in Kenya with best management practices (BMPs).

Under the guidance of her major professor, long-time CRSP HCPI Dr. Charles Ngugi, Cecilia is helping the AquaFish CRSP team to advance the adoption rate of BMPs in various regions in Kenya with the hope of improving the quality and quantity of local fish production. This work not only provides great benefit for the fish farmers involved, but also creates opportunities for students to understand the importance of well-tested BMPs and for them to play a role in disseminating proper techniques.



#### CAROLYN MUSYOKI

Carolyn first got involved with the AquaFish CRSP best management practices investigation in Kenya in 2010, which has been funding a portion of her graduate studies in Hydrobiology (Fisheries Resource Management) at the University of Nairobi. Her CRSP work on BMPs integrates well with her MSc research, *Evaluation of the Impact of the Economic Stimulus Program (ESP) Aquaculture Development Intervention on Income Generation in Kiambu County*, which she is carrying out under the mentorship of her major professor, Dr. Charles Ngugi. With a BSc in Agricultural Economics and Resource Management, Carolyn aims to complete her Master's research by June 2013 and hopes to continue working with small scale fish farmers for her PhD.

Realizing the importance of fish as a source of protein and the tragedy of dwindling wild fish resources, Carolyn's interest in aquaculture is rooted in the possibilities it provides for improving livelihoods. She states that "aquaculture, being one of the fastest growing sectors, has shown promising results and thus more people can access fish hence improving the society's nutritional status and at the same time it's a means of improving the livelihoods of the small scale fish farmers and [increasing] job creation." Simultaneously, Carolyn understands the challenges that aquaculture faces in Kenya including the lack of quality feeds and seeds, poor infrastructure, and pollution from pond effluents. Overcoming these challenges with techniques such as BMPs will increase the successes that Kenya is starting to see from the aquaculture industry—it is a source of alternative income, it has created new jobs for the youth and for women, and it has improved the nutritional health of local communities by making fish a more accessible food choice. Seeing some of these successes first hand, Carolyn considers her interactions with farmers during workshops as her most enjoyable experience in her work with AquaFish CRSP.





### ANTHONY MUTHONI

Anthony worked on his MSc in Fisheries Sciences at Kenyatta University with Dr. Charles Ngugi, ultimately striving to become a leading fish expert in Kenya. With support from the AquaFish CRSP Associate Award, he is pursuing his goals and is working to overcome one of the major challenges to fish farmers—affordable feeds. His master's thesis evaluates the *Effects of dietary protein levels on growth performance and yield of all male Nile tilapia (Oreochromis niloticus, linn.) in an integrated cage-cum-pond culture system* with the hopes of increasing profit margins for farmers by enhancing fish growth at a lower feed cost. The research aims to identify an optimum dietary protein level for maximum growth and yield for all-male Nile tilapia in an intensive cage-cum-pond system. In addition to providing the potential for increased profits, the results of Anthony's research will also be used to develop an enterprise budget as a financial guide for small-scale fish farmers.

One of his most enjoyable experiences has been "...being [involved] at Mwea Aquafish Farm, one of the highly productive private fish farm in the republic. I have had an opportunity to interact closely with fish, understanding their ecology, physiology, biology and most interestingly their social behavior. In particular, I've enjoyed working with Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*). I wake up every morning looking forward to learn[ing] more about this diverse group of organisms."



### JOHN WALAKIRA

John, a Ugandan PhD candidate at Auburn University, focused his research on the African Lungfish, a fish native to Uganda. His dissertation, *Culture of African Lungfish (Protopterus spp) in Uganda: Prospects in Aquaculture Development, Growth Performance in Tanks, and Potential Pathogens*, will help develop methods and technologies to increase fish productivity and reduce disease. This work is critically important to aquaculturalists and to threatened wild fish populations. Working alongside AquaFish US PI, Dr. Joseph Molnar and the National Fisheries Resources Research Institute in Kampala, John will continue his research and expand his focus on income generation and nutrition for small-scale farmers in Uganda.

John has been involved with AquaFish for the past several years, building on his biological sciences degree from Makerere University in Uganda. John's most valued experiences with AquaFish include sharing knowledge and learning research skills through working with scientists and farmers globally. He plans to continue to mentor young scientists and managers in aquaculture, and to join farmers in developing the aquaculture industry in Uganda. AquaFish is proud to announce that John is a recipient of the SARNISSA-ASAKUA Fish Health Competition and his work will reach a broad network of African aquaculturists.



## VIII. SYNTHESIS

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The AquaFish Management Entity (ME) brought together highly creative and knowledgeable people into functional advisory groups during ACRSP, and carried forward this successful structure into AquaFish Phase I. In Phase II, AquaFish streamlined advisory groups in response to USAID and BIFAD reviews suggesting a slimmer structure. Three advisory groups (two technical, one external) were retained and one (Emerging Issues Panel) was dissolved. These advisory groups provided linkages to the broad community engaged in global aquaculture and fisheries development issues.

In this fiscal year, the technical advisory groups (RCE and DTAP) were responsible for synthesizing information across regions and themes. These synthesis activities provide a means of increasing the impact and reach of the AquaFish mission and allow for more effective communication of program accomplishments.

### DEVELOPMENT THEMES ADVISORY PANELS (DTAP)

DTAP coordinators provide technical advice on emerging issues and identify 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 MT in integrating cross-cutting needs, and 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 following summaries highlight progress in FY13 on accomplishments categorized under the four DTAP development themes. Phase I Lead Coordinators are included below in each development theme progress report. Phase II changes are reflected in the list of DTAP program participants in Appendix 1.

#### **DTAP A: Improved Health and Nutrition, Food Quality, and Food Safety of Fishery Products**

*Lead Coordinator: Maria Haws (University of Hawai'i at Hilo)*

Up to 50% of the world's seafood supply may be lost or decreased in value due to poor production and post-harvest practices. Aquaculture now accounts for about 50% of the world's aquatic products supplies. There is also a strong relationship between environmental quality, aquaculture practices, and product quality and safety. Additionally, some of the world's most vulnerable demographic segments are particularly dependent upon aquaculture and fisheries for food. These same groups are also the most vulnerable to food borne illnesses and economic losses when products are affected by decomposition or contamination, or when they harbor pathogens. Improving the quality, safety, and availability of aquaculture products is crucial for food security, sustainability, and for increasing economic benefits for all stakeholders. Undernourishment is a worldwide problem among the poor that affects all ages and plays a major role in perpetuating poverty.

During FY13, AquaFish projects in Africa, Asia, and LAC focused directly and indirectly on alleviating this problem through a broad spectrum of activities and research. In Nicaragua, AquaFish researchers worked to develop value-added products and improve product safety as a way to amplify the benefits to fishers and vendors along the black cockle value chain and to improve food safety standards for cockle

consumers. Collaborators at CIDEA have been working with community members to add modifications to an existing solar-powered cockle depuration center to bring it into compliance with government HACCP requirements. AquaFish provided support for a graduate student from the University of Michigan, who conducted a nutrition study in rural Nepal as a way to explore the potential impact of small-scale aquaculture on childhood nutrition. Working closely with AquaFish researchers at the Institute of Agriculture and Animal Sciences (IAAS, now the Agriculture and Forestry University), Zachary's study involved 86 families in Southern Nepal. In Cambodia, AquaFish researchers conducted a value chain analysis of freshwater small-sized fish, a key source of protein and important food source for the rural poor. In Nepal and Uganda, AquaFish is making connections with the Nutrition Innovation Lab and additionally in Uganda with the International Livestock Research Institute as a way to collaborate on common activities and resources under CRP 3.7.

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

*Lead Coordinator: Kwamena Quagrainie (Purdue University)*

A key factor in developing and growing the aquaculture industry in rural areas is the domestic capacity to develop and extend locally adaptable technologies and practices to improve livelihoods. This is accomplished in a number of different ways, from adopting best management practices and developing value-added products, to discovering new markets. In this reporting period, AquaFish researchers made progress in laying the groundwork for income generation for small-scale fishers and farmers through value chain analysis (VCA) in seven countries and improving production practices for two air breathing fishes.

In FY13, AquaFish researchers in Indonesia, Ghana, Mexico, Cambodia, Nicaragua, and Nepal conducted VCA on key aquaculture products in each region as a way to better understand the market conditions and provide insight into where income generation opportunities exist or improvements can be made. The VCA results can be used to increase farmer incomes through new or improved market access, competitiveness, and efficiencies.

In another line of research, two AquaFish investigations are working toward developing and expanding markets for two air-breathing fish: gars (*Atractosteus* spp.) and chame (*Dormitator latrifons*) by improving culture techniques. Progress has already been made in the aquaculture of *Atractosteus* gars (tropical, Cuban, and alligator gars in particular) in Mexico, Cuba, and the southern US. Techniques to lower production costs will make gar culture more available to small-scale farmers and open new markets for local economies. The development of chame for aquaculture is still in the early stages, but continues to show promise for improving incomes.

### **DTAP C: Environmental Management for Sustainable Aquatic Resources Use**

*Lead Coordinator: Jim Diana (University of Michigan)*

AquaFish has two goals that relate to environmental management and 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 to contribute to sustainable intensification, national food security, income generation, and market access. In FY13, a group of investigations, called the "experimental pond unit assessment" (EPUA) established groundwork toward both of these goals: building human and institutional capacity with expertise on pond dynamics and water quality assessment for aquaculture and enhancing the opportunities for better pond management towards more efficient production techniques. This work will ultimately build the foundation for a program-wide global experiment, designed to quantitatively describe the physical, chemical, and biological principles of pond culture systems within the social, political, and economic context present at each AquaFish site. Information gained from the

global experiment can then be used to improve production technologies and enhance the sustainability of pond culture for small-scale fish farmers. The FY13 EPUA work took place in Bangladesh, Ghana, Kenya, Cambodia, Nicaragua, and Nepal.

In FY 2013, AquaFish continued research with air-breathing fishes - species that are good aquaculture candidates for adapting to the impacts of climate change and combating the pressures of overfishing. Because of their unique ability to breathe air, these fish can survive poor water quality and long droughts. As natural habitats become degraded and climate patterns become more variable, the value of these air-breathing fish species may prove to be very high. During FY13, AquaFish researchers continued work on gars (*Atractosteus* spp.) and chame (*Dormitator latrifons*).

#### **DTAP D: Enhanced Trade Opportunities for Global Fishery Markets**

*Lead Coordinator: Bob Pomeroy (University of Connecticut at Avery Point)*

In FY13, the development of new domestic and international markets for aquatic products continues to progress. The primary focus of this theme was to conduct a series of VCAs on key aquatic species cultured in Indonesia, Ghana, Mexico, Cambodia, Nicaragua, and Nepal. International development organizations are increasingly focusing attention on entrepreneurship and agricultural trade via linkages with better rewarding markets, promoting exports of agricultural products, and fostering competitiveness in the agricultural sector. VCA therefore provides a reference point for improvements in products and services, and for consequent improvements in the economic welfare of the poor by linking small householder farmers and their families with the market. The work done in this reporting year provided a foundation for moving into Phase II by developing a better understanding of the intricate linkages between the chain elements, performance, and value-added distribution to allow a determination of optimal institutional arrangements and policy approaches for smallholder participation.

#### **REGIONAL CENTERS OF EXCELLENCE (RCE)**

The Regional Centers of Excellence (RCEs) provide technical advice on emerging issues and identify 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. Two centers have been formed in each region and they coordinate activities within their specified area. 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. The RCEs and coordinators include:

**RCE–Africa**, *Lead Coordinators: Charles Ngugi & Hery Coulibaly*

**RCE–Asia**, *Lead Coordinators: Remedios Bolivar & Yuan Derun*

**RCE–LAC**, *Lead Coordinators: Wilfrido Contreras-Sánchez & Maria Célia Portella*



## IX. MONITORING AND EVALUATION

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The current AquaFish Monitoring and Evaluation (M&E) Plan was updated and submitted as a component of the AquaFish Innovation Lab application in February 2013 and was approved by USAID/OAA on 29 March 2013, with an additional update and approval on 9 September 2013. The Plan was initially formalized in 2007 to measure and evaluate progress and program impacts. In the current plan, benchmarks and milestones provide a means of exploring qualitative performance measures to complement the quantitative impact indicators and metrics designed by USAID for reporting under the Feed the Future Monitoring System (FTFMS). The milestones and benchmarks reported on below for FY13 represent only half of a year of project activity since Phase II began 31 March 2013.

### KEY DEVELOPMENT TARGETS: MILESTONES AND BENCHMARKS

The following conceptual framework helps ensure that targets are adequately addressed across the global portfolio, and facilitates feedback and continuous learning in order to improve processes and outcomes. The AquaFish gender strategy demonstrates a continued strong programmatic commitment toward gender inclusion. Gender is integrated into the four targets and also highlighted independently.

\*NOTE: Year-one benchmarks began 31 March 2013; therefore the current report as published in October 2013 represents only half of the annual project period.

#### **Research Target**

Produce end-user aquaculture research results that promote sustainable intensification of production systems, enhance food safety and nutrition, increase international trade opportunities, and contribute to responsible aquatic resource management.

#### **Program-wide Research Milestones**

- (1) Developed and adopted innovative and appropriate 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 habitat and populations.
- (3) Continuously funded research projects that meet or exceed the expectations of external peer-review panels.
- (4) AquaFish activities and outputs improved the availability of and access to nutrient dense foods.
- (5) Engaged local stakeholders in research design, implementation, and results reporting through active participation.

#### **Year 1 Benchmarks:**

- a. Request for Proposals approved by USAID and widely advertised for new projects with submitted proposals externally peer-reviewed.  
 Completed: *The AquaFish RFP was approved by USAID on 29 March 2013 and was released to five continuing US Lead Project PIs on 31 March 2013. All five submitted proposals progressed through an external peer-review process that included: external technical reviews, and an external peer-review panel and evaluation that took place on 20 May 2013. A widely advertised RFP for a new project in Burma was released on 11 May 2013.*
- b. Favorably reviewed proposals have activities initiated in a timely manner.

*In progress: Initial project started on 1 July 2013 for the five peer-reviewed proposals. The Africa Regional Orientation Meeting was held in Ghana on 5-7 July and attended by the two new Phase II AquaFish Project teams in Africa. The AquaFish Orientation Meeting was held in Washington DC on 23-24 September, attended by all five Lead US Project PIs and five Lead Host Country PIs.*

- c. Identified partners for gauging nutrition status and change. With or through the partners, established measurable baselines for the targeted groups for fish production levels, income, and diet.

*Completed: Engaged in collaborations with USAID Nutrition Advisor and Nutrition Lab AOR, Maura Mack on a number of topics related to human nutrition—including a concept note for work in Bangladesh with WorldFish. Collaborations with the Nutrition Innovation Lab in common host countries and other appropriate locations is leading to joint efforts in addressing human nutrition and establishing baselines. Key personnel in Nutrition Lab also reviewed Phase II proposals. Other collaborating institutions and organizations with a nutrition focus include the International Livestock Research Institute (ILRI) and CGIAR Research Program on Livestock and Fish (CRP 3.7).*

### **Capacity Building Target**

Focus AquaFish 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 Milestones - Regional**

- (1) Forged professional and managerial relationships between US and Host Country researchers and institutions.
- (2) Established a 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.
- (4) Identified gender issues in aquaculture and fisheries and adopted gender program-wide integration policies.

### **Year 1 Benchmarks:**

- a. Gender integration strategies adopted within all sub-awards.  
*Completed: All projects submitted a strategy, which was externally peer-reviewed and revised. A final programmatic review involving the USAID BFS Gender office was conducted, and BFS gender officer, Krista Jacobs met with PIs during the September 2013 AquaFish Orientation Meeting.*
- b. Regional Centers of Excellence continued within the AquaFish regions for research activities (i.e., Asia, Africa, and Latin America and the Caribbean).  
*Completed: Regional Centers of Excellence continue to be engaged in AquaFish activities by providing technical advice on emerging issues and identifying gaps in the portfolio from a regional perspective.*
- c. Formal Memoranda of Understanding adopted between all US and Host Country partners.  
*In progress: MOUs are drafted and in progress for the five Phase II projects.*

### **Information Dissemination Target**

Disseminate AquaFish research results to foster broad application of results among local stakeholders within governmental and non-governmental organizations, private sector, as well as for end-users, and the general public.



### Information Dissemination Milestones

- (1) Successful diffusion of AquaFish 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 results and technologies for farm operations adopted and policies for responsible aquatic resource management created.
- (5) AquaFish research published in regional, national, and international peer-reviewed journals.

### Year 1 Benchmarks:

- a. Dissemination efforts have continued through Aquanews, EdopNet, and the searchable online publication database.  
In progress: *Publications have continued with a Summer Issue of the AquaFish newsletter, Aquanews (Vol. 28, No.1) release in August 2013; uninterrupted monthly issues of EdOp Net released to a growing list of recipients; and a continuous stream of AquaFish Notices of Publication for peer-reviewed research reports by AquaFish researchers.*
- b. The importance of extension evident through integration of at least one outreach activity within each funded project.  
Completed: *Proposals were reviewed and revised to include one or more outreach activities in each project.*
- c. Research adoption encouraged by prioritizing the use of on- and off-farm trials to conduct research.  
Completed: *Research adoption is included in every Phase II project through a peer-reviewed Outreach and Dissemination Strategy and work that includes the use of on- and off-farm trial.*

### Gender Integration: Cross-Cutting Target

AquaFish is dedicated to improving gender inclusiveness in the aquaculture and fisheries sectors. Gender integration is implicit and interwoven into the above research, capacity building, and information dissemination milestones and benchmarks requested by USAID in its original RFA. Additional explicit guidance, in the form of program-wide gender integration initiatives, is provided below.

### Year 1 Initiatives:

- a. Require that all funded projects address gender inclusiveness within their planned scope-of-work.  
Completed: *In the 2013 Request for Proposal (RFP), guidance was provided to applicants to form projects around the core program components, which includes gender integration. In a more directed effort, the RFP also required the inclusion of at least one outreach activity that focuses on women and/or girls. Further, each project was required to submit a Gender Inclusiveness Strategy as a component of their overall research proposal. The AquaFish Management Team and USAID subsequently reviewed these plans prior to implementation. Projects were not implemented until these gender inclusiveness requirements were met.*
- b. Seek out USAID review of projects' gender inclusiveness plans and respond by improving plans prior to project implementation.  
Completed: *Guidance and reviews on project gender inclusiveness plans were sought out from BFS/USAID and staff from the Gender Office, HICD, and FTFMS.*

### USAID FEED THE FUTURE INDICATORS AND MONITORING SYSTEM

AquaFish reports under various impact reporting frameworks to achieve outcomes that have meaning for stakeholders, including Missions, Host Country decision-makers, and end-users. Target and Actual indicator metrics as recorded in October 2013 and reported through the Feed the Future Monitoring System (FTFMS) for FY13 are presented in Table IX-1. Also included are preliminary estimates of FY14 indicator targets. Formal FY14 indicator targets will be set after all subprojects are reviewed and approved.

Table IX-1. AquaFish Feed the Future Monitoring System 4.5.2 Indicators for FY13 (targets and actuals) and FY14 preliminary targets.

Indicator Number	Indicator	2013 Target	2013 Actual	2014 Target
4.5.2(2)	Number of hectares under improved technologies or management practices as a result of USG assistance			
	Total	9,983	9,998	10,023
	Continuing	9,983	9,983	9,998
	New	0	15	25
4.5.2(6)	Number of individuals who have received USG supported long-term agricultural sector productivity or food security training			
	Total	30	31	44
	Female	15	17	22
	Male	15	14	22
4.5.2(7)	Number of individuals who have received USG supported short-term agricultural sector productivity or food security training			
	Total	50	74	600
	Female	25	10	300
	Male	25	64	300
4.5.2(11)	Number of food security private enterprises (for profit), producers organizations, water users associations, women's groups, trade and business associations, and community-based organizations (CBOs) receiving USG assistance			
	Total	11	8	10
	New	1	8	4
	Continuing	10	0	6
4.5.2(39)	Number of new technologies or management practices in one of the following phases of development: (Phase I/II/III)			
	Total	5	5	8
	Phase 1 Number of new technologies or management practices under research as a result of USG assistance	3	4	4
	Phase 2 Number of new technologies or management practices under field testing as a result of USG assistance	2	1	4
	Phase 3 Number of new technologies or management practices made available for transfer as a result of USG assistance	0	0	0



## APPENDIX 1. PROGRAM PARTICIPANTS

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### PROJECT PERSONNEL DEFINITIONS

#### US Project Personnel

US Lead PI: PI at the US Lead Institution managing the project (Dr. Hillary Egna)

US Co-PI: Lead investigator at each US partner institution with a contractual relationship with the US Lead institution

US Investigator: Researcher working at a US Lead or contractual partner institution

US Research Assistant: Non-student employee assisting with research at a US Lead or contractual partner institution

US Collaborator: Researcher or cooperator offering services through a non-contractual agreement and with no monetary connection to the US Lead or partner institutions

#### Host Country Project Personnel

HC Lead PI: PI at the HC Lead Institution for the project

HC Co-PI: Lead investigator at each HC contractual partner institution other than the HC Lead institution

HC Investigator: Researcher working at an HC Lead or contractual partner institution

HC Research Assistant: Non-student employee assisting with research at an HC Lead or contractual partner institution

HC Collaborator: Researcher or cooperator offering services through a non-contractual agreement and with no monetary connection to the US/HC Lead or partner institutions

### MANAGEMENT TEAM STAFF

Oregon State University, Corvallis, Oregon USA

Hillary Egna Director & Lead Principal Investigator

Ford Evans Research Projects Manager

Kathryn Goetting Communications & Outreach Manager (from September 2013)

Jenna Borberg Communications & Outreach Manager (from August 2013)

Stephanie Ichien Research Program Assistant

Caleb Price Training and Gender Coordinator (from August 2013)

Paris Edwards Training and Gender Coordinator (from July 2013)

Shawn Hayward Web Master and IT Specialist

Cindi Claflin Office Specialist

Patty Heublein Office Specialist Assistant (from May 2013, part-time)

Claire Schrodtt Research Program Assistant (part-time from September through February 2013; full-time from March 2013)

### UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

Washington, DC USA

Harry Rea Agreement Officer's Representative (AOR; through 31 December 2012)

Harry Rea USAID Consultant (from 1 January 2013)

Joyce Turk	AOR (from 1 January 2013)
Shivaun Leonard	Activity Manager (from 1 July 2013)

### ADVISORY BODIES<sup>2</sup>

#### *External Program Advisory Council*

Christine Crawford	University of Tasmania, Australia
Nathanael Hishamunda	FAO, Rome, Italy

#### *Ex-Officio Members*

Harry Rea	USAID
Hillary Egna	Oregon State University

### PHASE I

(As of Implementation Plan 2009-2011)

#### TECHNICAL ADVISORY GROUPS

#### **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 at Avery Point

#### **Regional Centers of Excellence: Lead Coordinators**

Charles Ngugi	East & Southern Africa	Moi University, Kenya
Héry Coulibaly	West Africa	Direction Nationale de la Pêche, Mali
Remedios Bolivar	Asia	Central Luzon State University, Philippines
Wilfrido Contreras-Sanchez	LAC	Universidad Juárez Autónoma de Tabasco, Mexico
Yuan Derun	Asia	Network for Aquaculture Centers in Asia-Pacific, Thailand
Maria Celia Portella	South America	Sao Paulo State University, Brazil

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<sup>2</sup> During the interim between Phase I and Phase II, advisory panels were decommissioned. Dr. Crawford agreed to continue when the Phase II award was announced. BIFAD and USAID interviewed advisors, but there was no formal participation.

**CORE RESEARCH PROJECT RESEARCHERS*****Auburn University***

<b>Participants</b>	<b>Status</b>	<b>Country</b>
<b>USA</b>		
Joseph Molnar	US Lead PI	Auburn University
Claude E. Boyd	US Investigator	Auburn University
Karen Veverica	US Investigator	Auburn University
James O. Bukenya	US Co-PI	Alabama A&M University
Bill Tollner	US Co-PI	University of Georgia
Herbert Ssegane	US Investigator	University of Georgia
<b>Uganda</b>		
Levi Kasisira	HC Lead PI	Makerere University
Theodora Hyuha	HC Investigator	Makerere University
Monica Karuhanga Beraho	HC Investigator	Makerere University
Peter Mulumba	HC Investigator	Makerere University
Nelly Isyagi	HC Co-PI	Gulu University
Gertrude Atukunda	HC Co-PI	National Fisheries Resources Research Institute
John Walakira	HC Investigator	National Fisheries Resources Research Institute
<b>South Africa</b>		
Khalid Salie	HC Co-PI	Stellenbosch University

***North Carolina State University***

<b>Participants</b>	<b>Status</b>	<b>Country</b>
<b>USA</b>		
Russell Borski	US Lead PI	North Carolina State University
Peter R. Ferket	US Investigator	North Carolina State University
Upton Hatch	US Investigator	North Carolina State University
Charles R. Stark	US Investigator	North Carolina State University
Kevin Fitzsimmons	US Co-PI	University of Arizona
Christopher Brown	US Collaborator	US Department of Commerce- NOAA
<b>Philippines</b>		
Remedios B. Bolivar	HC Lead PI	Central Luzon State University

Wilfred Jamandre	HC Investigator	Central Luzon State University
Emmanuel M. Vera Cruz	HC Investigator	Central Luzon State University
Evelyn Grace T. de Jesus-Ayson	HC Co-PI	SEAFDEC-AQD
Maria Rovilla J. Luhan	HC Investigator	SEAFDEC-AQD
Hernando L. Bolivar	HC Collaborator	GIFT International Foundation
<b>Indonesia</b>		
Hassan Hasanuddin	HC Co-PI	Ujung Batee Aquaculture Center, Banda Aceh

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***Purdue University***


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<b>Participants</b>	<b>Status</b>	<b>Country</b>
<b>USA</b>		
Kwamena Quagraine	US Lead PI	Purdue University
Jennifer Dennis	US Investigator	Purdue University
Rebecca Lochmann	US Co-PI	University of Arkansas at Pine Bluff
Emmanuel Frimpong	US Co-PI	Virginia Polytechnic Institute & State University
<b>Kenya</b>		
Charles Ngugi	HC Lead PI	Kenyatta University
Judith Amadiva	HC Co-PI	Ministry of Fisheries Development
Sammy Macharia	HC Investigator	Ministry of Fisheries Development
Julius Manyala	HC Co-PI	Moi University
<b>Ghana</b>		
Stephen Amisah	HC Co-PI	Kwame Nkrumah University of Science & Technology
Nelson Agbo	HC Investigator	Kwame Nkrumah University of Science & Technology
<b>Tanzania</b>		
Sebastian Chenyambuga	HC Co-PI	Sokoine University of Agriculture
Berno V. Mnembuka	HC Investigator	Sokoine University of Agriculture
Nazael Madalla	HC Investigator	Sokoine University of Agriculture

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***University of Arizona***


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<b>Participants</b>	<b>Status</b>	<b>Country</b>
<b>USA</b>		
Kevin M. Fitzsimmons	US Lead PI	University of Arizona
Reynaldo Patiño	US Co-PI	Texas Tech University-Lubbock

<b>Mexico</b>		
Wilfrido Contreras-Sánchez	HC Lead PI	Universidad Juárez Autónoma de Tabasco
Carlos Alfonso Alvarez-González	HC Investigator	Universidad Juárez Autónoma de Tabasco
Mario Fernández-Pérez	HC Investigator	Universidad Juárez Autónoma de Tabasco
Arlette Hernández-Franyutti	HC Investigator	Universidad Juárez Autónoma de Tabasco
Ulises Hernández-Vidal	HC Investigator	Universidad Juárez Autónoma de Tabasco
Alejandro Macdonal-Vera	HC Investigator	Universidad Juárez Autónoma de Tabasco
Pablo Gonzales Alanis	HC Co-PI	Universidad Autónoma de Tamaulipas
<b>Guyana</b>		
Pamila Ramotar	HC Co-PI	Department of Fisheries
Vivek Joshi	HC Investigator	Department of Fisheries

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***University of Connecticut–Avery Point***


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<b>Participants</b>	<b>Status</b>	<b>Country</b>
<b>USA</b>		
Robert S. Pomeroy	US Lead PI	University of Connecticut at Avery Point
David A. Bengtson	US Co-PI	University of Rhode Island
Chong M. Lee	US Investigator	University of Rhode Island
<b>Cambodia</b>		
So Nam	HC Lead PI	IFReDI
Hap Navy	HC Investigator	IFReDI
Kao Sochivi	HC Investigator	IFReDI
Prum Somany	HC Investigator	IFReDI
<b>Vietnam</b>		
Tran Thi Thanh Hien	HC Co-PI	Can Tho University
Le Xuan Sinh	HC Investigator	Can Tho University

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***University of Hawai'i at Hilo***


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<b>Participants</b>	<b>Status</b>	<b>Country</b>
<b>USA</b>		
Maria Haws	US Lead PI	University of Hawai'i at Hilo

Konrad Dabrowski	US Co-PI	Ohio State University
<b>Mexico</b>		
Eladio Gaxiola Camacho	HC Lead PI	Universidad Autónoma de Sinaloa-Culiacán
Lorena Irma Camacho	HC Investigator	Universidad Autónoma de Sinaloa-Culiacán
Omar Calvario Martínez	HC Co-PI	CIAD
Guillermo Rodriguez Domínguez	HC Co-PI	Universidad Autónoma de Sinaloa-Mazatlán
Gustavo Rodriguez Montes de Oca	HC Investigator	Universidad Autónoma de Sinaloa-Mazatlán
Olga Olivia Zamudio Armenta	HC Investigator	Universidad Autónoma de Sinaloa-Mazatlán
Jose Cristobal Roman Reyes	HC Investigator	Universidad Autónoma de Sinaloa-Mazatlán
<b>Nicaragua</b>		
Carlos Rivas Leclair	HC Co-PI	CIDEA-UCA
Nelvia Hernandez del Socorro	HC Investigator	CIDEA-UCA

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**University of Michigan**


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<b>Participants</b>	<b>Status</b>	<b>Country</b>
<b>USA</b>		
James S. Diana	US Lead PI	University of Michigan
<b>Bangladesh</b>		
Mohammed Abdul Wahab	HC Co-PI	Bangladesh Agricultural University
<b>China</b>		
Liu Liping	HC Lead PI	Shanghai Ocean University
Jiang Min	HC Investigator	Shanghai Ocean University
Dai Xilin	HC Investigator	Shanghai Ocean University
Lai Qiuming	HC Co-PI	Hainan University
Wang Weimin	HC Co-PI	Huazhong Agricultural University
<b>Nepal</b>		
Madhav K. Shrestha	HC Co-PI	Institute of Agriculture & Animal Science
<b>Thailand</b>		
Derun Yuan	HC Co-PI	Network of Aquaculture Centres in Asia-Pacific
<b>Vietnam</b>		
Nguyen Phu Hoa	HC Investigator	Nong Lam University



<b><i>Oregon State University</i></b>		
<b>Participants</b>	<b>Status</b>	<b>Country</b>
		<b>USA</b>
Steven Bucolla	US Lead PI	Oregon State University
Rolf Fare	US Investigator	Oregon State University
John Antle	US Co-PI	Montana State University
Roberto Valdivia	US Investigator	Montana State University
<b>Central Projects</b>		
<b><i>Synthesis Project</i></b>		
Steve Buccola	US Lead PI	Oregon State University
John Antle	US Co-PI	Montana State University
Roberto Valdivia	US Investigator	Montana State University
<b><i>Communications Project</i></b>		
Peg Herring		Oregon State University
Jeff Hino		Oregon State University
Tiffany Woods		Oregon State University
<b><i>Cultural Practice, LLC</i></b>		
<b>Participants</b>	<b>Project</b>	
Deborah Rubin	Knowledge and Data Management Project	
Deborah Caro	Knowledge and Data Management Project	
Susan Johnson	Knowledge and Data Management Project	
Franklin Holley	Knowledge and Data Management Project	
Cait Nordehn	Knowledge and Data Management Project	

**PHASE II****TECHNICAL ADVISORY GROUPS****Development Themes Advisory Panel: Lead Coordinators**

Kwamena Quagraine	DTAP A	Purdue University
Joe Molnar	DTAP B	Auburn University
James Diana	DTAP C	University of Michigan
Robert Pomeroy	DTAP D	University of Connecticut at Avery Point

**Regional Centers of Excellence: Lead Coordinators**

Charles Ngugi	East & Southern Africa	Moi University, Kenya
Héry Coulibaly	West Africa	Direction Nationale de la Pêche, Mali
Remedios Bolivar	Asia	Central Luzon State University, Philippines
Wilfrido Contreras-Sanchez	LAC	Universidad Juárez Autónoma de Tabasco, Mexico
Yuan Derun	Asia	Network for Aquaculture Centers in Asia-Pacific, Thailand
Maria Celia Portella	South America	Sao Paulo State University, Brazil

**CORE RESEARCH PROJECT RESEARCHERS (proposed)*****Auburn University***

<b>Participants</b>	<b>Status</b>	<b>Country</b>
<b>USA</b>		
Joseph Molnar	US Lead PI	Auburn University
Claude Boyd	US Co-PI	Auburn University
James O. Bukenya	US Co-PI	Alabama A&M University
Kevin Fitzsimmons	US Co-PI	University of Arizona
E. William Tollner	US Co-PI	University of Georgia
<b>Uganda</b>		
John Walakira	HC Co-PI	National Fisheries Resources Research Institute
Theodora Hyuha	HC Lead-PI	Makerere University
Monica Beharo	HC Investigator	Makerere University
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Touch Bunthang	HC Investigator	IFReDI
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## APPENDIX 2. ACRONYMS

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**This list includes all acronyms used in AquaFish Innovation Lab (and CRSP) materials from 2006-2013.**

AA	Associate Award
ABW	Average Body Weight
ACIAR	Australian Centre for International Agricultural Research
ACRSP	Aquaculture Collaborative Research Support Program
AEZ	Agro-Ecological Zones
AFAF	Asian Fisheries and Aquaculture Forum
AFCRSP	Aquaculture & Fisheries CRSP
Africa RISING	Africa Research in Sustainable Intensification for the Next Generation, Ghana
AFU	Agriculture and Forestry University of Nepal
AIARD	Association for International Agriculture and Rural Development
AIT	Asian Institute of Technology, Thailand
ALF	African Lungfish
ANAF	Aquaculture Network for Africa
ANOVA	Analysis of Variance
AOP	Advanced Oxidation Process
APEC	Asia-Pacific Economic Cooperation
AQD	Aquaculture Department, SEAFDEC, Philippines
AquaFish	The Feed the Future Innovation Lab on Aquaculture & Fisheries (Formerly Aquaculture & Fisheries CRSP)
ASEAN	Association of Southeast Asian Nations
ATA	American Tilapia Association
AU	Auburn University, USA
AwF	Aquaculture without Frontiers, USA
BAAR	Board for Acquisition and Assistance Reform
BAU	Bangladesh Agricultural University
BFAR	Bureau of Fisheries & Aquatic Resources, Philippines
BFRI	Bangladesh Fisheries Research Institute
BFS	Bureau of Food Security, USAID
BIFAD	Board for International Food & Agricultural Development
BIOTECMAR	Cultivos & Biotecnológica Marina C.A. (Marine Growers and Biotechnology), Venezuela
BMA	Production System Design & Best Management Alternatives
BMI	Body Mass Index
BMP/BMPs	Best Management Practice(s)
BOD	Biochemical Oxygen Demand
BOMOSA	Boku, Moi and Sagana Aquaculture project
BSE	Bovine Spongiform Encephalopathy

BW	Brackish Water
CBA	Cost Benefit Analysis
CCM	Chama Cha Mapinduzi (Party of the Revolution), Tanzania
CDHS	Cambodia Demographic and Health Survey
cDNA	complementary Deoxyribonucleic Acid
CESASIN	Comite Estatal de Sanidad Acuicola de Sinaloa (State Committee for Aquaculture Health of Sinaloa), Mexico
CETRA	Centro de Transferencia Tecnológica para la Acuicultura (Technology Transfer Center for Aquaculture), Mexico
CFR	Community Fish Refuge
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 Aquatic Ecosystems Research - Central American University), Nicaragua
CIFAD	Consortium for International Fisheries & Aquaculture Development
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Wheat & Maize Improvement Center), Mexico
CIP	Country Investment Program, Bangladesh
CLAR	Central Laboratory for Aquaculture Research, Egypt
CLSU	Central Luzon State University, Philippines
CNS	College of Natural Sciences, Makerere University, Uganda
COD	Chemical Oxygen Demand
COMESA	Common Market for Eastern and Southern Africa
CP	Crude Protein
CP, LLC	Cultural Practice, Limited Liability Company
CPE	Carp Pituitary Extract
CPSR	Cooperativa Pesquera San Ramón (San Ramón Fisheries Cooperative), Mexico
CRC/URI	Coastal Resources Center/University of Rhode Island
CRD	Completely Randomized Design
CRP	Collaborative Research Program, CGIAR
CRSP	Collaborative Research Support Program
CSIR	Council for Scientific and Industrial Research, Ghana
CSISA	Cereal Systems Initiative for South Asia
CTU	Can Tho University, Vietnam
DA-BFAR	Department of Agriculture–Bureau of Fisheries and Aquatic Resources, Philippines
DASP	Department of Animal Science and Production, Sokoine University of Agriculture, Tanzania
DFID	Department for International Development, England
DNP	Direction Nationale de la Pêche (National Directorate of Fisheries), Mali
DO	Dissolved Oxygen
DOF	Department of Fisheries, Kenya
DTAP	Development Theme Advisory Panel

DWAF	Department of Water Affairs and Forestry, South Africa
EAC	East African Community
EC	<i>Escherichia coli</i>
ECP	Eye Color Pattern
EFA	Essential Fatty Acids
EFMS	Enhanced Fish Marketing System
EG	Economic Growth Indicators, USAID
EGAT	Bureau for Economic Growth, Agriculture, and Trade, USAID
EPA	Environmental Protection Agency, USA
EPT	<i>Ephemeroptera</i> , <i>Plecoptera</i> and <i>Trichoptera</i>
EU	European Union
FAA	Fisheries and Allied Aquaculture, Auburn University, USA
FAC	Freshwater Aquaculture Center, Central Luzon State University, Philippines
FACIMAR	Facultad de Ciencias del Mar, Universidad Autónoma de Sinaloa (Faculty of Marine Sciences, Autonomous University of Sinaloa), Mexico
FACT	Foreign Assistance Coordination and Tracking System, USAID
FAME	Fatty Acid Methyl Esters
FAO	Food and Agriculture Organization, United Nations
FAQ	Frequently Asked Questions
FARDeC	Freshwater Aquaculture Research and Development Center, Cambodia
FAST	Faculty of Aquatic Sciences and Technology, University of Dar es Salaam, Tanzania
FCR	Food (or Feed) Conversion Ratio
FD	Department of Fisheries, Kenya
FDA	Food and Drug Administration, USA
FDAP	Fisheries Development Action Plan, Cambodia
FF	Formulated Feed
FFA	Bidii Fish Farmers Association, Kenya
FGD	Focus Group Discussion
FiA	Fisheries Administration, Cambodia
FISH	Fisheries Improved for Sustainable Harvest, Philippines, <i>also</i>
FISH	Fisheries Income from Sustainable Harvest, USAID, Uganda
FIU	Florida International University, USA
FM	Fish Meal
FSF	Freshwater Small-sized Fish
FSV	Food Safety, Post Harvest, and Value-Added Product Development
FTF	Feed the Future, USAID
FTFMS	Feed the Future Monitoring System
GAF	Gender in Aquaculture Fisheries
GDP	Gross Domestic Product
GESAMP	Joint Group of Experts in the Scientific Aspects of Marine Environmental Protection, FAO
GHERS	Greater Harvest and Economic Returns From Shrimp, Bangladesh
GIFT	Genetically Improved Farmed Tilapia, <i>also</i>
GIFT	Genetically Improved Farmed Tilapia Foundation International Inc., Philippines



GIS	Geographic Information Systems
GLM	Generalized Linear Model
GMO	Genetically Modified Organism
GNADP	Ghana National Aquaculture Development Plan
GnRH <sub>a</sub>	Gonadotropin Releasing Hormone analogue
GON	Government of Nepal
GOP	Government of The Philippines
GTIS	Guyana Trade and Investment Support Project
HACCP	Hazard Analysis and Critical Control Point
HBS	Household Budget Survey
HC	Host Country
HCPI	Host Country Principal Investigator
HHI	Human Nutrition and Human Health Impacts of Aquaculture
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
HKI	Helen Keller Institute
HPLC	High Performance Liquid Chromatography
HSI	Hepatosomatic Index
IAAS	Institute of Agriculture and Animal Science, Nepal
IAGRI	Innovative Agricultural Research Initiative, Tanzania
IARC	International Agricultural Research Center(s), CGIAR
ICLARM	International Center for Living Aquatic Resources Management, WorldFish Center, Malaysia
IDRC	International Development Research Centre, Canada
IEHA	Presidential Initiative to End Hunger in Africa, USA
IFReDI	Inland Fisheries Research and Development Institute, Cambodia
IGF-I	Insulin-like Growth Factor-I
IGO	Intergovernmental Organization
IIFET	International Institute for Fisheries, Economics and Trade
IMS	Institute of Marine Sciences, Tanzania
IND	Climate Change Adaptation: Indigenous Species Development
INTSORMIL	Sorghum, Millet and Other Grains CRSP
IPM	Integrated Pest Management
IR	Intermediate Results Indicators, USAID
ISA	Instituto Sinaloense de Acuacultura y Pesca (Sinaloa Institute for Aquaculture and Fisheries), Mexico
ISD	Indigenous Species Development
ISSC	Interstate Shellfish Sanitation Conference, USA
ISTA	International Symposium on Tilapia in Aquaculture
IWMI	International Water Management Institute
JUGIPAED	Jinja United Group Initiative for Poverty Alleviation and Economic Development, Uganda
KAP	Knowledge, Attitude and Practice
KARDC	Kajjansi Aquaculture Research and Development Centre, Uganda
KBDS	Kenya Business Development Services, USAID
KII	Key Informant Interviews

KMALF	Kenya Ministry of Agriculture, Livestock and Fisheries
KNUST	Kwame Nkrumah University of Science and Technology, Ghana
KSh	Kenya Shillings
KU	Kenyatta University, Kenya
LAC	Latin America and Caribbean Regions
LC/MS	Liquid Chromatography/Mass Spectrometry
LCA	Life Cycle Assessment
LCCA	Life Cycle Cost Analysis
LEAD	Livelihoods and Enterprises for Agricultural Development, Uganda
LEAP	Leadership Enhancement in Agriculture Program (also referred to as <i>Borlaug LEAP</i> )
LHRHa	Luteinizing Hormone-Releasing Hormone analogue
LLC	Limited Liability Company
LMB	Lower Mekong Basin
LSD	Least Significant Difference
LST	Lauryl Sulfate Tryptose
LSU	Louisiana State University, USA
LWA	Leader with Associates Award
M&E	Management & Evaluation
MAFF	Ministry of Agriculture, Forestry and Fisheries, Cambodia
MAK	Makerere University, Uganda
MARENA	Ministerio del Ambiente y los Recursos Naturales (Ministry of Environment and Natural Resources), Nicaragua
MC	Microcystins
MDG	Millenium Development Goals, United Nations
ME	Management Entity
MER	Marketing, Economic Risk Assessment, & Trade
MIS	Market Information System
MNE	Mitigating Negative Environmental Impacts
MOF	Ministry of Fisheries, Ghana
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MRC	Mekong River Commission
mRNA	messenger Ribonucleic Acid
MS-222	Tricaine Methanesulfonate
MSNP	Multi-Sectoral Nutrition Plan, Nepal
MSs	Microsatellites
MSU	Michigan State University, USA
MT	17-Methyltestosterone, <i>also</i>
MT	Management Team
MU	Moi University, Kenya
MYAP	Multi-Year Assistance Program, USAID
NAAG	National Aquaculture Association of Guyana
NACA	Network of Aquaculture Centers in Asia, Thailand

NaFIRRI	National Fisheries Resources Research Institute, Uganda
NARC	Nepal Agricultural Research Council
NARO	National Agricultural Research Organization, Uganda
NARS	National Agricultural Research System (of Host Countries)
NB	<i>Nota Bene</i> (note well)
NC	North Carolina State University, USA
NCE	No-Cost Extension
NCRSP	Global Nutrition CRSP
NCSU	North Carolina State University, USA
NEPAD	New Partnership for Africa's Development
NFE	Nitrogen-Free Extract
NGO	Non-governmental Organization
NIC	National Investment Center, Ghana <i>also</i>
NIC	National Investment Center, Kenya
NL	Notochordal
NO <sub>2</sub> -N	Nitrite Nitrogen
NOAA	National Oceanographic and Atmospheric Administration, USA
NPRS	National Poverty Reduction Strategy, Cambodia
NSF	National Science Foundation, USA
NSSP	National Shellfish Sanitation Program, USA
OAA	Office of Acquisition and Assistance
OAA's	Other Aquatic Animals
OSU	Oregon State University, USA
PAC	Pilot Aquaculture Center
PACRC	Pacific Aquaculture and Coastal Resources Center, University of Hawai'i at Hilo, USA
PCR	Polymerase Chain Reaction
PD/ACRSP	Pond Dynamics/Aquaculture CRSP
PDF	Portable Document Format
PDI	Pellet Durability Index
PDV	Policy Development
PER	Protein Efficiency Ratio
PI	Principal Investigator
PLNSA	Prek Leap National School of Agriculture, Cambodia
PMP	Program Monitoring Plan
PO	Phenyl Oxidase
PMO	Project Management Office
POD	Peroxidase
PRA	Participatory Rural Appraisal
PRCA	Participatory Rural Communication Appraisal
PRICE	Poverty Reduction by Increasing the Competitiveness of Enterprises
PU	Purdue University, USA
QENP	Queen Elizabeth National Park, Uganda
QSD	Quality Seedstock Development

RCE	Regional Center of Excellence
ReCoMap	Regional Coastal Management Programme, European Union
RFA	Request for Assistance
RFP	Request for Proposals
RIA	Radioimmunoassay
RIDS	Rural Integrated Development Society, Nepal
RRA	Rapid Rural Appraisal
SADC	South African Development Community
SANREM	Peanut, Sustainable Agriculture and Natural Resource Management CRSP
SARNISSA	Sustainable Aquaculture Research Network in Sub-Saharan Africa
SBM	Soybean Meal
SEAFDEC	South East Asian Fisheries Development Center
SEDPIII	Third Five-Year Socioeconomic Development Plan, Cambodia
SEMARNAT	Secretaría del Medio Ambiente y Recursos Naturales (Secretariat of Environment and Natural Resources), Mexico
SFT	Sustainable Feed Technology
SGR	Specific Growth Rate
SIDA	Swedish International Development Cooperation Agency
SIRTD	Strategic Investment in Rapid Technology Dissemination
SIS	Small Indigenous Species (of fish)
SL	Standard Length
SMIS	Seafood Marketing Information System
SMS	Short Message Service
SNPs	Single Nucleotide Polymorphisms
SO	Superoxide Dismutase
SOU	Shanghai Ocean University, China
SPC	Soy Protein Concentrate
SPE	Solid Phase Extraction
SPSS	Statistical Package for Social Science
SR	Sex Reversed
SS	<i>Salmonella-Shigella</i>
SSF	Small-Sized Fish
SUA	Sokoine University of Agriculture, Tanzania
SUCCESS	Sustainable Coastal Communities and Ecosystems, EGAT/USAID
SUMAWA	Sustainable Management of Watersheds Project
TAFIRI	Tanzania Fisheries Research Institute
TAN	Total Ammonia Nitrogen
TAP	Technology Adoption and Policy Development
TCMP	Tanzania Coastal Management Partnership
THC	Total Hemocyte Counts
TIES	Training, Internships, Education and 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, USA
UA	University of Arizona, USA
UAPB	University of Arkansas - Pine Bluff, USA
UAS	Universidad Autónoma de Sinaloa (Autonomous University of Sinaloa), Mexico
UAS-C	Universidad Autónoma de Sinaloa–Culiacán, Mexico
UAS-M	Universidad Autónoma de Sinaloa– Mazatlán, Mexico
UAT	Universidad Autónoma de Tamaulipas (Autonomous University of Tamaulipas), Mexico
UBAC	Ujung Batee Aquaculture Center, Banda Aceh, Indonesia
UC	University of Connecticut at Avery Point, USA
UCA	Universidad Centroamericana (Central American University), Nicaragua
UCC	University of Cape Coast, Ghana
UG	University of Georgia, USA, <i>also</i>
UG	University of Ghana
UHH	University of Hawai'i - Hilo, USA
UJAT	Universidad Juárez Autónoma de Tabasco (Juarez Autonomous University of Tabasco), Mexico
UM	University of Michigan, USA
UNESP	Universidade Estadual Paulista (São Paulo State University), Brazil
URI	University of Rhode Island, USA
US	United States
USA	United States of America
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USG	United States Government
USSEC	United States Soybean Export Council
UV	Ultraviolet
VCA	Value Chain Analysis
VT	Virginia Polytechnic Institute and State University, USA
WAFICOS	Walimi Fish Cooperative Society Ltd, Uganda
WAS	World Aquaculture Society
WHO	World Health Organization
WIFIP	Women in Fishing Industry Project, Kenya
WIOMSA	Western Indian Ocean Marine Sciences Association, Tanzania
WIZ	Watershed & Integrated Coastal Zone Management
WRC	Water Research Commission, South Africa
WRI	Water Research Institute, Ghana
WSSV	White Spot Syndrome Virus
WWF	World Wildlife Fund
XLD	Xylose Lysine Desoxycholate



### APPENDIX 3. LIST OF PUBLICATIONS AND RESEARCH REPORTS

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The following is a list of peer-reviewed articles and research reports by AquaFish Innovation Lab (formerly CRSP) investigators on their AquaFish-sponsored research. Some of the publications before 2009 may be attributable in part to the Aquaculture CRSP. In the period from 2006-2008, the Aquaculture CRSP was also operational on a no-cost extension.

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## APPENDIX 4. PARTNERSHIPS & NETWORKS

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The AquaFish Innovation Lab (formerly AquaFish CRSP) works with partners to share expertise, engage stakeholders, and leverage funds. AquaFish develops and maintains linkages among universities and government ministries, departments of agriculture, and the private sector around the world.

Core research projects are encouraged to foster linkages with organizations including US minority-serving institutions, non-governmental organizations (NGOs), national agricultural research institutions, other CRSPs and Innovation Labs, international centers, private businesses, and others. Proposals, work plans, and project budgets were developed collaboratively between US and Host Country researchers, as were operational decisions such as budgeting, overall priority setting, and other collaborative activities related to AquaFish. As required by AquaFish, at least 50% of core research project funds are expended in or on behalf of the Host Country or region.

In addition to forming linkages through core research projects, AquaFish looks to advisory bodies such as the RCEs to establish and maintain linkages in Central and South America, Africa, and Asia.

Institutions, NGOs, and organizations that have participated as funded partners with the AquaFish Innovation Lab (formerly AquaFish CRSP) since its inception in 2006 are listed below. Funded partners include US and Host Country institutions that receive direct funding through subcontracts and MOUs through either the Leader Award or Associate Awards. Entities that solely received financial support via travel reimbursement, personal services agreements, or other shorter-term funding arrangements are not included as funded partners.

### FUNDED PARTNERS

#### US Partners

Alabama A&M University  
Auburn University  
Bemidji State University  
Cornell University  
Florida International University  
Indigenous Environmental Network, Minnesota  
Institute for Agriculture and Trade Policy, Minnesota  
Louisiana State University  
Michigan State University  
Montana State University  
North Carolina State University  
Ohio State University  
Oregon State University  
Purdue University  
Southern Illinois University at Carbondale

Texas Tech University  
University of Tennessee  
University of Arizona  
University of Arkansas at Pine Bluff  
University of California, Davis  
University of Connecticut at Avery Point  
University of Delaware  
University of Georgia  
University of Hawai'i at Hilo  
University of Hawai'i at Manoa  
University of Michigan  
University of Oklahoma  
University of Rhode Island  
University of Texas  
University of the Virgin Islands  
Virginia Polytechnic Institute & State University  
World Wildlife Fund

**International Partners**

Heifer International  
International Water Management Institute  
(IWMI) of the Consultative Group on  
International Agriculture Development (CGIAR)

**Bangladesh**

Bangladesh Agricultural University  
Khulna University  
Sushilan  
WorldFish, Dhaka

**Brazil**

Embrapa Meio Ambiente  
Sao Paulo State University  
Universidade Estadual Paulista, Centro de  
Acüicultura, Jaboticabal  
Universidade Federal do Amazonia

**Cambodia**

Cambodia Department of Fisheries  
Inland Fisheries Research and Development  
Institute

**China**

Hainan University  
Huazhong University  
Shanghai Ocean University (Formerly Shanghai  
Fisheries University)  
Southwest University  
Wuhan University  
Xiamen University  
Zhejiang University

**Columbia**

Centro Internacional de Agricultura Tropical  
(CIAT)

**Ecuador**

Ecocostas

**Ghana**

Kwame Nkrumah University of Science and  
Technology

**Guyana**

Guyana Department of Fisheries

**Honduras**

Centro Nacional de Investigación Piscícola El  
Carao  
Escuela Agrícola Panamericana, Zamorano  
University  
Laboratorio de Calidad de Agua La Lujosas  
Secretaría de Agricultura y Ganadería

**Indonesia**

Ujung Batee Aquaculture Center

**Kenya**

Department of Fisheries, Ministry of Agriculture  
and Rural Development  
FishAfrica  
Kenyatta University  
KMFRI Sangoro Aquaculture Station  
Ministry of Agriculture, Livestock and Fisheries  
Ministry of Fisheries Development-Kenya  
Department of Fisheries  
Moi University  
Mwea Aquafish Farm  
Nyanchwa College of Science and Technology  
University of Eldoret  
University of Nairobi

**Malawi**

Bunda College, Lilongwe  
International Center for Living Aquatic  
Resources Management (ICLARM)

**Mali**

Direction Nationale de La Pêche

**Mexico**

Centro de Investigacion de Alimentacion y  
Desarrollo (Research Center for Food &  
Development)  
Instituto Tecnológico del Mar  
Universidad Autónoma de Sinaloa–Culiacán  
Universidad Autónoma de Sinaloa–Mazatlán

Universidad Autónoma de Tamaulipas  
Universidad Juarez Autonoma de Tabasco

### **Nepal**

Agriculture and Forestry University  
Directorate of Fisheries Development  
Fisheries Research Center, Nepal Agricultural  
Research Council  
Institute of Agriculture & Animal Science  
Regional Agricultural Research Station

### **Nicaragua**

Center for Research of Aquatic Ecosystems-  
Central American University (CIDEA-UCA)

### **Peru**

Fondo Nacional del Desarrollo Pesquero  
Instituto de Investigaciones de la Amazonia  
Peruana (IIAP)  
Universidad Nacional de la Amazonia Peruana  
(UNAP)  
Universidad Nacional Mayor de San Marcos

### **Philippines**

Bureau of Fisheries and Aquatic Resources  
Central Luzon State University  
Southeast Asian Fisheries Development Center-  
Aquaculture

### **South Africa**

Stellenbosch University

### **Tanzania**

Fisheries and Aquaculture Development  
Division  
Ministry of Natural Resources and Tourism  
Ministry of Natural Resources and Tourism-  
Aquaculture Division  
Sokoine University of Agriculture  
University of Dar-es-Salaam  
Western Indian Ocean Marine Sciences  
Association

### **Thailand**

Asian Institute of Technology (AIT)  
Kasetsart University  
Network of Aquaculture Centers in Asia

### **Uganda**

Gulu University  
Makerere University  
National Fisheries Resources Research Institute-  
Aquaculture Research and Development Center

### **Vietnam**

Can Tho University  
Research Institution for Aquaculture No. 1  
University of Agriculture and Forestry (Nong  
Nam University)

**AFFILIATED LINKAGES (NON-FUNDED)****US Linkages**

American Soybean Association  
 AmeriSci International  
 Aquaculture without Frontiers (USA)  
 Brooklyn College  
 Coastal Resources Center-University of Rhode Island  
 Cultural Practice LLC  
 Delaware State University  
 Fish Farmacy  
 Fisheries Industry Technology Center-University of Alaska  
 Florida International University  
 Global Aquaculture Alliance  
 Goosepoint Oyster Inc.  
 National Oceanic and Atmospheric Administration--International Sea Grant  
 National Sea Grant Program Extension Office  
 Oxfam America  
 Pacific Shellfish Growers Association  
 Partners of the Americas  
 Peanut CRSP  
 Shrimp Improvement Systems  
 Sustainable Management of Watershed CRSP  
 Texas A&M University  
 Texas Parks & Wildlife Department  
 Texas Sea Grant  
 U.S. Food & Drug Administration  
 University of Texas  
 US Department of Commerce-NOAA  
 US-Mexico Aquaculture TIES Program  
 USAID SUCCESS Program (USA)  
 USAID Sustainable Coastal Communities & Ecosystems Program  
 World Aquaculture Society (USA)

**International**

International Institute for Fisheries Economics and Trade  
 Lake Victoria Environmental Management Project (Kenya, Tanzania, Uganda, Rwanda, Burundi)

US-Mexico Aquaculture TIES Program

**Argentina**

Universidad Nacional del Comahue

**Australia**

Australian Center for International Agricultural Research

**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 in Cambodia  
 Freshwater Aquaculture Research & Development Center  
 Inland Aquaculture Extension & Productivity Improvement Project  
 Prek Leap National School of Agriculture  
 Royal University of Agriculture  
 United Nations Food & Agriculture Organization in Asia-Pacific (Cambodia)

**Canada**

International Development Research Centre (Canada)

**Chile**

Foundation Chile

**China**

China Aquatic Products Processing & Marketing Association  
 Guizhou Normal University  
 Haoshideng Shrimp Farm  
 Huiting Reservoir Fisheries Management Company  
 Sichuan Aquaculture Engineering and Technology Research Center  
 Tongwei Co. Ltd

Zhanghe Reservoir Fisheries Management  
Company

**Costa Rica**

University of Costa Rica

**Egypt**

Academy of Scientific Research & Egyptian  
Universities  
Central Laboratory for Aquaculture Research  
Egyptian Society of Agribusiness  
Ministry of Agriculture & Land Reclamation

**Ghana**

FAO-Ghana  
FarmerLine  
Fisheries Department, Ministry of Food &  
Agriculture  
Ministry of Agriculture Fisheries Directorate  
United Nations Food & Agriculture  
Organization, Regional Office  
Water & Sewage Company  
Water Research Institute's Aquaculture Research  
Development Center

**Guatemala**

San Carlos University

**Guyana**

Anna Regina Fish Culture Station  
Guyana School of Agriculture  
Maharaja Oil Mill  
Mon Repos Aquaculture Center, Department of  
Fisheries  
National Aquaculture Association of Guyana  
Trafalgar Union Women's Cooperative  
University of Guyana  
USAID Farmer-to-Farmer Program  
USAID/GTIS Program  
Von Better Aquaculture

**Honduras**

Grupo Granjas Marinas, S.A.

**Indonesia**

Indonesian Department of Fisheries  
Ladong Fisheries College  
Ujong Batee Aquaculture Research and  
Extension Center

**Italy**

United Nations Food & Agriculture  
Organization

**Kenya**

Kenya Business Development Services  
Kenya Marine & Fisheries Research Institute  
National Investment Center  
Sagana Aquaculture Center  
Sagana Fish Farm  
Women in Fishing Industry Project

**Laos**

Regional Development Coordination or  
Livestock and Fisheries

**Lebanon**

American University of Beirut

**Malaysia**

WorldFish Center

**Mali**

Comite Estatal de Sanidad Acuicola de Sinaloa  
Ministre de L'Elvage de la Peche  
Ministry de L'Elvage de la Peche  
Ministry of Livestock and Fisheries (Ministère  
de l'Élevage 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**

Centro de Transferencia Tecnologica Para La  
Acuicultura (CETRA)  
Comite Estatal de Sanidad Acuicola de Sinaloa

Cooperativa Pesquera San Ramon  
Federation of Shrimp Cooperatives  
Institution for Research in Food and  
Development  
Instituto Nacional de Investigaciones Forestales  
y Agropecuarias  
Instituto Sinaloense de Acuacultura  
Mariano Matamoros Hatchery  
Regional Center of Education and Qualification  
for Sustainable Development  
Secretariat of Agricultural Development for the  
State of Tabasco  
Sinaloa State Fisheries Department  
Wetlands Conservation Program  
Women's Oyster Culture Cooperatives of  
Nayarit  
Women's Oyster Culture Cooperatives of Puerto  
Penasco

**Nepal**

Rural Integrated Development Society

**Netherlands**

Intervet-Schering Plough Animal Health  
Tilapia International Foundation

**Nicaragua**

Nicaraguan Ministry of the Environment

**Philippines**

Department of Agriculture  
Genetically Improved Farmed Tilapia  
Foundation International, Inc  
Mindanao State University  
South East Asian Fisheries Development Center  
-Aquaculture Division  
University of the Philippines at the Visayas  
(Institute of Fish Processing Technology)  
West Visayas State University

**Puerto Rico**

University of Puerto Rico

**South Africa**

Department of Water Affairs & Forestry  
Water Research Commission

**Tanzania**

Kingorwila National Fish Center  
Mbegani Fisheries Development Centre  
Nyegezi Fisheries Institute  
Tanzania Fisheries Research Institute

**Tasmania**

University of Tasmania

**Thailand**

CNN Aquaculture and Supply Company  
Department of Fisheries  
FAO in Asia-Pacific  
Network of Aquaculture Centers in Asia  
(Thailand)

**Uganda**

Blessed Investment Fish Farm  
Jinja United Group Initiative for Poverty  
Alleviation & Economic Development  
Namuyenge Mixed Farmers Ltd  
Source of the Nile Fish Farm  
Walimi Fish Cooperative Society Ltd

**United Kingdom**

UK Department for International Development  
University of Stirling

**Venezuela**

BIOTECMAR C.A.

**Vietnam**

Dong Nai Fisheries Company  
Nong Lam University