FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

Feed the Future Innovation Lab for Fish

Annual Report October 1, 2019 – September 30, 2020

Cooperative Agreement 7200AA18CA0030

USAID
FROM THE AMERICAN PEOPLE

MISSISSIPPI STATE UNIVERSITY
GLOBAL CENTER FOR AQUATIC FOOD SECURITY

Feed the Future Innovation Lab for Fish

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November 30, 2020

Prepared for:

Agreement Officer's Representative (AOR)

Feed the Future Innovation Lab for Fish (Fish Innovation Lab)

Bureau for Resilience and Food Security (RFS)

United States Agency for International Development (USAID)

Prepared by:

Mississippi State University

Global Center for Aquatic Food Security

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Management Entity Information

The Feed the Future Innovation Lab for Fish (Fish Innovation Lab) is managed by Mississippi State University (MSU) and is housed in the MSU Global Center for Aquatic Food Security, which is affiliated with the College of Veterinary Medicine.

Members of the Management Entity

- Mark L. Lawrence, Director (88%)
- Stephen Reichley, Risk Mitigation Specialist (25%)
- Peter Allen, Productivity Frontier Specialist (8%)
- Kathleen Ragsdale, Gender and Youth Equity Specialist (20%)
- Mary Read-Wahidi, Gender and Youth Equity Co-Specialist (15%)
- Shauncey Hill, Program/Finance Manager (100%)
- Kristen Dechert, Communications Manager (100%)
- Jared Dees, Grants and Contracts Manager (90%)
- Mark Peterman, Capacity Development Associate (20%)

External Advisory Board

The Fish Innovation Lab Management Entity (ME) is advised by the Fish Innovation Lab External Advisory Board (EAB), who provides strategic direction for Fish Innovation Lab goals and objectives, gives scientific oversight for Fish Innovation Lab activities, and monitors progress toward Fish Innovation Lab objectives.

Members of the Fish Innovation Lab External Advisory Board

- Rohana Subasinghe, FutureFish Managing Director
- Michael Phillips, Director of the Consultative Group on International Agricultural Research (CGIAR) Research Program on Fish Agri-Food Systems and WorldFish Director of Aquaculture and Fisheries
- Melba B. Reantaso, Aquaculture Officer at the Food & Agriculture Organization
- Bryan McCoy, Chief Executive Officer, Yalelo, and Director of FirstWave Group
- Karen Veverica, Former Director, Auburn University E.W. Shell Fisheries Research Center

Countries Where the Fish Innovation Lab Works

In federal fiscal year (FY) 2020, the Fish Innovation Lab implemented activities in Bangladesh, Cambodia, Kenya, Nigeria, and Zambia (Figure 1).

Figure 1: Location of Fish Innovation Lab activities.

Fish Innovation Lab Management Entity Partners

University of Rhode Island

- Elin Torell, Deputy Director (50%)
- Glenn Ricci, Capacity Development Specialist (5%)
- Karen Kent, West Africa Specialist (5%)
- Austin Humphries, East Africa Specialist (25%)

Research Triangle Institute International

- Joanna Springer, Monitoring, Evaluation, and Learning Advisor (100%)

Washington University in St. Louis

- Lora Iannotti, Nutrition Specialist (8%)

Texas State University

- Madan Dey, Asia Specialist (25%)

Regional coordinators

- Andrew Wamukota, East Africa Coordinator (50%)
- Md. Gulam Hussain, Asia Coordinator (50%)
- Sunil Siriwardena, West Africa Coordinator (50%)

Abbreviations and Acronyms

ADPs	Agricultural Development Programmes
AO	Agreement Officer
AOR	Agreement Officer's Representative
BAU	Bangladesh Agricultural University
BC	Bighead Catfish
BMGF	Bill and Melinda Gates Foundation
BMPs	Better Management Practices
BMU	Beach Management Unit
BSF	Black Soldier Fly
CE SAIN	Center of Excellence on Sustainable Agricultural Intensification and Nutrition
CGIAR	Consultative Group on International Agricultural Research
EAB	External Advisory Board
EMMP	Environmental Management and Mitigation Plan
FAO	Food and Agriculture Organization of the United Nations
FCS	Food Consumption Score
FGD	Focus Group Discussion
FTFMS	Feed the Future Monitoring System
FY	Federal Fiscal Year
GRADA-FIL	Gender Responsive Aquaculture/Fisheries Development Assessment
HC	Host Country
HDDS	Household Dietary Diversity Score
HFIES	Household Food Insecurity Experience Scale
HICD	Human and Institutional Capacity Development
IAA	Integrated Agriculture-Aquaculture
IACUC	Institutional Animal Care and Use Committee
IGBB	Institute for Genomics, Biocomputing, and Biotechnology
IMCs	Indian Major Carps
IRB	Institutional Review Board
ITF	Integrated Insect-to-Fish
KII	Key Informant Interview
KSU	Kansas State University
LSUAC	Louisiana State University Agriculture Center
LSMEs	Lean Subject Matter Experts
ME	Management Entity
MEL	Monitoring, Evaluation, and Learning
MSU	Mississippi State University
NGO	Nongovernmental Organization
NRDC	Natural Resources Development College
PI	Principal Investigator
PIRS	Performance Indicator Reference Sheet
QMRA	Quantitative Microbial Risk Assessment
RFA	Request for Applications
RTI	Research Triangle Institute International

RUA	Royal University of Agriculture
SCP	Single-Cell Protein
SEARCA	Southeast Asian Regional Center on Graduate Studies and Research in Agriculture
SMS	Subject Matter Specialists
SNP	Single Nucleotide Polymorphism
TSU	Texas State University
UNZA	University of Zambia
URI	University of Rhode Island
USAID	United States Agency for International Development
USG	United States Government
WCS	Wildlife Conservation Society
WEFI	Women's Empowerment in Fisheries Index
WRA	Women of Reproductive Age
WUSTL	Washington University in St. Louis
ZOI	Zone of Influence

Glossary

Aquaculture: “The farming of aquatic organisms, including fish, mollusks, crustaceans, and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated” (FAO, 1988).

Gender Integration: Strategies employed to ensure women’s and men’s attitudes, roles, responsibilities, concerns, and experiences are an integral dimension of the design, implementation, monitoring, and evaluation of research and extension. Differences are recognized and routinely addressed for all activities.

Gender Equality: Norms, values, attitudes, and perceptions required to attain equal status between women and men without neutralizing the biological differences between women and men.

Small-Scale fisheries: Also referred to as artisanal fisheries. Characteristics differ among countries, but the term generally means “traditional fisheries involving fishing households (as opposed to commercial companies), using a relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption” (FAO, 2014). “Women are significant participants in the sector, particularly in postharvest and processing activities. It is estimated that about 90% of all people directly dependent on capture fisheries work in the small-scale fisheries sector. As such, small-scale fisheries serve as an economic and social engine, providing food and nutrition security, employment and other multiplier effects to local economies while underpinning the livelihoods of riparian communities” (FAO, SSF Guidelines, 2015).

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Executive Summary

The Feed the Future Innovation Lab for Fish (Fish Innovation Lab) began in September 2018 and has completed its first 24 months. FY 20 was a transitional year for the Fish Innovation Lab as it completed its five one-year research and capacity-building activities (Quick Start activities). The Quick Start activities were implemented in Nigeria, Kenya, Bangladesh, and Zambia. The Fish Innovation Lab also launched 13 competitively awarded activities, which are being implemented in Nigeria, Kenya, Zambia, Bangladesh, and Cambodia. Together, the activities address the Fish Innovation Lab's theory of change.

- In Nigeria, Kenya, Cambodia, and Bangladesh, the Fish Innovation Lab is developing innovations to increase achieved yield of fish in aquaculture, improving availability and nutritional quality of feed, improving genetics and reliability of fish seed, and enhancing sustainable fisheries management to improve harvest yields and increase reliability.
- In Nigeria and Bangladesh, the Fish Innovation Lab is identifying and developing scalable technologies and practices that increase the tolerance of fish to biotic and abiotic stresses (including ecological resilience), improving diagnostic capabilities, maintaining healthy and bio-secure production environments, and reducing pre- and postharvest losses (including ensuring food safety).
- In Nigeria, Kenya, Zambia, and Bangladesh, the Fish Innovation Lab is identifying how aquaculture and fisheries can help improve nutrition and market opportunities (especially for vulnerable populations), improving equitable access to production assets (especially for women and youth), and establishing an enabling environment for fish production.

The Fish Innovation Lab Management Entity (ME) developed agreements with regional coordinators to manage and support the competitively awarded research-for-development activities. The ME implemented several activities aiming to encourage cross-activity learning. This included quarterly virtual platform meetings/learning sessions and the annual PI meeting. The Fish Innovation Lab also began developing research and learning agendas.

The Fish Innovation Lab experienced some setbacks due to the COVID-19 pandemic. Fortunately, the pandemic started after the Quick Start activities had concluded their fieldwork, but it delayed the startup of the competitively awarded research activities and made international travel impossible during the second half of the work plan year. Although the Fish Innovation Lab ME was unable to conduct field visits in quarters 3 and 4, the ME supported the research teams via the regional coordinators as well as email, phone, and remote meetings.

Focus Country Key Accomplishments

The Fish Innovation Lab supported the implementation of six activities in **Nigeria**. A Quick Start activity, which concluded in FY 20, addressed the advancement of aquaculture production through assessing postharvest losses in the fish value chain and identifying technologies and practices that have the potential to improve both incomes and diets. Five competitively awarded research-for-development activities were launched that are aimed at improving aquaculture feed, developing integrated aquaculture, implementing value-chain efficiency, reducing preharvest losses, and improving nutrition. Together the activities aim to enhance nutrition among vulnerable groups, improve diagnostic capabilities, maintain healthy and bio-secure production environments, improve aquaculture resilience, and identify and develop scalable technologies and practices that increase the tolerance of fish to biotic and abiotic stresses (including ecological resilience).

All Fish Innovation Lab activities in **Kenya** are focused on fisheries. A Quick Start activity, which was completed in 2020, mapped out the status of household nutrition in fishing and nonfishing households and identified barriers and entry points for increasing access to and consumption of sustainable fish among vulnerable populations in Kenya. The activity also identified potential fisheries options that can be tested for sustainability. Two new activities are investigating coral reef

fishery sustainability and small-scale fisheries, including how to more fully engage women in fisheries management. The activities are also concerned with how to improve access to sustainable fish among vulnerable populations.

In **Bangladesh,** a Quick Start activity aimed to improve aquaculture production and livelihoods of farming communities. The study found that rohu-based carp polyculture is profitable, but there is a yield gap that is due to inefficient farming and biotic and abiotic technical constraints. The activity also supported improved carp genetics by identifying genetic markers in the rohu carp genome. Two new research activities are addressing the aquaculture sector through value chains either by tracking behavior practices to trace fish contamination by foodborne pathogens or identifying innovative practices that enhance adoption and productivity. A third new activity is improving genetics and reliability of fish seed.

Two Quick Start activities completed in **Zambia** and one new activity started. One Quick Start activity partnered with the private sector to develop institutional capacity and pilot alternatives to fishmeal in commercial aquatic animal feeds. The second Quick Start activity revealed gender disparities within the fisheries sector and uncovered opportunities to improve nutrition and reduce postharvest loss. A competitively awarded activity will build on these findings by piloting actions to improve access to fish among young children and women of reproductive age, with the end goal of enhancing nutrition and food security in Zambia.

Two new activities were launched in **Cambodia**. The activities are working towards improving aquaculture and fisheries productivity by improving resilience and food security, with one activity geared towards aquaculture and the other towards fisheries. Both research activities are addressing gender equity and youth engagement.

Fish Innovation Lab Overview and Structure

Funded by USAID, the Fish Innovation Lab aims to reduce poverty and improve nutrition, food security, and livelihoods in developing countries by supporting the sustainable development of aquaculture and fisheries. To achieve these goals, the Fish Innovation Lab supports research and capacity-building activities targeting three program areas:

1. **Advancing productivity:** The Fish Innovation Lab works to identify and develop scalable technologies and practices that enhance opportunities for prosperity, nutrition, and resilience in aquaculture and fisheries, with the overarching objective to enhance food and nutrition security. This includes developing innovations to increase achieved yield of fish in aquaculture, improving availability and nutritional quality of feed (especially removal of fish meal and fish oil), improving genetics and reliability of fish seed, and enhancing sustainable fisheries management to improve harvest yields and increase reliability.
2. **Reducing and mitigating risks:** These Fish Innovation Lab activities identify and develop scalable technologies and practices that promote resilience and mitigate food security risks, especially through improved fish and environmental health. This includes increasing the tolerance of fish to biotic and abiotic stresses (including ecological resilience), improving diagnostic capabilities, maintaining healthy and bio-secure production environments, and reducing pre- and postharvest losses (including ensuring food safety).
3. **Improving human outcomes:** This Fish Innovation Lab program area generates evidence on how to sustainably and equitably improve economic opportunity, nutrition, and resilience in aquaculture and fisheries value chains, households, and communities. This includes identifying how aquaculture and fisheries can help improve nutrition and market opportunities (especially for vulnerable populations), equitable access to production assets (especially for women and youth), and establishment of an enabling environment for fish production.

Rationale for Aquaculture and Fisheries

Fish are a nutrient-rich and highly traded food commodity; as such, they are a unique global resource that offers opportunity for the Feed the Future Initiative to accomplish the goals of the Global Food Security Strategy for sustainable and equitable agriculture-led economic growth, strengthened resilience in people and systems, and improved nutrition—particularly for women and children. In the developing world, more than 2.6 billion people depend on aquaculture products and captured fish for more than 20% of their total animal protein — and in the Feed the Future countries of Bangladesh, Cambodia, Ghana, Sierra Leone, and Indonesia, fish constitute over 50% of animal protein intake (FAO, 2018. The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. License: CC BY-NC-SA 3.0 IGO). To meet the growing demand for food and quality protein (especially animal source protein), reduce potential conflicts over natural resources, and ensure equitable access to fish in developing countries, innovations are needed in both aquaculture and fisheries to foster sustainable, resilient, inclusive, and profitable production and marketing systems.

The aquaculture and fisheries sectors are important to global food security because:

1. **Fish provide high-quality animal protein and micronutrients**, including vitamins A, B12, zinc, iron, and selenium. In many of the Feed the Future countries (examples listed above), fish are the primary source of animal protein; thus, increased consumption of fish and/or fish products has potential to reduce childhood stunting and improve brain development and function.
2. **Fish are one of the most widely traded agricultural commodities worldwide**; increased trade (local and regional) has potential to improve livelihoods and increase incomes.
3. **Aquaculture and fisheries provide formal and informal employment opportunities** for women and youth.
4. **Aquaculture enables diversification of farming systems** through opportunities such as integrated aquaculture, providing increased economic resilience for producers.

Fish Innovation Lab Pillars

The Fish Innovation Lab funds **research for development**, which generates knowledge, innovations, and technologies and transfers information and innovations to stakeholders for achievement of impacts. Research for development requires scientific rigor, awareness of local context, and building of relationships to enable adoption and scaling. It is not an abstract quest for fundamental knowledge or the improvement of scientific theories, nor is it the straightforward delivery of goods and services associated with development work.

Fish Innovation Lab strategies are based on these pillars:

1. **Technology Innovations:** Innovative technologies to advance aquaculture and fisheries production result from productive collaborations among universities, private industry, government research agencies, and producers.
2. **Behavior Change:** Effective implementation of sustainable aquaculture and fisheries often requires voluntary behavioral changes among producers and fishers to comply with best practices. Socioeconomic research, therefore, is often required to determine the best methods to change behaviors.
3. **Value Chain Linkages:** Small-, medium-, and large-scale farms require linkages and support from private investors and industries up and down the value chain. Infrastructure development for industries to support producers (e.g., feed mills, seed stock production, harvesting and hauling equipment and services, and processing plants) is necessary for sustainable aquaculture development.
4. **Local Capacity Development:** Ensuring local institutional capacity that endures beyond Fish Innovation Lab-sponsored activities is achieved most effectively by building capacity in

partner organizations. One of the Fish Innovation Lab's goals is to build cooperative learning programs that foster two-way learning and the exchange of ideas and expertise between U.S. universities and international partners.

Theory of Change and Results Framework

The Fish Innovation Lab theory of change posits that: ***If*** innovative technologies from universities and nongovernmental organizations (NGOs) are more effectively developed and transferred to aquaculture producers and commercial support industries (particularly in feed and seed production), aquatic animal health and biosecurity capacity is effectively engaged to support aquaculture, behavior changes in producers and fishers are adopted to use sustainable practices, and equitable access to fish markets is enabled for fish producers and consumers, ***then*** goals of improved profitability and sustainability in fish production, increased resilience to cope with disease outbreaks and other threats, and more nutritious diets for vulnerable individuals (especially children and women) can be realized.

All Fish Innovation Lab activities connect to this theory of change and include three approaches, as specified in the Fish Innovation Lab results framework:

1. **Research for development.** Increased end-user aquaculture and fisheries research results promote sustainable, resilient intensification of production systems, enhance food safety and nutrition, increase trade and domestic market opportunities, and contribute to responsible aquatic resource management.
2. **Capacity building.** Activities result in increased capacity of local partners to independently generate and transfer fish-related knowledge, technologies, and practices to beneficiaries.
3. **Adoption of innovation and scaling.** Activities yield increased adoption of new technologies and practices, as well as other innovations.

Goals and Objectives

The overarching goal of the Fish Innovation Lab is to alleviate poverty and improve nutrition through reliable provision of fish, a nutrient-rich animal source food. Like all Feed the Future Innovation Labs funded by USAID, the Fish Innovation Lab will reach its goal by supporting a research for development program that will be composed of competitive subawards, commissioned research, and collaborations with international partners (universities, NGOs, private sector, and governmental research agencies). Buy-ins and associate awards will be used to extend Fish Innovation Lab activities and expand countries that are reached. The Fish Innovation Lab ME will implement activities that align to the following three objectives:

1. Advance aquaculture and fisheries productivity
2. Reduce and mitigate risks to aquaculture and fisheries
3. Improve human outcomes from the aquaculture and fisheries sector

These three objectives align with Fish Innovation Lab's three areas of inquiry, which are the focus of the Fish Innovation Lab research for development and capacity building programs. In Years 1 and 2, the activities undertaken within these objectives were implemented as Quick Start activities.

Research Strategy Development

The ME and ME Partners developed an overarching research strategy for the Fish Innovation Lab based on the thirteen competitively awarded activities. The main goal of the research strategy is to provide a framework for the cumulative contributions of the diverse set of research activities currently being funded. The research strategy will enable the ME and ME Partners to leverage the potential for comparative analysis between country contexts. It will also help ensure complementary research across the three areas of inquiry in support of Fish Innovation Lab intended results. The

research strategy was developed using a participatory approach through virtual sessions tailored to each target audience, as described below (Figure 2).

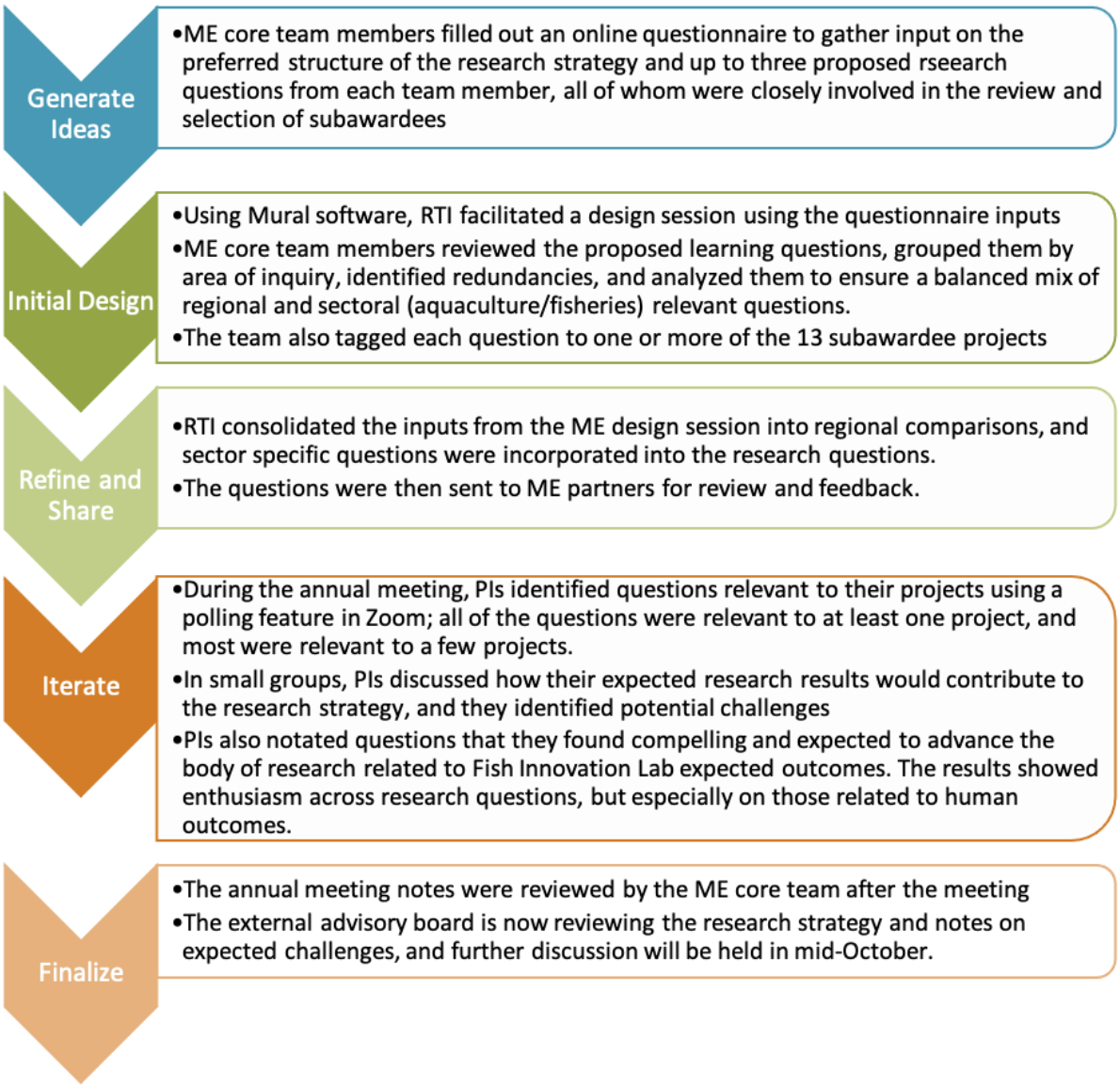

Figure 2. Research strategy development workflow.

Research Activity Reports

Objective 1: Advance aquaculture and fisheries productivity—completed Quick Start activities

Activity 1.1: Analysis of the aquaculture postharvest chain in Nigeria (Nigeria Cold-Chain Analysis)

U.S. PI: Julius A. Nukpezah, PhD, Mississippi State University
U.S. Co-PI: Joe Steensma, EdD, MPH, Washington University in St. Louis
HC PI: Tran Van Nhuong, PhD, WorldFish

Description: The activity aimed to analyze how to improve the contribution of aquacultured fish to the diet and household incomes of Nigerians, including poor and vulnerable women and children. It built on available data from public- and private-sector partners to map the aquaculture value chain in Nigeria. Geographic Information System tools were combined with field assessments using mobile data-collection tools to better understand the current aquaculture postharvest chain structure, efficiency, and key market constraints. The assessment complemented work conducted by the Bill and Melinda Gates Foundation (BMGF) and WorldFish. It identified opportunities for designing investments to improve the overall contribution of aquaculture to the well-being of Nigerians.

Objectives: The goal of the activity was to conduct a comprehensive analysis of the aquaculture postharvest chain of Nigeria to better understand the fate of harvested fish from production to consumption. The specific objectives were to:

1. Identify technologies and practices that provide income growth and improve diets, including postharvest loss reduction.
2. Identify and map the aquaculture market systems that improve productivity and reduce postharvest losses of aquaculture fish.
3. Identify gaps in the aquaculture postharvest sector in Nigeria.

Achievements: This Quick Start activity conducted a comprehensive analysis of the aquaculture postharvest chain of Nigeria. Activities were integrated with a BMGF-funded scoping study in Nigeria and executed by WorldFish and national partners. Using multi-criteria and participatory consultation approaches, eight states in Nigeria were selected for fieldwork, representing different agro-ecological zones, aquaculture production practices, poverty indices, and nutritional status. The activity analyzed the following elements of the Nigeria aquaculture postharvest chain:

1. **Characteristics of aquaculture production systems in Nigeria**. The activity analyzed the aquaculture value chain structure, finding that, while there were some variations between states, in general, the value chains were short and simple. The team also conducted cost-benefit analyses of tilapia and catfish and assessed postharvest loss along the aquaculture value chain.
2. **Aquaculture contributions to rural livelihoods and household incomes**. The study found that the most important factor influencing farmers' decisions to start aquaculture operations was from other farmers' successes and profitability.
3. **Aquaculture, women and youth engagement** – The activity found that men were more likely to participate in aquaculture production and processing activities, while women were more active in trading, wholesaling, and retailing activities.

Lessons learned: The study found that there is limited access to cold chain facilities in Nigeria. To cope with this, value chain actors keep transportation time short to maintain freshness and avoid spoilage. The average fish transport time for fresh tilapia and catfish were low (1.38 hours and 1.89 hours, respectively). A lesson learned was that postharvest losses are not pronounced and do not have a profound impact on the sector. Although both have low postharvest loss, catfish (due to its hardiness and variety of preparations) has less postharvest loss than tilapia.

Presentations and publications: Publications are in progress.

Activity 1.2: Replacing fishmeal with single-cell proteins in tilapia *Oreochromis niloticus* diets in Zambia (Zambia Feeds)

HC PI: Rodrigue Yossa, PhD, WorldFish
HC Co-PI: Rose Komugisha Basiita, PhD, WorldFish
U.S. PI: Delbert Gatlin, PhD, Texas A & M University

Description: Several ingredients have been investigated as alternatives to fishmeal in commercial aquatic animal feeds to support the sustainable growth of aquaculture globally. These alternative ingredients include, but are not limited to, insect meals and single-cell proteins (SCPs). SCPs can

be composed of yeast, bacteria, algae, or a combination. Zambia is unique in sub-Saharan Africa because it has high-quality, locally produced, commercial tilapia feed from Skretting Zambia and Aller Aqua Zambia feed mills, which are both located in Siavonga next to Lake Kariba. The commercial tilapia feed in Zambia uses soy and fishmeal as protein sources; replacement of fishmeal has the potential to increase profitability and sustainability of tilapia aquaculture in Zambia. This Quick Start activity evaluated the potential of replacing fishmeal in tilapia diets with SCP product developed by Meridian Biotech, a U.S. company. The SCP product evaluated (DY-Pro) is a yeast product. The Quick Start activity provided data to determine whether the product provides improved nutrition for tilapia and optimal levels of fishmeal replacement by evaluating growth, survival, nutrient utilization, and condition factor in tilapia. It further determined potential health benefits of the SCP product by evaluating effects on gut health. This activity provided institutional capacity development for Natural Resources Development College (NRDC) in Lusaka by improving facilities and building faculty expertise. It also provided individual capacity development for participating NRDC faculty and students.

Objectives: The purpose of this study was to investigate the effect of partially or totally replacing fishmeal by SCP ingredient in a tilapia (*Oreochromis niloticus*) commercial feed. The specific objectives were to:

1. Study the effect of partial or total replacement of fishmeal by SCP on the growth, survival, nutrient utilization, condition factor, and gut health in tilapia.
2. Estimate the optimum level of substituting fishmeal with SCP in tilapia diets.
3. Determine whether the SCP product is appropriate for tilapia nutrition.

Achievements: The activity upgraded the aquaculture facility at the NRDC in Lusaka by building a flow-through aquaculture system composed of a steel structure with three shelves, 30 aquaria, one 2000-liter tank, one 1000-liter tank, one air blower, one water pump, and plumbing. In the first half of 2020, the team finalized the feed formulation research protocol. Fishmeal was supplied by Aller Aqua Zambia, and the SCP was provided by Meridian Biotech. Seven experimental feeds were produced at TAMU early in 2020 and shipped to Zambia. WorldFish Zambia received the feeds and kept them frozen at NRDC until the start of the experiment. Yalelo supplied experimental fish, which were acclimated at the newly constructed facility at NRDC, testing the functionality of the new facility. The experiment effectively started in March 2020, when 11 fish with an average body weight of 11g per fish were stocked in each aquarium. Data were collected daily by the HC co-PI Masautso Sakala and two NRDC interns, who were hired to support the activity, while gaining hands-on aquaculture and research experience. Data on fish growth, feed intake, and water quality were collected according to the research protocol. The proximate composition of the fish and feed samples was analyzed in Zambia, and gut samples were shipped to the U.S. for gut immunohistochemistry. Following receipt of the lab analyses results, the data were analyzed and will be shared with Aller Aqua Zambia, Yalelo, and Meridian Biotech. A publication outlining the results of the experiment will be finalized in FY 21.

Lessons learned: The activity demonstrated that the use of DY-Pro tilapia diet can effectively help reduce the pressure on fisheries stocks by replacing 100% fishmeal in the tilapia diet without any significant effects on fish growth and condition factor. The research found a significant ($P<0.05$) linear regression between the replacement level of the fishmeal by the DY-Pro and the feed intake and feed conversion ratio. The increase in the replacement level of the fishmeal by the DY-Pro leads to a decrease in the feed intake and feed conversion ratio.

Presentations and publications:

Yossa, R., D. Gatlin, A.M. Greiling, R. Komugisha Basiita, M.E. Sakala, W. Baumgartner, D. Corace, & A. Taylor. (2020). Field Notes - Replacement of fisheries-derived fishmeal with yeast-derived proteins for sustainable aquaculture in Zambia. *The Chicago Council on Global Affairs*. https://www.thechicagocouncil.org/blog/global-food-thought/field-notes-replacement-fisheries-derived-fishmeal-yeast-derived-proteins [Cross-posted on Agrilinks].

Activity 1.3: Genome sequencing and development of SNP markers from rohu in Bangladesh (Rohu Sequencing)

U.S. PI: Attila Karsi, PhD, Mississippi State University
U.S. Co-PI: Dan Peterson, PhD, Mississippi State University
HC PI: Md. Samsul Alam, PhD, Bangladesh Agricultural University
HC Co-PI: Md. Akhtaruzzaman Khan, PhD, Bangladesh Agricultural University
HC Co-PI: John Benzie, PhD, WorldFish
HC Co-PI: Matthew Hamilton, PhD, WorldFish

Description: Bangladesh is an excellent example of the contribution of aquaculture to food security and livelihoods due to the importance of fish as a dietary source of protein and micronutrients. As a very important aquaculture species in Bangladesh, rohu carp accounted for about 13% of the total production of fish from ponds in 2016-2017. Polyculture practices have incorporated carps (such as rohu) for many years and recently have included combinations with small indigenous fish. However, improvements in broodstock selection are needed to increase the productivity of rohu. Broodstock selection has been initiated and family lines have been developed at WorldFish, but the evaluation of beneficial traits is needed to optimize and accelerate targeted family development. As a response, this activity identified challenges, possibilities, and needs of aquaculture in Bangladesh. Direct activity outputs included the evaluation of broodstock development, a high-quality genome sequence of rohu, and the identification of genome-wide single nucleotide polymorphism (SNP) markers for broodstock selection programs. The research aimed to inform selective breeding for additional carp species, such as silver carp and catla carp, and enable assessment of species impacts on pond productivity.

Objectives: The research goal was to improve aquaculture production and the livelihoods of farming communities in Bangladesh and surrounding regions by implementing sustainable genetic approaches. The objectives of the Quick Start activity were to:

1. Establish collaborations and conduct stakeholder surveys.
2. Conduct sequencing of the rohu (*Labeo rohita*) genome.
3. Identify genome-wide SNPs.

Achievements: This Quick Start activity assessed the constraints and need for development of rohu-based carp polyculture, focusing on profitability, efficiency, yield gap, youth engagement, species preference to culture, consumption, and nutritional perspective. The study used the stochastic production frontier to estimate the efficiency among a sample of 183 commercial farms practicing rohu-based carp polyculture located in five districts of Bangladesh. The potential yield gap, highest recorded yield gap, and experimental yield gap were calculated to determine the status of yield gaps among sampled farmers. A polynomial regression was used to highlight the relationship between different variables. Furthermore, a Tobit regression was employed to identify factors that influence the farmer's preference of rohu over other carps. A high-quality genome sequence for rohu carp was completed, and SNPs were identified that will enable genetic selection of rohu. Capacity in genome sequencing and SNP identification was developed at BAU.

Lessons learned: The study found that rohu-based carp polyculture is profitable. The gross margin, net margin, and benefit-cost ratio were all found to be positive. A technical efficiency analysis showed that the farmers were efficient, but the sample farmers nevertheless operated well below the production frontier. The yield gap is due to inefficiency of farmers and technical constraints (biotic and abiotic). The results indicate that abiotic factors are more responsible for yield loss than biotic factors. Productivity and efficiency were positively related where small farms were more productive and efficient than large farms. The results also revealed that a considerable portion of farmers were young – and that young farmers were more productive and efficient than older farmers. Most of the farmers preferred rohu as the main species in carp polyculture practice because of higher production, higher market demand, better feed conversion, and better taste and flavor. In terms of daily fish consumption by producer families, rohu alone contributed more than half to the total fish consumption and had significant contribution on daily protein requirements. Because

feed cost is the highest aquaculture input, greater attention should be placed on feed price to promote carp polyculture practice. Furthermore, farmers should be encouraged to apply the right amount of inputs to their ponds, which would enhance productivity and reduce the yield gap. Identification of SNPs in the rohu carp genome demonstrate that genetic analysis to support selection and improvement of rohu production traits is feasible.

Presentations and publications:

Hossain, E, Alam, S., Khan, A, & Dey, M. (2019). *Economics of rohu based carp polyculture in Bangladesh: Efficiency, yield gap and nutritional perspectives.* Presentation at the Biennial Conference of Fisheries Society of Bangladesh 2019.

Hossain, M. E. (2019). *Economics of rohu based carp polyculture in Bangladesh: Efficiency, yield gap and nutritional perspectives* [Master's thesis, Department of Agricultural Finance, Bangladesh Agricultural University].

Khan, A. (2019). *Economics of rohu based carp polyculture in Bangladesh: Efficiency, yield gap and nutritional perspectives.* Paper presented at the workshop titled Challenges, Needs and Potential of Aquaculture and Fisheries in Bangladesh.

Objective 1: Advance aquaculture and fisheries productivity—competitively awarded activities

Activity 1.4: Aquacultural and rural communities: Farm diversification strategy through integrated agriculture-aquaculture systems and nutrition-sensitive value chains for better nutrition outcomes

LEAD PI: Matthias Halwart, PhD, Food and Agricultural Organization of the United Nations
LEAD Co-PI: Yuan Xinhua, PhD, Food and Agricultural Organization of the United Nations
US PI: Esendugue G. Fonsah, PhD, University of Georgia
US Co-PI: Gary J. Burtle, PhD, University of Georgia
HC PI: E.K. Ajani, PhD, University of Ibadan
HC Co-PI: B.O. Omitoyin, PhD, University of Ibadan

Objectives: The activity goal is to secure supply and access to rice and fish, improve nutrition-sensitive diets, promote resource use efficiency, and generate employment and better livelihood options in the selected communities. Present challenges relevant for future needs of vulnerable populations will be addressed through appropriate research and targeted interventions. The activity will demonstrate the importance of technology innovations for enhancing and sustaining aquaculture production, economic opportunities for youth and women, and resilience of rural communities to food and nutrition security challenges. The objectives are:

1. The activity will consider the technologies that are accessible to local farmers and analyze how Integrated Agriculture-Aquaculture (IAA) systems influence the resilience, dietary diversity, livelihood options, rural employment (especially for youth and women), use of resources, and the role of institutional and policy innovations.
2. The activity will study how diversification of farming systems through IAA can contribute to producing more diversified and nutritious food for the local market and rural communities with consideration for all demographic strata (women, men, and youth).
3. The activity will study value chain enhancement through market access facilitation and marketing management.
4. The activity will study sustainability and long-term support of capacity development of farmers, extension workers, university students, and value chain actors for activity goals within and beyond activity locations.

Outcomes:

1. Suitable integrated rice-fish production technology will be developed through participatory research actions.
2. Understanding of convenient market access approaches and nutrition contributions of rice-fish farming products will be achieved.
3. Capacity development and enhancement of co-learning among all stakeholders (farmers, value chain actors, and extension workers) will be accomplished.

Achievements:

1. A knowledge base on agroecological wetlands suitable for integrated fish and rice farming was developed (Wetland map.docx). Action research was conducted (using a ground truth survey, aerial imagery, topographic data, and a digital elevation model) to develop a knowledge base on agroecological wetlands suitable for integrated fish and rice farming in the Kebbi and Ebonyi states. Two stakeholder meetings were conducted – one in Kebbi and one in Ebonyi. Three community-based stakeholders' meetings were conducted in each state.
2. Site selection and situational analysis of the activity communities were conducted.
    a. A community coordination and stakeholder workshop was conducted before site selection**.**
    b. One stakeholder meeting was organized in each of the participating states during which all concerned stakeholders, such as government officials, NGOs, and local government bodies, were involved in developing working modalities of the activity to be used in identification and selection of the beneficiary farmers.
    c. Baseline survey of the possible rice paddy areas for IAA in each of the participating states was conducted; thus, detailed information on the rice paddy areas suitable for integrated rice-fish farming were documented.
3. A functional innovation platform on IAA systems was established. Three site-specific innovation platform templates were put in place in Kebbi and Ebonyi states.
4. Research sites, farmer beneficiaries, and students (200 farmers minimum) were selected.
    a. Two farming system were identified in both states (Kebbi - lowland rice production and Ebonyi - rainfed/upland rice production).
    b. Four adaptive research sites (three in situ and one ex situ) each in Kebbi and Ebonyi states were identified and established (ongoing).
    c. 100 activity beneficiaries each were identified in Kebbi and Ebonyi states.
    d. Graduate students were selected from seven candidates interviewed for study of rice-fish farming systems, market access, and local fish feed production technologies. Study plan development is in progress.
    e. Local commodities were identified for potential utilization in fish feed formulation.
5. Adaptative research was designed and established in six selected sites (ongoing).
6. A food/fish consumption survey was conducted.
    a. Baseline fish consumption survey was done in the two activity states to generate data on the level of inclusion and nutritional contribution of fish in the diet of the communities.
    b. Household Dietary Diversity Score (HDDS), Food Consumption Score (FCS), and Household Food Insecurity Experience Scale (HFIES) were conducted to have a baseline overview of the food and nutrition status of households in the communities.

7. Preliminary work began on the knowledge base for fish feeds from local Nigerian ingredients.

Lessons learned: 1) The project activities are mostly time and season specific. This needs to be considered when developing the funding disbursement schedule. 2) Experimental learning through development of a site-specific innovation platform (comprised of the various stakeholders) will open clear opportunities for integration of rice and fish through the activity supports. 3) Innovative extension approaches, as adopted in the project implementation activities, with emphasis on the participation of target groups, show that the integration of aquaculture into smallholder farming systems holds great promise for success.

COVID-19 related lessons learned: The Nigerian national lockdown due to COVID-19, as well as U.S. and Italy travel restrictions, delayed activities and disrupted the implementation timeline. University of Georgia and FAO partners' in-country interactions with host country partners and other stakeholders were prevented. Field work planning was affected, and data collection was delayed. This negatively impacted the annual work plan because most of the activities were season specific. The impacted activities are planned for next year when COVID-19 restrictions, hopefully, will be over.

To be compliant with COVID-19 safeguards, the activity made a conscious effort to provide awareness campaigns, along with special training and support, to enable scientists and beneficiary communities involved in the activity implementation to meet new COVID-19-related health and hygiene requirements.

In addition, COVID-19 has led to increased local transportation costs (road and air), which has impacted the total activity cost. Some changes in the work plan and resource allocations may be required to include activities in response to the COVID-19 crisis.

Presentations and publications:

Ajani, E. K., & Omitoyin, B. O. (2020) *The project objectives and implementation arrangement.* Presentation at a stakeholder workshop and innovation platform in Kebbi and Ebonyi states.

Activity 1.5: No longer bugged by feed costs: Farming insects as sustainable and scalable aquaculture feedstock to improve catfish (Clariidae) producers' and consumers' livelihoods towards food security in Nigeria (Farming Insects)

US PI: Jennifer Pechal, PhD, Michigan State University
US Co-PI: Simone Valle de Souza, PhD, Michigan State University
HC PI: Bolarin T. Omonona, PhD, University of Ibadan

Objectives: This activity will evaluate integrated insect-to-fish (ITF) farming systems: 1) costs and conversion ratios of propagating black soldier fly (BSF) and processing into aquaculture feed; 2) feasibility and cost- effectiveness of organic waste streams (e.g., market waste) for BSF farming; 3) changes in pond yield and productivity resulting from BSF meal replacement in fish feed; 4) changes in nutrient profiles of farmed fish resulting from partial BSF meal substitution in fish feed; 5) economic viability and impacts of female-led small-scale BSF production enterprises; and 6) effects of BSF meal production and processing on labor, time allocation, and household income for the BSF farmers and fish farmers. We expect fish farmers to willingly learn about and adopt BSF meal because it is a low-cost, local-input, nonmechanized technology that will produce a substantial part of the animal protein needs of fish.

Outcomes: We expect these activities will produce the following evidence and service delivery: 1) BSF-based aquaculture feed will be developed that is noncompetitive with human food production to improve sustainability of the aquaculture industry; and 2) capacity of private sector, academic, and NGO stakeholders will be enhanced via training seminars and workshops. Ultimately, achievement of these outcomes should result in increased food and job security for vulnerable populations in Nigeria.

Achievements: The initiative to combat global hunger is a focus at the forefront of the Farming Insects activity. Despite the COVID-19 challenges that delayed on-the-ground research activities, this focus is kept in mind. Thus far, the team has attended the virtual annual meeting for all the PIs and regional learning agenda meetings. Several team meetings were held to identify avenues for moving forward under the restrictions, to keep all individuals safe, and slow the spread of COVID-19. The University of Ibadan team has communicated with relevant contacts in each site to understand the relevant population and develop survey sampling methods. The team contacted the program managers of the Ebonyi and Cross River Agricultural Development Programmes (ADPs) to obtain an understanding of how the fish farmers are organized in Ebonyi and Cross River and to establish links with the fisheries subject matter specialists (SMSs) of the two states. They received permission from the Cross River ADP program manager to work with the fisheries SMS, and permission is being pursued from the Ebonyi ADP. An ongoing literature review is being performed to support Objective 4. Drafts of a fish farmer survey are being developed with expected finalization in the next six weeks and implementation to occur by the end of the calendar year. Identification of the required capital investment and operational costs per stage of BSF and catfish production was subdivided into four sub-steps, with a plan to start in December 2020.

Lessons learned: The COVID-19 pandemic stalled activities. The activity team could not travel to the study area due to the lockdown. This is being eased now, so the team should be in the field soon after resolving some permission issues.

Presentations and publications: None to report

Activity 1.6: Improving efficiency in the Nigerian aquaculture sector by employing lean production systems (Lean Production Systems)

HC PI: Rohana Subasinghe, PhD, WorldFish
HC Co-PI: Sunil Siriwardena, PhD, WorldFish
US PI: Julius Nukpezah, PhD, Mississippi State University
US Co-PI: Joe Steensma, EdD, Washington University in St. Louis

Objectives: The research objective is to improve operational efficiency, reduce postharvest losses, improve waste management, and decrease the cost of production of catfish and tilapia in Nigerian aquaculture through application of Lean Production Systems. The goal is to explore how Lean Technology can be used in a developing country context, specifically in Nigeria, to identify benefits that are conferred to small-scale fish farmers as well as larger corporate aquaculture operations and processors. In short, the goal is to prevent the loss of value along the value chain and economize the process of raising fish and bringing them to market using Lean Technology.

Outcomes: Tilapia and catfish industries in Ogun and Delta states of Nigeria will adopt and apply science-based Lean Production System management concepts to increase efficiency by reducing production costs, waste, and postharvest losses. Application of these strategies will increase financial and social benefits to small-scale farmers and their families. If successful, the activity will implement a scaling program to drive down the costs of production within the sector, which has potential to decrease costs to consumers.

Achievements: The Lean Production System team conducted two fact-finding visits at activity sites in Ogun and Delta. The activities of the fact-finding visits were aimed at:

1. Organizing awareness meetings that establish relationships, build trust, and sell the benefit of being involved in the Lean activity. Awareness meetings also enabled understanding of the issues or problems impacting future participants, determining the pain-points within their areas of responsibility, and beginning the recruitment process to identify Lean subject matter expert (LSME) participants.
2. Organizing farm visits that entailed recruiting individuals to become LSMEs, walking through the facility, watching operations, talking to leadership and asking questions, talking with workers/farmers and asking questions, and looking for waste examples.

Other activities that were accomplished included development of LSME selection criteria, LSME and Lean-management curriculum development consultant recruitment, and training for these recruited participants. Recruitment of the activity MEL assistant and MEL data collection were accomplished.

Lessons learned: The lessons learned through this activity were primarily on the adaptations that can be made due to COVID-19. The team realized that some planned activities could be delegated to professionals in the host country and that some meetings could be held virtually.

Presentations and publications: None to report

Activity 1.7: Development of bighead catfish (*Clarias macrocephalus*) culture for sustainable aquaculture in Cambodia (Bighead Catfish)

HC PI: Lyda Hok, PhD, CE SAIN, Royal University of Agriculture
HC Co-PI: Rodrigue Yossa, PhD, WorldFish
US PI: Manuel 'Manny' Reyes, PhD, Kansas State University
US Co-PI: Delbert Gatlin, PhD, Texas A&M University

Objectives: The goal of the activity is to develop and apply new technologies on formulated sustainable feeds for bighead catfish (BC) (*Clarias macrocephalus*) culture that will increase income, promote gender equality, empower youth, provide nutritious food, and strengthen resilience in Cambodia, while building the capacity of local institutions to expand the farming of this species. The objectives are:

1. To develop and scale cost-effective feeds for sustainable culture of BC in Cambodia.
2. To strengthen the infrastructural and human aquaculture research capacities of local institutions.

Outcomes:

1. Sustainable fish culture technology to meet increasing demand of local catfish *Clarias macrocephalus* for local and regional markets will be developed.
2. The overfishing of local catfish *Clarias microcephalus* and the use of under-rated fish in BC feed will be reduced.
3. Knowledge and human capacity on aquaculture in Cambodia will be improved.

Achievements: During this reporting period, investigators developed the workplan of the Bighead Catfish team led by Royal University of Agriculture (RUA). The team identified networking links between the host country and the U.S. teams. Possible links between the Bighead Catfish activity and other Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN) projects in Cambodia were explored. The team requested funding from the Southeast Asian Regional Center on Graduate Studies and Research in Agriculture (SEARCA) for a SEARCA scholar to study at an aquaculture university in Malaysia on the thesis topic of bighead catfish with Dr. Yossa serving as a committee member. CE SAIN/RUA identified a graduate student to join the activity, and a project coordinator was identified through a competitive process. Both will join in December 2020 to support the project activities.

Lessons learned: Nothing to report at this time

Presentations and publications: None to report

Activity 1.8: Achieving coral reef fishery sustainability in the Kenyan biodiversity and climate refugia center (Coral Reef Fishery Sustainability)

LEAD PI: Timothy McClanahan, PhD, Wildlife Conservation Society
LEAD Co-PI: Nyawira Muthiga, PhD, Wildlife Conservation Society
HC PI: Emmanuel Mbaru, PhD, Kenya Marine and Fisheries Research Institute
US PI: Austin Humphries, PhD, University of Rhode Island

Objectives:

1. Determine the yield potential for coral reef climate refugia to support improved fisheries management.
2. Determine the best metrics for measuring sustainability to enhance the likelihood of sustainable management.
3. Improve the management capacity of communities to monitor fisheries and habitats and use this information for adaptive management.
4. Measure perceptions about natural resource use and sustainability among dependent communities and encourage realistic expectations.

Outcomes:

1. Estimations of sustainable yields specific for coral reefs at activity sites will be determined, and community knowledge will be improved.
2. The best metric for estimation of sustainability of fisheries will be determined, and community knowledge will be improved.
3. Community capacity will be improved through training in monitoring coral reef fisheries and ecology.
4. Perception by communities of resource use and sustainability will be changed, resulting in improved management practices.

Achievements: To determine the yield potential for coral reef climate refugia to support improved fisheries management, the activity team developed and submitted a one-year work plan outlining activities for the period, resource allocation, and a budgeting template. The work plan and a fisheries survey tool (described below) helped in activity kickoff and stakeholder engagement. Total sustainable yields were estimated by collecting important species at activity sites and enhancing community awareness and knowledge about the status of fisheries, especially yield potentials and limitations. A survey tool was developed that consisted of a fisheries and socioeconomic literacy questionnaire. It was tested on ten community stakeholders, who were also engaged and informed about the project status and activities. The pilot test of the literacy questionnaire helped in evaluating the tool's readiness for a full research study in the coming months.

Lessons learned: COVID-19 caused delays in activity implementation and necessitated development and implementation of measures and guidelines for the safety of participants.

Presentations and publications: None to report

Activity 1.9: Cryogenic sperm banking of Indian major carps (Catla, *Labeo rohita*, and *Cirrhinus cirrhosis*) and exotic carps (*Hypophthalmichthys molitrix*, *Hypophthalmicthys nobilis*, and *Ctenopharyngodon Idella*) for commercial seed production and brood banking (Cryogenic Sperm Banking)

HC PI: Md. Rafiqul Islam Sarder, PhD, Bangladesh Agricultural University
HC Co-PI: Mohammad Matiur Rahman, PhD, Bangladesh Agricultural University
US PI: Terrence Tiersch, PhD, Louisiana State University

Objectives: The overall objective is to increase production of Indian major carps (IMCs) and exotic carps by improving broodstock quality and seeds through establishing a national genetics program based on cryogenic sperm banking. The specific objectives are:

1. To develop donor broodstocks of IMCs and three exotic carps.
2. To cryopreserve sperm of IMCs and exotic carps and develop a cryogenic sperm bank.
3. To produce seeds of carps in hatcheries using cryopreserved sperm and characterize and assess their quality through growth studies and DNA microsatellite analysis.
4. To assess the performance of cryopreserved sperm for establishment of sperm banks in different regions.

5. To evaluate the adopting ability of technology by the stakeholders.

Outcomes:

1. Donor broodstocks (male and female) of IMCs from different river origins and three exotic carps will be developed.
2. Sperm of IMCs and exotic carps will be cryopreserved, and a cryogenic sperm bank will be developed.
3. Seeds of IMCs and exotic carps in public and private hatcheries using cryopreserved sperm will be produced, and quality will be characterized and assessed through growth studies and DNA microsatellite markers.
4. Performance of cryopreserved sperm will be assessed, and the feasibility of establishing sperm banks in additional regions will be evaluated.
5. Seeds produced with cryopreserved sperm will be supplied to 24 hatcheries (technology adoption) beyond the 22 selected (pioneer) hatcheries in four regions, and the growth and survivability of the seeds will be compared.

Achievements: During this time period, the activity recruited personnel, including field laborers, manager cum accountant, and PhD fellowship positions. Experimental ponds were prepared for rearing broods and stocking of fish. Experimental fish for broodstock development were collected, stocked in ponds, and are being reared with supplementary feed. The fish included Indian major carps of Halda and Padma river-origin. Three exotic carps have been collected from known good sources and are being reared in ponds. Fifty of these three exotic carps (recently collected from China) have been collected from a Government Fish Seed Multiplication Farm and are being reared in ponds.

The team attended the first in a series of five interactive virtual training workshops that were organized by Bangladesh Agricultural University (BAU) and the Louisiana State University Agriculture Center (LSUAC) on cryopreservation of sperm and repository development. The five interactive workshops were developed to provide training and facilitate cooperation. The workshops were also intended to familiarize the groups with the capabilities at each institution and to provide an understanding of the underlying principles, theory, and practice of cryobiology, cryopreservation, and repository development. The workshops included personnel of BAU (including MS and PhD students), LSUAC Aquatic Germplasm and Genetic Resources Center, LSU College of Agriculture International Relations, LSUAC Global Network, and outside collaborators (e.g., Department of Fisheries) in each country. The first workshop described the capabilities for aquatic germplasm preservation at BAU and overviewed the activity goals. The remaining four workshops are ongoing.

Lessons learned: Due to the outbreak of COVID-19, the team faced challenges. Since early spring, BAU remained closed, and no students were allowed to stay on the university campus. Therefore recruitment of MS students was not possible. Some sections of the BAU Research System are running with minimum staff and limited working hours, so processing and getting approval of necessary documents from authorities took more time. Selection of PhD fellows and manager cum accountant through in-person interviews was difficult. However, interviews were conducted, and candidates were selected in June. Collection of fish from different sources for broodstock development was very difficult due to restrictions on movement imposed by the government; however, the team successfully traveled to the collection site while maintaining safety measures and brought the fish to the BAU campus. Although physical visits to hatcheries were not possible, communications with the hatchery operators were maintained via mobile phone. Hands-on training of the BAU research team at LSUAC was not possible, so a virtual interactive training workshop was arranged, and the planning meeting was held.

Presentations and publications: None to report

Activity 1.10: Increasing sustainability of fisheries for resilience of Cambodian communities (Cambodian Fisheries and Food Processing)

US PI: Sandra Correa, PhD, Mississippi State University
US Co-PI: Wes Neal, PhD, Mississippi State University
US Co-PI: Peter Allen, PhD, Mississippi State University
US Co-PI: Thu Dinh, PhD, Mississippi State University
US Co-PI: Wes Schilling, PhD, Mississippi State University
HC PI: Som Sitha, MS, Wildlife Conservation Society
HC Co-PI: Simon Mahood, MS, Wildlife Conservation Society

Objectives:

1. Improve sustainable fisheries management by assessing changes in the existing fishery through the development of a protocol to monitor fish populations and implement a citizen science digital platform for documentation and analysis of harvest.
2. Educate and train villagers in standardized food processing and preservation techniques to reduce fish waste.

Outcomes:

1. Community and regional knowledge of fisheries management and postharvest food processing techniques will be increased in youth, women, and men.
2. A long-term dataset will be developed on artisanal fisheries diversity, abundance, size distributions, and reproductive stage, which will inform ongoing and future community-based management efforts.
3. Training of villagers in fisheries data collection and analysis will be done, which will allow successful transfer of the program to the Community Fisheries Council upon activity completion.
4. Postharvest training will be provided, which will add capacity to develop fish processing and preservation techniques for family-scale to village-scale fish handling.

Achievements: Required start-up documents were completed, which included finalizing a subaward contract for the HC partner, Wildlife Conservation Society (WCS) in Cambodia; submitting work plans for FY 20 and a modified work plan for FY 21 that adapted to COVID-19 international travel restrictions; and submitting a milestones payment schedule for WCS for year 1. Announcements to hire personnel and recruit graduate students in Cambodia were developed and posted, and WCS hired one project coordinator for objective 1 and reported the announcement for a project coordinator for objective 2.

An IRB protocol for human-subject research that contains the survey instruments and consent forms was developed and submitted. A data-management procedure was created to keep internal records of activities and outcomes for our team. Survey instruments, training materials, and an online Canvas course to launch the activity remotely in response to COVID-19 international travel restrictions were prepared.

A daily fishing logbook for fishers to systematically record their harvest was developed and translated to the Khmer language. The logbook contains instructions on how to record data and is supported by a laminated photographic fish-identification guide for the Sre Amble River. The photographic fish-identification guide includes 83 fish species likely to be caught and 158 species possibly to be caught in subsistence fishing within the Sre Amble River. A fisheries visual catalog was printed and laminated that includes a color photo of each fish, scientific name, and maximum length in centimeters (retrieved from FishBase.org). This guide is part of the logbook included in the citizen science kit that will be distributed among fishers participating in our program. The citizen science kits contain the logbook, instruments to measure fish length, and a photographic camera with Global Positioning System capability to confirm fish species identifications and record the location of fishing activity and fish species occurrence. Lastly, a training video was recorded to demonstrate how to record data that will be used in train-the-trainer workshops.

Lessons learned: The main challenges were related to administrative delays and international travel restrictions due to COVID-19. The response was to adapt activities to online training and revise the work plan for FY 20-FY 21 to postpone other activities. For training purposes, a Canvas course was developed to be used to conduct personnel training and other workshops.

Presentations and publications: None to report

Objective 2: Reduce and mitigate risks to aquaculture and fisheries—competitively awarded activities

Activity 2.1: Improving biosecurity: A science-based approach to manage fish disease risks and increase the socio-economic contribution of the Nigerian catfish and tilapia industries

LEAD PI: Mohan Chadag, PhD, WorldFish
LEAD Co-PI: Jerome Delamare-Debouttеville, PhD, WorldFish
LEAD Co-PI: Rohana Subasinghe, PhD, WorldFish
US PI: Larry Hanson, PhD, Mississippi State University
US Co-PI: Robert Wills, PhD, Mississippi State University
HC PI: Olanike K. Adeyemo, PhD, University of Ibadan
HC Co-PI: Oluwasanmi O. Aina, PhD, University of Ibadan

Objectives:

1. Understand epidemiology and health economics of catfish and tilapia aquaculture in Ogun and Delta states, Nigeria.
2. Understand health status of catfish and tilapia in a regional model by employing presumptive field and laboratory diagnostics.
3. Identify pathogens of economic significance circulating in Nigerian catfish and tilapia aquaculture using whole genome sequencing.
4. Develop better management practices (BMPs) and build capacity to reduce risks of disease outbreaks in catfish and tilapia aquaculture in Nigeria.
5. Develop science-based policies and strategies for reducing fish disease risks in Nigerian aquaculture for longer-term development beyond the 3 years of the activity.

Outcomes:

1. Risk factors for disease emergence, outbreaks, and spread, including seasonality issues with respect to environmental and climate change associated risks, will be identified.
2. Endemic, emerging, and exotic pathogens will be identified, and economic impacts will be quantified in regional models.
3. Whole genomes of key pathogens isolated from farming systems and seed supply networks will be sequenced by next generation sequencing.
4. Health management interventions for fish farming systems and fish seed supply chains that reduce fish disease risks, in the form of BMPs and capacity building activities tailored to the needs of various stakeholders, will be developed and implemented.
5. Research findings and capacity development activities will support development and operationalization of a simple and practical national aquatic animal health and biosecurity strategy for implementation by the national competent authorities.

Achievements: During this reporting period, the team contextualized WorldFish and the Norwegian Veterinarian Institute's Fish Epidemiology and Health Economics online tool for catfish and tilapia produced in Ogun and Delta states. An initial list of farms and hatcheries were identified for Ogun and Delta states for inclusion in the biological samples collection for an epidemiological survey, and informal calls were made to start the process of obtaining farmers' consent for participation in the

activity. An office at the University of Ibadan has been allocated to the activity for effective coordination of activities, and identification and recruitment of enumerators from the University of Ibadan were successfully completed. A program officer was identified, but engagement has been delayed to avoid paying remuneration when the activity has not commenced its field activities. Two master's degree students have been recruited for the activity. Because of COVID-19, schools are officially closed, but the students are available for virtual trainings. Standard operating procedures for fish health sampling for laboratory diagnostic testing were identified, and the team applied for Animal Ethic clearance.

Lessons learned: The COVID-19 pandemic has forced the investigators to adapt and learn how to work remotely and to develop materials for virtual meetings and trainings.

Presentations and publications: None to report

Activity 2.2: Identifying the major sources of fecal pathogens in Bangladeshi aquaculture value chains and evaluating the effectiveness of various risk reduction strategies (Sources of Fecal Pathogens)

US PI: Mohammad Aminul Islam, PhD, Washington State University
US Co-PI: Clare Narrod, PhD, University of Maryland
US Co-PI: Salina Parveen, PhD, University of Maryland Eastern Shore
HC PI: Mohammed Badrul Amin, PhD, International Centre for Diarrhoeal Disease Research, Bangladesh

Objectives:

1. Determine the prevalence of pathogens on Pangas catfish and tilapia at retail markets.
2. Understand behavioral practices of fish value chain actors that can impact microbial contamination of fish.
3. Assess fish value chain for microbial contamination and develop quantitative microbial risk assessment (QMRA) models characterizing exposure to pathogens along the fish value chain.
4. Conduct sensitivity analysis using QMRA models to identify critical points for implementing future intervention strategies.

Outcomes: This study will provide data on microbiological quality of fish at retail markets and along the supply chain. The study will provide an understanding of how behavioral practices among different value chain actors impact the load of microbial pathogens on fish, and the key players to train in a future intervention study. Results and data from this study will support science-based decisions on the most effective methods and key actors/locations where interventions can reduce microbial contamination of fish in informal markets of Bangladesh. Training of local laboratories on microbial methods and risk analysis will be useful not only for this study, but for expanded monitoring of the microbial quality of fish at sale.

Achievements: During this time period, the research protocol was submitted to icddr,b and Washington State University IRB, and the protocol was approved. SOPs for all test parameters and data collection tools were finalized after several rounds of review by our expert panel of investigators.

For capacity building, theoretical and hands-on training was provided to Government of Bangladesh staff from Quality Control Lab (Department of Fisheries, Ministry of Fisheries) and the Food Safety Lab (Institute of Public Health). The same capacity building training was provided to icddr,b staff from Environmental Health Laboratory and Food Safety and One Health Laboratory. Market mapping, including retail and wholesale, based on Zone of Influence (where possible) was completed. Qualitative tools for questionnaires and focus group discussions have been completed in both English and the native language (Bangla). Piloting of the sampling method and lab experiments have been completed. Based on the outcome of piloting results, field sampling and

routine laboratory activities related to the activity will start. A monthly virtual meeting with all the investigators hosted by U.S. PI Islam will occur.

Lessons learned: Due to the COVID-19 pandemic, activities were delayed and onsite training could not be delivered. However, this problem was adjusted by conducting training sessions virtually, and ultimately the trainings were completed without any difficulties. Delays in data collection and sample testing in the host country lab (icddr,b) are anticipated because it is not yet operating at full capacity.

Presentations and publications: None to report

Objective 3: Improve human outcomes from the aquaculture and fisheries sector—completed Quick Start activities

Activity 3.1: Improve nutrition among vulnerable populations in Kenya through increased access to and consumption of sustainable fish foods (SecureFish)

US PI: Lora Iannotti, PhD, Washington University in St. Louis
US Co-PI: Austin Humphries, PhD, University of Rhode Island
HC PI: Andrew Wamukota, PhD, Pwani University
HC Co-PI: Elizabeth Kamau-Mbuthia, PhD, Egerton University

Description: The SecureFish activity aimed to build a foundation for the Fish Innovation Lab goal to improve nutrition among vulnerable populations in Kenya through increased access to and consumption of sustainable fish as food from coastal marine fisheries. The activity conducted a comprehensive inventory of coastal marine fish for food that maintain ecosystem functioning and address micronutrient deficiencies in vulnerable groups. The activity also generated insights about current household fish consumption and social dynamics in low-income households. The market analysis outputs provided guidance on coastal marine fish species with potential as micronutrient sources.

Objectives:

1. Identify nutritious coastal marine fish for food that maintain ecosystem functioning.
2. Assess the acceptability and feasibility of these fish as foods for nourishing vulnerable populations of pregnant and lactating women, and young children.
3. Determine market conditions for ensuring availability, affordability, and safety of these coastal marine fish as food.

Achievements: The SecureFish team collected primary data from marine fishery communities and families in the Kilifi, Mombasa, and Kwale counties of Kenya in 2019. The purpose of the data collection was to understand current attitudes, behaviors, and beliefs around fish food consumption in vulnerable groups (i.e., women and young children). A rapid assessment of the acceptability and access to fish foods was also conducted. Quantitative data were collected from 100 fishing households and 100 nonfishing households. Twenty-one in-depth interviews were conducted with participants, including caregivers and community health workers. Both the nutrition- and fisheries-related data were cleaned, managed, and analyzed in FY 20. One publication has been submitted for peer-review in FY 20, and other publications are in development. Publications address 1) stunting differences in fishing vs. nonfishing households, 2) links between biodiversity and dietary diversity, 3) attitudes and behaviors toward fish as food for young children, and 4) fisheries catch and value-chain dynamics. The team has also presented and discussed the findings with community members and county-level nutrition and fisheries officers.

Lessons learned: The activity demonstrated that while fishing is an important livelihood, fish does not significantly contribute to the nutrient intake of children. Hence, there is an opportunity to develop nutrition education and social marketing messages on the importance of healthy diverse diets with special emphasis on fish nutrition for the growth and development of children. The team found that children in fishing households were more malnourished with higher rates of stunting,

underweight, and wasting – allowing for greater intervention response by increasing fish in complementary feeding diets and diversifying diets. The activity identified women fryers (Mama Karanga), as vital actors in the fisheries value chain. This is the only place that women are engaged in the fishery, and thus greater attention should be placed on gender equity and opportunity, including involving Mama Karangas in the decision-making related to fisheries management and value chain improvements. The team also identified octopus as being important for local wellbeing and livelihood, warranting further research into its nutritional benefits. Among the different fish species, tafi were the most sustainable option for fisheries that do not negatively impact ecosystem functioning, so gear modifications and interventions should be aimed at reducing pono and changu catches while increasing the catches of adult tafi. This could be done through increases in trap fishing (which was also the most sustainable gear type) and installing escape gaps in these traps to allow juveniles to escape.

Presentations and publications:

Publications (in process) for 1) anthropometry and dietary intakes, 2) qualitative research findings, and 3) value-chain analysis.

Publication (to be submitted to Nature Food): *Blue Prospects: Fish for Human Nutrition and Planetary Health.*

Wamukota, A. (2020, January 9). *SecureFish Kenya.* Presentation at the Annual Fishers Forum, Diani, Kenya.

Wamukota, A. (2020, March 12). *SecureFish Kenya.* Presentation at Unlocking a Resilient Blue Economy a workshop organized by CordIo EA/IUCN, Mombasa, Kenya.

Humphries, A. (2020). *Working towards ecosystem health solutions in Kenya.* Presentation at the University of California, Santa Cruz Coastal Science and Policy Seminar Series.

Activity 3.2: Assessing facilitators and barriers to aquaculture and fish consumption in Zambia (Fish4Zambia)

U.S. PI: Kathleen Ragsdale, PhD, Mississippi State University
U.S. Co-PI: Mary Read-Wahidi, PhD, Mississippi State University
U.S. Co-PI: Elin Torell, PhD, University of Rhode Island
HC PI: Lauren Pincus, PhD, WorldFish
HC Co-PI: Pamela Marinda, PhD, University of Zambia

Description: Fish provide essential micronutrients and contribute to a diversified diet for millions of people in Zambia, yet undernutrition is a serious problem in the country, where 40% of children under the age of five are stunted. Fish are a unique animal-source food that is rich in protein and essential fatty acids. Small fish have particularly high levels of micronutrients, especially in the bones, head, and gut. Because small fish are often eaten whole, they provide high nutritional benefits, especially for pregnant and lactating women and children in the first 1,000 days. Research to assess how small fish reach vulnerable household members (e.g., infants/children, pregnant/lactating women) in Zambia is lacking. Fish4Zambia outputs included 1) an assessment of existing fisheries enterprises disaggregated by key actors' gender and age, conducted to understand existing barriers and bridges to women- and youth-led fisheries development and to pinpoint leverage points for growing the sector and 2) a fish-flow study of actors' engagement across the fish value chain (i.e., as producers, processors, marketers, and consumers). Results informed the Fish Innovation Lab-supported postharvest value-chain activities, the USAID Zambia Mission, and the Government of Zambia investments in fisheries. Fish4Zambia contributed to Feed the Future objectives to understand why many Zambians (particularly women and children) lack dietary diversity and remain vulnerable to food insecurity and malnutrition.

Objectives: Fish4Zambia aimed to increase the quality/quantity of fish benefitting nutrition and food security in Zambia, especially for women and children in the first critical 1,000 days of life. The activity had the following objectives:

1. Assess the current state of small fish (e.g., kapenta and chisense) capturing, processing, and trading activities from point of catch through processing to local and distant markets for sale in both rural and urban areas.
2. Identify the social and gender barriers to entry and/or participation in these value chain activities for the different actors, particularly women and youth.
3. Assess how small captured fish are accessed by different consumer groups and consumed within households, especially in households in rural and urban areas distant from their source of production.
4. Explore the potential of upgrading the small-fish value chain via improving processing, storing, and trading methods to reduce postharvest losses and improve food safety.
5. Explore the use of small dried fish for further processing into fish powder and incorporating into locally appropriate foods for enhanced nutrition of women and children in the first 1,000 days of life.

Achievements: Fieldwork was conducted in mid-2019 in Zambia's Lake Bangweulu region to reveal gender disparities within the fisheries sector and uncover opportunities to improve nutrition and reduce postharvest loss. Working in collaboration with the Department of Fisheries, the Fish4Zambia team conducted separate focus group discussions (FGDs) with men, women, and youth engaged in fishery-sector activities, key informant interviews (KIIs) with Ministry of Health and Ministry of Fisheries and Livestock senior personnel, and the Women's Empowerment in Fisheries Index (WEFI) with adult men and women. The Fish4Zambia team developed novel sets of FGD guides, KII guides, and WEFI survey instruments to conduct this research.

The Fish4Zambia team compiled the quantitative and qualitative data, and three publications are in different stages of development. The quantitative publication features novel information as to how men and women in the same household report household-level hunger differently; it has been submitted for review to the World Development Journal. Two qualitative publications report on gender roles and the role of fish in the food system in the Lake Bangweulu fishing communities. These publications provide much needed information on how fish can be mobilized as a resource to improve the lives of fishing community members – and particularly women and youth who are susceptible to malnutrition.

Lessons learned: Men and women have bifurcated roles within the fish value chain in the Lake Bangweulu region. Men and women handle different fish, with women processing and selling/trading small and low-value fish and men prioritizing larger and higher value fish that is primarily sold fresh. Although both men and women in fishing communities benefit economically from the fisheries value chain, women are largely constrained to activities that are less profitable, and men participate in the most beneficial nodes of the fish value chain. The study found that it is essential to empower youth by engaging them in sustainable fisheries management and providing access to credit. This will enable male and female youth to participate fully in the fishery sector. Opportunities to improve nutrition via fish consumption are not optimally harnessed among Lake Bangweulu fishing communities because of existing social norms and low knowledge on the nutritional importance of fish in diets. Nutrition education is critical for mothers to acquire knowledge on the importance of fish and skills on how to better integrate fish in their children's' diet.

Presentations and publications:

Ragsdale, K., Read-Wahidi, M.R., Marinda, P., Pincus, L., Torell, E., & Kolbila, R. (Under Review). Adapting the WEAI to explore gender equity among fishers, processors, and sellers/traders at Zambia's Lake Bangweulu. *World Development*.

Ragsdale, K., Marinda, P., Read-Wahidi, M.R., Pincus, L., Torell, E., Kolbila, R., Mulilo, T., Sakapaji, R., Tembo, M., & Ingouf, L. (2019, November 18). *Fish4Zambia Report: Gender Disaggregated WEFI Results. Research in Zambia's Lake Bangweulu Region among Fishers, Processors and Traders*. USAID, Feed the Future Innovation Lab for Fish, Social Science Research Center, Mississippi State University. 41 pp.

Ragsdale, K., Marinda, P., Read-Wahidi, M.R., Pincus, L., & Torell, E. (2019, August 28). *Fish4Zambia Trip Report: July 14-July 28*. USAID, Feed the Future Innovation Lab for Fish, Social Science Research Center, Mississippi State University. 22 pp.

Marinda, P., Ragsdale, K., Read-Wahidi, M., Kolbila, R., Pincus, L., & Torell, E. (2020, February 24). *Fish4Zambia: Research to close fish consumption and nutrition gaps in Zambia's Lake Bangweulu region* [invited speaker]. Nutrition-Sensitive Fish Agri-Food Systems Workshop, Lusaka, Zambia.

Ragsdale, K., Marinda, P., Read-Wahidi, M., Pincus, L., & Torell, E. (2019, September 12). *Fish4Zambia: Research to close fish consumption and nutrition gaps in Zambia* [invited presentation]. Feed the Future Innovation Labs Principal Investigator Meeting, Washington, DC.

Ragsdale, K., Marinda, P., Read-Wahidi, M., Pincus, L., Torell, E., & Kolbila, R. (2020). *Fish4Zambia: Exploring food insecurity among fishing value chain actors at Lake Bangweulu*. Accepted Poster Presentation at the Fourth International Conference on Global Food Security, December 6-9, 2020, Montpellier, France.

Ingouf, L., Ragsdale, K., Read-Wahidi, M.R., Kolbila, R., Marinda, P., Pincus, L., & Torell, E. (2020). *Fish4Zambia: Exploring Household-Level Hunger Among Men and Women Engaged in Fishing Activities at Zambia's Lake Bangweulu*. Accepted Poster Presentation at the 2020 MSU Undergraduate Research Symposium, Mississippi State University, MS, April 15, 2020. Community-Engagement Research Track. [Cancelled due to COVID-19 pandemic, published proceeding available at https://www.honors.msstate.edu/sites/www.honors.msstate.edu/files/Abstract%20Booklet_Front%20Half_Spring%202020%28al%29_0.pdf].

Ragsdale, K., Kolbila, R., Marinda, P., Read-Wahidi, M.R., Pincus, L., & Torell, E. (2020). *Fish4Zambia Preliminary Results: Exploring Food Insecurity Among Men and Women in Zambia's Lake Bangweulu Region*. Accepted Oral Presentation at the 80th Society for Applied Anthropology Annual Meeting, March 18, 2020, Albuquerque, NM. [Cancelled due to COVID-19 pandemic].

Kolbila, R., Ragsdale, K., Marinda, P., Read-Wahidi, M.R., Pincus, L., & Torell, E. (2019). *Using Fish4Zambia Preliminary Results to Explore Food Insecurity Among Men and Women in Zambia's Lake Bangweulu Region*. Oral Presentation at the 2019 Mississippi State University Graduate Research Symposium, October 5, 2019, Mississippi State, MS. [Third Place Award].

Objective 3: Improve human outcomes from the aquaculture and fisheries sector—competitively awarded activities

Activity 3.3 Harnessing machine learning to estimate aquaculture production and value chain performance in Bangladesh (Harnessing Machine Learning)

US PI: Ben Belton, PhD, Michigan State University
US Co-PI: Amirpouyan Nejadhashemi, PhD, Michigan State University
HC PI: Mohammad Mahfujul Haque, PhD, Bangladesh Agricultural University
HC Co-PI: Khondker Murshed-e-Jahan, PhD, WorldFish

Objectives:

1. Identify emerging technologies and innovative practices in aquaculture value chains and pilot digital extension approaches that accelerate their adoption to enhance productivity, resilience, and human nutrition, while reducing the transaction costs and time associated with traditional forms of technical research and extension.
2. Use machine learning to automate extraction of data on ponds from satellite images and integrate with georeferenced survey data to accurately estimate fish production, employment, and economic value, improve the accuracy of official statistics, and enhance capacity to target investments and regulation.

3. Build organizational and individual capacity in Bangladesh for conducting state-of-the-art research on socio-economic and spatial dimensions of aquaculture development and contribute to societal capacity to create a more enabling environment for fostering sustainable aquaculture development.

Outcomes:

1. Information on new technologies, practices, and innovations in Bangladesh aquaculture value chains will be received by government, development partners and researchers.
2. Bottlenecks in adoption and scaling of innovative technologies and practices will be reduced.
3. Institutional capacity will be increased to independently generate accurate spatialized information on aquaculture area, production, women and youth participation, and contributions to the economy in Bangladesh and beyond.

Achievements: This activity is comprised of three components that feed into the three objectives: (1) surveys, (2) remote sensing, and (3) capacity building. Component 1 will survey a sample of 1,100 hatcheries, feed suppliers, farmers, and fish traders. Component 2 will utilize machine learning to extract and analyze data on fish ponds from satellite images to facilitate development of an interactive online data visualization tool utilizing data from component 1. Component 3 is dedicated to formal training and outreach that builds individual, organizational, and societal capacity.

Good progress was made during the first two quarters of the project towards activities under components 1 and 2. Activities oriented to component 3 will be initiated later in the project cycle. Activities under component 1 included the preliminary analysis of 2013 data to facilitate decisions on sampling strategy, the design of first questionnaire drafts (paper), completion of the IRB approval process, completion of the translation of all paper questionnaires and pretest of farm household paper questionnaire, and design of digital questionnaires and of farm household digital questionnaire. Under component 2, the review of available datasets was completed as well as setting parameters for image extraction.

Lessons learned: The challenges encountered during the last reporting period relate primarily to restrictions on travel and face-to-face meetings due to COVID-19.

Presentations and publications: None to report

Activity 3.4: Nourishing Nations: Improving the Quality and Safety of Processed Fish Products in Nigeria

LEAD PI: Lauren Pincus, PhD, WorldFish
US PI: Terezie Tolar-Peterson, EdD, MS, RDN, LDN, FAND, Mississippi State University
HC PI: Henrietta Ene-Obong, PhD, University of Calabar, Cross River State

Objectives:

1. Develop cost per nutrient guides by analyzing the nutrient and contaminant profile of select processed fish products and their respective prices in comparison to other animal source foods available in Delta state of Nigeria.
2. Build capacity among women and youth fish processors in Delta state to produce high quality, safe, and nutritious processed fish products for local consumption.
3. Educate women and youth fish processors in Delta state about the benefit of fish in human diet and develop low literacy tool to help them better market their product.

Outcomes:

1. Two MS students will be trained in research design, implementation, data analysis and interpretation, and manuscript writing.

2. One PhD student will be trained in development and implementation of a low literacy tool to teach about the benefits of fish in the diet.
3. Two datasets about fish contaminant levels and the cost per nutrient of processed fish products will be gathered from fish markets in Delta state.
4. Three scientific articles will be published in peer reviewed journals: 1) Cost per nutrient of processed fish products in comparison to other ASFs in Nigeria, 2) Food safety concerns of processed fish products in Nigeria, and 3) Development and testing of a low literacy tool to promote fish consumption.
5. Women and youth fish processing cooperative members will be trained in the benefits of fish for human consumption, how to use low literacy tools, fish handling and processing techniques, and business and marketing skills.

Achievements: The Nourishing Nations team developed a pre-/post-program survey instrument to measure changes in cooperative members' nutrition knowledge, business practices, and food safety practices. The survey will be administered to 50 women and youth who participate in the program and will be used in fulfillment of a MSU student's dissertation. The team submitted the survey and a description of the research methods to MSU's IRB and received exempt status.

Lessons learned: The team faced two main challenges within the last reporting period. The first challenge was a delay of University of Calabar's contract signing. As a result, the team was able to identify two MS students who will conduct many of the research activities outlined in the proposal but could not fully integrate them into the activity. There was a delay in officially contracting a project coordinator who will liaise with the women's fish cooperative and work with the students to help them complete their research. A suitable candidate has been identified, but the team was unable to hire this person and do not have funds in place to support exploratory trips between University of Calabar and Delta state. A second challenge has been the continuation of travel bans and mandatory quarantines due to COVID-19. This has made it impossible for the activity team to meet in Nigeria to do a site visit to familiarize themselves with the activity context and meet with activity stakeholders. To overcome this challenge, the team has identified a project coordinator who is already very familiar with the activity region. The result is the team must rely on this person to guide team members who are not familiar with Delta state and do not know key stakeholders within the region.

Presentations and publications: None to report

Activity 3.5: FishFirst! Zambia: Research for Development and Scaling Staple Fish Products for Enhanced Nutrition in the First 1,000 Days of Life

LEAD PI: Kathleen Ragsdale, PhD, Mississippi State University
US PI: Mary Read-Wahidi, PhD, Mississippi State University
HC PI: Pamela Marinda, PhD, University of Zambia
HC PI; Netsayi Mudege, PhD, WorldFish

Objectives: FishFirst! Zambia aims to increase quality/quantity of fish benefitting nutrition and food security in Zambia, especially for women of reproductive age (WRA; ages 15-49 years) and children in the first 1,000 days of life (<2 years). The objectives of FishFirst! Zambia are to:

1. Assess the current state of small pelagic fish harvesting, processing, and trading activities from point of catch through processing to local and distant markets for sale in rural and urban areas.
2. Identify social and gender barriers to entry and/or participation in these value chain activities for different actors, particularly women and youth.
3. Assess how small pelagic fish are accessed by different consumer groups and household consumption.

4. Explore potential of upgrading the small pelagic fish value chain via improving processing, storage, and trading methods to reduce postharvest losses and improve food safety.
5. Develop and test nutrient-enhanced Complementary Food for Africa + dried fish powder (ComFA+Fish) products/recipes for enhanced nutrition particularly benefiting WRA and children <2 years in vulnerable households.
6. Explore options to scale the production and dissemination of ComFA+Fish products/recipes with private and public sector actors, particularly women and youth entrepreneurs.

Outcomes: To meet objectives 1-3, FishFirst! Zambia outputs include 1) an assessment of existing fisheries enterprises disaggregated by key actors' gender and age to assess existing barriers and bridges to women- and youth-led fisheries development and pinpoint leverage points for growing this sector, and 2) a fish flow study of actors' engagement across the fish value chain (i.e., as producers, processors, marketers, and consumers). To meet objective 4, FishFirst! Zambia outputs include a multi-stakeholder workshop to explore potential of upgrading the small fish value chain via improving processing, storage, and trading methods to reduce postharvest losses and improve food safety. To meet objectives 5-6, FishFirst! Zambia outputs include 1) development and testing of nutrient-enhanced Complementary Food for Africa + dried fish powder (ComFA+Fish) products/recipes for enhanced nutrition particularly benefiting WRA and children <2 years in vulnerable households, and 2) exploration of options to scale the production and dissemination of the ComFA+Fish products/recipes with private and public sector actors, particularly women and youth entrepreneurs. FishFirst! Zambia contributes to Feed the Future objectives to understand why many Zambians – particularly WRA and children <2 years – continue to lack dietary diversity and remain vulnerable to food insecurity and malnutrition.

Achievements: The FishFirst! Zambia team officially announced the selection of Florence Malama, a University of Zambia (UNZA) master's student, to join the team and assist with in-country implementation of surveys at Lake Kariba. Malama is currently pursuing a Master of Science in human nutrition at UNZA, where she holds a Bachelor of Science in human nutrition. She has been involved in food and nutrition research projects in Zambia as a researcher, field supervisor, and enumerator. Malama will be directly supervised by HC PI Marinda (UNZA). Weekly meetings were implemented to discuss logistics of how the team will proceed with accomplishing the first stage of FishFirst! Zambia at Lake Kariba, Siavonga District due to the COVID-19 outbreak and international travel ban for lead PI Ragsdale. The MSU team members received developmental approval from the MSU IRB. The UNZA team member has begun the process of preparing FishFirst! Zambia protocol documentation for submission to the Ethics Review Committee of UNZA.

The FishFirst! Zambia team finalized the WEFI-FFZ (Women's Empowerment in Fisheries Index-FishFirst! Zambia) in late September. Correspondence with Cynthia McDougall (WorldFish) in late September indicated that WorldFish is nearing completion of a Pro-WEFI data-collection instrument (WF Pro-WEFI). As a result, Ragsdale is in the process of comparing the WEFI-FFZ to the WF Pro-WEFI to decide if the FishFirst! Zambia team needs to make further adjustments to the WEFI-FFZ. The FishFirst! Zambia team reviewed the QLAM (Quantitative Loss Assessment Method) in late September and FishFirst! Zambia is in the process of selecting the most pertinent items to include in the WEFI–FFZ. The team is working on finalizing a questionnaire and module, both of which are being translated for Tonga speakers.

Lessons learned: With the continuation of the global COVID-19 pandemic, it is clear that collaboration through online meetings between the U.S. PIs and Zambia PIs is highly beneficial when in-person meetings are impossible due to international travel bans.

Presentations and publications: None to report

Activity 3.6: Samaki Salama: Securing small-scale fisheries in Kenya for healthy nutrition and ecosystems

US PI: Lora Iannotti, PhD, Washington University in St. Louis
US Co-PI: Austin Humphries, PhD, University of Rhode Island

HC PI: Andrew Wamukota, PhD, Pwani University
HC Co-PI: Elizabeth Kamau-Mbuthia, PhD, Egerton University

Objectives:

1. Determine the effects of a multi-tiered social marketing campaign to promote fish nutrition, dietary diversity, and food safety on child growth.
2. Measure the impact of fishing gear cooperatives on gear modification and diversification, as well as catch dynamics and earnings.
3. Describe fish access, safety, and consumption in a representative inland county with a view towards potential future application of the *Samaki Salama* intervention package.

Outcomes:

1. The effectiveness of a bundled, integrated intervention on healthy nutrition, income growth, and sustainable fisheries in coastal communities of Kenya will be examined.
2. Model socio-environmental program framework for adaptation and replication in other small-scale fisheries and aquaculture communities in Kenya and globally will be developed.
3. Longitudinal difference-in-difference analyses will be completed for nutrition parameters during the first 1,000 days of life: dietary diversity, fish food intake, stunting prevalence, and height-for-age Z.
4. Other impacts will be monitored, specifically household wealth and expenditures, women decision-making and empowerment, fisheries yield, fishable biomass, fish spawning potential ratio, and fisher income and earnings.

Achievements:

- Create social marketing tools and delivery platform: A collaboration was initiated with the USAID Advancing Nutrition program in the development of the tool and delivery platform. A Memorandum of Understanding is under development between the USAID Advancing Nutrition program and MSU. It will provide a structure for current and future work.
- Collect nutrition and fisheries data: The WUSTL IRB application was started. Quantitative data collection instruments were reviewed and refined, and the survey creation in REDCap was begun. The team plans to use the same REDCap platform to collect fisheries data, which will allow for streamlined data integration and analysis.
- Design cooperatives with input from BMU leaders and fishers: Development of the approach for designing the fishing cooperatives was begun, and development of a short receptivity survey in REDCap that will be implemented by Pwani University was begun. The team also started reaching out to BMU leaders for their input via phone calls.
- In-depth interviews with key informants: Design of the qualitative data collection methodology and instruments was started. The formative qualitative research in Taita-Taveta will occur at the beginning of FY 20.
- Market structured observation: Designing the observation instrument was begun.
- Team management: The team communicated via biweekly team meetings.

Lessons learned: The Kenyan partners were unable to access funding in FY 20, which caused delays in the hiring of the Kenyan postdoc and the ability of the Kenyan partners to be compensated for their time. MSU worked with the team to modify the Kenyan partner milestones so that they can immediately begin to invoice for milestones achieved in September 2020.

Presentations and publications: None to report

Associate Award Research Activity Reports

There were no associate awards under the Fish Innovation Lab in FY 20.

Three concept notes for Associate Awards were submitted to the Fish Innovation Lab AOR for consideration for funding:

- Strengthening human and institutional capacity to respond and manage the risk of epizootic ulcerative syndrome (EUS) in Malawi. Lead PI: Melba Reantaso, UN Food and Agriculture Organization. Requested amount: $500,000 (not funded).
- COVID-19 impacts on fisheries: livelihoods, nutrition, and resilience in fish food systems. Lead institutions: Mississippi State University and WorldFish. Requested amount: $2,000,000 (not funded).
- Virtual tools and evidence-informed decision making for assessing and managing COVID-19 impacts in fish and aquatic food systems. Lead institution: WorldFish. Requested amount: $2,000,000 (not funded).

One concept note was submitted for funding to the American Soybean Association's World Initiative for Soy in Human Health program:

- Development of an extension video library for aquaculture in developing countries. Lead PI, Peter Allen, Mississippi State University. Requested amount: $45,000 (not funded).

Human and Institutional Capacity Building

Human and Institution Capacity Development (HICD) Activities

HICD is a critical component of the Fish Innovation Lab, which strives to catalyze local leadership, research excellence, and capacity. All Fish Innovation Lab-funded subawards include activities to strengthen local partner, student, extension, and broader stakeholder capacity. The strategy includes traditional classroom and online training, mentoring, partnering, and "learning by doing" models founded in collaborative research. Notable HICD accomplishments in FY 20 include:

- The Fish Innovation Lab's participation as a case study for a USAID capacity development toolkit, which is part of the Capacity Development for Agricultural Innovation Systems program development for Africa (led by the International Food Policy Research Institute), was completed. The toolkit allows stakeholders to identify capacities that are lacking in an agricultural sector and formulate an agenda for strengthening capacity and building an innovation network. The Nigeria Cold-Chain Analysis Quick Start activity was the Fish Innovation Lab case study. The Fish Innovation Lab's involvement was included in the final report for the Capacity Development for Agricultural Innovation Systems program. The Fish Innovation Lab also wrote and published a blog post about the HICD toolkit and validation workshop, which took place in Ibadan, Nigeria on September 3-4, 2019.
- During community-level dissemination activities, **the SecureFish Quick Start activity** shared information about the connections between fisheries management and human nutrition with fishers, caregivers, and county-level fisheries and nutrition officers. Discussion arising from results dissemination regarding improvement in nutritional adequacy and fish food diversity indirectly improved specific capacities related to fishery operations (through use of sustainable gear).
- **The Zambia Feeds Quick Start activity** brought together partners from the academic, research, development, public, and private sectors to implement research and development activities that will not only contribute to a solution to a global aquaculture problem, but also build the capacity of the local vocational institution (NRDC). Specifically, Masautso E. Sakala, who is the aquaculture training officer at NRDC and co-PI on this activity, was involved in every step of the three activities completed in the activity. He has thus gained

experience in aquaculture research, which will be used during his future teaching and training duties at NRDC. In addition, key staff gained training in technical and scientific aquaculture research. This training included students and interns who participated in the construction and other hands-on activities related to the experiments and activity.

- **The Rohu Sequencing Quick Start activity** trained three BAU master's students as enumerators for field data collection. Quality of survey data shows that the students were properly trained and have achieved competence in survey data collection. The BAU research team acquired field-level practical knowledge on rohu-based carp polyculture through farm visits and focus group discussion. The BAU PI acquired experience with genome data management by visiting the IGBB at Mississippi State University and U.S. fish farming by visiting catfish farms in Mississippi.
- **The Fish4Zambia Quick Start team** contributed to Fish Innovation Lab capacity building through a presentation to Fish Innovation Lab Quick Start PIs and co-PIs. Additionally, members of the team collaborated with the Fish Innovation Lab to organize and record a public presentation by Steven Cole, a gender specialist from the International Institute on Tropical Agriculture, which focused on gender dynamics in small-scale fisheries and aquaculture. This lecture was delivered on the Mississippi State University campus and shared publicly on the Fish Innovation Lab website.
- The **Cambodian Fisheries and Food Processing activity** is building capacity at a national scale through the hiring and training of two project coordinators and two graduate students. The activity has hired one of the project coordinators and received four applications for one of the graduate assistantship positions. An in-country mentor, Dr. Serey Sok at the Royal University of Phnom Penh, has also been engaged to advise the graduate students.

Short-Term Trainings

Fish Innovation Lab sub-awardees held two short-term trainings in FY 20, as shown in Table 1.

Table 1. Short-Term Trainings

Country of Training	Brief Purpose of Training	Who was Trained	Number Trained		
			M	F	Total
Bangladesh	**Cryogenic Sperm Banking**: Training was provided on cryopreservation of sperm (i.e., development of cryopreservation protocol and repository development) for applying cryopreserved sperm in fish breeding.	4 PhD students, 3 MS students, and 1 consultant	8	0	8
Bangladesh	**Sources of Fecal Pathogens:** Training improved technical capacity on basic microbiology and molecular techniques for the isolation and identification of various foodborne human pathogens from fish and environmental samples. We provided both theoretical and hands-on training to enable them to perform these experiments independently.	1. Three staff from Government of Bangladesh Quality Control Laboratory, Department of Fisheries 2. Two staff from Government of Bangladesh National Food & Safety Laboratory, Institution of Public Health 3. Three staff from Environmental Health Laboratory, icddr,b	7	1	8

Long-Term Trainings

The Fish Innovation Lab had one long-term training in FY 20, as shown in Table 2.

Table 2. Long-Term Trainings

Trainee Number	Sex	University	Degree	Major	Program End Date	Degree Granted	Home Country
1	M	Bangladesh Agricultural University	Master's	Agricultural Finance	December 2019	Y	Bangladesh

Implementation of Other Cross-Cutting Themes

The Fish Innovation Lab has four cross-cutting themes: gender equity and youth engagement, nutrition, resilience, and capacity development. The importance of integrating cross-cutting themes is gaining increasing acknowledgement within the broader Feed the Future Innovation Lab community. This is demonstrated by the development of a new USAID Innovation Lab community of practice around cross cutting themes. In FY 20, the Fish Innovation Lab deputy director participated in the establishment of this community of practice. FY 20 highlights related to gender and youth, nutrition, and resilience are summarized below.

Gender Equity and Youth Engagement

The gender and youth engagement theme is led by experts Kathleen Ragsdale and Mary Read-Wahidi. They support subaward activities by providing overall guidance and individualized support. In FY 20, the team published a technical brief: Gender Mainstreaming in Fisheries and Aquaculture Sectors: The Fish Innovation Lab's Framework, co-authored by Ragsdale, Read-Wahidi, and Torell and is posted on the Fish Innovation Lab website at https://www.fishinnovationlab.msstate.edu/newsroom/2020/07/gender-mainstreaming-fisheries-and-aquaculture-sectors-fish-innovation-labs. Ragsdale was also interviewed for and participated in a number of ongoing dialogues with ACDI/VOCA's Anna Garloch for the Feed the Future Advancing Women's Empowerment report, "Gender Integration in USAID's Agricultural Research Investments: A Synthesis of Key Findings and Best Practices," which featured numerous Innovation Labs, including the Fish Innovation Lab. The final version of the report was published in January 2020 and is available at https://www.agrilinks.org/sites/default/files/resources/feed-the-future-awe-co3-final-report-revised_27jan2020.pdf. An Agrilinks article about the report was posted on February 2020 and is available at https://www.agrilinks.org/gender-research.

The Fish Innovation Lab collaborated with Steven Cole of the International Institute of Tropic Agriculture to develop the novel Gender Responsive Aquaculture/Fisheries Development Assessment (GRADA-FIL). This is an evaluation tool for Fish Innovation Lab-supported research activities, targeting all PIs, co-PIs, project managers/coordinators, research staff, and undergraduate and graduate students involved in Fish Innovation Lab-supported activities. The GRADA-FIL was launched in September 2020, and survey data collection ended in November 2020.

Gender results associated with the Fish Innovation Lab research activities include:

- The **SecureFish Quick Start activity** addressed gender equity in Kenya through the inclusion of both male and female respondents in the quantitative and qualitative surveys. Community-level dissemination included both male and female attendees, and the presentation facilitators ensured both men and women had equal opportunity to share ideas. In addition, the research assistant team included the same number of male and female research assistants, who each had equal responsibilities with data collection, management, and analysis**.**
- In the **Nigeria Cold-Chain Analysis Quick Start activity**, results of the key informant interviews and focus group discussions indicated that there are unique gender roles in the aquaculture value chain. Men are more likely to participate in aquaculture production and processing activities, while women are more active in trading, wholesaling, and retailing activities.
- The **Rohu Sequencing Quick Start activity** investigated youth engagement in Bangladeshi fish farmers and found that approximately 47% of the fish farmers are 36-51 years old. These young to mid-life farmers were more productive and efficient than older farmers because they were early adopters of innovative production technology. The older farmers used more conventional production methods. For instance, the younger fish farmers used aerators for supplying oxygen in their ponds, acclimated fish fry before stocking in ponds to improve survival rates, prepared ponds with lime for better water quality, and used feeding trays for efficient use of feed.
- The **Fish4Zambia Quick Start activity** completed the gender disaggregated analysis of 397 WEFI surveys. The team members finalized data analysis and submitted results disaggregated by gender to the Fish Innovation Lab in November 2019. The University of Zambia team also completed a draft of the gender-disaggregated focus group discussion and key informant interview results and submitted to Mississippi State University, WorldFish, University of Zambia, and University of Rhode Island team members.
- The **Aquacultural and Rural Communities activity** in Nigeria incorporated action plans aimed at providing solutions for employment-generating opportunities through the enhancement of fish value chains, with the outlook of improving livelihoods,

generating/increasing income, and creating an enabling environment for women's economic interaction within the local value-chain system. Attention to gender inclusiveness is a core component of the activity and is integrated into all components of the activity. The engagement of women and youth and the impacts on them resulting from the activity is monitored through individual and group surveys. The GRADA-FIL was applied at the baseline and will be applied at the end of the intervention. At full implementation, the activity aims to improve food security, enhance economic opportunities for youth and women, improve resource-use efficiency, generate knowledge, and share results of agrobiodiversity and value-chain enhancement in rural communities of Kebbi and Ebonyi states.

- The **Lean Production Systems activity** fact-finding visits in Nigeria made contacts with 40 participants in two states (Delta and Ogun) identified for the activity; of those showing interest in the Lean activity, 20% are women and 10% are youth. These numbers exceed or meet the 10% female and youth participation rate in the activity.
- The **Nourishing Nations** trainings for women and youth fish processors in Nigeria will improve their nutrition knowledge, business skills, and food safety practices. The activity intends to directly improve gender inequalities and promote youth engagement in fish value chains. At the end of the trainings, the women and youth will be able to capture more profits from their businesses, improve the food safety quality of their products, and offer a more diverse array of nutritious processed fish products to their consumers. Planning for these trainings has begun, and the trainings will be offered in 2021.
- The **Farming Insects activity** in Nigeria conducted preliminary discussions with the aquaculture SMSs in Ebonyi and Cross River states, and the team learned that the majority of the fish farmers are men. Women are more involved in processing and marketing of fish. The research team has decided that all interested female fish farmers may participate in the activity, and the team hopes to give them equal voice with the male fish farmers.

Human Nutrition

Nutrition is an essential aspect of the Fish Innovation Lab – being both a cross-cutting theme and part of the human outcomes Area of Inquiry. The Fish Innovation Lab focuses on nutrition-vulnerable populations, including pregnant and lactating women, infants/children under five years old, and school-aged children. Subaward research activities include formative research to understand the role of fish in the diet and associated cultural attitudes, beliefs, and practices (e.g., Fish4Zambia, SecureFish, FishFirst! Zambia, and Samaki Salama) and market fish access and value chain dynamics (e.g., the Rohu Sequencing activity). Lora Iannotti at WUSTL provides expertise and leadership for the nutrition theme in the Fish Innovation Lab. Activity-specific nutrition results include:

- Initial findings from the **SecureFish Quick Start activity** indicate that fish is not widely consumed by young children in the four study sites in Kenya. This is particularly true among fishing households. Community-level discussions reveal this pattern may be due to the importance of selling fish as a livelihood strategy for fishing households, cost of purchasing fish in the market, and attitudes and beliefs about fish as an appropriate food for young children. Initial findings indicate that nonfishing communities consume more fish than fishing communities. This initial finding may have far reaching implication on the health, growth, and development of young children.
- The **Rohu Sequencing Quick Start activity** found that rohu-based aquaculture improves the access of fish-based nutrition for farmers in Bangladesh. Analysis shows that fish-farming households consumed approximately 41-grams of rohu per day on average followed by silver carp, mrigal, and catla. Moreover, rohu supplied from the fish farms contributed more than half of their daily fish consumption and 13.6% to the daily protein requirements.
- The **Fish4Zambia Quick Start activity's** research on postharvest losses in Zambia found that all species were at risk of spoilage, but chisense, which is a small fish that is important

from a food security perspective, suffers the most loss during the rainy season because it is processed solely by sun drying. This means that fishers, processors, and traders lose potential income due to either wasted fish or selling spoiled fish at low price. Women reported that insufficiently sun-dried fish was infested by maggots. Other than the economic loss, fish that has decomposed is unfit or unsafe for human consumption.

- Improving the nutrition of individuals and households, and collective communal nutrition security, are some of the major benefits of the **Aquacultural and Rural Communities activity**, which has a major focus on reducing malnutrition in Nigeria. Household Food Insecurity Experience Scale (HFIES), Household Dietary Diversity Score (HDDS), Food Consumption Score (FCS), and other relevant nutrition assessment tools are being deployed to measure the activity's impact on food and nutrition outcomes. These tools are part of the evaluation template for a fish-consumption survey.
- **Nourishing Nations** will train women and youth fish processors in peer-to-peer marketing techniques to expand access to fish products among the poor and vulnerable in Nigeria. The team will encourage fish processor participants to develop new products and marketing channels that are intended to reach poor women with young children. Participants will be encouraged to do market research with this target group to develop suitable products for them, as well as a marketing and distribution strategy to reach nutritionally vulnerable consumers.

Resilience of Value Chains/Households

Improving resilience in fisheries and aquaculture relies upon strengthening adaptive capacity and reducing the risks of recurrent crises, shocks, and stresses. Joanna Springer from RTI provides expertise in resilience for the Fish Innovation Lab, and ME Partners identified four subaward activities that address resilience at the systems level. Ecologically, resilience is addressed for fisheries in Cambodia and Kenya, and in terms of biosecurity resilience is an activity theme for aquaculture systems in Nigeria and Bangladesh. RTI wrote a blog post describing how Fish Innovation Lab activities are contributing to system resilience and the importance of measuring shocks and stress trends when designing and piloting development interventions in the aquaculture and fishery sectors. Activity-related achievements related to resilience include:

- **The SecureFish team** shared their results with the communities where data was collected in Kenya. During these dissemination exercises, value-chain actors (such as fishermen and Mama Karanga market vendors) were invited in an open forum where discussions focused on capacity adequacy and interventions necessary to strengthen value-chain governance and therefore manage shocks and stresses.
- Through **the Nigeria Cold-Chain Analysis activity**, research findings revealed that postharvest aquaculture value chains in Nigeria were short and simple, though there were variations in value chain configuration and coordination among studied states. Value chains in states with higher aquaculture concentration, such as Lagos, Ogun, Delta, and Rivers, have higher levels of complexity than those with small aquaculture production. In all states, value chain actors have limited cold storage facilities. From farm to fork, aquaculture fish products were marketed and sold in different forms including live fish, fresh fish, and smoked/dried fish. Given the poor infrastructure for transportation and limited electricity supply, value-chain actors keep products for a short duration then sell to the next actors.
- The **Aquacultural and Rural Communities activity** focuses on increasing the resilience of rural communities in Nigeria by promoting the diversification of the food production system and empowering stakeholders through the inclusion of a farmer self-management strategy, farmer-to-farmer knowledge sharing, and farmer involvement in the research design and implementation strategy. An analysis of the long-term potential of the intervention, through various studies conducted in the activity, will aid in the building up of the potentials and other value-adding benefits during the scale-up process.

Innovation Transfer and Scaling Partnership

Innovation Transfer

Nothing to report

Scaling Partnerships

The **Zambia Feeds Quick Start activity** featured a public-private partnership to promote adoption and scaling of the research findings. The private industry partners (Meridian Biotech, Aller Aqua Zambia, and Yalelo) each contributed to the activity, and they each have interest in potential adoption based on research results. An overview of the activity workflow is shown in Figure 3. Meridian Biotech provided the SCP ingredient, Aller Aqua Zambia provided the fish feed base mash, and Yalelo provided the tilapia. The research was conducted by Texas A&M University, Natural Resources Development College, and WorldFish.

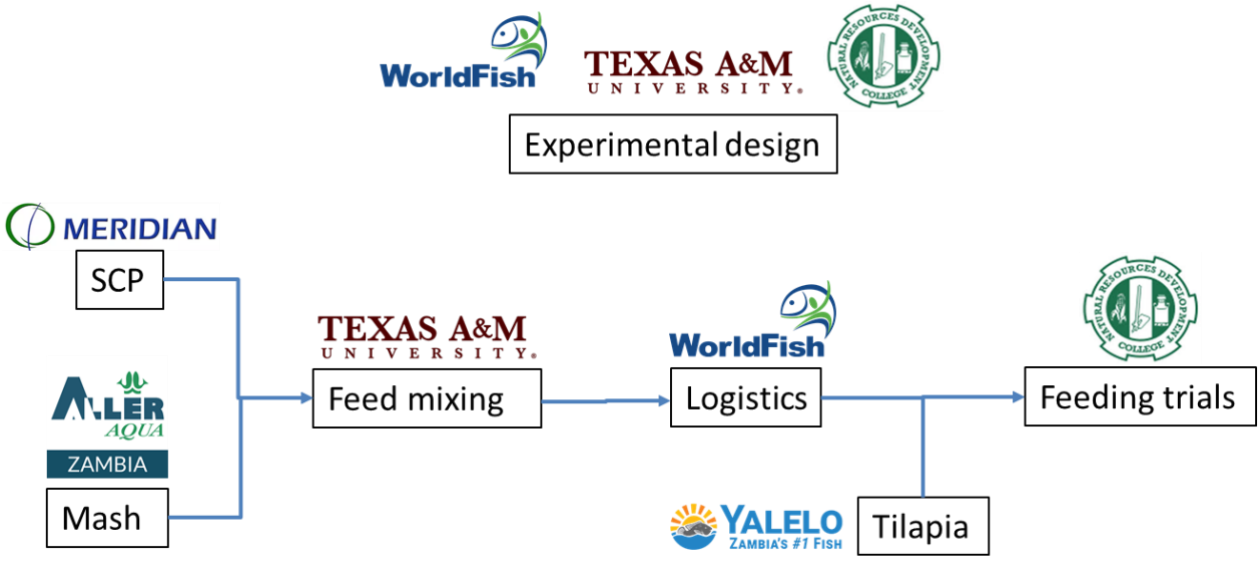

Figure 3. Zambia Feeds Quick Start activity scaling partnership schematic.

Environmental Management and Mitigation Plan (EMMP)

The Fish Innovation Lab EMMP was approved by the bureau environmental officer on July 8, 2019. During the competitive RFA selection and funding of subawardee research and capacity building activities, the ME reviewed all proposals from an environmental monitoring and compliance perspective. Following selection of the subawardee activities, the ME communicated with all of the new PIs to familiarize them with USAID's environmental mitigation and monitoring requirements to ensure that they understand the importance of environmental compliance and create effective mitigation and monitoring measures that are acceptable to the ME and USAID. Finally, upon selection of the 13 competitively awarded research activities, the Fish Innovation Lab revised its EMMP, which was submitted to and approved by USAID in Quarter 3 of FY 20.

Open Data Management Plan

The Fish Innovation Lab ME worked with all research teams to explain the data management plan. While the competitively awarded research activities are just getting started, the Quick Start activity teams are all prepared to submit their data once they have completed their data collection, analysis, and publication of results.

Management Entity and Partner Activities

The Fish Innovation Lab ME implements its research portfolio to achieve knowledge and technology adoption, scaling, and impact. Important activities completed in FY 20 were finalizing the selection of 13 activities in the competitive RFA process; communicating results, lessons learned, and success stories related to the Quick Start activities; and supporting the Quick Start activities as they concluded their field work and entered the data analysis, synthesis, and dissemination stages. The ME facilitated collaboration with other Feed the Future Innovation Labs and programs and explored opportunities, including the submission of concept notes for COVID-19-related associate awards.

Start-up of Competitively Awarded Fish Innovation Lab Activities and Conclusion of Quick Start Activities

The Fish Innovation Lab received 243 concept notes in response to its competitive request for applications (RFA) and invited 41 teams to submit full proposals. In November 2019, the Fish Innovation Lab ME selected 13 finalists, which were requested to make final proposal adjustments and provide all necessary documentation to complete the awards. Once the teams completed all tasks, the ME submitted subaward approval requests to the AOR and AO for final approval. After USAID AO approval, the ME worked with the subawardees to complete a number of grant-startup activities:

1. Subawards were finalized to each participating institution in the U.S. and in host countries.
2. Start-up work plans were finalized.
3. Data-management plans were developed.
4. Indicators and targets were developed.
5. Start-up trainings and meetings were organized.

Concurrently with starting the 13 competitively awarded activities, the ME also supported concluding the Quick Start activities. This included reviewing results and final reports as well as developing success stories and other materials that showcase the Quick Start activity results.

The Fish Innovation Lab ME developed an action plan for how to work through regional coordinators to manage and support the competitively awarded research-for-development activities. This included recruiting regional coordinators for Asia (Hussain) and West Africa (Siriwardena). In the first half of FY 20, members of the ME and ME Partners traveled to select countries to attend Fish Innovation Lab-related stakeholder and implementation meetings, meet with PIs and in-country coordinators, and visit research sites. Because of the COVID-19 pandemic, the Fish Innovation Lab ME was not able to conduct field visits to awarded research-for-development activities in quarters 3 and 4, but support was provided by the regional coordinators as well as remotely by the ME.

Implement Cross-Activity Learning

The Fish Innovation Lab implemented several activities aiming to encourage cross-activity learning. These include the quarterly virtual platform meetings/learning sessions, which are designed to allow the grantees to share lessons learned related to the Fish Innovation Lab Areas of Inquiry and strengthen integration of cross-cutting themes into programming. The meetings included formal presentations, facilitated dialogue, and group discussion. The Fish Innovation Lab ME

communicated with the ME Partners and PIs through monthly virtual meetings that included a mix of grants administration and technical updates. A virtual annual PI meeting was held in September 2020. Finally, the Fish Innovation Lab initiated its learning agenda and research agenda initiatives. The research agenda is centered around the Fish Innovation Lab's Areas of Inquiry and involved an interactive dialogue, which resulted in 13 draft research questions that cut across activities and countries. The research agenda will be refined and finalized in FY 21. The learning agenda is split into three subgroups: West Africa, Asia/aquaculture, and East Africa/fisheries. The Cambodia Bighead Catfish activity joined the Asia/aquaculture group, and the Cambodia Fisheries and Food Processing activity joined the East Africa/fisheries group. The learning agenda is an evolving process that will continue over the next two years.

Identifying Commissioned Research Activities to Fill Research Gaps

After the competitively awarded research activities were launched, the Fish Innovation Lab ME conducted an analysis of the funded research portfolio to determine if there are research gaps that remain to be addressed, and the ME identified strageic partnerships (including the Farmer-To-Farmer program) to address them. The Fish Innovation Lab ME also worked with the Fish Innovation Lab AOR to obtain USAID Missions' priorities to develop direct commissioned activities that enhance Mission interest in the Fish Innovation Lab. A total of six potential commissioned studies were identified in the last quarter of FY 20 and were invited to formally submit concept notes to the Fish Innovation Lab. The concept notes for the proposed commissioned studies were reviewed by three internal reviewers using the same review criteria that were utilized during the RFA competitive selection process. Five of the concepts were given ME approval to move forward, and one concept was rejected. If they receive AOR/AO approval and Mission concurrence, the commissioned activities will be finalized, and activities will be launched in FY 21.

Monitoring, Evaluating, and Learning (MEL)

The ME ensures accountability for implementation of the Fish Innovation Lab research portfolio using the Fish Innovation Lab MEL plan, which was approved in March 2019. In FY 20, ME Partner RTI coordinated Fish Innovation Lab MEL activities, which included:

1. Indicator data and supporting documents were collected, and the MEL section and indicator results were prepared for the annual report. Data were entered into the FTFMS, and USAID review questions related to the annual indicator data were answered.
2. The ME was supported in the launch of competitively awarded research activities by providing guidance on logic models, MEL plans, and indicators to all successful applicants.
3. A presentation was prepared and delivered on USAID MEL guidance and the Fish Innovation Lab MEL plan during virtual kick-off meetings for new grantees.
4. Planning and organization of learning agenda workshops for subawardees in Ibadan, Nigeria, and Bangladesh were supported (workshops were canceled due to COVID-19 travel restrictions).
5. The design, review, and finalization of the Fish Innovation Lab research strategy were facilitated using virtual methods such as questionnaires and interactive platforms, including Mural and Zoom.
6. Five video trainings on Fish Innovation Lab indicators, Performance Indicator Reference Sheets (PIRS), and target-setting were developed and delivered.
7. Target-setting forms were designed with Piestar, and the new forms were successfully implemented to set activity targets. Target numbers were reviewed and finalized, and in-depth consultations were conducted with subaward teams that needed additional support.
8. Virtual trainings on USAID rules and regulations were developed and delivered to Fish Innovation Lab subawardees.

9. A system for transfer of subawardee datasets was established, dataverse for the Fish Innovation Lab was set up, and guidance was developed and released on removing personal identifiers from datasets prior to sharing.

Management Entity – MSU

Mark Lawrence provided direction and oversight for all Fish Innovation Lab activities. Lawrence coordinated the Fish Innovation Lab ME and ME Partners. He served as the primary contact for the Fish Innovation Lab AOR and represented the Fish Innovation Lab at meetings and activities. Lawrence facilitated collaboration with current and potential research partners. The following meetings and activities were attended:

1. Multiple virtual meetings were conducted with PIs for competitively awarded activities to finalize objectives, participants, and budgets from October-December 2019.
2. Innovation Labs Council quarterly virtual meeting, December 3, 2019.
3. Association of Public and Land grant Universities-Office of International Programs joint webinar with Innovation Labs Council, February 27, 2020.
4. Fish Innovation Lab Virtual Kickoff Meeting for competitively awarded activities, March 20, 2020.
5. Innovation Labs Council virtual meeting on response to COVID-19, March 24, 2020.
6. Stakeholder Community Meeting on COVID-19's Impacts on Global Agriculture, Food Security and Resilience, USAID Bureau of Resilience and Food Security, April 23, 2020.
7. Africa Region USAID COVID-19 Implementing Partner Call, USAID Bureau of Resilience and Food Security, May 12, 2020.
8. Collaboration meetings with Marjatta Eilitta, director of the Farmer-to-Farmer program in Southern Africa, June 2020.
9. Organized a USDA NIFA collaboration meeting with Fish Innovation Lab U.S. PIs on July 7, 2020 with Amrit Bart (USDA NIFA National Program Leader for Aquaculture).
10. Presented keynote presentation at the UN Food and Agriculture Organization Zoom Webinar, “Innovative biosecurity approaches for a healthier aquaculture industry”, July 15, 2020.
11. Innovation Labs Council quarterly virtual meeting, September 10, 2020.
12. Innovation Lab & USAID Annual Meeting, September 15-16, 2020 (virtual); Innovation Labs Congressional event, September 17, 2020 (virtual); and Innovation Lab-Board for International Food and Agricultural Development annual meeting, September 29, 2020 (virtual).

Kathleen Ragsdale and **Mary Read-Wahidi** supported the Fish Innovation Lab as the Gender and Youth Specialist and Co-Specialist. In FY 20, Ragsdale and Read-Wahidi led the writing and publication of a technical brief and other materials listed in the gender and youth section of this report. They developed and launched the GRADA-FIL, which included developing the GRADA-FIL assessment, having the assessment reviewed by experts in the field, revising the GRADA-FIL based on the review of experts, and all aspects of developing the GRADA-FIL survey email list and the Qualtrics launch of the GRADA-FIL (including alpha/beta testing). The GRADA-FIL was launched in September 2020.

Peter Allen attended virtual meetings and served as a facilitator at several learning agenda meetings and a research strategy meeting. He provided expertise and served as a reviewer in aquaculture production. He initiated work on technical extension briefs and prepared and submitted short proposals associated with the technical briefs. He collaborated with WorldFish on its technical briefs.

Stephen Reichley joined the faculty of Mississippi State University and the Fish Innovation Lab in Quarter 4. He attended virtual meetings and served as a facilitator at the research strategy meeting. He also served as reviewer for the commissioned studies. He assisted the director in identifying strategic partnerships and preparing documents.

Shauncey Hill assisted the director and ME Partners in planning, organizing, and managing Fish Innovation Lab activities. She oversaw establishment of subawards for competitively awarded activities, ensured compliance with USAID and MSU rules and regulations, and coordinated programmatic support for the activities.

Kristen Dechert strengthened internal and external communications. Internally, she oriented new stakeholders and subawardees to the communications strategy and expectations, branding requirements, and ethical standards for photography and videography; facilitated and managed virtual workspaces for internal communication and teambuilding; and used digital communications to drive awareness of the Fish Innovation Lab brand and resources and to drive organization of content on platforms. Externally, she developed and launched videos for Quick Start activities, developed and distributed a quarterly newsletter, communicated lessons learned and success stories; amplified key milestones; showcased the Fish Innovation Lab at a conference; and tracked and contributed to USAID-led learning and sharing opportunities as requested.

Jared Dees worked with all competitively awarded activities to issue subawards, which required review to ensure financial compliance with USAID and MSU rules and regulations, establishment of milestones, and coordinating subaward management with MSU Office of Sponsored Projects. Dees also managed all subawards issued to ME Partners, and he supported Fish Innovation Lab virtual meetings.

ME Partner – URI

During FY 20, URI supported the Fish Innovation Lab ME by accomplishing several tasks:

1. URI supported the final selection and launch of 13 competitively awarded research activities as well as the completion of the five Quick Start activities. Austin Humphries, who is the East Africa specialist, provided support for all activities in Zambia and Kenya. He assisted the East Africa coordinator in supporting the Kenya Quick Start activities and the competitively awarded activities (McClanahan/WCS and Ragsdale/MSU). Elin Torell provided technical assistance to Quick Start activities in Kenya and Zambia, which included traveling to Kenya in November 2019 and conducting a field visit.
2. Annual work planning, semi-annual reporting, and monthly reporting for East Africa were supported by compiling drafts, communicating with PIs who have activities in Kenya and Zambia, editing, and formatting. Monthly ME Partner and PI meetings were attended. URI participated in Fish Innovation Lab ME retreats (virtually) and quarterly virtual platform meetings.
3. The ME was supported in the final selection of new research activities, which included reviewing final proposals and ensuring that they had adequately addressed reviewer feedback, appropriate budgets, and Zone of Influence (ZOI) inclusion.
4. The Fish Innovation Lab initial environmental examination and the EMMP were revised. The revised EMMP was submitted to and approved by USAID.
5. The ME was supported in developing PI start-up meetings for new grantees. This included preparing PowerPoint presentations on cross-cutting themes and a general introduction.
6. The Fish Innovation Lab's communications team was supported by providing inputs to newsletters and social media feeds, including blog posts.
7. URI provided technical assistance on issues related to small-scale fisheries.
8. The SecureFish team was supported in data analysis and development of activity reports.

9. Humphries traveled to St. Louis to work with ME nutrition specialist (Iannotti) on ME-related publication that is currently under review.
10. URI supported the ME in the development of research and learning agendas, which included facilitating sessions and group exercises and leading discussions for two fisheries learning agenda meetings.
11. The Fish4Zambia team was supported in data analysis, development of activity reports, and a publication submitted to *World Development Journal.*
12. Torell attended Innovation Lab directors' meetings and related activities, including the development of an Innovation Lab cross-cutting theme community of practice.
13. URI supported RTI in implementing the Fish Innovation Lab MEL plan, including Quick Start activity learning and quarterly indicator reporting.
14. Development of the Fish Innovation Lab Year 3 work plan and semiannual/annual reports were supported.

ME Partner – RTI

In addition to the activities listed under the MEL section, RTI conducted the following activities:

1. RTI supported annual work planning and annual reporting by contributing to drafts, communicating and collecting information from PIs, and doing ongoing consultation with MSU and URI.
2. Springer wrote and published a blog post for the Fish Innovation Lab's blog about the HICD toolkit and validation workshop in Ibadan, Nigeria in September 2019.
3. Springer, Annah Latané and Nicole Jacobs supported the ME in the final selection of competitively awarded research activities. This included hosting an in-person meeting in RTI's office to rank proposals, providing support in defining criteria and thresholds for consideration, and giving guidance to MSU on USAID rules and regulations for the competitive selection process. RTI was also involved in providing guidance on logic models, MEL plans, and indicators to all successful applicants.
4. The ME was supported in developing and delivering virtual kick-off meetings for competitively selected subawardees.
5. Nicole Jacobs planned, organized, and led a Fish Innovation Lab ME retreat to revise the work plan, establish communication protocols, and redefine roles and responsibilities for ME Partners. Jacobs traveled to MSU to lead and participate in the retreat.
6. RTI provided guidance and materials for training subawardees on USAID rules and regulations.
7. RTI introduced MSU to Smartsheet and supported MSU in setting up long-term scheduling for the Fish Innovation Lab using the platform.
8. MSU was supported in planning final reporting requirements for Quick Start activities using Piestar.
9. Jacobs and Springer facilitated and attended weekly planning meetings with MSU and URI.
10. Springer and Ciara Coughlin, supported by additional MEL staff from RTI, designed and conducted two learning agenda workshops for subawardees—one workshop per region/sector (Asia/aquaculture and West Africa). The East Africa/fisheries workshop, including Kenya, Zambia, and one Cambodia activity, will take place in October 2020.
11. Springer and Coughlin designed target-setting forms with Piestar and oversaw the successful rollout of the process. They reviewed and finalized the targets, including in-depth consultations with subawardee teams in need of additional support.

12. Springer drafted a blog post on Fish Innovation Lab contributions to system resilience.
13. Jacobs organized and delivered a virtual work-planning retreat.

ME Partner – TSU

Madan Dey coordinated various activities for the Fish Innovation Lab in Bangladesh and supervised the Asia regional coordinator, Hussain. During this reporting period, TSU conducted the following activities:

1. TSU developed effective partnership with agencies and institutions to support Fish Innovation Lab activities in Bangladesh, particularly with the Bangladesh Fisheries Research Institute (the only government aquaculture/fisheries research institute in the country), Department of Fisheries of the Government of Bangladesh, Bangladesh Food Safety Authority, Planning Commission of the Government of Bangladesh (the apex planning body in the country), agricultural/science and technology universities (including BAU and Patuakhali Science and Technology University), and private aquaculture industry groups.
2. Dey organized a seminar entitled “Challenges, Needs and Potentials of Aquaculture and Fisheries in Bangladesh,” which brought together academic, industry, and governmental leaders on December 26, 2019, at BAU in Mymensingh. More than 70 participants representing BAU, the Government of Bangladesh Department of Fisheries, Bangladesh Fisheries Research Institute, and aquaculture entrepreneurs attended the event. Shamsul Alam, member (senior secretary) of the General Economic Division of Planning Commission for the Government of Bangladesh, was presented as the chief guest. Yahia Mahmud, current director general of Bangladesh Fisheries Research Institute; Ahsan Bin Habib, dean and professor of fisheries at BAU, and Md. Akhteruzzaman, dean and professor of agricultural economics and rural sociology at BAU were special guests of the seminar. M.A. Sattar Mandal, emeritus professor of BAU, as well as former vice chancellor/CEO of BAU and former member of the Bangladesh Planning Commission, was the key discussant for the event. Various participants, including Senior Secretary Shamsul Alam, Yahia Mahmud, and Mandal, expressed strong support for Fish Innovation Lab activities in Bangladesh, which is instrumental for successful implementation of current and future Fish Innovation Lab activities in the country.
3. Dey presented a keynote paper entitled “Value Chains in Aquaculture and Fisheries in Bangladesh: Recent Advances and Future Research Directions," at the Fisheries Society of Bangladesh Biannual Conference held on December 27, 2019 in Mymensingh, Bangladesh.
4. TSU supported BAU to successfully complete the Quick Start activity entitled “Genome sequencing and development of SNP markers from rohu in Bangladesh.”
5. TSU helped successful initiation of five competitively awarded activities in Asia (three in Bangladesh and two in Cambodia).
6. Preparation of the following four background reports on Bangladesh aquaculture and fisheries was coordinated:
    a. Sustainable Marine Fisheries Management for Society and Economy (by Shahadat Hossain).
    b. Inland Aquaculture Development in Bangladesh: Past Trend and Future Strategies (by M.A. Mazid).
    c. Aquaculture and Fisheries Sector in Bangladesh: Overview and Government Priorities (by Hussain and Dey).
    d. Fisheries and Aquaculture in National Policy Framework of Bangladesh (by Shamsul Alam, Prasanna Surathkal, and Dey).

ME Partner – WUSTL

As a Fish Innovation Lab ME Partner, Lora Iannotti primarily provides technical inputs regarding nutrition and food security, a cross-cutting theme of the Fish Innovation Lab activities. During FY 20, she supported the ME in the following ways:

1. Iannotti provided technical inputs regarding nutrition and food security, a cross-cutting theme of the Fish Innovation Lab activities.
2. WUSTL participated in Fish Innovation Lab ME Partners and grantee meetings and calls.
3. Dissemination activities were supported internally among the USAID Innovation Labs and externally to the academic community and policymakers.
4. Iannotti provided analysis of the nutrition content and crafted nutrition messages for each recipe used in the Fish Innovation Lab newsletter. These messages are consistent with the Fish Innovation Lab's goal of highlighting the importance of fish in human nutrition.
5. WUSTL participated in Fish Innovation Lab meetings with research activities (offering nutrition inputs as needed).
6. Iannotti wrote a fish in evolutionary nutrition blog for the Fish Innovation Lab website.
7. Iannotti prepared and submitted a publication to the journal *Global Food Security*: Blue Prospects: Fish for Human Nutrition and Planetary Health. The manuscript was co-authored by Austin Humphries, Ivy Blackmore, Feng Chen, and Lauren Josephs.
8. Planning was initiated with USAID Advancing Nutrition to develop a social and behavioral change guide for nutrition-sensitive programming in Fish Innovation Lab activities.

Regional Coordinators and Regional Specialists

The three regional coordinators (M. Gulam Hussain, Andrew Wamukota, and Sunil Siriwadena) and regional specialists (Madan Dey, Austin Humphries, and Karen Kent) supported the Quick Start and competitively awarded activities in the field. The regional teams are responsible for coordinating, monitoring, and technically advising all research activities by the Fish Innovation Lab in their respective regions. The coordinators were particularly valuable this year as a critical link between the Fish Innovation Lab ME and the research teams during times of restricted international travel due to COVID-19. FY 20 activity highlights include:

1. **Supported Fish Innovation Lab-funded research activities:** The Asia regional coordinator made several field visits to Fish Innovation Lab-funded activity sites in Bangladesh and regularly contacted all lead/country PIs in Bangladesh and Cambodia via email and phone. Hussain provided aquaculture/fisheries support to teams in both Bangladesh and Cambodia, which included discussions regarding possible adaptation measures and resilience related to the COVID-19 pandemic. The East Africa team maintained communication with subawardees in Kenya and Zambia, and the West Africa team established working relationships with subawardees in Nigeria.
2. **Established reporting protocols**. The East Africa team developed a monthly reporting template for research activity PIs to complete. The monthly progress reports were critical in ensuring frequent interaction with activities and in updating the ME with the aim of ensuring that activities receive necessary support. Monthly reporting protocols were established for Asia and West Africa activities. Procedures were established for monthly updates through CE SAIN for communications with the Cambodia Mission.
3. **Connected with local stakeholders**. The East Africa team had engaging discussions with the Kenya Fisheries Service, Kenya Wildlife Service, and leaders and fishers in multiple Beach Management Units along the coast in Kilifi and Kwale Counties. As a result, the stakeholders are supportive of the Fish Innovation Lab research activities. The Asia team maintained communications with in-country public sector organizations and institutions, such

as the Department of Fisheries, the Bangladesh Fisheries Research Institute, universities, WorldFish Center, NGOs, and other stakeholders. The Asia coordinator kept the Fish Innovation Lab abreast of issues and priorities related to aquaculture and fisheries in Bangladesh. The West Africa coordinator facilitated connections between Fish Innovation Lab activities and local aquaculture producer organizations.

4. **Engaged in broader stakeholder outreach**. The East Africa regional coordinator participated in the Wildlife Conservation Society's Annual Fisher Forum in January 2020 to discuss the Fish Innovation Lab objectives and present results from the SecureFish activity. The two-day event was attended by over 100 fishers and stakeholders. The Asia regional coordinator delivered a keynote paper at the Bangladesh Fisheries Research Forum on "Sustainable Aquaculture and Fisheries Development in Bangladesh: Country Needs and Sectoral Priorities" held on November 2, 2019, in Dhaka, Bangladesh.
5. **Acted as members of the Fish Innovation Lab ME Partner team**. As ME Partners, the regional coordinators and specialists attended monthly ME Partner virtual meetings, learning and research agenda sessions, the annual meeting, and other meetings. They prepared and submitted monthly, semi-annual, and annual progress reports as well as other technical reports, such as the Quick Start activity final reports, assigned by the Fish Innovation Lab ME.

Communications

In FY 20, the Fish Innovation Lab ME implemented several internal and external communications activities connected to its Knowledge Management Plan:

Internal Communications

1. New stakeholders and subawardees were oriented to the communications strategy and expectations, branding requirements, and ethical standards for photography and videography.
2. Virtual workspaces were facilitated and managed for internal communication and teambuilding.
3. Digital communications were used to drive awareness of the Fish Innovation Lab brand and resources and to drive organization of content on platforms.

External Communications

1. Videos for all Quick Start activities were developed and launched.
2. A quarterly newsletter was developed and distributed.
3. Lessons learned from the Quick Start activities were communicated via print and/or digital media.
4. Materials such as success stories, showcasing methods and technologies, and activities' progress were developed and launched.
5. Key milestones were amplified via press releases, events, social media, website, and other channels.
6. Dechert attended, and the Fish Innovation Lab was showcased, at the World Food Prize meeting (October 16-18, 2019; Des Moines, Iowa).
7. USAID-led learning and sharing opportunities were tracked, and contributions were made to them as needed.

The Fish Innovation Lab uses its website as a conduit for distributing news releases and communications materials. All videos produced are available at

https://www.fishinnovationlab.msstate.edu/media/videos. All blogs and news items are available at https://www.fishinnovationlab.msstate.edu/newsroom and https://www.agrilinks.org/activities/feed-future-innovation-lab-fish. The Fish Innovation Lab continued to use the Piestar platform for collecting and organizing monitoring data from research activities, as well as subawardee activities and achievements.

Quarterly newsletters were distributed through the Fish Innovation Lab email list and website. A structured social media campaign was also implemented to distribute success stories as well as ad hoc material generated from subaward activities and partners. Results and success stories from the Fish Innovation Lab were regularly submitted for publication on the Feed the Future Agrilinks online community, which picked up the following stories in FY20 (all stories available at https://www.agrilinks.org/activities/feed-future-innovation-lab-fish):

- Women's Empowerment Key to Growth in the Fisheries and Aquaculture Sectors
- Identifying Barriers to Nutrition in Zambia's Lake Bangweulu Fishing Camps
- Fish Innovation Lab Deputy Director on Empowering Women and More Equitable Fisheries and Aquaculture Management
- Empowering Women Can Lead to Job Growth, Nutrition Security in Zambia
- Capacity Needs for Innovation in Nigerian Aquaculture
- Hilsa Shad Fishery Success in Bangladesh
- Students Trained as Enumerators to Assess Farmer Needs for Rohu Genetic Improvement
- Fish4Zambia Builds Capacity Through Student Fieldwork Training
- Reducing Post-Harvest Losses in Nigeria's Aquaculture Sector Contributes to Sustainable Development
- Replacement of Fisheries-Derived Fishmeal with Yeast-Derived Proteins for Sustainable Aquaculture in Zambia
- Improving the Fish Value Chain in Zambia
- From Harvest to Plate in Nigeria
- Improved Nutrition Security in Kenya Through Increased Access to and Consumption of Fish
- Increased Fish Intake Improves Brain Development for Young Children
- Threatened Fisheries Resources and Biological Diversity of Baikka Beel Sanctuary at Hail Haor Wetland in Bangladesh

Issues and General Lessons Learned

This section reports on issues and lessons learned by the Fish Innovation Lab ME. Issues and challenges encountered by individual activities are reported in their respective sections.

COVID-19

COVID-19 and associated travel restrictions required the Fish Innovation Lab communications team to cancel in-country visits for the Fish Innovation Lab ME and ME Partners, including site visits and trips related to communications and knowledge dissemination in Nigeria and at the World Aquaculture Society 2020 meeting in Singapore. Additionally, the team was unable to conduct videography during spring and early-summer lockdowns due to COVID-19. This delayed the release of the video on the Bangladesh Rohu Sequencing Quick Start activity (which has now been released) and the overview video of the Fish Innovation Lab (expected to be completed in FY 21). COVID-19 also greatly delayed the timeline for training subawardees. However, it provided an opportunity to develop online learning modules related to grants management, communications, and MEL. Although the final training package will be high-quality and interactive for users, the delay of over 6 months in training subawardees was not ideal.

The Fish Innovation Lab Annual Meeting had to be held virtually instead of in-person. The agenda was developed to maximize networking and interactive opportunities in the virtual space, and activities were designed to gather feedback on the research strategy. Learning agenda activities were also conducted virtually instead of in-country. Unfortunately, this meant that team participation was not as broad as intended, and as a result, networking opportunities were limited. The ME Partners also decided not to hold workshops on the Fish Innovation Lab theory of change or have in-depth discussions about learning themes to minimize the time burden to the PIs. However, the Fish Innovation Lab pivoted seamlessly to the virtual space and provided a robust process by incorporating questionnaires between sessions, maximizing the time in virtual sessions, and using online platforms, such as Mural, for interaction and input.

As described under the activities' lessons learned sections, COVID-19 has delayed field activities for most of the research activities. In-country lockdowns have also restricted the regional coordinators' abilities to visit activity sites. However, the coordinators and the ME continued to communicate with activity PIs via web meetings, email, and phone.

Other ME-Related Challenges

The process of USAID approval and award negotiations for the 13 competitively awarded activities progressed slower than expected. This delayed the MEL start-up as well as planned in-country capacity building and technical assistance. The ME had planned to hold three three-day regional meetings in Nigeria, Bangladesh, and Kenya to provide the new teams with overall guidance on the Fish Innovation Lab, establish expectations, develop the learning agenda, and familiarize the subawardees with USAID rules and regulations. As COVID-19 caused those meetings to be cancelled, the ME replaced them with e-training modules and separate virtual one-on-one and regional meetings that were held over the last quarter of FY 20.

The Fish Innovation Lab ME struggled to advance the resilience component of the Fish Innovation Lab portfolio because not all activities are good candidates for resilience programming. Activity design, planning, and measurement approaches need to be adapted to fulfill USAID's definitions of resilience, and this approach was not feasible during budget negotiations and other aspects of subawardee approval. To adjust for this circumstance, ME Partner RTI will advise four activities with potential for advancing system-level resilience on how they can frame and direct the outcomes of their studies and incorporate stress trends into measurements and recommendations.

Future Work

The next steps for the competitively awarded research for development activities are listed below. The Quick Start activities (numbered 1.1, 1.2, 1.3, 3.1, and 3.2) have been completed and are not presented in this list.

Table 3. FY 21 Research Activities

Research Activities
1.4. Aquacultural and Rural Communities activity • Production technological packages will be developed for sustainable integration of rice-fish farming in the participating states through the adaptive research. • Locally available feedstuffs will be assessed as suitable supplemental feeding for selected species in an IAA system. • Various end-market opportunities will be evaluated for the farm output with risk factors identification.

- On-farm adaptive research of rice-fish farming will be conducted.
- Economic, financial, and marketing research will be conducted to determine growers' profitability margins (return on investment), growers' acceptability of IAA systems, and consumer purchasing behavior and willingness to pay for local IAA production system products.

1.5 Farming Insects activity

- In the next three months, we will undertake the following:
  - Reconnaissance survey.
  - Listing of fish farmers in the study location.
  - Baseline survey.
  - Intervention started by setting up the demonstration plots for the black soldier fly larvae production.
  - Processing and mixing black soldier fly larvae with feed ingredients for making fish feed.

1.6 Lean Production Systems activity

- The Lean management curriculum will be developed for training of LSMEs.
- Farmers, processors, and cooperatives will be selected as activity participants.
- The MEL assistant will be recruited.
- Training of farmers, processors, and cooperatives in Lean management technology will be conducted.

1.7 Bighead Catfish activity

- The research facility will be designed.
- Materials will be purchased and installed to operationalize a wet lab for aquaculture feed nutrition research.
- Farmers and RUA personnel will be trained on applied scientific aquaculture research.

1.8 Coral Reef Fishery Sustainability activity

- Stakeholders will be engaged and trained in how to gather fisheries measurements.
- Data will be collected to determine the yield potential for coral reef climate refugia to support improved fisheries and determine the best metrics for measuring sustainability.
- Socioeconomic and scenario-based surveys will be developed to measure perceptions about natural resource use and sustainability among dependent communities.

1.9 Cryogenic Sperm Banking activity

- More fish will be collected for broodstock development.
- An inception workshop will be arranged.
- Hatchery operators will be selected.
- PhD fellows will join in the activity.
- MS students will be recruited.
- Training for hatchery operators will be started.
- Interactive workshops between LSU and BAU will be continued.

1.10 Cambodian Fisheries and Food Processing activity

- Activity-wide

- Two graduate students will be recruited, and the hiring of a livelihood specialist will be completed.
- WCS activity personnel (two graduate students, one project coordinator, and one livelihood specialist) will participate in online training courses on IRB protocol (for human-subject research compliance), fisheries management methods (data collection and management), focus group discussions, and sensory evaluation panels.

- Objective 1
  - Village meetings will be conducted to recruit fishers, and training of fishers will be conducted on fish data collection.
  - Fisheries data for Year 1 will be collected (15 fishers collecting fisheries data per fishing trip).
  - Fish samples will be collected for proximate and fatty acid analysis.
- Objective 2
  - IRB training for in-country personnel will be conducted.
  - Survey data of fish products, fish processing knowledge, and processing resources will be collected.
  - Focus groups will be conducted.
  - Sensory panels will be conducted.
  - The proximate and fatty acid composition of fish collected from Objective 1 will be analyzed.

2.1 Improving Biosecurity activity

- Activity staff will be recruited.
- The census list of farms and hatcheries will be finalized, and approval will be sought.
- Training of enumerators and project manager on epidemiology survey and biological sample collection and diagnostic techniques will be done.
- Piloting the epidemiology and samples collection on at least two farms will be done.

2.2 Sources of Fecal Pathogens activity

- Another round of piloting on sample collection, testing, and reporting will be done.
- Sample collection and testing will be started at the end of October and continue until we reach the target number of samples.
- Enumerators will start collecting data from retail markets via questionnaire-based survey, FGDs, and interviews.

3.3 Harnessing Machine Learning activity

- Pretesting and finalizing digital questionnaires will be done (October-November 2020). Survey implementation will be completed (October-December 2020) followed by data cleaning and analysis (December 2020-March 2021).
- Comparative analysis of 2013 and 2020 datasets will be done (February-June 2021). Emerging technological trends will be identified from the 2020 dataset (June-September 2021).
- In-depth interviews will be done with innovative farmers (June-September 2021).
- Ground truth remote sensing data will be done (October-November 2020). The algorithm will be revised based on ground truthing (October 2020-January 2021). Extracted data will be mapped and summarized (November 2020-February 2021), and scaled up estimates

of production, value added, and employment at zonal level will be done (March-August 2021).

- Stakeholder consultations on features for Global Information System interface will be done (Februanry 2021), and a data analytics capacity building workshop will be held.

3.4 Nourishing Nations activity

- Two MS students at the University of Calabar will be started.
- A research protocol will be developed to determine the cost/nutrient of animal-sourced foods in Delta state.
- A research protocol will be developed to determine contaminants in processed fish products in Delta state.
- A project coordinator will be hired.
- A women and youth fish processor cooperative will be selected.
- A training curriculum on nutrition, business skills, and food safety will be developed.

3.5 FishFirst! Zambia activity

- Work will be continued to further refine and hone our survey instruments.
- Work will be continued to coordinate the logistics of the FishFirst! Zambia fieldwork to collect the WEFI-FFZ, MDD–W, and MDD–IYC.
- Work will be continued to analyze results of the WEFI-FFZ, MDD–W, and MDD–IYC.
- Work will be continued to contribute to technical briefs and news briefs for the Fish Innovation Lab related to FishFirst! Zambia results.
- FishFirst! Zambia results will be presented at scientific conferences.

3.6 Samaki Salama activity

- Data-collection instruments will be designed.
- Social marketing tool and platform will be designed.
- IRB applications will be completed.
- Fisher co-op interventions will be designed.

The next steps for the ME and ME Partners in implementing the FY 21 annual work plan are listed in the table below.

Table 4. Upcoming activities for the ME and ME Partners

Management Activities
Management Entity – MSU 1. For activities selected for funding as commissioned studies, the Fish Innovation Lab ME will review and approve revised activity descriptions and budgets. Subaward requests and budgets will be submitted to the AOR and AO for approval. 2. The Fish Innovation Lab ME will ensure financial accountability of research subawards. The Fish Innovation Lab ME will coordinate with the MSU Office of Sponsored Projects to manage subawards to institutions funded through the competitive RFA. 3. Depending on COVID-19 travel restrictions, the ME will support Year 3 Fish Innovation Lab activities by travelling to countries to attend Fish Innovation Lab-related stakeholder

and implementation meetings, meeting with PIs and team members, and visiting research sites.

4. The ME will conduct virtual meetings for all PIs and co-PIs for all activities.
5. The ME will conduct an annual meeting in the US. The ME, ME Partners, AOR, EAB, and all subaward PIs will be invited. Subaward PIs are required to include a travel budget to attend the annual meeting in their subaward budgets.
6. The ME will develop an aquaculture information clearinghouse to be used for extension purposes on the Fish Innovation Lab website.
7. The ME will continue leading the Fish Innovation Lab communications efforts with website and social media maintenance, content generation and dissemination for quarterly newsletters, and feature articles. The ME also will maintain templates and other internal communications documents and will provide subawardees and ME Partners in-depth virtual communications training on rules and regulations related to communications, including those related to branding and marking, success stories, and ethical photography.
8. Members of the ME will continue to provide technical aquaculture expertise, support IACUC regulatory compliance of activities, work to provide technical assistance to ensure productivity of activities, provide gender impacts and youth engagement expertise, support the research agenda and activities, and assist the director with document and presentation preparation.

ME Partner – URI

1. Methods, results, and technologies will be identified that can be disseminated and scaled.
2. Support will be provided for development of success stories and other materials.
3. Support will be provided for the research activities virtually, including providing expertise, problem solving, and sharing lessons learned.
4. Research-for-development activities will be supported in implementing cross-cutting themes, particularly in human and institutional capacity development.
5. Individualized support will be provided to the research activities through periodic consultations and technical assistance.
6. Online learning modules, seminars, and extension materials will be developed and shared.
7. URI will participate in the Innovation Lab cross-cutting theme community of practice.
8. Support will be provided for HICD activities implemented by subawardees.
9. URI will coordinate, document, and share progress made by research activities (via monthly, quarterly, and annual meetings and progress reports).
10. URI will engage with regional stakeholders.
11. Virtual or in-person regional platform meeting(s) will be attended.
12. In collaboration with the AOR, commissioned studies will be implemented that complement the 13 competitively awarded research-for-development activities.
13. Development and launch of the learning agenda will be supported.
14. URI will prepare semi-annual and annual reports and the Year 4 work plan.
15. Fish Innovation Lab activity results will be disseminated to the scientific community via international conferences.

ME Partner – RTI

1. The three regional learning agendas will be developed based on inputs from the learning sessions.
2. Two virtual platform meetings per region/topic will be held (six total) to implement activities laid out in the learning agendas.
3. RTI will contribute to planning and facilitating the annual meeting and will lead a session to review and update the learning agendas and questions.
4. RTI will continue to work on MEL capacity-building with grantees, provide training on indicator reporting, and discuss results and narratives with teams.
5. RTI will continue to strengthen subawardees' application of the PIRS.
6. The commissioned research teams will be onboarded by providing training and collecting their targets.
7. Annual targets and results will be updated in the DIS system at the end of FY 21. At the beginning of FY 21, RTI is still finalizing targets and entering the data into the new DIS system.
8. RTI will complete delivery of the communications trainings for subawardees and continue to provide adaptations to existing training content as needed.

ME Partner – TSU

1. TSU will support successful implementation of all Fish Innovation Lab-funded activities in Asia (three in Bangladesh and two in Cambodia).
2. TSU will help research activity PIs to establish linkages with various government agencies, NGOs, and other stakeholders.
3. The following four background papers and technical briefs will be prepared and finalized:
    - Sustainable Marine Fisheries Management for Society and Economy
    - Inland Aquaculture Development in Bangladesh: Past Trend and Future Strategies
    - Aquaculture and Fisheries Sector in Bangladesh: Overview and Government Priorities
    - Fisheries and Aquaculture in National Policy Framework of Bangladesh
4. TSU will work with the PI/co-PI of the Bangladesh Rohu Sequencing Quick Start activity to prepare technical/journal articles.

ME Partner – WUSTL

1. WUSTL will continue working with USAID Advancing Nutrition to develop a social and behavioral change guide for Fish Innovation Lab activities.
2. Individual activities under Areas of Inquiry 1-3 will be individually contacted to initiate targeted nutrition inputs.
3. WUSTL will provide the communications team with nutrition stories, fish recipes, and other needs.

Regional Coordinators

1. Regional coordinators will participate in virtual platform meetings, research agenda, and learning agenda sessions.
2. Regional coordinators will communicate with lead/host country activity PIs to ensure successful implementation of activities, including monthly reporting.
3. Regional coordinators will help facilitate and problem solve when issues arise related to activity implementation, particularly related to COVID-19.
4. Coordination and monitoring of Fish Innovation Lab-funded activities will be done in their respective countries/regions.
5. Regional coordinators will participate in Fish Innovation Lab ME Partners monthly and quarterly meetings and any other Fish Innovation Lab virtual meetings and webinars, such as EAB meetings and the Quick Start activity final report session.
6. Planning of virtual MEL reporting will be facilitated.
7. Preparation and submission of monthly and quarterly progress reports will be done.
8. Regional coordinators will reach out to relevant government entities to share activity information and connect the activites to policymakers and other local stakeholders.

Appendices

Appendix 1: List of Fish Innovation Lab Competitively Awarded Activities

Bangladesh

- Cryogenic Sperm Banking of Indian Major Carps and Exotic Carps for Commercial Seed Production and Brood Banking. Lead PI: Md. Rafiqul Islam Sarder, Bangladesh Agricultural University. Award: $499,999.
- Harnessing Machine Learning to Estimate Aquaculture Production and Value Chain Performance in Bangladesh. Lead PI: Ben Belton, Michigan State University. Award: $499,903.
- Identifying Major Sources of Fecal Pathogens in Bangladeshi Aquaculture Value Chains and the Most Cost-Effective Risk Reduction Strategies. Lead PI: Mohammad Aminul Islam, Washington State University. Award: $485,150.

Cambodia

- Development of Bighead Catfish Culture for Sustainable Aquaculture in Cambodia. Lead PI: Lyda Hok, Center of Excellence on Sustainable Agricultural Intensification and Nutrition, Royal University of Agriculture. Award: $500,000.
- Increasing Sustainability of Fisheries and Aquaculture for Resilience of Cambodian Communities. Lead PI: Sandra Correa, Mississippi State University. Award: $424,615.

Kenya

- Achieving Coral Reef Fishery Sustainability in East African Biodiversity and Climate Refugia Centers. Lead PI: Timothy McClanahan, Wildlife Conservation Society. Award: $380,437.
- Samaki Salama: Securing Small-Scale Fisheries in Kenya for Healthy Nutrition and Ecosystems. Lead PI: Lora Iannotti, Washington University in St. Louis. Award: $499,985.

Nigeria

- Aquaculture and Rural Communities: Integrated Agriculture-Aquaculture as Farm Diversification Strategy. Lead PI: Matthias Halwart, Food and Agriculture Organization of the United Nations. Award: $498,593.
- Improving Biosecurity: A Science-Based Approach to Manage Fish Disease Risks and Increase the Socioeconomic Contribution of the Nigerian Catfish and Tilapia Industries. Lead PI: Mohan Chadag, WorldFish. Award: $623,143.
- Improving Efficiency in the Nigerian Aquaculture Sector by Employing Lean Production Systems. Lead PI: Rohana Subasinghe, WorldFish. Award: $533,924.
- No Longer Bugged by Feed Costs: Farming Insects as Sustainable and Scalable Aquaculture Feedstock to Improve Catfish (*Claridae*) Producers' and Consumers' Livelihoods Towards Food Security in Nigeria. Lead PI: Jennifer L. Pechal, Michigan State University. Award: $400,000.
- Nourishing Nations: Improving the Quality and Safety of Processed Fish Products in Nigeria. Lead PI: Lauren Pincus, WorldFish. Award: $396,398.

Zambia

- FishFirst! Zambia: Research for Development and Scaling Staple-Fish Products for Enhanced Nutrition in the First 1,000 Days of Life. Lead PI: Kathleen Ragsdale, Mississippi State University. Award: $500,403.

Appendix 2: Publications and Presentations

Peer-reviewed publications

- Failler, P., & Hussain, M. G. (2019). Policy interventions for the development of the Blue Economy in Bangladesh. *Journal of Ocean and Coastal Economics, 6*(2). Available at https://doi.org/10.15351/2373-8456.1099.
- Humphries, A. T., Gorospe, K. D., Carvalho, P.G., Yulianto, I., Kartawaijaya, T., Campbell, S. (2019). Catch composition and selectivity of fishing gears in a multi-species Indonesian coral reef fishery. *Frontiers in Marine Science, 6*(378). Available at https://www.frontiersin.org/articles/10.3389/fmars.2019.00378/full.
- Hussain, M. G., Failler, P., & Sarker, S. (2019). Future importance of maritime activities in Bangladesh. *Journal of Ocean and Coastal Economics, 6*(2), Article 3. Available at https://doi.org/10.15351/2373-8456.1104.
- Hussain, M. G., Uddin, S. A., & Failler, P. (2019). Potentials for the development of blue economy: Prospects and challenges of mariculture in Bangladesh. *Journal of Bangladesh, 9*(1), 7-21.
- Patil, P. G., Virdin, J., Colgan, C. S., Hussain, M. G., Failler, P., & Veigh, T. (2019). Initial measures of the economic activity linked to Bangladesh's ocean space, and implications for the country's Blue Economy policy objectives. *Journal of Ocean and Coastal Economics, 6*(2). Available at https://doi.org/10.15351/2373-8456.1119.
- Surathkal, P., & Dey, M. M. (2019). Import penetration and price relationships: An empirical analysis of the U.S. catfish market. *Aquaculture Economics & Management.* Available at https://www.tandfonline.com/doi/full/10.1080/13657305.2019.1699199.
- Torell, E., Bilecki, D., Owusu, A., Crawford, B., Beran, K., & Kent, K. (2019). Assessing the impacts of gender integration in Ghana's fisheries sector. *Coastal Management*. doi: 10.1080/08920753.2019.1669098. Available at https://www.tandfonline.com/doi/pdf/10.1080/08920753.2019.1669098?needAccess=true.

Technical reports

- Hussain, M. G. (2019, October 29). *Improved breeding and farming practices of tilapia in Bangladesh* [blog post]. Available at https://tilapialoversociety.com/2019/10/29/improved-breeding-and-farming-practices-of-tilapia-in-bangladesh-m-gulam-hussain/?fbclid=IwAR1qCywLx0Vj6rSEez_Fq4pVqB_SobQ7zYSqw5033cKo_RZvo916d1oXjUw.
- Yossa, R., Gatlin, D., Greiling, A.M., Komugisha Basiita, R., Sakala, M.E., Baumgartner, W., Corace, D., & Taylor, A. (2020, March 19). Field Notes - Replacement of fisheries-derived fishmeal with yeast-derived proteins for sustainable aquaculture in Zambia. *The Chicago Council on Global Affairs Global Food for Thought.* https://www.thechicagocouncil.org/blog/global-food-thought/field-notes-replacement-fisheries-derived-fishmeal-yeast-derived-proteins.

Presentations

- Dey, M. M. (2019, December 27). *Value chains in aquaculture and fisheries in Bangladesh: Recent advances and future research directions* [Invited keynote presentation]. Fisheries Society of Bangladesh Biannual Conference, Mymensingh, Bangladesh.
- Humphries, A. (2020, February 24). *Working towards ecosystem health solutions in Kenya* [Presentation]. University of California, Santa Cruz Coastal Science and Policy Seminar Series, Santa Cruz, CA.
- Hussain, M. G. (2019, November 2). *Sustainable aquaculture and fisheries development in Bangladesh: Country needs and sectoral priorities* [Keynote presentation]. Bangladesh

Fisheries Research Forum Sustainable Aquaculture and Fisheries Development in Bangladesh: Country Needs and Sectoral Priorities seminar, Dhaka, Bangladesh.

- Hussain, M. G. (2019, December 26). *Aquaculture and fisheries sector in Bangladesh: Overview and government priorities* [Paper presentation]. Challenges, Needs and Potentials of Aquaculture and Fisheries in Bangladesh seminar, Mymensingh, Bangladesh.
- Hussain, M. G. (2019, December 27). *Potentials of marine fisheries and mariculture under the concept of blue economy development in Bangladesh* [Keynote presentation]. Fisheries Society of Bangladesh Biennial Conference, Mymensingh, Bangladesh.
- Khan, M. A. (2019, December 26). *Economics of rohu based carp polyculture in Bangladesh: Efficiency, yield gap and nutritional perspectives* [Paper presentation]. Challenges, Needs and Potential of Aquaculture and Fisheries in Bangladesh workshop, Mymensingh, Bangladesh.
- Khan, M. A., & Alam, M. S. (2020, March 5). *Economics of rohu* (Labeo rohita) *based carp polyculture in Bangladesh and necessity for genetic improvement programs* [Guest lecture]. Mississippi State University, Mississippi State, MS.
- Kolbila, R., Ragsdale, K., Marinda, P., Read-Wahidi, M., Pincus, L, & Torell, E. (2019, October). *Fish4Zambia: Research to close fish consumption and nutrition gaps in Zambia.* Presentation at the 2019 Mississippi State University Graduate Research Symposium, Mississippi State, MS.
- Lawrence, M. L. (2020, July 15). *Antimicrobial resistance in aquaculture: a One Health global management issue* [Invited keynote presentation]. UN Food and Agriculture Organization Zoom Webinar, "Innovative biosecurity approaches for a healthier aquaculture industry", Virtual Dialogues on the Road to the 34th Committee On Fisheries.
- Marinda, P., Noelle, N., Genschick, S., & Thilsted, S.H. (2020, February 24-25). *The potential contribution of small fish to dietary nutrient adequacy and nutritional status of women of reproductive age and under-five children in Zambia* [Poster presentation]. Nutrition-Sensitive Fish Agri-Food Systems Workshop, Lusaka, Zambia.
- Marinda, P., Ragsdale, K., Read-Wahidi, M.R., Kolbila, R., Pincus, L., & Torell, E. (2020, February 24). F*ish4Zambia: Research to close fish consumption and nutrition gaps in Zambia's Lake Bangweulu region* [Oral presentation]. Nutrition-Sensitive Fish Agri-Food Systems Workshop, Lusaka, Zambia.
- Ragsdale, K., Kolbila, R., Marinda, P., Read-Wahidi, M.R., Pincus, L., Torell, E. (2020, March 17-21). *Fish4Zambia preliminary results: Exploring food insecurity among men and women in Zambia's Lake Bangweulu region.* Accepted Oral Presentation for the Society for Applied Anthropology Annual Meeting, Albuquerque, NM. [conference canceled due to COVID-19].
- Ragsdale, K., Marinda, P., Read-Wahidi, M., Pincus, L., Torell, E., & Kolbila, R. (2020, June). *Fish4Zambia: Exploring food insecurity among fishing value chain actors at Lake Bangweulu* [Accepted poster presentation]. Fourth International Conference on Global Food Security, Montpellier, France. [conference canceled due to COVID-19].
- Wamukota, A. (2020, January 9). *SecureFish Kenya* [Presentation]. Annual Fishers Forum, Diani, Kenya.
- Wamukota, A. (2020, March 12). *SecureFish Kenya* [Presentation]. Unlocking a Resilient Blue Economy in Mombasa, Kenya, workshop organized by CordIo EA/IUCN, Mombasa, Kenya.

Appendix 3: Data Management

Quick Start activities pursued one of two pathways regarding data management prior to closing out awards:

1. Activities uploaded cleaned datasets after removing personally identifiable information to the Fish Innovation Lab Piestar platform, alongside embargo requests.
2. Activities uploaded clean datasets after removing personally identifiable information to an open-source website, such as the Harvard Dataverse.

In both cases, activities included information needed for USAID's Development Data Library.

Appendix 4: FY 20 Indicator Results Table

EG.3-2: Number of individuals participating in USG food security programs

FY 20 Target: 250

FY 20 Actual: 166

Disaggregation: 103 males and 63 females; 33 youth and 28 non-youth

Justification for deviation from target: Initial targets were set based on Year 1 targets as a placeholder until new subawards were approved. Subaward start-up was delayed due to COVID-19, and target setting for FY 20 was not done before the end of the reporting period. Activities will start in FY 21.

Indicator result narrative: Results for FY 20 for EG.3-2 reflect the activities of two Quick Start activities. SecureFish in Kenya held two dissemination workshops to share study findings for 16 Kilifi and Kwale County fisheries and nutrition officers. The team also held four dissemination workshops for 80 caregivers, fishers, and community health workers at the Shimoni Fish Landing Site, Uyombo Fish Landing Site, Vipingo Community Space, and Tiwi Conference Hall. Rohu Sequencing in Bangladesh held a stakeholder workshop, including academics, researchers, development workers, and policy makers. They discussed the role of rohu in the economy and nutrition.

EG.3.2-7: Number of technologies, practices, and approaches under various phases of research, development, and uptake as a result of USG assistance

FY 20 Target: 3

FY 20 Actual: 3

Disaggregation: Two in Phase I – Under Research (1 – Plant and Animal Improvement; 1 – Production Systems); One in Phase II – Field Testing (1 – Social Science)

Justification for deviation from target: N/A

Indicator result narrative: Results for FY 20 for EG.3.2-27 reflect the results of three Quick Start activities. In total, three technologies, practices, or approaches were under research in FY 20. In Bangladesh, in the area of plant and animal improvement, genome sequencing and SNP markers that will lead to genetic improvement of rohu were researched. In Zambia, in the area of production-systems research, using single-cell proteins to replace fishmeal in tilapia diet was researched. In Zambia, in the area of social science research, the acceptability of fish powder for a nutritional supplement for women and children was researched.

EG.3.2-24: Number of individuals in the agriculture system who have applied improved management practices or technologies with USG assistance

FY 20 Target: 23

FY 20 Actual: 1

Disaggregation: 1 – Government

Justification for deviation from target: Initial targets were set based on Year 1 targets as a placeholder until new subawards were approved. Subaward start-up was delayed due to COVID-19, and target setting for FY 20 was not done before the end of the reporting period. Activities will start in FY 21.

Indicator result narrative: Results for FY 20 for EG.3.2-24 reflect the activities of one Quick Start activity. As part of Zambia Feeds, a researcher at the Zambia Natural Resource Development College (NRDC) in Lusaka gained hands-on experience in the building and

management of a wet laboratory and the planning and implementation of a scientific aquaculture experiment.