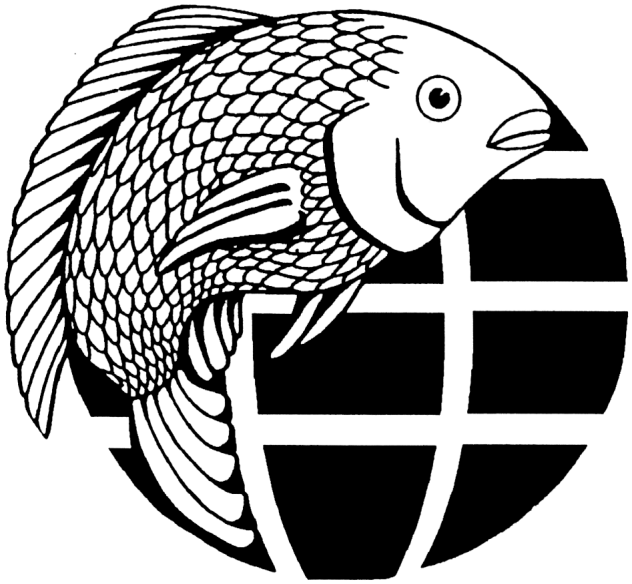
Aquaculture Collaborative Research Support Program

ADDENDUM TO THE TWELFTH WORK PLAN



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Aquaculture
Collaborative Research Support Program

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Twelfth Work Plan

The *Twelfth Work Plan*, published in Fall 2005, described a standardized set of experiments to be undertaken by the Aquaculture Collaborative Research Support Program (CRSP) through July 2006, the end of the current grant period. Subsequently, USAID has provided the necessary funds to continue ongoing research and outreach activities for one additional year. This addendum contains details related to new work plans and official changes to the work plans as described in the *Twelfth Work Plan.* Program activities are funded in part by Grant No. LAG-G-00-96-90015-00 from the USAID and by participating US and Host Country institutions. The authors' opinions expressed herein do not necessarily reflect the views of USAID.

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Section A: New Work Plans

Kenya Training of Trainers and Regionalization of Aquaculture Training Activities

Applied Technology and Extension Methodologies (12ATE11) / Activity / Kenya

Collaborating Institutions
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Chris Langdon and James Bowman

Department of Fisheries and Aquatic Sciences, Moi University
Charles C. Ngugi

Objectives
New Objectives for the OSU/Kenya Project under this proposal are:

- To teach Kenyan Fisheries Officers (FOs) how to conduct pond construction and management courses for extension workers and farmers in Kenya ("training trainers");
- To supervise newly trained FOs in conducting two additional pond construction and management courses for Fisheries Assistants (FAs);
- To promote regional collaboration on training activities and to strengthen short courses planned for other countries in the region by supporting the participation of Kenyan PI Charles Ngugi in those training sessions. Specific goals of these training sessions will include:
  - Providing training on pond management, fish feed, and fish health management,
  - Teaching the principles and benefits of record keeping, and
  - Teaching simple methods for assessing and evaluating costs and benefits

Significance
Training programs for farmers and extension agents have typically been developed and carried out independently in the several African countries in which the ACRSP has been involved. Following the cessation of activities in Rwanda in 1994, the bulk of CRSP-sponsored training done in Africa has occurred in Kenya, where well over a dozen two- and three-week training courses have been conducted and where considerable effort has been put into the development of training materials, including PowerPoint teaching modules and a Fish Farming Handbook (Ngugi et al. 2001, 2004, 2005a, 2005b; Omolo et al. 2005). More recently, the University of Arkansas at Pine Bluff and its collaborating African institutions have also planned farmer training programs to be held in neighboring Tanzania, in Ghana, and in Kenya.

This supplemental work proposal addresses several new objectives for the OSU/Kenya project, including conducting additional training courses (a short course to train trainers, followed by two additional courses taught by the new trainers) in Kenya and providing support for the participation of Kenyan PI Charles Ngugi in training courses held in other countries in the region.

The intent of training trainers in Kenya is to increase the number of individuals who can effectively teach pond construction and management techniques to extension agents and farmers.

Providing for the participation of Charles Ngugi in training courses in Tanzania, Ghana, or other countries is intended to make the experiences and materials developed by the Kenya Project available for training efforts in the Region as a whole. Through his work with the ACRSP in Kenya, Ngugi has gained a great deal of experience in conducting this type of training course. He has concurrently developed a number of teaching modules (PowerPoint) on many of the topics typically taught in such courses. Ngugi is particularly skilled in the practical aspects of pond construction, pond and hatchery management, and in effectively teaching these to farmers and extension workers. His teaching style makes the material he presents highly accessible to the

trainees. He is fluent in both of the major international languages of East Africa, Swahili and English, and will therefore be readily able to teach in training courses in other countries.

Anticipated Benefits

Ten Fisheries Officers will be trained to train other extension workers (Fisheries Assistants) and farmers (up to 30) in appropriate methods for pond construction and management. These farmers and extension workers will be able to apply that knowledge to new and existing fish ponds, leading to increased production of both fingerlings and food fish on their farms.

On the outreach and education side, course instructors in other parts of the region will benefit from the experiences of Kenyan workers in methods for teaching these techniques to farmers and extension agents. Training modules and the fish farming handbook drafted by members of the CRSP/Kenya project will be available for use and can be modified or improved following these training courses, both with respect to their organization and to the technical information provided.

Finally, collaboration on training efforts will strengthen the training capacities of all of the institutions involved, including those of the collaborating institutions in Tanzania (Mkindo Farmers Training Center, Sokoine University of Agriculture, Kingorwila National Fish Center, and the Tanzania Fisheries and Aquaculture Development Division) and Ghana (Kwame Nkrumah University of Science and Technology and the Fisheries Department, Ministry of Food and Agriculture, Accra) as well that of the Moi University Department of Fisheries and Aquatic Sciences (Eldoret, Kenya).

Activity Plan

Location of Work

- Short courses to train trainers in Kenya will be held at either the Moi University Fish Farm, Eldoret, or Sagana Fish Farm, Sagana.
- Training in Tanzania will be conducted at the Mkindo Farmers Training Center (MFC), with a visit also to the Kingorwila National Fish Center.
- Participation in the WAS conference will involve travel to Florence, Italy.

Methods

Training of Kenyan Trainers

Up to ten (10) selected Fisheries Officers (FOs) of the Kenyan Fisheries Department (FD) will be brought to the training center for an intensive two-week course on how to teach relevant aquaculture skills to farmers and/or other FD employees (e.g., Fisheries Assistants, "FAs") who routinely work with farmers. Trainees will be selected jointly by the Director of Fisheries (Nancy Gitonga) and the Head of the Moi University Department of Fisheries and Aquatic Sciences (MU-FISH) (Charles Ngugi), and will be based on criteria such as the potential for fish farming in the officer's area of assignment, the officer's prior performance in aquaculture extension activities in their assigned area, their apparent understanding of aquaculture (as demonstrated in previously-attended short courses or in their subsequent field work), and their ability and desire to participate in training and education (extension, outreach) activities. Topics covered will be similar to those of previous training sessions, including evaluation of suitable sites for ponds, proper construction of ponds, and appropriate management practices for completed ponds (an example course outline from a previous course is attached). However, in this case emphasis will be on <u>how to teach</u> these skills to others, rather than on the technical information itself (the assumption is that those selected will have already attended one of the technical short courses). Thus some attention will also be given to the details of planning, logistics, and budgeting for putting on a course.

Following the one-week training session the trainees will conduct two, two-week short courses for FAs or farmers in areas to be selected by the FD Director and the MU Department Head. This may be done by forming the ten new trainers into two five-person training teams; each team could then run one of the courses. Again, course content will be similar to that of previous two-week short courses offered to FAs. Two or more of the original trainers will monitor the progress of these courses, providing assistance and guidance to the new trainers as needed.

The first edition of the fish farming handbook being developed by the CRSP/Kenya Project will be used as the "text" for these courses. Suggestions regarding ways in which the handbook can be improved will be noted and suitable modifications will be planned for future editions.

Farmers Training in Tanzania
A five-day training workshop for farmers, to be conducted in collaboration with Mkindo Farmers Training Center (MFC), has been planned by the ACRSP UAPB/Tanzania project. Major topics to be covered include pond construction and management, fish health, fish nutrition, and fish economics. Instruction will be provided by three persons from Sokoine University of Agriculture (SUA), two persons from Kingorwila National Fish Center (KNFC), two persons from MFC, one person from UAPB, and one person from the Moi University Department of Fisheries and Aquatic Sciences (Kenya). The workshop will be held in early 2006. Twenty-five fish farmers from different participating villages in the Morogoro Region will be trained, with a focus on the training of women and household members who typically manage fish ponds. Further details on this workshop are given in the UAPB proposal. Similar short courses may be conducted with appropriate institutions in other parts of the region, for example in Ghana.

This proposal plan provides for the participation of Charles Ngugi, of the Moi University Department of Fisheries and Aquatic Sciences, in these training sessions. Dr. Ngugi will bring a wealth of valuable experience and expertise to these courses, along with an intimate knowledge of the teaching modules (PowerPoint) that have been used in similar courses in Kenya and the recently drafted Fish Farming Manual for Kenya.

Regional and Global Integration
These proposed activities directly address Objective 2 in the CRSP Regional Plan for Africa (PD/A CRSP, 1997), which is "To assist in the development and conduct of aquaculture training courses and programs, with emphasis on pond operation and management." They also address the overall goals of strengthening research and extension institutions in the region and encouraging technology transfer among research and extension institutions in the region.

Schedule
- The one-week training-of-trainers (FOs) course will be conducted in June 2006.
- The two-week training courses taught by the FOs will be conducted soon after the one-week course (June through July, 2006).
- The Tanzanian farmers training course will be conducted in mid 2006.
- Training sessions to be held at additional regional locations will be held in mid 2006.
- A brief summary report for each training session will be written within one month of completion of the course.
- A final report on these supplemental activities will be submitted by June 30 2007.

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Aquaculture CRSP Sponsorship of the Second International Symposium on Cage Aquaculture in Asia

Applied Technology and Extension Methodologies (12ATE12) / Activity / Thailand and China

Collaborating Institutions

Asian Institute of Technology (AIT)
Yang Yi
Zhejiang University (ZJU), China
Shao Qingjun
University of Michigan
James S. Diana, C.Kwei Lin

Objectives

1. To organize a special session on environmentally-friendly integrated cage-cum-pond culture system at the Second International Symposium on Cage Aquaculture in Asia;
2. To provide travel support for five invited speakers on the special session from Aquaculture CRSP institutions in Asian countries;
3. To provide travel support for four or more contributors from Aquaculture CRSP institutions in Asian countries;
4. To provide three environment awards to recognize research that addresses environmental concerns of cage aquaculture;

Significance

It is believed that cage aquaculture promises huge potential to meet increasing demands of seafood products. Modern cage aquaculture especially off-shore cage aquaculture has been developed rapidly since late 1990s in Asia countries, while many challenges such as appropriate culture technologies and environmental impacts have been emerging as major concerns. The international symposium specifically to address concerns of cage aquaculture in Asia, the First International Symposium on Cage Aquaculture in Asia, was thus held in 1999 in Taiwan (Liao and Lin 2000). To address the emerging issues of cage aquaculture in Asia, the Second International Symposium on Cage Aquaculture in Asia has been scheduled on 3-8 July 2006 in Zhejiang University, Hangzhou, China (www.caa2.org). Aquaculture CRSP researchers at AIT have played important roles in both symposia, and Aquaculture CRSP has been invited as one of co-sponsors for the second symposium. To promote environmentally-friendly integrated cage-cum-pond culture systems developed by Aquaculture CRSP in Asia especially in China, a special session will be held at the second symposium. It is a great opportunity to expand the Aquaculture CRSP influence in Asia especially in China.

Travel support is very important to the researchers from developing countries to present their findings, understand the latest development, and exchange information with counterparts in international conferences. Aquaculture CRSP institutions in Asian countries will benefit from the travel support, which will ensure a strong international participation of Aquaculture CRSP host countries PIs.

Anticipated Benefits

Aquaculture CRSP researchers will benefit from the presentations made in the symposium, while other participants from all over the world particularly Asian countries will also benefit from the achievements of Aquaculture CRSP.

Activity plan

Site: The Second International Symposium on Cage Aquaculture in Asia – AIT, Thailand and Zhejiang University, Hangzhou, China.

Methods: Yang Yi serves as vice chairperson of the organizing committee and chairperson of the scientific committee, and has approval by the committees to organize the special session: Environmentally-Friendly Integrated Cage-cum-Pond Culture Systems - Aquaculture CRSP.

An Aquaculture CRSP committee will be formed to select travel grant awardees. The selection criteria will be based on the quality of the work, past participation in Aquaculture CRSP projects and other available support. If partial support can be generated from other funding sources, the travel grants may be split to support additional participants.

The committee will evaluate presentations (both orals and posters) related to environmental issues of cage aquaculture based on the quality of work and determine Aquaculture CRSP Environment Awards.

Schedule

January 2006:	Announce Aquaculture CRSP Awards in the symposium's second announcement;
February 2006:	Invite Aquaculture CRSP researchers in Asia countries to apply for travel support;
March 2006:	Establish selection committee;
April 2006:	Receive papers;
May-June 2006:	Select and invite researchers who will receive travel support, and make logistic arrangements for them;
3-8 July 2006:	Organize the special session during the symposium; Determine Aquaculture CRSP Environment Awards;
30 June 2007:	Submit final report.

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Promoting Environmentally-Friendly Integrated Cage-Cum-Pond Culture Systems

Applied Technology and Extension Methodology (12ATE13) / Activity / China

Collaborating Institutions
Asian Institute of Technology (AIT)
Yang Yi
Bangladesh Agricultural University (BAU), Bangladesh
Md. A. Wahab
Institute of Agriculture and Animal (IAAS), Nepal
Madhav K. Shreastha
Can Tho University (CTU), Vietnam
Nguyen Thanh Phuong
Huazhong Agricultural University (HAU), China
Wang Weimin
University of Michigan
C. Kwei Lin and James S. Diana

Objectives
1. To produce a manual on the integrated cage-cum-pond systems developed by Aquaculture CRSP;
2. To promote the integrated cage-cum-pond systems developed by Aquaculture CRSP through the manual, promotional brochures produced in different languages, and workshops to be held in different countries.

Significance
The integrated cage-cum-pond culture system is a system in which high-valued fish species are fed with artificial diets in cages suspended in ponds, where filter-feeding fish species are stocked to utilize natural foods derived from cage wastes. This integrated system has been developed and practiced using combinations of catfish-tilapia (Lin 1990; Lin and Diana 1995) and tilapia-tilapia (Yi et al. 1996; Yi 1997; Yi and Lin 2000, 2001) in Thailand. Although cages were set up in Nile tilapia monoculture ponds in all previous work mentioned above, this integrated system can be applied in polyculture systems. In polyculture, ponds are stocked with several species of different feeding habits together. It is impossible to target feeding to only high-valued species, because low-valued species consume the feed resulting in economic inefficiency unless an integrated system is adopted. Compared to the nutrient utilization efficiency of about 30% in most intensive culture systems (Beveridge and Phillips 1993; Acosta-Nassar et al. 1994), the nutrient utilization efficiency could reach more than 50% in integrated cage-cum-pond systems, resulting in the release of less nutrients to the surrounding environment (Yi 1997). Therefore, the integrated cage-cum-pond culture system has been regarded as an environmentally-friendly aquaculture system.

Recently, Aquaculture CRSP has funded the on-station and on-farm trials with different high-valued local species in cages in carp polyculture ponds in Bangladesh, Nepal, and Vietnam. The participating farmers have shown much interest in these integrated cage-cum-pond systems, which provide opportunities for small-scale poor farmers to use their limited resources to culture a small amount of high-valued species in their ponds, thus generating more income and improve their livelihood. CARITAS, a Bangladesh NGO, is conducting the on-farm trial in its network farmers' ponds, has become convinced by the encouraging results and has decided to promote this integrated system through its network.

To promote the environmentally-friend integrated cage-cum-pond culture systems, appropriate means for information dissemination should be developed, including producing a manual and posters and conducting workshops.

Anticipated Benefits

This technology will provide small-scale farmers an opportunity to generate more income and improve their livelihood using their scare resources; and will benefit small-scale farmers in Asian and other countries, where the integrated systems can be practiced.

Activity Plan

Activity 1: Producing a Manual for Environmentally-Friendly Integrated Cage-Cum-Pond Culture Systems.

The outline of the manual is as follow:

Traditional aquaculture systems
- Cage culture
- Pond culture
- Environmental impacts of aquaculture effluents
- Integrated fish/livestock or poultry culture system

Principle and concept of environmentally-friendly integrated cage-cum-pond culture systems
- Nutrient flow
- Nutrient recycling
- Ratios of caged fish and open-pond fish

Practical considerations for environmentally-friendly integrated cage-cum-pond culture systems
- Species selection for cages
- Species selection for ponds
- Cage design, construction, and placement in ponds
- Feed and feeding management

Practices of environmentally-friendly integrated cage-cum-pond culture systems
- Hybrid catfish in cages and Nile tilapia in ponds
- Fattening Nile tilapia in cages and nursing Nile tilapia ponds
- Other high-valued species in cages and carps in ponds

Prospects of environmentally-friendly integrated cage-cum-pond culture systems

Approximately 500 copies of the manual will be printed, distributed at workshops and mailed to aquaculture agencies and institutions.

Activity 2: Producing promotional brochures for environmentally-friendly integrated cage-cum-pond culture systems in different languages.

Two-page promotional brochures will be produced in Bengali, Chinese, Nepalese and Vietnamese. Approximately 500 copies of the brochure in each of the above languages will be printed, distributed at workshops and mailed to aquaculture agencies and institutions in above countries.

Activity 3: Conducting four workshops on environmentally-friendly integrated cage-cum-pond culture systems.

Three 1-day workshops will be held in Dhaka of Bangladesh, Katmandu of Nepal, and Can Tho of Vietnam. Approximately 120 participants (about 40 for each workshop) from government fisheries/extension agencies, NGOs, academic institutions, students and farmers will be invited to attend the workshops. The workshop in China will be organized as a special session in the 2nd International Symposium on Cage Aquaculture in Asia to be held on 3-8 July 2006 in Hangzhou of China.

Regional Integration

Pond culture is the most common aquaculture practice in the world. This integrated cage-cum-pond culture system can be adopted worldwide, and may provide an appropriate option for small-scale rural farmers to make higher profit and diverse products.

Schedule

June - December 2006. Report submission: not later than 30 April 2007.

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Post-Tsunami Training in New Aquaculture Technologies in Thailand and Indonesia

Applied Technology and Extension Methodologies (12ATE14) / Activity /
Indonesia and Thailand

Collaborating Institutions

AARM, Asian Institute of Technology
Amrit Bart
Coastal Resources Center, University of Rhode Island
James Tobey
University of Arizona.
Kevin Fitzsimons

Objectives

a. Train communities devastated by the December 26, 2004 tsunami in more sustainable aquaculture technologies (Freshwater catfish, brackish water tilapia culture, seaweeds, bivalves, abalone).
b. Conduct a series of short courses in affected communities demonstrating alternatives to shrimp pond culture.
c. Determine how the introduction of new production technologies (small-scale hybrid catfish seed and grow out culture, brackish water tilapia, seaweeds, mollusk culture) affects aquaculture growth.
d. Examine change in livelihood attitudes toward fish culture and wild capture following a major natural disaster to the capture fishery fleet.

Significance

On 26 December 2004, at 6:58 a.m. (local time), a 9.0 magnitude earthquake occurred in deep water off the western coast of Northern Sumatra, Indonesia. The earthquake triggered a massive tsunami. Large waves struck without warning and severely impacted the coasts of South and Southeast Asia, including Indonesia, Thailand, Sri Lanka, India, stretches of the Malaysian coast and many small islands in the Andaman Sea.

The 26 December tsunami devastated Thailand's entire Andaman coast strip. A total of 392 villages and some 54,500 people were affected by the tsunami, with more than 5,000 deaths recorded and many others missing. Over 4,500 fishing boats were destroyed or seriously damaged. Across the Andaman coast, tens of thousands are without jobs, income, have dwindling means of survival, and few if any alternatives. Residents want jobs and to get back with their lives.

With this sudden impact on fisheries and other resource dependent livelihoods, the need to restart and diversify livelihoods is acute. In the long run, livelihood development creates disaster resilient communities because communities with diverse economic bases are not dependent on just one activity.

New and diversified livelihoods means introducing new production technologies to coastal villages. Aquaculture offers an alternative livelihood with potential for expansion in the project site. This study explores the openness of aquaculturists and others to adopt new catfish hatchery technology that would permit an expansion in catfish culture in the selected communities. We will also provide training in other aquaculture crops believed to provide diversity and more sustainable coastal aquaculture compared to the monoculture of shrimp in ponds. Following the tsunami disaster, thousands of fishers are without jobs. This study will also examine the openness of fishers to be part time fish farmers, thereby reducing overexploitation of the fisheries and livelihood dependence on the wild capture fishery.

The proposed study builds on and would be supported in part by the USAID Post-Tsunami Sustainable Coastal Livelihoods Program, a model program to demonstrate sustainable coastal communities that are resilient to economic and environmental shocks. The goal of the program is

to rebuild and diversify sustainable coastal livelihoods of severely affected fishing communities on the Andaman Coast of Thailand and to demonstrate effective practices of community-based disaster preparedness. The Program is implemented by the Coastal Resources Center of the University of Rhode Island in partnership with the Asia Institute for Technology (AIT), University of Hawaii, and other local partners.

The Indonesian aspects would be jointly supported by the World Aquaculture Society Tsunami Relief Fund, the Ujong Batee Aquaculture Center and Aquaculture without Frontiers. Direct cash match of $10,000 would come for the WAS fund. Additional in-kind contributions would come from Professionals International and Aquaculture without Frontiers, delivering course materials, providing transportation and assisting with translations.

This award to URI was made through the Sustainable Coastal Communities and Ecosystems (SUCCESS) Cooperative Agreement with USAID. This study, therefore, also builds working relationships between SUCCESS and CRSP.

Anticipated Benefits

The study will benefit tsunami survivors, especially fishermen and former shrimp farm employees, in the study area and will have a wider impact on sustainable aquaculture development through replication of technology in the region.

In addition to this direct benefit to tsunami affected communities, a longer-term and more global benefit is to provide information critical to diversification of livelihoods in post-disaster situations and contribute to understanding of processes that lead to the adoption of technology in fish farming. Knowledge of adoption of technology in the Thailand study site will contribute to our understanding of how to better target rehabilitation assistance and increase desired benefits to affected communities and vulnerable groups. The experience and knowledge from the study will be disseminated through a regional learning workshop that the Sustainable Coastal Livelihoods Program is hosting in January. Study hypotheses, methods and early findings will be presented at the workshop. In the long run, livelihood development, diversification and improved technology create communities that are more disaster resilient because communities with diverse economic bases are not dependent on just one activity.

Methods: The study focuses on 5 rural villages in Ranong Province of Thailand and 2 villages in Aceh Province of Indonesia. Several of these villages on the coastal strip facing the Andaman Sea and the Straits of Malacca were severely affected by the tsunami with loss of homes, lives and a large proportion of the fleet of fishing boats and gear at varying degree. Primarily dependent on the sea for livelihoods, the tsunami left fishing families in a very vulnerable position. It is our hypothesis that faced with greatly increased vulnerability, fishers and others will be especially open to experimenting with new livelihoods and technology.

Currently, there are a small number of aquaculturists in the 7 villages.

We will conduct a series of workshops to train participants in catfish, tilapia, seaweed, and various mollusk culture techniques. Fishers, employees from damaged shrimp farms, and women from the affected villages in need of employment will be invited to attend. The trainings will be conducted by Thai and Indonesian Bahsa speaking graduate students and faculty from the Asian Institute of Technology and the professional staffs of the Ujong Batee Aquaculture Center and Ladong Fisheries College.

We will establish a small-scale hybrid catfish hatchery in one Thai village, use this as a training and demonstration facility for Thai villages, and provide training in catfish culture. Our intention is then to closely monitor the emerging catfish culture industry in the villages and understand what villages and who within the villages are more apt to adopt new technology and expand the industry.

In Sumatra, we will collaborate with the Ladong Fisheries College and aquaculture staff at Ujong Batee Aquaculture Center to hold two training workshops. We will also utilize experimental

ponds recently stocked with assistance from the Aquaculture without Frontiers and Professionals International (two NGO's supporting aquaculture restoration in Aceh Province.)

A survey instrument will be developed and a baseline assessment conducted of catfish culture, technology, markets, and employment. Monthly monitoring and key informant interviews will then be the basis for tracking the rate of adoption of new technology and the impacts of technological change in all communities, those severely affected and those little affected by the tsunami.

In addition to the small-scale hatchery and culture training, another catalyst to aquaculture is a micro-finance revolving fund supported by the Sustainable Coastal Livelihoods Program. Through this scheme, entrepreneurs in 5 of the 7 villages will have access to small loans of up to about US$500 per person or larger amounts for entrepreneurs who pool together in a business proposal.

The data for the study will be the baseline plus about 5 months of monitoring. Hypotheses and methods will be shared at a regional Learning Workshop in January 2006 convened by the Sustainable Coastal Livelihoods Program. A final report focusing on differences in the adoption of technology across communities and types of entrepreneurs will be prepared in April.

Regional and Global Integration

This study addresses issues in the adoption of aquaculture technology applicable to similar situations in other countries. It also addresses questions of coastal disaster rehabilitation and diversification of livelihoods.

Through its links with the USAID Sustainable Coastal Livelihoods Program, the study is connected with regional and global learning networks. In particular, the study will be featured at a regional post-tsunami learning workshop in Bangkok in January 2006.

An update of the project will also be presented at the World Aquaculture Society conference to be held in May 2006 in Florence, Italy. A special session reporting on Aquaculture CRSP projects has been scheduled and this project will be included in the project reports.

Schedule

Project start date	December 1, 2005
Installation of small-scale hatchery and training	December 2005
Baseline analysis	December 2005
Culture training	January 2006
Monthly surveys	January 06 – April 06
Regional Learning Workshop	January 06
End date and final report	June 30, 2007

Bivalve Market Study in Pacific Mexico

Economic/Risk Assessment and Social Analysis 6 (12ERA6)/Study/Mexico

Collaborating Institutions

University of Hawaii at Hilo
Maria Haws (Lead US PI)
University of Alaska Fairbanks at Kodiak
Quentin Fong (US co-PI)
Center for Research for Food and Development
Francisco Martinez Cordero (Lead HC PI)
Autonomous University of Sinaloa
Guillerno Rodriguez Dominguez (HC co-PI)

Objectives

The overall objective of this work is to identify the principal constraints and opportunities that local and regional markets have for the bivalve products produced by cooperatives and individual producers in coastal communities of Sinaloa and Nayarit, Mexico. Oysters (*Crassostrea gigas* and *Crassostrea corteziensis*) and clams (various spp.) will be the focus of this work since these are the most commonly cultured bivalves, although information on other species will be collected simultaneously where possible. The two oyster species have important differences that may affect consumer preference and biological feasibility. *C. gigas* is not native and most seed is supplied by a U.S. company; this species is most widely cultivated along the northern coast. *C. cortenziensis* is native to Mexico, but is very similar to *C. virginica* and is more commonly cultured on the southern coast. It is unclear how the two species may perform in the various markets and information is needed to determine how to best allocate oyster farming development efforts. Both areas being studied have numerous coastal communities where bivalve culture is currently conducted or is planned for the near future. Gaining a better understanding of markets, market trends, prices, and obstacles will inform the development of a bivalve industry for Pacific Mexico and assist producers in obtaining more direct benefits.

The specific objectives for this work are:

- To identify the marketing variables: product, price, distribution, and communication as well as the potential for demand by the three main regional markets (Los Cabos, Mazatlán and Puerto Vallarta) and assess characteristics of the smaller local markets;
- To conduct a survey by mail and personal interviews among large restaurants and hotels in these locales, to determine market preference for attributes of BSM and Nayarit oysters and clams;
- To review secondary sources of information for the two main wholesale markets in Mexico: Guadalajara and Mexico City to estimate potential demands and competition opportunities;
- To determine the feasibility and concerns for BSM´s and Nayarit's oyster and clam producers based on current market and regulatory conditions; and
- To assess market preferences to inform the marketing and development efforts of mariculture cooperatives and individual farms.

This work also has a capacity building element. Dr. Quentin Fong (Fisheries Industry Technology Center/University of Alaska/Sea Grant), internationally renown for his work in aquatic product marketing will provide training to qualified specialists at CIAD, UAS and UAN in specialized skills required for marketing research and extension. Dr. Cordero is an Aquaculture Economist at CIAD and routinely assists aquaculture producers in the economic aspects of best management practices and farm management. Additionally, Drs. Fong and Cordero will work together to hold community meetings and workshops not only to collect information, but to raise awareness among producers and vendors as to basic marketing concepts that they can immediately utilize to improve their businesses and to share project outcomes with them.

This work will also serve as a model for other CRSP countries and USAID/SUCCESS sites. Bivalve production is growing in many coastal nations including the USAID/SUCCESS sites, and

market uncertainties and lack of capacity to work in this area are widespread. The information produced, methodologies and recommendations of the Mexico study can benefit other sites. In particular, the methodologies and skills required to conduct rigorous and useful market studies and how to effectively use this information as part of a marketing extension effort will be the emphasis of the workshop to be held in Mexico; the training materials developed for Mexico will also be used at the SUCCESS sites.

Significance

This work supports other investigations in the Twelfth Work Plan jointly led by the University of Hawaii and the Autonomous University of Sinaloa along with a wide array of institutional and community-based partners. The other investigations are intended to overcome one of the principal barriers to improving and expanding bivalve culture, i.e. lack of capacity, regulations and baseline data to certify bivalve growing waters to assure shellfish sanitation. Research conducted during the Eleventh Work Plan clearly indicated that continuation and future expansion of the shellfish industry in a way which does not impact human health depends on making progress towards producing shellfish which is both safer in a real sense, and which is perceived as safer by consumers in Mexico (residents and tourists). Additionally, good potential to export to other parts of Mexico and other countries is believed to exist if shellfish growing waters can be certified to meet national and international standards.

Two investigations in the Twelfth Work Plan address this issue. The first is a shoreline survey and water quality monitoring program of two wetlands areas (BSM and Boca Camichin) where bivalves are cultured or projects are being started. The second investigation has a policy objective of working with other researchers, regulators and community members to share the results of the scientific research, then develop and work towards implementation of steps to assure safer shellfish production. At the same time, several of the partner institutions have independent research and extension efforts to further develop the bivalve industry.

The work proposed here targets another principal constraint not otherwise addressed in the Twelfth Work Plan to expanded bivalve culture in the region and elsewhere, i.e. marketing issues related to current and future bivalve production. Understanding how and where producers and communities can better market their products can result in more direct and increased benefits to stakeholders. Information will also guide development of new farms and of new species. This work will fill gaps in the collective knowledge of the stakeholders as they work together to advance bivalve culture in poor coastal communities.

Increased capacity for marketing concepts and tools among the collective stakeholders involved in the regional efforts will provide the basis for future work in this area in Mexico and other CRSP countries.

Anticipated Benefits

Target groups for this work include: aquaculture extension workers and researchers in Pacific Mexico; key private sector representatives; bivalve growers in Nayarit, Sinaloa and Sonora; Women's oyster culture cooperatives of Nayarit; Women's oyster culture cooperative of Puerto Peñasco; Conservation International; Universidad Autonoma de Sinaloa (UAS, Culiacan and Mazatlan Campuses); CIAD (Center for Food and Development Research); Sinaloa Institute for Aquaculture (ISA); UCA, the Central American University of Nicaragua; Ecocostas, an NGO dedicated to conservation and sustainable development for Latin America; State Committee for Aquatic Sanitation (CESASIN); and the Federation of Shrimp Cooperatives. Linkages will also be made to the NOAA International Sea Grant efforts through participation of Maria Haws and Quentin Fong, Sea Grant personnel/associated faculty from Hawaii and Alaska. Stakeholders from the four USAID/SUCCESS sites will also be participants or clients for this work.

Quantifiable benefits will include: demonstrated increases in marketing research skills for local economists and extension agents; increased knowledge and data related to markets, preferences, prices and costs for bivalves; documents and training materials; and improved outreach to communities and farmers producing or selling bivalves.

Activity Plan

The market identification part of the work consists of two phases. Phase one consists of identifying potential customers, conducting focus interviews and survey design. Tourism directories will be used to locate entities that are currently using or that may be interested in purchasing live seafood for their business. The tourism industry in the northwestern region of Mexico is growing, and is characterized by high-income visitors, who sustain a large number of seafood restaurants. Further, a subset of the identified potential respondents will be interviewed in person to help focus on the most important attributes that a live seafood buyer favors. A market survey will be designed based on the results of the focus interviews (e.g. Kotler, 1997; Blakenship et. al. 1998).

But local consumers in local, smaller markets won't be neglected. Although the average Mexican citizen consumes a relatively small amount of seafood per year, consumption on the Pacific coast is higher and bivalves are the most demanded segment of seafood. Bivalves are fully recognized and consumed at the point of sales, fresh or in cocktails. Bivalves consumption is also high during certain Mexican holiday periods. Therefore current and potential consumption will be assessed using surveys in the cities of Guasave and Los Mochis, two large cities in Sinaloa State on the Pacific coast where "typical" local consumers and vendors reside.

The surveys will gather data to analyze desired product characteristics such as appearance, color, size, species etc. rated by the respondents using a pointed scale system. Purchase intent (will buy or will not buy) and the willingness-to-pay for different product forms will also be determined. Further, information on other marketing variables such as desirable shelf-life, packaging form, mode of delivery, expected volume to be used, seasonality of demand, etc. will also be gathered. Finally, the gathered data will be analyzed by discrete-choice regression analysis to determine the relative contributions of product quality and other marketing variables to the purchase intent and/or the levels of satisfaction towards different product prototypes (e.g. Ben-Akiva and Lerman, 1997; Greene, 2000).

A second, general objective of this work is to identify regulatory bottlenecks in harvesting and transporting bivalves in Mexico. This has been pinpointed as an area of concern by communities and extension agents as the key stakeholders (community-based producers and vendors) are largely found in rather isolated and distant wetlands areas where access to larger distribution chains is difficult. There are also uncertainties regarding the capacity of existing seafood distributors to comply with the specific requirements to transport or store live bivalve in an effective and safe manner. This work will include a legal review to identify regulations governing the sale and transport of seafood in Mexico, key constraints and opportunities, with the focus on bivalves. Each regulation will be outlined as an appendix to the final document.

Based on these two elements, the study finally will assess market incentives or deterrents for the development and expansion of the bivalve industry. Drs. Cordero and Fong will also liaise with the main project work team (e.g. UHH and UAS) currently implementing the Twelfth Work Plan to update the team on progress, receive input and to present the end results of the work. Additionally, CESASIN, the Sinaloa State Committee for Aquaculture Sanitation, a regional research and extension agency, will be a key client for this work as they are currently expanding their successful efforts in extension and aquaculture sanitation to develop a similar initiative for bivalve producers.

Final products will include: a project report of findings; a "marketing study tool box" consisting of a detailed description of this study's methodology and general guidance on how to conduct similar marketing studies; training materials in basic marketing concepts in Spanish; one AquaNews article; and at least one peer-reviewed publication. We will also liaise with the local Mexican press (newspaper and radio), which have regularly publicized the BSM management initiatives and the aquaculture development efforts.

Regional and Global Integration

This work implements one of the recommendations stemming from the Eleventh Work Plan and complements the Twelfth Work Plan to build on efforts by URI, UHH, CIAD, UAS, Conservation International and CESASIN in the Pacific states of Sonora, Sinaloa and Nayarit to strengthen and expand a sustainable and viable form of aquaculture for coastal Latin America. Findings and capacity building resulting from this work will inform current and future industry development efforts in Mexico and other Latin American countries. Additionally, this work will contribute to a series of international extension training efforts to be undertaken for a five-year period by the USAID/EGAT-sponsored SUCCESS project (Sustainable Coastal Communities and Ecosystems) in other CRSP regions such as Nicaragua, Ecuador, East Africa and Thailand.

Schedule

Started date: December 1, 2005.
End date: The final report will be submitted by 31 July 2006.

Task								
	D	**J**	**F**	**M**	**A**	**M**	**J**	**J**
Updated literature and stakeholder surveys			**X**					
Design of marketing surveys			**X**					
Execution of marketing research			**X**	**X**	**X**			
TDY Quentin Fong to assist with data analysis and interpretation				**X**				
Community workshops-Mexico				**X**	**X**		**X**	**X**
Publication of training modules and final report							**X**	**X**

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Student Exchange Program to Strengthen Capacity in Chinese Environmental Studies of Aquaculture

Production System Design and Integration (12PSD9) / Experiment / Thailand and China

Collaborating Institutions
Asian Institute of Technology (AIT)
Yang Yi
Hainan University, China (HNU)
Lai Qiumin
Huazhong Agricultural University, China (HAU)
Wang Weimin
University of Michigan
C. Kwei Lin and James S. Diana

Objectives
1. To expose students in different academic environment, enhance students' knowledge in aquaculture and environment, and establish closer collaboration between Aquaculture CRSP and Chinese institutions through student exchange;
2. To investigate the integrated shrimp/Gracilaria culture systems, to quantify the nutrient budget in the integrated systems, and assess the economic and environmental impact of the integrated systems;
3. To assess effects of application of phytase in aquafeed on feed utilization efficiency and phosphorus discharged to the environment.

Significance
China is the largest aquaculture producer in the world, producing about 70% of the world's farmed aquatic products. Aquaculture and culture-based fisheries have been developed and intensified rapidly in China since late 1970s. However, environmental impacts of aquaculture and culture-based fisheries have become serious concerns, and such environmental concerns have not been fully addressed through research and education at various levels. Inappropriate aquaculture practices have polluted most public waters such as rivers, lakes, and reservoirs, due mainly to lack of environmental awareness and environmentally-friendly aquaculture technologies.

A workshop on collaboration between Aquaculture CRSP and Chinese institutions in aquaculture and environmental management was held in May 2005 in Wuhan of China. During the workshop, 59 constraints to aquaculture development and environmental management in China were identified and 27 prioritized researchable topics were developed (Yi *et al.* in press). As a follow-up of this workshop, a student exchange program is proposed in this study aiming to strengthen capacity in environmental studies of aquaculture through their thesis research. One MSc student from the University of Michigan will conduct a study on the integrated shrimp/*Gracilaria* culture systems in Hainan of China, while one MSc student from Huazhong Agricultural University will conduct a study on the application of phytase in aquafeed at AIT.

Shrimp production in China increased from 87,831 metric tons (MT) in 1981 to 1,270,819 MT in 2001 (FAO 2003). However, the rapid expansion of intensive shrimp culture has caused negative environmental impacts (Pruder 1992; Phillips *et al.* 1993; Boyd and Clay 1998; Fast and Menasveta 2000; Lin 2000). Research shows that 66% (Briggs and Funge-Smith 1994) to 88% (Jackson *et al.* 2003) of total nitrogen, and as high as 94% (Briggs and Funge-Smith 1994) of total phosphorus added to intensive shrimp ponds ended up in effluents and sediments. These nutrients and organic matter, if not treated before dispersal into surrounding ecosystems, may potentially result in low dissolved oxygen levels, hyper-nitrification and eutrophication, and sedimentation in receiving waters (reviewed in NCC 1990, cited by Phillips *et al.* 1993). Biological treatments explore the possibility of using nutrients in effluents to produce products with economic values. Seaweeds especially *Gracilaria* are excellent candidates to be used in either recirculation or open systems for intensive shrimp culture. *Gracilaria* have been widely cultured in China to be used as

raw materials for many industries. Recently, *Gracilaria* have been found to be preferred feed for cultured abalones, providing them a better market and higher price (>US$0.15/kg in China; Lin 2005). More importantly, *Gracilaria* spp. can be used as biofilter to extract nutrients from seawater to control eutrophication (Chen 2000). Many shrimp farmers are integrating shrimp culture with *Gracilaria* culture in Hainan province of China (Lai, personal communication). Integrated shrimp/*Gracilaria* culture is practiced in three systems: (1) polyculture in the same ponds; (2) alternative shrimp and *Gracilaria* culture in the same ponds; and (3) recirculating culture of shrimp and *Gracilaria* – recirculating water from shrimp ponds to *Gracilaria* ponds then back to shrimp ponds. However, those integrated culture systems, which have been adopted by local farmers, have never been surveyed or investigated scientifically (Lin 2005).

In freshwater aquaculture effluents, phosphorus is a critical pollutant to the aquatic environment. Excessive excretion of phosphorus into water can stimulate the growth of phytoplankton, thus reducing dissolved oxygen and causing water pollution (Miller *et al.* 1974; Boyd 1990; Sugiura *et al.* 1999). Dicalcium phosphate is commonly supplemented as major phosphorus source to aquafeed especially in the aquafeed with plant by-products such as soybean meal as major ingredients. On the other hand, approximately two thirds of the total phosphorus in plant feedstuffs is bound as phytate-phosphorus (Lall *et al*. 1991) and are practically not available for fish (NRC 1993), due to the lack of an intestinal phytase for efficient phytate hydrolysis during digestion (Jackson *et al*. 1996; Liebert and Portz 2005). The availability of indispensable minerals such as calcium, zinc, magnesium and iron may also be negatively affected by phytate (Papatryphon *et al.* 1999). Besides, phytate can combine with protein as low digestible chelate complexes to reduce the availability of dietary protein and amino acids (Liu *et al*., 1998; Sugiura *et al*., 2001). Furthermore, phytate may interfere with the digestibility of lipids and starch (Cosgrove 1966). It has also been reported that growth and feed efficiency in commonly cultured fish species such as carps, tilapias, trout, and salmon is negatively affected by the phytate contained in the diets (Francis *et al*. 2001). Addition of phytase, which is produced by microorganisms and specific to phytate hydrolysis, into aquafeed has been considered an ideal way for producing a cost effective and low polluting aquafeed. The application of phytase in aquaculture was reported by Ketola (1975) as early as in 1970s, while most studies on the effects of supplemental phytase on nutrient utilization or growth of fish have started since the mid 1990s in common aquaculture species such as trout, common carp, channel catfish, salmon, stripped bass (Storebakken *et al*. 2000). The problem associated with application of phytase in aquafeed is that the enzyme cannot tolerate high temperature (>80ºC) during feed pelleting process. Thus, the purposes of this study are to pre-treat soybean meal using phytase, to optimize the substitution level of phytase for dicalcium phosphate in Nile tilapia (*Oreochromis niloticus*) feed, thus minimizing phosphorus excretion by Nile tilapia to the environment.

Anticipated Benefits

The proposed student exchange program will benefit the students at the University of Michigan, Hainan University, Huazhong Agricultural University and AIT, in terms of strengthening student capacity in environmental studies of aquaculture, increasing environmental awareness of students especially Chinese students. The results of the two MSc thesis research work will benefit the shrimp and tilapia farmers as well as environment in China.

Activity Plan

Site: Haikou, Hainan province, China; and AIT, Thailand.

Methods:

Study A: Integrated shrimp/*Gracilaria* culture in Hainan province of China

This experiment will be conducted by a student team consisting of one American MSc student and four Chinese senior BSc students in Hainan of China. The team will be led by the American Msc student and supervised by HC-PIs.

Survey

Field survey area: major shrimp/*Gracilaria* integrated farming area in Haikou, Hainan province of China. Sixty farms will be randomly selected from the study area, 20 farms for each integrated culture system.

Data collection: A structured checklist with open-ended questions will be used to interview farmers. Information will be collected on climate conditions, farm

operational profile, seed supply, culture systems, source water and water management, pond management, feed and feeding management, waste management, and socio-economic conditions of farmers.

Data analysis: Descriptive statistical methods.

Field measurements

Pond facility: 12 farmers' ponds with 3 ponds for each for polyculture and rotation culture systems and 6 ponds for the recirculation system will be randomly selected

Duration: 3 months

Stocking density: farmers' practice;

Test species: South American white shrimp (Litopenaeus vannamei); Seaweed (Gracilaria spp.)

Nutrient inputs: farmers' practice.

Sampling schedules:

Water quality: Monthly water quality sampling for analyses of total ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, total Kjeldahl nitrogen, soluble reactive phosphorus, total phosphorus, total suspended solids, total organic matter, and chlorophyll a (APHA et al. 2000). DO, pH, temperature, salinity and Secchi disc depth will be measured in situ during sampling times.

Shrimp/ Gracilaria production: total harvests.

Soil: samples will be analyzed at beginning and end of the experiment for moisture, bulk density, total organic matter, TN, and TP.

Feed: monthly analyses for moisture, TN, and TP.

Partial enterprise budgets will be estimated to assess costs and values of shrimp and Gracilaria spp. crops.

Statistical design, null hypothesis, statistical analysis:

There will be three treatments with three replicates each: (A) polyculture of shrimp and Gracilaria; (B) shrimp monoculture in shrimp/ Gracilaria rotation culture ponds; and (C) a shrimp/Gracilaria recirculation system: circulating water from a shrimp pond to a Gracilaria pond then back to the shrimp pond.

Null hypotheses: There are no differences in shrimp production, water quality, effluent quality, and nutrient utilization among treatments.

The results of shrimp production, water quality, effluent, and nutrient utilization will be analyzed for significant differences among treatments using ANOVA.

Study B: Application of phytase in Nile tilapia feed

This experiment will be conducted by a Chinese Msc student at AIT.

Experiment B-1: Pre-treatment of plant feedstuff using phytase

Facility: 60 aluminum trays

Treatment period:

Six hours at 50-55ºC and pH 5 adjusted by citric buffer for treatment of four plant feedstuffs: soybean meal, soft white winter wheat, wheat flour and corn meal.

Test species: none

Stocking density: none

Nutrient input: none

Water management: maintain at 0.6-m depth

Sampling schedules:

Proximate composition of four plant ingredients will be analyzed before and after phytase treatment.

Statistical design, null hypothesis, statistical analysis:

The experiment will be conducted in completely randomized design with five treatments and three replicates per treatment for each plant feedstuff. The treatments are five levels of phytase doses, that is, 0, 500, 750, 1,000, and 1,500 U/kg soybean meal.

The null hypothesis is that doses of phytase have no effect on the proximate composition of the plant feedstuffs before and after phytase treatment and among different phytase doses.

The data will be analyzed using *t*-test, ANOVA and regression.

Experiment B-2: Apparent digestibility of Nile tilapia fed the all-plant diet prepared by phytase pre-treated plant feedstuff

Facility: 15 fiberglass jars of 40 L in volume; one air stone will be put in each jar.

Culture period: 10 days

Test species: Nile tilapia

Stocking density: 10 fish of 40 g in size per jar

Nutrient input: fish will be fed the prepared diets twice daily to apparent satiation.

Water management: maintain at 0.6-m depth

Sampling schedules:

Water quality: DO, pH, temperature and total ammonia nitrogen will be measured during fecal collection.

Proximate composition of the prepared diets will be analyzed before and after phytase treatment.

Fecal collection: fecal collection will start after one week acclimation period.

Diets and fecal samples will be analyzed for amino acid, crude protein, total phosphorus, and phytase phosphorus based on hydrolysis resistant organic matter (HROM) as the non-absorbable indicator (AOAC 2000).

Statistical design, null hypothesis, statistical analysis:

All experimental diets will be formulated to contain 30% crude protein. There will be five treatments and three replicates each: soybean meal pre-treated with phytase at 0, 500, 750, 1,000 and 1,500 U/kg diet.

The null hypothesis is that doses of phytase have no effect on the proximate composition and apparent digestibility before and after phytase treatment and among different phytase doses.

The data will be analyzed using t-test, ANOVA and regression.

Experiment B-3: Phytase replacement of dicalcium phosphate in all-plant diets for Nile tilapia

Facility: 6 or 9 circular cement tanks of 0.5 m in diameter

Culture period: 3 months

Test species: Nile tilapia

Stocking density: 30 fish of 50-100 g in size per tank

Nutrient input: fish will be fed the prepared diets twice daily at 5%, 3% and 2% body weight per day.

Water management: maintain at 0.7-m depth

Sampling schedules:

Water quality: standard CRSP protocol, weekly water quality sampling and diel analysis at various depths, daily measurements of DO, pH, and temperature.

Proximate composition of the prepared diets will be analyzed before and after phytase treatment, bone ash and phosphorus will also be determined.

Fish will be sampled biweekly to adjust feed ration.

Statistical design, null hypothesis, statistical analysis:

The best phytase dose from the above experiment will be used to pre-treat plant feedstuffs. All experimental diets will be formulated to contain 30% crude protein. There will be two or three treatments and three replicates each depending on the results of the above experiment: A. control diet (non-treated by phytase); B. diet prepared by phytase treated plant feedstuff and supplemented with calcium monophosphate; C. diet prepared by phytase treated plant feedstuff without supplement of calcium monophosphate.

The null hypothesis is that replacement levels of phytase for dicalcium phosphate have no effects on tilapia growth, survival, FCR, feed utilization efficiency, and phosphorus excretion.

The data will be analyzed using ANOVA and regression.

Regional Integration

Shrimp and tilapia are widely cultured in the region and many parts of the world. The environmental- friendly integrated shrimp/*Gracilaria* culture systems and the environmental-friendly feed treated by phytase will be a new step in production technology that will promote efficient production as well as environmental sustainability.

Schedule

June to December 2006, report submission: no later than 30 June 2007.

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Kenya Capacity Building: Student Research and Thesis Support

Seedstock Development and Availability (12SDA5) / Study / Kenya

Collaborating Insitutions

Department of Fisheries and Wildlife, Oregon State University
Chris Langdon and James Bowman

Department of Fisheries and Aquatic Sciences, Moi University
Charles C. Ngugi

Objectives

New objectives for the OSU/Kenya Project under this proposal are:

- To provide support for research and thesis work of current graduate students pursuing aquaculture studies at Moi University, Kenya
- To provide stipend support for undergraduate aquaculture students working on their senior projects at Moi University, Eldoret, Kenya, or Sagana Fish Farm, Sagana, Kenya.
- To provide support for one student to present research results at the "AQUA 2006" conference in Florence, Italy.

Significance

Since the mid 1990s, fish farming has been undergoing a major revival in Kenya. After several decades during which many previously constructed ponds fell into disuse, renewed efforts by organizations such as the Kenya Fisheries Department, the FAO, the Belgian Survival Fund, and the Aquaculture CRSP to conduct research and disseminate results about appropriate practices, farmers are now realizing that fish farming can be a profitable enterprise. This has resulted in the revival of some previously abandoned ponds, the construction of numerous new ponds, and a renewed enthusiasm for fish farming among farmers. While some farming of rainbow trout (*Oncorhynchus mykiss*) is practiced in the cool highlands around Mt. Kenya and Mt. Elgon, the primary species cultured in most of the country are the Nile tilapia (*Oreochromis niloticus*) and the African catfish (*Clarias gariepinus*).

Most of the research conducted in the last decade by the Aquaculture CRSP has focused on basic pond culture techniques (appropriate fertilization and feeding regimes) for tilapia grown in static-water ponds, but a growing interest in the culture of the African catfish and production of catfish fingerlings has led, in recent years, to research focused on improving the survival of catfish fry reared to the fingerling stage. There are many remaining questions regarding the culture of both tilapia and catfish, two of which will be the focus of this additional research.

For example, it is not known whether the standard pond fertilization regime practiced in production ponds in Kenya is appropriate for the conditioning of broodfish for spawning. One of our new objectives is to examine variations to the standard fertilization regime to see if broodfish conditioning can be improved.

One of the standard recommendations for tilapia culture in Kenya has been to stock catfish with the tilapia at a rate of 5-10% of the number of tilapia stocked. This recommendation has been made primarily as a way to control the unwanted reproduction that usually occurs in tilapia ponds, but farmers do also realize the benefit of a second species being produced for sale or consumption. This is a significant problem for tilapia farmers in Kenya because there are as yet no producers of sex-reversed fingerlings in the country, so farmers either rely on hand-sexed all male populations or must resort to the stocking of mixed-sex fingerlings; in either case reproduction early in the culture period usually becomes a problem. Our new objective related to this issue is to examine various tilapia/catfish stocking ratios to determine if a ratio other than the standard recommendation would be more advantageous in terms of tilapia or catfish yields.

Quantified Anticipated Benefits

- Two additional graduate students will be trained and gain experience in aquaculture and related aquatic sciences topics, pond research methods, and various aspects of tilapia and catfish breeding and culture,
- New information will be obtained on the fecundity and energetics of tilapia brooders conditioned in static ponds under different feeding regimes,
- New information will be obtained on the effects of different stocking density combinations on the yields of tilapia and catfish, and
- One student will gain valuable experience in preparing and presenting the results of their thesis research at a major international conference.

General Activity Plan

Location of Work

- Masters students currently enrolled in aquaculture studies in the Moi University Department of Fisheries and Aquatic Sciences will be supported. Their coursework and research will be conducted entirely on the Chepkoilel Campus of Moi University and at the Moi University Fish Farm.
- Travel support will be provided for Dr. Ngugi and one MSc. student to the WAS conference in Florence, Italy, to make presentations.

Methods

- Students will be selected based on their academic qualifications and the relevance of their proposed research to the goals of the Aquaculture CRSP. Two students, Mr. James Mugo Bundi and Ms. Elizabeth Mwikalia Nyanchiri have tentatively been selected. Descriptions of their proposed research are described below.
- Students will complete coursework as required by Moi University and its Department of Fisheries and Aquatic Sciences.
- Research topics will be selected and research conducted under supervision of Drs. Charles Ngugi (Moi University) and James Bowman (Oregon State University).
- Registration and travel arrangements for student participation in "AQUA 2006," Florence, Italy, will be handled by Drs. Ngugi and Bowman.

Research Design—James Mugo Bundi

- Pond facilities: 100m^2 ponds at the Moi University Fish Farm
- Culture period: Five months or until fish are ready to spawn, whichever comes earlier
- Stocking rate(s): 4 fish per m^2, with a sex ratio of 3 males for each female
- Stocking size: Mean weight 50g
- Test species: Nile tilapia, *Oreochromis niloticus*
- Nutrient inputs: Variations on the standard fertilization regime currently recommended for static-water earthen production ponds in Kenya, which includes: Organic fertilizers applied at a rate of 500 kg/ha/week, DAP applied at a rate of 20 kg/ha/week, and UREA applied at a rate of 30 kg/ha/week.
    - Variations on this standard fertilization regime will include:

Fertilization alone
Fertilization with wheat bran
Fertilization with a formulated diet containing 25% crude protein

- Water management: Static water ponds, with outflow only as a result of rainfall and water additions only as necessary to replace evaporation and seepage. Water quality parameters will be analyzed as described by Boyd and Tucker (1992).
- Sampling schedule: Fish sampling will be monthly while water quality parameters will be done fortnightly.
- Statistical design:
    - Null hypothesis: The fecundity and energetics of tilapia (Oreochromis niloticus) brooders conditioned under different feeding regimes will not be significantly different
    - Statistical analysis: Fish condition factor and fecundity will be analysed as described by Lagler (1977) while one way ANOVA will be used to test the significance of differences among treatments.

Research Design—Elizabeth Mwikalia Nyanchiri

- Pond facilities: 100m2 ponds at the Moi University Fish Farm
- Culture period: Five months, or until fish have reached marketable size, whichever comes earlier
- Stocking rate(s): Tilapia and catfish will be stocked at three different ratios (treatments). These treatments, based on wet weight, will be in the following ratios: 2:1, 6:1, and 19:1, for tilapia and catfish respectively.
- Test species: Nile tilapia, Oreochromis niloticus and African catfish, Clarias gariepinus
- Nutrient inputs: The standard fertilization/feeding regime currently recommended for static-water earthen production ponds in Kenya:
    - Organic fertilizers applied at a rate of 500 kg/ha/week,
    - DAP applied at a rate of 20 kg/ha/week
    - UREA applied at a rate of 30 kg/ha/week
    - Supplemental feeding: feeding will be done twice a day with a formulated diet containing 32% crude protein.
- Water management: Static water ponds, with outflow only as a result of rainfall and water additions only as necessary to replace evaporation and seepage. Water quality parameters will be analyzed as described by Boyd and Tucker (1992).
- Sampling schedule: Sampling will be twice a month to monitor growth and adjust feeding rate.
- Statistical design:
    - Null hypothesis: The yields of Nile tilapia (Oreochromis niloticus) and African catfish (Clarias gariepinus) reared together in different stocking ratios will not be significantly different
    - Statistical analysis: Data on growth, survival and yield will be subjected to ANOVA using Minitab Ver. 13.0 software. Duncan's multiple range test will be used to compare differences in treatment means. Significance level will be at _ =0.05.

Regional and Global Integration

These proposed activities directly address Objective 2 in the CRSP Regional Plan for Africa (PD/A CRSP, 1997), which is "To assist in the development and conduct of aquaculture training courses and programs, with emphasis on pond operation and management." They also address the overall goals of strengthening research and extension institutions in the region and encouraging technology transfer among research and extension institutions in the region.

Schedule

- Final selection of supported graduate students will be made in March 2006.
- Students' pond research will commence in April or May, 2006, and be completed by September 2006.
- AQUA 2006 will take place May 9-13, 2006.
- Student theses will be completed by 30 April 2007.
- A final report on these activities will be submitted by June 30, 2007.

References

Boyd, C.E. and Tucker C.S. 1992. Water Quality and Pond Soils Analysis for aquaculture. Alabama Agricultural Experimental Station, Auburn University, Alabama, USA.

Lagler, K.F. 1977. Freshwater Fishery Ecology, Second Edition. WM. C. Brown Publishers, Oubuque, IOWA, USA

PD/A CRSP, 1997. Working paper on regional plans. July, 1997. Pond Dynamics/Aquaculture Collaborative Research Support Program, Oregon State University. Corvallis, Oregon, 26 pp.

Amazon Aquaculture Outreach: 5th International Aquaculture Extension Course in the Amazon Region and 1st Meeting for The Amazon Region Aquaculturists

Sustainable Development and Food Security 5 (12SDF5)/Activity/Ecuador

Investigators
Southern Illinois University at Carbondale
Christopher C. Kohler
Susan T. Kohler
William Camargo
Fundación Ecológica Arcoiris, Ecuador
Ricardo Burgos
Universidad Nacional de la Amazonia Peruana, Peru
Marina Del Aguila
Universidad Mayor de San Simón, Bolivia
Mabel Maldonado
Universidad Federal do Amazonia, Brazil
Marle Angélica Villacorta Correa
Instituto de Investigaciones IMANI, Leticia, Colombia
Santiago Duque
Peace Corps, Ecuador
Leach Kirk

Objectives
Train participants on the use of technological tools, facilitate the exchange of strategies, experiences, and learned lessons on rural aquaculture extension for the management and reproduction of native Amazon species.

Significance
Fish culture has been practiced for over three decades in the Peruvian Amazon and for over fifty years in Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, and Venezuela (the Amazon region). The countries comprising the Amazon region are linked by major river systems, particularly the drainages comprising the Amazon and Orinoco Rivers. The largest diversity of freshwater fishes in the world is contained within these drainages.

The 5th International Aquaculture Extension Course in the Amazon Region and the 1st Meeting for The Amazon Region Aquaculturists is one of the Aquaculture CRSP Work Plan 12 Amazon Basin Aquaculture Research and Outreach (12SDF1) activities that Southern Illinois University Carbondale (SIUC-USA) is currently implementing with the collaboration of Universidad de la Amazonia Peruana (UNAP, Peru), La Universidad Nacional de Colombia (UNAL, Colombia), Peace Corps Ecuador, USAID Ecuador, Arcoiris (Ecuadorian NGO), Universidade Federale Do Amazonas (UFAM-Brazil), Instituto Nacional de Pesquisas da Amazónia (INPA-Brazil), and Universidad Mayor de San Simón (Cochabamba, Bolivia). This Project has been carried out since 1 July 2004 through 31 August 2006 with the funding provided by Aquaculture CRSP/USAID.

The 5th International Aquaculture Extension Course in the Amazon Region and the 1st Meeting for The Amazon Region Aquaculturists are part of a series of events that have been successfully organized in the Amazon region by a group of institutions since 2002:

I Curso internacional de acuicultura para productores y extensionistas en la Amazonía. Iquitos (Perú). 25-30 April, 2002. Sponsors/Organizers: CRSP (USAID), IIAP, UNAP y Gobierno Regional. Participating countries: Brazil, Colombia, Ecuador and Peru (19 participants).

II Curso internacional de acuicultura para extensionistas de la Amazonía. Iquitos (Peru). 25-30 August, 2002. Sponsors/Organizers: CRSP (USAID), IIAP, UNAP y Gobierno Regional. Participating countries: Bolivia, Brazil, Colombia, Ecuador and Peru (23 participants).

III Curso internacional de acuicultura para extensionistas de la Amazonía. Pucallpa (Perú). 18-21 August, 2003. Sponsors/Organizers: CRSP (USAID), IIAP, UNAP, Gobierno Regional, Marina de Guerra Participating countries: Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela (63 participants).

I Curso Internacional de Nutrición de Peces Tropicales. Pucallpa (Perú) Agosto 22, 2003. Sponsors/Organizers: CRSP (USAID), IIAP, UNAP, Gobierno Regional, University of Arkansas. Participating countries: Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela (63 participants).

IV Curso internacional de acuicultura con especies promisorias de la Amazonía – Profesionales y Estudiantes. Leticia (Colombia) / Benjamín Constant (Brasil) 21-24 July, 2004. Sponsors/Organizers: CRSP (USAID), UNAL, Alcaldía y Gobernación, Sinchi, Acuarios Leticia, INPA, Incoder, Acuiamazonas, IDAM. Participating countries: Brazil, Colombia, Ecuador, Peru and Venezuela (57 participants).

IV Curso internacional de acuicultura con especies promisorias de la Amazonía –Productores. Leticia (Colombia), 22-24 July, 2004. Sponsors/Organizers: CRSP (USAID), UNAL, Alcaldía y Gobernación, Sinchi, Acuarios Leticia, INPA, Incoder, Acuiamazonas, IDAM. Participating countries: Brazil and Colombia (20 participants).

I Curso internacional de Cultivo de Peces Ornamentales. Leticia (Colombia), 25-27 July, 2004. Sponsors/Organizers: CRSP (USAID), UNAL, Alcaldía y Gobernación, Sinchi, Acuarios Leticia, INPA, Incoder, Acuiamazonas, IDAM. Participating countries: Brasil y Colombia (18 participants).

Southern Illinois University Carbondale (USA) will be the international coordinating institution for both events and the NGO Fundación Ecológica Arcoiris under the Sustainability Program and Regional Union (PSUR in Spanish), in Morona Santiago (Ecuador), will be the national coordinating institution. The PSUR initiative is part of the binational peace plan between Ecuador and Peru, funded by USAID. During the last 5 years Arcoiris has facilitated research and development in the aquaculture sector in the South of the Ecuadorian Amazon region.

Anticipated Benefits

The development of sustainable aquaculture will benefit many sectors throughout the Amazon region. Rural farmers will benefit from the addition of an alternative form of agriculture. Aquaculture production requires considerably less land than that needed for cattle ranching. Moreover, ponds can be used year-after-year whereas rain forest lands converted to traditional agricultural practices are rarely productive for more than a couple of seasons. Such lands, once abandoned, usually can no longer support normal jungle growth. Both rural and urban poor will benefit by the addition of a steady supply of high quality protein in the marketplace. Aquaculture of *Colossoma*, *Piaractus,* and *Arapaima* should relieve some of the fishing pressure on these overharvested, native species. The two former genera have been suggested to play a crucial ecological role in disseminating seeds from the flooded forest (Goulding 1980; Araujo-Lima and Gouling 1997). Accordingly, the aquaculture of *Colossoma* and *Piaractus* may be ecologically as well as economically and nutritionally beneficial to the inhabitants of the Peruvian Amazon. Host country consumers and fish farmers, researchers, extensionists and planners, local and foreign Latin American governmental organizations and/or NGOs and users of global CRSP-sponsored models and data will benefit from this activity. Development of a Latin American network of Amazonian species producers and researchers has begun to catalyze regional efforts to fortify the growing industry and to explore new aquaculture candidates to diversify production in this highly productive and species-rich region.

Activity Plan

Site: The 5th International Aquaculture Extension Course in the Amazon Region and 1st Meeting for The Amazon Region Aquaculturists will be held in the city of Macas, Ecuador, from 11-15 April, 2006.

Methods:
Objective 1: Train participants on the use of technological tools, facilitate the exchange of strategies, experiences, and learned lessons on rural aquaculture extension for the management and reproduction of native Amazon species.

Two intensive training courses (one for producers/indigenous communities and another for professionals/students) for a large group (100 participants) of governmental and non-governmental personnel conducting aquaculture research and/or extension activities in the Amazon Basin will be offered at The Instituto Saleciano Macas, Ecuador. This training plan will continue with the very successful program that has so far trained over 40 extensionists from Bolivia, Brazil, Colombia, Ecuador and Peru. For each course, ten qualified candidates from Ecuador's neighboring Amazon countries will be invited to participate, as well as a similar number from Ecuador. The course will be offered to train aquaculturists and experts in aquaculture related degrees in extension techniques. Techniques which have been practiced successfully by IIAP and Terra Nuova, including Aquaculture CRSP's new experiences in the region through WP 11. Extension personnel will also learn pond construction, broodstock selection and handling, spawning techniques, incubation, larviculture, grow out, disease prevention and treatment, all specifically related to native cultured species of *Colossoma sp., Piaractus sp., Arapaima sp., Prochilodus sp. and Brycon sp.* (fish), and Congompe and Churo (mollusks). To teach hormone injection, spawning, fertilization, incubation and larviculture techniques. A CD-ROM displaying all the course material for the Amazon aquaculture-training course will also be produced.

Regional and Global Integration
An objective of the Regional Plan is to maintain and expand outreach and networking activities in the Amazon region. This proposal expands on this objective by training more personnel in neighboring countries as well as enhanced training in Ecuador.

Schedule
All activities will take place from 11-15 April 2006. The final report will be submitted by July 31, 2006.

References
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Goulding, M. 1980. The Fishes and the Forest. University of California Press. London. 78 pp.

The Eagle of the North and the Condor of the South Aquaculture Exchange Project – Peru

Sustainable Development and Food Security 6 (12SDF6)/Activity/Peru

Investigators

Southern Illinois University at Carbondale
Christopher C. Kohler
Susan T. Kohler
William Camargo
Institute for the Investigation of the Peruvian Amazon
Fred Chu

Objectives

The exchange program builds the initial foundation to further build upon the following components:

- Appropriate aquaculture models and technology
- Appropriate Indigenous economic and community development pathways
- Aquaculture's role and contribution to biodiversity, sustainability, food security and community wellness
- Aquaculture and the environment and Indigenous traditional ecological knowledge
- Aquaculture information transfer and network building between the North and the South
- Organization of aquaculture
- Indigenous aquaculture and the non-indigenous world
- Aquaculture in the context of aquatic resources management
- Planning for aquaculture development
- Expanding educational and training opportunities

Significance

All Indigenous Peoples and cultures communicate with the water world. Water life has supported Indigenous Peoples for all time. Many Indigenous People recognize the turtle, whale or salmon as their crest, totem, or clan. Fish, shellfish and other aquatic life remain an integral part of Indigenous Peoples life-way and culture.

Today the water life is threatened. There are many reasons, including industrial development, urban expansion, agriculture, and colonial western forms of governmental laws and regulations. Aquaculture, the controlled cultivation of aquatic organisms, offers promise for expanding upon Indigenous Peoples' health and sustainability of the water world. Properly developed, aquaculture enhances core cultural objectives such as biodiversity, sustainability, food security and community wellness.

While Indigenous People have practiced aquaculture for thousands of years, the modern science of aquaculture is relatively recent. In North America there are about 50 active aquaculture projects being undertaken by Indigenous Peoples, primarily as projects through tribal governmental initiatives. These projects are primarily economic development oriented (providing jobs) with some traditional cultural values incorporated into aquatic rearing practices. The potential for further integration of the controlled cultivation of aquatic organisms (aquaculture) into Indigenous culture can directly address biodiversity, sustainability, food security and community wellness. Further exploration of these issues has not been pursued to any great degree in the North as well as the South. Indigenous aquaculturists work in relative isolation from each other and other non-Indigenous aquaculture-oriented organizations.

The Indian Nations component of Heifer Project International (HPI) and the Indigenous Environmental Network proposes development of a collaborative relationship with Oregon State University (OSU). This collaborative work is intended to serve as a future link to other Indigenous and non-Indigenous organizations that work with aquaculture. It is with the intent that this collaboration creates an opportunity for Indigenous individuals representing tribal

governmental projects, universities, organizations and community-based groups, to participate in an exchange training program in regards to aquaculture. Because this exchange takes place in the western hemisphere between the north and south this exchange would be called an "Exchange between the Eagle of the North and the Condor of the South." It is with hope that this training reinforces Indigenous Knowledge and the cosmovision of Indigenous Peoples.

Anticipated Benefits
The Eagle of the North and the Condor of the South aquaculture exchange program are important for a number of reasons. They are:

- Creates an initial organizational framework to evaluate aquaculture in terms of Indigenous culture and development
- Allows for balance between more economically-oriented approaches in the North and more community-based approaches in the South aquaculture
- Brings together Indigenous People from the North and South to learn from and share with each other in a comprehensive manner
- Provides an in-depth training opportunity to envision the practice of aquaculture in a manner that benefits Indigenous people and the water world.

Criteria:
The Indian Nations component of Heifer Project International (HPI) and the Indigenous Environmental Network proposes that approximately 15 participants from the Northern hemisphere travel to meet and exchange information with Southern Indigenous aquaculturists in Mexico and Peru. These participants will be selected by a committee of Indigenous Peoples and include the following minimum qualifications:

- Active work, career goals in aquatic resources management/aquaculture
- Active work, career goals in health, nutrition, community development related to fisheries/aquaculture
- Active work, career goals in Indigenous planning/development with understanding of project management

Activity Plan
Site: The project will take place in Iquitos, Peru, as well as include visits to surrounding aquaculture facilities.

Methods: The exchange activity will primarily involve informal and formal discussions as well as touring of aquaculture facilities in order to facilitate further exchange of ideas.

Regional and Global Integration
An objective of the Regional Plan is to maintain and expand outreach and networking activities in the Amazon region. This activity expands on this objective by linking indigenous peoples from the Northern and Southern Hemispheres of the Americas.

Schedule
Tentative Program:

Day 1
Arrival to Pucallpa
City Tour
Rest at the hotel

Day 2
07.00 – 09.00 h. Trip to Calleria (rural community inhabited by Shipibo-Conibo Indians)
09.15 – 10.00 h. Arrival to Calleria: Welcome words by Shipibo-Conibo leaders.
10.00 – 10.20 h. Personal introductions (all participants)
10.30 – 12.30 h. Workshop begins: North American experiences with aquaculture
12.30 – 14.00 h. Recess for Lunch

14.00 – 17.00 h. Workshop continues: Shipibo-Conibo experiences with aquaculture
17.00 – 18.30 h. Dinner
18.30 – 20.00 h. Cultural exhibitions by Shipibo-Conibo people
Stay in Calleria

Day 3
07.00 – 08.30 h. Breakfast
09.00 – 11.00 h. Workshop continues: The role of CRSP in developing sustainable aquaculture in the world. The Condor/Eagle Project
11.00 – 11.30 h. Workshop ends. Final words of CRSP, Eagles and Condor leaders
12.00 – 14.00 h. Return to Pucallpa
14.00 – 15.30 h. Lunch at Yarinacocha Lake
Time to walk and shop in Pucallpa

Day 4
07.00 – 12.00 h. Trip to Imiría Lake Station
12.00 – 14.00 h. Arrival and Lunch at Imiría
14.30 – 15.00 h. Trip to Caimito (rural community inhabited by Shipibo-Conibo Indians)
15.00 – 15.30 h. Arrival to Caimito: Welcome words by Shipibo-Conibo leaders.
15.30 – 17.30 h. Experiences exchange between Eagles group and Shipibo-Conibo people of Caimito
18.00 –18.30 h. Return to Imiría Lake Station
19.00 – 20.30 h. Dinner
Stay at Imiría Lake Station

Day 5
06.00 – 10.00 h. Visit to the Fish Cage Culture Station at Imiría Lake
10.30 – 13.30 h. Trip to Masisea
13.30 – 14.30 h. Lunch at Masisea
14.30 – 17.30 h: Visit to lakes where native fish (Colossoma and Piaractus) were stocked.
17.45 – 18.30 h. Return to Pucallpa
Stay at Pucallpa

Day 6
Return to Lima

The final report will be submitted by 31 July 2006.

Student Research to Assess Environmental Impacts of Cage Aquaculture in Tong An Bay in Fujan Province of China

Water Quality and Availability (12WQA6) / Study / China

Collaborating Institutions
Asian Institute of Technology
Yang Yi
Xiamen University (XMU), China
Yongquan Su
University of Michigan
C. Kwei Lin and James S. Diana

Objectives
1. To increase environmental awareness of MSc students;
2. To investigate the integrated cage/seaweed culture system;
3. To investigate the environmental conditions in cage culture bay;
4. To assess the potential effects of seaweed in reuse of nutrients derived from cage culture;
5. To enhance the environmental awareness of farmers and local government staff.

Significance
Cage culture is commonly practiced world wide in both freshwater and marine environments, including open ocean, estuaries, lakes, reservoirs, ponds and rivers (Beveridge 1987). Mariculture including cage culture in coastal areas of China has played relatively minor role in food production until recently. China is endowed with 32,000 km of coastline along its mainland and numerous islands, accounting for 1.3 million hectares of shallow sea and mudflat. The potential coastal habitats for aquaculture sites are estimated to occupy 170,000 ha of shallow sea, 180,000 ha of bay and gulf, and 589,000 ha of mudflat.

With the exceptions of few species, almost all marine finfish are cultured in cages which are located in sheltered bays and shallow sea. It is estimated that one million cages are used in culture of marine fish of which more than 50 species are reared in southern China. The typical cages are built with a dimension of 3 x 5 meters and 3-4 meter deep, and constructed with multifilament nylon nets and Styrofoam floats. In most cases, each farm may own a nest of cages, from a dozen to a hundred. Each cage complex is also completed with living quarters on sites to manage and guard the cages. The congregation of cage farmers forms sizable communities in many bays up- and down the coast in southern China such as Fujan and Hainan provinces. As a result of rapid expansion in cage culture in bays, water quality is reported to have deteriorated so much that fish disease outbreaks have occurred. Lack of proper sanitation facility for household wastes also poses a serious risk to public health with water born diseases, and to fish marketability as well as water quality for fish culture. As official permit and regulations for setting up cages vary with local governments, but rampant unregulated development is a common occurrence (Lin 2005).

There are several species of seaweed cultured in southern China. The species cultured in Fujan province with cooler water are members of *Porphyra, Undaria, and Gracilaria*. In bays and lagoons, seaweeds are cultured along side with fish cages to extract the nutrients derived from cage wastes (Chen 2000). However, those integrated systems, while adopted by local farmers, have never been surveyed or investigated scientifically (Lin 2005).

Anticipated Benefits
The results of this research will enhance the environmental awareness of Chinese MSc students as well as farmers and provide information directly to farmers for better management their cage culture areas based on water quality. It will also allow governmental agencies to establish policy and plans for cage culture development. It will benefit thousands of cage farmers in coastal areas in China and other countries in the region in long term.

Activity Plan

This study will be conducted by a group of MSc students at Xiamen University as their thesis work.

Location of the work: Laboratory and logistic support: Xiamen University; field site in Tong An Bay, Fujan province of China;

Study plan and methodology:

Socio-economic aspects of cage farmers will be investigated by interviewing 100 farmers using a set of designed questionnaires. A structured checklist and open-ended type of questionnaires will be designed. The questionnaires will consist of socio-economic characteristics of farmers, cage and seaweed culture practices, investment cost and return, problems and other information.

Water samples will be taken monthly at four locations (near shore, middle of cage culture area, interface between cage culture and seaweed culture areas, and just after the seaweed culture area) for analyzing total ammonia nitrogen, total nitrogen, total phosphorus, total suspended solids, total organic matter and chlorophyll *a* following standard methods (APHA et al. 1985). DO, pH, temperature, salinity and Secchi disc depth will be measured during the sampling time.

Feed and seaweed will be analyzed for its proximate composition and N & P contents.

Relevant environmental regulations will be reviewed and governmental agencies interviewed for the information about regulations, enforcement and farmers' attitudes.

A one-day workshop will be held to disseminate collected information to selected farmers and fisheries officers.

Regional Integration

As cage culture in open sea is widely practiced in Asian countries, this case study will provide an important methodology as protocols of environmental impact.

Schedule

June - December 2006. Report submission: not later than 30 June 2007.

References

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Section B: Updated Work Plans

Supplemental funding was provided for 12ATE9 to meet the project objectives provided below.

Special Sessions, Travel and Poster Awards at 2005 and 2006 World Aquaculture Conferences and Aquaculture America–2006

Applied Technology and Extension Methodology (12ATE9) / Activity / Philippines

Collaborating Institutions
University of Arizona
Kevin Fitzsimmons
Central Luzon State University
Remedios Bolivar

Objectives
1. Provide 5 pre-conference awards to deserving Aquaculture CRSP network researchers.
2. Provide 3 student poster awards.
3. TC/WAS travel and presentations by TC members.

Significance
This supplemental funding will provide support for three Technical Committee members to participate in the World Aquaculture Society meetings to be held in Florence Italy, May 9-13, 2006. The funding will also provide smaller pre-conference awards to 5 other scientists. Three awards will also be provided for student poster presenters during the WAS conference.

Schedule
End date: 30 June 2007.

The plan of work for this study was revised to reflect an additional objective (#5) that will focus on basic information and analysis of economic information comparable to what was obtained previously in Honduras.

Understanding the Aquacultural Knowledge and Information System for Commercial Tilapia Production in Nicaragua: Economics, Institutions, and Markets

Sustainable Development and Food Security (12SDF2)/Study/Nicaragua

Collaborating Institutions

Department of Agricultural Economics & Rural Sociology, Auburn University
Joseph J. Molnar
Panamerican Agriculture School, Zamorano
Daniel E. Meyer

Objectives

1. To provide a baseline perspective on the state of tilapia aquaculture in Nicaragua.
2. To describe the Aquacultural Knowledge and Information System for tilapia culture in Nicaragua.
3. To conduct case studies of functioning clusters of medium-scale commercial producers.
4. To identify the barriers and constraints to commercial aquacultural development in Nicaragua.
5. To assess the economic viability of different medium-scale tilapia production strategies in Nicaragua.

Significance

An assessment of Nicaragua's growing aquaculture sector identified tilapia as one of a series of and opportunities to strengthen exports and business investment (USDA-FAS 1995b). The Central American Free Trade Agree favors non-traditional exports such as tilapia, shrimps, oriental vegetables, fruit, melons and tobacco (USAID 2003a, 2003b). Thus tilapia is identified as focal activity for developing the Nicaraguan economy. Norwegian interests are active in marine farming in Nicaragua. A Norwegian firm is the principal shareholder in Nicanor, the largest fishery group in Nicaragua. Nicanor built a modern value-added processing company and is investing in aquaculture equipment for tilapia in 2002.

An Aquaculture Knowledge and Information System (AKIS) is a system of people and institutions that generates, transfers, and utilizes aquacultural knowledge and information (Berdegu and Escobar 2001, FAO and World Bank 2000). The AKIS for tilapia comprises the private firms, nongovernmental organizations (NGOs), and public agencies involved in the generation and modification of knowledge, and in the transmission and exchange of information, relating to aquaculture (Byerlee 2004). The system is characterized by its key subsystems: research, extension, and education. Farmers -- their needs and opportunities -- drive education, extension, and research. Farmers should, but often do not, provide direct input into design, funding, priority setting, execution, and evaluation of these key subsystems (Van den ban and Hawkins 1996).

Although the Nicaragua's AKIS may not be well articulated, the organizations, agencies, and firms working in aquaculture have different capacities and advantages, and play different roles (FAS 1995). Once these are understood, their responsibilities and objectives may be better coordinated to avoid overlap and achieve complementarities. The central actors in most developing-country AKIS are farmers' organizations, farmers, and (government) research and extension organizations (Jensen et al. 1995).

In some AKIS, organizations such as NGOs and commercial enterprises may be central to technology generation and dissemination, and in all systems such organizations are active in technology and information flow to some extent (Eponou and Peterson 1999). It is not clear how the cluster of firms, agencies, and organizations is functioning in Nicaragua or how this is

contributing to aquacultural development (Porter 2000, Schmitz 1997). Efforts to expand aquacultural development are predicated on an AKIS that can stimulate producers and respond to their information and technical needs (Clark 2003, 2004, Cash et al. 2003).

Investments in AKIS are of increasing importance to address needs of rural people and assure future food security and environmental sustainability. Nicaragua is a growing part of the global supply chain for shrimp. Tilapia may play an important role as rotational crop for the industrialized sector and as a viable enterprise for commercial producers oriented toward domestic markets (USDA-FAS 1995a). Hughes (2000) identified three broad areas with high potential for tilapia production in Nicaragua where farms and infrastructure already exist – Esteli-Matagalpa and the Central Highlands, Leon-Chinandega, and the coastal lowlands of both oceans.

In the coastal lowlands, industrialized shrimp and tilapia farms are a central aspect of the Nicaraguan AKIS. Nicaragua has the most area of land suitable for commercial shrimp farming in Central America with estimates exceeding 30,000 ha. More than 5 million pounds of farm-raised shrimp were processed in Nicaragua in 2004. There are at least four plants that process farm-raised shrimp. Some purchase from producers and others custom process under farm brand labels (USDA-FAS 1995a). As tilapia is often employed as a rotational crop for shrimp, this has important implications for the development of the infrastructure for tilapia production.

Environmental organizations are a central part of the AKIS in Nicaragua as they are important voices in the dialogue shaping the regulation of commercial aquaculture. The first species of tilapia was introduced to Nicaragua from El Salvador in 1959. Current environmental concerns focus on industrialized production of tilapia in freshwater lakes (Gutierrez 2001, Guillen 2003).[1] Nicanor SA recently opened a tilapia farm and processing plant on the shores of San Ramon, Ometepe. Effluents have threatened Lake Cocibolca and environmentalists fear that continuous growing of tilapia would cause sedimentation problems, as occurred in Lake Managua. Molina (2003) asserts that the discharge from tilapia farms would be comparable to the untreated water from a city of 83 thousand people.

Away from the lakes, tilapia farming continues to be a viable, albeit less controversial, enterprise. In Las Chinas community, a USAID tilapia culture demonstration project was initiated in response to the coffee crisis.[2] Participating families have tilapia for their own consumption and for local market sales. The farmers received financing and technical assistance in setting up the ponds and raising tilapia (USAID 2003a).
Much of the tilapia supplied to markets in Nicaragua is caught wild from lakes and reservoirs. Larger tilapia are processed as frozen fillets and either exported to the United States or sold to Nicaraguan supermarkets. Engle et al. (2001, 2003a. 2003b) conducted surveys of restaurants, supermarkets, and fish markets to show that tilapia are well known in Nicaragua. Wild-caught tilapia was sold by a majority of fish market vendors, but 26% of supermarkets and 21% of restaurants sold tilapia. Fish markets and supermarkets in Nicaragua do not appear to be viable market outlets because wholesale tilapia prices appear to be too low for farm-raised products. Neira and Engle (2001) report that rural farmers need to enter into the marketplace with appropriate products in order to obtain adequate returns on investment and sweat equity. They

[1] The aboriginal name for this lake, Cocibolca (Nicaragua) means "sweet sea". It is the largest lake in Central America and one of the very few, or perhaps the only, freshwater lake to have sharks, although their numbers have dropped precipitously. Cocibolca is one of the 40 largest lakes in the world by both surface area and volume. Its origins are both tectonic and volcanic.
[2] In the late 1990s, Brazil and Vietnam began flooding the market with cheap beans, causing a nearly 5-year-old global coffee crisis that forced scores of Central American Arabica-bean farms to shut down and destroyed the livelihoods of thousands of growers and workers. The glut sent prices plummeting on world commodities markets: Coffee selling for nearly $2 a pound wholesale in 1997 sold for less than 50 cents in 2001 and 2002. Small-scale farmers and those who produced lower-quality Arabica beans faced little or no demand for their crops. In Central America, farmers and pickers fled to cities in search of food and jobs. Over the past year, prices have recovered somewhat on the exchanges. Still, some growers struggle to make a profit and must weigh whether to abandon coffee. Tilapia is an alternative enterprise for some of these growers.

conclude that the most promising markets for small-scale tilapia farmers appear to be restaurants and supermarkets because these outlets pay higher prices for fish than vendors in open-air markets.

The challenge to tilapia farmers is to raise the size of tilapia required to produce the preferred sizes of fillets. To produce the size fillet preferred by restaurants (87 g) will require farms to produce 580 g tilapia. The even larger size of fillet preferred by supermarkets makes this outlet even more challenging. Engle and Neira (2003) found that one-fourth of supermarkets in the country sold farm-raised tilapia in spite of the substantial fishery for tilapia in Lake Nicaragua. Tilapia was not sold due to off-flavor, lack of supply, and fears of selling contaminated fish from Lake Nicaragua. Tilapia farms and processors in Nicaragua will need to guarantee and ensure a consistent supply of good-flavor, high-quality, and safe tilapia products. The AKIS must work in a coherent way to achieve these objectives in the tilapia industry.

Economic Viability and Estimated Profitability

The profitability of the two markets for tilapia products will bes assessed with the information provided by producers and restaurant managers acquired during the course of the investigation. It is anticipated that different combinations of inputs and practices such as water exchange, feeding system, and stocking rate indicate that producers implement two levels of management in their aquaculture enterprises: semi-intensive and intensive management. The additional analysis will compare the parameters used in the cluster to identify each management level. Preliminary information suggests that the market for fresh tilapia is based on estimated production cost per kilogram of live-weight in the semi-intensive level of around US$1.02 and US$1.82 for the intensive management level. The estimated profit per kilogram of fresh tilapia produced for each management level for pond-bank sales would be US$ 1.38 or 135% margin for the semi-intensive, and $ 0.58 (31% margin) for the intensive management. These estimates will be confirmed and clarified in interviews with producers and others knowledgeable about the costs of production in Nicaragua.

In the market for prepared tilapia the estimated costs in Honduras were $ 1.81 per prepared meal. We will seek to verify the parallel costs in Nicaragua. Similarly, the fresh fish cost an average of US$1.09 with other accompanying food items, and labor (estimated at $ 0.72/meal) in Honduras. On average prepared tilapia in Olancho, Honduras restaurants had a sales price of $ 3.03 per meal. The estimated net profit is $ 1.22 (67%) per meal served. This basic information about market prices and production costs will complement the broader information about institutional processes for research, technical assistance, and industrial organization among tilapia producers in Nicaragua.

Anticipated Benefits

Direct target groups of the study will be:

- The baseline assessment will provide an overview of the production capacity, infrastructure, and location of tilapia production in Nicaragua.
- The AKIS in Nicaragua will benefit from a comprehensive assessment of the information and market resources available for tilapia growing in that nation.
- A minimum of 50 producers (men and women) will directly benefit from the farmer meetings and training that will take place in conjunction with the study. These fish farmers will be informed of the results of the study and receive our recommendations as to how to improve their production protocols/techniques and the quality of the fish they market.

Indirect target groups will be:

- Approximately 2000 small-scale tilapia farmers will benefit by having better technical services available through training programs made available to NGOs.
- The study will provide an opportunity for a graduate student to learn about the situation of local fish farmers and disseminate this information to other students at this institution and at technical meetings in Central America.
- The study will enhance institutional understanding of the status of tilapia culture and the AKIS in Nicaragua, as well in two specific locales where medium-scale tilapia culture is progressing or has a high potential to progress.

- Information and materials derived from this study will be useful for aquaculture development activities in other countries of Central and South America.

Research Design

Site: The fieldwork for this activity will involve multiple sources of information and perspective. The study is based on a series of interviews with public-sector decision-makers, representatives of fish culture organizations, ecological organizations, and nine discussion groups, each with a different profile in different areas where tilapia culture is expanding or has high potential to expand. The farmers are chosen on the basis of various criteria, primarily the size of their operation, age, expectations with regard to succession, and intensity of tilapia culture practices. These socio-economic and structural factors are emphasized in the literature as affecting implementation of aquaculture policies and support services.

Methods: The proposed plan includes the following sequence of tasks:
Baseline perspective: We will seek documents and recent surveys of the aquaculture sector from knowledgeable individuals in Nicaraguan public agencies and private organizations. A synthesis of this information will be presented as an extended section or chapter in the project report. Additional information will emerge from the individual and group interviews.

Identification of study locales: Information will be obtained about national statistical sources about the regional distribution of tilapia farming and production. Based on interviews with industry leaders and responsible officials in aquaculture planning and management, two locales will be identified for more intensive study and the conduct of focused group interviews with tilapia producers. The Esteli-Matagalpa and the Central Highlands, Leon-Chinandega, and the coastal lowlands of both oceans have been noted as areas of high potential (Hughes 2000).

Conduct of Individual and Group Interviews: The design of this study follows the data triangulation research strategy described by Yin (1989). Key informant interviews will follow a positional and network sampling approach to conduct open-ended conversations with knowledgeable officials from public agencies, NGOs, and industry groups. In each locale, three sets of producer discussion groups of 8-12 participants will address marketing, production, and seed supply issues.

One set of discussion groups will be with established commercial tilapia farmers; a second group is with young farmers with recent experience in tilapia culture; and a third group is comprised of small producers with experience in tilapia culture primarily for home consumption or marketing at the village level. The discussion groups will address strengths, weakness, opportunities, and threats to tilapia production with each category of farmers. Thus, the case study results will summarize primary data from six focus groups and 12-18 interviews with knowledgeable individuals on the national, regional, and local levels.

Analysis: An Auburn University graduate student and a Nicaraguan graduate student will conduct the focus group interviews and collaboratively summarize the comments and insights expressed by participating tilapia producers. The report of this research is termed a descriptive case study, that is it will primarily describe what is happening and why, to show what the situation for tilapia culture in Nicaragua is like. The results may be especially useful to help interpret other data that may be available in subsequent research, such as survey data. The portrayal of the country situation as an AKIS also may be useful for project planners and government officials who can design research and extension programs in ways that more effectively utilize the organizational and institutional resources working in tilapia culture.

Regional and Global Integration

We plan a formal integration of this activity with the overall region. The work will be jointly conducted by Zamorano personnel (faculty, staff and students). In-country personnel (Suyapa Triminio) will assist in organizing training sessions in selected Central American Countries. Much progress has been made with the development of Web-based materials. Personnel at

Zamorano have developed excellent interest and capability in serving as a web host. A cornerstone of our activity will build on experiences learned as we conclude the present work plan with training exercises in Guatemala, El Salvador, and Nicaragua.
A Spanish-language leaflet will make the central findings of the study available to the Nicaraguan AKIS.

Schedule

- Desk study and review of the literature will take place during the first 6 months of the project
- The intervening period will be devoted to fieldwork and analysis of the data.
- The last six months of the project will be devoted to completion of the dissertation, and preparation and submission of the final report and summary leaflet in June of 2006. We will endeavor to publish results in periodicals read by producers in Nicaragua, as well as serials read by scientists and instructors.
- The survey and study of fingerling producers and inventory of NGOs will be realized during the period August of 2005 until November 2005. Analysis and reporting will be completed by June of 2006.

Report Submission:
As was done for the previous work plan, Quarterly progress reports will be submitted and a final report will be submitted at the end of the second year (June 2006). A report, spanning the two years of this activity is planned to be submitted to the PD/A CRSP by June 30, 2006.

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