POND DYNAMICS/AQUACULTURE
COLLABORATIVE RESEARCH SUPPORT PROGRAM

ADDENDUM TO THE NINTH WORK PLAN

Printed Fall 2000

The *Ninth Work Plan*, published in Spring 1999, described a standardized set of experiments to be undertaken by the Pond Dynamics/Aquaculture Collaborative Research Support Program beginning between 1 August 1998 and 1 May 1999. This addendum contains official changes relating to schedules and/or methods to the work plans as described in the *Ninth Work Plan*. Program activities are funded in part by Grant No. LAG-G-00-96-90015-00 from the United States Agency for International Development (USAID), Global Bureau, Office for Agriculture and Food Security. The authors' opinions expressed herein do not necessarily reflect the views of USAID.

Pond Dynamics/Aquaculture CRSP
Oregon State University
418 Snell Hall
Corvallis, Oregon 97331-1643 USA

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INTRODUCTION

The goal of the CRSPs current five-year USAID grant, the *Continuation Plan 1996–2001*, is to provide a basis for improving the sustainability of aquaculture production systems. This approach uses two building blocks to identify research priorities: research in production systems; and capacity building via research support. Research in production systems is organized into three research areas (Production Optimization, Environmental Effects, and Social and Economic Aspects), which are further subdivided into specific research themes.

The Ninth Work Plan of the Pond Dynamics / Aquaculture CRSP describes activities to be conducted by the CRSP beginning between 1 August 1998 and 1 May 1999, to be finished by 30 April 2001. Previous activities under this grant are described in the Eighth Work Plan, which covered the period from 1 August 1996 to 31 July 1998. Work under the Ninth Work Plan will be implemented at the following research sites: Mexico, Honduras, Peru, Kenya, the Philippines, Thailand, and the US.

Work in Honduras was interrupted at the conclusion of the Eighth Work Plan, and a request for proposals was issued to identify a new lead institution for the Honduras work. The University of Georgia was selected as the new lead institution for the Honduras project, with Auburn University as a collaborating US institution. The Honduran counterpart institution is the Escuela Agrícola Panamericana El Zamorano.

Five new work plans for work to be undertaken as part of the new Honduras Project appear here for the first time. Also appearing here for the first time are four additional work plans, study codes 9RCR8, 9NS4, 9ER4, and 9HCD4. 9RCR8, which was approved in order to increase host country participation, and 9NS4 were approved after funds were made available when other Ninth Work Plan awards were declined. 9ER4 replaces the discontinued Education Development Component Eighth Work Plan activity HCD1B, “Create a CRSP Fellowship Program to Provide Appropriate Support for Graduate-Level Students.” 9HCD4 replaces the Ninth Work Plan activity 9HCD2, “Building Research Capacity in CRSP Host Countries.” The award for 9HCD2 was declined; thus, the responsibility for funding a Philippine graduate student (the objective of 9HCD2) was moved to the Philippines Project and subsequently funded as 9HCD4. These new work plans comprise Section A of the following report; Section B contains revised experimental designs, and Section C contains revised schedules.

Two projects were offered but declined funding for proposals submitted for consideration under the Ninth Work Plan Request for Proposals. The work plans for these investigations were printed in the *Ninth Work Plan.* One is the Education Development Component, the Philippines component of which has been taken up by the lead Philippines Project. The other is the Aquaculture Systems Modeling Research project previously carried out at the University of California, Davis. One Reproduction Control project (9RCR6) was funded but later modified to restrict the scope of research, and another reproduction control project (9RCR7) was cancelled due to a lack of success with the induction protocol. These modifications are documented in Section D.

There is no longer a procedure for requesting approval of work plan changes from the Technical Committee (TC) and Program Management Office (PMO). Instead, researchers will provide notice of work plan changes by completing a form developed by the Technical Progress Subcommittee (TPS) of the TC to be submitted to the PMO along with other annual reporting elements. The information collected on the form will serve the TPS, the External Evaluation Panel, and others in evaluating progress on Ninth Work Plan projects. Project Leaders are still advised to contact the Management Entity if changes cause the research to differ significantly from that in the original approved work plan. Subsequent addenda, if any, will be published annually.

SECTION A: NEW WORK PLANS

EFFLUENTS AND POLLUTION

Collaborating Institution
Auburn University
Claude Boyd
Oscar Zelaya

Effects of Water Recirculation on Bottom Soil and Water Quality in Aquaculture Ponds

Effluents and Pollution Research 4 (9ER4) / Study

Note: This work plan replaces the discontinued Education Development Component Eighth Work Plan activity HCD1B, "Create a CRSP Fellowship Program to Provide Appropriate Support for Graduate-Level Students." It appears here for the first time.

Objective
To measure changes in physical and chemical characteristics of pond water and soils in response to varying density of production and in the presence or absence of water recirculation.

Significance
Nutrient enrichment of pond waters is an essential management practice in aquaculture. However, the discharge of pond effluents may result in deterioration of the receiving waters. There is considerable interest in reducing the negative environmental impacts of aquaculture in Honduras. One of the most promising methods for reducing the environmental effects of pond aquaculture is to use water-recirculating systems to minimize the discharge of effluents.

Anticipated Benefits
This research will demonstrate if water recirculation may be used to prevent the use of water exchange and release of pond effluents during high-density pond culture of aquaculture species. The findings will allow a discussion of the feasibility of using water recirculation to minimize the discharge of pond effluents in aquaculture in Honduras, and the environmental implications of aquaculture with or without recirculation in Honduras. The findings will be of great benefit to those seeking ways of promoting environmentally responsible aquaculture in Honduras and other nations.

This research will also contribute to a better understanding of pond dynamics. As an investigation that makes up the thesis project of a CRSP-sponsored host country graduate student, this research will provide an environment for learning research techniques, sampling methods, and analytical protocol that will be very useful to the student and to his country.

Identification of Beneficiaries
Aquaculturists throughout Central America, the US, and other countries that experience water quality problems related to the discharge of aquaculture effluents.

Study Design
Site: Research ponds at the Claude Peteet Mariculture Center, Gulf Shores, Alabama.

Pond Facilities: 12 ponds, each with a surface area of 1000 m^2 and an average depth of 1.2 m. The ponds have plastic liners covered with a 15-cm layer of soil.

Culture Period: 21 weeks (7 May–30 September 1999).

Culture Species: *Penaeus vannamei.*

Stocking Rate: High-density ponds will be stocked at 50 postlarvae (PL) m^{-2}; low-density ponds at 25 PL m^{-2}.

Water Management: Ponds without water circulation will be filled and water added only to replace losses to evaporation. In recirculation ponds, water will be pumped from culture ponds to treatment ponds and then pumped back to the culture ponds. Water retention time in treatment ponds will be one week, and culture and treatment ponds have equal volume.

Other Inputs: A 35% protein pelleted feed will be purchased from Burris Feed Mill, Slidell, Louisiana. The feeding rates will increase as shrimp biomass increases according to a standard feeding table. Feeding trays will be used to prevent overfeeding.

Treatments (with three replications each) as follows:
High-density production with water recirculation
High-density production without water recirculation
Low-density production without water recirculation

Note: In the water recirculation treatment, three unstocked ponds of the same size as the production ponds will be used as water treatment reservoirs for the recirculation system.

Sampling Plan: Water samples representing the surface 80-cm stratum will be taken weekly throughout the culture period with a water column sampler. Water analysis will be done the day after samples are taken for the following parameters: soluble reactive phosphorus, total phosphorus, total nitrogen, nitrites, nitrates, and total suspended solids. At least twice a month, fresh samples will be collected for biochemical oxygen demand and chlorophyll *a* analysis.

Soil samples will be collected from 12 places in each pond before stocking and before harvesting. For each soil sampling, three consecutive levels from the surface are considered: the first 2.5 cm, the second 2.5 cm, and the level from 5 to 10 cm. The soil samples will be dried and stored. They will be analyzed between December 1999 and June 2000. The parameters for the soil analyses include pH, carbon, nitrogen, and sulfur. Soil respiration analysis will be run for the samples taken from the first 2.5-cm layer.

Statistical Methods and Hypotheses: Analysis of variance techniques will be used to determine if differences exist among treatments with respect to soil and water quality variables.

The null hypotheses are as follows: Water and bottom soil quality will not differ between high-density ponds with and without water circulation; water and bottom soil quality will not differ between low- and high-density ponds with or without water circulation; and water and bottom soils quality will not differ between high-density ponds with water recirculation and low-density ponds without recirculation.

Schedule

Soil and water sampling:	23 April to 30 September 1999
Laboratory analyses:	24 April 1999 to 30 June 2000
Data analysis:	June 1999 to June 2000

Report Submission

Progress report due:	31 July 2000
Final deliverable (thesis) due:	30 March 2001

Honduras Research

Collaborating Institutions
Escuela Agrícola Panamericana El Zamorano
Dan Meyer
Freddy Arias

University of Georgia—Lead US Institution
Brahm Verma
E. William Tollner

Auburn University
Joseph J. Molnar
Tom Popma
Robert Nelson

Cooperating Institution
Centro Internacional de Agricultura Tropical (CIAT)
E. Bronson (Ron) Knapp

Linkages of Aquaculture within Watersheds and Concurrent Design of Hillside Ponds

Appropriate Technology Research 2 (9ATR2) / Activity

Objectives

1) To elicit farmers' and change agents' perspectives about the role of aquaculture within hillside watersheds;
2) To identify design criteria (needs and constraints) for hillside ponds in participation with end users; and
3) To develop alternative pond designs suited to local conditions.

Significance

The hillsides of Latin America cover about 1 million km^2 and provide livelihood for some 20 million people, among whom roughly half are classified as "poor" and live in marginalized, rural communities (Knapp et al., 1997). Principal Central American countries (followed by % area in steep-slope agriculture) are: Honduras and Nicaragua (80%), Costa Rica (70%), and El Salvador and Guatemala (75%) (CIAT, 1996). Typically, the hilly landscape is very heterogeneous and made up of small plots. About half of the hillsides ecosystem in Latin America is progressively deteriorating due to the combined effects of deforestation, overgrazing, destructive tillage techniques, improper water management, and unfavorable socioeconomic conditions (Whiteford and Ferguson, 1991; Knapp et al., 1997). This has serious implications for agroecological sustainability.

Together with other watershed management initiatives (e.g., soil conservation measures, agroforestry), pond aquaculture can play an important role in stabilizing these ecosystems (Scherr and Yadav, 1997) as testified by Asian experiences (e.g., Nepal, the Philippines). Fishponds also serve multiple roles including water conservation, income generation and food production. However, hillside ponds are rare in Central America apparently because of high costs associated with mechanized earth moving and / or high labor needs for hand construction, and lack of knowledge of alternate designs suited to local conditions. Further, research by both Zamorano (Lee, 1997) and CIAT (1997) suggests that poor understanding of biophysical (landscape) and socio-economic (lifescape) linkages among farmers in hillside watersheds impedes more sustainable use of land / water resources in Honduras.

In this activity, tools that have been developed by UGA, Zamorano, CIAT, and the SANREM CRSP (Bellows et al., 1995) will be used in a participatory setting with farmers to elicit their perspectives on linkages between pond aquaculture operations and watersheds. We believe that this will lead to an increased understanding (among farmer groups and technical assistance personnel) about how natural resources within watersheds can be exploited in a more sustainable fashion. Additionally, we will use concurrent (implying a participatory process) engineering design principles (Veland, 1992) to identify the needs of fish farmers ("customers") interested in hillside aquaculture, their socio-economic and environmental constraints, and the level of technologies available to construct ponds. These criteria will then be used to develop alternate designs (which address farmer needs and constraints) that can be used for pond construction.

Anticipated Benefits

Expected benefits include an improved understanding of biophysical and socio-economic linkages between aquaculture and the associated watersheds, which has implications for sustainable resource management. The work will also help to document perspectives of farmer communities with regard to the role of aquaculture in the agroecosystem(s), which may provide insights into better ways of introducing technology. An indirect benefit is the training (with elements of natural resource planning, social perspectives of resource use, and agricultural-aquacultural interactions) that will be imparted to CIAT and Zamorano staff. The lack of such interdisciplinary training has been identified as a major weakness of the National Agricultural Research System (NARS) in Honduras (Contreras, 1992).

Assessment of design criteria with concurrent farmer inputs is a critical element of developing pond design plans suitable to hillsides. It is expected that this participatory process itself will be beneficial to personnel (e.g., technicians and students) from Zamorano. Further, application of engineering principles for assessment of soil / terrain characteristics and water availability in the hillsides will likely lead to more robust pond designs, which in turn has broad applications in Honduras and other parts of Central America.

Activity Plan

Location of Work: The field work for this activity will occur in a representative hillside micro-watershed in the Comayagua department of Honduras. A major portion of the work will, however, be undertaken at Zamorano and at UGA campuses where additional facilities and expertise is available.

Methods: The proposed plan includes the following sequence of tasks:

Identification of a Representative Micro-Watershed: The first task will be to identify a micro-watershed that typifies hillside regions and has existing fish farmers, including operators who use land and water resources for a range of agriculture-related activities. It would also be useful to determine if some of the existing farmers plan to build additional ponds because participation is likely to be enhanced by a merging of research and farmer interests. Watershed identification will be done by a team of UGA, Zamorano, and CIAT personnel.

Identification and Documentation of Linkages: As indicated earlier, existing tools will be used in a participatory manner to identify watershed linkages. Examples of these tools include the Participatory Landscape / Lifescape Appraisal (PLLA) tool developed by the SANREM CRSP (Bellows et al., 1995) and an interactive (physical) game based on the commercial product Jenga® (Lee, 1997). These tools are somewhat complementary in that the PLLA approach consists of formally identifying linkages together with small groups of people, documenting them, and then discussing implications of the linkages. The Jenga-based game involves building a tower of wooden blocks (colored green, brown and blue to represent forests, soils, and water respectively in a watershed configuration), and then asking individuals / groups to develop resource extraction strategies. Various outcomes (collapse of the towers indicating catastrophic events such as impacts of hurricanes / earthquakes, stable but less productive systems, and productive but less stable systems) are possible, after which discussions take place to understand implications and connectivity among resource users in watersheds. We have modified Lee's (1997) game and have successfully used it in a multiple stakeholder workshop recently held in collaboration with CIAT at Managua, Nicaragua. Documentation for this game (in Spanish) is available in Nath et al. (1999). Experiences gained with these tools specifically with regard to their implications for future aquaculture development will be documented both in Spanish and English.

Development of the Design Team: The working team for the pond design work will be assembled from UGA, Auburn and Zamorano PIs, students from Zamorano, interested farmers, extension agents / NGOs, and local leaders.

Identification of Design Criteria: The working team will identify critical design elements including socio-economic constraints (land size, resource / labor availability, etc.), environmental limitations (soil quality, slopes, water availability, etc.) and economic profitability. Using this initial assessment, a range of design concepts will be generated by the working team within the limitations that have been identified. Design criteria will be further refined using GIS (Geographical Information Systems) and modeling software (see below).

Analysis and Modeling: This task will involve use of data and analysis tools to further assess the design criteria and identify suitable pond locations in the possible areas. In terms of spatial datasets, CIAT has developed a detailed atlas for Honduras, which includes the latest datasets including an updated soils map as well as a digital terrain model (DTM) at the 50 m resolution level. These datasets together with climatic data provide a useful foundation for the modeling work.[1]

Design of pond structures depends highly on local topography and soils characteristics. Calculations will be made for embankment stability based on soil characteristics. Using bracketed values of storage requirement and given topography, modeling tools will be used to bracket embankment volumes needed to create hypothetical storage requirements. Efficacy of the pond designs for the intended uses will be evaluated by considering the resulting depths and other geometrical characteristics, storage volume and useful life from sedimentation considerations.

Documentation and Delivery of Pond Designs: The pond designs developed will be documented and discussed with farmers during a follow-up trip to Honduras (with the same working team). Ideally, we would like to have one or more farmers invest in pond implementation using the proposed designs - however, this will depend on their interest and motivation to do so. In collaboration with Zamorano and other institutions, we will also pursue the possibility of seeking resources to build one or more ponds provided all parties are agreeable. The rationale behind this thinking is that we believe it is unsustainable for the PD / A CRSP to fund activities such as pond construction - once the program leaves, it is less likely that additional ponds will be constructed. Instead, farmers should be encouraged to either invest in the construction or seek in-country resources to do so. Further, if the CRSP were to fund pond construction, it is likely that no more than a couple of ponds would be constructed; we would then be faced with the sensitive task of choosing from among different farmers.

Regional Integration

We do not plan a formal integration of this activity with the overall region. However, the work will be jointly conducted by Zamorano personnel (faculty, staff, and students). An indirect regional link is likely to occur if one or more of the participating students are from other Central American countries.

Schedule

Work will commence by October 1999. Initial tasks (identification of watersheds, documentation of linkages, and development of design criteria) will be completed by December 2000. The remaining tasks will be completed by April 2001.

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1 A hydrological model (Joep Luitjen, University of Florida, personal communication) developed specifically for small Latin American hillsides is also available for use in this activity. Other modeling tools for locating ponds and assessing water availability over long-term periods are also available in the US. These tools will help pinpoint suitable locations for ponds, and determine if adequate water is available for aquaculture. CAD (computer aided design) tools will be used to develop actual design blueprints for ponds within the criteria imposed by the requirements and constraints of hillside farmers. Computer tools are also available to assess the structural integrity of “virtual” models of ponds in response to different operating conditions. Tools that may be used include RUSLE®, an implementation of the USDA-ARS Revised Universal Soil Loss Equation; SEDCAD®, a watershed scale surface hydrology and sedimentology single storm simulation model; CREAMS, a USDA surface hydrology multiple storm simulation model capable of running over an entire year; and Finite Element Analysis to evaluate structural integrity of the designs. These packages require numerous inputs regarding weather, land use practices and soils data, all of which are available are available in CIATs GIS atlas for Honduras.

Report Submission

Two reports, spanning the two years of this activity, are planned. These will be respectively submitted to the PD/A CRSP by 31 July 2000 and 30 April 2001.

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Decision Support for Policy Development: Planning Conferences for Collaborating Researchers, Public Agencies, and Nongovernmental Organizations Working in Aquaculture

Adoption / Diffusion Research 7 (9ADR7) / Activity

Objective

To foster linkages among national and regional organizations—including nongovernmental organizations (NGOs), national agricultural research institutions, other CRSPs, and international agricultural research centers—toward the common purpose of post–PD / A CRSP aquacultural development.

Significance

The "Red Nacional de Acuicultura" (National Aquaculture Network) was created by the Food and Agriculture Organization (FAO) in 1992 to integrate international institutions and the private and public sector of Honduras. Among the participants were: Dirección General de Pesca y Acuicultura (DIGEPESCA), Universidad Nacional Autónoma de Honduras (UNAH), Escuela Agrícola Panamericana El Zamorano, Escuela Nacional de Agricultura (ENA), Agricultural School John F. Kennedy, Peace Corp Honduras, Federación de Productores y Exportadores (FPX), Asociación de Acuicultores de Honduras (ANDAH), and Instituto Nacional de Agricultura (INA).

In place for about a year, FAO organized the network with the intention of eventually withdrawing in favor of Honduran management. Unfortunately, leadership problems caused most organizations to suspend participation and FAO moved on. Zamorano is now in a position to reactivate this network as a hub for information exchange, research activity, and policy leadership.

What is needed is a series of events that will reawaken the dialogue and focus attention on a strategic vision for aquaculture development in Honduras and on the problems and possibilities of small- and medium-scale tilapia aquaculture (Kaimowitz, 1991). We propose to accomplish this not only through a series of planning conferences, but also through the collaboration and exchanges that such meetings will be designed to stimulate.

The agricultural sector in Honduras is currently being modernized under a World Bank–supported project (1998–2002). However, discussions are still ongoing as to the mechanisms of modernization and decentralization. At the present time, in part because aquaculture is handled under the Ministry of Natural Resources (DIGEPESCA), aquacultural sector development is not being concurrently pursued. We believe that there is a unique opportunity to pursue capacity building and institutional strengthening for aquaculture through the networks that have been established by our collaborators—CIAT—and Zamorano. Further, given the resources that are being put into place by various donor agencies (including USAID) following Hurricane Mitch, the proposed work is a strategic intervention that can potentially put aquaculture at the forefront of natural resource–based activities in the country.

Policy development work is a fairly long-term activity, and actual policies might not be put into place at the end of the two-year project for which resources are being requested from the PD / A CRSP. However, the major contribution of the proposed work is not to actually develop policies (the specifics of these must evolve from the stakeholders themselves), but to foster the development of an enabling environment within which plans that address social, environmental, and economic concerns can be developed in a participatory manner, and within which expertise and information is shared. Discussions with donor agencies (e.g., FAO and the World Bank) suggest that resources may be made available for aquacultural sector development, provided the initiatives and specific plans are developed by Honduran institutions. For instance, the FAO has indicated an interest in supporting sustainable shrimp culture in the Gulf of Fonseca, which borders Honduras, Nicaragua, and El Salvador.

The concept of an enabling environment has been identified as a key prerequisite for sustainable aquacultural development (Shehadeh and Pedini, 1997). Experiences in natural resource management initiatives for the hillside regions of Latin America (CIAT, 1997) suggest that creating partnerships among stakeholders involved in managing and / or using natural resources is part of the process of fostering an enabling environment; the other aspect is to adopt an integrated decision-making framework for use in such environments (Nath et al., 1999a). The latter framework (referred to as concurrent decision-making) has been applied in workshop settings for natural resource management initiatives in Central America (Honduras, Nicaragua) and similar work is planned for South America (Colombia, Ecuador). With the exception of Ecuador (where the work is in collaboration with the SANREM CRSP), these initiatives are being pursued with CIAT.

A number of nongovernmental organizations have had an enduring focus on rural communities in Honduras. Donor coordination to support new farmers and existing fish culture practitioners is vital. Pluralistic ignorance—mutual unawareness of one another's actions and intentions—is a common condition among organizations in a developing country. Nonetheless, this is not an acceptable rationale for the lack of communication and joint action among projects and agencies in Honduras. Donors must work together jointly to complement and extend the activities of the government.

Donor support will be particularly important for sustaining the promise of fish culture among the mid-sized and subsistence sector in Honduras. Tilapia has a role in integrated, small-scale, mountain farming systems where fish ponds may be an appropriate farm enterprise for a segment of small holders with a water source, manure supply, and some management ability. The USAID Hillside project has targeted this segment of poor, small farms. Activities focused on hillside agriculture could incorporate fish culture as one enterprise in an array of alternatives available to farmers.[1]

Anticipated Benefits

The creation of an enabling environment within which stakeholders can interact in a participatory manner would provide a sound foundation for developing policies and plans for aquaculture development. Previous experience (e.g., CIATs networks in Central America) suggests that very productive and long-term partnerships can be developed among personnel within such environments. Other benefits include training opportunities for Zamorano staff and other institutions in the concurrent decision-making process, thereby building capacities in these institutions.

This activity is intended to integrate the activities and leadership of Zamorano into the matrix of organizations and agencies working in aquacultural development. There is a clear need to articulate a strategic, multidisciplinary, and cohesive approach to aquaculture development, research, and outreach in Honduras and the Central American region.

Identification of Beneficiaries

Public and private organizations working in the tilapia industry are the primary targets of this activity with the ultimate objective of improving support for producers in Honduras.

Collaborative Arrangements

The three institutions will work together to foster productive relationships among tilapia researchers, instructors, and technical assistance providers throughout the country, and to the rest of Central America where appropriate and feasible. We will link to FAO and other international organizations working in aquacultural development in Central America.

Activity Plan

We will conduct a series of three meetings with expanding levels of participation. These meetings will be organized to coordinate project activities and to involve other institutions in the PD/A CRSP program. An established literature on extension programs and methods will be used to guide outreach efforts (Albrecht et al., 1990a, 1990b; Engle and Stone, 1989). Expected participants include representatives of farmer organizations, collaborating researchers, NGOs working in aquaculture, and officials from international organizations.

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[1] El Centro Internacional de Agricultura Tropical (CIAT) is conducting various projects in Central America focusing on participation and conservation of natural resources. Specifically, "Proyecto CIAT-Laderas (CIATHILL)" is undertaking a series of investigations at three scales; regional (Centro América); national (Honduras and Nicaragua); and in specific sites at different elevations in Honduras and Nicaragua. The work sites are in the departments of Atlantida, Yoro, and El Paraiso in Honduras, and in the department of Matagalpa (San Dionisio) in Nicaragua. <www.intertel.hn/org/ciathill/SITIOS/Sitios.htm>

The first task will be to identify and interact on an individual level with the primary actors involved with development of the aquaculture sector. Through the PD/A CRSP, Zamorano, and CIAT networks, some actors are well known (e.g., DIGEPESCA, Ministry of Agriculture, ANDAH, the World Bank, USAID/Honduras, FAO, CIDA). However, others including local community representatives, women's groups, and NGOs will have to be contacted and informed of our interest in pursuing development of the aquaculture sector. It should be noted that interactions with producers will occur throughout the course of the project through the systematic investigation described in 9ADR8, "Production strategies characterizing small- and medium-scale tilapia farms: Approaches, barriers, and needs," as well as through the farmer meetings and informal interaction that will occur in connection with the other studies following Chambers et al. (1983) and Kaimowitz (1991).

- Meeting 1 will be held at the beginning of year 1 of the project at El Zamorano for two days. The first meeting will take place at inception of the project to bring the collaborating researchers into interaction over the objectives and timetables of this project. This meeting will feature a tour of Zamorano facilities and extended discussion over the problems and possibilities of the project as it bears on the management of El Carao, fingerling production, the provision of technical assistance to producers, and policy development activities. UGA, AU, and Zamorano researchers and technical staff will be the primary participants. This meeting may be held as a pre-conference event to the Latin American Aquaculture Conference at San Pedro Sula.

- Meeting 2 will be held in the middle of year 1 in Tegucigalpa and will feature a review of the prospects, potentials, and problems facing tilapia production in Honduras with a focus on the services and supporting activities necessary to ensure the viability of the industry. A comprehensive three-day workshop will follow, in which the concurrent decision-making approach and supportive tools will be used. The approach involves development of a group vision, detailed analysis of stakeholder roles, development of individual and group goals, identification of assessable indicators, identification of influences impeding attainment of goals, development and evaluation of decision alternatives, selection of suitable alternatives, and examination of sequencing activities to be pursued (Nath et al., 1999a). Researchers, technical staff, and extension leaders will be the primary participants, along with representatives of DIGEPESCA and other public/private organizations working in aquaculture.

Decision support tools that we have used in such workshops included automated (computerized) templates to record stakeholder perspectives, sharing of these perspectives through intelligent tools that interpret these perspectives and classify them according to those unique to individuals and those that are common to all stakeholders, tools for conflict resolution (Nute et al., 1999), and model/GIS outputs (e.g., maps of land use, production potential). These tools are being developed at the University of Georgia as part of a grant from CIAT. Further, manuals for facilitators and participants (in both English and Spanish) are being developed (Nath et al., 1999b). In other words, we will leverage work on that grant for the PD/A CRSP activity. Our experience has been that these workshops should be kept to a small number of participants (fewer than 20), should involve mini-groups (of about five people) with planned and spontaneous feedback sessions, and must be facilitated by a team consisting of a lead facilitator, together with personnel trained in the process.[2]

- Meeting 3 will be held at the end of year 2 in San Pedro Sula for two days. It will feature a dialogue over the progress of tilapia culture in Honduras with the objective of identifying practical matters that impede progress of the industry. This will be a widely publicized symposium that will draw together all sectors of the tilapia industry in Honduras. It also should be of interest to the broader community of public and private organizations working in aquacultural development in Central America.[3] This symposium should provide a capstone perspective on the prospects and possibilities

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[2] The lead and supporting facilitators will be identified after consultations with various Zamorano personnel in Honduras. It will be necessary to train the identified personnel in the concurrent decision-making process and associated facilitation skills prior to the actual workshop. We have already undertaken such training activities in Honduras and Nicaragua in association with CIAT.

[3] Escuela Nacional Agrícola (ENA) is located in the town of Catacamas, department of Olancho. Managed by the Ministry of Natural Resources (Ministerio de Recursos Naturales) as a semi-autonomous institution that offers a three-year Agronomy degree. ENA fish culture facility has 26 ponds that are used for education, training, and to

for aquacultural development focusing on the experiences and achievements of the Honduran industry.

Regional Integration

The proposed work is complementary to UGAs other activities in Nicaragua and Honduras, and is expected to strengthen them. In our discussions with Nicaraguan counterparts (via CIATs network), we will inform them about initiatives being pursued in Honduras and stimulate interest in pursuing similar ones in their country. If resources permit, we will also engage one or more Nicaraguans who will be trained in concurrent decision-making (May 1999) to apply their skills in the aquaculture context. Such personnel can potentially serve as lead facilitators in Nicaragua should an occasion arise there. The symposium will be advertised in other Central American countries (Costa Rica, El Salvador, Guatemala, Nicaragua, and Panama) thereby providing opportunity for a wider impact. Zamorano is expected to benefit from such activities in terms of experience gained, training opportunities, and increased exposure as the lead institution for aquaculture in Honduras.

Identification of Deliverables

The deliverables for this activity will be the minutes of each planned meeting. In addition, a detailed report will also be developed for the second conference. Finally, proceedings of published abstracts will be generated following the final conference.

Schedule

The work will commence by mid-October 1999. The initial meetings among project personnel and other stakeholders will occur by October 1999, and the proposed workshop will be conducted in October 2000. The final conference will be held in March 2001. Follow-up tasks will be completed by April 2001.

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produce food for the students. ENA has ties with the Organización Latino Americana para el Desarrollo de la Pesca (OLDEPESCA—Latin American Organization for Fisheries Development) has a branch for Central America called PRADEPESCA (Proyecto Regional de Apoyo al Desarrollo de la Pesca en Centro America). With EEC support, a 14-pond research unit was built in Catacamas near the ENA campus (Molnar et al., 1997).

Production Strategies Characterizing Small- and Medium-Scale Tilapia Farms: Approaches, Barriers, and Needs

Adoption / Diffusion Research 8 (9ADR8) / Study

Objective

Conduct analysis of Honduras tilapia producer perceptions of production processes, limitations, constraints, and possibilities.

Significance

Rural people in Honduras constitute almost 61 percent of the total population (Stonich, 1992; Barham and Childress, 1992). They have little access to basic development goods—food, shelter, potable water, sanitation systems, education, communications, roads, and markets. Eighty percent of all rural people live in poverty. Sixty-six percent of farmers who produce basic grains, the country's staple food, have access to only eight percent of all cultivable land. This 66 percent has, on average, slightly more than one hectare of land to secure a year's supply of basic grains to feed a family with approximately six children and to produce a surplus for the nation.[1] Given the high levels of poverty in Honduras, it will be particularly important to attend to the problems that small- and medium-scale farmers have in realizing the cash potential of their tilapia crop.

To illustrate the problems farmers face in rural Honduras, we cite a description of one particular locality. CIAT researchers' account of Yoro, in Central Honduras, is illustrative. The principal commercial distribution channel is the intermediary or coyote. Such persons generally do not live in the community, instead traveling from San Pedro Sula, Morazán, El Progreso, El Negrito, Comayagua, Siguatepeque, or El Salvador. Sometimes the intermediary provides equipment services at high prices and finance at high interest rates.[2] Although there are ponds and aquaculture activities in Yoro, this activity is not described in the CIAT account. The most important distribution problems of rural producers center on price followed by the availability of opportunities to sell their product on a regular basis (Abbot, 1993; Molnar et al., 1996). Rural producers in Honduras face particular difficulties due to the difficult terrain, poor road system, and fragmentation in the rural sector.

In the survey data they examined, Molnar et al. (1996) found that almost half the Honduran farmers said that middlemen purchased some or all of their fish. A higher proportion of farmers that sold tilapia to restaurants in Honduras than in the other PD / A CRSP country samples. Honduran farmers were the most confident about being able to sell their tilapia at some price, even if it was not what they originally asked. The most common distribution method for farmers in all countries was pond bank sales to neighbors and others coming to the ponds at harvest. Word-of-mouth knowledge about prospective harvests or the willingness to partial harvest for immediate sale remain primary means for marketing tilapia for most small- and medium-scale farmers.

Most research on the tilapia in Latin America deals with high-volume exports and the potential to increase sales of fresh and frozen tilapia fillets in the US (Engle, 1997; Nelson et al., 1983). Little work has focused on understanding the problems and prospects of domestic sales for small- and medium-scale tilapia producers. Wholesalers, distributors, and urban restaurant buyers typically rely on connections to

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[1] Rural women's educational level is equivalent to men's, but both are deficient. Illiteracy is concentrated in rural areas where, according to 1988 statistics, 51 percent of the population is illiterate. The historical trend that discriminated against young girls' education has been rectified in Honduras, according to recent census data. Comparing women to men, slightly more women are literate than men. The poverty of the rural population is manifested by chronic malnutrition. Multiple births without adequate spacing and nearly continuous breast feeding have even greater negative consequences for women's health. Depending on the region, illiterate women in rural Honduras have an average of between 6.7 and 8.2 children in their lifetimes, averages that are among the highest in Latin America. Seventy percent of all breast-feeding mothers suffer from Vitamin A deficiency, and iron intake is estimated at 40 percent of the recommended level. The rural population suffers from both caloric and protein deficiencies that limit mental and physical growth as well as the capacity for continuous physical activity. <www.fao.org / docrep / u8654e / u8654e01.htm>

[2] <www.intertel.hn / org / ciathill / YORO / Yoro.htm>

large-scale producers who can provide a regular supply of uniform product. The target audience for this project has many barriers to participation in these distribution channels associated with distance, cost of transportation, and knowledge of the workings of these opportunities. Thus, we hypothesize that small- and medium-scale farmers rely largely on a diverse set of local strategies for realizing cash from their tilapia crops.

Although tilapia can be a source of steady income, the enterprise is not likely to generate rapid or large profits. Producers holding exaggerated expectations tend to define normal results as disappointment or failure. Thus, some of the negative sentiment about tilapia in Honduras stems from unrealistic views of the rate of adoption and impacts of tilapia production (Molnar and Lovshin, 1995). Small- and medium-scale farmers may more profitably rely on strategies such as pond bank sales, partial harvesting for local delivery to restaurants or markets, or other niche arrangements that reflect situational opportunities.

Anticipated Benefits

Enhanced understanding of production barriers, distribution difficulties, and disincentives to participation in tilapia culture are important ingredients in effort to assist farmers in increasing their production. The project must understand and anticipate those factors that make farmers anxious about the benefits they will receive from new or reactivated fish ponds.

Identification of Beneficiaries

Tilapia producers and technical advisors will be the primary beneficiaries of this study.

Collaborative Arrangements

Auburn and Zamorano will work together to develop a survey instrument assessing the distribution and production problems of tilapia producers. It is intended that this study be conducted in collaboration with the Zamorano principal investigator and the socioeconomist to be employed by Zamorano.

Experimental Design/Methods

The socioeconomist employed by Zamorano will conduct interviews with approximately 20 tilapia farmers at each of five regionally representative fingerling supplier sites throughout Honduras (Casley and Kumar, 1988). As many women producers as possible will be interviewed so that the study results can identify their special problems and needs. An interview instrument will be collaboratively developed and pretested by the researchers. This instrument will be used in personal interviews with tilapia farmers to obtain experiences and perceptions of the distribution process.

Identification of Deliverables

A report entitled “Perceptions, Experiences, and Production Problems Encountered by Tilapia Farmers in Honduras” will be issued. This report will describe the distribution strategies and frequently encountered difficulties of small- and medium-scale tilapia farmers in Honduras.

Schedule/Time Line

An interview schedule used previously in 1992 will be developed and adapted to reflect current farm-level conditions in Honduras. Data collection will be completed by November 2000. A preliminary version of the results will be presented at the second planning conference to be held in Tegucigalpa in October 2000. The final conference will be in March 2001. A final report will be available by 30 April 2001.

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Technical Assistance for Fingerling Production Serving Small- and Medium-Scale Tilapia Producers

Adoption / Diffusion Research 9 (9ADR9) / Activity

Objective

Provide technical assistance to public and private fingerling tilapia production sites in order to improve their capacity to serve small- to medium-scale farmers.

Significance

A central issue shaping the future of tilapia culture in Honduras is fingerling supply. Farmers in remote places face difficulties obtaining fingerlings. Molnar and Lovshin (1995) found that fingerlings were hard to obtain for some farmers, but were not a reason for withdrawing. Failure to restock was more a symptom of lack of motivation or other disinterest than a cause in and of itself. Farmers who were interested could find fingerlings if they attended to the search. For some farmers in remote areas, transport may be difficult, costly, and hard to organize.

These conditions underscore the importance of increasing the number of private fingerling producers, enhancing autonomous fingerling production among small-scale producers in remote locales, and stabilizing the public and nongovernmental sectors as a brood stock supplier. It also should be noted, that fingerling sales days at research stations also represent important opportunities to interact with farmers about their problems and experiences, present informational programs, distribute technical materials, and otherwise communicate with producers.

The Comayagua research station El Carao has not been a reliable supplier of fingerlings to area farmers. Molnar and Lovshin (1995) received reports that some producers made the journey to the facility only to be told that fingerlings were not available. Others complained about unreliable reverse-sexing of fingerling batches, and the ensuing high level of reproduction experienced in grow-out ponds. The committed producers who made these comments would return on another day or find other fingerling sources. Nonetheless, the word-of-mouth reputation of the facility surely serves to discourage new entrants or others considering the reactivation of empty fish ponds.

Given the historically uneven performance of the public sector, it is vital that private sources of seed stock become the foundation for the industry. Pricing policies of government stations have served to discourage development of fingerling suppliers in the private sector. The low prices asked by the government station tend to undermine incentives for fingerling production in Honduras.

Two large farms on the north coast produce sex-reversed male tilapia fingerlings, but their programs did not seem to be well understood by producers in the rural sector. In other parts of Honduras, farmers rely on the El Carao station, Zamorano University, or a diverse set of local producers for their seedstock. El Carao plays a vital role in the production of fingerlings and has been the long-term focus of aquacultural research in Honduras. Now we are proposing to augment the station's capability by allying its fingerling distribution programs with Zamorano's.

Anticipated Benefits

This activity will allow better coordination of technical assistance activities between the PD / A CRSP, Zamorano, the El Carao station, and other fingerling producers. Fingerling price and availability are key factors influencing the sustainability of the enterprise. The price must be sufficient to stimulate fingerling production and attract additional private seed producers, particularly in areas of the country that are not well-supplied at present. Improvements are sorely needed in the quality and availability of fingerlings supplied by the public sector, as well as the pricing policies of the stations. The training and fingerling sales programs offered by Zamorano reflect one hopeful example of how private institutions can support aquacultural development.

Identification of Beneficiaries

Small and medium-scale tilapia farmers in Honduras.

Collaborative Arrangements

Auburn University and Zamorano will work together through upper-class students at Zamorano to provide technical assistance to fingerling producers and undertake sex-reversed tilapia fingerling production at Zamorano. Zamorano will identify and employ the students. The students also will support the research activities of 9PDR2 and work with Auburn University personnel in this and the work with aquacultural producers described in 9ADR10, "Training and technical assistance for Honduras institutions working with small- and medium-scale tilapia producers."

Methods

Selected upper-class students at Zamorano will work with the staff of public and private fingerling production stations to support sex-reversed tilapia production activities. The students also will provide support to the activities of other PD / A CRSP research activities and support the overall program of outreach and technical assistance that is being undertaken by this project.

Identification of Deliverables

At least two workshops for fingerling producers will be held. A national listing or database of tilapia producers will be developed and maintained. The primary outcome of this activity will be improvements in the quality and quantity of sex-reversed tilapia fingerlings from Zamorano and other public and private fingerling suppliers. In addition, the students will support reproduction operations and will assist in the conduct of research by other components of this project. The primary deliverables of the activity are improved fingerling production, improved information about fingerling producers, and an improved system of technical support for their activities.

Schedule/Timeline

Selected upper-class students at Zamorano will be employed to assist in the implementation of this activity. A program of inventory, contact, and technical assistance will be in place by March 2001. We will have a national database of fingerling producers, a regular system of communicating with them, and have conducted a series of workshops by 30 April 2001.

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Training and Technical Assistance for Honduras Institutions Working with Small- and Medium-Scale Tilapia Producers

Adoption / Diffusion Research 10 (9ADR10) / Activity

Objective

Build capacity of Honduran technical assistance providers through improved understanding of aquacultural technologies.

Significance

The now-expired Peace Corps program of technical support to fish culture probably represents the most focused on-farm assistance most farmers received in Honduras (Cerezo, 1993). Unfortunately, this effort ended in August 1995. Although the national extension effort in aquaculture has been fragmented and underfunded from the beginning, it does have a presence in many parts of the country and has had some relationship to the PD / A CRSP.

The Honduras PD / A CRSP conducted on-farm trials with resource-limited and small- and medium-scale commercial fish farmers in the southern, central and northern regions of Honduras (Green et al., 1992). The results demonstrated that PD / A CRSP production systems were more productive than the traditional tilapia production system used in Honduras. Limited enterprise budget analysis indicated that both PD / A CRSP systems resulted in significant income above variable costs, an indicator of the economic viability of the systems.[1]

Green et al. (1992) note that the systems tested in this trial were not developed for subsistence fish farmers, but rather for small-to-medium-scale commercial fish farmers who have the capability to purchase the necessary factors of production. The researchers felt this group of fish farmers would have the greatest likelihood of benefiting from freshwater aquaculture in Honduras.[2]

Molnar et al. (1996) found that a third of the Honduran tilapia farmers in their survey questioned the fit of tilapia with the other activities of their farm household. About 60 percent of the Hondurans thought that tilapia was less profitable than their other activities. Of the four surveyed nations, Hondurans were most likely to report themselves as planning to build new ponds (39 percent). The perceived profitability of tilapia relative to other farm activities was lowest in Honduras, where 23 percent thought it was more profitable than other farm activities. Overall, Hondurans were least happy with the returns from tilapia.

Molnar and Lovshin (1995) found that many of the farmers they observed had problems attending to the proper feeding and maintenance of tilapia crops. Campesino farming systems tend toward crop production and cattle husbandry. The widespread presence of free-ranging chickens illustrates the passive approach to animal production often taken by producers. Similarly, intensive fishpond management is an unfamiliar production strategy. Feeding also often means a cash outlay, a difficult proposition for risk-averse, cash-short small-scale producers. Most small-scale producers Molnar and Lovshin (1995) visited undertook some level of feeding and manure provision, but intensive production was not widely practiced.

The methods used for reaching different segments of the population of tilapia producers must be diverse and appropriate reflecting the specific needs and barriers they encounter (Huisman, 1990). Small-scale

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[1] More recently, Green (Auburn University, personal communication) maintains that there are few or no sustainable technological packages for profitable tilapia production available to tilapia farmers in Central America. Only 12 of 41 production systems developed during the mid- to late-1980s by the PD / A CRSP were profitable and none yielded the larger-sized fish required by urban and export markets.

[2] The trials conducted directly by El Carao and PD / A CRSP personnel also involved farmers located in diverse geographic regions of Honduras. Consequently, much time and expense were expended on travel; time spent on travel was time not available to work directly with participant farmers. Green et al. (1992) caution that future trials should be limited to one to two geographic zones, e.g., the Comayagua Valley, at a time, which would allow greater contact with the farmers of each zone and a more efficient transfer of technology. Subsequent trials would then be conducted in a different geographic zone. Thus, the beginnings of a technology transfer program met institutional resource limitations that must be understood before subsequent efforts are undertaken.

producers may take extra efforts to motivate given their understandable aversion to risk and the extreme difficulties of their day-to-day circumstances and struggle for survival. The use of participatory methods to define research strategies and extension interventions may be particularly important for the latter target category. In particular, it is important to help potential adopters decide if they have the proper resources and interest to make productive use of their time and energies.

Chin and Benne (1976) identify normative - reeducative strategies as a general class of approaches that use social action research as strategy for change. A number of common elements characterize this family of strategies. First, client system involvement where more than just technical solutions are needed. The approach implies mutual and collaborative interventions between farmers and researchers. Many of the problems that constrain the progress tilapia producers are related to the larger context of the nation or region. Nonetheless, the problems and limitations are real to the producers and must be taken into account as we focus on improving the practice of tilapia aquaculture in Honduras.

Second, sometimes nonconscious, nontechnical problems impede solutions and these are a challenge to identify. Such barriers to change prevent the use of improved technical information even when it is readily available (Hatch et al. 1995). Extension methodologies must be selected and implemented in ways that respond to the context and needs of the target category of users (Engle and Stone, 1989; Veverica and Molnar, 1997). We intend to contact international and domestic NGOs to enlist their support in reaching existing tilapia farmers as well as those small- and medium-scale farmers who might also benefit from involvement in the enterprise.

Finally, the methods and concepts of behavioral sciences are resources to be use selectively, relevantly, and appropriately in this effort to link established technical understanding to farmer needs. The goal is improving the problem-solving capabilities of the system, in this case the knowledge system available to tilapia producers in Honduras. Using this strategy implies some level of qualitative and quantitative data collection, data analysis, and feedback. Other elements include training of managers and technicians, communication with research users, and the training of internal change agents. The overarching objective is releasing and fostering growth in the persons who make up the system to be changed, in this case providers of technical assistance to tilapia producers, as well as the producers themselves. Many of the obstacle to achieving this growth in technical capacity are complex and unanticipated (Cernea, 1991).

Anticipated Benefits

Enhanced technical assistance capacity available to small- and medium-scale Honduran tilapia producers from nongovernmental organizations is the primary intended benefit of this activity. Honduran tilapia farmers will benefit from the stimulated and augmented institutional capacity that will be available to meet their needs.

Identification of Beneficiaries

Small- and medium-scale tilapia producers in Honduras.

Collaborative Arrangements

Auburn University and Zamorano will work together to provide a series of farmer meetings and training sessions for technicians and farmers. These field days, demonstrations, and workshops will target NGO technicians and producers with basic information, diagnostics, and the opportunity to influence the PD/A CRSP development agenda. A number of NGOs have been active in fish culture with small-scale producers. CARE and some Swiss volunteers have reportedly developed pond projects, but Save the

Children has built and stocked fish ponds in a variety of locations around the country. Investigators will attend and participate in as many of these meetings as scheduling and travel arrangements will allow.[3]

Experimental Design/Methods

These field days and training meetings for farmers, as well as national and international NGO technicians will be held at various sites around Honduras as negotiated with the NGOs and other organizations. Some events may take place on the Zamorano aquaculture facility. We will rely on the basic array of extension methods to listen to farmers, answer their questions, and provide technical assistance to them (Van den Ban and Hawkins, 1998). The full-time socioeconomic technician to be employed by this project will work with the investigators to organize the activities, contacts, and meetings subsumed under this objective.

Schedule/Time Line

At least ten field days or training meetings will be held over the course of the project. Three meetings will be held by September 2000 and an additional seven by 30 April 2001.

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[3] One set of links to existing and potential new farmers could be made though the network of grassroots and communal organizations that exists in Honduras. These include: the Honduran Women Farmer Federation (FEHMUC), the National Association of Honduran Women Farmers (ANAMUCH), the Women Farmers Integrated Development Committee (CODIMCA) and the Secretariat of Women Issues of the Farmer Alliance (SWIFA) with the rural organizations: the National Farmers Union (UNC), the Farmer Alliance of Honduran Organizations (ALCONH), the National Federation of Agricultural Workers (CNTC) and the Honduras Diversified Agricultural Farming Federation (FECADH). <www.fao.org/gender/static/casest/hon/hon-e-04.htm#TopOfPage>

Philippines Research

Collaborating Institutions
Central Luzon State University
Remedios Bolivar

Florida International University—Lead US Institution
Christopher Brown

Educational Development Activities in Support of Tilapia Aquaculture in the Philippines

Human Capacity Development 4 (9HCD4) / Activity

Note: This work plan replaces the Ninth Work Plan activity 9HCD2, "Building Research Capacity in CRSP Host Countries." It appears here for the first time.

Objectives
To further the formal education and training of an outstanding graduate student in the Aquaculture Master's or PhD program at the Freshwater Aquaculture Center, and to improve the capabilities of aquaculture teaching laboratories at this facility.

Significance
The educational programs at the Freshwater Aquaculture Center, Central Luzon State University have improved rapidly and are acknowledged and accredited as national leaders in this sort of specialized scientific education in the Philippines. The proposed educational work there will result in increased competitiveness Among the best students for a special training opportunity, a unique and cosmopolitan training experience for the person selected, and a general upgrade of teaching laboratories used by both undergraduate and graduate students in aquaculture.

Anticipated Benefits
We anticipate that the interest in this special fellowship will be keen, leading to striving for accomplishment among potential recipients. We are confident that the physical repairs and restocking of teaching laboratories will convey immediate benefits resulting in improvements to the quality of education in such areas as water quality management and fish disease diagnostics and control. The training of a student on an international level will help elevate the status of education at CLSU both for that student and for his or her home institution, and could thereby contribute to the process of generating a new scientific leader. In summary, we have designed the planned activities to help bring an excellent Philippine educational program further into the international community.

Research Design
A student will be selected from among participants in a graduate research program at the Central Luzon State University, with some specialized interest in aquaculture. He or she will be chosen both for the potential to benefit from the training experience, and for research accomplishments to date. During the period in which the trainee will be supported by the EDC project, participation in the continuing PD / A CRSP project at Central Luzon State University is expected in addition to the continuation of his or her own research program. Technical training will include travel for scientific exchange to both the Asian Institute of Technology and Florida International University.

Teaching laboratories have been evaluated and a prioritized list of needed improvements is under development. The planned upgrades of the teaching laboratories will include restocking chemicals, repair and calibration of instruments (such as replacement of probes, etc.), and repair or replacement of a centrifuge.

Regional Integration
The student trainee will spend approximately one week at the Asian Institute of Technology, during which time he or she will be actively involved in hatchery and growout activities and laboratory analyses. This exposure will increase the scientific integration of two regionally important aquaculture

centers, and is likely to lead to further exchanges following the specific interaction to be sponsored within the scope of this project.

Schedule
This round of study and training will be begun immediately upon the execution of a Contract, as soon as funds become available. Our plan is to begin in June 2000 and complete work by April 2001.

Report Submission
Final report due on or before 30 April 2001.

THAILAND RESEARCH

Collaborating Institutions

Asian Institute of Technology
Amrit Bart

The University of Michigan—Lead US Institution
James S. Diana
C. Kwei Lin
Yang Yi

The Application of Ultrasound to Produce All-Male Tilapia Using Immersion Protocol

Reproduction Control Research 8 (9RCR8) / Study

Note: Research under this work plan, which was approved in order to increase host country participation, did not commence until September 1999. It was funded with funds made available when other Ninth Work Plan awards were declined. It appears here for the first time.

Objectives

1) To examine the efficacy of using ultrasound technology to enhance the delivery of androgens with slight modification of the immersion techniques proposed in the Ninth Work Plan; and
2) Assess the amount of methyltestosterone (MT) residue in a commercial tilapia hatchery in Thailand using standard RIA or HPLC protocol.

Significance

Control of reproduction is one of the priority areas of the PD / A CRSP *Continuation Plan 1996–2001*. Reproduction control of tilapia is critical to the success of most forms of production because tilapia have such high reproductive capacity. Various management practices have been used to control reproduction and produce all-male populations, including use of hormones, selective breeding, and androgenetic techniques. In the Eighth Work Plan, studies were initiated to develop methods for inducing androgenesis in tilapia. In the Ninth Work Plan, studies are proposed to continue development of androgenetic techniques—namely the use of irradiation protocols. This investigation will use ultrasound technology to enhance the delivery of androgens. Past CRSP research has already identified appropriate methods for the delivery of androgens such as methyltestosterone, trenbolone acetate, and methyldihydrotestosterone.

Experimental Design

Masculinization

1) Test three different androgens (trenbolone acetate, methyldihydrotestosterone, and methyltestosterone) and their ability to masculinize tilapia using an immersion protocol.
2) Based on the findings of the above protocol, use cavitation-level ultrasound to enhance delivery at various doses and at different duration of treatments.

MT Residue

1) Determine the accumulation and clearance rate of MT in small systems (aquaria and cement tanks).
2) Survey the level of MT present in commercial hatchery water column and sediments of ponds fed with MT-incorporated diet.
3) Verify the incidental masculinization of tilapia from reuse of this water.

Schedule

Detailed preparation of protocol:	September–November 1999
Experimental period:	January–May 2000
Analysis:	June–August 2000
Preparation of final report and manuscripts:	September–October 2000

Semi-Intensive Culture of Tilapia in Brackishwater Ponds

New Aquaculture Systems / New Species Research 4 (9NS4) / Experiment

Note: Research under this work plan did not commence until July 2000. It was funded with funds made available when other Ninth Work Plan awards were declined. It appears here for the first time.

Objectives

1) To determine appropriate fertilization regimes in brackishwater ponds;
2) To investigate nutritional value and digestibility of specific marine phytoplankton as food organisms to tilapia; and
3) To exploit underutilized or abandoned shrimp ponds for tilapia production.

Significance

Many tilapia species are euryhaline and can grow in saline water after proper acclimation (Suresh and Lin, 1993). A variety of red tilapia have been successful cultured in saline waters (Watanabe, 1991). However, most of those tilapia culture trials were conducted in intensive systems with pelleted feeds, requiring frequent water exchanges or cages. Compared to the voluminous literature available for semi-intensive culture of tilapia in freshwater ponds, information on semi-intensive culture in saline ponds is almost non-existent. The species composition, feeding, and nutritional value of phytoplankton for tilapia growth in freshwater are relatively well understood, notably in works by Hepher (1982), Moriarty (1973), Bowen (1982), and recently the CRSP project (Egna and Boyd, 1997). The PD / A CRSP project did conduct a brief experiment on Nile tilapia grow-out in fertilized brackishwater ponds in the Philippines in 1984. In that experiment, the fish production was extremely low resulting from high mortality due to uncontrolled high salinity. We are assuming that fertilization rates for brackishwater ponds are similar to rates for freshwater ponds. Common CRSP guidelines have been 4:1 N:P inputs and 4 kg ha^{-1} d^{-1} of N.

During the last few years, the desire to culture tilapia in brackishwater ponds has been widely expressed in Southeast Asia as well as Central / South America (Green, 1997). The major reason for this need is that there are a large number of shrimp ponds available, either resulting from failure in shrimp farming or desires to diversify shrimp culture. Tilapia appears to be the most reasonable choice for such a culture system, because there are few domesticated finfish species that feed on low-cost natural foods, such as detritus and plankton. This interest in brackishwater culture is particularly strong in Thailand and Vietnam where shrimp culture is now commonly reduced to one crop per year, leaving the ponds empty for half a year. Tilapia culture is also attractive to shrimp farmers as a byproduct to utilize abundant phytoplankton in either shrimp ponds or their effluents.

Anticipated Benefits

This experiment will provide some guidelines on fertilization regimes for tilapia culture in brackishwater ponds, and on tilapia feeding and nutrition on natural organisms in these ponds. Successful trials of tilapia culture in brackish water ponds will provide farmers with a low-risk species available to stock in thousands of empty ponds in coastal Southeast Asia. Such aquaculture can be profitable in itself and over time may help reclaim these pond areas to agriculture.

Experimental Design

Site: Asian Institute of Technology.

Methods: Pond research.

Pond Facility: 18 cement ponds (6 m^2) with soil bottoms.

Culture Period: 5 months.

Stocking Density: 2 fish m^{-2}.

Test Species: Thai strain red tilapia.

Nutrient Input: 4 kg N ha^{-1} d^{-1} treatments of 4:1 and 2:1 N:P ratios.

Water Management: Water depth: 0.8 m; salinity: 10, 20, and 30 ppt.

Sampling Schedule: Regular CRSP protocols for water quality and biological parameters. Partial budgets will be calculated to estimate cost of inputs and value of fish crop. Biweekly assessment will be done for plankton composition and species eaten by fish.

Statistical Design and Analysis: 2 × 3 factorial with 2 fertilizer inputs and 3 salinities; each treatment in triplicate. Results will be analyzed with ANOVA for significant difference.

Salinity will be initially regulated by trucking hypersaline water to AIT and diluting it to the appropriate concentration. Flooded ponds will be inoculated with phytoplankton. Marine parasite infections will be evaluated by visual examination of dead fish for ectoparasites.

An initial trial of marine plankton consumption will be done by producing monospecific cultures of *Thalassiosira*, *Skeletonema*, *Chlorella*, and *Tetraselmis*. Each species will be fed to young tilapia in the lab for two weeks. Growth will be determined to estimate prey consumption and nutrition from each algal species.

Null Hypothesis: Salinity and fertilizer treatments do not affect fish production.

Regional Integration

The tilapia culture in brackishwater ponds is relevant to all countries in the Southeast Asia region where extensive coastal zones exist. The pond culture technologies developed for freshwater ponds by the CRSP project will be transferred to brackishwater systems where appropriate.

Schedule

July–September 2000

Report Submission

30 November 2000

References

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SECTION B: REVISED EXPERIMENTAL DESIGNS

MEXICO RESEARCH

Masculinization of Tilapia by Immersion in Trenbolone Acetate: Growth Performance of Trenbolone Acetate–Immersed Tilapia

Reproduction Control Research 5B (9RCR5B) / Experiment

Experimental Design Modification
Sampling will end at four months rather than six months. A subsample of fish will be maintained through six months of age to determine if the fish mature.

Culture Period: 120 days for offspring (subsample through 180 days).

Fate of Methyltestosterone in the Pond Environment: Detection of MT in Pond Soil from a CRSP Site

Effluents and Pollution Research 2B (9ER2B) / Experiment

Experimental Design Modification
The hapas used for feeding MT to tilapia fry in Tabasco, Mexico, will be located at one end of the pond and the hapas used for control tilapia will be located at the other end of the pond. Soil samples will be taken from directly below the hapas, as well as 2, 5, and 10 m away from the pond along its length. Samples from the Sagana Station in Sagana, Kenya, will need to be taken when the station sets up another sex-reversal experiment.

PERU RESEARCH

Spawning and Grow-Out of *Colossoma macropomum* and/or *Piaractus brachypomus*

New Aquaculture Systems / New Species Research 3A (9NS3A) / Study

Note: 9NS3A did not appear as a separate work plan in the *Ninth Work Plan*. The modification below addresses objective 1 of 9NS3, which is being carried out under a subcontract with the University of Arkansas at Pine Bluff.

Experimental Design Modification
Additional information on nutrition of *P. brachypomus* will be obtained via feeding experiments to be performed by Rebecca Lochmann at the University of Arkansas at Pine Bluff. Large juvenile fish are from research facilities in Peru; these were sent in July 2000 and are adapting to local conditions and are on feed. Small trials will be conducted to bracket the dietary requirement of this species for Vitamin C and / or E. Basic information on vitamin requirements in this species is lacking. Both of these vitamins are present at high levels in the natural diets of the species, and both are known to affect reproduction in other fish species. Bracketing the vitamin C and E requirements of large juvenile fish would provide information that would be immediately useful for grow-out diets, and could be used as baseline data for determining requirements of broodstock for these vitamins in the future.

Kenya Research

Fish Yields and Economic Benefits of Tilapia/*Clarias* Polyculture in Fertilized Ponds Receiving Commercial Feeds or Pelleted Agricultural By-Products

Feeds and Fertilizers Research 2 (9FFR2) / Experiment

Experimental Design Modification

The feeding regime featured the use of pig finisher pellets with regular fertilization rather than the use of poultry pellets. Fish were fed at a rate of 2% body weight per day rather than 3% body weight per day, and there was no progressive decrease in the daily feed ration as fish grew. Ponds were stocked at densities closer to 20,000 than 30,000 fish per hectare.

Use of Pond Effluents for Irrigation in an Integrated Crop/Aquaculture System

Effluents and Pollution Research 1 (9ER1) / Experiment

Experimental Design Modification

The original design called for the use of irrigation water combined with differing levels of fertilization with P. In the modified design, different water sources were used instead. The three water sources were canal water (with low P and low N), pond water (with 1 to 3 mg P l^{-1} and 5 to 10 mg N l^{-1}), and a 50 / 50 mix of canal and pond water. This was done to match the ongoing global experiment. The irrigation rate was increased from 500 mm per treatment after the second planting cycle to counter evaporation.

The experiment was prolonged to a third planting, rather than a single repetition, to counter the effects of drought.

Kale replaced tomatoes as one of the crops grown because the survival rate of tomatoes rendered the first experiment a failure. Kale's total biomass and edible portion are closely related; in addition it is widely consumed and easy to grow. Kale is not an export crop; thus, researchers grew one export crop (French beans) and one local consumption crop (kale).

The soil's ability to strip P and N under flood irrigation conditions was evaluated by an add-on soil column test that formed the basis of an M.S. thesis.

Aquaculture Training for Kenyan Fisheries Officers and University Students

Adoption / Diffusion Research 3 (9ADR3) / Activity

Experimental Design Modification

The training plan has been modified to include direct farmer training, using farmer field days as the chosen method, rather than training sessions for Fisheries Extension Officers alone. While the original plan called for training of 280 Fisheries Extension Officers, the new plan estimates that 300 officers and farmers will be trained. In addition, the number of training days has been altered. The original plan called for a total of 105 training days; the new plan calls for 250 training days. Finally, training locations have been changed to include only Sagana Fish Farm and the Cheploilel Campus of Moi University.

Philippines Research

Collaborating Institutions
Central Luzon State University
Remedios Bolivar

Florida International University—Lead US Institution
Christopher Brown

Reduction of Rations below Satiation Levels

Feeds and Fertilizers Research 3 (9FFR3) / Experiment

Note: The following work plan replaces that in the *Ninth Work Plan* in full.

Objective
To conduct a series of experiments designed to test the effect of reducing the rations of tilapia to a sub-satiation level. This follows a successful demonstration (year 1) that delayed onset of feeding reduces production costs significantly, without compromising yields or product quality significantly.

Significance
The point of these studies is to develop options for farmers who wish to increase production but for whom full-scale intensification is impractical. For many farmers in rural areas of the Philippines, mechanical aeration and refrigerated feed storage are not feasible, nevertheless the incentive to improve yields over those possible with traditional culture remains strong. Based on earlier PD / A CRSP studies in Thailand, we have worked with Philippine farmers to introduce the principle that judiciously applied supplemental feeding well below the theoretical maximum can improve yields substantially. Farmers participating in our own year one d of studies have already adopted our experimental method of sub-maximal supplemental feeding, which was clearly cost-effective. The coming experiments will address another means of providing modest feed supplementation, by feeding at rations below satiation level.

Anticipated Benefits
Although feeding the maximum amount that fish will consume probably leads to the most rapid possible growth, it is not a cost-effective use of feeds. Not only does this approach elevate feed costs unnecessarily, it can compromise water quality and consequently increase the risk of disease. We are testing feeding techniques that raise growout productivity well above baseline levels, in the most cost-effective means possible. Increased farm profit is therefore one of our goals; this also ties into the broader objectives of enhanced economic stability and improved nutrition.

Research Design
Experimentation will adhere to the methods detailed proposed in our approved research proposal. In short, the year two experiments consist of a series of comparisons of productivity in pond-growouts involving the feeding twice daily of fish at rates experimentally determined to approximate 67% and 100% of satiation. A minimum of 9 farms will participate in these trials, with the end-points of assessing growth, yields, and uniformity of fish produced under these feeding regimens. As in year 1, the relative cost-effectiveness of the feeding strategies will be analyzed and contrasted.

Regional Integration
We plan a technical exchange with the Asian Institute of Technology, during which time we will explore the best current hatchery and growout methods currently used at both facilities. It is a stated goal of our project to help Central Luzon State University fulfill its' potential as a regional center for aquaculture research, education, and technology dissemination.

Our experimental approach involves the application of locally-milled feeds which utilize rice bran and other rice byproducts, and our farm trials also involve the growout of a special strain of Genetically Improved Farm Tilapia developed by ICLARM and currently provided by the GIFT Foundation. Thus an important objective of our work is to integrate divergent agriculture activities, interests, and resources in Central Luzon.

Schedule
Our plan is to begin in June 2000 and complete work by April 2001.

Report Submission
Final report due on or before 30 April 2001.

Timing of the Onset of Supplemental Feeding of Tilapia in Ponds

Feeds and Fertilizers Research 4 (9FFR4) / Study

Experimental Design Modification
The onset of feeding will start at 45 and 75 days-in-ponds instead of 30 and 60 days-in-ponds.

Tilapia will be stocked at an individual weight of 1 g per fish instead of 5–10 g per fish.

Production of Improved Extension Materials

Adoption / Diffusion Research 6B (9ADR6B) / Activity

Note: This one-year work plan replaces objective 2 of 9ADR6 in its entirety.

Objective
The goal of the proposed work is to develop and disseminate improved pond management options for intensified production of tilapia by farmers with different resources and capabilities. The specific objective is to:

- develop improved materials and practices for wider dissemination of results.

Pond production of tilapia and other fishes in central Luzon, already one of the Philippines' most productive inland regions, would benefit from the dissemination of a comprehensive approach to a range of intensity levels, all having a sound theoretical and empirical basis, and all having been demonstrated under local conditions.

Beneficiaries
The primary beneficiaries will be the fish producers and consumers of central Luzon, with much wider effect including other regions of the Philippines and Southeast Asia. Yields and parameters, in differing from those obtained on-station in Thailand, will illustrate differences and ranges of outcomes to be expected elsewhere, for example in AITs target area in Vietnam, Laos, and Cambodia.

Other beneficiaries will include other faculty and staff of CLSU, staff of BFAR and other government agencies, and the clientele (students, advisees) of all. CRSP researchers will benefit from the comparisons noted above, and be better able to design and predict outcomes of work in other locations.

Finally, this work has direct applicability to the US tilapia industry because feeds are a major input cost at all levels of system intensification, and all information about the response of fish growth to different feeding practices is valuable when systems are analyzed or designed anew.

Work Plan and Technical Considerations
1) *Characterization of the Research Site*
The Freshwater Aquaculture Center at Central Luzon State University has already been the subject of general site characterization, including a description of the site layout, climate, water and soil quality parameters (Bowman and Clair, 1996; Egna, 1997).

2) *Proposed Collaborative Work*
Because this work is oriented to prompt dissemination, the goal of this activity will be production of a sequence of handout pamphlets and presentation aids (overhead computer screen projection, videotape recordings) matched to each of the anticipated stages of technical progress in on-farm trials associated with works plans 9FFR3 and 9FFR4.

Experimental Design
Extension will be facilitated by production of illustrated pamphlets describing each of the stages discussed above. The fertilization and feed leaflets used by the Asian Institute of Technology (AIT) projects in Northeast Thailand will serve as a model for development of materials here. These will be refined by circulation of drafts to other organizations (Bureau of Fisheries and Aquatic Resources, BFAR) involved in aquaculture extension functions, and by reviews of draft documents by selected recipients to determine the clarity, effectiveness, and appropriate technical level of the information. Farmers participating in on-farm trials (as part of work plans 9FFR3 and 9FFR4) will be given multiple copies of the pamphlets appropriate to each completed trial, for distribution to their own neighbors and visitors. The high level of literacy in the Philippines makes distribution of printed materials an effective nationwide mechanism for dissemination.

Expected Outcomes
The extension materials will be available for at least the first trial and workshop, with those for the second near at hand. Project personnel and others will have learned how to use the appropriate tools and materials, which will likely be shared widely at FAC, and will have this project's products as examples.

Schedule
Production of improved extension materials completed: October 2000
Final report due: April 2001

Report Submission
Final report due on or before 30 April 2001.

THAILAND RESEARCH

Lotus-Fish Culture in Ponds: Recycling of Pond Mud Nutrients
(Originally titled Taro-Fish Culture in Ponds:
Recycling of Pond Mud Nutrients)

New Aquaculture Systems / New Species Research 1 (9NS1) / Experiment

Note: The following work plan replaces that in the *Ninth Work Plan* in full.

Experimental Location and Design Modification

Due to the unavailability of facilities in Nepal, the study was conducted at the Asian Institute of Technology. Additionally, lotus is more appropriate than taro to be cultured in fish ponds in terms of nutrient removal and economic return.

Objectives

- To assess the pond mud nutrient recovery by lotus plants;
- To assess pond mud characteristics after lotus-fish culture;
- To compare fish growth between with and without taro integration.

Significance

Regular fertilization in fish ponds accumulates nutrients in pond mud. One hectare of old pond mud was reported to have the equivalent of 1.85 tons of urea and 2.30 tons of TSP (Shrestha and Lin, 1996) or 2.8 tons of urea and 3.0 tons of TSP (Yang and Hu, 1989). Pond muds are a major sink for phosphorus, and adsorption capacity is related to mineral composition and clay content of pond muds (Shrestha and Lin, 1996). Release of adsorbed-P to the water column is minimal, and phytoplankton are not as effective to utilize adsorbed-P as rooted crops. Roots extended in interstitial water of soil provide a better opportunity to extract P from soil (Denny, 1972; Boyd, 1982; Smart and Barko, 1985) and hence, pond muds have been widely used to fertilize land crops (Muller, 1978; Little and Muir, 1987; Christensen, 1989; Shrestha and Lin, 1996). However, removing pond mud is labor intensive and its practicability is questionable (Edwards et al., 1986). Alternatively, lotus-fish culture may be considered to utilize reserve nutrient in muds. Lotus (*Nelumbo nucifera*) is an aquatic emergent plant that is seen to grow as tall as one meter. Lotus is an important and popular cash crop in many Asian countries. It is commonly planted in fields or ponds with nutrient-rich muds, with a growing season of 100 to 150 days. It can extract nutrients from pond sediments efficiently. The co-culture and rotated culture of lotus and fish have been practiced in China for many years. Water levels of ponds can be increased as lotus grows. Fish can be stocked when water levels reach 30 cm and harvested 4 to 5 months after lotus is planted. Additionally, lotus shoots will provide a substrate for the growth of epiphytic algae, which is consumed by tilapia (Bowen, 1982; Lowe-McConnell, 1982; Shrestha and Knud-Hansen, 1994).

Anticipated Benefits

Results of the experiment will provide information on lotus-fish culture and recycling of pond mud nutrients, which are otherwise wasted. It will generate information on bottom mud characteristics altered by rooted plants. It may benefit small-scale farmers of Asian countries for resource utilization where lotus is commonly grown as a cash crop.

Research Design

Location: Asian Institute of Technology.

Methods: Pond research.

Pond Facility: 9 ponds of 200 m^2 size.

Culture Period: 5 months.

Test Species: Nile tilapia (*Oreochromis niloticus*); lotus (*Nelumbo nucifera*).

Stocking Density: Tilapia 2 / m^2; lotus plant spacing 2 x 1 m.

Nutrient Input: Weekly fertilization by urea and TSP @ 4 kg N and 1 kg P ha^{-1} d^{-1}. No fertilization for the lotus-only treatment.

Water Management: After lotus planting, water level will be increased as the height of lotus plant increases. Once the water level reaches 30 cm, tilapia will be stocked. Water level will be increased with growth of lotus up to 1 m depth.

Sampling Plan: Biweekly and monthly diel water quality following standard CRSP protocol. Initial and final pond mud sampling for organic C, total N, available N, total P, available P, soil pH.

Partial budgets will be estimated for cost of inputs and value of fish and lotus. Fish growth and survival will only be assessed at the end of the experiment due to sampling difficulties. Fish and lotus will be harvested by draining. Nutrient budgets will be estimated for all ponds.

Experimental Design, Hypotheses, and Statistical Methods: Experiment will have 3 treatments in triplicates: a) lotus-fish culture, b) only fish, and c) only lotus. The null hypotheses are that there will be no differences in mud nutrient contents, soil characteristics, fish growth, and nutrient recovery between pairs of treatments. Significant differences will be tested using ANOVA.

Regional Integration

Lotus is a popular cash crop in many Asia countries. Nile tilapia is commonly cultured in the region. Small-scale farmers are resource limited and lotus-fish culture may utilize waste nutrient resources otherwise.

Schedule

February to August 2000

Report Submission

November 2000

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Integrated Recycle Systems for Catfish and Tilapia Culture

Effluents and Pollution Research 3 (9ER3) / Experiment

Note: The following work plan replaces that in the *Ninth Work Plan* in full.

Objectives

1) To use effluents from intensive catfish ponds as nutrients for tilapia culture ponds, and thus to reduce effluent effects from catfish culture.
2) To gain extra fish production at low cost, making aquaculture more profitable to farmers.

Significance

Clarid catfish has been one of the most popularly cultured freshwater fish in Southeast Asia. The present annual production in Thailand is estimated to be 50,000 tonnes. As an air breather, catfish can be grown at extremely high density (100 fish m^{-2}) with standing crop in pond culture reaching as high as 100 tonnes ha^{-1} (Areerat, 1987). The fish are mainly cultured intensively and fed with trashfish, chicken offal or pelleted feed, which generally causes poor water quality and heavy phytoplankton blooms throughout most of the growout period. To maintain the tolerable water quality for fish growth, pond water is exchanged at later stages of the culture cycle (which is 120 to 150 days). The effluents containing concentrated phytoplankton biomass and nutrient, are unsuitable to irrigate rice fields because unbalanced N:P ratios (high nitrogen content) cause rice to fail to fruit. Wastewater disposal from catfish ponds has become a serious problem, especially in the Northeast Thailand where surface waters are in short supply. Farmers often discharge the wastewater to adjacent rice fields, which are damaged by this input. To fully utilize the effluents, unproductive wetlands can be excavated for tilapia culture. Such diversification and integration are regarded as important practices to enhance aquaculture sustainability (Alder et al., 1996; Pillay, 1996).

The wastes from catfish cultured in cages have been shown to be effective for producing phytoplankton to support Nile tilapia culture in the same pond (Lin et al., 1990; Lin and Diana, 1995). Similarly, tilapia reared in cages, feeding on phytoplankton in intensive channel catfish ponds, were shown to improve pond water quality as well as produce an extra crop (Perschbacher, 1995).

Anticipated Benefits

The integrated recycle system will be able to produce tilapia using effluents from intensive catfish ponds, which otherwise would be a source of pollution to surface waters. Economically, the profit margin of catfish culture will be augmented with tilapia at minimal cost. This system will provide scientific information on mass balances of nutrients and optimization of biological productivity.

Research Design

Location: AIT campus, Bangkok.

Pond facility: 7 earthen ponds of 200 m^2 size. One pond will be partitioned to three equal compartments by small mesh net for the control. Other six ponds will be partitioned to two compartments: 1/3 pond area (67 m^2) for catfish and 2/3 pond area (133 m^2) for tilapia.

Culture period: 90 to 120 days until catfish reach 200 to 300 g size.

Stocking density: 25 catfish m^{-2}; 2 tilapia m^{-2}.

Test species: Hybrid catfish (*Clarias macrocephlus* × *C. gariepinus*); Nile tilapia (*Oreochromis niloticus*).

Nutrient inputs: Pelleted feed for catfish, effluents recirculated to tilapia compartments; tilapia compartments will also be fertilized for the first month.

Water management: Pond water depth to be kept at 1 m; The water between catfish and tilapia compartments can exchange through the partitioning net. In artificial water circulation treatment, the water in catfish compartment will be continuously circulated by submersed pumps to tilapia compartment at a rate of one exchange per week. No artificial water circulation will be done in the first month.

Sampling schedule: Water quality parameters will be analyzed biweekly and diel samples monthly, following standard CRSP protocols. Partial budgets will be estimated to assess costs and value of fish.

Statistical design and analysis: The experimental treatments will include catfish alone (treatment A, control), catfish and tilapia without artificial water circulation (treatment B), and catfish and tilapia with artificial water circulation (treatment C). Each treatment will be conducted in triplicate. Ponds will be flooded and stocked with fish. Nutrient budgets will be determined.

Null hypothesis: Water exchange between catfish and tilapia compartments does not affect water quality and fish production.

Regional Integration

In the SE Asian region, both clarid catfish and tilapia are widely cultivated with traditional segregated pond culture systems. The integrated systems will be a new step in production technology that will promote efficient production as well as environmental sustainability.

Schedule

July to November 1999

Report Submission

March 2000

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SECTION C: REVISED SCHEDULES

POND DYNAMICS

Pond Soil Characteristics and Dynamics of Soil Organic Matter and Nutrients

Pond Dynamics Research 2 (9PDR2) / Study

Old Schedule
Data Collection: July 1998–April 2000
Final Report Due: June 2000

New Schedule
Data Collection: July 1998–June 2000
Data Analysis: Through November 2000
Final Report Due: April 2001

MARKETING AND ECONOMIC ANALYSIS

Rapid Economic Evaluation Tools

Marketing and Economic Analysis Research 5 (9MEAR5) / Study

Old Schedule
Data Collection: 1999–2000
Final Report Due: April 2001

New Schedule
Data Collection: November 1999–April 2001
Final Report Due: April 2001

DECISION SUPPORT SYSTEMS

Decision Support Systems for Fish Population Management and Scheduling in Commercial Pond Aquaculture Operations

Decision Support Systems Research 2 (9DSSR2) / Study

Note: The start date for 9DSSR2 that appeared in the *Ninth Work Plan* is incorrect; the correct dates appear below.

Schedule
Models for Size Distribution Analysis will begin 1 July 1999.
Decision Support for Scheduling Harvest Operations and Assessing Economic Outcomes will begin 1 January 2000.
Inventory Management will begin 1 July 2000.
Farmer Training will be completed by 30 April 2001.

Enhancing the POND© Decision Support System for Economics, Education, and Extension

Decision Support Systems Research 3 (9DSSR3) / Study

Old Schedule
Start of Investigation: August 1998
End of Investigation: July 2000
Final Report Due: July 2000

New Schedule
Start of Investigation: August 1998
End of Investigation: April 2001
Final Report Due: April 2001

MEXICO RESEARCH

Masculinization of Tilapia by Immersion in Trenbolone Acetate: Growth Performance of Trenbolone Acetate–Immersed Tilapia

Reproduction Control Research 5B (9RCR5B) / Experiment

Old Schedule
Data Collection: April–October 1999
Final Report Due: December 1999

New Schedule
Data Collection: December 1999–May 2000
Final Report Due: July 2000

Masculinization of Tilapia by Immersion in Trenbolone Acetate: Detection of Trenbolone Acetate in Water after Treatment

Reproduction Control Research 5C (9RCR5C) / Study

Old Schedule
Data Collection: October 1999–March 2000
Final Report Due: July 2000

New Schedule
Data Collection: March–September 2000
Final Report Due: November 2000

Fate of Methyltestosterone in the Pond Environment: Detection of MT in Pond Soil from a CRSP Site

Effluents and Pollution Research 2B (9ER2B) / Study

Old Schedule
Data Collection: September 1998–September 1999
Final Report Due: December 1999

New Schedule
Data Collection: May 1999–May 2000
Final Report Due: July 2000

Peru Research

Development of Sustainable Pond Aquaculture Practices for *Colossoma macropomum* in the Peruvian Amazon

New Aquaculture Systems / New Species Research 3 (9NS3) / Study

Old Schedule:
Data Collection: October 1998–November 2000
Report Due: June 2000

New Schedule
Data Collection: October 1998–April 2001
Final Report Due: 30 April 2001

Spawning and Grow-Out of *Colossoma macropomum* and/or *Piaractus brachypomus*

New Aquaculture Systems / New Species Research 3A (9NS3A) / Study

Note: 9NS3A did not appear as a separate work plan in the *Ninth Work Plan*. The modification below addresses objective 1 of 9NS3, which is being carried out under a subcontract with the University of Arkansas at Pine Bluff.

Old Schedule:
Data Collection: October 1998–November 2000
Report Due: June 2000

New Schedule
Data Collection: July 2000–April 2001
Final Report Due: 30 April 2001

Kenya Research

Fish Yields and Economic Benefits of Tilapia/*Clarias* Polyculture in Fertilized Ponds Receiving Commercial Feeds or Pelleted Agricultural By-Products

Feeds and Fertilizers Research 2 (9FFR2) / Experiment

Old Schedule
Start of Investigation: July 1999
End of Investigation: November 1999
Final Report Due: June 2000

New Schedule
Start of Investigation: November 1999
End of Investigation: May 2000
Final Report Due: December 2000

Fish Yields and Economic Benefits of Tilapia/*Clarias* Polyculture in Fertilized Ponds Receiving Commercial Feeds or Pelleted Agricultural By-Products

Feeds and Fertilizers Research 2A (9FFR2A) / Experiment

Note: 9FFR2A did not appear as a separate work plan in the *Ninth Work Plan*. The modification below addresses objective 1 of 9FFR2, which is being carried out under a subcontract with the University of Arkansas at Pine Bluff.

<u>Old Schedule</u>
Data Collection: July–November 1999
Final Report Due: June 2000

<u>New Schedule</u>
Feeding Trial: July 1999–May 2000
Isotopic Analysis: July 2000–December 2000
Final Report Due: April 2001

Use of Pond Effluents for Irrigation in an Integrated Crop/Aquaculture System

Effluents and Pollution Research 1 (9ER1) / Experiment

<u>Old Schedule</u>
Data Collection: November 1998–February 2000
Final Report Due: February 2000

<u>New Schedule</u>
Data Collection: November 1998–March 2000
Final Report Due: July 2000

On-Farm Trials: Evaluation of Alternative Aquaculture Technologies by Local Farmers in Kenya

Appropriate Technology Research 1 (9ATR1) / Study

Central Province Trials
<u>Old Schedule</u>
Start of Investigation: July 1999
End of Investigation: July 2000
Final Report Due: February 2001

<u>New Schedule</u>
Start of Investigation: November 1999
End of Investigation: November 2000
Final Report Due: April 2001

Western Region Trials
<u>Old Schedule</u>
Start of Investigation: January 2000
End of Investigation: October 2000
Final Report Due: March 2001

<u>New Schedule</u>
Start of Investigation: November 2000
End of Investigation: April 2001
Final Report Due: April 2001

PHILIPPINES RESEARCH

Reduction of Rations below Satiation Levels

Feeds and Fertilizers Research 3 (9FFR3) / Study

Old Schedule
Start of Investigation: September 1999
End of Investigation: January 2000
Final Report Due: July 2000

New Schedule
Start of Investigation: June 2000
End of Investigation: April 2001
Final Report Due: April 2001

Timing of the Onset of Supplemental Feeding of Tilapia in Ponds

Feeds and Fertilizers Research 4 (9FFR4) / Study

Old Schedule
Start of Investigation: January to February 1999
End of Investigation: May 1999
Final Report Due: July 1999

New Schedule
Start of Investigation: April 1999
End of Investigation: October 1999
Final Report Due: December 1999

THAILAND RESEARCH

Lotus-Fish Culture in Ponds: Recycling of Pond Mud Nutrients (Originally titled Taro-Fish Culture in Ponds: Recycling of Pond Mud Nutrients)

New Aquaculture Systems / New Species Research 1 (9NS1) / Experiment

Old Schedule
Data Collection: June–December 1999
Final Report Due: March 2000

New Schedule
Data Collection: February–August 2000
Final Report Due: November 2000

Culture of Mixed-Sex Nile Tilapia with Predatory Snakehead

New Aquaculture Systems / New Species Research 2 (9NS2) / Experiment

Old Schedule
Data Collection: July–November 1999
Final Report Due: January 2000

New Schedule
The original experiment was completed as planned, but snakehead dug holes in the ponds dikes and occurred in ponds of all treatments. The researchers are repeating the experiment and are attempting to eliminate the movement of snakehead between ponds.
Final Report Due: September 2000

Integrated Recycle Systems for Catfish and Tilapia Culture

Effluents and Pollution Research 3 (9ER3) / Experiment

Old Schedule
Data Collection: March–August 1999
Final Report Due: November 1999

New Schedule
Data Collection: July–November 1999
Final Report Due: March 2000

SECTION D: CANCELLED WORK PLANS

REPRODUCTION CONTROL

Monosex Tilapia Production through Androgenesis: Verification of Androgenically Produced Males, Their Viability, and the Influence of the Female on Progeny Sex Ratios

Reproduction Control Research 6B (9RCR6B) / Study

At the time the *Ninth Work Plan* was printed, the PMO had approved this study for funding, but formal subcontract work was still in progress. The proposed investigation was a three-part study under work plan code 9RCR6, "Monosex tilapia production through androgenesis." In subsequent negotiations, the scope of the original research plan was restricted to include only one of the three proposed studies, "Selection of individuals for sex inheritance characteristics for use in monosex production (9RCR6A)," which was published in the *Ninth Work Plan*.

Monosex Tilapia Production through Androgenesis: Growth of Genetically Derived Males in Production Settings

Reproduction Control Research 6C (9RCR6C) / Study

At the time the *Ninth Work Plan* was printed, the PMO had approved this study for funding, but formal subcontract work was still in progress. The proposed investigation was a three-part study under work plan code 9RCR6, "Monosex tilapia production through androgenesis." In subsequent negotiations the scope of the original research plan was restricted to include only one of the three proposed studies, "Selection of individuals for sex inheritance characteristics for use in monosex production (9RCR6A)," which was published in the *Ninth Work Plan*.

Monosex Tilapia Production through Androgenesis

Reproduction Control Research 7 (9RCR7) / Study

The objectives of 9RCR7 were to use androgenetic procedures to develop direct induction of YY-male Nile tilapia. This was to be done using an induction protocol whereby phenotypic markers would indicate males in the broodstock. While use of the induction protocol has shown some success, the production of viable androgenotes has been low. After two years of applying the induction protocol, none of the androgenotes survived beyond early juvenile development. Since no androgenotes have reached maturity, the hypothetical 1:1 sex ratio of androgenotes cannot be verified and further progeny testing of the putative YY males cannot be accomplished so as to test the hypothesis of all-male progeny in breedings with putative YY males.

AQUACULTURE SYSTEMS MODELING

Model for Determining Aquaculture Pond Water Quality and Effluent Characteristics

Aquaculture Systems Modeling Research 2 (9ASMR2) / Study

At the time the *Ninth Work Plan* was printed, the PMO had approved this study for funding, but formal subcontract work was still in progress. During subsequent negotiations the Principal Investigator for 9ASMR2 declined the funding and the study was cancelled.

Human Capacity Development

Building Research Capacity in CRSP Host Countries

Human Capacity Development 2 (9HCD2) / Activity

At the time the *Ninth Work Plan* was printed, the PMO had approved this activity for funding, but formal subcontract work was still in progress. During subsequent negotiations the Principal Investigator for 9HCD2 declined the funding and the activity was cancelled.

Institutionalizing EDC Activities in CRSP Countries

Human Capacity Development 3 (9HCD3) / Activity

At the time the *Ninth Work Plan* was printed, the PMO had approved this activity for funding, but formal subcontract work was still in progress. During subsequent negotiations the Principal Investigator for 9HCD3 declined the funding and the activity was cancelled.