**AquaFish CRSP**

**Implementation Plan 2009–2011**

**Addendum III**

**2011–2012 Transition**

**Draft**



Aquaculture & Fisheries

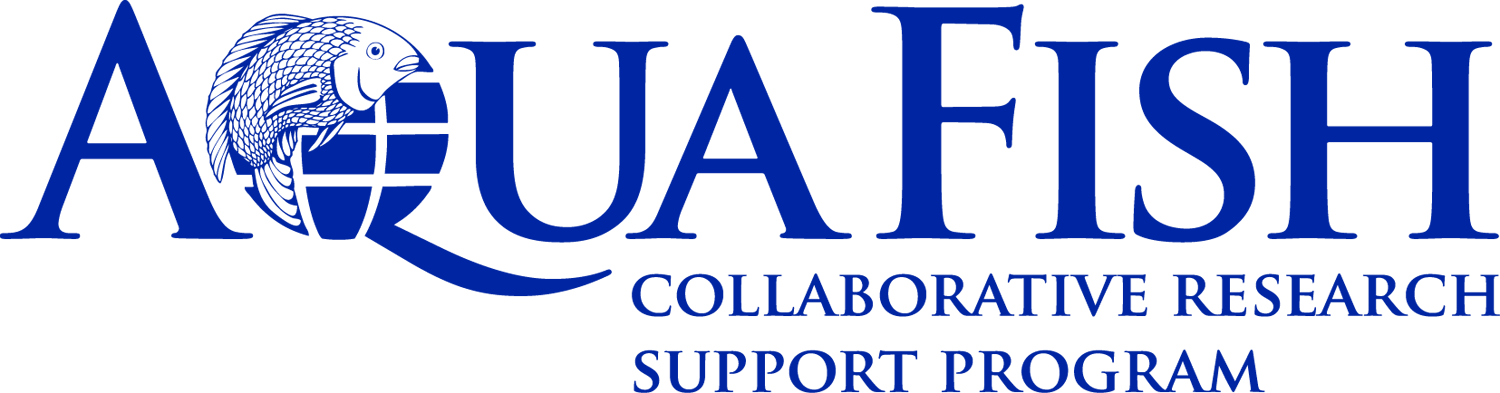
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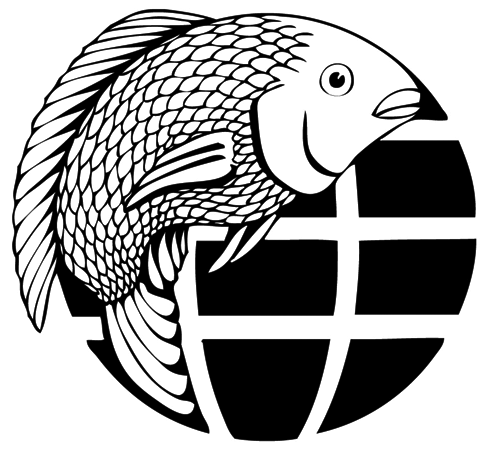
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**AquaFish CRSP Implementation Plan 2009–2011, Addendum**

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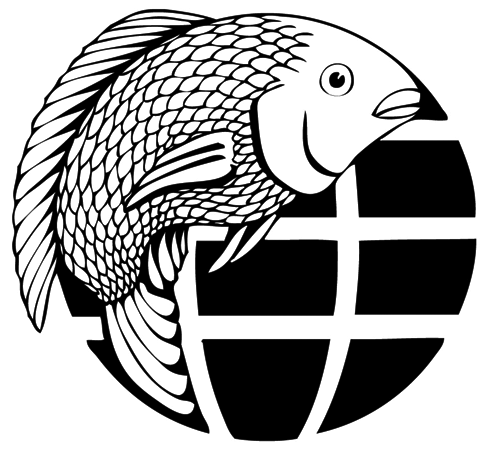
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**Cover Photo**

Earthen ponds in Kenya where CRSP-trained farmers raise catfish fingerlings to sell as baitfish to Lake Victoria fishermen who use them to catch high-value Nile perch. Photo by Ford Evans.

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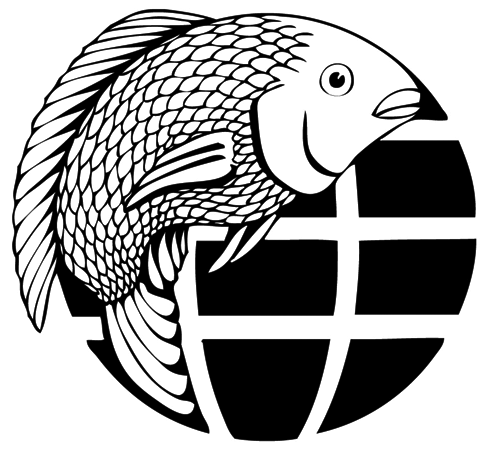
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# introduction

This third addendum to the AquaFish CRSP *Implementation Plan 2009-2011* includes transition investigations for each of the seven core research projects in experimental pond unit assessment and value chain analysis. Three projects are also continuing with studies on air breathing fish species candidates for aquaculture, which they initiated under the *Implementation Plan 2009-2011, Second Addendum.*

Value Chain Analysis

CRSP researchers in each project are evaluating the value chain for one aquatic species in a partner Host Country. As part of this research component, Dr. Robert Pomeroy, an international expert in value chain analyses, will lead a workshop for fellow CRSP researchers. This program-related workshop will focus on mapping techniques and approaches for uniform data collection and value chain analysis across the seven core research projects. Dr. Pomeroy has tentatively scheduled the workshop in July to take advantage of CRSP attendance at the International Institute of Fisheries Economics & Trade conference in Tanzania, IIFET 2012.

Experimental Pond Unit Assessment (EPUA)

As a global-style research project, this set of investigations is designed to develop a baseline set of physical, chemical, and biological characteristics of aquaculture ponds and build capacity at each research site to complete all of these measures. The experimental framework draws upon methods formulated under the former Pond Dynamics/Aquaculture CRSP. The overall goal of this experimental approach is to establish a uniform research direction for basic work needed to develop small-scale aquaculture. Future AquaFish CRSP programs would be able to draw upon the EPUA results to further develop methodology for customizing management practices for any given aquaculture system.

Air Breathing Fishes

Researchers associated with the Auburn University, University of Hawai’i at Hilo, and University of Michigan projects are continuing work on three air-breathing fish species groups with high potential as aquaculture species. In Uganda, Auburn University investigators are taking next steps in the characterization of African lungfish. Since this freshwater fish can survive in low oxygen conditions, its aquaculture potential is promising for smallholders in drought-stricken areas of Africa. A Latin American species native to the Pacific coast, chame is already a traditional fish of the poor. University of Hawai’i researchers will be focusing on developing spawning and rearing methods for this species under hatchery conditions. The University of Michigan project is working with gars, another Latin American species group. These species are excellent aquaculture candidates due to their rapid growth potential, adaptability to high densities, and high tolerance of low water quality conditions. CRSP researchers will be experimenting with feeding strategies and population density, water quality, and salinity tolerance trials.

# Research Project Investigations

**Topic Area**

## Production System Design & Best Management Alternatives

❖

### Experimental Pond Unit Assessment in Uganda

Production System Design & Best Management Alternatives/Activity/09BMA08AU

#### Collaborating Institutions & Lead Investigators

Auburn University (USA) Joseph J. Molnar

National Fisheries Resources Research Institute (Uganda) John Walakira

[Awaiting submission of final work plan]

### Experimental Pond Unit Assessment in Bangladesh

Production System Design & Best Management Alternatives/Activity/09BMA09NC

#### Collaborating Institutions & Lead Investigators

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North Carolina State University (USA) Russell Borski

Harry Daniels

#### Objectives

1. Evaluate ponds in North Central and Southwest region of Bangladesh and Eastern North Carolina for their physical, chemical, and biological characteristics during a growout.

2. Evaluate the ability of BAU to complete all of these measures.

#### Significance

The physical, chemical, and biological characteristics of ponds are critical features to optimizing efficiency and developing best management practices for the culture of finfish, shellfish and seaweeds. We propose a series of activities to evaluate ponds for their physical, chemical, and biological characteristics during a growout, and the second is to determine the ability of each research site to complete all of these measures. The following describes a series of measurements that will be carried out at each experimental site for the AquaFish CRSP, and outlines some of the reasons for these measurements. The methods for pond characterization are well described in a number of publications, including Egna et. al. (1987), Egna and Boyd (1997) and the *Standard Methods for the Examination of Water and Wastewater* (APHA et al. 2012).

##### Physical characteristics

A number of physical characteristics that includes pond morphometry, pond soils, pond depth, evaporation rate, seepage rate, and water temperature are critical for undertaking quality experiments in ponds. Morphometry, or the physical shape of the pond, is important as it is essential for determination of pond water volume, assessment of water loss and replacement, and for calculating crop stocking numbers based on water volume. Usually morphometry is measured from the pond banks, and the actual working pond morphometry then is dependent on how much water is added to the pond. Morphometry can most easily be assessed by measuring the depth at regular intervals, *e.g.* every meter, along transects that span the pond from the bank top. The surface area and pond volume can be calculated at a given depth for the working pond.

Pond depth is a simpler measure that describes the amount of water in a pond at any time. It is usually measured at the deepest point in a pond, which is often either the center or the depth at the drain or monk. Measures of pond depth are generally taken daily, and water is often replaced on a weekly basis to maintain a regular pond depth. Pond depth is also controlled during a rain event by the drain standpipe or monk boards, which only allow water to reach a certain level before it is discharged. For this work, depth will be measured and water replaced weekly, if necessary. Also, it is important to measure the loss of water from a pond during rainfall events, as this water will carry nutrients and other materials.

Evaporation of water occurs continually from a pond, depending on humidity, temperature, and wind. We can measure evaporation rate simply with an evaporation pan, and relate it to the other physical parameters mentioned above. Typically, evaporation is not measured regularly in aquaculture ponds. For this work, it will be measured at stocking, mid grow out, and harvest.

Seepage is a similar measure that takes into account the water leakage from a pond. It does vary with pond depth, and again it strongly affects water use in aquaculture. Seepage can be measured by evaluating changes in pond depth and those changes expected to occur due to evaporation. This team will measure seepage at the same time as evaporation rate, to simplify the calculations.

Water temperature is the last physical parameter to be measured. Because ponds are shallow and exposed to sunlight and wind they tend to warm up dramatically during the day, may stratify on calm days, and mix thoroughly on windy days or at night. So temperature must be measured multiple times at multiple depths to get relevant information. It would be most relevant to do continual measurements at about hourly intervals at multiple depths, at least including surface, mid-depth, and just off the bottom. The simplest method for this is to use a data sonde that can continually measure and record temperature. If this is not available, then a temperature meter can be used and either set up for continual measures or manually used each hour at each depth needed. The measures can provide a good overview of the temperature characteristics influencing the pond, and also can be used to determine rates of primary production in the pond. Finally, because seasonal events also strongly influence temperature, and because it is an important factor influencing animal physiology, this research team will also measure temperature at the 3 depths on weekly basis.

Chemical Parameters

The chemistry of pond water and effluent can dramatically affect the pond ecosystem as well as the organisms being cultured. It also is an indicator of management methods and their success. While a very large number of variables can be monitored, we will focus on those most commonly related to production in a pond. These include dissolved oxygen, pH, alkalinity, phosphorus, various forms of nitrogen, and dissolved and suspended solids. Salinity would be another important factor for marine or brackish water systems.

Dissolved oxygen (DO) is also a very important parameter for survival of animals in ponds. Like temperature, DO can stratify dramatically in ponds and also changes dramatically over the diel period. Maximum DO occurs during the day in ponds with much primary production, and the minimum occurs at dawn after a long night of respiration alone. Also, if pond water stratifies, then most likely oxygen will stratify even more strongly than temperature. This is particularly true in shallow ponds as most commonly light penetration is limited to the upper 40 cm or so of water, and all primary production occurs in this zone, while in deeper waters, even during the day, limited oxygen may be produced and oxygen levels could decline from the time of first stratification until the pond is mixed again in the evening. Therefore, like temperature, DO should be measured frequently on a diel basis and at various depths, again most reasonably the surface, mid-water, and bottom for ponds of depths around 1 m. It will also be measured regularly at dawn on a weekly basis to evaluate longer-term trends.

pH is the measure of acidity in the water. It is affected by a large number of chemical characteristics, including the water source, the balance of carbon in the water, and other acids or bases in solution. It also can show variations with depth and with time, as it is affected by forms of carbon in the pond and therefore by rate of primary production, at least in waters with moderate to low levels of alkalinity. Therefore, pH should be measured frequently over a 24-hr period, as is done with DO and temperature. Since pH influences toxicity of NO2 and NH3, it should be measured weekly on a composite sample.

Alkalinity is a measure of the combination of carbon in the water. It includes carbon in the forms of carbon dioxide, carbonate, and bicarbonate. Water usually becomes more basic in pH with greater concentrations of dissolved carbon. Therefore measure of alkalinity is usually done by titrating water to a set level of pH. Highly alkaline waters have lots of carbon for primary production, and therefore are usually limited by phosphorus, nitrogen, or light penetration. However, low alkalinity waters, particularly those below 30 mg/L alkalinity as CaCO3, may become limited in carbon as well. The addition of feed or organic fertilizer, which contain ample carbon, to pond waters can increase alkalinity. However, if just inorganic forms of TSP and NH3 are used for fertilization, then alkalinity may decline and carbon becomes limiting to primary production. Alkalinity can be measured once a day to get a reasonable idea of the carbon conditions in a pond. However, if changes in pond water are to be used to determine primary production rates, then alkalinity should be measured on a diel basis similar to temperature, DO, and pH. So both weekly and diel measures are appropriate.

In temperate freshwaters, phosphorus is considered the major limiting nutrient. In such waters, addition of inorganic phosphorus can result in increased rates of primary and secondary production, and depending on the species present, increased production of the target organisms. While several forms of phosphorus are found, their conversion tends to occur very rapidly. Therefore, total phosphorus concentration in pond water is a common measurement of overall phosphorus levels. Although phosphorus can vary over the day or at depth, it is not so dramatic as DO and temperature. Therefore, total phosphorus will be measured during midday using a mixed water column sample. This mixed sample would include water from all depths of the pond, and is usually collected with a large pipe that can be lowered and sampled to include all depths in the column. The measurement frequency should be weekly.

If phosphorus is the limiting nutrient in pond water, then its addition will increase primary production. However, at some level phosphorus will become available in surplus, and then no further increase in primary production will occur with additional inputs. If regular water quality measurements were being made, this point would be obvious by phosphorus increasing in concentration in the water column. At this point some other nutrient has become limiting, and most likely this will be nitrogen. Addition of nitrogen, in the form of urea, nitrate, and the like can further stimulate primary production. Combined supplementation of nitrogen and phosphorus will then continue to drive up even higher rates of primary production. Previous CRSP work showed that the optimum rate of fertilization is 4 kg N and 1 kg P per ha per day (28 kg and 7 kg/ha/week). At this optimum rate, both nitrogen and phosphorus are input at rates that allow high rates of primary production yet do not result in drastic declines in DO and give high production rates for Nile tilapia (Boyd and Egna 1997). We have used this as well as higher rates for silver carp and found no major difference in production of carps. Therefore, we will use the CRSP rate (28 kg and 7 kg/ha/week) in assessing ponds during tilapia and silver carp polyculture.

Nitrogen in pond water varies in form depending on the nitrogen cycle. Depending on the aerobic nature of the pond water, and on pH, some of these forms can be toxic while others are necessary for primary production. For those reasons, it is useful to measure all forms of nitrogen in the pond. Nitrate (NO3) is the most readily taken up by plankton for photosynthesis, and is often the dominant form of nitrogen in the water. Ammonia (NH4+) is the primary product of aquatic organisms. It can be toxic when converted to ammonium (NH3) at high water pH. Nitrite (NO2) is an intermediate form of nitrogen in the nitrogen cycle as it is converted from NH3 to NO3, and can also be toxic to animals at high pH. Finally, total Kjeldahl nitrogen (TKN) is the nitrogen dissolved in the water as well as that found in microorganisms in the water column. Dissolved inorganic nitrogen is the sum of NO2, NH3, and NO3. We will measure all of these forms, including NO2/ NO3, NH3, and TKN in our pond characterizations. Since nitrogen forms do not show large changes with depth or time of day, they will be measured weekly using a composite water sample around midday.

The final chemical variable for freshwater systems is a measure of solids. Total dissolved solids (TDS) include many of the elements listed before, plus others. Suspended solids are those that are un-dissolved substance within the water column usually due to the source water. Suspended solids cause turbidity, and can limit primary production by reducing light penetration. While many components of suspended solids will settle out of supply water if it is held in a calm state, some colloids of clay will remain in solution and raise turbidity. In any case, both total suspended solids (TSS) and TDS will be measured on a weekly basis like phosphorus and nitrogen.

##### Biological characteristics

Besides the biomass and production of the target organisms in a pond, other biological characteristics are important. Phytoplankton production in ponds is of interest as it can provide an assessment of overall natural food productivity of a pond. The amount of phytoplankton can be estimated either by the rate of primary production or through a measure of the phytoplankton standing crop. While bacteria and other microbes may be very important in pond culture, we have not regularly measured microbial processes in pond waters.

Phytoplankton in the water may be characterized by their species composition, but this is a tedious process and usually not undertaken unless an experimental protocol is particularly interested in the production of certain phytoplankton species. However, total plankton biomass is a variable of interest to most pond culture systems. We can estimate plankton standing crop by measuring light penetration. Since algae in pond water block light penetration, the lower the light penetration, the higher the plankton standing crop. Of course, solids in the water can also influence light penetration, and the best comparisons would be when changes in light penetration are measured over time in a water system. The simplest measure of light penetration is the Secchi disk, which is lowered into the water until it disappears from sight. The amount of light penetration is twice the Secchi disk depth, since for one to see light reflection from the disk, light has to penetrate both down to the disk and back up to the eye. Usually a measure of 2xSDD is considered the compensation point or the depth at which sufficient light penetrates to allow for primary production. Thus in this case a shallow SDD indicates high concentration of plankton, and a deep SDD indicates less plankton biomass. Since biomass is often related to production, low SDD may also indicate high rates of primary production, although this measure is less directly proportional than the relationship to biomass.

Another measure of plankton biomass is the concentration of chlorophyll in the water column. Since chlorophyll is present in all photosynthesizing algae, it is an indicator of algal biomass. Again, we typically measure chlorophyll-a because it is the dominant form of chlorophyll in freshwater systems. We will measure it on a weekly basis from combined water samples.

Primary production is a measure of the rate of photosynthesis. Historically, it was measured by the light-dark bottle method, and the increase in DO in a bottle of water with light allowed to penetrate was used as an estimate of net primary productivity (photosynthesis minus respiration in the organisms contained in the bottle), while the decline in DO in the bottle kept in the dark was a measure of respiration only, and the sum of respiration plus NPP gave the gross primary production of the organisms in the bottle. This works well for low productivity, natural waters where it may take several days to measure an increase in the light bottle and a decline in the dark bottle. In highly eutrophic aquaculture ponds, the high amounts of material added result in high rates or respiration, and dark bottle DO often declines to near zero in a matter of hours. Similarly, since light penetration and primary production are related to depth and stratification in ponds, a number of bottles at different depths would be necessary to reasonably approximate whole pond production. Several studies have shown that the light-dark bottle method is not suitable for estimating primary production in aquaculture ponds.

A second method, which is preferable as an estimate of primary production in aquaculture ponds, is the whole pond method. This method uses the increases in DO during the day and the declines at night to approximate photosynthesis and respiration in the pond. Of course, diffusion at the pond surface may also influence DO levels, so it may be necessary to correct for diffusion in the estimate. Once again, since the values of DO, pH, alkalinity, and temperature are being collected at 3 depths and on a regular basis over the diel period; we can use these to calculate the net primary productivity, respiration, and gross primary productivity of the whole pond system. Templates for these calculations are available in several CRSP documents. For a reasonable estimate of whole pond production, measurements of DO, temperature, pH, and alkalinity should be taken at dawn, midday, dusk, midnight, and the next dawn.

In summary, this proposal lists the main water quality variables to be monitored in pond aquaculture, and the reasons for the number and frequency of those measurements. A table below lists the variables again and their metrics. Methods for the measurement of each parameter are in Egna et al. (1987) and were partly based on APHA et al. (2012).

#### Quantifiable Anticipated Benefits

1. An improved understanding of the physical, chemical and biological characteristics of aquaculture ponds in Bangladesh will be gained including identification of the experimental opportunities and potential limits of BAU research sites.
2. The training of project personnel will build human capacity with expertise on pond dynamics and water quality assessment for the aquaculture industry.
3. Pond characterization will enhance the capacity to develop better pond management strategies needed to promote more efficient seafood production and increase incomes for poor communities.

#### Research Design & Activity Plan

Data will be collected from ponds in North Central region of Bangladesh in Mymensingh at the BAU Fisheries Field Laboratory during Nile tilapia *(Orechormis niloticus)* and silver carp (*Hypophthalmichthys molitrix*) growout ponds, and from ponds in the Khulna region of Southwest Bangladesh during growout of prawns (*Macrobrachium rosenbergii*). The Khulna region is a coastal area, where freshwater prawn aquaculture has the potential to significantly expand. Efforts has so far been directed towards improvement of production systems, no attempt has ever been taken in these ponds to assess the various characteristics for optimization of management strategies for sustainable production systems. Parallel data will be collected from ponds in rural Eastern North Carolina at the NC Tidewater Research Station (Plymouth, NC). Prawn culture has emerged over the past several years as a backyard aquaculture industry in North Carolina, and pond characterization during culture, particularly during the early stages when pond natural productivity is critical, is needed for improving management practices.

Twelve freshwater ponds at BAU on-station will be stocked with Nile tilapia and silver carp at a ratio of 1:1 (2 fish/m2) and separated into 3 groups: Four ponds will receive fertilization alone, 4 will receive fertilization + daily feed (3% body weight of total fish), and 4 will receive fertilization + feed on alternate days (3% body weight of total fish). Ponds will be prepared according to standard procedures and fertilizes will be applied one week before stocking and every week thereafter at 28 kg N and 7 kg P/ha/week (CRSP developed standard fertilization rate) using inorganic fertilizers, urea and TSP. Locally available commercial feeds will be used.

Four freshwater prawn ponds in the Khulna region will be selected from a Government Fish Farm and stocked with prawns PL (post larvae) at 2 pieces/m2. Ponds will be prepared according to standard procedures and fertilizer will be applied one week before stocking and every week thereafter at 28 kg N and 7 kg P/ha/week, using either local organic and/or inorganic fertilizers. Locally available commercial feeds will be used.

Post larvae freshwater prawns will be stocked at 2 pieces/m2 in six ponds at the Tidewater Research Station in Eastern North Carolina and grown out extensively under common industry standards (D’Abramo et al. 2009). Three ponds each will receive either a high or a low water stable pelletized feed. Both series of ponds will be fertilized weekly at a rate of 28 kg N and 7 kg P/ha/week.

Ponds will be managed for 90-120 days, and then harvested. Weekly measurements as described above and also in Table 1 will be done in midweek from water collected at the center of the pond. Diel measurements will be made 3 times; once in the second week, midpoint and final week of growout using the methods described above.

Table 1. Physical, chemical, and biological characteristics to be sampled during pond characterization.

| **Variable** | **Daily Frequency** | **How often** | **Type of sample** |
| --- | --- | --- | --- |
| Pond morphometry | - | Once |  |
| Pond depth | Once | Daily | One |
| Evaporation | Once | 3 times | One |
| Seepage | Once | 3 times | One |
| Temperature | Diel measures | 3 times | 3 depths |
| Dissolved oxygen | Diel measures | 3 times | 3 depths |
| pH | Diel | 3 times | 3 depths |
| Alkalinity | Diel | 3 times | 3 depths |
| Water depth | Once | Weekly | Whole pond |
| Temperature | Once | Weekly | 3 depths |
| DO | Once | Weekly at dawn | Composite sample |
| pH | Once | Weekly | Composite sample |
| Alkalinity | Once | Weekly | Composite sample |
| Total phosphorus | Once | Weekly | Composite sample |
| Total Kjeldahl nitrogen | Once | Weekly | Composite sample |
| Ammonia | Once | Weekly | Composite sample |
| NO3/NO2 | Once | Weekly | Composite sample |
| Secchi disk depth | Once | Weekly | Whole pond |
| Chlorophyll-a | Once | Weekly | Composite sample |

Production data including survival, growth rate, and yield will be made for fish and shellfish from all ponds. Differences among treatment groups will be assessed by ANOVA where appropriate. ANOVA will be used to evaluate changes in water quality over time and/or between treatments. In addition to chemical concentrations, diel measurements will be used to determine stratification in the ponds and primary productions rates. These will also be compared among treatments using ANOVA where appropriate.

#### Schedule: April 2012 – September 2012

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### Experimental Pond Unit Assessment in Ghana

Production System Design & Best Management Alternatives/Activity/09BMA10PU

#### Collaborating Institutions & Lead Investigators

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Kwame Nkrumah University of Science & Technology (Ghana) Stephen Amisah

Nelson W. Agbo

#### Introduction

In furtherance of the broader objectives of the AquaFish CRSP, a set of experimental sites are being developed across select countries across Africa, Asia, and the Americas, where common experiments will be carried out to investigate aquaculture technologies and management practices that may be transferable among regions. Better management practices developed through these activities will support sustainable development of aquaculture with minimum environmental impacts.

#### Objectives

1. Evaluate ponds at two experimental sites for their physical, chemical, and biological characteristics during a grow-out.
2. Develop a baseline set of physical, chemical, and biological characteristics of ponds for future AquaFish CRSP experiments.
3. Build on existing training opportunities, institutional networks, and research and extension capacity to promote small-scale aquaculture development in Ghana.

#### Significance

#### Quantifiable Anticipated Benefits

* Two research and development facilities, the KNUST fish farm and the Pilot Aquaculture Center (PAC) of the Fisheries Directorate of the Ministry of Agriculture will be enhanced for their capacity to generate high-quality scientific information on pond and environmental soil and water quality, thereby providing the needed confidence in these facilities for use in future AquaFish CRSP research.
* KNUST and PAC personnel will acquire further knowledge and practical skills, and will in turn train students and fisheries officers in various aspects of pond water quality management.
* Outreach opportunity will be provided through a Best Management Practices (BMP) workshop, where fisheries officers and farmers interact in a rare forum for extension.
* KNUST and the Fisheries Directorate working together with Virginia Tech on this project furthers the objective of capacity building and institutional networking both within Ghana and across continents to benefit development of aquaculture in Ghana.

#### Activity Plan

##### Location

Study will be conducted in the Ashanti Region of Ghana by Ghanaian and US experts and trainees. The primary site of the study is the KNUST farm situated on the campus of the University in Kumasi. The secondary site is PAC, the experimental farms of the Fisheries Directorate in Ashanti Region, located in Tano-Odumasi, north of Kumasi. Six ponds will be studied at KNUST and 4 ponds will be studied at PAC, for a total of 10 ponds from two sites. We consider the two farms as replicates and ponds within a farm as subsamples to help estimate with-in site variation. Four of the ponds at KNUST and all 4 ponds at PAC will be ponds already being used in AquaFish CRSP experiments involving comparison of Tilapia (*Oreochromis niloticus*) growth on locally manufactured sinking feed, formulated floating feed, recycled pond water, and fresh pond water. The two additional ponds at KNUST will not be stocked.

##### Methods

The KNUST farm, being primary site, will be under the full protocol of measurements described in the sections below, whereas the PAC site will be treated as a pilot site, with all measurements as described in the protocol below but with measurements made less frequently, i.e., on a biweekly basis. Ponds will be monitored for a minimum of 3 months to a maximum of 6 months during which time tilapia growth will be monitored under the related experiment. This will add value to the data obtained in addition to providing the needed baseline information for future experiments and validation of the capacity of these research facilities to execute a rigorous protocol of water quality and environmental data collection. The methods for pond characterization will follow Egna et al. (1987), chapters in Egna and Boyd (1997), and the *Standard Methods for the Examination of Water and Wastewater* (APHA et al. 2012) or a version not older than 2007.

**Physical and chemical characterization**: The characteristics we will measure include pond morphometry, pond soils, pond depth, evaporation rate, seepage rate, water temperature, and a suite of water chemistry variables.

Morphometry will be measured by measuring depths at 1-m intervals along several transects across the pond, from the top of one bank to the opposite bank. These points will be interpolated to develop a bathymetric map of each pond so that the surface area and pond volume can be calculated at each depth for the working pond. Pond depth will also be measured at the deepest point daily, and will serve as the basis for weekly water replacements if needed. We will measure evaporation rate with an evaporation pan, and relate it to the other physical measures. Amount of water discharged during rain, if any, and seepage will be determined from the daily measurements of pond depth and evaporation. Pond bottom soils will be measured for their physical and chemical properties but the suite of variables will depend on capacity of the Soils Research Institute in Kumasi and the cost of analysis by the lab. Possible variables will include percent clay, silt, sand, and organic matter, as well as pH (wet), P, Ca, Mg, K, Na, total N (%), NH4-N (ppm), NO3-N, CEC (meq/100 g), soluble salts (mmhos/cm), Al (ppm), Fe, Zn, Mn, Cu, SO4-S, lime requirement (SMP), free CaCO3 (meq/100 g), Exch-H (meq/100 g), and Exch-Na (meq/100 g). Soils samples to be analyzed will be collected at various locations from the pond bottom (before flooding for ponds that are dry prior to the sampling). Composite cores will be taken from wet ponds. Water temperature will be measured frequently and profiled vertically for each pond for surface, mid-depth, and bottom. Temperature loggers will be used. The water chemistry variables that will be measured include dissolved oxygen, phosphorus (as TP), various forms of nitrogen (TKN, NO2, NO3, and NH3/NH4+), pH, alkalinity, and dissolved and suspended solids (TDS and TSS). The measurement schedule depends on the spatio-temporal variability of each variable and the expected co-variation among these variables (Table 1).

**Biological characterization**: We will estimate plankton standing crop by measuring light penetration, using the Secchi disc method, and compensation point determined as 2 × Secchi disc depth. We will also measure the concentration of chlorophyll-*a* for a more direct indication of phytoplankton biomass and pond productivity. Since the values of DO, pH, alkalinity, and temperature are being collected at 3 depths and on a regular basis over the diel period; we will use these to calculate the net primary productivity, respiration, and gross primary productivity of each pond. Each pond will include one additional dawn, midday, dusk, midnight, and the following dawn’s measurement of DO, pH, alkalinity, and temperature before the end of the experiment to allow for the use of templates developed by previous CRSP work to produce reliable estimates.

**Training and networking***:* In addition to the intensive data collection on pond dynamics, we will utilize this research for training of students, fisheries officers, and farmers. This will be accomplished by leveraging ongoing AquaFish CRSP work. We will engage fisheries officers and MPhil students of KNUST as field and laboratory technicians and as resource persons during scheduled workshops on pond water quality management and aquaculture BMPs. We expect up to 8 regional fisheries officers in the Ashanti, Brong-Ahafo, and Western regions of Ghana and three MPhil students of KNUST to be involved with various aspects of this project. In addition, at least 100 farmers are expected to attend the BMP workshop in June 2012, during which these MPhil students and fisheries officers will serve resource-person roles (for example, as breakout group leaders) to help educate farmers about the importance of proper water quality management and the techniques and options available when they need advice.

Table 1.- Summary of water measurements and sampling schedule.

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Daily Frequency | How often | Type of sample |
| **PHYSICAL & CHEMICAL** |  | | |
| Pond morphometry | - | Once |  |
| Pond soils | - | Once | Composite |
| Pond depth | Once | Daily | One |
| Water depth | Once | Weekly | Whole pond |
| Evaporation | Once | 3 times | One |
| Seepage | Once | 3 times | One |
| Temperature | Diel measures | 3 times | 3 depths |
| DO | Diel measures | 3 times | 3 depths |
| DO | Once | Weekly at dawn | Composite |
| pH | Diel measures | 3 times | 3 depths |
| Alkalinity | Diel measures | 3 times | 3 depths |
| TP, TDS/Conductivity, TSS | Once | Weekly | Composite |
| TKN, NH3/NH4+, NO2/NO3 | Once | Weekly | Composite |
| **BIOLOGICAL** |  | | |
| Secchi disk depth | Once | Weekly | Whole pond |
| Chlorophyll-a | Once | Weekly | Composite |

#### Schedule

**Start date**: January 1, 2012 **End date**: September 29, 2012

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Activity/Month** | **Jan**  **12** | **Feb**  **12** | **Mar**  **12** | **Apr**  **12** | **May**  **12** | **Jun**  **12** | **Jul**  **12** | **Aug**  **12** | **Sep**  **12** |
| Site selection/protocol development | X | X |  |  |  |  |  |  |  |
| Start of monitoring activities |  |  | X |  |  |  |  |  |  |
| Ongoing pond monitoring activities |  |  |  | X | X | X | X | X |  |
| First quarterly report |  |  | X |  |  |  |  |  |  |
| Second quarterly report |  |  |  |  |  | X |  |  |  |
| BMP workshop |  |  |  |  |  | X |  |  |  |
| End of activities |  |  |  |  |  |  |  |  | X |
| Data analysis and report preparation |  |  |  |  |  |  |  |  | X |
| Delivery of final report |  |  |  |  |  |  |  |  | X |

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### Experimental Pond Unit Assessment in Kenya/Tanzania

Production System Design & Best Management Alternatives /Activity/09BMA11UA

#### Collaborating Institutions & Lead Investigators

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Sokoine University of Agriculture (Tanzania) Sebastian Chenyambuga

[Awaiting submission of final work plan]

### Experiment Pond Unit Assessment in Cambodia

Production System Design & Best Management Alternatives /Activity/09BMA12UC

#### Collaborating Institutions & Lead Investigators

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Inland Fisheries Research & Development Institute (Cambodia) So Nam

Freshwater Aquaculture Research & Development Center (Cambodia) Nen Phanna

Can Tho University (Vietnam) Vu Ngoc Ut

#### Objectives

1. To evaluate ponds in Southeastern Cambodia for their physical, chemical, and biological characteristics during a grow out.
2. To determine the ability of IFReDI/FARDeC to complete all of these measures.

#### Significance

In Cambodia fish provide a main source of protein and essential nutrients of daily diet for millions of people, especially for the poor households in rural areas; and also contribute to the national economy. It contributes more than 75 percent of people’s animal protein intake (Ahmed et al. 1998; So Nam and Buoy Roitana, 2005). The national fish consumption rate is in average of 23-31kg capita-1 year-1 (So Nam and Nao Thuok 1999). Fish consumption and export are mainly supplied by fish catches from inland waters. Since wild fish catches have dramatically declined from year to year due to illegal and overfishing; and fish demand have also been increased in response to rapid population growth, aquaculture sector has been practiced in the country. 80 percent of aquaculture production comes from cages and pens in Tonle Sap Great Lake, Tonle Sap, Mekong and Bassac River systems (Mekong River Commission 2002); and the commercial species cultured in cages include the river catfish *Pangasianodon* *hypophthalmus* and giant snakehead *Channa Micropeltes*. Raising fish in ponds and paddy fields is less developed in Cambodia (MRC, 2002), contributing about 15-20 percent of total aquaculture production. Since 2005 small-scale aquaculture has been jointly promoted and supported by the government, NGOs and international agencies (e.g. JICA, PADEK, AIT, etc.) for the poor and in the areas far away from natural water bodies which are lack of fish consumption. The small-scale cultures are mainly in ponds, rice fields and integrated fish farming with livestock and vegetables. The main species cultured in those systems, particularly in pond, include Tilapia, Chinese carp, Indian carp and some indigenous species (e.g. silver barb, walking catfish, river catfish).

Currently, pond culture has increased in number and may play an important role in aquaculture development throughout the country in the future. Pond characteristics, physical, chemical and biological factors, interact in pond ecosystem as well as the organisms being culture (Egna & Boyd, 1997). Water quality in fish ponds is a major factor determining the production of fish (Egan and Boyd, 1997). Evaporation and seepage contribute to the water losses from the pond, resulting in higher densities of fish in the pond which can lead to various water quality problems (Egna and Boyd, 1997) causing stress to fish or direct mortality and lowering the production per cycle. The study of pond characterization, water quality, nutrient cycling and water use in pond aquaculture have been done in many parts of the world. For example in the neighboring countries like Thailand and Vietnam, many researches and studies in the field of aquaculture have been done and their aquaculture sectors have rapidly developed. So far Cambodia’s aquaculture is less developed because lack of research and study has been conducted and lack of experts of this field. So, it is necessary to conduct a research on physical, chemical and biological characteristics of aquaculture pond during growth out since it may contribute to aquaculture development in Cambodia.

This pond characterization experiment has two goals; the first is to evaluate ponds at each research site for their physical, chemical, and biological characteristics during a grow out, and the second is to determine the ability of each research site to complete all of these measures. The methods for pond characterization are well described in a number of publications, including Egna et al. (1987) and the *Standard Methods for the Examination of Water and Wastewater* (multiple versions of this are available; the most recent is APHA et al. 2012). The purpose of this document is to describe a series of measurements that will be carried out at each experimental site for the AquaFish CRSP, and to outline some of the reasons for these measurements.

#### Quantifiable Anticipated Benefits

* The completion of a pond characterization experiment in Southern Cambodia will provide a complete understanding of the strengths and weaknesses of IFReDI and FARDeC for further experiment.
* A better understanding of the physical, chemical, and biological characteristics of Cambodian ponds will aid culturists in determining better methods of feeding, fertilizing, and managing water quality. This could lead to increased profits, the supply of high quality fish protein to Cambodian communities with limited food resources, and the overall growth of the aquaculture sector.
* 100 scientists, researchers, resource managers, government officials, non-government organizations, and inter-governmental organizations concerned with and working on the pond aquaculture in Cambodia and Vietnam, and Asia Pacific region will be better informed of (1) evaluation of ponds at the research site for their physical, chemical, and biological characteristics during a grow out, and (2) the assessment of ability of the research site to complete all of these measures through project reports and two training workshops in Cambodia and Vietnam.
* Two undergraduate students will be supported and trained through their B.Sc. thesis research.
* At least 50,000 pond fish culture farmers in Cambodia and Vietnam will benefit from this Investigation through the two training workshops and further communication and dissemination of research results provided by Department of Aquaculture of the Cambodian and Vietnamese governments.

#### Research Design & Activity Plan

##### Location of work

The experiment will be conducted in 12 growth-out ponds at Freshwater Aquaculture Research and Development Center (FARDeC), Prey Veng province, Cambodia. Some samples for water quality analysis (Table 1) will be taken and analyzed at Laboratory of Can Tho University, Vietnam.

##### Experimental set-up

|  |  |  |
| --- | --- | --- |
| **Pond Treatments** | **Replicated ponds** | **Inputs** |
| I | 4 | Fertilizer alone (control) |
| II | 4 | Feed alone |
| III | 4 | a combination of feed and fertilizer |

##### Pond preparation

Prior to filling the pond, bottom weed are removed manually, then agricultural limestone are applied evenly over the pond bottom two weeks prior to fertilization. Fertilization will commence one week before stocking.

##### Nutrient inputs:

1. Fertilization will be at 4 kg N and 1kg P per hectare daily, using local nutrient sources that are either organic or inorganic, and will be applied once a week.
2. Feeding will be done twice daily at morning and evening. Locally available feeds will be used. Feeding will be applied ad libitum.
3. Feeding will be at half satiation (as determined in the second treatment).

##### Stocking procedures

All ponds will be stocked with male (mono-sex) Nile tilapia *Oreochromis niloticus* of average weight between 25 and 30 grams. Stocking density is at 2 fish/m2 (600 fish per 300 m2 pond).

##### Duration of experiments

The experiment will be conducted for a period of five months (150 days). The experimental cycle will run during the rainy season starting from 01st of April till 30th of August.

##### Data collection and analysis

Data including yield, growth rate, and survival will be made for fish from all treatments, and comparisons made using ANOVA. Changes in water quality between treatments and over time will be tested using ANOVA. In addition to chemical concentrations, diel measurements will be used to determine stratification in the ponds and primary productions rates. These will also be compared among treatments using ANOVA.

Table 1. Physical, chemical, and biological characteristics to be sampled during pond characterization.

| **Variable** | **Daily Frequency** | **How often** | **Type of sample** |
| --- | --- | --- | --- |
| Pond morphometry | - | Once |  |
| Pond depth | Once | Daily | One |
| Evaporation | Once | 3 times | One |
| Seepage | Once | 3 times | One |
| Temperature | Diel measures | 3 times | 3 depths |
| Dissolved oxygen | Diel measures | 3 times | 3 depths |
| pH | Diel | 3 times | 3 depths |
| Alkalinity | Diel | 3 times | 3 depths |
| Water depth | Once | Weekly | Whole pond |
| Temperature | Once | Weekly | 3 depths |
| DO | Once | Weekly at dawn | Composite sample |
| pH | Once | Weekly | Composite sample |
| Alkalinity | Once | Weekly | Composite sample |
| Total phosphorus | Once | Weekly | Composite sample |
| Total Kjeldahl nitrogen | once | Weekly | Composite sample |
| Ammonia | Once | Weekly | Composite sample |
| NO3/NO2 | Once | Weekly | Composite sample |
| Secchi disk depth | Once | Weekly | Whole pond |
| Chlorophyll-a | Once | Weekly | Composite sample |

*Source: Adopted from Jim Diana (2012)*

#### Schedule

This activity is planned to be implemented as below:

|  |  |  |
| --- | --- | --- |
| **Activity** | **Beginning** | **Ending** |
| Experimental designs | 03/2012 | 04/2012 |
| Hand-on training on “Water sampling and water quality analysis” in Vietnam | 03/2012 | 04/2012 |
| Implementation of the experiments | 04/2012 | 08/2012 |
| Analysis of results and report preparation | 08/2012 | 09/2012 |
| Training workshop on “Consultation and dissemination of EPUA results” in Cambodia | 08/2012 | 09/2012 |

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Table 2: Procedures and methods for sampling

| **Parameter** | **Procedure** | **Instrumentation** | **Analytical method** | **Reporting unit** | **Authors** |
| --- | --- | --- | --- | --- | --- |
| Rainfall | Install three rain gauges at study site. Read and empty at 24 hour interval; report average of three reading. |  |  | cm/day | Egna, 1987 |
| Evaporation | Install PVC chambers (each with 5.6 mm inner diameter, 200 mm height and area of 24.63 m2) near pond surface.  Fill chamber with pond water, take reading of the difference in water level at 24 hour interval daily basis. | PVC chamber built outside with transparent graded scale. |  | m3/day | Nhan et al., 2008 |
| Seepage | Install PVC pipes (each with 8 cm diameter and 1.5 m long) at three random sites of each pond by pushing one end into pond bottom at average depth of 30 cm, and protruding other end above the water surface. Fill the pipe with water to the zero mark in the morning and record difference in water height next morning at 24 hour interval. | PVC pipe built outside with transparent graded scale tubing on outside of the main pipe. |  | m3/day | Muendo et al., 2005 |
| Pond depth | Install staff gauge in each pond and read to the nearest 0.5 cm at the same time each day. Maintain 0.9 m average depth on daily basis. | No type specific |  | m | Egna, 1987 |
| Pond temperature | Near the center of each pond take reading at 25 cm below the water surface, at midwater, and at 25 cm above the bottom. Take reading once per week; if probe is used, calibrate using a precision thermometer. | Model 57 dissolved oxygen meter with temperature indicator. |  | oC | Egna, 1987 |
| Dissolved Oxygen | Near the center of each pond, take reading at 25 cm below water surface, midwater and 25 cm above the bottom. Sample once per week at dawn and as part of monthly diurnal study at 4 hour intervals beginning 30 minutes before sunrise until after sunrise. | Model 57 Dissolved Oxygen Meter |  | mg/l | Egna, 1987 |
| pH | Take measurements from three pooled 90 cm column samples per pond once per week, and as part of the diurnal study at 4-hour intervals. Pooled samples should be taken to the laboratory and measured within the hour. Meter should be calibrated with standard buffers at pH 7 &4. | pH meter with Combination Electrode |  | pH unit | Egna, 1987 |
| Alkalinity | Weekly at 14:00 h as part of even week diurnal study, collect one sample (by pooling three 90-cm column samples from each pond. Keep samples cool in refrigeration unit or ice chest, and analyze within 24 hours | HachDigital Titrator  Test kit/Alkalinity; Lower or higher Alkalinity Method (APHA , 1980) |  | mg CaCO3/l | Egna, 1987 |
| Ammonia | Weekly at 14:00 h collect one sample (by pooling three 90 cm column samples) from each pond. Samples should be refrigerated and analyzed within 24 hours. | Kontes or comparable Kjedahl nitrogen apparatus | standard method (APHA) | mg/l | Egna 1987 |
| NO3/NO2 | Weekly at 14:00 h collect one sample (by pooling three 90 cm column samples) from each pond. Samples should be refrigerated and analyzed within 24 hours. | Kontes or comparable Kjedahl nitrogen apparatus | standard method (APHA) | mg/l | Egna, 1987 |
| Total Kjedahl nitrogen | Weekly, starting two days after each fertilizer application, and once per month as part of the diurnal study for each pond, pool three 90 cm column samples. Composite samples should be refrigerated and analyzed within 24 hours. | Kontes or comparable Kjedahl nitrogen apparatus |  | mg/l | Egna, 1987 |
| Total phosphorus | Weekly, starting two days after each fertilizer application, and once per month as part of the diurnal study for each pond, pool three 90 cm column samples. Composite samples should be refrigerated and analyzed within 24 hours. |  | Persulfate Digestion and Ascorbic Acid/ Colorimetric Method (American Public Health Association, 1980 | mg/l | Egna, 1987 |
| Secchi disk visibility | Sample are collected twice each week between 11:00 h and 14:00h on the same days as chlorophyll analyses at two locations in each pond |  | Calculate Secchi disk visibility using procedure described by Lind OT 1974. | cm | Egna, 1987 |
| Chlorophyll-a | Collect one sample per pond by pooling three 90-cm column samples. Take sample twice each week with one sampling period coinciding with monthly diurnal study. |  | Spectrophotometric Determination (APHA, 1980). Standard Method for examination of water and waste water, 15th ed; Washington; DC. pp 950-954. | mg/m3 | Egna, 1987 |

### Experimental Pond Unit Assessment in Nicaragua

Production System Design & Best Management Alternatives /Activity/09BMA13UH

#### Collaborating Institutions & Lead Investigators

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#### Background

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

#### Objectives

This pond characterization experiment has two goals; the first is to evaluate ponds at a key research and demonstration site for their physical, chemical, and biological characteristics during a grow out, and the second is to determine the ability of each research site to complete all of these measures. The methods for pond characterization are well described in a number of publications, including Egna et al. (1987) and the *Standard Methods for the Examination of Water and Wastewater* (multiple versions of this are available, the most recent is APHA et al. 2012). The purpose of this document is to describe a series of measurements that will be carried out at each experimental site for the AquaFish CRSP, and to outline some of the reasons for these measurements.

Specific objectives**:**

1. To evaluate freshwater aquaculture ponds in Nicaragua for their physical, chemical, and biological characteristics during a grow out cycle.
2. To determine the ability of CIDEA/UCA to complete all of these measures with accuracy and precision.

#### Significance

Increasingly aquaculture supplies more of the world’s seafood, providing 50% of the world’s supply in 2010 (FAO 2010). As of 2002, fish supplied 20% of the world’s protein (FAO 2002). As the world’s population continues to grow and resources become yet more taxed, improving the efficiency and sustainability of production systems is ever more critical.

Multiple species of tilapia are cultured in the world and this group of fishes is growing in importance both as a species for domestic consumption and for export in Nicaragua. Tilapia are easy to culture because they are not commonly affected by diseases and water quality problems. They also grow very fast under crowded condition and high level of production can be achieved, because they feed on plankton and benthic organism. This fish is very popular for culture in developing countries it can be cultured at all levels of intensity (Egna and Boyd, 1997). Improving and adapting methods to individual locations is important to increase the efficiency of tilapia production. Tilapia is the primary freshwater culture fish in Central America, yet Nicaragua lags behind other Central American countries in production volume and development of locally-appropriate production methods.

Pond management it is a key factor because the major effort and expense occur in the grow-out of fingerling fish to marketable sized animals in ponds. Mistakes in management also can reduce yield and lead to the death of all or part of the fish in a pond.

Many factors are involved in pond management, beginning with the site selection design and construction considerations (Hajek and Boyd, 1994). Climate meteorological factors can’t be controlled by producers, but other factors can be controlled such plankton density, soil and water characteristic, feeding programs, drugs and harvest time. The location of aquaculture project in wetlands, water pollution by pond effluents, soil and water pollution by solid wastes from aquaculture and social conflicts over sources and space allocation are examples of some of the problems that can result from poor design or badly managed aquaculture project.

CIDEA/UCA is the leading research, training and extension center in Nicaragua. Its freshwater demonstration farm, La Polvosa, is located near Managua and has been in production for about five years, yet production is believed to be sub-optimal. More research is needed to identify improved water quality and pond management methods, as well as to train new staff. While CIDEA/UCA has good laboratory facilities, improvement of analytical procedures is needed, particularly since rigorous procedures have not been recently conducted for freshwater fish production since CIDEA/UCA has most recently been focused on marine shrimp production and methods and parameters associated with that activity. This work will allow CIDEA/UCA staff to strengthen its ability to collect and analyze samples and data, as well as detect any short-comings or flaws in its analytical or human capacity. Since La Polvosa is located in an area where fish farming is projected to grow and which has good conditions for this, information obtained as a result of this research will have wider applicability.

##### Physical characteristics

A number of physical characteristics are important in aquaculture, particularly for the completion of quality experiments in ponds. The most obvious ones include pond morphometry, pond soils, pond depth, evaporation rate, seepage rate, and water temperature.

Morphometry, or the physical shape of the pond, is important because it describes the physical place where experiments occur, and helps to assess water loss and replacement in volume. Usually morphometry is measured from the pond banks, and the actual working pond morphometry then is dependent on how much water is added to the pond. Morphometry can most easily be measured by simply making a number of transects across the pond itself, from the bank top, and measuring the depth at regular intervals (usually some frequency like 10 per transect or every meter) across the transect. In this manner, the surface area and pond volume can be calculated at each depth for the working pond.

Pond soils have a strong effect on the chemical conditions in overlying waters. At times acidic soils must be treated to reduce their impact on water quality, and at other times ponds may need to be compacted or have sediments removed to improve water retention and quality. Therefore, we have consistently measured pond soil conditions as part of our experiments characterizing pond ecology. Often these measures are difficult to do in our own labs, and therefore collected soils have been sent to other soil labs for analysis. Our list of measurements in the past includes percent clay, silt, sand, and organic matter, as well as pH (wet), P, Ca, Mg, K, Na, total N (%), NH4-N (ppm), NO3-N, CEC  (meq/100 g), soluble salts (mmhos/cm), Al (ppm), Fe, Zn Mn Cu SO4-S lime requirement (SMP), free CaCO3  (meq/100 g), Exch-H  (meq/100 g), and Exch-Na  (meq/100 g). Soils samples to be analyzed are collected from the pond bottom before flooding, and usually a composite sample from a variety of parts of he pond bottom is collected. We have used both government labs in host countries as well as US university labs for our soil characterization.

Pond depth is a simpler measure that describes the amount of water in a pond at any time. It is usually measured at the deepest point in a pond, which is often either the center or the depth at the drain or monk. Our measures of pond depth are generally taken daily, and water is often replaced on a weekly basis to maintain a regular pond depth. Pond depth is also controlled during a rain event by the drain stand pipe or monk boards, which only allow water to reach a certain level before it is discharged. For our work, depth will be measured and water replaced weekly, if necessary. Also, it is important to measure the loss of water from a pond during rainfall events, as this water will carry nutrients and other materials.

Evaporation of water occurs continually from a pond, depending on humidity, temperature, and wind. We can measure evaporation rate simply with an evaporation pan, and relate it to the other physical parameters mentioned above. We typically have not measured evaporation that regularly in ponds, probably only 2-3 times per grow out. For our case, that would be at stocking, mid grow out, and harvest.

Seepage is a similar measure that takes into account the water leakage from a pond. It does vary with pond depth, and again it strongly affects water use in aquaculture. Once again, seepage can be measured by evaluating changes in pond depth and those changes expected to occur due to evaporation. We should measure seepage at the same time that we measure evaporation rate, to simplify the calculations.

Finally, water temperature is the last physical parameter to be measured. This is complicated by the fact that ponds are shallow and exposed to sunlight and wind. Therefore, they may warm dramatically during the day, may stratify on calm days, and may mix thoroughly on windy days or at night. So temperature must be measured multiple times at multiple depths to get relevant information. The existence of data sondes that can monitor temperature and oxygen over time have simplified this process, and it would be most relevant to do continual measurements at about hourly intervals at multiple depths, at least including surface, mid-depth, and just off the bottom. The measures can provide a good overview of the temperature characteristics influencing the pond, and also can be used to determine rates of primary production in the pond. Finally, because seasonal events also strongly influence temperature, and because it is an important factor influencing animal physiology, we should also measure temperature at the 3 depths on weekly basis.

##### Chemical Parameters

The chemistry of pond water and effluent has dramatic effects on the pond ecosystem as well as the organisms being cultured. It also is an indicator of management methods and their success. While a very large number of variables can be monitored, in our pond experiments we have focused on those most commonly related to production in a pond. These include dissolved oxygen, phosphorus, various forms of nitrogen, pH, alkalinity, and dissolved and suspended solids. For marine or brackish water systems, obviously salinity would be another important factor.

Dissolved oxygen (DO), like temperature, can stratify dramatically in ponds and also changes dramatically over the diel period. Maximum DO occurs during the day in ponds with much primary production, and the minimum occurs at dawn after a long night of respiration alone. Also, if pond water stratifies, then most likely oxygen will stratify even more strongly than temperature. This is particularly true in shallow ponds as most commonly light penetration is limited to the upper 40 cm or so of water, and all primary production occurs in this zone, while in deeper waters, even during the day, limited oxygen may be produced and oxygen levels may decline from the time of first stratification until the pond is mixed again in the evening. Therefore, like temperature, we should measure DO on an hourly basis and at various depths, again most reasonably the surface, mid-water, and bottom for ponds of depths around 1 m. The simplest method for this is to use a data sonde that can continually measure and record DO and temperature. If this is not available, then a DO meter can be used and either set up for continual measures or manually used each hour at each depth needed. Since DO is also a very important parameter for survival of animals in ponds, we should also measure it regularly at dawn to evaluate longer term trends. These measures should be done on a weekly basis.

In temperate freshwaters, phosphorus is considered the major limiting nutrient. In such waters, addition of phosphorus in the form of triple super phosphate can result in increased rates of primary and secondary production, and depending on the species present, increased production of the target organisms. While phosphorus is found in several forms, most commonly we have measured the total phosphorus concentration of pond water since the conversion between these forms tends to occur very rapidly. While phosphorus can vary over the day or at depth, it is not so dramatic as DO and temperature. Therefore, we most commonly measure total phosphorus during midday using a mixed water column sample. This mixed sample would include water from all depths of the pond, and is usually collected with a large pipe that can be lowered and sampled to include all depths in the column. The measurement frequency should be weekly.

If phosphorus is the limiting nutrient in pond water, then its addition will increase primary production. However, at some level phosphorus will become available in surplus, and then no further increase in primary production will occur with additional inputs. If regular water quality measurements were being made, this point would be obvious by phosphorus increasing in concentration in the water column. At this point some other nutrient has become limiting, and most likely this will be nitrogen. Addition of nitrogen, in the form of urea, nitrate, and the like can further stimulate primary production. Combined supplementation of nitrogen and phosphorus will then continue to drive up even higher rates of primary production. Pond experiments in Thailand, for example, have shown us that that optimum rate of fertilization is 4 kg N and 1 kg P per ha per day. At this optimum rate, both nitrogen and phosphorus are input at rates that allow high rates of primary production yet do not result in drastic declines in DO and give high production rates for Nile tilapia.

Nitrogen in pond water varies in form depending on the nitrogen cycle. Depending on the aerobic nature of the pond water, and on pH, some of these forms can be toxic while others are necessary for primary production. For those reasons, we tend to monitor all forms of nitrogen in the pond. Nitrate is the most readily taken up by plankton for photosynthesis, and is often the dominant form of nitrogen in the water. Ammonia (NH4+) is given off as a waste product by aquatic organisms. It can be toxic when it is converted back to ammonium (NH3) at high water pH. Nitrite (NO2) is an intermediate form of nitrogen in the nitrogen cycle as it is converted from NH3 back to NO3, and can also be toxic to animals at high pH. Finally, total Kjeldahl nitrogen (TKN) is the nitrogen contained dissolved in the water as well as that found in microorganisms in the water column. Dissolved inorganic nitrogen is the sum of NO2, NH3, and NO3. In our pond characterization we will measure all of these forms, including NO2/ NO3, NH3, and TKN. Since nitrogen forms do not show large changes with depth or time of day, they will also be measured weekly using a composite water sample around midday.

pH is the measure of acidity in the water. It is affected by a large number of chemical characteristics, including the water source, the balance of carbon in the water, and other acids or bases in solution. It also can show variations with depth and with time, as it is affected by forms of carbon in the pond and therefore by rate of primary production, at least in waters with moderate to low levels of alkalinity. Therefore, we measure pH hourly at each depth, as was done with DO and temperature. Data sondes often have pH as an added variable measured, making this a fairly simple measure. Otherwise, manual measurement with a pH meter will be necessary. Since pH influences toxicity of NO2 and NH3, we should also measure it weekly on a composite sample.

Alkalinity is a measure of the combination of carbon in the water. It includes carbon in the forms of carbon dioxide, carbonate, and bicarbonate. With more dissolved carbon in the water, usually the water becomes more basic in pH, and therefore the measure of alkalinity is usually done by titrating water to a set level of pH. Highly alkaline waters have lots of carbon for primary production, and therefore are usually limited by phosphorus, nitrogen, or light penetration. However, low alkalinity waters, particularly those below 30 mg/L alkalinity as CaCO3, may become limited in carbon as well. If feed or organic fertilizers are added to pond waters, they can increase alkalinity because they have lots of carbon contained within. However, if just inorganic forms of TSP and NH3 are used for fertilization, then alkalinity may decline and carbon become limiting to primary production. While we can simply measure alkalinity once a day to get a reason able idea of the carbon conditions in a pond, if we use the changes in pond water to determine primary production rates, then we should measure alkalinity on a diel basis similar to temperature, DO, and pH. So both weekly and diel measures are appropriate.

The final chemical variable for freshwater systems is a measure of solids. Total dissolved solids include many of the elements listed before, plus others. Suspended solids are those that are in the water column usually due to the source water, but not dissolved. Suspended solids cause turbidity, and can limit primary production by reducing light penetration. While many components of suspended solids will settle out of supply water if it is held in a calm state, some colloids of clay will remain in solution and raise turbidity. In any case, both TSS and TDS should be measured on a weekly basis like phosphorus and nitrogen.

In mariculture, salinity is also an important characteristic. Total salinity is a measure of the ions in solution in water, usually expressed in parts per thousand. It can be measured easily with a refractometer. Marine waters are in the 30-35 ppt range, brackishwater in the 0.5-30 ppt range, and freshwater 0-0.5 ppt. Since marine organisms may be affected strongly by changes in salinity, we generally would measure salinity along with the other variables like TP and NH3 on a weekly basis. It is not necessary to measure salinity in freshwater pond culture, and may require more frequent measures in a brackishwater culture.

In addition to our regular measures of pond water quality, we also monitor water quality of pond effluents released at harvest. Chemically these would include all of the measures done above on a weekly basis. In addition, we monitor water overflow during rain or water import events, but rather than make a quantitative measure, we just indicate whether overflow occurred on any particular date.

##### Biological characteristics

Besides the biomass and production of the target organisms in a pond (which we are not measuring in this experiment), other biological characteristics are important. Generally the interest would be in the amount of phytoplankton production in ponds, either by estimating the rate of primary production or the phytoplankton standing crop. While bacteria and other microbes may be very important in pond culture, we have not regularly measured microbial processes in pond waters.

Phytoplankton in the water may be characterized by their species composition, but this is a tedious process and usually not undertaken unless an experimental protocol is particularly interested in the production of certain phytoplankton species. However, total plankton biomass is a variable of interest to most pond culture systems. We can estimate plankton standing crop by measuring light penetration. Since algae in pond water block light penetration, the lower the light penetration, the higher the plankton standing crop. Of course, solids in the water can also influence light penetration, and the best comparisons would be when changes in light penetration are measured over time in a water system. The simplest measure of light penetration is the Secchi disk, which is lowered into the water until it disappears from sight. The amount of light penetration is twice the Secchi disk depth, since for one to see light reflection from the disk, light has to penetrate both down to the disk and back up to the eye. Usually a measure of 2xSDD is considered the compensation point or the depth at which sufficient light penetrates to allow for primary production. Thus in this case a shallow SDD indicates high concentration of plankton, and a deep SDD indicates less plankton biomass. Since biomass is often related to production, low SDD may also indicate high rates of primary production, although this measure is less directly proportional than the relationship to biomass.

Another measure of plankton biomass is the concentration of chlorophyll in the water column. Since chlorophyll is present in all photosynthesizing algae, it is an indicator of algal biomass. Again, we typically measure chlorophyll-a because it is the dominant form of chlorophyll, and measure it on a weekly basis from combined water samples.

Primary production is a measure of the rate of photosynthesis. Historically, it was measured by the light-dark bottle method, and the increase in DO in a bottle of water with light allowed to penetrate was used as an estimate of net primary productivity (photosynthesis minus respiration in the organisms contained in the bottle), while the decline in DO in the bottle kept in the dark was a measure of respiration only, and the sum of respiration plus NPP gave the gross primary production of the organisms in the bottle. This works well for low productivity, natural waters where it may take several days to measure an increase in the light bottle and a decline in the dark bottle. In highly eutrophic aquaculture ponds, the high amounts of material added result in high rates or respiration, and dark bottle DO often declines to near zero in a matter of hours. Similarly, since light penetration and primary production are related to depth and stratification in ponds, a number of bottles at different depths would be necessary to reasonably approximate whole pond production. Several studies have shown that the light-dark bottle method is not suitable for estimating primary production in aquaculture ponds.

A second method which is preferable as an estimate of primary production in aquaculture ponds is the whole pond method. This method uses the increases in DO during the day and the declines at night to approximate photosynthesis and respiration in the pond. Of course, diffusion at the pond surface may also influence DO levels, so it may be necessary to correct for diffusion in the estimate. Once again, since the values of DO, pH, alkalinity, and temperature are being collected at 3 depths and on a regular basis over the diel period; we can use these to calculate the net primary productivity, respiration, and gross primary productivity of the whole pond system. Templates for these calculations are available in several CRSP documents. For a reasonable estimate of whole pond production, measurements of DO, temperature, pH, and alkalinity should be taken at dawn, midday, dusk, midnight, and the next dawn.

#### Quantifiable Anticipated Benefits

*Quantifiable benefits* will include: development of a rigorous and ample database of physical, chemical and biological parameters for the La Polvosa freshwater demonstration farm. The staff will also increase their capacity to collect and analyze samples and data, as well as interpret the findings in order to improve pond management and tilapia production.

##### Metrics:

* Number of institutions directly or indirectly benefiting from the training: 2
* Number of individual participants in extension and technical training: 5
* Students involved: 1
* Training modules produced: 1
* CRSP newsletter articles: 1
* Peer-reviewed journal article: 1

#### Research Design & Activity Plan

##### Study area

This work will be executed in the Demonstration and Training Farm “La Polvosa”, located in the Municipality of Mateares, Department of Managua. The farm is located 45 km from the capital of Managua. It is in region that is considered good for aquaculture development for tilapia and other freshwater fish.

##### Experimental design

For this study, four ponds will be utilized, two which measure 150 m2 and two which measure 200 m2. Each pond is 1.5 m in depth and has a pond liner. Water levels will be maintained at 1-1.2 meters. Each pond will be stocked with tilapia fingerlings at a density of 8 fish/m2 for a total of 5,600 fingerlings. Base on previous experience, a survival of 85% is predicted. The fish will be fed pelleted fish feed (28% protein) at a rate to be determined by a standard feeding table. In general, fish weighing 1.5 pounds each can be obtained in 6 months, although due to the four month period of this study, a lower average harvest weight is predicted.

##### Sampling and data collection

Biomass sampling will be conducted every 15 days after stocking to obtain estimates of length (cm) and weight (g), as well as survival. Water quality samples will be taken as described in Table 1. Bacteriological samples will also be taken and will include *Esherichia coli*, fecal coliforms, total coliforms, *Enterococcus*, and *Pseudomonas*. Fish tissues will also be tested for *Pseudomonas* and *Aeromonas*. Samples of the solids on the pond bottom will be twice during the culture cycle.

**Table 1.** Physical, chemical, and biological characteristics to be sampled during pond characterization.

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Daily Frequency** | **How often** | **Type of sample** |
| Pond morphometry | - | Once |  |
| Pond depth | Once | Daily | One |
| Evaporation | Once | 3 times | One |
| Seepage | Once | 3 times | One |
| Temperature | Diel measures | 3 times | 3 depths |
| Dissolved oxygen | Diel measures | 3 times | 3 depths |
| pH | Diel | 3 times | 3 depths |
| Alkalinity | Diel | 3 times | 3 depths |
| Water depth | Once | Weekly | Whole pond |
| Temperature | Once | Weekly | 3 depths |
| DO | Once | Weekly at dawn | Composite sample |
| pH | Once | Weekly | Composite sample |
| Alkalinity | Once | Weekly | Composite sample |
| Total phosphorus | Once | Weekly | Composite sample |
| Total Kjeldahl nitrogen | once | Weekly | Composite sample |
| Ammonia | Once | Weekly | Composite sample |
| NO3/NO2 | Once | Weekly | Composite sample |
| Secchi disk depth | Once | Weekly | Whole pond |
| Chlorophyll-a | Once | Weekly | Composite sample |

Data including yield, growth rate, and survival will be made for fish from all treatments, and comparisons made using ANOVA. Changes in water quality between treatments and over time will be tested using ANOVA. In addition to chemical concentrations, diel measurements will be used to determine stratification in the ponds and primary productions rates. These will also be compared among treatments using ANOVA.

#### Schedule

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Activity** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** |
| Acquisition of materials and supplies for laboratory analyses; production supplies | x |  |  |  |  |  |
| Pond preparation | x | x |  |  |  |  |
| Obtain fish fingerlings |  | x |  |  |  |  |
| Pond stocking |  | x |  |  |  |  |
| Sample collection and analysis |  | x | x | x | x | x |
| Collection of benthic samples |  |  | x |  |  | x |
| Pond harvest and collection of production data |  |  |  |  |  | x |
| Final analysis of results, production of reports |  |  |  |  |  | x |

#### Student Involvement

One undergraduate student obtaining her degree in Environmental Quality, Erika Pastora, will be involved with this work. Three CRSP staff persons, Nelvia Hernandez, Erick Sandoval and Juan Ramon Bravo, are also in the process of obtaining their Masters degrees and are using their work experience with CRSP to satisfy some course requirements for practical work.

### Experimental Pond Unit Assessment in Nepal

Production System Design & Best Management Alternatives/Activity/09BMA14UM

#### Collaborating Institutions & Lead Investigators

Institute of Animal & Agricultural Science (Nepal) Madhav Shrestha

University of Michigan (USA) James S. Diana

#### Objectives

1. To evaluate ponds in Southern Nepal for their physical, chemical, and biological characteristics during a grow out.

1. To determine the ability of IAAS to complete all of these measures.

#### Significance

This pond characterization experiment has two goals; the first is to evaluate ponds at each research site for their physical, chemical, and biological characteristics during a grow out, and the second is to determine the ability of each research site to complete all of these measures. The methods for pond characterization are well described in a number of publications, including Egna et al. (1987) and the *Standard Methods for the Examination of Water and Wastewater* (multiple versions of this are available, the most recent is APHA et al. 2012). The purpose of this document is to describe a series of measurements that will be carried out at each experimental site for the AquaFish CRSP, and to outline some of the reasons for these measurements.

##### Physical characteristics

A number of physical characteristics are important in aquaculture, particularly for the completion of quality experiments in ponds. The most obvious ones include pond morphometry, pond depth, evaporation rate, seepage rate, and water temperature.

Morphometry, or the physical shape of the pond, is important because it describes the physical place where experiments occur, and helps to assess water loss and replacement in volume. Usually morphometry is measured from the pond banks, and the actual working pond morphometry then is dependent on how much water is added to the pond. Morphometry can most easily be measured by simply making a number of transects across the pond itself, from the bank top, and measuring the depth at regular intervals (usually some frequency like 10 per transect or every meter) across the transect. In this manner, the surface area and pond volume can be calculated at each depth for the working pond.

Pond depth is a simpler measure that describes the amount of water in a pond at any time. It is usually measured at the deepest point in a pond, which is often either the center or the depth at the drain or monk. Our measures of pond depth are generally taken daily, and water is often replaced on a weekly basis to maintain a regular pond depth. Pond depth is also controlled during a rain event by the drain stand pipe or monk boards, which only allow water to reach a certain level before it is discharged. For our work, depth will be measured and water replaced weekly, if necessary. Also, it is important to measure the loss of water from a pond during rainfall events, as this water will carry nutrients and other materials.

Evaporation of water occurs continually from a pond, depending on humidity, temperature, and wind. We can measure evaporation rate simply with an evaporation pan, and relate it to the other physical parameters mentioned above. We typically have not measured evaporation that regularly in ponds, probably only 2-3 times per grow out. For our case, that would be at stocking, mid grow out, and harvest.

Seepage is a similar measure that takes into account the water leakage from a pond. It does vary with pond depth, and again it strongly affects water use in aquaculture. Once again, seepage can be measured by evaluating changes in pond depth and those changes expected to occur due to evaporation. We should measure seepage at the same time that we measure evaporation rate, to simplify the calculations.

Finally, water temperature is the last physical parameter to be measured. This is complicated by the fact that ponds are shallow and exposed to sunlight and wind. Therefore, they may warm dramatically during the day, may stratify on calm days, and may mix thoroughly on windy days or at night. So temperature must be measured multiple times at multiple depths to get relevant information. The existence of data sondes that can monitor temperature and oxygen over time have simplified this process, and it would be most relevant to do continual measurements at about hourly intervals at multiple depths, at least including surface, mid-depth, and just off the bottom. The measures can provide a good overview of the temperature characteristics influencing the pond, and also can be used to determine rates of primary production in the pond. Finally, because seasonal events also strongly influence temperature, and because it is an important factor influencing animal physiology, we should also measure temperature at the 3 depths on weekly basis.

##### Chemical Parameters

The chemistry of pond water has dramatic effects on the pond ecosystem as well as the organisms being cultured. It also is an indicator of management methods and their success. While a very large number of variables can be monitored, in our pond experiments we have focused on those most commonly related to production in a pond. These include dissolved oxygen, phosphorus, various forms of nitrogen, pH, alkalinity, and dissolved and suspended solids. For marine or brackish water systems, obviously salinity would be another important factor.

Dissolved oxygen (DO), like temperature, can stratify dramatically in ponds and also changes dramatically over the diel period. Maximum DO occurs during the day in ponds with much primary production, and the minimum occurs at dawn after a long night of respiration alone. Also, if pond water stratifies, then most likely oxygen will stratify even more strongly than temperature. This is particularly true in shallow ponds as most commonly light penetration is limited to the upper 40 cm or so of water, and all primary production occurs in this zone, while in deeper waters, even during the day, limited oxygen may be produced and oxygen levels may decline from the time of first stratification until the pond is mixed again in the evening. Therefore, like temperature, we should measure DO on an hourly basis and at various depths, again most reasonably the surface, mid-water, and bottom for ponds of depths around 1 m. The simplest method for this is to use a data sonde that can continually measure and record DO and temperature. If this is not available, then a DO meter can be used and either set up for continual measures or manually used each hour at each depth needed. Since DO is also a very important parameter for survival of animals in ponds, we should also measure it regularly at dawn to evaluate longer term trends. These measures should be done on a weekly basis.

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##### Biological characteristics

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A second method which is preferable as an estimate of primary production in aquaculture ponds is the whole pond method. This methods uses the increases in DO during the day and the declines at night to approximate photosynthesis and respiration in the pond. Of course, diffusion at the pond surface may also influence DO levels, so it may be necessary to correct for diffusion in the estimate. Once again, since the values of DO, pH, alkalinity, and temperature are being collected at 3 depths and on a regular basis over the diel period; we can use these to calculate the net primary productivity, respiration, and gross primary productivity of the whole pond system. Templates for these calculations are available in several CRSP documents. For a reasonable estimate of whole pond production, measurements of DO, temperature, pH, and alkalinity should be taken at dawn, midday, dusk, midnight, and the next dawn.

##### Summary

This document lists the main water quality variables to be monitored in pond aquaculture, and the reasons for the number and frequency of those measurements. A summary table below lists the variables again and their metrics. Methods for the measurement of each parameter are developed in Egna et al. (1987) and were partly based on APHA et al. (2012).

#### Quantifiable Anticipated Benefits

The completion of a pond characterization experiment in Southern Nepal will provide a complete understanding of the strengths and weaknesses of IAAS for further experiments. Through this understanding improvements in the infrastructure and training of project personnel could be done if necessary to fulfill future research. In addition, a better understanding of the physical, chemical, and biological characteristics of Nepalese ponds will aid culturists in determining better methods of feeding, fertilizing, and managing water quality. This could lead to increased profits, the supply of high quality fish protein to communities with limited food resources, and the overall growth of the aquaculture sector.

#### Research Design & Activity Plan

Locations: Data collection will be focused in Chitwan, Nepal. Twelve ponds will be used for the work, with 4 control ponds receiving fertilization alone, 4 fully fed ponds with feed applied ad libitum, and 4 combined ponds with both feed and fertilizer applied, feeding at half satiation (as determined in the second treatment).

All ponds will be stocked with sex-reversed Nile tilapia (*Oreochromis niloticus*) at 2 fish/m2. Fertilization will commence one week before stocking. Fertilization will be at 4 kg N and 1 kg P per hectare daily, using local nutrient sources that are either organic or inorganic, and will be applied once a week. Feeding will be done twice daily at midday and evening. Locally available feeds will be used.

Ponds will be managed for 120 days, and then harvested. Weekly measurements as described above and also in Table 1 will be done in mid-week from water collected at the center of the pond. Diel measurements will be made 3 times; once in the second, ninth, and 15th week using the methods described above.

Data including yield, growth rate, and survival will be made for fish from all treatments, and comparisons made using ANOVA. Changes in water quality between treatments and over time will be tested using ANOVA. In addition to chemical concentrations, diel measurements will be used to determine stratification in the ponds and primary productions rates. These will also be compared among treatments using ANOVA.

Table 1. Physical, chemical, and biological characteristics to be sampled during pond characterization.

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Daily Frequency** | **How often** | **Type of sample** |
| Pond morphometry | - | Once |  |
| Pond depth | Once | Daily | One |
| Evaporation | Once | 3 times | One |
| Seepage | Once | 3 times | One |
| Temperature | Diel measures | 3 times | 3 depths |
| Dissolved oxygen | Diel measures | 3 times | 3 depths |
| pH | Diel | 3 times | 3 depths |
| Alkalinity | Diel | 3 times | 3 depths |
| Water depth | Once | Weekly | Whole pond |
| Temperature | Once | Weekly | 3 depths |
| DO | Once | Weekly at dawn | Composite sample |
| pH | Once | Weekly | Composite sample |
| Alkalinity | Once | Weekly | Composite sample |
| Total phosphorus | Once | Weekly | Composite sample |
| Total Kjeldahl nitrogen | once | Weekly | Composite sample |
| Ammonia | Once | Weekly | Composite sample |
| NO3/NO2 | Once | Weekly | Composite sample |
| Secchi disk depth | Once | Weekly | Whole pond |
| Chlorophyll-a | Once | Weekly | Composite sample |

#### Schedule

April 2012 – September 29, 2012

#### Literature Cited

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**Topic Area**

## Indigenous Species Development

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## Prospects and Potential of African Lungfish (*Protopterus* spp.) for Aquaculture in Uganda

Indigenous Species Development/Study/09IND09AU

#### Collaborating Institutions & Lead Investigators

Auburn University (USA) Joseph J. Molnar

National Fisheries Resources Research Institute (Uganda) John Walakira

[Awaiting submission of final work plan]

### Developing Feeds for Larval *D. latifrons* (Chame) Larvae

Indigenous Species Development/Study/09IND10UH

#### Collaborating Institutions & Lead Investigators

University of Hawai’i at Hilo (USA) Maria Haws

Armando Garcia-Ortega

North Carolina State University (USA) Mike Frinsko

Universidad Autónoma de Sinaloa- Culiacán (Mexico) Eladio Gaxiola Camacho

Universidad Autónoma de Sinaloa- Mazatlán (Mexico) Guillermo Rodriguez Dominguez Gustavo Rodriguez Oca de Montes

#### Executive Summary

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

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

This work encompasses three aspects: 1) further research to develop adequate first feeds to allow for hatchery production of the species; 2) conduct a study to elucidate the socio-economic aspects of chame utilization, stakeholder perceptions, habitat issues and threats; and 3) conduct a workshop with stakeholders on the use, management, aquaculture and food safety of chame. These efforts are conducted in the context of existing integrated coastal zone management programs for two States in southern Mexico.

#### Introduction

For this effort, we have chosen to focus on continuing research sponsored by the AFCRSP to develop a native fish species (“chame”, *Dormitator latifrons*) found throughout LAC that holds tremendous potential for aquaculture. Chame has been demonstrated to grow well in ponds in Ecuador using fingerlings obtained from the wild or from shrimp ponds. Chame enter shrimp ponds through the water supply and grow well there. Normally these fish were regarded as pest since they consumed shrimp feed, but recent aquaculture work has established a market for the fingerlings. Trials demonstrated that market size chame can be obtained in 6-9 months in monoculture or in polyculture with marine shrimp using a variety of feeds ranging including shrimp feeds, chicken feed or either of these mixed with vegetable sources such as mashed plantain or corn. Pond fertilization also appears to be an effective strategy for reducing feed needs. The omnivorous and detritivorous feeding habits of chame are another point in its favor, given the need for developing native species that are also low on the trophic chain. Additionally, the flesh is firm, white and has a mild flavor. This species is a facultative air breather and can be transported without water for several days. In the Ecuador trials, fingerlings were transported in crates wrapped in banana leaves and burlap bags to retain some moisture. This characteristic may also have benefits as climate change impacts lead to changes in temperature and precipitation regimes. Chame may also offer an alternative to small-scale shrimp farmers when disease or high input prices affect their ability to produce shrimp.

Given that chame has been targeted as a new aquaculture species for Latin America, dependence on wild fingerlings is not the most sustainable or economically feasible manner of developing either wide spread small-scale aquaculture, nor larger scale endeavors. CRSP researchers began working in 2009 to develop hatchery methods, primarily induced spawning and larval feeding, as well as elucidating basic biological and development characteristics of this species that could inform aquaculture research. Induced spawning using LHRHa either by implantation or injections, as well as inducing off-season maturation with modifications in rearing conditions and/or repetitive injections of 17α-methyltestosterone and human chorionic gonadotropin was achieved for males and females.

Larval feeding trials were less successful. A variety of micro-organisms (enriched and un-enriched), biofilms and artificial larval feeds were tested. The primary obstacle appears to be the very small mouth size (80-100 µ for the first 5 days) which appears to inhibit ingestion of most micro-organisms. Although some artificial feeds were ingested and particles were observed in the gut, larvae did not survive. These feeds may not be nutritionally adequate. Research findings suggest that chame larvae might not possess a sufficient degree of digestive tract morphological development and enzymatic activity to utilize the feeds tested. Some efforts are being directed towards a better understanding of this process in chame larvae using histological analysis since more insight into larval development is needed. Progress in developing hatchery methods, however, still depends on finding a suitable prey or inert diet for this fish at early ontogenetic stages of development.

*D. latifrons* is also a fisheries target species in some parts of its range, and may also be caught as bycatch in shrimp or other fisheries. In Ecuador, there is concern about the greatly diminished abundance of this species, which is related to the disappearance or degradation of its wetland habitats. This was one of the factors in the inability of local producers to obtain sufficient fingerlings to keep their chame aquaculture going. In Mexico and parts of Central America, it is eaten by some indigenous populations, and may also serve as a source of food during lean times or when other, more desirable fish species are not available. The actual extent of its utilization is not fully known, hence the concern as to whether it may be affected by aquaculture or by changes in habitat use, fisheries or other factors. Moreover, relatively little is known about the life history, reproductive strategies or other biological characteristics of this species. Hence, in 2011, a study of chame population dynamics in Sinaloa and Nayarit States was initiated. Findings suggest that these populations are in relatively good shape, but concerns exist that migration routes used by the fish are blocked by dams and other structures of all scales. It also became apparent that its catch rate and utilization was not well quantified or understood.

This past experience has suggested several strategies. New species of micro-organisms (i.e. freshwater rotifers and particularly small marine copepods) with potential as live food in aquaculture as well as new artificial larval feeds may offer a solution to improving survival at first feeding and weaning. Application of methods used for hybrid striped bass larval feeding (i.e. carefully timed production of greenwater cultures) may also prove to be successful. Small, easy to digest artificial diets such as those utilized for spotted rose snapper (*Lutjanus guttatus*) and bullseye puffer (*Sphoeroides annulatus*) will also be tested.

To further knowledge of the threats to chame habitats and to increase understanding of utilization by different socio-economic and ethnic groups, we propose conduct a study of chame habitat and socioeconomic aspects of its utilization. We will also hold a workshop for the various stakeholders for chame aquaculture and fisheries including fishers, women’s groups, state and federal agencies and university researchers and extension agents to exchange information and experiences with chame, including developing a strategy for moving forward with chame aquaculture and fisheries management. Dr. Silvia Paz, UAS researcher, will also present her research findings on the presence of gnathosomosis in chame as a possible health issue.

#### Vision Statement

This work will lead to development of hatchery methods so that chame can become a common culture species to improve food security in Latin America. Moreover, this research will contribute to increased understanding of the basic biology, fisheries dynamics and utilization of this species to lay the foundation for improved fisheries and aquaculture management.

###### Study 1: Developing Feeds for Larval D. latifrons (Chame) Larvae

#### Objectives

This work will continue efforts to find an adequate source of live micro-organisms and artificial diets for larval chame to permit hatchery production.

#### Significance

*D. latifrons* can be cultured in ponds using methods similar to those used for tilapia and these yield good results. Chame has been recognized as having the potential to be the “new tilapia” for Latin America, but aquaculture currently depends on the ability to obtain adequate numbers of wild fingerlings. This is an unsustainable strategy for future industry development. Development of hatchery methods will not only provide a reliable source of stock for aquaculture farmers, it will also allow researchers to conduct other types of research such as feed trials. Past research indicates that most standard live foods such as marine rotifers are too large for the chame larvae, which has a mouth gap of 80-100 µ for the first five days, to ingest. Several forms of artificial feeds have been successfully ingested, as evidenced by direct observation of particles in the digestive tract, but it is believed that these were not digestible since no fecal products were observed and the larvae did not survive. If either live feeds or artificial feeds can be developed, this will represent a significant advance for chame culture.

#### Quantifiable Anticipated Benefits

*Quantifiable benefits* will include: development of hatchery methods, number of students and technicians trained, development of a prototype hatchery, increased availability of information and increased interest in culture of a native species.

Metrics

Number of institutions directly or indirectly benefiting from the training: 6

Number of individual participants in extension and technical training: estimated at: 12

Number of communities: 5

Number of private businesses (including cooperatives and women’s groups): 5

Students involved: 2 under CRSP support and 4 more as technical assistance (FACIMAR-UAS)

CRSP newsletter articles: 1

Peer-reviewed journal article: 1 or 2

Benefits to the U.S.: there is interest in chame culture in the U.S. Chame is currently being imported from Ecuador and sold in the New York fish markets. It is also being exported to Europe and some Asian countries. Chame is found in southern California and a related species, *D. maculatus*, is found at the Gulf of Mexico. The latter has been targeted for aquaculture development as a commercial bait species (Gaudé et al., 2010). Aquaculture potential for these species may exist in the U.S. In the case of Hawaii, we hope to apply results from these studies to reproductive studies of 4 species of endemic fish from the taxonomic families Gobiidae and Eleotridae for aquaculture and conservation purposes.

#### Research Design & Activity Plan

Three strategies to achieve larval fish survival first feeding and during weaning will be utilized:

1. Artificial pond rearing of chame larvae;
2. Use of micro-zooplankton (<50 microns) as initial feed;
3. Use of highly digestible artificial microdiets; and
4. Mixed feeding programs.

##### Artificial pond rearing of chame larvae

We will collaborate with Mike Frinsko, Aquaculture Area Agent, NC Cooperative Extension, to test two alternative feeding strategies. Mr. Frinsko will be sharing his many years of experience stocking larvae hybrid striped bass in fertilized “fry” ponds. Larvae of this reciprocal cross (*Morone chrysops x Morone saxatilis*) are similar in size to chame larvae and require a first feeding of very small zooplankton. By carefully timing pond filling to stocking, 4 day old fry (time of first feeding) are stocked when natural populations of encysted rotifers begin to hatch from their resting stage in the pond soils. The numerous species available allow the larvae a broad nutrient “platform” from which to grow. The Mazatlan marine sciences research facility is a traditional mariculture research site; tank based, with no ponds available. As such, we would like to mimic the pond methods in our tanks (Ludwig, 1999). Depending on temperature (25-28 °C), we will first fertilize the tank water (5 ppt and 10 ppt) with a combination of organic (wheat bran) and inorganic fertilizers (sources of nitrogen and phosphorous) until the phytoplankton density is at least 12 cm Secchi depth. At that point we will inoculate the tanks (1000 liters) with 10-15 Kg/L dried surface soils collected along the Presidio river (15 miles from FACIMAR-UAS) and other water bodies nearby, where chame are known to spawn and grow in natural conditions. Rotifers encysted in the soil will hatch in the tanks and feed on the various phytoplankton already growing as a result of the fertilization. Unlike most marine larviculture practices where axenic zooplankton cultures are used, we will purposefully culture numerous rotifer species simultaneously to simulate the successful strategies used in pond culture situations. To enhance our opportunity for success, we will culture the zooplankton using 6 tanks staged 2 days apart. At this point (March, 2012) we have conducted a preliminary trial of massive rotifer production using such approach and we had remarkable results, achieving rotifers counts up to 300 rotifers per ml, in a very simple and cost-efficient way.

##### Use of micro-zooplankton (<50 microns) as initial feed

Other feeding alternatives include obtaining rotifers of particularly small strains from other locations in Mexico, including a collaboration with the Laboratorio de Acuicultura Tropical, División Académica de Ciencias Biológicas, Universidad Juárez Autónoma Tabascoto obtainrotifers such as *Brachionus quadridentatus brevispinus* (lorica length 12-14 microns) and *B. angularis* (lorica length 10-12 microns) (Dr Jeane Rimder Indy, UJAT Tabasco Personal Communication) for mass culture. These will be tested to evaluate consumption by chame larvae. A copepod strain, Amphiascoides paratopus (Harpacticoida: Miraciidae) that produces relatively small nauplii (40-60 µm) will be obtained in collaboration with CIAD Mazatlan (Ana Puello M.Sc. CIAD-Mazatlán, Personal Communication). Lastly, we will sieve rotifers produced in the “artificial ponds” to ensure only those of 50 um or less will be fed. Rotifers and copepod nauplii will be added to the larvae tanks 3 or more times daily to maintain the desired concentration of a minimum of 15 rotifers/L in small volume culture units (either 1, 3 or 20 liter containers). Our goal will be to confirm both consumption and digestion of these small zooplankton and follow larval growth to at least the stage where they can be weaned to live Artemia and/or a dry diet.

##### Use of highly digestible artificial microdiets

The second critical point during the larval rearing of fish requiring live food at first exogenous feeding is the acceptance and utilization of artificial diets at the time of weaning. In most marine fish the optimal weaning time is closely related to the time when all digestive capacities are fully developed. Since weaning implies a shift of feeding from live food to dry inert diets, high mortalities are present. The use of highly digestible artificial microdiets has been proven to be effective in the larval culture of tropical marine fish (García-Ortega et al., 2003; García-Ortega, 2009). The use of decapsulated cysts of Artemia as a source of protein in microdiets for fish yields high protein digestibility coefficients close to 90% (García-Ortega et al., 2000). In the present proposal, we aim to use microdiets formulated with high protein content (>50% dry weight) with a significant content of n-3 highly unsaturated fatty acids (HUFA) to improve chame growth and survival. Two different strategies will be tested in the artificial ponds tanks or designated tanks for weaning. One involves the co-feeding of live food and the microdiet from the earliest time possible when fish larvae can ingest feed particles of 150 μm size, which it is expected when the larvae reaches a size of at least 5 mm in length. The second strategy involves the use of copepods or enriched live food prior the time of weaning. During co-feeding the microdiets are supplied to the larval tanks in small quantities each time new live food is provided at least four times a day, increasing the amount and particle size of the microdiet as the fish are growing until the larvae are completely adapted to feed on it. In the second strategy, during weaning the microdiet will be fed in excess each day prior to the supplying of live food to the tanks. Each day the amount of supplied live food is gradually reduced 10%. It is expected chame larvae will be completely weaned onto the artificial microdiet in approximately ten days. Depending on the larvae preference the microdiets will be provided either in floating or sinking form.

The formulation and preparation of microbound diets will be done at PACRC- UH Hilo using two different binders: alginate and carboxymethyl cellulose. The artificial microdiets will be prepared in several particle size ranges starting from 150-300 μm, 300-500 μm, 500-850 μm and 850-1200 μm. Larval growth and survival will be determined before and after the co-feeding and weaning periods. We will included in these trials other diets such as a dried custard-type diet has been shown effective with numerous marine fish and crustaceans (Kovalenko et al., 2002) and will be ground to the appropriate size for chame larvae to ingest. These diets will be provided by Mike Frinsko (NC extension agent). Also, we will evaluate several new commercial lines of larval feeds. Such diets include MERA LV1 (20 um), LV2 (100 µm) (Novus Int.) and Micro mac 30-70 µm (Aquafauna Biomarine®) among others.

##### Mixed feeding schedules evaluation

In previous trials, we attempted feeding using commercial micro-particulate diets. We were able to demonstrate feed consumption with several of the diets, including dry spirulina, microalgae substitutes (Algamac and Artemac, Aquafauna Biomarine®), live food replacement diets (artificial plankton, Argent®) among others such as a gourmet diet made with a combination of fresh yolk egg and infant soy-based powder formula. Substantial evidence of the ingestion of feed particles was observed in the intestinal tract. We hypothesize the larvae were unable to digest the feeds, or that a significant transition to available food must take place within 2-4 days after these dry diets were offered; thus as a final last experiment we propose an evaluation of a combined feeding schedule using either microparticulated spirulina, a microalgae substitute (Algamac or Algamac-Plus) or our previously described gourmet diet (egg+ infant formula) for 1, 2 or 3 days for immediate partial or total transition to any of the above described life feed sources or artificial diets for later chame larvae survival and growth estimation (as Fulton´s modified condition index).

Statistical Analysis**:** Analyses will be performed using the SAS® statistical software Ver 9.1. Data on larval survival, condition index and length increase will be subjected to one-way analysis of variance (ANOVA). Larval performance in terms of food type and timing of addition (trial 4) will be analyzed using a multi-factorial analysis of variance. In all cases, significant results will be followed by a comparison of means using the Fishers´s Least Significant Difference (LSD) Test. Normality and homogeneity of variance tests will be performed on raw data. Sample distributions violating assumptions will be log-transformed before analysis. Data, expressed as percentages, will be arc sine-transformed before analysis. All differences will be regarded as significant at P < 0.05.

#### Schedule

Broodstock collection, gonad evaluation and hormone induction trials: May-September 2010. Diet preparation and delivery to FACIMAR-UAS (Mazatlán) May-July 2012. First feeding trials (artificial ponds and microzooplankton) August-September 2012. Feeding and weaning experiments August-September 2012. Collection of data on larval performance synthesis of data and preparation of manuscripts and fact sheets and final reports- September 2012.

#### Student involvement:

One undergraduate student will participate in this effort at PACRC-UH Hilo in the development of the artificial microdiets.

Two Master degree students: Jeniffer Velazquez Sandoval and Vanesa Vianney Lopez Lopez as well as three undergraduate students Sayra Yadira Peralta Rendon, Xitlaly Guadalupe Brito Martinez and Mario Alberto Torres Aguirre will be actively involved on broodstock maintenance, induced spawning, egg incubation and conduction on feeding trials. Also, they will be participating on the live feed production either as axenic cultures or collection of soil material, water preparation, fertilization and follow-up of rotifer blooms in tanks.

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###### Study 2: Effects of Habitat Degradation and Socio-Economic Aspects of the Utilization of the Pacific Fat Sleeper (*Dormitator latifrons*)

#### Objectives

The proposed research will be focused on improving the understanding of the utilization of *chame* (Pacific Fat Sleeper, *Dormitator latifrons*) in two Mexican States, Sinaloa and Nayarit, as well as issues associated with habitat degradation and restriction of migratory routes. Data will be compiled in a GIS dataset and maps produced for use in coastal spatial planning efforts for fisheries management and integrated coastal management efforts underway in these two States.

#### Significance

Currently chame is an unregulated species. Aside from the lack of protection offered by regulations, statistics are also not kept of its capture and use. Several unanticipated findings from the 2011 chame population study (09IND03UH) conducted in southern Mexico were that many of the migratory routes used by chame had been blocked by either small-scale or large-scale dams, and water diversions. Chame migrate between freshwater and estuarine areas on a seasonal basis, in part due to their reproductive cycle. The extent to which migration appeared to be blocked was surprising to the researchers. Climatic and anthromorphogenic influences may also be affecting the reproduction of chame. For example, large numbers of chame are trapped in isolated seasonal freshwater lagoons which form along the coast during the rainy season. It is known that gonad maturation occurs in these fish, but it is not known whether egg laying or reabsorption of the gonad occurs as the lagoons dry up and disappear. This may be an issue of concern now that droughts are more common and prolonged, possibly as an effect of global climate change.

Moreover, it became clear that the utilization, marketing and unintended capture of chame was largely unknown. Purposeful destruction of chame was also observed to be occurring when it was caught as bycatch in the coastal fisheries or when the fish are present in shrimp ponds. At the same time, chame may be more widely consumed than was previously thought. Chame are caught and sold locally as food, and are also captured for use as bait for other fisheries. Given that aquaculture development of chame is being pursued and that various factors appear to be adversely affecting wild chame populations, increasing the understanding of the socio-economic aspects of this species and its fishery and habitat would appear to be merited. Increased knowledge of the factors affecting the chame and the populations which utilize it will aid in future aquaculture and fisheries management efforts.

#### Quantifiable Anticipated Benefits

*Anticipated benefits include*: this work will increase the knowledge of fisheries habitat, basic biology and ecology of the chame and improve the understanding of how chame is utilized. The GIS database and maps will be available for multiple stakeholders to use for their own purposes.

*Target groups* for this work include: aquaculture extension workers and researchers in Pacific Mexico and Ecuador; key private sector representatives; fish growers in Sinaloa, Oaxaca and other Mexican southern states; Universidad Autónoma de Sinaloa (UAS, Culiacan and Mazatlan Campuses). Groups benefiting in Ecuador include Ecocostas, an NGO dedicated to conservation and sustainable development for Latin America and potentially many fish growers in the Manabi and Esmeraldas Province coastal areas. There are also groups interested in culturing chame in Nicaragua; results will be shared with the CRSP partner in Nicaragua, CIDEA/UCA.

*Quantifiable benefits* will include: GIS maps and database; improved knowledge of the biology and ecology of the chame; improved knowledge of the socioeconomic aspects of chame utilization; identification of threats to the chame population; and recommendations for chame management.

##### Metrics

Number of institutions directly or indirectly benefiting from the training: 6

Number of individual participants in extension and technical training: estimated at: 12

Number of communities: 5

Number of private businesses (including cooperatives and women’s groups): 5

Students involved: 1

CRSP newsletter articles: 1

Peer-reviewed journal article: 1

#### Research Design & Activity Plan

The methods used here are similar to those used previously to document and quantify fisheries and utilization aspects for the blue crab (Rodriguez-Dominguez et al 1999, Rodriguez-Dominguez et al 2000 and Rodriguez-Dominguez et al 2004) which was at one time unregulated on the Pacific coast of Mexico. The researcher for this work, Guillermo Rodriguez Dominguez, led research efforts that documented catch and utilization of blue crabs, and worked with regulatory agencies and communities to develop voluntary co-management measures and legal regulations which have now formalized management of the crab fishery. A similar approach will be used here to collect information from users, and to characterize the habitat issues associated with chame.

Structured and open-ended interviews will be conducted with chame users including fishers, vendors, aquaculturists and consumers in the Mexican states of Sinaloa and Nayarit to identify and locate problems and issues associated with chame in these areas. The magnitude of the habitat or other human-induced issues will be evaluated using GIS and where possible, the number of fish or total weight of the population affected will be estimated. Site surveys will also be conducted. For example, interviewees will be asked about: which watershed areas have been affected by construction that prevents chame migration; how many tons of chame are discarded when caught as bycatch in other fisheries; how much and where chame is consumed or sold locally; seasonal patterns of consumption and sales; which shrimp farms have problems with chame; and how is chame used as bait. Chame will also be collected from sites throughout the two States to examine them for reproductive stage and how habitat degradation may be affecting the reproductive process.

The collected data will be used to develop a GIS database and maps to assist with management decision-making.

#### Schedule

This work will begin in May 2012 with the interviews and site surveys, and will continue until the end of August 2012. Final data analysis and reports will be completed by the end of September, 2012.

#### Student Involvement

One undergraduate student (Favier Gomez Medina, male) will be involved on this effort for evaluate reabsorption of chame gonads in critical habitats. Guillermo Rodriguez Dominguez is the Principal Investigator for this work, and is also now a CRSP graduate student since he has returned to school to complete his doctorate in 2010.

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###### Workshop: The Chame (*Dormitator latifrons*)–An Alternative Fisheries Species and Contributor to Aquaculture Diversification

#### Objectives

Considerable research has been done on chame in Mexico and Ecuador. CRSP sponsored work includes three efforts, “Induced spawning and larval rearing of *Dormitator latifrons* (09IND04UH)” and “Stock assessment of *D. latifrons* (09IND03UH), as well as an additional grant for continuation of the first effort. The objective of the proposed workshop is to inform stakeholders about the research findings, collect new information and discuss strategies and recommendations for management guidelines and use of chame for aquaculture diversification.

#### Significance

Outreach to a wide variety of stakeholder is particularly important from a fisheries perspective as many conservation and management efforts are more effective when executed at the community level. For example, the effort to improve management of the blue crab fishery along the Pacific Coast of Mexico was successful due to the early involvement of fishers, who once made aware of the need for regulations, presented demands to the government for improved management, which led to the official adoption of the recommended regulations. Additionally, this effort will make people more aware of the value of chame and the need to prevent waste through discarding unwanted specimens.

#### Quantified Anticipated Benefits

This workshop will benefit both researchers, as well as communities, regulators and other chame users.

##### Metrics

Number of institutions directly or indirectly benefiting: 6

Number of individual participants in technical training: 35

Number of communities benefiting: 10

Number of documents produced or contributed to: 1 (meeting proceedings)

Students involved: 1 undergraduate

Publications: 3 (technical report, article for CRSP newsletter, DVD of presentations)

Number of new or improved products: 1

#### Activity Plan

The workshop will be held in Mazatlan, a central meeting point for regional stakeholders. Researchers and chame users (e.g. representatives from indigenous groups, cooperatives) will be invited to make presentations. Panel discussions will be held on conservation needs and the use of chame for aquaculture diversification. Discussions will also be held on how to expand the existing market for chame. Dr. Silvia Paz, a specialist in gnathostomiasis, will present her work on the presence of these parasites in chame and potential human health issues.

#### Schedule

This work will take place at the end of August 2012 to allow for completion of the other components of this proposal so that research findings can be presented at the workshop.

#### Student involvement

One undergraduate student will assist with the workshop.

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### Development of Sustainable Feeds, Improved Stocking Densities, and Salinity Management in Closed Recirculating Systems for Gar (*Atractosteus spp*.) Culture

Indigenous Species Development/Experiment/09IND11UM

#### Collaborating Institutions & Lead Investigators

University of Michigan (USA) James S. Diana

Solomon R. David

Universidad Juarez Autonoma de Tabasco (Mexico) Wilfrido M. Contreras-Sánchez

#### Objectives

1. To refine fish meal substitution using by-products (treatments 25, 50, 75 and 100% substitution).
2. To determine optimal densities for rearing tropical gars (*Atractosteus tropicus*, treatments 25, 50 and 100 fish/m3).
3. To determine success of closed and recirculating filtration systems on water quality and growth of Cuban gars (treatments closed versus recirculating systems).
4. To determine the effect of salinity on growth of Cuban gars (treatments salinity 0 ppt, 5 ppt).

#### Significance

Gars are a group of ancient air-breathing fishes that make up the family Lepisosteidae. The family consists of two genera, *Atractosteus* and *Lepisosteus*, and seven extant species. The genus *Lepisosteus* consists of the longnose gar (*L. osseus*), shortnose gar (*L. platostomus*), spotted gar (*L. oculatus*), and Florida gar (*L. platyrhincus*); *Atractosteus* consists of the tropical gar (*A. tropicus*), Cuban gar (*A. tristoechus*), and alligator gar (*A. spatula*). Although the fossil record for gars exhibits a Pangeaic distribution, extant species are relegated to North & Central America and Cuba, and range from southern Canada (longnose gar) to Costa Rica (tropical gar) (Suttkus 1963, Wiley 1976).

Gars are top-level predators in their native ecosystems and are characterized by their elongate jaws, cylindrical bodies, and diamond-shaped ganoid scales. Their maximum size and age varies with species from approximately 80 cm and 10 years (shortnose gar) to 300 cm and over 70 years (alligator gar). Gars are generally polyandrous in reproductive strategy, with multiple male individuals spawning with 1-2 females. Gars spawn during late spring and early summer in temperate regions, and during the rainy season in tropical regions. Growth is extremely rapid, with all species capable of reaching 30 cm or more in their first growing season (young–of-the-year alligator gar can reach over 30 cm, 250 g in 3 months).

##### Aquaculture

Gars are excellent candidates for aquaculture as they exhibit rapid growth to large sizes, are highly resistant to disease, can be maintained at high densities, readily adapt to artificial feed at early life stages, and are highly tolerant of low water quality conditions due to their air-breathing abilities (Alfaro et al. 2008). Their tolerance of low water quality via aerial respiration also allows for a less complicated technological system for aquaculture, as opposed to other fishes which may require considerable aeration and water turnover. Gars are therefore well-suited for culture in developing regions.

Much progress has already been made in the aquaculture of *Atractosteus* gars (tropical, Cuban, alligator), primarily in regions of Mexico, Cuba, and the southern United States. Broodstock for all three species have been established and are currently maintained in their native regions, and juveniles have been released to help restock diminishing wild populations. Further efforts are being made in the southern US to protect alligator gar populations and manage them as a viable sport fishery, as well as increase its potential as a food fish. Gars are already popular food fish in various regions of Mexico and Cuba.

Due to their unique appearance and predatory nature, gars are becoming increasingly popular in the ornamental fish trade. Gars have been sought-after aquarium fish in southeast Asia for many years, and are growing in popularity in the United States and other countries. The Florida gar, native to only a small portion of the southeastern United States, is the most popular aquarium species of gar in the US (usually wild-caught) and most readily available abroad. Prices in the United States range from $15-$40 USD for 20-35 cm individuals. Other gar species at similar sizes command a much higher price largely due to their rarity in the aquarium hobby, such as $200 USD for an individual tropical gar and over $300 USD for a Cuban gar (in the United States). Tropical and Cuban gars are also highly valued overseas; in Singapore 15 cm tropical gars average $150 USD and Cuban gars $400 USD. Ironically, tropical and Cuban gars are among the most commonly cultured gar species. Specimens exhibiting genetic mutations in pattern or coloration (i.e. melanistic, xanthochroic, leucistic) command an even higher price, ranging from $1000 to over $5000 USD. Hybrid gars, although rare in the trade, are also much sought-after.

##### Research Concepts

In its efforts to successfully culture tropical gars for food and restocking of wild populations, Mexico has greatly increased the body of knowledge surrounding gar biology, ecology, and aquaculture. In contrast, little information is available on the culture of Cuban gars, and few papers on either species have been published in scientific literature. Even with the progress over the past two decades, there still remains much to be learned and developed for successful and sustainable gar culture.

We propose to investigate 3 major aspects of gar aquaculture with the goal of applying our findings to present and new operations in developing countries. Our studies will involve tropical and Cuban gars and will focus on further developing their **(1)** potential as food fish, **(2)** value and availability in the ornamental fish trade, and **(3)** better understanding their roles in native biodiversity.

Culture of tropical and Cuban gars is directly beneficial to their respective developing regions as a local source of protein, additional revenue to farms from sales to the ornamental fish trade, and restocking local wild populations to help conserve biodiversity.

#### Quantifiable Anticipated Benefits

##### Further Aquaculture Potential & Role as Food Fish

Because gars are air-breathers they should perform well in completely closed recirculating systems, potentially using less water for culture. Gars may also be cultured in systems with reduced or no additional aeration, further reducing energy consumption. Several gar species have been shown to have moderate to high salinity tolerances (compared to other teleost and non-teleost freshwater fishes), and in some cases showed improved growth under saline conditions (Suchy 2009). Furthermore, gars from different latitudes may exhibit different growth rates (latitudinal variation) therefore specific populations may be better candidates for culture than others. By comparing our growth models with those from other regions (specifically with the wide-ranging tropical gar) we may determine the populations with the highest capacity for growth and therefore production in culture. There is also potential in culturing hybrid gars to take advantage of the faster growth of one species (i.e. Cuban gar), but managing fewer and/or younger broodstock of another species (tropical). These practices could be incorporated into existing operations to potentially increase efficiency, sustainability, and production, as well as making the technology for gar culture more accessible to developing regions.

Tropical and Cuban gars are already popular food fish in their respective regions, therefore demand already exists. Because of their fast growth rates to large sizes, individuals can reach market size after a single growing season. Increased productivity based on new research could also enhance potential export of these fishes as a food source, whether to neighboring regions or beyond.

##### Ornamental Fish Trade

In the ornamental fish trade, tropical and Cuban gars are the most expensive and sought-after species, and they are seldom available in the United States (where gars are becoming increasingly popular in the hobby). Ironically, these two species (along with the alligator gar) are cultured in greater numbers than any *Lepisosteus* gars, yet wild-caught Florida gars are the most abundant gar species in the US aquarium trade. Increased networking between aquaculture operations and ornamental fish suppliers could lead to additional revenue for gar farms as well as decrease pressure on potentially sensitive wild populations. Increased popularity and availability of gars in the ornamental fish trade would also lead to better public awareness of gars in general, potentially decreasing their needless extermination by anglers and others considering them merely trash fish. Increased public awareness by ornamental fish trade on a local level may also help develop further interest in sustainable culture practices as well as conservation efforts.

##### Role in Biodiversity

Successful and sustainable aquaculture of gars is also valuable from a biodiversity perspective. Culturing tropical, Cuban, and alligator gars has been useful in replenishing depleted wild stocks which have suffered due to overfishing and habitat loss. A tropical gar program in Mexico further involved the public by allowing elementary school children to raise juveniles to fingerlings and release them into native waters, therefore helping to conserve native biodiversity. Continued research on various aspects of gar biology and ecology provides a better understanding of their role in native ecosystems and can better inform conservation efforts. Few scientific papers have been published on Cuban and tropical gars, our studies would help fill a major void in the existing body of knowledge on gar ecology and culture.

Our proposed research would address all 3 of these major aspects of air-breathing fishes aquaculture, providing useful results for the culture of these fishes in developing regions as well as benefits in a global context. We currently have access to broodstock and juveniles needed for the proposed experiments, as well as the facilities (closed recirculating and flow-through systems) and experience to carry them out starting immediately.

Deliverables on this research will include at least three peer-reviewed papers as well as at least two articles for *Aquanews* to present results to a more general audience. The resulting growth models based on different feed types will also provide the basis for further experiments on other gar species and gar culture in general.

#### Research Design & Activity Plan

Objectives

With our current stocks of both species, we will be able to develop growth models based on different feeding, filtration, water quality, and stocking regimes using common environment experiments. Our primary experiments will investigate the following:

1. Determine fishmeal replacement using by-products (treatments 25, 50, 75 and 100% substitution).
2. Determine optimal densities for rearing tropical gars (treatments: 25, 50 and 100 fish/m3)
3. Determine differential growth of Cuban gars in closed and recirculating filtration systems as

well as variation in water quality (treatments: closed system, recirculating system).

1. Determine effects of salinity on growth of Cuban gars (treatments: salinity 0 ppt, 5 ppt)

From these trials we hope to develop low-cost and environmentally-friendly methods (such as using feeds with lower fishmeal content) for culture of tropical and Cuban gars in developing regions so they can be applied to all three major aspects listed above.

##### Experimental Design

1. **Determine fishmeal replacement using by-products***.* Fish weighing about 15 g will be used. Four treatments will be evaluated (25, 50, 75 and 100% fishmeal substitution) in three replicates. The fishes will be cultured in a recirculation system (every tank stocked with 10 fish). Fish length and weight will be measured every 15 days to determine growth over the course of the experiment. From these growth data we will determine optimal feed types and stocking densities. From these trials we hope to develop low-cost and environmentally friendly methods (such as using lower-fishmeal content feeds) for culture of the tropical gar.
2. **Determine optimal densities for rearing tropical gars**. Tropical gars of about 15 g size will be held in a recirculating systems at 25, 50 and 100 fish/m3 for culture. Each treatment will be replicated. Length and weight of fish will be measured every 15 days, and grow out will be 60 days. We will determine not only growth under different conditions but also water quality (DO, NH3, NO2-NO3, TKN, TP) using standard methods in each system.
3. **Determine differential growth of Cuban gars in closed and recirculating filtration systems as well as variation in water quality**. Cuban gars (N = 40) will be divided into two treatment groups, closed system and recirculating system. Each treatment will consist of 20 fish divided into four 170 L fiberglass tanks (5 fish per tank). Closed system treatment will use a small sponge filter to maintain water quality. Recirculating system treatment will use a large central biofilter and reservoir to maintain water quality. Cuban gars will be fed ad libitum on freeze-dried krill (starting at approximately 10% mean body weight) for 30 min after which excess feed will be removed. In initial pilot feeding trials with Cuban gars, freeze-dried krill was shown to have the highest growth (g) per feed amount (g) compared to other feed types. This feed type also had the lowest impact on water quality therefore we will use this feed type for experiments 3 and 4. Water quality measurements (ammonium, nitrite, nitrate, pH) will be taken weekly. Length and weight of each fish will be measured on experiment days 1, 15, and 30, with growth evaluated primarily from weight. ANOVA and ANCOVA tests will be used to determine significant differences (if any) in water quality parameters and growth between treatments.
4. **Determine effects of salinity on growth of Cuban gars.**Cuban gars (N = 40) will be divided into two treatment groups, salinity treatments of 0 ppt (freshwater) and 5 ppt. Each treatment will consist of 20 fish divided into two 1,000 L round fiberglass tanks (10 fish per tank). Water quality will be maintained by a high-capacity external canister filter. Fish will be fed ad libitum on freeze-dried krill (initially at 10% mean body weight) for 30 minutes after which excess feed will be removed. Length and weight of each fish will be measured at experimental days 1, 15, and 30, with growth evaluated primarily by weight. ANOVA and ANCOVA tests will be used to determine significant differences (if any) in growth between treatments.

Research projects for tropical gars will be carried out by Wilfrido Contreras-Sanchez at UJAT in Tabasco, Mexico, and projects for Cuban gars will be carried out by James Diana and Solomon David at The University of Michigan in the United States. We will be using the same methodology for our gar culture projects (feed type will also be the same for fishmeal substitution experiments).

Schedule

1 June 2011 to 30 September 2012 Report submission: 29 September 2012.

Schedule includes:

* Acquire and pellet-train juvenile gars – June 1 – June 21 2011 (UM)
* Initial feed/growth trials for conventional feed – June - November 2011 (UM)
* Begin growth trials using different stocking densities – June 14- August 1 2011 (UJAT)
* Begin growth trials using alternative feed types – June 14 – August 2011 (UJAT)
* Acquire and begin training on experimental feed from UJAT – March 2012 (UM)
* Begin growth trials using alternative feed types – April 1 – April 30 2012\* (UM)
* Begin growth trials using closed vs. recirculating systems – May 15 – June 15 2012\* (UM)
* Begin growth trials using freshwater vs. saline treatments – June 30 – July 31 2012\* (UM)
* Develop growth models based on all experimental data – August - September 2012
* Preparation of final reports – through 29 September 2012

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**Topic Area**

## Marketing, Economic Risk Assessment & Trade

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### Value Chain Analysis in Uganda

Marketing, Economic Risk Assessment & Trade/Activity/09MER05AU

#### Collaborating Institutions & Lead Investigators

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[Awaiting submission of final work plan]

### Value Chain Analysis of Seaweed in Aceh, Indonesia

Marketing, Economic Risk Assessment & Trade/Activity/09MER06NC

#### Collaborating Institutions & Lead Investigators

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Coco Kokarkin

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#### Objectives

The goal of the study is to foster the successful participation of small-scale Aceh seaweed polyculture producers in the Indonesian seaweed production/marketing system. The objectives are as follows:

1. Describe and evaluate the existing value chain of seaweed production in Aceh Indonesia.
2. Develop recommendations to improve local system efficiency and participation of small-scale seaweed polyculture producers in Aceh, Indonesia.

#### Significance

The USAID CRSP AquaFish program in Aceh, Indonesia has focused on promoting the adoption and best aquaculture practices (BMP) for seaweed polyculture systems. These systems involve a more sustainable use of small-scale *tambak* culture systems that incorporate seaweed (*gracellaria)* into shrimp and fish culture systems. The technical and environmental benefits of polyculture of seaweeds in shrimp and fish ponds are well documented (Ryder et al. 2004a,b; Marinho-Soriano et al. 2002; Nelson et al. 2001; Neori et al. 2000). Based on our current AquaFish CRSP, polyculture of seaweeds in shrimp and fish ponds has proven to be popular in several coastal communities. Cultural practices for these fish and seafood crops and their combinations in various polyculture systems are being established and provide an economically viable alternative for small scale *tambak* producers. However, production refinements continue to be needed to adjust best management practices with the addition of seaweed into the polyculture system and market opportunities and constraints have limited small-scale farmer participation in the local/regional seaweed market system. Although farmers are reasonably satisfied with the benefits to polyculture, farming system refinements and better understanding of seaweed marketing (Tveras and Kvaloy 2004) are constraints to small farmers decisions to increase their participation in seaweed polyculture.

***Milkfish, shrimp and tilapia.*** Milkfish is an extensively cultured, inexpensive source of fish protein for local markets and its culture has a long consistent history of successful production and marketing. Shrimp culture has experienced severe disease problems with white spot virus, a problem that is significantly reduced with co-culture of seaweed. There generally have been few disease problems with milkfish or tilapia. Common shrimp harvest size ranges from 20-40/kg and tilapia are sold at about 400-500g. Typical stocking of tilapia and milkfish is in the range of 2,000-3,000 per ha; feeding at these densities generally produce 200 kg/ha of crop with a typical price of 6,000 -10,000 rupiah per kg, based on feed quality. This feeding rate results in final harvest of about 550 kg total (tilapia and milkfish). Seed are often from seed collectors who capture wild stocks.

Tilapia culture is still evolving both in production and marketing sense. Hired labor is generally not used. Neighbors help each other harvest and each farmer does the various tasks during the season on his own. Harvest labor is the only task that requires a substantial effort in a constrained period of time. Sales are almost totally to brokers; however, some farmers rent stalls in local markets with some success. The consumer expects the seller to clean fish as requested. Current 2011 prices per kg are approximately 15,000 rupiah for black tilapia (*nilotica*), 8,000 for red tilapia (*mozzambica*) and 15,000 for milkfish. The possibility of cross breeding existing strains with Tilpaia *honorum* has been suggested to increase male population, but not rigorously tested.

***Seaweed****.*Seaweed polyculture has an excellent opportunity to be incorporated into and provide several important benefits to the existing aquaculture system. However, this potential contribution is only beginning to materialize. Efforts to address several marketing and production constraints have been initiated, but results from these efforts are still pending. Reducing risk and uncertainty inherent in these constraints can increase adoption and addressing them is key to establishing seaweed polyculture as an accepted alternative for aquaculture farmers.

Current production constraints are generally related to seaweed polyculture interaction with other aspects of the polyculture system, e.g., yield, odor, shrimp virus. Support is needed to initiate and continue applied research and extension on (1) relationship between white spot virus and other polyculture (tilapia, milkfish, and seaweed); (2) interaction of odor and crops in polyculture system (tilapia, shrimp, milkfish, and seaweed), and (3) continuous updating of appropriate polyculture BMP’s, e.g., species mix, stocking densities, complementarities.

Post-harvest processing and marketing issues are clearly constraining, and are as important as production constraints in establishing Aceh farmer’s long-term viable competitive position in the seaweed market supply chain. These are activities that farmers are generally not aware of or well skilled at. The post-harvest chain of activities – drying, weighing, cleaning, packaging, storage, selling, and transport – each involve challenges.

A nascent effort was developed in 2011 for a buyer/assembler from Medan to purchase one 15 MT truckload of dried, cleaned, packaged seaweed weekly. Approximately 400 ha of seaweed in Aceh were ready for harvest and at least 20 farmers were prepared to be part of the arrangement. The incentive for the buyer is based on his need to provide a minimum export shipping weight of 500 MT; this volume requirement has been difficult to obtain from nearby producers in Medan. The buyer will provide the transportation and a small loan to assist in buying materials and paying a labor cost to expand drying rack capacity. The loan will be paid through for payments, subtracting 25% of debt from receipts due to farmers. It is anticipated that both of these levels of participation will expand dramatically once profitability is demonstrated.

A farmer representative was designated who will play a key role in the arrangement’s potential success; the buyer will deal exclusively with this individual. The representative will undertake sales transactions (Hobbs 1996). In addition, this representative will be responsible for managing the weighing, drying, cleaning, packaging and storage of seaweed. The seaweed will be stored in 25 kg bales until the minimum quantity is reached for scheduled deliveries. As success is demonstrated, other seaweed growing areas in Aceh are expected to begin harvesting and additional representatives will be needed in these other locations. Success of this representative will be important in determining whether this marketing arrangement is sustainable and whether other representatives will perform this function as production capacity expands. If this arrangement is successful, it will provide a mutually beneficial opportunity in assuring that the buyer can meet freighter minimum volume and quality and that the farmers will have an additional income source with a very low input cost.

#### Quantified Anticipated Benefits

1. The ability of small-scale *tambak* producers in Aceh Indonesia to reap the employment and income benefits of inclusion in the seaweed value chain in Indonesia will increase.
2. *Tambak* producers will diversify their portfolio of income generating opportunities, thereby decreasing risk associated with any other polyculture enterprises.
3. Market and processing activities will provide added employment opportunities.

#### Activity Plan

***Location***

In-country data collection will be accomplished and interviews conducted during May to August 2012, by Hatch and Jamandre with the assistance of Hasanuddin and Cocarkin. The focus of this in-country effort will be UBAC in Banda Aceh, Samalanga demonstration site in Bireun District, Lancang in Pidie District, Trengadring Multi Species Hatchery in Pidie Jaya District, Bayu in Aceh Utara District, Banda Aceh local markets and Medan regional markets.

***Methods***

Secondary data series on seaweed statistics will be obtained from various Indonesian agencies, especially Department of Fisheries. Previous studies on the production and marketing of seaweed also will serve as sources of secondary information. Likewise, UBAC and in-country collaborators will serve as sources of secondary information. Officers and staff of appropriate government agencies and other industry personalities are additional sources.

The following primary data will be collected: the key players and their respective roles, activities, and services provided, the supply chain product requirements (especially quality standards) product, information and money flows, critical logistics issues (including problems in production and marketing), extension services, and external influences (Cooper et al. 1997).

Data collection and in-country travel and interviews will need the flexibility to follow the chain and will focus on:

1. identification of specific activities and services, key players, logistical issues, external influences, and flow of product, information and payment.
2. evaluation of efficiency, flexibility and overall responsiveness (Porter 1985).
3. description of behavioral, institutional and process,
4. development of recommendations to foster the successful participation of Acehnese seaweed polyculture producers.

The existing production/marketing system imposes constraints on the opportunity for seaweed polyculture, but it also provides an opportunity to benefit farmers not only through its own culture but also on positive interaction with the existing polyculture system – shrimp, milkfish and tilapia. The economic contribution of seaweed polyculture must be analyzed not solely in the cost and returns to seaweed, but of equal importance the effects on the cost and returns to the other crops in the polyculture system. This contribution can be viewed as a pond management strategy that reduces both biological and economic risk. Benefits of biological risk reduction are largely related to potential disease and water quality improvements and economic risk management is addressed through portfolio diversification that ameliorates potential yield and price fluctuations. This analysis will focus on improved understanding of the regional and national supply/value chain (Ramasamy 2007) and the ability of local producers to benefit from production for and marketing to consumers outside the local area. Improved value chain analysis and understanding will lead to increased ability of Acehnese producers to participate in the national and international value chain.

The analysis will focus on better understanding of:

1. key customers and product requirements
2. product form
3. volume requirement
4. major players and their activities
5. major routes of product
6. payment flow
7. information flow
8. external influences

Who are the key customers and what are their product requirements (especially quality standards)? Who are the key players and what are their respective roles? How do product, information and money flow through the supply chain? What are the activities and services provided at each level in the supply chain? What are the critical logistics issues? What are the external influences? (Williamson 1979).

Seaweed value chain maps will be developed for each market level, e.g., producer, assembler, transporter, wholesaler, exporter, to identify specific activities and services, key players, logistical issues, external influences, and flow of product, information and payment. Seaweed value chain performance in Aceh will be evaluated for efficiency, flexibility and overall responsiveness. *Tambak* producers are not generally accustomed to performing many of the processing/marketing activities that will be required for successful participation in the regional and national seaweed market supply and value chain in Indonesia (Neish 2008). Better racks have been constructed for drying and logistics of this process in terms of on farm drying versus drying at a consolidating point need to be investigated for greatest efficiency. Cleaning, weighing, drying, packaging and storage will need to be coordinated by key personnel. Identification of a representative who can coordinate these activities, can negotiate for the group with buyers, and has the confidence and trust of the producer group is an important potential constraint. Payment and information dissemination need to be coordinated. Areas for improvement in Acehnese seaweed value chain (i.e. behavioral, institutional and process) will be identified. Analysis of these processes in other seaweed growing areas will be useful but must be adapted to Acehnese *tambak* conditions.

Recommendations to foster the successful participation of Acehnese seaweed polyculture producers will be provided. What are barriers for producers to meet the quality, quantity and timing requirements imposed by the marketing system? Areas for improvement in the supply chain will be identified and specific policy recommendations will be formulated with the end in view of improving the Aceh *tambak* seaweed polyculture sector through an improved supply and value chain management.

**Schedule**

* Schedule May-June 2012 – In-country travel (Hatch and Jamandre) to Aceh Indonesia and marketing centers (e.g., Medan and Jakarta) as deemed appropriate.
* July 2012 – Analyses completed.
* August 2012 - Technical report drafted and submitted to Hasanuddin and Cocarkin for comment.
* September 2012 – Final report completed.

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### Assessment of Tilapia Value Chain in Ghana

Marketing, Economic Risk Assessment & Trade/Study/09MER07PU

#### Collaborating Institutions & Lead Investigators

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#### Objectives

1. Characterize current tilapia value chain in Ghana.
2. Analyze tilapia value chain performance in terms of cost-benefits comparisons.
3. Identify areas for improvement in value chain.
4. Provide recommendations for strategic improvements and long term sustainability.

#### Significance

Aquaculture production has the potential to contribute to alleviating hunger and poverty in Sub-Saharan Africa. Ghana has made tremendous improvements in the aquaculture industry with large commercial production of tilapia from cage culture and the traditional pond culture. The aquaculture industry in Ghana has therefore demonstrated improvements in competitiveness, producing tilapia species that feed low on the food chain in well adapted, environmentally friendly and profitable farming systems.

The performance of tilapia value chain in Ghana can be used to achieve sustainable food production and poverty alleviation through improvements in market access and competitiveness. For example, smallholder fish farmers through linkages among the different stakeholders such as the input suppliers, processors, traders, and other retailers can manage the flow of goods and services to enhance their economic wellbeing. Proper linkages could results in increased productivity and efficiency and provide access to new markets. Value-chain linkages improve information flow and learning capacities and also help to reduce transaction costs, and increased productivity in terms of value and profitability generate increasing incomes in a sustainable manner. Value chain collaboration then becomes very important for smallholder producers in developing countries to ensure access to new and profitable markets.

#### Quantified Anticipated Benefits

1. Identification of areas of intervention in the tilapia value chain for improvements
2. An efficient tilapia supply chain that fosters the development of viable market opportunities for tilapia producers
3. Results will provide information to assist the tilapia supply chain performance for flexibility and overall responsiveness to information flow
4. Identification of areas for improvement in supply chain relating to behavior, institution and process

#### Activity Plan

A schematic outline of the methodology and activity plan is presented in figure 1.

##### Objective 1: Characterize current tilapia value chain

Characterization of tilapia value chain will first involve a review of the relevant literature and government reports to provide an overview of the tilapia industry and any trends in the general aquaculture industry in Ghana. The various levels and actors in the value chain will be identified in the process and then tilapia supply chain maps developed that provides an outline of the chain.

A Value Chain Analysis (VCA) map will plot the flow of goods and services in the value chain and determine how behavior plays a role in success The maps would provide information on specific activities and services at each stage of the chain, key players, logistical issues, flow of product and information, nature of transactions among stages of the chain/actors and other external influences to the chain performance.

##### Objective 2: Analyze tilapia value chain performance in terms of cost-benefits comparison

Analyze tilapia supply chain performance for efficiency, flexibility and overall responsiveness. The key players identified under objective 1 will be examined for their roles/activities/services in the chain, assess any product grades and standards associated with each stage, and how product, information and payment flows from one stage to the next and vice versa. Issues relating to logistics, production, distribution, marketing and other external influences will be examined. Data will be collected through a survey of the main actors identified and chain performance accomplished using a series of quantitative measures:

1. Cost Benefit Analysis (CBA) - A CBA will be used as a decision tool, measuring all costs and benefits in financial/monetary values to assess performance in the form of a ratio. The value of the ratio of the present value of benefits to present value of costs greater than one indicated profitability.
2. Porter’s 5 forces framework – Porter’s competitive analysis will assess the performance of the various aquaculture value chain actors in terms of the marketing mix factors using performance radar charts and factor evaluation matrices (FEMs). The competition analysis will also assess 5 competitive forces - competitive rivalry, the threat of new entrants, bargaining power of suppliers, threat of substitutes, and bargaining power of buyers.
3. SWOT analysis - The SWOT analysis would involves assessing the external factors for perceived opportunities and threats at each stage in the value chain as well as evaluating the aquaculture industry's internal strengths and weaknesses.

##### Objective 3: Identify areas for improvement in value chain

The data collected and analysis (qualitative and quantitative) completed under objective 2 above will provide the basis for identifying stages in the Ghanaian tilapia value chain that needs improvements.

##### Objective 4: Recommendations for strategic improvements and long term sustainability

Recommendations will be provided based on the results.

Figure 1: A Schematic Outline of Methodology and Activity Plan



#### Schedule

|  |  |
| --- | --- |
| Literature Review, Survey Design | May 2012 |
| Survey pretests and refinements | May 2012 |
| Survey administration | June – July 2012 |
| Data analysis | August 2012 |
| Reports | September 2012 |

### Value Chain Analysis in Kenya/Tanzania

Marketing, Economic Risk Assessment & Trade/Activity/09MER08UA

#### Collaborating Institutions & Lead Investigators

University of Arizona (USA) Kevin Fitzsimmons

Kenyatta University (Kenya) Charles Ngugi

Sokoine University of Agriculture (Tanzania) Sebastian Chenyambuga

[Awaiting submission of final work plan]

### Value Chain Analysis of Freshwater Small-Sized Fish in Cambodia

Marketing, Economic Risk Assessment & Trade/Activity/09MER09UC

#### Collaborating Institutions & Lead Investigators

Inland Fisheries Research & Development Institute (Cambodia) So Nam

Hap Navy

Can Tho University (Vietnam) Le Xuan Sinh

University of Connecticut-Avery Point (USA) Robert Pomeroy

#### Objectives

The objectives of the activity are:

1. To conduct a value chain analysis of freshwater small-sized fish in the Lower Mekong Basin of Cambodia in order to propose improved marketing and management solutions.
2. To conduct a training and provide technical assistance to other AquaFish CRSP investigations on value chain analysis.

#### Significance

In the Mekong region, many capture fisheries resources have been largely overexploited and, as a result, development of aquaculture has been encouraged to provide the protein, income, employment and export earnings for some countries. Such a development trend implies that sufficient feed for aquaculture production will be available. One source of feed is small sized fish. There is increasing demand and trade in the lower Mekong region of Cambodia and Vietnam for small sized fish for (1) local consumption (e.g. fresh, dried); (2) direct feed (e.g. livestock, high value species aquaculture); (3) fish meal production (e.g. poultry, aquaculture); and (4) value-added products (e.g. fish sauce).

There is also increasing conflict between the use of small sized fish for feed and for human consumption. In some cases, such feeds are comprised of fish species traditionally used as cheap food for people and this allocation of fish resources to aquaculture may result in negative impacts of food security and livelihoods. It is the economics of the different uses of small sized fish in different localities that direct the fish one way or the other. There are also trade-offs between direct food benefit and the indirect employment and income generation opportunities afforded by feeding to aquaculture. It has been argued that it would be more efficient and ethical to divert more of the limited supply to human food, using value-added products. Proponents of this suggest that using small sized fish as food for domestic consumers is more appropriate than supplying fish meal plants for an export, income oriented aquaculture industry, producing high-value commodities. On the other hand, food security can also be increased by improving the income generation abilities of poor people, and it can be argued that the large volume of people employed in both fishing and aquaculture has a beneficial effect. This raises some important questions regarding the social, economic and ecological costs and benefits of aquaculture, its sustainability and future trends.

To date, there has been no comprehensive study of the marketing system for small sized fish in the Lower Mekong Basin (LMB). The small sized fish industry for food and feed in the LMB of Vietnam and Cambodia has spontaneously developed without any comprehensive analysis of the markets for the products, particularly the lack of information on the stakeholders and marketing practices. Therefore, there is a need to conduct a study covering all of the aspects of value chain for small sized fish in the LMB. The results of this study will be useful for management and any further development of the small sized fish industry, as well as contribute to food security, job creation and marketing of fish products in the LMB.

The value chain framework has been used as a powerful analysis tool for the strategic planning of an organization. It has been applied to the understanding of commodity chains and export strategies in a number of developing countries and for various commodities. Value chain analysis helps the managers to identify the key activities within the firm which form the value chain for that organization, and has the potential to identify the sustainable competitive advantages for a company. Such analysis focuses on the interaction of actors along each step of the production system (from raw producer to consumer) as well as the linkages within each set of actors.

#### Quantified Anticipated Benefits

***Objective 1***

150 scientists, researchers, resource managers, government officials, non-government organizations, and inter-governmental organizations concerned with and working on the issue of small-sized fish in Cambodia and Vietnam, and in the Asia-Pacific region in general, will be better informed and have recommendations for improved management of freshwater small-sized fish in the Lower Mekong region in order to re-establish stocks to support food security and poverty alleviation through project report and two consultation meetings conducted in Cambodia and Vietnam.

***Objective 2***

12 AquaFish CRSP investigators will be trained in value chain analysis and will return to their country/institution to work with others on value chain research and/or train others on value chain analysis.

#### Activity Plan

***Location of Work***

The activity will be implemented in: (1) project areas in Cambodia and Vietnam and (2) a training/workshop in Tanzania.

***Methods***

The value chaindescribes the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use (Kaplinsky and Morris, 2001). Capture fisheries feed into diverse and spatially extensive networks of supply and trade that connect production with consumers, adding significant value and generating important levels of employment (the value chain). To some extent, this system can be used to provide an important mediation and buffering function to increasing variability in supply and source location, but direct impacts will also affect its ability to do so. This system can also be used to reduce vulnerability and increase adaptive capacities of fishers and fishing households.

The value chain encompasses many economic agents (individuals, companies, government). From the perspective of the value chain, it is relatively unimportant how impacts are distributed among the economic agents that comprise it. As a result, value chain analyses do not have to address many of the difficult policy decisions that determine how impacts are distributed. The value chain perspective is important because it offers insights that would not surface in studies focused on individual economic agents or particular policy frameworks. A value chain analysis can also uncover insights into the challenges that face the sector as a result of different drivers of change, such as climate change, including small firms’ and fishers’ competitiveness in changing markets. A value chain perspective of the small-scale fisheries sector can reveal response strategies that enhance the sustainability and competitiveness of the entire value chain and the economic agents that comprise it. Value chain analysis helps to effectively isolate the binding constraints that affect the sector in a systematic manner. The set of issues that emerge from such a detailed analysis at a sector level has implications for both the public and private sectors alike. Some of the issues are sector-specific, and others are relevant across an economy and apply to many sectors and firms in a country. It also provides an opportunity to find policy positions that can be supported by the sectors different economic agents and important stakeholders.

The idea of value chain is quite intuitive. A value chain refers to the full range of activities that are required to bring a product (or a service) from conception, through the different phases of production, to delivery to final consumers and disposal after use (Kaplinsky, 2000; Kaplinsky and Morris, 2001). Further, a value chain exists when all the stakeholders in the chain operate in the way to maximize the generation of value along the chain. This definition can be interpreted in a narrow or in a broad sense. In the narrow meaning, a value chain includes the range of activities performed within a firm to produce a certain output. The ‘broad’ approach to value chain looks at the complex range of activities implemented by various economic agents (primary producers, processors, traders, service providers, etc) to bring a raw material to the retail of the final product. The ‘broad’ value chain starts from the production system of the raw materials and will move along the linkages with other enterprises engaged in trading, assembling, processing, etc. The concept of value chain encompasses the issues of organization and coordination, the strategies and the power relationship of the different economic agents in the chain. The idea of value chain is associated with the concept of governance which is of key importance for fisheries because fisheries value chains crucially depend on the utilization of natural and environmental resources. The value chain framework can also be used to understand social ties and traditional norms which can be used to draw conclusions on the participation of the poor and the potential impact of value chain development on poverty reduction and food security.

The world of production and exchange is complex and heterogeneous. Not only do value chains differ (both within and between sectors), but so, too, do national and local contexts. So there is no mechanistic way of applying value chain methodology. Each chain will have particular characteristics, whose distinctiveness and wider relevance can only be effectively captured and analyzed though an understanding of the broader issues which are involved.

Three main research streams may be recognized in the value chain literature: (i) the filière approach, (ii) the conceptual framework elaborated by Porter (1985) and (iii) the global approach proposed by Kaplinsky (2000), Gereffi (1994, 1999) and Gereffi and Korzeniewicz (1994).

Value chains are complex, and particularly in the middle tiers, individual firms may feed into a variety of chains. Which chain – or chains – is/are the subject of enquiry therefore very much depends on the point of entry for the research inquiry. In each case, the point of entry will define which links and which activities in the chain are the subject of special enquiry. The entry point and the concentration of the value chain analysis are directly related to the desired development outcome from supporting the value chain. For example, if the focal point of the enquiry is in the design and branding activities in the chain, then the point of entry might be on design houses, or the branding function in key global marketing companies. This will require the research to go backwards into a number of value chains which feed into a common brand name (for example, the different suppliers to Nestle). At the other end of the scale, a concern with small and medium sized firms, which feed into a number of value chains, might require the research to focus on final markets, buyers and their buyers in a number of sectors, and on a variety of input providers. The key entry point that will be used in this proposal is the impact of the development and operation of the small-scale fisheries value chain on food security and poverty resulting from climate change.

The value chain approach is mainly a descriptive tool to look at the interactions between different economic agents. As a descriptive tool it has various advantages in so far it forces the analyst at considering both the micro and macro aspects involved in the production and exchange activities. The commodity-based analysis can provide better insights into the organizational structures and strategies of different actors and an understanding of economic processes which are often studied only at the global level (often ignoring local differentiation of processes) or at the national/local levels (often downplaying the larger forces that shape socio-economic change and policy making).

The methodology should address the following issues, and begins with understanding the nature of final markets, which are increasingly the driver in many value chains:

* The point of entry for value chain analysis
* Mapping value chains
* Product segments and Critical Success Factors in final markets
* How producers access final markets
* Benchmarking production efficiency
* Governance of value chains
* Upgrading in value chains
* Distributional issues

Kaplinsky and Morris (2001) stress that there is no “correct” way to conduct a value chain analysis; rather, the approach taken fundamentally rests upon the research question that is being answered. Nonetheless, four aspects of value-chain analysis as applied to agriculture are particularly noteworthy.

***Method for Objective 1***

Questionnaires will be designed and pretested for interviewing the following groups of stakeholders of the freshwater small sized fish industry:

* fishers
* processors
* traders (wholesalers and retailers for food and feed)
* transporters
* aquaculturists (snakehead and catfish)

The value chain analysis will consist of the following:

Firstly, at its most basic level, a value-chain analysis ***systematically maps the economic agents*** participating in the production, distribution, marketing, and sales of a particular product (or products). This mapping assesses the characteristics of economic agents, profit and cost structures, flows of goods throughout the chain, employment characteristics, and the destination and volumes of domestic and foreign sales (Kaplinsky and Morris, 2001). Such details can be gathered from a combination of primary survey work, focus groups, PRAs, informal interviews, and secondary data.

Second, value-chain analysis can play a key role in ***identifying the distribution of benefits of economic agents in the chain***. That is, through the analysis of margins and profits within the chain, one can determine who benefits from participation in the chain and which economic agents could benefit from increased support or organization. This is particularly important in the context of developing countries (and agriculture in particular), given concerns that the poor in particular are vulnerable to the process of globalization (Kaplinsky and Morris, 2001). One can supplement this analysis by determining the nature of participation within the chain to understand the characteristics of its participants.

Third, value-chain analysis can be used to ***examine the role of upgrading within the chain***. Upgrading can involve improvements in quality and product design that enable producers to gain higher-value or through diversification in the product lines served. An analysis of the upgrading process includes an assessment of the profitability of actors within the chain as well as information on constraints that are currently present. Governance issues play a key role in defining how such upgrading occurs. In addition, the structure of regulations, entry barriers, trade restrictions, and standards can further shape and influence the environment in which upgrading can take place.

Finally, value-chain analysis can ***highlight the role of governance*** in the value-chain. Governance in a value-chain refers the structure of relationships and coordination mechanisms that exist between economic agents in the value-chain. Governance is important from a policy perspective by identifying the institutional arrangements that may need to be targeted to improve capabilities in the value-chain, remedy distributional distortions, and increase value-added in the sector.

At the heart of the analysis is the mapping of sectors and key linkages. The value-added of the value-chain approach, however, comes from assessing these intra- and inter-actor linkages through the lens of issues of governance, upgrading, and distributional considerations. By systematically understanding these linkages within a network, one can better prescribe policy recommendations and, moreover, further understand their reverberations throughout the chain.

***Method for Objective 2***

A three-day training/workshop on Value Chain Analysis will be held in Tanzania (Dar el Salaam or Zanzibar) on 11-13 July 2012. The purpose of this training/workshop will be to assist the other AquaFish CRSP value chain investigations to analyze data and prepare reports. This training/workshop will be conducted by two University of Connecticut faculty members (Pomeroy and Warner). Day 1 will be training on value chain and fish market analysis and examples of its use in aquaculture and fisheries. Day 2 and 3 will be hands-on technical assistance to each project team with analysis of their data and in preparing an outline for their final report. We will have each team present their objectives, methods and data to all participants to allow for group learning and sharing.

**Schedule**

This activity is planned to be implemented as below:

|  |  |  |
| --- | --- | --- |
| Activity | Beginning | Ending |
| Planning the value chain analysis | 04/2012 | 05/2012 |
| Implementation of value chain analysis | 05/2012 | 08/2012 |
| Analysis of results and report preparation | 08/2012 | 09/2012 |
| Training and analysis workshop in value chain analysis for AquaFish CRSP investigations. | 06/2012 | 07/2012 |

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### Value Chain Analysis for Black Cockles (*Anadara tuberculosa* and *A. similis*)

Marketing, Economic Risk Assessment & Trade/Study/09MER10UH

#### Collaborating Institutions & Lead Investigators

University of Hawaii at Hilo (USA) Maria Haws

Armando Garcia-Ortega

Central American University (Nicaragua) Nelvia Hernandez

Erick José Sandoval Palacio

Wendel Carl Selexza

Juan Ramón Bravo

Eufresia Cristina Balladares

Maria Christina Espinoza

Wilber Herrera

Gleyman Aristides Cruz

Leticia Guadamuz

#### Background

Previous CRSP sponsored research (CRSP investigation 07HHI05UH in 2007-2009) (Haws et al. 2012) enabled a preliminary value chain analysis for the black cockle in Nicaragua. The black cockle (*Anadara* sp.) is an important fisheries and aquaculture product through Latin America, and also in Africa and Asia. The preliminary value chain analysis provided useful information for cockle management. One short fall however, was the lack of adequate resources to collect data on all aspects of cockle marketing, and some cost and price data was also difficult to collect. Hence, more in-depth and updated information would be valuable at this point in time. Additionally, although the preliminary study was not comprehensive, the findings along with other research results indicated that two key points exist in the value chain that would improve benefits to the fishers and community-based consolidators/vendors. These are the depuration and certification of black cockles. Methods were developed by which cockles can be depurated and product safety assured in less than three days. Both field and laboratory depuration trials were conducted. While both were effective, the water quality conditions in most estuaries where collectors work are too variable to guarantee that depuration can always be conducted. Hence, UCA has built a small, solar-powered depuration center in the community of Aserradores which can be easily operated by local producers once they are trained. The Nicaraguan government inspectors have advised, however, that the center will not comply with established HACCP requirement unless minor modifications are made. Additionally, dialogues with the Nicaraguan government have indicated that the depurated product can be certified and previous market studies suggest that certified product may yield a higher volume of sales and potentially higher prices. It was also found that there is a high level of interest in value-added products made from cockles, which might further increase the value to vendors. CIDEA will incorporate value added experiences from El Salvador and Mexico for the development and testing of value added cockle products.

#### Objectives

This proposed work will:

1. Enable a more rigorous value chain analysis to be conducted to update the previous, preliminary study.
2. Develop and test selected added-value products.
3. Modify the depuration center to comply with HACCP requirements and train collectors to operate it to improve product safety and allow for eventual certification of the product.

#### Significance

The proposed work will increase understanding of the value chain for cockles to inform resource management and business development decision-making. Moreover, Nicaragua has relatively few value added products for seafood, with the result that most producers or fishers received relatively few economic benefits. Most benefits accrue to restaurants and vendors in larger urban areas. Developing simple and safe value added products will allow inhabitants of rural or smaller urban areas to derive more economic benefits from seafood products. Previous experience with women’s oyster farming cooperatives have demonstrated that community based groups can develop and safely produce certain value added shellfish products. CIDEA also works with partners in El Salvador that support fishers groups to do the same. Moreover, new products and an increased knowledge of food safety and handling will reduce the loss of products due to poor handling, and decrease the incidence of food borne illnesses.

#### Quantified Anticipated Benefits

This work will contribute to improving economic benefits to producers and small vendors, as well as improve product safety and reduce waste.

*Metrics:*

* Number of institutions directly or indirectly benefiting from the training: 3
* Number of individual participants in extension and technical training: 8
* Number of communities benefiting from extension services: 1
* Students involved: 2
* Training modules produced: 1
* CRSP newsletter articles: 2
* Peer-reviewed journal article: 1

#### Activity Plan

The CIDEA/UCA team will work an economist specialist with expertise in marketing to conduct research with producers, vendors, consumers and restaurant owners to evaluate costs, prices, methods of selling products and related issues such as the percentage of loss, food safety issues and related topics. CIDEA will also work with cockle collectors and small-scale vendors to develop a limited range of value added cockle products and test these with consumers. Food handling and safety training will be included in this. CIDEA has previous experience with similar food development activities as they assisted four coastal communities to develop community-based bread bakeries. At the same time, CIDEA will work with community members to add modifications to the existing solar-powered cockle depuration center to bring it into compliance with government requirements for HACCP. Community members will also continue to be trained in the operation of the center.

**Schedule**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Activity** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** |
| Final design of value chain analysis study | x |  |  |  |  |  |  |  |
| Data collection for VCA study |  | x | x | x | x |  |  |  |
| Data analysis and preparation of final report |  |  |  |  |  | x |  |  |
| Development and testing of value added products |  | x | x | x |  |  |  |  |
| Preparation of report and community presentations for value added products |  |  |  |  | x | x |  |  |
| Modifications to depuration center | x | x | x |  |  |  |  |  |
| Inspection of center by government officials |  |  |  | x |  |  |  |  |
| Production of outreach materials |  |  |  |  | x | x |  |  |
| Final reports to CRSP |  |  |  |  |  | x |  |  |

#### Student Involvement

Two undergraduate students from the Aquaculture and Engineering departments will be involved. Three CRSP staff persons, Nelvia Hernandez, Erick Sandoval and Juan Ramon Bravo, are also in the process of obtaining their Masters degrees and are using their work experience with CRSP to satisfy some course requirements for practical work.

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### Value Chain Analysis of Carp Polyculture Systems in Southern Nepal

Marketing, Economic Risk Assessment & Trade/Activity/09MER11UM

#### Collaborating Institutions & Lead Investigators

Institute of Animal and Agricultural Science (Nepal) Madhav Shrestha

University of Michigan (USA) James S. Diana

#### Objectives

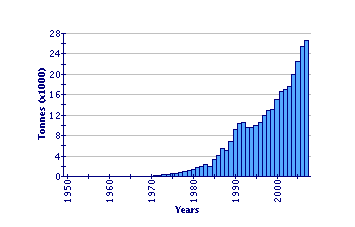
1. To conduct an analysis of carp polyculture production, harvesting, processing, distribution, markets, and sales in Southern Nepal.

1. To organize data into a value chain diagram and to use the diagram to draw insight

into possible improvements in the aquaculture sector.

#### Significance

Although aquaculture has been practiced in Asia for thousands of years (FAO, 2012), it is fairly new in Nepal. It wasn’t until the 1940s that the country began raising fish, and an additional 40 years passed before any significant progress was made in the field (FAO, 2012). Considering Nepal’s late start in aquaculture practices, it is no surprise that the county is yet to contribute substantially to the huge volume of Asian aquaculture production (Asia produced 92.5% of the world’s total aquaculture in 2008 (FAO, 2010)) or benefit largely from the economic improvements that aquaculture has been shown to create (FAO, 2010). Recently, however, Nepal has shown marked increase in aquaculture production (Figure 1). Carp polyculture has been developed as a popular system, and research has been made into cage fish culture, rice-fish culture, and the production of cold water cultures of species such as snow trout and rainbow trout at higher altitudes (FAO, 2012). Additionally, aquaculture in Nepal has been shown to benefit rural communities by providing an important supply of protein and additional income generation, and by empowering women who care for fish ponds (Bhujel et al, 2008).

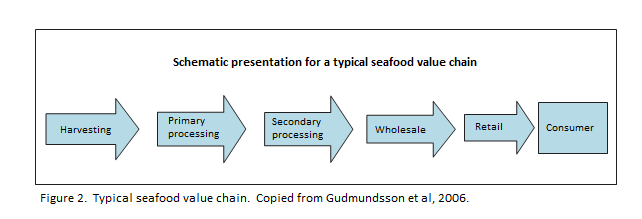


**Nepal Aquaculture Production**

Figure 1. Reported aquaculture production in Nepal from 1950. Figure copied from FAO.org

Given the increase in aquaculture production in Nepal and its social, cultural, and economic benefits, research must be carried out in order to address the overall value of aquaculture within the country and the potential for the aquaculture business to grow into a successful and sustainable operation. In order to complete this task, a value chain analysis can be carried out to explore the relationships between the steps of the production, processing, and distribution of cultured fish species in Nepal. This analysis will provide managers with a systematic and analytical tool that helps to show the processes, costs, and impacts of the entire aquaculture sector.

The general concept of a value chain is to link all of the steps of production, processing, and distribution of a product together, and then to analyze each step as it relates to those that precede it and follow it. In doing so, the value chain describes all of the activities responsible for bringing a product from creation to ultimate disposal (Hempel, 2010).



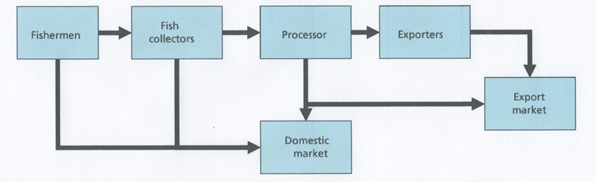


Figure 3**.** A simple value chain for Nile perch in Tanzania. Copied from Hempel, 2010.

In aquaculture, value chains have been conducted throughout the world in order to better understand aquaculture production. The specific purposes of value chain analyses vary depending on the needs of a particular area, but they always serve to define the value of an aquaculture system in order to improve functionality. In Africa, these analyses have been carried out to assess the efficiency of developing country aquaculture distribution systems.

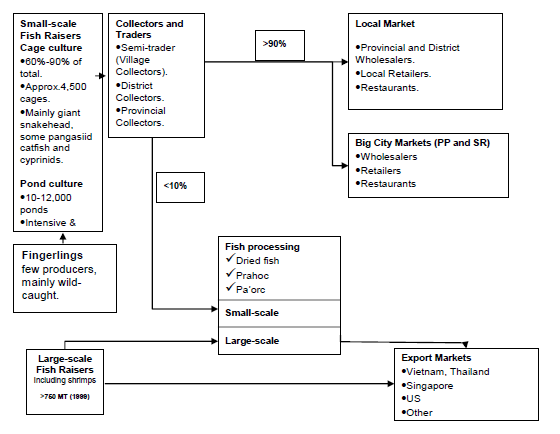


Figure 4. Cambodia aquaculture value chain diagram. Copied from Peramune, 2010.

In Tanzania, for example, a value chain analysis for Nile perch demonstrated that the establishment of a fisheries management system to control allowable catch, improvement in infrastructure, and the allowance of host country fish traders would help to improve profitability (Hempel, 2010).In Asia, value chains have been used to provide insight into

weaknesses in the aquaculture sector, thereby allowing for the development of problem solving strategies. In Cambodia, for example, a value chain analysis found that fish farmers were constrained by unstable fingerling production. In order to address this limitation, strategies were developed to provide technical training for fingerling producers (Peramune, 2010).

Given the early stages of aquaculture development in Nepal, a value chain would be best applied to evaluating limitations in the potential growth of the sector. Taking this into consideration, the following topics have been highlighted as research areas, and questions and comments have been made regarding specific concerns.

* **Fingerling Production** – Is there adequate fingerling production to accommodate the demand for cultured fishes in Nepal? Are fingerlings wild caught?
* **Fish Feed** – Do fish farmers have adequate feed to produce fish to meet demand? What feeds are used?
* **Seasonality** – Rural lowland communities in Nepal are only able to raise fish in the monsoon season when water is plentiful. How does this restraint effect fish production?
* **Transportation** – What transportation methods exist for shipping raised fishes to distant markets? How far away can fish be safely transported?
* **Export** – Does a market exist for export of cultured fishes across country borders?
* **Market Concerns** – What is the nature of the demand for cultured fish in Nepal?

#### Quantified Anticipated Benefits

The completion of a value chain analysis in Southern Nepal will provide a complete understanding of the strengths and weaknesses of the carp polyculture business. Through this understanding all of those involved in the sector, from fingerling producers to fish farmers to those involved with fish sales, will be informed of management strategies to improve their particular service. This will lead to increased profits, the supply of high quality fish protein to communities with limited food resources, and the overall growth of the aquaculture sector.

#### Activity Plan

##### Locations:

Data collection will be focused in Chitwan, Terai, Nepal. Interviews will be

conducted in 4-5 locations throughout Nepal, including Rampur and surrounding areas, Kathar, and Kathmandu. Value Chain Mapping will be carried out with the aid of Bob Pomeroy in Tanzania.

##### Data Collection

In order to understand the relationship between different stages in the carp polyculture value chain, representatives who work in each stage must be interviewed. Individuals will therefore be identified in the fields of fingerling production, fish farming, fish processing, fish transportation, fish sales, and fish purchasing, and these individuals will be interviewed regarding their interaction with the product and the distribution benefits, what they view as strengths and weaknesses in the production chain, how information is shared between different stages, and knowledge of market trends. IAAS professor and Nepal aquaculture expert Madhav Shrestha will serve as the first contact in terms of determining value chain actors, and individuals will then be selected and interviewed. If possible, multiple professionals from each value chain stage will be interviewed.

##### Value Chain Mapping

Attendance at Bob Pomeroy’s value chain workshop at IIFET 2012 in Tanzania in July will aid in the first creation of a value chain map. This will also serve as a time for data quality assessment. If it is determined that additional data is needed, further data collection will be carried out upon return to Nepal following the Conference.

##### Analysis of Opportunities and Constraints

Following the previous steps, opportunities for improvement and specific constraints of the carp polyculture value chain will be described in a final report.

#### Schedule

May 2012 – September 29, 2012

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