

# IV. Abstracts of Technical Reports

## A. Global Studies and Activities

### THE EFFECT OF MANAGEMENT STRATEGIES ON NUTRIENT BUDGETS: HONDURAS

*Interim Work Plan, Global Experiment*

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#### *Abstract*

Semi-intensive shrimp production in Honduras is based upon use of formulated diets to supply nutrients for shrimp growth. Unconsumed feed contributes nutrients to pond water, which when discharged may deteriorate water quality in receiving waters. This experiment focused on the development of nutrient budgets (nitrogen and phosphorus) in semi-intensively managed shrimp ponds receiving a low or high protein feed to 1) assess the fate of nutrients added to shrimp ponds, 2) rank the importance of nutrient sources and sinks, and 3) evaluate the potential pollutional impact of specific pond management systems. Eight 1.67-ha earthen ponds located on a commercial shrimp farm on a riverine estuary of the Gulf of Fonseca, Honduras, were used for this dry-season study. Two treatments (20% and 30% protein feed) were tested using a completely randomized design with four replicates per treatment. Ponds were stocked with hatchery-produced post-larval (PL) *Penaeus vannamei* to achieve a final stocking rate of approximately 80,000 shrimp/ha. Ponds were harvested 87 days

after stocking. Gross shrimp yields and mean final weights did not differ significantly between treatments, and averaged 412 kg/ha and 490 kg/ha, and 6.1 g and 5.7 g for the 20% and 30% protein feed treatments, respectively. Total nitrogen and phosphorus, chlorophyll-*a* and BOD<sub>2</sub> concentrations in inlet water were significantly lower than in pond water. However, no significant differences were detected between treatment water quality means. Significantly greater quantities of nitrogen and phosphorus were added to ponds as feed in the 30% protein feed treatment. Feed accounted for 41% and 52% of added nitrogen, and 47% and 55% of added phosphorus in the 20% protein and 30% protein feed treatments, respectively. Inlet water, either from the initial fill or from water exchanges and replacement, was the source of all other nitrogen and phosphorus added to ponds. Harvest of shrimp accounted for 36% to 37% of applied nitrogen and 19% to 20% of applied phosphorus.

### THE EFFECT OF MANAGEMENT STRATEGIES ON NUTRIENT BUDGETS: THAILAND

*Interim Work Plan, Global Experiment, Thailand*

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#### *Abstract*

Nitrogen and phosphorus budgets in ponds with different fertilization and feeding regimes were compared. Two experimental treatments were conducted in triplicate in six 280 m<sup>2</sup>-earthen ponds at Bang Sai Station in Ayutthaya Province, Thailand. In treatment A, ponds were fertilized throughout the

experimental period, and beginning on day 80 commercial feed (30% crude protein) was added. In treatment B, ponds were fertilized until day 80, and then fertilization was discontinued and commercial feed (30% crude protein) only was added following day 80. Ponds were stocked with sex-reversed all male Nile tilapia at 3 fish/m<sup>2</sup>. Feeding rate was adjusted weekly for each pond according to the total amount of feed consumed during one hour in the morning (1000-1100 h). The water depth of each pond was maintained at 1 m, and ponds were topped off weekly to replace losses to seepage and evaporation. Fish growth in treatment A was significantly better than treatment B. The maximum mean weight of treatment A was 314 g per fish and total yield was 227.8 ± 4.4 kg per pond compared with a maximum mean weight of 248 g per fish and a total yield of 182.4 ± 16.9 kg per pond for treatment B. DO values for both treatment A and B were variable, ranging from 1.0 to 10.6 mg/l. Mean total alkalinity values in treatments A and B were 104.3 ± 21.7 and 88.4 ± 2.4 mg/l CaCO<sub>3</sub>, respectively. Treatments A and B had TAN concentration means of 0.72 ± 0.31 and 0.24 ± 0.03, respectively; mean chlorophyll-*a* concentrations for treatment A and B were 139.7 ± 36.2 and 110.8 ± 15.5 µg/l, respectively. Total inputs of nitrogen were significantly higher for treatment A than treatment B; however, significant differences were not observed between treatments for nitrogen and phosphorus losses due to fish harvest. Losses of N and P in discharged water at harvest and the nutrient content in effluent water at harvest were not significantly different between treatments (*p* > 0.05). The nutrient budget indicated that major portions of the total N and P inputs to ponds were not accounted for in the estimated losses. Unaccounted losses for all ponds ranged from 70.66% to 78.01% for N and 81.88% to 87.25% for P of the total inputs. The large amounts of nitrogen unaccounted for could be attributed to losses through denitrification processes in pond bottom sediments.

### THE EFFECT OF MANAGEMENT STRATEGIES ON NUTRIENT BUDGETS: A COMPARISON OF MONO-SEX SWANSEA GMT AND MIXED-SEX GIFT NILE TILAPIA (*OREOCHROMIS NILOTICUS*)

*Interim Work Plan, Philippines Study 2 and Global Experiment*

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#### *Abstract*

The growth responses of two tilapia groups, mono-sex Swansea GMT and mixed-sex GIFT Nile tilapia (*Oreochromis niloticus*), were compared using two of the nutrient input regimes specified in the Interim Work Plan's Global Experiment: fertilizer only (weekly fertilization with urea and 16-20-0) and fertilizer (weekly fertilization with urea and 16-20-0) followed by feed (27% protein content). Four treatments tested the management regimes using a 2 × 2 factorial design; three replicates were conducted for each treatment. All ponds were stocked with tilapia fingerlings weighing 4-7 g/individual fish at a density of 3 fish/m<sup>2</sup>. African catfish (*Clarias gariepinus*) weighing 2.2-3.1 g/individual fish were also stocked at 0.3 fish/m<sup>2</sup> to serve as predator control of tilapia reproduction. Water depth was measured and adjusted weekly to 0.9 to 1.0 m, and water samples were taken between 0600 hours and 0900 hours every two weeks. Fish were sampled monthly for individual weight and bulk weight. Fed ponds were sampled twice monthly so that

rations could be adjusted for growth. After 150 days ponds were harvested and drained. Survival by pond ranged from 81% to 97% with the exception of a pond with 58% survival. The fed treatments produced significantly more fish than the fertilizer-only treatments, 8266 kg/ha/annum versus 5438 kg/ha/annum, respectively. For both the fed treatment and the fertilization-only treatment, yields of stocked tilapia were greater for GMT than GIFT fish. The average weight of individual fish did not differ significantly between strains in either feed regime. Survival was also significantly better for GMT than GIFT fish for both fed- and unfed-treatments. Catfish and tilapia reproduction significantly contributed to total fish yields—catfish yields constituted 14.0% to 27.8% of the total crop for fed ponds and 10.5% to 14.3% of the total crop for unfed ponds. In the fed treatment, the mono-sex GMT tilapia significantly outperformed the mixed-sex GIFT tilapia.

#### APPLICATIONS OF HEAT BALANCE AND FISH GROWTH MODELS FOR CONTINENTAL-SCALE ASSESSMENT OF AQUACULTURE POTENTIAL IN LATIN AMERICA

*Interim Work Plan, DAST Study 3*

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#### *Abstract*

Assessments of aquaculture potential over large geographic areas require estimates of fish yields that are possible with different culture species. In the past, these estimates were based on historical data. Such approaches are limited because they do

not consider various factors that affect fish growth and the data required to estimate fish yield may not be available for the entire region to be analyzed. An alternative approach was used in this study to estimate fish yields in Latin America as part of a FAO effort to assess aquaculture potential in the region using a geographical information system (GIS). The approach involved the application of the POND<sup>®</sup> heat balance model to generate water temperature profiles for continental Latin America. These profiles were then used in the POND<sup>®</sup> fish growth model together with pre-set satiation feeding levels and harvest sizes to assess the number of crops per year possible under commercial-scale (CS) aquaculture conditions for four fish species: Nile tilapia (*Oreochromis niloticus*), tambaquí (*Colossoma macropomum*), pacu (*Piaractus mesopotamicus*), and common carp (*Cyprinus carpio*). The potential for small-scale (SS) or subsistence farming of Nile tilapia and common carp was also examined. The results suggest that relatively large areas of Latin America are suitable for CS farming of the four species considered in the study. That is, 66% to 73% of the surface area of continental Latin America is suitable for carp culture. Similarly, the suitable land area ranges from 55% to 66% for tambaquí, 48% to 60% for pacu, and 9% to 43% for Nile tilapia. For SS farming, about 34% and 70% of the land area is suitable for Nile tilapia and carp respectively. Simulation results suggest that integration of the fish growth model within GIS is a useful mechanism to address the effects of various factors (primarily water temperature and feeding rates) on fish yields over large geographic regions, and to estimate the production potential at various levels of culture intensity. The fish growth model predictions obtained from this study have been combined with analyses of other factors within the overall GIS that are important in the assessment of aquaculture potential (i.e., water requirements, urban market potential, potential for farm gate sales, availability of agricultural by-products as feed/fertilizer input, and engineering and terrain suitability for pond construction) to identify areas of Latin America that are either very suitable, suitable, marginally suitable, or unsuitable for aquaculture development.

## APPLICATIONS OF POND<sup>®</sup> AS A TOOL FOR ANALYSIS AND PLANNING

*Interim Work Plan, DAST Studies 1 and 2*

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### *Abstract*

The POND<sup>®</sup> decision support software framework provides a variety of models that can be used either in combination or as stand-alone tools to generate information for pond aquaculture planning and management. This report focuses on practical applications of the POND<sup>®</sup> software. A water budget model that considers various sources (regulated inflow, precipitation and runoff) and sinks (evaporation, seepage, effluent discharge, and overflow) was used to predict water requirements for CRSP sites in Thailand Asian Institute of Technology (AIT) and Honduras (El Carao) over a full growing season. The difference between actual and predicted amounts of regulated water inflow for AIT was only 20.3 m<sup>3</sup>, whereas for El Carao predicted water requirements were 141.3 m<sup>3</sup> lower than the amounts actually added, apparently due to poor estimates of evaporative water loss at this site. Data from the Global Experiment used to test PONDCLASS fertilization guidelines at various CRSP sites indicated that revisions to the guidelines were necessary. These revisions, which have been implemented in the form of a model in POND<sup>®</sup>, include the following: 1) the use of gross instead of net primary productivity to estimate nutrient requirements for algae, 2) consideration of nitrogen and phosphorus cycling in ponds, and 3) functional representation of the effects of nutrient concentrations and temperature on algal growth. Results of model verification suggested that the revised guidelines generated fertilization rates that were in general more conservative than those recommended by PONDCLASS, and were consistent with previous work—responsive fertilization strategies (i.e., strategies that account for ambient pond water conditions during evaluations of pond nutrient needs) are likely to be superior in terms of cost and fertilizer use efficiency compared to fixed input

strategies. Numerical experiments were also undertaken to assess feed requirements for aquaculture ponds via the use of the POND<sup>®</sup> bioenergetics (BE) model. Comparison of a fixed feeding regime to a 100% satiation feeding protocol for Nile tilapia (*Oreochromis niloticus*) cultured in fertilized ponds at three elevations suggested that the former practice was likely to be economically inefficient, because it did not consider natural food consumption, and variations in fish appetite due to seasonal water temperatures. A second experiment that examined supplemental feed requirements for fertilized ponds stocked with Nile tilapia at 1 and 2 fish m<sup>-2</sup> indicated that requirements would be about four to five times higher in the ponds stocked at the higher density; further, the model indicated that supplemental feeding in these ponds should be initiated about two months before it was needed in the ponds stocked at 1 fish m<sup>-2</sup>. A third set of experiments examined feed requirements for unfertilized Nile tilapia ponds located at three elevations (MSL, 500 m and 1000 m). Predicted feeding rates decreased over time from 7.1% to 2.1% BW d<sup>-1</sup> for the MSL site, from 6.6% to 1.4% BW d<sup>-1</sup> for the 500 m site, and from 1.5% to 0.6% BW d<sup>-1</sup>. An effort was also undertaken to simulate plankton biomass changes in Nile tilapia ponds stocked at 1, 2 and 3 fish m<sup>-2</sup> by the use of the more complex POND<sup>®</sup> models. Results indicated that although zooplankton biomass was similar for all three treatments, the biomass of two phytoplankton pools (A and B) differed substantially among the treatments, presumably due to increased grazing pressure in simulated ponds with a high fish biomass, and also because the overall phytoplankton biomass was divided into two pools for which tilapia were assumed to have different preferences. Finally, sensitivity analyses were conducted with the POND<sup>®</sup> heat balance and fish growth models. Daily pond water temperatures predicted via the use of the former model were most sensitive to mean air temperature, followed by relative humidity, short-wave solar radiation, cloud cover, and wind speed. These results further support the argument that CRSP data collection protocols should include measurements of relative humidity and cloud cover in addition to variables that are already measured. Sensitivity analysis of the fish growth model to ten principal parameters indicated that it is extremely sensitive to five anabolic and one catabolic parameters.

### PD/A CRSP CENTRAL DATABASE

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#### *Abstract*

In Spring 1993 the CRSP Central Database was transferred from the University of Hawaii at Hilo to Oregon State University where it is now managed. Since the transfer, the following improvements have been instituted: The database is now managed under Microsoft Access and consists of one computer file containing multiple data tables. Relational data structures and experiment treatment specifications have been implemented. A user and investigator interface to the Central Database is now provided at a designated Internet Web (<http://biosys.bre.orst.edu/crspDB/>). The data search strategy supported by the database Web site interface is based on a site, time, production-methods approach for defining and extracting data subsets. Principle investigator reference information will appear automatically as users extract specific data sets. In addition to the database Web site, the database will be available at the world-wide environmental data Web site maintained by the Consortium of International Earth Science Information Network (CIESIN). Further, for intensive users of the database, the entire database is also available on electronic media.

### DOING DEVELOPMENT BY GROWING FISH: A CROSS-NATIONAL ANALYSIS OF TILAPIA HARVEST AND MARKETING PRACTICES

#### *Interim Work Plan, Socioeconomic Study*

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#### *Abstract*

The tilapia enterprise plays a diverse set of roles in farm and family systems. The level of intensity of fish culture is contingent on the needs of the family and the resources—land, labor, and capital—that can be applied to the activity. In some cases, industrial-scale tilapia farms play a significant role in aquacultural development by providing fingerlings, processing facilities, and a corporate voice in national aquacultural policy. This paper focuses on the production and marketing experiences of medium and small-scale family farms where fish farming can make the most immediate contribution to family well-being. Survey and interview data was compiled from four PD/A CRSP countries—Rwanda, Honduras, Philippines, and Thailand regarding production cycle characteristics, marketing constraints, and relative prices of fish. Production cycles in the Philippines were the shortest (139 to 149 days) with two crops produced; fish produced ranged 173-199 g. Honduran fish farmers produced one to two crops per year in a period of 194 to 263 days with fish averaging 274-570 g. In Thailand, larger fish resulted for both medium- and small-scale operations that utilized a longer production cycle (307 to 358 days). The price of tilapia in the Philippines ranged from \$0.97 to \$2.34 per kg; however, in Thailand and Honduras prices for tilapia ranged from \$0.12 to 0.99 and \$0.68 to \$1.65 per kg, respectively. Sixty percent of Rwandan farmers did not sell fish from their final harvest. Small- and medium-scale Honduran farmers kept 20% more production for home consumption than Pilipino farmers and 12% more production than Thai farmers. Farmers from both the Philippines and Thailand of medium- and large-scale farms sold 100% of their production. Small-scale farmers from the Philippines kept a portion of their production, whereas small-scale Thai farmers sold 100% of their production. Two thirds of the farmers surveyed reported no marketing problems. Concern regarding earning the desired price for fish arose in Thailand, Honduras, and the Philippines. Three quarters of Rwandan farmers, approximately half of the Honduran farmers, and almost all the farmers from Thailand and the Philippines felt that larger fish would be easier to sell. Further research of marketing channels is recommended for the

improvement of product distribution and as well for direction of production inputs to farmers.

Institutional participants may be the prime target for PD/A CRSP activities; however, non-governmental organizations may be an important mechanism for connecting small- and medium-scale farmers with CRSP research and technological developments.

Activities such as NGO trainer instruction, assistance to national institutions in the organization of seminars and training programs for NGOs, and encouragement of NGOs to adopt aquaculture in assistance activities may be valuable outlets for the diffusion of PD/A CRSP research.

## B. Central America

### EFFECT OF DIET PROTEIN ON FOOD CONVERSION AND NITROGEN DISCHARGE DURING SEMI-INTENSIVE PRODUCTION OF *PENAEUS VANNAMEI* DURING THE WET SEASON

*Interim Work Plan, Honduras Study 1 (Part I)*

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#### *Abstract*

The objective of this study was to evaluate the effect of diet protein level and feeding rate on shrimp yields, food conversion ratio (FCR), and nitrogen effluents. Earthen ponds ranging in area from 0.7 ha to 2 ha were stocked with *Penaeus vannamei* post larvae at 24/m<sup>2</sup>. The larvae were fed high or low rates of a commercially formulated pellet containing 20% or 40% crude protein, respectively. Protein level or feeding rate did not significantly effect gross shrimp yield or mean shrimp size. Feeding rate, but not protein level, significantly affected FCR, which was higher at the higher feeding rate. No interaction was detected between protein level and feeding rate for yield, mean shrimp size, or FCR. A high protein diet fed at a low rate did not influence production any more than a low protein diet fed at a low rate. Mean material exchange in treatment ponds was negative (greater mass discharge than mass intake) for total nitrogen, total phosphorus, chlorophyll-*a*, and BOD<sub>2</sub>, and positive for dissolved inorganic nitrogen. There was a net discharge of filterable phosphate at the high feeding rate and a net

accumulation at the low feeding rate. More total nitrogen was introduced into ponds by shrimp, water, and feed than was removed from ponds as harvested shrimp and discharge water. The mean treatment difference between input and output nitrogen was significantly higher at the high feeding rate than the low feeding rate. Protein level had no significant effect on the nitrogen balance.

#### **EFFECT OF DIET PROTEIN ON FOOD CONVERSION AND NITROGEN DISCHARGE DURING SEMI-INTENSIVE PRODUCTION OF *PENAEUS VANNAMEI* DURING THE DRY SEASON**

*Interim Work Plan, Honduras Study 1 (Part II)*

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##### *Abstract*

Results of previous research in Honduras have demonstrated that shrimp production is similar at feed protein levels ranging from 20% to 40%, when shrimp are stocked at densities ranging from 5 to 11 /m<sup>2</sup>. Additionally, a 50% reduction in the feeding rate did not affect dry-season shrimp production. The objective of this experiment was to determine the effect of dietary protein and feeding rate on feed conversion and nitrogen discharge in semi-intensive production of *Penaeus vannamei*. Twelve 1.67-ha earthen ponds located on a commercial shrimp farm were used in a completely randomized study design. Three treatments, with four replicates per treatment, were tested: a 20% and

30% protein feed applied at 50% of the feeding curve, and a 20% protein feed applied at 75% of the feeding curve. Ponds were stocked with hatchery-produced post-larval (PL) *Penaeus vannamei* to achieve a final stocking rate of approximately 80,000 shrimp/ha. Ponds were harvested 87 days after stocking. Gross yields of head-on shrimp ranged from 412 to 534 kg/ha for the 87-day production period. Feed protein content did not affect gross shrimp yields significantly; however, gross yield of whole shrimp fed the 20% protein feed was significantly greater at the 75% feed curve rate compared to 50% feed curve rate. Feed conversion ratios (FCR) were close to one, and were significantly lower with the 30% protein feed and at the 50% feed rate. Nitrogen and phosphorus additions to ponds as feed were significantly greater with the high-protein feed and with the low-protein feed at the higher feed rate. Significant differences in nitrogen or phosphorus concentrations in water discharged from ponds were not detected among treatments.

#### **ESTUARINE WATER QUALITY**

*Interim Work Plan, Honduras Study 2*

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##### *Abstract*

The objective of this study was to monitor estuarine water quality in order to detect trends over time, and evaluate the impact of shrimp farming on water quality. Water samples were collected at intake pumps of shrimp farms. Samples were taken every 1 to 2 weeks from at least 12 sampling sites distributed over six estuaries in the shrimp farming area of southern Honduras. Water samples were

analyzed and summarized according to estuarine type, location, season, month, and year for total settleable solids, total ammonia nitrogen, filterable reactive phosphate, chlorophyll-*a*, total alkalinity, salinity, and BOD<sub>7</sub>. Data collection and analyses are in progress. A preliminary analysis of total nitrogen was completed for El Pedregal estuary. Nitrogen input as feed was greatest during the rainy season due to increased shrimp growth in this season; however, there was no accumulation of nitrogen from heavy feeding because of flushing by runoff. During the dry season, a period of relatively light feeding, nitrogen concentrations tended to increase, because of insignificant freshwater input and low exchange with bay water. Overall total nitrogen concentration did not increase with time, primarily because runoff from rainfall flushes the estuaries yearly.

**SEX REVERSAL OF TILAPIA: 17 $\alpha$ -METHYLTESTOSTERONE DOSE RATE BY ENVIRONMENT AND EFFICACY OF BULL TESTES**

*Interim Work Plan, Honduras, Study 4*

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*Abstract*

Sex reversal of newly hatched tilapia generally is accomplished via oral administration of 17 $\alpha$ -methyltestosterone (MT), which has been incorporated into a starter fish feed at 60 mg MT/kg feed. Other investigators have reported sex reversal of tilapia at dose rates less than 60 mg MT/kg feed; however results from some of these studies are inconsistent, and it is difficult to separate treatment environment effects. Naturally occurring sources of testosterone may be an alternative to using a synthetic androgen, which also is an anabolic steroid, for tilapia sex reversal. Bull testes are a by-product of the beef industry in the US, and are a potential source of dietary testosterone for tilapia sex

reversal. The objectives of this research were: 1.) to determine the efficacy of different dosage rates of MT for sex reversal of fish treated in different environments, and 2.) to evaluate the potential of freeze-dried bull testes as a dietary source of testosterone for tilapia sex reversal. Newly hatched Nile tilapia (*Oreochromis niloticus*) were stocked at 8 fry/l into 80-l glass aquaria located inside a hatchery building or into hapas suspended in 20-m<sup>3</sup> outdoor concrete tanks. Trout chow was the carrier for MT, which was incorporated into the feed at 0, 10, 20, 30 and 40 mg MT/kg of feed. Frozen bull testes, obtained from a meat packing plant, were freeze-dried, ground, and mixed with trout chow either in a 1:1 or 1:3 freeze-dried testes: trout chow ratio. The use of freeze-dried bull testes (BT) as a source of testosterone was not effective in producing tilapia populations of 95% or greater males. The percentage of males ( 54%) in populations fed a ration containing 25% BT did not differ from non-treated populations (52.4%). The percentage males (64.8%) obtained when BT composed half of the ration was significantly greater than non-treated populations. Indoor and outdoor treatments did not affect the ability of 17 $\alpha$ -methyltestosterone to alter the sex ratio of tilapia. Greater than 97% male populations were obtained at dose rates of 15 mg, 30 mg, 45 mg and 60 mg MT/kg feed when fish were treated in indoor aquaria or outdoor hapas.

## STUDY OF CHEMICAL VARIABLES IN TWO ESTUARIES OF SOUTHERN HONDURAS

*Interim Work Plan, Honduras Study 3 (Part I)*

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*Abstract (Printed as submitted)*

Two major shrimp producing estuaries, El Pedregal and the San Bernardo, were sampled weekly at high and low tides for five weeks during the rainy season of 1995. The sampling period spanned a lunar cycle when tidal levels fluctuated. Water samples were collected from the surface, mid depth, and near the bottom. Samples were taken at four stations along a longitudinal transect of each estuary that discharges into the Gulf of Fonseca. Water was analyzed for BOD<sub>5</sub>, total phosphorus, filterable phosphate, nitrate nitrogen, total nitrogen, total ammonia, chlorophyll-*a*, and total suspended solids. El Pedregal estuary had significantly higher concentrations of organic material and more nutrients than the San Bernardo. Mean nutrient concentrations were significantly higher at low tide than at high tide, probably because estuarine water was diluted with relatively pristine gulf water during the high tide. Nutrient concentrations were not predictably stratified along the lengths of estuaries. There was no apparent pattern between nutrient concentrations and lunar phase in either estuary. High freshwater inflow from rainfall probably masked lunar and longitudinal effects of estuarine hydrology. There were few water quality differences between the surface and bottom of estuaries, except for total settleable solids which tended to be higher at the bottom. Otherwise, high tidal fluctuation kept water vertically mixed in the main estuarine channels.

(This thesis was in partial fulfillment of the Ingeniero Agrónomo degree, Escuela Agrícola Panamericana, Zamorano, Honduras. Abstract translation by David Teichert-Coddington)

## PHYSICO-CHEMICAL CHARACTERIZATION OF TWO ESTUARIES OF SOUTHERN HONDURAS DURING THE RAINY SEASON

*Interim Work Plan, Honduras Study 3 (Part II)*

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*Abstract (Printed as Submitted)*

Two major shrimp producing estuaries, El Pedregal and the San Bernardo, were sampled weekly at high and low tides for five weeks during the rainy season of 1995. The sampling period spanned a lunar cycle when tidal levels fluctuated. Dissolved oxygen, temperature, and salinity were recorded at 50-cm intervals from surface to bottom. Measurements were taken at seven stations in El Pedregal and six stations in the San Bernardo. The stations were located along a longitudinal transect of each estuary that discharges into the Gulf of Fonseca. Both estuaries are influenced by rivers. The Black River (Rio Negro) enters the San Bernardo at its head, and the Choluteca River enters the El Pedregal near its mouth. Salinity of the San Bernardo was less than that of the El Pedregal due to river flow through the estuary. In both estuaries, but particularly in the San Bernardo, salinity increased closer to the gulf because of intrusion by higher salinity gulf water. Mean estuarine salinity was significantly higher during high tide. The distance upstream that gulf water exchanged with estuarine water could be demonstrated from the change in salinity at various depths during tidal exchange. Dissolved oxygen concentrations of estuarine water increased with greater influence of the gulf. In both estuaries, dissolved oxygen concentrations were significantly higher near the gulf than upstream. Dissolved oxygen was also significantly higher during the high tide, and during the new moon.

(This thesis was in partial fulfillment of the Ingeniero Agrónomo degree, Escuela Agrícola Panamericana, Zamorano, Honduras. Abstract translation by David Teichert-Coddington)

## C. East Africa

### MASCULINIZATION OF TILAPIA THROUGH IMMERSION IN 17 $\alpha$ -METHYLTESTOSTERONE OR 17 $\alpha$ -METHYLDIHYDROTESTOSTERONE

*Interim Work Plan, Africa Study 2*

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*Abstract*

The use of all-male populations increases the efficiency and feasibility of tilapia aquaculture. The objective of this study was to determine the efficacy of a short term immersion procedure for masculinizing Nile tilapia (*Oreochromis niloticus*). Two synthetic androgens were evaluated, 17 $\alpha$ -methyl dihydrotestosterone and 17 $\alpha$ -methyltestosterone. Three-hour exposure of fry at 10 days and 13 days post-fertilization in methyl dihydrotestosterone at 500 mg/l produced sex ratios greater than 93% male. Immersions in methyl dihydrotestosterone at 100 mg/l and methyltestosterone at 500 mg or 100 mg/l were unsuccessful at producing all-male populations. Immersion of Nile tilapia in 500 mg/l methyl dihydrotestosterone may provide a practical alternative to the use of steroid-treated feed. Furthermore, when compared with current techniques for steroid-induced sex inversion of tilapia, short term immersion shortens the treatment period and reduces the risk of worker exposure to anabolic steroids.

### EXPERIMENTAL EVALUATION OF LIME REQUIREMENT ESTIMATORS FOR GLOBAL SITES

*Interim Work Plan, Africa Study 3*

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*Abstract*

Artificial enclosures ("isolation columns") were constructed and placed in an earthen pond to investigate their utility as test units for pond treatments and to compare results with results obtained from a series of experiments designed to evaluate alternative lime requirement determination methods in laboratory microcosms. Six 30-cm diameter columns were placed in the pond at depths of approximately 1 m. Three units were treated with agricultural limestone at a rate calculated to completely neutralize soil acidity and three units remained untreated. Water column samples were taken from each isolation column and from the open pond adjacent to the columns and examined for total alkalinity after 1, 3, 7, 14, 21, and 28 days. Bottom soil from the same pond was used to conduct parallel treatments in 800-ml laboratory microcosms. Total alkalinities in the open pond and in unlimed columns remained relatively low throughout the experiment, and trends in unlimed columns were similar to those in the open pond, suggesting that the columns themselves had little effect on alkalinity. Alkalinities in the limed columns rose to almost 30 mg/l CaCO<sub>3</sub> within 24 hours and continued to rise throughout the experiment, reaching approximately 50 mg/l by day 28. Alkalinities in unlimed laboratory microcosms rose initially, but declined to about 12 mg/l by the end of the experiment, whereas alkalinities in limed microcosms rose to over 60 mg/l by day 14 and then gradually declined, reaching about 52 mg/l by day 28. Alkalinity trends in both limed and unlimed microcosms differed noticeably from trends in pond enclosures, and significant differences were observed among all day-28 alkalinities except those in limed microcosms and limed isolation columns. This suggests that results in either the isolation columns or the microcosms or both may not be representative of the effects of liming in real ponds.

## CHARACTERIZATION OF SOILS FROM POTENTIAL PD/A CRSP SITES IN EAST AFRICA

*Interim Work Plan, Africa Study 4*

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### *Abstract*

Nine soil samples were collected from five potential PD/A CRSP research sites in East Africa during site evaluation visits in 1994 and 1995. Samples were returned to Oregon State University, where their physical and chemical composition was characterized. Clay contents ranged from 4.4% to 81.7%. Three samples were alkaline (pH 7.22-8.01), two were approximately neutral (pH 6.55-6.85), and four were acidic (pH 5.08-5.55). SMP lime requirements ranged from 0 kg to 10,898 kg/ha. Organic matter contents ranged from 0.25% to 6.31%. All but one of the sites would have been acceptable, in terms of soil quality, as PD/A CRSP research sites. Soil characterization data were made available to supplement other information used in evaluating and selecting the new site for PD/A CRSP research in Africa.

## EFFECT OF FEED STORAGE TIME AND STORAGE TEMPERATURE ON GROWTH RATE OF TILAPIA FRY AND EFFICACY OF SEX REVERSAL

*Interim Work Plan, Africa Study 8*

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### *Abstract*

Effects of storage conditions of methyltestosterone-treated feed on fish growth and sex reversal were evaluated. A common source of feed was treated with 60 mg methyltestosterone/kg, stored frozen,

and then held under one of the following six conditions: 1.) 26 days at ambient conditions before use, 2.) seven days at ambient conditions before use, 3.) zero days at ambient conditions before use, 4.) two months at 4°C and zero days at ambient conditions before use, 5.) two months at 4°C and 7 days at ambient conditions before use, and 2 months at 4°C and 26 days at ambient conditions before use. These rations were fed to *Oreochromis niloticus* fry for 28 days. Fry with an initial length of 10.4 mm were stocked at 4,000/m<sup>3</sup> in outdoor hapas and fed at 15%, 12%, 8%, and 4% body weight per day during weeks 1, 2, 3, and 4, respectively. Growth and survival were determined after the 28-d treatment period. Fry were reared to a minimum size of 4 cm. Fish were sexed using the gonadal squash technique and the percent of male, female, and intersex fish was determined. Feed storage conditions had no effect on the percentage of males produced. All hormone-treated feeds resulted in > 99% male populations. Storage conditions had no effect on growth, FCR, or fish survival when fish were treated in fertile fish ponds. Mean fish weight after 28-d of treatment was 0.9 g, FCR was < 1, and survival averaged > 55%.

## REPRODUCTIVE EFFICIENCY, FRY GROWTH, AND RESPONSE TO SEX REVERSAL OF NILE AND RED TILAPIA

*Interim Work Plan, Africa Study 6*

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### *Abstract*

Reproductive efficiency, fry growth, survival, feed conversion, and sex reversibility of red tilapia, a synthetic breed derived from *Oreochromis niloticus*, *Oreochromis aureus*, and *Oreochromis mossambicus*, were compared with Nile tilapia *Oreochromis niloticus*. In four trials, brooders of red and Nile tilapia were stocked in separate ponds and allowed

to spawn for 215 to 230 degree-days (13 to 19 days) using two ponds per fish type. A complete harvest of the pond to collect fry from the harvest basin was completed, and fry were graded ( $\leq 14$  mm,  $> 14$  mm) and enumerated. Fry ( $\leq 14$  mm) from both types of brooders were stocked at 4000/m<sup>3</sup> in outdoor hapas and given feed containing 60 mg/kg 17 $\alpha$ -methyltestosterone. Hormone treatment periods were 0, 14, 21, and 28 days. After 28 days of confinement, fry were harvested and growth and survival determined. Fry were reared for an additional 58 days and the sex was determined using the gonadal squash method. Brood survival was similar for both types of fish ( $p < .05$ ). There was no difference in the number of fry/kg of brood female produced by each fish type. Fecundity was directly correlated with temperature. Red x red brooders produced an average of 77% red and 23% wild-type (black) fry. There was no difference in the percent males obtained from hormone-treated fry of either parental line. Mean fry survival and growth was similar for fry of both red and Nile tilapia.

## AFRICAN SITE EVALUATION AND DEVELOPMENT PLANNING

### *Interim Work Plan, Africa Study 1*

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### *Abstract*

Under Work Plan 7, Study C, a site selection strategy was developed to begin the process of replacing the site at Rwasave, Rwanda. That site was lost because of the outbreak of war and civil violence in 1994. The following outlines the site-selection strategy employed:

- Establish site evaluation criteria with input from the Technical Committee and include criteria defined in the Board of International Food and Development Guidelines.
- Gather information on potential sites from CRSP members, agency publications, interviews, United States Agency for International Development (USAID) Strategic Objectives, USAID Missions, and other sources.
- Visit the most promising sites, using the evaluation criteria as a template for gathering information in-country.
- Recommend a site after committee interaction.
- Submit the site recommendation to the Management Entity (ME) for administrative review and to the Technical Committee for technical review.
- The final selection of the site will be made by the ME.
- Initiate the required Memoranda of Understanding (MOU) with host country entities.

Fifteen site evaluation criteria were developed with assistance from the ME and Technical Committee of the Pond Dynamics/Aquaculture (PD/A) CRSP to guide data collection. USAID site-selection criteria were incorporated into the process. Under the current study, additional site visits were accomplished and developed into formal evaluations. The Sagana Fish Culture Farm in Kenya was recommended as a prime site during the PD/A CRSP Annual Meeting in January, 1996. Once approved, a proposal to develop a CRSP site at Sagana in cooperation with the Kenya Ministry of Tourism and Wildlife and its Department of Fisheries was submitted to the government of Kenya. A development plan for that station was also outlined. The government of Kenya, through the Ministry of Treasury and the Ministry of Tourism and Wildlife, recently approved our preliminary proposal and invited the Africa PD/A CRSP Project to submit a Memorandum of Understanding to formalize working relationships at Sagana Fish Culture Farm.

### GONADAL DIFFERENTIATION IN NILE TILAPIA AS A FUNCTION OF GROWTH RATE AND TEMPERATURE

*Interim Work Plan, Africa Study 7*

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#### *Abstract*

Research on, and actual on-farm use of  $17\alpha$ -methyltestosterone to masculinize tilapia fry has been conducted for many years. While it has been logically inferred that the presumptive gonad in *Oreochromis niloticus* differentiates at some time during the first 28 days of feeding, research data supporting this has been somewhat inconclusive. It is also not known what effect water temperature and growth rate have on the process. These are crucial factors, since tilapia fry around the world grow at a very wide range of rates during this time period. In this study, Nile tilapia fry were reared at two temperatures ( $30^{\circ}$  and  $22^{\circ}\text{C}$ ) and two growth rates (fast and slow). Growth rates were achieved by using a "high" or "low" feed rate. At each temperature, the high ration approximated satiation based on preliminary data from a previous study, and fell at a rate of 15% every 4 days. The low ration on Day 0 was 1/4 the initial high ration and fell at 1/3 the rate (5% every 4 days). The feeding and sampling period was 28 days. Ten fish per day were randomly removed from one aquarium in each treatment and preserved. Preserved fish will be embedded in paraffin, sectioned, stained and mounted for microscopic examination of the gonads. To date, all fish samples have been collected and the histological work remains to be done. It is anticipated that the results of this work will benefit both tilapia producers and consumers by pinpointing the time at which hormone use is effective, thus resulting in a reduction of the amount needed for sex reversal.

### RISK ANALYSIS OF OPTIMAL RESOURCE ALLOCATION BY FISH FARMERS IN RWANDA

*Work Plan 7, Africa Study 7*

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#### *Abstract*

Although many small-scale fish farming projects around the world promote fish production as a source of low-cost protein, increasing evidence demonstrates that fish can be an important cash crop, even for resource-limited farmers. A mathematical programming model was developed from survey data collected with the help of Rwandan farmers to determine optimal resource allocation on subsistence farms in Rwanda. The specific objective of the study was to conduct an economic risk analysis of fish production on subsistence fish farms in Rwanda. At low levels of willingness to incur risk, the optimal product mix was to select those crops that had low variability in yield and those cash crop options with low coefficients of market risk. Explicit estimation of risk parameters in the model generated equivalent results to those of models specified to meet household nutritional requirements. Both approaches demonstrated the preference of subsistence farmers to select crops with stable, although sometimes lower, yields to maximize food security.

## OPTIMAL RESOURCE ALLOCATIONS BY FISH FARMERS IN RWANDA

*Interim Work Plan, Africa Study 10*

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### *Abstract*

Although many small-scale fish farming projects around the world promote fish production as a source of low-cost protein, increasing evidence demonstrates fish to be an important cash crop, even for limited-resource farmers. A mathematical programming model was developed from survey data of Rwandan farmers to determine optimal resource allocation on subsistence farms in Rwanda. The specific objective of the study was to determine farm plans that maximize returns to a representative Rwandan farm family's resources, subject to constraints of the farm family's proteinic and caloric requirements. The average land holdings for both individually- and cooperatively-managed farms were too low to meet the minimum nutritional needs of a family. Government policy makers should take into consideration that a minimum of 0.20 ha and 0.51 ha were required for individually- and cooperatively-managed farms, respectively, to meet household nutritional requirements. Fish production was a profitable enterprise for subsistence farmers in Rwanda, that competes well for scarce land resources. If fingerlings can also be sold, fish is the optimal cash enterprise across most regions and throughout the year in Rwanda. Without a ready market for fingerlings, cabbage production was the profit-maximizing cash crop for the period from July through October when cabbage prices were high. However, from November through June when cabbage prices were low, fish production even without fingerling sales was the cash crop that maximized profits. Regional price differences had less effect on optimal product mix than the seasonality of prices. The exception was the region closest to Kigali where high sweet potato prices in October provided an incentive for sweet potatoes to

be raised as a cash crop. Soybeans, sweet potatoes, and maize were selected to meet household nutritional requirements. Fish production was selected as the principal cash crop, lending support to the evidence that fish is more important as a cash crop than as a primary protein source in Rwanda. Low-cost technologies that increase fish yield have significant positive impacts on net farm income.

## D. Southeast Asia

### STOCKING DENSITY AND SUPPLEMENT FEEDING

*Work Plan 6, Thailand Study 6*

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### *Abstract*

The purpose of this experiment was to determine the upper limits of tilapia production utilizing supplemental feeding. Fish were stocked at three, six, and nine fish/m<sup>2</sup>. The fish were supplementally fed to satiation during culture for 194 days. Growth, survival, yield, and water quality were evaluated during the experiment. Growth continued in a linear fashion throughout the experiment. Density-dependent growth occurred with the lowest stocking density, which had a significantly higher growth rate than the intermediate stocking density. The intermediate stocking density had a significantly higher growth rate than the highest stocking density. Survival also differed significantly among treatments, with lowest survival at the highest density. Feeding rate averaged 1.65% BW/d, and was not significantly different among treatments. Feed conversion rate

averaged 0.40 and also was not significantly different among treatments. Dissolved oxygen (DO) content differed significantly among treatments, with mean DO at 0600 hr significantly lower in the high density treatment than in the low density treatment. Also, the total number of data-logged hours when DO was less than 1 mg/l was significantly different among treatments, with the low density treatment having significantly fewer hours of low DO than the high density treatment. Alkalinity and dissolved inorganic nitrogen also differed significantly among treatments. The DIN and ammonia levels were significantly higher in high density ponds than in low density ponds. Partial economic analysis indicated that stocking densities of 3 and 6 fish/m<sup>2</sup> at growout were profitable, while a stocking density of 9 fish/m<sup>2</sup> was unprofitable. The most profitable system was stocked 6 fish/m<sup>2</sup> and intensively fed. If the fish had been allowed to grow to 500 g in size and reach a market price of \$150 per pond, then this system would have been particularly profitable.

#### **WATER QUALITY IN LABORATORY SOIL-WATER MICROCOSMS WITH SOILS FROM DIFFERENT AREAS OF THAILAND**

*Interim Work Plan, Africa Study 5*

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(Printed as Submitted)

##### *Abstract*

Forty-five soil samples were collected from aquaculture areas in 23 provinces of Thailand to include six soil orders that vary in physical and chemical properties. Soil-water microcosms were prepared containing 5 g of soil and 150 ml of distilled water. Microcosms were held on an oscillating table shaker (150 rpm) for 1 week at

25°C in the dark. Water pH and concentrations of dissolved nutrients, total alkalinity, and total hardness were measured. Differences in properties within soil orders caused wide variation in composition of solutions and differences in concentrations of dissolved substances and pH were not related to soil order. Regression analyses revealed significant correlations between concentrations of soil nutrients extractable in dilute acid (0.05 N HCl plus 0.025 N H<sub>2</sub>SO<sub>4</sub>) or in neutral, 1 N ammonium acetate and aqueous concentrations. Correlation coefficients usually were higher for dilute-acid extractable nutrients than for ammonium acetate extractable ones. Correlation coefficients based on dilute-acid extractable nutrients follow: soluble reactive phosphorus ( $r = 0.816$ ); calcium ( $r = 0.685$ ); magnesium ( $r = 0.470$ ); potassium ( $r = 0.959$ ); sodium ( $r = 0.977$ ); manganese ( $r = 0.462$ ); boron ( $r = 0.399$ ). The correlation between soil and solution iron was not significant and aqueous concentrations of copper and zinc were below detection limit. Hardness was correlated with soil carbon ( $r = 0.710$ ) and soil pH was a good predictor of alkalinity ( $r = 0.877$ ). Soil pH and aqueous pH were also highly correlated ( $r = 0.939$ ). Findings suggest that soil characteristics can be used to predict pH and concentrations of several dissolved substances in soil-water systems under aerobic conditions.

#### **FINISHING SYSTEM FOR LARGE TILAPIA**

*Interim Work Plan, Thailand Study 4*

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##### *Abstract*

An integrated culture system was compared with a mixed-pond culture system in an experiment to achieve the following: 1) determine the effect of different stocking densities of open-pond small tilapia on the growth performance of both caged and open-pond large tilapia, and 2) assess the

overall growth performance of both large and small tilapia in each system. Six ponds, each containing two 4 m<sup>3</sup>-net cages, and six open-water ponds, all without cages, were stocked with 400 sex-reversed, large tilapia (122-125 g) per pond. Sex-reversed small tilapia (15-16 g) were stocked at 1.4 fish/m<sup>3</sup> and 2 fish/m<sup>3</sup> in both the integrated and the mixed-pond culture systems. Commercial floating pellets containing 30% crude protein were given to cages in the integrated system and to open water in the mixed-pond system twice daily at the feeding rates of 3%, 2.5%, and 2% body weight per day for the first, second, and third month, respectively. Water quality was analyzed biweekly for DO, temperature, pH, NH<sub>3</sub>, and chlorophyll-*a*. Growth of large tilapia in cages of the integrated culture system was better than of large tilapia of the mixed-pond culture system. Extrapolated net yields of large tilapia in the integrated culture system (4.3 and 3.3 t/ha/crop for the low and high density treatments, respectively) were significantly greater than the extrapolated net yields of the mixed-pond culture system (2.8 and 2.7 t/ha/crop for the low and high density treatments, respectively). Feed conversion ratios were also significantly lower for the integrated culture system (0.92 and 1.04 in the low and high density treatments, respectively) than the mixed-pond culture system (1.22 and 1.16 in the low and high density treatments, respectively). This experiment demonstrated the practicality of a tilapia-tilapia cage-cum pond integrated rotation system that is based on the intensive culture of adult Nile tilapia in cages and the semi-intensive culture of small Nile tilapia in the surrounding open-water earthen pond.

## POLY CULTURE IN DEEP PONDS

*Interim Work Plan, Thailand Study 3*

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### *Abstract*

The objective of this study was to assess the effects of carp-tilapia polyculture on water quality and fish yield in deep, rain-fed ponds. Four experimental treatments, conducted in twelve 800 m<sup>2</sup> ponds, at the Department of Fisheries-Udorn Thani Station, Thailand were as follows: (T1) ponds stocked with Nile tilapia (*Oreochromis niloticus*) at 2 fish/m<sup>2</sup>, (T2) ponds stocked with Nile tilapia (2 fish/m<sup>2</sup>) and common carp (*Cyprinus carpio*) at a density of 1000 carp/ha, (T3) ponds stocked with Nile tilapia (2 fish/m<sup>2</sup>) and common carp at 2000 carp/ha, and (T4) ponds stocked with Nile tilapia (2 fish/m<sup>2</sup>) and common carp at 3000 carp/ha. Sex-reversed, all male tilapia (4-5 g average weight) and common carp (450-500 g average weight) were used to stock the ponds. Ponds were fertilized weekly with chicken manure and supplemented with urea and TSP; fish were harvested after 186 days of culture. Growth was measured monthly and the chemical and physical conditions of the pond water were monitored. One-way analysis of variance was used to statistically analyze treatment effects. Pond water temperature and DO between surface and bottom water were not significantly different; TAN, TKN, TP and chlorophyll-*a* concentrations among treatments were also not significantly different. Fish growth performance of Nile tilapia did not significantly differ between monoculture and polyculture treatments. For all polyculture treatments, common carp lost weight during the experimental period. Weight loss of common carp may be attributed to an undesirable feeding environment.

**CARP/TILAPIA POLY CULTURE ON ACID-SULFATE SOILS***Work Plan 7, Thailand Study 5*

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*Abstract*

PD/A CRSP research in Thailand has concentrated on the dynamics of *Oreochromis niloticus* monocultures. Because *O. niloticus* is primarily a planktivore, the addition of the benthic detritivore *Cyprinus carpio* was hypothesized to lead to increased system productivity through the conversion of currently unutilized benthic matter into fish flesh. A five-month experiment was conducted in earthen ponds with a 200 m<sup>2</sup> surface area at the Asian Institute of Technology. Five treatments that included carp stocking densities of 0, 0.1, 0.3, 0.5, and 0.7 fish/m<sup>2</sup> were conducted in triplicate. Ponds were fertilized weekly with chicken manure, urea, and triple super phosphate (TSP). Preliminary results revealed that tilapia growth was slow and uniform across blocks and treatments. This may have occurred because larger fish (> 25 g/fish) initially intended for the stocking of this experiment were erroneously selected from the batch to stock a different experiment. Carp growth was density dependent and inversely related to stocking density; carp of initial (pond mean) weights ranging from 11 g to 40 g/fish grew to pond means ranging from 41 g to 270 g/fish during a five month period. Through the first half of the experiment, there was little indication of treatment-related differences in water quality except in measures of turbidity. Total suspended solids were markedly lower in ponds without carp.

**ON-FARM PRODUCTION TRIALS WITH NILE TILAPIA IN FERTILIZED PONDS IN HIGHLAND AND LOWLAND AREAS OF THE PHILIPPINES***Interim Work Plan, Philippines Studies 1 and 3*

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*Abstract*

Three on-farm yield trials, were conducted during a coherent production period of four to six months on Luzon island in the Philippines. Two of the trials took place in lowland areas of central Luzon, Nueva Ecija province; the third was conducted at elevations of 1000 to 1700 m in Mountain province. The farmers were instructed to use the CRSP fertilization guidelines. Data were collected from 54 ponds ranging in size from 25 m<sup>2</sup> to 5865 m<sup>2</sup>. Extrapolated yields from fertilized ponds were highly variable ranging from approximately 500 kg/ha/yr to above 3900 kg/ha/yr. The primary factor determining yields was the density of stocked fish which survived to harvest ( $R^2 = 0.69$ ). Two of the farmers used feeds and attained yields over 9000 kg/ha/yr.

## GLOBAL EXAMINATION OF RELATIONSHIP BETWEEN NET PRIMARY PRODUCTION AND FISH YIELD

*Interim Work Plan, Thailand Study 1*

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### *Abstract*

Previous PD/A CRSP research has examined the relationship between primary productivity and net yield of *Oreochromis niloticus* using data from individual experiments or earlier versions of the Central Database. In an effort to develop a more generalized model, a global analysis of this relationship was conducted using a recent version of the Central Database as the source of raw data. Average daytime net primary productivity (dNPP) and net fish yield (NFY) were computed for 505 ponds. dNPP ranged from < 1 to > 17 mg DO/l/daylight period. NFY were as high as 12 g fish/m<sup>2</sup>/d although most values were below 2 g fish/m<sup>2</sup>/d. There was an exponential relationship between dNPP and NFY.

## E. Data Analysis and Synthesis Team

### AQUACULTURE POND MODELING FOR THE ANALYSIS OF INTEGRATED AQUACULTURE/ AGRICULTURE SYSTEMS: FISHPOND ORGANIC MATTER AND NITROGEN DYNAMICS

*Interim Work Plan, DAST Study 5*

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### *Abstract*

Modifications to a model for simulating integrated aquaculture-agriculture systems described previously are presented in this report. The changes described relate to the simulation of organic matter concentration and of nitrogen dynamics. Processes taking place in the sediments are considered in both the organic matter and nitrogen models, and the models are described in some detail. Sample simulations are presented, and the rates of organic matter accumulation in the water column and sediments, of nitrate accumulation, and of fish growth are discussed.

**MODELING OF TEMPERATURE AND DISSOLVED  
OXYGEN IN STRATIFIED FISH PONDS USING  
STOCHASTIC INPUT VARIABLES**

*Interim Work Plan, DAST Study 4*

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*Abstract*

A model of water temperature, dissolved oxygen (DO), and fish growth in stratified fish culture ponds has been developed and described in previous reports. The model uses stochastically-generated weather parameters as inputs. Two major modifications to the model are described in this report: the procedure for generating daily and hourly solar radiation data has been changed; and oxygen consumption by nitrification was separated from the water column respiration term. In the previous version of the model, the procedure for generating solar radiation values was based on the mean and variance of historical data for each day. Simulation results are presented for temperature, dissolved oxygen, and fish growth. All results are presented as mean, maximum, and minimum values for the output variables obtained after 20 simulations that spanned a period of over 80 days. Temperature and dissolved oxygen values are shown for three depths in the pond: surface water, mid-depth, and bottom water.