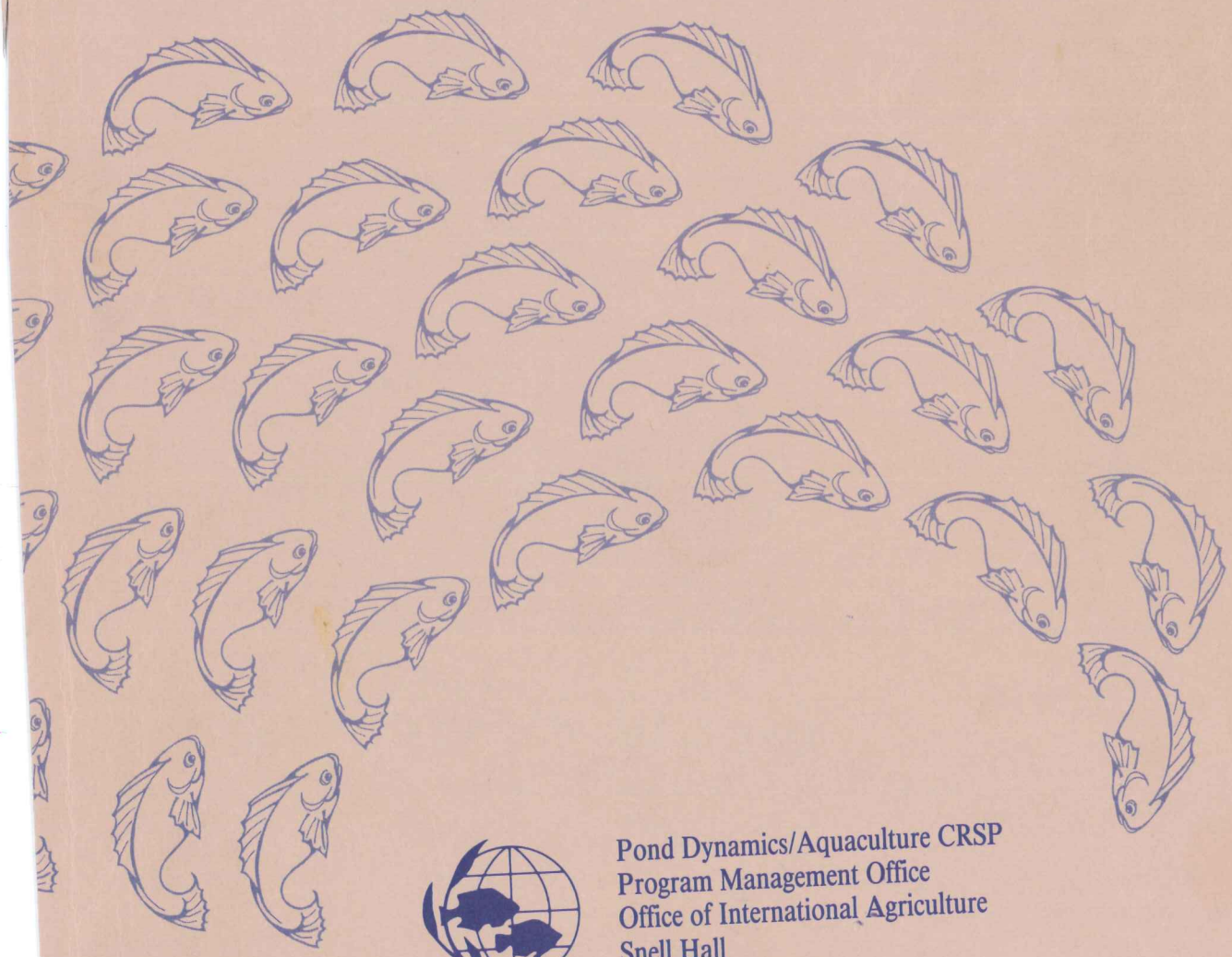
Pond Dynamics/Aquaculture Collaborative Research Data Reports

Volume One: General Reference

Site Descriptions, Materials and Methods for the Global Experiment



Pond Dynamics/Aquaculture CRSP
Program Management Office
Office of International Agriculture
Snell Hall
Oregon State University
Corvallis, Oregon 97331
(503) 754-2228

POND DYNAMICS / AQUACULTURE COLLABORATIVE RESEARCH DATA REPORTS

Volume One. General Reference: Site Descriptions, Materials and Methods for The Global Experiment

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Compiled and edited by Hillary S. Egna, Nancy Brown, and Michele Leslie

Pond Dynamics / Aquaculture
Collaborative Research Support Program
Office Of International Research and Development
Snell Hall
Oregon State University
Corvallis, Oregon 97331 USA

James E. Lannan, Director (1982 - May 1987)

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TABLE OF CONTENTS

	pg
I. Introduction	1
II. Site Descriptions	3
Honduras	3
Indonesia	7
Panama, Aquadulce	11
Panama, Gualaca	15
Philippines	19
Rwanda	22
Thailand	26
III. Description of Experiments	29
First Cycle of the CRSP Global Experiment	30
Second Cycle of the CRSP Global Experiment	32
Third Cycle of the CRSP Global Experiment	35
IV. Materials and Methods	39
V. Data Management	67
Literature Cited	75
Appendix A. Pond Management Procedures	77
Appendix B. Production of Oreochromis niloticus Fingerlings	79
Appendix C. Procedure for Pond Soil Sampling and Analysis	83

LIST OF FIGURES AND TABLES

pg

Table 1a. Daily Measurements. Work Plan 1. 40
Table 1b. Daily Measurements. Work Plan 2. 41
Table 1c. Daily Measurements. Work Plan 3. 42

Table 2a. Biweekly and Weekly Measurements. Work Plan 1. 43
Table 2b. Biweekly and Weekly Measurements. Work Plan 2. 45
Table 2c. Biweekly and Weekly Measurements. Work Plan 3. 47

Table 3a. Monthly Measurements. Work Plan 1. 51
Table 3b. Monthly Measurements. Work Plan 2. 55
Table 3c. Monthly Measurements. Work Plan 3. 59

Table 4a. Occasional Measurements. Work Plan 1. 61
Table 4b. Occasional Measurements. Work Plan 2. 63
Table 4c. Occasional Measurements. Work Plan 3. 65

Table 5. Site, Template, and Season Codes for the Central Data Base 73

I. INTRODUCTION

The Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) represents an international community of researchers and institutions dedicated to strengthening health and nutrition in developing countries by improving the efficiency of pond aquaculture systems. It is one of several agricultural CRSPs supported by the U.S. Agency for International Development under the authority of Title XII of the International Development and Food Assistance Act of 1975.

The "global experiment" in Pond Dynamics/Aquaculture is the major CRSP research activity, covering the period from 1982 to 1987. The global experiment was designed to quantitatively describe the physical, chemical and biological principles of pond culture systems. The information gained from the global experiment will be used to improve production technologies and develop quantitative production functions to facilitate rigorous economic analyses of aquaculture systems.

Standardization is a key element of the global experiment. Standardization permits the comparison of data from diverse geographic locations. The experimental design involves monitoring specified environmental and fish production variables in accordance with standardized work plans in twelve or more ponds at each of seven geographical locations. The variables observed, frequency of observation, and materials and methods are uniform for all locations. The field data are filed in a centralized data base, called the CRSP Data Base. Statistical methods will be used to test hypotheses about correlations between variables and to evaluate the sources of variance within ponds, between ponds within locations, and between locations.

The CRSP Data Base will be used to develop predictive models of the processes occurring in pond culture systems. The models will be used to: provide guidance for ongoing and future research; predict the performance of existing and proposed pond systems subject to specific inputs and constraints; and improve the operation and efficiency of pond culture systems.

The global experiment includes three cycles of experiments. Each cycle consists of two series of observations, one during the dry season and one during the wet season. The objective of the first cycle is to create a detailed baseline of chemical, physical, and biological data on all ponds treated with a standard level of inorganic fertilizer. In the second experimental cycle, ponds treated with inorganic fertilizer are compared to ponds treated with organic fertilizer. In the third cycle, the responses of ponds to different levels of organic fertilizer are compared.

The goal of the Pond Dynamics/Aquaculture Collaborative Research Data Reports (referred to as Data Reports) is to record the PD/A CRSP

Data Base and to present interpretations of site specific results. The PD/A CRSP has conducted the global experiment at seven project sites in six developing countries: Thailand, Indonesia, the Philippines, Panama, Honduras, and Rwanda. The first volume of these reports provides descriptive information for each of the PD/A CRSP sites. It presents the physical characteristics of each site, including a geographical sketch, climatology, and water and soil analyses. Volume One will serve as the reference volume for the entire report series. Subsequent volumes will focus on each site separately. Each volume will include one cycle (wet and dry seasons) of the PD/A CRSP global experiment. Therefore, with few exceptions, each project site will have three volumes devoted to it, representing the results of the three cycles of the global experiment. The experimental cycles are described in PD/A CRSP Work Plans 1 to 3, which are summarized in this first volume.

II. SITE DESCRIPTION

HONDURAS/AUBURN UNIVERSITY

Site: Pond Dynamics/Aquaculture CRSP
El Carao Aquaculture Experiment Stn.
Direccion Agricola Regional
Comayagua, Comayagua
Honduras

Latitude/Longitude: 14°26'N 87°41'W **Elevation:** 583 m

Average Annual Rainfall: 764.6 mm **Avg. Ann. Temperature:** 19.6° - 31.0°C

Average Pond Water Temperature: 26.54°C + 0.5°C

Geographical Location: The El Carao Aquaculture Experiment Station is located in the Comayagua Valley, 8 km from the city of Comayagua and 131 km from the capital city of Tegucigalpa.

General Description of Facility: The El Carao Station is the largest of a series of aquaculture stations operated by the Direccion General de Recursos Naturales Renovables, Ministry of Natural Resources. It has major responsibilities in production of tilapia and Chinese carp fingerlings for distribution to fish farmers. In addition, the station provides technical assistance to fish farmers, as well as a broad range of training courses. The station consists of offices, a water quality-biological limnology laboratory, a modest technical library, a storage building and complex of ponds. The latter includes twelve ponds of 500 m^2, twelve 1000 m^2 ponds, and twelve 2,000 m^2 ponds. The twelve 1000 m^2 ponds have been assigned to the CRSP.

Water Supply: The water is supplied by gravity to the ponds from a 4000 m^2 reservoir, which itself is fed by irrigation canals originating at the Selguapa River. A wet lab area comprised of ten 20 m^2 and eight 2 m^2 concrete holding tanks is supplied with well water from an on-site well.

Support Facilities: Students from the Nacional Autonomous University of Honduras conduct senior thesis research at the CRSP site, and also assist in various station activities. The Honduran Foundation for Agricultural Research, La Lima, is used for soil and complete water analyses. Oregon State University Soil Testing Laboratory analyzed samples from all PD/A CRSP sites before initiation of the Global Experiment. Pelleted fish feeds are available from two in-country feed mills; the feeds average 23% protein. A variety of agricultural by-products, e.g., corn gluten, wheat bran, rice bran, etc., are available from the various mills; some products are only available regionally. Inorganic fertilizer, all of which is imported, is available at agricultural supply stores; fertilizer availability is only partially reliable. Layer chicken litter is widely available at low cost.

Source water analysis (mg/l):

pH:	8.05	Soluble Orthophos:	0.085 mg/l PO_4-P
Alkalinity:	30.89 mg/l $CaCO_3$	Ammonia:	0.111 mg/l NH_3-N
Salinity:	--	Nitrate:	0.075 mg/l NO_3-N
Tot. Hardness:	22.82 mg/l $CaCO_3$	Total Phosphorous:	0.131 mg/l PO_4-P
Calcium Hardness:	15.62 mg/l $CaCO_3$	Calcium:	2.63
		Magnesium:	1.86
		Sodium:	4.84
		Potassium:	4.25
		Copper:	<0.02
		Zinc:	0.03
		Sulfate:	<1.0
		Chloride:	5.2
		Boron:	<1.0
		Iron:	1.19
		Manganese:	0.04

Soil analysis: Results of soil analysis by the Oregon State University Soil Testing Laboratory prior to initiation of CRSP experiments are as follows:

Pond	pH	P (mg/l)	K (mg/l)	Ca (meq/100g)	Mg (meq/100g)	Organic Matter (%)
B-1	8.0	15	956	52	4.6	1.20
B-2	8.6	14	991	54	3.2	0.76
B-3	8.8	11	1053	58	4.0	0.51
B-6	8.3	18	956	57	4.0	0.56
B-7	8.9	9	176	49	3.9	0.76
B-8	8.4	14	148	48	3.8	1.20
B-9	8.3	18	1190	55	3.6	1.10
B-10	8.6	9	1073	58	3.8	1.10
B-11	8.8	13	1092	56	3.8	1.40
B-12	8.7	11	878	55	4.2	1.50
Mean	8.5	13	851	54	3.0	1.01

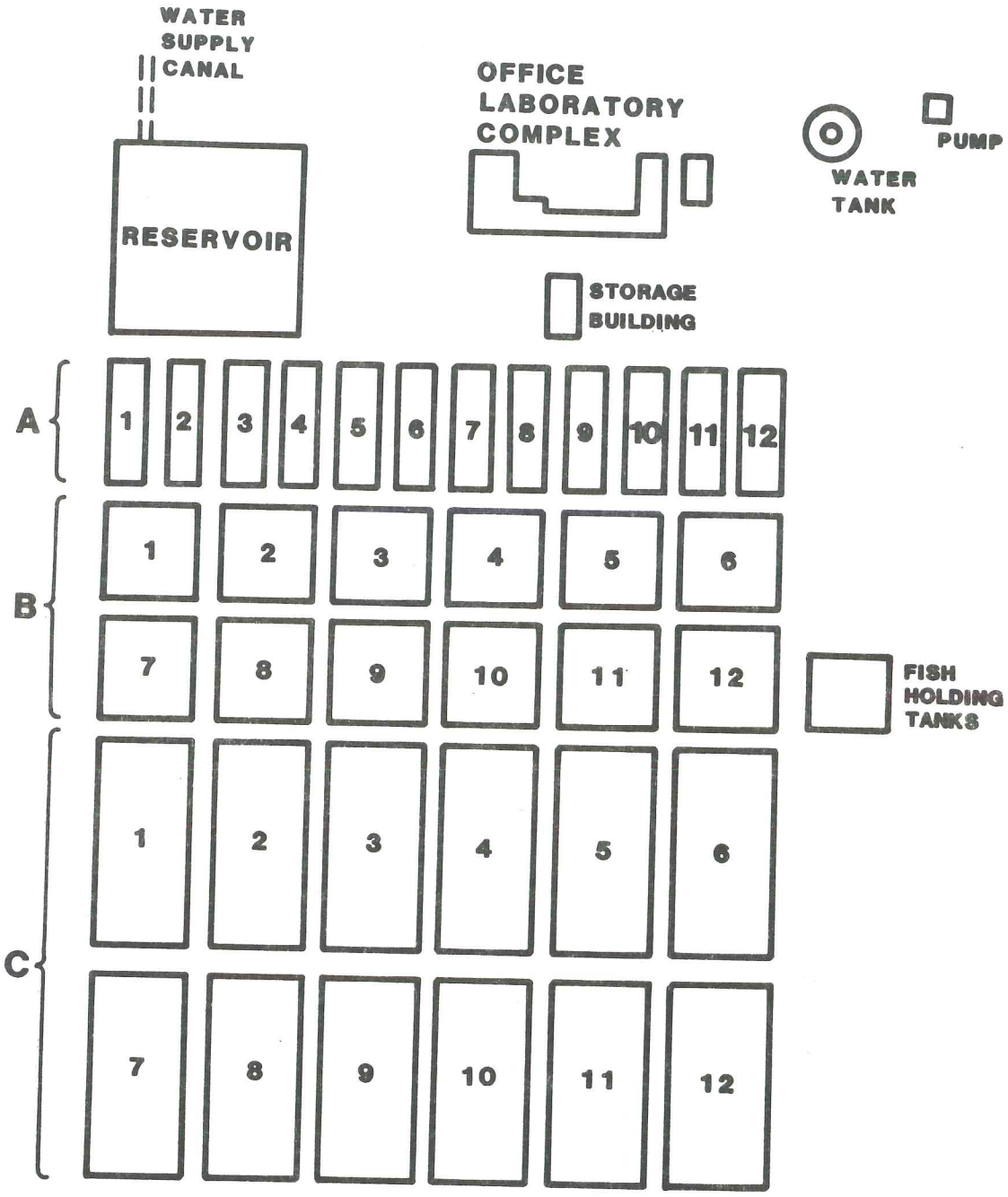
Pond	Zn (mg/1)	Cu (mg/1)	Mn (mg/1)	NO3-N (mg/1)	SMP* Lime Req. (%)	$CaCO_3$ (%)
B-1	1.70	4.8	12.2	22.6	7.5	1.2
B-2	1.20	2.9	4.7	0.9	7.5	2.0
B-3	0.88	3.3	12.7	5.2	7.5	5.1
B-6	2.20	4.6	9.0	30.7	7.5	3.3
B-7	0.64	3.3	7.3	10.2	7.5	1.7
B-8	2.10	4.2	4.3	14.8	7.5	1.3
B-9	1.50	4.8	8.1	1.9	7.5	2.4
B-10	0.64	3.1	6.0	5.2	7.5	4.0
B-11	0.84	2.6	4.0	1.9	7.5	4.1
B-12	0.90	4.0	17.1	3.2	7.5	3.2
Mean	1.16	3.8	8.5	9.7	7.5	2.8

* SMP = buffering test for soil

For Further Information Contact:

Lic. Jonathan Espinoza O.
Pond Dynamics/Aquaculture CRSP
Head of Fisheries Dept.
Direccion General de Recursos
Naturales Renovables
Ave. La Paz
Tegucigalpa
Honduras, Central America

Dr. Ronald Phelps
Pond Dynamics/Aquaculture CRSP
Dept. of Fisheries & Allied Aquaculture
Auburn University
Auburn, Alabama 36849



"EL CARAO" AQUACULTURE EXPERIMENT STATION
COMAYAGUA, HONDURAS

NOTE: CRSP PONDS ARE NUMBERED B1 THROUGH B12

INDONESIA/MICHIGAN STATE UNIVERSITY

Site: Pond Dynamics/Aquaculture CRSP
Institut Pertanian Bogor
Jl. Raya Pajajaran
Bogor, West Java
Indonesia

Latitude/Longitude: 6°6'S 106° 7' E **Elevation:** 220 m

Average Annual Rainfall: 350 mm **Avg. Annual Temperature:** 23° - 33°C

Average Pond Water Temperature: 28.5°C

Geographical Location: The Darmaga Fisheries Station of the Institut Pertanian Bogor (IPB) is located approximately 10 km from Bogor, West Java.

General Description of Facility: There are 40 ponds at the Darmaga Fisheries Station, 12 of which are used for CRSP research; eight in standardized CRSP research and four in special topic research. Each pond is 10 m wide, 20 m long, and 1 m deep. Eight ponds are being used for fish grow-out experiments. A Water Conditioning System was completed in December 1984. One of the three laboratory buildings on-site is used in support of the CRSP project. It is equipped with the necessary items for performing chemical, biological, and physical analyses. There is also an office equipped with a computer and a small library.

Water Supply: The water source is precipitation which falls on Mount Salak, a volcanic peak located south of Bogor. The water is supplied by an irrigation canal which flows by the fisheries station. Water is diverted from the irrigation canal into a baffled, cement-walled settling basin, and from there flows either through the Water Conditioning System or through a feeder channel from which water can be diverted into the individual ponds.

Support Facilities: The Darmaga Fisheries Station is a facility of the Department of Aquaculture in the Faculty of Fisheries at IPB. Members of the faculty conduct their research at the station and are available to interact with CRSP personnel. Services of the analytical laboratory of the Faculty of Soils at IPB are used for chemical analyses on fertilizers and pond soils (particularly SMP for lime requirement). The Soils Laboratory of the Ministry of Agriculture in Bogor has been used for x-ray defraction identification of clays in pond hydrosoils. Personnel are available for consultation in the Inland Fisheries Research Center of the Ministry of Agriculture and the National Institute of Biology, both located in Bogor.

Source water analysis (mg/l):

pH:	7.2		
Alkalinity:	23.8	Ammonia:	--
Salinity:	--	Nitrate:	--
Tot. Hardness:	21.2	Phosphorous:	--
		Calcium:	0.46
		Magnesium:	2.56
		Sodium:	6.66
		Potassium:	1.45
		Copper:	0.03
		Zinc:	0.03
		Sulfate:	8.0
		Chloride:	4.4
		Boron:	<1.0
		Iron:	9.30
		Manganese:	0.33

Soil analysis: The pond soils are of volcanic origin. They are predominately clays which are non-swelling and permeable. Oregon State University pond soil test analyses are as follows:

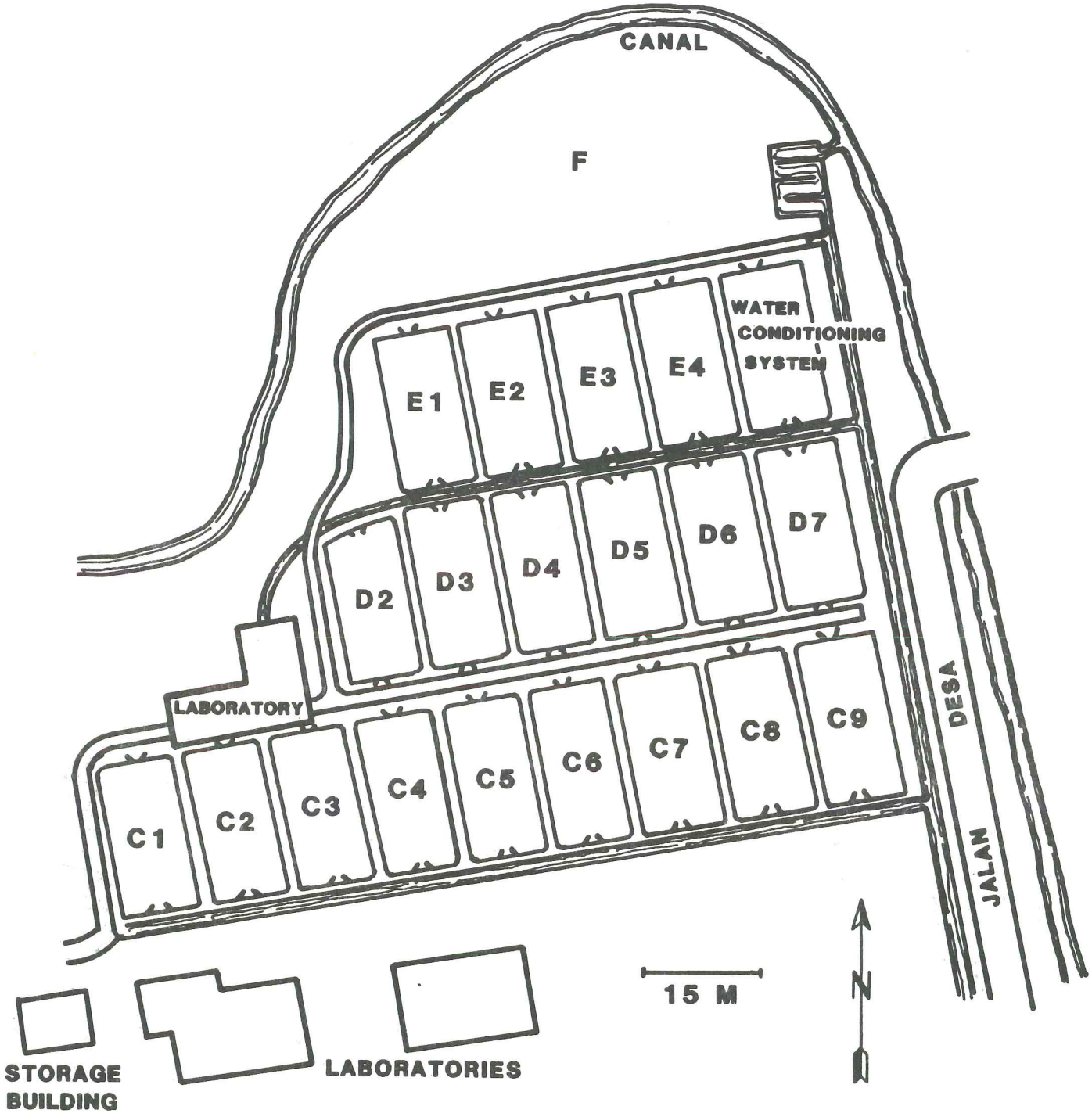
Pond #	pH	P (ppm)	K (ppm)	Ca (meq/100g)	Mg (meq/100g)	Organic Matter (%)
C-1	5.8	6	257	7.8	2.5	3.7
C-2	6.1	4	187	7.8	2.4	3.2
C-3	6.2	4	191	8.3	2.5	3.0
C-4	6.0	4	203	8.3	2.2	2.9
C-5	6.0	7	226	8.8	2.5	3.1
C-6	5.8	4	207	8.2	2.5	3.0
C-7	5.5	4	222	7.5	2.5	2.8
C-8	6.1	4	254	8.2	2.3	2.5
C-9	6.2	2	250	7.4	2.2	0.8
D-7	6.3	1	250	7.6	2.4	2.1
D-6	6.2	1	211	8.1	2.3	2.6
D-5	6.2	2	190	7.0	3.1	---

Pond #	Zn (ppm)	Cu (ppm)	Mn (ppm)	NO_3-N (ppm)	SMP lime req. (%)	$CaCO_3$ (%)
C-1	6.0	5.9	119.2	1.2	6.5	<0.2
C-2	4.5	5.5	99.2	0.8	6.7	0.2
C-3	4.6	5.9	120.0	2.1	6.8	<0.2
C-4	3.6	5.0	130.4	11.9	6.8	<0.2
C-5	4.4	5.3	144.0	18.6	6.5	<0.2
C-6	3.7	4.6	99.2	20.1	6.5	<0.2
C-7	2.8	4.0	156.0	31.6	6.5	<0.2
C-8	3.8	4.8	144.0	8.5	6.7	0.3
C-9	3.1	3.9	184.0	2.1	6.7	<0.2
D-7	2.1	3.4	180.0	4.4	6.5	<0.2
D-6	3.0	4.3	192.0	1.2	6.5	<0.2
D-5	-	-	-	-	6.6	-

For further information contact:

Dr. Muhammad Eidman
Pond Dynamics/Aquaculture CRSP
Faculty of Fisheries
Institut Pertanian Bogor
Jl Raya Pajajaran Bogor
Bogor
Indonesia

Dr. Cal McNabb/Dr. Ted Batterson
Pond Dynamics/Aquaculture CRSP
Dept. of Fisheries & Wildlife
Natural Resources Building
Michigan State University
East Lansing, Michigan 48824



THE DARMAGA FISHERIES STATION
INSTITUTE PERTANIAN BOGOR
WEST JAVA, INDONESIA

NOTE: CRSP PONDS ARE NUMBERED C1 - C9, D5 - D7.

PANAMA-AQUADULCE/AUBURN UNIVERSITY

Site: Pond Dynamics/Aquaculture CRSP
Brackishwater Experiment Station
"Ing. Enrique Ensenat"
Aguadulce, Cocle
Panama

Latitude/Longitude: 80°29'N 8°15'W **Elevation:** 0

Average Annual Rainfall: 1453 mm **Avg. Annual Temperature:** 23.8°- 33.5°C

Average Pond Water Temperature: 28.4°C

Geographical Location: The Brackishwater Experiment Station (BES) "Ing. Enrique Ensenat" is located approximately 5 km south of the town of Aguadulce, 1/2 km north of the Port of Aguadulce, and 190 km from Panama City. The area is characterized topographically by extensive mud flats on the seaward side, and flat land on the landward side.

General Description of Facility: The BES is part of the aquaculture station network established and administered by the General Directorate of Aquaculture (DINAAC) of the Ministry of Agriculture Development (MIDA) of the government of the Republic of Panama. The BES consists of two phases of earthen ponds: Phase 1 with 42 experimental ponds measuring from 500-650 m^2 in surface water area; a 1.4 ha reservoir pond; a 1.1 ha production pond; two pump stations; an office-laboratory building; a processing building; and a storage building. Phase 2 is located 1 km from Phase 1 and consists of 10 production ponds (ranging from 0.2 to 1.0 ha in surface water area), one pump station, and a storage building.

Water Supply: Water for Phase 1 and Phase 2 is pumped from a branch of the Palo Blanco Estuary. The same branch serves both as a source of water and a drainage canal for the BES and neighboring shrimp farms. Water to Phase 1 CRSP ponds is pumped by a diesel-powered hydraulic pump from the estuary branch to the 1.4 ha reservoir pond, then again pumped by a diesel-powered hydraulic pump.

Support Facilities: A joint agreement with the Agricultural Research Institute of Panama (IDIAP) allows DINAAC to request occasional assistance in the analysis of feedstuffs and fertilizers and to determine concentration of chemical components in water and soil samples. All fertilizer and feed is generally provided by DINAAC for CRSP experiments. Organic fertilizer is in short supply, and inorganic fertilizer can be purchased from importers in unmixed form and blended. A new firm presently under construction in Aguadulce will produce only shrimp feed. University of Panama students have conducted thesis research at the BES on special topics related to the pond dynamics trials. There is a small library at the BES; a larger collection is available at the DINAAC offices, one hour from BES in Santiago.

Source water analysis (mg/l):

pH:	8.79	Ammonia:	0.638
Alkalinity:	--	Nitrate:	0.052
Salinity:	40%	Phosphorous:	0.239
Tot. Hardness:	--		

Soil analysis: The average soil texture was 51.0% clay, 31.4% silt, 16.0% sand, and 1.06 organic matter. The initial soil nutrient characteristics were:

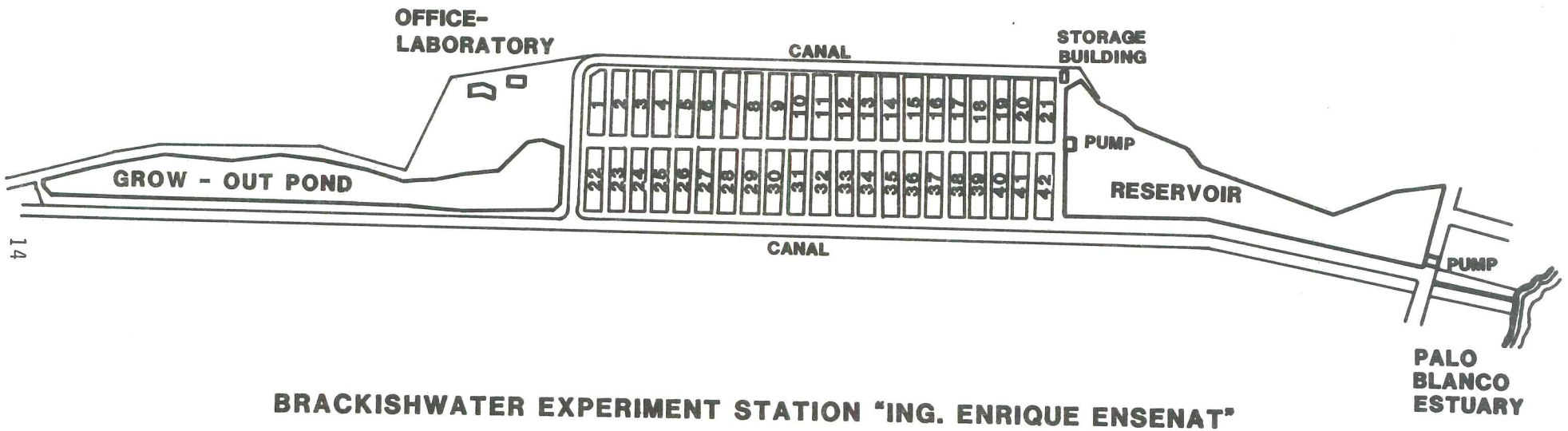
Pond #	pH	P (ppm)	K (ppm)	Ca (meq/100 ml)	Mg (meq/100 ml)	Na (meq/100 ml)	B (meq/100 ml)
4	6.5	12	1716	5.9	20.3	53	13.5
7	7.2	7	1833	6.4	20.5	71	14.1
13	6.4	14	1755	4.4	20.3	57	13.2
14	6.5	12	1560	4.9	17.8	49	13.3
16	6.9	13	1482	4.8	18.3	47	14.1
21	7.6	7	2379	10.0	21.5	67	17.5
25	6.9	13	1950	6.2	22.6	61	16.7
28	6.8	13	2067	7.4	25.0	78	20.4
34	6.9	13	1989	9.8	25.1	76	21.9
35	7.3	15	1911	5.6	19.6	66	19.1
37	7.3	13	1911	7.3	21.4	70	19.0
42	7.6	6	2145	9.3	19.8	61	22.2

Pond #	Organic Matter %	Zn (ppm)	Cu (ppm)	Mn (ppm)	NO_3 (ppm)	$CaCO_3$ %
4	1.2	1.2	4.0	48.2	2.6	.2
7	1.2	1.2	4.6	39.4	.6	.2
13	1.2	1.4	3.0	17.2	9.8	.2
14	.9	1.2	3.0	29.8	9.1	.2
16	1.1	1.2	3.6	44.4	8.9	.2
21	1.5	1.4	5.2	40.8	1.2	.2
25	.96	1.2	4.2	32.8	3.0	.2
28	1.3	1.0	3.0	18.8	3.0	.2
34	1.3	1.6	5.2	21.2	2.3	.2
35	.69	1.4	4.0	13.2	3.7	.2
37	.74	1.6	4.0	19.0	4.4	.2
42	.85	1.2	5.8	54.6	.8	.2

For further information contact:

Dr. Richard Pretto M.
Pond Dynamics/Aquaculture CRSP
Direccion Nacional de Acuicultura
Ministerio de Desarrollo
Agropecuario
Santiago de Veraguas
Republica de Panama

Dr. Ronald Phelps
Pond Dynamics/Aquaculture CRSP
Dept. of Fisheries & Allied Aquaculture
Auburn University
Auburn, Alabama 36849



BRACKISHWATER EXPERIMENT STATION "ING. ENRIQUE ENSENAT"

AGUADULCE, PANAMA

NOTE: CRSP PONDS ARE NUMBERED 4, 7, 13, 14, 16, 21, 25, 28, 34, 35, 37, 42.

PANAMA-GUALACA/AUBURN UNIVERSITY

Site: Pond Dynamics/Aquaculture CRSP
Estacion Acuicola
Agricolas de Panama
Gualaca, Chiriqui
Panama

Latitude/Longitude: 82°19'E 8°31'N **Elevation:** 100 m

Average Annual Rainfall: 4320 mm **Avg. Ann. Temperature:** 17° - 34°C

Average Pond Water Temperature: 23° - 29°C

Geographical Location: The Gualaca Freshwater Aquaculture Research Station (Estacion Experimental Dulce Acricola-Gualaca) is located at the base of the Andes Mountain Chain, 2 km south of the town of Gualaca. The nearest city, David, is 27 km to the southwest.

General Description of Facility: The station is administered by DINAAC (Direction Nacional de Acuicultura) but it also functions as part of an IDIAP (Instituto de Investigation Agropecuaria de Panama) facility located in Gualaca. The station is comprised of 33 earthen ponds of 800 m^2, 10 earthen ponds of 300 m^2, a water analysis laboratory, a feed formulation laboratory, a wet laboratory for aquaria studies, a drive-in fish holding area with 16 concrete tanks equipped with gravity-fed running water, space for a fish hatchery, and a dormitory for students.

Water Supply: The water supply for the station is gravity-fed by a canal (Quebrada del Pueblo) which diverts water from the Rio Chiriqui, a river draining the mountains north of the station.

Support Facilities: The Gualaca aquaculture station is jointly supported by IDIAP and DINAAC. IDIAP supplies the land, helps maintain the facility and pays the salary of the station manager. IDIAP also runs a chemical analysis and soil lab near the fish station where feed, soils, and minor elements of water can be analyzed. Lab personnel provide expertise on topics related to local soils, chemical analysis, forage and animal husbandry. A library with materials pertinent to aquaculture is located 2½ hours away at DINAAC headquarters in Santiago. Fertilizer and limestone are readily available in David and feed is obtained in bulk from a supplier near Santiago. Additional personnel resources in the form of student labor are occasionally available from a branch of the University of Panama in David. These students have the option of doing their thesis in an area of aquaculture or aquatic biology.

Source water analysis (mg/l):

pH:	6.4	Ammonia:	0.93
Alkalinity:	18.4	Nitrate:	0.001
Salinity:	--	Ortho Phosphorous:	0.011
Tot. Hardness:	14.6	Calcium:	--
		Magnesium:	0.921
		Sodium:	2.71
		Potassium:	0.43
		Copper:	Trace
		Zinc:	0.015
		Sulfate:	2.0
		Chloride:	6.0
		Boron:	--
		Iron:	0.12
		Manganese:	Trace

Soil Analysis: The soils are strongly acidic with a base saturation of 8-13% and a CEC* less than 24 meq/100 g. Analysis after one application of limestone is as follows:

Pond #	pH	K (mg/100ml)	Ca (mg/100ml)	Mg (mg/100ml)	Na (mg/100ml)	Organic Matter (%)
1	5.1	0.150	4.46	0.83	0.297	2.6
2	5.1	0.138	3.77	0.86	0.237	2.7
3	4.9	0.136	1.93	0.89	0.257	2.3
4	4.7	0.122	1.39	0.58	0.249	3.1
5	4.9	0.116	1.72	0.49	0.264	2.1
6	5.0	0.134	2.56	0.64	0.926	3.9
7	4.9	1.115	2.02	0.57	0.271	2.3
8	5.0	0.380	2.56	0.70	0.554	2.0
9	5.0	0.130	2.03	0.52	0.409	3.0
10	5.2	0.128	2.16	0.49	0.128	3.2
X	5.0	0.255	2.46	0.66	0.255	2.7
SD	0.1	0.222	0.95	0.95	0.396	0.6

* CEC = Cation Exchange Capacity

Pond #	SO_4^{-2} (ppm)	Al (mg/100ml)	Cl (meq/100ml)	CO_3 (meq/100ml)	Sand (%)	Loam (%)	Clay (%)
1	20.2	2.8	0.030	**	42	24	34
2	14.9	4.5	0.020	**	48	24	28
3	13.7	7.4	0.089	**	44	26	30
4	14.2	7.8	0.020	**	44	26	30
5	11.9	7.8	**	**	42	26	32
6	20.7	4.5	**	**	54	22	24
7	15.2	4.98	0.020	**	40	24	36
8	12.5	6.88	**	**	52	22	26
9	19.5	6.17	0.015	**	50	24	26
10	19.5	3.56	0.020	**	46	24	30
X	16.2	5.64	*0.031	**	46	24	30
SD	3.4	1.82	*0.026	**	5	2	4

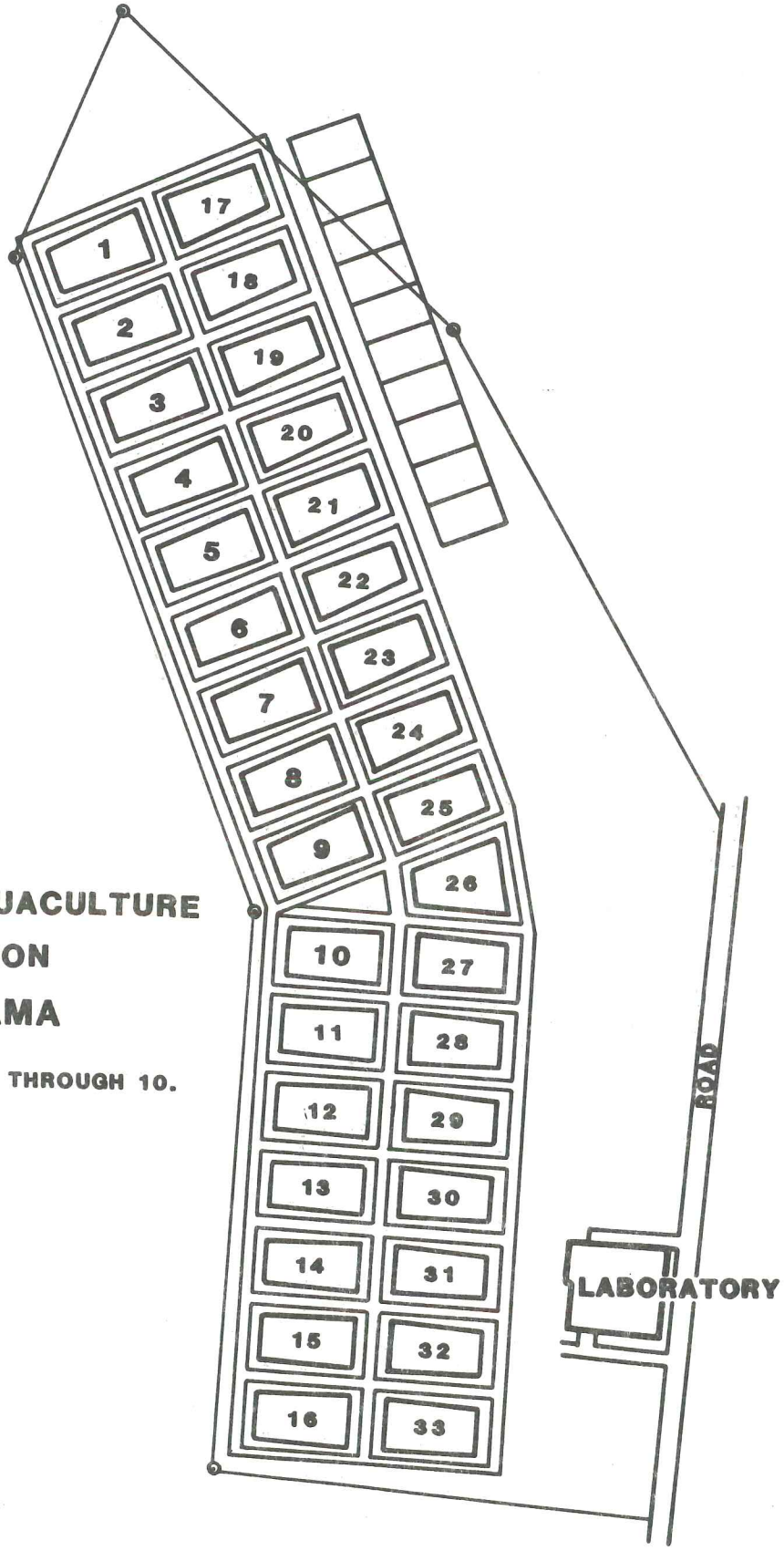
*The mean does not include those ponds containing trace concentrations.

**Trace

For further information contact:

Dr. Richard Pretto M.
Pond Dynamics Aquaculture CRSP
Direccion Nacional de Acuicultura
Ministerio de Desarrollo Agropecuario
Santiago de Veraguas
Republic de Panama

Dr. Ronald Phelps
Pond Dynamics/Aquaculture CRSP
Dept. of Fisheries & Allied Aquaculture
Auburn University
Auburn Alabama 36849



GUALACA FRESHWATER AQUACULTURE RESEARCH STATION

GUALACA, PANAMA

NOTE: CRSP PONDS ARE NUMBERED 1 THROUGH 10.

PHILIPPINES/UNIVERSITY OF HAWAII

Site:

Pond Dynamics/Aquaculture CRSP
Brackishwater Aquaculture Center
College of Fisheries
University of the Philippines in the Visayas
P.O. Box 138
Iloilo City
Republic of the Philippines

Latitude and Longitude: 10°45'15"N 122°30'20"E **Elevation:** 3.59 m

Average Annual Rainfall: 2100 mm **Avg. Annual Temperature:** 27°C

Average Pond Water Temperature: 24.9 - 33.5°C

Geographical Location: The Brackishwater Aquaculture Center (BAC) is centrally located 650 km south of Manila on the island of Panay, in the island group known as the Visayas. The BAC is located at Leganes, Iloilo, 22 km from the site of the University of the Philippines in the Visayas (UPV) in Iloilo proper.

General Description of Facility: Pond facilities include 215 ponds with a water surface area of 18 ha. The 21 ponds assigned to CRSP research are 1000 m^2 each. Extensive site facilities include an administrative building with offices, classrooms, conference room, library, radio room, chemistry labs, a wet laboratory with aquaria, fresh and sea water supply and compressed air; a feed processing and storage building; a nursery and hatchery building; a soil chemistry laboratory, a utility building; a dormitory and cafeteria for students; and staff housing for security and pond management personnel. There are over 60 permanent personnel for research and administration and 21 faculty members from the College of Fisheries actively participating in research and training at BAC.

Water Supply: Each of the 215 ponds is served by two water canals, which allows independent filling and draining by tidal flow from Gui-gui Creek, Leganes.

Support Facilities: There are three Apple personal computers with over 100 documented programs available at the station, which can be used to process and analyze CRSP data. Those conducting research at the BAC include BAC staff, academic staff, and graduate students from UPV. Approximately 10-15 graduate students conduct thesis research at the BAC each year. Numerous commercial aquaculture operatives are located in the vicinity of the BAC. Feed and organic and inorganic fertilizers are readily available. Shrimp and prawn post-larvae can be obtained from both wild and hatchery sources. A variety of finfish fry including tilapia, milkfish, and seabass are also available on a seasonal basis.

Source water analysis:

pH:	7.05 - 9.72	Nitrate:	not available
Alkalinity:	51.14 - 193.80 ppm	Nitrite:	0.0016 - 0.6510 ppm
Salinity:	6 - 37 ppt	Ammonia:	0.0047 - 3.9204 ppm
Tot. Hardness:	n/a	Reactive Phosphorus:	0.0047 - 1.9329 ppm

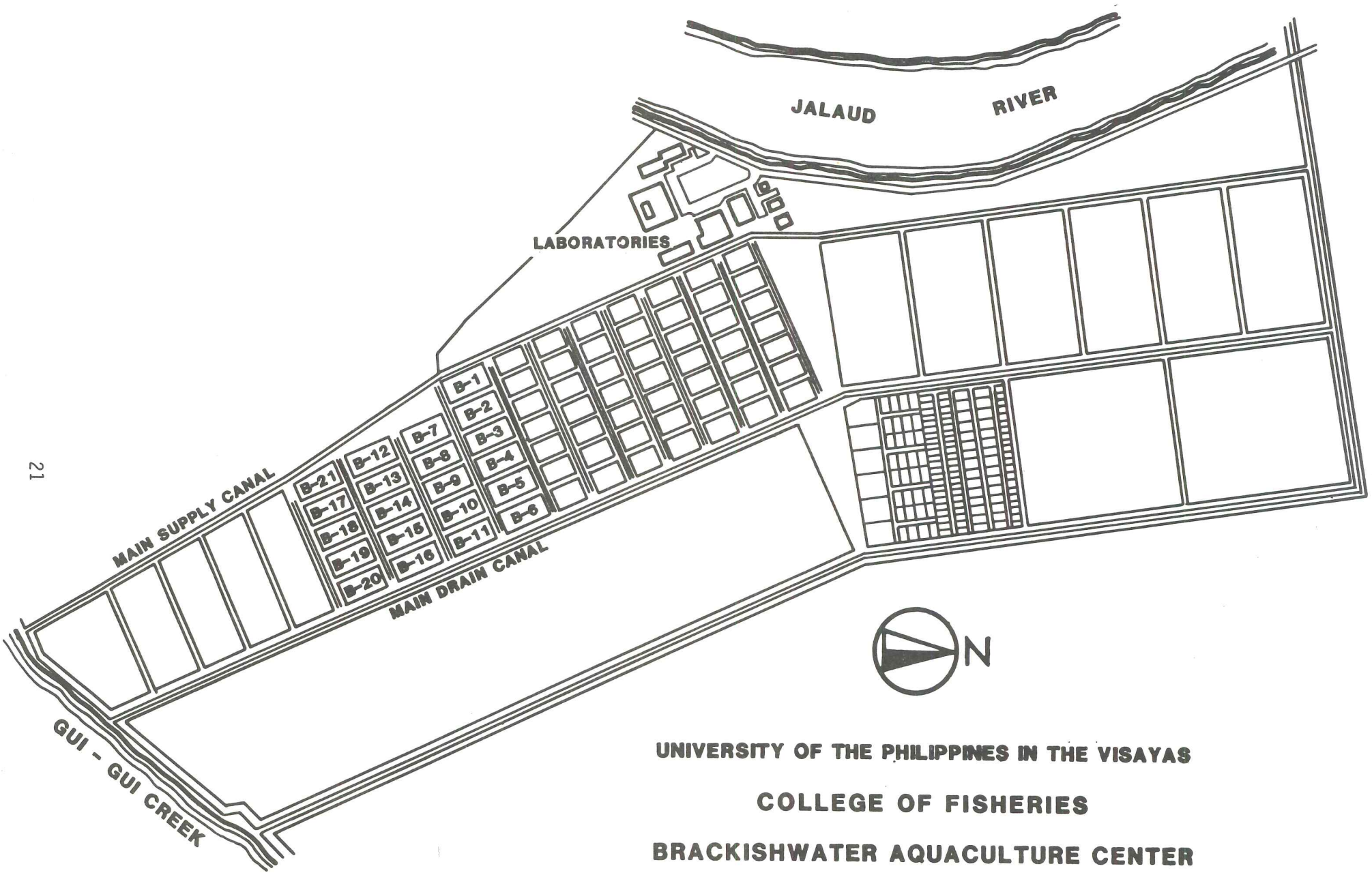
Soil Analysis: Soil analyses taken at the beginning of the experiment, before organic fertilizer was applied:

Pond	Wet pH	Dry pH	Avail. P (ppm)	Organic Matter (%)	Tot. N (ppm)	Alum. (ppm)	Iron (ppm)
B01	6.61	6.75	20.0	1.64	0.061	<0.100	201.60
B02	6.74	7.20	24.3	1.34	0.058	<0.100	68.70
B03	6.67	6.95	24.5	3.13	0.075	<0.100	77.90
B04	6.70	7.00	22.8	3.43	0.077	<0.100	242.90
B05	6.25	6.70	19.7	2.69	0.072	<0.100	64.00
B06	5.52	6.65	22.0	2.21	0.052	<0.100	36.50
B07	6.76	6.65	13.2	3.03	0.058	<0.100	57.30
B08	6.54	6.70	18.8	2.25	0.049	<0.100	41.10
B09	6.44	6.80	11.8	1.98	0.042	<0.100	40.90
B10	5.21	5.25	7.9	2.51	0.058	<0.100	41.20
B11	6.52	7.25	14.4	1.61	0.049	<0.100	54.90
B14	6.85	7.50	27.7	2.76	0.079	<0.100	454.20
B15	6.81	7.20	28.7	2.75	0.075	<0.100	582.80
B16	6.92	7.00	28.8	4.52	0.110	<0.100	618.80
B17	7.21	7.20	19.1	3.00	0.075	<0.100	2469.00
B18	7.05	7.40	32.5	4.48	0.099	<0.100	1054.00
B19	6.51	7.30	31.3	3.04	0.106	<0.100	1510.00
B20	6.79	7.00	28.0	3.40	0.107	<0.100	1142.00

For further information contact:

Dr. Rogelio O. Juliano, Dean
College of Fisheries
University of the Philippines
in the Visayas
P.O. Box 138
Iloilo City 5901
Republic of the Philippines

Dr. Philip Helfrich
Dr. Arlo Fast
University of Hawaii at Manoa
Hawaii Inst. of Mar. Biology
P.O. Box 1346
Coconut Island
Kaneohe, Hawaii 96744



UNIVERSITY OF THE PHILIPPINES IN THE VISAYAS

COLLEGE OF FISHERIES

BRACKISHWATER AQUACULTURE CENTER

LEGANES, ILOILO

NOTE: CRSP PONDS ARE NUMBERED B-1 THROUGH B-21.

RWANDA/OREGON STATE UNIVERSITY

Site:

Pond Dynamics/Aquaculture CRSP
Faculte d'Agronomie
Universite Nationale du Rwanda
BP 117
Butare, Rwanda

Latitude/Longitude: 2° 40' S 29° 45'E **Elevation:** 1700 m

Average Annual Rainfall: 1200 mm **Avg. Ann. Temperature:** 14 - 28°C

Average Pond Water Temperature: 19° - 23° C

Geographical Location: The CRSP research site is located in Rwasave, approximately 2 km from Rwanda's second largest city of Butare, and about 130 km south of the capitol city of Kigali.

General Description of Facility: The station is approximately 3 km from the National University of Rwanda, Butare campus. It has a total area of 18 ha, of which 4.8 ha is currently in ponds. Of 31 ponds, 21 are reserved for CRSP research. The remainder serve for fingerling production and as grow-out ponds. The laboratory building has three offices, each with 12 m^2 of surface, a laboratory of 42 m^2, and a storage area of 44 m^2.

Description of Water Supply: Water is supplied by the Rwabuye River. The supply canal runs 2.5 km from a small dam in the river to the station. The canal passes through some cultivated marshlands where there is some exchange with standing water.

Support Facilities: Library and university facilities are near but limited. The station employs one laboratory technician and two assistants, a computer-trainee, and 60 station workers and guards. The only feed currently available is rice bran, which is available in limited but currently adequate quantities. Fertilizer is available but expensive. Animal manure is in short supply but also adequate for current needs.

Source water analysis (mg/l):

pH:	6.5 - 7.0	(not yet taken)
Alkalinity:	17.0 mg $CaCo_3$/l	
Salinity:	--	
Hardness:	43.3 mg $CaCO_3$/l	

Soil analysis: Soil analysis from the Oregon State University Soil Analyses Lab is as follows:

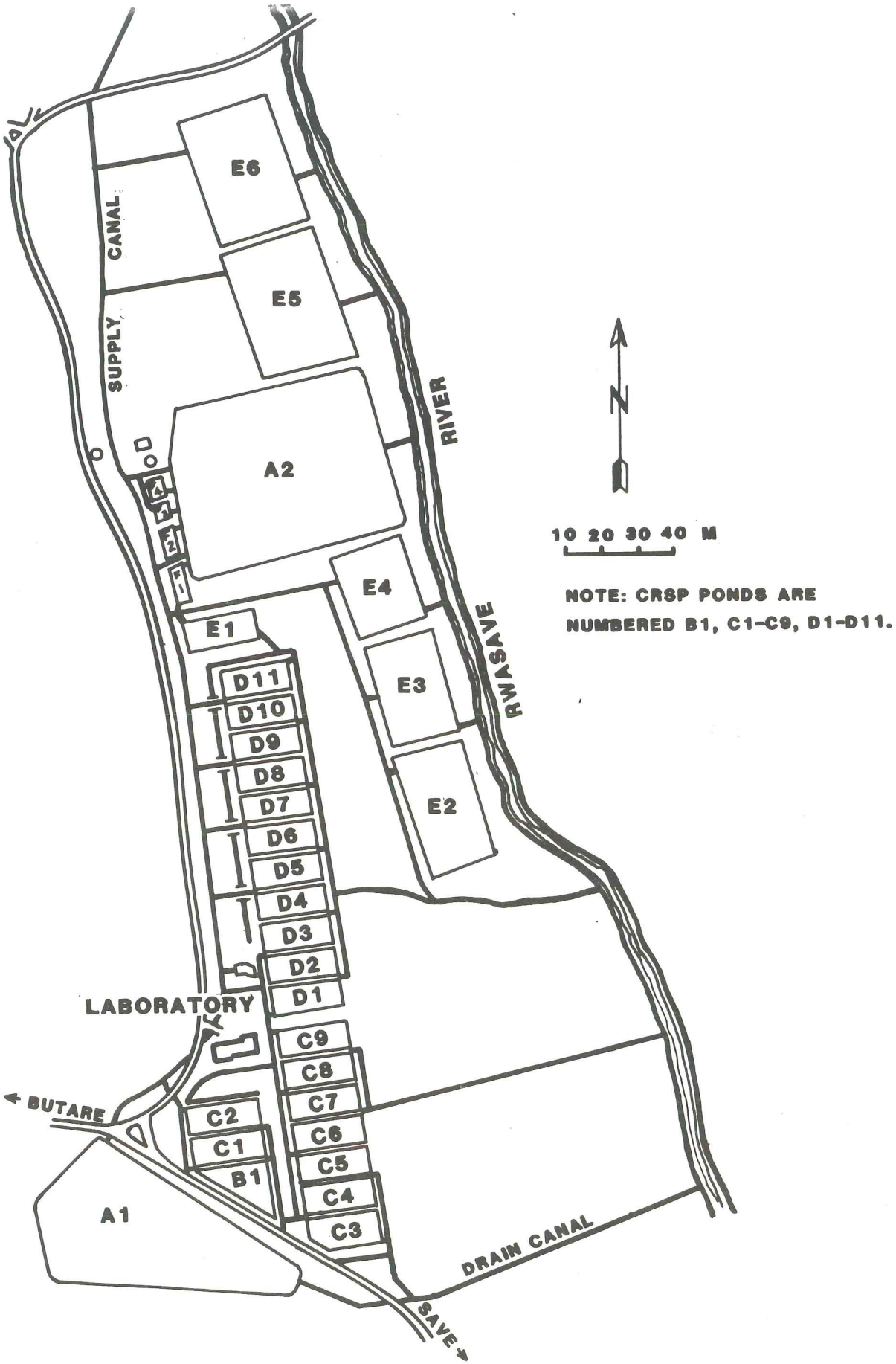
Pond	pH	P (ppm)	K (ppm)	Ca (meq/100g)	Mg (meq/100g)	Na (meq/100g)	Organic Matter (%)
B1	--	--	59	11.4	1.3	.13	--
C1	--	--	39	2.9	.68	.07	--
C2	4.7	4	55	2.1	.51	.09	5.1
C3	--	--	31	2.1	.66	.10	--
C4	--	--	31	2.9	.82	.11	--
C5	--	--	31	3.7	1.1	.10	--
C6	--	--	23	3.9	1.1	.10	--
C7	--	--	23	2.7	.69	.10	--
C8	--	--	23	2.0	.71	.09	--
C9	4.8	2	23	1.7	.46	.08	.67
D1	4.5	3	39	1.8	.65	.10	1.2

Pond	NO_3-N NH_4-N	SMP Lime Req. (%)	SO_4-S SO^4-S	CEC	Soluble Salts
B1	--	6.3	65.10	15.3	--
C1	--	5.6	31.37	17.6	--
C2	5.1 25.1	5.8	21.05	13.3	.30
C3	--	6.8	18.95	4.5	--
C4	--	6.2	37.78	9.5	--
C5	--	5.9	47.19	16.2	--
C6	--	5.6	32.68	17.1	--
C7	--	5.8	25.49	10.5	--
C8	--	6.4	23.01	6.1	--
C9	.60 16.5	6.5	9.41	4.9	<.15
D1	.80 11.0	6.2	56.86	6.2	.45

For further information contact:

Dr. Valens Ndoreyaho
Pond Dynamics/Aquaculture CRSP
Faculte d' Agronomie
Universite Nationale du Rwanda
BP 117
Butare, Rwanda
Africa

Dr. Richard Tubb
Mr. Wayne Seim
Pond Dynamics/Aquaculture CRSP
Dept. of Fisheries & Wildlife
Oregon State University
Corvallis, OR 97331



NATIONAL UNIVERSITY OF RWANDA

FISHERIES STATION

RWASAVE, RWANDA AFRICA

THAILAND/UNIVERSITY OF MICHIGAN

Site: Pond Dynamics/Aquaculture CRSP
National Inland Fisheries Institute (NIFI)
Bangkhen
Bangkok 9
Thailand

Latitude/Longitude: 14°11' 100°30' **Elevation:** 5 m

Average Annual Rainfall: 1372 mm **Avg. Ann. Temperature:** 28°C

Average Pond Water Temperature: 28°C

Geographical Location: The CRSP experimental site is located in Ayutthaya, approximately 60 km from the capital city of Bangkok. The station is in the central plain characterized by low and flat terrain, which extends to the Gulf of Thailand 80 km south.

General Description of Facility: The Ayutthaya Station is under the jurisdiction of the Royal Thai Department of Fisheries. It has a total area of 32 ha and includes an office building, laboratory, hatchery complex, a pumping station, 20 concrete ponds, 68 earthen ponds, and a 29,000 m_2 reservoir. Staff housing is currently under construction. Sixteen ponds are available for CRSP use in addition to a large brooding pond and several small concrete tanks.

Water Supply: The station receives its water supply directly from the Chao Phaya River through an open canal. The water is pumped to the reservoir from which it is drained to the ponds by gravity flow or pumping.

Support Facilities: Almost all laboratory and personnel at the National Inland Fisheries Institute (NIFI) and the Faculty of Fisheries at the Kasetsart University are accessible to the CRSP project. There is an adequate library at NIFI including FAO-compiled fisheries literature. Fish feeds are available through either commercial dealers or manufactured by NIFI's nutrition department. Organic fertilizers are abundantly available from local farms.

Source water analysis (mg/l):

(Reservoir)

pH:	8.6
Alkalinity:	92 $CaCO_3$
Tot. Hardness:	184 $CaCO_3$
Ammonia:	0.038
Nitrate-nitrite:	0.033
Total Phosphorus:	0.05
Ortho-phosphate:	<0.005

(Pond Water - Avg. of 12 Ponds)

Calcium:	281.7
Magnesium:	217.3
Sodium:	499.1
Potassium:	3.0
Chloride:	700
Sulfate:	816
Iron:	7.2
Zinc:	Trace
Copper:	Trace

Soil analysis: Soil at the Ayutthaya Station is characteristically high in clay (60%) and low in sand.

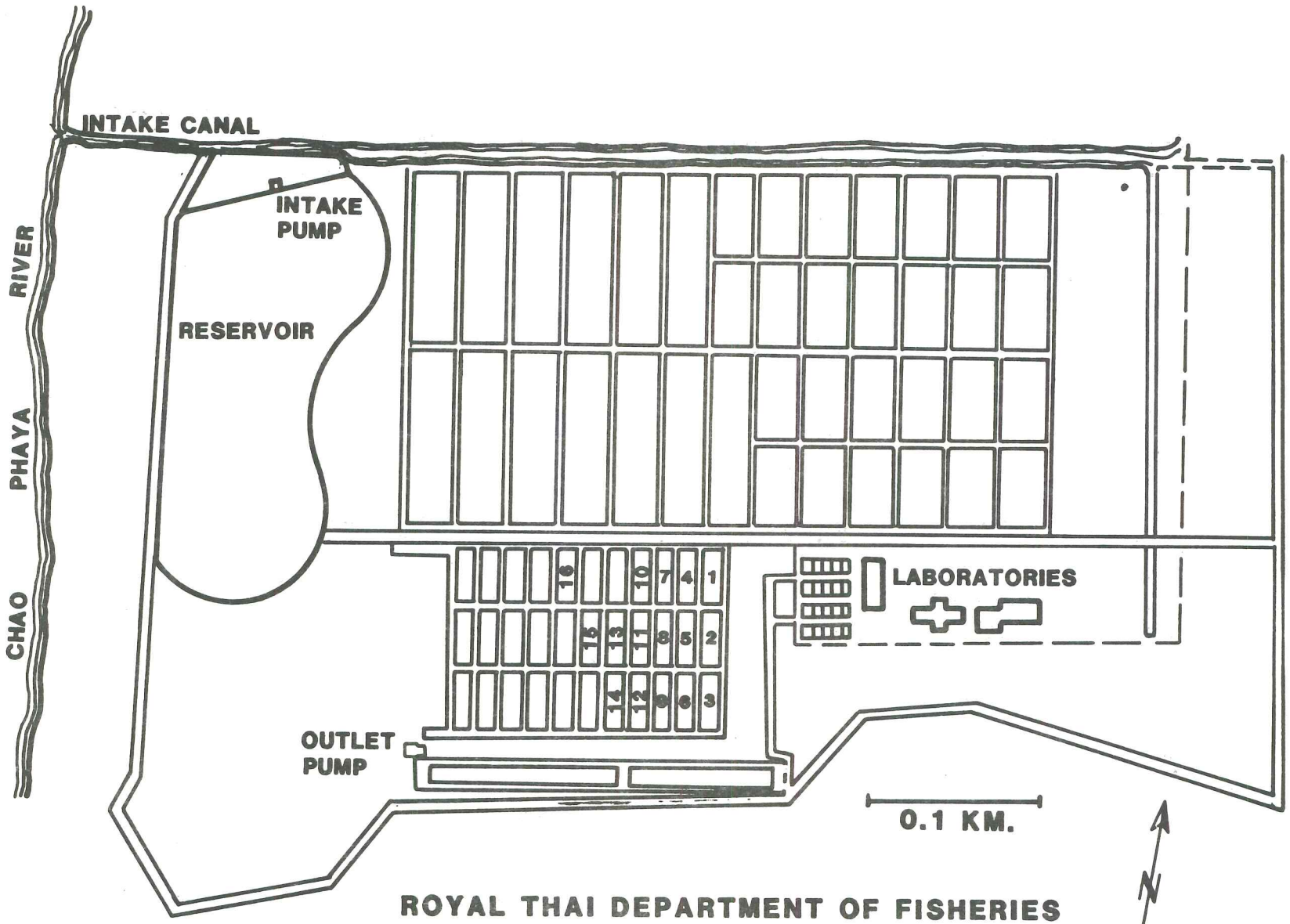
Pond	pH	Total P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Organic Matter (%)	Zn (ppm)	Cu (ppm)
1	7.0	450	98	3760	1250	0.77	1.2	2.2
2	7.7	420	214	4480	1150	1.04	1.2	1.6
3	7.5	406	98	3700	1105	0.91	1.2	2.4
4	7.5	450	105	4480	1650	0.64	1.2	3.2
5	7.0	450	112	3940	1300	0.70	2.0	1.0
6	7.5	420	126	4680	1250	0.64	1.2	1.6
7	7.4	420	124	5160	1250	0.50	2.0	1.6
8	7.4	420	118	4040	1200	0.91	2.0	1.6
9	7.4	450	108	5250	1500	0.50	1.2	2.2
10	7.5	420	98	4360	1150	0.64	2.0	2.2
11	7.6	390	87	3700	1370	0.77	1.2	1.6
12	7.3	460	112	4060	1110	1.04	2.0	1.0

Pond	Mn (ppm)	SMP Lime Req. (%)	SO_4S	Al (ppm)	Fe (ppm)	Sand (%)	Silt (%)	Clay (%)
1	161	-	85.42	25	20	10	23	67
2	54	-	88.54	36	28	14	24	62
3	115	-	77.08	44	8	10	24	66
4	83	-	102.08	22	20	10	22	68
5	125	-	77.08	96	35	13	23	64
6	29	-	91.67	36	8	11	20	69
7	105	-	116.67	52	35	12	22	66
8	100	-	169.79	48	38	10	24	66
9	27	-	112.50	48	20	12	20	68
10	21	-	116.67	30	20	10	21	69
11	63	-	82.29	22	16	9	21	70
12	135	-	104.17	28	20	14	23	63

For further information contact:

Dr. C. Kwei Lin
Asian Institute of Technology
Bangkok
Thailand

Dr. James Diana
Pond Dynamics/Aquaculture CRSP
School of Natural Resources, Dana Bldg.
University of Michigan
Ann Arbor, Michigan 48109



ROYAL THAI DEPARTMENT OF FISHERIES

NATIONAL INLAND FISHERIES INSTITUTE

AYUTTHAYA STATION

AYUTTHAYA, THAILAND

III. DESCRIPTION OF EXPERIMENTS

During the planning of the PD/A CRSP, researchers recognized the need to improve the existing data base on pond culture systems. The technical literature about pond aquaculture abounds with general operating guidelines; however, the lack of standardization in experimental design, data collection, and analysis precludes statistical comparison between studies. Thus, these studies are of limited utility in predicting the performance of pond culture systems. The PD/A CRSP developed a standardized data base that can be used to evaluate pond performance over a broad range of environments. Quantitative expressions derived from the data base can be used to improve production technology and facilitate economic analyses of pond culture systems.

Experimental Design

The statistical design for the global experiments involves monitoring environmental and fish production variables at seven geographical locations. The different locations provide a spectrum of pond environments. Observations specified in the annual work plans (experimental cycles) are made on twelve or more ponds at each location, except at Gualaca where ten ponds were used. The pond variables observed, frequency of observation, materials and methods for determination, and standardized reporting units are presented below and in Section IV (Materials and Methods).

Observations at each location are recorded by the research team involved at that location, and all data is filed in a centralized CRSP Data Base. Standard statistical methods will be used to test statistical hypotheses about correlations between variables and to evaluate the sources of variance within ponds, between ponds within locations, and between locations. Because of the relatively large number of locations and ponds at each location, the experimental design has substantial statistical power.

CRSP Work Plans

The PD/A CRSP technical plans are developed by a research team composed of U.S. and host country Principal Investigators, and the PD/A CRSP Technical Committee. Each work plan presents detailed experimental protocol for one experimental cycle. A cycle involves two series of observations of four to five months duration. One set of observations is made during the dry season and the other during the wet season.

Three work plans have been developed to date. The rationale has been to manage all ponds in exactly the same way to establish a detailed baseline of pond variables. Then in subsequent experiments, the pond environments are manipulated in different ways and the responses observed.

FIRST CYCLE OF THE CRSP GLOBAL EXPERIMENT

The first work plan was developed at a meeting of PD/A CRSP participants in Davis, California on March 2 and 3, 1983. This work plan specified standard methods for pond preparation and monitoring. All ponds were prepared in the same way, fish were stocked at the same levels, and specified variables were observed during both the wet and dry seasons.

Technical Objectives

1. To compile a quantitative baseline of chemical, physical and biological parameters for each work location;

2. To observe quantitative physical, chemical and biological responses to various levels of inorganic fertilizer application to pond culture systems, and to test for significant correlations with and between work locations;

Considerations in developing the first work plan

The sites of the research projects can be categorized as: brackish to marine tropical locations in Panama (Aquadulce) and the Philippines; warm, tropical, freshwater locations with elevations below 700 m and average temperatures above 25°C in Honduras, Panama (Gualaca) and Thailand; and temperate, tropical, freshwater locations with elevations above 750 m and average temperatures of 25°C or below in Indonesia and Rwanda. These categories serve as a general reference; a great deal of variation is anticipated within these categories.

To establish a common reference point between locations, Oreochromis niloticus (Tilapia nilotica) was used as the culture organism. This tilapia is found in all the participating PD/A CRSP countries. It offers great potential as a research organism in that it responds well to a variety of levels of pond management, including inorganic and organic fertilization, and several qualities of supplemental feeds.

The level and quality of nutrient input can be used as another reference point. Finding a source of nutrients common to all locations was problematical. Feeds and animal manure vary from location to location in both availability and composition. Consequently, inorganic fertilizer was selected for use in the first PD/A CRSP experiment. A standard formulation was used at all locations, and applied at a level representative of contemporary practices.

EXPERIMENTAL PROTOCOL

Sampling procedures, frequencies, and methods of analysis are described in Section IV, Materials and Methods. The variables that were measured during the first experimental cycle are:

1. Physical environmental measurements--required at all sites:
   solar radiation (light)
   rainfall
   wind speed and direction
   air temperature
   pond soil characteristics
   pond temperature extremes (fluctuation)
   pond depth (fluctuation)
   hydrologic characteristics
   pond morphology

2. Water analyses--required during production experiments:
   dissolved oxygen
   temperature
   pH
   alkalinity
   total hardness
   water quality characteristics

3. Water analyses--recommended during production experiments (not required during Cycle I):
   ammonia nitrogen
   nitrate
   total phosphorus
   total dissolved phosphorus
   total dissolved reactive phosphorus (dissolved orthophosphate)

4. Growth and yield measurements--required during production experiments:
   growth
   reproduction
   survival

5. Biological limnology measurements--required during production experiments:
   secchi disk visibility
   chlorophyll *a*

6. Biological limnology measurements--recommended during production experiments (not required for Cycle I):
   light-dark bottle experiments
   qualitative identification of phytoplankton, zooplankton and benthos

SECOND CYCLE OF THE CRSP GLOBAL EXPERIMENT

The plan for the second experimental cycle was developed during the PD/A CRSP Annual Meeting in Atlanta, Georgia on April 10-12, 1984. At this meeting, participants reviewed accomplishments and discussed problems encountered during the first cycle of experiments. They then developed a detailed plan for the second experimental cycle. In the second experiment, the responses of ponds receiving organic fertilizers were compared to ponds receiving inorganic fertilizers.

Technical Objectives

1. To compare the physical, chemical, and biological responses measured in the freshwater ponds treated with inorganic and organic fertilizers;

2. To compare physical, chemical, and biological responses measured in the brackish water/marine ponds treated with manure, manure plus inorganic fertilizer, manure plus feed, and manure plus fertilizer plus feed.

Considerations in developing the second work plan

Site specific problems were encountered during the first experimental cycle. The second work plan includes a series of pilot experiments intended to circumvent site specific problems.

Experimental Protocol

The second cycle of the PD/A CRSP experiment continued the standardized global experiments. The standardized experiments involved the culture of Oreochromis niloticus at five sites and penaeid shrimp at two sites.

The second cycle of experiments was designed to expand the quantitative baseline established during the first year of research. In addition, the second cycle tested the working hypothesis that organic fertilization would improve water quality and would produce higher fish yields than inorganic fertilization. In statistical terms, the primary hypothesis would be stated as:

Primary H_o = organic and inorganic fertilization result in the same fish production.

During the second cycle, Oreochromis niloticus was used at the PD/A CRSP brackish water research site in the Philippines and at freshwater research stations at four other host countries: Honduras, Indonesia, Rwanda and Thailand. The PD/A CRSP research team in the Philippines also carried out a set of experiments using penaeid shrimp. A second brackish water station in Panama conducted its standardized experiments with penaeid shrimp exclusively. The experimental design differed for Oreochromis niloticus and penaeid shrimp.

Fresh Water Experiments

A minimum of twelve earthen ponds were used for second cycle experiments. Numbers of replicates per treatment were dictated by variation among ponds observed in the first cycle.

Pond Treatments	Recommended Pond Replicates	Treatment Description
I	4-6	organic fertilizer
II	4-6	inorganic fertilizer
III	4	site specific plans

Nutrient Inputs. Fertilizer treatments for the second cycle were:

I. Organic fertilizers- chicken manure or other locally available animal wastes were added at a rate of approximately 500 kg/ha/wk.
II. Inorganic fertilizers in the form of triple sugar phosphate (0-46-0) and urea were added at levels of total P and N in the organic fertilizers used in the environment.

Pond Preparation. Preparation of ponds for experiments, including the method for satisfying lime requirements of pond muds was specified in the Second Work Plan and is presented in Appendix A.

Stocking Procedures. All ponds were stocked with male Oreochromis niloticus of average weight between 25 and 50 grams. The standard stocking density is one fish per square meter (10,000 fish per hectare). The Second Work Plan specified methods for production of Oreochromis niloticus fingerlings (see Appendix B).

Duration of Experiments. Two experiments were accomplished during the second cycle. Each experiment was conducted for a period of five months (150 days). The experimental cycle was established so that one experiment was run during the wet season and the other was run during the dry season. In some instances, it was difficult to complete an entire experiment in a particular season. In such cases, however, the final 90 days of the culture period occurred within a single climatic season.

Brackish Water and Marine Experiments

The following treatments were applied at the brackish water/marine ponds in the Philippines and Panama:

Pond Treatment	Recommended Pond Replications	Treatment Description
I	4	manure
II	4	manure + inorganic fertilizer
III	4	manure + feed
IV	4	manure + fertilizer + feed

Nutrient Inputs. I. Manures: dried chicken manure was applied as a pre-treatment to ponds at a rate of 2000 kg/ha; manure was broadcast over the pond bottom.

II. Inorganic fertilizers: 200 kg/ha of 16N-20P-0K was broadcast over the pond prior to filling.

III. Feed: a 25% protein feed was added to the pond beginning on day 31.

Stocking. Approximately four juvenile penaeid shrimp were stocked per square meter. Species selection depended on local availability of stocks.

Duration of Experiments. The experimental periods lasted 90 to 120 days.

Variables Measured. Sampling methods, frequencies, and methods of analysis are described in the following section (IV). The variables measured during the second experimental cycle were:

1. Physical environment measurements--required at all sites:
   solar radiation (light)
   rainfall
   wind speed
   air temperature
   pond soil characteristics
   pond temperature extremes
   pond depth
   hydrologic characteristics

2. Water analyses--required during production experiments:
   dissolved oxygen
   temperature
   pH
   alkalinity

total hardness
water quality characteristics
total nitrogen
ammonia nitrogen
nitrate
total phosphorus
dissolved orthophosphate (filterable reactive phosphorus)

3. Growth and yield measurements--required during production experiments:
growth
reproduction
survival

4. Biological limnology measurements--required during production experiments:
secchi disk visibility
chlorophyll a
chlorophyll b,c (brackish water sites only)

5. Biological limnology measurements--recommended during production experiments (not required for Cycle II):
light-dark bottle experiments
qualitative identification of phytoplankton, zooplankton and benthos

THIRD CYCLE OF THE CRSP GLOBAL EXPERIMENT

The third cycle of pond dynamics experiments was developed by the PD/A CRSP participants at the Annual Meeting in Honolulu, Hawaii on March 18-20, 1985. Based on their experiences to date, they developed an experimental plan to compare the responses of ponds to varying levels of organic fertilizer addition.

Technical objectives

1. To compare physical, chemical, and biological responses measured in freshwater ponds treated with organic fertilizers at the rates of 125, 250, 500, and 1000 kg/hectare/week;

2. To observes differences in physical, chemical and biological responses to brackish water/marine ponds stocked with shrimp; bivalves and shrimp; and fish, bivalves, and shrimp;

3. To observe physical, chemical and biological responses to pretreatment in brackish water/marine ponds;

4. To compare physical, chemical and biological responses in brackish water/marine ponds subjected to varying rates of water exchange.

Experimental protocol

The third cycle of experiments expanded the quantitative baselines initiated during the first two years of research. In addition, the third cycle was designed to demonstrate the level of organic fertilization that would produce optimal fish yields.

During the third cycle, Oreochromis niloticus, preferably the Ivory Coast strain, was used at the CRSP brackish water research site in the Philippines and at freshwater research stations in the five other host countries: Honduras, Indonesia, Panama, Rwanda and Thailand. The PD/A CRSP research team in the Philippines also carried out a set of experiments using penaeid shrimp (Penaeus monodon). A second brackish water station in Panama (Aquadulce) conducted its standardized experiments with penaeid shrimp (P. vannamei) exclusively. The experimental design differed for Oreochromis niloticus and penaeid shrimp.

Fresh Water Experiments

A minimum of twelve earthen ponds was used in experiments during the third cycle. Organic fertilizer, chicken manure, or other locally available animal wastes were added on a dry matter basis at the rates indicated below.

Pond Treatments	Recommended Pond Replicates	Organic Fertilizers (kg/ha/wk)
I	3	125
II	3	250
III	3	500
IV	3	1000

Nutrient Inputs. Fertilizer treatments for the third cycle are outlined in Appendix A.

Pond Preparation. The procedure for preparing ponds for experiments, including the method for satisfying lime requirements of pond muds, is presented in Appendix A.

Stocking Procedures. All ponds were stocked with male Oreochromis niloticus of average weight of 25 grams. The standard stocking density was one fish per square meter (10,000 fish per hectare). The recommended method for production of Oreochromis niloticus fingerlings is described in Appendix B.

Duration of Experiments. Two experiments were accomplished during the third cycle. Each experiment ran for a period of four months (120 days). The experimental cycle was established so that one experiment ran during the wet season and the other ran during the dry season. In some instances, it was difficult to complete an entire experiment in a particular season. In such cases, the final 90 days of the culture period occurred within a single climatic season.

Brackish Water and Marine Experiments

The PD/A CRSP project teams in Panama and the Philippines investigated the impact of biological and physical manipulations on water quality in brackish water and marine ponds. The following treatments were applied:

Biological Manipulation: the Philippines

Pond Treatment	Biological Manipulation	Pond Replicates With Circulation	Pond Replicates Without Circulation
I	Shrimp	3	3
II	Shrimp and Bivalves	3	3
III	Shrimp, Bivalves, and Milkfish	3	3

Physical Manipulation: Panama (Aguadulce)

Pond Treatment	Pond Replicates	Water Exchange % Pond Volume/day	Nutrient Pretreatment
1	3	0	no
2	3	5	no
3	3	10	no
4	3	20	no
5	3	5	yes

Nutrient Inputs. I. Manures: dried chicken manure was applied as a pretreatment to ponds at a rate of 2000 kg/ha, manure was broadcast over the pond bottom.

II. Feed: a 25% protein feed was added to the pond beginning on day 31.

Stocking. Approximately four juvenile penaeid shrimp were stocked per square meter of pond. Penaeus vannamei was used in Panama and Penaeus monodon was used in the Philippines. Bivalves and milkfish (Chanos chanos) were stocked as biological water quality control organisms in the Philippines. Bilvalve species and stocking rates were determined based on local availability, literature reviews, and trial testing. Milkfish were stocked at rates similar to those used in preliminary experiments of the first cycle of the PD/A CRSP experiment.

Variables Measured. Sampling procedures, frequencies, and methods of analysis are described in the following section (IV). The variables measured during the third experimental cycle were:

1. Physical environment measurements--required at all sites:
   solar radiation (light)
   rainfall
   wind speed
   air temperature
   pond soil characteristics
   pond temperature extremes
   pond depth
   hydrologic characteristics

2. Water analyses--required during production experiments:
   dissolved oxygen
   temperature
   pH
   alkalinity
   total hardness
   water quality characteristics
   total nitrogen
   ammonia nitrogen
   nitrate
   total phosphorus
   dissolved orthophosphate (filterable reactive phosphorus)
   silicates (brackish water and marine sites only)

3. Growth and yield measurements--required during production experiments:
   growth
   reproduction
   survival

4. Biological limnology measurements--required during production experiments:
   secchi disk visibility
   chlorophyll *a*
   chlorophyll *b*,*c* (brackish water sites only)

5. Biological limnology measurements--recommended during fish production
   experiments (not required for Cycle III):
   primary productivity
   qualitative identification of phytoplankton, zooplankton and benthos

IV MATERIALS AND METHODS

The various measurements required during the three years of the Global Experiment are outlined in this section. Also included are brief descriptions of sampling methods, instrumentation, and analytical methods. The tables in this section are based on CRSP Work Plans 1, 2, and 3.

Subsequent volumes of the Data Report Series will specify details of materials and methods if significant divergence from the original Work Plans occurred.

TABLE 1a. DAILY MEASUREMENTS. WORK PLAN 1.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Solar Radiation	Install Solar Monitor and Quantum Sensor at study site and read at 24-hour intervals.	LI-COR Solar Monitor Model LI-1776 and Quantum Sensor Model LI-190SB	———	$E/m^2/day$
Rainfall	Install three rain gauges at study site. Read and empty at 24-hour intervals; report average of three readings.	No type specified. Recommended gauge from Grassroot Co., Wisconsin.	———	cm/day
Wind Speed	If instantaneous windspeed and direction meter are already in use, read at appropriate intervals to correlate with thermal and oxygen stratification of ponds. Spot readings should be made at the same time as diurnal DO and temperature readings.	Instantaneous wind speed and direction meter comparable to Taylor Model 110930 is acceptable if already in use. For new purchase, recommend totalizing anemometer comparable to WEATHERtronics Model 2510.	———	km/hour
Air Temperature	Install three maximum-minimum thermometers in the shade near ponds; read weekly or at appropriate intervals.	Maximum-Minimum thermometer comparable to Taylor Model 5460.	———	Max: ^oC Min: ^oC
Pond Depth	Install staff gauge in each pond and read to the nearest 0.5 cm at intervals that seem appropriate to site conditions. Maintain 0.9 m average depth throughout experiments.	No type specified.	———	m

TABLE 1b. DAILY MEASUREMENTS. WORK PLAN 2.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Solar Radiation	Install Solar Monitor and Quantum Sensor at study site and read at 24-hour intervals.	LI-COR Solar Monitor Model LI-1776 and Quantum Sensor Model LI-190SB	———	$E/m^2/day$
Rainfall	Install three rain gauges at study site. Read and empty at 24-hour intervals; report average of three readings.	No type specified.	———	cm/day
Wind Speed	If instantaneous windspeed and direction meter are already in use, read at appropriate intervals to correlate with thermal and oxygen stratification of ponds. With preferred totalizing anemometer, read between 0800 h. and 0900 h. and record average hourly wind speed.	Instantaneous wind speed and direction meter comparable to Taylor Model 110930 is acceptable if already in use. For new purchase, recommend totalizing anemometer comparable to WEATHERtronics Model 2510.	———	km/hour
Air Temperature	Install three maximum-minimum thermometers in the shade near ponds; read at 24-hour intervals and report average maximum and average minimum.	Maximum-Minimum thermometer comparable to Taylor Model 5460.	———	Max: ^oC Min: ^oC
Pond Depth	Install staff gauge in each pond and read to nearest 0.5 cm at the same time each day. Maintain 0.9 m average depth on daily basis.	No type specified.	———	m

TABLE 1c. DAILY MEASUREMENTS. WORK PLAN 3.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Solar Radiation	Install Solar Monitor and Quantum Sensor at study site and read at 24-hour intervals.	LI-COR Solar Monitor Model LI-1776 and Quantum Sensor Model LI-190SB	———	$E/m^2/day$
Rainfall	Install three rain gauges at study site. Read and empty at 24-hour intervals; report average of three readings.	No type specified.	———	cm/day
Wind Speed	If instantaneous windspeed and direction meter are already in use, read at appropriate intervals to correlate with thermal and oxygen stratification of ponds. With preferred totalizing anemometer, read between 0800 h. and 0900 h. and record average hourly wind speed.	Instantaneous wind speed and direction meter comparable to Taylor Model 110930 is acceptable if already in use. For new purchase, recommend totalizing anemometer comparable to WEATHERtronics Model 2510.	———	km/hour
Air Temperature	Install three maximum-minimum thermometers in the shade near ponds; read at 24-hour intervals and report average maximum and average minimum.	Maximum-Minimum thermometer comparable to Taylor Model 5460.	———	Max: ^oC Min: ^oC
Pond Depth	Install staff gauge in each pond and read to nearest 0.5 cm at the same time each day. Maintain 0.9 m average depth on daily basis.	No type specified.	———	m

TABLE 2a. BIWEEKLY AND WEEKLY MEASUREMENTS. WORK PLAN 1.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Dissolved Oxygen *	Near center of each pond, take readings 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.	Yellow Springs Instrument (YSI) Model 57 Dissolved Oxygen Meter. Calibrate meter each month using the Winkler Method (as described by APHA, 1980) or a Hach Digital Titrator Kit/Dissolved Oxygen.	Winkler or Iodometric Method (American Public Health Association, 1980. Standard Methods for The Examination of Water and Waste Water. Washington, DC, 15th ed. pp.388-399.)	mg/ l
Pond Temperature Extremes	In three ponds, place two maximum-minimum thermometers each at locations of 25 cm below the water surface and at 25 cm above the bottom of the ponds. Take weekly readings.	No type specified.	———	max: ^{o}C min: ^{o}C
Pond Temperature *	Near the center of each pond, take readings at 25 cm below the water surface, 25 cm above the bottom, and at midwater. Take readings once per week, and as part of the monthly diurnal study at 4-hour intervals beginning 30 minutes before sunrise until after sunset. If a probe is used, calibrate using a precision thermometer.	YSI Model 57 Dissolved Oxygen Meter with Temperature Indicator.	———	^{o}C
pH *	Take measurements from 3 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 and pH 4.	pH Meter with Combination Electrode comparable to Orion 200 Series with Ross Model 81-55 Electrode.	———	pH Units

* *Indicates parameters to be measured as part of monthly diurnal studies.*

TABLE 2a. (continued). BIWEEKLY AND WEEKLY MEASUREMENTS. WORK PLAN 1.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Secchi Disk Visibility	Samples are collected twice each week between 1100 h. and 1400 h. on the same days as chlorophyll analyses (with one sampling period coinciding with monthly diurnal study), at 2 locations in each pond.		Calculate Secchi Disk Visibility using procedure described by Lind, O.T. 1974. Handbook of common methods in limnology. C.V. Mosby Company, St. Louis, Missouri. pp.22-23.	cm
Chlorophyll a *	Collect one sample per pond by pooling three 90-cm column samples. Take samples twice each week with one sampling period coinciding with monthly diurnal study.		Follow methods outlined by Wetzel, R.G. 1979. Limnology. W.B. Saunders Co., Philadelphia. 743 pp.	mg/m^3

* *Indicates parameters to be measured as part of monthly diurnal studies.*

TABLE 2b. BIWEEKLY AND WEEKLY MEASUREMENTS. WORK PLAN 2.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Dissolved Oxygen *	Near center of each pond, take readings at 25 cm below water surface, midwater and 25 cm above the bottom. Sample weekly at dawn and as part of monthly diurnal study at 4-hour intervals beginning 30 minutes before sunrise until after sunrise the next day.	Yellow Springs Instrument (YSI) Model 57 Dissolved Oxygen Meter. Calibrate meter each month using the Winkler Method (as described by APHA, 1981) or a Hach Digital Titrator Kit/Dissolved Oxygen.	Winkler or Iodometric Method (American Public Health Association, 1980. Standard Methods for The Examination of Water and Waste Water. Washington, DC, 15th ed. pp.388-399.)	mg/ l
Pond Temperature Extremes	In three ponds, place one maximum-minimum thermometer at 25 cm below the water surface and one at 25 cm above the bottom of the ponds. Take weekly readings.	No type specified.	———	max: °C min: °C
Pond Temperature *	Near the center of each pond, take readings at 25 cm below the water surface and 25 cm above the bottom. Take readings once per week, and as part of the monthly diurnal study at 4-hour intervals beginning 30 minutes before sunrise until after sunset. If a probe is used, calibrate using a precision thermometer.	YSI Model 57 Dissolved Oxygen Meter with Temperature Indicator.	———	°C
pH *	Take measurements from 3 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 and pH 4.	pH Meter with Combination Electrode comparable to Orion 200 Series with Ross Model 81-55 Electrode.	———	pH Units

* *Indicates parameters to be measured as part of monthly diurnal studies.*

TABLE 2b. (continued). BIWEEKLY AND WEEKLY MEASUREMENTS. WORK PLAN 2.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Secchi Disk Visibility *	Samples are collected twice each week on the same days as chlorophyll analyses (with one sampling period coinciding with monthly diurnal study), at 2 locations in each pond.		Calculate Secchi Disk Visibility using the procedure described by Lind, O.T. 1974. Handbook of common methods in limnology. C.V. Mosby Company, St. Louis, Missouri. pp.22-23.	cm
Chlorophyll a *	Collect one sample per pond by pooling three 90-cm column samples. Take samples twice each week with one sampling period coinciding with monthly diurnal study.		Spectrophotometric Determination (American Public Health Association (APHA), 1980. Standard Methods for the Examination of Water and Waste Water. 15th ed., Washington, DC pp.950-954.	mg/m^3
Total Kjeldahl 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 Kjeldahl Nitrogen apparatus.	Semi-Micro Kjeldahl Method (Michigan State University Limnological Research Laboratory, 1984. Unpublished memo on total Kjeldahl Nitrogen determination. East Lansing, MI. 5 pp.); or in-country analysis by qualified laboratory.	mg/l

* *Indicates parameters to be measured as part of monthly diurnal studies.*

TABLE 2c. BIWEEKLY AND WEEKLY MEASUREMENTS. WORK PLAN 3.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Dissolved Oxygen *	Near center of each pond, take readings at 25 cm below water surface, midwater and 25 cm above the bottom. Sample weekly at dawn and as part of monthly diurnal study at 4-hour intervals beginning 30 minutes before sunrise until after sunrise.	Yellow Springs Instrument (YSI) Model 57 Dissolved Oxygen Meter. Calibrate meter each month using the Winkler Method (as described by APHA, 1981) or a Hach Digital Titrator Kit/Dissolved Oxygen.	Winkler or Iodometric Method (American Public Health Association, 1980. Standard Methods for The Examination of Water and Waste Water. Washington, DC, 15th ed. pp.388-399.)	mg/ l
Pond Temperature Extremes	In three ponds, place one maximum-minimum thermometer at 25 cm below the water surface and one at 25 cm above the bottom of the ponds. Take weekly readings.	No type specified.	———	max: ^{o}C min: ^{o}C
Pond Temperature *	Near the center of each pond, take readings at 25 cm below the water surface and 25 cm above the bottom. Take readings once per week at 1400 h., and as part of even week diurnal study at 4-hour intervals beginning 30 minutes before sunrise until after sunset. If a probe is used, calibrate using a precision thermometer.	YSI Model 57 Dissolved Oxygen Meter with Temperature Indicator.	———	^{o}C
pH *	Take measurements from 3 pooled 90-cm column samples per pond once per week at 1400 h., 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 and pH 4.	pH Meter with Combination Electrode comparable to Orion 200 Series with Ross Model 81-55 Electrode.	———	pH Units

* *Indicates parameters to be measured as part of even week diurnal studies.*

TABLE 2c. (continued). BIWEEKLY AND WEEKLY MEASUREMENTS. WORK PLAN 3.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Alkalinity *	Weekly at 1400 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. (The special water chemistry analyses carried out at the beginning and end of experiments can be used to determine Ca^{++} contribution to total hardness). See occasional measurements.	Hach Digital Titrator Test Kit/Alkalinity (optional)	Low or High Standard Alkalinity Method (as appropriate), American Public Health Association, 1980; or Hach Test Kit.	mg $CaCO_3$ /l
Total Hardness	Weekly at 1400 h., collect one sample (by pooling three 90-cm column samples) from each pond. Samples should be refrigerated and analyzed within 7 days.	Hach Digital Titrator Test Kit/ Total Hardness (optional)	EDTA Titrimetric Method (American Public Health Association, 1980); or using Hach Test Kit.	mg $CaCO_3$ /l
Ammonia	Weekly at 1400 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 Kjeldahl Nitrogen Apparatus.	Nesslerization Method (Michigan State University Limnological Research Laboratory, 1984).	mg/l
Nitrate	Weekly at 1400 h. collect one sample (by pooling three 90-cm column samples) from each pond. Samples should be refrigerated and analyzed within 24 hours.	———	Cadmium Reduction Method (Michigan State University Limnological Research Laboratory, 1984)	mg/l

* *Indicates parameters to be measured as part of even week diurnal studies.*

TABLE 2c. (continued). WEEKLY MEASUREMENTS. WORK PLAN 3.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Secchi Disk Visibility *	Samples are collected weekly, in the early morning on the same days as chlorophyll analyses (with one sampling period coinciding with even week diurnal study), at 2 locations in each pond.		Calculate Secchi Disk Visibility using the procedure described by Lind, O.T. 1974. Handbook of common methods in limnology. C.V. Mosby Company, St. Louis, Missouri. pp.22-23.	cm
Chlorophyll a *	Collect one sample per pond by pooling three 90-cm column samples. Take samples weekly with one sampling period coinciding with monthly diurnal study.		Spectrophotometric Determination (American Public Health Association (APHA), 1980. Standard Methods for The Examination of Water and Waste Water, 15th ed., Washington, D.C. pp. 950-954.	mg/m^3
Total Kjeldahl Nitrogen *	Sample weekly at 1400 h. For each pond, pool three 90-cm column samples. Composite samples should be refrigerated and analyzed within 24 hours.	Kontes or comparable Kjeldahl Nitrogen apparatus.	Semi-Micro Kjeldahl Method (Michigan State University Limnological Research Laboratory, 1984. Unpublished memo on total Kjeldahl Nitrogen determination. East Lansing, MI. 5 p.); or in-country analysis by qualified laboratory.	mg/l

* *Indicates parameters to be measured as part of even week diurnal studies.*

TABLE 2c. (continued). BIWEEKLY AND WEEKLY MEASUREMENTS. WORK PLAN 3.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Total Phosphorus	Weekly at 1400 h., collect one sample (by pooling three 90-cm column samples) from each pond. Samples should be refrigerated and analyzed within 24 hours. (Optional)	———	Persulfate Digestion and Ascorbic Acid/Colorimetric Method (American Public Health Association, 1980).	mg/l
Dissolved Ortho-phosphate (Filterable Reactive Phosphorus)	Weekly in early morning, collect one sample (by pooling three 90-cm column samples) from each pond. Samples shouldbe refrigerated and analyzed within 24 hours. (Optional)	———	Preliminary filtration and Ascorbic Acid/Colorimetric Method (American Public Health Association, 1980).	mg/l

TABLE 3a. MONTHLY MEASUREMENTS. WORK PLAN 1.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Alkalinity *	As part of the monthly 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. (The special water chemistry analyses carried out at the beginning and end of experiments can be used to determine Ca ++ contribution to total hardness). (See occasional measurements.)	Hach Digital Titrator Test Kit/Alkalinity (optional)	Low or High Standard Alkalinity Method as appropriate (American Public Health Association, 1980. Standard Methods for The Examination of Water and Waste Water, 15th ed. Washington, DC pp. 253-257); or Hach Test Kit.	mg $CaCO_3$ /l
Total Hardness *	As part of monthly diurnal study, collect one sample (by pooling three 90-cm column samples) from each pond. Samples should be refrigerated and analyzed within 7 days.	Hach Digital Titrator Test Kit/ Total Hardness (optional)	EDTA Titrimetric Method (American Public Health Association, 1980. Standard methods for The Examination of Water and Waste Water, 15th ed. Washington, DC pp. 194-199); or use Hach Total Calcium Hardness Test Kit Model HAC-DT with Digital Titrator.	mg $CaCO_3$ /l
Ammonia *	As part of monthly diurnal study, collect one sample (by pooling three 90-cm column samples) from each pond. Samples should be refrigerated and analyzed within 24 hours.	———	Follow standard methods for Phenate Procedure (American Public Health Association, 1980).	mg/l
Nitrate *	As part of monthly diurnal study, collect one sample (by pooling three 90-cm column samples) from each pond. Samples should be refrigerated and analyzed within 24 hours.	———	Follow standard methods for the Phenodisulfonic Procedure (American Public Health Association, 1980).	mg/l

* *Indicates parameters to be measured as part of monthly diurnal studies.*

TABLE 3a. (continued). MONTHLY MEASUREMENTS. WORK PLAN 1.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Total Phosphorus *	As part of the monthly diurnal study, collect one sample (by pooling three 90-cm column samples) from each pond. Samples should be refrigerated and analyzed within 24 hours. Optional: 3 additional sampling periods during weeks 1, 10, and 19. Take samples just prior to fertilizer application, 12 hours after application and at 1, 2, 3, 6, and 14 days after application.	———	Persulfate Digestion and Ascorbic Acid/Colorimetric Method (US Environmental Protection Agency, 1979).	mg/l
Dissolved Ortho-phosphate (Filterable Reactive Phosphorus)	Same as for total phosphorus (shown above).	———	Preliminary filtration and Ascorbic Acid/Colorimetric Method (American Public Health Association, 1980. Standard Methods for The Examination of Water and Waste Water, 15th ed. Washington, DC pp. 409-426).	mg/l
Fish/Shrimp Group Weight	At 30-day intervals throughout each experimental cycle, collect a grab sample that is equivalent to 10% of initial stock from each pond and weigh as a group. Indicate number of individuals in grab sample. †	———	———	kg/number of individuals
Fish/Shrimp Mean Weight per individual	Take a representative 10% subsample of the grab sample referenced above, weigh and count individuals. Express as mean weight per individual.	———	———	g

* *Indicates parameters to be measured as part of monthly diurnal studies.*

† *Note: If substantial variation is observed or if reproduction is suspected, divide sample into centimeter groups; count and weigh each group. Any female tilapia observed should be removed and replaced with a male of similar weight. Any animals collected other than those stocked should be counted, weighed, and discarded. Record observations on reproduction and fish health.*

TABLE 3a. (continued). MONTHLY MEASUREMENTS. WORK PLAN 1.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Fish/Shrimp Mean Length per Individual	Take a representative 10% subsample of the grab sample referenced above, determine total length of each individual and express as mean length per individual.	———	———	cm
Tilapia Reproduction	At termination of experiments, all fish should be removed from the pond. A random sample equivalent to 10% of initial stocking will be weighed and measured as described below (†). The total number of fish removed should be determined and the total biomass calculated. Any fish other than tilapia should be counted by species, weighed, and measured.	———	———	g/number of individuals
Fish/Shrimp Health	During monthly sampling, record observations regarding shrimp/fish health. If disease/disorder is noted, estimate incidence (see Appendix A).	———	———	text
Primary Productivity §	Place three sets of light-dark bottles mid-depth in each pond. Incubate for four hours. Use solar monitor data to extrapolate results to entire photoperiod. Light/dark bottles recommended. Measure chlorophyll a (required).	None specified.	As described in: Wetzel, R.G. and G.E. Likens. 1979. Limnological Analyses. WB Saunders Co., Philadelphia. 357 pp.	mg $c/m^3/d$
Phytoplankton Composition §	Collect samples monthly and when changes in the community are observed using a plankton net with a collection bottle attached. Use a compound microscope and appropriate references to identify major groups (e.g. green, blue-green, diatom) and the relative abundance of each group (abundant, common, rare).	———	———	group/relative abundance

§ *Indicates analyses that are recommended but not required.*

† *Note: If substantial variation is observed or if reproduction is suspected, divide sample into centimeter groups; count and weigh each group. Any female tilapia observed should be removed and replaced with a male of similar weight. Any animals collected other than those stocked should be counted, weighed, and discarded. Record observations on reproduction and fish health.*

TABLE 3a. (continued). MONTHLY MEASUREMENTS. WORK PLAN 1.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Zooplankton Composition §	Monthly and when changes in the community are observed, collect at least three 90-cm column samples per pond. Use a microscope to identify invertebrates to at least the level of order and note relative abundance (abundant, common, rare).	———	———	order/relative abundance
Benthos Composition §	Monthly and when changes are observed, collect at least three cores of mud per pond. Identify at the level of order and note relative abundance (abundant, common, rare).	———	———	order/relative abundance

§ Indicates analyses that are recommended but not required.

TABLE 3b. MONTHLY MEASUREMENTS. WORK PLAN 2.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Alkalinity *	As part of the monthly 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. (The special water chemistry analyses carried out at the beginning and end of experiments can be used to determine Ca++ contribution to total hardness). (See occasional measurements.)	Hach Digital Titrator Test Kit/Alkalinity (optional)	Low or High Standard Alkalinity Method, as appropriate, (American Public Health Association, 1980. Standard Methods for The Examination of Water and Waste Water, 15th ed. Washington, DC pp. 253-257); or Hach Test Kit.	mg $CaCO_3$ /l
Total Hardness *	As part of monthly diurnal study, collect one sample (by pooling three 90-cm column samples) from each pond. Samples should be refrigerated and analyzed within 7 days.	Hach Digital Titrator Test Kit/ Total Hardness (optional)	EDTA Titrimetric Method (American Public Health Association, 1980. Standard Methods for The Examination of Water and Waste Water, 15th ed. Washington, DC pp. 194-199); or Hach Test Kit.	mg $CaCO_3$ /l
Ammonia *	As part of monthly diurnal study, 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 Kjeldahl Nitrogen Apparatus.	Nesslerization Method (Michigan State University Limnological Research Laboratory, 1984. Unpublished memo on total Kjeldahl nitrogen determination. East Lansing, MI. 5 pp).	mg/l
Nitrate *	As part of monthly diurnal study, collect one sample (by pooling three 90-cm column samples) from each pond. Samples should be refrigerated and analyzed within 24 hours.	———	Cadmium Reduction Method (Michigan State University Limnological Research Laboratory, 1984. Unpublished memo on total Kjeldahl nitrogen determination. East Lansing, MI. 5 pp).	mg/l

* *Indicates parameters to be measured as part of monthly diurnal studies.*

TABLE 3b. (continued). MONTHLY MEASUREMENTS. WORK PLAN 2.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Total Phosphorus *	As part of the monthly diurnal study, collect one sample (by pooling three 90-cm column samples) from each pond. Samples should be refrigerated and analyzed within 24 hours. Optional: 3 additional sampling periods during weeks 1, 10, and 19. Take samples just prior to fertilizer application, 12 hours after application and at 1, 2, 3, 6, and 14 days after application.	———	Persulfate Digestion and Ascorbic Acid/Colorimetric Method (American Public Health Association, 1980. Standard Methods for The Examination of Water and Waste Water, 15th ed. Washington, DC pp. 409-426).	mg/l
Dissolved Ortho-phosphate * (Filterable Reactive Phosphorus)	Same as for total phosphorus (shown above).	———	Preliminary filtration and Ascorbic Acid/Colorimetric Method (American Public Health Association, 1980. Standard methods for The Examination of Water and Waste Water, 15th ed. Washington, DC pp.409-426).	mg/l
Fish/Shrimp Group Weight	At 30-day intervals throughout each experimental cycle, collect a grab sample that is equivalent to 10% of initial stock from each pond and weigh as a group. Indicate number of individuals in grab sample.†	———	———	kg/number of individuals
Fish/Shrimp Mean Weight per individual	Take a representative 10% subsample of the grab sample referenced above, weigh and count individuals. Express as mean weight per individual.	———	———	g

* *Indicates parameters to be measured as part of monthly diurnal studies.*

† *Note: If substantial variation is observed or if reproduction is suspected, divide sample into centimeter groups; count and weigh each group. Any female tilapia observed should be removed and replaced with a male of similar weight. Any animals collected other than those stocked should be counted, weighed, and discarded. Record observations on reproduction and fish health.*

TABLE 3b. (continued). MONTHLY MEASUREMENTS. WORK PLAN 2.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Fish/Shrimp Mean Length per Individual	Take a representative 10% subsample of the grab sample referenced above, determine total length of each individual and express as mean length per individual.	———	———	cm
Tilapia Reproduction	Concurrent with measurement of fish growth, note the total number and total weight of fry/fingerlings collected during the monthly sampling.	———	———	number of individuals g
Fish/Shrimp Health	During monthly sampling, record observations regarding shrimp/fish health. If disease/disorder is noted, estimate incidence.	———	———	text
Primary Productivity §	Take water samples monthly and incubate for four hours in paired light-dark bottles suspended mid-depth in ponds. Use solar monitor data to extrapolate results to entire photoperiod (chlorophyll biweekly).	LI-COR Solar Monitor Model LI-1776 and Quantum Sensor Model LI-190SB.	Oxygen Method, adapted from the American Public Health Association, 1980. Standard Methods for The Examination of Water and Waste Water, 15th ed. Washington, DC pp. 950-954, 957-959.	mg carbon fixed/m 3 /day
Phytoplankton Composition §	Collect samples monthly and when changes in the community are observed, using a plankton net with a collection bottle attached. Use a compound microscope and appropriate references to identify major groups (e.g. green, blue-green, diatom) and the relative abundance of each group (abundant, common, rare).	———	———	group/relative abundance

§ Indicates analyses that are recommended but not required.

† Note: If substantial variation is observed or if reproduction is suspected, divide sample into centimeter groups; count and weigh each group. Any female tilapia observed should be removed and replace with a male of similar weight. Any animals collected other than those stocked should be counted, weighed, and discarded. Record observations on reproduction and fish health.

TABLE 3b. (continued). MONTHLY MEASUREMENTS. WORK PLAN 2.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Zooplankton Composition §	Monthly and when changes in the community are observed, collect at least three 90-cm column samples per pond or use trap or zooplankton net, as appropriate. Use a microscope to identify animals to the level of order and note relative abundance (abundant, common, rare).	———	———	order/relative abundance
Benthos Composition §	Monthly and when changes are observed, collect at least three cores of mud per pond. Process samples through a No. 30 sieve, sort organisms and fix in a 10% formalin or a 70% ethanol solution. Identify at the level of order and note relative abundance (abundant, common, rare).	———	———	order/relative abundance

§ *Indicates analyses that are recommended but not required.*

TABLE 3c. MONTHLY MEASUREMENTS. WORK PLAN 3.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Fish/Shrimp Group Weight	At 30-day intervals throughout each experimental cycle, collect a grab sample that is equivalent to 10% of initial stock from each pond and weigh as a group. Indicate number of individuals in grab sample.†	———	———	kg/number of individuals
Fish/Shrimp Mean Weight per individual	For a representative 10% subsample of the grab sample referenced above, weigh and count individuals. Express as mean weight per individual.	———	———	g
Fish/Shrimp Mean Length per Individual	For a representative 10% subsample of the grab sample referenced above, determine total length of each individual and express as mean length per individual.	———	———	cm
Tilapia Reproduction	Concurrent with measurement of fish growth, note the total number and total weight of fry/fingerlings collected during the monthly sampling.	———	———	g/number of individuals
Fish/Shrimp Health	During monthly sampling, record observations regarding shrimp/fish health. If disease/disorder is noted, estimate incidence.	———	———	text

† *Note: If substantial variation is observed or if reproduction is suspected, divide sample into centimeter groups; count and weigh each group. Any female tilapia observed should be removed and replaced with a male of similar weight. Any animals collected other than those stocked should be counted, weighed, and discarded. Record observations on reproduction and fish health.*

TABLE 3c. (continued). MONTHLY MEASUREMENTS. WORK PLAN 3.

Parameter	Procedure	Instrumentation	Analytical Method	Reporting Unit
Primary Productivity ¥	Take water samples monthly and incubate for four hours in paired light-dark bottles suspended mid-depth in ponds. Use solar monitor data to extrapolate results to entire photoperiod.	LI-COR Solar Monitor Model LI-1776 and Quantum Sensor Model LI-190SB.	Oxygen Method, adapted from the American Public Health Association, 1980. Standard Methods for The Examination of Water and Waste Water, 15th ed. Washington, DC pp. 950-954, 957-959.	mg carbon fixed/m ^{3} /day
Phytoplankton Composition §	Collect samples monthly and when changes in the community are observed, using a plankton net with a collection bottle attached. Use a compound microscope and appropriate references to identify major groups (e.g. green, blue-green, diatom) and the relative abundance of each group (abundant, common, rare).	———	———	group/relative abundance
Zooplankton Composition §	Monthly and when changes in the community are observed, collect at least three 90 cm column samples per pond or use trap or zooplankton net, as appropriate. Use a microscope to identify animals to the level of order and note relative abundance (abundant, common, rare).	———	———	order/relative abundance
Benthos Composition §	Monthly and when changes are observed, collect at least three cores of mud per pond. Process samples through a No. 30 sieve, sort organisms and fix in 10% formalin or 70% ethanol solution. Identify at the level of order and note relative abundance (abundant, common, rare).	———	———	order/relative abundance

§ Indicates analyses that are recommended but not required.

¥ Optional modified diurnal curve method used in shallow Philippine shrimp ponds. Refer to: McConnell, W.J. 1962. Productivity relations in carboy microcasms. Limnol. 7: 35-43 and Welch, H.E. 1968. Use of modified diurnal curves for the measurement of metabolism in standing water. Limnol. Oceanogr. 13:679-687.

TABLE 4a. OCCASIONAL MEASUREMENTS. WORK PLAN 1.

Parameter	Procedure	Reporting Unit
Pond Soil Characteristics: pH Phosphorus Extractable Bases (Ca, Mg, K, Na) Organic Matter Total Nitrogen Nitrate Nitrogen Cation Exchange Capacity Soluble Salts Metals (Al, Fe, Zn, Mn, Cu) Sulfate Sulfur Lime Requirement Exchangeable H Exchangeable Na Free $CaCO_3$ or $CaCO_3$ Equivalent	Collect a sample of pond mud from each pond (see Appendix D).	As appropriate.
Morphometric Characteristics: Maximum length Maximum Width Area Depth Volume	At project initiation and whenever pond facilities are changed, map ponds as described by Lind, O.T. 1975. Handbook of common methods in limnology. C.V. Mosby Company, Saint Louis. pp. 26-31.	m, m^2, m^3 (as appropriate)
Hydrologic Characteristics: Surface Inflow Precipitation Outflow Evaporation Seepage (calculated)	In the course of each pond experiment, a water budget should be made for each pond. Surface Inflow/Outflow and Evaporation should be determined using procedures described inWood, 1974 (Wood, J.W. 1974. Diseases of Pacific Salmon: Their Prevention and Treatment. State of Washington, Dept. of Fisheries, Olympia, WA. pp. 71-77) or comparable approaches. The contribution of precipitation should be calculated using rainfall data, while seepage must be estimated based on rainflow, inlet water, and evaporation.	m^3/day

TABLE 4a. (continued) OCCASIONAL MEASUREMENTS. WORK PLAN 1.

Parameter	Procedure	Reporting Unit
Water Quality Characteristics §: Alkalinity Total Hardness pH Ammonia Nitrate Orthophosphate Total Phosphorus Chloride * Sulfate * Boron Calcium * Copper Iron Magnesium * Potassium * Sodium * Zinc	At the end of an experiment and before starting another, collect a pooled sample of three 90-cm columns of water from each pond and water supply source. Samples should be analyzed on site by local laboratories or by the Michigan State University Limnological Laboratory.	As appropriate
Fish/Shrimp Production: Initial Stocking number stocked •group weight •mean weight per individual •mean length per individual	The initial stock should be weighed as a group and counted. Tilapia should be sexed individually. Weigh and measure a 10% sample of the initial stock (use total length for tilapia measurements). Refer to sections on stocking in Appendix B.	number of individuals kg g cm
Termination of Experiments •mean weight per individual •total number harvested •group weight (calculated) •survival (% of initial number stocked) Reproduction	At the termination of experiments, all fish/shrimp should be removed from each pond . Weigh and measure a random sample equivalent to 10% of the initial stocking. Determine the total number of fish/shrimp from each pond and calculate total biomass. Any fish other than tilapia should be sorted by species, counted, weighed, and measured.	number of individuals g kg %

* *Listed by the Technical Committee as being of greatest importance.*

§ *Recommended but not required.*

TABLE 4b. OCCASIONAL MEASUREMENTS. WORK PLAN 2.

Parameter	Procedure	Reporting Unit
Pond Soil Characteristics: pH Phosphorus Extractable Bases (Ca, Mg, K, Na) Organic Matter Total Nitrogen Nitrate Nitrogen Cation Exchange Capacity Soluble Salts Metals (Al, Fe, Zn, Mn, Cu) Sulfate Sulfur Lime Requirement Exchangeable H Exchangeable Na Free $CaCO_3$ or $CaCO_3$ Equivalent	At the end of an experiment, collect twelve 15-cm core samples from each pond. Combine and dry as described in Appendix C. Take a 200g subsample of rock-free, dried mud from each pond and analyze using either a qualified local laboratory or the Oregon State University Soil Testing Laboratory.	As appropriate.
Morphometric Characteristics: Maximum length Maximum Width Area Depth Volume	At project initiation and whenever pond facilities are changed, map ponds as described by Lind, O.T. 1974. Handbook of common methods in limnology. C.V. Mosby Company, Saint Louis. pp. 5-16.	m, m^2, m^3 (as appropriate)
Hydrologic Characteristics Surface Inflow Precipitation Outflow Evaporation Seepage (calculated)	In the course of each pond experiment, a water budget should be made for each pond. Surface Inflow/Outflow and Evaporation should be determined using procedures described in Wood, 1974 (Wood, J.W. 1974. Diseases of Pacific Salmon: Their Prevention and Treatment. State of Washington, Dept. of Fisheries, Olympia, WA. pp. 71-77) or comparable approaches. The contribution of precipitation should be calculated using rainfall data, while seepage must be estimated based on rainflow, inlet water, and evaporation.	m^3/day

TABLE 4b. (continued) OCCASIONAL MEASUREMENTS. WORK PLAN 2.

Parameter	Procedure	Reporting Unit
Water Quality Characteristics: Alkalinity Total Hardness pH Ammonia Nitrate Orthophosphate Total Phosphorus Chloride * Sulfate * Boron Calcium * Copper Iron Magnesium * Potassium * Sodium * Zinc	At the end of an experiment and before starting another, collect a pooled sample of three 90-cm columns of water from each pond and water supply source. Samples should be analyzed on site by local laboratories or by the Michigan State University Limnological Laboratory.	As appropriate
Fish/Shrimp Production: Initial Stocking •number stocked •group weight •mean weight per individual •mean length per individual	The initial stock should be weighed as a group and counted. Tilapia should be sexed individually. Weigh and measure a 10% sample of the initial stock (use total length for tilapia measurements). Refer to sections on stocking in Appendix B.	number of individuals kg g cm
Termination of Experiments •mean weight per individual •total number harvested •group weight (calculated) •survival (% of initial number stocked)	All fish/shrimp should be removed from each pond 150 days (90-120 days for shrimp) after stocking. Weigh and measure a random sample equivalent to 10% of the initial stocking. Determine the total number of fish/shrimp from each pond and calculate total biomass. Any fish other than tilapia should be sorted by species, counted, weighed, and measured.	number of individuals g kg %

** Listed by the Technical Committee as being of greatest importance.*

TABLE 4c. OCCASIONAL MEASUREMENTS. WORK PLAN 3.

Parameter	Procedure	Reporting Unit
Pond Soil Characteristics: pH Phosphorus Extractable Bases (Ca, Mg, K, Na) Organic Matter Total Nitrogen Nitrate Nitrogen Cation Exchange Capacity Soluble Salts Metals (Al, Fe, Zn, Mn, Cu) Sulfate Sulfur Lime Requirement Exchangeable H Exchangeable Na Free $CaCO_3$ or $CaCO_3$ Equivalent	At the end of an experiment, collect twelve 15-cm core samples from each pond. Combine and dry as described in Appendix C. Take a 200g subsample of rock-free, dried mud from each pond and analyze using either a qualified local laboratory or U.S. Laboratory.	As appropriate.
Morphometric Characteristics: Maximum length Maximum Width Area Depth Volume	At project initiation and whenever pond facilities are changed, map ponds as described by Lind, O.T. 1974. Handbook of Common Methods in Limnology. C.V. Mosby Company, Saint Louis. pp. 5-16. Note inflow and outflow locations, pertinent surrounding elevations, and buildings and structures on the site. Measure or calculate the listed morphometric parameters.	m, m^2, m^3 (as appropriate)
Hydrologic Characteristics Surface Inflow Precipitation Outflow Evaporation Seepage (calculated)	In the course of each pond experiment, a water budget should be determined for each pond. Surface Inflow/Outflow and Evaporation should be determined using procedures described in Wood, 1974 (Wood, J.W. 1974. Diseases of Pacific Salmon: Their Prevention and Treatment. State of Washington, Dept. of Fisheries, Olympia, WA. pp. 71-77) or comparable approaches. The contribution of precipitation and evaporation should be calculated using rainfall data, while seepage must be estimated based on rainflow, inlet water, an evaporation.	m^3 /day

TABLE 4c. (continued) OCCASIONAL MEASUREMENTS. WORK PLAN 3.

Parameter	Procedure	Reporting Unit
Water Quality Characteristics: Alkalinity Total Hardness pH Ammonia Nitrate Orthophosphate Total Phosphorus Chloride * Sulfate * Boron Calcium * Copper Iron Magnesium * Potassium * Sodium * Zinc	At the end of an experiment and before starting another, collect a pooled sample of three 90-cm columns of water from each pond and water supply source. Samples should be analyzed on site by local laboratories or by the Michigan State University Limnological Laboratory.	As appropriate
Fish/Shrimp Production: Initial Stocking number stocked •group weight •mean weight per individual •mean length per individual	The initial stock should be weighed as a group and counted. Tilapia should be sexed individually. Weigh and measure a 10% sample of initial stock (use total length for tilapia measurements). Refer to sections on stocking in Appendix B.	number of individuals kg g cm
Termination of Experiments •mean weight per individual •total number harvested •group weight (calculated) •survival (% of initial number stocked) Reproduction	All fish/shrimp should be removed from each pond 150 days (90-120 days for shrimp) after stocking. Weigh and measure a random sample equivalent to 10% of the initial stocking. Determine the total number of fish/shrimp from each pond and calculate total biomass. Any fish other than tilapia should be sorted by species, counted, weighed, and measured.	number of individuals g kg %

** Listed by the Technical Committee as being of greatest importance.*

V. DATA MANAGEMENT

Standardized data are tabulated at each research location for the three experimental cycles in accordance with CRSP work plans. Each project team had the option of independently analyzing their data and publishing results. In all cases, however, the data tabulations are filed in a centralized CRSP Data Base maintained by the Program Management Office. The entire data set is thus made available to all PD/A CRSP participants and to the Data Synthesis Team. The latter body was appointed by the PD/A CRSP Board of Directors to analyze and synthesize data and to develop a model. The various activities of Team members are supported as part of the U.S. Research Component.

Subsequent volumes of these Data Reports will contain data for three cycles of the global experiment. Data will be presented for each PD/A CRSP research location, by experimental cycle. The following provides a brief description of the management of data and acts as a reference for the completed data templates that will appear in subsequent volumes of this series.

The CRSP Data Base Management System is composed of three elements: data reporting, file management, and information retrieval.

Field data are reported to the Program Management Office by each CRSP project. Several commercial software packages (i.e. Lotus 1-2-3 for the IBM, Multiplan for IBM, Multiplan for Apple IIe) were used to tabulate data at the research locations. The option was available to report data on any other program written for either the Apple IIe or the IBM PC that is consistent with the system and templates used by the Program Management Office. The selection of software for reporting data depended on the computer hardware used and on the project's desire to perform statistical analyses outside of the centralized CRSP data synthesis function.

The spread sheet files received from the projects are modified by the Program Management Office and are entered directly into the Data Base Management System using RBASE (by MICRORIM) on a microcomputer. The RBASE files are then moved from the microcomputer to a mainframe computer using a local area network.

The Data Base Management System provides numerous options for data retrieval. Users may process data on personal computers using commercial software (including RBASE). Magnetic tape files for mainframe and minicomputers are available in virtually any format specified by the user. Direct access to the mainframe computer via various telecommunications is another alternative.

Twelve templates have been developed for use in data reporting. The templates and their file names are as follows:

	TITLE	FILE NAME
A.	Daily Weather Measurements	WEATHER
B.	Daily Pond Measurements	DAYPOND
C.	Miscellaneous Observations Including Fish Health	MISCELL
D.	Weekly and Twice-Weekly Measurements	WEEKLY
E.	Diurnal Measurements	DIURNAL
F.	Fish/Shrimp Stocking, Sampling, and Harvesting	FISH
G.	Plankton and Benthos	PLANKTON
H.	Water Quality Characteristics	WATERQ
I.	Pond Soil Characteristics	SOIL
J.	Pond Morphometrics	MORPH
K.	Analysis of Nutrients and Lime	NUTRIENT
L.	Nutrient and Lime Inputs	INPUTS

Along with the column headings on each template, the units used in reporting the data (e.g. "mg/l" or "deg C") and the precision to which measurements should usually be made (e.g. [xxx] indicates that the measurement will usually be a whole number with up to three digits) are included.

If data were not available for a given cell or column, the cell was left blank (i.e. a symbol or zero was not entered).

Each line of data includes the identifying columns. These columns are Site, Date, Pond and Time (for dissolved oxygen and diurnal measurements), and Experimental Cycle and Season.

Instructions for Individual Templates
(from: CRSP Data Base Instructions for Data Entry, ed. 1.1, April 1986. CRSP Program Management Office, Oregon)

A. WEATHER (Daily Weather Measurements)

This template is used to record daily weather data by CALENDAR YEAR (six-month periods if an APPLE IIe with only 128K is used), rather than by experiment.

"Evaporation" was not specified in the Work Plans as a value to be reported on a daily basis. However, since it was measured on a daily basis in order to calculate the overall evaporation value for each experiment (specified in the Work Plans as an "occasional" measurement), evaporation is recorded on this template.

B. DAYPOND (Daily Pond Measurements)

This template is used to record daily pond depths to the nearest centimeter, rather than to the nearest half-centimeter as specified in the Work Plan. In addition, the following information is recorded:

"Water Inflow" - If water was added to a pond (not by the rain), a Y (yes) appears. If water was not added, an N (no) was recorded. This information will be used in water budget studies, and replaces information asked for as "Hydrologic Characteristics" in the Work Plans.

"Pond Overflow?" - If the pond overflowed because too much water was added to the pond, the answer was "yes," so a Y was entered. If the answer was "no," an N was entered.

The "Number of Dead Fish/Shrimp" that were observed in each pond on a specific date is recorded on this template. The appropriate "Species Code" is also entered using the code lists (Table 5). Mortality information is optional. If more than one species died, more than one data line was used.

C. MISCELL (Miscellaneous Observations Including Fish Health)

This template provides a place to record miscellaneous observations of the ponds. The only observation of this type specifically asked for in the Work Plans is "Fish Health," which was requested as a part of the monthly records of fish sampling.

D. WEEKLY (Weekly and Twice-Weekly Measurements)

This template is used to record data that is collected on a weekly or twice-weekly basis. For those items to be collected twice per week (secchi disk readings and chlorophyll readings), there are two data lines for each week. The Work Plan for the third experimental cycle no longer calls for twice-weekly measurements. Only complete weeks of data are included.

In order to minimize confusion which might result from reports which contain more data than is required or data which is listed as optional by the Work Plans, an "Extra Data?" column has been included in this template. For each row, a Y is entered if the data are required or listed as optional by the Work Plan. If the data are extra (i.e. observations that are not requested or suggested in the Work Plans), an N is entered.

The time at which D.O. samples were taken is entered in the "D.O. Sample Time" column.

Under the columns titled "Oxygen," "Pond Temp," "Max Temp," and "Min Temp," "top" refers to 25 cm below the water surface, "mid" refers to midwater, and "bot" refers to 25 cm above the pond bottom.

"Max Temp" and "Min Temp" are the "Pond Temperature Extremes" specified in the Work Plans.

"Alka" (alkalinity), "T. Hard" (total hardness), "Ammonia N," "NO3-N" (nitrate N), "Total P," (total phosphorus) and "Ortho PO4-P" (dissolved orthophosphate P) were not weekly measurements in the first and second Work Plans, but were in the third.

"Ammonia N" is the "Ammonia Nitrogen" measurement required by the Work Plans.

For "S. Disk" (Secchi Disk Visibility) measurements, "A" and "B" are the two locations for each pond.

Chlorophyll b and c were not required for freshwater experiments.

E. DIURNAL (Diurnal Measurements)

This template is used to record all of the diurnal data for one day (data collected from the ponds throughout one day). While diurnal measurements were to be done on a monthly basis for the first two experimental cycles, during the third cycle they were recorded every two weeks ("even-week measurements").

"Time" was entered as a four-digit number (twenty-four hour clock).

Notes pertaining to "top," "mid," and "bot" measurements for "Weekly Measurements" (Template D) also apply to diurnal measurements.

F. FISH (Fish Stocking, Sampling, and Harvesting)

This template is used for recording data on stocking, sampling, and harvesting of fish (or shrimp).

The "Activity Code" column indicates whether data pertain to stocking, sampling, or harvesting activities. The abbreviations "STK," "SAM," and "HAR" are used respectively.

"Whole Population" refers to all of the animals of the indicated species that were stocked into or harvested from the pond. Under "Sample Weight" and "Sample Length," columns are provided for the number of individuals in the sample, the mean

values, and for the standard deviations. Samples were collected at any time including stocking and harvest.

G. PLANKTON (Plankton and Benthos)

This template is used to report on "Primary Productivity," "Phytoplankton Composition," "Zooplankton Composition," and "Benthos Composition." These are discussed in the Work Plans as monthly measurements. The codes 1, 2, and 3 are used to indicate whether the specified groups of organisms are "rare," "common," or "abundant," respectively (Table 5).

H. WATERQ (Water Quality Measurements)

This template is used to record water quality data from samples that are collected at the beginning of each experiment and again at the end of the experiment. As with the template for "Weekly" measurements, additional columns have been provided for "NO_2-N" and "Total NO_2&$_3$-N."

I. SOIL (Pond Soil Measurements)

This template is used for recording data from soil samples taken at the end of each experiment--after the pond is drained and before filling it to start a new experiment.

J. MORPH (Pond Morphometrics)

This template is used to record the area and volume of each pond for each depth listed.

K. NUTRIENT (Analysis of Nutrients and Lime)

The Work Plans specify that the various limes and fertilizers used be analyzed. This template is used to record the results of these analyses. The "Codes" are listed on Table 5. If a nutrient is used for which no code is given, a temporary letter code starting with T is recorded. Each of the following is reported as a percentage of dry matter: N, P, K, Organic C, and S. Sulfur is an optional measurement that can be important in areas with acid sulphate soils.

L. INPUTS (Nutrient and Lime Inputs)

This template provides space for recording data on Nutrient Inputs such as "Feed," "Manure," "Inorganic" (fertilizer), and "Lime." Codes for feed types, manure, inorganic fertilizer, and lime are listed in Table 5.

File Names

Each DATA FILE was given a file name consisting of an 8-character letter/number combination designated in the following way:

The first character is a single letter indicating the research site (Table 5).

The second character is a single letter indicating which template was used (i.e. what type of report is contained in the data file). The third through eighth characters are a six-digit number showing the first date on which data in this file were collected. This will be the date on the first line of data in the file. The date was entered with the day first, month second, and year last.

For example :

AA010186 (for Aquadulce, daily WEATHER file beginning on 1 January, 1986), or
EB271183 (for Bogor, DAYPOND file beginning on 27 November, 1983).

Table 5. Code Lists.

Site Codes

A = Aguadulce (Panama)
B = Gualaca (Panama)
C = Ayutthaya (Thailand)
D = Nong Sua (Thailand)
E = Bogor (Indonesia)
F = Comayaga (Honduras)
G = Iloilo (Philippines)
H = Butare (Rwanda)

Experimental Cycle Codes

1 = First Cycle
2 = Second Cycle
3 = Third Cycle
0 = Between Cycles

Season Codes

D = 1 = Dry
W = 2 = Wet
B = Between Seasons

Activity Codes

STK = Stocking
SAM = Sampling
HAR = Harvesting

Water Inflow Question Codes

Y = yes = If water was added to pond
N = no = If water was not added

Pond Overflow Question Codes

Y = yes = If pond did overflow
N = no = If pond did not overflow

Plankton Abundance Codes

1 = If a group is rare
2 = If a group is common
3 = If a group is abundant

Template Codes

A = Weather
B = Daypond
C = Miscell
D = Weekly
E = Diurnal
F = Fish
G = Plankton
H = Waterq
I = Soil
J = Morph
K = Nutrient
L = Inputs

Fish / Shrimp Species Codes

nil = Oreochromis niloticus
hor = O. hornorum
nxh = O. niloticus x O. hornorum hybrid
cha = Chanos chanos
van = Penaeus vannamei
sty = P. stylirostris
mon = P. monodon

Nutrient and Lime Codes

Feed Types

FD1 = Feed Type 1
FD2 = Feed Type 2

Manure

CHICK = Chicken
DUCK = Duck
PIG = Pig
COW = Cattle
HORSE = Horse

Inorganic Fertilizer

TSP = Triple Superphosphate
UREA = Urea

Lime

$CaCO_3$ = $CaCO_3$
CaMg = $Ca\,Mg(CO_3)_2$

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APPENDIX A

The following procedures for pond preparation and fertilization were taken from the Second Work Plan of the Pond Dynamics/Aquaculture CRSP. The Third Work Plan also referred to these procedures.

Pond Management Procedures

1. Pond Preparation

   A. Water inlets should be screened with saran filter cloth (Memphis Net & Twine) or nylon hose covering (Domestic Fabrics, Inc.) to prevent the introduction of fish and eggs into the pond. Where the water inlet is a pipe, the saran screen can be sewn into a bag form and attached to the water inlet using a screw clamp or twine.

   B. Water outlets should be screened with coarse screen to prevent the escape of fish.

   C. If possible, the pond should be thoroughly dried so as to ensure no residual fish/fish eggs are present upon filling.

      1) If the ponds can't be thoroughly dried, rotenone (1-2 mg/1) should be applied to the filled pond or applied to puddles. Rotenone will generally degrade within one to two weeks at warm water temperatures.

   D. Prior to filling the pond, bottom weeds should be removed manually. Herbicides should not be used.

      1) If weeds occur in a pond while the experimental cycle is in progress, an attempt should be made to manually remove all that is possible. Obtain a wet weight on weeds removed.

2. Pond liming and fertilization

   A. Agricultural limestone, $CaCO3$ or $CaMg(CO3)2$, is the liming material of choice for fish ponds. Lime can be applied to either dry or full ponds. Even distribution of the lime is important.

      1) Lime should be applied at least two weeks prior to fertilization.

      2) The lime requirement of each pond should be determined as part of routine soil analysis (follow procedure as described in: American Public Health Association. 1980. Standard Methods for the Examination of Water and Wastewater, 15th ed. APHA, Washington, DC pp. 194-199.

3) Lime should be analyzed to determine its neutralizing value prior to use so that proper amounts of lime can be later added to the ponds.

B. When possible, inorganic fertilizer for each complete experimental cycle will be purchased in one lot.

1) A random sample of inorganic fertilizer will be collected from each lot for nutrient analysis. Samples will be analyzed for N, P and K.

2) Fertilizer should be stored in a locked storage area, protected from rain and sunlight, and not in contact with the ground.

3) Each inorganic fertilizer dose will be weighed out and placed in a porous bag or container in the middle of the pond. This device will be anchored in place such that it is within the top 25 cm of the water column. A burlap bag is not recommended as it rots quickly; a woven plastic fertilizer bag is satisfactory. Prior to introducing the new fertilizer into the bag, mix/crumble any residual in the bag aid in nutrient dispersion. Fertilizer should not be broadcast over the pond surface.

4) Provide a detailed explanation in reports if an ernate method of fertilizer application is used.

C. Organic fertilizer for each complete experimental cycle must be of one type, preferably dried chicken manure. If possible, manures should be obtained from a single facility.

1) A random sample of organic fertilizer will be collected from each lot for nutrient analysis. Samples will be analyzed for N, P, K and C.

2) Fertilizer should be stored as described above for inorganic fertilizer.

3) Each organic fertilizer dose will be weighed out and broadcast over the pond using a slurry method if required to facilitate uniform distribution.

4) Report any deviations from the Work Plan as required above for inorganic fertilizer.

D. Water and water quality management are outlined in detail in the Work Plan.

E. Fish Health

APPENDIX B

The following procedure for the production of Oreochromis niloticus fingerlings was taken from the Second Work Plan. The Third Work Plan also referred to this procedure.

Production of Oreochromis niloticus Fingerlings

The assumed objective is to produce all-male (hand-sexed) fingerlings at least 25 g in size, of approximately the same age (± one month).

A. Brooder Spawning Ponds (SP)

1. Stock with adults (50 + g) at a density of 7,500-10,000/Ha (= 0.75 - 1.0/m^2), at a sex ratio of one male to three females.

2. Feed broodfish daily with a good quality supplemental ration, beginning with a rate of about 20 kg/ha and increasing to 25 kg/ha by the sixth week.

3. Begin partial harvesting of seed at week (newly hatched fish) three by passing a 1/4" mesh seine across the pond.

4. Transfer fry and fingerlings to the first of a nest of grader boxes described as follows:

   a) All seed to a wire cage, 3/4 to 1" mesh: retains sexable size fingerlings, allows smaller seed to pass through to next grader.

   b) Nylon mesh hapa, 1/2" mesh: retains fish equal in size to those reared for two to three weeks in the fingerling nursery pond, allows smaller seed to pass through to next grader.

   c) Nylon mesh hapa, 1/4" mesh: retains fish for stocking into initial phase of fingerling nursery pond.

5. Completely harvest all seed and drain pond at the end of six weeks.

6. Estimated seed production = 80,000 +/ha/week.

B. Fingerling Nursery Ponds (FP)

1. All seed removed from the SP pond in week three and in subsequent weeks all seed from the SP, FP-1 and FP-2 ponds are graded as indicated below. Small fingerlings graded into the 1/4" mesh hapa (<1 g in size) are stocked into pond FP-1 at a density of 150,000-175,000/ha. Large fingerlings graded into the 1/2" mesh hapa (1-25 g in size, not yet sexable) are stocked into pond FP-2 at a density of 50,000-75,000/ha. Sexable male fingerlings (<25 g in size) are stocked into pond

FP-3 at a density of 30,000-50,000/ha. All females found should be eliminated from the nursery ponds.

Males of at least 50 g can be distinguished either by the size or shape of the genital papilla (Figure B-1). The male genital papilla is large and contains two orifices. The female genital papilla is usually smaller but also contains two orifices. Sex identification can be facilitated by slightly staining the urogenital papilla with crystal violet on a cotton swab (Anderson and Smitherman, 1978).

2. Due to differential sizes of seed graded over weeks three through seven, an attempt will be made to hasten growth of seed in the FP-1 and FP-2 ponds by providing a supplemental feed, and to halt growth of sexed males in FP-3 by denying supplemental feed. Feed the same food as fed to the brooders in the SP pond, in a ground form, at the daily rate of 5% body weight for fingerlings in both FP-1 and FP-2. All male fingerlings in FP-3 should not be fed, but the manure and inorganic fertilizer applications are expected to provide an adequate nutrition for maintenance.

C. Pond Preparation

1. Prior to stocking brooders or seed into their respectively assigned ponds, the following treatments should be carried out in each pond:

a) Air dry pond for at least two weeks prior to filling with water.

b) Fill pond with water filtered through a saran sock.

c) Fertilize each pond two weeks before stocking fish with the following:

1) Inorganic fertilizer, at the rate of 120 kg/ha of 0-20-0, suspended in a porous bag in the upper half of the water column,

2) Animal manure (fresh, if possible - and of a good quality), at the rate of 1000 kg/ha spread evenly from each pond bank.

Requirements for pond space and brood fish to produce 16,000 males (25 + g in size) in a four-week period.

Assume 50% mortality of seed in the nursery phase (30% of original number in FP-1, 15% of original in FP-2, 5% of original in FP-3).

Total No. seed needed from SP pond =

16,000 male = 32,000 mixed sex = 50% overall

mortality = $\frac{32,000}{.50}$ = 64,000 total seed,

64,000/4 weekly harvests = 16,000 seed/harvest

SP Pond Area

With productivity of 80,000 seed/ha spawning area/week,

16,000 seed/week requires 2000 m^2 of pond area.

$\frac{16,000}{80,000} \times \frac{10,000\ m^2}{ha} = 2000\ m^2$

Total No. Brooders Needed

Stocked at 1 brooder/m^2, and at a sex ratio of 1 male:3 females,

2000 brooders are required (500 male + 1500 female)

FP-1 Pond Area

16,000 seed (as a maximum)/week, stocked at 175,000 seed/ha

(assuming retention time for seed in FP-1 of 1 week)

requires $\underline{1000\ m^2}$

No. sur No. surviving seed: 16,000 - (.30) (16,000) = 11,200

FP-2 Pond Area

11,200 seed (as a maximum)/week, stocked at 75,000/ha

(assuming retention time of 2 weeks in FP-2)

requires $\underline{3000\ m^2}$

No. surviving seed = 11,200 - (.15) (16,000) = 8,800

FP-3 Pond Area

8,800 seed (as a maximum)/week, stocked at 50,000/ha

less 50% discarded as females = 4,400/week,

(assuming retention time of 4 weeks in FP-3)

requires $\underline{3,500\ m^2}$

Total Pond Area Required = (2000 + 1000 + 3000 + 3500)m = $\underline{9,500\ m^2}$

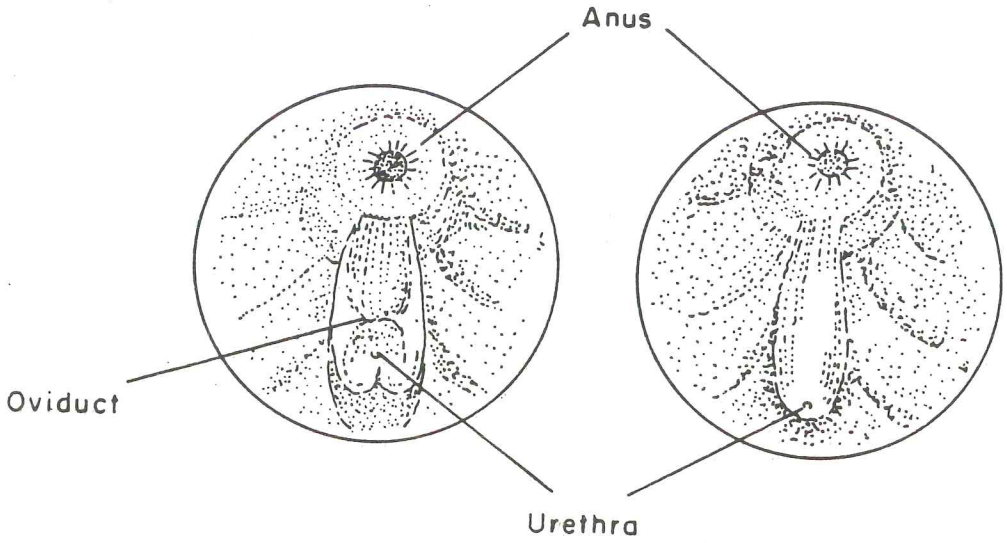


FIGURE B-1

GENITAL ORIFICES OF THE FEMALE (LEFT) AND MALE (RIGHT) OREOCHROMIS NILOTICUS

Source: Lovshin, L. L. and A. B. DaSilva, 1975. Culture of monosex and hybrid O. niloticus. Paper presented at the FAO/CIFA Symposium on Aquaculture in Africa, 30 September - 6 October 1975 in Accra, Ghana. CIFA/75/SR 9, Food and Agricultural Organization of the United Nations, Rome, Italy. 14 pp.

APPENDIX C

PROCEDURE FOR POND SOIL SAMPLING AND ANALYSIS

Pond mud will be analyzed for particle size distribution and concentration of a number of constituents. Samples should be taken from each pond prior to initiating each of the two experiments during the third cycle. Analyses may be carried out by qualified laboratories within host countries or the U.S.

Sufficient time should be allowed for analysis by laboratories such that results will be received in time to apply lime if necessary. About two weeks should be allowed between application of lime and the first fertilizer application (see Appendix A).

Soil Sampling

1. Begin at the shallow end of each of the twelve empty ponds, opposite the drain.

2. Proceed in an 'S' shape toward the deep end of each pond, collecting 12 core samples of the top 15 cm of bottom material.

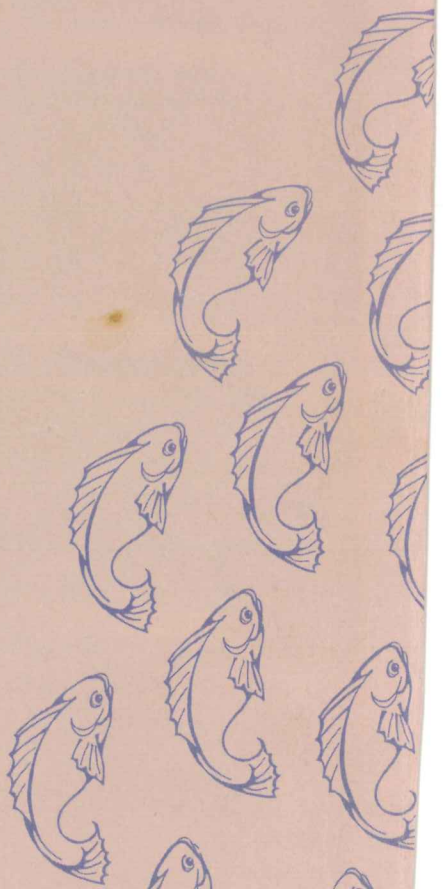
3. For each pond, combine the 12 subsamples and mix the composite thoroughly. Note that wet mud mixes more easily than dry mud.

4. Spread each mud sample in a thin layer on a plastic sheet to dry.

Analysis

Researchers should identify a qualified laboratory or laboratories in the U.S. or host country capable of carrying out the particle size distribution analysis and the 22 tests identified on Table C-1. The amount of each sample required and handling and labeling procedures should be determined in each case. Soil samples entering the U.S. must be accompanied by USDA form and shipping label. These may be obtained (in advance) from the laboratory accomplishing the analyses.

TABLE C-1
SOIL ANALYSIS

Analysis
Determination of clay, silt, and sand fractions (by pipette method and including removal of organic matter)
Sample preparation (grinding, handling, storage)
pH
Phosphorus
Extractable Bases (Ca, Mg, K and Na)
Organic Matter
Total Nitrogen
Nitrate Nitrogen (NO_3-N) and Ammonium Nitrogen (NH_4-N)
Cation Exchange Capacity
Soluble Salts
Heavy Metals (Zn, Mn and Cu)
Sulfate-Sulfur (SO_4-S)
SMP Lime Requirement
Free $CaCO_3$ or $CaCO_3$ Equivalent[1]
Exchangeable H
Exchangeable Na
Aluminum
Iron
TOTAL per sample cost, excluding analyses for aluminum and iron.

[1]If it is known that soil pH is below 7, then no free $CaCO_3$ will be detected and this analysis is unnecessary.