POND DYNAMICS/AQUACULTURE COLLABORATIVE RESEARCH SUPPORT PROGRAM SITE DESCRIPTIONS

July 1999
2nd printing, September 2000

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The Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) is partially supported by the US Agency for International Development under Grant No. LAG-G-00-96-90015-00 and by the participating US and Host Country institutions. The contents of this document do not necessarily represent an official position or policy of USAID.

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Introduction

The Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) represents an international community of researchers and institutions dedicated to the following goals:

- optimizing the efficiency of pond aquaculture systems,
- minimizing the negative environmental impacts of fish culture,
- exploring the socioeconomic intricacies associated with fish farming,
- disseminating scientific and technical information, and
- developing economical and culturally appropriate aquaculture strategies.

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.

This volume grew out of the *Pond Dynamics/Aquaculture Data Reports*, *Volume One*, *General Reference: Site Descriptions*, *Materials and Methods for the Global Experiment*, designed as an introduction to the Data Reports series. Data Reports contain the results of the CRSP Global Experiment, a series of experiments conducted in an identical manner at sites in different parts of the world. The first edition (Egna et al., 1989) includes descriptions of each of the seven sites participating in the first three cycles of the Global Experiments, as well as descriptions of and methods for those cycles and procedures for pond management, fingerling production, and soil sampling and analysis.

The second edition (Bowman and Clair, 1996) builds on the first edition, adding information on new CRSP research sites (two additional sites in Thailand and one each in the Philippines, Honduras, and Egypt). Since the Data Report series includes only those data resulting from the first three cycles of the Global Experiment and because site-specific research to complement the global experiments has increased in importance, the second edition of the Site Descriptions does not contain procedural descriptions.

Since 1982, the PD/A CRSP has conducted research in 13 countries. This volume contains descriptions of many of the research sites, including those that participated in the first three cycles of the Global Experiment (Panama, Honduras, Rwanda, Thailand, the Philippines, and Indonesia), the results of which make up the CRSP Data Report series. Additional sites where CRSP research was conducted (including later global experiments as well as cross-cutting and regional research) are located in Egypt, Kenya, Peru, Mexico, Guatemala, and Nicaragua. Site descriptions for Egypt, Kenya, and Peru are included in this volume; those for other recently added countries may appear in a future edition. Data for sites which are no longer active CRSP research sites were accurate as of the time of last CRSP involvement.

Many of the field data collected in CRSP research are filed in the CRSP Central Database, which can be ordered on CD-ROM or accessed via the Web at <biosys.bre.orst.edu/crspDB/>. The results of PD/A CRSP research are published in scientific journals as well as in CRSP Data Reports, Research Reports, and annual Administrative and Technical Reports. Many of these reports can be accessed electronically at <pdacrsp.orst.edu/pubs/publications.html>. A complete list of CRSP publications and information can be requested from:

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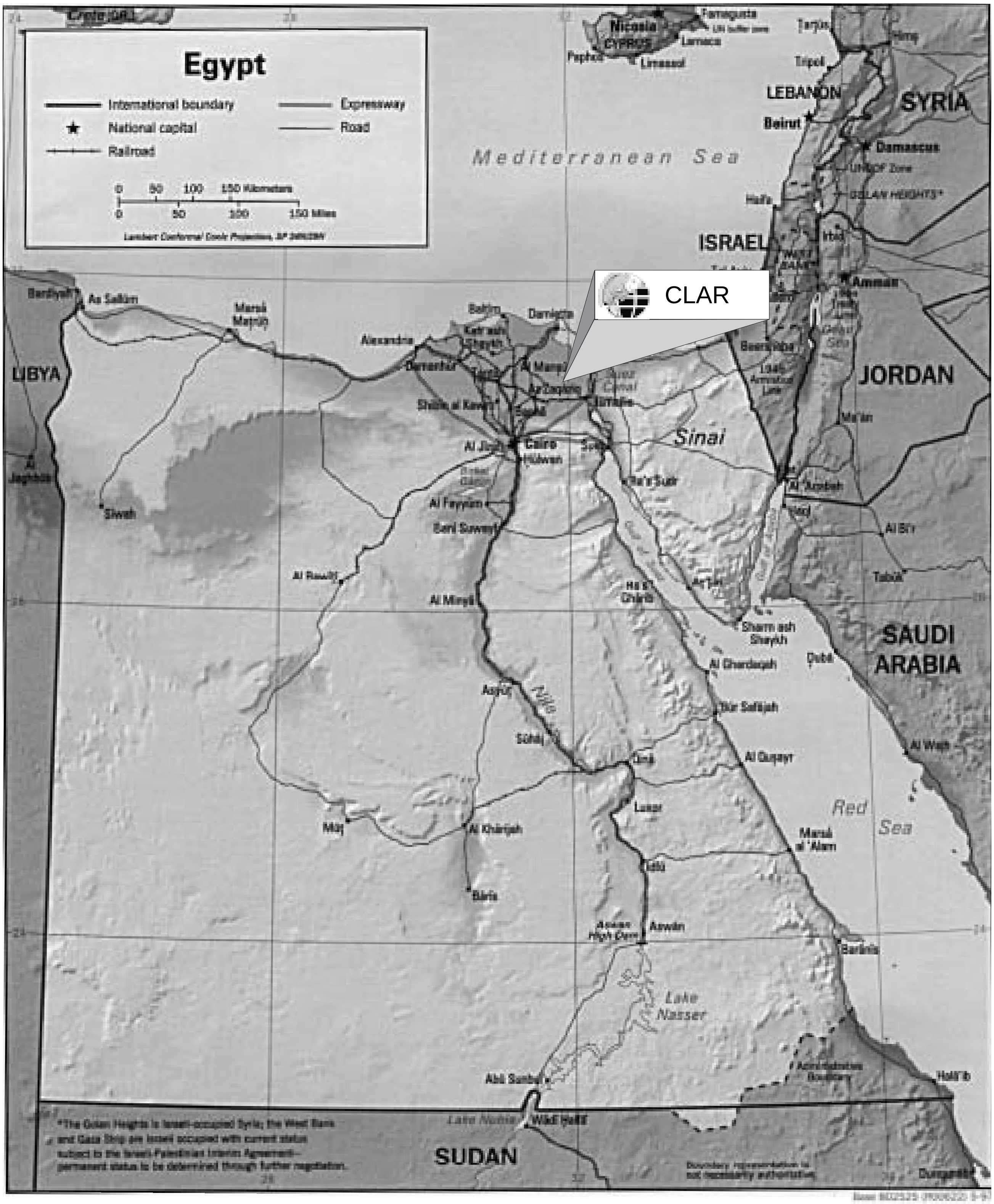
Fax: 541-737-6408
Internet: <pdacrsp.orst.edu>

References

Bowman, J. and D. Clair (Editors), 1996. Pond Dynamics/Aquaculture Collaborative Research Data Reports, Volume 1, Second Edition, General Reference: PD/A CRSP Site Descriptions. PD/A CRSP, Oregon State University, Corvallis, Oregon, 74 pp.

Egna, H.S., N. Brown, and M. Leslie (Editors), 1989. Pond Dynamics/Aquaculture Collaborative Research Data Reports, Volume 1, General Reference: Site Descriptions, Materials and Methods for the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 84 pp.


Egypt
International boundary
National capital
Railroad
Expressway
Road
0 50 100 150 Kilometers
0 50 100 150 Miles
Mediterranean Sea
CLAR
LIBYA
ISRAEL
LEBANON
SYRIA
JORDAN
SAUDI ARABIA
SUDAN
Sinai
Red Sea
Nile
Lake Nasser
Nicosia
CYPRUS
Beirut
Damascus
Amman
Alexandria
Cairo
Al Minya
Asyut
Luxor
Aswan
Siwah
Sharm ash Shaykh
Al Ghardaqah
Abu Simbel
Wadi Halfa
*The Golan Heights is Israeli-occupied Syria; the West Bank and Gaza Strip are Israeli occupied with current status subject to the Israeli-Palestinian Interim Agreement—permanent status to be determined through further negotiation.

CLAR

A central theme of CRSP-supported research at the Central Laboratory for Aquaculture Research (CLAR), Abbassa, Egypt, was the effort to control the encroachment of aquatic weeds such as *Azolla*, *Typha*, and *Phragmites* into pond areas.

CLAR lies in the heart of the Nile Delta, a vast fertile plain that stretches from Cairo north to the Mediterranean coast.

Abbassa
Central Laboratory for Aquaculture Research (CLAR)

Site Status: Former Prime Site, 1992 to 1995

Location: Abbassa, Abou Hammad, Sharkia, EGYPT

Caption/Description: The Central Laboratory for Aquaculture Research (CLAR) is located in Abbassa, Abou Hammad, Sharkia Governorate, approximately 70 km northeast of Cairo and 25 km east of the city of Zagazig. It is about 80 km inland from the Mediterranean Sea.

Description of Area/Region

Climate

Köppen-Trewartha classification* **BWh***: *Dry desert (arid)* group (BW); *hot tropical-subtropical* type (h).

Temperatures

In the coastal areas temperatures range from approximately 14 to 37°C, while in the desert areas the range is greater, with lows around 6 (as low as 0°C in winter) and highs reaching 46°C. Prevailing northerly winds throughout the year moderate potential extremes of temperature. Average air temperatures around Cairo range from about 13 to 30°C, while those at Abbassa range from 4 to 40°C, with pond water temperatures ranging from 9 to 34°C.

Precipitation

Rainfall is low throughout the country, but increases somewhat towards the north, nearer the Mediterranean, where it averages about 200 mm annually. In Cairo the average annual rainfall is between 25 and 29 mm, while at Abbassa (part way between Cairo and the Mediterranean) annual rainfall averages between 25 and 50 mm. Rainfall may occur only once in several years in many of Egypt's desert areas.

Humidity

Very dry climate, with slightly greater humidities along the Mediterranean.

Seasonality

Nearly constantly dry, with a hot season from May to September, and a cool season from November to March.

Topography

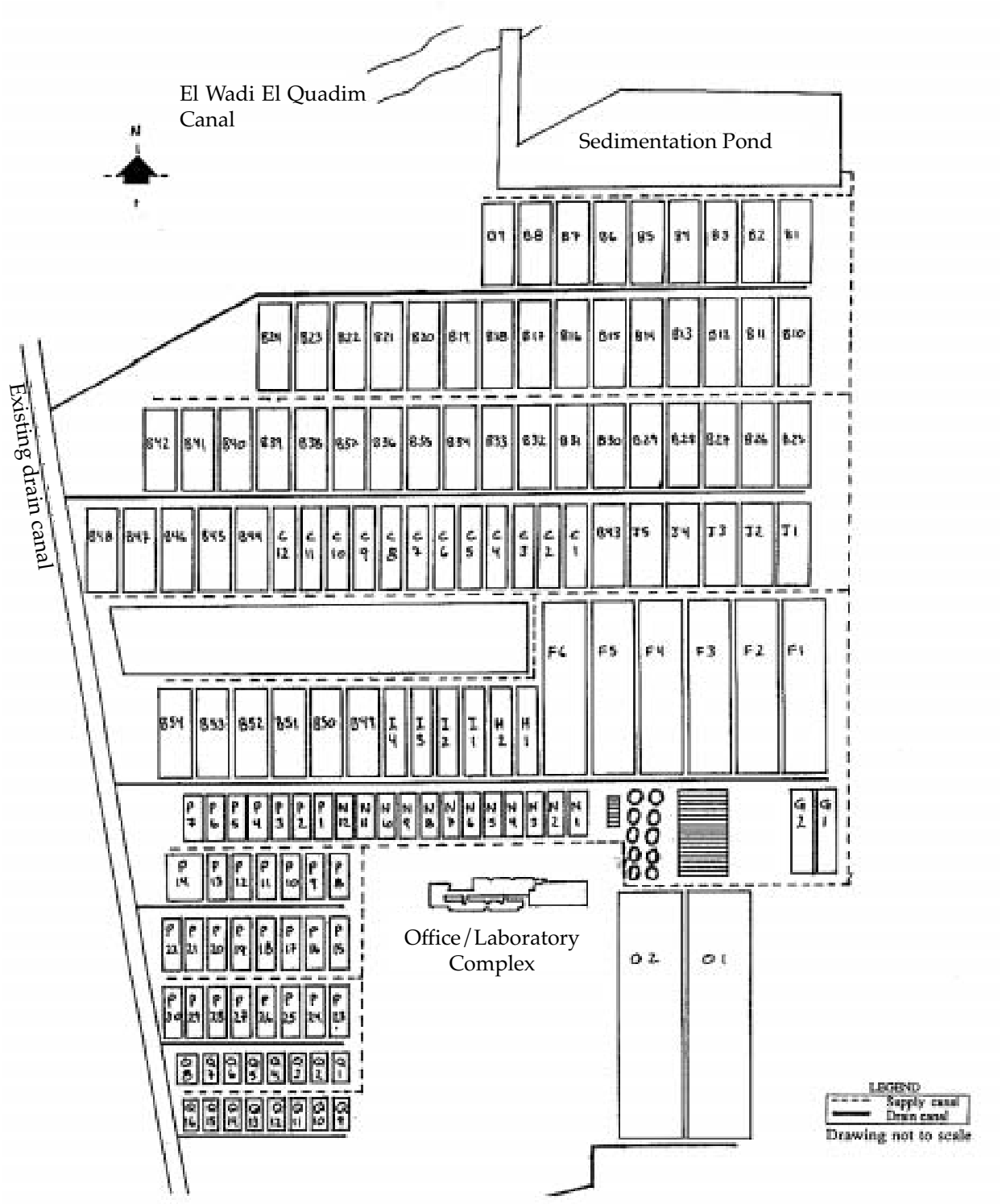
CLAR is north of Cairo in "Lower Egypt," the relatively flat, fan-shaped delta of the Nile River after it leaves the narrow, cliff-lined valley to which it is confined farther south. The delta, formed by the deposition of silt by the Nile, Rashid, and Dumyat rivers, is the most fertile region in Egypt; its perimeter lines nearly 250 km of the coastline of the Mediterranean Sea. Other than along the Nile valley south of Cairo, little vegetation is found outside the Nile delta. Elevations throughout the delta are low, and some localized depressions are below sea level. The only significant natural relief in the area is outside the delta to the south and west, including a plateau area gradually rising from Cairo to elevations of about 600 m near the Gulf of Suez in the east and extending southward into the Arabian Desert, as well as a narrow ridge running west-southwest from Cairo. A few peaks in the eastern plateau / Arabian desert area reach elevations of 2,100 m along the coast of the Red Sea. To the west the Western Desert (or Libyan Desert) contains a vast expanse of sand known as the Great Sand Sea as well as several areas below sea level. The Qattarah Depression is the most extensive, covering an area of about 18,000 km^2 and reaching a depth of 133 m, the lowest elevation anywhere in Africa.

Geology and Soils

Silt and other materials deposited by the Nile have formed the vast and highly fertile Nile Delta.

* Asterisked items are defined or described in the glossary.

Layout of CLAR



Description of CLAR

Map Coordinates	Elevation
30°32'N and 31°44'E	6 m

General

CLAR was divided into nine departments: aquaculture, limnology, nutrition, genetics, biology/ecology, aquacultural economics, processing/quality control, fish health, and hatchery/reproductive physiology. CLAR facilities included staff and administrative offices, a library, an auditorium, numerous dry and wet laboratories, a garage/workshop, central stores, and 155 earthen ponds and 56 concrete tanks/raceways that were all available for research. Pond areas ranged from 0.05 to 2.1 ha and totaled approximately 46 ha, while concrete tank/raceway areas ranged from 15 to 250 m^2. PD/A CRSP research was conducted in 0.01- (round ponds), 0.1- (P series), and 0.42-ha (B series) earthen ponds. CRSP research at the CLAR included studies to identify methods for dealing with the continuing problem of encroachment of emergent and floating vegetation into the ponds. Foremost among problem species were *Phragmites* (papyrus) and *Typha*—both emergent types—and *Azolla* (water fern) and water hyacinths—both floating plants. CLAR and CRSP collaborators also worked to reduce problems associated with the contamination of ponds by "wild" fish. All laboratories were well equipped, with sophisticated analytical instruments that permitted most routine analyses to be conducted in-house.

Water Supply

The source of practically all surface water in Egypt is the Nile River. CLAR was supplied with water from the Ismalia canal by way of the El Wadi El Quadim supply canal. The Ismalia canal originated from the Nile River in Cairo and flowed eastward to the Suez Canal. Water flowed from the El Wadi El Quadim supply canal to the CLAR sedimentation pond and then into the CLAR supply canal. Ponds could be drained only partially by gravity; pumps were required to completely drain them. Water flowed from the ponds to CLAR drain canals, which drained into an existing irrigation drainage canal. Water entering the ponds at CLAR was alkaline, with a pH of about 8.0, total alkalinity of about 220 mg l^{-1}, total hardness of near 190 mg l^{-1}, and calcium hardness of about 120 mg l^{-1}.

Soils

Soils of most of the CLAR research ponds used in CRSP research were clayey (40–60% clay), with CECs* that ranged from 34 to 45 meq per 100 g. The soils were alkaline and contained high levels of Ca, Mg, and Na.

* Asterisked items are defined or described in the glossary.

Support Facilities at CLAR

There were 21 other research institutes and central laboratories within the Agricultural Research Center. CLAR researchers were able to consult with colleagues in these institutes as necessary. Many CLAR senior researchers had advanced degrees (Ph.D.s), and were affiliated with one or more universities in Egypt, where they directed student research and periodically taught. The majority of the CLAR technical staff were pursuing advanced degrees (M.S. or Ph.D.) at Egyptian universities; these students conducted their thesis research at CLAR under supervision of the major professors and the CLAR department head.

Affiliations

In-Country	US
Central Laboratory for Aquaculture Research Agricultural Research Center Ministry of Agriculture and Land Reclamation Abbassa, Abou Hammad, Sharkia EGYPT	Department of Fisheries and Allied Aquacultures Auburn University, AL 36849 USA Zoology Department University of Oklahoma Norman, OK 73019-0235 USA

Current Contacts

In-Country	US
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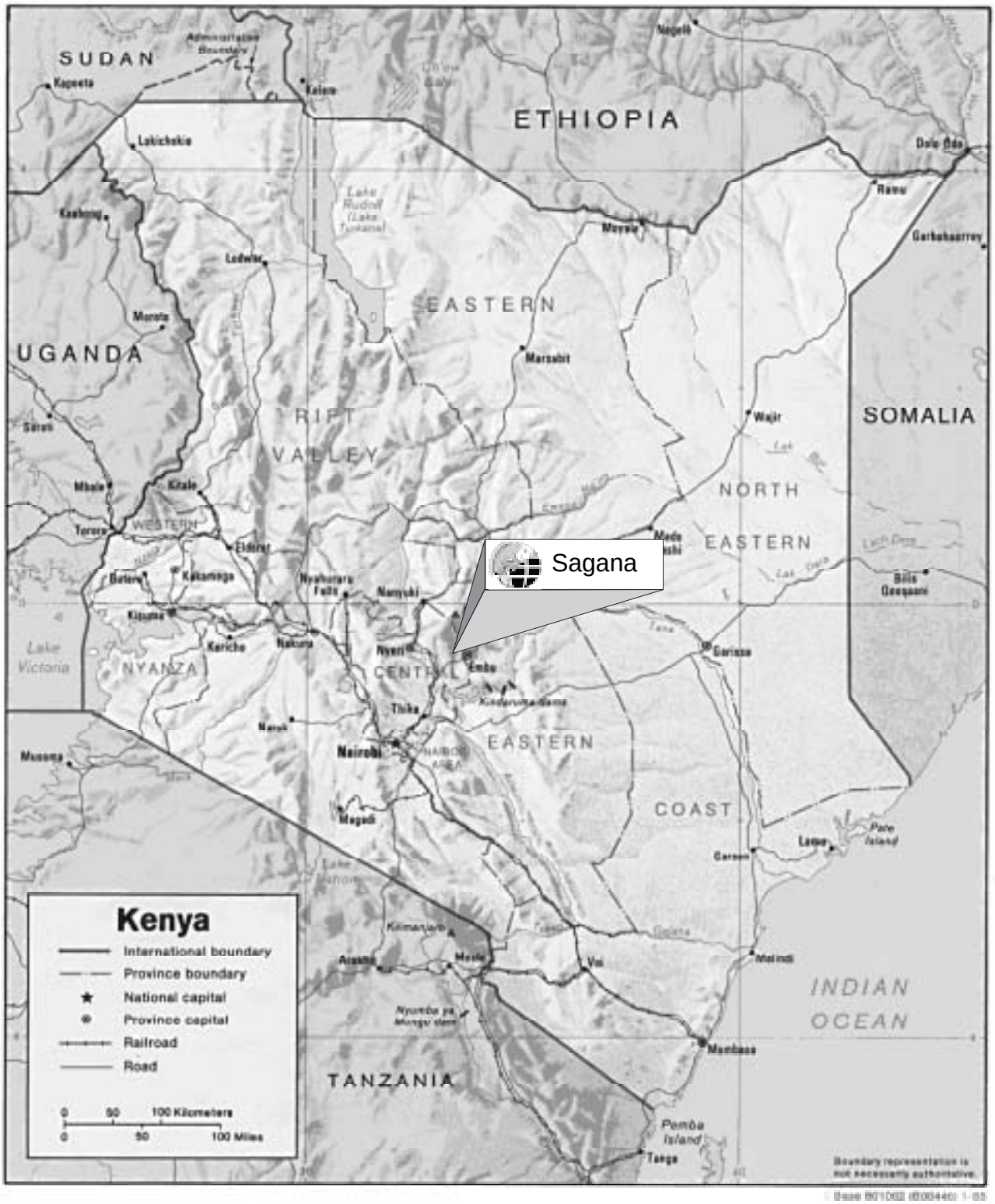
Sagana
Kenya
International boundary
Province boundary
National capital
Province capital
Railroad
Road
0 50 100 Kilometers
0 50 100 Miles
SUDAN
ETHIOPIA
UGANDA
SOMALIA
TANZANIA
EASTERN
RIFT VALLEY
NORTH EASTERN
WESTERN
NYANZA
CENTRAL
COAST
NAIROBI AREA
INDIAN OCEAN
Lake Victoria
Nairobi
Mombasa
Nakuru
Eldoret
Kisumu
Thika
Embu
Garissa
Wajir
Marsabit
Meru
Nanyuki
Kitale
Lodwar
Lokichokio
Kapoeta
Moyale
Malindi
Lamu
Voi
Tanga
Pemba Island
Lake Rudolf (Lake Turkana)
Boundary representation is not necessarily authoritative.

Sagana

Sagana Fish Farm facilities include a hatchery (shown above), water quality laboratory, poultry unit, zero-grazing unit, and agroforestry project.

Sagana Fish Farm comprises 20 ha of ponds on a 50-ha site in Kenya's Central Province. Ponds are dug in black cotton soils formed from volcanic rocks on a gently sloping plateau approximately 60 km south of Mt. Kenya.

Sagana Fish Farm

Site Status: Active Prime Site, 1996 to present

Location: Sagana Fish Farm, Sagana Township, Kirinyaga District, Central Province, KENYA

Caption/Description: Sagana Fish Farm is located 2 km outside of Sagana Township, in Kenya's Central Province, 105 km northeast of Nairobi.

Description of Area/Region

Climate

Köppen classification* **Aw***: *Humid tropical* group (A), *tropical wet-and-dry* type (w). Distinct dry and rainy seasons are observed.

Temperatures**

Daily average: 17 to 23°C
Cool season average: 17 to 19°C
Warm season average: 19 to 23°C
Daily minimum: 14 to 19°C
Daily maximum: 20 to 30°C

Precipitation

The 30-year average annual rainfall at Sagana is 1,166 mm. Total rainfall for the interval from 26 November 1997 to 26 November 1998 was 1,385 mm, as compared with a total of 1,570 mm for 1997.

Humidity

Humidity in the highland region surrounding Sagana ranges from around 90% in the early morning to about 40% in the afternoon during the dry season to 50-60% in the rainy season (Nelson, 1984)***. Monthly averages of pond-side humidity observations at Sagana during the CRSPs first year ranged from 63% (October) to 79% (July). Observations were made at 2400 hours daily.

Seasonality

The warmest period is February through April. There is a distinct cool season between June and August, when rainfall is at a minimum. Even though there is little rain, the skies tend to be overcast much of the day during this period. A rainy period known as the "short rains" occurs between October and December. The "long rains" fall from March through May with a single-month peak of 500 mm or more in April.

Topography

Sagana is situated at the edge of a large plain at the southern foot of Mt. Kenya, resulting in a climate that is slightly warmer than areas just 30 km farther north. The farm is characterized by gently rolling topography with several steep hills in the immediate area. The ponds are located on a relatively flat area that slopes gently from north to south.

Geology and Soils

Soils are formed on volcanic rocks from Mt. Kenya—latest Pliocene to Pleistocene basalts, phonolites, and pyroclastics. In areas with free drainage conditions on moderate to steep slopes, lateritic* and red to reddish-brown soils are present. In Sagana, the black cotton soils indicate that the soils have formed under restricted drainage conditions, which are the result of low rainfall and the presence of level to moderate slopes.

* Asterisked items are defined or described in the glossary

** Temperatures are based on measurements from late 1997 to late 1998. According to local residents, 1997-1998 was cooler than normal for the Sagana area.

*** Nelson, H.D., 1984. Kenya, a country study. Foreign Area Studies, The American University, Washington, D.C.

Description of Sagana

Map Coordinates	Elevation
0°39'S, 37°12'E	Sagana Fish Farm is at 1,230 m. Mt. Kenya (elevation 5,199 m) lies approximately 58 km to the north.
General	**Water Supply**
Sagana Fish Farm, situated immediately outside the small town of Sagana, covers an area of approximately 50 ha, of which 20 ha is in ponds. There were originally 60 ponds of various sizes, ranging from 5 m^2 to 2 ha in size. During 1997, three of the original 4,000-m^2 ponds were converted to twelve 800-m^2 ponds suitable for research. Additional ponds are being converted to this more practical size as time and funding allow. Site facilities include office buildings and a conference room, a storage building for supplies and equipment, a small wet-lab/hatchery building, a water quality laboratory renovated with CRSP assistance, a library/computer room, staff housing, and two guest houses. Electricity, telephone service, and clean water are provided. Two Land Rovers (one provided by the CRSP) are available to support farm activities.	Water for the station is diverted from the Ragati River by a small rock barrier and delivered by gravity through a canal that runs along the north side of the pond area. The supply canal can provide 10 to 30 m^3 water min^{-1}; it is normally managed to carry about 15 m^3 water min^{-1}. Most of the canal is earthen, but there are several concrete control structures between the river and the farm. Parts of the canal near the station are lined with concrete, and concrete diversion structures are used to force water into secondary canals and ponds as needed.
Soils	
Mainly black cotton soils, high in 2:1 type clay minerals (70 to 90% clay), with CECs* typical for that type of soil (30 to 55 meq per 100 g), and pH values ranging from 5.4 to 7.5.	

* Asterisked items are defined or described in the glossary.

Support Facilities at Sagana

Sagana Fish Farm is operated by the Fisheries Department of the Government of Kenya, which assigns officers to the station for this purpose. Students from the University of Nairobi, Moi University, and several other institutions conduct field studies at Sagana. A good water quality laboratory has been developed at the station through CRSP support; some other types of analysis (e.g., fish and feed analyses) are carried out at the University of Nairobi. Supplies of fertilizers, chicken feed, and feed ingredients such as rice bran are generally readily available, at least in Nairobi, which is approximately 100 km away.

Affiliations

In-Country	US
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Current Contacts

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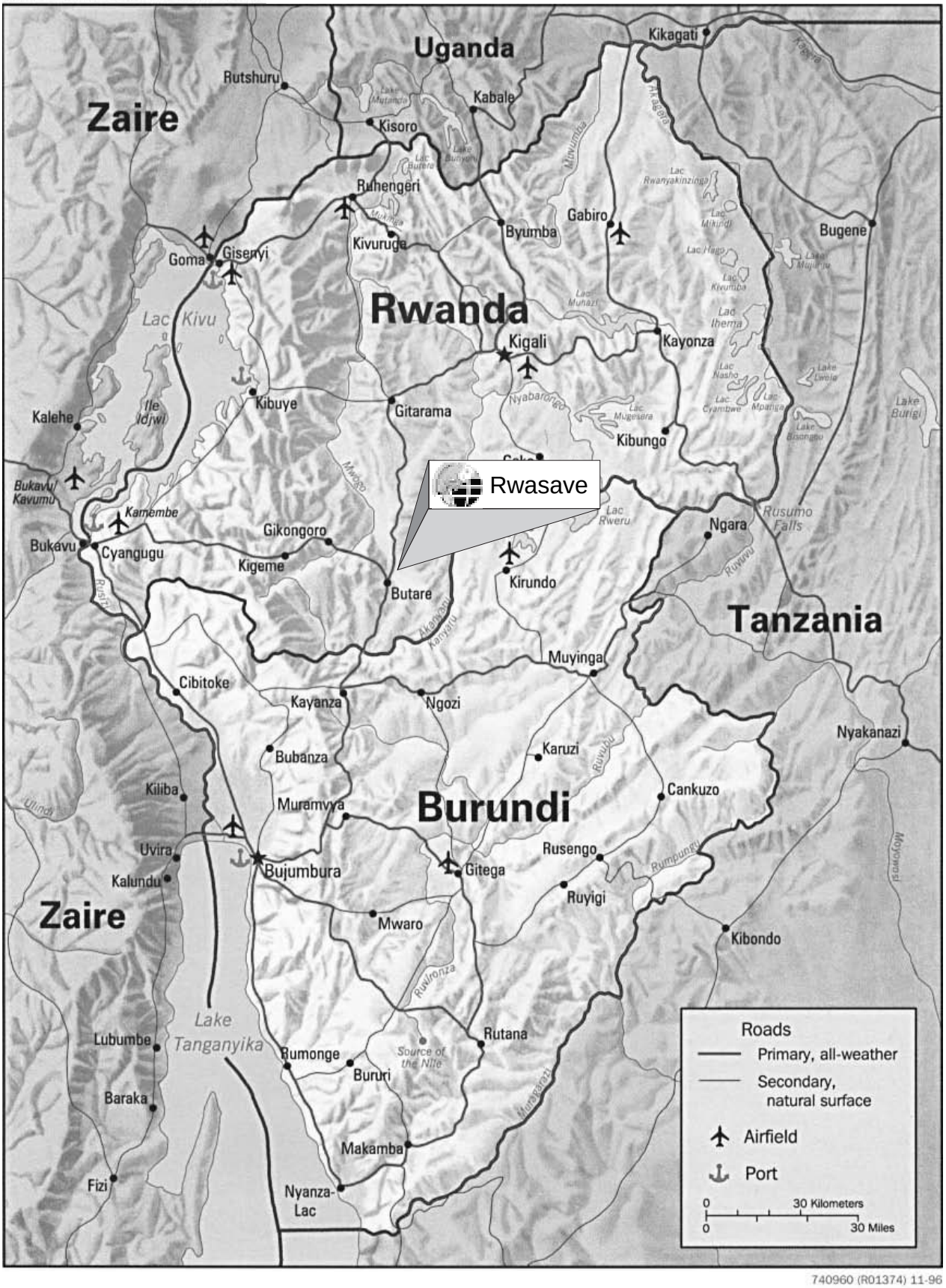
Rwanda and Burundi



Rwasave

The Rwasave Fish Culture Station consisted of more than 60 research and production ponds, as well as office, laboratory, training, fish processing, and holding tank facilities.

The steep slopes and deep valleys of much of central and western Rwanda limited fish pond development to smaller-sized ponds on valley bottoms. Access to markets and supplies was also made difficult by the rugged terrain.

Rwasave Fish Culture Station (Station Piscicole de Rwasave)

Site Status: Former Prime Site, 1983 to 1994

Location: Rwasave, Butare, RWANDA

Caption/Description: Rwasave is located approximately 2 km from Butare, Rwanda's second-largest city, and about 130 km south of the capital city of Kigali.

Description of Area/Region

Climate

Köppen-Trewartha classification* **GAw***: *Hills or low mountains* (G), *humid tropical* group (A), *tropical wet-and-dry* type (w).

Temperatures

Mean monthly temperatures for the country range from 21.3°C in October to 19.0°C in November. Nighttime temperatures can fall below 10°C in the mountainous areas where aquaculture is practiced; afternoon temperatures are seldom over 35°C. Average annual air temperatures at Rwasave range between 14 and 28°C, and pond temperatures between 19 and 23°C.

Precipitation

Rainfall for the country as a whole ranges from 700 to 2,000 mm annually. Mean monthly rainfall values at Rubona (near Rwasave) range from a low of 7.3 mm (July) to a high of 182.7 mm (April), with an average annual rainfall of 1,139 mm. Average annual rainfall at the Rwasave Station is about 1,200 mm.

Humidity

Mean monthly humidity values at Rubona range from 59% in July to 83% in April.

Seasonality

Rwanda has four identifiable seasons: a long dry season (mid-June to mid-Sept.), a short rainy season (mid-Sept. to mid-Dec.), a short dry season (mid-Dec. to mid-Feb.), and a long rainy season (mid-Feb. to mid-June).

Topography

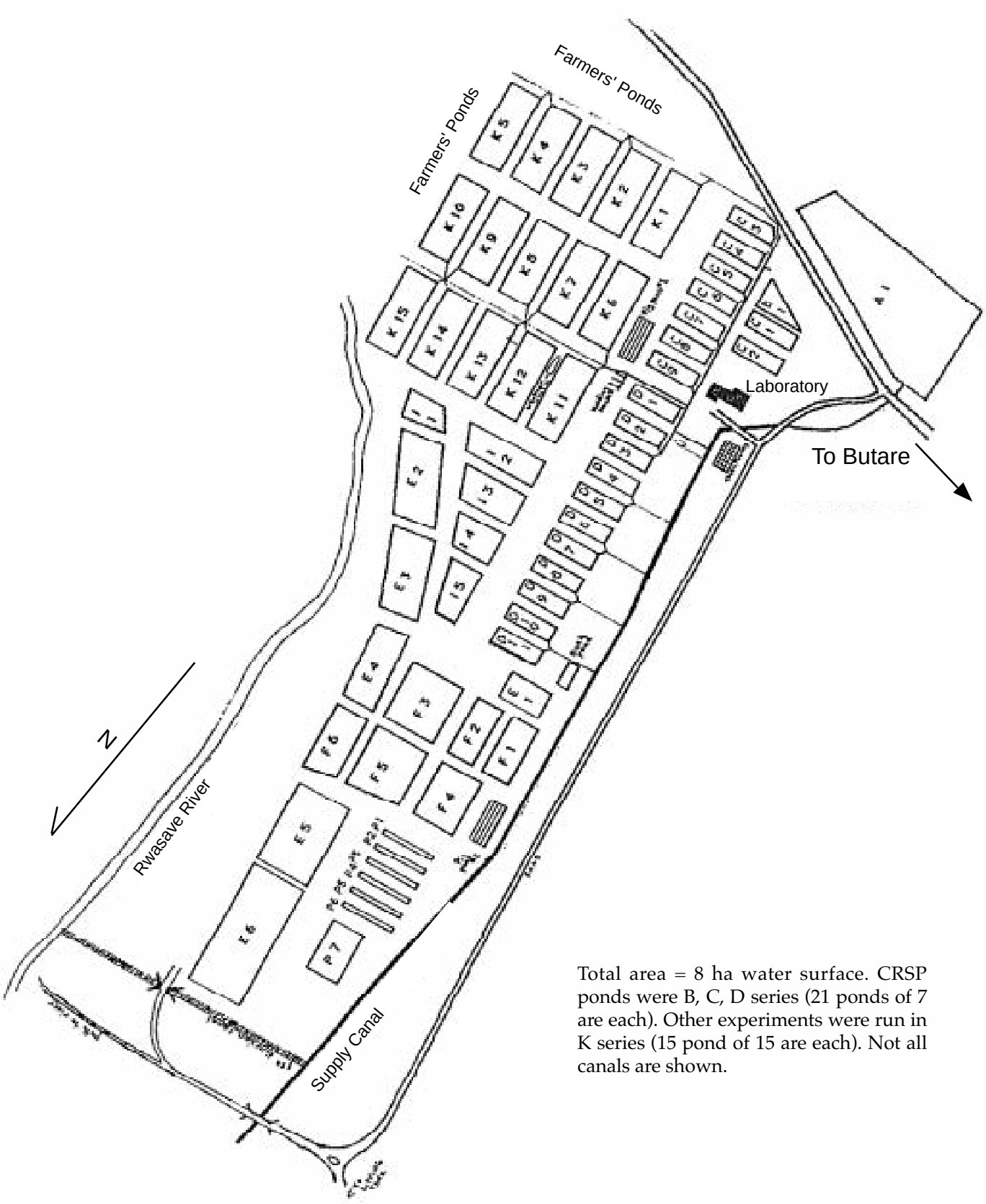
Rwanda's three major geographic regions are the Eastern Shelf (1,000-1,500 m), a hilly Central Plateau (1,500-2,000 m), and the Zaire/Nile divide, a range of high mountains (2,000-3,000 m) running north/south parallel to Lake Kivu on the western border with Zaire. Most of the country is hilly or mountainous and lies above 1,500 m. The western mountain range includes five volcanoes whose peaks range from 3,000 to 4,500 m in elevation. Rwanda has 23 major lakes (including the 2,370-km^2 Lake Kivu) and numerous rivers. Most aquaculture occurred at altitudes of 1,300 to 2,500 m because water was limited at lower elevations. The ruggedness of the terrain of most of the aquacultural area limited the sizes of ponds as well as access to supplies and markets. Pond development was restricted to *marais**. Marais belonged to the state, while uplands were private lands.

Geology and Soils

Most of the land mass of Rwanda is very rugged and broken up, with steep mountain slopes and deep valleys. The exposed materials are weathered Precambrian rocks and outcrops or sedimentary deposits derived from such materials. Soils in the Virunga Mountains, a chain of volcanoes in the north, are poorly developed and mostly uncultivable due to the young age of the volcanoes. Some valleys in the north have organic soils, but much of the Central Plateau is dominated by lateritic soils* on the hillsides and alluvial soils in the valley *marais**, with occasional pockets of organic soils.

* Asterisked items are defined or described in the glossary.

Layout of Rwasave Fish Culture Station



Total area = 8 ha water surface. CRSP ponds were B, C, D series (21 ponds of 7 are each). Other experiments were run in K series (15 pond of 15 are each). Not all canals are shown.

Description of Rwasave Fish Culture Station

Map Coordinates	Elevation
2°40'S and 29°45'E	1,625 m
General	**Water Supply**
The station was approximately 3 km from the National University of Rwanda, Butare campus. It had a total area of 18 ha, of which over 7 were in ponds. There were twenty-one 700-m^2 ponds, fifteen 1,500-m^2 ponds, and at least 25 other ponds of various sizes. The twenty-one 700-m^2 ponds were reserved for CRSP research. The remainder served for fingerling production and as grow-out ponds. The laboratory building had three offices, each with an area of 12 m^2, a laboratory, and a storage area. Another building included a training room, an office, a holding tank/aquarium area, and a large, covered, outdoor multipurpose area for training, aquarium experiments, fish processing, and other activities. Another, smaller building included a wet lab and a holding tank area. Personnel at the station included a station manager, a CRSP research associate, a driver, and a secretary/computer operator.	Water was supplied by the Rwabuye River. The supply canal ran 2.5 km from a small dam in the river to the station. The canal passed through some cultivated marshlands where there was some exchange with standing water. At the beginning of CRSP work at Rwasave, the supply water had a pH of 6.5 to 7.0, alkalinity of 17 mg l^{-1}, and a hardness of 43 mg l^{-1} (alkalinity and hardness given as mg $CaCO_3$ l^{-1}).
Soils	
Soils at the Rwasave Station were quite acidic, with pH values reported prior to the beginning of experiments in 1995 ranging from 4.5 to 4.8. Organic matter contents ranged from 0.7 to 5.1, and CECs* ranged from 4.5 to 17.6.	

* Asterisked items are defined or described in the glossary.

Support Facilities at Rwasave Fish Culture Station

Library and university facilities were near but limited. The station employed one laboratory technician and two assistants, a computer-trainee, and 60 station workers and guards. The only feed available was rice bran, which was available in limited but adequate quantities. Fertilizer was available but expensive. Animal manure was in short supply but also adequate for station needs.

Affiliations

In-Country	US
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Current Contacts

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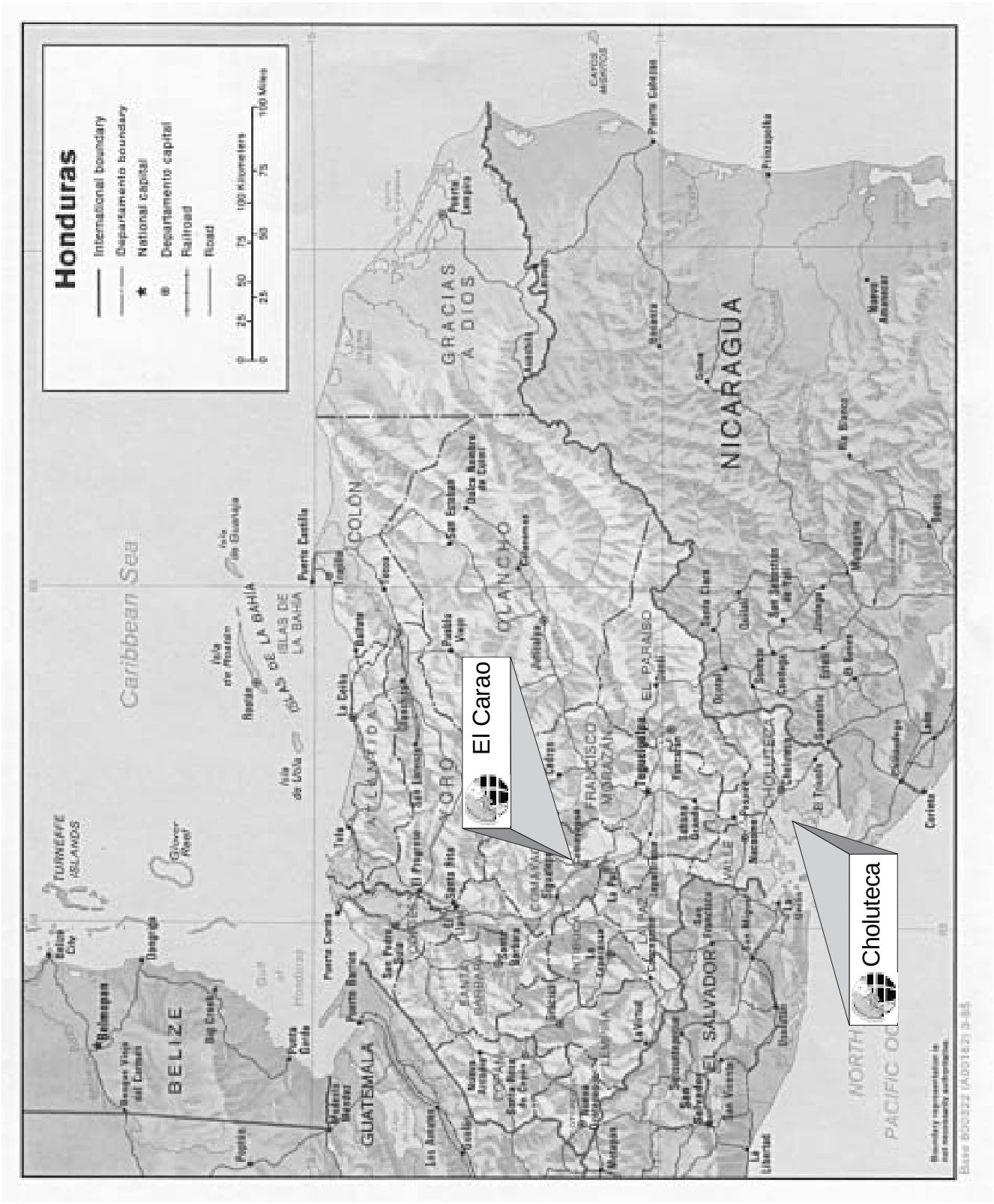

Honduras
International boundary
Departamento boundary
National capital
Departamento capital
Railroad
Road
Caribbean Sea
BELIZE
GUATEMALA
EL SALVADOR
NICARAGUA
GRACIAS A DIOS
COLÓN
OLANCHO
CORTÉS
YORO
ATLÁNTIDA
EL PARAÍSO
FRANCISCO MORAZÁN
CHOLUTECA
VALLE
COMAYAGUA
SANTA BÁRBARA
COPÁN
OCOTEPEQUE
LEMPIRA
INTIBUCÁ
LA PAZ
ISLAS DE LA BAHÍA
El Carao
Choluteca

Choluteca

Shrimp ponds in the Choluteca area are constructed in extensive, low-lying salt flats ("playones") found in the coastal area along the Gulf of Fonseca, southern Honduras.

Soil and water chemical analyses for CRSP-supported research in the Choluteca area were carried out at the La Lujosa Water Quality Laboratory.

Choluteca

Site Status: Former Prime Site, 1992 to 1998

Location: Selected sites in the shrimp-producing area around the periphery of the Gulf of Fonseca, Department of Choluteca, southern Honduras.

Caption/Description: Research in the Choluteca area was conducted at selected estuarine sampling sites and on selected collaborating shrimp farms around the periphery of the Gulf of Fonseca, Department of Choluteca, southern Honduras.

Description of Area/Region

Climate

Köppen classification* **Aw***: *Humid tropical* group (A); *tropical wet-and-dry* type (w).

Temperatures

Mean annual air temperatures in the coastal regions are around 27°C. Monthly average maximum air temperatures near the Gulf range from 33°C during October and November to 38°C during April. Monthly minimum air temperatures range from 19°C in December to 24°C in April.

Precipitation

Annual rainfall averages 1,450 mm, with most of this falling during the period from May through October (rainy season). Less than 12 mm rain is observed per month between December and April. River flows in the area fluctuate in accordance with precipitation; for example, the discharge of the Negro River becomes negligible during prolonged dry periods, and that of the Choluteca may be less than 2 $m^3 s^{-1}$ during such periods. The mean annual flow of the Choluteca is about 45 $m^3 s^{-1}$.

Humidity

Humidity is very low in Choluteca during the period from November to February.

Seasonality

The climate of southern Honduras has a distinct dry season, which lasts from November to April and is characterized by lower air temperatures and rainfall than during the rainy season.

Topography

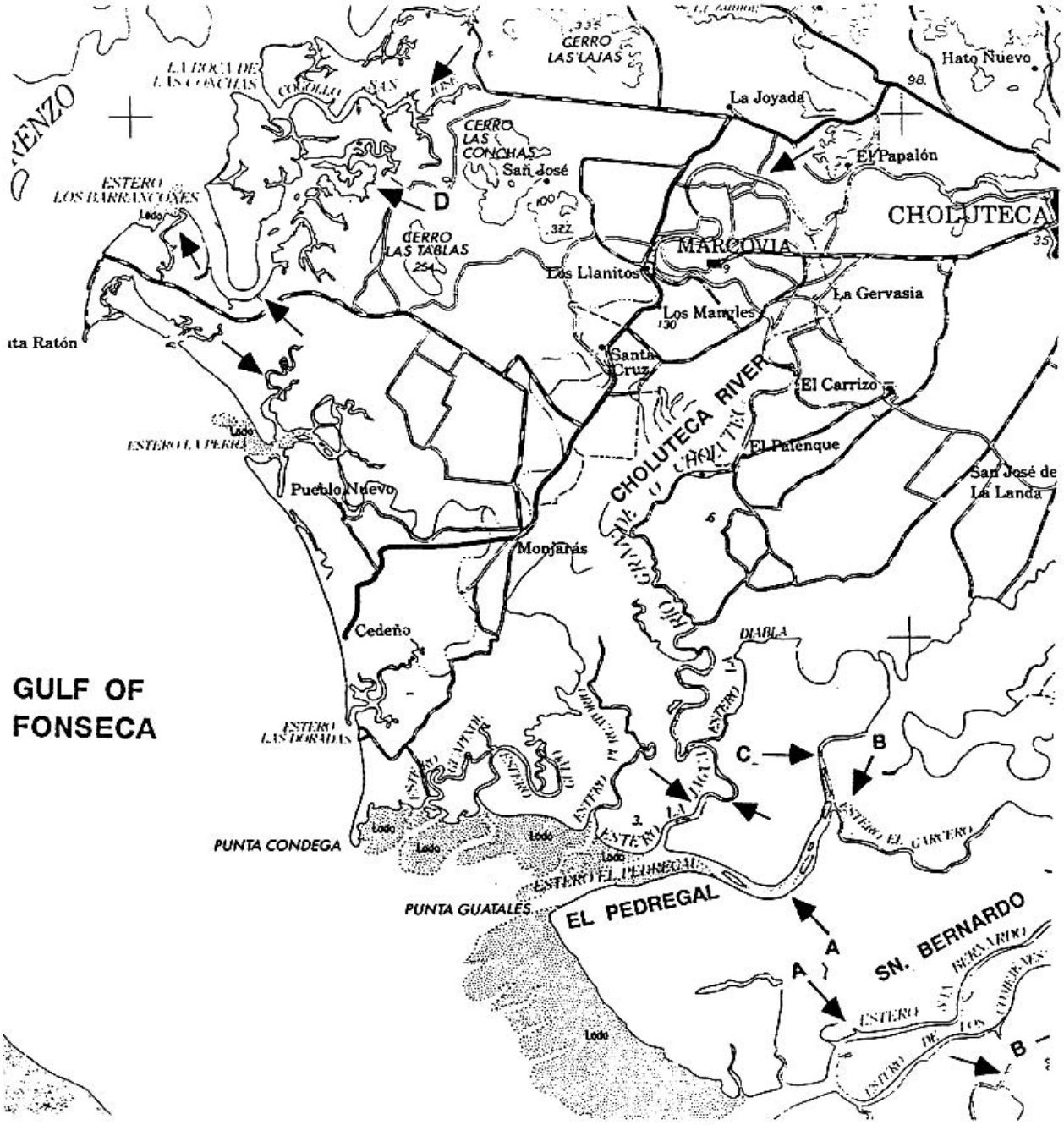
The Choluteca research area is in the low, coastal, estuarine environment of several major rivers and numerous embayments around the periphery of the Gulf of Fonseca. Mangrove forests fringe the Gulf, and coastal plains dominate the landscape up to 60 km inland from the Gulf.

Geology and Soils

The entire southern (Pacific) side of Central America is considered a seismic area, containing several active volcanoes. Soils in the study area are of volcanic origin, formed by processes of alluviation and sedimentation in a brackishwater environment.

* Asterisked items are defined or described in the glossary.

Map of Choluteca



Map of study area in southern Honduras bordering the Gulf of Fonseca. Letters and arrows indicate farms and sampling points where research has been conducted.

Description of Choluteca

Map Coordinates	Elevation
13°20'N and 87°15'W	0 m

General	Water Supply
The size of ponds and total area in ponds of the commercial shrimp-producing farms involved in CRSP research in this area varied widely, so descriptions of individual facilities are not included here.	Supply water for all shrimp farms in the area came from estuaries of the Gulf of Fonseca, and was delivered to the farms by pumping. River flows are highly variable throughout the year due to the distinct difference between the rainy and dry seasons. The Choluteca River, for example, may exhibit a dry season flow rate as low as 2 m^3 s^{-1}, whereas it is as high as 1,500 m^3 s^{-1} during the rainy season. Quality of water was highly variable, depending on the specific source used (gulf embayment, Choluteca River, or riverine estuaries) and on the season. Seasonal differences were large in the rivers and riverine estuaries, but relatively minor in gulf embayments. Total alkalinity and salinity were higher in the estuaries during the dry season but were kept relatively low by rainfall and river flow during the rainy season. Estuarine salinities could be near zero during the rainy season while reaching hypersaline levels during the dry season.

Soils

Ponds were excavated primarily in salt flats. Pond soils contained sodium concentrations as high as 10,000 mg l^{-1} and concentrations of calcium, magnesium, and potassium as high as 2,100, 2,300, and 1,000 mg l^{-1}, respectively. Most soils in the area were alkaline, with pH values greater than 7 (range 6.73–7.49). CECs* ranged from 19.5 to 22.1 meq per 100 g soil, and clay percentages ranged from 20 to 45%, depending on the location.

* Asterisked items are defined or described in the glossary.

Support Facilities at Choluteca

The La Lujosa Water Quality Laboratory was available for conducting all the water quality analyses needed in CRSP-sponsored studies. The research program was supported by the Honduran National Association of Aquaculturists (ANDAH), the Federation of Export Producers (FPX), and the Dirección General de Pesca y Acuicultura, Secretaría de Agricultura y Ganadería, Honduras.

Affiliations

In-Country	US
Dirección General de Pesca y Acuicultura Secretaría de Agricultura y Ganadería Gobierno de Honduras HONDURAS	Department of Fisheries and Allied Aquacultures Auburn University, AL 36849 USA

Current Contacts

In-Country	US
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El Carao

The El Carao National Fish Culture Research Center is located in the Comayagua Valley, in the mountainous area of central Honduras.

Drained tilapia spawning ponds at El Carao, showing drain structures and complete coverage of the pond bottom by tilapia nests.

El Carao National Fish Culture Research Center (Centro Nacional de Investigación Piscícola El Carao)

Site Status: Former Prime Site, 1983 to 1987 and 1988 to 1998

Location: Dirección Regional de Agricultura y Ganadería, Comayagua, Comayagua, HONDURAS

Caption/Description: The El Carao Aquaculture Experiment Station is located in the Comayagua Valley, 8 km from the city of Comayagua and 131 km north of the capital city of Tegucigalpa, approximately halfway between the northern and southern coasts.

Description of Area/Region

Climate

Köppen classification* **Aw***: *Humid tropical* group (A), *tropical wet-and-dry* type (w). The higher elevations in the interior mountains of Honduras temper the generally tropical climate of the region.

Temperatures

Mean annual air temperatures in the coastal regions are around 27°C, while those in the upland, interior areas are cooler, at about 21°C. Annual air temperatures at the El Carao station range from 19.6 to 31.0°C, with a mean of about 25.5°C. Pond water temperatures at El Carao average around 26.5°C.

Precipitation

The average annual rainfall of some mountain valley areas is just over 1,000 mm, but rainfall may be over 2,500 mm annually in northern coastal areas; at El Carao it is about 765 mm. During Cycle I of the CRSP experiments, rainy season precipitation was 565 mm, whereas it was 200 mm in the dry season.

Humidity

Mean annual humidity in Tegucigalpa (131 km to the southeast of Comayagua) is 74%. Humidity is lowest in March and April, when it is around 63%, and highest in September and October, at about 80–81%.

Seasonality

The climate of Honduras is characterized by a distinct dry season, which lasts from November to May and has both lower air temperatures and rainfall than does the rainy season. The average number of days with rain in Tegucigalpa (131 km southeast of Comayagua) ranges from 1 in January and February to 14 in September and October.

Topography

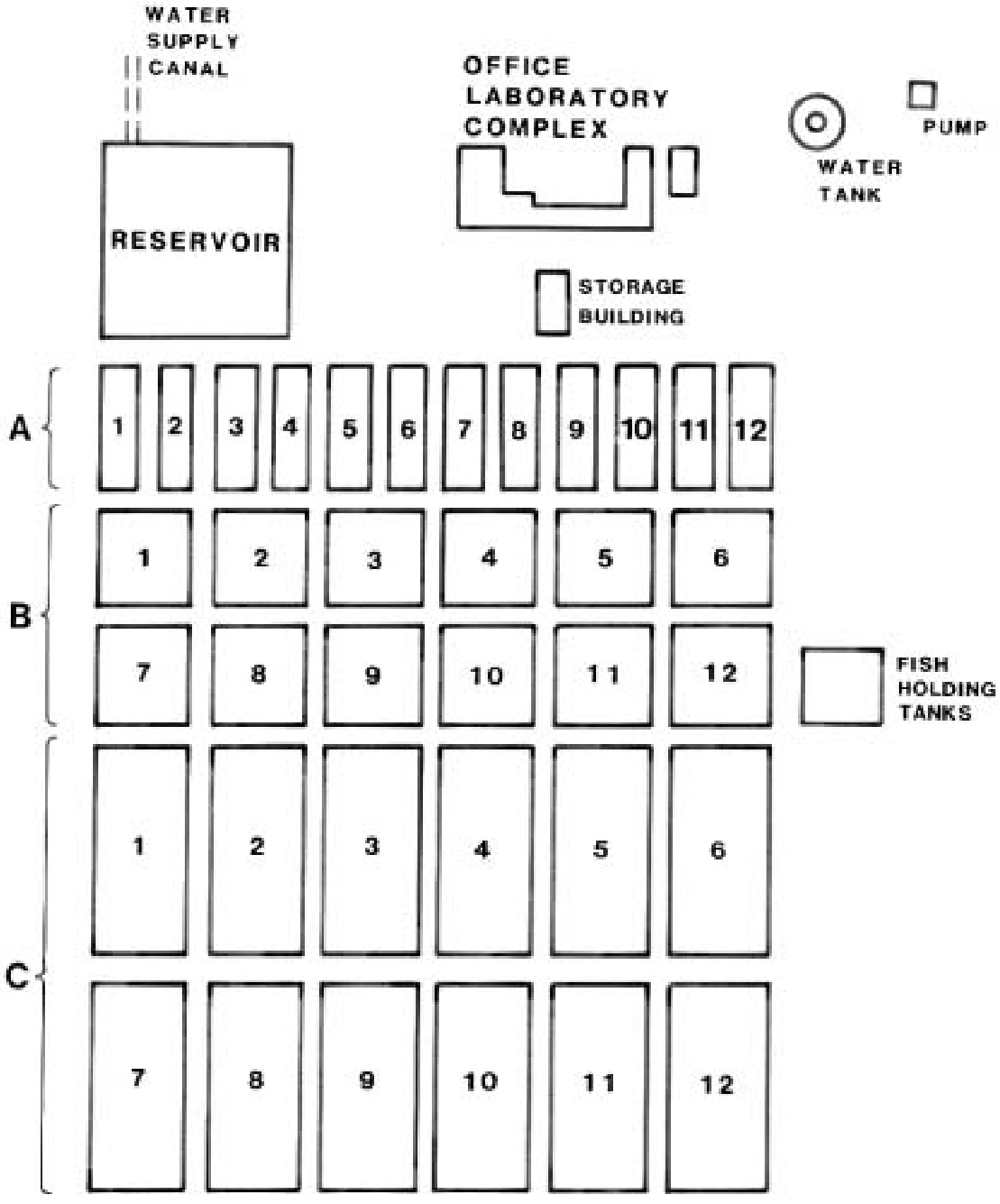
Most of the interior of Honduras is a plateau of fertile plains, broken by deep valleys and mountain ranges of volcanic origin, and with elevations in the range of 500 to 2,000 m. The ridges of these ranges generally parallel the coastlines, running northwest to southeast. The town of Comayagua and the El Carao station are situated in the Comayagua Valley of this plateau area; elevations in the valley range from 550 to 750 m. The mountainous interior plateau is bracketed by two coastal strips: the 640-km northern coast along the Caribbean Sea and the short, 64-km strip on the Gulf of Fonseca on the Pacific.

Geology and Soils

Mountain ranges throughout Central America are a part of the Andes–Rockies mountain chain, formed by plate tectonic activity and stretching through the western portion of the Americas from Alaska to Chile. All of the Central American isthmus is considered semi-stable with respect to seismic activity, and the entire southern (Pacific) side is considered a seismic area, containing several active volcanoes. Soils are thus of volcanic origin.

* Asterisked items are defined or described in the glossary.

Layout of El Carao



Note: CRSP ponds are numbered B1 through B12.

Description of El Carao

Map Coordinates	Elevation
14°26'N and 87°41'W	583 m

General

The El Carao Station was the largest of a series of aquaculture stations operated by the Ministry of Agriculture and Livestock (Dirección General de Pesca y Acuicultura, Secretaría de Agricultura y Ganadería). It had major responsibilities in production of tilapia*, Chinese carp*, tambaquí*, and guapote tigre* fingerlings for distribution to fish farmers. In addition, the station provided technical assistance to fish farmers, as well as a broad range of training courses. The station consisted of offices, a water quality/biological limnology laboratory, a modest technical library, a storage building, and a complex of 36 ponds. The latter included twelve ponds of 500 m^2, twelve 1,000-m^2 ponds, and twelve 2,000-m^2 ponds. All ponds had concrete sumps for fish harvesting. The twelve 1,000-m^2 ponds were assigned to the CRSP. A wet lab area included ten 20-m^2 and eight 2-m^2 concrete holding tanks and four 2-m-diameter round concrete spawning tanks.

Water Supply

Water for the station was supplied by gravity from a 4,000-m^2 reservoir, which itself was fed by irrigation canals originating at the Selguapa River. The wet lab area was supplied with water from an on-site well. Surface (canal) water was slightly alkaline, with a pH of approximately 8.0, a total alkalinity of about 30 to 43 mg l^{-1}, and a total hardness of about 23 to 31 mg l^{-1}. The wet lab was supplied with water from a well.

Soils

The soils in the 12 CRSP-operated ponds averaged just over 50% clay in the upper 15 cm. The initial organic matter contents of the pond soils was relatively low, the highest level being about 1.3%. The soils were alkaline, with pH values of 8.0 to 8.9 and free $CaCO_3$ levels ranging from 3.8 to 9.6%. Accordingly there was no lime requirement for any of the CRSP-operated ponds. The CECs* of the El Carao soils ranged from 17.7 to 33.6 meq per 100 g soil.

* Asterisked items are defined or described in the glossary.

Support Facilities at El Carao

Students from the Universidad Nacional Autónoma de Honduras conducted senior thesis research and assisted in various station activities at El Carao. The Honduran Foundation for Agricultural Research, La Lima, was used for soil and complete water analyses. Pelleted fish feeds were available from two in-country feed mills. A variety of agricultural by-products, e.g., corn gluten, wheat bran, rice bran, etc., were available from the various mills; some products were only available at agricultural supply stores; fertilizer was usually available. Layer chicken litter was widely available at low cost.

Affiliations

In-Country	US
Dirección General de Pesca y Acuicultura Secretaría de Agricultura y Ganadería Gobierno de Honduras HONDURAS	Department of Fisheries and Allied Aquacultures Auburn University, AL 36849 USA

Current Contacts

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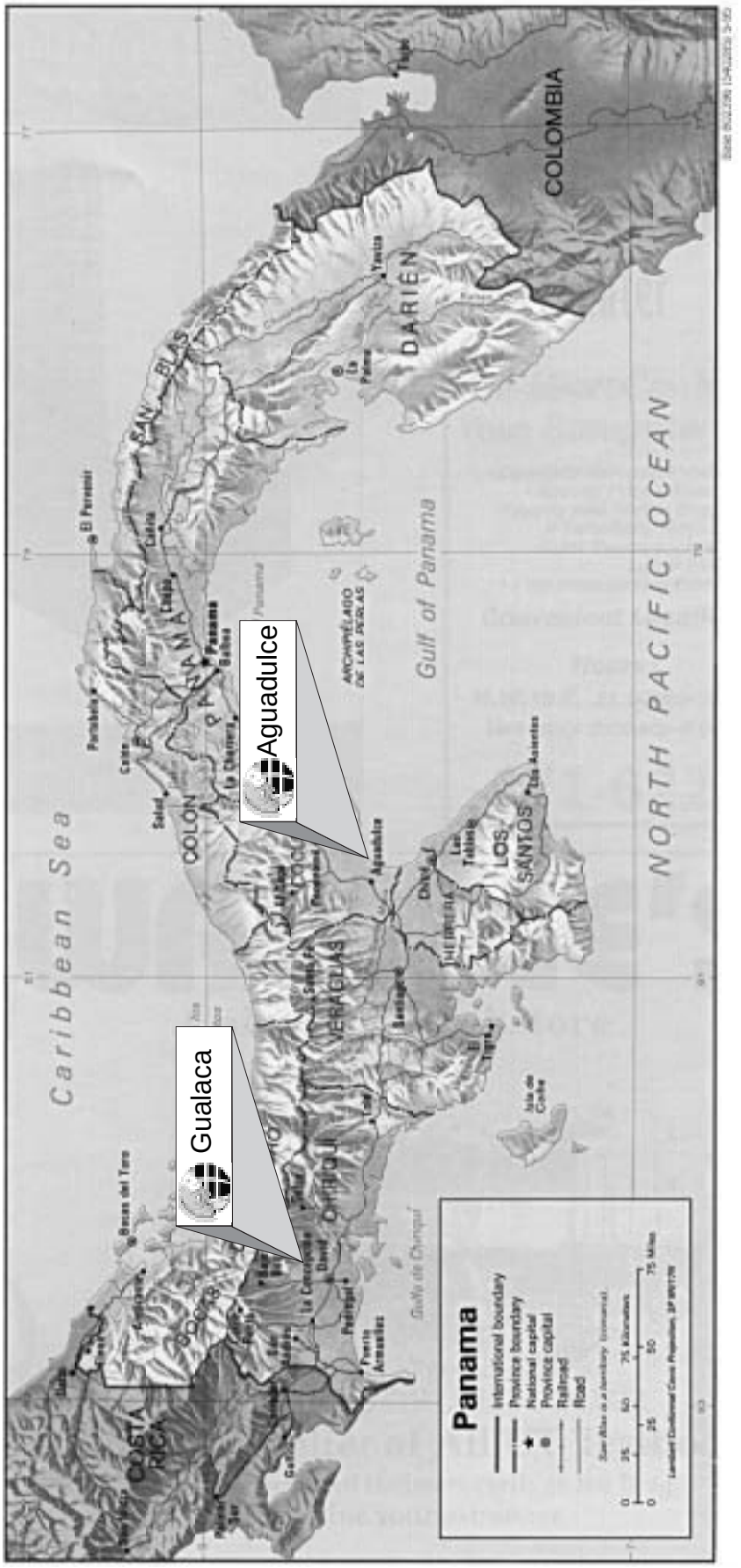

Caribbean Sea
Gulf of Panama
NORTH PACIFIC OCEAN
COLOMBIA
COSTA RICA
DARIÉN
SAN BLAS
COLON
VERAGUAS
LOS SANTOS
Gualaca
Aguadulce
Panama
International boundary
Province boundary
National capital
Province capital
Railroad
Road

Aguadulce
Brackishwater Experiment Station "Ingeniero Enrique Ensenat"

Site Status: Former Prime Site, 1983 to 1987

Location: Aguadulce, Cocle, PANAMA

Caption/Description: The Ingeniero Enrique Ensenat Brackishwater Experiment Station (BES) is located approximately 5 km south of the town of Aguadulce, 0.5 km north of the Port of Aguadulce, and 190 km west of Panama City. It is within a zone of approximately 1,500 ha of commercial shrimp farms adjacent to Parita Bay on the Pacific coast of Panama.

Description of Area/Region

Climate

Köppen classification* **Aw***: *Humid tropical* group (A), *tropical wet-and-dry* type (w). Distinct rainy and dry seasons are observed.

Temperatures

Average annual temperatures for Panama as a whole range from 23 to 27°C. At higher altitudes in the interior regions the average annual temperature is nearer to 19°C. Average annual temperatures at the BES were between 23.8 and 33.5°C. This resulted in average pond water temperatures of 28.4°C.

Precipitation

Average annual rainfall for the Pacific side of the country is about 1,650 mm; at the BES it was 1,453 mm.

Humidity

Humidity is generally high during the rainy season but lower during the remainder of the year.

Seasonality

Panama experiences a tropical wet-and-dry climate, with a dry season that lasts from December to April and rains during the remainder of the year.

Topography

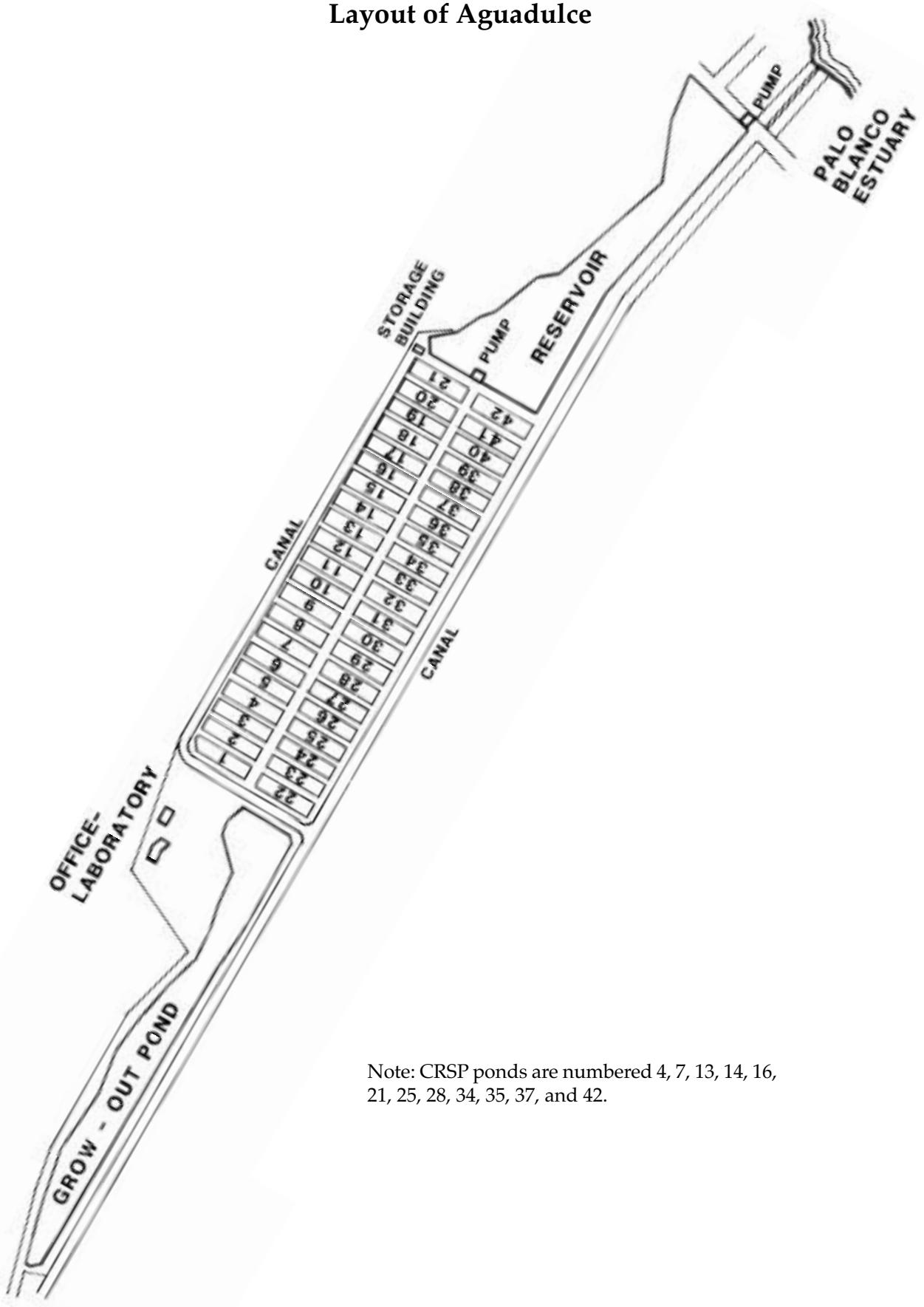
The area immediately around the station is characterized topographically by extensive mud flats and mangrove forests on the seaward side and coastal plain on the landward side.

Geology and Soils

Mountain ranges throughout Central America are a part of the Andes–Rockies mountain chain, stretching through the western portion of the Americas from Alaska to Chile. The Central American isthmus is considered semi-stable with respect to seismic activity, and the entire southern (Pacific) side is considered a seismic area, containing several active volcanoes. Soils in Panama are of volcanic origin, although in the flat coastal area around Aguadulce they are predominantly formed by recent alluvial processes, together with changes brought about by weathering, sedimentation, and exposure to seawater. Soils around Aguadulce have high clay contents, and the influence of seawater is reflected in relatively high contents of elements such as Na.

* Asterisked items are defined or described in the glossary.

Layout of Aguadulce



Note: CRSP ponds are numbered 4, 7, 13, 14, 16, 21, 25, 28, 34, 35, 37, and 42.

Description of Aguadulce

Map Coordinates	Elevation
8°15'N and 80°29'W	0 m

General	Water Supply
The Brackishwater Experiment Station (BES) was part of the aquaculture station network established and administered by the General Directorate of Aquaculture (Dirección Nacional de Acuicultura—DINAAC) of the Ministry of Agriculture Development (Ministerio de MIDA) of the government of the Republic of Panama. Its primary functions included both research and seed production. The BES consisted of two phases of earthen ponds. Phase 1 included 42 experimental ponds measuring from 500 to 650 m^2 in surface 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 was located 1 km from Phase 1 and consisted of 10 production ponds ranging from 0.2 to 1.0 ha in area, a pump station, and a storage building.	Water for Phase 1 and Phase 2 was pumped from a branch of the Palo Blanco Estuary. The same branch served both as a source of water and a drainage canal for the BES and neighboring shrimp farms. Water to Phase 1 CRSP ponds was pumped by a diesel-powered hydraulic pump from the estuary to the 1.4-ha reservoir pond, then pumped to the ponds by a diesel-powered hydraulic pump. This water had a pH of between 7.2 and 8.6. Salinity ranged from about 10 ppt during the wet season to over 45 ppt during the dry season.

Soils

The texture of soils in the CRSP research ponds averaged 51% clay, 31% silt, and 16% sand, and they contained an average of approximately 1% organic matter (range of 0.7 to 1.5 in 12 ponds). They were approximately neutral, with pH values ranging from 6.4 to 7.6, and contained very little free $CaCO_3$ (0.2% in all ponds).

Support Facilities at Aguadulce

A joint agreement with the Agricultural Research Institute of Panama (IDIAP) allowed DINAAC to request occasional assistance in the analysis of feedstuffs and fertilizers and to determine concentrations of chemical constituents in water and soil samples. All fertilizer and feed was generally provided by DINAAC for the CRSP experiments. Organic fertilizer was in short supply, and inorganic fertilizer could be purchased in unmixed form from importers and blended to the desired combinations. University of Panama students conducted thesis research at the BES on special topics related to the pond dynamics trials. There was a small library at the BES; a larger collection was available at the DINAAC offices in Santiago, one hour from the BES.

Affiliations

In-Country	US
Dirección Nacional de Acuicultura (DINAAC) Ministerio de Desarrollo Agropecuario (MIDA) Santiago de Veraguas REPUBLICA DE PANAMA	Department of Fisheries and Allied Aquacultures Auburn University, AL 36849 USA

Current Contacts

In-Country	US
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Gualaca Freshwater Aquaculture Research Station (Estación Experimental Dulce Acuicola de Gualaca)

Site Status: Former Prime Site, 1983 to 1987

Location: Estación Experimental Dulce Acuicola de Gualaca, Agricoles de Panama, Gualaca, Chiriqui, PANAMA

Caption/Description: The Gualaca Freshwater Aquaculture Research Station (Estación Experimental Dulce Acuicola de Gualaca) is located at the base of the Andes mountain chain, 2 km south of the town of Gualaca, in western Panama. The nearest city, David, is 27 km to the southwest.

Description of Area/Region

Climate

Köppen classification* **Aw***: *Humid tropical* group (A), *tropical wet-and-dry* type (w). Distinct rainy and dry seasons are observed.

Temperatures

Annual air temperature at Gualaca ranges from 17 to 34°C, and pond water temperatures at the station ranged from 23 to 29°C.

Precipitation

Average annual rainfall at Gualaca is 4,320 mm. Most of this rainfall occurs during the rainy season (May–November), with little rain falling between December and April.

Humidity

Mean annual relative humidity in the Gualaca area is 83%. It ranges from lows of 67 to 68% in February and March to highs of 88 to 90% from June through November.

Seasonality

A distinct dry season, running from December through April, is observed in the Gualaca area. During this period there is often no rainfall. Towards the end of April rainfall begins to increase, reaching an average of 11 to 13 mm per day during May and June, slacking off a bit during July, then again increasing to a maximum of around 27 mm per day in September.

Topography

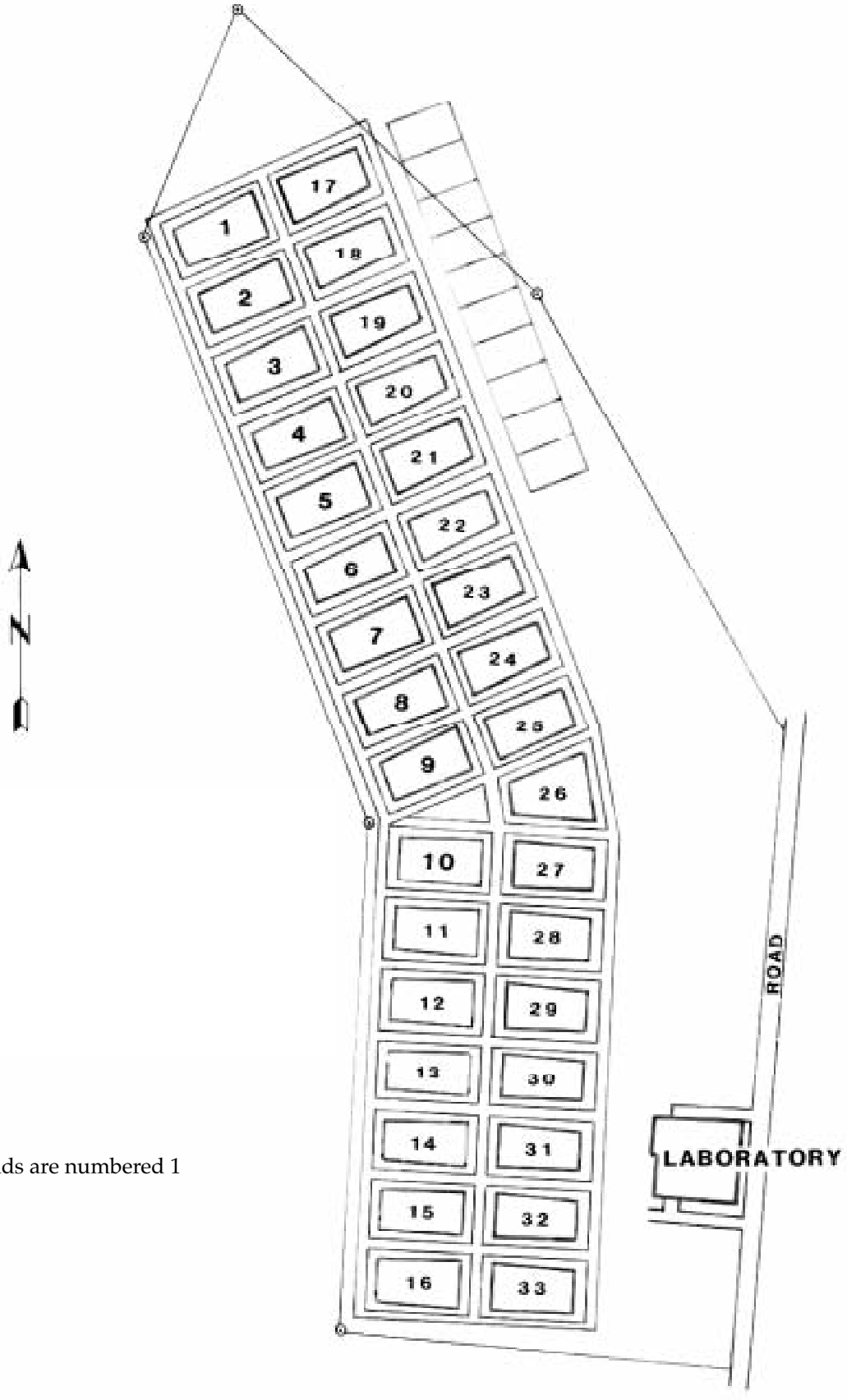
The Cordillera Central mountain chain forms the backbone of the portion of Panama west of the Panama Canal. Average elevations here range from 1,000 to 2,000 m, but the highest peaks, including the Volcan de Chiriqui, approximately 45 km northwest of Gualaca, rise to elevations of over 3,350 m. Gualaca lies near the foot of the southern slopes of these mountains, at an elevation of 100 m, and approximately 25 km from the coast at the Gulf of Chiriqui on the Pacific Ocean.

Geology and Soils

Mountain ranges throughout Central America are a part of the Andes–Rockies mountain chain, formed by plate tectonic activity and stretching through the western portion of the Americas from Alaska to Chile. All of the Central American isthmus is considered only semi-stable with respect to seismic activity, and the entire southern (Pacific) side is considered a seismic area, containing several active volcanoes. Soils in Panama are thus of volcanic origin; those in the area around the Gualaca site are alluvial Inceptisols* that are acidic and highly permeable.

* Asterisked items are defined or described in the glossary.

Layout of Gualaca



Note: CRSP ponds are numbered 1 through 10.

Description of Gualaca

Map Coordinates	Elevation
8°31'N and 82°19'W	100 m

General	Water Supply
The Gualaca station was built in 1984 to supply fingerlings of tilapia*, carp, and other fish to producers in the area and to conduct aquacultural research. It was administered by DINAAC (Dirección Nacional de Acuicultura), but it also functioned as part of an IDIAP (Instituto de Investigacion Agropecuaria de Panama) facility located in Gualaca. The station was 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 aquarium 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.	The water supply for the station was gravity-fed by a canal (Quebrada del Pueblo) that diverted water from the Rio Chiriqui, a river draining the mountains north of the station. Water from these mountain watersheds was typically soft and infertile. At the beginning of CRSP research at this site (1983), water from the canal had a pH of 6.4 and low alkalinity and hardness readings of 18.4 and 14.6 mg l^{-1} (as $CaCO_3$), respectively.

Soils

The ponds at Gualaca were excavated in the alluvial soils that are typical of the area, but because these soils proved to be too permeable, a layer of red clay (Ultisol*) material was later added in an attempt to reduce seepage. Ultisols are typically high in kaolinitic clay minerals, however, and although clay contents ranged from 24 to 36% in the Gualaca ponds, seepage remained high even after the ponds were lined. The soils were quite acidic at the beginning of CRSP work, with pH values ranging from 4.7 to 5.2 and base saturations between 8 and 13%. The CECs* of the soils were less than 24 meq per 100 g. Organic matter in these pond soils ranged from 2.0 to 3.9%.

* Asterisked items are defined or described in the glossary.

Support Facilities at Gualaca

During the time that the CRSP conducted research at the Gualaca aquaculture station it was jointly supported by IDIAP and DINAAC. IDIAP supplied the land, helped maintain the facility, and paid the salary of the station manager. IDIAP also ran a chemical analysis and soil lab near the fish station, where feed, soils, and minor elements of water could be analyzed. Lab personnel provided expertise on topics related to local soils, chemical analysis, forage, and animal husbandry. A library with materials pertinent to aquaculture was located 2 1/2 hours away at DINAAC headquarters in Santiago. Fertilizer and limestone were readily available in David, and feed could be obtained in bulk from a supplier near Santiago. Additional personnel resources in the form of student labor were occasionally available from a branch of the University of Panama in David. These students had the option of doing their thesis work in an area of aquaculture or aquatic biology.

Affiliations

In-Country	US
Dirección Nacional de Acuicultura (DINAAC) Ministerio de Desarrollo Agropecuario (MIDA) Santiago de Veraguas REPUBLICA DE PANAMA Instituto de Investigacion Agropecuaria de Panama (IDIAP) Gualaca, Chiriqui REPUBLICA DE PANAMA	Department of Fisheries and Allied Aquacultures Auburn University, AL 36849 USA

Current Contacts

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CRI–Loreto
COLOMBIA
ECUADOR
LORETO
BRAZIL
BOLIVIA
CHILE
SOUTH PACIFIC OCEAN
Quito
Manta
Ambato
Guayaquil
Cuenca
Tumbes
TUMBES
Loja
Talara
Sullana
PIURA
Piura
Paita
AMAZONAS
Chachapoyas
Lambayeque
Chiclayo
CAJAMARCA
Cajamarca
LA LIBERTAD
Trujillo
Salaverry
Chimbote
ANCASH
Huaraz
Tingo Maria
HUANUCO
PASCO
Cerro de Pasco
Huacho
Lima
Callao
LIMA
JUNIN
Huancayo
HUANCAVELICA
Huancavelica
ICA
Nazca
AYACUCHO
Ayacucho
APURIMAC
Abancay
CUSCO
Cusco
Machupicchu
AREQUIPA
Arequipa
MOQUEGUA
TACNA
Tacna
Arica
PUNO
Juliaca
Puno
Desaguadero
La Paz
Iquitos
Leticia
Benjamin Constant
Yurimaguas
Tarapoto
Moyobamba
SAN MARTIN
Pucallpa
Santa Lucia
Cruzeiro do Sul
UCAYALI
Rio Branco
Cobija
MADRE DE DIOS
Puerto Maldonado
Peru
International boundary
Department boundary
National capital
Department capital
Railroad
Road
Callao is the capital of the Constitutional Province of Callao which has the status of a department but is too small to be shown on this map.
0 100 200 Kilometers
0 100 200 Miles
Transverse Mercator Projection, CM 71°W

CRI–Loreto

Marcos J. De Jesús

IIAP crew seining for *Colossoma macropomum* broodstock at the CRI–Loreto research site in Peru.

Marcos J. De Jesús

Hatchery facilities at the CRI–Loreto research site. Broodstock tanks, egg incubators, and larvae-rearing circular tanks are visible.

Centro Regional de Investigaciones–Loreto (CRI–Loreto)
Instituto de Investigationes de la Amazonia Peruana

Site Status: Active Companion Site, 1996 to present

Location: Instituto de Investigaciones de la Amazonia Peruana (IIAP), Centro Regional de Investigaciones–Loreto (CRI–Loreto), Iquitos, PERU

Caption/Description: CRI–Loreto is located 7 to 10 km southeast of Iquitos, Peru. The region is heavily populated, and commercialization and industrialization have led to significant deforestation. Secondary succession tropical forests are predominant.

Description of Area/Region

Climate

Köppen classification* **Af***: *Humid tropical* group (A), *tropical wet* type (f). No dry season; at least 60 mm of rainfall in the driest month.

Temperatures

Average temperature: 26.5°C
Average high temperature: 31.5°C
Average low temperature: 21.4°C

Precipitation

Annual precipitation in the Iquitos region exceeds 2,500 mm. Monthly rainfall is greatest in March (310 mm) and lowest in July and August (150 mm).

Humidity

A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 55% (September) to 63% (April).

Seasonality

Most of the rain occurs between January and June. Temperature does not vary greatly throughout the year (monthly average highs and lows vary by < 2.3°C throughout the year).

Topography

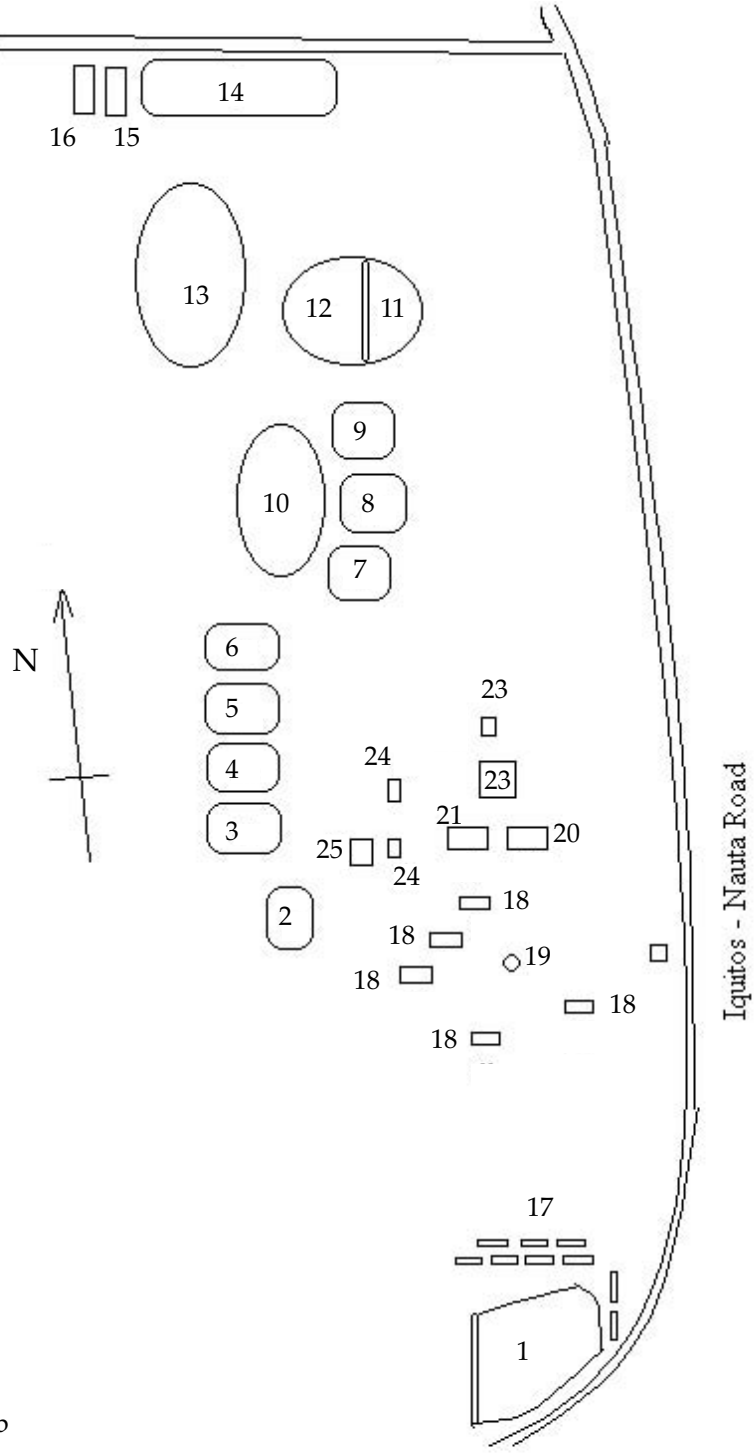
The region is sloping and full of hills. Most of the facility is declared floodplain since it divides the Itaya and Nanay tributaries to the Amazon River. It is built within a densely vegetated area on a land gradient suitable for gravity-fed ponds.

Geology and Soils

The Amazon floodplain in Peru started to develop as the river drainage began to flow east with the rise of the Andes mountain range 15 million years ago. Silt carried from the Andes formed most of the islands throughout the river course. This highly nutritive silt provided large areas for trees to colonize. With constant changes in river paths, still occurring today, silt deposits remain exposed as forested hills. Lower regions become subject to flooding when river levels rise to 10 to 11 m. The site is located in a hilly region, where some hilltops stand approximately 140 m above sea level. Soil and terrain were diagnosed as moderately suitable for aquaculture ponds: 2–8% slope; 75–150 cm effective soil depth; 40–80% gravel and stones; soil and texture loamy or clayey without swell-shrink, and not organic; 4–8 dS m^{-1} salinity; pH 5.5–7.2; catclays not present; gypsum not present.

* Asterisked items are defined or described in the glossary.

Layout of CRI–Loreto



Legend

1. 3,100-m^2 pond
2. 650-m^2 pond
3. 1,347-m^2; 1,368-m^3 pond
4. 1,198-m^2; 1,532-m^3 pond
5. 1,158-m^2; 1,278-m^3 pond
6. 1,015-m^2; 900-m^3 pond
7. 600-m^2 pond
8. 600-m^2 pond
9. 600-m^2 pond
10. 2,443-m^2 pond
11. 1,408-m^2 pond
12. 2,642-m^2 pond
13. 5,320-m^2; 4,490-m^3 pond
14. 2,940-m^2 pond
15. 1,000-m^2 pond
16. 1,000-m^2 pond
17. 60-m^2 ponds (nine)
18. Offices/housing
19. Water tower (well)
20. Laboratory
21. Administration
22. Service building (storage)/feed lab
23. Supply and tool house
24. 45- and 50-m^3 cisterns
25. Fish hatchery

Description of CRI–Loreto

Map Coordinates	Elevation
3°45'10"S and 73°11'29"W	100 to 120 m
General	**Water Supply**
There are nine 60-m^2 rectangular fry ponds and sixteen grow-out and brood ponds, ranging from 600 m^2 to 5,320 m^2. The hatchery facility is approximately 65 m^2 and is equipped with a sand-based mechanical filter, six 200-US-gallon concrete brood tanks, a twelve-30-l-jar incubating system with a 40-US-gallon fry receptacle, a laboratory table, cabinets, and counter top with sinks for prep work.	Water is gravity-fed throughout the facility from two cisterns (45 and 50 m^3) that are filled with rainwater. An artesian-well-filled water tower is used as an auxiliary source. Ponds are filled during flood season with rainwater. The precipitation increase affects the water chemistry in rivers and ponds. The ponds at CRI–Loreto exhibit a mixture between white (turbid, with silt particles, ochre-colored, transparency of 0.1–0.5 m, pH of 6.2–7.2) and black (transparency of 1.3–2.9 m, olive-brown to coffee-brown in color, pH 3.8) water properties. Minimum dissolved oxygen levels generally remained above 1.0 mg l^{-1}, and usually averaged above 4.0 mg l^{-1}. Total ammonia nitrogen remained below 1.0 mg l^{-1}. Carbon dioxide levels were less than 22 mg l^{-1}. Waters are soft (hardness 20 mg l^{-1}, alkalinity 20 mg l^{-1}, conductivity 96 µohm cm^{-2}) and slightly acidic (morning pH 6.3–7.1). Average transparency ranged from 29 to 125 cm.
Soils	
Soils are predominantly sand in a mixture with clay and a little silt.	

Support Facilities at CRI–Loreto

During the CRSP research in Peru, IIAP, Universidad Nacional de la Amazonia Peruana (UNAP), and Southern Illinois University at Carbondale have collaborated jointly to support all activities performed at the site. IIAP and UNAP have their own libraries, and the Amazon and Municipal Libraries are available in the city of Iquitos as additional sources of information. Feed ingredients for research fish and pond organic and inorganic fertilizers are provided by reliable sources in town. Diets are formulated by Dr. Fernando Alcántara and prepared at the IIAP facility. IIAP also provides maintenance, security, and other professional personnel that assist in operations. An on-site meteorological station was created to obtain weather data with the consultation from Servicio Nacional de Meteorología y Hidrología (SENAMHI). The IIAP facilities are equipped with several Internet-ready computer stations, telephone and fax services, and shortwave radio communication devices. Professional consultation is provided by IIAP scientists and UNAP faculty. Valuable help is volunteered by dedicated students from UNAP, who benefit from the experiences offered though CRSP research.

Affiliations

In-Country	US
Instituto de Investigaciones de la Amazonia Peruana Iquitos PERU Universidad Nacional de la Amazonia Peruana Iquitos PERU	Fisheries Research Laboratory Southern Illinois University at Carbondale Carbondale, IL USA

Current Contacts

In-Country	US
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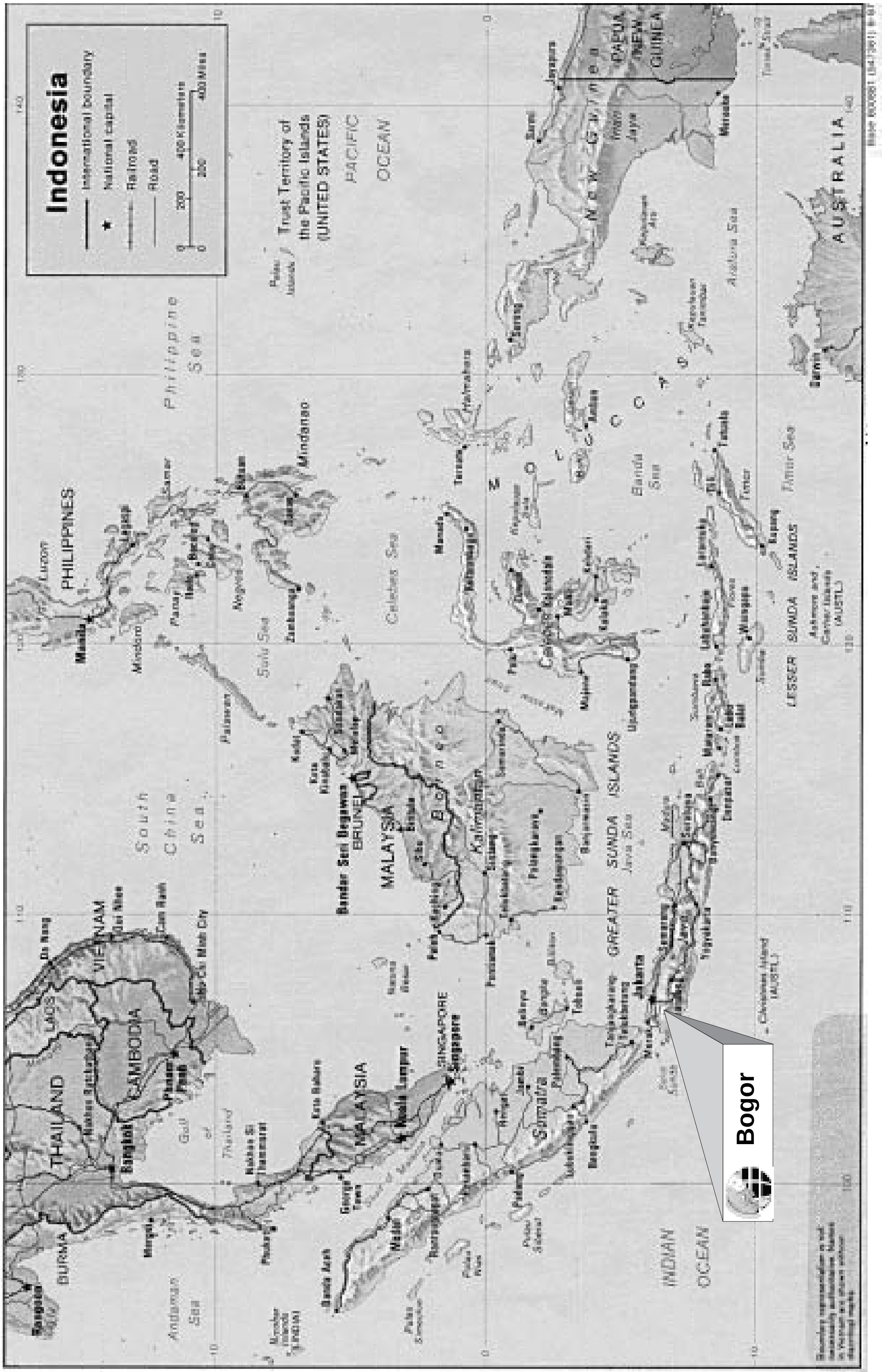

Indonesia
International boundary
National capital
Railroad
Road
Trust Territory of
the Pacific Islands
(UNITED STATES)
PACIFIC
OCEAN
Philippine
Sea
PHILIPPINES
Luzon
Mindanao
Sulu Sea
Celebes Sea
South
China
Sea
VIETNAM
LAOS
CAMBODIA
THAILAND
BURMA
Andaman
Sea
MALAYSIA
BRUNEI
SINGAPORE
Singapore
Sumatra
Kalimantan
Jakarta
Java Sea
GREATER SUNDA ISLANDS
LESSER SUNDA ISLANDS
Banda
Sea
Timor Sea
Arafura Sea
PAPUA
NEW
GUINEA
AUSTRALIA
INDIAN
OCEAN
Bogor

Bogor

Ponds at Babakan Fisheries Station were lined with concrete to eliminate water loss by seepage through highly permeable soils. Offices and analytical laboratories are shown in background.

Source water for the Babakan Fisheries Station and area rice paddies came as runoff from the slopes of nearby Mt. Salak. The highly leached volcanic soils in this area are acidic, and water flowing over and through them had low levels of hardness and alkalinity.

Bogor
Babakan Fisheries Station, Bogor, Indonesia

Site Status: Former Prime Site, 1983 to 1987

Location: Darmaga, Bogor, West Java, INDONESIA

Caption/Description: The Babakan Fisheries Station of the Institute Pertanian Bogor (IPB) is located near the village of Darmaga, approximately 10 km from Bogor, in West Java.

Description of Area/Region

Climate

Köppen classification* **Af***: *Humid tropical* group (A), *tropical wet* type (f). No dry season; at least 60 mm of rainfall in the driest month.

Temperatures

Average annual temperatures range from 23 to 33°C. Average pond temperature is 28.5°C.

Precipitation

Rainfall on the volcanic peaks and surrounding uplands of Java is high: greater than 3,000 mm yr^{-1} along the mountain chain and as much as 7,500 mm yr^{-1} in parts of Central Java. The average annual rainfall at the Babakan Station is consistent with these figures—it was reported to be 3,500 mm at the beginning of CRSP research activities at the site.

Humidity

Humidity is high, with frequent low clouds, low visibility, and little evaporation from the ponds.

Seasonality

Climatic conditions at Babakan lack seasonal attributes and show little variation over an annual cycle.

Topography

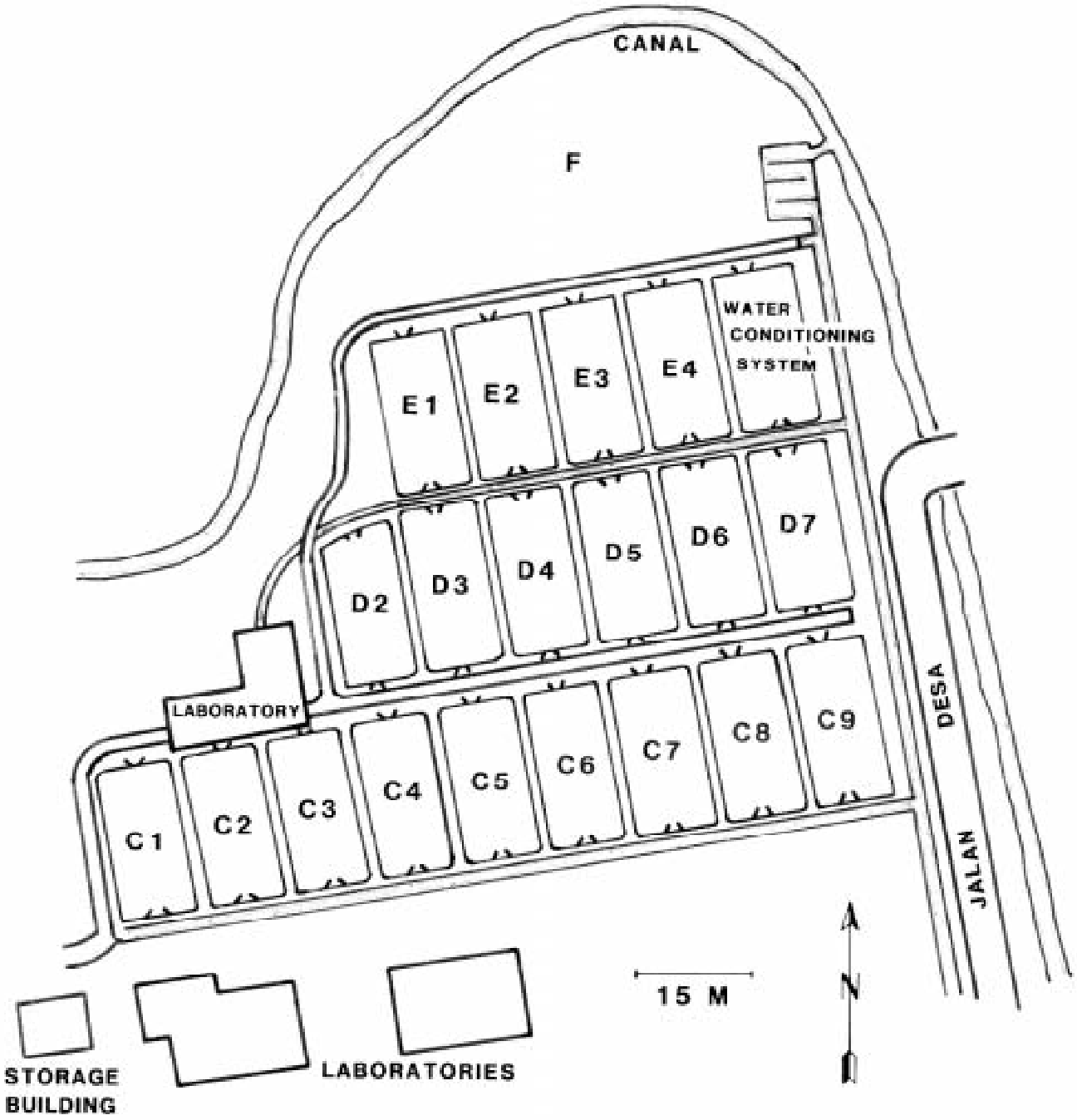
The island of Java is part of the Indonesian archipelago that stretches 5,600 km from east to west on the southwest rim of the Pacific basin. The backbone of Java consists of 25 major volcanic peaks that rise between 1,900 and 3,700 m above mean sea level. The volcanoes and intervening land constitute a chain approximately 940 km long between the latitudes 6.0 and 8.5°S.

Geology and Soils

Java was formed by arc volcanism associated with subduction of Indian Ocean seafloor in the Java Trench south of the island. The peaks continue to grow by lava flows and upheaval of ash. Among the peaks are low-elevation ridges of limestone. These are uplifted coral reefs largely of Miocene origin. The distribution of soils that developed from materials of volcanic and coral reef origin is of great significance for aquaculture, because groundwater and runoff from volcanic regions of high rainfall can be expected to be low in minerals, while mineral concentrations can be eight to ten times greater in drainage from limestone regions. The drainage basin in which the Babakan Station is located is characterized by highly leached and permeable volcanic soils that have a low alkalinity.

* Asterisked items are defined or described in the glossary.

Layout of Bogor



Note: CRSP ponds are numbered C1–C9 and D5–D7.

Description of Bogor

Map Coordinates	Elevation
6°6'S and 106°7'E	220 m

General

There were 40 ponds at the Babakan Fisheries Station, 12 of which were used for CRSP research. Each pond had an area of 200 m^2 (10 m wide x 20 m long) and was 1 m deep. A water conditioning system was completed in 1984. One of the three laboratory buildings on site was used in support of the CRSP project. It was equipped with the necessary instruments for performing chemical, biological, and physical analyses. There was also a small library and an office equipped with a computer.

Water Supply

Water for the station was supplied by gravity from a 4,000-m^2 reservoir, which itself was fed by irrigation canals originating at the Selguapa River. The wet lab area was supplied with water from an on-site well. Surface (canal) water was slightly alkaline, with a pH of approximately 8.0, a total alkalinity of about 30–43 mg l^{-1}, and a total hardness of about 23–31 mg l^{-1}.

Soils

The pond soils were predominately clays of volcanic origin. Although the clay content was high (62%), they were dominated by halloysite (a non-swelling clay mineral) and therefore quite permeable, and the ponds were susceptible to high rates of water loss due to seepage. Initial pH readings for the CRSP-operated ponds ranged from 5.5 to 6.3, and organic matter contents ranged from 0.8 to 3.7%. Free $CaCO_3$ was 0.3% or less in all ponds, and lime requirements ranged from 2,025 to 6,375 kg ha^{-1} (agricultural limestone). Soil phosphorus was 7 ppm or less in all ponds.

Support Facilities at Bogor

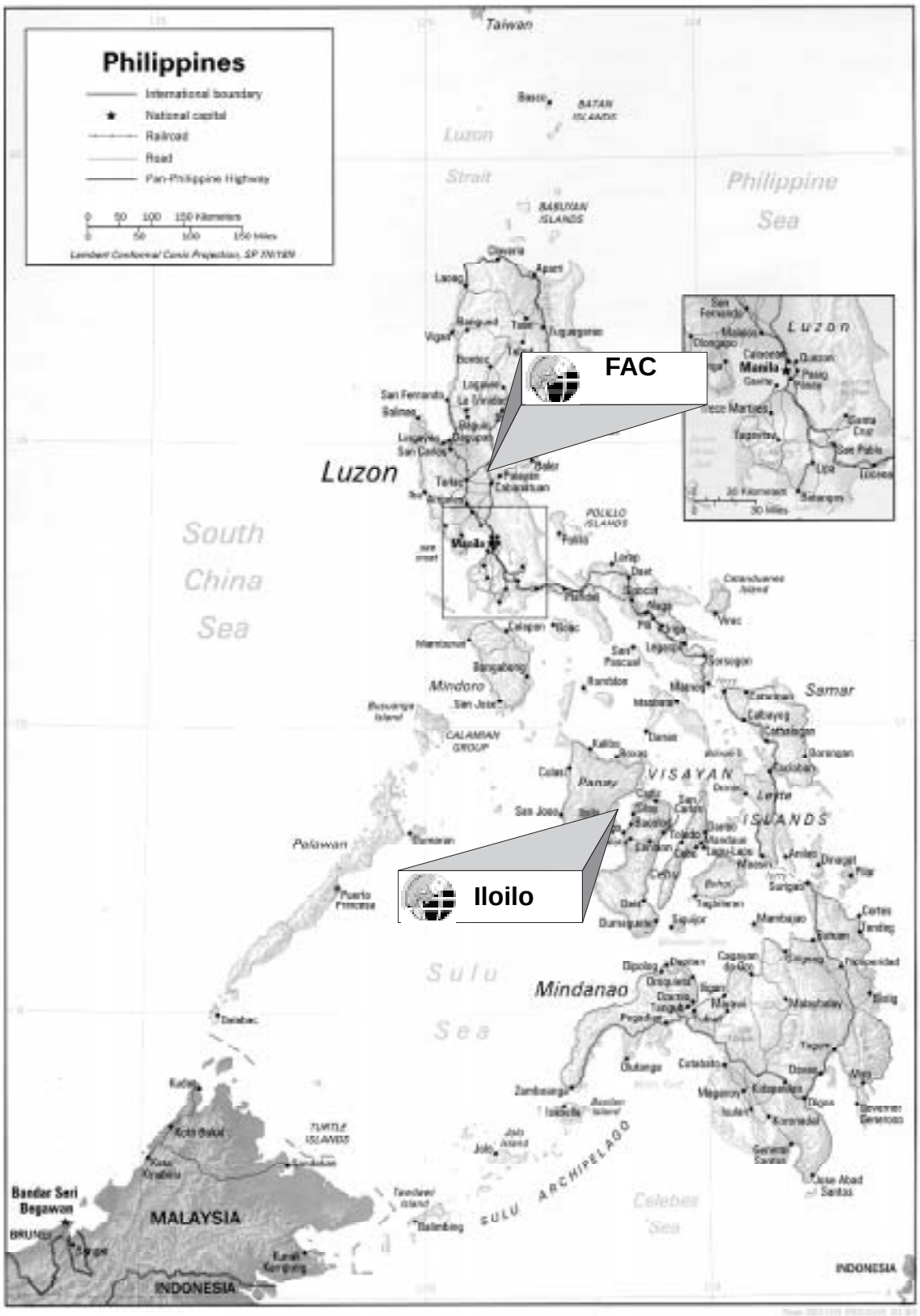
Members of the Faculty of Fisheries of the IPB conducted their research at the station and were available to interact with CRSP personnel. The services of the analytical laboratory of the Faculty of Soils at IPB were available for analyses of fertilizers and pond soils (particularly for lime requirements by the SMP method). The Soils Laboratory of the Ministry of Agriculture in Bogor was used for x-ray diffraction identification of clay minerals in the pond soils. Personnel of the Inland Fisheries Research Center (Ministry of Agriculture) and the National Institute of Biology, both in Bogor, were available for consultation.

Affiliations

In-Country	US
Department of Aquaculture Faculty of Fisheries Institute Pertanian Bogor (IPB) Jl. Raya Pajajaran Bogor, West Java INDONESIA	Department of Fisheries and Wildlife Michigan State University East Lansing, MI 48824 USA

Current Contacts

In-Country	US
Department of Aquaculture Faculty of Fisheries Institute Pertanian Bogor (IPB) Jl. Raya Pajajaran Bogor, West Java INDONESIA	Dr. Hillary Egna, Director Pond Dynamics/Aquaculture CRSP Oregon State University 400 Snell Hall Corvallis, OR 97331-1641 USA Tel: 541-737-6415 Fax: 541-737-3447 email: egnah@ucs.orst.edu


Philippines
International boundary
National capital
Railroad
Road
Pan-Philippine Highway
Taiwan
Luzon
Strait
Philippine Sea
BATAN ISLANDS
BABUYAN ISLANDS
FAC
Luzon
Manila
South China Sea
POLILLO ISLANDS
Mindoro
Samar
CALAMIAN GROUP
VISAYAN ISLANDS
Leyte
Panay
Palawan
Iloilo
Puerto Princesa
Sulu Sea
Mindanao
TURTLE ISLANDS
Bandar Seri Begawan
MALAYSIA
BRUNEI
INDONESIA
SULU ARCHIPELAGO
Celebes Sea
INDONESIA

FAC

The FAC has over 100 earthen ponds, some up to 2,500 m^2. CLSUs College of Fisheries shares FACs technical staff, facilities, and research responsibilities with CRSP researchers.

The FAC is located at Muñoz, Nueva Ecija, Luzon, in a vast, low-lying alluvial plain known as the "rice bowl" of the Philippines. Research here includes a considerable effort in the area of rice–fish systems.

Freshwater Aquaculture Center (FAC)
Central Luzon State University

Site Status: Companion Site 1992 to 1998; Prime Site 1998 to present

Location: Central Luzon State University, Muñoz, Nueva Ecija, PHILIPPINES

Caption/Description: FAC is located at the northeasternmost extension of Central Luzon State University (CLSU), 1.5 km from the main university campus. CLSU is 3.5 km northeast of the town of Muñoz, in the province of Nueva Ecija. Muñoz is approximately 150 km north of Manila and lies in the heart of the central valley of Luzon, which is the "rice bowl" of the Philippines.

Description of Area/Region

Climate

Köppen classification* **Aw***: *Humid tropical* group (A), *tropical wet-and-dry* type (w).

Temperatures

The average annual temperature in the province of Nueva Ecija is 27.8°C. In 1995 the maximum and minimum air temperatures at the FAC were 35.5 and 23.1°C, respectively.

Precipitation

Average annual rainfall in the province is about 2,250 mm. Most of the rainfall occurs between the months of May and October.

Humidity

Mean annual relative humidity is normally in the range of 74 to 78%. It is hot and dusty from March to May.

Seasonality

There are two distinct seasons in this part of the Philippines. The dry season begins in about December and lasts through April or May, and the rainy season begins in June and continues through November.

Topography

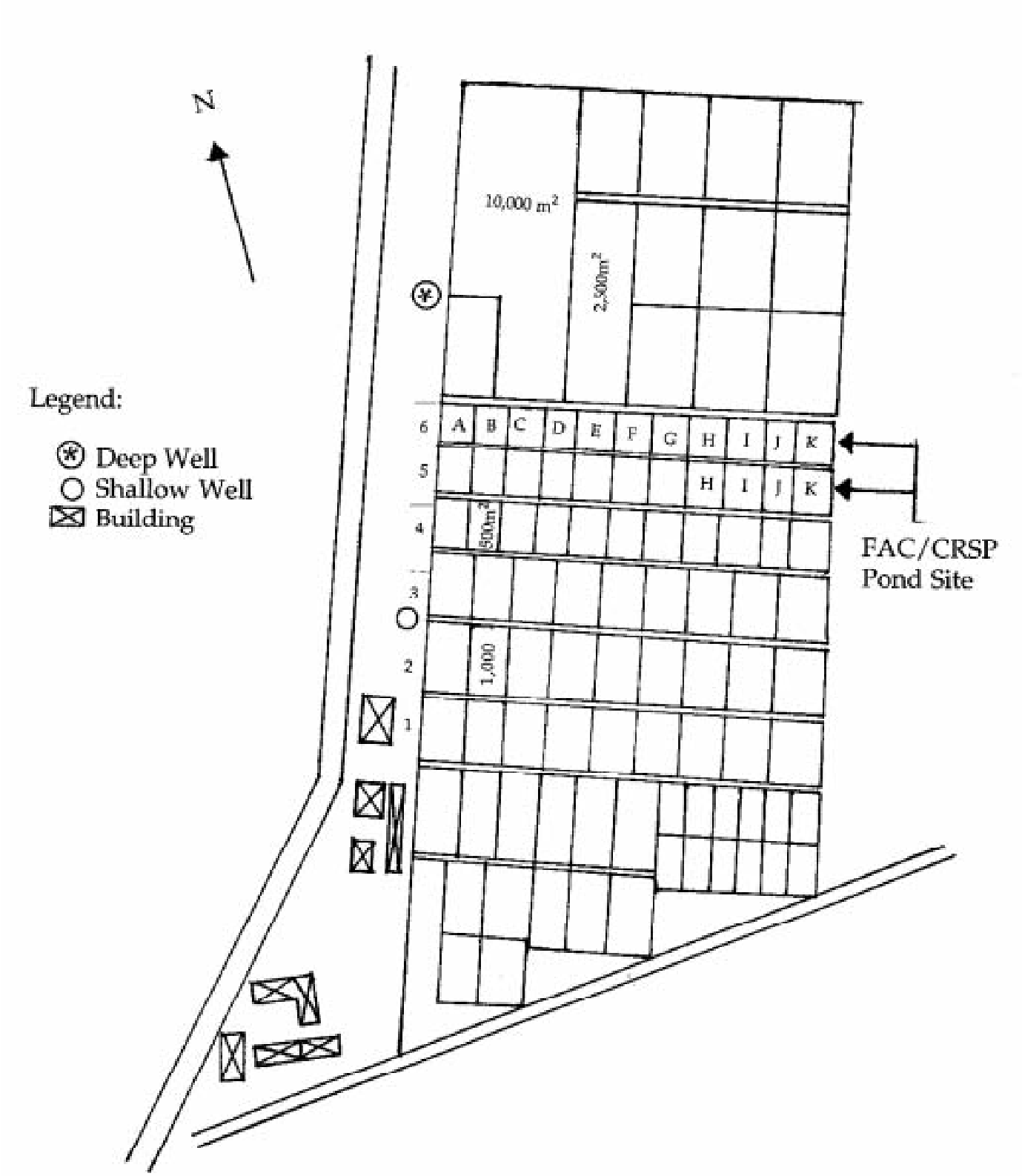
The central valley is a vast, relatively flat lowland that stretches approximately 150 km from Manila Bay in the south to the Lingayen Gulf on the western coast of Luzon. The elevation of most of this lowland area is less than 40 m. The Zambales Mountains flank the plain to the west, while the Sierra Madre range lies on its eastern side.

Geology and Soils

The Philippines archipelago is part of a major western Pacific seismic fault system. The entire region is characterized by active volcanoes (12 of them in the Philippines), and all of the Philippine islands are subject to occasional earthquakes. Many of the peaks of the rugged mountains that make up the Philippine islands are dormant or extinct volcanoes. Soils in the central valley of Luzon are largely alluvial, clayey, and alkaline.

* Asterisked items are defined or described in the glossary.

Layout of Freshwater Aquaculture Center



Description of FAC

Map Coordinates	Elevation
15°43'N and 120°54'E	30 m

General	Water Supply
FAC is a semi-autonomous unit in the University, loosely linked with the Research, Extension, and Training Unit (RET) of CLSU in its organizational and management structure, such that RET only monitors FACs activities. FAC is a separate unit parallel in status to the College of Fisheries (CF). At present the two units are sharing technical staff and facilities. The total work force is 60. The senior staff (12) devote half of their time to research at the Center and the other half to academic duties in the CF and Department of Aquaculture, Institute of Graduate Studies. Pond facilities include 98 earthen ponds ranging in size from 400 to 2,500 m^2. Twenty-four 500-m^2 ponds and a 2,500-m^2 pond are assigned to the CRSP research program. Additional ponds are being used by the University College of Swansea-FAC Project on "YY-GMT"; another 8 ha are used as ICLARM-BFAR-CLSU "GIFT" (Genetically Improved Farmed Tilapia) breeding facilities; and there is a rice-fish experimental area. There are numerous concrete and fiberglass tanks and a hatchery/wet lab building. The Center maintains laboratories equipped with facilities and equipment for fish physiology, soil and water quality analytical chemistry, fish pathology, fish nutrition, and feed development.	Water comes to the station through open canals from the 8,420-ha Pantabangan Reservoir, which is located about 30 km from the FAC. Two deep wells and six shallow wells provide additional water for the Center.

Soils

Pond soils at the FAC have very high clay contents, with an average of 62.5% for the ponds used in CRSP experiments. In 1993 the mean CEC* for the CRSP ponds was 38.8 meq per 100 g; exchangeable base measurements were 23.7, 14.5, and 1.1 meq per 100 g for Ca, Mg, and Na, respectively. The soils are alkaline, with base saturation* values of 100% and an average pH of 7.6.

* Asterisked items are defined or described in the glossary.

Support Facilities at FAC

The Center has about 10 PCs, including a dedicated CRSP computer with Internet and email capability. Eight to twelve local and international graduate students conduct their research at the FAC each year. Improved breeds of tilapias, carps, and catfishes, feeds and fertilizers, and labor for pond operation and maintenance are always readily available.

Affiliations

In-Country	US
Central Luzon State University Muñoz, Nueva Ecija PHILIPPINES	University of Hawaii at Manoa Kaneohe, HI USA

Current Contacts

In-Country	US
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Iloilo

Each pond at the Brackishwater Aquaculture Center in Iloilo, Philippines, was served by two water canals: one for filling by tidal flow and one for draining.

There were over 215 ponds, covering more than 18 ha, at the Brackishwater Aquaculture Center. Twenty-one 1,000-m^2 ponds were assigned to the CRSP research program.

Iloilo
Brackishwater Aquaculture Center, Iloilo, Philippines

Site Status: Former Prime Site, 1983 to 1987

Location: Brackishwater Aquaculture Center, Leganes, Iloilo, PHILIPPINES

Caption/Description: The Brackishwater Aquaculture Center (BAC) is 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 Province, 22 km northeast of the site of the University of the Philippines in the Visayas (UPV) in Iloilo City proper.

Description of Area/Region

Climate

Köppen classification* **Am***: *Humid tropical* group (A), *tropical rainforest* type (m). Short dry season.

Temperatures

Temperatures throughout the Philippines average around 26°C during the dry season (December to May), with the lowest average monthly temperatures (25.5°C) observed in January. The hottest average monthly temperatures (in May) are around 28°C. The average annual temperature in Leganes is 27°C. Average pond water temperatures at the BAC are between 24.9 and 33.5°C.

Precipitation

Average annual rainfall at the site of the BAC is 2,100 mm.

Humidity

Humidity ranges from 71% in the dry season (March) to 85% in the rainy season (September).

Seasonality

Climate is characterized by a long rainy and a short but distinct dry season. Heavy rains are experienced between May and October; between July and October these may include damaging typhoon-type storms. During the dry season—December through February—the lowland areas are generally hot and dusty although temperatures rarely exceed 37°C.

Topography

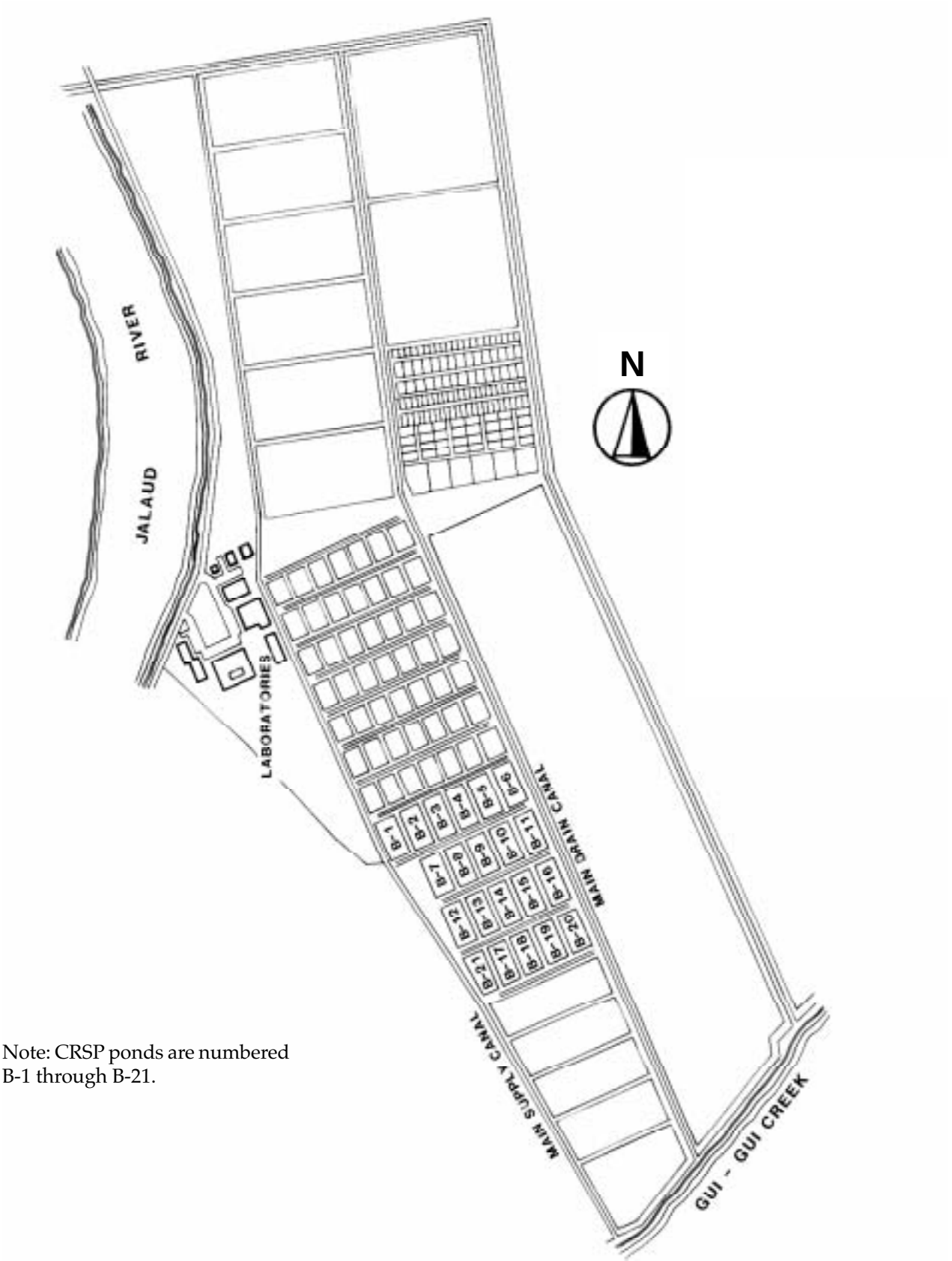
The BAC is located in a triangle of coastal flatland on the southern side of the Island of Panay. The town of Leganes lies between the Jaro and Jalaud rivers, which drain the higher-elevation areas to the north and northeast and empty into the Iloilo Strait east of Iloilo City. The Iloilo Strait separates the island of Iloilo from nearby smaller Guimaras Island and the larger Negros Island to the southeast. The Cordilleras Range, with its highest peaks at just over 2,000 m in elevation, flanks this valley area to the west, running north and south along the entire western side of Panay Island. Lower mountains and hills occupy the eastern point of Panay Island.

Geology and Soils

The Philippines archipelago is part of a major western Pacific seismic fault system, and all of the Philippine islands are subject to occasional earthquakes. In addition, the entire region is characterized by active volcanoes (12 of them in the Philippines), and many of its mountains are dormant or extinct volcanoes.

* Asterisked items are defined or described in the glossary.

Layout of Iloilo



Note: CRSP ponds are numbered B-1 through B-21.

Description of Iloilo

Map Coordinates	Elevation
10°45'N and 122°30'E	4 m

General	Water Supply
The BAC is one of three brackishwater sites at which the CRSP has collaborated. Pond facilities included 215 ponds with a water surface area of 18 ha. The 21 ponds assigned to the CRSP research program were 1,000 m^2 each. Site facilities included a comprehensive administrative building with offices, classrooms, conference room, library, radio room, chemistry labs, and a wet laboratory with aquaria and supplied with fresh and sea water and compressed air. Other facilities included 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 were over 60 permanent employees for research and administration and 21 faculty members from the College of Fisheries who participated actively in research and training at the BAC.	Each of the 215 ponds was served by two water canals, which allows independent filling and draining by tidal flow from Gui-gui Creek, Leganes. Water supplied to the ponds had a pH ranging from 7.05 to 9.72, alkalinity ranging from 51 to 194 mg l^{-1} (as $CaCO_3$), and salinity ranging from 6 to 37 ppt.

Soils

The BAC was constructed on acid-sulfate soils* typical of coastal areas. Because the dikes were very large relative to pond size, acidic runoff was a major problem during the early days of the station. After several years of use and treatment, the soils at the BAC had pH values ranging from 5.25 to 7.50 (dry) and levels of organic matter ranging from 1.34 to 4.52%. Aluminum levels were all low (< 0.100 ppm) but iron concentrations varied widely among ponds, ranging from a low of 36.5 ppm to a high of 2,469 ppm.

* Asterisked items are defined or described in the glossary.

Support Facilities at Iloilo

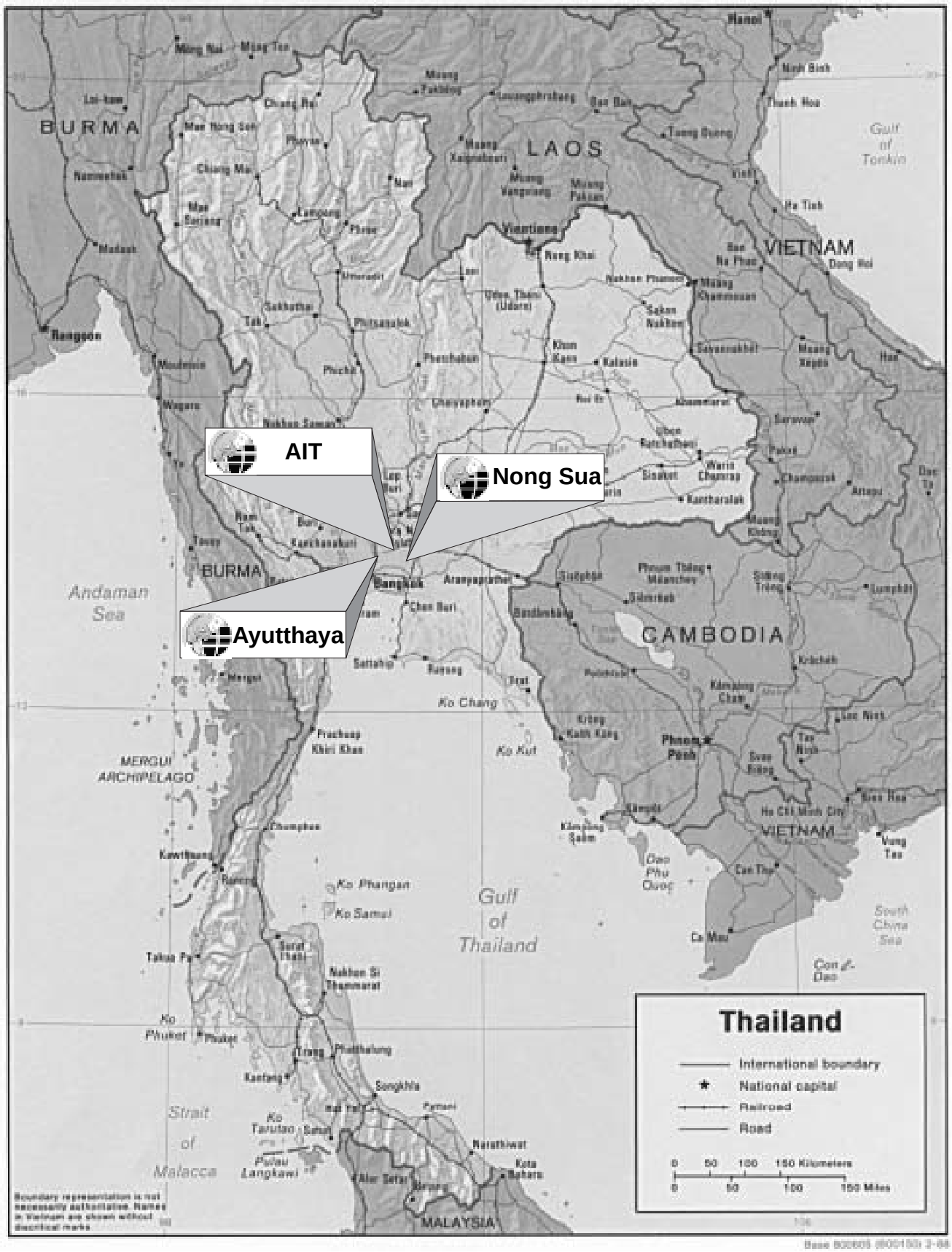
Those conducting research at the BAC included BAC staff, academic staff, and graduate students from UPV. Approximately 10 to 15 graduate students conducted thesis research at the BAC each year. Numerous commercial aquaculture operatives were located in the vicinity of the BAC. Feed and organic and inorganic fertilizers were readily available. Shrimp and prawn post-larvae could be obtained from both wild and hatchery sources. A variety of finfish fry, including tilapia, milkfish, and seabass were also available on a seasonal basis.

Affiliations

In-Country	US
College of Fisheries University of the Philippines in the Visayas Iloilo City, Iloilo PHILIPPINES	University of Hawaii at Manoa Hawaii Institute of Marine Biology Kaneohe, HI USA

Current Contacts

In-Country	US
The Dean College of Fisheries University of the Philippines in the Visayas P.O. Box 138 Iloilo City 5901 PHILIPPINES	Dr. Hillary Egna Pond Dynamics/Aquaculture CRSP Oregon State University 400 Snell Hall Corvallis, OR 97331-1641 USA Tel: 541-737-6415 Fax: 541-737-3447 email: egnah@ucs.orst.edu


AIT
Nong Sua
Ayutthaya
BURMA
LAOS
VIETNAM
CAMBODIA
Gulf of Thailand
Andaman Sea
Strait of Malacca
MALAYSIA
Thailand
International boundary
National capital
Railroad
Road

AIT

Earthen ponds used for CRSP research at the Asian Insitute of Technology (AIT) outside of Bangkok, Thailand.

Aquaculture research at the Asian Institute of Technology has also included work in the area of integrated aquaculture–agriculture systems, using pigs, buffaloes, ducks, vegetables, and goats in various combinations.

AIT
Asian Institute of Technology

Site Status: Active Prime Site, Southeast Asia; 1987 to present

Location: Km. 42, Klong Luang, Pathum Thani Province, THAILAND

Caption/Description: AIT is located near the town of Rangsit, in the southern portion of Thailand's central plain and approximately 40 km north of Bangkok.

Description of Area/Region

Climate

Köppen classification* **Aw***: *Humid tropical* group (A), *tropical wet-and-dry* type (w). Distinct dry and rainy seasons are observed.

Temperatures**

Annual averages for the area: 26.7–28.9°C
Range of monthly averages: 25.7–30.1°C
Absolute minimum temps: 5.0–12.2°C
Absolute maximum temps: 39.4–43.9°C

Precipitation**

5.1–269.2 mm per month and 1,092–1,600 mm annually; low month is January, with an average of 1 day of precipitation, and high month is September, with an average of 21 days of precipitation.

Humidity**

A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 64–76%.

Seasonality

All of Thailand has clearly defined wet and dry seasons, with little temperature variation throughout the year; the *rainy season* is from May to October, the *cool dry season* is from November to February, and the *hot dry season* is from March to May; the hottest month is generally April, and the coolest is January.

Topography

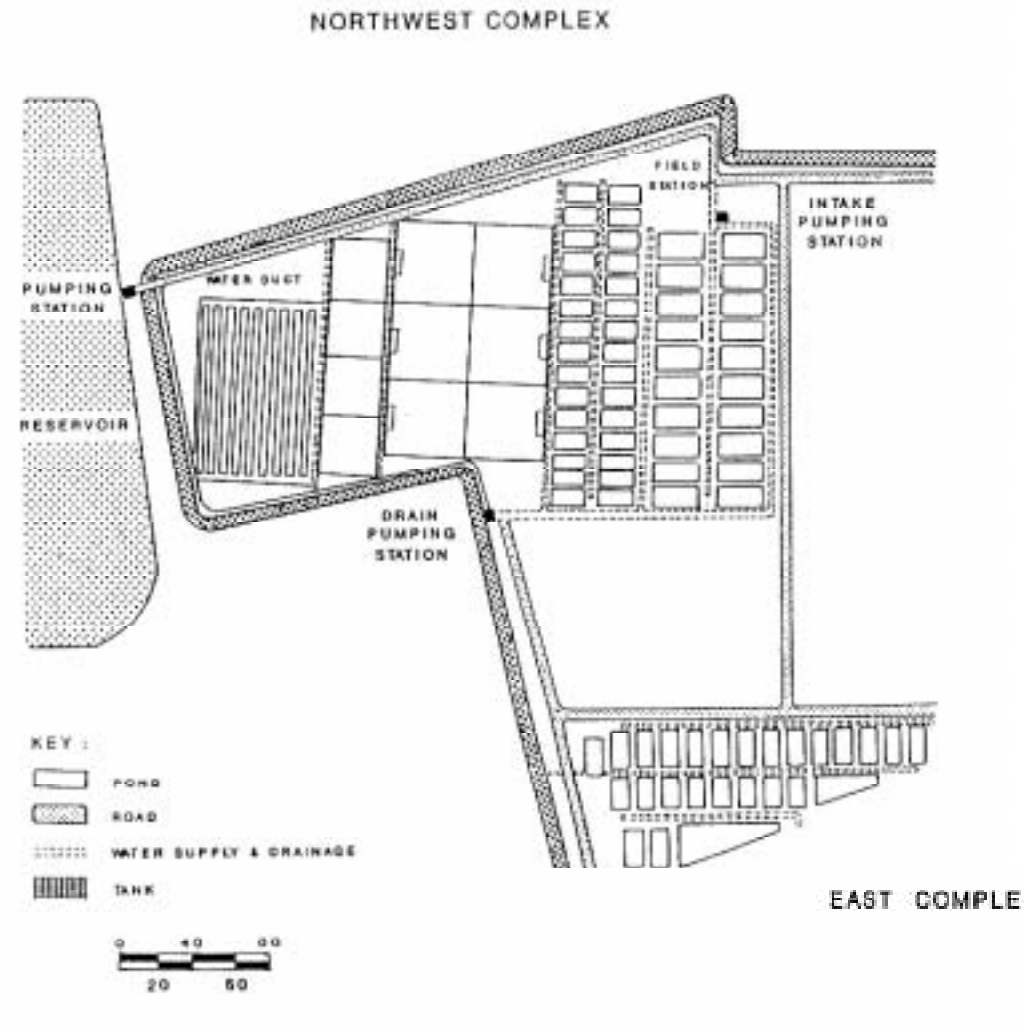
The area is part of Thailand's vast, nearly level central alluvial plain (the Chao Phraya Plain or Menam Plain). A slope of 1:10,000 results in an elevation of just 4 m at Ayutthaya, which is approximately 60 km inland from Bangkok, and 23 m at Paknampho, which is 241 km from the Gulf. Many canals crisscross the region, connecting the Chao Phraya and other rivers and providing communication links and irrigation. In the dry season tidal influences are clearly seen up to 80 km inland; in the rainy season flooding makes the area appear to be a single vast lake.

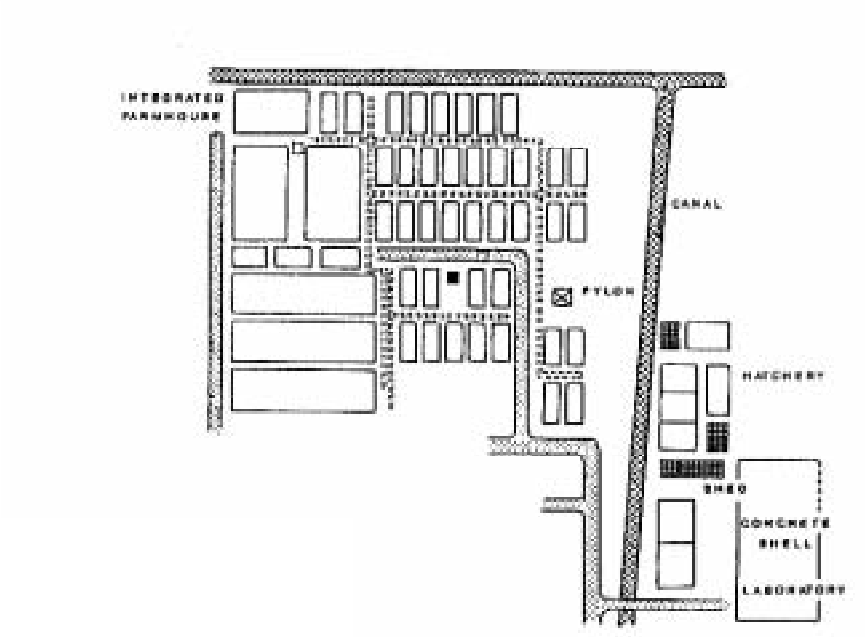
Geology and Soils

The central plain is in the basin of the Chao Phraya river and its tributaries. It was formed by the continual deposition of clays, silts, and sands by these rivers during annual flood periods, resulting in depths of alluvial material exceeding 100 m above bedrock in much of the area. The load of alluvial material carried by the Chao Phraya River has been estimated to extend the delta into the Gulf of Thailand by as much as 7 m annually. The plain is flanked in the north by the Uttaradit Mountains, in the west by the Bilauktaung Range (which forms the boundary with Burma), in the South by the Gulf of Thailand, and by the Khorat Plateau in the east. "Bangkok Dark Heavy Clay" soils are typical in the area around Rangsit and AIT. These soils have a developed profile to a depth of about 1.8 m, have nearly black surface layers, are typically low in organic matter, and are often saturated with groundwater.

* Asterisked items are defined or described in the glossary.
** Data are for Rangsit, from 1927 to 1955.

Layout of AIT





Description of AIT

Map Coordinates	Elevation
14°20'N and 100°35'E	5 m

General

The AIT campus occupies an area of approximately 160 ha near the town of Rangsit, north of Bangkok. AITs research pond complex is one of several aquacultural facilities operated by its *Agricultural and Food Engineering Division*. It includes about 150 earthen ponds, in sizes ranging from 200 to 2,000 m^2, a 5-ha reservoir, 120 concrete tanks, and an area for growing terrestrial crops that may be of interest as fish feed components. An adjacent area is used for rearing livestock (ducks and goats) that can be used in integrated aquaculture/agriculture research. Other facilities include a 500-m^2 laboratory complex that houses instruments for measurement of the biological, physical, and chemical parameters of importance in aquaculture, a covered fish feed preparation area, a fish harvest processing area, and a covered hatchery area. The hatchery facility includes 100 indoor rearing tanks and a water conditioning and recirculating system.

Water Supply

Supply water for the AIT pond complex comes from a rain-fed canal and reservoir. In 1995 the pH of this source was 7.3 and the total alkalinity was about 84 mg l^{-1}. Ammonia-N was 6.16 mg l^{-1}, and nitrate-nitrite was 0.01 mg l^{-1}. Reactive phosphorus was measured at 0.02 mg l^{-1}, and total phosphorus PO_4-P was 0.15 mg l^{-1}.

Soils

The pond soils at AIT (20 ponds) are quite acidic, with pH values averaging between 3.6 and 4.5. They have clay contents averaging 51% and organic matter contents averaging 1.08%.

Support Facilities at AIT

AIT has a close working relationship with the Royal Thai Department of Fisheries, NACA (Network of Aquacultural Centers in Asia Pacific), and Kasetsart University. In addition to opportunities for collaboration in research and facility sharing, an Internet database (FISHNET) on fish nutrition, aquatic animal health, and professional services in aquaculture is being initiated.

Affiliations

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Current Contacts

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Ayutthaya

Sampling of CRSP tilapia ponds at the Ayutthaya Freshwater Fisheries Station, which is located near the town of Bang Sai, near Ayutthaya, in the central plain of Thailand.

The Ayutthaya site, like those at AIT and Nong Sua, is located in the vast Chao Phraya Plain of central Thailand. Elevations throughout much of this area are so low that tidal influences are seen up to 80 km inland during the dry season.

Ayutthaya
Ayutthaya Freshwater Fisheries Station

Site Status: Active Prime Site, Southeast Asia; 1984 to present

Location: Ayutthaya Freshwater Fisheries Station, Bang Sai, Ayutthaya Province, THAILAND

Caption/Description: The Ayutthaya Freshwater Fisheries Station is located at Bang Sai, near the town of Ayutthaya in Thailand's central plain, and approximately 60 km north of Bangkok.

Description of Area/Region

Climate

Köppen classification* **Aw***: *Humid tropical* group (A), *tropical wet-and-dry* type (w). Distinct dry and rainy seasons are observed.

Temperatures**

Annual averages for the area: 26.7–28.9°C
Range of monthly averages: 25.7–30.1°C
Absolute minimum temps: 5.0–12.2°C
Absolute maximum temps: 39.4–43.9°C

Precipitation**

5.1–269.2 mm per month and 1,092–1,600 mm annually; low month is January, with an average of 1 day of precipitation, and high month is September, with an average of 21 days of precipitation.

Humidity**

A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 64–76%.

Seasonality

All of Thailand has clearly defined wet and dry seasons, with little temperature variation throughout the year; the *rainy season* is from May to October, the *cool dry season* is from November to February, and the *hot dry season* is from March to May; the hottest month is generally April, and the coolest is January.

Topography

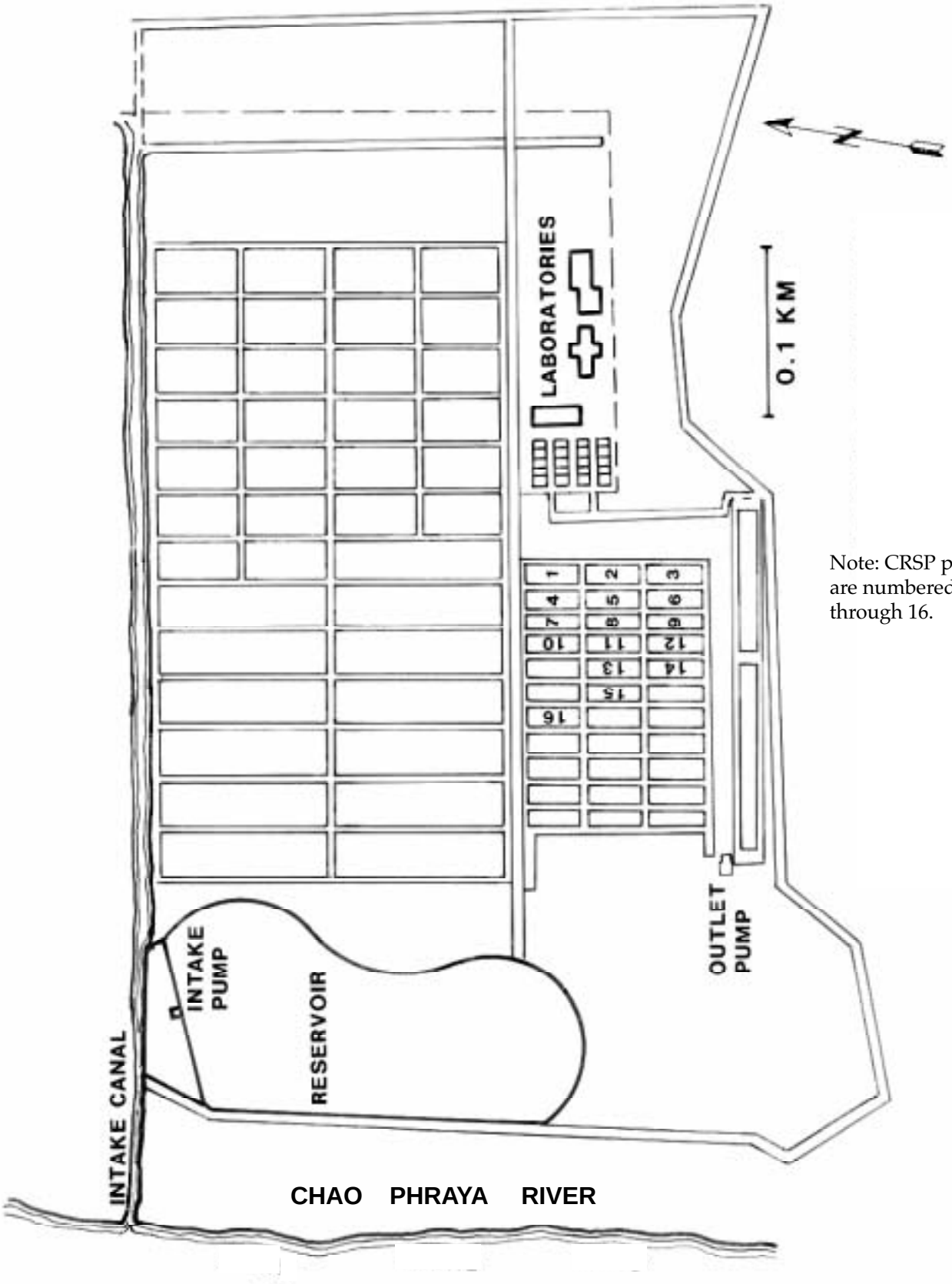
The area is part of Thailand's vast, nearly level central alluvial plain (the Chao Phraya Plain or Menam Plain). A slope of 1:10,000 results in an elevation of just 4 m at Ayutthaya, which is approximately 60 km inland from Bangkok, and 23 m at Paknampho, which is 241 km from the Gulf. Many canals crisscross the region, connecting the Chao Phraya and other rivers and providing communication links and irrigation. In the dry season tidal influences are clearly seen up to 80 km inland; in the rainy season flooding makes the area appear to be a single vast lake.

Geology and Soils

The central plain is in the basin of the Chao Phraya river and its tributaries. It was formed by the continual deposition of clays, silts, and sands by these rivers during annual flood periods, resulting in depths of alluvial material exceeding 100 m above bedrock in much of the area. The load of alluvial material carried by the Chao Phraya River has been estimated to extend the delta into the Gulf of Thailand by as much as 7 m annually. The plain is flanked in the north by the Uttaradit Mountains, in the west by the Bilauktaung Range (which forms the boundary with Burma), in the South by the Gulf of Thailand, and by the Khorat Plateau in the east. "Bangkok Dark Heavy Clay" soils are typical in the area around Rangsit and AIT. These soils have a developed profile to a depth of about 1.8 m, have nearly black surface layers, are typically low in organic matter, and are often saturated with groundwater.

* Asterisked items are defined or described in the glossary.
** Data are for Rangsit, from 1927 to 1955.

Layout of Ayutthaya



Note: CRSP ponds are numbered 1 through 16.

Description of Ayutthaya

Map Coordinates	Elevation
14°11'N and 100°30'E	5 m

General	Water Supply
The Ayutthaya station covers a total area of 32 ha, which includes an office building, laboratory, hatchery complex, a pumping station, 20 concrete ponds, 68 earthen ponds varying in size between 400 and 3,200 m^2, a 29,200-m^2 reservoir, and staff housing. Sixteen ponds, each approximately 245 m^2 in area, were available for CRSP research.	The water is pumped to the reservoir from which it is supplied to the ponds by gravity flow or pumping. Water supplied from the reservoir is alkaline, with a pH of about 8.6 and a total alkalinity of 92 mg l^{-1}. Ammonia is about 0.038 mg l^{-1}, nitrate-nitrite about 0.033 mg l^{-1}, total phosphorus about 0.05 mg l^{-1}, and orthophosphate less than 0.005 mg l^{-1}.

Soils

The soils at the Ayutthaya station have high clay and low sand contents. The clay fraction in ponds used by the CRSP averages about 66%, whereas the sand fraction averages about 11%. The soils are alkaline, with an average pH of 7.4, and have relatively high calcium and magnesium contents. They have relatively low organic matter contents, averaging around 0.75% in the CRSP-operated ponds.

Support Facilities at Ayutthaya

Laboratory and personnel at the National Inland Fisheries Institute (NIFI) and the Faculty of Fisheries at Kasetsart University are available to the CRSP project. NIFI has an adequate library, including FAO literature. Fish feeds are available through either commercial dealers or manufactured by NIFIs nutrition department. Organic fertilizers are abundantly available from local farms.

Affiliations

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Nong Sua
Nong Sua Fish Hatchery

Site Status: Former Prime Site, Southeast Asia; 1983 to 1984

Location: Nong Sua Fish Hatchery, Nong Sua, Pathum Thani Province, THAILAND

Caption/Description: The Nong Sua Fish Hatchery is located on the eastern edge of Thailand's Chao Phraya plain, near the village of Nong Sua, and approximately 100 km northeast of Bangkok.

Description of Area/Region

Climate

Köppen classification* **Aw***: *Humid tropical* group (A), *tropical wet-and-dry* type (w). Distinct dry and rainy seasons are observed.

Temperatures**	Precipitation**
Annual averages for the area: 26.7–28.9°C Range of monthly averages: 25.7–30.1°C Absolute minimum temps: 5.0–12.2°C Absolute maximum temps: 39.4–43.9°C	5.1–269.2 mm per month and 1,092–1,600 mm annually; low month is January, with an average of 1 day of precipitation, and high month is September, with an average of 21 days of precipitation.
Humidity**	**Seasonality**
A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 64–76%.	All of Thailand has clearly defined wet and dry seasons, with little temperature variation throughout the year; the *rainy season* is from May to October, the *cool dry season* is from November to February, and the *hot dry season* is from March to May; the hottest month is generally April, and the coolest is January.

Topography

The area is part of Thailand's vast, nearly level central alluvial plain (the Chao Phraya Plain or Menam Plain). A slope of 1:10,000 results in an elevation of just 4 m at Ayutthaya, which is approximately 60 km inland from Bangkok, and 23 m at Paknampho, which is 241 km from the Gulf. Many canals crisscross the region, connecting the Chao Phraya and other rivers and providing communication links and irrigation. In the dry season tidal influences are clearly seen up to 80 km inland; in the rainy season flooding makes the area appear to be a single vast lake.

Geology and Soils

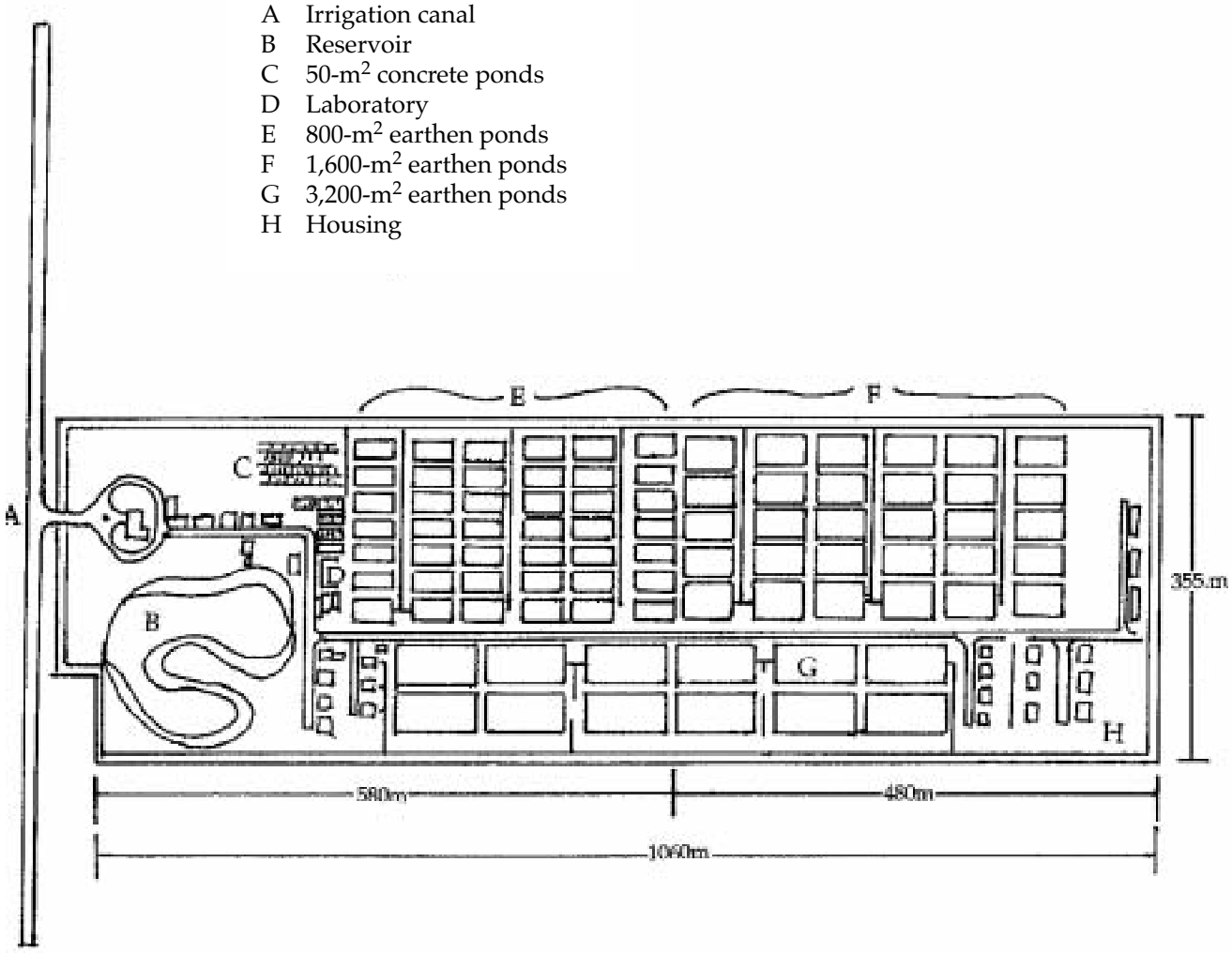
The central plain is in the basin of the Chao Phraya river and its tributaries. It was formed by the continual deposition of clays, silts, and sands by these rivers during annual flood periods, resulting in depths of alluvial material exceeding 100 m above bedrock in much of the area. The load of alluvial material carried by the Chao Phraya River has been estimated to extend the delta into the Gulf of Thailand by as much as 7 m annually. The plain is flanked in the north by the Uttaradit Mountains, in the west by the Bilauktaung Range (which forms the boundary with Burma), in the South by the Gulf of Thailand, and by the Khorat Plateau in the east. "Bangkok Dark Heavy Clay" soils are typical in the area around Rangsit and AIT. These soils have a developed profile to a depth of about 1.8 m, have nearly black surface layers, are typically low in organic matter, and are often saturated with groundwater.

* Asterisked items are defined or described in the glossary.
** Data are for Rangsit, from 1927 to 1955.

Layout of Nong Sua

Legend

A Irrigation canal
B Reservoir
C 50-m^2 concrete ponds
D Laboratory
E 800-m^2 earthen ponds
F 1,600-m^2 earthen ponds
G 3,200-m^2 earthen ponds
H Housing



Description of Nong Sua

Map Coordinates	Elevation
14°11'N and 100°54'E	5 m

General	Water Supply
The Nong Sua facility covered a total of 38 ha. Pond facilities included fifty 10-m^2 concrete ponds, thirty 50-m^2 concrete ponds, forty-two 800-m^2 earthen ponds, thirty 1,600-m^2 earthen ponds, twelve 3,000-m^2 earthen ponds, and a 14,500-m^2 reservoir. In addition to the ponds, there were an office building, 2 laboratories, 30 staff housing units, a water tower and treatment pond, a pumping station, and a storage building.	The water supply for the station was from the Krong Yai irrigation canal, which filled the station reservoir through a sluice gate. Water for the irrigation canal came from the Chao Phraya River. Fish ponds received water from the reservoir through a series of primary and secondary concrete inlets. The ponds could be filled by gravity flow when the reservoir water level was greater than 5 m. Pumping was occasionally required to fill the ponds. Water quality in the canal was adversely affected by large quantities of silt from the Chao Phraya, leachates from the acid sulfate soils of the area, and a variety of pesticides from nearby plantations. The oxygen content of the water was often low, particularly during the dry season, and nutrient levels were too low to be detected.

Soils
The soils at Nong Sua were typical acid-sulfate soils*, with pH readings averaging 4.1 for the 12 ponds used in CRSP research. The highly acidic nature of these soils was reflected in their lime requirements, which ranged between 16.6 to 21.05 tons ha^{-1} during the first CRSP experiments at Nong Sua. Aluminum concentrations in the soils were relatively high, averaging 1,131 ppm. The clay content of these soils was also very high, averaging close to 67%, and the sand content was correspondingly low, averaging just 9.8%.

* Asterisked items are defined or described in the glossary.

Support Facilities at Nong Sua

Excellent logistic and facility support was received by the CRSP project at Nong Sua. Almost all of the laboratories and personnel at the National Inland Fisheries Institute (NIFI) and the Faculty of Fisheries at Kasetsart University were accessible for the project. In addition, many laboratories of the Thai Department of Agriculture were located on the Kasetsart campus and available to the project on request. There was a moderate library facility at NIFI. Fish feeds were available either from commercial dealers or from NIFIs nutrition section. Both organic and inorganic fertilizers were readily available in the area.

Affiliations

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Glossary

Acid-sulfate soils: highly acidic soils (pH usually < 3.5) that derive their acidity from the presence of acid-forming minerals (e.g., sulfur compounds), rather than from simple exchange acidity; oxidation of the sulfur compounds (e.g., upon exposure to air and drying) produces sulfuric acid.

Af climate (Köppen system): climatic regime in which the average temperature of the coldest month of the year is 18°C or higher (A) and in which every month has 60 or more mm of precipitation (f).

Am climate (Köppen system): climatic regime in which the average temperature of the coldest month of the year is 18°C or higher (A) and which has a short dry season; precipitation in the driest month is less than 60 mm, but equal to or greater than [10 - (annual rainfall in cm/25)] (m).

Aw climate (Köppen system): climatic regime in which there are well-defined wet and dry seasons ("tropical wet-and-dry" climate); the average temperature of the coldest month of the year is 18°C or higher (A) and in which there is a well-defined dry season during the winter, with precipitation during the driest month is less than [10 - (annual rainfall in cm/25)] (w).

Base saturation (also sometimes referred to as Base Saturation Percentage): the portion (percentage) of the cation exchange capacity of a soil that is occupied by basic cations; the remainder is occupied by acidic cations and is referred to as the "base unsaturation."

Base unsaturation: the portion (percentage) of the cation exchange capacity of a soil that is occupied by acidic cations; the remainder is occupied by basic cations and is referred to as the "base saturation."

BWh climate (Trewartha system): dry, desert climate; hot, tropical-subtropical, and constantly dry. Potential evaporation exceeds precipitation, and the average annual temperature is not less than 18°C.

Cation exchange capacity (CEC): the capacity of a soil to adsorb cations; cations are adsorbed at exchange sites and can be released in exchange for other cations.

CEC: see cation exchange capacity.

Chinese carp: any of several cyprinid (family Cyprinidae) fishes originating from China, including the grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molotrix*), and bighead carp (*Aristichthys nobilis*).

Common carp: the species *Cyprinus carpio*.

Companion site: a secondary research site of the CRSP in a given geographic region; a limited program of research is supported by periodic visits by the US researcher stationed at a prime site.

GAw climate (Köppen-Trewartha system): Aw climate modified by effects of higher elevation (i.e., cooler temperatures) in low hills or mountains. In the case of high mountains, the modifier H is used instead of the G.

Guapote tigre: the species *Cichlasoma managuense*.

Inceptisols: in the Soil Taxonomy classification, soils in humid regions that are as yet poorly developed, e.g., with little accumulation of clay or iron or aluminum oxides; a cambric horizon (a subsurface layer that has been changed by physical movement or chemical reactions) is often present.

Köppen classification: the most commonly used system of classification of climates worldwide, based primarily on temperature and precipitation regimes; published first in 1901, the most commonly referred-to version, including maps, is the publication *Grundriss der Klimakunde*, published in Berlin in 1931.

Köppen-Trewartha classification: climatic classification system modified from the Köppen and Trewartha systems, as described by Willy Rudloff in *World Climates*, with tables of climatic data and practical suggestions, 1981.

Lateritic soils: tropical soils that contain a subsurface layer that is rich in iron and that becomes very hard upon exposure and drying and will not soften when re-wetted; the presence of iron often lends a distinctive red color to the soil.

Marais: swampy, moist valley floors and river flood plains (Rwanda).

Prime site: the primary research site of the CRSP in a given geographic region; a full research program is carried out at the site.

Tambaquí: the species *Colossoma macropomum*.

Tilapia: may include any of several species in the genus *Oreochromis*, the genus *Sarotherodon*, or the genus *Tilapia*; in PD/A CRSP usage, "tilapia" most commonly refers to the species *Oreochromis niloticus* (sometimes also classified as *Tilapia nilotica*).

Trewartha classification: a modification of the Köppen climate classification system by Glenn Trewartha (most recent publication is *An Introduction to Climate*, fifth edition, by Glenn Trewartha and Lyle Horn); like the Köppen system, this system is based mainly on temperature and precipitation patterns.

Ultisols: in the Soil Taxonomy classification, soils that have subsurface accumulations of clay but are low in bases (low base saturation); usually moist, but some are dry some of the time during the warm season; often high in 1:1 clay minerals such as kaolinite.