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LAKE NICARAGUA FISHERIES SURVEY

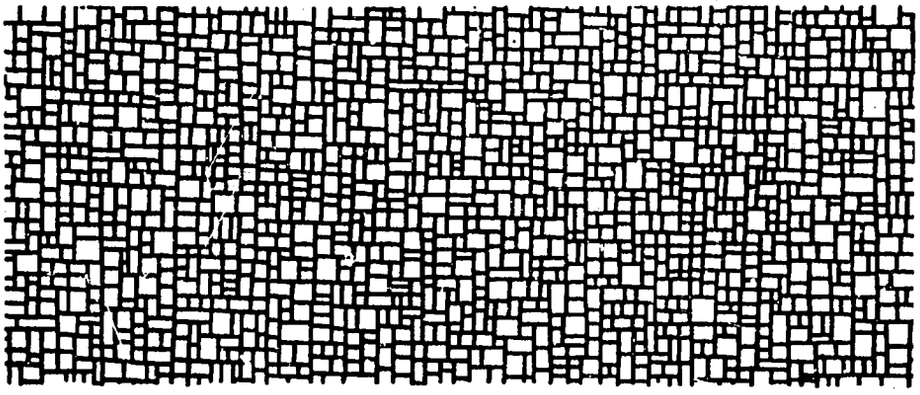
William D. Davies, et al

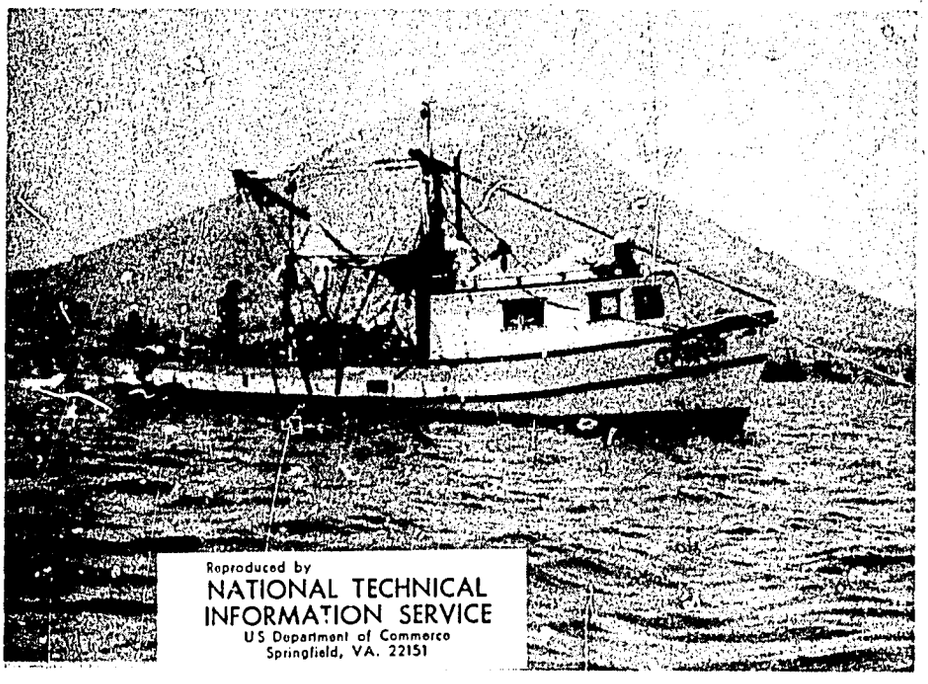
Auburn University

Prepared for:

Agency for International Development

15 June 1972





LAKE NICARAGUA FISHERIES SURVEY

BY WILLIAM D. DAVIES INTERNATIONAL CENTER FOR AQUACULTURE DEPARTMENT OF FISHERIES AND ALLIED AQUACULTURES AUBURN UNIVERSITY AUBURN, ALABAMA 36830 AND PHILIP C. PIERCE AGRICULTURE DIVISION, BUREAU OF EAST AFRICAN AFFAIRS AGENCY FOR INTERNATIONAL DEVELOPMENT U. S. DEPARTMENT OF STATE WASHINGTON, D. C. 20523

PROJECT: A.I.D./csd-2270

PUBLISHED: JUNE 15, 1972 DATE OF SURVEY: FEBRUARY 27-MARCH 17, 1972

BIBLIOGRAPHIC DATA SHEET	1. Report No. NU-639.21-D257	2.	3. Recipient's Accession No. AB 224 415
4. Title and Subtitle "Lake Nicaragua Fisheries Survey"			5. Report Date Jun 72
			6.
7. Author(s) William D. Davies, and Philip C. Pierce.			8. Performing Organization Rept. No.
9. Performing Organization Name and Address International Center for Aquaculture Auburn Univ. Auburn, Ala. 36830			10. Project/Task/Work Unit No. Proj. 931-11-180-787
			11. Contract/Grant No. AID/csd-2270-211(d)
12. Sponsoring Organization Name and Address Department of State Agency for International Development Washington, D.C. 20523			13. Type of Report & Period Covered
			14.

15. Supplementary Notes

16. Abstracts

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3. Experimental fishing survey (five days) on the research vessel GASPAR, Lake Nicaragua

4. Aerial survey of Lake Nicaragua.

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17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group 639

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 55
	20. Security Class (This Page UNCLASSIFIED	22. Price $3.50

FORM NTIS-35 (REV. 3-72) USCOMM-DC 14952-P72

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Published: June 15, 1972
Date of Survey: February 27 - March 17, 1972

Acknowledgements

Significant contributions to the successful completion of this survey were made by: Ing. A. Zepeda, Lic. Sergio Martinez, and Sr. Rodolfo-Jarquin of the National Development Institute of Nicaragua (INFONAC); Mr. R. W. Ellis, fishery biologist, Food and Agriculture Organization of the United Nations; Messrs. K. Koenig, T. H. Enersen, G. Fleming, and R. Beatty, U. S. Peace Corps Volunteers associated with the Lake Nicaragua Program.

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1.0 RECOMMENDATIONS

1.01 In order to develop an effective Development Program for Lake Nicaragua, the government must provide funds to expand the personnel assigned to this project. Present personnel in INFONAC are: a Director, an Administrator, and a Biologist. Little meaningful progress, regardless of the planning, can be achieved by such low-level staffing. Technical assistance by personnel from A.I.D., FAO, or the U. S. Peace Corps can only be effective if it is providing on-the-job training for Nicaraguan personnel.

1.02 Expansion of the fisheries of Lake Nicaragua depends primarily upon having markets for the catch. Present consumption of fish in Nicaragua is estimated at 2.18 kg (4.8 lbs) per capita, and reasons for the low consumption are not definitely known. A marketing survey should be made to determine whether the consumption rate is due to comparative prices of fish and other meat products, to insufficient quantities available on local markets, to poor quality of the fish when they reach the market, or to consumer preference for other foods.

Major expansion of the demand for fish on local markets depends upon the answers to these questions and their solution. Also, the possibility of export markets for surplus fish should be determined, along with the quality control standards and facilities that would be needed for high quality export fishery products. Host-country personnel needed for the above marketing studies are a minimum of 1 marketing specialist, 1 biologist, and 3 technical assistants.

Assistance in planning the studies and surveys should be provided in the host country by short-term visits of marketing specialists and/or short-term training (3 months) of the personnel abroad.

1.03 The fisheries on the east coast of the lake are handicapped by the distance from market, lack of refrigerative storage and transportation facilities, and lack of facilities and expertise in production of high quality dried fish. The marketing study should include investigation of these problems, and estimates of the cost and benefits of providing adequate facilities, and training in processing and transportation of high quality fishery products to market.

1.04 The potential for expanding the sawfish and shark fishery of Lake Nicaragua appears limited. However, the fishery for guapote, mojarra, and gar basically represents an untapped resource which only requires the stimulus of assured markets for development. It is strongly suggested, therefore, that any investigational program formulated for Lake Nicaragua include a study of present and future demands for these fish, and alternate ways of meeting these demands.

1.05 The investigational program for Lake Nicaragua should include accurate assessment of: 1) numbers of fishermen, full-time and part-time; 2) amount of fishing effort; 3) fishing methods, including cost and life of fishing gear; 4) species and size composition of the catch; 5) major fishing grounds; 6) seasonal fishing effort with relationship to weather conditions such as wind and rain; 7) existing methods of processing the catch for

market; and, 8) cost and price data for the more important food fishes with information on the seasonal variation.

1.06 Gear development studies should be conducted with costs and effectiveness of new gear compared to that of the traditional fishing methods.

1.07 If the Nicaraguan Government considers the program of sufficient importance to increase materially the personnel assigned to the study, it is recommended for the Lake Nicaragua Project that A. I. D. provide one fisheries advisor for a period of four years. He should be experienced in lake survey techniques, fishing gear, and fish population dynamics; in addition, he should have general knowledge in the areas of fish marketing and economics. The fisheries advisor will provide on-the-job training for counterpart personnel of the host country and coordinate work activities of U. S. Peace Corps Volunteers assigned to the fisheries project.

1.08 In addition to the senior fisheries advisor, the services of at least two U. S. Peace Corps Biologists, fluent in Spanish and with training in freshwater fisheries, should be requested for a four-year period. The PCV's will assist local counterparts in the investigational program for Lake Nicaragua.

1.09 Participant training abroad should be provided for a minimum of two host-country personnel for a 2-year period. Study tours should be scheduled so that both participants are not out of the country at the same time in order that they may acquire significant on-the-job training

experience under the guidance of the professional fisheries advisor.

Graduate study should be at a university that offers a good program in fisherv biology and lake management. A 2-year period will be required to complete an advanced degree program (Master of Science).

1.10 A program to promote the culture of freshwater shrimp is not recommended until research has solved most of the difficulties in rearing the shrimp past the critical larval stages and to commercial size. However, a survey should be made to determine the species and maximum size of freshwater shrimp in Nicaragua. The marketing personnel could obtain the specimens from local fishermen as part of their duties.

1.11 The construction of experimental earthen ponds on the 5,000-square meter site at Granada cannot be recommended because the soil in that area contains a moderate amount of sand and seepage likely would be high, requiring frequent and expensive pumping to maintain water levels.

In lieu of earthen ponds, it is suggested that a number of large plastic pools (swimming pool type) be installed at this site for use in investigating growth of freshwater shrimp and for certain other biological studies. The pools should be installed so that each can be filled and drained individually. Water supply system for the pools should include both well-water and water from the lake. A layer of soil, taken from the bottom of the lake, 100 to 150 mm (4 to 6 inches) deep should be placed in each plastic pool prior to utilizing pools for experimentation.

1.12 Pen cultures cannot be recommended for the west side of the lake due to extreme wave action in the lake and water level variation amounting to 3 to 4 meters annually. Under these conditions, it would be difficult and expensive to construct and maintain pens in Lake Nicaragua.

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2.0 INTRODUCTION

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1. Present employment is with U. S. Corps of Engineers.

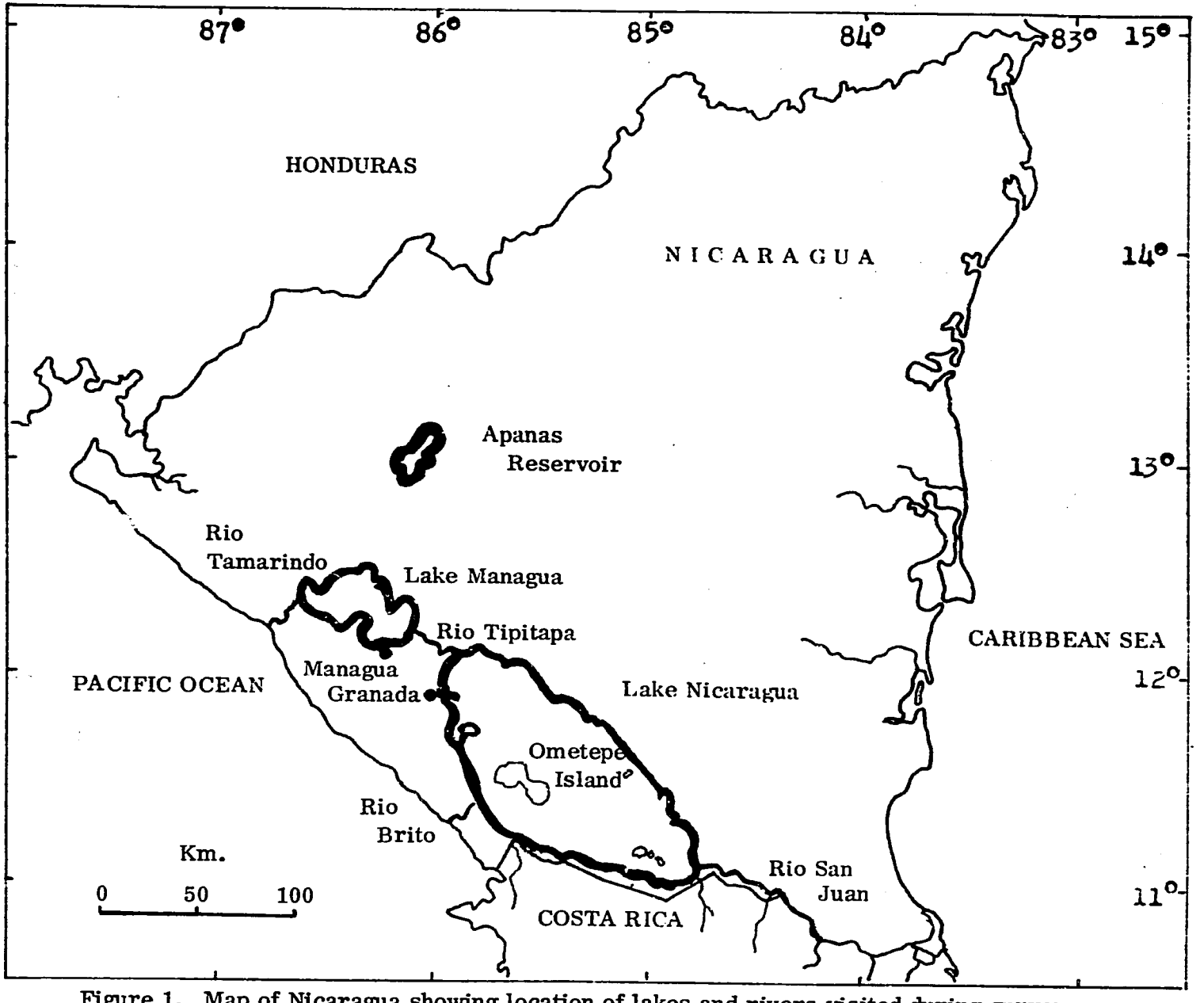

Figure 1. Map of Nicaragua showing location of lakes and rivers visited during survey.

3. Experimental fishing survey (five days) on the research vessel GASPAR, Lake Nicaragua.

4. Aerial survey of Lake Nicaragua.

5. Trip to Apanas Reservoir to observe the fishery and a fishing cooperative.

6. Trips to several coastal streams to assess the relative abundance of freshwater shrimp.

3.0 GEOGRAPHY AND CLIMATE

Nicaragua, the largest of the Central American Republics with an area of 130,018 square kilometers (50,200 square miles), lies between the Caribbean Sea and the Pacific Ocean. It is bordered by Honduras on the north and Costa Rica on the south. The eastern lowlands adjacent to the Caribbean, comprising over one-half of the total area of the country, are densely forested and sparsely populated. In this area, rainfall is high--averaging 3,750 mm (150 inches) annually. The western plains on the Pacific side are densely populated and make up the country's most important agricultural region. Here, rainfall averages 2,000 mm (80 inches) per year. The central highlands extends to mountainous regions in the north.

The climate is hot and humid averaging 29 C (84 F) at sea level and approximately 21 C (70 F) at higher elevations. There is a pronounced dry season extending from early November to March.

4.0 POPULATION, NUTRITION, AND FISH CONSUMPTION

Population in Nicaragua was estimated at 1.9 million in 1969, giving this country the second lowest population density of any country in the Central American region--98 inhabitants per square kilometer (38 per square mile). On the other hand, the annual growth rate of 3.5 per cent is one of the highest in Central America and, in fact, the world.

Average per capita calory intake was estimated at 2,190 from 1959-61, and at 2,550 in 1962. The total protein available per capita in 1962 was 64.1 grams, of which 28.7 grams or 44.7 per cent were animal proteins (FAO, 1968). Of the animal proteins only 2 grams or 7 per cent were from fish. The average diet appears at present adequate in both calories and proteins. Since the population in increasing annually at 3.5 per cent, it will be necessary for an annual increase of 3.5 per cent in production of food crops to maintain the present level.

Government statistics indicate a relatively low consumption of fish products. For example, the annual per capita consumption of beef is about 14 kg (30 lbs) compared to only 2.18 kg (4.8 lbs) of fish. Freshwater fish accounted for only 23 per cent of the total amount of fish consumed. The following table gives the annual per capita consumption and source of fish products in Nicaragua in 1967.

Source of Product	Per Capita Consumption	
	kilograms	pounds
Artisanal sea fishery	1.15	2.53
Industrial sea fishery	0.09	0.20
Artisanal freshwater fishery	0.51	1.13
Shrimp fishery	0.06	0.15
Lobster fishery	----	0.01
Imported fish products	0.37	0.82
TOTALS	2.18	4.84

Unfortunately statistics were not available over a period of years to document consumer preference trends. However, it appears that per capita consumption of fish products has stabilized (as has the consumption of chicken and pork), while consumption of beef has increased.

Fish are sold by the pound in the supermarkets, but fishermen and local markets sell fish by the string, or by the piece in the case of gar, Lepisosteus tropicus. A "pinae" is a string of fresh fish, usually guapote (mainly Cichlasoma managuense, C. dovi, or C. friedrichstahli) or mojarra (Cichlasoma citrinellum and C. nicaraguense), that has as few as two fish when the demand is high, or as many as eight when the demand is low or the fish extremely small. A "pinae" containing four to six fish weighs approximately 0.7 kg (1.5 lbs).

During this survey the price of fish in supermarkets was 1.50 to 2.00 cordovas[1] ($0.21 to 0.28) per pound for sawfish filets and for whole guapote and red snapper. In local markets, "pinaes" of fish were selling for 2.00 to 5.00 cordovas ($0.28 to 0.70) depending upon the time of day; and dried gar was selling

1. Rate of exchange: 1 cordova = $0.14 U.S.

for 1.00 to 5.00 cordovas ($0.14 to 0.70) depending upon the size of the piece. In contrast, prices for poultry and ground beef were 2.90 and 4.90 cordovas ($0.41 and 0.68) per pound, respectively. It should be noted that the price of fish is highest just prior to the Easter Holiday season.

Fishermen selling their fish to middlemen appeared to be receiving a fair price as there was relatively little markup in the market price. For example, fishermen were receiving approximately 45.00 cordovas per dozen for dried gar weighing about 18 pounds ($0.34/lb). These fish would not usually sell for more than 60.00 cordovas ($0.41/lb) in the market.

The annual catch of fish in Nicaragua is given by FAO (1970) as follows:

Year	Metric Tons	Annual Per Cent Increase in Catch
1966	6,000	
1967	6,500	8.3
1968	6,900	6.1
1969	7,200	4.3
1970	7,500	4.1
Average	6,820	

5.0 GOVERNMENT DIVISIONS RESPONSIBLE FOR FISHERIES

In Nicaragua, three governmental agencies are involved in fisheries. The Ministry of Economy is principally responsible for the regulation of commercial fishing, the Ministry of Agriculture has jurisdiction over conservation of marine resources, while the National Development Institute (Instituto de Fomento Nacional or INFONAC) has a division (Division de Pesca) that is concerned with the

development of the fishing industry. INFONAC is the governmental agency that is highly interested in the potential of Lake Nicaragua in terms of development of a viable fishing industry. It would be desirable for these three divisions to set up a committee to coordinate their respective activities in the conservation, development, and management of the inland and marine fisheries, or to reorganize it under one division that is responsible for all phases of fisheries.

6.0 FISHERIES RESOURCES OF NICARAGUA

6.01 Water Resources

The Republic of Nicaragua has abundant freshwater resources compared to other Central American countries. Lake Managua with a surface area of 1,295 km^2 (319,995 acres) and a maximum depth of 30 m (98 ft) and Lake Nicaragua with a surface area of 7,700 km^2 (1,902,670 acres) and a maximum depth of 60 m (197 ft) lie in a central basin bounded by highlands and the Pacific Ocean on the west and the Mosquito Coast and Caribbean Sea on the east. These two great lakes are connected by the Rio Tipitapa. Lake Nicaragua flows into the Caribbean Sea through the Rio San Juan.

Various physical and chemical characteristics of these lakes directly influence the fisheries. Lake Managua receives untreated sewage from the city of Managua (population 300,000). As a result, local inhabitants consider the lake to be polluted and the fish not good to eat. At times large fish kills occur in the lake that are believed to be caused by subsurface volcanism. It may also be caused by upwelling of bottom waters containing insufficient oxygen to support fish.

Both Lake Managua and Lake Nicaragua are affected by strong winds, especially during the months from January to May. These winds generally blow from east to west causing any thermal stratification to disappear. Bottom sediments become suspended and this, coupled with the usually high plankton production, causes a low transparency. These winds also make transportation difficult for the few vessels that operate on the lakes. Small fishing vessels, less than 5 m (16 ft) in length, can operate only in protected areas during this time of year.

Other freshwater resources of Nicaragua include numerous crater lakes that differ widely in their characteristics. Lake Apoyo attains a maximum depth of 110 m (361 ft) and is extremely clear, while Lake Nejapa is at times less than 1 m (3.28 ft) in depth and has a low transparency.

The Apanas Reservoir, 3,686 ha (9,216 acres) is the only large impoundment in Nicaragua. It lies in the eastern central portion of the country and is approximately 100 km (62 miles) north of Lake Managua.

The fishery of this reservoir was determined from interviews with local fishermen during this survey. The commercial fish catch consists solely of guapote, which the fishermen take by hook and line using small pieces of fish for bait, although occasionally artificial lures are utilized. Beginning at 6:00 AM daily, the fishermen go out in the canoes and fish for bait using worms, and then proceed to the fishing grounds along the edge of water hyacinths in water three to 10 m (10 to 30 ft) deep. Hand lines rather than poles are used.

There are approximately 100 fishermen currently fishing Apanas Reservoir and of these, 30 belong to a fishing cooperative. Each evening the members of the cooperative bring or send their daily catch to the cooperative's headquarters which is located near the southwest end of the reservoir. The daily catch of each fisherman is recorded and then tallied every Saturday when the fishermen are paid approximately $0.10 per pound of fish. Records indicated that the average catch per fisherman per week was approximately 14.4 kg (30 lbs) and was worth approximately $3.00.

This does not reflect the fish that the fishermen keep for their own consumption. Of the 30 members, 10 own stock in the cooperative and the remaining 20 sell fish to the stockholders only. The ten members who own stock clean the daily catch "Tipitata" style (gutted and backbone removed) and place them in a freezer. Twice weekly the catch is taken to Managua where the fish are sold to restaurants, supermarkets, and occasionally the military. It was reported that the cooperative delivered approximately 500 kg (1,100 lbs) of fish to Managua each week regardless of the season and that the price of approximately $0.25 per pound remained fairly stable for the fish dressed "Tipitata" style. Adequate cold storage facilities are available at the lake and the fish are transported to Managua in a refrigerated van where they sell at a higher price than fish of poorer quality coming from Lake Nicaragua by way of Granada.

The reservoir is not overfished at the present time and indications are that the cooperative could sell more fish. There is a program being considered which proposes to control aquatic weeds of the reservoir, and this program could either improve or impair the fishing in Apanas Reservoir.[1]

Coastal streams in Nicaragua are abundant. Those flowing into the Caribbean meander and are slow flowing, while those flowing into the Pacific are swift, due to a much steeper gradient. Most streams appear to be relatively free of domestic and industrial pollution; however, those few streams that transverse the cotton-growing areas are thought to receive considerable amounts of pesticides.

6.02 Distribution of Fishes

Surprising little information is available concerning the fish species found in Nicaragua. This is especially true for Lake Nicaragua, which for some time was thought to support landlocked populations of marine fishes (two elasmobranchs and the Atlantic tarpon). These were later found to be migrants from the ocean. Recent studies on the lake include those by Thorson (1964, 1970, and 1971) which describe the biology and movements of the bull shark, Carcharhinus leucas, and to some extent the sawfishes, Pristis perotteti and P. pectinatus. These fish were found in considerable numbers in experimental gill netting by Hagberg (1968) in the Granada area of Lake Nicaragua.

A list of species found in the lake is presented in Appendix 1. Of these, only the shark, sawfishes, tarpon, snook, gar, guapote, and mojarra are considered to be of commercial importance.

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1. Control of aquatic weeds in Apanas Reservoir is discussed in detail by a memorandum from Philip C. Pierce directed to Carl D. Koone, Rural Development Officer, U.S.A.I.D. Mission to Nicaragua, dated May 5, 1972.

6.03 Fishing Activities

Lake Managua and Lake Nicaragua at present support a relatively small number of full-time fishermen (fishermen fishing more than 50 per cent of the time). It appears that the small commercial catch from Lake Managua does not reach the local markets of Granada and Managua. Lake Nicaragua, with approximately 600 fishermen harvesting approximately one million pounds of fish per year, supplies these markets with the majority of freshwater fish sold.

The majority of fishermen usually fish only during the dry season, November to March. It is during this time that the catch has a market value of two to three times as much as at other times of the year. Consequently, many fishermen tenant farm during the months of April to October and fish occasionally only for their own consumption.

6.04 Freshwater Shrimp Fishery

Freshwater shrimp can be caught in many of the streams flowing into the Pacific. At present this fishery is confined to the few areas where roads are available to local markets. A similar situation probably exists along the Atlantic coast, but there is no evidence for this. Fishing effort appears to be concentrated on the Rios Tamarindo and Brito. Although the number of fishermen participating in this fishery is probably not great, those interviewed indicated they needed to fish only one or two days per week to satisfy local restaurant demands. Using various types of gear, cast nets or small gigs, fishermen were able to harvest between 30 and 60 pounds per day (live weight) during the dry season. At other times of the year, high water made fishing difficult. A higher yield is likely possible fror

the streams now being fished. However, since so few streams are involved, maximum sustained yield probably would not be of sufficient magnitude to warrant development of export markets.

7.0 LAKE NICARAGUA

7.01 Lake Characteristics

Lake Nicaragua is oval shaped and measures 135 km (84 mi) long by 70 km (43 mi) wide, its long side running northwest to southeast. The lake's basin can be described as "saucer shaped" having a bottom comprised principally of mud and sand with an occasional small outcropping of rocks. The lake is further characterized by the presence of three large islands (Ometepe, Zapatera, and Mancarron), and numerous small islands. Ometepe Island is composed of two active volcanoes, Ometepe and Maderas. Depth sounding data indicate that Lake Nicaragua is rather shallow with an average depth of 17 m (56 ft). The deepest area of the lake is near the southeastern shore of Ometepe Island,where a depth of 60 m (197 ft) has been recorded.

The water level of the lake fluctuates approximately three to four m (10 to 13 ft) each year, the lowest and highest levels occurring in April and October, respectively. The prevailing easterly winds during the dry season commonly reach velocities of 20 knots (23 mi/hr). Therefore, most of the western shore of the lake (from Las Cocoas in the north to Colon in the south) consists of wave-swept, debris-strewn, gray, sandy beaches. Exceptions to this are areas protected by large near-shore islands and peninsulas, and where rivers and streams parallel the shore before entering the lake.

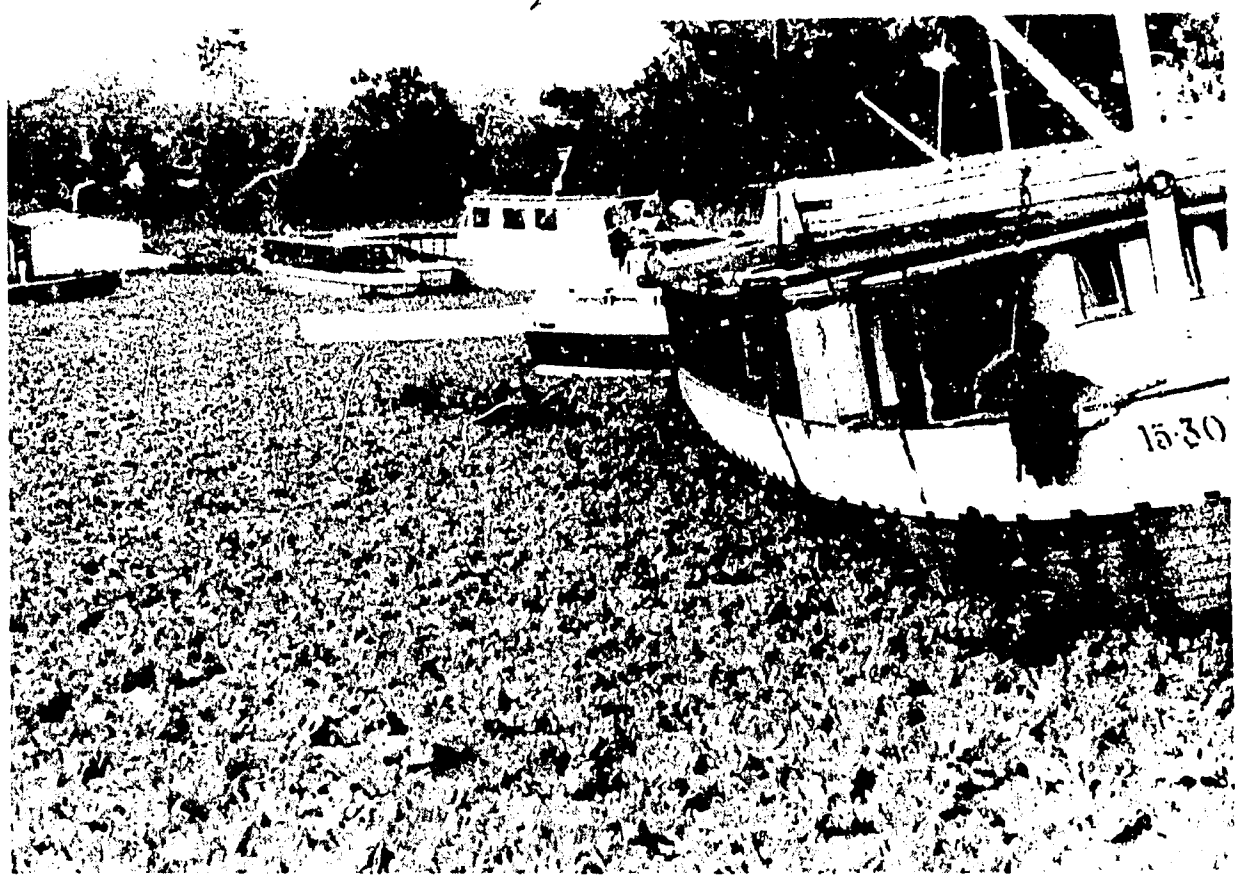
On the wind-protected eastern side of Lake Nicaragua much of the shoreline is covered with flooded dead bushes, and aquatic plants. Apparently these bushes became established approximately seven years ago when a drought caused the water level to remain below normal for a long period. Most of the aquatic plants observed were water hyacinth (Eichhornia crassipes) and water lettuce (Pistia stratiotes). These species are particularly abundant at the mouth of rivers and streams entering the lake and often form extensive floating plant islands. These islands are commonly colonized by a variety of other plant species, many of which are not truly aquatic, but they are able to grow due to the support of dense growths of hyacinth and water lettuce.

An aerial survey conducted during this study indicated that an estimated 60 per cent of the eastern shoreline contains flooded bushes and aquatic plant growth, and that virtually all of the lake shore is "weedy" along the 60 km (37 mi) of shoreline between Colon and San Carlos.

The water of Lake Nicaragua has a low transparency--less than 0.5 m (1.6 ft) at the time of this survey. However, in or near the mouth of the rivers entering the lake, the water is much clearer, at least during the dry season. The turbid condition of the lake proper is attributed to soil colloids and other particulate matter kept in suspension by high winds, and to high plankton production.

7.02 Status of Lake Nicaragua's Fishing Industry

Data collected during this survey indicated that the number of full-time fishermen has not increased appreciably over the past several years. However, it is likely that if the demand for fish increases, a number of the present part-time



Figures 2 and 3. View of a secluded bay area on Lake Nicaragua following a tropical storm which concentrated a large quantity of the floating aquatic plant, Pistia stratiotes. Below is a close up photograph of an individual water lettuce plant.

fishermen may increase their effort to full-time in the future. Also, indications are strong that the fish catch from this lake could be at least doubled by the existing fishermen population using the same gear if market conditions were such to encourage greater fishing effort.

Furthermore, the lake's overall fisheries resources are far from being exploited to their maximum. If the estimated current annual harvest of 45,455 kg (one million pounds) is accurate, the lake is yielding only 0.56 kg/ha (0.5 lb/acre), which amounts to approximately 50 per cent of freshwater fish consumed. Apparently, the current fish catch does not approach the lake's potential, with the possible exception of the catch of sawfishes and sharks.

7.021 Sawfish and Shark Fishery

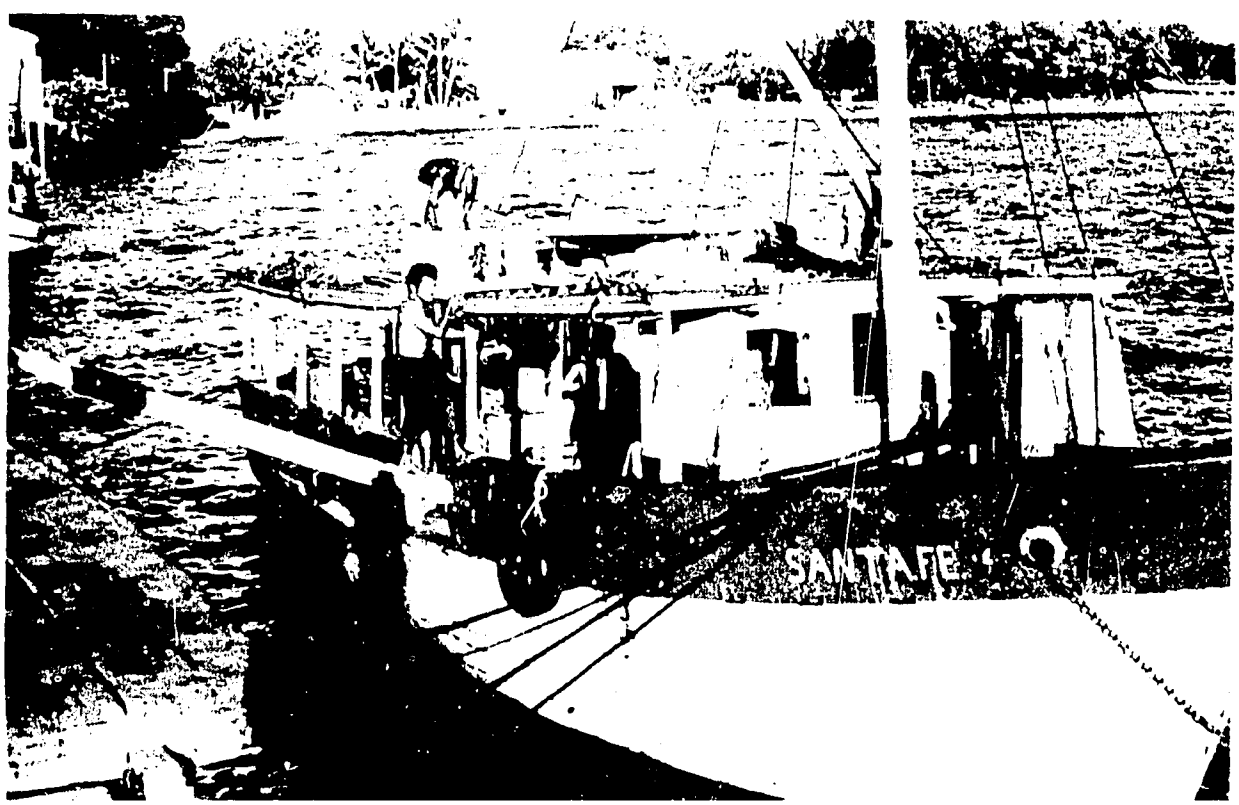
Even though it is reported that sawfish and shark have always made up a significant portion of Lake Nicaragua's fish catch, it has only been in the past three years that a substantial increase in this fishery has occurred. The principal reason for this increase is due to the establishment of a fish processing plant located in Granada. This firm, COPESCA, is owned and managed by Enrique Sandino. The plant has a cold storage capacity of 13,636 kg (30,000 lbs) and a freezing capacity of 909 kg (2,000 lbs) per day. To assure a steady flow of sawfish the company has contracted with approximately 50 fishermen in the San Carlos area. Some of the fishermen are provided with gill nets and/or boats and outboard motors. The fishermen are paid $0.05 to 0.07/lb for dressed meat. Also, the company provides cold boxes and ice to groups of fishermen for storing their catch until it is picked up by the company's transport boat. The company has two

transport boats that are utilized alternately to deliver ice and pickup the fishermen's catch at San Carlos. Generally, both boats make one complete trip every five or six days. The two boats have a combined cold storage capacity of 8,409 kg (18,000 lbs). However, the amount of fish (mostly sawfish filets) delivered to the processing plant each week has seldom exceeded 2,275 kg (5,000 lbs).

Although sawfish is the company's current interest, it has begun processing guapote, gaspar, and mojarra with the hope of expanding it's operation. The guapote and mojarra, as well as the sawfish and shark, are usually sold fresh-frozen to local supermarkets. The sawfish and shark meat is usually sold packaged in 1-lb plastic bags, whereas, guapote and mojarra are sold whole (gutted). The gaspar are dried and sold locally and some have been exported to Guatemala City and Guadamola on occasion.

Even though some sawfish and shark are caught more or less throughout the lake, most of the current effort is now near San Carlos where the lake flows into the San Juan River. This trend has increased each year since the sawfish fishery was intensified three years ago. There are some indications that this fishery may be overexploited: 1) the fishing effort has consistently moved closer and closer to where these marine species must enter or leave the lake; and, 2) the high number of tag returns recovered (reported to be approaching 40 per cent). Each tag is worth approximately $3.00 to the fishermen when returned, but it is believed that many tags are never turned in because the fishermen discard or lose them before they learn the tags are worth money, or they hold onto the tags not knowing where to return them.

Figures 4 and 5. The principal commercial fishery in Lake Nicaragua is shark and sawfish for which fishermen receive approximately $0.05/lb for dressed fish. Commercial transport boats (as shown below) collect transport, and process these fish into filets which sell in local markets in Managua for approximately $0.25/lb.



In addition, these fish are known to move in and out of the lake and it is not known how many of the tagged fish have remained in the lake. If all of them have remained, 40 per cent (not counting those tags captured but not returned) may not indicate excessive cropping. But, if even 25 per cent of the tagged fish left the lake, or were not reported, the 40 per cent tag return would represent a higher harvest rate. Based on the limited amount of data gathered during this survey, the sawfish catch may be higher than desirable for sustained yields. The data available on the sawfish fishery should be compiled to determine if there are definite indications that these fish are already being over harvested. It is known that sawfish and sharks, particularly sharks, are being fished heavily at the mouth of the San Juan River in Costa Rica. There are indications that this fishery is having an impact on the upstream movement of sharks. The manager of a sport fishing camp (Tarpon Camp), located approximately halfway between the lake and the Caribbean Sea, indicated that in the past few years fishermen have not had any problems with sharks attacking tarpon as the latter were being landed, whereas formerly this had been a problem.

It should also be mentioned that dried fins and tails of the sawfish and shark bring a premium export price and there are indications that a large number of these fishes are harvested each year for their fins and tails alone. Regulations should be promulgated and enforced to prevent this wasteful practice.

The nets used by the sawfish and shark fishermen are made by the fishermen themselves or locally. The mesh size most commonly used is 150 to 250 mm (6 to 10 inch) stretched mesh. This range will take both sawfish and shark, and occasionally

tarpon. The net is made out of almost any heavy cord available, but those observed during this survey were constructed of several different kinds of binding twines that the fishermen had obtained as scrap from a local industry. The nets are usually only about 1.5- to 2.5-m (5- to 8-feet) deep, but they may be several hundred meters in length. They are fished on the bottom in water ranging from 3- to 12-m (10- to 40-feet) deep.

The boats used are larger than the 3- to 5-m (10- to 16-feet) boats utilized close to shore by guapote, gaspar, and mojarra fishermen. The fishermen lift their nets each morning before the winds come up. The sawfish does not normally fight until his rostrum is lifted out of the water. Therefore, the fishermen slowly lift the nets until the entangled fish's rostrum is near the surface of the water and then strike the fish with a heavy object on the end of the fish's rostrum, where the main sensory organ is located. This immediately immobilizes the fish making it easy and safe to handle. The fish is then lifted over the side of the boat where the rostrum is chopped off near the head. To safeguard against losing the fish and to facilitate loading, a rope is often tied through the gill slits.

After unloading the fish on shore, they are dressed by first removing the fins and tails, followed by two large filets (skinned) down each side of the spinal cord. The carcasses are left on the beach and the filets, tails and fins are taken to the fishermen's home at which time they are processed further or marketed fresh. If the meat of the shark or the sawfish is to be dried, it is cut up, salted, and hung out to dry in the sun.

The fishermen may leave their nets in the same place for several weeks, depending upon fish catch. If they are fishing primarily for sawfish, it is not necessary to run nets every day. Since only the rostrum of this species becomes entangled in the nets, it can live for several days without severe injury. Sharks, however, must be processed immediately as they die quickly after being netted.

7.022 Guapote, Mojarra, and Gaspar Fishery

Whereas expansion of the sawfish fishery is limited, the fishery for guapote, mojarra, and gaspar represents an untapped resource which only awaits the stimulus of assured markets for development. For example, the eastern shore is yielding what has been roughly computed to be less than one pound per acre. This is an extremely low average figure and probably a higher rate of cropping is taking place in local areas. However, most tropical waters are capable of substantially greater yields, considerably in excess of 10 kg/ha (9 lbs/A). Other evidence that greater yields are possible was gathered during the survey by fishing a monofilament gill net 30.5 m (100 ft) in length, 1.2 m (4 ft) in depth, 75-mm (3-inch) stretch mesh, and a twine size of 0.3 mm (0.012 inch) in diameter. This sampling indicated a population of mojarra dominated by senile fish. Usually fish of this condition would not readily be found in even a moderately-fished stock.

Should market demands increase, there is good reason to believe that the fishery could be rapidly expanded by investments in improved gear, particularly monofilament nets and vessels capable of extending the range of the fishermen, and refrigeration facilities for storage and transport to insure fish of good quality when they reach the market.

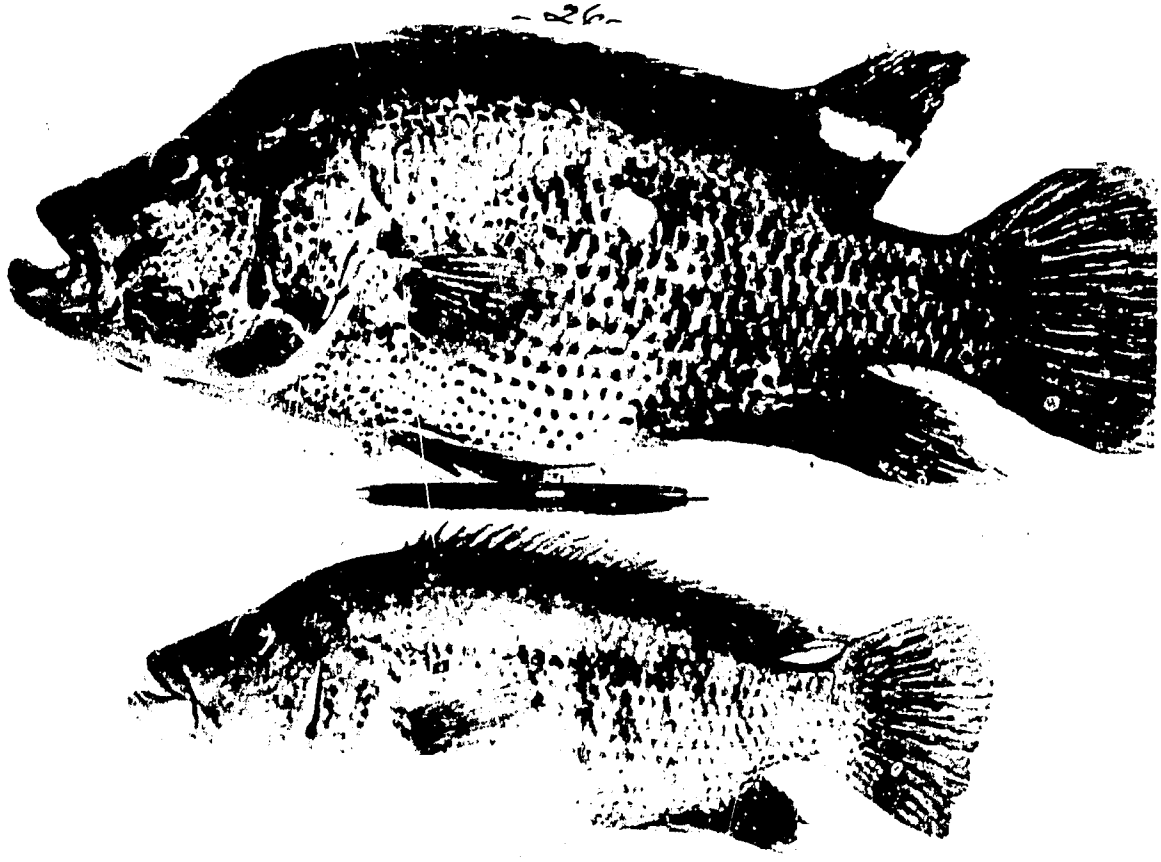
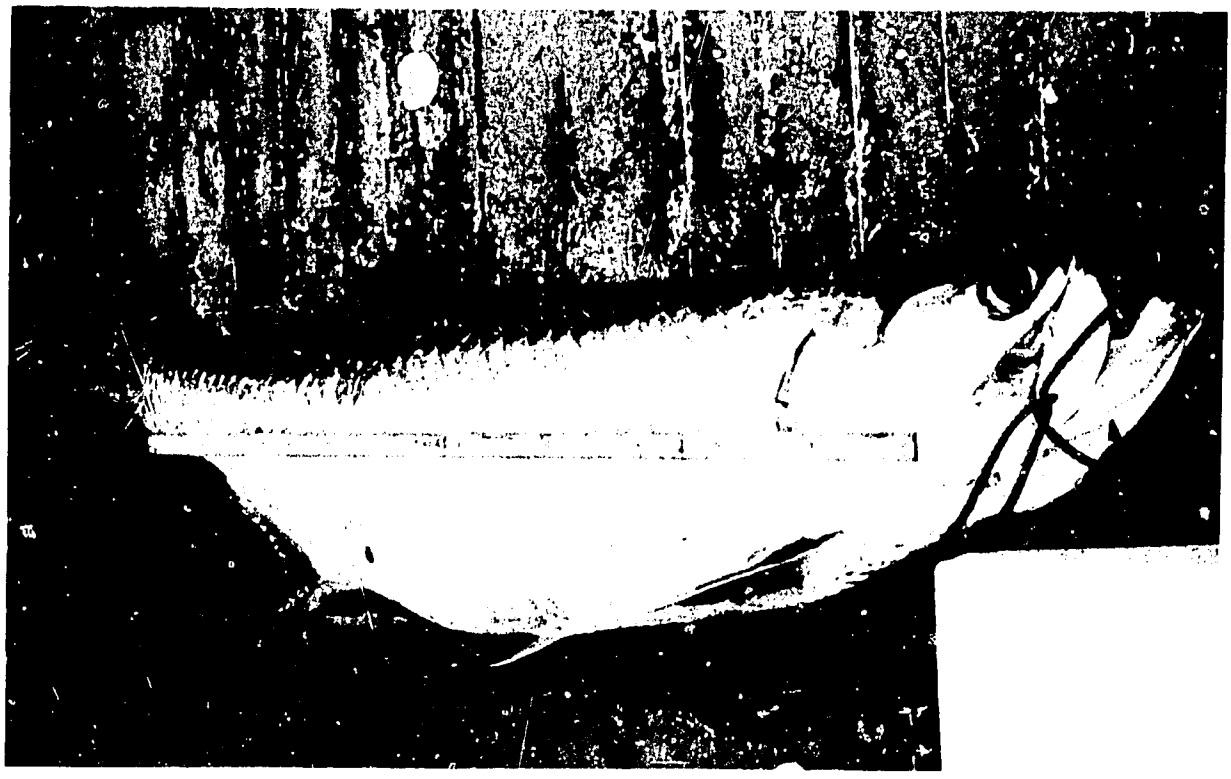


Figure 6. Two freshwater fish species, Cichlasoma managuense (above) and C. friedrichstahli (below), locally called the guapote, make up an important segment of the food fish fishery of Lake Nicargua. The present low yield of approximately one-half lb/A/year for Lake Nicaragua could be greatly increased.

Figure 7. The tarpon, Megalops atlantica, shown below is over 1 m in length. This species occurs in Lake Nicaragua and with the snook, Centropomus parallelus, provides a potential sport fishery that may be of considerable importance.



The preferred habitat for these species appears to be in and around the aquatic weed beds of Lake Nicaragua. However, some guapote and mojarra are also found among rocks. Apparently, the very large gaspar move off-shore and return to the shallows to spawn during the rainy season. However, little effort is made by the local fishermen to catch these fish off-shore.

The gill-net fishery for guapote, gar, and mojarra is essentially a family enterprise. One family may have from one to three canoes and fish two nets per canoe. The nets, constructed from cotton or nylon multifiliament twine, are usually 18 m (60 ft) to 30.5 m (100 ft) long, 0.9 m (3 ft) to 1.2 m (4 ft) deep, and have a mesh size (stretch measurement) of 75 to 125 mm (3 to 5 inches). Nets of this type cost the fisherman approximately 100 cordovas ($15.00) for nylon and 35 cordovas ($5.00) for cotton. Floats are whittled from wood, and weights are made of fired clay. The majority of fishermen indicated a preference for nylon, but because nylon costs more, cotton nets are still used.

Although most of the guapote, mojarra, and gaspar are taken with gill nets, some are caught by hook and line, particularly in the rocky areas such as the islands around Granada. The guapote and mojarra fishery around the Isles of Granada is unique in that these fish are usually caught by women and children who use small fish and worms as bait. Their catch is kept alive in liveboxes in the lake until there are enough fish to take to market in Granada where the fish are sold fresh.

Based on the numbers of fresh fish observed in the local market in Granada on two separate occasions during this survey, the catch from the Isle of Granada must account for several hundred pounds each day.

The west side of the lake has much less fish production potential than the wind-protected, shallow, and weedy eastern shore. These weedy areas are apparently prime habitats for gaspar, guapote, and mojarra since most of the fishing effort is there. Gill nets are the most common type of fishing gear used but some fishermen also use hooks and harpoons. The latter being primarily used for taking gaspar.

Most of the canoes used in this fishery consist of wooden dugouts. These normally cost between $40 and $50 if purchased already made, and approximately $20 to $25 if the fisherman makes it himself. Larger log canoes will cost as much as $100.

Fishing in the weedy areas is done mainly in the early morning hours starting at 1:00 to 2:00 AM. Fishermen set shallow nets along the edge of weed beds and then, using poles and paddles, strike the weed beds and water in an attempt to drive the fish into the nets. The net is then immediately picked up, the fish removed, and set again in another area where the procedure is repeated. Interviews with a number of fishermen indicated that as many as nine such sets could be made in one night. The fishermen normally return home by mid-morning at which time the catch is cleaned, processed, and marketed.

During the dry season these shallow, weedy areas become quite clear. Therefore, it is very likely that the fish can easily see the heavy twines that the

Figure 8. Photograph of the Isletas de Granada where mojarra and guapote are caught with hook and line and sold fresh in Granada and Managua. Usually there is at least one family living on each of the islands.

Figure 9. Typical fishing canoe under construction at Lake Nicaragua. Depending upon size, canoes cost between $40 and $100.

fishermen use in making the gill nets. This may be the reason why the fishermen have chosen to "drive the fish into nets" rather than leave nets unattended overnight.

Because the fishing area on the eastern side of the lake is far from the principal markets on the west, almost all of the fish catch is sold in the salt-dried form. This is fine for the gaspar, which according to fishermen and consumers alike, is not eaten in the fresh form. But it is not suitable for the guapote and mojarra since their quality is much poorer in the dried form than in the fresh form. Therefore, if any effort or investment is going to be made to increase the utilization of these two species at Lake Nicaragua, economic means must be developed to deliver them to the markets in a fresh state. One possible way to do this would be to have the fishermen hold these fish alive in liveboxes, as is currently done in the Granada area, and then deliver them fresh to the nearest port to rendevous with a lake transport rigged to haul fresh fish. Another possibility would be to establish cold storage facilities at the major port cities where the fishermen could sell their fish directly. Due to a rural electrification program that is currently underway, it should not be long until most of these port cities will be provided with electricity.

For the dried gaspar there is another problem. Because many of the local inhabitants cannot afford refrigeration, the fish must either be cooked and consumed soon after purchase or it must be dried so that it will keep for at least a reasonable length of time without spoiling. The traditional method of "fast" drying is impossible during the rainy season as the resulting product is either over-salted or nearly spoiled by the time it is sold.

The poor quality of dried fish during the wet season is probably one reason why the demand is low at this period.

The low demand results in a low price and therefore discourages the fishermen to put much effort into fishing. This is unfortunate since gaspar fishing is reported to be much better during the rainy season than it is during the dry season. Smoking is out of the question since wood is usually scarce and too costly to use in smoking fish. Therefore, if gaspar are to be marketed in quantity and be of good quality during the wet season, economic methods for drying or smoking must be developed. Mr. Sandino, owner and manager of COPESCA in Granada, proposed to buy gaspar filets from fishermen in the San Carlos area and dry them in the new drying oven at the processing plant. This dryer has a capacity of 682 kg per day (1,500 lbs), but currently the company only dries 182 kg/day (400 lbs) and this only during the Holy Season when the market for dried fish is greatest. Mr. Sandino feels, however, that there is a potential export market for dried gaspar. He stated that representatives from Puerto Rico have advised him that they will buy all of the dried gaspar that Lake Nicaragua can produce. This is interesting since these fish seem to be abundant in Lake Nicaragua. Therefore, should this Puerto Rican market develop, it would probably be economical to invest in establishing centrally located lake-side driers, or facilities to haul the fresh filets to the processing plant in Granada.

Figure 10. This fisherman's morning's catch (mainly guapote) is being cleaned and and fileted at lakeside prior to being marketed. Improved facilities for dressing, refrigeration, and transport would result in a much improved quality of fish in the markets.

7.023 Sport Fishing

Some sport fishing is done at the lake, particularly in the quiet waters along the Isles of Granada. However, there is no real effort to expand this industry. Tarpon and snook are present to some extent throughout the lake, but possibly not in sufficient numbers to guarantee success. However, the greatest deterrent is the lake's rough water condition and the distance the prime fishing grounds are from adequate tourist facilities.

The exception to this is the tarpon fish camp located on the San Juan River where fishermen are flown directly from Managua to the fish camp. The camp accommodates 16 fishermen at a time. The cost is approximately $100 per day per fisherman. Another camp has recently been established nearby and problems have already developed over rights to fishing grounds. However, for the lake, the greatest potential for snook fishing is probably in the San Carlos area. Here fishing should be excellent, based on observations and interviews with fishermen and U. S. Peace Corps Volunteers. However, weather conditions in this area are only suitable for outdoor activities for four to six months out of the year.

8.0 INVESTIGATIONAL PROGRAM RECOMMENDED FOR LAKE NICARAGUA

The original research plan for the lake fisheries project was scheduled for a three-year period, and was to begin in January, 1971. The objectives of the original plan are described in detail in Volume 11, No. Especial, Boletin Informative de Pesca, INFONAC, 1971.

In summary these objectives were to:

1. Identify physical and chemical characteristics of the lake.

2. Identify existing fishery resources in the lake by trawl and gill net fishing.

3. Gather life history information on the commercially important species.

4. Determine migration patterns, growth and mortality rates for commercially important species through a tagging program.

5. Assess the potential equilibrium yield for the various fisheries.

Considerable equipment has been collected for the project, and a base of operations, including offices, museum, library, and laboratory has been established on the lake shore at Granada. A 11-m (36-foot) multi-purpose fishing vessel has been acquired together with skiffs, outboard motors, and different types of fishing gear.

Much of the gear, however, was originally purchased for marine exploratory fishing studies and is not entirely suited for investigating freshwater fisheries. For example, both the multi- and monofilament gill nets are constructed of heavy twine and are profusely hung with excessively large floats and weights.

Due to various delays in receiving equipment, the first survey of the lake was conducted in October, 1971. To date about three quarters of the lake has been surveyed, principally with a small trawl, with the following results:

1. The open areas of the lake with waters more than 3 m (10 ft) in depth appear to be populated with bottom-dwelling fish that rarely reach 0.2 kg (0.5 lb) in weight (considered the minimum commercial size in Nicaragua).

These assumptions are based primarily upon trawl catches using shrimp try nets with 1.5-m or 5-ft mouth; also echo-traces indicated few large fish and a scarcity of surface or mid-water schools of smaller fish.

2. Most commercial species, other than sawfish, shark, snook, and tarpon are found in less than 3 m (10 ft) of water in or around submerged brush, vegetation, and rocks. Most fishing activity for these species is concentrated on the eastern shore and around Granada.

3. Some limnological and biological information has been collected. The physical and chemical characteristics of the lake are within the normal range for large tropical lakes. Some information on food habits for commercial fish species is available.

The objectives of the original program have been recently revised in an attempt to bring project goals more in line with available resources. The revised objectives are included in the Appendix. In summary, the biological survey will be completed on the remaining quarter of the lake; efforts will continue to identify commercially important species. However, biological and limnological studies will be restricted to representative locations on the lake where greater effort can be placed on determining the biological characteristics of the fished stocks and in gathering data on the chemical and physical characteristics of the lake.

Revised goals for the lake project still appear too ambitious for available personnel and need to be altered to include fewer general activities. To carry out the revised program would require a force of five biologists and five technical assistants for a period of five or more years.

A preliminary census of fishing activity is recommended to provide data on present landings, amount of effort now being expended and size composition of the catch. Also, it is important to be able to accurately locate specific areas on the lake. A grid system using existing topographic maps is recommended for this purpose.

The fishermen census can be accomplished in conjunction with exploratory and experimental fishing. Trawl surveys should continue until consistent results are obtained for a given area. Special emphasis should be given to experimentally comparing various types of gill nets and other fishing equipment.

Also nets should be constructed with a minimum of floats and weights. For comparative evaluation, they should be fished as stationary nets and in the manner commonly used by fishermen (repeatedly setting nets and driving fish into them). In the latter case, nets or net material could be loaned to fishermen (for example in the Playuela area near Granada) and their catch and other data recorded daily by project personnel. Also recommendations or comments by the fishermen participating in the study concerning the fishing characteristics of these nets, ease of repair, etc., would be extremely important information.

The Lake Nicaragua Development Program should include a marketing study emphasizing the development of export markets for freshwater fish. This study should be conducted concurrently with the biological program on the lake. A first step would be to determine grading and processing standards for potential export markets, and secondly, to explore existing markets by comparing costs of fishing, processing, and transportation to determine if an

economic advantage exists for the Lake Nicaragua fisheries. If markets are discovered, attempts should be made to project the demand.

Another objective of the marketing study would be to determine reasons for the comparatively low consumption of fish in Nicaragua. One method for determining deficiencies in existing marketing processes is a sample survey by interview. Several very efficient techniques are available that will account for many sources of bias usually encountered in interview sampling. Another method would be to implement the marketing survey in which the buying habits of the consumer are determined from questionnaires distributed through the school systems. While the latter method would be more easily implemented and cost less than a well-designed interview survey, the results would also contain biases of unknown magnitude.

Although INFONAC is providing considerable support in equipment funds and in administering the program, it has provided only one field position, that of one biologist. If satisfactory progress in the investigational program of Lake Nicaragua is to be achieved, additional host-country personnel must be assigned to the project. It is suggested that two biologists and two technicians be assigned to the Lake Nicaragua project. If the Nicaraguan Government considers the program of sufficient importance to increase personnel, it is recommended that A. I. D. provide one fisheries advisor for a period of four years to provide on-the-job training for counterpart personnel and coordinate work activities of the investigational program.

INFONAC personnel presently assigned to the lake project are not trained in fishery biology and have little experience in working with freshwater fisheries. Hence, it is suggested that two selected host-country fishery personnel be provided with scholarships for university training abroad in fisheries biology. These scholarships should provide support for at least 24 months of training at a university that offers a good program in fishery biology and lake management.

It is important that any program devised for Lake Nicaragua include adequate emphasis in the training of host-country personnel in order that in the future Nicaraguans will have the expertise necessary to enable them to carry out effective work programs in freshwater fisheries. Lake Nicaragua is a very valuable natural resource, and the wise utilization of this renewable resource will become increasingly important in the future.

9.0 CONFERENCES

U. S. Government

Mr. Carl D. Koone	U.S.A.I.D. Rural Development Officer
Mr. Mack H. McLendon	U.S.A.I.D. Deputy Rural Development Officer
Mr. William Dewey	U. S. Peace Corps, Director
Mr. Anthony Theilen	U. S. Peace Corps, Associate Director
Mr. Kurt Koenig	U. S. Peace Corps Volunteer - Biologist
Mr. Richard Beatty	U. S. Peace Corps Volunteer - Biologist
Mr. Tom Emerson	U. S. Peace Corps Volunteer - Fisherman
Mr. Gary Fleming	U. S. Peace Corps Volunteer - Generalist

Nicaraguan Government

Mr. Donald Briceno	INFONAC, Department of Industry
Mr. Jamil Urroz	INFONAC, Division of Fisheries, Marine Section
Mr. Aldo Zepeda	INFONAC, Division of Fisheries, Lake Nicaragua Development Program
Mr. Sergio Martinez	INFONAC, Division of Fisheries, Lake Nicaragua Development Program
Dr. Enrique Guererro	Lake Nicaragua Development Program, Ministry of Economics
Mr. Justo Sandino	ENALUF, Engineer, Lake Apanas

United Nations (FAO - UNDP)

Dr. Guy de Moras	FAO, Regional Fisheries Officer
Dr. Richard Croker	UNDP, Fisheries Consultant
Mr. Robert W. Ellis	FAO, Fisheries Biologist
Mr. Bruno Rosetti	FAO, Captain - Master Fisherman

Private Industry

Mr. Enrique Sandino	COPESCA, Owner and Manager
Mr. David Callejos	COPESCA, Assistant Manager
Mr. Alfredo Bequillard	Tarpon Camp, Owner and Manager

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11.0 ITINERARY

February 27	Arrived Managua, Nicaragua
February 28	Conferences with officials of U.S.A.I.D., FAO, and U. S. Peace Corps
February 29	Conferences with officials of Instituto de Fomento Nacional (INFONAC) in Granada
March 1	Conferences with officials of INFONAC in Managua; traveled to Granada
March 2, 3, 4, 5	Aboard vessel, "Gaspar", on Lake Nicaragua
March 7	Visited fishing villages in Granada area
March 8	Conferences with FAO officials in Managua
March 9	Visited National University; Rio Tamarindo, Leon
March 10	Visited fish processing plant in Granada
March 13	Davies: Conferences with U.S.A.I.D. officials in Managua; Pierce: Lake Apanas, Jinotega
March 14	Davies: Rio Brito, Rivas; Pierce: Lake Apanas, Jinotega
March 15	Lake Nicaragua
March 16	Conferences with FAO Survey Team, Managua
March 17	Departed Nicaragua

12.0 APPENDIX

12.01 List of Fish Identified from Lake Nicaragua

Carcharhinidae	
Carcharhinus leucas	Bull shark
Pristidae	
Pristis pectinata	Sawfish
P. perotteti	Sawfish
Lepisosteidae	
Lepisosteus tropicus	Gar, Gaspar
Elopidae	
Megalops atlantica	Tarpon
Clupeidae	
Dorosoma chavesi	
Synbranchidae	
Synbranchus marmoratus	
Characidae	
Astyanax fasciatus	
A. nasutus	
Bramocharax bransfordi	
Brycon guatemalensis	Machaca
Bryconamericus scleroparius	
Hyphessobrycon tortuguerae	
Rhoadsia eigenmanni	
Roeboides guatemalensis	
Gymnotidae	
Gymnotus cylindricus	
Pimelodidae	
Rhamdia barbata	
R. managuensis	
R. nicaraguensis	

Cyprinodontidae

Rivulus isthmensis

Poeciliidae

Alfaro cultratus
Belonesox belizanus
Gambusia nicaraguensis
Neoheterandria umbratalis
Phallichthys amates
P. tico
Poecilia gilli
P. sphenops
Poecilia sp.
Poeciliopsis gracilis

Atherinidae

Melaniris sardina

Centropomidae

Centropomus parallelus	Snook

Pomadasyidae

Pomadasys boucardi

Cichlidae

Cichlasoma centrarchus	
C. citrinellum	Mojarra
C. dovi	Guapote
C. friedrichstahli	Guapote
C. labiatum	
C. longimane	
C. managuense	Guapote
C. nicaraguense	Mojarra
C. nigrofasciatum	
C. rostratum	
Herotilapia multispinosa	
Neetroplus nematopus	

Eleotridae

Gobiomorus dormitor

13.0 REVISED WORK PLAN FOR BIOLOGICAL PHASE OF PROGRAM

Part I.

The principle objective of the project is to evaluate the commercial fisheries resources of Lake Nicaragua. The project became operational in July, 1971, when the Granada facilities were opened. The first fishing trip was made in October of the same year. Since that time three-quarters of the lake have been surveyed.

A work plan for the biological phase of the program was drawn up in February, 1971, a copy of which is attached to this report. This plan has since been found to be too ambitious for the resources presently at the disposal of the project. Therefore, the plan has been revised and tentatively includes the following:

1. Completion of the biological survey on the remaining quarter of the lake with almost total emphasis on the fish fauna

   A. Methods of sampling representative areas

      1) Trawls with try net and larger nets
      2) Gill nets of varied mesh sizes and depths

   B. Data to be collected

      1) Identification of all fish to species level
      2) Length and weight frequencies
      3) Scale samples
      4) Stomach samples
      5) Relative abundance

2. Determination of the commercially important species (CIS)

   A. Basis for determining CIS

      1) Interpretation of biological data previously gathered
      2) Economic considerations
      3) Cultural habits affecting fish consumption

   B. Probable choices presently:

      1) First-class fish
         a. Guapote (Cichlasoma dovi , C. managuense, C. friedrichstahi)
         b. Snook (Centropomus parallelus)
         c. Sawfish (Pristis perotteti)

2) Second-class fish
   a. Gar (Lepisosteus tropicus)
   b. Mojarra (Cichlasoma citrinellum, C. nicaraguense)
   c. Machaca (Brycon guatemalensis)

3. Intensive biological investigations

A. Fisheries biology

1) Site selection - several sites will be chosen as the locations for these investigations. Criteria will be:
   a. Abundance of commercially important species
   b. Variety of environments achieved among sites
   c. Availability of fishermen to aid in the capture of specimens
   d. Possible sites include Los Cocos, Las Isletas de Granada, Ometepe, San Miguelito and San Carlos

2) Objectives - determine the following factors for a subpopulation of the selected species:
   a. Population structure
   b. Existence of a definite spawning season
   c. Growth rate
   d. Gear selectivity

3) Tentative methods of investigation
   a. Tag-recapture
   b. Length and weight frequencies
   c. Scale examinations
   d. Stomach contents
   e. Analysis of data obtained from existing sawfish fishery
   f. Fishing with a variety of gear (gill nets, trawls, traps electricity, etc.)

B. Other studies

1) Several permanent limnological stations will be set up at representative sites throughout the lake. Factors to be studied include:
   a. Temperature
   b. Transparency of water
   c. pH
   d. Dissolved oxygen
   e. Alkalinity
   f. Hardness
   g. Nitrates and nitrites
   h. Iron ions
   i. Phosphates

2) Concentrations of DDT and DDE will be monitored at several locations

4. After a period of not less than one year the information gathered from the activities above will be used to project estimates of the commercial fishery resources of the lake.

Part 2.

DESCRIPTION OF PRESENT STUDIES

Many of the activities listed in the revised work plan above have been initiated currently. The following is a brief summary of the investigations and results which have been obtained to date.

1. Summary of the lake - While the majority of the sampling stations have been located along the eastern coast, information gathered from interviews and examination of maps would indicate that nearly all major habitats have been visited during the current survey.

   A. Most species of potential commercial importance are more abundant in water less than 10 feet deep.

      1) The guapote is primarily a shallow water fish in the lake.

      2) The snook, gaspar (gar), machaca, and tarpon, are most frequently caught in shallow waters.

   B. The deeper areas of the lake presently have little potential to support an intensive commercial fishery.

      1) Surprisingly few fish have been found in waters deeper than 25 feet.
         a. In 25 to 45 feet of depth the predominant species in the catch are small cichlids, especially Cichlasoma longimane.
         b. In areas of 50 feet and more, large quantities of clams have been obtained, while the fish fauna has almost exclusively been small catfish of the genera Rhamdia.

      2) Very few large fish and no schools of fish have been detected on the echosounder.

These are only hypotheses at present, needing much more study to prove their validity. Most information gathered to date, however, supports them.

2. Microfauna - Only one publication has been found on the microfauna of Lake Nicaragua, a report by Gilby and Swain on ostracods and one species of the class Cyanophyceae abundant in the lake. Arrangements were made with specialists in the U.S. to send them samples for proper identification. Those organisms being examined are copepods, diatoms, cladocerans, and oligochaete worms.

   A. Cyclopoid copepods - Dr. Harry C. Yeatman (University of the South); predominant species, Thermocyclops inversus.

   B. Oligochaete worms - Dr. Richard Nowmiller (University of California - Santa Clara); predominant species, Limnodrilus hoffmeisteri and L. udakemianus, also present in considerable quantity is Aulocrilus cernosvitovi.

   C. The findings of the other experts are expected in the near future.

3. Stomach samples - The following have been observed in samples of the respective species:

   A. Cichlasoma citrinellum - mostly snails with some ostracods and dipteran larvae

   B. C. longimane - mostly copepods and ostracods with some small snails

   C. C. nicaraguense - small and large snails with some dipteran larvae

   D. C. rostratum - dipteran larvae and large snails

   E. C. centrarchus - small snails and plants

   F. C. managuense - dipteran larvae and fish (scales)

   G. Neetroplus nematopus - (1 specimen) plant material

   H. Rhamdia sp. - dipteran larvae, fish and large snails

   I. Dorosoma chavesi - dipteran larvae and ostracods

   J. Megalops atlantica - small Astyanax sp. and Dorosoma chavesi

   K. Brycon guatemalensis - 3 to 4 inch fish and plants

   L. Lepisosteus tropicus - large cichlids

   M. Carcharhinus leucas - cichlids

4. Scales - For the most part the scale studies have proven to be somewhat inconclusive; most of the cichlids do not show any type of "annular" ring until they have a length of approximately 15 to 18 cm. Since spawning has been noted in specimens of much smaller size, this ring does not appear to be caused by spawning. Inconclusive results have been obtained with the B. guatemalensis and Centropomus parallelus. The only species which has yielded promising results has been the Megalops atlantica. The ring formation/length frequency is similar to that found in the specimens taken in the sea.

5. DDT analysis - Several bottom samples have been submitted to a national testing laboratory to have the DDT concentration determined, but little information of value has been obtained. In the future a more organized system is to be established.