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FISHCULTURE SURVEY REPORT

FOR PANAMA

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1.0 ITINERARY OF AUBURN TEAM, APRIL 27 - MAY 22, 1970

April 27	Arrived Panama City, Republic of Panama
April 28	Initial meeting with officials of the government of Panama, Fisheries Department, and U.S.A.I.D. to discuss purpose of survey and formulate itinerary.
April 29	Fishing Cooperative, Program De Pesca De Farallon, Rio Hato. Governor's Office, Santiago, Veraguas Province.
April 30	Potential sites for fisheries station, Veraguas Province.
May 1	Dominguez Shrimp Pond, Las Cumbres, Panama Province.
May 2	Lake Madden, Panama and Colon Provinces.
May 4	Promarina, S.A. Fish Meal Plant, Puerto Caimito, Panama Province.
May 5	Department of Marine Biology, University of Panama, Panama City.
May 6	Planning meeting at CONEP conference room with U.S.A.I.D. and Ministry of Commerce and Industry officials, Panama City.
May 7	Florida State University, Canal Zone Branch. Directorate of Marine Resources.
May 8	Potential sites for fisheries station on University of Panama Farm (Faculty of Agronomy) near Tocumen Airport, Panama City.
May 9	Aerial observation of pond sites in the Tocumen Airport area.
May 11	Frigorificos De Chiriqui (shrimp packing plant), David, Chiriqui Province. Potential sites for fisheries stations, David. Fresh-water shrimp farm, Guayabal. Lakes Gulnar and Grande, Volcan. Rainbow trout streams, Cerro Punta.
May 12	Rainbow trout streams in Rio Caldera and tributaries, Boquete. Potential site for fisheries station, Gualaca.
May 13	Potential site for fisheries station near hydroelectric plant, David.

May 14	Site of proposed sugar refinery and potential fisheries station, La Raya de Santa Maria. National Institute of Agriculture, Divisa.
May 15	Pond sites, University of Panama Farm (Faculty of Agronomy) Tocumen Airport area.
May 18	United Fruit Company shrimp farm, Puerto Cortez, Honduras.
May 19	United Fruit Company catfish farm, La Lima, Honduras.
May 21	Final conferences in Panama City with representatives of U.S.A.I.D., government of Panama, University of Panama, private industry, FAO, and Peace Corps.
May 22	Departed Panama

2.0 RECOMMENDATIONS

2.01 That a cooperative program involving U.S.A.I.D., the University of Panama and Auburn University be established to provide an aquacultural testing facility for research and teaching. The University of Panama, Faculty of Agronomy, has a 608-hectare experiment station which contains suitable sites for a water storage reservoir and 12 to 16 hectares of experimental ponds. University officials appeared enthusiastic at the prospect of such a cooperative program and indicated willingness to make available the required amount of land. The program should include the initiation of an aquacultural curriculum in the Faculty of Agronomy.

2.02 That simultaneously, a cooperative program among U.S.A.I.D., the Directorate of Marine Resources of the Ministry of Commerce and Industry, and Auburn University is recommended for development of a combination fish hatchery-demonstration fish farm. Emphasis would be on extension of commercial fish farming methods. Suitable sites for the fish hatchery-demonstration fish farm are located at David, Chiriqui Province, and La Raya de Santa Maria, Veraguas Province.

2.03 That graduate training in fisheries should be provided at Auburn University for participants from both the University of Panama and the Directorate of Marine Resources. Two participants should begin two-year programs for the M.S. degree initially, with two participants added each year so that 4 students would be on the Auburn campus in any year. This program

should continue until sufficient biologists are trained for research and teaching staff at the University of Panama and for inland fisheries management throughout the country.

2.04 That an Auburn Team, upon completion of the surveys and mapping requested for tentative station sites, return to Panama for a period of 1 month to supervise planning of experimental ponds and laboratory facilities, and assist in preparing cost estimates for construction and operation of fishery stations.

2.05 That two advisors from Auburn be provided to supervise construction of ponds and laboratories, to initiate aquacultural research and to assist in the establishment of a fisheries curriculum at the University of Panama.

2.06 That the program of research developed at the University of Panama would include determination of the suitability for culture of Panamanian fishes and freshwater shrimps that are widely distributed in the country. Research should be shifted to exotic species, if local species show little promise for commercial production.

2.07 That research and teaching collection of freshwater fishes and invertebrates be prepared in a joint effort of the University of Panama, Auburn University and the Directorate of Marine Resources. Fish and shrimp species utilized for food or sport should be collected first. Specimens would be identified at Auburn University and returned to the Faculty of Agronomy and the Directorate of Marine Resources for cataloguing, storage and use in teaching

3.0 FISHCULTURE SURVEY REPORT FOR PANAMA

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3.01 Introduction

The Auburn Team made a survey in Panama April 27 to May 22, 1970, under the auspices of U.S.A.I.D. and the Ministry of Commerce and Industry, Republic of Panama. Primary objectives were to assess the potential of fish culture in Panama: (1) as a source of low-cost protein, and (2) as the basis of a new industry.

During the survey, three Pacific provinces were visited: Panama, Veraguas, and Chiriqui (Figure 1). The first is located in east-central Panama and embraces the Panama Canal Zone. Veraguas is west-central, and Chiriqui is westernmost of the provinces.

Panama is divided into 10 provinces, 3 on the Atlantic (Caribbean) Coast and 7 on the Pacific Coast. The provinces are subdivided into districts and these into corrigimientos.

The national economy is dependent mainly on the Panama Canal Company and agriculture. Chief exports are bananas, petroleum derivatives, shrimp, sugar, cacao and abaca.

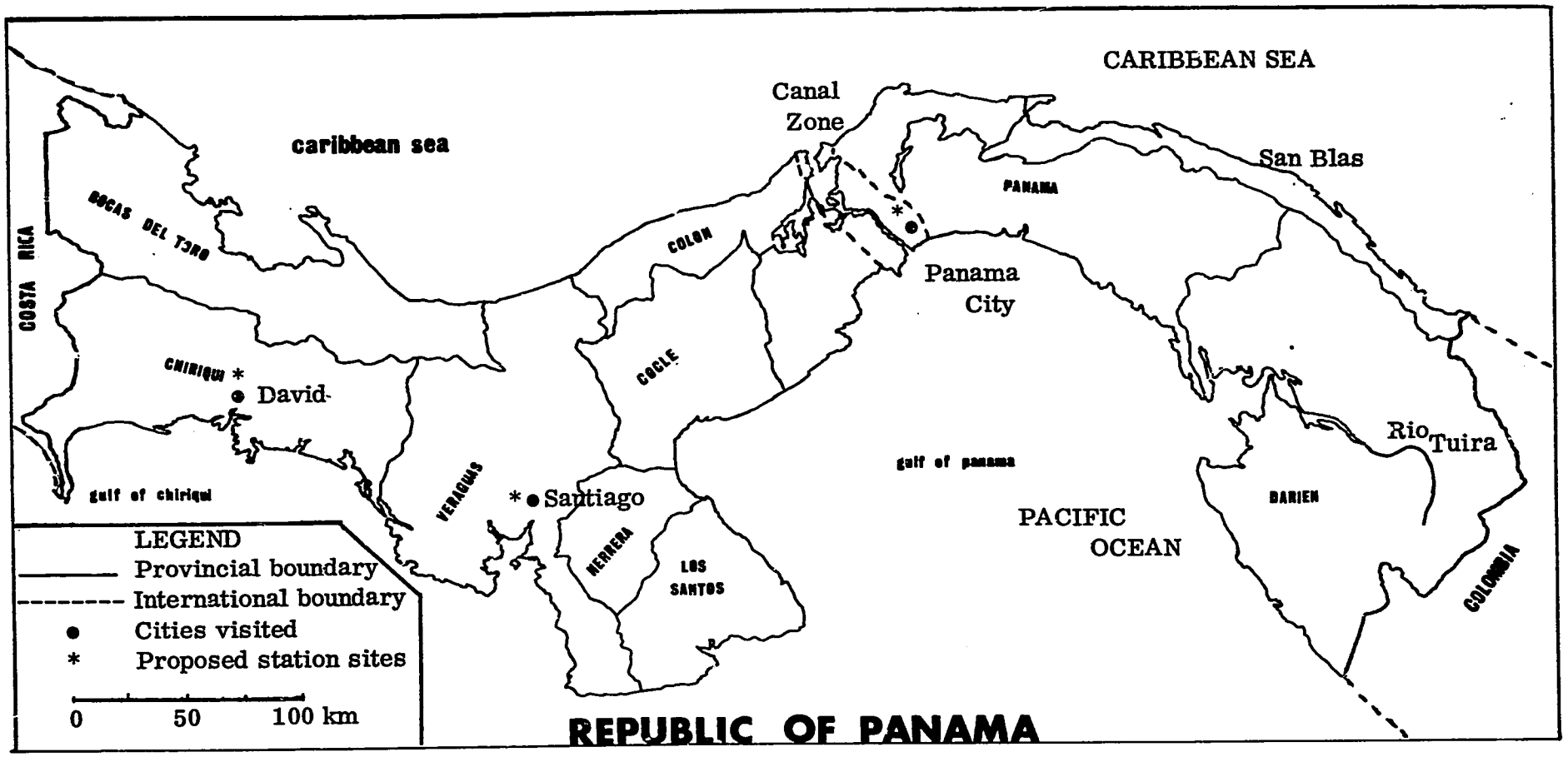


Figure 1. Map indicating principal localities visited by Auburn Team: David*, Chiriqui Province ; La Raya de Santa Maria*, Veraguas Province ; and Panama City*, Panama Province.

3.02 Nutrition

The population of Panama is 1.5 million with an annual rate of increase of 3.3 per cent. At the present rate, the population will double in 21 years. This indicates need for immediate action toward quantitative and qualitative improvement of the food supplies for the people of Panama.

Most urgent nutritional needs in developing countries are those of increasing both the supplies of calories and of high quality protein. The worldwide average protein requirement has been estimated to be 57.3 grams per capita per day, of which 19 grams should be animal protein.

The following table indicates the amounts of protein per capita available in Panama from various sources for the years 1959-1961 (U.S. Department of Agriculture, 1964a).

Product	Grams of Protein per Capita per Day
Cereals	26.9
Sugar, fruits, vegetables	10.8
Meat	10.1
Fish	1.0
Fats	0.1
Milk and cheese	5.2
Eggs	1.1
Total	55.2

The total average available protein was 55.2 grams per capita per day,

with that from animal sources totaling 17.5 grams per capita per day. Interestingly for a seabound country, only 1.0 gram of the latter was from fish. The average available protein in 1956-1958 was 54.6 grams per capita per day, indicating an increase of 0.6 grams per capita during this period. Projections by the U.S. Department of Agriculture (1964b) indicate that protein availability in 1970 will be 61.3 grams per capita, of which 21.7 grams per capita will be from animal sources. This would indicate adequate diets for Panamanians, however, the above figures are the average available per capita, and since equal distribution is seldom realized, many persons within the country are without adequate protein in their diets.

3.03 Geographical Data

Panama has a land area of 75,648 km^2. It is located approximately 7° to 9° 40' North Latitude by 77° to 83° West Longitude. The country, which extends West to East, is bordered on the North by the Atlantic (Caribbean) Ocean and by the Pacific Ocean on the South. Costa Rica borders the western and Colombia the eastern side of Panama. The shape of Panama is long and narrow, the greatest length is 450 miles and the greatest width is 150 miles.

Low mountain ranges extend for the length of Panama, thus forming a continental divide. The highest peak, Mount Chiriqui, lies near the Costa Rican border. The mountains slope from this peak to a region of low hills near the the center of the country (Colon and Panama Provinces), through which the Panama Canal passes. East of the Canal, the mountains gradually rise to 7,000

feet near the Colombian border. Most of the people live in western Panama between the Canal and Costa Rica. Thick rainforests cover much of eastern Panama and the Caribbean Coast of western Panama.

Generally, Panama has a hot climate with almost no seasonal changes in temperature. Temperatures in the lowland areas average about 80 F throughout the year. Mountain temperatures at elevations above 4,000 feet average 66 F, but sometimes drop to 50 F.

The Caribbean Coast extends 426 miles, while the Pacific Coast is 767 miles in length. The chief gulfs are Mosquitoes on the Caribbean Coast and Chiriqui and Panama on the Pacific Coast.

Panama has numerous small, shallow rivers running abruptly from the mountains to the oceans. Many streams are less than 50 miles long. The only river of significant commercial importance is the Rio Tuira, 125 miles long, which flows through eastern Panama near Colombia. Rivers of lesser importance are the Chagres and the Chepo, both in central Panama.

3.04 Rainfall Data

Generally, the rainy season lasts from May to December in Panama. Rainfall on the Atlantic Coast, still largely forested, averages 130 inches annually. The Pacific coastal provinces receive considerably less rainfall, and average 68 inches. In Table 1 selected rainfall data are provided to illustrate the precipitation pattern in the provinces of Panama, Veraguas and Chiriqui.

Table 1. Rainfall distribution for Panama, Veraguas, and Chiriqui Provinces from 1960 through 1967*

Years		Panama (Tocumen)	Veraguas (San Francisco)	Chiriqui (Pueblo Nuevo)
1960				
	(mm)	----	2,957	----
	(inches)	----	116.41	----
1961				
	(mm)	2,309	2,592	----
	(inches)	90.90	102.04	----
1962				
	(mm)	1,480	----	----
	(inches)	58.26	----	----
1963				
	(mm)	----	3,225	4,038
	(inches)	----	126.96	158.97
1964				
	(mm)	1,966	3,084	3,798
	(inches)	77.40	121.41	149.52
1965				
	(mm)	1,813	2,282	2,563
	(inches)	71.37	89.84	100.90
1966				
	(mm)	1,921	----	4,656
	(inches)	75.62	----	183.30
1967				
	(mm)	1,896	2,081	3,692
	(inches)	74.64	81.92	145.35

*Republic of Panama, 1969. Meteorologia: Ano 1967. Contraloria General, Direccion De Estadistica y Censo. Ano XXVIII, Serie "L", 48 p.

3.05 Areas Suitable for Pond Construction

No soil map of Panama was made available to the Auburn Team, but several regions exist in Panama where soils are suitable for pond construction. Alluvial plains near the Pacific Coast, particularly in Chiriqui, Cocle and Panama Provinces, showed special promise. Some of these areas have been used for wetland rice production. Soil borings in the flood plain of Rio David, city of David, Chiriqui Province, indicated good clay soils to a sufficient depth for pond construction. Soils in the mountainous areas generally contained so much rock that construction would be difficult. Several ponds had been built successfully in the low clay hills surrounding Panama City.

3.06 Status of the Fisheries

Records available on the fisheries of Panama refer only to the marine and coastal fishery. The freshwater fishery is apparently a subsistence one, as no strictly freshwater forms are found on the market in Panama or David. Information on freshwater fishes with a catalog of species occurring in Panama appears in the Appendix.

Shrimping operations substantially dominate the commercial fishing industry in Panama. For 1969, the Directorate of Marine Resources reported the catch of 12,230,892 pounds of shrimp (heads off). Of this, exports accounted for 9,692,277 pounds worth $9,730,609. Shrimp was thus the third-ranking Panamanian export, accounting for approximately 10 per cent of all export value.

Figures 2 and 3. Some seafoods sold in Panama City fish market.

Incidental to shrimp trawling and anchoveta purse seining operations in 1969, a total of 3,278,372 pounds of fresh fish was brought to market for an estimated retail value of $655,674. The table below, from data supplied by the Directorate of Marine Resources, summarizes quantity and value of exported marine products, 1969.

Product	Net Weight (lb)	Value F.O.B. ($U.S.)	Mean Value (per lb)
Shrimp	12,462,606	9,730,609	1.00
Lobster	34,132	63,735	1.87
Fresh fish	575	234	0.41
Fish meal	4,480,567	276,126	0.06
Fish oil	682,130	55,038	0.08
Totals	17,660,010	10,125,742	0.57

Trends in the fishery are indicated by the catch of shrimp, and the catch of anchovy and herring for fish meal during the period 1965-1969. Data in the table below are from the U.S. Department of the Interior (1969) and the Directorate of Marine Resources.

Item	Catch (thousands of pounds)				
	1965	1966	1967	1968	1969
Shrimp	12,825	12,372	14,177	13,200	12,463
Anchovy and herring	72,664	145,540	144,084	144,560	-------

Indirect controls on the shrimping industry, consisting of limiting total number of trawlers at 232, apparently has been fairly effective in regulating the catch. There is concern that this control will not be sufficient as the fleet is modernized, and efforts are being made to shift some of the vessels into anchovy and threaded herring fishing.

The fish reduction industry in Panama during 1968 consisted of only one company, Promarina, S.A. The production of fish meal was increased from 7,849 short tons in 1967 to 12,000 short tons in 1968. At the same time, fish oil production rose from 3,040 short tons to 7,500 short tons. In 1970, a second company had begun operation in the production of fish meal and fish oil.

Efforts have been made to increase the local market for fish oil and fish meal to protect the industry from world price fluctuations. Price controls had resulted in a local price for Panamanian fish meal at $140 per short ton compared to approximately $200 per short ton for Peruvian fish meal in the United States market.

Some information on the price of marine fish and other seafoods was obtained by visiting the fish market in Panama City. The prices agreed closely with retail prices of fish handled through the fishermen's cooperative at El Farallon, Cocle Province. In Table 2 is included the common names and scientific names, when available, with price per pound of the marketed fishes.

Of the fishes, practically all are taken incidentally in the shrimp trawlers and brought to the market after being stored on ice for several days. A few species, including corvina, sierra, pargo and mero, are captured by artisan fishermen

Table 2. Names and prices for certain seafoods marketed in Panama City

Common Name			
Spanish	English	Scientific Name	Price Per Pound ($U.S.)
	Fishes		
Corvina	Sea trout	*Cynoscion* sp.	0.30
Pargo	Snapper	*Lutjanus* sp.	0.30
Robalo	Snook	*Centropomus* sp.	0.30
Sierra	Mackerel	*Scomberomorus* sp.	0.25
Mero	Grouper	*Mycteroperca* sp.	0.25
Bobo	Threadfin	*Polynemus* sp.	0.10
Cojinao	Blue runner	*Caranx* sp.	0.10
Cazon	Shark	*Sphyrna* sp.	0.10
Caballito	Moonfish	*Vomer* sp.	0.10
Congo (Bagre)	Catfish	*Bagre* sp.	0.10
Jurel	Jack	*Caranx* sp.	0.10
Bonito	Bonito	*Sarda* sp.	0.10
Lenguado	Flounder		0.10
	Barracuda	*Sphyraena* sp.	0.10
	Whiting		0.15
	Amberjack	*Seriola* sp.	0.10
	Pompano	*Trachinotus* sp.	0.10
Guabina	Goby	*Guavina* sp.	0.25
Herrero			0.10
Salmoneta			0.10
	Spadefish	*Chaetodipterus* sp.	0.10
	Tripletail	*Lobates* sp.	0.15
	Shellfishes		
Camarones chicos	Small shrimp*		0.35
Camarones rojos	Pink shrimp		0.70
Camarones blancos	White shrimp		1.00
Langosta (tails)	Spiny lobster	*Panulirus argus*	1.40
Langosta china (tails)	Sand lobster	*Panulirus gracilis*	0.60
Almeja	Clam	*Polymesoda* sp.	0.10
Conchuelo	Scallop	*Pecten* sp.	0.10
Mejillon	Mussel	*Mytella* sp.	0.10

*All shrimp prices were heads on.

Figures 4 and 5. High quality Panamanian fish meal produced at Promarina, S.A., anchovy and herring reduction company.

with hook and line and brought to the market in a slightly more fresh state.

Practically all fish are sold fresh in Panama. There is one small plant near David, Frigorificos De Chiriqui, S.A., which produces 300-400 pounds of frozen fish filets per week as a sideline to its frozen shrimp operation. These are all utilized locally.

The distribution system for fish is so poorly developed in Panama that fish do not travel far from the docks even where an over-supply is available. Fish remain in the markets, with the price dropping as the day passes, until all are sold.

Data supplied by U.S.A.I.D./Panama indicates that per capita consumption of fish and shellfish in Panama for 1967 was 18.5 pounds. This is exceeded in Latin America only by Chile (20.9 pounds), Jamaica (24.1 pounds), and Venezuela (24.1 pounds), but is much lower than countries with well-developed fishery resources such as Japan (61.2 pounds), Taiwan (31.4 pounds), Denmark (47.5 pounds), and Sweden (45.1 pounds).

Statistics from the Direccion de Estadistica y Censo, Contraloria General, for 1967 indicate per capita consumption as 20.68 pounds, an increase of nearly 5 pounds compared to 1960. However, the fish and shellfish accounted for only 7.6 per cent of the proteins in the Panamanian diet. Reasons for a relatively low fish consumption in a largely seabound country are not well understood, but appear to be problems of supply and product distribution, rather than the preference by Panamanians for other foods.

The freshwater fisheries of Panama are poorly known, mainly because

of the absence of a tradition for freshwater commercial fisheries and sport fishing. The inland waters of Panama are small compared to many other countries, and consist mainly of short, shallow rivers, which are relatively infertile. The inland fishery has apparently been a subsistence one for local residents on the streams. There has been little incentive for the government to sponsor studies on the freshwaters, and even academic endeavors have been very limited.

Taxonomic studies (Meek and Hildebrand, 1916; Hildebrand, 1938; Loftin, 1965) on the freshwater fishes of Panama have enumerated 207 species, less than 10 of which are utilized extensively for food. No information was available on the value of these fishes in isolated local trade. An additional 5 species have been introduced for sport fishing.

No reference collection of freshwater fish specimens or of biological information concerning them exists in Panama. A collection has been made and deposited in the U.S. National Museum, but is, of course, unavailable to those locally engaged in research, management or teaching.

3.07 Governmental Divisions Responsible for Fisheries

The Direccion General de Recursos Marinos (Directorate of Marine Resources) was formed in 1968 as part of the Ministry of Commerce and Industry. The organization of the directorate is as follows:

Direccion General de Recursos Marinos
Director General

Departamento de Investigaciones y Pesca Exploratoria
Chief

Seccion de Investigaciones Biologicas
Biologist
Assistant Biologists - 4

Seccion de Pesca Exploratoria
Master Fisherman - 1 (to be appointed)
Boat Captain - 1 (to be appointed)
Crew - 4 (to be appointed)

Seccion de Fomento de Pesca Artisanal
Supervisor
Peace Corps Volunteers - 7

Departamento de Estadistica Pesquera
Chief Statistician
Assistant Statistician - 1
Statisticians - 3

Departamento de Mercadeo
Marketing Specialist - 1
Home Economists - 2

Departamento de Zarpes y Naves
Chief
Inspectors - 2

The objectives of the Directorate have been broadened considerably since the governmental fisheries agency was elevated from a department in the Ministry of Agriculture to a directorate with several departments in 1968. The annual budget was increased from $40,000 to $140,000. The function of the original department was largely one of statistics collection on the marine fishery. The present agency is still oriented almost exclusively toward marine capture fisheries, but has the framework within which biological investigations could

be initiated in marine, brackishwater or freshwater fisheries. A serious obstacle to such studies at present is the shortage of biologist personnel, and the total lack of personnel trained in freshwater fisheries.

In contrast to practically all other countries, the Republic of Panama has no research laboratory for determining biological information on the fisheries, and no hatcheries for production and distribution of young fish. Apparently not even private fish hatcheries exist.

Difficulties which have hindered the development of the fisheries agency since its beginning some 17 years ago may be summarized as: (1) insufficient funds, particularly prior to the recent restructuring, (2) lack of trained personnel, and (3) lack of experimental facilities such as research laboratories, ponds and field equipment. In May, 1970, the fisheries personnel received their first vehicle with which to travel into the field since the agency was created.

Because of the increasing interest in aquaculture among Panamanians, especially in catfish culture, shrimp culture and sport fishing, it appears advisable to establish within the Directorate a department dealing exclusively with fish culture and other aquacultures. Activities and studies might include culture of shrimp, molluscs and other aquatic organisms as well as various fish species.

3.08 Fisheries Training in Panama

There is no high school or university in Panama which offers a professional or academic degree in fisheries biology or a related field. The University of

Panama within its Faculty of Natural Sciences and Pharmacy, has a School of Biology with a Department of Marine Biology. The School offers 5-year degree courses in zoology or botany, and plans to add a degree in marine biology. The marine biology program is supported jointly by the University of Panama and UNESCO, and is directed by Dr. Luis Howell Rivero, staff member for UNESCO since 1954. Included in the program, which has been underway at the University for 3 years, was establishment of a reference collection of marine organisms followed by studies on life history and ecology. Early emphasis was on life cycles of shrimps, anchovy, and herring, Panama's commercially important marine animals. To date, specimens were collected with a borrowed Coast Guard vessel, but arrangement has been made with the University of Miami to supply a trawler for future collections. Maintenance will be by the University and the Directorate of Marine Resources.

Two semester courses in marine science are taught by Dr. Howell Rivero: Ichthyology (6 credits), and Marine Biology (5 credits). Informal courses, which he teaches as graduate seminars, include Marine Ecology and Marine Invertebrates.

The research and teaching program in marine biology is carried on by Dr. Howell Rivero with the aid of two University counterparts and six assistants. Specialties of the staff include: Phytoplanktology, Zooplanktology, Ichthyology, Life Cycles of Marine Invertebrates, Ecology of Marine Communities, and Chemistry.

There is a proposal before the United Nations and the Republic of Panama for the establishment of an Institute of Marine Science as a national program with

regional cooperation. The proposal, reportedly being viewed favorably by the United Nations, would provide for a 10 man-years of expertise by FAO, to begin in 1972. Additionally, the University of Panama plans to construct a new science building which would provide housing for the expanded marine programs.

3.09 Inland Fisheries in Panama

3.091 Rivers and Streams

The rivers of both the Caribbean and Pacific Coasts of Panama are relatively short and infertile and generally do not support significant commercial fisheries. The largest river, Rio Tuira in Darien Province, is fished for local markets by the Indians, but no data were available on the extent of the fishery.

Subsistence fishery in smaller rivers and streams reportedly include trap, spear, and hook-and-line capture of the sabalos, Brycon sp., and the catfish, Rhamdia wagneri. The freshwater mullet, Joturus pichardi, occurring only at the base of waterfalls, takes the hook readily and is prized as a food and game fish. Ut d to a lesser degree are characins of the genus Hoplias, and gobiids of the genera Philypnus and Guavina.

Rivers and even the smaller streams in Panama apparently have populations of freshwater shrimp, most notably Macrobrachium sp. These shrimp, the males of which sometimes exceed 1 pound in weight, are taken at night in the shallow, clear streams after shining the eyes of the animals with lights. Another method of capture is with the nasa, a rounded funnel trap woven from wooden slats and baited with fish or beef. No estimate of catch from rivers or streams

for any species of fish or shrimp was available.

Whatever the production of the rivers and streams, however, it is reportedly declining from the illegal use of dynamite and rotenone toxicants from local plants. There are laws forbidding the use of such capture methods, but no enforcement. Equally as serious is the stream and watershed alteration resulting from the traditional nomadic farming practices. These include clearing and burning to prepare crop lands, no matter if the farm is on a mountainside. Terracing, and watershed cover practices, are non-existent. Flooding is predictable and common, resulting in the apparent loss of a rainbow trout fishery in Chiriqui Province. Periodic destruction of the stream beds through flooding, and the elevation of mean stream temperatures by 4 to 5 degrees F in 40 years are likely the main factors causing decline of the trout fishery.

3.092 Lakes

Only two natural lakes of consequence are known in Panama. The lakes, Gulnar and Grande, occupy craters of extinct volcanoes near Volcan, Chiriqui Province, at an elevation of approximately 4,500 feet. Three species of small characins were originally found in the lakes, but it is not known if these have survived since the introduction of largemouth bass and bluegill from Florida in 1955 to 1958. Lake Gulnar (30 acres) was stocked with 100 largemouth bass fingerlings in 1955, followed in 1958 with 100 bluegill fingerlings. Lake Grande (60 acres) was stocked on the same dates with 100 largemouth bass fingerlings and 50 bluegill fingerlings, respectively.

The introductions, made by the Jensen family who own the surrounding lands, were both successful. Light fishing in the lakes has yielded good catches of bass and bluegill. Lake Gulnar has produced bass of 8 pounds and bluegill of 1.5 pounds. It is not known how large the fish populations are, but the lakes appear clear and relatively infertile. The surface temperature in late afternoon at Lake Gulnar was only 75 F on May 11. Since this was the hottest part of summer, it appears the temperature is only marginal for spawning of bluegill.

3.093 Reservoirs

Reservoirs in Panama are two: Madden Lake, on the Rio Chagres, and Gatun Lake, both constructed for operation of the Panama Canal locks. Neither supports an extensive fishery, but in the past four years an exciting sport fishery for peacock bass has been developing in Gatun Lake and the Panama Canal.

The peacock bass or tucunare, *Cichla ocellaris*, was imported from Colombia for stocking in a small private impoundment on the east side of Gatun Lake. The tucunare, stocked in combination with *Tilapia mossambica*, apparently swam out of the pond at high water and found its way down stream into Gatun Lake and the Panama Canal in 1966.

Sport fishermen in the Canal Zone are reportedly now catching numerous tucunare up to 8 pounds in weight. The population of this fish is apparently still in the expansion stage, but no population studies have been made before or since the accidental stocking. Such studies are needed to determine the impact of this introduced predator on the native fishes of Gatun Lake, and to predict effects

of similar introductions of exotic species in other areas of Panama. Now that the tucunare are part of the Gatun Lake population, biological information is needed for future management of the fishery.

At least two more large reservoirs are planned for Panama in the near future. One is an irrigation reservoir in Veraguas Province, and the other a hydroelectric reservoir in Panama Province. The fish populations should be assessed in the watersheds before dam construction so as to more effectively plan for management of the reservoir waters for fish production.

3.094 Ponds

3.0941 Construction

Ponds in Panama apparently are few; the number is estimated at less than 100, located principally near Panama City. The purpose of most ponds appear to be for sport fishing and/or cattle watering.

Sites for ponds and proper soils for dam construction seemed to be abundant in the rolling foothills near the Panama Canal Zone. In this area, the mountain range is lowest. The proper width for emergency spillways are being determined by trial and error; as a result, many dams have been washed out in the rainy season.

Rainfall in the Panama City area is approximately 80 inches annually, and concentrated in about 6 months. Successfully constructed ponds, with generous spillways, were located in pasture land with watershed to pond surface ratios of 10:1 and 20:1. Usually, the ponds with most constant water levels were located on sites with springs as a source of water.

Only two ponds were observed west of Panama Province. One, an excavated pond on the site of a small spring in Veraguas Province was almost dry at the beginning of the rainy season. Another, in Chiriqui Province, was under construction, and water was to be supplied from a canal. The soil was rocky and gravelly, (the pond was being excavated) and the pond was to have concrete sides. All these factors contribute to expensive construction. Obviously, advice in pond construction is greatly needed in Panama.

3.0942 Fishes Stocked

Information on the species of fishes to stock in ponds and in what numbers or proportions they should be stocked is non-existent in Panama. Many attempts have been made to stock fishes as in other countries, with occasional success. Largemouth bass and bluegill stocked together have produced viable populations in two small natural lakes. Largemouth bass stocked alone produced crowded bass. Tucunare and bluegill together provided fair fishing for both species. Tucunare and *Tilapia mossambica* in combination apparently is providing good fishing in one pond. *T. mossambica* alone was unsatisfactory. These results are inconclusive, however, since native fishes were never removed from the ponds before stocking the exotic species.

Table 3 summarizes all known introductions of exotic species of fishes in Panama, the majority of which were for establishment of sport fish populations in private ponds.

Table 3. Summary of introduction of exotic species of fishes into Panama

Species	Year	Source	Stocked (Province)	Population Established
Largemouth bass	1917	U.S.	Gatun Lake (Panama)	Negative
Largemouth bass	1925	U.S.	Gatun Lake (Panama)	Negative
Largemouth bass	1955	U.S.	Lake Grande (Chiriqui)	Positive
Largemouth bass	1955	U.S.	Lake Gulnar (Chiriqui)	Positive
Largemouth bass	----	U.S.	Lake Goofy (Panama)	Positive
Largemouth bass	----	U.S.	Green Lake (Cocle)	Positive
Bluegill	1917	U.S.	Gatun Lake (Panama)	Negative
Bluegill	1925	U.S.	Gatun Lake (Panama)	Negative
Bluegill	1958	U.S.	Lake Grande (Chiriqui)	Positive
Bluegill	1958	U.S.	Lake Gulnar (Chiriqui)	Positive
Bluegill	----	U.S.	Lake Las Cumbres (Panama)	Positive
Bluegill	----	U.S.	Green Lake (Cocle)	Negative
Crappie	1925	U.S.	Gatun Lake (Panama)	Negative
Catfish	1917	U.S.	Gatun Lake (Panama)	Negative
Guppy	1910	Barbados	Gatun Lake (Panama)	Negative
Guppy	----	----	Bennett Lake (Cocle)	Positive
Goldfish	----	----	Bennett Lake (Cocle)	Positive
Swordtail	----	----	Bennett Lake (Cocle)	Positive
Tucunare	1964	Colombia	Lake Las Cumbres (Panama)	Positive
Tucunare	1965	Colombia	Lake Cemento Panama (Panama)	Positive
Tucunare	1966	LCP*	Gatun Lake (Panama)	Positive
Tucunare	1969	LCP*	Agronomy Lake (Panama)	Positive
Tilapia mossambica	1964	Colombia	Private lake (Panama)	Positive
Tilapia mossambica	1965	Private lake	Lake Cemento Panama (Panama)	Positive
Tilapia mossambica	1966	Private lake	Lake Las Cumbres (Panama)	Positive
Tilapia mossambica	1969	LCP*	Agronomy Lake (Panama)	Positive
Tilapia mossambica	----	LCP*	Green Lake (Cocle)	Positive
Rainbow trout**	1925	U.S.	Rio Chiriqui Viejo (Chiriqui)	Positive
Rainbow trout	1968	U.S.	Rio Caldera (Chiriqui)	Unknown
Rainbow trout**	1969	U.S.	Rio Caldera (Chiriqui)	Unknown

*LCP - Lake Cemento Panama
**Introduced as fertilized eggs

3.0943 Freshwater Shrimp Culture in Ponds

Numerous reports were received regarding the presence of large freshwater shrimp occurring in small streams in widespread localities of Panama. Such a population was present in a small stream, Rio Las Lagas, near Las Cumbres 15 miles northeast of Panama City. Ten years ago, Lake Las Cumbres (34 acres) was formed by the impoundment of Rio Las Lagas. The population of shrimp persisted after impoundment, and still is the basis for a fairly extensive fishery. For capture, the natives use the nasa, a trap woven from wooden slats, baited with fish or beef.

In May, 1968, Sr. Antonio Dominguez stocked 8 adult shrimp from Lake Las Cumbres into a 1.5-acre pond on his farm a few miles away at La Laguna. In latter 1968, shrimp were first taken in 1/4-inch mesh wire traps baited with beef scrap. Through April, 1970, it was estimated that 1,000 adult shrimp averaging 70 grams had been harvested by trapping. The trapping effort was only 1 day per week, using 2 multi-funnel wire traps, each with a volume of approximately 1 cubic meter. An additional catch of several hundred shrimp was taken in a unique sport fishery utilizing a long-handled dip net and stale bread loaves for bait. A total harvest of 100 pounds per acre was estimated from the small pond over a 24-month period.

During the period, no fertilizer was added to the pond, but approximately 60 pounds of stale bread per week was fed. During 1969, many young shrimp were found among submerged weeds, principally Chara sp., but it was not

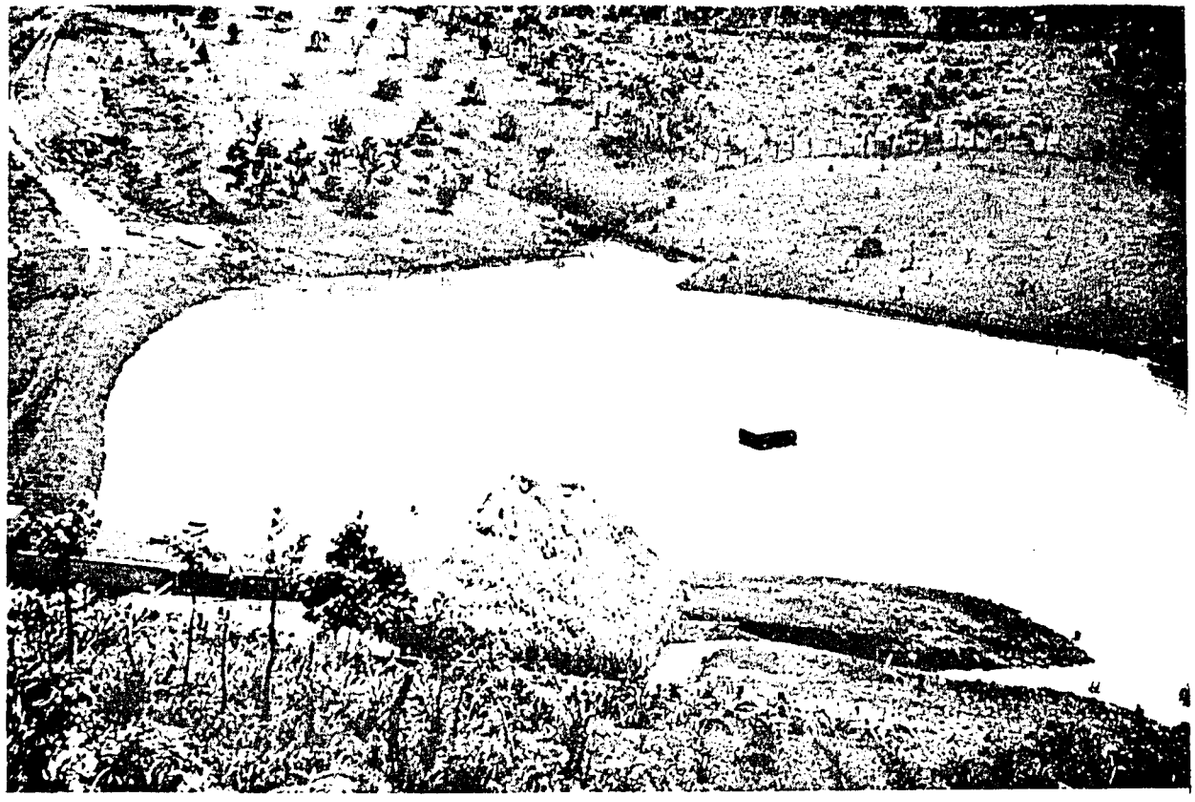
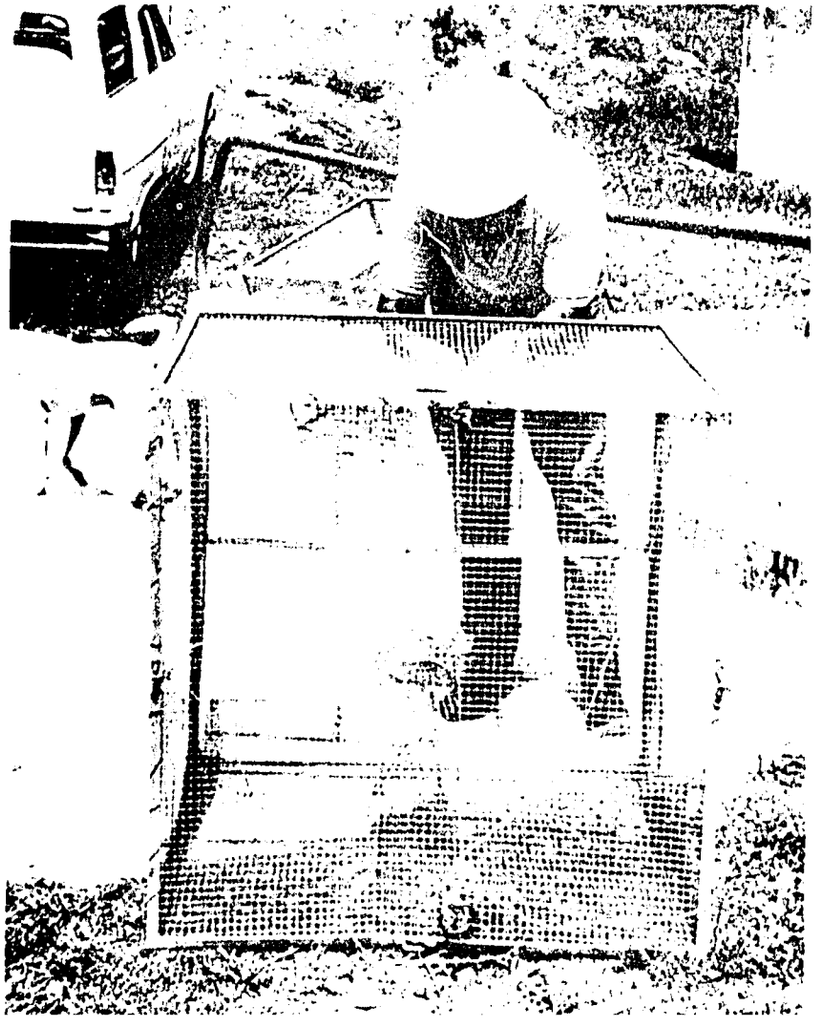
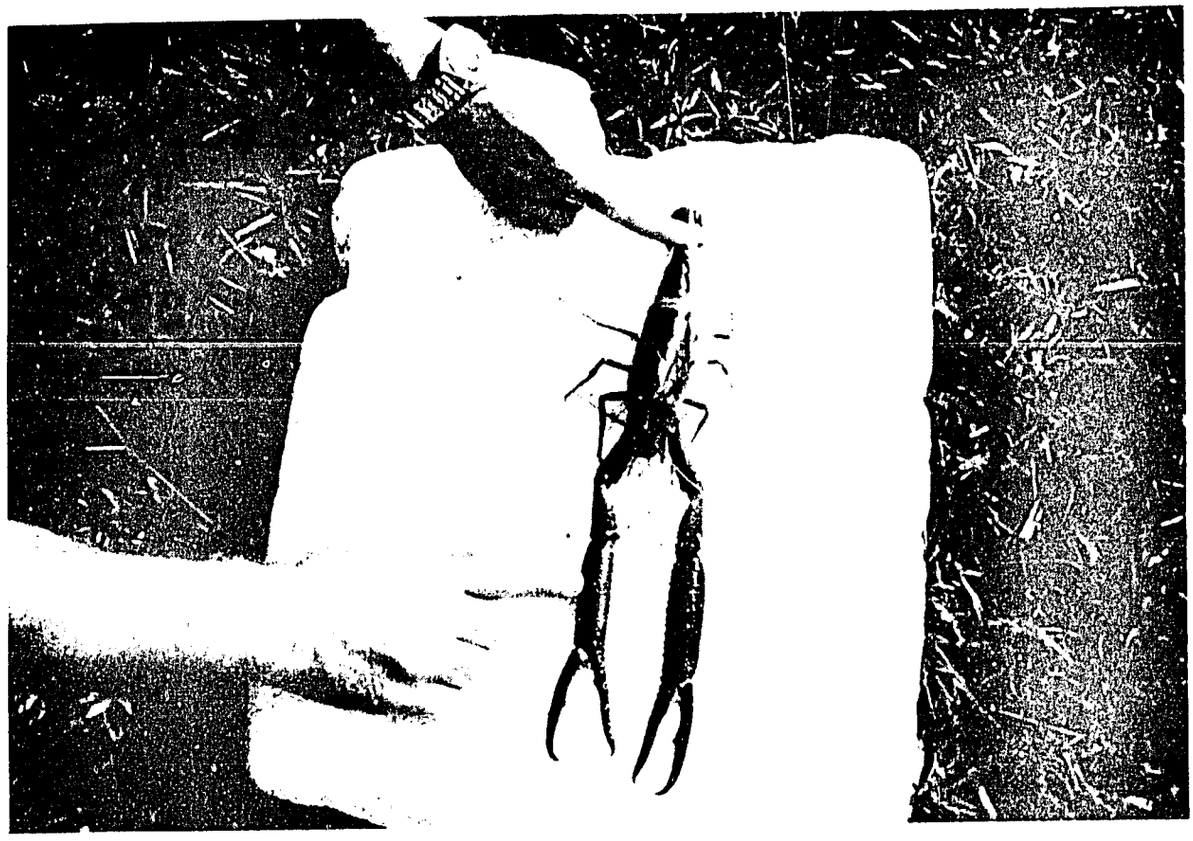


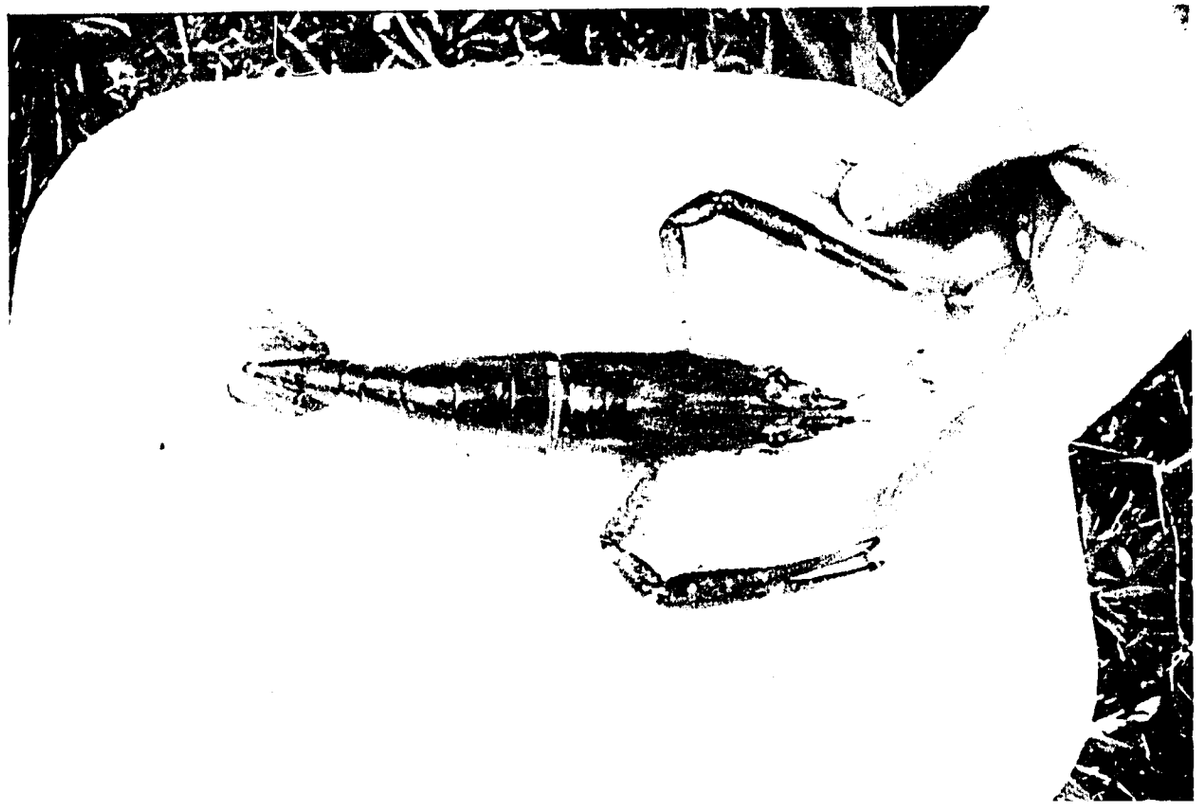
Figure 6. Freshwater shrimp pond, owned by Antonio Dominguez, Panama Province.

Figure 7. Wire trap used in harvesting freshwater shrimp from ponds.





Figures 8 and 9. Male (above) and female (below) freshwater shrimp, Macrobrachium sp., from Dominguez Pond, Panama Province.



known whether they were feeding on the weed or seeking shelter.

In May and June, 1970, the Auburn Team visited the Dominguez Pond and determined that the shrimp were of the genus Macrobrachium. This was particularly exciting, since indications were that the shrimp were completing their life cycle within the confines of the 1.5-acre pond. The shrimp were taken with eggs in June-July, 1969, and in June, 1970. Further, small shrimp were found among the weeds in summer, 1969. Although the shrimp could possibly have traveled to saltwater for spawning and young returned to the pond, barriers within the concrete spillway would make this quite unlikely. During May-June, 1970, several male shrimp were captured, which were 24 inches in total length from telson to tips of chelae, and weighed 1.0 to 1.25 pounds each. Since these were the largest taken during the 24-month harvest period, it appears some shrimp live more than 1 year.

Seven shrimp from the Dominguez Pond were transported live to Auburn University Fisheries Research Unit on June 25, 1970. Three were females with eggs, and all were placed in small ponds for observations on their biology. However, it is very important that research on these potentially valuable shrimps be done in Panama.

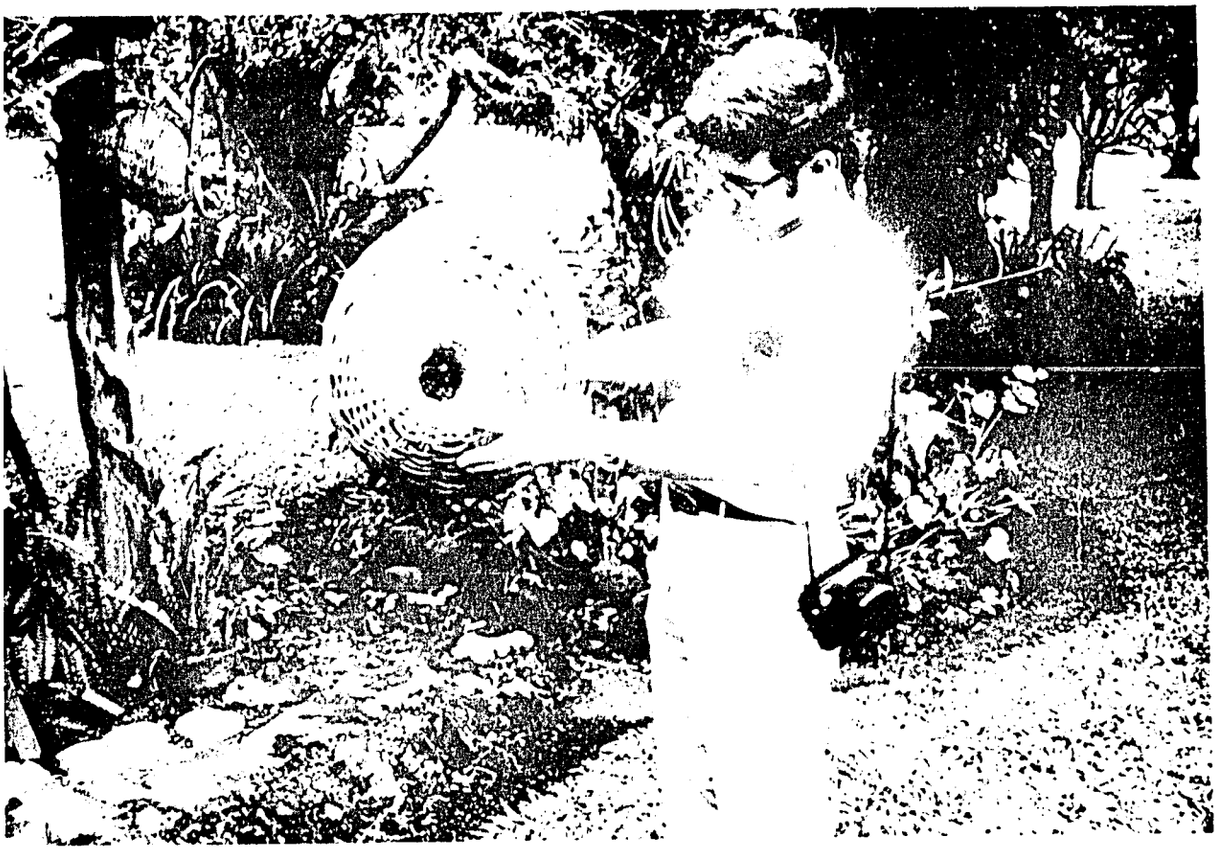
The presence of freshwater shrimp was also reported in El Valle, a volcanic crater in Cocle Province. Mr. Irving Bennett, who owns a farm within the crater, stated that his family and employees had often captured shrimp weighing up to 0.5 pound from a stream on his property. On one occasion, when he drained a small pond fed by the stream, a shrimp weighing 1 pound was

recovered. Indications again are that the shrimp complete their life cycle in freshwaters of El Valle. Although the Pacific Ocean is only 30 miles away, there is a 90-foot waterfall at the crater rim as the stream flows toward the sea. It appears unlikely that shrimp could make the journey to saltwater and return.

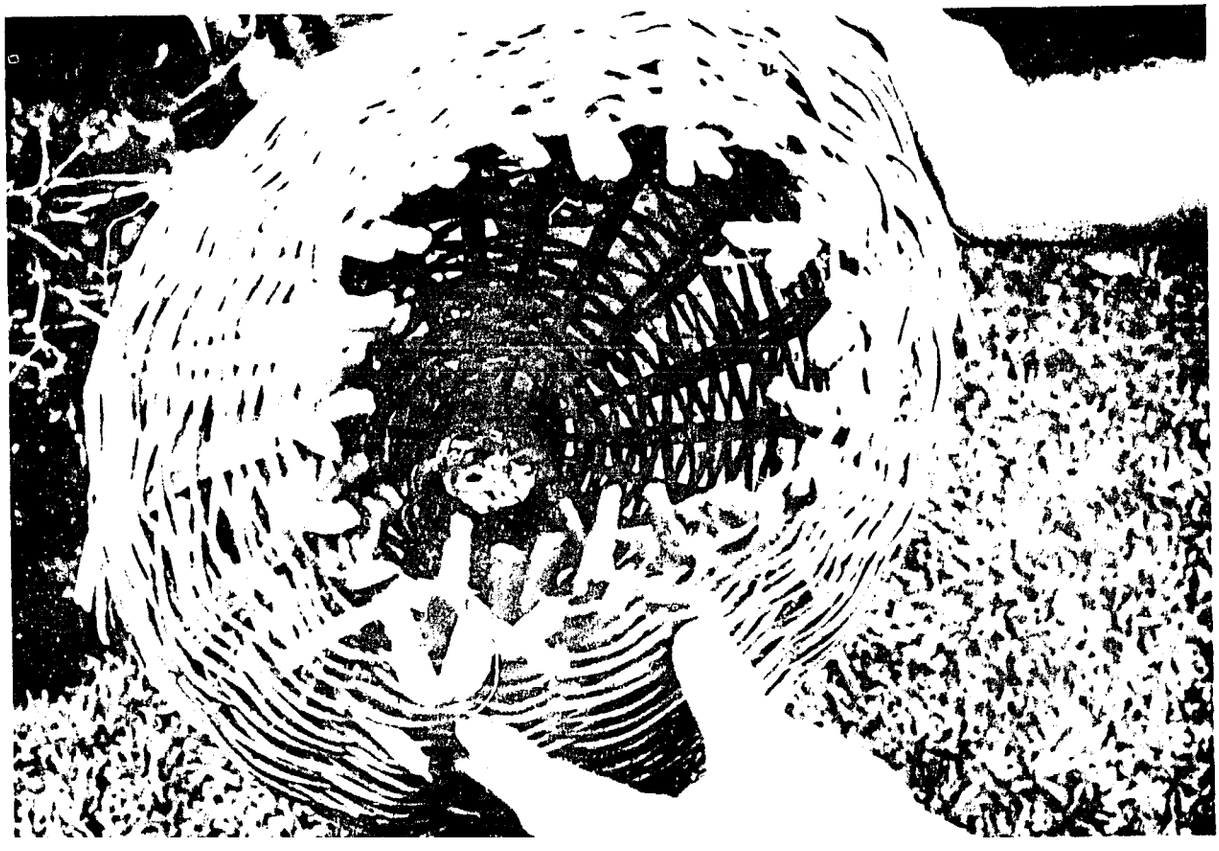
Local freshwater shrimp populations were also discovered in streams of Chiriqui Province near David. Capture methods were similar to those used in Panama and Cocle Provinces. Nasa traps were common, but hand capture at night with lights was most popular.

A shrimp farm under construction was visited near Guayabal in Chiriqui Province, some 20 miles northeast of David. The farm, owned by Luis Alberto Romero and managed by Herman Patino, consisted of a series of three interconnected ponds with a total areas of 2.3 hectares (5.5 acres). The ponds, to be completed by June, 1970, would receive water from a permanent canal diverted from Rio Papayal. The ponds were to be stocked with 4,000 female shrimp, captured from the canal by periodic draining. Sr. Patino, who has studied the shrimp as a hobby for 12 years, says each female shrimp has 30,000 to 40,000 eggs per laying. The same female is reported to spawn 3 to 4 times per year. Larvae hatched within 3 to 8 days and young shrimp were reared to an undetermined size in aquaria, fed on corn meal and various food scraps.

Shrimp in the ponds will be fed cooked chicken tripe, cooked coconut, corn and slaughterhouse wastes. Since is is reported that the local shrimp mature in 6 to 8 months, multiple crops of shrimp averaging 70 grams are



Figures 10 and 11. The nasa, a trap woven from wood fiber, traditional gear for capturing freshwater shrimp from streams and impoundments in Panama.



expected by the owner. The crops, if produced, will be marketed, heads on, at approximately 60 cents per pound.

Unfortunately, this shrimp farming enterprise was undertaken without pilot studies run in ponds. Much research needs to be done on the culture of the shrimp in order to produce a firm foundation for the potential industry.

The Auburn Team on May 11, 1970, observed some freshwater shrimp which had been captured from the water supply canal adjacent to the Romero pond and were being held in wire baskets until utilized for broodstock. Males were approximately 14 inches in total length (including chelae) and weighed about 180 grams. Females were about 9 inches in total length and weighed approximately 60 grams. One female was carrying eggs which were brownish in color and about 0.5 mm in diameter. From the color of the eggs, it appeared that embryonic development was well advanced. Temperature in the water of the canal was 82 F.

3.10 Location of Sites for Inland Fisheries Research Stations

At present, there is no facility in the Republic of Panama for research, teaching, or demonstration in inland fisheries or aquaculture. It is imperative that such facilities be established if progress is to be made toward determining whether catfish can be produced commercially in Panama, determining the culture potential of Panamanian fishes, developing the sport fisheries in ponds and reservoirs, and establishing a freshwater shrimp production industry.

With cooperation of U.S.A.I.D./Panama, the Ministry of Commerce and Industry, provincial government officials and private industry, numerous sites for fisheries stations in Panama, Veraguas and Chiriqui Provinces were investigated by the Auburn Team.

3.101 Veraguas Province

After visiting many areas in Veraguas Province, a satisfactory site for a fisheries research station was located at La Raya de Santa Maria. This site is adjacent to the flood plain of the Rio Santa Maria and contains approximately 1,500 hectares of land with principally red and black clay soils extending several feet in depth. A portion of this area, which is being developed for sugar cane production apparently could be made available by the government of Panama for a fishery station. The engineer in charge of the project indicated an irrigation canal will provide water to the mill and farm area from the Rio Santa Maria. Pumps will have a capacity of 30,000 gallons per minute, while only 17,000 gallons per minute will be required for operation of the mill and farm. Thus, 13,000 gallons of water per minute would be available to supply a fishery research station.

Advantages of the proposed location, provided the sugar mill is constructed, include: (1) excellent soil type for ponds, (2) adequate water at no cost, (3) construction costs of ponds might be reduced by utilizing government-owned heavy equipment, (4) a new road to the site (9.6 kilometers from the Pan American Highway) is under construction by government agencies. Disadvantages

include: (1) remoteness of the area in relation to major population and industrial centers, (2) limited present demand for the potential fishery products and poorly developed fish distribution system in the sparsely settled areas, and (4) lack of local enterprise which provide by-products useful in making fish feeds.

3.102 Chiriqui Province

An ideal location for a fishery station was located within the city limits of David near the conjunction of Rio David and the Pan American Highway. The area consists of 37 hectares of flood plain adjacent to the Rio David. The land has 5 owners with holdings of 2 to 10 hectares each. A 10 foot x 3 foot canal, with a flow of approximately 30 cubic feet per second, has been diverted from the river at the upper end of the plain and follows the edge of the plain for one half its length. The canal terminates at an electricity generating plant, the turbines of which were originally turned by water. The plant is now diesel operated, so most of the water would be available for filling ponds should a fishery station be located there.

The soil in the plain was examined, and found to have sufficient silt and clay to form good earthen ponds. Large rocks were present in the soil, especially in the central section of the plain. It appeared unlikely that the rocks would interfere with construction of dams, since they appeared isolated at random locations within the soil, and did not seen to represent porous pockets through which water would be lost.

Advantages of this site include its proximity to water supplies, good soil, favorable location for residences of station staff, and availability of local agricultural and industrial by-products with which to make fish feeds. Intense interest on the part of local businessmen to initiate fishery research as the basis for establishing a new industry is an added benefit.

3.103 Panama Province

The best site for a fishery station for research and teaching was located on lands allocated to the Faculty of Agronomy, University of Panama. This land, adjacent to Tocumen Airport, 15 miles east of Panama City, covers 608 hectares. The land is presently used for plant breeding research with new varieties of corn, rice and certain vegetables. Dr. Enrique Ensenat, Dean of the Faculty of Agronomy, has built a 4-hectare lake on the premises for sport fishing with tucunare and tilapia. The Dean is very enthusiastic about the potential of fish culture in Panama and has offered to cooperate in the development of a fishery research facility. He pointed out a location where a small dam some 300 feet long and 20 feet high could impound a reservoir of approximately 8 hectares. This water could be used to supply a proposed complex of 0.04-hectare research ponds in the plain below the dam. An area of 40 hectares was tentatively offered as a site for pond construction. Soils have a high content of silt and clay, and appear excellent for pond construction.

In view of the availability of lands so near the capital of Panama and the University of Panama, it appears desirable to make every effort to locate a

fishery station on university lands near the Tocumen Airport. All factors considered, this site is probably the best available in the Republic of Panama.

4.0 ASSESSMENT OF THE POTENTIAL FOR DEVELOPMENT OF THE INLAND FISHERIES AND AQUACULTURE IN PANAMA

4.01 History of Inland Fisheries

Traditionally, there has been very limited freshwater commercial fisheries and sport fishing in Panama. The inland water area of the country is small, and consists mainly of short, shallow rivers, which appear relatively unproductive. Any fishery is apparently a subsistence one for local residents on the streams. No strictly freshwater fishes appear in the fish markets of Panama.

4.02 Consumption of Fish

Fish consumption in Panama is approximately 19 pounds per capita per year. This is less than half the amount consumed in countries with well-developed fishery resources such as Japan, Sweden or Denmark, and is low for an essentially sea-bound country. Most of the fish available are marine species caught incidental to shrimp or anchovy fishery. Poorly developed fish handling and distribution facilities result in the majority of Panamanians not having the regular opportunity to obtain fish products. It appears that fish consumption would be greatly increased with availability, particularly in the interior of the country.

4.03 Aquaculture in Panama

The fish cultures in Panama have consisted mainly of introductions of several foreign species for sport fishing. These stockings were made without the benefit of testing to determine how well the fishes grow under local climatic conditions, or to determine effects upon native fish species. The success of the introductions has been highly variable.

4.04 Research and Training in Fisheries

In order to provide a sound basis for fish cultures, research must be done to evaluate performance of aquatic species under local conditions. There is, however, no facility in Panama for research and training in the inland fisheries. There is limited coursework available in Marine Biology at the University of Panama, but none directed toward aquaculture or fish production.

Within the Faculty of Agronomy of the University of Panama, there appears a desirable framework to develop a curriculum for aquaculture. The staff includes experts in soils, entomology, plant sicence, selective breeding, and animal nutrition. These specialities have important relations to the science of fisheries. Equally important, the Dean of the Faculty of Agronomy is enthusiastic about aquaculture as a potential for developing industry and for providing low-cost protein in Panama. The Faculty has agreed to the desirability of developing a research and teaching program in aquaculture.

For the most effective training program in aquaculture, there must be located near the University of Panama a field laboratory with experimental ponds for evaluating fishes and invertebrates where both teachers and students may be actively involved in research. The Faculty of Agronomy has the location for such a facility within its 608-hectare experiment station near Tocumen Airport, 15 miles from the University. Fulfilling requirements of topography and soils, the site includes space for a 8-hectare storage reservoir and 12 to 16 hectares of experimental ponds. The Dean of the Faculty of Agronomy stated that this site, and more land if necessary, could be made available for a fisheries program.

4.05 Demonstration and Extension of Fishculture Methods

Since the fisheries agency of the government of Panama has dealt principally with marine capture fisheries, there are presently no fish hatcheries or demonstration fish farms in the country. To effectively promote fish production and bring the latest methods derived from research into practical use, a demonstration-extension program is essential.

A facility with both ponds of hatchery size and ponds of commercial size, established by the government in an area where fishculture might be developed into a viable industry, would serve an important role in answering questions currently being raised by potential entrepreneurs in fish and shrimp farming.

4.06 Available Inputs for a Fishculture Industry

4.061 Capital Availability for Aquacultures

Of prime importance, there is capital available in private sectors of Panama for investment in fish farming and enthusiasm is high. Investment has already been made in a freshwater shrimp farming venture, and numerous individuals are planning to raise channel catfish, perhaps even before local research is done to determine its advisability. Other businessmen in Panama are sincerely pursuing ways to provide low-cost protein for the campesino, and are willing to invest money and time for promotion of fish products to this end. Civic-minded citizens in Chiriqui Province had obtained information on tilapia culture from Guatemala, and were seeking technical details before promoting this as a food source for people of low income. A civic leader in Panama Province was devoting personal resources to culture of freshwater shrimp, seeking the development of this fishery to provide nutritious food for the campesino.

4.062 Land and Labor

Suitable lands for pond construction were observed in Panama, Cocle, Veraguas and Chiriqui Provinces. Probably, usable soils and sites could be found in the alluvial and coastal areas throughout Panama. In proximity to industrial centers, lands of Panama and Chiriqui are best located for commercial production.

Labor is readily available, and cost of common labor is approximately $4.00/day.

4.063 Ingredients for Fish Feeds

Fish meal, the prime ingredient for fish feed pellets, is produced locally in Panama Province, and is priced at $140.00 per short ton, compared to $200.00 per short ton in the United States. Apparently, the quality of Panamanian anchovy meal is comparable or superior to that from other countries.

Agricultural products from Panama include corn, wheat, soybeans, and rice. Available from nearby countries is cottonseed meal. Industrial by-products include bone meal, meat meal, and distillers solubles. Because of the flourishing poultry industry, antibiotics and vitamin premixes are readily available.

It appears that a good pelleted feed for pond-reared fishes could be produced in Panama at approximately $120.00 per short ton.

4.064 Climate

Water temperatures near sea level in Panama vary little throughout the year, usually ranging from 78 to 82 F. Optimum growing temperature for channel catfish and several other warmwater fishes appears to be near 80 F. With this 12-month growing season at optimum temperature, multiple crops of fish and shrimp should be possible. With proper research to determine most efficient fishes and combination of fishes and/or shrimp, the production per hectare per year in ponds could be 2 to 3 times that in a temperate climate.

4.07 Interest and Enthusiasm

Probably the most important factor in Panama favoring development of inland fisheries and aquacultures is the interest among the private sector, in potential industry investment, in recreation and in civic projects. Government officials and U.S.A.I.D. in their response to the needs of the private sector will no doubt effect the establishment of some form of a program in inland fisheries and aquaculture.

5.0 CULTURE OF SHRIMP AND CATFISH IN HONDURAS

On May 18, 1970, the Auburn Team traveled to San Pedro Sula, Honduras, to observe the shrimp and catfish culture operations of the United Fruit Company. The tour, arranged by U.S.A.I.D./Panama, included Srs. Juan McKay, Juan Obarrio, and Archimedes Franquesa of the Ministry of Commerce and Industry, Republic of Panama, and Mr. Irving Bennett, private sector. The guide was Mr. James Hall, who manages the catfish farm.

5.01 Shrimp (Marine) Culture

The experimental shrimp farm of the United Fruit Company (with Armour and Company) is managed by Mr. Jerry Broom who is an Auburn fisheries graduate. The farm consists of four ponds near the Caribbean shore at Puerto Cortes, 40 miles from San Pedro Sula. Two ponds are 0.20 hectare each, and two are 2 hectares each. Sea water is pumped into the earthen ponds and delivered through saran

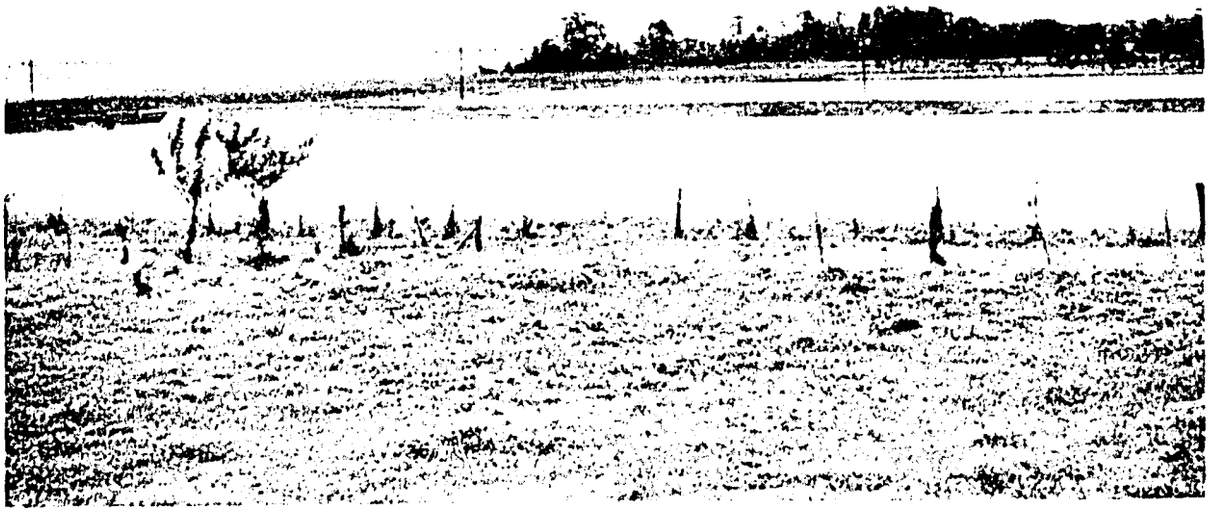


Figure 12. Experimental production ponds at United Fruit Company shrimp farm, Puerto Cortez, Honduras.

Figure 13. Saltwater shrimp, fed on fish feed, are reared from postlarvae to harvestable size in 5 weeks.

or plastic screen one week prior to stocking shrimp postlarvae. Fertilizer is added at the rate of 40 pounds per hectare of 16-20-0 in one application. Postlarval shrimp for stocking are obtained by collection of berried female white shrimp in the Gulf of Panama. The females are flown to the University of Miami, where the eggs are hatched and postlarvae produced. Postlarvae of 10 mm total length are flown to San Pedro Sula and stocked in the ponds at Puerto Cortes. Stocking rate is 4,860 per hectare, and shrimp are fed catfish feed at up to 10 per cent of body weight daily. The postlarvae grow to 30 mm in 2 weeks and are 25-28 count per pound in 8 weeks. At this time, they are harvested and production is 121 to 161 pounds per hectare. If postlarval shrimp are available, five crops can be grown annually, totaling 810 pounds per hectare. Present cost of production is 50 to 55 cents per pound, heads on. With a planned hatchery facility for producing postlarvae, it is hoped that this cost can be reduced.

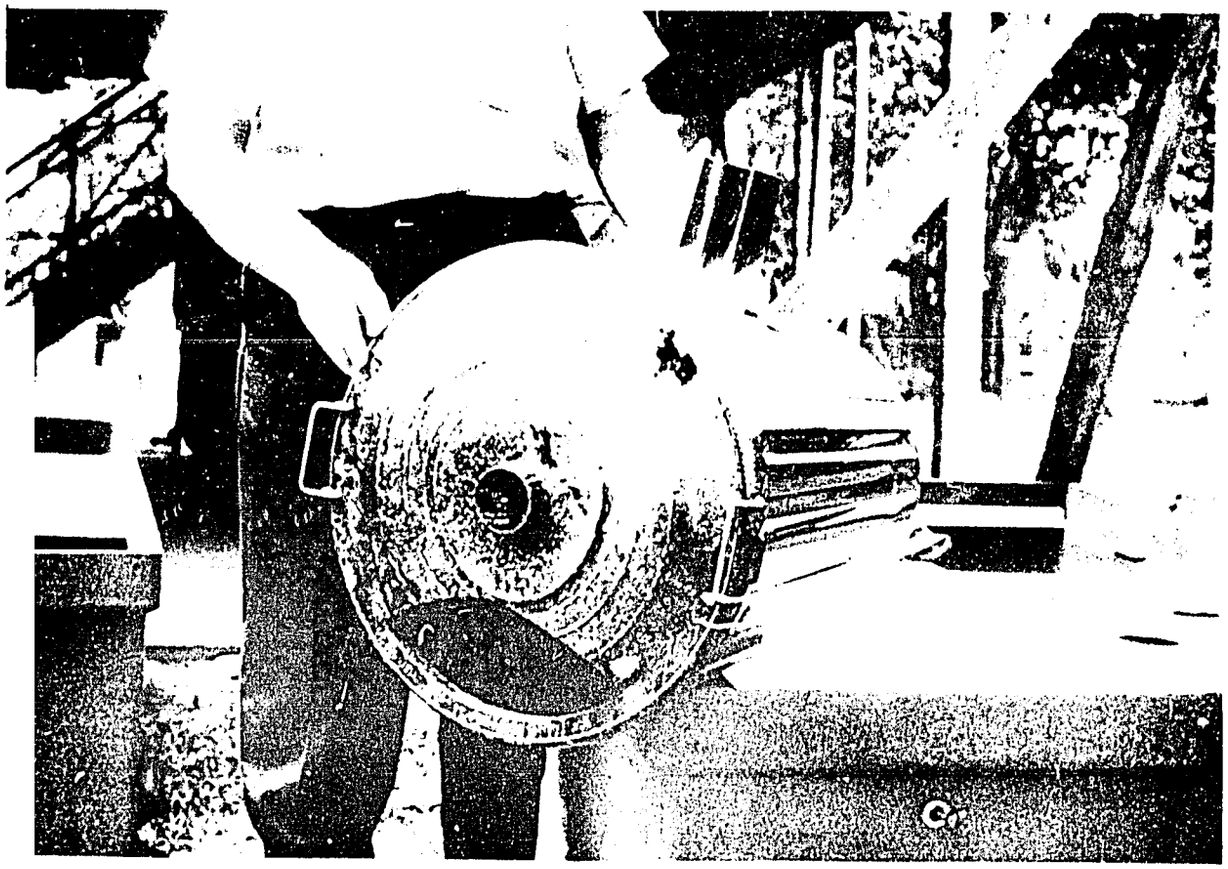
This pilot operation has been so promising that the staff has been expanded to include a biologist, Dr. Eric Heald from the University of Miami, who will rear postlarvae on site. Plans are being made to build a 405-hectare shrimp production farm in the near future. Potential sites are at La Ceiba, 75 miles from Puerto Cortes, and Golfito and Puntarenas on the Pacific shore of Costa Rica. Requirements for sites include rainfall not exceeding 80 inches annually, since sea-strength water in the production ponds is preferred. At Puerto Cortes, top drains and overflows are used to remove freshwater from the surface of the production ponds where it collects because of its lesser density. Temperature in the ponds at Puerto Cortes, where shrimp are reared successfully, ranges

from a low of 70 F in November to a high of 87 F. On May 18, 1970, temperature in the ponds at 12:00 Noon was 82 F.

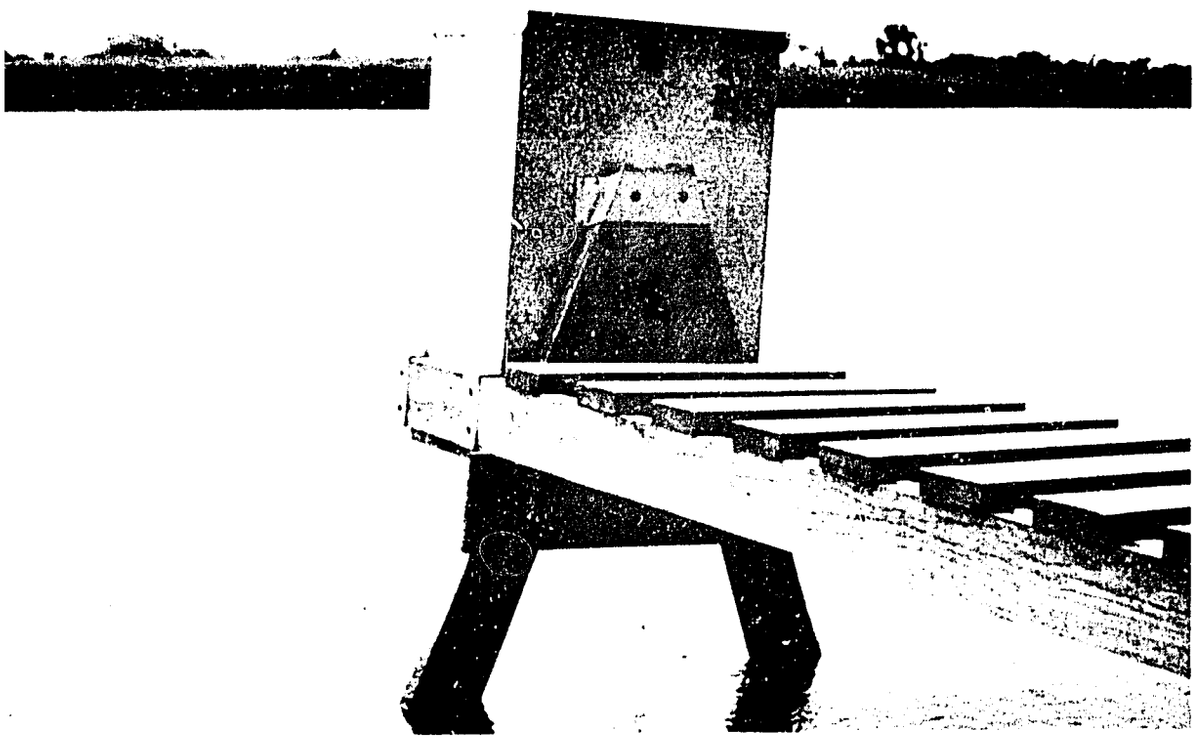
5.02 Catfish Culture

The experimental catfish farm of the United Fruit Company is located between La Lima and El Progresso, about 20 miles from San Pedro Sula. The pilot farm includes 9 ponds: four are 2.8 hectares each, two are 0.81 hectare each, two are 0.61 hectare each and one is 11 hectares. Water supply is from the Rio Ulna, and some 8,100 gallons per minute are pumped 8 hours per day to replace evaporation and seepage from the 26 hectares. Ponds are 3 to 5 feet deep, and temperatures range from 70 to 87 F. Probably because of regular winds, temperature and oxygen levels are similar top to bottom in the ponds.

Channel catfish broodstock were flown from Arkansas in September, 1968, and were spawned in March to July, 1969, by pairing in pens. Males averaged 6 pounds and females 4.5 pounds. The same brood fish were spawned again in 1970, after completing a year in the tropical environment. A problem was encountered with bringing brood fish down to Honduras from Arkansas in March, 1969. The fish, expected to spawn in late April or early May, began spawning in March before facilities were completed. Channel catfish have been spawned by pairing in pens and by the open pond method, but several unexplained difficulties have arisen in handling egg masses and producing fingerlings. Spawning began on February 20 and was underway on May 19, 1970.



gures 14 and 15. Spawning container (above) and demand feeder (below) for channel catfish used at catfish farm owned by United Fruit Company, La Lima, Honduras.



Because of difficulties with disease in eggs and fry, most fingerlings in 1969 production experiments were air freighted from Arkansas. The experimental ponds were stocked at rates of 405 to 2,024 fingerling channel catfish per hectare. After 180 days of feeding with demand feeders, the following growth was achieved:

Stocking Rate (per hectare)	Average Weight (pounds)
2,024	0.8
1,215	1.0
810	1.2
405	1.6

Conversion of feed (with 30 per cent crude protein, 2.5 per cent crude fat, and 10 per cent crude fiber) has yielded an estimated ratio of 1:1 in ponds, with little variation between ponds with different stocking rates. The ponds all have fairly heavy populations of small cyprinodonts and characins which entered with water pumped from Rio Ulna. It is not known if the small fishes form part of the food of the catfishes, or if they compete for fish feed.

Mr. Hall plans the expansion of the catfish production facility to 405 hectares by 1972, with on-site processing and freezing facility. With two crops per year, a production of 4,000,000 pounds may be possible for the year 1972. In 1971, market studies in the United States will be conducted with 500,000 pounds of dressed catfish from the United Fruit Company facility. Retail price is expected to be $0.80 to $0.85 per pound, compared to approximately $1.25 per pound for U.S.-reared catfish. Markets in Europe as well will be explored. Included in the catfish products to be eventually offered are heads-off fish, filets

from larger fish, and fish sticks made by pulping flesh left on the skeletons after fileting.

It appears the United Fruit Company's catfish operation has several factors which promote efficiency of production and effective competition with other sources, including the wild catfish fishery in the Amazonas Region of Brazil. Less costs for land, construction, labor and feed head the list. Year-round water temperatures are near 80 F, which is optimum for channel catfish feed conversion and growth. Multiple crops are possible, with timing of harvest adjusted to suit markets. Prevailing winds help to prevent stratification and oxygen deficits in ponds, lessening the likelihood of mass mortality of the fish.

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United States Government

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8.0 APPENDIX

Table 4. Monthly air temperatures (1967) in the vicinity of fishery station sites located in Chiriqui, Panama, and Veraguas Provinces*

Month	Panama (Tocumen)				Chiriqui (Puerto Armuelles)				Veraguas (Canazas)			
	Max. (°C)	Min. (°C)	Mean (°C)	Mean (°F)	Max. (°C)	Min. (°C)	Mean (°C)	Mean (°F)	Max. (°C)	Min. (°C)	Mean (°C)	Mean (°F)
January	30.7	23.0	26.8	80.2	30.1	19.3	24.7	76.5	29.6	18.5	24.0	75.2
February	30.9	22.3	26.6	79.9	31.1	20.0	25.6	78.1	29.6	18.1	23.8	74.8
March	30.9	22.8	26.8	80.2	31.8	20.3	26.0	78.8	30.1	19.3	24.7	76.5
April	30.9	23.6	27.2	81.0	30.7	21.6	26.2	79.2	30.0	18.5	24.2	75.6
May	31.2	23.8	27.5	81.5	30.4	21.9	26.2	79.2	29.9	18.6	24.2	75.6
June	29.6	23.2	26.4	79.5	28.6	21.2	24.9	76.8	29.3	18.9	24.1	75.4
July	30.0	23.0	26.5	79.7	28.8	21.3	25.0	77.0	29.6	18.3	24.0	75.2
August	30.7	23.0	26.8	80.2	28.9	21.6	25.2	77.4	29.5	18.5	24.0	75.2
September	31.1	21.8	26.4	79.5	28.6	21.2	24.9	76.8	29.4	18.5	24.0	75.2
October	30.6	21.9	26.2	79.2	28.2	21.4	24.8	76.6	29.4	18.1	23.8	74.8
November	30.9	22.1	26.5	79.7	28.2	21.4	24.8	76.6	29.2	18.3	23.8	74.8
December	31.4	21.2	26.3	79.3	29.0	20.7	24.8	76.6	29.0	17.4	23.2	73.8

* Republic of Panama, 1969. Meteorologia: Ano 1967. Contraloria General, Direccion De Estadistica y Censo. Ano XXVIII, Serie "L", 48 p.

Table 5. Temperature data collected in freshwaters of Panama by the Auburn Team, April 29 to May 15, 1970

Temperature	Date	Time	Elevation (feet)	Province	Description of Water Body	Tributary to River
81 F	4/29/70	3:00 PM	250	Veraguas	Tiny stream 2-6' wide x 6-12" deep	Rio San Pedro
76 F	4/30/70	9:00 AM	250	Veraguas	Tiny stream 1-2' wide (spring)	Rio San Pedro
78 F	4/30/70	10:00 AM	200	Veraguas	Stream 10' wide x 1' deep	Rio San Pedro
79 F	4/30/70	Noon	150	Veraguas	Stream 10' wide x 1-2' deep	Rio Santa Maria
87 F	5/1/70	10:30 AM	500	Panama	Dominguez Pond (1.5A x 6-10')	Rio Las Lagas
83 F	5/1/70	Noon	500	Panama	Zauner Pond (0.5A x 3-5')	Rio Las Lagas
88 F	5/1/70	1:00 PM	500	Panama	Dominguez Pond (1.5A x 6-10')	Rio Las Lagas
86 F	5/1/70	5:30 PM	500	Panama	Dominguez Pond (1.5A x 6-10')	Rio Las Lagas
74 F	5/4/70	11:00 AM	1,800	Cocle	Stream 10' wide x 6-12" deep	Rio Anton
77 F	5/4/70	Noon	1,800	Cocle	Stream 2' x 6"	Rio Anton
72 F	5/4/70	1:00 PM	1,800	Cocle	Stream 4' x 6"	Rio Anton
80 F	5/11/70	11:00 AM	30	Chiriqui	Stream 2' x 6"	Rio David
82 F	5/11/70	Noon	200	Chiriqui	Canal 6' x 6" (from R. Papayal)	Rio Chiriqui
68 F	5/11/70	4:00 PM	4,100	Chiriqui	Spring, heavy flow (2' x 1')	Rio Chiriqui Viejo
75 F	5/11/70	4:30 PM	4,100	Chiriqui	Seepage spring (2' x 4")	Rio Chiriqui Viejo
70 F	5/11/70	5:00 PM	4,100	Chiriqui	Stream 10' x 6"	Rio Chiriqui Viejo
68 F	5/11/70	5:00 PM	4,100	Chiriqui	Spring (2' x 1')	Rio Chiriqui Viejo
75 F	5/11/70	5:30 PM	4,100	Chiriqui	La Laguna Lake - Lake Gulnar	Rio Chiriqui Viejo
55 F	5/11/70	7:00 PM	5,600	Chiriqui	Stream (spring fed) (10' x 6-12")	Rio Chiriqui Viejo
61 F	5/11/70	7:30 PM	5,100	Chiriqui	Rio Chiriqui Viejo	Rio Chiriqui Viejo
66 F	5/11/70	8:00 PM	4,100	Chiriqui	Stream 4' x 6"	Rio Chiriqui Viejo

Table 5.--continued

Temperature	Date	Time	Elevation (feet)	Province	Description of Water Body	Tributary to River
63 F	5/12/70	8:00 AM	3,300	Chiriqui	Rio Caldera (Boquete	Rio Caldera
62 F	5/12/70	9:30 AM	3,600	Chiriqui	Stream 10' x 6-12"	Rio Caldera
60 F	5/12/70	10:30 AM	5,200	Chiriqui	Stream 2' x 6"	Rio Caldera
62 F	5/12/70	Noon	5,000	Chiriqui	Rio Chicero 20' x 1'	Rio Caldera
60 F	5/12/70	Noon	5,000	Chiriqui	Spring by Rio Chicero 2' x 6"	Rio Caldera
61 F	5/12/70	12:30 PM	5,200	Chiriqui	Spring 1' x 1'	Rio Caldera
65 F	5/12/70	2:30 PM	3,300	Chiriqui	Stream 10' x 1'	Rio Caldera
83 F	5/12/70	4:30 PM	300	Chiriqui	Irrigation canal 3' x 1'	Rio Chiriqui
81 F	5/12/70	4:30 PM	300	Chiriqui	Rio Esti 30' x 1-5'	Rio Chiriqui
79 F	5/12/70	6:30 PM	30	Chiriqui	Hydroelectric canal 10' x 18"	Rio David
76 F	5/13/70	9:00 AM	30	Chiriqui	Hydroelectric canal 8' x 18"	Rio David
80 F	5/13/70	Noon	40	Chiriqui	Spring fed pond 0.1 acre	Rio David
80 F	5/15/70	2:00 PM	40	Panama	10-acre pond 1-8'	Rio Tocumen

Table 6. Checklist of fishes in the fresh waters of Panama*

Ariidae

1. Felichthys pinnimaculatus
2. Selenopsis dowi
3. Galeichthys seemani
4. G. jordani
5. G. guatemalensis
6. Netuma planiceps
7. N. oscula
8. Arius multiradiatus
9. A. tuyra

Doradidae

10. Trachycorystes amblops

Ageneiosidae

11. Ageneiousus caucanus

Pimelodidae

12. Imparales sp.
13. Rhamdia wagneri
14. R. rogersi
15. R. underwoodi
16. R. heteracantha
17. Pimelodus clarias
18. Pimelodella chagresi

Pygidiidae

19. Pygidium striatum
20. P. septentrionale

Callichthyidae

21. Hoplosternum thoracatum

Loricariidae

22. Plecostomus plecostomus
23. Lasiancistrus planiceps
24. Chaetostoma fischeri
25. Ancistrus chagresi
26. A. spinosus
27. Leptoancistrus canensis
28. Loricaria uracantha
29. L. filamentosa
30. L. variegata
31. L. altipinnis
32. Sturisoma panamense
33. S. citurense

Astroblepidae

34. Astroblepus longifilis

Characidae

35. Curimata magdalenae
36. Apareiodon dariensis
37. A. compressus
38. Characidium marshi
39. C. sp.
40. Compsura gorgonae
41. Cheirodon affinis
42. Saccoderma sp.
43. Phanagoniates macrolepis
44. Gephyrocharax atricaudata
45. G. intermedius
46. G. whaleri
47. G. sp.
48. Astyanax bimaculatus
49. A. fasciatus
50. A. f. aeneus
51. A. ruberrimus
52. A albeolus
53. A. kompi

*Loftin, H. G. 1965. The geographical distribution of freshwater fishes in Panama. Dissertation. Florida State University. 275 p.

Table 6.--continued

Characidae - cont'd

54. Bryconamericus emperador
55. B. zeteki
56. B. cascajalensis
57. B. ricae
58. B. sp.
59. Hemibrycon dariensis
60. Hyphessobrycon panamensis
61. Gasteropelecus maculatus
62. Creagrutus affinis
63. Roeboides guatemalensis
64. R. occidentalis
65. R. salvadoris
66. Brycon striatulus
67. B. chagrensis
68. B. behreae
69. B. guatemalensis
70. B. petrosus
71. B. obscurus
72. B. argenteus
73. Piabucina panamensis
74. P. festae
75. Ctenolucius hujeta
76. Hoplias microlepis
77. H. malabaricus

Sternarchidae

78. Sternopygus dariensis
79. Eigenmannia virescens
80. Hypopomus occidentalis
81. Sternarchus rostratus

Gymnotidae

82. Gymnotus carapo

Poeciliidae

83. Alfaro cultratus
84. Poecilia caucana
85. P. sphenops

Poeciliidae - cont'd

86. Brachyrhaphis terrabensis
87. B. episcopi
88. B. punctifer
89. B. cascajalensis
90. B. sp.
91. Gambusia nicaraguensis
92. Priapichthys panamensis
93. P. dariensis
94. Neoheterandria tridentiger
95. N. cana
96. Poeciliopsis turrubarensis
97. P. elongata
98. P. retropinna
99. Phallichthys amates

Cyprinodontidae

100. Rivulus brunneus
101. R. chucunaque
102. R. volcanus
103. R. hildebrandi
104. R. montium
105. Oxyzygonectes dovii

Cichlidae

106. Aequidens coeruleopunctatus
107. Geophagus crassilabris
108. Cichlasoma maculicauda
109. C. guttulatum
110. C. sieboldi
111. C. tuyrense
112. C. nigrofasciatum
113. C. spilurum
114. C. altifrons
115. C. alfari
116. C. calobrense
117. C. citrinellum
118. C. longimanus
119. C. umbriferum
120. C. sp. A

Table 6.--continued

Cichlidae - cont'd

121. C. sp. B
122. Neetroplus panamensis
123. Herotilapia multispinosa

Pristidae

124. Pristis microdon

Synbranchidae

125. Synbranchus marmoratus

Anguillidae

126. Anguilla rostrata

Elopidae

127. Megalops atlantica
128. Elops saurus

Clupeidae

129. Sardinella stolifera
130. Ilisha fuerthii

Engraulidae

131. Anchoviella elongata
132. A. lucida
133. A. curta
134. Anchoa spinifer
135. A. panamensis

Belonidae

136. Strongylura marina

Syngnathidae

137. Syngnathus elcapitanense

Syngnathidae - cont'd

138. Pseudophallus mindii
139. Oosthethus lineatus

Atherinidae

140. Thyrinops chagresi

Mugilidae

141. Agonostomus monticola
142. A. macracanthus
143. Joturus pichardi
144. Mugil curema
145. Chaenomugil proboscideus

Carangidae

146. Caranx hippos
147. Oligoplites saurus

Centropomidae

148. Centropomus pectinatus
149. C. parallelus
150. C. undecimalis
151. C. nigrescens
152. C. unionensis
153. C. robalito
154. C. armatus
155. C. ensiferus

Lutjanidae

156. Lutjanus novemfasciatus
157. L. colorado
158. L. aya
159. L. argentiventris

Pomadasyidae

160. Pomadasys crocro
161. P. bayanus

Table 6.--continued

Gerridae

162. Eucinostomus argenteus
163. Gerres cinereus
164. Diapterus peruvianus
165. D. brevimanus

Sciaenidae

166. Micropogon altipinnis
167. Stellifer sp.
168. Bardiella ronchus
169. Ophioscion strabo
170. Cynoscion albus

Tetraodontidae

171. Sphaeroides annulatus
172. S. testudineus

Eleotridae

173. Gobiomorus dormitator
174. G. maculatus
175. Dormitator maculatus
176. D. latifrons
177. Eleotris picta
178. E. sp.
179. E. pisonis
180. E. amblyopsis
181. Leptophilypnus fluviatilis
182. L. panamensis
183. Euleptoeleotris clarki
184. E. shropshirei
185. Hemieleotris latifasciatus
186. H. levis
187. Guavina guavina

Gobiidae

188. Garmannia hildebrandi
189. G. homochroma
190. Bathygobius soporator

Gobiidae - cont'd

191. Gobionellus microdon
192. G. daguae
193. G. claytoni
194. Microgobius miraflorensis
195. Awaous tajasica
196. A. transandeanus
197. Sicydium salvini
198. S. antilarrum
199. S. punctatum

Dactyloscopidae

200. Dactyloscopus crossota

Gobiesocidae

201. Gobiesox nudus
202. G. potamius

Bothidae

203. Citharichthys gilberti

Soleidae

204. Achirus fonsecensis
205. A. mazatlanus
206. A. fluviatilis
207. Trinectes maculatus

Table 7. List of freshwater fishes* from the Tocumen Airport area, Rio Bayano Drainage to the Panama Canal, Panama Province

Pimelodidae

13.** Rhamdia wagneri
18. Pimelodella chagresi

Pygidiidae

19. Pygidium striatum

Callichthyidae

21. Hoplosternum thoracatum

Loricariidae

22. Plecostomus plecostomus
26. Ancistrus spinosus
27. Leptoancistrus conensis

Astroblepidae

34. Astroblepus longifilis

Characidae

35. Curimata magdalenae
39. Characidium sp.
40. Compsura gorgonae
41. Cheirodon affinis
44. Gephyrocharax atricaudata
49. Astyanax fasciatus
51. Astyanax ruberrimus
61. Gasteropelecus maculatus
64. Roeboides occidentalis
70. Brycon petrosus
72. Brycon argenteus
73. Piabucina panamensis
75. Ctenolucius hujeta
76. Hoplias microlepis

Sternarchidae

80. Hypopomus occidentalis

Poeciliidae

85. Poecilia sphenops
90. Brachyrhaphis sp.

Cyprinodontidae

101. Rivulus chucunaque

Cichlidae

106. Aequidens coeruleopunctatus
111. Cichlasoma tuyrense

Synbranchiidae

125. Synbranchus marmoratus

Mugilidae

141. Agonostomus monticola

Pomadasyidae

161. Pomadasys bayanus

Eleotridae

174. Gobiomorus maculatus
176. Dormitator latifrons
177. Eleotris picta

Gobiidae

191. Gobionellus microdon
196. Awaous transandeanus
197. Sicydium salvini

*Loftin, H. G. 1965. The geographical distribution of freshwater fishes in Panama. Dissertation. Florida State University. 275 p.
**Numbers accompanying species are according to Loftin's checklist.

Table 8. List of freshwater fishes* from the Canal Zone area, Rio Chagres Drainage and Gatun and Madden Lakes, Colon and Panama Provinces

Pimelodidae

12.** Imparales sp.
13. Rhamdia wagneri
18. Pimelodella chagresi

Pygidiidae

19. Pygidium striatum

Loricariidae

22. Plecostomus plecostomus
24. Chaetostoma fischeri
25. Ancistrus chagresi
28. Loricaria uracantha

Characidae

40. Compsura gorgonae
44. Gephyrocharax atricaudata
51. Astyanax ruberrimus
54. Bryconamericus emperador
60. Hyphessobrycon panamensis
63. Roeboides guatemalensis
67. Brycon chagrensis
70. Brycon petrosus
73. Piabucina panamensis

Sternarchidae

80. Hypopomus occidentalis

Poeciliidae

85. Poecilia sphenops
89. Brachyrhaphis cascajalensis

Cichlidae

106. Aequidens coeruleopunctatus
107. Geophagus crassilabris
108. Cichlasoma maculicauda

Anguillidae

126. Anguilla rostrata

Elopidae

128. Elops saurus

Syngnathidae

139. Oosthethus lineatus

Atherinidae

140. Thyrinops chagresi

Pomadasyidae

160. Pomadasys crocro

Eleotridae

173. Gobiomorus dormitator
175. Dormitator maculatus
179. Eleotris pisonis
180. Eleotris amblyopsis
181. Leptophilypnus fluviatilis

Gobiidae

195. Awaous tajasica
198. Sicydium antillarum

Gobiesocidae

201. Gobiesox nudus

*Loftin, H. G. 1965. The geographical distribution of freshwater fishes in Panama. Dissertation. Florida State University. 275 p.
**Numbers accompanying species are according to Loftin's checklist.

Table 9. List of freshwater fishes* from the La Raya de Santa Maria area, Rio Santa Maria and Rio San Pedro Drainages, Veraguas Province

Pimelodidae

**
12. Imparales sp.
13. Rhamdia wagneri
18. Pimelodella chagresi

Pygidiidae

19. Pygidium striatum

Loricariidae

22. Plecostomus plecostomus
28. Loricaria uracantha
32. Sturisoma panamense

Characidae

35. Curimata magdalenae
40. Compsura gorgonae
41. Cheirodon affinis
45. Gephyrocharax intermedius
51. Astyanax ruberrimus
59. Hemibrycon dariensis
64. Roeboides occidentalis
66. Brycon striatulus
75. Ctenolucius hujeta
76. Hoplias microlepis

Sternarchidae

79. Eigenmannia virescens
80. Hypopomus occidentalis
81 Sternarchus rostratus

Poeciliidae

90. Brachyrhaphis sp.
93. Priapichthys dariensis
94. Neoheterandria tridentiger
96. Poeciliopsis turrubarensis

Cyprinodontidae

102. Rivulus volcanus

Cichlidae

106. Aequidens coeruleopunctatus
110. Cichlosoma sieboldi

Synbranchidae

125. Synbranchus marmoratus

Mugilidae

141. Agonostomus monticola

Eleotridae

174. Gobiomorus maculatus
176. Dormitator latifrons

Gobiidae

196. Awaous transandeanus
197. Sicydium salvini

*Loftin, H. G. 1965. The geographical distribution of freshwater fishes in Panama. Dissertation. Florida State University. 275 p.
**Numbers accompanying species are according to Loftin's checklist.

Table 10. List of freshwater fishes* from the David area, Rio Chico, Rio Chiriqui, and Rio Chiriqui Viejo Drainages, Chiriqui Province

Pimelodidae

13.** Rhamdia wagneri
14. Rhamdia rogersi
18. Pimelodella chagresi

Loricariidae

22. Plecostomus plecostomus
28. Loricaria uracantha

Characidae

35. Curimata magdalenae
40. Compsura gorgonae
45. Gephyrocharax intermedius
52. Astyanax albeolus
65. Roeboides salvadoris
66. Brycon striatulus
76. Hoplias microlepis

Poeciliidae

86. Brachyrhaphis terrabensis
90. Brachyrhaphis sp.
96. Poeciliopsis turrubarensis
98. Poeciliopsis retropinna

Cyprinodontidae

102. Rivulus volcanus
103. Rivulus hildebrandi

Cichlidae

106. Aequidens coeruleopunctatus
110. Cichlasoma sieboldi
114. Cichlasoma altifrons
117. Cichlasoma citrinellum
118. Cichlasoma longimanus

Synbranchidae

125. Synbranchus marmoratus

Syngnathidae

137. Syngnathus elcapitanense

Mugilidae

141. Agonostomus monticola

Eleotridae

174. Gobiomorus maculatus
178. Eleotris sp.

Gobiidae

197. Sicydium salvini

*Loftin, H. G. 1965. The geographical distribution of freshwater fishes in Panama. Dissertation. Florida State University. 275 p.
**Numbers accompanying species are according to Loftin's checklist.