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Progress Report on Fisheries Development in Northeastern Brazil

II.

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AUBURN UNIVERSITY
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Progress Report on Fisheries Development in Northeastern Brazil

II. Reservoir Fisheries of Northeastern Brazil

W. D. DAVIES[1]

INTRODUCTION

THE UNITED STATES Agency for International Development has been providing assistance to the Government of Brazil in freshwater fisheries since 1966 under a program entitled, "Fish Production, Processing and Marketing." The DNOCS[2] has the responsibility for inland fisheries; assistance has been made available to DNOCS through agreements administered by SUDENE.[3] The USAID project agreements to date have consisted of monetary and technical assistance contracted to the United States Bureau of Commercial Fisheries[4] (from 1966 to 1971) and the Auburn University Agricultural Experiment Station International Center for Aquaculture (from 1969 to 1974).

The project goal established for this assistance is to create within DNOCS a freshwater fisheries group capable of planning and conducting practical research programs in the fields of fish culture, fisheries biology, and food technology. The objectives are to increase fish production in northeastern Brazil through proper management of the freshwater fisheries, improve fish processing methods, and to introduce intensive fishculture techniques. Once these objectives are achieved, then a certain degree of progress can be made in improving the general well-being of the people by increasing the amount of protein available for human consumption and by creating opportunities for capital investment.

This report will summarize and evaluate USAID assistance in fisheries biology, with special emphasis on the Auburn University Contract AID, csd-2270, Task Order No. 4 (November 1970-August 1972). A brief description of the Drought Polygon of northeastern Brazil, the reservoir fisheries, and the marketing systems will be followed by sections on past and present strategy, project status, and recommendations for future action.

BACKGROUND

The Drought Polygon

Nine states comprise the area of northeastern Brazil, from Bahia in the south to Piaui in the north. Except for the littoral zone and the area west of 44° West Longitude, all of the above states are included in an area termed the Drought Polygon. This area consists of approximately 1 million square kilometers, or about 70 per cent of northeastern Brazil. The littoral zone usually extends several miles inland to where the land rises to form a low plateau. Characteristic geographical features are intermittent streams and low, rounded remains of Precambrian igneous extrusions. The permanent rivers of this region are the Parnaiba and the Sao Francisco *(4)*.

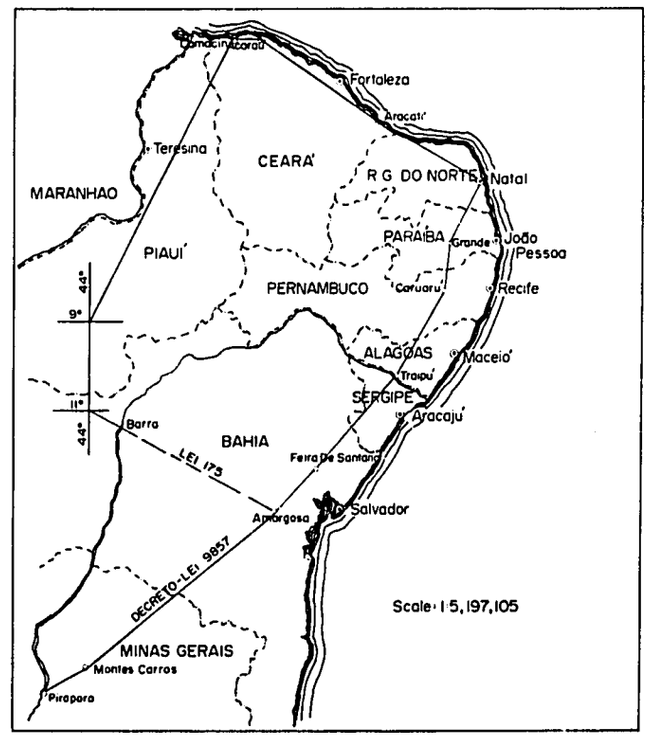

FIG. 1. Map of northeastern Brazil showing the Drought Polygon.

The plateau region is plagued by frequent droughts and poor soil fertility. Even in non-drought years, there is usually a 6- to 8-month period with little or no rainfall. As a result, the region is experiencing slow economic development *(9)*. Also, the diet of the people is markedly inadequate in proteins, especially in the high quality proteins which are present in meat and fish products. The present low dietary level has

[1] Assistant Professor, Department of Fisheries and Allied Aquacultures.
[2] Departamento Nacional de Obras Contra as Secas (National Department of Works Against the Drought).
[3] Superintendencia do Desenvolvimento do Nordeste (Superintendency for the Development of the Northeast).
[4] Now the National Marine Fisheries Service.

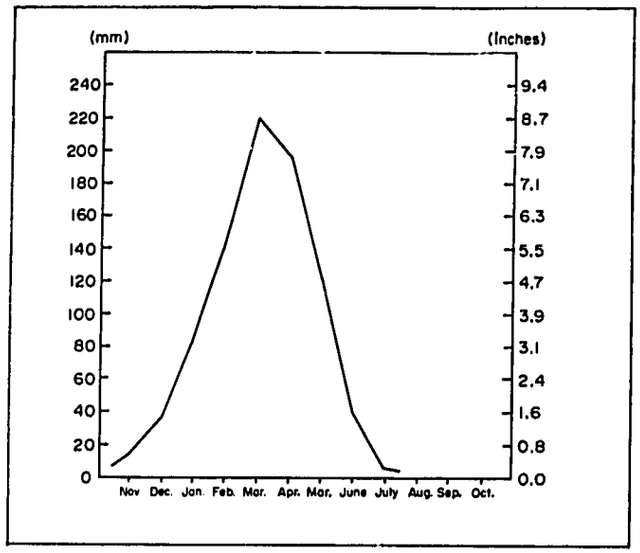

FIG. 2. Average monthly precipitation (1912-1967, Nov.-July) for the State of Ceara, Brazil.

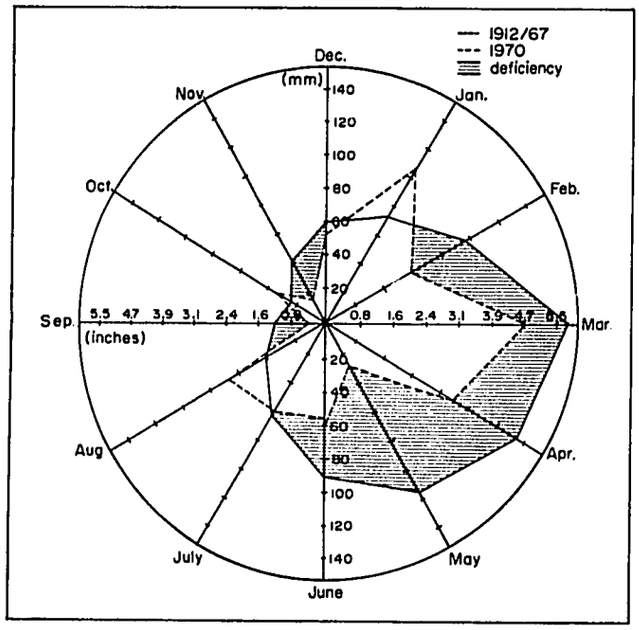

FIG. 3. Average monthly precipitation (1912-1967) for northeastern Brazil compared with monthly precipitation for 1970, a drought year.

only been maintained by bringing new, marginal lands into production. Chemical fertilizers, farm mechanization, and irrigation practices have not as yet been brought into general use. The present rate of increase of the population is 2.4 per cent annually.

The DNOCS

As a means of countering the effects of the drought, the Government of Brazil has been constructing reservoirs in this region. Since 1945, DNOCS has been the responsible agency and has constructed or assisted in the construction of approximately 850 reservoirs. These are estimated to represent about two-thirds of the major available sites for large reservoirs. Of these, 254 are classified as public reservoirs; 117 contain 2 million cubic feet or more of water (unpublished DNOCS statistics). These reservoirs were used at first for water storage to serve as oases during periods of drought, and later for irrigation, hydro-electric power, and fish production.

Characteristic physical and chemical features of these waters are as follows: temperature differences from top to bottom (less than 3°F) are usually not sufficient to prevent mixing of the water column by wind action. However, during calm periods, water greater than 10 meters in depth can become devoid of oxygen. Alkalinity remains between 55 and 88 p.p.m., pH 7.0 to 8.0, and salinity 60 to 100 p.p.m. Yearly variation in surface elevation can be as great as three meters. During the rainy season (March-July), the reservoirs often will overflow *(3)*.

DNOCS has the responsibility for managing the freshwater fishery resources. They have established fish hatcheries at Ico, Ceara (Lima Campos); Maranguape, Ceara (Amanari); Caico, Rio Grande do Norte (Itans); and Itiuba, Bahia (Jacurici). They also have a Center for Fisheries Research at Pentecoste, Ceara, a Division of Fisheries and Fish Culture in each of four regions to collect fishery statistics, and a Directory of Fisheries and Fish Culture for administrative purposes. The Fisheries Services within DNOCS are depicted in the following abbreviated organizational chart.

Organization of Fishery Services within DNOCS

- Ministry of the Interior
  - Director General, DNOCS
    - General Directory of Administration
      - Directory of Finance and Records
    - General Directory of Irrigation
      - Directory of Studies and Projects
      - Directory of Irrigation
      - Directory of Fisheries and Fish Culture
        - Center for Fisheries Research
        - Division of Fisheries and Fish Culture
    - Directory of Works and Equipment
    - Directory of Regions (4)
      - Division of Administration
    - Directory of Irrigation
      - Division of Studies and Works
      - Division of Assistance
      - Division of Fisheries and Fish Culture
        - Fish Hatchery Stations
      - Division of Water and Dams

Since 1945, fishery activities within DNOCS have been mainly concerned with production of fingerlings to stock new impoundments and the collection of fishery statistics. For example, once a dam has been closed, a DNOCS fisheries team will usually poison the natural population of fish to eradicate the various species of piranha. They will then stock the reservoir with several species of fish that have been acclimated from the Amazon, Parnaiba, and Sao Francisco rivers. Once populations are established, fishing is permitted. Fishermen must register their gear and pay a small fee per unit of gear as indicated in Table 1.

At present, each fisherman must report to a guard station each day he fishes to record and weigh his catch. Regulations which are currently imposed on the fishery take the form of gill net mesh restrictions, quantity of gear, and closed seasons.

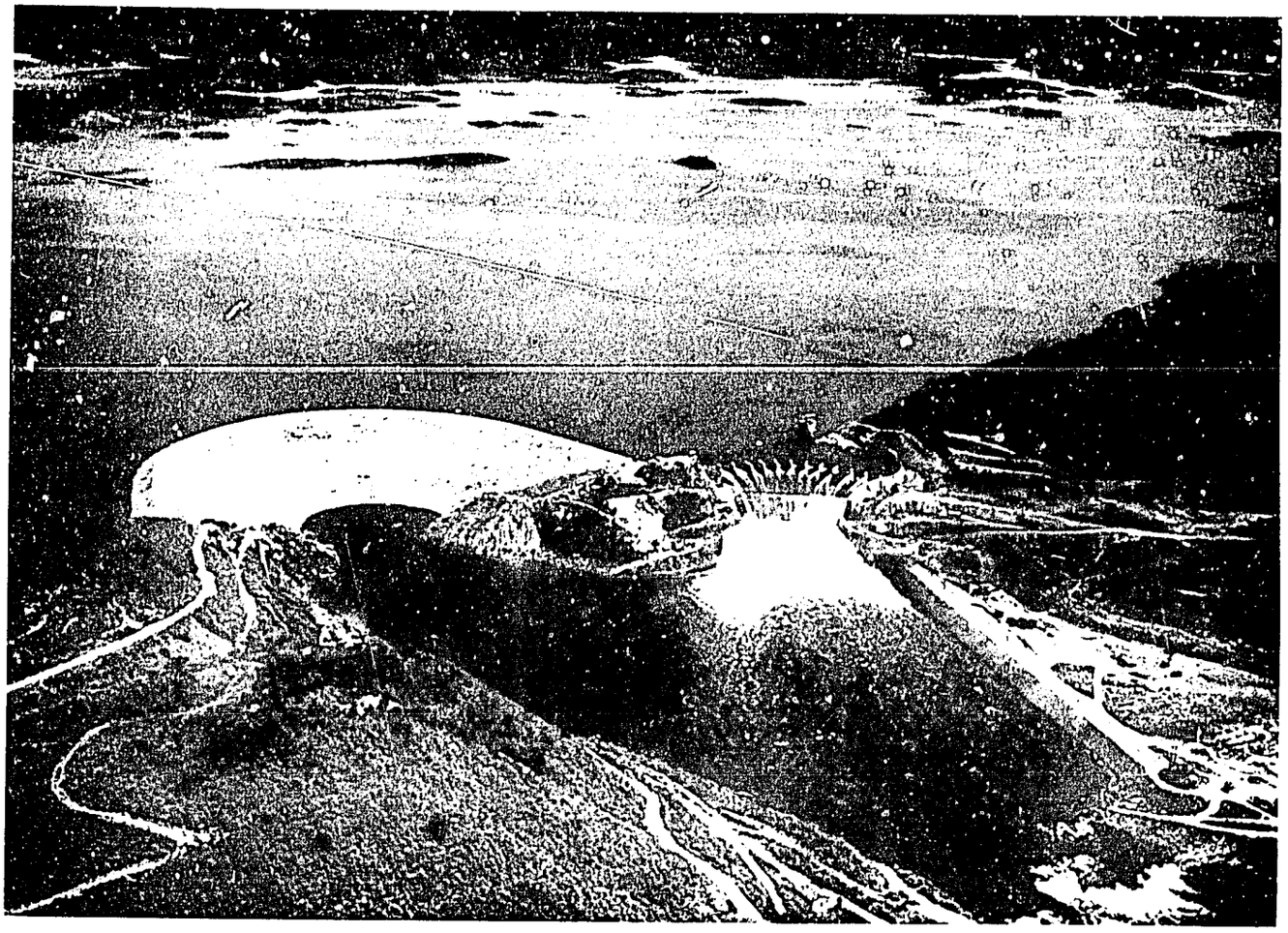

FIG. 4. Reservoir Oros, with a surface area of approximately 35,000 hectares (87,500 acres) is the largest impoundment in the State of Ceara.

TABLE 1. MONTHLY COST PER UNIT FOR VARIOUS TYPES OF FISHING GEAR USED IN THE RESERVOIR FISHERIES OF NORTHEASTERN BRAZIL

Gear	Unit	Cost[1]	
		Cruzeiros	*U.S. dollars*
Cast net (cotton)	1		
greater than 2 m.		1.50	0.25
less than 2 m.		0.75	0.13
Cast net (nylon)	1		
greater than 2 m.		2.50	0.43
less than 2 m.		2.00	0.34
Sinking gill net	1 m.	0.03	.....
Floating gill net	2 m.	0.05	.....
Hand line (one hook)	1	1.00	0.17
Long line	hook	0.03	.....
Pole and line	1	1.00	0.17
Canoe (without motor)	1	1.50	0.25
Canoe (with motor)	1	15.00	2.55

[1] Rate of exchange as of July, 1972: Cr 1.00 = U.S. $0.17.

Freshwater Fisheries

Production

The freshwater fisheries of northeastern Brazil are presently yielding approximately 40,000 metric tons per year with an equivalent dollar value of about 6.6 million. This production is about equal to the yield of fish from marine fisheries in the Northeast as shown in Table 2.

TABLE 2. ESTIMATED LANDINGS FROM FRESHWATER AND MARINE FISHERIES

Year	Total Brazil	Northeast
	Metric tons	*Metric tons*
1966	368,367	91,258
1967	361,680	99,685
1968	414,529	98,240

Freshwater fish production has increased in recent years due mainly to fisheries developing on newly impounded waters. The reported increase, however, may also reflect more efficient efforts by DNOCS in gathering catch data. Table 3 shows the yield from reservoirs on which DNOCS has estimated total catch *(2)*.

The distribution by state for the 77 reservoirs under DNOCS jurisdiction in 1968 is presented in Table 4. The contribution by state to the total catch for that year is also included.

The reservoir fisheries in Ceara are producing near average yields per unit of area when compared with other tropical, inland lake fisheries. Based on DNOCS catch statistics

and the reported area for four reservoirs, yields per hectare were calculated, and are presented in Table 5.

TABLE 3. FRESHWATER FISH PRODUCTION FROM PUBLIC RESERVOIRS UNDER DNOCS CONTROL

Year	Total production	Number of reservoirs represented in total
	Metric tons	
1950	626	12
1951	1,041	12
1952	755	12
1953	639	12
1954	489	12
1955	492	12
1956	921	16
1957	1,118	16
1958	1,547	22
1959	1,839	22
1960	2,305	22
1961	6,446	25
1962	7,798	26
1963	10,125	27
1964	8,660	53
1965	10,387	66
1966	11,082	66
1967	10,016	66
1968	11,936	77

TABLE 4. DISTRIBUTION AND 1968 CATCH FOR DNOCS RESERVOIRS

State	Number of reservoirs	Catch
		Metric tons
Piaui	7	118
Ceara	36	8,047
R. G. do Norte	7	370
Paraiba	11	1,970
Pernambuco	3	539
Alagoas	5	32
Sergipe	1	1
Bahia	6	834
Minas Gerais	1	25

TABLE 5. YIELD PER HECTARE FOR FOUR DNOCS RESERVOIRS

Reservoir	Reported area	Yield			
		1965	1966	1967	1968
	Hectares	*Kg./ha*[1]	*Kg./ha.*	*Kg./ha.*	*Kg./ha.*
Araras	9,625	260(228)	236(208)	144(127)	112(98)
Pereira de Miranda	5,024	110(97)	73(64)	54(47)	92(81)
Lima Campas	1,514	54(47)	59(52)	86(76)	87(77)
Forquilha	987	84(74)	59(52)	52(46)	71(62)

[1] Numbers in parentheses show lb./A.

Gear

The principal type of fishing gear used in the reservoir fisheries is the monofilament gill net, although other types of gear are common. These nets were first introduced in 1957, and within a few years they completely replaced cotton nets. Current regulations prohibit the use of a mesh smaller than 9 centimeters (stretch measurement) for sinking nets and 5 centimeters for floating nets (3.54 and 1.97 inches respectively). These nets are usually 50 to 100 meters (164 to 328 feet) in length, 1 to 2 meters (3.3 to 6.6 feet) in depth, and hung on a one-half basis with a minimum of floats and weights. Twine size is usually between 0.20 and 0.30 millimeters in diameter.

FIG. 5. Monofilament gill nets, the main type of fishing gear used in the reservoirs of northeastern Brazil, are usually set in the evening and fished the following morning.

Floating gill nets are commonly used to take sardinha (*Triportheus angulatus*) and beiru (*Curimata* sp.), while sinking nets primarily take curimata comum (*Prochilodus cearensis*), pescada do piaui (*Plagioscion squamosissimus*), traira (*Hoplias malabaricus*), piau comum (*Leporinus friderici*), and piau verdadeiro (*Leporinus* sp.). Float lines are used exclusively for traira, while long lines and hand lines are used mainly for pescada do piaui. A pole and line is the preferred gear for tucunare (*Cichla temensis* and *Cichla ocellaris*) and apaiari (*Astronotus ocellatus*).

Fishermen

Fishermen commonly live on the margin of the reservoirs where they also tend small farms. Recent surveys have shown that although a fisherman may register his gear each month, he will fish a greater number of days during the months from August to February. During the rest of the year he is occupied with cultivating his land or working on the farms of large landowners.

The portion of his catch that he sells during the year is worth approximately 1,920.00 cruzeiros (U.S. $326.09), which is less than the minimum wage established for this region (CR $2,188.80 per year, Ceara, 1972). He will receive on the average CR $1.00 per kilogram (U.S. $0.08 per pound) for his catch, which eventually sells for CR $2.00

FIG. 6. Long lines baited with small freshwater shrimp are used mainly for taking pescada do piaui *(Plagioscion squamosissimus)*.

to CR $3.00 per kilogram (U.S. $0.15 to 0.23 per pound) in urban markets.

The average fisherman has six dependents who will consume about 20 per cent of his catch. He usually owns his canoe, hooks, nets, and lines, but in many cases these items were financed through the intermediary who buys his catch. He has sufficient income to purchase a bicycle and a radio, but he usually cannot afford to send his children to the local schools.

Marketing

Recent study groups have indicated that the demand for fish products in northeastern Brazil exceeds the supply. However, freshwater fish products in this region have traditionally been a low priced food item when compared to pork, poultry, and beef as shown in Table 6.

TABLE 6. RANGE IN PRICE PER KILOGRAM FOR FISH AND MEAT PRODUCTS, MAY, 1972, FORTALEZA, CEARA

Product	Range in price per lb.	
	CR	*U.S.*
Whole freshwater fish	1.50- 3.50	0.11-0.19
Whole saltwater fish	3.50- 8.00	0.19-0.62
Salted fish products	2.00- 5.00	0.15-0.39
Ground beef	4.00- 6.00	0.31-0.46
Pork leg	5.00- 7.00	0.39-0.54
Whole chicken	8.50-12.00	0.65-1.09

The low price of freshwater fish products is partly due to the usually poor quality of the product. The handling, distribution and marketing systems are outdated and unsanitary. For example, fish landed in the morning are never eviscerated. Fish captured by gill nets may have been dead in the water from 6 to 12 hours. The warm water (82-86° F) encourages enzymatic and bacterial action resulting in rapid putrification. If the fish are not sold before they begin to bloat, they are salted and sundried.

The distribution system involves middle-men who transport fresh and salted fish products to markets by truck, bicycle, or on foot. Around larger reservoirs, fish are often held in ice chests for several days and are usually transported twice a week to urban markets. There the fish are sold directly to retailers who maintain stalls in the markets and to street vendors who carry their product from house to house. Fresh and salted fish products are supplied to interior, rural markets from local reservoirs.

Very few retailers have facilities for holding fish more than a day. As a result they characteristically buy less fish than they could possibly sell to protect themselves from loss.

PAST STRATEGY

Agreement Organization

At the beginning of this program, the Bureau of Commercial Fisheries contract personnel proposed to increase protein production through freshwater fisheries resource management. A primary consideration was the establishment of a functional institution within DNOCS capable of developing and applying management principles. This unit was to be funded by financial contributions from CONTAP[5] (through SUDENE), USAID, and DNOCS. After several delays, the basic structure for headquarters and laboratory space was rented in July 1967. An additional 9 months were needed to design and construct facilities for biological, limnological, and technological research. This institution was called the CONVENIO DPAN[6]; the suggested organization and staffing are shown in the chart on the following page.

The plan called for developing a close working relationship with concerned Brazilian government agencies, these being SUDENE and SUDEPE[7], which have the responsibility for program supervision and funding respectively. Also, it was essential that the functions of the new research group be well defined within the DNOCS structure so as to avoid duplication of effort and to provide for a clear chain of command. As a result, the CONVENIO DPAN was administratively placed under the direction of Dr. Osmar Fontenele, Directory of Fisheries and Fish Culture *(7,8,10)*.

It was partly due to these early organizational problems that two of the three Bureau of Commercial Fisheries contract personnel were stationed in Recife, Pernambuco, with the Agriculture and Rural Development Division, USAID, rather than in Fortaleza, Ceara, where the CONVENIO DPAN is located. An obvious drawback to this arrangement was the difficulty it imposed on technical assistants in fisheries biology when they tried accompaning their Brazilian counterparts on many of the field trips.

Agreement Inputs

DNOCS personnel (usually 10 to 13) assigned to the project often had considerable field experience as fisheries biologists; however, they usually held university degrees in the fields of agronomy, agricultural engineering, veterinary medicine, pharmacy, or chemistry. In addition, they usually had little experience working as an interdisciplinary group.

Because of this, emphasis was placed on participant training early in the program. To date, 6 participants have received special 9-month courses at various universities in the United States. Three have received training in food processing, one in fisheries biology, one in limnology, and one in fish culture. Five of the six participants have remained di-

[5] Conselho de Cooperacao Tecnica de Alianco para o Progresso (Technical Cooperation Council of the Alliance for Progress). Now the Sub-Secretaria de Cooperacao Economica de Tecnica Internacional—SUBIN (Sub-office for International Economic and Technical Cooperation).

[6] Desenvolvemento da Pesca nos Acudes do Nordeste (Development of the Northeastern Reservoir Fisheries).

[7] Superintendencia do Desenvolvimento da Pesca (Superintendency for Fisheries Development).

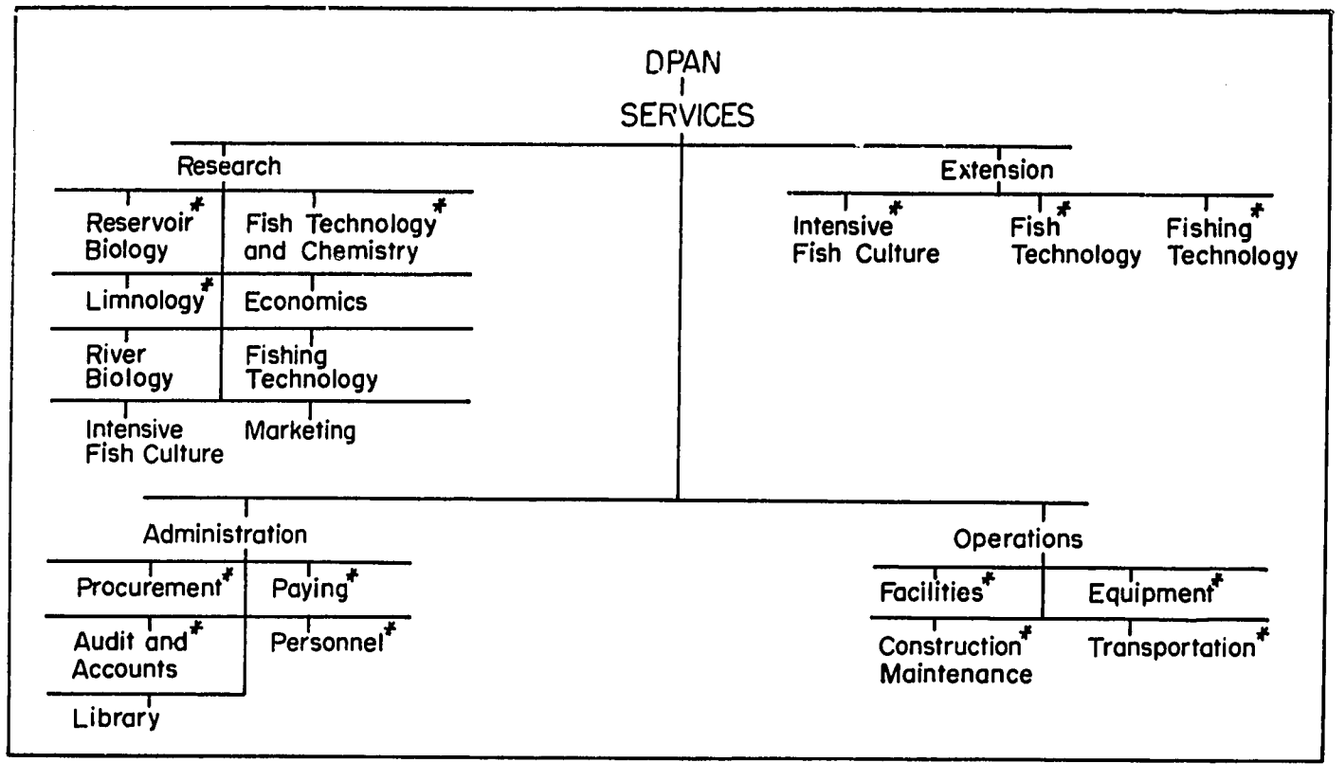

FIG. 7. Freshwater Fisheries Resource Management personnel chart (asterisks indicate sections now functioning).

rectly associated with the program. They returned not only with improved technical abilities, but with a much better attitude toward applied research work. Also, four participants from the CONVENIO DPAN and other sectors within DNOCS have recently returned from a 2-month tour of fish hatchery and laboratory facilities in the United States *(5)*.

Additional assistance and training was provided by contracting consultants from Auburn University for periods up to 10 weeks in 1966, 1967, and 1968. Teams consisting of three men each worked with Brazilian counterparts at several reservoirs and local fish hatcheries to determine the potential for increased fish production. Various methods of stock assessment that provided a logical framework for planning continued studies were introduced. Several of the 1966 team's recommendations, namely that the natural fish production from reservoirs could not be substantially increased and that a program of intensive fish culture in small ponds be initiated, were significant in that they altered the emphasis of the CONVENIO DPAN from fishery biology and food technology to intensive fish culture *(1)*.

A short-term marketing study conducted under USAID sponsorship in 1967 upheld the feasibility of using intensive fish culture for increasing the food supply and decreasing protein deficiency in northeastern Brazil *(6)*. A typical marketing study, to be conducted simultaneously with the development of intensive fish culture systems, was recommended to ascertain the extent of the market potential.

To date, 54 ponds, with a total surface area of 4 hectares, and a field laboratory have been constructed on a site near Pentecoste, Ceara. A fish culture specialist contracted from Auburn University arrived in October 1969, to assist in fish culture research activities. A program of technological assistance in fish culture and extension is presently scheduled through June 1974.

CURRENT STRATEGY

Objectives

Technical assistance in fisheries biology of reservoirs will terminate with Task Order 4, Auburn University-Brazil Contract, AID/csd-2270 in August 1972, culminating almost 6 years of advice and direction to the project. The broad objectives of Task Order 4 were to assist the Brazilian counterpart biologists in developing management policy from existing research findings and to advise on present and future activities.

Upon my arrival in Fortaleza in October 1970, I found that although a tremendous amount of data had been collected very little had been accomplished in their analysis to form a basis for management recommendations and scientific publications. Although the two Brazilian counterparts assigned to the project were diligent workers, they were not aware in many cases of methods of analysis basic to fishery investigations.

After becoming familiar with the desires and needs of my counterparts and the reservoir fisheries in general, I proposed the following work schedule:

1. To accompany the Brazilian biologists on all of their field trips (usually 5 to 10 working days per month) in order to introduce new field methods and recommend revisions in existing ones.
2. To actively assist in the summary, analysis, and publication of existing data.
3. To demonstrate acceptable procedures for sampling programs and in the design and analysis of experiments.
4. To increase the harvestable production in terms of pounds of fish through the introductions of new species.
5. To assist in the preparation of proposed recommendations for the rational exploitation of the fishery resources.

In many cases, it would have been impossible to recommend more efficient methods of operation without becoming totally familiar with the reservoir fisheries, the market and distribution systems, and the life style and needs of the fishermen. It was considered equally important to be aware of the cost of data collecting in terms of total cash expenditures and manpower requirements so that adopted procedures could be continued without USAID or CONTAP financial contributions.

Initial Recommendations

A first step was to limit field activities to two reservoirs (rather than four) and to restrict activities to collecting data essential for developing management policy. Two reservoirs that were characteristic in size and age of many of the public reservoirs in northeastern Brazil were chosen. These were Forquilha and Banabuiu, 987 and 9,000 hectares in surface area and 22 and 7 years in age respectively.

Experimental Gill Net Studies

Initial recommendations dealt with modifying routine sample survey techniques so as to obtain data of greater precision. For example, DNOCS biologists, while conducting routine gill net selection studies, were not standardizing the length, depth, and twine size of the individual nets, thus making a definitive determination of gill net selection difficult. Previously collected data were adjusted in the final analysis using factors obtained by experimentally fishing a series of old and new (uniform) nets. These data, along with information on growth and mortality, will provide the basis for recommending mesh size regulations.

Continued routine fishing of experimental gill nets is recommended until the net selection characteristics for commercially important species are determined. In addition to length and weight measurements already being taken, girth measurements should be recorded and the relationship between total length and maximum girth determined. From this information the relationship between the girth for mean selection lengths and mesh size, which is helpful to understanding how fish are retained in the net, can be estimated.

Fishing Effort

Routine sampling of the commercial catch at guard stations provided an opportunity to estimate the effort actually being applied to the fishery. For example, when gill nets, hooks, and thrust baskets are all being used to capture a species, the relative fishing power of each type of gear must be determined to gauge individual units of effort. Once overall effective fishing power is determined, catch per effort unit is easily calculated and is an essential factor in many methods of analysis.

Periodic sampling of the guard stations should continue on several reservoirs to determine effort as it is applied to each species. A non-uniform probability sampling scheme has been proposed based on the number of fishermen reporting to a guard station and sampling those stations chosen during a 1-week period each quarter.

Tagging Studies

There are several methods for estimating fishing and natural mortality for a commercially fished population. One method, a tagging program, was carried out on Reservoir Forquilha. The success of the program required the full cooperation of the fishermen. Arrangements for prompt payment of tag returns and a genuine show of gratitude were effective in achieving this cooperation. Also, special studies carried out in ponds gave an indication of tag loss and tagging mortality. This study, while mainly serving as a demonstration, has already provided essential information for computation of maximum sustained yields for the traira fishery.

FIG. 8. Fishery guard with a curimata pacu (*Prochilodus* sp.).

Traira were chosen because of their ease of capture. Fish in excellent condition for tagging could be caught with thrust baskets. However, information of this type is needed for other commercially important species. One method for collecting a large number of fish for tagging is with a boat-mounted electric shocker. However, a suitable portable generator (230 volts AC with rated output of 3,000 watts) has not been located in Brazil. Because of the importance of this information for developing management policy, efforts should be made by DNOCS to import a suitable generator.

Fisherman Survey

A fisherman survey was initiated to obtain specific information on the economic status of a fishing family, methods of processing and distribution of the catch, and the status of the market during various times of the year. This information is essential for evaluating proposals for fishing cooperatives and proposed purchases of outboard motors, larger vessels, and other equipment. Fishermen are interviewed when

they weigh and record their catch at the guard station. Only current information is requested as it is difficult for the fishermen to relate past events without exaggeration. Surveys of this type should continue and be conducted in conjunction with periodic sampling of the guard stations.

Species Introduction

Studies were introduced to investigate the food habits, growth potential, reproductive requirements, and habitat occupied for several fish species. This knowledge is essential for choosing species for introduction into reservoirs to increase production. It is very likely that the successful introduction of a new species will have some affect on existing populations. A gain in harvestable production is sometimes possible at the expense of existing populations with little or no commercial value; for example, the introduction of a commercially valuable predator that feeds on species having a low market value.

FIG. 9. The tucunare or peacock bass is normally taken with a pole and line baited with freshwater shrimp or piabas. This species is *Cichla temensis*.

As part of this program, the effect of an accidently-introduced population of tucunare on other fish populations in Reservoir Banabuio is being studied. The tucunare is a predator that inhabits the margin of reservoirs. It is a fine food fish, having few spines and firm flesh, and contributes significantly to the monetary value of the commercial catch in reservoirs when it is present. The results of these studies to

FIG. 10. The paiche or pirarucu *(Arapaima gigas)* has been introduced into several reservoirs in the Northeast. Almost all of the larger individuals entering the catch are harpooned.

date indicate that the tucunare is a very efficient predator that restricts its feeding for the most part to marginal areas. These areas often contain 80 to 110 kilograms per hectare (70 to 97 pounds per acre) of tucunare, while the total weight of other species that commonly inhabit the margin – acara comum (*Cichlasoma bimaculatum*), jacunda (*Crenicichlat saxatilis*), piaba chata (*Astyanax* sp.) – is much reduced from what is considered normal for other reservoirs in northeastern Brazil.

The potential food requirements of the tucunare and how predator-prey relationships will vary between reservors must be understood before recommending introductions into other reservoirs. A first step would be to conduct experimental studies in ponds using tucunare in combination with other species. However, present DNOCS policy prohibits the introduction of this species into watersheds where it does not already exist. As a result, tucunare have not been introduced on the Pentecoste Fish Culture Research Station, where such studies could most logically take place. It is recommended that DNOCS reconsider this policy to the extent that both species of tucunare be permitted to be introduced onto the Pentecoste station for experimental purposes.

Publications

Technical publications are an important part of any research program. This is especially true in Brazil where there

is a scarcity of published information on the biology of indigenous fishes. The reluctance of counterpart biologists to publish data from sample surveys and experimental studies was due in a large part to an unawareness of convenient methods of analysis. To counter this, several sets of typical data were chosen as examples and analyzed using accepted methods. In all cases the interpretation of results stressed management implications. The following manuscripts were prepared for publication in the journal, *Boletim do DNOCS:*

1. Age and Growth of Curimata Comum (*Prochilodus cearensis*) in Reservoir Pereira de Miranda Ceara.
2. A Preliminary Analysis of Timbo Sampling in Reservoir Pereira de Miranda, Ceara.
3. Selectivity of Monofilament Gill Nets for Pescada do Piaui (*Plagioscion squamosissimus*) in Reservoir Pereira de Miranda, Ceara.
4. Computation of Surplus Production for Traira (*Hoplias malabaricus*) in Reservoir Forquilha, Ceara.

Age and Growth of Curimata Comum

The growth characteristics of a fish species has important management implications. For example, the expected growth in length over time is an important consideration in setting gill net restrictions, while growth in weight is used in several methods for estimating yield. Individual lengths, weights, and scale samples of curimata comum collected from Reservoir Pereira de Miranda (1966-1970) were analyzed to demonstrate methods for calculating growth.

Scales of curimata comum have well defined rings that can consistently be identified by trained observers. The rings are formed during the spawning migration that takes place during the height of the rainy season. At this time there is reduced growth due to a cessation of feeding and the formation of sex products. This study validated these rings as annuli, and the assigned ages were then used to compute the von Bertalanffy growth equation in length.

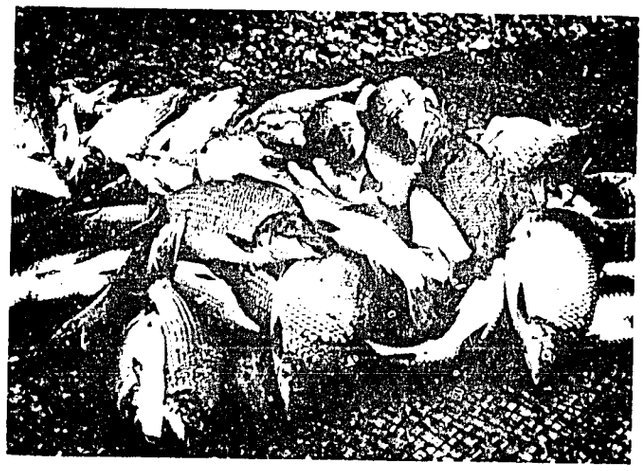

FIG. 11. A good catch of curimata comum (*Prochilodus cearensis*). Most of these fish appear to be in their second year. In Reservoir Pereira de Miranda this species will reach an average length of 25.3 cm. (9.9 in.) in 1 year, 33.7 cm. (13.2 in.) in 2 years, and 44.8 cm. (16 5 in.) in 3 years.

It is recommended that the scale method for determining age be tried for other species having similar spawning habits. These include piau verdadeiro (*Leporinus* sp.), sardinha (*Triportheus angulatus*), piau comum (*Leporinus friderici*), and beiru (*Curimata* sp.).

Other methods must be used for species that have multiple spawns in any one year and, as a result, do not develop a well-defined mark on their scales. These are apaiari (*Astronotus ocellatus*), tucunare (*Cichla temensis* and *C. ocellaris*), pescada do piaui (*Plagioscion squamosissimus*) and traira (*Hoplias malabaricus*). In this case, increased growth recorded from tag recaptures could be used. Length-frequency tabulations have not been helpful in separating age groups.

Samples from Fish Populations Taken by Rotenone (Timbo)

The use of powdered timbo or other rotenone containing products for sampling fish populations is common throughout the world. An analysis of 29 population samples taken by rotenone in Reservoir Pereira de Miranda during the period 1966-1970 was used to demonstrate the variability among samples for estimates of standing crop, relative abundance of species, proportional balance of groups of species, and the relative strength of year-classes. In addition, the number of samples required from similar habitats was estimated for various limits and levels of confidence.

The purpose was to demonstrate the desirability of proper planning in research activities. Clearly it is desirable to avoid making the number of samples so small that estimates are too imprecise to be useful. Equally it is desirable to avoid taking more samples than are needed to reduce costs of manpower and material.

Because of the extreme variability of these data and the relatively high cost of sampling with timbo, it is recommended that this procedure be used only when initiating a study on a new reservoir to identify the majority of species present or when large numbers of fish are needed for qualitative biological studies.

Experimental Gill Net Studies

The monofilament gill net is the principal type of fishing gear used in the reservoir fisheries of northeastern Brazil. Knowledge of the selection characteristics of these nets is essential for proper management of the fishery. For example, these data, in addition to information on growth and mortality, provide a basis for recommending mesh size restrictions.

The catch of pescada do piaui from experimental gill netting was analyzed to determine the selection characteristics of these nets. The authors first assumed a normal frequency distribution and estimated its parameters from ratios of catches from successive nets. From these data it appeared that sufficient justification existed to recommend that the allowable mesh size be reduced from 9 to 7 centimeters (stretch measurement) in waters where pescada do piaui are primarily taken.

It is recommended that routine experimental gill netting should continue until sufficient data exist for determining net selection characteristics for curimata comum, traira, piau comum, and piau verdadeiro. It will then be possible to recommend a compromise mesh size that best suits the multispecies reservoir fishery.

Surplus Production

Attainment of the maximum sustained yield is sometimes considered the main objective of fishery management. Proposals estimating sustained yield usually consider rates of recruitment, growth, and natural mortality. However, one proposal relates potential sustained yield of a population to its abundance and rate of fishing.

Using the information gained from the tagging demonstration of traira in Reservoir Forquilha, the total catch as reported by DNOCS, and the adjusted units of effort for gill nets, hooks, and thrust baskets, the surplus reproduction for this species was calculated. Actually, three levels of surplus production were calculated using adjusted and unadjusted rates of fishing mortality. When tag returns were adjusted for tag loss and tagging mortality, the surplus production was calculated to be 30 per cent greater than the present average commercial catch, thus indicating that the population is being harvested somewhat below the optimum rate.

Obviously such studies are of considerable importance in determining the status of a fishery and in estimating potential yield. It is recommended that surplus production be determined for all commercially important species once estimates of fishing mortality are available. However, each estimate must be carefully interpreted in terms of the accuracy and precision of each factor entering into the computation and the correctness of basic assumptions inherent to this method.

PRESENT STATUS

The actual impact of technical assistance in fisheries biology can best be evaluated in qualitative terms such as institutional growth and maturity and expansion of human skills. Admittedly, a quantitative evaluation in terms of increased production of freshwater fish products would be more appropriate. However, a greater period of time is needed to adequately verify such indicators. For example, because of the variation in annual weight yield from reservoir fisheries, at least 8 to 10 years of information will be needed to verify a 10 per cent increase in yield.

Expansion of Human Skills

Up to the time the CONVENIO DPAN was formed, Brazilian biologists working in the Northeast had little formal training in fishery science. Their research efforts had been qualitative and descriptive rather than quantitative, resulting in information that was not readily transformed into management policy.

This situation has improved to the extent that counterpart biologists can plan and execute studies to gain specific information. For example, DNOCS recently requested an immediate recommendation on whether the fishery of a large reservoir could be industrialized, i.e., the addition of large outboard motor boats and the construction of cold storage facilities. The proposed plan called for a relatively large cash expenditure and would require a substantial increase in catch of commercially important species to justify the costs. Whether such an increase in effort would cause an appreciable decrease in catch per effort unit and eventually result in a reduced yield can best be answered by an understanding of the rates of growth, mortality, and recruitment for the individual species concerned. However, the counterpart biologists, having gained an appreciation for the principles of population dynamics, were able to use available catch and effort data to approximate the amount of fishing the resource could accept on a sustained basis.

Long range plans developed by counterpart biologists reflect an increased appreciation for sampling and experimental error. In past studies, a small number of samples or insufficient replication in an experiment often resulted in estimates of low precision and of questionable value. In this respect, their plans now give careful consideration to economy of effort and the resources available.

Institutional Growth

The CONVENIO DPAN is recognized by DNOC as an effective scientific institution capable of administering programs in fish culture and fishery biology, and they have pledged continued support to this institution when USAID contributions cease. To ensure the continued development of CONVENIO DPAN and the fisheries project, the following recommendations are offered:

1. Additional academic training in the special field of population dynamics would be desirable. Such a program should include instruction in automatic data processing techniques so that returning participants can take advantage of the computer time that is becoming increasingly available in the Fortaleza area. DNOCS should provide graduate degree scholarships for project personnel at the University of Sao Paulo Department of Biological Sciences, where such training is possible.

2. It is essential that program personnel receive training in the special fields of fish diseases and parasites and fish nutrition. This training could be carried out in Brazil during a 3-week program by a team of two professors from the International Center for Aquaculture, Auburn University. An ideal location for this training would be the DNOCS Training Center which is located less than a mile from the Pentecoste Fish Culture Research Station. Adequate facilities exist for 26 individuals, which would permit approximately 10 biologists from other government agencies to participate in the program. It is recommended that AID provide special training funds for this assistance upon the request of the Brazilian Government.

3. It is possible that individual projects within the CONVENIO DPAN have their roles too narrowly defined. As a result, cooperation between projects, especially in sharing facilities and manpower, could be improved. In this respect it is recommended that the Director of the CONVENIO DPAN review the activities of each project to define areas of mutual interest where cooperation is possible. The result will be an institution much more effective in using available resources.

4. Although a library exists within the CONVENIO DPAN, it is not functional. No method exists for indexing the location of material or the deposition of items loaned. As a result, books and subscriptions obtained are largely unusable. Attempts to organize the library in the past have been unsuccessful because individuals assigned the task were not qualified or were not hired on a permanent basis. It is therefore recommended that DNOCS hire a qualified librarian on a permanent basis to organize and expand the existing facility.

Marketing and Distribution of Fish Products

The marketing and participant training programs recommended in the report, "Short-Term Marketing Study of the Intensive Freshwater Fisheries Development of Northeast Brazil," *(6)* were not implemented. In this report, the author described the existing marketing and distribution systems as archaic and unsanitary. In 1972 there has been no improvement in the system. Although this report was concerned with market development in conjunction with the development of intensive fish culture systems, the same ills affect the marketing and distribution of the commercial catch from

the reservoir fisheries. As a result, both projects would benefit from the findings of the study.

Because the present marketing system is recognized to be a limiting factor to future development of the freshwater fishing industry of northeastern Brazil, it is recommended that action be taken to determine the market potential for handling, marketing, and distribution. If the Government of Brazil requests USAID technical assistance, suitable counterpart personnel could come from the newly formed graduate program in agricultural economics, School of Agronomy, University of Ceara. The Government of Brazil could provide support through in-country training scholarships in fish marketing.

CONCLUSIONS

Technical assistance rendered under the Auburn University Brazil Contract, AID/csd-2270, Task Order No. 4, served to consolidate the results of previous assistance in fishery biology of reservoirs and to stress the importance of more advanced methods of assessing fish stocks, of sampling, and of design and analysis of experiments. Obviously the form of advice required changes with advancements in institutional development and increasing human skills. In this case, inputs provided were appropriate because of progress made under previous technical assistance in fishery biology.

The freshwater fish stocks of northeastern Brazil are being moderately to heavily exploited. As a result, rather precise estimates of population parameters are required for developing management policy. In tropical areas, fisheries are usually based on a number of species. However, in northeastern Brazil the number of commercially important species in any one reservoir is not great, usually numbering between 3 and 8. The currently recommended approach is to analyze the data for each species separately, taking into account any interactions, and add the results together. However, as new species are introduced, this approach may prove to be unworkable. An alternate approach would be to treat the species complex as a unit and relate fishing effort to the combined catch of all species.

The Brazilian counterpart biologists are well aware of these options. They now have the necessary technical skills and understanding to conduct basic studies on growth, mortality, and gear selection characteristics, and to use these data to determine management policy. Additional inputs into this project, such as scholarships for advanced graduate studies and equipment purchases, can and should be supplied by the Brazilian Government.

To ensure the continued development of the CONVENIO DPAN and the fisheries biology project, additional AID inputs are desirable. These are special training funds for a 3-week course in fish diseases and parasites and fish nutrition to be presented in Brazil, technical assistance for at least 1 year in the fields of fishery marketing and economics, and a once-a-year visit by a specialist in fish population dynamics to evaluate expected gains.

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APPENDIX

Fish Species Common to Reservoirs of Northeastern Brazil

Common name	Family	Species
Acclimated species		
Apaiari°	Cichlidae	*Astronotus ocellatus*
Tucunare comum°	Cichlidae	*Cichla ocellaris*
Tucunare pinima°	Cichlidae	*C. temensis*
Tilapia°	Cichlidae	*Tilapia rendalli*
Pescada do piaui°	Sciaenidae	*Plagioscion squamosissimus*
Pescada AMC°	Sciaenidae	*P. surinamensis*
Piau verdadeiro°	Characidae	*Leporinus* sp.
Curimata pacu°	Characidae	*Prochilodus* sp.
Pirarucu°	Arapaimidae	*Arapaima gigas*
Regional species		
Beiru°	Characidae	*Curimata* sp.
Piaba chata	Characidae	*Astyanax* sp.
Piaba nao pintada	Characidae	*Hyphessobrycon paryellus*
Piabucu	Characidae	*Curimata elegans*
Piau comum°	Characidae	*Leporinus friderici*
Curimata comum°	Characidae	*Prochilodus cearensis*
Traira°	Characidae	*Hoplias malabaricus*
Pirambeba	Characidae	*Serrasalmus* sp.
Piranha	Characidae	*Serrasalmus* sp.
Sardinha	Characidae	*Triportheus angulatus*
Bodo	Loricariidae	*Plecostomus plecostomus*
Cangati°	Auchenipteridae	*Trachycorystes galeatus*
Guaru	Poeciliidae	*Poecilia vivipara*
Moreia branca	Gobiidae	*Awaous transadeanus*
Moreia preta	Gobiidae	*Eleotris pisonis*
Mucu	Synbranchidae	*Synbranchus marmoratus*
Timbiro	Engraulidae	*Pterengraulis atherinoides*

° Indicates commercially important species.