Capture Fishery and Aquaculture Potential
in the State of Amapá, Brazil

by

Leonard L. Lovshin
International Center for Aquaculture and Aquatic Environments
Auburn University, Alabama 36849, U.S.A.

Richard Wallace
Extension Marine Specialist
AUMERC\SG
4170 Commanders Dr.
Mobile, Alabama 36615, U.S.A.

Fernando Kubitza
Universidade de São Paulo
Escola Superior de Agricultura "Luiz de Queiroz"
Departamento de Zootecnia
Av. Pádua Dias, 11
Caixa Postal 9
Piracicaba, São Paulo 13418-900 Brazil

Ronaldo B. Barthem
Museu Paraense Emilio Goeldi
Departamento de Zoologia/Sector de Ictiologia
Caixa Postal 399
Belém, Pará 66040 Brazil
# TABLE OF CONTENTS

I. Executive Summary ............................................................................................. 4

II. Introduction ............................................................................................................ 6

III. Aquaculture ........................................................................................................... 7
    A. Food Fish .......................................................................................................... 7
       1. Culture Systems ................................................................................... 7
       2. Fish Species ........................................................................................... 8
       3. Land ...................................................................................................... 10
       4. Water .................................................................................................... 10
       5. Fertilizers and Feeds ......................................................................... 11
       6. Processing ........................................................................................... 12
       7. Markets ................................................................................................. 13
       8. Support Services to Aquaculture .................................................... 13
       9. Government Regulations ................................................................ 14
    B. Ornamental Fish ........................................................................................... 14
    C. Conclusions ................................................................................................... 15
    D. Recommendations ........................................................................................ 16

IV. Shrimp Capture .................................................................................................. 17
    A. Marine Shrimp .............................................................................................. 17
       1. Management ...................................................................................... 19
       2. Research .............................................................................................. 19
    B. Freshwater Shrimp ....................................................................................... 19
    C. Processing and Infrastructure .................................................................... 20
    D. Conclusions ................................................................................................... 21
    E. Recommendations ........................................................................................ 21

V. Capture Fisheries ................................................................................................ 22
    A. Fishing Areas ................................................................................................. 22
       1. Amazon Estuary .................................................................................. 22
       2. Internal Delta ..................................................................................... 23
       3. Lower Amazon ................................................................................... 23
       4. Other Fishing Areas .......................................................................... 24
    B. Major Stocks .................................................................................................. 24
       1. Saltwater Catfish ............................................................................... 24
          a. Gurijuba .................................................................................. 24
          b. Other Sea Catfish .................................................................. 24
       2. Freshwater Catfish ............................................................................... 25
          a. Piramutaba .............................................................................. 25
          b. Dourada .................................................................................. 26
          c. Piraiba or Filhote ................................................................... 26
          d. Tamoatá ................................................................................. 26

-2-
3. Sciaenidae ........................................................................................................ 27  
   a. Pescada Amarela ....................................................................................... 27  
   b. Corvina ..................................................................................................... 27  
   c. Pescadinho Gó ....................................................................................... 27  
   d. Pescada Branca ...................................................................................... 27  
4. Other Species ................................................................................................ 27  
C. Management .................................................................................................. 28  
   1. General ...................................................................................................... 28  
   2. Piramutaba ............................................................................................... 28  
   3. Dourada, Filhote, Pescada Branca, Pescada Amarela, and Pescadinho Gó .................................................................................... 29  
4. Gurijuba ........................................................................................................ 29  
5. Other Amazon River Species ........................................................................ 29  
D. Research ...................................................................................................... 29  
E. Processing and Marketing ........................................................................... 30  
F. Overseas Exports ......................................................................................... 31  
G. Domestic Sales ............................................................................................. 31  
H. Conclusions .................................................................................................. 32  
I. Recommendations ........................................................................................ 33  
   1. Research .................................................................................................. 33  
      a. Saltwater Catfish .................................................................................... 33  
      b. Freshwater Catfish .............................................................................. 33  
      c. Sciaenidae ............................................................................................. 33  
   2. Processing and Marketing ......................................................................... 33  
      a. General ................................................................................................. 33  
      b. Saltwater Catfish .................................................................................. 34  
VI. Annex—Itinerary .......................................................................................... 35  
VII. Bibliography ............................................................................................... 38  
VIII. Acknowledgment ...................................................................................... 40  
IX. Map, Tables, and Figures ............................................................................ 41
I. Executive Summary

A four-man team composed of two aquaculture specialists and two capture fishery specialists was fielded by the International Center for Aquaculture and Aquatic Environments, Auburn University under contract to Champion International Corporation to evaluate the potential for aquaculture, and expansion of the capture fisheries in the state of Amapá, Brazil. The team spent June 16 to 24 in the city of Belém, Pará and Amapá interviewing government officials, fish and shrimp processors and fishermen. Visits were made to local fish markets, suppliers of animal feeds and agricultural chemicals in Belém and Macapá, a feed mill in Belém, port facilities in Amapá City, Calçoene, and Santana, and two fish farmers in Macapa. Car and plane travel allowed observation of water and land resources for aquaculture in eastern and central Amapá. Total alkalinity, hardness and pH were measured in numerous rivers, two lakes and two fish ponds.

The two industrialized capture fisheries enterprises in the region are for piramutaba, a schooling Amazon River catfish, and for marine shrimp along the north coast of Amapá. Numerous other freshwater and marine fishes are captured by artisanal fishermen. Pescada amarela (Acoupa weakfish) and gurijuba (sea catfish) are two high-valued marine fishes captured in coastal waters on the north coast of Amapá by artisanal fishermen. The piramutaba fishery is centered in the lower Amazon River and its estuary near Belém, Pará, while the marine shrimp fishery is located primarily north and south of the Amazon River mouth. The number of boats allowed to fish and times of year when fishing is permitted are controlled by the government for both marine shrimp and piramutaba. In 1993, 48 boats caught 10,000 metric tons of piramutaba. Piramutaba exported to the U. S. was valued at 3 million dollars. One hundred and sixty-five shrimp vessels registered in Pará and Amapá harvested 3,172 metric tons of marine shrimp in 1995. Most piramutaba and marine shrimp along with much of the freshwater and marine fish caught by artisanal fishermen are landed in Belém for processing because facilities are more extensive, unloading of the catch is quicker and prices paid are higher than in Santana. The piramutaba fishery is located closer to Belém than Santana and processing should remain centered in Belém. However, the marine shrimp and fish capture fishery on the north coast of Amapá is much closer to processing facilities in Santana than Belém. Modernization of fish processing facilities in Santana, and the construction of a new processing facility in Calçoene on the north coast of Amapá, coupled with an increase in prices offered to fisherman, could entice most of the north coast catch to Amapá. Investment in a modern, fish processing plant, or modernization of an existing processing facility, could prove lucrative. Major expansion of the marine shrimp fishery does not seem advisable based on existing data. Catch per unit effort of marine shrimp suggests that more boats will not significantly increase the catch but more information is needed on lesser known shrimp found in
both deep and shallow water. However, there may be opportunities for expansion of the shrimp fleet in Santana given the current processing capability and proximity to the northern shrimp grounds. Catch rates and potential yields of the principal marine fishes captured in shallow coastal waters are not known, so expansion should proceed with caution and adequate monitoring.

Amapá has vast quantities of land and flowing and standing water that can be used for farming fish in earthen ponds, flowing water, or cages. A humid, tropical climate, modern port facilities, fish processing and cold storage facilities, and duty free privileges on imports, are other features offered by Amapá in support of aquaculture development. However, while abundant and free of pollutants, water tested in Amapá has low mineral content and total alkalinity which makes the water unproductive unless corrected with limestone. No limestone deposits are exploited in Amapá at this time. Production systems based on primary production of phytoplankton, even when pond waters are fertilized, will not yield many fish per area of water without limestone applications. Systems that do not depend on primary production to feed fish require nutritionally balanced, pelleted diets to grow fish and obtain high yields. Fish feeds available in Macapá are expensive. No pelleted fish feeds are made in Amapá or Belém. Pelleted fish feeds sold in Macapá are manufactured in south-central Brazil and are trucked to Amapá. Amapá has few agricultural by-products or grains that could be used to make fish feeds. Overland transportation costs to Amapá are expensive because trucks are barged across the Amazon River.

The only fish species native to the Amazon River that have proven suitable for fish culture are tambaqui, pirapatina and matrinxa. All can be fed with local fruits, nuts, and seeds, corn and other grains, as well as pelleted fish diets. However, overseas markets for these bony fishes are undeveloped and may prove difficult to enter. No other fishes from the Amazon River have been tested for culture suitability although a number of native fishes may prove excellent for farming after extensive testing in research ponds. Non-native tilapia is found in Amapá and is the best species available for farming at this time. Culture methods for tilapia are well developed and established markets for processed tilapia are found in the U.S. and Europe. The legality of culturing a fish exotic to the Amazon River system in Amapá must be established with the federal government. Presently, whatever fish is farmed in large quantities in Amapá will have to be sold outside of cities located on or near the Amazon River. Fish captured from the Amazon River are still readily available for reasonable prices in cities located on or near the river. Most farmed fish can not be priced low enough to compete with fish captured from the rivers. Most farmed fish will have to be sold in the south of Brazil or overseas.

At this time, the high cost of limestone, fertilizers and fish feeds purchased in Brazil and trucked to Amapá increases production costs and makes fish farming a high risk investment. Fish farmed in Amapá would have to compete in the
market with fish grown in other regions of Brazil and in other countries with a tropical climate. Importation of large quantities of fish feeds or fish feed ingredients and limestone by ship from the south of Brazil or the U. S. may improve the economic viability of farming fish in Amapá.

II. Introduction

Amapá has an area of 140,276 km² and is bordered by French Guyana on the North, the state of Pará on the South and West and the Atlantic Ocean on the East. Macapá, the capital city, is located on the Equator and the state has a humid, tropical climate. Average annual air temperature varies between 25 and 26°C, average maximum air temperature varies between 29°C in February and March to 32°C in October and average minimum air temperature is about 24°C throughout the year. Average annual rainfall in Macapá is 2,500 mm with February, March, April and May the wettest months and September, October and November the driest months. The state has abundant freshwater resources, dominated by the Amazon river and many smaller rivers and streams, swamps and seasonal wetlands. Rivers along the east coast and central Amapá flow into the Atlantic Ocean while rivers in the southern and western portion of the state flow into the Amazon River. Most of the state is covered by tropical rainforest but a narrow band of grassland savanna runs south to north through the center of the state.

The government reported about 300,000 inhabitants in Amapá in 1991 but presently, the state is estimated to have 600,000 inhabitants of which 75% live in Macapá and the neighboring port city of Santana. Principal economic activities are mining (manganese and gold), forestry products (extraction and farming), fresh and salt water capture fisheries, water buffalo and cattle ranching, palm oil, rubber latex and Brazil nut extraction. Agriculture is generally limited to subsistence farming and a few palm and fruit tree plantations. With the closing of the manganese mine in Serra do Navio within two years, the remaining major economic activity will be the farming of pine and eucalyptus trees by Champion International Corporation and Jari Project. Macapá is one of two free ports in Brazil and aquaculture, pond construction and fish processing equipment, agricultural supplies and feeds can be imported duty free.

An international airport is located in Macapá with several flights weekly to Cayenne in French Guyana and 3 or 4 daily flights to major Brazilian cities. A modern port located at Santana on the Amazon River is capable of receiving large ocean cargo freighters. The port has facilities for loading and storage of refrigerated and nonrefrigerated containers, manganese ore and wood chips. Trucks carrying food stuffs and agricultural supplies purchased in the south of Brazil are transported 30 to 36 hours across the mouth of the Amazon River from Belém on barges. The major highway in Amapá runs from Macapá north to the French Guyana border. Only 150 km of this highway are asphalt, the remaining portion of the highway is a graded, dirt road which is transitable.
year round, but requires cautious driving in the rainy season. The remaining roads are graded dirt and become difficult to drive during the rainy season. Santana and Macapá are connected by an all weather road. Electricity is supplied to Macapá, Santana and other cities in the south of Amapá by a hydroelectric dam located on the Araguari River, and fossil fuel generation plants. The generation capacity of the hydroelectric dam and fossil fuel plants has been reached and during times of low rainfall, electricity is rationed. Small cities in the east and north of Amapá have individual electric generators.

The International Center for Aquaculture and Aquatic Environments, Auburn University, at the request of Champion International Corporation, provided a 4-man team to evaluate the capture fishery and aquaculture potential in the state of Amapá. Two Auburn University specialists, one each in aquaculture and capture fisheries, and two Brazilian specialists, one each in aquaculture and capture fisheries formed the evaluation team. Champion International Corporation contracted Auburn University at the request of the Amapá government, which indicated strong interest in fisheries programs as a means to improve economic development within the state. The study was performed from June 16 through 24, 1997 with logistical support provided by Champion International Corporation in Amapá. Discussions were held with government officials and scientists connected with the study and control of the capture fishery on the lower Amazon River and Atlantic Ocean, and aquaculture in Amapá. Fish processors and fishermen in Belém, Pará and in Amapá were also interviewed. Fish markets, feed mills and agricultural supply stores were visited in Belém and Macapá. Two small fish farms near Macapá were visited. A two-day car trip permitted the team to survey capture fishery installations and boat landings in Amapá City and Calçoene, and land and water resources for aquaculture along the main north-south highway in Amapá. A three hour plane flight provided an aerial view of coastal and inland water and land resources in Amapá. A calendar of events detailing the teams activities is found in annex 1.

III. Aquaculture

A. Food fish

1. Culture systems - Methods for growing food fish can be divided into semi-intensive and intensive systems. The semi-intensive system depends on the water to produce the aquatic plants and animals that will provide most of the food necessary to grow a crop of fish. Fish are cultured in ponds receiving only enough water to maintain optimum culture depth. Water is introduced only to replace losses, which are normally due to evaporation and seepage. Entrance of water into the pond is strictly controlled. Pond waters are fertilized with agricultural fertilizers or animal manures to improve phytoplankton production and increase the amount of small crustaceans and insects available for the fish to eat. Agricultural by-products can be used to further fertilize pond waters or feed fish. In regions where commercial fish feeds are unavailable or
are expensive, growing plants and animals through fertilization of pond waters may be the only way to culture fish economically. The ability of the pond water to utilize the fertilizers to increase primary productivity will determine the amount of fish that can be raised per unit area of pond. Fish cultured using fertilizers must feed on the food items produced in the pond low on the food chain. Carnivorous fish that feed on small fish are not suited to this system of culture.

The intensive system does not depend on natural pond foods to grow fish but on commercial fish feeds. Most modern fish culture is based on commercially produced feeds, usually in pelleted form. Normally, pelleted diets must be nutritionally balanced to provide all the nutrients the fish need for optimum growth. Where water is abundant, fish can be densely stocked into ponds or concrete tanks provided with daily or hourly exchange of water volume. Cages can be placed in lakes and reservoirs and densely stocked with fish. Caged fish must also be fed a balanced, pelleted diet for fast growth. Fish cultured using pelleted diets can feed high or low on the food chain as long as they will accept the pellets. Fish culture based on nutritionally balanced pelleted diets is profitable only when the feed is produced at a reasonable cost or the fish raised can be sold at a high price.

2. Fish species - Amapá has numerous native freshwater fish species that might be cultured. However, little is known about their reproduction in captivity or suitability for culture. Tambaqui, pirapitinga and matrinxa are three species native to the Amazon River that can be cultured in ponds. Reproduction, fingerling production and growth in ponds to market size has been studied. These species feed on fruits and seeds that fall into the river and will eat pelleted diets as well as a variety of locally produced fruits, nuts and grains. Tambaqui are cultured in the Northeast and Central regions of Brazil and in ponds near Macapá. Tambaqui, pirapitinga and matrinxa are widely accepted as food fishes within the Amazon River basin but may have limited marketability outside the region because of the intramuscular Y-shaped bones present in the flesh. Tambaqui, pirapitinga and matrinxa are available seasonally in fish markets in Belém and Macapá for a medium price (Table 1). The largest producer of tambaqui in Macapá had 7 ha of ponds and was selling his 1 to 2 kg tambaqui whole, fresh in two local supermarkets for $3.27 U. S. /kg., and as a sport fish in his fee-fishing ponds for $3.77 U. S./kg. The producer complained about the low price he received for his tambaqui in the neighborhood fish markets in Macapá and was trying to sell his tambaqui in Belém with little success. Several bank financed tambaqui farms near Belém have failed for unknown reasons.

Other native species found in the fish markets of Belém and Macapá and accepted by consumers are tucunaré, dourada, filhote, piramutaba and pirarucu.

1 Brazilian, English and scientific names of fishes described in this report are found in Table 3.
Dourada, filhote and piramutaba are captured from the Amazon River in large quantities, processed and sold in the south of Brazil. While these species may display culture potential based on future research studies, little is known about their suitability for culture at this time. All are predators and will have to be cultured with pelleted feeds. All have excellent flesh quality and no intramuscular bones.

The scaled pirarucu may hold the best culture potential of the fishes mentioned above. The pirarucu is one of the largest freshwater fish in the world reaching in excess of 150 kg. The fish is reported to grow from 50 g to 8 to 10 kg in one year. Pirarucu is an air-breather which would permit high stocking densities and feeding rates with little fear of death due to low dissolved oxygen. Pirarucu will reproduce naturally in ponds and can be trained to accept pelleted diets. Pirarucu has good flesh quality and has one of the highest market prices of fish sold in Belém and Macapá (Table 1). The fish is accepted by consumers in the south of Brazil but is rarely found for sale. Pirarucu may someday be widely cultured in those regions of the world with a tropical climate but more research is required to determine if the author's optimism is warranted.

Tucunaré, pirarara and surubin are predaceous fishes native to the Amazon River system that grow rapidly in culture ponds and have good flesh qualities. Studies in south-central Brazil have demonstrated that these fishes reproduce in captivity, fingerlings can be produced in ponds and they can be trained to accept pelleted diets. However, further studies are required to determine if these fishes can be economically grown to market size in ponds.

Tamoatatá is a small armored catfish found in the lakes and swamps of Amapá. The catfish is very hardy, is able to breathe air, and is the last fish to die when the wet weather lakes and wetlands dry during the arid months of the year. Villagers are able to harvest the fish by hand in small mud holes. The catfish has an orange colored flesh that is appreciated by local inhabitants. An export market to several European countries of unknown quantity exists in French Guyana. The tamoatatá is unknown in the south of Brazil. Tamoatatá feeds on benthic organisms and organic material and would likely respond well to pond fertilization and feeding with agricultural by-products. Tamoatatá is easily reproduced in captivity but little is known about its suitability for culture.

Fish species exotic to Brazil and found in Amapá are common carp and the Nile tilapia. The scaled common carp was seen in a pond in Macapá but is not recommended for culture because of poor flesh quality and intramuscular Y-shaped bones which make marketing the fish in Brazil and overseas difficult. Native to Africa, Nile tilapia is cultured in ponds around the world in regions with tropical and subtropical climates. Methods for successfully culturing tilapia are well known. The fish is cultured and marketed in Brazil and export markets for tilapia exist in the U. S. and Europe. Tilapia has many excellent features including ease of reproduction, feed requirements low on the aquatic
food chain, resistance to poor water quality, diseases and handling, and good flesh quality. Tilapia can be cultured in both semi-intensive and intensive systems and is a good candidate for culture in Amapá if the federal government permits the culture of exotic species in the Amazon River basin.

3. Land - Most of Amapá is uninhabited although much of the best land along the main north - south highway has been purchased as an investment. Most of the purchased land is not used productively. A great deal of land remains in government hands and can be purchased for, $28 to $37 U. S./ha in undeveloped regions. Land closer to Macapá can be purchased for $93 to $187 U.S./ha. Most of the land in Amapá is covered with tropical rainforest, so removing the timber would be costly unless the tropical hardwood trees can be sold. However, the central savanna grassland and eastern coastal wetland and lakes regions have enormous potential for pond construction. Champion International Corporation has purchased large tracts of land in the central savanna for its plantations of pine and eucalyptus trees. The best region for pond construction appears to be in the area between Pracuuba and Calçoene in eastern Amapá. The land is flat and sparsely vegetated, soils appear to have a high clay content (soils were not analyzed for clay content) and surface water sources abundant. The authors assume that because of the many rivers, streams, lakes and wetlands in the region, shallow wells would provide an abundant source of pumped water. Land south of Pracuuba has savanna grasslands but the topography is more rugged and vast expanses of flat land are not as readily available as north of Pracuuba. The region south of Pracuuba has excellent potential for building small reservoirs to trap the abundant rainfall.

While land is abundant, cheap and appears to have a high clay content, the nutrient quantity and pH of soils are poor. The Champion International representative stated that soil pH was 4.5 to 5.5 and contained little organic matter. The soils had the appearance of the red, laterite clay soils so prevalent in eastern Alabama and much of Georgia.

4. Water - The water of some rivers, lakes, wetlands and fish ponds were sampled for pH, total alkalinity, total hardness and carbon dioxide using a FF-II Hach water quality kit. Dissolved oxygen and temperature readings were taken with a YSI-55B dissolved oxygen meter. Results from this survey are summarized in Table 2. The approximate location of the sites sampled are illustrated in the map at the end of this report.

Although large amounts of water are available in most of the state, Amapá’s natural waters are predominantly acid. Total alkalinity and hardness seldom exceed 5mg CaCO3/l, and pH values are often 6.0 or below. Water from the Amazon River, a fish pond treated with quick lime, and rivers on the east coast of Amapa under a marine tidal influence (river Amapazinho, sampled at a site 15km from the sea) has higher total alkalinity and hardness.
Correction of low alkalinity/hardness waters with some type of liming material is required for high fish production in standing water ponds. Waters with a total alkalinity and hardness under 10 mg/l will need about 4,000 kg/ha of high grade agricultural lime to increase total alkalinity and hardness to more than 25 mg/l, the minimum concentration considered appropriate for semi-intensive fish culture. Waters with total alkalinity and hardness between 10 and 20 mg/l will require about 2,000 kg/ha of high grade agricultural limestone to correct. Agricultural limestone used in Amapá is trucked from other Brazilian states and the current price of limestone supplied in small quantities by agricultural supply stores in Macapá is the equivalent of $283 U.S./metric ton (MT). According to information supplied by vendors, the price can be reduced to $113 to $189 U.S./MT purchased in large quantities in Brazil and shipped to Santana. Amapá has no exploited limestone deposits at this moment. However, there is an unconfirmed report of a limestone deposit recently found near the depleted manganese mine on Serra do Navio. Serra do Navio is served by a railroad system that could transport limestone to Macapa and Santana. The quality and size of this limestone deposit are unknown, but a low cost source of limestone will reduce the cost of agriculture and pond fish culture in Amapá.

5. Fertilizers and Feeds - A semi-intensive fish culture system using fertilizers requires correction of water through liming (presently an expensive practice) and results in lower yields per area of water compared to intensive culture systems using complete feeds. However, the low cost of land in Amapá would favor a large pond area/semi-intensive operation based on fertilizer use. Unfortunately, prices for inorganic fertilizers in Amapá are also expensive. Local suppliers sell 25 kg bags of urea (45% N) for the equivalent of $495 U.S./MT, and triple superphosphate for $672 U.S./MT. Organic fertilizers (manures and low cost plant by-products) are not readily available since few intensive animal husbandry operations or developed agricultural industries are found in Amapá. Fertilizers may be imported from the United States and shipped in large quantities to Amapá cheaper than fertilizers can be trucked from southern and central Brazilian states to Amapá. Champion International is currently shipping rock phosphate from North Carolina at a transportation cost of $33.50 U.S./MT (insurance included). Loads less than 1,000 MT can be shipped for $44.00 U.S./MT.

A 28% crude protein floating fish feed is sold in Amapá. This feed is trucked from Goiás state in central Brazil and sold at $646 U.S./MT in Macapá. One of the two fish producers visited used floating feed but he had no idea of the costs involved with feeding a pelleted diet. The second producer, who had more fish culture experience and depended on the profit from his fish ponds for part of his salary, used a mixture of locally purchased meat and bone meal and dende palm oil cake to lower costs.
Agriculture in Amapá is still at a subsistence level. Therefore, the supply of feed grains in Amapá comes entirely from other Brazilian states. By-products from processing native palms such as dendê ($189 U. S./MT) and acaí (no price found) have been used to feed pigs and dairy cows. However, these products have poor nutritional value and a limited availability to support intensive animal production. Locally produced meat and bone meal is priced at $340 U. S./MT. Soybean meal ($396 to $443 U. S./MT) and corn ($189 U. S./MT) comes from other Brazilian states and are expensive in Amapá. Pig and poultry mineral and vitamin supplements are available at prices that add almost $14 U. S./MT to a nutritionally balanced fish feed. Vitamin C prices were not found in Amapá or in Pará. The price of ethyl-cellulose coated ascorbic acid in São Paulo is $9.4 U. S./kg and including freight costs to Amapá should add about $4 U. S./MT of fish feed.

A pelleted, sinking feed made up of 10% meat and bone meal (40% CP), 45% soybean meal (45% CP), 45% ground corn (9% CP), vitamin and mineral supplements will have an ingredient cost of almost $336 U. S./MT in Amapá. Grinding, pelleting, labor and other costs related to feed processing are not included. Amapá has no feed processing plant to make sinking, pelleted feeds. Belém, Pará has two feed plants with pelleting capabilities. Sinking pellets can be trucked from Pará to Amapá at a cost of $50 U. S./MT. The same feed formula presented above would have an ingredient cost of $240 U. S./MT in Pará. Adding processing and shipping costs and manufacturer profits, sinking pellets from Pará should arrive in Amapá at a price no less than $340 to $360 U. S./MT.

Floating pellets in bags manufactured in São Paulo state, purchased in large quantities and transported by boat would reach Santana at prices no less than $500 to $550 U. S./MT. These prices would not support a profitable fish culture operation. Importing feeds from other countries such as the United States could be considered for a large aquaculture operation. Bulk 32% crude protein floating catfish feeds manufactured in the southeastern United States are priced at $260 to $280 U. S./MT. Adding $100.00 U. S./MT transportation cost would still land the feed in Santana cheaper than it can be purchased in São Paulo and shipped to Amapá.

6. Processing - The fish processing industry, while in need of modernization, is firmly established in Belém and Santana. Fish cultured in Amapá can be cleaned, filleted, blast frozen at 0 to -10°C and packaged in Santana. Wastes from fish and shrimp processing are discarded. Three fish processing plants in Santana have a combined cold storage capacity of 1,640 metric tons of frozen fish. Fish cultured within 150 km north of Macapá in the center of the state can be transported to Santana on an all-weather road. Fish farms located further than 150 km north of Macapá or located in the eastern or western portions of the state would have to consider road improvement to assure that fish could be transported to Macapá during the rainy season.
Expansion of fish processing in Santana may be limited by a restricted supply of electricity during some periods of the year.

7. Markets - Fresh and saltwater fish supplied by the capture fishery are widely available at reasonable cost (Table 1) in Macapá and Belém. Farmed fish, with the possible exception of pirarucu, are unlikely to compete economically in the market with fish captured from the wild. The high cost of farming fish in Amapá will require that cultured fish be priced higher than fish captured from the wild. The market for fish in the south of Brazil is excellent and prices are high. Fish sold in the south of Brazil will have to be those fishes without intramuscular Y-shaped bones. Small quantities of fresh fish can be flown daily from Macapá to the south of Brazil if prices paid in the south are high enough to pay for freight costs. Fish from the capture fishery are trucked in refrigerated containers from Santana and Belém to markets in the south of Brazil. Trucking cost adds an additional $0.09 U.S./kg of fish from Belém and $0.11 to $0.14 U.S./kg of fish from Santana. Freight is reasonably priced because trucks bringing frozen produce from the south of Brazil to Belém and Macapá are willing to backhaul fish at a low price to markets in the south to reduce expenses. Processed fish could be shipped overseas from Santana in refrigerated containers. However, exporting a container of fish overseas normally requires a full container, 20,000 kg of whole or filleted frozen fish. A large fish farm would be needed to supply the fish required to fill a container weekly with processed fish.

At this time, the only fish that could be farmed and exported to Europe and the U.S. is tilapia. Tamoatá has a small export market for whole frozen fish in French Guyana and several countries in Europe. Piramutaba, filhote and dourada from the Amazon River capture fishery are frozen and exported to the U.S. where they compete with the channel catfish, farmed in the southeastern U.S. However, as mentioned above, nothing is known about the suitability of these fishes for culture except tilapia. Specialty markets in the U.S. for large, scaled Amazon River fishes (tambaqui and pirarucu for example) sold to white tablecloth restaurants specializing in exotic dishes are reported. Whether this specialty market for large, frozen Amazon River fish will accept a smaller cultured version of the same species is unknown.

French Guyana is a French state, and thus has direct access to France and the European Common Market. Fish exported to French Guyana would automatically be accepted into France and other European Common Market countries with no taxes or restrictions other than those placed on European Common Market trading partners. Exporting fish to French Guyana to gain access to the European Common Market is likely easier and more profitable than exporting directly to France.

8. Support Services to Aquaculture - While extremely interested and supportive of efforts to develop aquaculture, the government provides few
services to aquaculture in Macapá. Individuals knowledgeable in modern fish culture techniques were not in evidence in Macapá or Belém. No facilities to perform research on the culture suitability of Amazon River fishes were found in Belém or Macapá. A small fish culture research station is found at the National Institute for Amazon Research located in Manaus. Presently, persons interested in developing fish culture in Amapá would have to elaborate their own research program with the Amazon River fishes. Only tambaqui, pirapitinga and matrixá can be cultured without an in-depth study of culture methods. Technical assistance would have to be contracted in the south of Brazil or in the U.S.

9. Government Regulations - Talks were held with the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) and Secretaria Estadual do Meio Ambiente, agencies in charge of regulating and authorizing use of the land and water in Amapá, concerning regulations dealing with aquaculture. Any aquaculture project has to be registered and authorized by the central office of IBAMA in Brasília, the capital of Brazil. The regional IBAMA office in Macapá can assist potential investors obtain authorization to farm fish. IBAMA representatives in Belém and Amapá were unaware of any restrictions on the farming of species exotic to the Amazon River basin such as tilapia. However, word of mouth among government officials, university scientists and fish farmers in the south of Brazil is that IBAMA will soon place restrictions on the farming of aquatic species outside of their native, or in the case of tilapia, presently established ranges. Thus, investors interested in farming fish in Amapá may be prohibited from growing tilapia by law. Potential investors should consult IBAMA officials in Brasília before investing money in tilapia culture in Amapá.

There don’t appear to be any laws regulating the construction of fish ponds in wetlands in Amapá. Some of the best areas for pond construction in the state are in wetlands. Again, potential investors should consult local officials controlling environmental use before constructing ponds.

B. Ornamental Fish

Amapá rivers, lakes and wetlands have a tremendous diversity of fish species which can be exploited for ornamental purposes. Numerous rivers, lakes and wetlands were sampled with a 5-mm mesh seine net to collect fish in shallow water. Many of the species collected had a strong appeal as ornamental fish. The genera of some of the fish collected were identified using Dr. H.A. Axelrod's, Atlas of Freshwater Aquarium Fishes, and are summarized as follows: 1) Family Cichlidae: Cichlasoma spp., Crenicichla spp., Cichla spp. and Astronotus spp.; 2) Family Characidae: Hyphessobrycon spp., Hemigrammus spp., Serrasalmus spp., Mylossoma spp., Myleus spp. and Astyanax spp.; 3) Family Prochilodontidae: Leporinus spp. and Prochilodus spp.; 4) Other fish: Plecostomus spp., Farlowella spp., Corydora spp. and Acestrorhynchus spp.
Brazilian records indicate an international trade of 35 million ornamental fishes collected from the Amazon River. Most of these fishes are captured in the Rio Negro basin in the state of Amazonas. Besides the international market, there is a well-established web for trading ornamental fishes in the southern states of Brazil. In the metropolitan area of São Paulo city there are 3,500 pet stores that trade ornamental fish, a growing economic activity.

No information is available on the capture or culture of ornamental fishes in Amapá. To date, the knowledge of breeding and raising Amazon River system ornamental fishes is scarce and restricted to a few species. Research efforts are needed to develop reproduction and production technology to culture most of these fishes. Improvements in collection, transporting and holding techniques would also improve the survival of wild-caught ornamental fishes, and help improve profits throughout the Amazon region, including Amapá.

C. Conclusions

Amapá has abundant land and water resources and a humid tropical climate favorable for aquaculture. Additionally, fish processing and modern port facilities are available in Santana. Equipment and supplies for fish farming, pond construction and processing can be imported free of state and federal import taxes. However, there are a number of disadvantages in Amapá that make investment in fish culture a high risk venture at this time.

Semi-intensive cultures require that water quality be corrected with limestone to improve primary productivity and increase natural fish food organisms. Pond waters that are not corrected with limestone will not respond well to fertilization and low fish yields will result. At this time, limestone must be purchased in northeast or central Brazil and trucked to Macapá at high cost. The mineral poor, low alkalinity waters and acidic soils will require about 4,000 kg/ha of agricultural lime to correct, which is costly. A report of a limestone deposit in Serra do Navio is unconfirmed but would provide a big economic boost to Amapá’s efforts to develop agriculture and fish culture. Chemical fertilizers to fertilize pond waters are also transported from the south and are expensive. Little animal manure is available for fertilizing fish ponds. Palm oil cake is the only locally produced agricultural by-product that could be used to fertilize fish ponds. Because Macapa is a duty free port, shipping limestone and fertilizers from the U.S. or other South American countries in large quantities should be investigated.

Fish that are raised in semi-intensive cultures must feed low on the food chain to take advantage of the plants and small animals produced in the pond. At this time, not one fish native to the Amazon River that feeds low on the food chain is known to be suitable for semi-intensive culture. Tamoatá has the potential for semi-intensive culture but more studies are needed to determine performance in fertilized ponds, and its market potential. Tilapia would be the best choice for semi-intensive culture at this time. Culture methods are well
established and domestic and export markets exist. Care must be taken to determine if laws prohibiting the culture of fish exotic to the Amazon River basin have been enacted by the federal government.

Intensive culture with commercially produced feeds is not dependent on the nutrients and minerals in the water to produce plants and animals to feed the fish. Nutritionally balanced feeds can provide all the nutritional components needed for good fish growth. Fish can be intensively cultured in earthen ponds and concrete tanks with water exchange or in cages floating in lakes and reservoirs. Numerous rivers, streams, springs, and lakes provide abundant water for intensive culture. However, intensive culture is dependent on pelleted, nutritionally balanced feeds. Amapá has no feed mills and few locally produced feed ingredients. Pelleted feeds and most feed ingredients are transported to Amapá from central Brazil at great expense. Feed mills with pelleting machines are found in Belém but none are producing fish feeds. Additionally, the quality of fish feeds produced in central and southern Brazil required for intensive culture is inconsistent. The expense of pelleted, nutritionally balanced feeds in Macapá at this time makes profitable intensive fish culture difficult. A source of lower priced pelleted feeds would improve the chances of profitable intensive fish culture. Shipment of large quantities of fish feeds from the southern U.S. or feed grains from southern Brazil or the U. S. to Santana should be investigated.

Tambaqui, pirapitinga and matrixxã are the only native species which could be farmed intensively in Amapá. A good market for these species outside the Amazon River basin must be found. Tilapia can also be grown intensively. Other fishes native to the Amazon River system with market potential are unstudied in intensive culture systems. Additionally, most of these fishes are predacious and acceptance of pelleted diets and the nutritional quality of these diets remains to be tested. Of the native fishes untested in intensive culture systems, pirarucu may have the most potential and should be given priority if and when research facilities are available.

Presently, unless cheaper sources of limestone and/or pelleted feeds can be found in Amapá, the chances of starting a profitable fish culture industry competitive in Brazilian and world markets with fish cultured in the south of Brazil and other tropical countries will be difficult. Tilapia is the only fish which can be farmed today in Amapá with known market potential overseas. A small capture/culture industry of native ornamental fishes for export to the south of Brazil and overseas may have economic potential.

D. Recommendations
1. A detailed economic analysis using the cost of imported shipments of limestone, nutritionally complete pelleted feeds and/or feed grains from the south of Brazil or the U. S. to the duty free port of Santana is needed. Obtaining cheaper limestone and/or feeds would improve the chances of an economically
viable fish culture industry in Amapá. Processed fish would have to be sold in the south of Brazil or overseas.

2. A number of fishes native to the Amazon River are likely suitable for semi-intensive and intensive fish farming. Research is needed to determine which fishes are suitable for culture, best methods of culture, market potential and economic viability. Champion International can assist the state of Amapá build and operate a fish culture research facility that can test native Amazon River fishes for culture suitability. No immediate economic return will be gained from a research program. Research is a long term investment in the future. However, if one or two new native fishes can be found suitable for intensive culture and with flesh characteristics acceptable to Brazilian and overseas consumers, the economic impact on Amapá can be great. Fishes from the Amazon river that have proven culture potential will be in great demand among fish farmers in tropical climates world wide. Amapá could become the leader of research and culture of native Amazon River fishes in Brazil.

The International Center for Aquaculture and Aquatic Environments can provide technical assistance to Champion International and Amapá state in the design and operation of fish culture research facilities and training of private and government biologists in fish culture.

3. Tambaqui, pirapitinga and matrinxa are three species native to the Amazon River that can be cultured in Amapá if a cheap and reliable source of pelleted feeds and secure markets both in Brazil and overseas can be found. A study of market locations, prices and product forms for these species in Brazil, the U. S. and Asia should be performed to determine if large-scale farming of these fishes is warranted.

IV. Shrimp Capture

A. Marine Shrimp

The traditional areas for shrimping in north and northeast Brazil extend from the Parnaiba River on the southeast to the northern most tip of the state of Amapá. Fishermen report that shrimp are caught in depths between twenty and ninety meters and that the best fishing is between forty and fifty meters.

Government reports from the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renovaveis (IBAMA) indicate that the primary species of shrimp in the landings is camarao-rosa (southern brown shrimp). Other species of commercial importance known to occur in the area include:

- red spotted shrimp
- southern white shrimp
- southern pink shrimp
- seabob
Further offshore, in depths of three hundred to eight hundred meters, several species of deep water shrimp and prawns have been found according to records from various research cruises. These included:

- pink speckled shrimp
- giant red gamba shrimp
- purple head prawn
- scarlet prawn

The shrimp vessels we observed in Porto Santana were similar to those found in the U.S. They were powered by a single diesel engine, had freezer storage, deployed a standard shrimp trawl from each of two outriggers, were seventeen to twenty meters in length and had a crew of five. A recent report on the fisheries of Amapa indicates that there are also one or two vessels twenty-three meters in length and three or four that are thirty-one meters in length. One captain stated that the seventeen meter boats can hold about thirty metric tons of shrimp while the larger twenty meter boats could only hold twenty-five metric tons. The difference being due to the configuration of the freezing system. The captain noted that the larger (twenty meter) boats use more fuel and hold less shrimp.

Shrimp vessels working out of Porto Santana are owned by the processor and typically make trips of fifty days, five times a year with seven days off between trips. It takes twenty-four to fifty hours to reach the shrimping grounds and trips are limited by fuel and shrimp storage capacity.

Data provided by IBAMA on shrimping for vessels from the states of Amapa and Para show an average of four trips per season, thirty-one days at sea per trip and an annual catch of 23 metric tons in 1994. In comparison, the large, profitable shrimp vessels in the U.S. Gulf of Mexico are often owner operated, pull 4 nets, make 14-30 day trips, have crews of 3 to 4 and expect to catch 23 to 36 metric tons per year to break even.

Fishermen and processors stated that shrimp landings were higher in the past. These observations are supported by landings data from IBAMA (Figure 1.). Landings alone do not provide much information on the status of stocks. IBAMA has good records on shrimp landings and the amount of effort expended to catch the shrimp. When catch and effort are combined a better picture of the stocks can be obtained. At the beginning of fishing a new stock, the catch (landings) is expected to rise as the effort increases. As the fishery reaches its maximum potential, further effort does not result in corresponding increases in catch. Declines in catch as effort increases are often viewed as a sign of overfishing in the absence of other explanations.
A plot of catch and effort (Figure 2) does not provide a clear picture of whether the fishery has reached or passed its full potential. High efforts are associated with both low and high catches. It should be noted that fluctuations in shrimp landings are not unusual and can often be explained by natural variability in environmental conditions.

Shrimp fisheries throughout the world are being criticized for the large amount of sea life that is inadvertently caught along with the target species. This incidental catch is commonly referred to as bycatch. Bycatch falls into two categories - the portion that is kept and the portion that is discarded. The discarded portion is often further divided depending on why it was discarded (e.g. regulatory and economic). According to IBAMA, the ratio of whole shrimp to total bycatch off the coast of Amapa is 1:2.4 while the ratio of whole shrimp to bycatch that is kept is about 1:2.1 indicating that the proportion of discards is low. More than sixty species are caught in shrimp nets, but less than ten have marketable value. Pescada gô is an important species in the bycatch and has a ready market.

1. **Management** - Management measures for the marine shrimp fishery in the northeastern Brazil include a limit on the number of vessels licensed to shrimp (250) and a closed season (December 20 through February 28). Not all of the two hundred and fifty licenses are currently issued and approximately thirty are available from IBAMA. It also appears that not all of the licensed boats are actively fishing. The closed season is supported by data from IBAMA which indicate that larger more valuable shrimp are being landed since the closure was put in place.

2. **Research** - The government agency, IBAMA, keeps records of the shrimp catch, number of vessels fishing, number of fishing trips, number of fishing days and days at sea. As discussed previously, this information is very useful in assessing the status of shrimp stocks. However, the data appear to be based on the assumption that all the shrimp caught are one species when several species are known to be present in the area. The Centro de Pesquisa e Extensao Pesqueira do Norte do Brasil (CEPNOR) of IBAMA is also undertaking a survey of the offshore resources which has the potential to provide fishery independent data on the exploited shrimp stocks, information on unexploited stocks of shrimp and other species as well as on environmental conditions in the area.

**B. Freshwater Shrimp**

Significant but unknown amounts of freshwater shrimp are landed in Belem (approximately five hundred metric tons at the Ver o Peso market) and
in Macapa - Porto Santana. These shrimp are caught by artisanal fishermen in small basket traps along the edges of the Amazon River. The product is very similar to marine shrimp, but apparently does not get as large. Much of the production is salted and sold in local markets. One processor in Porto Santana reported that they had tried to industrialize freshwater shrimp, but could not say why they did not succeed. Another freshwater shrimp, Pitu, is much larger (17-25 cm), is kept on ice and brings a good price in local markets.

C. **Processing and Infrastructure**

Generally speaking, most of the fishery production at the mouth of the Amazon and the coast of Amapa is landed in Belem or shipped to Belem and processed. Some fourteen processors operate in Belem, six of which handle shrimp while there are only three processors in Amapa and only one is currently processing shrimp.

The three Amapa processors are all located in Porto Santana and all indicated a need for more product. One stated that they were only using twenty percent of capacity, another forty percent of capacity while a third was not processing any fish or shrimp at all at the time of the interview. Product from Porto Santana is shipped to Belem before further shipping despite the local availability of containerized shipping.

On the north coast, Calcoene has an ice plant with an ice delivery system for conveniently loading boats. Docking and unloading space is limited. The channel was said to be more navigable than the channel at Amapa and boats working out of this area had capacities of up to nineteen tons. Much of the fish landed here is apparently reiced and trucked to Porto Santana for further processing. Shark fins and swim bladders from Pescada amarillo and Guriiuba were being sold by fishermen directly to specialized buyers.

The town of Amapa also has an ice plant which is several hundred meters from the river and ice must be transported to the boats. The ice plant is capable of producing eight metric tons of ice during the twenty-one hours that electrical power is available. The operator states that he only sells about 1.5 to 2 metric tons per day.

The boats in the port of Amapa are small, generally one to two tons. Fishermen stated that the channel was shallow and difficult to navigate, particularly for larger vessels. Electricity is supplied by generators and is not available twenty four hours a day in both towns.
The major road from Macapa to Amapa and Calcoene is gravel most of the way. It is reasonably well maintained although there are some obvious problem spots during the wet season. The roads into Amapa are not as well maintained.

D. Conclusions
The marine shrimp fishery appears to be approaching full exploitation. Questions remain about the efficiency of the existing fleet, status and identity of exploited stocks and the potential for harvesting and marketing alternative stocks including bycatch. Despite these uncertainties the proximity of Porto Santana to the northern shrimping grounds and the existing shrimp processing capabilities suggests that a higher proportion of the existing fleet could be accommodated in the State of Amapa. Freshwater shrimp remain a tantalizing but poorly understood resource.

Basic infrastructure in the north can be improved to encourage investment in processing facilities. Further development of the shrimp fishery and associated catch should be undertaken with caution and with adequate science-based monitoring of the fisheries.

E. Recommendations
1. Evaluate in depth the efficiency of shrimp fishing operations with specific reference to the advantages and disadvantages of enlarging the Amapá fleet within the 250 license limit.

2. Refine studies of the shrimp fishery to include:
   a. Document the contribution of the different species of shrimp to the total catch by month.
   b. Obtain additional life history information on the major species and examine likely causes (e.g. river flow) of annual or longer periods of variability.
   c. Examine data from A&B to learn more about the status of each species. For example, with more information on the distribution and abundance of each species perhaps some areas could be open to shrimpers during the current closure period or perhaps other areas should be closed at other times.

3. Ensure the continuation of the IBAMA - CEPNOR offshore study, particularly in regards to deep water shrimp and other resources and encourage industry (commercial fishermen) involvement in the offshore work. Findings from these studies could lead to a limited
fishery for some shrimp vessels that are otherwise idle during the December to February closure.

4. Develop basic infrastructure along the north coast such as improved roads and reliable electricity.

5. Examine the feasibility as well as the costs and benefits of navigational and dock improvements in Calcoene and Amapá. Calcoene appears to have some natural advantages, but an in depth study is needed.

6. Review the barriers for developing a freshwater shrimp industry. Reliability of supply, processing technology and marketing will be important points to consider.

7. Facilitate marketing studies to determine why some bycatch species (e.g. Pescadinha go) are not more fully utilized.

8. Establish a science-based monitoring and assessment program for the developing gill net fishery and for the shrimp bycatch fishery.

V. Capture Fisheries

Amapá State is located north of the Amazon River mouth in a strategic fishing area of the lower Amazon River region. Amapá's location permits the state's fishing fleets to explore important fish stocks found in the Amazon River, and its estuary, and the Atlantic Ocean.

A. Fishing Areas

Barthem (1995) divides the fishery areas of the lower Amazon system into: 1. estuary; 2. inner delta; 3. Amazon River; 4. Madeira-Beni-Mamoré rivers; and 5. Tocantins river (Figure 3). Fishermen from Amapá utilize three of these areas: the estuary, the inner delta and the Amazon River.

1. Amazon Estuary - The Amazon estuary covers the mouths of the Amazon and Tocantins Rivers and the coast along northeast South America. This area is strongly influenced by water and sediments discharged from the Amazon River, which increase the fish and shrimp productivity along the coasts of Amapá and French Guyana. The composition of fish and shrimp populations change seasonally in response to the volume of water and sediments discharged from the river (Egler and Schwassmann 1962; Meade et al 1979; Barthem 1985; Barthem and Goulding 1997).

Sioli (1966) delimits the outer border of the estuary as a line which stretches from the North Cape in Amapá south to "Ponta Tijuca" in Pará, a distance of 380 km. A true delta is not found in the Amazon River mouth due to the strong Equatorial Current which pushes the Amazon River discharge to the northwest.
along the Amapá and French Guyana coasts. On the south side of the Amazon River mouth, an inner delta is found between the Xingu River mouth and the Marajó, Caviana, Mexiana and Gurupá Islands.

The Amazon River estuary can be divided into four sections in relation to the Equatorial Current: 1. the North Coast (Norte); 2. Amazon River Mouth (Foz Amazônica); 3. Marajó Bay (Baía de Marajó); and 4. Saltwater Coast (Salgado) (Figure 3). Fleets from Amapá fish the Amazon Mouth and the North Coast. The Amazon River estuary is the only fishing zone of the region where two technologically and economically different fishing fleets carry out activities: the industrial fleet and the traditional or artisanal fleet.

The industrial fleet only uses trawl nets. Vessel length varies between 17 to 27m, capacity from 20 to 105 tons and engine power from 165 to 565 hp. The catch is sold to the fish processing industries and the final product is exported overseas or to other Brazilian states. All boats in the industrial fleet operating in the estuary carry the Brazilian flag. Some of the industrial fishing companies are supported, in part, by international investment, especially Japanese. The artisanal fleet is fairly heterogeneous, both as to the type of fishing tackle used (drift gillnets, fish traps and trotline) and the vessel capacity, ranging from canoes to ships with a 40 ton capacity (Barthem 1995). The drift gillnets used by artisanal fishermen have a mesh size ranging from 14 to 20 cm and length can reach more than 3,000 m.

2. Internal Delta - The inner region of the Amazon river estuary is defined by Sioli (1996) as the inner delta which contains a large number of islands, such as Marajó, Caviana, Mexiana and Gurupá (Figure 3). The waters remain fresh throughout the year and the river flow in the inner delta is reversed daily along most of its length in accordance with the tides. Few industrial fishing boats operate in the inner delta, but a large number of artisanal fishermen living on the islands use row boats to exploit freshwater prawns, Macrobrachium spp.. The prawns are caught in small baited traps known as “matapis” placed by the dozens along the banks of the river. The dried and salted prawns are sold to middlemen that travel among the islands and carry the prawns to large urban centers for resale. (Barthem 1995).

3. Lower Amazon - The Lower Amazon region extends along the Amazon River from the mouth of the Madeira River east to the mouth of the Xingu River (Figure 3). The lower Amazon River has no tidal inversion, however the tide is felt as far inland as the mouth of the Tapajós River. The water level of the Amazon River oscillates during the year in response to rainfall, with a maximum difference between low and high water levels of 7 m at the mouth of the upper Tapajós River and a minimum of 2.5 m at the Xingu River mouth. Fishermen located in the main cities of the Lower Amazon region, such as Santarém, Óbidos and Monte Alegre, will compete with fishermen from Manaus upriver and with fishermen from Belém and Amapá.
downriver. Fishing is practiced most of the year in the flooded plains and forests. Commercial capture of catfish takes place in the main channels of the rivers and their branches only in the summer, when the rivers are at their lowest levels and the catfish are migrating (Barthem 1995).

4. Other Fishing Areas - On the islands of the internal delta and along the Amapá coast extensive areas of forest and savanna are flooded during the rainy season (January to May) forming numerous lakes and swamps. Some freshwater species are abundant in this environment, especially the tamoatá.

B. Major Stocks

Numerous species from the Amazon Basin and the Atlantic Ocean are harvested by the industrial and artisanal fisheries. The most important stocks can be aggregated into 6 major groups: saltwater shrimps, freshwater shrimps, saltwater catfish, freshwater catfish, Sciaenidae and other species. Table 3 lists the scientific and English and Brazilian common names of the species observed in the fish markets visited in Amapá and Pará.

1. Saltwater Catfish - The saltwater catfishes are represented by the family Ariidae, composed mainly of the genera Arius, Bagre and Cathorops.

a. Gurijuba - Gurijuba is the most important marine catfish captured by the artisanal fishery along the Amazon estuary and north coast of Amapá. This species has been exploited in the Amazon estuary since the last century (Veríssimo 1895) and along the northeast coast of South America from Pará to French Guyana (Puyo 1936). The local people prize the Gurijuba head and flesh for its special flavor, but the fish is not widely appreciated in regions of Brazil outside of Amapá and Pará. The swimbladder of the Gurijuba is dried and exported to Japan, China and England. The most important fishing area for Gurijuba is the Amapá Coast, responsible of 41% of the Gurijuba landed in the Ver-O-Peso fish market in Belém. Boats from Pará and Amapá catch Gurijuba in the shallow coastal waters with 20-cm stretch mesh drift gillnets and trotlines. Gurijuba is the second most important fish of the Amapá capture fishery after dourada. In 1996, landings of Gurijuba in Amapá and Ver-O-Peso market in Belém were 190 metric tons (MT) and 312 MT, respectively.

A sample of 585 individuals measured in Ver-O-Peso fish market had an average fork length of 68 cm, with a minimum of 40.5 cm and a maximum of 130.5 cm (Figure 4). Gurijuba spawn in the Amazon estuary during the rainy season between November and March. The entire life cycle of this fish appears to be completed in the Amazon estuary. No information on the age of sexual maturity is available. Gurijuba is a predator consuming mainly fish and invertebrates.

b. Other Sea Catfish - Several species of the genus Arius and Bagre are abundant in the Amazon estuary, but the market for them is poor. Usually,
these catfishes are the by-catch of the industrial and artisanal fisheries and fishermen avoid areas where these species are abundant.

2. Freshwater Catfish - Three freshwater catfishes of the Pimelodidae family are important in the industrial and artisanal fisheries in the Amazon estuary and river: piramutaba, dourada, and piraiba or filhote. Another important catfish is the tamoatá of the Callichthyidae family, abundant in the flooded areas near the Amapá coast and islands of the inner delta.

a. Piramutaba - Piramutaba is the most important fish by weight and value in the capture fishery on the Amazon River. The abundance of piramutaba stocks stimulated the Brazilian government to provide incentives to the private sector to build cold storage and processing facilities beginning in 1968. Piramutaba is not highly appreciated as a food fish by consumers located along the Amazon River. However, processors discovered that large quantities of piramutaba could be exported to the United States and lesser amounts were also exported to Germany, Japan, Holland and Nigeria (Barthem and Goulding 1997).

Industrial fishing for piramutaba began in 1970. Two boats, each pulling one end of a trawl seine, drag the net over the muddy bottom of the Amazon estuary. Most piramutaba are captured from the mouth of the Amazon River and Marajó Bay near Belém. Only 3% of the piramutaba landed in the Ver-O-Peso fish market were captured from the Amazon River mouth near Amapá. Most piramutaba are sold to processing plants, only a small percentage is sold in open fish markets in Amapá and Belém. Piramutaba harvest peaked at 22,000 MT in 1977 and decreased to almost 5,000 MT in 1992 (Figure 5). Barthem and Petrere (1995) estimated the piramutaba mortality due to fishing during 1984 and 1985 to be higher than the mortality that would sustain the industrial fishery. They concluded that piramutaba stocks were close to being overfished (Figure 6). The prediction that piramutaba stocks were overfished is consistent with the observed decrease in catch per unit effort since the peak harvest in 1977. Exportation of piramutaba has also decreased. In 1980 the value of piramutaba exports was over $10 million U.S. and in recent years export value has declined to around $2 million U.S. (Figure 7).

Piramutaba is also harvested by the artisanal fleet using 14-cm mesh drift gillnets and trotlines. Mean total length of harvested piramutaba is around 44 cm (Figure 8). Piramutaba is the second most important fish by weight landed at the Ver-O-Peso fish market and 9th most important by weight in Amapá. In 1996, a total of almost 1,000 MT of piramutaba was landed in Ver-O-Peso and 33 MT in Amapá. Piramutaba migrate from the Amazon estuary to the upper Amazon to spawn, traveling more than 3,000 km in a year. Spawning occurs near the Brazilian border with Colombia and Peru. Adult piramutaba are piscivorous and juveniles feed on small invertebrates (Barthem and Goulding 1997).
b. Dourada - Dourada is the most important fish by weight captured by the artisanal fishery in the Amazon River. Fishermen from Brazil, Colombia and Peru harvest dourada along the entire Amazon river and its estuary. This species is also the most important fish landed at the Ver-O-Peso fish market and Amapá in 1996 with 3,390 MT and 204 MT, respectively. The most important fishing areas for dourada are the Amazon River mouth and the Lower Amazon River, which are responsible for more than 60% of the capture landed at Ver-O-Peso. The most common fishing gear for dourada is the drift gill net, with mesh size measuring between 16 and 18 cm. Like piramutaba, dourada migrate between the Amazon estuary and the upper Amazon to spawn near the borders of Colombia and Peru. Dourada is piscivorous when adult and feeds on small invertebrates when young. Average fork length of dourada captured in the Amazon River estuary is 60.5 cm and is smaller than the average fork length of dourada captured from the upper regions of the Amazon River (Figure 9). Barthem and Goulding (1997) feel that only immature dourada are found in the Amazon estuary. At the moment, there are no reasons to conclude that dourada stocks are over-fished.

c. Piraiba or Filhote - Piraiba or filhote refer to different size classes of the same catfish species. The filhote has a fork length of less than 1.2 m while Piraiba has a fork length larger than 1.2 m. In this report, piraiba and filhote will be reported as filhote. Filhote is the largest catfish of the Amazon River basin, and is perhaps the largest of all South American river fishes. The length composition of 1,366 filhotes landed at Ver-O-Peso had a median fork (total) length of 76 cm and a maximum length of 2.2 m (Figure 10). Restaurants in Belém and Macapá prefer to serve filhote for their catfish dishes instead of piramutaba and dourada.

Total landings of filhote are less than for dourada and piramutaba. Ver-O-Peso received 255 MT and Amapá 9 MT in 1996. The most important fishing areas for filhote are the Amazon River mouth and lower Amazon River, accounting for more than 70% of total filhote landings at Ver-O-Peso. The most common fishing gear for filhote are 18-cm mesh drift gillnets and trotlines.

Filhote feeds on large fish and it grows and spawns in the Amazon River estuary. Filhote does not migrate up the river to spawn like piramutaba and dourada, but it will swim to upper river areas following and feeding on schools of piramutaba.

d. Tomoatá - Tomoatá is a small armored catfish that lives in the swamps and lakes along the Amapá coast and the islands of the inner delta. Tomoatá can survive in waters with low dissolved oxygen. Fishing takes place in the dry season when the tamoatá are concentrated in the swamps and small ponds. Fishermen use a beach seine to capture the fish. Tomoatá and several other species caught at the same time are sold in the Ver-O-Peso market for less than $0.20 U.S. /kg live weight during the dry season.
3. **Sciaenidae** - There are four important fishes of the family Sciaenidae found in the Amazon River estuary. Pescada amarela, corvina and pescadinha go are found in salt and brackish water while pescada branca is only found in fresh water.

a. **Pescada Amarela** - Pescada amarela is the largest and most valuable of the Sciaenidae. Pescada amarela's value is due to its large size, usually longer than 1m at harvest, its tasty meat and its swimbladder, worth three times more per kilogram than Gurijuba swimbladders. The most important fishing areas for pescada Amarela are along the north coast of Amapá and Marajó Bay, which are responsible for almost 85% of the pescada amarela landed at Ver-O-Peso. Weights of pescada Amarela landed at Ver-O-Peso and Amapá were 1253 tons and 22 MT in 1996, respectively. Restaurants in Belém and Macapá usually reserve pescada Amarela for their most expensive fish dishes.

b. **Corvina** - Corvina is very similar in appearance but smaller in size than pescada Amarela and is often sold as pescada Amarela to unknowing consumers. The market price of Corvina is less than that of pescada Amarela and the value of its swimbladder is half that obtained for the swimbladder of Gurijuba. Corvina and pescada Amarela are caught in the same place, there is not a specific fishery for Corvina.

c. **Pescadinha Gó** - Pescadinha go is the most abundant Sciaenidae in the Amazon River estuary. The marketable size ranges between 20 to 30 cm and it is caught by the artisanal and industrial fisheries. Shrimp boats have usually discarded pescadinha go and only recently has a market been established. Artisanal fishermen catch pescadinha go with small mesh, monofilament drift gillnets.

Pescadinha go is the third most important species by weight landed at Ver-O-Peso. In 1996, 2,432 MT of pescadinha go were landed at Ver-O-Peso, 91% captured from salt water off the coast of Pará. The weight of pescada go landed in Amapá is insignificant.

d. **Pescada Branca** - Pescada branca may be a complex of species that scientists are unable to separate taxonomically. Pescada branca lives in fresh waters and tolerates little salt water. Landings registered in Ver-O-Peso and Amapá in 1996 were 1792 and 22 MT, respectively. Pescada branca captured by artisanal fishermen using 14-cm drift gillnets in freshwater zones of Marajó Bay and the Amazon river mouth compose almost 74% of the pescada branca landed at Ver-O-Peso.

4. **Other Species** - Several species of sharks and skates are abundant in the Amazon River estuary. The bull shark is the most common large shark captured, and the Bico de Pato, an endemic species of northeastern South
America, is the most common small shark captured. Shark fisheries are related more to the exportation of fins than to meat consumption. Price for the big dorsal fin can reach values that are 7 times the price for Gurijuba swimbladders.

C.   Management
1. General - Rapid development of the commercial fishery during the 1970's resulted in conflicts between subsistence, artisanal and industrial fishermen in the Amazon River estuary (Penner 1980; Melo 1985 & 1989; Loureiro 1985), the lower Amazon River (Hartmann 1989; McGrath et al 1993) and the central Amazon River (Salati et al 1983; Lima-Ayres 1994). Conflicts due, in part, to the over-fishing of Amazon River fish stocks such as piramutaba and tambaqui were reported (Merona & Bittencourt 1988; Ruffino & Naum 1994). The Brazilian government agency responsible for management of fish populations in the Amazon River, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), intervened in these conflicts by imposing regulations meant to protect the declining fish stocks. However, regulations were based on meager scientific information and enforcement of the regulations was precarious due to lack of boats and manpower.

IBAMA has adopted a variety of management strategies to control fish exploitation depending on the species captured, the amount of information available on the fish populations, methods of capture and amounts extracted. Management strategies can be divided into two methods: 1. do nothing and 2. place restrictions on fish capture. Doing nothing is frequently adopted when: 1. administrators judge that restrictions on the commercial fishery suggested by scientists to increase fish stocks are not necessary, 2. not enough scientific information on the biology and capture of the fish stocks is available to develop control measures so restrictions are ignored, 3. Financial resources are not allocated by the central government to enforce restrictions placed on the fishery.

When restrictions are adopted and enforcement attempted by IBAMA, the restrictions are based on the following management strategies: 1. limit access to fishing areas (Zoning), 2. restrict the use of certain fishing gear, 3. control or limit the mesh size of the fishing nets, 4. prohibit fishing in defined seasons; 5. control fishing effort through quotas and licenses on the fishing boats, and 6. create reserves where fishing is prohibited or limited to subsistence fishermen (Bayley 1981; Bayley & Petrere 1989; Petrere 1992).

2. Piramutaba - The piramutaba industrial fishery in the estuary is regulated by three restrictive measures: 1. zoning, 2. limits on the mesh size of the trawl net codend and, 3. control fishing effort by limiting the number of boats. The industrial fleet is prohibited from capturing piramutaba in the Amazon estuary from parallel 00°05'N in the south to meridian 48°00' W in the west. Creating a zone prohibiting industrial fishing of piramutaba is an attempt to minimize conflicts between the industrial and artisanal
fleets. Also, the codend of trawl nets used by industrial fishermen to capture piramutaba must have a minimum mesh size of 10 cm and the number of licensed boats is limit to 48. However, regulations are not strictly enforced and 60 boats are fishing piramutaba in the estuary and the forbidden zone is not respected by the fishermen.

3. Dourada, Filhote, Pescada Branca, Pescada Amarela, and Pescadinha Gó - These species are fished by the artisanal fishery and there are no restrictions placed on their capture.

4. Gurijuba - The Gurijuba fishery is regulated by the Amapá State. The capture of Gurijuba with gillnets along the north coast of Amapá is forbidden during the reproductive period between November and March. Similar restrictions are not placed on the Gurijuba fishery in the Amazon River estuary. The restriction on gillnetting affects only the fishermen of Amapá State. However, fishermen from Pará state continue to capture Gurijuba with gillnets along the Amapá coast during the reproductive season. The restriction on gillnet fishing is not enforced on fishermen from Pará because the Gurijuba are landed in Belém and law enforcement authorities do not know where the fish were captured. Restrictions on Gurijuba capture have to include fishermen from both Amapá and Pará. The prohibition of gillnet use during Gurijuba spawning season in Amapá as presently enforced is not an effective method to protect Gurijuba during spawning. To protect Gurijuba during its spawning season, an important Gurijuba spawning area should be closed to all fishing by fishermen from Amapá and Pará.

5. Other Amazon River Species - Fishing in the Amazon River and its tributaries is regulated in different places by one or more of the following restrictions: 1. regulation of minimum stretch mesh size for gillnets, 2. establishment of a minimum capture length for nine species, such as 55 cm for tambaqui and 150 cm for pirarucu, 3. prohibition of pirarucu fishing in the Brazilian and Colombian Amazon basin for 6 months, 4. legislation of "Piracema", that prohibits fishing activity during spawning migrations and, 5. a specific case in lake "Grande de Monte Alegre" near Santarém. The lake is divided into two sections, one section for exploitation by commercial fishermen and another section reserved for subsistence fishing by river-side communities.

D. Research

Current problems with fisheries management on the Amazon River are related to the unknown amount of fish captured and the large expanse and heterogeneity of the environment and productivity of the waters in each tributary. The Amazon Region does not have a fisheries research tradition. The first fish capture statistics were published at the end of the last century by Veríssimo (1895).
In the early 1970's, SUDEPE, the governmental institution responsible for the administration of fish resources at that time, started recording fish landings in Belém and other cities on the Amazon River estuary. At the end of the 1980's control of fish landings was suspended in the city markets and records of fish landings were restricted to processing plants.

The Museum Goeldi started recording fish landings in the Ver-O-Peso market in 1993, the principle fish market of Belém. At the same time, studies related to the fishery biology of piramutaba and other commercially important freshwater catfishes were initiated. The project is financed by the Brazilian Government and will terminate in July, 1997. Fisheries statistics from the Ver-O-Peso market presented in this report were the results of this project.

The Center of Fisheries Research of the North of Brazil (CEPNOR) is located in Belém and was initiated in 1995 as a center of study and information on fisheries activities along the north coast of Brazil and in the Amazon River region. CEPNOR is supported by the Ministry of the Environment and controls the piramutaba and marine shrimp landings at the industrial fish and shrimp processing companies.

In 1996, the Japan International Cooperation Agency (JICA) funded a collaborative project with the Museum Goeldi and CEPNOR to assist the Brazilian government survey the capture fishery in the Amazon River mouth. The project was concluded in March 1997.

The Environmental Secretary of Amapá State (SEMA) is heading a project financed by the World Bank and the Brazilian Environmental Ministry aimed at protecting the environment and developing the capture fisheries. The project is multidisciplinary and has as a main objective to organize the fishermen and people related to the capture fish industry. Researchers from the Amapá Research Institute (IEPA) are collecting information on Gurijuba capture to assist the government manage this fishery.

Finally, the Amapá government, with financial assistance from the Interamerican Development Bank, has begun surveying fishermen, fish mongers and fish and shrimp processing plants to collect data used to suggest means of promoting sustainable fisheries development within the state. Fisheries statistics reported for Amapá in this report were obtained from information generated by this survey.

E. Processing and Marketing

Fishermen from Amapá and Pará States fish on the Amazon River estuary, inner delta and lower Amazon. Fish captured from these regions are sold to local, national, and international markets. Fish are sold in local markets of small cities located along the Amapá coast. Fish are also transported by boat and truck to the big cities of the region, Belém or Macapá. Fish
landed in the large cities are either processed and exported to markets in the south of Brazil and overseas, or are sold fresh and whole in local markets.

Fish processing plants are situated in Santana, the second largest city in Amapá or in Belém and Vigia in Pará. A small number of ice plants providing ice to industrial and artisanal fishermen are scattered along the Amapá and Pará coasts. Fish and shrimp processing plants must pass a sanitary inspection by the government to obtain a license to export processed fish overseas. Fish processing plants that sell fish only within Brazil do not have to pass government sanitary inspections. Of the three fish processing plants located in Amapá, only the Leal Santos Fish Company has a license to export fish. The other two fish processing plants only sell fish to states in southern Brazil.

F. Overseas Exports

Marine shrimp exports from Amapá generated more than $4 million U.S. in revenues in 1996. Marine shrimp was the only seafood exported and its value represented 4.14% of the total export revenues earned by the State in 1996. Other export products ranked ahead of marine shrimp by value were wood (56.08%), manganese ore (18.86%), chromium ore (8.42%), and palm hearts (7.08%). The company exporting marine shrimp harvests their shrimp along the Amapá coast and shares the fishing grounds with boats from other Brazilian states and French Guyana. Shrimp boats from French Guyana fish illegally in Brazilian waters.

G. Domestic sales

No records are available on the amount or value of fish sold to consumers in Amapá or in other Brazilian states. The state government does not tax domestic fish sales and has little interest in maintaining records of fish sales. Local fish prices are regulated in part, by the demand for and prices paid for fish in the south of Brazil. Presently, fish prices for fish in the south of Brazil are high and thus, local fish prices are also high. Government statistics show that the per capita consumption of fish in the Amazon River basin is 55 kg/year, the highest of any region in Brazil. The price of fish in Macapá (Table 1) has increased to levels that make fish purchases increasingly difficult for lower income inhabitants. However, the increase in fish prices has stimulated increased fishing effort by local artisanal fishermen.

The fishing fleets of Amapá and Pará harvest from the Lower Amazon, the inner delta and the North Coast. The fish processing plants compete among themselves for fish and to meet the demands of fish consumers in southern Brazil (Figure 11). Fishing boats harbored in Santana and other ports along Amapá coast are located closer to fishing grounds on the Lower Amazon, inner delta and North coast than boats harbored in Belém. The shorter distance to processing plants in Santana lowers boat fuel costs and should result in more fishing trips per year, increasing profits. However, fishing boats from Belém
and some boats from Amapá prefer to sell their fish in Belém because fish processing plants are able to offload their fish faster, reducing loses due to spoilage and offer higher prices than processing plants in Amapá. Also, boat captains are able to purchase nets, engine parts and other equipment and obtain boat repairs easier and cheaper in Belém. The Government plans to install a technical school in Calçoene to teach fish processing technology, and engine and boat repair skills to provide more employment opportunities for the people in the region.

The Pacífico fish processing company installed a small cold storage plant in Calçoene to receive and hold fish captured along the north coast of Amapá. The company rents the ice plant run by the Calçoene city government to replenish ice to about 50 fish boats operating from the Calçoene harbor and other smaller ports on the north coast. The ice plant also provides ice to the trucks which transport the fish to Santana for Pacífico. Truck drivers spend about 8 to 9 hours in the summer and 12 hours in the rainy season to transport fish from Calçoene to Santana. Fishermen get lower prices for their fish in Calçoene compared with Santana and Belém, but they can be back to the fishing areas in five days. Fishermen that sell their fish in Belém or Santana will spend 15 days or more in transit and will spend more fuel.

Other products obtained from fishing activities along the north coast are catfish and sciaenid swimbladders and shark fins. Swimbladders and shark fins are exported to China, Japan and England and their commercialization is not controlled by the state. Table 4 lists the prices for swimbladders and shark fins. Fishermen estimate that 1 ton of whole fish is required to obtain 18 to 20 kg of swimbladders. The Pacífico Company pays R$1.30/kg for whole Gurijuba. Thus, 1 ton of Gurijuba is worth R$1,300.00 plus R$260.00 for swimbladders, an almost 20% increase in value over the price for whole fish.

Table 1 compares fish prices in the fish markets visited. Even though Amapá is located near major fishing areas, fish prices noted in the Macapá fish market are the same or higher than fish prices recorded in Belém. Amapá City, a small town on the North Coast, had lower fish prices than Macapá and Belém.

H. Conclusions

Saltwater and freshwater catfishes along with several members of the drum family (Sciaenidae) comprise most of the fish landings in the state of Amapá. The industrial piramutaba fishery is centered in Belém; the stock is overexploited, is highly regulated, and offers little opportunity for Amapá. The other freshwater catfishes are harvested by artisanal fishermen and relatively little is known about the health of their stocks. The saltwater catfish Gurijuba is an important resource for Amapá, is marginally regulated, and is the subject of a new management study. A market for the swim bladders creates added value for this fishery.
Pescada Amarela may have the greatest potential for further development in Amapá. The meat and swim bladder are highly valued, and the fish appears to be abundant off the north coast. Little is known of its biology and the status of the stock.

The other species of drum (Corvina, Pescadinha Gó, and Pescada Branca) are also important contributors to the fisheries of Amapá, but as with the other species, most of the production ends up in Belém, and as with others species, little is known about the status of the stocks. Pescadinha Gó, which is caught incidentally with saltwater shrimp, could contribute more to the overall production if markets could be found.

Sharks appear to be an incidental catch of other fisheries but are highly valued due to the prices paid in the export markets for the fins.

Processing plants, boat unloading areas, navigation and transportation infrastructure along the north coast are important ingredients for further development of fisheries in Amapá. Significant also are the apparent differences in prices paid to fishermen between Belém and Macapa/Santana.

I. Recommendations

1. Research -
   a. Saltwater Catfish - The ariid catfishes are poorly known in the Amazon mouth. Studies of biology, growth, length frequency composition and total catch are important for the purpose of management of these species.

   b. Freshwater Catfish - The migration of these catfishes involve three countries for their management. In the estuary, the most important studies are related to the growth and mortality of the young fish. In the upper Amazon, the studies have to be concentrated on the reproduction behavior. In the middle Amazon, the studies can be concentrated on the migration and food behavior.

   c. Sciaenidae - The harvesting of the pescadinha gó are being stimulated by the increase of fish demand in southern Brazil. This stock needs be studied before the exploitation reaches unsustainable levels.

2. Processing and Marketing -
   a. General - The north coast of Amapá may be the last under-exploited fishing area of Brazil. If Amapá wants to improve income to the state through exploitation of these fishing grounds and compete with Pará for the fish captured along the north coast, Amapá needs to improve infrastructure in that region. All weather roads from Calçoene and Amapá City to Santana and a secure source of electricity are needed. Also, a line
of credit is necessary to finance improvements in the Calçoene and Amapá City harbors, processing and cold storage facilities and to provide incentives to open small businesses that will supply the fishery industry with boat and motor repair and gear and engine parts.

b. Saltwater Catfish - Food technology is poorly developed in the Northern region of Brazil. Several stocks are not exploited or are not valued in spite of their high quality for consumption. Ariids are very abundant in the estuary but only one species is valued.
VI. Annex 1 - Itinerary

Calendar of Events during Evaluation of Capture Fishery and Aquaculture Potential in the State of Amapá, Brazil
June 16 to 25, 1997

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Event and Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 15</td>
<td>1:30 pm</td>
<td>Lovshin, Kubitza and Wallace arrive in Belém, Pará and meet Barthem.</td>
</tr>
<tr>
<td>June 16</td>
<td>7:30 am</td>
<td>Visit to Ver-o-Peso fish market in Belém</td>
</tr>
<tr>
<td></td>
<td>11:00 am</td>
<td>Visit to the Primar Fish Processing Plant and discussion of fish and shrimp processing and marketing with Fernando Abeu Pinto, owner.</td>
</tr>
<tr>
<td></td>
<td>4:00 pm</td>
<td>Visit to AMASA marine shrimp processing plant.</td>
</tr>
<tr>
<td></td>
<td>5:00 pm</td>
<td>Discussion with Wilson Yuji Nagashim, owner and captain of marine shrimp boats.</td>
</tr>
<tr>
<td>June 17</td>
<td>8:00 am to</td>
<td>Lovshin and Kubitza visit Pindaré Animal Feed Factory and speak with Edimar Santos, vice-director. Several animal feed supply stores were also visited.</td>
</tr>
<tr>
<td></td>
<td>12:00 noon</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8:00 am to</td>
<td>Barthem and Wallace travel to the Museu Paraense Emilio Goeldi to review commercial fish capture and marketing statistics from the lower Amazon and</td>
</tr>
<tr>
<td></td>
<td>12:00 noon</td>
<td>North Coast of Amapá.</td>
</tr>
<tr>
<td></td>
<td>2:00 pm to</td>
<td>Visit the office of the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) and meet with Ítalo José Vieira, head of</td>
</tr>
<tr>
<td></td>
<td>4:00 pm</td>
<td>CEPNOR and responsible for research on the commercial fish and shrimp fishery in the lower Amazon River and Atlantic Ocean.</td>
</tr>
<tr>
<td></td>
<td>7:00 pm</td>
<td>Team travels to Macapá and meets Champion International representative, Renato Ribeiro Santos.</td>
</tr>
<tr>
<td>June 18</td>
<td>9:00 am to</td>
<td>Meeting with representatives of the Institute of Rural development in Amapá, (RURAP), Secretary of Agriculture (SEAF), State Research Institute of</td>
</tr>
<tr>
<td></td>
<td>10:30 am</td>
<td>Amapá (IEPA), Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), Secretary of the Environment of Amapá (SEMA), Land Institute of Amapá (TERRAP), Fishermen’s Federation of Amapá (FEPAP) and Renato R. Santos of Champion International.</td>
</tr>
</tbody>
</table>
June 19
Lovshin and Kubitza depart Macapá with Gizeldo C. Barros (RURAP) as driver to travel north to Amapá City.

June 20
8:00 am to 4:00 pm
Return to Macapá from Amapá City.

June 21
6:30 am to 11:30 am
Visit to fish markets, supermarket, agricultural supply store and animal feed store in Macapá.

1:00 pm to 4:00 pm
Visit to fish farm near Macapá.

June 22
6:30 am to 11:30 am
Plane flight - aerial view of the east coast and central regions of Amapá.

1:00 pm to 4:00 pm
Free

June 23
8:00 am to 11:00 am
Visit to fish farm near Macapá

2:30 pm to 5:30 pm
Lovshin and Kubitza visit IBAMA freshwater turtle reproduction and culture research station, Porto Grande district.

2:30 pm to 5:30 pm
Barthem and Wallace visit Leal Santos Pescados marine shrimp processing plant and meet with the manager, Mr. Dinaldo.

6:00 pm to 7:00 pm
Visit with Fernando G. Santos, president of the International Chamber of Commerce of Amapá.

June 24
9:00 am to 11:00 am
Meeting in SEAF to report on conclusions and recommendations of fishery and aquaculture evaluation in Amapá to the Minister of Agriculture, Maria Benijna Geronimo, Vice-minister of
Agriculture and advisor to SEAF, Alcione Cavalcante.

10:00 am to 11:30 am
Barthem meets with representatives of the Secretary of the Environment of Amapá (SEMA), Mr. Gemac, Program for Coastal Management (PGC), Mr. Marcelo, and State Secretary of Industry and Commerce (SEIC), Mr. Zoila.

11:30 am to 12:30 pm
Meeting with L. Fernando Allegretti, consultant to government of Amapá. Knowledgeable about laws governing aquaculture development.

2:00 pm to 2:30 pm
Meeting with Adalberto P. Silva, general manager of Champion International, Amapá.

2:30 pm to 4:00 pm
Team meets to discuss conclusions and recommendations of evaluation and organization of final report.

8:00 pm
Leave Macapá for Belém.

June 25
9:15 am
Lovshin leaves for South of Brazil.

3:15 pm
Kubitza and Wallace leave for Sao Paulo.
VII. Bibliography


VIII. Acknowledgment

The Auburn University team would like to thank Renato Santos of Champion International for providing logistical support in Amapá. Thanks also to Gizeldo C. Barros of RURAP for guiding Lovshin and Kubitza to potential fish farming sites during our trip to Amapá city and for providing insights into the economy of Amapá. Finally, we would like to thank the Minister of Agriculture Maria Benijna Geronimo, Minister of Agriculture fishery specialist Ana Rosa Araujo and Victoria J. Isaac, consultant for the Interamerican Development Bank for providing us with a copy of "A Pesca no Estado de Amapá: Alternativas para o seu Desenvolvimento Sustentável". The report provided valuable insights into the status, potential and needs of capture fishery and aquaculture activities in Amapá.
Table 1. List of prices in Brazilian currency obtained in different fish markets and prices paid by processors to fishermen (R$1=US$1.07)

<table>
<thead>
<tr>
<th>Species</th>
<th>Fish Markets</th>
<th>Processing Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Belém (landing dock)</td>
<td>Belém (covered market)</td>
</tr>
<tr>
<td>Acari-Bodó</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>Aracú</td>
<td>2.00-2.50</td>
<td></td>
</tr>
<tr>
<td>Arraia</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>Camarão Regional</td>
<td>2.00-2.50</td>
<td></td>
</tr>
<tr>
<td>Camorim</td>
<td>4.50</td>
<td></td>
</tr>
<tr>
<td>Curimatá</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>Dourada</td>
<td>2.00 2.50</td>
<td>1.50-2.50</td>
</tr>
<tr>
<td>Espadarte</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Filhote or Piraiba</td>
<td>3.00 4.00</td>
<td>3.00-3.50</td>
</tr>
<tr>
<td>Gurijuba</td>
<td>2.50</td>
<td>1.50</td>
</tr>
<tr>
<td>Jaraqui</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>Mandubé</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>Mapará</td>
<td>1.00 1.00-1.50</td>
<td></td>
</tr>
<tr>
<td>Matrinxá</td>
<td>3.50</td>
<td></td>
</tr>
<tr>
<td>Pacamum</td>
<td>2.50</td>
<td></td>
</tr>
<tr>
<td>Pescada Amarela</td>
<td>3.00-3.50 3.50 2.00</td>
<td>1.40-2.30</td>
</tr>
<tr>
<td>Fish</td>
<td>Price Range</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>Pescada Branca</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>Pescadinha Gó</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>Piramutaba</td>
<td>1.50-2.00</td>
<td></td>
</tr>
<tr>
<td>Piranambu</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>Piranha</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Pirarucu</td>
<td>3.00-8.00</td>
<td></td>
</tr>
<tr>
<td>Pitú</td>
<td>12.00</td>
<td></td>
</tr>
<tr>
<td>Sarda</td>
<td>2.50</td>
<td></td>
</tr>
<tr>
<td>Tambaqui</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>Tamoatá</td>
<td>0.70-0.80</td>
<td></td>
</tr>
<tr>
<td>Trára</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Tucunaré</td>
<td>1.50-2.50</td>
<td></td>
</tr>
<tr>
<td>Beef (first quality)</td>
<td>2.50-4.00</td>
<td></td>
</tr>
<tr>
<td>Beef (second quality)</td>
<td>2.00-2.50</td>
<td></td>
</tr>
<tr>
<td>Frozen whole chicken</td>
<td>2.00</td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Water quality parameters of some rivers, lakes, wetlands, and fish ponds in Amapá

<table>
<thead>
<tr>
<th>Site #</th>
<th>Temp. °C</th>
<th>pH</th>
<th>Total alkalinity mg/l</th>
<th>Total hardness mg/l</th>
<th>Oxygen mg/l</th>
<th>Carbon dioxide mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlimed fish pond</td>
<td>1</td>
<td>30.0</td>
<td>6.0</td>
<td>5</td>
<td>3</td>
<td>5.5</td>
</tr>
<tr>
<td>Limed fish pond</td>
<td>1</td>
<td>29.5</td>
<td>7.0</td>
<td>43</td>
<td>38</td>
<td>8.6</td>
</tr>
<tr>
<td>Amazon River</td>
<td>2</td>
<td>31.7</td>
<td>7.5</td>
<td>13</td>
<td>16</td>
<td>8.6</td>
</tr>
<tr>
<td>Private fish pond</td>
<td>3</td>
<td>30.3</td>
<td>6.5</td>
<td>14</td>
<td>13</td>
<td>2.5</td>
</tr>
<tr>
<td>Cuiau (wetland)</td>
<td>4</td>
<td>28.9</td>
<td>5.5</td>
<td>0</td>
<td>0</td>
<td>4.5</td>
</tr>
<tr>
<td>Baln. Porto Grande</td>
<td>5</td>
<td>26.0</td>
<td>5.5</td>
<td>0</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>Araguari River</td>
<td>6</td>
<td>28.8</td>
<td>6.5</td>
<td>7</td>
<td>3</td>
<td>7.2</td>
</tr>
<tr>
<td>Tracajatuba River</td>
<td>7</td>
<td>27.0</td>
<td>6.5</td>
<td>1</td>
<td>1</td>
<td>7.6</td>
</tr>
<tr>
<td>Tartarugalzinho River</td>
<td>8</td>
<td>26.2</td>
<td>6.0</td>
<td>2</td>
<td>5</td>
<td>7.9</td>
</tr>
<tr>
<td>Pracuuba Lake</td>
<td>9</td>
<td>31.0</td>
<td>6.0</td>
<td>3</td>
<td>5</td>
<td>5.6</td>
</tr>
<tr>
<td>Breu River</td>
<td>10</td>
<td>25.4</td>
<td>6.0</td>
<td>0</td>
<td>0</td>
<td>6.8</td>
</tr>
<tr>
<td>Enrique River</td>
<td>11</td>
<td>25.7</td>
<td>6.0</td>
<td>0</td>
<td>0</td>
<td>7.7</td>
</tr>
<tr>
<td>Amapazinho River</td>
<td>12</td>
<td>28.1</td>
<td>7.0</td>
<td>17</td>
<td>500+</td>
<td>5.1</td>
</tr>
<tr>
<td>Calafate River</td>
<td>13</td>
<td>25.9</td>
<td>6.5</td>
<td>2</td>
<td>2</td>
<td>7.8</td>
</tr>
<tr>
<td>Well water (Calafate)</td>
<td>14</td>
<td>-</td>
<td>5.0</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Matapi River</td>
<td>15</td>
<td>26.6</td>
<td>6.0</td>
<td>0</td>
<td>0</td>
<td>6.3</td>
</tr>
</tbody>
</table>

1 Tidal river influenced by the Atlantic Ocean
### Table 3. Names of species referred to in this report

<table>
<thead>
<tr>
<th>Brazilian</th>
<th>Scientific</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acari-Bodó</td>
<td>Loricariidae</td>
<td>Armored catfish</td>
</tr>
<tr>
<td>Aracú</td>
<td>Anostomidae</td>
<td></td>
</tr>
<tr>
<td>Arraia</td>
<td>Dasyatis spp.</td>
<td>Skate</td>
</tr>
<tr>
<td>Bico de Pato</td>
<td>Isogomphodon oxyrhincus</td>
<td>Daggernose Shark</td>
</tr>
<tr>
<td>Cabeça-Chata</td>
<td>Carcharhinus leucas</td>
<td>Bull Shark</td>
</tr>
<tr>
<td>Camarão</td>
<td>Penaeopsis serrata</td>
<td>Pink Speckled Shrimp</td>
</tr>
<tr>
<td>Camarão</td>
<td>Aritaeomorpha foliaccea</td>
<td>Giant Red Gamba Shrimp</td>
</tr>
<tr>
<td>Camarão</td>
<td>Plesiopeaus edwardsianus</td>
<td>Scarlet Prawn</td>
</tr>
<tr>
<td>Camarão Branco</td>
<td>Penaeus schmitii</td>
<td>Southern White Shrimp</td>
</tr>
<tr>
<td>Camarão Regional</td>
<td>Macrobrachium spp</td>
<td>Freshwater Shrimp (Prawn)</td>
</tr>
<tr>
<td>Camarão Rosa</td>
<td>Penaeus brasiliensis</td>
<td>Pinkspotted Shrimp</td>
</tr>
<tr>
<td>Camarão Rosa</td>
<td>Penaeus notalis</td>
<td>Southern Pink Shrimp</td>
</tr>
<tr>
<td>Camarão Rosa</td>
<td>Penaeus subtilis</td>
<td>Southern Brown Shrimp</td>
</tr>
<tr>
<td>Camarão Sete Barbas</td>
<td>Xiphopenaeus kroyerii</td>
<td>Seabob</td>
</tr>
<tr>
<td>Camorim</td>
<td>Centropomus parallelus</td>
<td>Snook</td>
</tr>
<tr>
<td>Carpa Comum</td>
<td>Cyprinus carpio</td>
<td>Common Carp</td>
</tr>
<tr>
<td>Corvina</td>
<td>Cynoscion virescens</td>
<td>Green weakfish</td>
</tr>
<tr>
<td>Curimatá</td>
<td>Prochilodus scrofa</td>
<td></td>
</tr>
<tr>
<td>Dourada</td>
<td>Brachyplatystoma flavicans</td>
<td>Freshwater Catfish</td>
</tr>
<tr>
<td>Espadarte</td>
<td>Pritis microdon</td>
<td>Sawfish</td>
</tr>
<tr>
<td>Filhote or Piraiba</td>
<td>Brachyplatystoma filamentosum</td>
<td>Freshwater Catfish</td>
</tr>
<tr>
<td>Gurijuba</td>
<td>Arius parkeri</td>
<td>Sea Catfish</td>
</tr>
<tr>
<td>Jaraqui</td>
<td>Semaprochilodus spp.</td>
<td></td>
</tr>
<tr>
<td>Mandubé</td>
<td>Ageneiosus spp.</td>
<td></td>
</tr>
<tr>
<td>Mapará</td>
<td>Hypophthalmus spp.</td>
<td></td>
</tr>
<tr>
<td>Matrinchá</td>
<td>Brycon spp</td>
<td>Brycon</td>
</tr>
<tr>
<td>Pacamum</td>
<td>Batrachoides surinamensis</td>
<td>Pacuma Toadfish</td>
</tr>
<tr>
<td>Pescada Amarela</td>
<td>Cynoscion acoupa</td>
<td>Acoupa Weakfish</td>
</tr>
<tr>
<td>Pescada Branca</td>
<td>Plagioscion squamosissimus</td>
<td>Freshwater Drum</td>
</tr>
<tr>
<td>Pescadinha Gó</td>
<td>Macrodon ancylopon</td>
<td>King Weakfish</td>
</tr>
<tr>
<td>Piramutaba</td>
<td>Brachyplatystoma vaillantii</td>
<td>Freshwater Catfish</td>
</tr>
<tr>
<td>Piranambu</td>
<td>Pinirampu pirinampus</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. (Cont.)

<table>
<thead>
<tr>
<th>Brazilian</th>
<th>Scientific</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piranha</td>
<td><em>Serrasalmus spp.</em></td>
<td>Piranha</td>
</tr>
<tr>
<td>Pirapema</td>
<td><em>Tarpon atlanticus</em></td>
<td>Tarpon</td>
</tr>
<tr>
<td>Pirapitinga</td>
<td><em>Piaractus brachypomus</em></td>
<td>Redtail Catfish</td>
</tr>
<tr>
<td>Pirarara</td>
<td><em>Phractocephalus hemioliopterus</em></td>
<td></td>
</tr>
<tr>
<td>Pirarucu</td>
<td><em>Arapaima gigas</em></td>
<td></td>
</tr>
<tr>
<td>Pitú</td>
<td><em>Macrobrachium spp</em></td>
<td>Freshwater Shrimp (Prawn)</td>
</tr>
<tr>
<td>Sarda</td>
<td><em>Pellona flavipinnis</em></td>
<td>Yellowfin River Prawn</td>
</tr>
<tr>
<td>Surubin</td>
<td><em>Pseudoplatystoma spp.</em></td>
<td>Catfish</td>
</tr>
<tr>
<td>Tambaqui</td>
<td><em>Colossoma macropomum</em></td>
<td></td>
</tr>
<tr>
<td>Tamoatá</td>
<td><em>Hoplosternum litoralle</em></td>
<td>Plated Catfish</td>
</tr>
<tr>
<td>Tilápiã do Nilo</td>
<td><em>Oreochromus niloticus</em></td>
<td>Nile Tilapia</td>
</tr>
<tr>
<td>Traira</td>
<td><em>Hoplias malabaricus</em></td>
<td></td>
</tr>
<tr>
<td>Tucunaré</td>
<td><em>Cichla spp.</em></td>
<td>Peacock Bass</td>
</tr>
</tbody>
</table>
Table 4. Prices of swimbladder (SB) of catfishes and sciainids and fin (FN) sharks

<table>
<thead>
<tr>
<th>Species</th>
<th>Kind of product</th>
<th>R$/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pescada</td>
<td>SB</td>
<td>37.00</td>
</tr>
<tr>
<td>Amarela</td>
<td>SB</td>
<td>37.00</td>
</tr>
<tr>
<td>Corvina</td>
<td>SB</td>
<td>6.00</td>
</tr>
<tr>
<td>Camorim</td>
<td>SB</td>
<td>6.00</td>
</tr>
<tr>
<td>Gurijuba</td>
<td>SB</td>
<td>12.00-13.00</td>
</tr>
<tr>
<td>Small Shark</td>
<td>FN</td>
<td>12.00-13.00</td>
</tr>
<tr>
<td>Big Shark</td>
<td>FN</td>
<td>87.00</td>
</tr>
<tr>
<td>Bico de Pato</td>
<td>FN</td>
<td>6.00</td>
</tr>
</tbody>
</table>
Figure 1. Number of shrimp vessels and shrimp landings (talis) from Para and Amapa.

- No. of Vessels
- Landings (Metric Tons x 1000)

Year

Data from IBAMA - CEPNOR

Figure 2. Catch and effort for the shrimp fishery of Para and Amapa (1970 - 1996)

- Catch

Data from IBAMA-CEPNOR
Figure 3. Fishing areas of the Amazon Region (Barthem 1995)

1- Amazon Estuary
2- Inner Delta
3- Amazon River System
4- Madeira-Beni-Marã­ River System
5- Tocantins River System

a- North
b- Amazon Mouth
c- Marajó Bay
d- Salted
Figure 4. Fork length composition of gurijuba landing in Belém Fish Market
Figure 5. Annual catch of piramutaba by industrial fishing fleet based in the Amazon estuary
Figure 6. The catch per unit effort (tons/fishing day/boat) of piramutaba by the industrial fleet.
Figure 7. Value of piramutaba exports since 1978
Figure 8. Frequency distribution of piramutaba size classes in the estuary (Barthem and Goulding 1997)

Mean = 44.2 cm
N = 2,942
Figure 9. Frequency distribution of dourada size classes in the estuary (Barthem and Goulding 1997)

Estuary (1983)
Mean = 60.5 cm
N = 8,507
Figure 10. Frequency distribution of filhote size classes in the estuary
Figure 11. The flow of fish production originated in harvest the Lower Amazon, the Inner delta and the North Coast with the fish fleet of Pará.