

THE STATUS OF AQUACULTURE IN SOUTH AMERICA

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## INTRODUCTION

The Inter-American Development Bank (IDB), a financial institution with 25 years of existence, is comprised of 43 member countries: 25 from Latin America and the Caribbean and 18 from North America, Europe and Asia. It acts as the main source of funds for developmental projects in the Latin American region.

Nineteen years ago, the IDB began promoting the possibilities and significance of fishery development in Latin America. The experience gained over these years indicates that financial development agencies can make contributions to the progress of this sector if they have an accurate diagnosis on the sector, including natural and human resources, institutions, government policies, infrastructure, production capacity and developmental potential.

In response to the bank's desire to know the present situation of aquaculture in South America, its forestry and fisheries section hired a summer intern to conduct this update.

The purpose of this report is to provide the IDB with the available information on the current status of aquaculture in most of its South American member countries.

Questionnaires were sent to each countries competent private and public institution as well as some universities. Although most of the questionnaires were returned, they contained partial information at best. The voids left, were filled with the help of the Foreign Fisheries Analysis Branch's (NMFS) files and a literature search of specialized magazines, journals and books.

## CHAPTER I

### OVERVIEW AND ANALYSIS

### GENERAL ASPECTS

The origins of aquaculture date back several centuries before Christ in Asia and especially in China. In China fish were raised in dirt ponds to provide an important part of the human diet. This was done with the marginal effort of farmers and their families. Brackish water aquaculture probably began in Indonesia in the 13th century by convicts who were forbidden to engage in agriculture. In Latin America aquaculture began with the Mayans who cultured the fish trapped in flood plains. It first received widespread attention at the turn of the century as a means of populating rivers, lakes and other bodies of water, both for sport fishing and for home consumption.

Modern South American aquaculture probably began at the turn of the century in Chile by private individuals stocking their water with rainbow trout. Most of the early attempts in South American aquaculture involved either rainbow trout or carp.

Aquaculture is the controlled or partially controlled production of finfish, shellfish or crustaceans in either fresh or salt water, with the purpose of increasing its production and yield. It is essentially a technique aimed at optimizing the natural conditions for production of aquatic organisms. Breeding under controlled conditions reverses natural mortality rates of 10-90% found in the wild, to the 60-90% survival rates found in the controlled systems. In addition to faster growth rates, more uniform development and special selected characteristics can be obtained when subject to control.

Aquatic organism are cultivated for a wide variety of purposes. Some of these are for the production of food, improvement of natural populations by means of recruitment and artificial transplants, production of species for sport fishing, production of bait fish, culture of ornamental fish, cultivation for recycling of organic wastes, culture of pearls, species used to control pests or to maintain the natural equilibrium of an aquatic environment, etc.

Depending on the extent of human participation in the natural life cycle of aquatic organisms, a distinction is usually made among (1) extensive aquaculture ; (2) semi-intensive aquaculture and (3) intensive aquaculture.

- (1) The first case refers simply to the introduction of individuals of one or more species in a watercourse for the sole purpose of increasing the population, which is expected to allow an increase in fishing. The basis of the system is that fish feed on the naturally available food, without the need of supplements. This type of

aquaculture is practical mainly in large bodies of water, it requires small investment and limited resource management, and brings modest increases in yield. It can be used in any body of water with a small fish population like new reservoirs such as hydroelectric dams and watering places.

- (2) Semi-intensive aquaculture demands greater control on the natural environment, generally through treatment of the water to produce, or make available, greater quantities of food for the cultured fish. Depending on ecological conditions and species selected, semi-intensive aquaculture can double or triple the productivity of a natural fishery per unit of area. Its capital costs are comparatively low, although operating cost depend on the cost of the necessary inputs. This type of aquaculture can sometimes involve a certain physical work that will improve the natural environment.
- (3) Intensive aquaculture involves maximum or total control of the factors having an impact upon the production and growth of aquatic organisms to ensure the highest possible productivity. It can go all the way from treating the water used to managing the production of seed, incubation, grow-out period, and breeding of broodstock.

The level of productivity from intensive aquaculture is without doubt the highest and depends primarily on the proper management of natural factors such as water quality, type of species, quality of the species, quality of feed, design of culturing media (ponds, lagoons, banks, etc), sanitary conditions, disease prevention and control and many more.

#### CURRENT WORLD PRODUCTION

World annual fish production from aquaculture was estimated at 1 million tons in 1966/67. A partial estimates based on figures from 36 countries put it at 2.6 million tons in 1970. A better, but still preliminary, estimates made in 1973 indicated 5 million tons, comprising 3.7 million tons of fish and 1.3 million tons of crustaceans, mollusks and algae. Production for 1976 were estimated at 6 million tons, equivalent to 12% of the total catch of fish used for direct human consumption that year. The latest figure available, 1983, put production at a total of 7.1 million metric tons, an increase of 18% since 1976.

Few statistics are available on the aquaculture production of South America. However, it can be estimated at about

129,136 tons per year most of which comes from Brazil and Ecuador. Production figures by groups are given in table 1.

## REGIONAL SITUATION

### General Situation of Aquaculture

The most important progress in Latin American aquaculture has been in mariculture. The culture of shrimp, mussels, oysters and scallops has attained major commercial scale in several countries of the region.

In addition, there has been good progress and increasing interest in cold water aquaculture of salmonids, especially salmon in southern Chile and Argentina.

In freshwater aquaculture the principal gains have been made in warm water regions, almost entirely in the raising of tilapia and carp in ponds. In some countries, particularly Brazil, commercial production of native species has begun with great success.

### Freshwater Aquaculture:

Cold waters: In the cold waters of the region (below 16°C) there are two species of importance for commercial and restocking purposes, trout and "Pejerrey". These two species are cultured in most of the countries of the region with different degrees of success. In Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, and Venezuela, government stations have been established for the production of trout, which are used primarily to populate rivers, lakes and reservoirs. The programs are implemented without adequate monitoring over the management of the resource, and this ultimately has an adverse effect on productivity.

Commercial aquaculture in the coldest water of the region is limited to two species: trout and "pejerrey". Trout aquaculture technology has been adopted in all of the countries in South America and production has been estimated in the order of 4,000 tons.

Pejerrey culture techniques are well known but only a few commercial operations are underway. Most of it is produced by the government to populate natural or artificial bodies of water.

Warm waters: Possibly in no other region of the world is there a greater number of native warm water species than in Latin America. The limited research done to date has identified some of the species with potential value for aquaculture. Special efforts are being made by Brazil, Colombia, Ecuador, Peru and Venezuela to develop the commercial culture of their native species. Some success has been attained in Brazil; approximately 50 commercial ventures have been developed which culture native species. Nonetheless, since the required technology has been developed for only a few species, there has not yet been significant progress from a commercial stand point.

Owing to the lack of technological advances in the breeding of native species, almost all warm water aquaculture involves tilapia and carp, which are foreign species.

Tilapia and carp are the leading warm water species produced in the region. Nonetheless, little of this production goes to urban markets. It is used mainly for home consumption or sold at points near the ponds, and is often the major or only source of animal protein accessible to the local inhabitants. One factor that makes tilapia difficult to sell in urban markets is its small size, since in most places the people are accustomed to consuming larger fresh water species caught in rivers. In a few countries, notably Brazil, concerted efforts have been made to manage this resource in order to regulate growth and obtain larger fish.

The exportation of ornamental fish is an important activity in many countries. Recently Colombia and to a much lesser extent Peru have begun to produce ornamental fish.

#### Mariculture:

Brackish waters: In Ecuador, Brazil, Peru and Colombia the production of shrimp has had an explosive development since it is probably the most profitable type of aquaculture in the region today. Total production for the region is approximately 29,000 MT. Although most of the culture has been made using extensive aquaculture, it is rapidly progressing into the use of semi-intensive or intensive techniques.



The problem of post larvae availability associated with this large production is being solved by the construction of shrimp hatcheries. In Ecuador alone more than 50 hatcheries have received approval to operate in 1986.

The breeding of mullet - an anadromus species which begins its growth in fresh or brackish water and continues it in the sea - has not reached commercial importance in the region, although some initial progress has been made in Brazil and Colombia.

Sea water: The breeding of scallops, mussels and oysters are third in importance in commercial aquaculture. Scallop culture is most important in Peru, but Chile is rapidly advancing towards mass production of this mollusk. Total production for Peru reached 3,600 MT in 1985.

Mussel culture is important in Chile and Venezuela. Chile produced in 1985 over 1,500 tons of mussels, while Venezuela produced 456 tons.

Up to the present there has been no breeding of ocean fish, but Chile has developed a salmon pen-culture industry that looks quite promising. Last year total production reached 1,200 tons and it is estimated that production will reach 6,000-7,000 tons by the year 1990. Also Chile is trying to maintain a migratory population of salmon. These fish, which inhabit fresh water during their juvenile phase, swim to the sea to feed until they reach adult age, returning to their original habitat to spawn. The main objective of this program is to introduce a stable population of these fish on the basis of appropriate conditions of the rivers of Patagonia and Tierra del Fuego, in combination with ocean currents to facilitate the migration of the species to the rich fishing grounds of Antarctic krill and their subsequent return to the rivers of origin. Some success has been attained in this endeavor in the last couple of years. Returns of 1% have been obtained in the southern portion of Chile by Fundacion Chile's station at Curaco de Velez (Chiloe).

### Human Resources and Extension Services

#### Availability of Personnel:

With the exception of Chile, no country of the region has a sufficient number of professionals and technical personnel adequately trained to assist in the intensive development of the potential that aquaculture can offer.

### Training Programs:

All, but Paraguay and Uruguay have some sort of training programs in aquaculture, although they vary as to the type of training given. Chile, Peru, Ecuador, Colombia, Brazil and Venezuela have courses leading to the degree of aquaculture specialist. All countries in the region can provide courses and training in biological sciences.

### Extension Services:

Most countries have some sort of extension services but most of them are inadequate or their budgets are too small to be effective. Good extension services are essential for the development of activities in this field, primarily on small rural fish farms, whose profit margins do not cover the cost of professional services.

### Legal and Institutional Aspects

#### Legislation:

There are varied provisions in the countries concerning fishing resource management, protection of the environment, land and water use and ownership, and regulations of various kinds. Most countries have some form of legislation or regulations specifically on aquaculture, but most are incomplete or only deal with certain types of aquaculture. Nevertheless, legal provisions are gradually developing in accordance with the most common types of aquaculture in each country, as problems like ownership of species cultivated in public waters, their marketing, sanitary protection, losses due to pollution, arise.

#### Administrative Structure:

Most countries of the region have administrative structures for the development of aquaculture, but almost all of these are weak or incomplete. Although most have specialized units their infrastructure, budget, and personnel are small. In many countries several government agencies are concerned with this field, and in some mariculture and fresh water aquaculture are under the jurisdiction of different agencies.

### Outlook for Development

The greatest potential offered by the region in the short term is in the culture of shrimp, prawn, oysters, mussels

and salmon. The medium-term potential would consist of the breeding of native fish.

Special attention should be given to the ornamental fish culture. Brazil, Colombia, Venezuela, Ecuador and Peru have species which are part of this trade. Many species can be produced with existing aquaculture techniques, and at present this is being done on a small commercial scale in Colombia, Peru and Brazil. The fear of the governments of exporting countries that native species are being overfished, as well as the fear of governments of importing countries that diseases are being introduced, can greatly increase the demand for ornamental fishes cultured in controlled conditions.

Native species undoubtedly offer great potential for the development of aquaculture in the region. In Colombia, Brazil and Venezuela, commercial operation have begun to produce native species, with a fair degree of success.

#### Limitations and Critical Problems

Natural Limitation: Apparently no natural limitation exist, except in certain parts of Brazil and Peru where large stretches of land are flooded each year.

The availability of land suitable for aquaculture cannot be considered separately from the availability of suitable and unpolluted water. From the natural standpoint the limitations in terms of the availability of land/water are not a matter of concern in the region, except near most of the big cities and intense agriculture devoted areas subject to heavy applications of pesticides.

#### Technical Limitations:

- a) Lack of infrastructure. It has been noted that the starting point of any aquaculture project, whether intensive, extensive or for repopulation, is an adequate infrastructure of services. This consists of (i) egg and seed producing stations, and in some cases hatcheries, (ii) sanitary and general technical assistance; (iii) timely supply of adequate feeds at reasonable cost, (iv) supply of the required fertilizer; (v) marketing structure. All countries in the region lack or have an inadequate infrastructure in the services mention, this is especially true for the low profit products like tilapia and carp.
- b) Availability of technologies. In General, Latin America faces no limitation in terms of access to culture technologies, particularly in the case of foreign species (e.g., trout, carp, tilapia, shrimp).

The problems arise when this technology has to be adapted for this region, for when one country adapts the technology it does not communicate these developments to the countries culturing similar species. This problem has partially been solved by the American Regional Aquaculture Center (CERLA) located in Brazil which has an information service that is responsible for obtaining, analyzing and disseminating information on aquaculture developments in the region.

- c) Personnel and extension services. This factor seems to be the major technical impediment to the rapid development of aquaculture in the region. Nonetheless, it is slowly being overcome as more universities and public agencies become interested in teaching aquaculture related courses. Extension services are beginning to develop but much work and investment is still needed to attain effective services.
- d) Markets. In the case of fish products for export (e.g., shrimp and salmon) with sufficiently known and stable markets and prices, this factor poses no special limitations. But in the case of new activities which will generate nontraditional food products especially in rural areas or provincial cities the problem of entry into the market can be serious. The case of tilapia is interesting in this regard. Because of its size, which is generally smaller than that of other fresh water species usually consumed, the consumer tends to undervalue it even though the price may be lower. Nonetheless, when properly presented with sufficient knowledge on the part of the consumer and at a suitable price, it can quickly become a widely accepted product. Particular care must be taken, in the case of regional as subsectoral aquaculture projects with many fish farms, to assign the responsibility for marketing to experts and dynamic agencies.
- e) Duplication of efforts. Most of the universities and research centers in each country and some at the South American level are conducting similar types of research on the same or closely related species.

The economic hardship being suffered by most, if not all, universities and research centers make resources hard to obtain. These scarce resources should not be wasted in duplication of research; rather there should be a national and/or regional communications network to coordinate research activities so as to obtain maximum benefit from limited resources .

### Recommendations for Future Action

Training. This activity should, wherever necessary, be promoted. This can be done through the appropriate financing of these activities, like fellowship, and education grants. Training should be at both the professional level and, above all, middle-level technicians.

In each country an agricultural training school could be made responsible for training middle-level technicians to work in aquaculture.

Technical coordination. High priority should also be assigned to the exchange of information since valuable resources are currently being wasted.

Institutional organization development also requires the establishment of effective institutional structures to plan, assist and guide the growth of the industry in all its forms.

Legislation. In general the existing legislation should be revised and modified to support and protect the proper development of aquaculture.

Market studies and promotion are necessary to determine the capacity of markets to absorb the production of various species cultivated, it will be necessary to carry out coordinated studies of markets and prices at the national or international level.

Sanitary Protection should be implemented in each country to avoid introducing new diseases into their own fish and to be able to present a good clean product.

Extension services need to be strengthened especially in countries that develop fish farming in ponds for home consumption or small scale production.

# AQUACULTURE PRODUCTION-1985 (MT)

COUNTRY	FINFISH	MOLLUSCS	CRUSTACEANS	SEAWEED	TOTAL
Argentina	400			-	400
Bolivia	1,200				1,200
Brazil*	79,799		1,197		81,396
Chile	1,453	1,730		6,800	9,983
Colombia	2,000		810		2,810
Ecuador	834		27,000		27,000
Paraguay	5				5
Peru	750	3,600	650		5,000
Venezuela	450	458			908
TOTAL	86,891	5,788	29,657	6,800	

GRAND TOTAL: 129,136

\*1983 Data from Food and Agriculture Organization. 1986. Aquaculture and Rural Development. Nineteenth FAO Regional Conference for Latin America and the Caribbean, LARC/86/7.

Rest of data from the questionnaires returned by each country.

## CHAPTER II

### SITUATION BY COUNTRY

## ARGENTINA

### a) Commercial Aquaculture:

There are 10 commercial farms producing rainbow trout, for the local market found in the following provinces: Rio Negro, Neuquen, Cordoba, Jujuy and Buenos Aires. Another five farms are projected to become operational in 1986 or 1987.

### b) Research and Development Centers

The following are national fish culture centers depending on the Direccion Nacional de Pesca Continental.

Salmon Culture Center of San Carlos de Bariloche (Rio Negro) having in 1986 attained a record production of seven million fertilized eggs of rainbow trout. It also produces fertilized eggs of brown trout and Salvelinus fontinalis.

Fish culture center of "Rio Limay" of Plotlier-Neuquen. Specialized in the production of Percichthys sp according to the countries needs to repopulate local waters. It hatches approximately 30 million eggs a year.

Fish culture center of "Embalse" (Cordoba) hatches million "pejerrey lacustre" (Basilichthys bonariensis) to repopulate local waters, and "bagre de arroyo" (Rhamdia sapo) using intensive and semiintensive culture methods.

Fish culture center of "Sierra de la Ventana" (Buenos Aires). It does not have its own egg production but it hatches eggs from the center of San Carlos de Bariloche and Plotlier (Neuquen) to keep the local water stocked with rainbow and brown trout.

These national centers provide the eggs, fingerlings and broodstock to supply the country and private individuals interested in stocking and/or repopulating their streams, lakes, reservoirs and tanks.

The following are Regional Fish Culture Centers depending on the competent provincial aquaculture services.

Hydrobiological station of "Chascomis" (Province of Buenos Aires). Cultures "pejerrey lacustre."



Fish culture station of "Rio Olivia de Ushuaia" (Tierra del Fuego). Cultures several species of salmonids from the aquaculture stations of San Carlos de Bariloche; hatches, raises and seeds Atlantic salmon (Salmo salar) imported from Canada in an attempt to establish salmon runs in the area.

Fish culture station of Dique La Florida (Province of San Luis). It cultures "pejerrey lacustre" and rainbow trout.

Fish culture stations of Dique La Cienaga (Province of Jujuy). Cultures "pejerrey lacustre"

Culture center of Jala (Province of Jujuy). Cultures rainbow trout.

Fish culture station El Manzano (Province of Chubut). Cultures rainbow , brown and brook trout.

Fish culture station Arroyo Baggett (Province of Chubut). Cultures rainbow , brown and brook trout.

Fish culture station Villa Dolores (Province of Cordoba). Cultures "pejerrey lacustre".

Fish culture station El Cadillal (Province of Tucuman). Cultures "pejerrey lacustre".

Fish culture station Cabra Corral (Province of Salta). Cultures "pejerrey lacustre".

Fish culture station of Ullum (Province of San Juan). Cultures rainbow trout, "perca" and "pejerrey lacustre".

#### Research Centers:

Instituto Nacional de Investigacion y Desarrollo Pesquero (INIDEP) dependent of the Subsecretary of Agriculture, Livestock and Fisheries, Subsecretary of Fisheries, located in Mar del Plata (Province of Buenos Aires) and its research centers of:

"Rosario"

"Bella Vista" "Salto Grande"

Instituto Nacional de Limnologia - Santo Tome (Province of Santa Fe).

Instituto de Limnologia de Berisso - La Plata  
(Province de Buenos Aires).

Centro de Ecologia Aplicada del Litoral (CECOAL) -  
Corrientes (Province of Corriente).

Departamento de Ictiologia - Museo Argentino de  
Ciencias Naturales "Bernardino Rivadavia" (Capital  
Federal).

Laboratorio de Ictiologia - Museo de Ciencias  
Naturales de la Plata - La Plata (Province of  
Buenos Aires).

Departamento de Biologia de la Facultad de  
Ciencias Exactas y Naturales U.B.A (Capital  
Federal).

Direccion Provincial de Recursos Naturales y  
Ecologia. Ministerio de Asuntos Agrarios - La  
Plata (Province de Buenos Aires).

Laboratorio de Ictiologia - Instituto Antartico  
Argentino. Direccion Nacional del Artico (Capital  
Federal).

c) Human Resources and Extension Services

At present there are 250 biologists working in fish biology and related disciplines. Forty-four professionals and 21 technicians are working in aquaculture. With regard to training, 22 universities offer degrees in biology, and 8 in veterinary science. The University of Comahue offers technical training in aquaculture and fisheries, under an agreement with the Direccion Nacional de Pesca, which makes available its fish culture center of Bariloche, Neuquen and Embalse for the in hand experience of the student.

Extension programs are carried out by the Direccion Nacional de Pesca Continental's specialized technicians all over the country with the help of the regional centers.

d) Legal Aspects and Institutional Framework

Legislation:

There is federal and provincial legislation on fishing in inland water. In general, it is recognized that the authority to regulate fishing in inland waters and fish culture activities lies with the provinces. Actually, the most complete legislation in this regard is found in the rural codes of each province. Authorization is granted for the establishment of fish hatcheries in publicly owned waters, provided that navigation in those water is respected.

The most important legislation on land tenure and use is Federal Law 20593, known as the Law on Agrarian Development or Transformation. With regard to the ownership, tenure and use of waters in Argentina, there are national and provincial public waters and privately owned waters, the latter being those lying completely within the same property. In general, the rest are public waters under provincial jurisdiction, except in matters of navigations. There is no Federal Water Code, and therefore the waters are subject to the National Constitution, the Provincial Constitution, the Civil Code and the Rural Codes of the provinces.

In general, legislation on protection of the environment is primarily a matter for the provinces. There is a draft National Environmental Protection act, drawn up by the Sub-Secretaria de Planiamiento Ambiental. Neither the provincial legislation nor this draft contain specific regulation on aquaculture, but they do include standards for the prevention of water pollution.

The Subsecretaria de Pesca has recently submitted a draft of a new law regulating aquaculture and inland fisheries, which has not yet been approved.

Aquaculture Administration:

The federal agency responsible for inland and maritime fisheries in Argentina is the Subsecretaria de Pesca, under the Secretaria de Agricultura, Ganaderia y Pesca, which belongs to the Ministry of Economic Affairs. The Subsecretaria now directs the two Direcciones Nacionales de Pesca Maritima, Algologia y Caja Maritima, and Pesca Continental and also the Instituto Nacional de Investigacion y Desarrollo Pesquero (INIDEP).

e) Development Potential

Potential Areas

Mountain cold water: The Andes region has abundant water resources suitable for the breeding of trout.

Pampa region: Throughout the Pampa region there are many large and small lakes, whose waters offer potential for more development of aquaculture of the native pejerrey and local trout (Percichthys sp).

Rivers: In the region of the Parana and Uruguay rivers in northern Argentina there are considerable land and water resources suitable for the development of aquaculture projects.

Coastal region: In certain coastal regions it is possible to establish the culture of oysters and mussels. These regions include Bahia Blanca, Golfo de San Jose and Golfo Nuevo.

Suitable Species:

Trout  
Pejerrey  
Local Trout  
Oysters  
Mussels  
Salmon

f) Limitation to Development

Natural and Environmental:

The development of aquaculture in Argentina faces no limitation due to the scarcity of land or water. Water pollution is still limited, except in the lower part of the largest rivers.

Personnel:

There are no major limitations due to the lack of personnel. Argentina has a substantial number of graduate biologists who could specialize in aquaculture.

## Bolivia

### a) Commercial Aquaculture

There is only one commercial farm that raises approximately 1,200 tons of Rainbow trout per year.

### b) Research and Development Centers

The Club de Pesca "Arco Iris": Through a concession from MACA and with technical assistance from the Departamento de Vida Silvestre, has reactivated the operations of a trout hatchery that has a production capacity of 120,000 fingerlings.

Corporacion de Desarrollo del Potosi: Has a trout hatchery.

Universidad Mayor de San Andres: The Centro de Planificacion y Coordinacion de La Investigacion Cientifica y Tecnologica of this university is conducting studies on ecology, hydrobiology, geology and physics in conjunction with a technical assistance agency of the government of France.

### c) Human Resources and Extension Services

The Centro de Desarrollo Pesquero has three specialists in ecology and aquaculture. It is also receiving assistance from two Japanese experts, one a specialist in trout culture and the other an ichthyologist.

CONEPLAN an agency of the ministry of planning and coordination, has a specialist in fish culture and fish biology.

### d) Training Programs

The Centro de Desarrollo Pesquero has just finished the first nacional fishing development course for their staff.

The Complejo Pesquero Para el Altiplano gives regular courses on fish culture to the general public in the region.

Three of the nine universities in Bolivia are training biologists, the Universidad Mayor de San Andre of La Paz, Universidad Mayor Gabriel Rene Moreno in Santa Cruz, and the Universidad Mayor de San Simon.

These three universities together are training 100 students per year in the fields of biology.

e) Legal Aspects and Institutional Framework

Legislation:

There are no specific legal provisions on aquaculture, which are covered by Decree-Law 12301 of March 14, 1975, "Law on Wildlife, National Parks, Hunting and Fishing." The legislation on fishing resources is contained in the last 38 articles of that law. Of these, the following are directly applicable to aquaculture: Article 115, which prohibits the introduction and stocking of new species of fish and other aquatic animals without prior authorization from CDP, and also prohibits the stocking of foreign species in bodies of water without express authorization, as well as the exportation of fish and other living native aquatic animals; Article 121, which requires CDP approval of the plan of operations that must be submitted by the interested party for the utilization of private and state bodies of water, whether natural or artificial; Article 122, which provides for revision of operating concessions to the state when the scheduled work has not been initiated within one year or progress and purpose have not been demonstrated in the undertaking, at the discretion of CDP; and Article 131, which empowers CDP to authorize the operation of fish hatcheries and farms by private persons or institutions.

The legislation available is set forth in Decree-Law 03464 of August 2, 1953. The ownership and use of waters in Bolivia are governed by a decree of September 8, 1879, which was raised to the status of law on November 28, 1906. The provisions on control of the environment are set forth in the law on Wildlife, chapter XI. Mention should be made of Article 123, which declares the maintenance and reforestation of watersheds of rivers, lakes and ponds to be of public utility, prohibiting deforestation of the border vegetation; Article 124, also pertaining to trees or shrub

vegetation on river banks; Article 125, which refers specifically to the pollution of rivers and lakes waters and Article 127, which deals with alterations of the aquatic environment.

#### Aquaculture Administration:

In the public administration of Bolivia, aquaculture falls directly within the competence of the Ministry of Rural and Agricultural Affairs (MACA), through its new Centro de Desarrollo Pesquero (CDP) established in January of 1985.

Each of the nine departments into which the country is divided (Chuquisaca, La Paz, Cochabamba, Oruro, Potosi, Tarija, Santa Cruz, Pando and Beni) has a regional development corporation affiliated with the Direccion de Planificacion Regional of the Ministry of Planning. In the field of aquaculture, CORDEPAZ (Corporacion Regional de Desarrollo de la Paz) has been carrying out some activities, including the function of financing agencies.

#### f) Development Potential

There are regions in which water is abundant and its utilization minimal; in others, where requirements for consumption exceed availability, the needs are pressing. In general, however, it can be said that the country has sufficient bodies of water of different temperatures to support major commercial aquaculture projects.

#### (i) Suitable Species:

- Trout
- Tilapia
- Carp
- Pejerrey

#### g) Limitations to Development

There are no serious problems, in terms of natural elements, for fish culture, the country has vast regions with abundant waters and optimum conditions. The lack of personnel is one of the most critical limiting factors for the development of aquaculture. There are not enough scientists and technicians to assume responsibility for programs and carry out projects in aquaculture.

## BRAZIL

a) Commercial Aquaculture

Although no production data is available for Brazil, there are 367 commercial enterprises involved in aquaculture. These can be broken down by species as follows:

<u>Specie</u>	<u>No. of Commercial Operations</u>
<u>Cyprinus carpio</u>	132
<u>Oreochromis sp.</u>	48
<u>Penaeus sp.</u>	80
<u>Rana catesbeiana</u>	15
<u>Salmo gairdneri</u>	14
<u>Prochilodus sp.</u>	12
<u>Colossoma sp.</u>	9
<u>Micropterus salmoides</u>	7
<u>Odontheistis bonariensis</u>	7
<u>Xiphophorus sp.</u>	6
<u>Cicha ocellaris</u>	5
<u>Hoplias lacerdae</u>	5
<u>Brycon sp.</u>	4
<u>Mugil sp.</u>	4
<u>Tilapia rendalli</u>	3
<u>Astronotus ocellatus</u>	2
<u>Crassostrea brasiliiana</u>	2
<u>Lebiste reticulata</u>	2
<u>Leporinus sp.</u>	2
<u>Rhandia sp.</u>	2
<u>Astianax astianax</u>	1
<u>Centrodorus undecimalis</u>	1
<u>Artemia salinas</u>	1
<u>Macrobrachium rosenbergii</u>	1
<u>Triportheus angulatus</u>	1
<u>Perna perna</u>	1

Shrimp: Commercial shrimp farming in Brazil began in 1982 with the import of the species Penaeus japonicus. Currently shrimp farmers are replacing this species with Penaeus aztecus, P. schmitti and P. brasiliensis, all native species with a great potential for farming. A few farmers are also cultivating the species Penaeus vannamei and P. stylirostris.



Brazil has 7,700 kilometers of coastline with a large area suitable for the cultivation of shrimp. The state of Bahia, in northeast Brazil, is reported to have the largest potential area which according to state government sources comprises some 200 thousand hectares.

It has been estimated that shrimp farms in Brazil will produce 4,000 metric tons of shrimp annually by 1990.

b) Research and Development Centers

Northern Region:

Estacao de Piscicultura de Acre does research on Oreochromis niloticus and Cyprinus carpio.

Instituto Nacional de Pesquisas da Amazonia (INPA) does research on Colossoma macropomum, Brycon sp., Prochilodus brahma and Mylossoma sp.

Secretaria de Agricultura Terra Alta Estacao de Piscicultura de Terra Alta does research on Astronotus ocellatus, Oreochromis niloticus, Colossoma macropomum, Hoplosternum litorale, Prochilodus brahma and Cichla ocellaris.

Northeast region:

Universidade Federal de Alagoas (UFAL) does research on Mugil brasiliensis.

Laboratorio de Biologia Marinha (LABIOMAR) does research on Perna perna.

Comissao Executiva do Plano de Lavoura does research on Oreochromis niloticus.

Cacaueira (CEPLAC) does research on Prochilodus argenteus.

Estacao de Piscicultura de Ilheus does research on Colossoma bidens.

Maricultura de Bahia Ltda does research on P. vannamei and P. stylirostris.

Estacao Jacurici (DNOCS) does research on Plagioscion squamosissimus and Triportheus angulatus.

Estacao de Piscicultura de Jequie/PROBID does research on Oreochromis niloticus.

Universidade Federal do Ceara (UFC) does research on Oreochromis niloticus.

Centro de Ciencias Agrarias (CCA) Departamento de Engenharia de Pesca does research on Oreochromis niloticus, Oreochromis hornorum and Cyprinus carpio.

Estacao de Piscicultura Pedro de Azevedo (DNOCS) does research on Colossoma macropomum, Leporinus sp., Astronotus ocellatus, Oreochromis niloticus and Cyprinus carpio.

Estacao de Piscicultura Valdemar C. de Franca (DNOCS) does research on Prochilodus argenteus, Prochilodus cearensis, Colossoma bidens, Arapaima gigas, Triportheus angulatus, Tilapia rendalli, Oreochromis niloticus, Oreochromis hornorum, Leporinus sp. and Cichla ocellaris.

Centro de Investigações Ictiológicas Rodolpho Van Ihering does research on Cyprinus carpio, Oreochromis niloticus, Astronotus ocellatus, Colossoma macropomum, Prochilodus sp., Colossoma bidens, Hipopotthalmichthys molitrix, Cichla ocellaris, Clarias sp. and Leporinus sp.

Universidade Federal do Maranhão does research on Macrobrachium rosenbergii.

Universidade Estadual do Maranhão (UEMA) does research on O. niloticus x O. hornorum, Oreochromis niloticus and Cichla ocellaris.

Posto de Piscicultura de Gurjão (Prodecor/Prefeitura de Gurjão) does research on Oreochromis niloticus.

Posto de Piscicultura de Souza (Sudepe/Prodecor/Prefeitura de Souza) does research on Oreochromis niloticus.

Posto de Piscicultura de SUDEPE does research on Cyprinus carpio and Oreochromis niloticus.

Universidade Federal da Paraíba does research on Oreochromis niloticus.

Universidade Federal Rural de Pernambuco - Departamento de Pesca does research on Mugil brasiliensis.

IPA - Empresa Pernambucana de Pesquisa Agropecuária does research on Macrobrachium rosenbergii

Usina Salgado does research on Oreochromis niloticus, Oreochromis hornorum and Oreochromis mossambicus.

Universidade Federal de Pernambuco e does research on Mugil sp.

Estacao de Piscicultura de Ibimirim does research on Oreochromis niloticus, Cyprinus carpio and Astronotus ocellatus.

Estacao de Piscicultura de Petrolina does research on Oreochromis niloticus, Cyprinus carpio and Prochilodus argenteus.

Estacao de Piscicultura de Piripiri (DNOCS) does research on Oreochromis niloticus, Astronotus ocellatus and Prochilodus cearensis.

Secretaria da Agricultura do Estado do Rio Grande do Norte - Projecto Camarao does research on Penaeus japonicus.

Universidade Federal do Rio Grande do Norte - (U.F.R.N.) - Departamento de Oceanografia e Limnologia does research on Oreochromis niloticus.

Estevao Oliveira - Estacao do DNOCS does research on Prochilodus cearensis, Plagioscion squamosissimus, Colossoma bidens, Oreochromis niloticus, Oreochromis hornorum, Leporinus sp., Arapaima gigas, Triportheus angulatus, Colossoma macropomum, Tilapia rendalli and Cichla ocellaris.

Estacao de Piscicultura de Caico does research on Oreochromis niloticus, Arapaima gigas, and Prochilodus sp.

Estacao de Piscicultura de Pacatuba (SUDEPE) does research on Cyprinus carpio, Prochilodus argenteus and Oreochromis niloticus.

Estacao de Betume (CODEVASF) does research on Cyprinus carpio and Prochilodus argenteus.

Southeast Region:

Posto de Piscicultura de Colatina does research on Cyprinus carpio, Oreochromis niloticus and Oreochromis hornorum.

Centrais Electricas de Minas Gerais S/A CEMIG.

Projecto de Piscicultura de Tres Marias (CODEVASF) does research on Prochilodus argenteus, Salminus maxillosus, Brycon sp., Cyprinus carpio and Oreochromis niloticus.

Empresa de Pesquisa Agropecuaria de Minas Gerais (EPAMIG) does research on Cyprinus carpio, Oreochromis niloticus, Hoplias lacerdae and Rana catesbeiana.

Estacao de Piscicultura de Furnas does research on Colossoma mitrei, Salminus maxillosus, Cyprinus carpio, Oreochromis niloticus, Hoplias lacerdae and Prochilodus scroffa.

Estacao de Piscicultura de Volta Grande (CEMIG) does research on Salminus maxillosus, Colossoma mitrei, Astronotus ocellatus, Hoplias lacerdae, Arapaima gigas, Leporinus sp., Prochilodus scroffa, Colossoma macropomum, Oreochromis niloticus, Plagioscion squamosissimus and Astianax astianax.

Estacao de Piscicultura de Felixlandia (EPAMIG) does research on Oreochromis niloticus, Cyprinus carpio and Hoplias lacerdae.

Estacao de Piscicultura de Igarape (EPAMIG) does research on Cyprinus carpio, Oreochromis niloticus and Hoplias lacerdae.

Estacao de Piscicultura de Leopoldina (EPAMIG) does research on Cyprinus carpio, Oreochromis niloticus and Oreochromis hornorum.

Estacao de Piscicultura de Vicosia (EPAMIG) does research on Cyprinus carpio, Oreochromis niloticus, Astianax astianax, Oreochromis hornorum, Hoplias lacerdae and Micropterus salmoides.

Estacao de Piscicultura de Lavras (Escola Superior de Agricultura de Lavras- ESAL) does research on Oreochromis hornorum, Cyprinus carpio and Oreochromis niloticus.

Estacao de Piscicultura de Uberlandia (SUDEPE) does research on Cyprinus carpio and Oreochromis niloticus.

Estacao de Piscicultura da EAFB (EAFB/MEC/COAGRI) does research on Oreochromis niloticus, Oreochromis hornorum, Hoplias lacerdae, Cichla ocellaris and Astianax astianax.

Estacao de Piscicultura de Forestal (CEDAF/UFV) does research on Cyprinus carpio, Oreochromis niloticus and Rhandia sp.

Estacao de Piscicultura de Forestal (CEDAF/UFV) does research on Hoplias malabaricus and Astianax sp.

Posto de Piscicultura de Rio Pomba (EAFRP/MEC/COAGRI) does research on Oreochromis niloticus and Oreochromis hornorum.

Posto de Piscicultura de Machado (EAFM/MEC/COAGRI) does research on Oreochromis niloticus.

- Instituto de Pesquisas da Marinha - IPqM Projecto Cabo Frio does research on Mugil brasiliensis and Crassostrea brasiliana.

Universidade Federal Rural do Rio de Janeiro (UFRRJ) does research on Oreochromis niloticus, Oreochromis hornorum, Tilapia rendalli, Cyprinus carpio, Cichla ocellaris and Hoplias lacerdae.

Estacao de Piscicultura de Forestal (CEDAF/UFV) does research on Hoplias molabaricus and Astianax sp.

Posto de Piscicultura de Rio Pomba (EAFRP/MEC/COAGRI) does research on Oreochromis niloticus and Oreochromis hornorum.

Posto de Piscicultura de Machado (EAFM/MEC/COAGRI) does research on Oreochromis niloticus.

Empresa Pesqueira Agropecuaria do Estado do Rio de Janeiro (PESAGRO) does research on Macrobrachium rosenbergii.

Unidad de Mitilicultura do Instituto de Pesca does research on Perna perna.

Southern Region:

Companhia Paranaense de Eletricidade (COPEL) does research on Salmo gairdneri, Cyprinus carpio, Oreochromis niloticus and Micropterus salmoides.

Fundacao Instituto Agronomico do Parana (IAPAR) does research on Cyprinus carpio and Tilapia rendalli.

Estacao de Piscicultura de Toledo does research on Oreochromis niloticus, Cyprinus carpio, Prochilodus scroffa and Colossoma mitrei.

Universidade Federal de Santa Marie (UFSM) does research on Rhandia sp.

Posto de Piscicultura de Lagoa dos Quadros does research on Odonthestis bonariensis, Rhandia sp. and Cyprinus carpio.

Estacao de Piscicultura de Ernestina (CEEE) does research on Odonthestis bonariensis and Cyprinus carpio.

Universidade Federal Rural do Rio de Janeiro (UFRRJ) does research on Oreochromis niloticus, Oreochromis hornorum, Tilapia rendalli, Cyprinus carpio, Cichla ocellaris and Hoplias lacerdae.

Universidade Federal Rural do Rio de Janeiro (UFRRJ) does research on Astronotus ocellatus.

Colegio Agricola de Universidade Federal Fluminense (UFF) does research on Oreochromis niloticus and Cyprinus carpio.

Farol de Sao Tome does research on Tilapia rendalli.

Trajano de Moraes does research on Cyprinus carpio, Oreochromis niloticus and Micropterus salmoides.

Posto de Truticultura do Instituto de Pesca Horto Forestal de Campos do Jordao does research on Salmo gairdneri.

Instituto Oceanografico da Universidade de Sao Paulo (USP) does research on Penaeus paulensis and Penaeus brasiliensis.

Universidade Federal de São Carlos does research on Cyprinus carpio and Oreochromis niloticus.

Faculdade de Medicina Veterinária e Agronomia de Jaboticabal does research on Colossoma mitrei and Oreochromis niloticus.

(CESP) Estação de Piscicultura de Jupiá does research on Salminus maxillosus.

Posto de Truticultura da SUDEPE does research on Salmo gairdneri.

(CERLA) Centro Regional Latino-Americano does research on Colossoma macropomum, Colossoma mitrei and Ctenopharyngodon idella.

Unidade de Ranicultura do Instituto de Pesca does research on Rana catesbeiana.

Unidade de Piscicultura do Instituto de Pesca does research on Cyprinus carpio and Oreochromis niloticus.

Unidade de Ostreicultura do Instituto de Pesca does Research on Crassostrea brasiliensis and Crassostrea gigas.

Estação de Piscicultura de Viçosa does research on Rhandaia sp., Cyprinus carpio and Odontheistis bonariensis.

Estação de Piscicultura de Osório does research on Cyprinus carpio and Odontheistis bonariensis.

Centrais Elétricas do Sul do Brasil S/A (ELETROSUL) does research on Oreochromis niloticus and Cyprinus carpio.

Instituto de Pesquisa e Extensão da Pesca (IPEP).

Universidade Federal de Santa Catarina (UFSC)  
Departamento de Aquicultura does research on Mugil brasiliensis and Penaeus sp.

Pedras Blancas (Posto de Incubação) does research on Salmo gairdneri.

São Joaquim (Posto de Incubação) does research on Salmo gairdneri.

Estacao de Piscicultura (PROBID/Chapeco) does research on Cyprinus carpio.

Estacao Experimental de Cacador does research on (Cyprinus carpio).

Estacao Experimental de Aquicultura Centro de Ciencias Agrarias (UESC) does research on Mugil brasiliensis.

Estacao Experimental da Lagoa da Conceicao does research on Mugil brasiliensis, Tilapia rendalli and Oreochromis niloticus.

Fundacao Municipal 25 de Julio does research on Oreochromis niloticus, Cyprinus carpio, Crenicichla lacustris and Plecostomus commersonii.

Estacao de Piscicultura de Camboriu does research on Cyprinus carpio and Oreochromis niloticus.

(v) Central Region:

Posto de Piscicultura do Ipe (SUDEPE) Antonio Carlos Lassi Lopes does research on Cyprinus carpio.

Estacao Experimental de Piscicultura de Anapolis does research on Cyprinus carpio and Oreochromis niloticus.

Universidade Federal de Goias (U.F.G.) Escola de Agronomia e Veterinaria (EAV) does research on Cyprinus carpio and Oreochromis niloticus.

c) Human Resources and Extension Services

Little information is available in this regard, but in 1983, 327 professionals and 161 amateurs were working in aquaculture. Regular courses in aquaculture are given at Jabotacabal (Sao Paulo) and at the Rural University of Rio de Janeiro. At present there is no specialized extension service for aquaculture at the national level, but extension programs are carried out by each regions Agriculture Department and by the DNOCS's regional centers.



d) Legal Aspects and Institutional Framework

Legislation

The General Fisheries Law of Brazil (D2 221 of February 28, 1967) includes only three very general articles related to aquaculture. Two of these require the registration of fish farmers and those marketing their products. The other provides that the public authorities shall promote the establishment of aquaculture stations and furnish technical assistance to private fish farmers. The Water Code, Decree 24643 of July 10, 1934, includes specific provisions referring to aquaculture, although it deals with concessions for water use and provides for aqueduct easement. Land tenure and use are governed by Law 4504 of November 3, 1964 and Decree 59566 of November 14 1966, which regulates agrarian contracts. Law 5709 of October 7, 1971 specifically regulates the aquisition of rural property by foreign residents in the country and for foreign corporations authorized to operate in Brazil. Water pollution is covered by the Law on Fisheries and the Water Code, while the Forestry Code (Law 4771 of September 15, 1965) deals with the protection of watercourses, lakes, ponds and reservoirs.

Aquaculture Administration:

The institutional structure in the fisheries sector of Brazil is both heterogeneous and complex. The Federal Institutions directly or indirectly involved in this field are under five ministries: Agriculture, Education, Interior, Navy and Mines & Energy. The state agencies are in similar situations.

Federal Institutions:

Superintendencia de Desenvolvimento de Pesca (SUDEPE), is attached to the Ministry of Agriculture and established by Law 10 of October 11, 1962. Its structure is set forth in Decree 73632 of February 13, 1974 and in Ministry of Agriculture Order 105 of March 5, 1975. SUDEPE maintains several fish culture stations which do research mainly on carp, tilapia and some native species. These are:

- 1) Posto de Piscicultura da Sudepe (Jodo Pessoa).
- 2) Estacao de Piscicultura de Pacatuba.
- 3) Estacao de Piscicultura de Uverlandis.
- 4) Posto de Piscicultura do Ipe.

National Research Institute of Amazonas (INPA). It maintains agreements with SUDEPE and with the Max Planck Foundation for limnological studies in the region. Currently it is carrying out research on culturing native species.

Naval Research Institute conducts studies on aquaculture at its base at Cabo Frio, Rio de Janeiro. Mainly on Mugil brasiliensis and Crassostrea brasiliensis.

National Department of Drought Control Works (DNOC) under the Ministry of the Interior carries on extension work in aquaculture.

Superintendencia de Desenvolvimento de Amazonas (SUDAM) under the Ministry of the Interior. Its Department of Natural Resources provides incentives for activities in this field in the eastern part of Amazonas.

Superintendencia de Desenvolvimento do Nordeste (SUDENE) under the Ministry of the Interior. It has a Division of Fisheries which operates in aquaculture.

Centrais Electricas de Furnas under the Ministry of Mines and Energy has developed extensive aquaculture in its reservoirs and has sponsored research on the induced reproduction of dorado.

Companhia de Desenvolvimento do Valle do Sao Francisco (CODEUASF) under the Ministry of the Interior provides extension services for aquaculture in its area of activity.

Federal Universities - Activities in the field of aquaculture have been carried on mainly by Federal Universities of Pernambuco, Rio Grande do Norte, Rural University of Rio de Janeiro, Bahia, Rural University of Pernambuco and Alagoas.

#### State Institutions:

Innumerable state agencies have undertaken research and actual attempts at aquaculture at various times. The following are some of the principal state agencies involved in aquaculture: Executive Group for Development of the Fisheries Industry, Rio Grande do Sul; Secretariats of Agricultura of the states of Rio de Janeiro, Rio Grande do Sul, Mato Grosso and Goias. Instituto do Pesca do Estado de Sao Paulo; School of Veterinary Medicine of Joboticabal fish Culture Section; Centrais Electricas de Sao Paulo.

e) Development Potential

Mariculture:

Large areas of the coast are too exposed and are very sandy, which makes them unsuitable for mariculture. The coast from Amazonas to Paranaiba seem to offer possibilities for mariculture, but the lack of physical infrastructure hinders its development. The estuaries in the region of Maceio, Aracaju and Salvador, as well as the estuary of the Sao Francisco River and the coastal lagoons near Rio de Janeiro, Paranagua, Sao Fransisco do Sul, Porto Alegre and Rio Grande are promising for the development of aquaculture.

Continental Aquaculture:

Amazon region: (States of Acre, Amazonas, Para, Federal Territories of Amapa, Rio Blanco, Rondonia and parts of Maranhao, Goias and Mato Grosso). This region produces a large quantity of fish, from natural sources and consequently there is little need to promote aquaculture there. However, the region has great potential for fish culture, especially in ponds, except in large areas of Amazonas where the annual floods would make aquaculture difficult.

Northeast region: (States of Maranhao, Piaui, Ceara, Rio Grande do Norte, Paraibas, Pernambuco, Alagoas, Sergipe, Bahia and Minas Gerais). This region has little fresh water since all rivers except the Paranaiba and the Sao Fransisco are dry at certain times of the year. The coastal flats have great potential for the culture of shrimp.

South Central region: (States of Rio Grande de Sul, Santa Catalina, Parana, Sao Paulo, Rio de Janeiro, Espiritu Santo and parts of Minas Gerais, Goias and Matto Grosso). This region includes the large basins of the Paraguay, Paraiba, Parana and Uruguay rivers. It has the largest fish consuming markets, as well as the greatest potential for the development of fish breeding in commercial farms and ponds. Coastal areas also offer potential for the culture of shrimp and prawns.

Suitable Species:

Trout  
Mussel  
Prawns  
Carp  
Tilapia  
Oysters  
Ornamental Fish  
Mullet  
Shrimp  
Curimato  
Piau  
Native Species

f) Limitation to DevelopmentNatural and Environmental:

There are no major overall natural limitations to the development of aquaculture. What can cause problems is the pollution of waters in the south central region of the country, where extensive agricultural development requires the use of insecticides.

Personnel:

The progress of aquaculture in Brazil is limited, except in the northeast, by the shortage of trained personnel at various levels and the lack of extension services. While substantial progress has been made in research at some institutions, there is some duplication of efforts, which diminishes the efficiency of the limited number of technicians in the country.

## CHILE

a) Commercial AquacultureMariculture:

Oysters (Ostrea Chilensis): In 1986 production of cultured oysters was about 120 tons, down from 188 tons in the peak production year, 1980. This was due mainly to large natural production.

There are 16 oyster culture stations which employ the following methods of production: Longlines (an independent system used in coastal areas at relatively deep sites - 4 to 20 meters); fixed line (lines attached to fixed stakes, used in shallow places, preferably 0.5 to 1 m at low tide).

It is worth noting that 30 leases have been given by the government and only 16 are in use; most of them in the X Region.

Pacific oyster (Crassostrea gigas): This species was introduced in 1978 due to its rapid growth and high yield. In 1981 total production was 28 tons, all of it produced by Fundacion Chile's Station in Tongoy.

Mussel:

- 1.) Mytilus chilensis: In 1984 1,389 tons were produced in the IX, X and XI Regions of the country using rafts and long lines.

Currently there are 19 commercial ventures for mussel culture. They are facing two main problems, the collection of seed and markets.

- 2.) Choromytilus chorus: 136 tons were produced in 1984 by 9 growers, an increment of 53 tons from 1983.

Scallops (Chlamys purpurata): Only recently has there been any attempt to culture it in Chile. During 1984 a production of 57 tons was obtained using Japanese technology.

### Macroalgae:

Pelillo (Gracilaria sp.): The culture of Gracilaria began in 1976 with the transplant of algae from natural banks into pre-selected grounds in the northern part of Chile.

Production in 1984 reached 6,800 tons but is expected to increase sharply as new grounds are planted in northern and southern Chile, in the upcoming years.

### Freshwater Aquaculture:

Rainbow trout: Currently only 2 commercial trout farms exist, Aguas Claras in the central region and Lago Llanquique Ltda in the southern region. Their combined production reached only 253 tons in 1985.

Salmon: Beginning in 1968 the efforts to introduce Pacific salmon increased sharply. Currently 11 companies with 15 centers are cultivating: coho, pink and Atlantic salmon using pens. In 1986 their total production reached 1200 tons--a 17/fold increase since 1980.

The estimated production for this year will more than double last year, and is expected to reach 2500 tons. By the year 1990, production is estimated to reach 6,000 - 7,000 tons.

### b) Research and Development Centers

Fundacion Chile: With several stations along the Chilean coast, is conducting aquaculture research on:

1. Oysters
2. Salmon
3. Flat fish
4. Abalone
5. Scallops

Universidad del Norte: Department of Marine Research with Japanese technology and monies are conducting aquaculture research on:

1. Oysters
2. Abalones
3. Crayfish
4. Scallops
5. Several spp of Sea Weed.

Instituto Profesional de Osorno. Currently concentrates their research on Salmonid culture in the southern portion of Chile. de  
Ser. Nac. Pesca.

Several research centers owned by the Servicio Agrícola y Ganadero for the production of oyster seed and mussel culture.

Universidad Catolica de Valparaiso: With its fish culture station at Rio Blanco cultures and does research on rainbow trout.

Universidad Catolica de Chile: With its marine biology lab at Las Cruces does applied and basic research in the culture of sea urchin (Loxechinus albus), "Loco" (Concholepas concholepas), and sea weed (Porphyra columbina and Gelidium sp.)

Universidad de Concepcion, Dichato Marine Biology Station: Conducts research on mussels (Choromytilus chorus), and mytilus chilensis, oysters (Ostrea chilensis), and the algae Gracilaria sp.

Universidad Austral de Chile: Experimental culture center in Yaldad carries out research on the culture of the mussels Choromytilus chorus and Mytilus chilensis.

The Servicio Nacional de Pesca: Has several centers dedicated to the culture of mussels, oysters and salmon.

- 1) Pullingue oyster culture station.
- 2) Putemun mussel culture station.
- 3) Experimental fish culture station Dr. Shiraishi.
- 4) Experimental fish culture station Ensenada Baja.

Universidad de Antofagasta. Currently concentrates their research on sea weed and prawn culture.

#### c) Human Resources

Chile has a substantial number of technicians in aquaculture. In 1984, 126 students graduated in aquaculture engineering and another 500 students in fisheries related areas.

In the next 3 years this figure will increase sharply since in 1985 three more universities have begun to teach aquaculture related courses.

Nine Universities offer fisheries related degrees which produce more than enough graduates for the need of the country. Currently there is an excess of professions in the area, which can be slowly absorbed as the commercial ventures in aquaculture grows in Chile.

The following institutions are involved in government extension services in aquaculture:

Instituto de Fomento Pesquero (IFOP), specializing in the technology of mariculture, basic biology and extension.

Servicio Agrícola y Ganadero (SAG), specializing in the production of seed of various species.

Servicio Nacional de Pesca and Subsecretaria de Pesca; specializing in the general extension of aquaculture.

Instituto Nacional de Capacitacion Profesional (INACAP), specializing in practical instruction in applied technologies.

Corporacion de Fomento de La Produccion (CORFO).

d) Legal Aspects and Institutional Framework

The fisheries law of Chile which is DFL 34 of March 12, 1931 is not explicit in the matter of aquaculture. By decree 619 of October 10, 1967 regulations were issued for the establishment and functioning of facilities for breeding, culture and fattening of mollusks for commercial purposes and of hatcheries for the marketing of these species.

Authorization from the ministry of agriculture is required to carry on breeding, culture, reproduction or fattening of mollusks, and for the raising of shellfish for commercial purposes.

By decree 2442 of 1978 the Subsecretaria de Pesca was created and it has the function of development of rules and regulations for the extension of aquaculture products.

Supreme Decree 175 of 1980 defines aquaculture related terms, gives power to the Subsecretary of Pesca to approve permits for the establishment of aquaculture operations



given that the permit request contains all the necessary information required by law. This Decree also gives the Servicio Nacional de Pesca (SERNAP) the authority to control and regulate the aquaculture activity in Chile.

The Ministry of Defense by decree 340 of 1960 regulates the marine concession for any use.

The Ministerio de Salud by decree 60 of 1982 regulates the locations of aquaculture facilities in relation to the sanitary conditions.

The Ministerio de Relaciones Exteriores by decree 676 of 1978 reaches an agreement for technical cooperation between the government of Japan and Chile for the introduction of Pacific salmon and the culture of scallops.

e) Development Potential

Potential Areas:

Northern region: Has great potential for mariculture of oysters, scallops, fin fish, etc.

Central region: Has 1,300,000 m<sup>3</sup> of dammed water; little potential for commercial aquaculture and a large supply of maritime fish.

Southern region: Suitable for the culture of salmonids, mollusks and algae.

Austral region: Favorable for ocean ranching of Salmonids.

Suitable Species:

Trout (Salmo trutta)

Rainbow trout (Salmo gairdneri)

Salmon (Oncorhynchus kisutch, O. tshawytscha, and O. keta)

Oysters

Scallops

Seaweed

Crawfish

Mussels

f) Limitation to Development

Natural and Environmental:

The countries water and land resources present no major limitation to the development of the type of aquaculture suitable for the environment.

Personnel:

There is no shortage of professional and technical personnel for the development of aquaculture.

## COLOMBIA

a) Commercial Aquaculture:

Cold Waters: Trout (Salmo gairdneri) culture has had a great development in the Andean region of the country. Fingerlings production reached the 4 million mark in 1985. Currently there are 30 trout farms with a combined production of 1,500 tons.

Temperate Waters: Carp (Cyprinus carpio) is cultured at the family level and its production is destined for self consumption. No production estimates have been made. "Mojarra Plateada" (Oreochromis niloticus) are farmed in 10 hectare ponds with a total production of 50 tons/year. Great interest exists in increasing the production of the Mojarra in this region.

Warm Water: Most of the aquaculture in Colombia is being carried out here. The most common species used are Oreochromis niloticus and "Cachama" (Colossoma sp.) but no production figures are available. For 1987 it is hoped they could obtain 4,500,000 fingerlings of O. niloticus and 450,000 of Colossoma sp.

Macrobrachium rosenbergii: Shows excellent culture prospective but the lack of seed has curtailed any effort. It must be noted that Colombia has the culture technology available for this prawn.

Other species used for aquaculture are: "bocachico" Prochilodius reticulatus magdalenae; "Lisa, Lebrandre" Mugil sp., "Sabalo" Megalops atlanticus, "dorada" Brycon moorei cinuensis, "sabaleta" Brycon henni, "mojarra amarilla" Petenia Kraussi and "mojarra negra" Petenia umbrifera, but due to low yields obtained up to now, they are used experimentally and for repopulation of rivers, lakes, dams, etc. only.

Ornamental fish: This type of aquaculture has risen quite sharply in the last few years due to high yields and a growing export market. They are mostly located in departments of Valle del Cauca and Meta. The main species used belong to the following families: Anabidae, Cyprinidae, and Poeciliidae. Research is being conducted in the culture of Cichlidae, Caracidae, and Loricaridae as ornamental fishes.

Mariculture: The commercial farming is mainly geared towards the production of shrimp using the following species: Penaeus vannamei, P. stylirostris, P. brasiliensis and P. schmitti. A total of 457 ha., 257 in the Caribbean and 200 in the Pacific, are being used with a production of 1,000 lb. tails/ha and 2.3 crops a year. Extensive aquaculture is currently being used but it is rapidly progressing to semi-extensive and intensive aquaculture. Current production is estimated at 810 T.

There are no detailed studies on the amount of land available for shrimp culture, but preliminary studies suggest that at least 40,000 hectares on both coast are available.

The current demand for post-larvae shrimp is greater than 80,000,000 per year. Since natural seed is not readily available, the industry is studying the establishment of several hatcheries for the production of post-larvae to ensure good development of the shrimp industry in Colombia.

b) Research and Development Centers

Mariculture:

INDERENA has 2 centers devoted to mariculture research.

- 1) Centro de Investigaciones Pesqueras (Cartagena). Which carry out research relating to culture and diet development for the following species: Penaeus vannamei, P. brasiliensis, P. schmitti, Macrobrachium rosenbergii, and Mugil sp.
- 2) Centro de Investigaciones Pesqueras de Tumaco. Which carries out experimental culture, production, and capture of post-larvae of P. vannamei and P. stylirostris.

COLCIENCIAS which has a marine research center, Invemar, carries out the experimental culture of the mangrove oyster Crassostrea rhizophorae.

CORPOURABA. One of its research centers, Cimus, at Turbo does research on the culture of marine shrimp (farming, extension and capture of natural post-larvae) and the mangrove oyster, Crassostrea rhizophorae.

## Freshwater Aquaculture:

### Regional Corporations

- 1) CAR: (fish culture station of Tota and Neusa) conducts research and produces rainbow trout (Salmo gairdneri) fingerlings.
- 2) CVS (fish culture station of Larica). Conducts research on the culture of fish on the Sinu River and on the reproduction of "dorada" Brycon moorei simiensis and "bocachico" Prochilodus reticulatus.
- 3) C.R.Q.: Culture, extension and production of eggs and fingerlings of rainbow trout.

CORTOLIMA: Culture, production, extension, repopulation and dietary optimization for "mojarra plateada" Oreochromis niloticus.

### INDERENA

- 1) Fish culture station of Repelon (Atlantic) has research programs on the culture of the native species to the lower part of the Magdalena river, production of "mojarra plateada" Oreochromis niloticus, "bocachico" Prochilodus reticulatus magdalenae, "cachama" colossoma spp. fingerlings and the experimental culture of Macrobrachium rosenbergii for diet development.
- 2) Fish culture station of Gigante has research programs on the culture of native species to the upper part of Magdalena River, production of fingerling and extension programs for the culture of "mojarra plateada" Oreochromis niloticus, "carpa" Cyprinus carpio, "tucunare" Cichla ocellaris, and "mojarra negra" Petenia umbrifera.
- 3) Fish culture station of Timbio: Culture, extension and production of fingerlings of "mojarra plateada" Oreochromis niloticus, and "Carpa" Cyprinus carpio.

Caldas University (Experimental fish culture center):  
Experimental culture of "mojarra plateada"  
"bocachico", "mojarra hervibora" Tilapia rendalli, and  
rainbow trout.

Other institutions like the Federacion Nacional de Cafeteros, Instituto Tecnico Salesiano, Universidad de Cordoba, Secretaria de Agricultura Departamentales and CORPOURABA have research and extension services on fish culture.

c) Extension

The principal extension agency, at the national level is INDERENA through its projects of Integrated Rural Development (DRI) and the Development of River Systems PRIDECV.

Through these programs 1421 small farms have introduced aquaculture in their lands. Production estimates are hard to obtain since the production is almost exclusively for the farmers family. Nevertheless, DRI in the departments of Huila, for 1984, produced 217 tons of "mojarra plateada" Oreochromis niloticus and 20 tons of "cachama" Colossoma sp. at Meta.

On private farms the fisheries programs of INDERENA through its extension activities have restocked 317,379 fingerling of the following species: "lisa" Mugil spp, "mojarra plateada" Oreochromis niloticus, "bocachico" Prochilodus reticulatus, "mojarra amarilla" Petenia Kraussii, "mojarra negra" Petenia umbrifera, "carpa" Cyprinus carpio and "tucunare" Cichla ocellaris.

d) Training Programs

University of Bogota - Fundacion Jorge Tadeo Lozano. This university has a school of Marine Sciences and Food Technology which trains marine biologists and limnologists.

University of Caldas. The School of Veterinary Medicine has a fish culture section which participates actively both in the training of specialists and in experimental fish culture.

University of Cordoba. This university has an aquaculture department that is currently researching the species of the Sinu River and reproduction, extension and culture of "dorada" Brycon moorei sinuensis and the "bocachico" Prochilodus reticulatus Magdalena. It also gives several courses on aquaculture and zootecnia.

Servicio Nacional de Aprendizaje (SENA), in collaboration with the University of Caldas, has a program for the development of rural fish culture at the family level.

INVENAR. Has a post-graduate program in conjunction with the Universidad Nacional, at the masters level for marine biologists.

INDERENA. Through agreement, it gives specialized aquaculture courses to extension agents of other institutions.

e) Legal Aspects and Institutional Framework

Legislation:

The basic law on fisheries is Legislative Decree 0376 of December 13, 1957, complemented by the code of renewable natural resources and protection of the environment, Decree 2811/79. The reference to aquaculture is limited to definition of this activity. Pursuant to Articles 289 and 291 of the code, INDERENA has prohibited the breeding of tilapia to the Departments of Caldas,, Risaralda, Quindio and Valle. Part III of the code of Natural Resources regulates the utilization of waters, while Title II deals with concessions for their use. Basically, the provisions on environmental protection are contained in the code of Natural Resources and Protection of the Environment. It refers to the conservation and presentation of waters in Title VI, part III, and to protection of the marine environment in Part IV. Article 186 prohibits destruction of the natural vegetation of canal banks. Provisions on water pollution also are contained in Chapter VIII of the Sanitary code, Decree 1371 of 1958.

Law No. 135, the Social Agrarian Reform Law governing the use of land, was enacted in 1961. Its provisions were strengthened by Law 1 of 1968 and Law 4 of 1973. Part VII of the code of Natural Resources subjects the use of soil to a number of conditions aimed at conservation.

### Aquaculture Administration:

INDERENA: The Instituto de Desarrollo de los Recursos Naturales Renovables, under the Ministry of Agriculture, was established by Decree 2420 of September 26, 1960, which reorganized the Division of Natural Resources of the Ministry of Agriculture and the Corporacion Autonoma Regional de los Valles del Magdalena y del Sinu (CVM), agencies with similar functions. Its principal purpose is to administer the renewable natural resources of the country.

One of its functions is to expand fish culture. INDERENA's statutes were approved by Ministry of Agriculture Decree 842 of May 26, 1969.

The organizational structure of the Institute is set forth in order 40 of December 7, 1976. Of direct interest to aquaculture, there is a Subgerencia de Fomento de Pesca, Fauna Terrestre, comprising three divisions: Pesca y Acuicultura Continental, Pesca y Acuicultura Maritima, and Fauna Terrestre. Their functions are set forth in Resolution 0181 of January 20, 1977.

- SENA - Servicio Nacional de Aprendizaje: reorganized by Decree 3123 of December 26, 1968. SENA is attached to the Ministry of Labor and Social Security. In collaboration with the University of Caldas, it is carrying out work in fish culture at the family level. SENA has its own income and its statutes were approved by Decree 1847 of November 4, 1969.
- DRI - Integrated Rural Development Project: The DRI project is a coordinated program of 14 government agencies supervised by INDERENA and aimed at raising the standard of living of approximately 45,000 families of small-scale farmers located in five large areas of the country. In granting subloans for production, marketing and fish culture, DRI gives preference to cooperatives. The activities eligible for financing include acquisition of fingerlings, infrastructure and equipment, as well as some labor.



- Corporacion Autonoma Regional del Cauca (CVC): Was established by Decree 3110 of October 22, 1954 and reorganized by Decree 1707 of July 18, 1960; it is attached to the Ministry of National Planning. Its main purpose is to promote the conservation and development of lands making up the hydrographic basin of the Upper Cauca and the nearby Pacific slopes. The corporation maintains an Institute of Tropical Fish Culture in Buga.

Other autonomous regional corporations may operate in a manner similar to CVC. A Government Decree (NO. 127 of January 26, 1976) transferred the seven corporations formerly under the Ministry of Agriculture to the National Planning Ministry.

f) Development Potential

To meet the development needs of aquaculture the National Fisheries Plans - PLANIPES - was developed. It will try to solve the main problems by guiding, coordinating and promoting public and private investments, to obtain high social and economical returns.

The topography of Colombia, its rainfall system, its location between the Pacific Ocean and the Caribbean Sea, the systems of the Orinoco and the Amazon, together with the presence of the Andes Range which crosses the country from south to north, are advantageous condition for various types of aquaculture. The Cauca and Magdalena rivers waters the most fertile areas of the country and offer great potential for the development of aquaculture. The coastal zone on the Pacific and the Caribbean have ecological conditions for mariculture. The Savanna and Andean regions have favorable conditions for the culture of trout, carp, catfish, and pejerrey. The eastern plains region, particularly between the Meta and Vichada rivers, offers possibilities for fish culture.

- (i) Suitable Species: With the varied possibilities offered by Colombia, the following species may be mentioned

- Trout
- Tilapia
- Carp
- Catfish
- Bocachico
- Tucunare
- Mullet
- Mojarra Amarilla

- Ornamental Fish
- Macrobrachium
- Shrimp
- Crab (Callinectes toxotes)
- Piargua (Anadora Spp)
- Sabaleta
- Dorado
- Oysters
- Mussels

g) Limitations to Development

Colombia enjoys excellent conditions for all types of commercial aquaculture. The chief limiting factors may be the lack of trained technicians for propagation and management of shrimp and prawn seed; fish reproduction, nutrition, diet development, fish pathology and extension services.

## ECUADOR

a) Commercial Aquaculture

Shrimp Culture: Ecuador is the worlds major shrimp culturing country. A combination of biological, climatic, and topographical factors combine to make Ecuador one of the best locations in the world to grow shrimp. In 1985 the total production of Penaeus vannamei and P. stylirostris reached 27,000 tons. Precise data are not available, but Ecuador has an estimated 70,000 hectares of ponds, in the provinces of Guayas, El Oro, Manabi and Esmeralda, with as much as 7,000 hectares of unused pond capacity.

Approximately 60% of the total acreage is used in extensive production, whose yields average 160 pounds per acre per crop (1.3 crops per year) and accounts for approximately 30% of total production. Another 34% is used in semi-extensive production where yield averages 490 pounds per acre per crop (1.8 crop per year) and accounts for approximately 50% of total production. The remaining 6% is used in semi-intensive production where yields average 702 pounds per acre per crop (2.4 crops a year) and accounts for 26% of the total production.

Despite rising operating cost and variable prices in 1985, the most serious short-term problem facing Ecuatorian shrimp farms is the availability of post-larvae. The dependence on wild, seasonally available post-larvae resulted in major shortages problems and a resulting decline in total harvest and producing creage during 1985. It has been estimated that 30% to 40% of Ecuador's ponds were not restocked and/or were left dry due to the lack to post-larvae during the second half of 1985.

The post-larvae problem has stimulated the interest in building hatcheries. In 1983, there were only a few commercial hatcheries operating in Ecuador. In 1986, more than 50 hatcheries had received approval to operate, with an aggregate annual potential capability of generating 4.7 billion nauplii. With these new hatcheries some observers believe Ecuador will be producing over 60,000 tons of cultured shrimp by 1990.

Small Scale Aquaculture: Due to a FAO-IDB cooperation program that developed the National Fisheries Development project for Ecuador, the private industry has been able to produce 38 tons of rainbow trout (Salmo gairdneri) in the Sierra region last year. It is expected that production will increase sharply in the next couple of years as the government and private industry further develop the market and culture technics for this species. The government has produced 12 tons of rainbow trout to stock lakes, rivers and dams.

Other species produced by the government are: Brown trout (Salmo trutta) 15 tons; Black Bass (Micropterus salmoides), Carp (Cyprinus carpio) 30 tons; chame (Dormitatus latifrons) 0.1 tons.

On the other hand private industry has produced 48 tons of carp, 700 tons of chame and 1.4 tons of bocachico, all using intensive or semi-intensive culture technic.

b) Research and Development

Chirimachay: This is a government trout station located near Cuenca, with a production capacity of about 100,000 fingerlings per year, which are used to populate local waters and to encourage local farms to culture trout.

Chillogallo: This is a warm water station owned by the government and used for experimental work with Cyprinidae. It has limited facilities since there are only three ponds with a total area as 0.25 Ha. Moreover, the supply of water is inadequate (1 liter per second, at a very low temperature).

Proyecto Mojada: Estacion J.F. Intriago Arrata is a trout culture station dependent on the Direccion General de Pesca, it has incubation and fingerling rearing capabilities. It's production is used mainly for restocking rivers, lakes and dams.

Estacion Eugenia Febres Cordero: Located on the coast conducts research on the best culture systems for the following native tropical species: Dormitatus latifrons (chame); Centropomus unionensis (robalo); Cetopsigiton sp. (bagre), Brotola curier (corvina) and Mugil curema (lisa).

A number of other institutions both private and public have aquaculture centers. They are PREDESUR, CREA, MAG, CRM with Fundacion "Ciencia", and Consejo Provincial de Pichincha.

PREDESUR: With its centers at El Oro, Loja and Zamora has developed, with the help of the Peace Corps, its own fish culture program. It currently has 14 stations for the culture of carp and tilapia nilotica in the three provinces. Many of these projects have become operational due to the help received by U.S. AID.

CREA: Has centers at Azuay and Morona-Santiago that develops its own programs in the production of trout for stocking of lakes, ponds and rivers and for sale to private parties.

MAG: Has centers at Pastaza, Napo, Santo Domingo de los Colorados, Puerto/Quito and los Bancos, with ponds for the culture of carp and tilapia for commercial sale.

Consejo Provincial de PICHINCHA: Since 1981 has opened the fish culture center of Nanegal, for carp and tilapia, the fish culture center of Cayambe, for rainbow trout, and the fish culture center of Jerusalem for development of sport fishing.

#### c) Training Programs

Escuela Superior Politecnica del Litoral: As of 1986 has begun to offer a 4 year "Licenciado" degree in aquaculture.

Universidad Tecnica de Machala: This institution had its first graduating class of biologists in shrimp culture in 1986.

Facultad de Ciencias Naturales: This institution has 177 graduates in the area of biology/aquaculture with 15 new graduates each year. They conduct research on the following topics:

1. Physiology of the "chame"
2. Diet testing on the "vieja azul" (Acquidens rivulatus)
3. Mass culture of worms as fish food.
4. Laboratory culture of fresh water Chlorella sp.
5. Tetraselmis-chui culture
6. Larval development of Macrobrachium panamensis
7. Wild Artemia salinas as diets for larval stages of Penaeus stylirostris and Macrobrachium sp.

University of Guayaquil: This university offers courses leading to a degree in biology, with special reference to marine aspects.

Museo de Ciencias del Instituto de Ciencias Naturales: This museum conducts work on the system of native aquatic fauna, and has facilities for post graduate training.

Instituto Oceanografico de la Armada - Division de Biologia Marina: The division of marine biology of this institution carries on research in four areas: primary production, zooplankton, benthos, and experimental culture of algae as food for cultivated aquatic species.

d) Extension Programs

At present Ecuador has no extension programs in aquaculture.

e) Legal Aspects and Institutional Framework

Legislation:

The law on fishing and fisheries development (No 178 of February 12, 1974) and its regulations (Decree 759 of July 30, 1974) are the basis of the system. Other provisions deal with the establishment of shrimp hatcheries (Order 12771 of September 5, 1975, Ministry of Natural and Energy Resources)

Aquaculture Administration:

Ministry of INDUSTRIA, COMERCIO E INTEGRACION: The MICET has the Direccion General de Pesca under which is the department of fish culture. It is responsible for approving the development plans of the sector and establishing priorities for research and implementation

Ministry of Agriculture and Livestock (MAG) with its Rancho Donald where it cultures carp and tilapia for commercial sale.

Instituto Nacional de Pesca (INP): Originated under an agreement with FAO and UNDP, and was established as a permanent agency by Decree 582-A of December 8, 1960.

Escuela de Capacitacion Pesquera: Associated with INP, this school was established at Manta, Manabi Province.

Empresa Pesquera Nacional (EPNA): Established by Decree of January 2, 1973, and attached to MICET. Its statutes were approved by Decree 779 of July 2, 1973. It can organize or form companies for the development and marketing of fish and their by-products.

f) Development Potential

Potential Areas:

Cold Water: The Andean region of the country has abundant water and land resources for the establishment of commercial trout breeding.

Warm Water: The coastal plains of Ecuador have significant potential for the development of fish culture in ponds. In addition, a system of fish breeding can be established in combination with rice growing. The eastern plains of Ecuador are suitable for the establishment of aquaculture in the future, once the necessary infrastructure have been built.

Coastal Region: This is the most important region of the country since it can produce over 100,000 million pounds of shrimp if the problem of post-larvae is solved. This region can also support the introduction of Macrobrachium sp as a major commercial enterprise in its river system.

Suitable Species:

Ocean shrimp (Penaeus Vannamei and P. stylirostris)

River shrimp (Macrobrachium sp)

Trout

Chame (Dormitatus latifrons)

Ornamental fishes

Tilapia

Carp

g) Limitation to Development

Natural and Environmental:

There is no serious environmental limitation to trout culture in the Andean region of the country. On the other hand, the development of fish culture on the coastal region is limited by the use of land and water for agriculture, as well as possible pollution of the water by insecticides. On the coast, the expansion of shrimp culture is limited by the short term problem of seed availability.

Personnel:

The principal problem facing Ecuador's fish culture is the lack of qualified personnel at all levels. Crustacean aquaculture has received attention such that in the future there will not be a pressing need for trained personnel, but there is a lack of personnel in the short terms.



## PARAGUAY

### a) Commercial Aquaculture

The current development of aquaculture is unique in Latin America. There has been extensive construction of small and medium size privately owned ponds, operated virtually without technical assistance. Carp and tilapia are bred in ponds in most cases, for the consumption by the owner and his family. Some of the fish produced, mainly carp, also are sold to persons living near the ponds. This development has been concentrated in the central part of the country, east of Asuncion. The lack of technical assistance to fish farmers has resulted in low yields in the breeding of fish. In general, the ponds are poorly constructed and poorly managed. No attempt has been made to control the propagation of Tilapia, with the result that the ponds produce a large number of small fish that cannot be sold in the local market.

Both hydroelectric dams, ITAIPU and YACYRETA, have begun the creation of big experimental stations to stock the reservoirs.

### b) Research and Development Center

Instituto de Ciencias Basicas - National University of Asuncion: This institute has a small research unit with a few ponds; it does however, have adequate laboratory facilities.

Caaguazu: This is a small experimental farm financed by the United States organization Vecinos Mundiales. The station has a small number of ponds which carry out a limited program with tilapia and local species of catfish.

Instituto Agronomico de Cascupe: Has carried an experimental fish culture for which it built, a few years ago, two ponds and several basins for tilapia and carp.

Instituto de Bienestar RURAL (IBR), Department of Paraguari: Ten ponds were built and stocked with tilapia and carp brought from Brazil. The purpose of this program is to interest settlers in building their own family size ponds. Construction of 10 more ponds was done in 1976 at Pribebuy, Ita Moroti and Gonfra Gue, for the same purpose.

Servicio Agropecuario de las Fuerzas Armadas: Lagoons at Remonta, located at Companhia Costa Sosa Luque and consisting of two lagoons of 8,000 m<sup>2</sup> and 6,000 m<sup>2</sup> and four small ponds. These ponds were built in order to teach aquaculture to those in compulsory military service engaged in agricultural work. The ponds have been stocked with tilapia and carp.

c) Human Resources

There are very few personnel with training and experience in aquaculture. The Instituto de Ciencias Basicas of the National University of Asuncion is the only institution offering courses in biology. The Institute has a Department of Natural Sciences which confers the degree of Licenciado in natural sciences (biology), following a four-year course.

d) Legal Aspects and Institutional Framework

Legislation:

Paraguay has no legislation on fishing as such. There are only some regulatory provisions, especially resolutions of the ministry of agriculture, to regulate specific aspects of fishing in rivers and other bodies of water under state jurisdiction. Waters are the property of the landowner, who may use them without the need of any license. Decree Law 3729 of April 20, 1979 set forth regulations for the management of public waters. In accordance with the law, public waters are defined as those arising on private property and leaving the property where they arise. Any inhabitant of the country may request their use, provided that he does not cause injury to third parties and remains subject to state control. The same decree-law established a National Council on Public Waters. Matters pertaining to land use and tenure are governed basically by Law 859 of March 29, 1963, which established the "Agrarian Statute" aimed at the elimination of large estates and the establishment of agrarian settlements.

### Aquaculture Administration:

The Ministry of Agriculture is the agency directly concerned with aquaculture. The unit with specific responsibility for this activity is the Division de Caza, Pesca y Piscicultura of the Departamento de Control Agrícola y Forestal, which in turn is under the Direccion de Normas y Control Agropecuario y Forestal, one of the four directorates through which the ministry operates. The division has very limited physical and economical resources for the development of aquaculture. It has no center or stations for research. However the following agencies have expressed interest or have a structure and action program suitable for the incorporation of aquaculture in their areas of activity: Instituto de Bienestar Rural (IBR) an autonomous institution established by Law 852 of March 1963 as the agency responsible for implementing the development program of the agricultural sector financed with domestic resources. The Banco Nacional de Fomento (BNF) is the state's principal financial instrument in agriculture and industry. It was established by Decree-Law 281/61. Through its Agricultural Promotion Program the BNF has granted 48 loans to fish farmers for capital investment, equipment and working capital. These loans have been made for five to ten-year periods with mortgage guarantees, at the market rate of interest (12% p.a.) to farmers interested in aquaculture and undertaking to use the loan for commercial fish farming operators.

#### e) Development Potential

##### Potential Areas:

The southern region of the country, and particularly the region of the Parana and Paraguay rivers, offers potential for the development of warm water pond aquaculture.

##### Suitable Species:

Tilapia  
Carp  
Catfish  
Pejerrey

e) Limitations to Development

Natural and Environmental:

Water temperature: In fish culture ponds the water temperature can range from a minimum of 4 C to a maximum of 30 C. The low temperatures during the winter season limit the growth of carp and tilapia. It is possible to develop the breeding of catfish, but this will suffer from the same problem since fish growth is curtailed during the three winter months. On the other hand the low winter temperatures offer a slight advantage for the present system of tilapia culture, in which the tilapia spawn only twice a year, mitigating the problem of overpopulation of ponds.

Pollution: The use of insecticides in the cultivation of cotton--an important export product for the country--may pose a problem for the development of aquaculture in certain regions.

Personnel:

The shortage of professionals trained in aquaculture, and the lack of technical assistance from other organizations, are the main obstacles to the progress of aquaculture. None of the improvements made in the breeding of tilapia and carp in other countries have been introduced in Paraguay. In order to continue the improvement and expansion of aquaculture, and to implement programs permitting the introduction of new techniques and species there is a need for training at two levels: post graduate studies and extension services. These could easily be established within the Instituto de Ciencias Basicas of the National University of Asuncion. The programs of the existing agricultural schools could include the training of extension workers in aquaculture. The promotion of aquaculture and the organization of the required extension services could be done through the IBR. This Institute has close relations with the existing settlements and with the Ministry of Agriculture, which has technical assistance agencies in various parts of the country.

## URUGUAY

a) Commercial Aquaculture

At present there is no commercial aquaculture in operation.

b) Research and Development Centers

Laguna del Sauce fishculture station: This station is operated by the Instituto Nacional de Pesca (INAPE). Its main activity is the production of pejerrey fingerlings for repopulation. The station has capacity to produce one million eggs per year. It also conducts culture research on catfish and prawns.

Centro de Investigaciones Pesqueras y Piscicultura de Constitucion: This station is also operated by the INAPE but conducts research on the culture of catfish, prawn and other siluriformes in thermal springs.

Centro de Investigaciones Marinas in La Palma: In this region a number of experiments have been conducted on mussels (Mytilus edulis platensis).

Instituto de Investigaciones Pesqueras de La Facultad de Veterinaria: Research is currently being conducted on fish parasitology.

Facultad de Humanidades y Ciencias of the Republica University: This center conducts research on fish diseases.

c) Human Resources

There are very few professionals with training in aquaculture working in the country.

d) Training Programs

There are no training programs in aquaculture or courses leading to degrees in this field. The School of Veterinary Medicine of the Republica University is the center most concerned with fishing at present.

e) Legal Aspects and Institutional Framework

Legislation:

The Law on Fisheries (No. 13833 of December 29, 1969) and its regulations (Decree 711 of October 28, 1971) contain no specific provisions on commercial aquaculture. The Rural Code (Law of July 17, 1975 and Law 10024 of June 14, 1941) contains provisions on the construction of canals, ditches and aquaducts and on concessions for the establishment of fish hatcheries, which are granted by the municipalities. Authorization for this purpose is given in perpetuity. The Law on Fisheries contains provisions aimed at the prevention of water pollution.

Aquaculture Administration:

Instituto Nacional de Pesca (INAPE), an agency under the Ministry of Agriculture and Fisheries established by Law 14484 of December 18, 1975, is responsible for the Administration of Fisheries in Uruguay. The matters within its competence specifically include the promotion of aquaculture in all its forms.

f) Development Potential

Potential Areas:

There are about 23,000 hectares of coastal lagoons in which mariculture can be developed. The country has about 40,000 watering places for cattle with a total area of 40,000 hectares, many of which are suitable for fish culture while retaining the purpose for which they were built. Fishculture can be introduced in many regions of the interior, on river banks and possibly in hydroelectric reservoirs. In the Department of Cerro Largo, Treinta y Tres and Rocha there is a rice growing area of 35,000 hectares on which fish cultures can be developed.

Suitable Species:

Mussels  
Shrimp  
Pejerrey  
Mullet  
Sabalo  
Prawn

g) Limitations to Development

Natural and Environmental:

There are no major natural limitations to the development of aquaculture. The use of insecticide should be restricted in rice-growing areas where fishculture is introduced.

Personnel:

The major impediment to the development of aquaculture is the shortage of skilled personnel at all levels.

## VENEZUELA

### a) Commercial Aquaculture

Trout (Salmo gairdneri): There are four farms, Santo Domingo, Moconogue, Monterrey and Paraiso, that produce trout using intensive culture techniques. Several lakes have been stocked with fingerlings in the Orinoco zone. Total production of trout for 1985 reached 345 tons.

Mussels (Perna perna): The culture of these mussels have been developed in the Gulf of Cariaco using ropes suspended from rafts or fixed platforms. At present two private companies, Productora de Mejillon Marino and Cultivos Marinos C.A. and a small cooperative, Sociedad de Cultivadores de Mejillon del Golfo de Cariaco are culturing these mussels. Total production or 1985 reached 458 tons.

Cachamas (Colossoma sp.): Two intensive culture facilities grow cachama, Aquafin and Pablo Rodrigues which produced 100 tons in 1985.

### b) Research and Development Centers

The Direccion General Sectorial de Pesca, Acuicultura has several stations in the country which carry our research on the following species: Penaeus sp., Colossoma macropomum, Perna perna and Salmo gairdneri.

Centro de Investigaciones Cientificas: Located on the island if Margarita, this center, part of Universidad de Oriente, conducts research programs on marine aquaculture with the following species:

- 1) Mullet (Mugil curema and M. liza).
- 2) Shrimp (Penaeus brasiliensis)
- 3) Mojarra (Diaptermus plumieris).
- 4) Oysters (Crassostrea rizophorae, Melongens melongena, Chricoreus brevifrons).
- 5) Mussel (Perna perna).

University of Zulia, Maracaibo: This station conducts research on fresh and salt water shrimp.

Estacion de Investigaciones Marinas de Margarita (EDIMAR), Instituto Universitario de Tecnologia del Mar (IUTEMAR): These centers, which are operated by the



Fundacion La Salle de Ciencias Naturales, conduct research on: Mussels (Perna perna), oysters (Crassostrea rizohporae), shrimp (Penaeus japonicus, P. schmittii, P. brasiliensis), freshwater prawns (Macrobrachium rosenbergii, M. caveinus, M. acanthurus), brine shrimp (Artemia sp.), cachama (Colossoma sp.), anchoveta (Anchoviella manamensis).

Centro de Estudios Oceanologicos: This station located at Puerto Cabello, is operated by Universidad Simon Bolivar. Its work in the fields of aquaculture is concerned with the development of techniques for the culture of Pecten yic yac and P. lincolaris, as well as oysters (C. rizophorae).

Universidad Central de Venezuela is currently carrying out research on the field of fish diseases.

Universidad Centro Occidental Lisano al Varado (UCOLA): This university is carrying out research on the reproduction of the cachama.

Several other institutions are conducting aquaculture research. Universidad Simon Bolivar, Universidad Simon Rodrigues, Universidad del Tachira, Fundacion Cientifica Los Roques, Instituto Agrario Nacional, and Corporacion Venezolana de Guayana but no research topics were available.

#### c) Projects Under Study

The Direccion de Investigaciones Pesqueras dependent of the Fondo Nacional de Investigaciones Agropecuarias has a 2.6 million dollar loan from the Inter-American Development Bank to carry out research and transfer technology in the culture of shrimp (Penaeus sp.), cachama (Colossoma macropomum) and the mussel (Perna perna).

The Facultad de Veterinarian of the Universidad Central de Venezuela has begun talks with CERLA in order to create a regional fish pathology center.

Eight companies have registered with the Division de Acuicultura of the Ministerio de Agricultura y Cria to conduct shrimp culture in the country. It is estimated that for 1990 shrimp culture should reach 7,500 tons in 2,900 ha of culture.

#### d) Human Resources

The number of professionals working on aquaculture related activities reached 85 persons by the end of 1986. This figure includes the private and public staff.

e) Training Programs

Primary and middle level: The Fundacion La Salle gives a course in aquaculture at the Instituto Universitario de Tecnologia del Mar (IUTEMAR), where 20 students per year can obtain the bachelors degree. Up to 1986 60 students have graduated from this center.

The Liceo Nautico Pesquero, also part of the above Fundacion, gives a degree in marine zootecnia with a capacity of 20 students per year. Up to 1986 200 students had graduated.

Licenciado in Biology: Central, Zulia, Oriente and Los Andes University offer courses leading to the degree of "Licenciado" in biology.

Post graduate education: At present post graduate studies can be pursued at the Universidad de Oriente, which has a course leading to the master's degree in marine biology, with courses in mariculture and fish culture, and the Universidad Central which has a course leading to the masters degree in fish pathology and aquaculture.

f) Extension Programs

At present there is no extension service.

g) Legal Aspects and Institutional Framework

Legislation:

The Law on Fisheries of June 27, 1949 contains no specific provisions concerning aquaculture. With regard to mariculture, Resolution 337 of July 3, 1974 regulates mussel culture using rafts. There is also a special resolution on the capture of wild ornamental fish (Resolution 346 of July 3, 1979). Pursuant to Article 20 of the Law of Fisheries and the Law on Protection of Wild Fauna (of September 11, 1970), the Ministry of Agriculture has issued two resolutions prohibiting the importation, introduction and culture of tilapia and carp, except for scientific research (Resolution 338 of July 3, 1974).

By Decree 1567 of May 11, 1976 the President created the National Aquaculture Plan, which established priorities for the development of aquaculture for Venezuela.

The Ministry of Agricultura y Cria in November of 1984 dictated a Decree of Law (MAC-OPSA 153, of May 4, 1984) that regulates the introduction of live samples of shrimp of the Genus Penaeus for culture and scientific research.

By Decree 59, of March 2, 1984 the President of Venezuela dictates that at least 17% of the commercial banks loans are to be made to the agriculture sector which includes aquaculture.

There is no water code in Venezuela, the legal status of waters is basically quite similar to that of land. Private waters are those lying completely within the same properties. All others belong to the nation, the states or the municipalities. However, concessions may be granted on this type of water for industrial use, including aquaculture.

The Law on the Environment is a very general law aimed at the establishment of administrative agencies for protection of aquaculture against pollution of the water or the air.

#### Aquaculture Administration:

Since May of 1985, the old Direccion General Sectorial de Desarrollo Pesquero (DGSDP) of the Ministry of Agriculture and "Cria" (MAC) changed its name to Direccion General Sectorial de Pesca y Acuicultura (DGSPA). At the same time the Division de Acuicultura is created under this new DGSPA. This Division de Acuicultura has as its main objectives the preparation of National Aquaculture Politics and Plans.

With regard to water, the state agency which plans, executes (in collaboration with the Ministry of Public Works) and administers closed bodies of waters in Venezuela, regardless of their purpose is the Instituto Nacional de Obras Sanitarias (INOS). This agency works with MAC in programs for fish repopulation.

The Ministry of the Environment and Renewable Natural Resources is responsible for all matters pertaining to the quality of life, environment and renewable natural resources. In addition, the Law on the Environment of June 16, 1976 established the Consejo Nacional del Ambiente, comprising representatives of all ministries and autonomous, public and private agencies concerned with the problems of environmental protection and improvement.

## h) Development Potential

### Potential Areas:

Cold waters: The Andean region of Venezuela has abundant land and water resources suitable for the development of fish culture, both in ponds and at the industrial level, throughout the Orinoco basin.

Coastal waters: Venezuela has extensive coastal water suitable for aquaculture. Special mention may be made of Lake Maracaibo, the Gulf of Cariaco, the Gulf of Paria and the Orinoco delta.

### Suitable Species:

Mussels  
Oysters  
Trout  
Pejerrey  
Prawn  
Shrimp

Native fresh water species especially cachama (*Colossoma* sp.), *Prochilodus* sp. and mojarra *P. kraussi*.

Ornamental fish: Venezuela has a great variety and number of fish of this type, and is among the world's leading exporters.

*Artemia* salina eggs.

## i) Limitation to Development

### Natural and Environmental:

The principal limitation to the immediate development of fresh water aquaculture is the governments ban on the use of carp and tilapia for this purpose. As a result fish culture based on the production of commercial native species depends on the development of an adequate technique for their breeding. There are no limitations due to the scarcity of land and water for different types of aquaculture. One possible limitation to culturing mussel and shrimp may be the insufficient availability of natural seed.

Personnel:

In the immediate future the progress of aquaculture will be limited by the shortage of trained personnel, both at the professional level and middle-level technicians. The now on-going programs at the mentioned universities should in the future solve part of these needs.

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