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DEVELOPMENT PROGRAMS FOR INLAND AND COASTAL FISHERIES FOR LATIN-AMERICAN COUNTRIES

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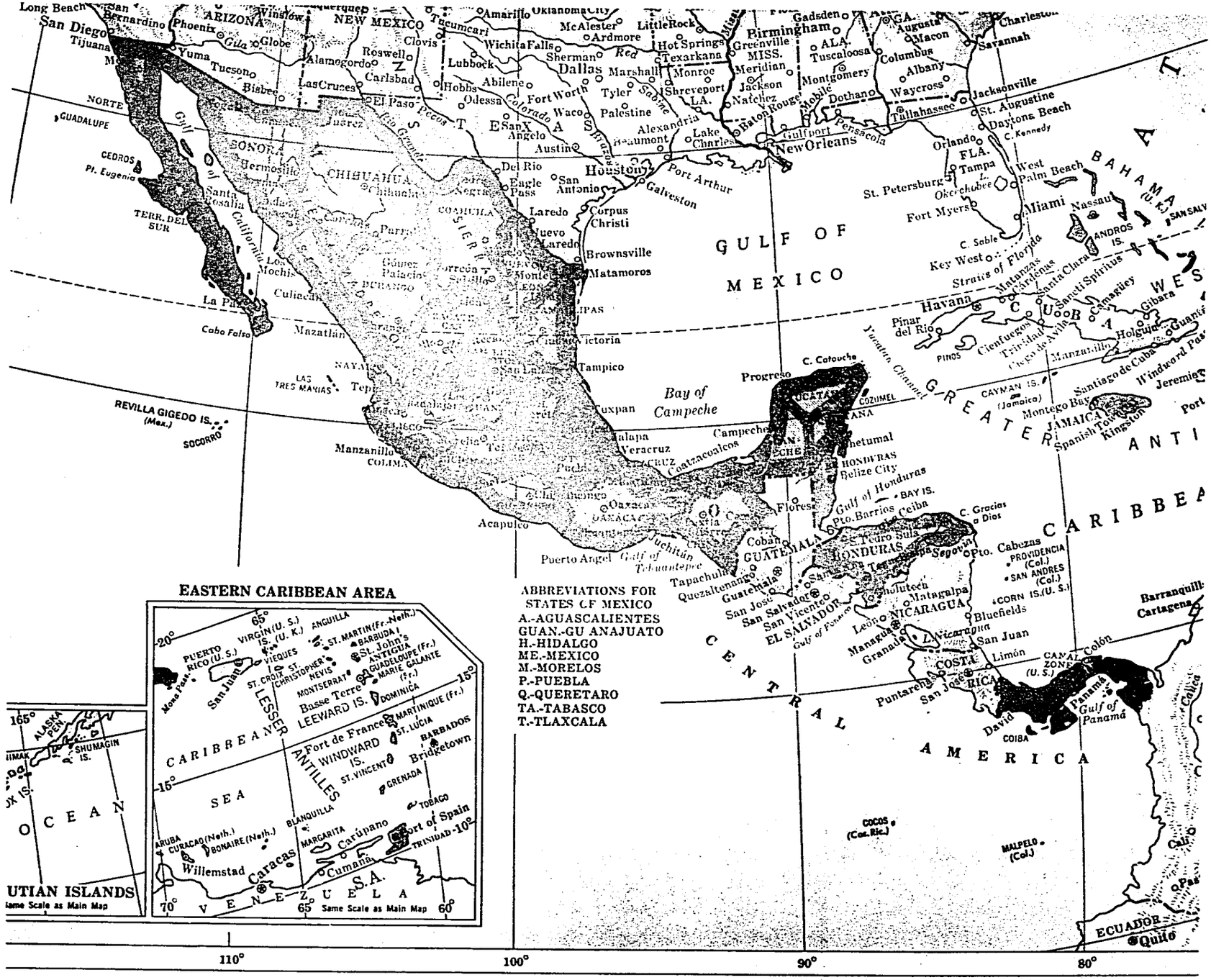
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GUAN.-GU ANAJUATO
H.-HIDALGO
ME.-MEXICO
M.-MORELOS
P.-PUEBLA
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T.-TLAXCALA
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DEVELOPMENT PROGRAMS FOR INLAND AND COASTAL FISHERIES FOR LATIN-AMERICAN COUNTRIES

INTRODUCTION

The total world catch of fish in 1971 was given by FAO as 69,400,000 metric tons, an increase of 59.2 percent over the catch in 1961 (Table 1). During this same period, the catch of fish by Latin-American countries rose from 6,748,000 to 13,539,000 metric tons, a 100 percent increase. Of this catch, however, over 78 percent was caught by Peru, and 8.1 percent by Chile, which were principally anchovy that went to production of fish oil and fish meal for sale abroad. If the catch of these two countries is excluded, the remaining countries increased their catch, principally of fishes used for food, from 868,200 to 1,748,400 metric tons, also a 100 percent increase. Insufficient records were available in most countries to enable estimation of the catch of freshwater fish. Worldwide, 12.8 percent was estimated to be from freshwaters. In Colombia, freshwater fish made up 17.9 percent of the total; in Surinam, 15.6 percent; in Venezuela, 9.7 percent and in land-locked Paraguay, 100 percent.

The percent of required animal protein supplied by fish in average diets of various countries was estimated by FAO as follows:

COUNTRY	PERCENT OF ANIMAL PROTEIN
Surinam	41.7
Peru	19.4

Table 1: World Catch of Fish - 1961 and 1971

Country	Catch, 1000 M.T. for 1961	1971	Percent Increase 10 years	Fresh-water Fish 1000 M.T.	% of catch	Total fish kg/person
World	43,600	69,400	59.2	8,850	12.8	
Argentina	101.9	229.0	124.7	2.2	1.0	9.8
Bolivia	0.5	1.2	140.			0.2
Brazil	281.9	515.4	82.8	36.5	7.1	5.5
British Honduras	0.9	1.4	55.6			11.7
Chile	429.8	1,179.2[2]	174.4			133.5
Colombia	43.0	76.0	76.7	13.6	17.9	3.5
Costa Rica	3.2	8.4	162.5			4.7
Cuba	30.6	126.2	312.4			14.8
Dominican Republic	1.6	4.3	168.8			1.1
Ecuador	38.6	91.5	137.0			14.5
El Salvador	8.0	16.2	102.5			4.6
French Guiana	0.6	0.9	50.0			17.6
Guatemala	1.3	5.0	284.6			1.5
Guyana	7.4	15.5	109.5			21.7
Haiti	-	2.5	-			0.6
Honduras	0.6	3.8	533.3			1.5
Jamaica	11.5	18.0	56.5			9.6
Mexico	225.4	402.5	78.6	1.6	2.0	8.3
Nicaragua	-	9.4	-			4.7
Panama	11.4	62.4	447.4			43.7
Paraguay	-	1.0	-	1.0	100.0	0.4
Peru	5,450.2	10,611.4[1]	94.7	80.0	0.8	757.4[3]
Uruguay	10.5	14.4	37.1			4.9
Venezuela	84.9	138.9	63.6	12.6	9.7	13.4
Surinam	4.7	4.5	-	0.7	15.6	11.0
Total	6,748.5	13,539.0	100.6			Average 49.55[4]

FAO Yearbook of Fisheries Statistics, Vol. 32, 1971, Pages 4-10.

1. Peru = 78.4 % of catch
2. Chile = 8.7 % of catch
3. Peru = only 1.8 % used for food in country
4. Average excluding Peru and Chile = 7.36

COUNTRY	PERCENT OF ANIMAL PROTEIN
Venezuela	16.7
British Honduras	16.4
Ecuador	12.9
Chile	12.5
Brazil	10.6
Colombia	5.9
Argentina	2.1
Uruguay	1.3
Bolivia	0.9
Paraguay	0.4

Total areas, populations, and people/square mile in the 1971 census for various Latin-American countries are given in Table 2. Principal areas of high population density are in the Carribean and in Central America. However, the rate of population increase in Latin-America is among the highest in the world, with populations expected to double within 20 to 30 years. Present areas of diet deficiencies are indicated to be in Central America, the Caribbean countries and the northern and western coast of South America, with deficiencies also in Northeast Brazil.

The role of fisheries in Latin-America can be expected to increase, with additional expansion of the catch of shrimps, lobsters, and pelagic fisheries offshore. The anchovy fishery is considered to have been overfished, and sustained yield is estimated to drop to as low as 50 percent below the high catches

Table 2: Latin American Countries, Areas, Populations

Country	Area-Acres	Populations	Density/mi^2
Argentina	686,180,480	23,362,204	21.8
Bolivia	271,463,680	5,060,000	11.9
Brazil	2,103,340,800	93,215,301	28.4
British Honduras	5,674,880	119,645	13.5
Chile	187,043,840	8,834,820	30.2
Colombia	281,430,400	21,770,000	49.5
Costa Rica	12,528,000	1,790,000	91.4
Cuba	28,299,520	8,553,395	193.4
Dominican Republic	12,042,240	4,006,405	212.9
Ecuador	70,069,120	6,300,000	57.5
El Salvador	5,286,400	3,541,000	428.7
French Guiana	22,486,400	51,000	1.5
Guatemala	26,906,880	5,350,000	127.3
Guyana	53,120,000	714,000	8.6
Haiti	6,856,960	4,202,755	392.5
Honduras	27,697,280	2,580,000	59.6
Jamaica	2,708,480	1,865,400	440.8
Mexico	487,424,000	48,381,547	63.5
Nicaragua	32,123,520	1,984,000	39.5
Panama	18,693,120	1,428,082	48.9
Paraguay	100,510,080	2,386,000	15.2
Peru	317,582,080	14,010,000	28.2
Surinam	40,343,680	410,000	6.5
Uruguay	46,190,080	2,920,000	40.5
Venezuela	225,371,520	10,399,000	29.5
Total	5,071,373,440 (7,924,021 sq. mi.)	273,234,544	34.5

of preceding years. Many marine fisheries are considered to have already reached maximum sustained yield and the possible increase in total worldwide catches is estimated by the Russians and FAO to level off at about 100,000,000 metric tons, or an increase of 45 percent above the present catch.

This projected limit to the catch from the oceans by conventional fishing adds to the desirability of each nation developing to best advantage its capability to produce fishery products from inland, estuarine and coastal waters through better management of natural waters, and by the development of highly productive aquacultures. The plans which follow are for the purpose of achieving these objectives.

1. A. Organization of consortium of specialists from U.S. universities and governmental research laboratories specializing in aquacultures and management of fisheries of inland and coastal waters.

To facilitate research and training of personnel in the cooperating Latin-American countries, the Auburn University International Center for Aquacultures will develop a Consortium of specialists from federal and/or state Research Stations and from Universities specializing in research and teaching of the various fields and skills required for research-extension-development and management of aquatic natural resources in inland and coastal waters. This will include such subjects as

Aquacultures in cold and warm waters, brackish and sea waters for:

Fishes	Oysters	Crabs	Clams
Shrimps	Mussels	Lobsters	

Limnology

Pollution and water chemistry

Statistical planning of surveys and research, and data processing and interpretation

Planning of research stations, experimental ponds and research laboratories

Fish nutrition and feeding

Fish parasites and diseases and their control

Fishing gear

Socioeconomic surveys

Processing and marketing

Organizational planning

Training of administrators, technicians, and research and extension specialists

These services would be coordinated and made available through the International Center for Aquacultures under contract with individual Latin American Countries for the types of services they would consider most valuable to them.

B. Formation of a Consortium of Latin-American governmental agencies who have responsibility for development and management of aquatic resources in inland, estuarine and coastal waters and in-country Universities providing training and research in these fields.

It is considered desirable that participating Latin-American country agencies and Universities organize themselves into a Consortium for

mutual help and to facilitate rapid transmission of new developments among the cooperating countries.

C. Annual or biennial workshop

It is proposed that the International Center for Aquacultures take the responsibility of initiating, with the help of an organizing Committee, an annual or biennial workshop of not over 4 days duration to be attended by members of both Consortiums to review results of research, developments in management, and the effectiveness of extension programs in the Americas, and to make plans for succeeding years. Specialists from other countries would be invited to present recent important advances to keep members of the Consortiums familiar with world-wide developments. The place of meeting would be selected by a committee from among the countries officially volunteering to act as host.

2. Training

Training is an essential part of fisheries development in any country. Management and utilization of fishery resources in natural waters and development of aquaculture as an industry requires trained administrators, professionals and technicians. It is recommended that training be given high priority in designing a program for fisheries development in Latin America.

Following is a list of the types of training required:

A. Short term training for professionals in the U.S.A. or third countries. Latin-American Nationals would spend 6 to 9 months taking

formal courses visiting research stations, extension centers and fish management projects and fish farms. They would return to their respective stations to implement fisheries and aquaculture projects.

B. On-the-job training, in-country, by U.S.A. or third country professionals

Once nationals with short term training return to their countries, U.S.A. or third country professionals should be sent to the country for one or two years to provide counterpart on-the-job training.

C. Degree training for professionals

U.S.A. or third country professionals in the country to provide counterpart on-the-job training would help identify promising young professionals to receive degree training in the U.S.A. or third countries. Graduate degree training should be stressed when possible; however, in the beginning stages of the program it may be necessary to send some students for undergraduate degrees.

D. On-the-job training of technicians

Good technical people are indispensable in developing a fisheries and aquaculture program in a country. Although they will receive some training on the job, an effort should be made to provide them with special schools and short courses.

E. Development of University programs in country

As soon as practical, degree granting programs should be established at one or more of the best Universities in-country. Progress in fisheries development on a national scale will require an adequate supply of well trained

young professionals. When countries are unable to provide an adequate degree-granting program, it may be necessary to establish regional programs. Regional schools of fisheries and aquacultures in Latin America could be successful because of the common language and customs of many of the people.

F. Training for administrators

Administrators of the fisheries and aquaculture programs should visit with their counterparts in other countries of Latin America and in the U.S.A. to become familiar with new developments and to upgrade their efficiency as administrators.

G. Continuing education

Development of fisheries and aquaculture programs capable of adapting to changing national needs requires that some consideration be given to continuing education for administrators, teachers, professionals and technicians. Continuing education should be one of the functions of the local Universities; however, exchange teachers, short term visits by U.S.A. and third country professionals, and short term tours to the U.S.A. and third countries would also contribute.

3. Research Facilities

From a preliminary survey, the research facilities needed in each cooperating country to develop methods for management of the aquatic resources in inland and coastal waters and for the development of aquacultures can be determined. Assistance in this planning is available from the Auburn University International Center for Aquacultures, assisted by other members of the U.S.

Consortium. Included in these plans would be the central and regional research laboratories and their equipment; need for experimental pond stations and associated facilities.

A. Research laboratories

These include laboratories for:

1. Water chemistry and pollution control
2. Parasite and disease control
3. Fish nutrition and feeds
4. Data processing for fishery statistics and research data

Most of these laboratories would be centrally located, but some may be necessary in local areas working on specific problems--for example on cold waters, warm waters or coastal fisheries.

Training in the use of advanced equipment for chemical analysis can be made available at research stations in the U.S. Consortium.

B. Need for experimental pond stations

The purpose of such stations is manyfold. They must be available to develop system of aquaculture; to test efficiency and feeding habits of various species that will be used in cultures or for stocking into new reservoirs or lakes; to develop methods for spawning promising species; and for testing of management methods on a preliminary basis.

They are also needed as a place where the new extension worker may :n how to raise a crop of fish or shrimp, before being assigned to the task

of teaching farmers how to do it. In addition, short courses for those interested in becoming fish farmers can best be held there where the fish and methods of culture can be seen.

Such stations must be carefully located with respect to the purpose they are to serve, but this is not all the requirements. Too many fisheries divisions in various parts of the world have already constructed stations on soils that will not hold water, where inadequate water was available to operate the pond systems, or where adequate space was not available to construct the number of ponds necessary for research. Assistance and advice is available from the Auburn University International Center for Aquacultures on planning such stations including the number and sizes of ponds, area needed for the station, water supply needed and on-site tests of the water-retention capacity and suitability of the soils for a research station. Soil profiles must be determined to a minimum depth of 4 meters to evaluate rates of seepage. The size and equipment for laboratories, facilities for storage and pelleting of feeds, and that for draining, sorting, processing, and freezing fish should be provided. For larger countries, one or more stations will be needed. For smaller countries, a centrally-located research station might be shared by a consortium of countries.

4. Hatchery Facilities

While research stations can serve rather widely in one or more countries, hatcheries must be constructed to serve local areas by providing the fish, shrimp,

or other animals needed for stocking into public waters and in private waters for aquacultures. The distance that one hatchery can serve depends upon the transportation facilities available. If the fish are to be transported by truck over good roads, a hatchery may serve areas within a 200-mile radius. If people must walk from the hatchery carrying fish to their ponds, then the area it can serve is greatly reduced.

One additional service which hatcheries and extension specialists can provide is to teach interested farmers how to spawn the fish or shrimp for sale to their neighbors, so that the necessity for governmental hatcheries can be reduced as much as possible, and the fish may be locally available.

Location of hatcheries, adequacy of water supplies, water-retention and suitability of land for pond construction should be planned with the help of experts. A good hatchery is an example and guide to farmers wishing to raise fish, whereas a poorly-constructed hatchery on lands that will not hold water is a monument to ineptitude on the part of the agency responsible.

5. Surveys

In some Latin-American Countries the nature and extent of the fresh, coastal and estuarine water resources suitable for fish production is not well documented; therefore surveys of inland waters (lakes, streams and reservoirs) and coastal and estuarine habitats for assessing the magnitude of aquatic resources and estimating potential yield from existing fish stocks are required.

Preliminary surveys have been completed by the International Center for Aquaculture, Auburn University in cooperation with the following countries.

Brazil (Northeast), Aug. 1972 Sept. 1972	Haiti, May, 1972
Colombia, Sept. 1970	Nicaragua, March 1972
Costa Rica, May 1970	Panama, Sept. 1970
Ecuador, Dec. 1969, May 1971 Dec. 1971	Paraguay, Sept. 1970
El Salvador, April 1971	Peru, Sept. 1970, Aug. 1971, April 1972
Guyana, June 1969	

These surveys should be expanded to supply specific information for the planning of management, research and utilization of the aquatic living resources.

Experienced staff from the International Center for Aquaculture is available to conduct surveys and make recommendations upon request of the host country and U.S.A.I.D. Mission. The following countries have not been surveyed by Auburn University staff members and little information is readily available on the extent and state of their freshwater and estuarine fisheries.

Argentina	Honduras
Bolivia	Jamaica
Brazil (Central & Southern)	Mexico
British Honduras	Surinam
Chile	Uraguay
Dominican Republic	Venezuela
French Guiana	
Guatemala	

Fisheries projects presently are in progress in Northeast Brazil, Panama and El Salvador under bilateral agreement between these countries and USAID under contract with Auburn University International Center for Aquaculture. One freshwater fishery project under FAO is in progress in Ecuador and survey by FAO was made in Peru.

A list of the surveys and end-of-tour reports on Latin-America fisheries made by the International Center follows:

Brazil

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6. Pollution of Rivers and Coastal Waters

Exploitation of mineral resources and industrial development without adequate safeguards for the quality of water in rivers and coastal waters is a serious problem in several Latin American countries. It is impractical to develop a fisheries management program for natural waters without arallel efforts to develop a program to maintain water quality at a level re-uired to sustain fish life; consequently in countries interested in developing anagement plans for rivers and coastal waters some attention should be irected toward pollution monitoring, abatement and control.

Cultural and Socioeconomic Aspects Associated with Development of Natural Fisheries.

What is harvested for local market sales depends upon the cultural ackground of the people involved. In developing countries certain food tems have a traditional market value, at least in a relative sense when compared to other food items. As a result certain food items are traditionally associated with various economic groups.

Freshwater fish products in Latin America are often the lowest priced meat product available and are usually the only source of animal protein that is routinely consumed in many households. However, marketing systems are often archaic and unsanitary which results in serious restriction on the distribution and sale of fish products. Therefore to reap the benefits of developing unexploited fisheries, concurrent inputs are essential to define the magnitude of the existing market and predict future market demands.

These studies would involve a description of the human population, in terms of demographic characteristics, class structure and consumer preference, and an evaluation of the performance of existing marketing processes.

Assistance in planning, coordinating and implementing these studies should be accomplished by University personnel from the U.S. Consortium or third countries.

8. Fisheries in Inland Waters.

A common problem in many developing countries is overexploitation of existing freshwater fisheries by unregulated commercial fishing activity. Non-selective gear and unrestricted fishing can quickly bring a fishery to economic extinction. This is especially true as the market distribution facilities improve and the demand for the catch exceeds the level that the fish stocks can sustain. Therefore, systematic collection of catch statistics, fishing effort and length-weight data on economically important species from both cold and warm water lakes, rivers and reservoirs is an important con-

sideration. The biological factors which are important to management decisions can be evaluated by the relationship of catch to the total amount of fishing and the size of the fish caught. These data are especially important for assessment in the early development of a fishery, and form the basis for comparison of rates of growth, condition and suitability of habitats for a species in rivers, streams, lakes and ponds. Cold water habitats, with trout usually as the only important commercial species present, are particularly vulnerable to overexploitation, and as a result require careful management.

Also, in the process of obtaining fishery statistics, other information can usually be obtained rather cheaply, such as the reproductive biology, food habits, and seasonal abundance of important fish species. This type of information is not usually available in developing countries, and is important in understanding the dynamics of the resource in terms of increasing the economic benefits from a fishery. This is especially true in warm water lakes and reservoirs where, for example, a more desirable species could be stocked to better utilize an available food supply or provide a forage base for existing fish populations.

Assistance in planning the collection and analysis of fishery statistics can often be accomplished through short term consulting trips by university personnel from the United States or third countires.

9. Management of Coastal and Estuarine Fisheries

Coastal fisheries are some of the most valuable in each country, and

include those for fish, shrimps, oysters, mussels, clams, and crabs. The responsibility for their management varies from country to country, sometimes being under the division dealing principally in offshore marine fisheries and elsewhere under the division responsible for inland and coastal fisheries. Coastal fisheries are variously defined as those as far out in the ocean or bay as a man can walk, or as far out the artesanal fisherman with boat powered by oar, sail or small motor can fish and return the same day. Other pertinent characteristics of these fisheries are that they tend to be overfished closer to shore, and it becomes progressively more necessary to fish farther and farther out. In times of high wages and high employment ashore, fishing pressure decreases drastically; in hard times and low employment ashore, greater numbers again revert to fishing for a living. The coastal fisheries thus act as a very important buffer, absorbing unemployed man-power. The estuarine and coastal areas are also the nursery grounds for many important fishes, shrimps and other seafoods. At the same time they are vulnerable to land-based pollution, erosion, and loss from fill-in of marsh lands and shallow waters for housing and industry. Best management of these valuable waters must start by best usage of the land to reduce erosion and flash-flooding, control of pollution by industry, use of biologically degradable pesticides by agriculture, and better sewage treatment by cities. Problems created by these sources are transported by the rivers to the estuarine - coastal waters and for this reason, their management is tied to those of inland waters.

Management of fisheries in these waters is principally one of restriction of the catch to the maximum sustained annual yield. At the same time, this is difficult because of the great numbers of small fishermen involved, their low level of catch, and consequently of income. Since anyone can enter these fisheries with little capital or equipment, licensing and amount of the license is the principal means available for preventing overfishing. Landing records, size of fish caught and fishermen effort involved are the statistics needed to evaluate changes in the catch and hopefully to detect overfishing.

Penaeid shrimps are migratory, spawning offshore and migrating into estuarine areas, where they gradually grow to harvestable size and migrate outward again to the ocean. Management includes periodic evaluation of the abundance and size of these young shrimps in various parts of the bays and estuaries so that intensive fishing may be delayed until most of the shrimps are of acceptable harvestable size. Controls for management include licensing to regulate number of fishermen, zones closed to fishing where shrimps are too small and control of types of fishing gear. Landing records, numbers of boats and fishermen engaged must be accumulated over the years to evaluate the value and extent of the fishery and to detect possible overfishing or underutilization.

Abundance of oysters, mussels and clams are usually limited principally by suitable areas for setting. The young oyster must have a clean surface free of barnacles and periphyton upon which to set, for example a suitable attachment surface, known as "Cultch ", is a clean oyster shell. This

shell in turn must be on a suitable substrate; in soft muds it will sink below the surface and the oyster will perish. In sands, it may be covered to the extent that the young oyster cannot open its shell to feed or respire. Suitable sites are limited to hard bottoms of a clay-sand mixture sufficiently stiff to support the weight of the cultch and attached oysters, and where the range of salinity allows growth of the oyster, while being unfavorable for predatory drills, starfish and diseases.

Management methods can consist of setting out suitable clean substrate on suitable bottom soils just prior to the time of setting of the young oyster (spat), or in moving young oysters from areas where crowded to other areas of low density where they can grow to large size, although these are sometimes classified as the first step in primitive oyster culture. Monitoring of the abundance of fecal Bacterium coli and closure of the oyster reefs to harvest when the pollution count is dangerously high may be necessary.

Other problems for marketing of these very perishable products are those of providing landing facilities, icing, and canning under sanitary conditions. Analyses should be made for content of heavy metals and of pesticides in seafoods that are to be sold abroad.

Specialists in various phases of management of estuarine and coastal waters can be made available for consultation and advice through the U.S. Consortium to countires needing these services.

10. Development of Aquacultures

Many types of aquacultures have been developed for use under various conditions. These include cultures in cold and warm freshwaters and in brackish and seawater using ponds with still water or flowing water; raceways with flowing water, cages suspended in surface waters of streams, ponds, reservoirs and bays; and pens constructed in the margin of reservoirs or bays.

Various levels of management and production may be used. However, merely constructing a pond and adding fish has an expected production of only 100 to 200 kg/ha which is not sufficient to justify costs of the pond and use of the land.

The next step upward is stocking or one or more efficient species of fish and use of either organic or inorganic fertilization. The principal inorganic fertilizer needed is superphosphate. Organic fertilizers may include manures, grasses and wastes from agricultural crops. These techniques can raise production to from 1,000 to 3,000 kg/ha.

The step beyond this is feeding, with a supplemental feed or complete feeds. A supplemental feed may be a single ingredient such as cottonseed meal or spoiled grains or mixtures of two or more materials containing plant protein and is useful only when the fish cultured are in a pond or other envioronment where they can also eat a considerable quantity of natural fish-food organisms. The complete feed contains all amino acids, vitamins and other factors needed for growth and may be used for fish in cages or raceways when natural fish-

food organisms are not available to fish. It is also required in ponds for extremely high production where the natural fish-food organisms would be inadequate to upgrade a supplemental feed. Depending upon the quality of feed, the waste-disposal system within the culture and the efficiency of the fish being cultured, productions from 3,000 to over 12,000 kg/ha have been produced without running water. Where water is run through to remove wastes, production may increase to above 100,000 or more kg/ha of pond or raceway. Raceway production has reached well above this figure, with the maximum approaching 500,000 kg/ha of raceway, but actual production is regulated by the rate of exchange of the water, the species cultured, and the quality of the feed and rate of feeding.

Combination cultures of ducks-fish, hog-fish and chickens-fish where the farm animal is fed directly and the fishfoods are produced by the wastes often are highly productive and profitable.

The problems in cultures are to identify suitable efficient species and species combinations that are highly acceptable on the market and can be produced at a profit. The probabilities of a culture being financially rewarding can be estimated from research results on average costs of production and on economic survey of marketing possibilities.

Additional problems are the availability and costs of needed inputs, including land, pond construction costs, labor, fertilizers, crop residues and wastes, feeds, transportation, markets and credit.

Among the problems are many that can be coordinated with current research in the U.S. and with other members within the consortium of Latin-American countries.

Problems for Cooperative Research would include:

A. Comparative testing of species of fish, and other aquatic animals for culture.

This is urgently needed in Latin America, since this area contains over half of the known species of fishes in the world, as well as many potentially valuable species of shrimps, molluscs, and other animals that might be cultured. At the present time, the capabilities for culture of any of these species is largely unknown and the principal cultures presently used are for imported species of fishes--rainbow trout, common carp and tilapias.

For identification of species suitable for culture, it is essential to know the type of natural foods utilized by each species. This type of research can often be done by biological laboratories in Universities who have suitable trained personnel to identify the fish-food organisms, and to supervise this research by students.

Testing of promising species must be done in ponds at experimental stations that can evaluate the efficiency of utilization of both natural and prepared feeds, and the production that can be obtained per hectare. To qualify as a suitable species for culture, it must give a production in excess of 1 metric ton per ha, and when fed on prepared feeds must yield 1 kg of live fish of the species cultured for each 1.5 to 2.0 kg dry feed utilized.

Some limited testing is in progress in various countries including El Salvador, Brazil, Panama, Colombia, Ecuador, and Peru. However, so few

research stations are presently available for this evaluation and these stations have so few ponds available for the tests, that progress in identifying suitable species for culture will be very slow unless a coordinated crash program is developed in the Latin American countries and more experimental ponds are constructed for this purpose.

Meanwhile present facilities could be supplemented by conducting tests for efficiency and production in cages and pens constructed in the margin of reservoirs. Of the two, the pen is more suitable for this research as its use does not require a complete feed such as needed for cage culture. The fencing can be constructed in movable sections that can be repositioned as water level in the reservoir drops during dry weather.

When promising species are identified for pond-testing, then methods of spawning must be developed so that they can be tested by farmers on a semi-commercial scale. Here again, research on methods of spawning can be conducted in aquaria at Universities as a background and supplement to similar research at governmental Stations.

After testing by farmers on a semi-commercial basis has shown that the fish are acceptable on local markets and that the farmer can grow the fish at a profit, this culture is then ready for wide dissemination by the Extension Specialists. Problems encountered with water quality, fish kills, fish diseases and other troubles must be reported back to the Research Station and Universities for solution.

B. Fish feeds and feeding

This is another field where coordinated effort is needed and where the consortium of Universities and Stations in the U.S. can make a major contribution because of their long experience in this field. Since production of protein of high quality is the primary aim of fish cultures and other aquacultures, protein conversion factors and protein quality determinations are needed for each step in conversion of plant protein to animal protein within the various cultures. This makes necessary determination of distribution of essential amino acids in materials fed and product produced for various systems of aquaculture. This analytical service can be provided by cooperating U.S. Research Stations.

In all concentrated fish feeds that are considered complete feeds, it is presently necessary to include 10 to 15 percent of animal protein, principally fish meal. With present and projected scarcities of fish meal and other animal proteins available from commercial sources, it is absolutely essential to develop complete feeds that do not require inclusion of animal proteins and their associated "growth factors". Fish meal, in addition to its excellent content of amino acids, apparently contains one or more unknown growth factors which in part are responsible for faster growth and more efficient conversion of feed to fish, chickens and other animals. The chemical nature of these factors must be determined and other cheap sources for them found, so that high-priced fish meal will not be needed in prepared feeds.

In the interim, while research is identifying the growth factors and formulating alternatives, research should be conducted using supplemental

feeds with proteins from plant sources only, while raising a secondary crop within the culture to produce the necessary animal protein for direct consumption by the fish or other animal being cultured as the primary species.

For example, catfish may be cultured with a plankton-feeding fish, such as Tilapia aurea, which does not compete with the channel catfish; however, the catfish do feed directly on young tilapia, thus getting their required animal protein. When the pond is drained, an additional 500 to 1000 kg/ha of small tilapia per acre remain for use in supplementing other fish or chicken diets and an additional 500 kg of large tilapia is available for sale.

A combination of mussels or clams with catfish or other species feeding upon them may be a suitable combination to provide necessary animal protein, and also a surplus at draining that can be used for human nutrition, or for supplementation of chicken feed, fish feed, or feed for other animals.

C. Preparation of length-weight tables of fishes

The length-weight data on fishes accumulated in all Latin-American countries will be combined in a computer program to develop standard average length-weight relationships for each species and for each river system. These will subsequently be useful in calculation of changes in relative condition of a species at different seasons, over various periods of time, as a result of over fishing or underfishing, or as a result of other management practices.

Similar tables can be prepared for shrimps or other aquatic animals of commercial importance.

D. Reduction of wastes within ponds where fish or other aquatic animals are being cultured and in the waters draining into streams

Biological methods for reduction of wastes within aquacultures and in outflowing waters must be developed for the many-fold purpose of increasing production, reducing possibility of fish kills from low oxygen and reducing to a minimum release of wastes affecting dissolved oxygen, or of excessive nutrients causing obnoxious algal blooms downstream.

This will include uses of plankton-feeding fish, mussels and clams to reduce suspended particulate matter; use of fish, shrimp or crayfish to reduce benthic wastes; and use of aquatic plants to remove excess nutrients. When possible, fish and other animals will be used as this will result in added production of animal proteins for direct human consumption or for use as a source of animal protein for fish feeds, chicken feeds or pig feeds. In each country, the various organisms that appear of promise for the above goal will be identified and tested for use in the cultures for primary species, and will also be used in a raceway or settling pond system for water to be released downstream--or to be recycled. These procedures will also be useful in treatment of waters that receive domestic sewage and/or certain organic wastes from food processing plants.

E. Shrimps for culture in freshwaters

The present high cost of shrimps and probability of even higher costs make shrimp a promising species for commercial culture in both brackish water-seawater and in freshwaters. The Macrobrachiun group of shrimps

migrate into salt water with salinities of 18-25 ppt for spawning and the larval stages must stay in waters with salinity above 10 ppt until the juvenile stage. After this they migrate upstream into freshwaters where they grow to maturity. Methods have been developed for spawning and raising the young to the juvenile stage but highly productive methods of culture to marketable size have not yet been fully developed.

A world-wide search is being made to discover species of shrimps of suitable size for commercial culture that spend all their life cycle in freshwater. Certainly the great river systems of South America are among the most promising areas for such a search because of the extremely varied habitats and the long distances from the ocean to their headwaters. Each species of shrimp that attains sufficient size should be identified, its spawning requirements determined and subsequently tested for possible commercial culture.

Certain research stations in the U.S. and in Taiwan have information on spawning of the Macrobrachiun group and techniques for raising them to the juvenile stage.

F. Cultures for shrimps in coastal ponds

Certain of the penaeid shrimps have also been spawned and raised to juvenile stage by various stations in Japan, Taiwan, and in the U.S. However, highly productive and efficient cultures have not yet resulted. Development of suitable shrimp cultures, especially in the tropical coastal areas of Central and South America should be intensively pursued because of

the high export value of shrimp as well as their high nutritional value for local consumption.

G. Culture of molluscs in coastal waters

Improved methods of culture for oysters, mussels and clams in coastal waters should be developed. This is a cheap source of protein because its production results from utilization of plankton present and largely unutilized in coastal waters. No feeding is necessary. Oyster and mussels can be greatly increased by providing suitable clean substrate for their setting, such as clean shells, or bamboo or wood posts placed out when the spat are ready to attach themselves.

Suitable local species must be identified and cultures developed for those giving high production and that are acceptable on local or international markets. Because of the highly perishable nature of molluscs, only the canned product may be salable abroad. Molluscs may prove a cheap source of animal protein for inclusion in feed for other animals raised in agriculture or in aquaculture.