Conclusion

Development and design of new equipment is a problem for both the biologist and oceanographer. The use of oceanographic equipment should not be limited to the science of oceanography for these instruments show promise in marine biology. The instrument's transposition from the field of oceanography to that of biology is, in cases, a problem of modification or redesign while in other cases it is only a problem of application. Newer and better instruments are needed in both fields and it is the responsibility of the men using the instruments to make their needs known or to modify and redesign existing instruments to their particular needs.

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Fish Culture Project in Haiti

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THE POSSIBILITY of developing fish culture as a source to supply protein food to the people in Haiti was first visualized by Professor Ernest F. Thompson of Yale University. In the 1948 Report of the United Nations Mission to Haiti Thompson observed, "Haiti possesses a very considerable area of lakes, rivers, irrigation canals and ditches, vast land capable of being flooded and a great variety of shallow lagoons, both salt and fresh; and these are at present unproductive or produce only at an extremely low level, and most of them have little or no agricultural potential. In addition there are considerable rice field areas the flooding of which is contemplated." Further, in connection with fish culture, the Mission recommended, "Before deciding on a program of pond culture development the service of a first class specialist familiar with successful practices in other countries should be secured for making an extended survey;

if in the light of such survey decision is taken to embark on fish farming, the specialist should be retained for a number of years to lay out pilot operations and supervise their implementation; further steps should be taken to train at least two local men in the principles of fish culture, these men to be responsible for following up the plans of the specialist."

The fishing industry of Haiti has not yet been developed. Marine fish landings are extremely small, being estimated at about 1,000 metric tons per annum, and the harvest from the fresh waters is much smaller. The country had to import each year an average of 3,050 metric tons of salt dried and hard smoked fish, valued at 2,061,310 gourdes or $412,260 for the fiscal years 1916-17 to 1948-49. The total of locally produced and imported fish are only enough to supply the Haitian population of 3.2 million about 1.2 kg. per capita per annum. Animal proteins of other kinds are also extremely scarce in the country and the people do not receive a balanced diet.

The development of the marine fisheries is usually regarded as a good measure to meet such requirements of the country. However, no achievement along this line can be expected unless a considerably long period is to be spent in training fishermen to handle fishing boats and gear, and some other practices that will give quicker results must be sought at the same time. Fish culture is recommended for the reason of its comparatively simple technique and easy application. It can become an integral part of the rural economy when it is well established.

Although it cannot be said at present that the Haitian peasants are fish-eating people like the islanders of many other parts of the world, there is no indication that they have any prejudice against eating fish. The purchasing power of the peasants is low, but if they can produce fish themselves from ponds in their back yards, rice fields, rivers and lakes where the cost of production is correspondingly low, they would have no difficulty in procuring this valuable food.

To implement the recommendation of the United Nations Mission the Government of Haiti requested the United Nations and the specialized agencies to continue the Expanded Technical Assistance Programme on various fields of work in the country. Among the experts sent to Haiti the writer was assigned by the Food and Agriculture Organization (FAO) on June, 1950 to carry out a substantial survey with a view to formulating a practical scheme on fish culture development.

A field survey was considered necessary to collect information for drawing up a plan of action. Beginning in June 1950 the survey was carried out in cooperation with the staff of the various sections of the Department of Agriculture.

The first important point of the survey was to find out if there are any indigenous fishes which could be used for profitable cultivation in ponds. Secondly, attention was paid to the natural freshwater systems such as rivers and lakes, the sources of water supply and the land available for pond construction. Particular attention was paid to the periodically flooded rice fields, swamps, rivers and lakes. Thirdly, it was necessary to find out what kinds of food material, such as peanut meal, rice bran, oil cakes, copra waste, and fertilizers were available. Fourthly, the climatic and meteorological data, which are important with reference to selection of species of fishes for cultivation and to pond management, were collected as far as possible. Finally, observations on socio-economic condition of the people were made, and evaluated with reference to the planning and execution of the prospective fish culture project.

The survey covered the typical low land areas such as Plaines du Cul-de-Sac, de Léogane, de Petit-Goave, des Cayes, de l'Arcahaie, Artibonite and du Nord. Many rivers and lakes were visited and fish were caught for examination. The result of the survey can be summarized as follows:

The existing waters are strikingly unproductive, evidently due to the absence of prolific and fast growing fishes. Even in the big rivers like the Artibonite, the Estère, la Ravine du Sud, the Grande Anse and in the Etang Miragoane, Etang Saumatre only two groups of fishes, the poeciliids and the cichlids, are common. In the family Poeciliidae, *Gambusia dominicensis* Regan, *Limia melanonotata* Nichols and Myers, *L. nigrofasciata* Regan, are most common. *Cichlosoma haitiensis* (Tee-Van) was the only species observed of the family Cichlidae. The poeciliids are small, extremely prolific fishes. They are excellent mosquito larva destroyers. *Cichlasoma*, on the other hand, grow slowly and are unable to propagate well. In the flooded rice fields and basins along the Rivière de l'Estère of the Artibonite Valley cichlids are produced, but of not large enough quantity to be of importance. The only fishes of certain economic importance are the young of *Sicydium plumieri* (Bloch) and *S. punctatum* Perugia, which multiplies by millions, probably in brackish waters in the bays and along the coast and ascend rivers in the months of January to April. Also to be found are the young of the fresh water eel, *Anguilla rostrata* le Sueur. Individuals of the following marine species are usually caught in the lower part of the rivers: *Megalops atlanticus* (Cuv. & Val.), *Mugil liza* Cuv. & Val., *Mugil curema* Cuv. & Val., *Mugil trichodon* Poey, *Agonostomus monticola* (Bancroft), *Centropomus undecimalis* (Bloch), *Centropomus pectinatus* Poey, *Centropomus ensiferus* Poey, *Gobiomorus dormitor* Lacépède, *Dormitator maculatus* Bloch, *Eleotric pisonis* (Gmelin), *Gobiosoma* sp.

Among these marine species which ascend rivers the fresh water mullet, *Agonostomus monticola*, is most common and can be caught in considerable quantities, although areas where large schools of young *Agonostomus* might be found have not been discovered.

Most of the valleys, low land areas, plains, mud flats, and mangrove swamps are suitable for pond construction, and in many cases water supply is adequate. Many large areas of rice fields are flooded during the rainy season for several months, a period long enough for a certain hardy, rapidly growing and prolific species of fishes to thrive and to give rise to high yields. Several lakes can be made more productive by stocking with certain types of fish and letting them propagate for a number of years until a stage of maximum production is reached.

A favorable condition for fish culture development in Haiti is the absence of predatory freshwater fishes. The so-called fresh water eel, fresh water mullet, the gobies, the snooks, the snappers, etc. are mild predators but all of them spawn in the sea and only a few (e.g. the eel and the mullet) ascend into rivers and lakes far inland. Their chance of entering fish ponds is limited; even in brackish water ponds many sea fish can be screened out at the sluice when water is admitted. In some of the bigger lakes turtles are found, but because of their size and breeding habit they are easily placed under control. It is fortunate that no one has yet introduced any predatory fish into this country purposely or by mistake.

Many kinds of cheap food material such as peanut meal, cotton seed oil cake, copra waste, rice bran, kitchen waste, etc. are available in considerable quantity in some parts of the country.

The climate of Haiti is tropical. For the greater part of the country the

atmospheric temperature ranges from about 16°C in winter to 35°C in summer. On some hilly regions higher than 1600 mètres above sea level the temperature drops to below 5°C in winter and never rises higher than 25°C in summer. Rainfall varies greatly in different parts of the country. There are small areas in the south peninsula of the island where an annual precipitation over 2000 mm occurs. Large areas of the country receive 1000-1500 mm of annual rainfall, while in some districts, this is less than 500 mm. The water supply for fish culture in ponds should be adequate.

The selection of a fish for pond culture on a commercial scale is based on the following criteria:

1) The fish should be either herbivorous or omnivorous in feeding habit;
2) It should be fast growing;
3) Its fry should be easily obtainable.

In accordance with these points the following species have been suggested:

1. The yellow-tailed fresh water mullet, *Agonostomus monticola* (Bancroft) is abundant in practically all the streams of Haiti. It is omnivorous eating algae and other food. Beebe and Tee-Van (1928) found seeds, berries, insects and mites in stomachs of three fishes examined. In an aquarium the writer found it eating cereals, dried shrimp powder and cornmeal. Large specimens will swallow small fishes and snails. A. J. Thomas, fisheries officer of Jamaica, states that it grows to about four pounds in reservoirs (personal communication). However, its growth rate and spawning habits are not known and its life history should be thoroughly investigated before the species can be claimed to be profitable for pond culture. Small ponds of both running and stagnant water types should be built for experiments.

2. The common carp, *Cyprinus carpio* Linn. is the hardiest and most easily propagated fish at the present time. It can be acclimatized to all regions, although it thrives best in the temperate zones. It is cultivated with great success throughout the world in ponds and rice fields. For these reasons the introduction of this fish in Haiti appears to be justified. Not only could the carp significantly increase the productivity of the streams, lakes and rivers of Haiti, but also the useful poeciliids and the fresh water mullet, which is now considered desirable for propagation in ponds, would not be affected by the introduction, since they do not thrive in the same habitat. The mullet thrives only in the rapid clear water mountain streams, while the common carp requires a deep slow-moving or stagnant water with luxuriant vegetation. The poeciliids thrive in shallows and on the surface.

Carp living in the rivers and lakes are practically all scaled and rather long in form. Scaleless types e.g., the leather and mirror carp, are bred for pond culture. In recent centuries fish culturists in central Europe, especially Germany, have been able to breed certain variety of leather and mirror carp which grow extremely fast and supply excellent meat for the table. The fatbellied carp of South China are very hardy and spawn readily in captivity in a subtropical or tropical climate. They have been successfully introduced and propagated in Indo-China, Thailand (Siam) Malaya and Indonesia. The drawback to using this variety is that it does not grow very fast, the maximum rate being 1-1½ kg in two years or more.

The mixed variety of the "German carp" which were introduced to the United States, Japan, Ceylon, India and Palestine do not spawn so readily in all waters but grow very fast, especially in warm waters where the temperature remains above 20°C the year round. A fish culturist in Madras, India reports that he found a 2-year old carp weighing 4 kg. The Japanese fish farmers usually

obtain carp of 2 years old weighing 2½ kg even from congested ponds. This explains the high yield of the common carp ponds in Japan and Palestine where the harvest comes over 2 tons per hectare with the application of artificial feeding. Japanese fish farmers have managed to produce over 100 kg of carp per sq. m. in a small running water pond with heavy artificial feeding within a period of 7 months. It was considered worthwhile to try the rearing of the German carp in Haiti for profit.

3. Sepat Siam, *Trichogaster pectoralis* (Regan), has proved to be one of the most successful species for "rough release" in rice fields and lakes and irrigation canals in Malaya and the Celebes. It is extremely prolific. The yield has reached more than a metric ton per hectare per annum. As the rice fields and the lowlands of Haiti are flooded for several months in very much the same manner as in Malaya and the Celebes, the introduction of Sepat Siam would be beneficial to the farmers living in these areas.

4. *Tilapia mossambica* Peters, was first introduced into St-Lucia, British West Indies, from Malaya in 1950. In the same year about 400 of them were shipped by air from St-Lucia to Jamaica where they established themselves and thrived.

Although Tilapia does not grow rapidly to a large size in fresh water, it is easily handled by fish farmers who have no previous experience with fish culture. The advantage lies in its hardiness, extremely prolific nature and readiness to take many kinds of oil meals and cereal brans. Being a mosquito larva destroyer, it grows particularly well in rice field, ditches and irrigation canals.

Mr. Soong Min Kong, the Fisheries Research Officer of Federal Malaya and Singapore reports that *Tilapia mossambica* grows to a length of 22 cm and to a weight of 150 grams in fresh waters. In brackish water they do much better, growing up to 900 grams each. D. Hey in his book *"The culture of freshwater fish in South Africa"* mentions that this fish grows to 5 lbs in South Africa, with the average in the vicinity of 2½ lbs. Productivity of *Tilapia mossambica* is about 1000 kg per hectare per annum in brackish water with no additional feeding. In fresh water the same result is obtained with additional feeding of rice bran. Similar results were observed in Jamaica.

5. The Cichlid, *Chichlosoma haitiensis* (Tee-Van) is found to be a dominant species in most rivers and lakes where the water is more or less stagnant or slow moving. It is a hardy species and omnivorous in feeding habit, but grows slowly, making it less desirable for pond culture.

6. The Sea Mullet, *Mugil curema* (Cuvier and Valenciennes) is abundant in brackish water tidal streams, rivers mouths and inshore waters. When brackish water ponds are built it should be the major fish to be reared there. The life history of this fish is in need of immediate study.

On the basis of the above observations, a 5-year working scheme was drawn and submitted to the Government of Haiti by FAO and was accepted. A budget of 50,000 gourdes or 10,000 U.S. dollars was provided by the Government for the fiscal year 1950-51 to cover the cost of pond construction, introduction of fishes and other local expenses and the FAO Technical Assistance programme provided the salary, allowances, and travelling expenses outside Haiti for the technical expert. Under such cooperative fiscal arrangements the actual work of pond construction started at the end of November 1950.

In the fish culture project three stages of development are visualized. The first is to establish a fish fry nursery with a few experimental ponds for propagating the exotic domesticated fishes as well as indigenous species. When a stock of fish fry is assured and ready for distribution the next step will be the

building of demonstration and extension centres in suitable localities in the country. Lastly, marketing and utilization of the fish produced in ponds must be seriously considered for any incentive to produce more fish can come only from the farmer's confidence that his effort will be rewarded.

In the first two years of the fish culture scheme, therefore, work is to be concentrated on the construction of nursery and experimental ponds and on the introduction of exotic fishes. In November, 1950 selection of sites for two small nurseries and plans for pond construction were begun. Mr. Leonce Bonnefil and Mr. Emanuel Garnier were authorized by their Government to carry out the work.

Through the preliminary survey carried out in June to August, 1950, the yellow-tailed fresh water mullet, *Agonostomus monticola* (Bancroft) was found to possess certain characteristics which are desirable for culture in ponds. Although the source of its fry is still unknown it was considered to be worth while to construct some type of experimental running water ponds for cultivation of this mullet. The conditions of the pond would be as similar to the natural habitat of the fish as possible. For this purpose a small area of 600 sq. m. immediately above 6 hectares of the rice fields in Mariani was selected, where constant water supply from a spring can be obtained all the year. On the same grounds small ponds are to be built for breeding of *Trichogaster pectoralis* or *Tilapia mossambica*.

Meanwhile, carp culture in ponds as well as in rice fields was planned. A piece of land 1.7 hectares in area in the Damien agriculture farm was selected for use as a carp nursery and experimental centre. The place is wooded with cocoa-nut trees and is adequately irrigated by two canals, one leading water from a stream and the other from an underground water pumping station of the farm.

Work on the construction of simple ponds was started late in November, 1950. By the end of April 1951, 7 ponds were completed. The 7 ponds are of the following dimensions:

In Mariani:		In Damien:	
Pond A	10m x 15m x 1m	Pond S 1	15m x 20m x 70cm
Pond B	16m x 15m x 1m	Pond S 2	14.5m x 20m x 70cm
Pond C	8.3m x 13.6m x 80cm	Pond L 1	27m x 51m x 90cm
		Pond L 2	35m x 50m x 60cm

Mariani lies in a small valley on the steep side close to the southern shore of the Port-au-Prince Bay. The ground of this district is covered with a thick layer of conglomerating calcareous pebbles, gravels and sand. The top soil is not deep in this area. When ponds are built on such ground they are not likely to hold water well unless a layer of mud or clay of 20 cm or more thick is placed on the bottom. A layer of mud should also be added to the inside of the embankments. The following steps have proved to be effective in improving the impermeability of the 3 ponds in Mariani: the bottom is levelled and packed with heavy rollers or rammers; mud or clay is added to at least 15 cm in thickness; the pond is filled with water; cattle are driven in or labourers are employed to paddle in the pond while water is kept flowing in to fill the interspaces between the pebbles and gravel with mud or clay.

The ground in Damien is covered with a layer of fine calcareous sand or sandy loam of considerable depth, which consists mainly of broken pieces of coral and shells. The ponds constructed in this area are found to hold water much better than those in Mariani, although the loss of water through seepage

still amounts around 5 cm in 24 hours. This water is replaced two or three times a week from the irrigation canals. The permeability is expected to be reduced in time as more silt is precipated to the bottom.

It was planned to build 4 more ponds before the end of this fiscal year for rearing of fry and adult fish, but as excavation work is difficult and uneconomical during the rainy season, which extends from April to October in Port-au-Prince area, further pond construction had to be postponed until November.

Attempts have been made to procure a supply of *Trichogaster pectoralis* from a few sources for breeding and feeding experiments but so far they are not successful.

Tilapia mossambica was introduced to Jamaica, British West Indies in 1950 where it multiplies and establishes itself. The Fisheries Officer of Jamaica sent a supply of 113 *Tilapia* to Haiti in June, 1951.

Through the arrangement of Dr. Stillman Wright of U.S. Fish and Wildlife Service, a shipment of 123 carp fingerlings was received from Mr. Jack Snow, fish culturist of U. S. Marion Fish culture Station, Alabama on February 22, 1951. The fish arrived here in perfect condition. Their measurements were recorded as follows:

Size	Length	Weight
Average	17cm	72 grams
Smallest	15cm	57 grams
Largest	20cm	90 grams

These fingerlings, from the spawn of April or May, 1950 in the experimental ponds of the Marion Station, belong to the high-bodied, scaled carp said to be of German origin. Again in September 12, another shipment of 300 carp fingerlings was received with the help of Mr. H. S. Swingle of the Alabama Polytechnic Institute.

The mild tropical climate in Haiti is favourable for the growth of carp. In about 5 months each of the 23 carp in a pond grew on the average from 160 to 2040 grams gaining 1880 grams in weight as shown in the following table:

Date	4-5-51	18-8-51	8-10-51
Average length (cm)	23	45	52
Average weight (gr)	160	1360	2040

The smallest carp examined in October 8, 1951 weighed 1810 grams and the largest 2260 grams.

The 103 Tilapia introduced from Jamaica on June 22, 1951 grew from 4 cm to 18 cm, weighing about 80 grams each in 2 months. Meanwhile they multiplied by hundreds at the end of August.

At the present stage of development of the project it is too early to ascertain the productivity of ponds in Haiti, but preliminary observations indicate that high yield of ponds could be expected through association of species, artificial feeding, application of fertilizers, regulaton of water supply, proper harvesting, etc. A small pond of approximately 100 sq. m. in area in Mariani, for example, has yielded 13 kg of fish and shrimp in 4 months rearing, or 3915 kg per hectare per annum. Another pond of about 320 sq. m. in Damien produced 38.16 kg. of carp alone in a period of 5½ months, or 2600 kg per ha per annum.

For the practice of combination of species in ponds built in the plains, valleys and swamp areas near the sea, the preliminary experiments show that

the following kinds of fishes and crustacea would become of considerable importance.

The freshwater mullet, *Agonostomus monticola* (Bancroft), the gobies, *Dormitator maculatus* (Bloch), *Electris pisonis* (Gmelin), *Awaous taiasius* (Lichtenstein), *Evorthodus lyricus* (Girard); the short rostrum Shrimp, *Macrobrachium carcinus* (Linn.), the long rostrum shrimp, *Macrobrachium acanthurus* (Wiegmann).

A number of people were impressed by the rapid growth of carp and Tilapia in the experimental ponds and have asked for advice in building ponds. Steps are being taken to supply fish fingerlings from the nursery when their ponds are ready for stocking.

An experiment was started on May 21 to find out whether the *Gambusia* and *Limia* will thrive as usual in the carp ponds. Over 100 *Gambusia* and *Limia* were put into a pond with 23 carp. A few hundred more were also placed in other ponds and the canal in Damien. Meanwhile hundreds of young Poeciliids were observed in the drainage canal. The water in the canal is clear with good growth of *Spirogyra*. The poeciliids introduced into the ponds appear to live very well. They were seen swimming under the shade of the coconut tree near the shore, and at the end of two months after introduction thousands of poeciliids, mostly young ones, were observed in all the ponds in Damien. No mosquito larvae were observed in any of the ponds.

In order to train local staff to follow up the project and extend fish ponds to the whole country after the FAO expert leaves, two fellowships on fish culture were provided by the FAO Technical Assistance Programme. These will enable Haitians to study abroad. The first Fellow went to the Far-East in September 1951 to study modern commercial fish farming on a large scale. The next Fellow will go abroad sometime in 1952, after the first has returned.

The writer has been deeply impressed and encouraged by the manner in which the Haitian government officials have cooperated in this project. The keen interest and efficiency expressed by the officers appointed by their Government to administer and direct the project have expedited the work and have made it possible to accomplish more than was expected.

Thanks are due to the U.S. Fish and Wildlife Service and the Fisheries office, Jamaica, B. W. I. for the arrangements they made to send the carp yearlings and the *Tilapia* fingerlings to Haiti. The cooperation given by the Service Cooperatif Inter-American de Production Agricole (SCIPA) in supplying machines to excavate the big ponds is acknowledged. To many friends, workers, and technical experts who have supplied data, information, comments and suggestions concerning the fish culture project the writer is indebted. Without the help and cooperation as mentioned above, the progress of the present fish culture project would be impossible.

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Sport Fishes of the Vicinity of the Gulf of Honduras, Certain Caribbean Islands, and Carmen, Mexico*

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GULF OF HONDURAS AND THE CARIBBEAN

PART I

A study of the fishes in the vicinity of the Gulf of Honduras was made in conjunction with an archeological survey of the region. The expedition was made in January and February, 1950, under the auspices of the Institution for Andean Research, Inc. The sport fishing possibilities of the area were explored, as there appears to be no published information on this subject. The survey was not made in the best fishing season and the party moved on so frequently that no one locality could be thoroughly investigated, but it is hoped that the information contained herein may be of some assistance to persons who have occasion to be in the areas studied and wish to try the sport fishing. This paper groups the facts discovered with the species of fish concerned, while a regional summary at the end of each part lists the species seen and also enumerates fish which were not seen but whose presence was reported by local people. While only the sport fish are discussed here, a collection including other local fishes was made for later study.

Mr. Charles S. Bird, Colonel John K. Howard and the archeologists Dr. Alfred V. Kidder, Dr. Gordon Eckholm and Mr. Gustav Stromsvik, as well as Captain Matthew English of the vessel "Irmay" and his crew, all contributed greatly to the success of the ichthyological work. Valuable assistance was also obtained from officials of the United Fruit Company and from Mr. R. K. Masson, Port Captain and Collector of Customs at Belize. Dr. Lionel A. Walford, Chief of the Branch of Fishery Biology, U. S. Fish and Wildlife Service, directed the first ten days of intensive collecting, setting up procedures which were followed during the remainder of the trip.

There are scattered populations of tarpon (*Tarpon atlanticus*) in rivers and lagoons of the northwestern Caribbean. The Trujillo area was the only one on the coast of Honduras in which these fish were encountered. In the canal at Puerto Castilla, many strikes were obtained by trolling small spoons and two or three very small tarpon were landed. The fish striking appeared to range from three to twelve pounds, except for one which looked to be of nearly fifty pounds. Residents said that tarpon had frequented the steamer dock at Puerto Castilla when it was used by the fruit ships. Some of these fish were also seen in the entrance to the lagoon of Guaimoreto, where fishermen reported that

* Contribution No. 611 from the Woods Hole Oceanographic Institution.