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Marine food production: problems and prospects for Latin America *

by

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Abstract: The present rate of fish consumption in Latin America is very low despite the existence of large fishery resources in the region. In view of the need for additional dietary protein which exists in many parts of Latin America, increasing the production and availability of fishery products should be given high priority in national and regional planning.

Increased production from marine fisheries in Latin America can occur through exploitation of presently un- or under-utilized stocks, and also through reduction of waste in present fisheries, both via utilization of presently discarded bycatches and via reduction of postharvest spoilage and processing losses. The greatest need in capture fisheries, however, is for institutional arrangements which will allow rational management of stocks and prevent overfishing. This need is made all the more pressing by the establishment of 200 mile economic control zones.

Mariculture is a second means by which the production of food from the sea can be enhanced. Its potential in Latin America appears to be great, although largely unexplored at present. The early stage of development of mariculture (as well as of freshwater aquaculture) in Latin America offers an opportunity to plan and coordinate the future course of aquacultural development to a greater extent than in other regions of the developing world. Establishment of a Latin American aquacultural research network is recommended with one or two lead centers and various outreach stations; such a network would provide needed impetus to aquacultural development by improving through multidisciplinary research the technological base for culture and by performing essential training and extension functions. Research should initially examine the suitability of local species for culture, going on to investigate systems of true marine polyculture and the utilization of locally available feeds and fertilizers (including agricultural and other wastes). Whatever species or species complexes are chosen for mariculture, techniques for controlling reproduction are in need of concerted research attention. Lying at the interface between mariculture and marine fisheries, sea ranching of anadromous and perhaps also non-anadromous species may offer significant potential for increasing yields in certain areas, especially if combined with overall management strategies for the species in question.

Increasing the availability of seafood to the populace, especially those sectors of society which now experience a dietary protein deficiency, is perhaps the most challenging problem connected with marine food

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resources in Latin America. The problem has a technological dimension in the need for processing and marketing highly perishable products in situations where refrigeration is not available, and in the need, in some instances, to create new products acceptable to the people. From this point of view, the development of local fish farming and poultry industries based on fishmeal as a feed ingredient may be the most efficient and practicable means of making the large industrial fish resources of Latin America available for local consumption. The problem also has social, economic, and political dimensions, as the economic incentive to export fishery products may work against the humanitarian incentive to channel them so as to fill local needs.

The World Food Conference in 1974 estimated that 3 million people in Latin America were malnourished (United Nations, 1974 a). Given this fact, it is perhaps surprising that the people of Latin America consume relatively small amounts of fish, even though fish resources are abundant in the area. High rates of fish consumption –say, over 20 g of fish per person per day– occur in Latin America almost exclusively in the Caribbean islands or nations bordering the Caribbean (FAO, 1971). In some of these countries, fish supply close to 20% of the total intake of protein (Table 1) and are therefore of crucial importance in the diets of the people, but such countries are among the smallest Latin American nations. More than 80% of the region's total population consumes an average of only 1 to 7 g of fish per person per day (Fig. 1). In 1970, Latin America contained 8% of the world's population but accounted for only 4% of the world's fish consumption (Robinson and Crispoldi, 1975).

In 1970, the catch of Perú alone made up 17.9% of the total world fish catch, making Perú the world's leading fishing nation. The anchoveta fishery suffered a drastic decline in 1972 (Fig. 2), from which it has not yet recovered, but even in 1974 Perú was the fourth ranking fishing nation in the world. The anchoveta caught off Perú and Chile –which constituted almost 90% *of* Latin America's total fish catch before 1972– are reduced to oil and fishmeal and largely exported, thus having little direct impact on local nutrition. Latin America presents a paradoxical situation wherein malnutrition is a problem, fish consumption is low, but fishery resources are abundant. In the face of these facts, it is relevant to ask what the potential is for expanding food production from the sea in Latin America and what this food can do to improve the nutritional well-being of Latin Americans.

FISHERY POTENTIAL OF LATIN AMERICA

The amount of food available from marine fisheries can be increased in several ways. The catches of underutilized species can be increased, and fisheries can be initiated for presently unutilized species. Reduction of various forms of waste can increase the availability of marine food without any increase in the catch.

Prospects for increased catches: The spectacular Peruvian fishery has dwarfed those of other Latin American nations, but if one focusses specifically on these other nations a trend of fairly steady increases in catches is evident over the last 20 years (Fig. 3). A leveling off of the catch seems to have occurred in some instances in 1973 and 1974, but the estimates of unexploited potential given below suggest that there is no biological reason why the rates of increase cannot continue, or even grow, over the next few years at least.

TABLE 1

Fish protein as a percentage of total protein consumed in Latin American countries (Data from FAO, 1971)*

Region and country	Percentage
CARIBBEAN	
Barbados	18.5
Cuba	5.1
Dominican Republic	12.0
Haiti	0.6
Jamaica	18.6
Trinidad and Tobago	10.2
CENTRAL AMERICA	
Costa Rica	2.3
El Salvador	2.0
Guatemala	0.4
Honduras	0.6
México	1.2
Nicaragua	1.4
Panamá	9.3
SOUTH AMERICA	
Argentina	1.1
Bolivia	0.9
Brazil	3.3
Chile	5.6
Colombia	2.2
Ecuador	2.2
Guyana	11.8
Paraguay	0.2
Perú	6.7
Surinam	18.2
Uruguay	1.2
Venezuela	5.4

* Figures pertain to 1970 except in the following cases: Bolivia, Cuba, Haití, Jamaica, México, and Trinidad and Tobago, 1964-66; Barbados, 1966; Guyana, 1967; Dominican Republic, Perú, and Surinam, 1968; Argentina, 1969.

The only published study which treats the fishery resources of the region comprehensively (Gulland, 1971) estimates that the Southwest Atlantic is capable of sustaining 6.5 million metric tons of additional harvest beyond 1968 levels, and the Western Central Atlantic (which includes the United States fishery in the Gulf and part of its Atlantic coast fishery) and Eastern Central Pacific areas are capable of supporting an additional 4.1 and 5.3 million metric tons respectively. If one adds the increase of 0.6 million metric tons which Gulland postulates for the Southeast Pacific (which must come from demersal fishes and pelagic stocks other than anchoveta), a total increase in the fish catch for these areas of 16.5 million metric tons above 1968 levels seems possible. This would amount to more than a doubling of the 1968 catch. A major unanswered question is whether the anchoveta fishery of Perú will regain its pre-1972 levels of productivity or remain at current levels; this will obviously have a profound effect upon the overall fisheries production of Latin America.

It will be useful for the purposes of this paper to consider in broad terms the various categories of marine food resources of actual or potential importance in Latin America. The following discussion is based primarily on FAO data presented in Gulland (1971), FAO (1972), and in the more recent Fishery Country Profiles prepared by FAO. The area in Latin America with the largest unexploited potential is the Southwest Atlantic, where 3.8 million metric tons of demersal fishes (hakes and small gadoids) and 5.0 million metric tons of shoaling pelagic fishes (herrings, sardines, and especially anchovies) were estimated to be available in 1968.

Catches from this area have not greatly increased since 1968, so that the potential for harvesting these resources remains for the most part unrealized. In other areas there are opportunities for more modest increases in the marine catch, again primarily in the categories of demersal and shoaling pelagic fishes. Among underexploited demersal resources, hake stand out as offering perhaps the greatest opportunities for expansion. Hake stocks off Mexico's Baja California coast, Northern Perú and Ecuador, and Chile could support increased fishing. Among pelagic resources, most tuna stocks in Latin American waters are already heavily harvested, but opportunities for expanding harvests of small tunas do exist (Suda, 1973). More importantly, jacks, mackerels, and especially clupeoids could be caught at greater levels in several areas. For example, the northern anchovy *(Engraulis mordax)* population off the west coast of Baja California in Mexico, and the sardine resources of the same area and the Gulf of California, could sustain catches of some hundreds of thousands of metric tons per year, and Mexico is encouraging the development of a fishery for these stocks (FAO, 1976 b).

There are significant stocks of small, midwater fishes, such as myctophids (lanternfishes) and gonostomatids (lightfishes), in Latin American waters. Such fishes occur in many parts of the world ocean but are nowhere harvested commercially. If harvested, they would probably be used for fish meal, and harvesting would frequently need to be highly energy-intensive, although at certain times and places huge quantities could be easily harvested by midwater trawling (Gulland, 1971). There is some concern that harvesting these fishes –as well as other underexploited resources, such as squid– could have an adverse effect on catches of fishes at higher trophic levels, such as tunas, which feed on them (Suda, 1973).

Exploitable crustacean resources are of limited tonnage when compared to finfish but are of extremely high value. For example, in Mexico shrimp make up only 18% of the catch by weight but 50% by value (FAO, 1976 b). As a

consequence of their value, most crustacean stocks in Latin American waters are presently harvested at or close to maximum levels. FAO estimates indicate that approximately 200,000 metric tons of crustaceans could be harvested beyond 1968 levels in Latin American waters (including the United States Gulf region and part of its southern Atlantic coast). Shrimp and crabs dominated these stocks (92,000 and 102,000 metric tons, respectively), with lobsters coming in a distant third (at 13,000 metric tons). Levels of exploitation of these stocks have undoubtedly risen since 1968, and the greatest current need in most instances –especially in the shrimp fisheries– is for strict management rather than expansion. Crustacean landings are almost without exception exported from Latin American countries and constitute an important source of foreign exchange. This can be true even in small countries with limited resources. In Belize, for example, where the main commercial fishery is for the lobster *Panulirus argus,* export of fishery products has amounted to U. S. $1.25-1.50 million annually, making fishing third among foreign currency items for that country (FAO, 1973 a).

The large populations of krill *(Euphausia superba)* in Antarctic waters have attracted a good deal of attention. Some estimates indicate that an annual harvest of 50 million metric tons of krill could be sustained (Lyubimova *et al.,* 1973). The U.S.S.R. is developing a fishery for these crustaceans (Lyubimova *et al.,* 1973), but geographic proximity has sparked interest in some South American countries in exploiting this resource. Chile is already conducting a pilot project for harvesting, processing, and marketing krill in a frozen fish-stick form. As in the case of midwater fishes, the energy requirements for harvesting krill could become a serious limiting factor, and entire new processing and marketing systems are required. Perhaps the most intriguing suggestion for harvesting krill involves a form of aquaculture; this will be discussed more fully below.

Galatheid crabs are currently only lightly harvested in most areas but appear to offer substantial opportunities for increased harvests in Latin American waters. Large populations of galatheids occur off both coasts of Baja California, between Costa Rica and Mexico, and off Perú and Chile. Gulland (1971) estimates that it might be possible to realize annual harvests of the order of one million metric tons.

Molluscan resources of Latin America include high seas squids and various oysters, clams, and mussels in shallow waters, as well as other forms of local importance such as conchs and octopus in the Caribbean. The squid stocks are poorly known and little exploited at present, although Suda (1973) estimates that an annual harvest of between two and three million metric tons of squid is possible in the four fishery areas surrounding Latin America. The total squid catch by Latin American countries in 1974 was only 7,435 metric tons. Naturally occurring oysters and mussels are harvested in Latin America, but the large-scale production of these forms depends on cultivation and will be discussed below under Mariculture.

Small-scale fisheries: There is a sharp division of fisheries in Latin American countries into two sectors, the large-scale and the small-scale. The small-scale fisheries are traditional coastal fisheries carried out in a labor-intensive way from small craft (frequently not motorized) with limited gear, little capital investment, little or no processing of the catch, and with an object of subsistence or sale to a local market. Such small-scale fisheries exist in all Latin American countries, and in some they are the only fisheries. Overlaid on this traditional sector in some, but not all, Latin American countries, is the commercial or large-scale sector. It is heavily capitalized, uses modern vessels, often of considerable size, and depends on

infrastructural amenities such as large ports, processing plants, and established marketing (usually exporting) channels. This sector includes tuna fishing, shrimp trawling, and the reduction fisheries.

Until recently, most development efforts focussed on commercial fisheries to the exclusion of small-scale fisheries. However, there is now a growing awareness of the importance of small-scale fisheries, and increasing attention is being devoted to them by national and international development programs (see, for example, Estes, 1976). In one area a regional center–the "Center for the Development of Traditional Fishing Communities in the Bay of Bengal"–has even been proposed (FAO, 1977). The importance of small-scale fisheries cannot be denied: they account for about 25% of the total world fish catch and about 40% of the catch of food fish, and estimates of the number of people involved in small-scale fisheries worldwide range from 8 to 25 million (Day, 1976). Small-scale fisheries allow harvesting of certain products whose distribution patterns make other forms of capture impractical. They also get fish to the people who need it as a protein source, a role in which the larger enterprises are notably ineffectual (Domike, 1976). A major problem in small-scale fisheries development is to improve efficiency without changing the labor-intensive nature of the fishery (FAO, 1973 b). Of equal importance is the need to upgrade the quality of the product by improved preservation procedures, such as the provision of ice (see below) and the wider application of traditional methods (Brown and Pariser, 1975). Improving the shelf life of the product through simple techniques such as salting and drying could greatly increase the availability of fish in areas remote from the sea (Pigott, 1976).

Reducing waste: The availability of marine protein in Latin America could be substantially increased even without any increase in the catch, if the considerable waste which now occurs could be reduced. Large amounts of fish, varying from 70 to 90% of the total catch (Allsopp, 1976), are caught in shrimp trawl fisheries. Because of their low value in comparison to the shrimp, most or all of these fish are usually discarded. This discarded bycatch represents a tremendous waste of potentially useful marine protein, and estimates of the worldwide bycatch loss are of the order of 5 to 10 million metric tons (Allsopp, 1976; United Nations, 1974 b). Unfortunately, most attempts to save the shrimp bycatch have failed. A recent economic study investigated various alternative systems for holding and landing the bycatch in the shrimp trawl fishery of the Western Gulf of Mexico (freezer units, brine immersion tanks, an onboard fishmeal plant, an extra crew member, and a mother ship) and found that none were economically viable "except under very restrictive conditions" (Nichols *et al.*, 1975). The profit potential was simply not great enough to encourage adoption of the systems. Nevertheless, devising means of utilizing the shrimp bycatch is a major challenge facing worldwide fisheries, since it is estimated that the bycatch may reach 20 million metric tons by the year 1985 (United Nations, 1974 b). As fish values climb in the coming decades, it may be expected that economic incentives to conserve the bycatch will rise.

For fish which are retained and landed, there are considerable losses due to spoilage and processing waste. This problem is particularly acute in developing countries with limited refrigeration and processing facilities and is most pronounced in small-scale fisheries where losses of up to 40% may occur (Day, 1976). The simple provision of ice may be the most effective way to reduce spoilage in such situations. It is worth noting that ice is much more effective in preventing fish spoilage in the tropics than in the temperate zones (Disney, 1976). In countries with more advanced processing facilities there may still be large amounts of waste,

much of which would be reclaimed with technologies such as deboning machines and extraction of proteins (Pigott, 1976). Shipboard deterioration, especially in large industrial fisheries, is a source of large losses which theoretically could be reduced by applying known technologies, but, as in the case of the shrimp bycatch, economic incentives to do so may not now exist.

The need for management: The ocean surrounding Latin America contributes a large part of the world's fish catch, and it could with proper development provide even more. But this potential cannot be realized, and even the present levels of production may not be sustained, if inadequate attention is devoted to problems of fisheries management. One need only glance at Peru's catch record for the last quarter century (Fig. 2) to become aware of the potential for catastrophic declines in fishery yields, and collapses of other heavily exploited clupeoid stocks (Murphy, 1973) show that such declines can take place in a variety of situations. In all fisheries, as in agriculture, environmental fluctuations induce uncontrollable and unpredictable changes in yields. Added to this natural variability is the influence of human activities, which can be decisive in the present day because of the relatively advanced state of large-scale fishing technology. Boerema and Gulland (1973) point out that by 1971 the Peruvian fishing fleet had developed such a massive fish catching capacity that it could harvest its total allowable catch (which in that year constitued approximately 15% of the total world fish catch) in about 90 days. Better management can prevent the build-up of such wasteful fishing efforts, with rewards estimated to be of the order of U. S. $ 1 billion annually (United Nations, 1974 b).

Silvert (1977) has generated models of the economics of overfishing which show that, in certain economic situations, fishing strategies which maximize present value are bound to lead to extinction of the resource. Interestingly, his results show that the larger the initial population, the greater the danger of extinction, because the larger resource makes it more economically attractive to make large investments in the extraction industry. The history of the anchoveta fishery is perhaps an illustration of such a situation. As Silvert suggests, and the experience in Perú demonstrates, direct government intervention may be the only way to avoid massive declines in catch. The chances of such intervention succeeding would be greatly enhanced by improved understanding of the population dynamics of the species in question. Even acknowledging the highly complex nature of this subject, especially when a number of interacting species are involved, it nevertheless seems important to continue theoretical studies and population and community modeling so that a scientific basis for rational management can be created.

Economic control zones extending 200 miles (or more) out to sea have been established by many nations and will probably become universal, whether this be done unilaterally by coastal nations or through international agreement at the United Nations Conferences on the Law of the Sea. This may in some instances place great responsibilities for fisheries management on nations which have not previously dealt with these problems and have very limited management capabilities. Concern has also been expressed that in some instances fisheries production may decline during the transition from exploitation by foreign fleets to exploitation by the coastal states claiming extended jurisdiction, owing to the time required to develop a fishing capability. In such situations, joint ventures with developed countries can play an important role (Honda, 1973). These considerations, as well as the mobility and geographical distribution of fish stocks and fisheries, argue strongly for a regional approach to fisheries management (FAO,

1977). Such an approach is not new in this hemisphere. Important regional bodies which already exist include the Inter-American Tropical Tuna Commission (IATTC), the Western Central Atlantic Fishery Commission (WECAFC), the Regional Fisheries Advisory Commission for the Southwest Atlantic (CARPAS), and the Intergovernmental Oceanographic Commission Association for the Caribbean and Adjacent Regions (IOCARIBE). It is to be hoped that through these and perhaps other institutions the urgent needs for fisheries management in Latin America can be met even in the face of changing jurisdictional claims.

MARICULTURE

While fishery resources will probably be fully exploited or nearly so by the year 2000, the demand for aquatic foods will undoubtedly continue to increase in Latin America, as elsewhere, due to population growth and rising affluence (Robinson, 1973). If this demand is to be met, a source of seafood other than capture fisheries must be found, and the cultivation of marine organisms, or mariculture, is the only possible alternative. It cannot take the place of fisheries but can be an important supplement.

In Latin America, unlike Southeast Asia and China, there is no indigenous tradition of aquaculture. The undertaking is new in this region, but already it has attracted considerable attention. The 1974 FAO Symposium on Aquaculture in Latin America reflected the level of activity in this field by the inclusion in its agenda of 51 contributed papers, in addition to 15 country reports (FAO, 1976 a). Many of the papers at that meeting dealt with freshwater aquaculture, a pursuit which has enormous potential (some of it already being realized) in Latin America but one which is beyond the scope of this paper. In 1975 the total aquacultural production of Latin America was 73,893 metric tons, of which 35% was freshwater fish, the rest being primarily marine molluscs (oysters and mussels grown from natural spatfall) (Pillay, 1976 a). The technology of mariculture lags behind that of freshwater aquaculture, largely because of the simpler life cycles of freshwater animals. But with adequate attention to key research problems, along with training and extension, mariculture appears to have the potential of adding significantly to Latin America's food budget and to its economic well being.

The main groups of marine organisms cultured throughout the world are crustaceans, molluscs, and fishes. In addition, marine algae (seaweeds) are cultured in certain parts of the world, but these serve primarily as condiments or sources of industrial colloids rather than as food.

Crustacean culture: As in capture fisheries, the very high market value of crustaceans has made them an object of great interest in aquaculture. Crustacean mariculture in Latin America is almost entirely confined to penaeid shrimp. Some experimental work with crabs has been carried out but has encountered the same problems of aggressiveness and cannibalism which have attended similar efforts elsewhere (FAO, 1976 a). Penaeid culture is aimed at the export market; aside from the obvious economic objective of earning foreign exchange, such culture can provide local benefits through employment and stimulation of ancillary industries. Because of the lack of methods for inducing sexual maturation in captivity, sites for penaeid culture have usually been located in areas where wild postlarvae are available (Cobo Cedeño, 1974) or in proximity to shrimp fisheries which provide a ready source of gravid females to supply hatcheries (Webber, 1975). The supply of

gravid females is still a problem, but successes in inducing maturation and spawning in captive penaeids have recently been reported by several research groups (e. g., Aquacop, 1975; Beard *et al.,* 1977; Caubere, 1976; Santiago *et al.,* 1976). With continued research it is to be expected that induced maturation and spawning will become routine, thus freeing penaeid culture from the constraint of relying on gravid females from shrimp fisheries or on collection of wild postlarvae. Besides control over reproduction, studies of diseases, nutrition–especially the development of locally produced feeds–and the economics of shrimp culture are needed. In 1975, only Ecuador produced significant quantities of crustaceans in Latin America through aquaculture (Pillay, 1976 a), but commercial operations have been established in other countries, and this trend will probably continue as research problems receive more attention and the economic incentive attracts governments and investors.

Mollusc culture: The culture of molluscs is believed to have substantial promise in Latin America (FAO, 1976 a), but production is presently limited. In 1975 the total production of molluscs through culture in Latin America was 47,130 metric tons; 95% of this was accounted for by oysters produced in Mexico, the rest being mussels and oysters from Chile (Pillay, 1976 a). Cultivation is in an experimental or incipient commercial stage in certain other Latin American countries (Lizárraga, 1974; Nikolíc *et al,* 1976; Penchaszadeh, 1974; Vélez R., 1974). Techniques of culture are basically similar, involving collection of natural spatfall and growth in rafts (oysters) or ropes (mussels). Problems impeding expansion of mollusc culture include lack of biological information on the species, lack of information on seed collection or on seed production in hatcheries, pollution, and lack of economics and marketing information (FAO, 1976 a). Nevertheless, the state-of-the-art is ahead of that of both crustaceans and finfish, and if economics and marketing assessments are favorable, expansion of mollusc culture in Latin America is virtually inevitable.

Fish culture: The culture of crustaceans, and to a great extent that of molluscs, is aimed primarily at producing high-priced food for export or consumption by affluent sectors of the local population. In contrast, fish culture–at least in freshwater–is viewed as a source of inexpensive animal protein for low-income persons who in many areas have dietary deficiencies (FAO, 1976 a). Whether this will prove true of marine fish culture remains to be seen.

There is at present no commercial culture of marine fish in Latin America, and even research in this field is extremely limited. Extensive culture of mullet *(Mugil* sp.) is being tested in estuarine areas of Northeastern Brazil, where yields of two metric tons/ha/year with no supplementary feeding have been reported (Vallet and da Silva, 1974), and experimental mullet culture is also being carried out in coastal lagoons in Cuba (Anon., 1976). Aside from this work, little has been done to explore the potential of marine finfish culture in Latin America, although croakers and snook are under study in Venezuela (Salaya, 1974).

The potential of marine fish culture must be viewed as long-term, except where there are natural sources of fry. The production of the fry of marine fish in hatcheries needs considerable research attention. While it is now a fairly straightforward process to induce spawning in ripe fish, procedures must be standardized for each species; hormone preparations must be made more available, reliable, and standardized; and methods of inducing maturation through

environmental manipulation or hormone treatment need study. The true bottleneck in marine fish culture, however, is rearing the delicate larval stages which are characteristic of most marine fishes, especially those with small, pelagic eggs. While progress in this area has been more slow than one would have hoped, the problems are probably not insurmountable. Hatchery-based commercial production of mullet *(Mugil cephalus)* is occurring now in Taiwan, and semi-commercial culture of red sea bream *(Chrysophrys major)* produced in hatcheries is being pursued in Japan (Japan Fisheries Association, 1975). Important technical developments have also occurred recently, such as the use of artificial larval feeds (Barnabe, 1976).

Beyond the hatchery stage, the problems of marine fish culture are very similar to those of fish culture in freshwater, namely the determination of the most appropriate production systems (e. g., ponds, cages) for given situations, the development of artificial feeds, and control of diseases. Genetic improvement is another prime area for concern which promises large returns to research efforts (Moav, 1976). A key element in fish culture is feeding and the costs of feeds. From this point of view, herbivores are most suitable for mariculture. In many instances, fertilization of ponds with inorganic or organic fertilizers may produce very respectable yields of herbivorous species without supplementary feeding. Besides mullet (see above), which are detritus feeders, there are probably a number of other marine fish species which feed low on the food chain and which could be considered for mariculture. Milkfish *(Chanos chanos),* which is the basis of the extensive brackish water pond culture systems of Southeast Asia, also occurs in Mexico and Central America and has been mentioned as a candidate for culture in Mexico (Ramírez-Granados, 1974). This and other groups of herbivorous or omnivorous marine fishes deserve research attention in Latin America. If enough attention is devoted to examining such fishes, it may not be too much to hope that true marine polyculture systems will develop analogous to the freshwater polyculture systems practiced in Asia, in which a variety of niches in one pond is filled by the various cultured species (Bardach *et al.,* 1972).

Although most species of *Tilapia* are freshwater forms, some, like *T. mossambica* and *T. aurea,* do quite well in sea water. Few studies of *Tilapia* culture in sea water have been carried out, but since various *Tilapia* species are already established in South America, such culture should be examined as a means of utilizing marine waters for the production of inexpensive protein for local consumption. It would eliminate the problem of larval rearing, which is presently such an obstacle to the culture of most marine fishes. Cage culture of *Tilapia* in freshwater is reported to be quite successful (Coche, 1976, 1977), and there is no reason why the same approach will not work with *T. mossambica* or *T. aurea* in sea water. The feeding habits of *Tilapia* are such that rations compounded from locally available plant materials may prove adequate (Coche, 1977). Experimental work on *T. aurea* cage culture in sea water has been conducted in Puerto Rico (Pagán-Font, 1974) and preliminary studies currently underway in Hawaii with *T. mossambica* are showing encouraging results (R. C. May and others, work in progress). Small-scale cage culture operations in inshore waters could probably be established with minimal capital and serve as subsistence or artisanal production units. This would only be possible, however, with adequate governmental support in the form of hatcheries, extension services, and research on appropriate feeds. Governmental hatcheries are needed to produce all-male stocks, either through hybridization (if saltwater-tolerant, all-male hybrids can be found) or through hormone treatment (Guerrero, 1975, 1976). In cage culture the problem of over-reproduction among *Tilapia* is eliminated (Pagán-Font, 1975), but all-male stocks would result in

enhanced growth rates and would reduce the possibility of invasion of local waters by escaped fish, which has been a ubiquitous problem with *Tilapia.*

The culture of carnivorous marine fishes, either in cages or in ponds, demands close attention to nutrition, particularly the provision of high protein ingredients in the diet. This may at first appear an unwise use of resources, as indeed it may be in some cases, but, as described below, fish culture can play a role in making the products of reduction fisheries available for local human consumption. There are also instances in which the availability of cheap trash fish, which may otherwise be wasted, can stimulate the culture of carnivorous species and thus turn the wasted commodity to good use (Chua and Teng, 1977). . In Latin America, areas with shrimp fisheries and discarded by-catches exist and could in theory provide large amounts of trash fish, which could in turn stimulate a substantial culture industry for carnivorous fish species. Most cultured penaeid shrimp species (as well as a variety of freshwater fish and crustacean species which are cultivated or under consideration for culture) also require high protein diets, and the foregoing considerations apply to them as well as to carnivorous marine fish. The increasing cost of fishmeal has already made trout and salmon culturists look for substitute feedstuffs (e. g., Fowler and Banks, 1976; Gropp *et al.,* 1976; Cross, 1977), and the recommendation has been made that local feed ingredients be investigated in Latin America (FAO, 1976 a). Various local feed sources for aquaculture in tropical areas have been suggested (Glude, 1976; see also, National Academy of Sciences, 1975), but clearly there is need for a comprehensive survey of such potential sources and feed trials with selected fish and crustacean species.

Another approach to marine fish culture is referred to as "artificial recruitment" or "culture-based fisheries." This approach involves producing fry in hatcheries and releasing them at a small size into the ocean for harvest at a later time, after growth has taken place on natural foods in the sea. Artificial recruitment is most well developed in the case of anadromous species, particularly salmon (McNeil, 1976), where it is usually called "sea ranching." In Latin America an interesting opportunity exists for testing the sea ranching of salmon. Joyner *et al.* (1974) have suggested that salmon be produced in hatcheries at the southern tip of South America and released into the West Wind Drift, where they could feed on the vast quantities of krill surrounding Antarctica, the harvest and utilization of which in any other way presents enormous difficulties. Returning salmon could be collected in large salmon traps. This approach would have the advantage of making the krill resource available for human consumption with little expenditure of energy, in contrast to the expense of a vessel fishery for krill. Possible problems include the unresolved legal question of ownership.

Salmon are not the only candidates for sea ranching. Calaprice (1976) lists 114 species of anadromous fishes, some of which might prove suitable for culture. The fish faunas of the Amazon, Orinoco, and Parana Rivers have not been fully explored and may contain other anadromous candidates for sea ranching. The artificial recruitment of non-anadromous species is another intriguing possibility. However, despite large-scale release programs for penaeid shrimp and red sea bream in Japan (Hanamura, 1976; Japan Fisheries Association, 1975) and suggestions for such endeavors elsewhere (Rao, 1977), this concept has yet to be proven. In tropical Latin America the sciaenids (drums and croakers) may offer potential for ranching analogous to that of red sea bream in Japan. Sciaenids are among the most popular foodfish in tropical Latin America, and because of their general inshore habits, released fish might be readily available to coastal fishermen. Encouraging

results have been reported recently for induced maturation, spawning, larval rearing, and growout culture of sciaenids (Colura, 1974; Frishman, 1975; Haydock, 1971; Luebke and Strawn, 1973; Upchurch, 1977). Ranching programs with such inshore species will be most productive if coupled with overall management strategies for the species concerned, including habitat enrichment (artificial shelters) and restrictions on sizes which can be captured. Prior ecological assessment of the area to be used would be essential; release of hatchery-rared fish might be ineffectual or even have a negative effect if adequate food is not available.

Implementation of mariculture development: A number of research tasks in mariculture have been mentioned here, but there are also other essential prerequisities to the full realization of the potential of mariculture in Latin America, as elsewhere. These include development of processing methods, creation of infrastructure, availability of technical services (e. g., supplying seed; producing feed, diagnosing and treating diseases, etc.), the provision of credit for mariculturists (Hamlisch, 1976), creation of extension services (Pillay, 1976 b), and, very importantly, the training of manpower. In order to implement programs to fill these needs, along with accomplishing the important multidisciplinary research tasks, organization is required on a regional basis, in conjunction with strong national efforts. This has been pointed out repeatedly during the last several years by international bodies concerned with the development of aquaculture (e. g., TAC, 1974; FAO, 1976 a; FAO, 1976 c). Concerning Latin America specifically, at the 1974 Symposium on Aquaculture in Latin America it was recommended that a Latin American Center for Aquaculture be established, to be closely linked to national aquaculture centers, with the objectives of undertaking research on problems of a regional nature, organizing training, compiling and disseminating information, and providing assistance in disease diagnosis and control (FAO, 1976 a). It was also recommended that close linkage be maintained with national centers where research, application of methods, and training could take place on a local level. FAO was encouraged to seek funding from such organizations as OAS, IDB, UNDP, and others, to establish the network of centers as soon as possible. The early stage of development of aquaculture in Latin America offers a unique opportunity to plan the future course of this development so as to avoid inefficient, piecemeal approaches. Merely holding annual meetings at which aquaculturists from all interested Latin American countries meet to exchange ideas and become updated, could have an enormously salutary effect. In this context it is most encouraging to note the recent creation of the Asociación Latinoamericana de Acuicultura, which held its first meeting in Venezuela in November, 1977.

Increasing the availability of marine protein: Increasing the production of foods from the sea can have several objectives, including increasing foreign exchange earnings, providing employment, and increasing the local availability of food. Production for export certainly has its proper economic and social role, but in view of the nutritional situation of much of Latin America, it would seem important to stress the provision of food for local populations who presently experience dietary protein deficiencies. This suggests that more emphasis on small-scale fisheries is called for, as well as on simple mariculture operations which can be practiced with little capital in inshore areas, such as the *Tilapia* systems discussed above. Such an emphasis is in agreement with a current trend of thinking among agriculturists, who see labor-intensive, small-scale farming as the most

effective way of increasing food production by, *and availability to* the poor segments of society (e. g., Wortman, 1975, 1976). The rural and urban poor do not have money to buy foods, but at least the rural poor can, with help, produce food, sometimes with surprisingly high efficiency.

Increased availability of fish in Latin America will be beneficial only if there is a demand for these products. The traditionally low rates of fish consumption in Latin America suggest that governments may need to promote fish as food, and fish promotion efforts have been undertaken by several countries. It may also be necessary in some cases to develop new products acceptable to the people. This could represent an opportunity rather than a liability, if the products developed are ones which resist deterioration and can be stored and transported, thus increasing availability in areas remote from the site of harvest.

Most of Latin America's marine food production comes from industrial fisheries, and it is important to consider ways or making this huge amount of protein more available to the people. Diverting an increasing proportion of the anchoveta catch to direct human consumption is an objective of the Peruvian govemment (FAO, 1976 d), and diversion of a certain proportion of the anchoveta catch is no doubt possible (Appleyard, 1973). But current opinion is that–due to the bulk of the catch, the small size of the fish, and deterioration–large quantities of anchoveta cannot be used in this way with current technologies (Popiel and Sosinski, 1973; Pigott, 1976). Hence reduction to meal and oil is "the only economically available technique" (Pigott, 1976) of dealing with this resource. Given this situation, there appear two alternative ways of increasing the availability of this protein to the people. One is to process it into a dried protein concentrate for human food supplements (Pigott, 1976), and the other is to use it for animal feed in Latin American countries rather than in North America and other developed areas. There appear to be technical and economic problems with the first altemative, although with decreases in price and improvements in flavor, inclusion of fish protein in local food products such as baked goods would be possible (Hulse, 1974). This could serve as a means of improving the nutritional status of people through use in institutional feeding programs (schools, etc.), and, where incomes are high enough, direct marketing. The second alternative–the development of Latin American animal production industries based in part on fishmeal as feed–would have the advantage of requiring no new technology. The availability of fishmeal could stimulate fish farming, both freshwater and marine, as well as poultry production, which is increasing in importance in developing countries (Biely *et al.,* 1971; Brant, 1974). Such animal production systems could serve as efficient means of utilizing industrial fishes and other nutrient sources which otherwise would be difficult to make into acceptable human food. If such products are to be available to the poor, however, they will have to be produced by the poor themselves or included in institutional feeding programs, since the poor by definition have no money with which to purchase them. These considerations, however, fail to come to grips with the major problem, which is the tremendous demand for the products of industrial fisheries on the part of developed countries and the consequent tremendous economic incentive for developing countries to export these products. Perhaps more emphasis on export *within* Latin America would be at least a partial solution, but it would be only partial because of the limited demand and purchasing power of most countries in the region.

RESUMEN

La tasa actual de consumo de pescado en América Latina es muy baja a pesar de la existencia de importantes recursos de pesquería en la región. En vista de la necesidad que hay de proteína adicional en muchas partes de Latinoamérica, se le debe dar una alta prioridad en la planificación nacional y regional al aumento de la producción y disponibilidad de productos del mar.

Un aumento en la producción de la pesca marina en América Latina puede ocurrir mediante la explotación de existencias que en la actualidad no se explotan o son subexplotadas, así como también por la reducción del desperdicio de la pesca actual, por medio de la utilización, tanto de la pesca no selectiva, como del desperdicio post-cosecha y las pérdidas en el momento del procesamiento. La mayor necesidad en la pesca, sin embargo, reside en la administración institucional que permita el manejo racional de existencias y que evite la pesca excesiva. Tal necesidad se hace aún más urgente por el establecimiento de las zonas de control económico de 200 millas

La maricultura es otro medio de aumentar la producción de alimentos del mar y su potencial en Latinoamérica parece ser grande, aunque en gran parte no explorado hasta el momento. La etapa precoz de desarrollo de la maricultura (así como de la acuacultura de agua dulce) ofrece en Latinoamérica una oportunidad para coordinar el curso futuro del desarrollo de la acuacultura en forma más amplia que la que ocurre en otras regiones del mundo en desarrollo. Se recomienda el establecimiento de una red latinoamericana de investigación en acuacultura, con uno o dos centros principales y varias estaciones secundarias. Tal red podría proveer el impulso necesario para el desarrollo de la acuacultura por medio del mejoramiento de la base tecnológica para el cultivo y por el efecto de adiestramiento y de la extensión a través de la investigación multidisciplinaria. Al inicio, la investigación debería examinar la idoneidad de especies locales para el cultivo y luego investigar sistemas de verdadero policultivo marino y la utilización de pienso localmente disponible y de abonos (incluyendo desperdicios agrícolas y otros desperdicios). Sean las que fueren las especies o los complejos de especies que se escojan para la maricultura, se necesita la atención esmerada de investigación de técnicas para controlar la reproducción. A la par de la maricultura y la pesca marina, al establecimiento de granjas piscícolas de especies anádromas y tal vez no anádromas, puede ofrecer un potencial significativo para el aumento de rendimiento en ciertas áreas, especialmente si se combina con el manejo general de estrategias para determinadas especies.

El problema de mayor reto en relación con los recursos de alimentos marinos en Latinoamérica es el aumento de la disponibilidad de alimento marino para el pueblo en general, especialmente para aquellos sectores de la sociedad que sufren una deficiencia proteica. El problema tiene una dimensión tecnológica en el sentido que implica la necesidad de procesar y llevar al mercado productos altamente perecederos, en situaciones en que no hay refrigeración, y de crear nuevos productos que sean aceptables por el pueblo en general. En tal sentido, el desarrollo del cultivo de peces y de cría de aves de corral basado en el uso de harina de pescado como alimento, puede constituir la manera más eficaz y práctica de hacer disponible para el consumo, los grandes recursos industriales de pescado de América Latina. El problema también tiene dimensiones sociales, económicas y políticas, puesto que el incentivo económico para exportar productos del mar puede contrarrestar el incentivo humanitario de dirigirlos hacia el uso local.

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Fig. 1. Numbers of people in Latin America at various levels of fish consumption (Data from FAO, 1971).

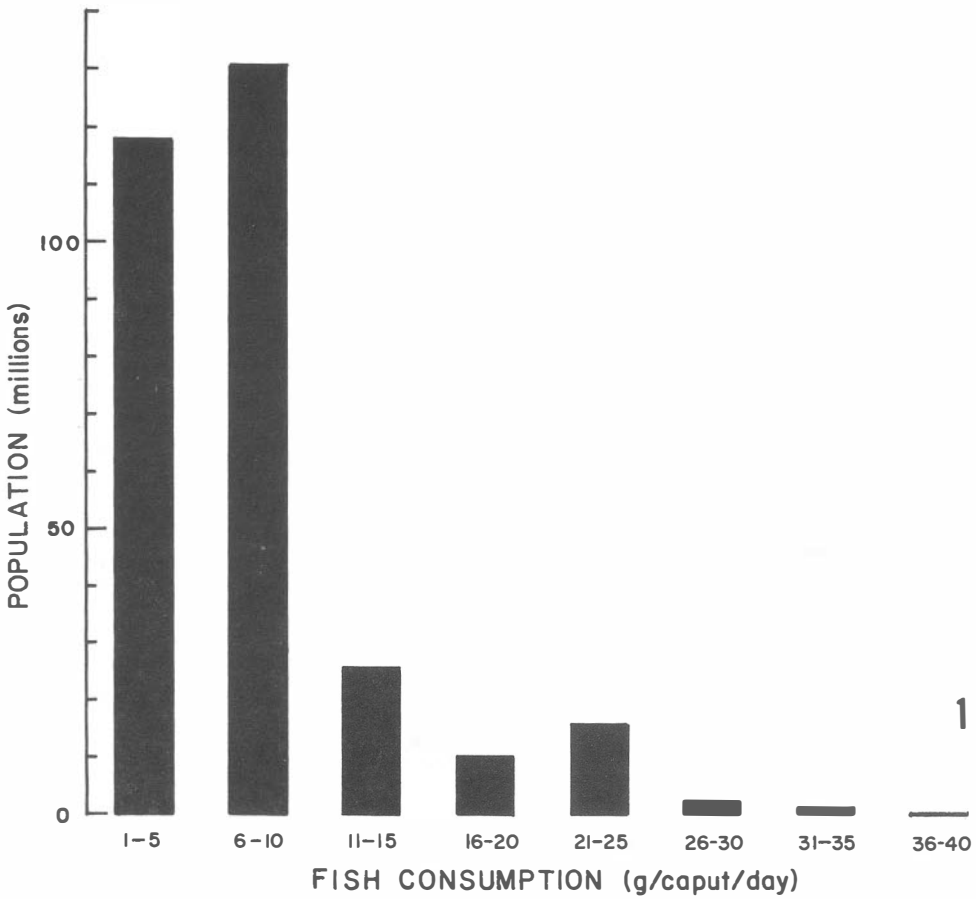
POPULATION (millions)
100
50
0
1
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
FISH CONSUMPTION (g/caput/day)

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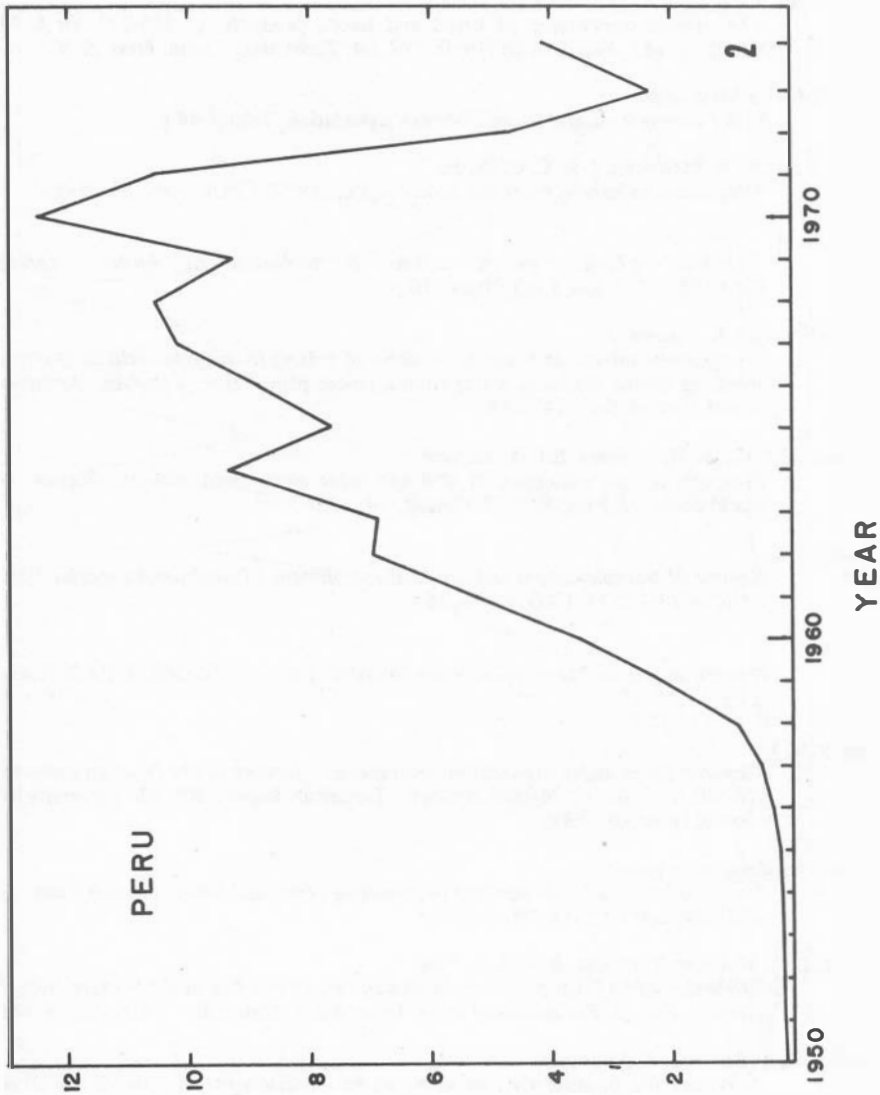
Fig. 2. Fish catch of Perú, 1950–1974. (Data from FAO Yearbooks of Fishery Statistics).


PERU
2
FISH CATCH (million metric tons)
12
10
8
6
4
2
1
1950
1960
1970
YEAR

Honda, K.
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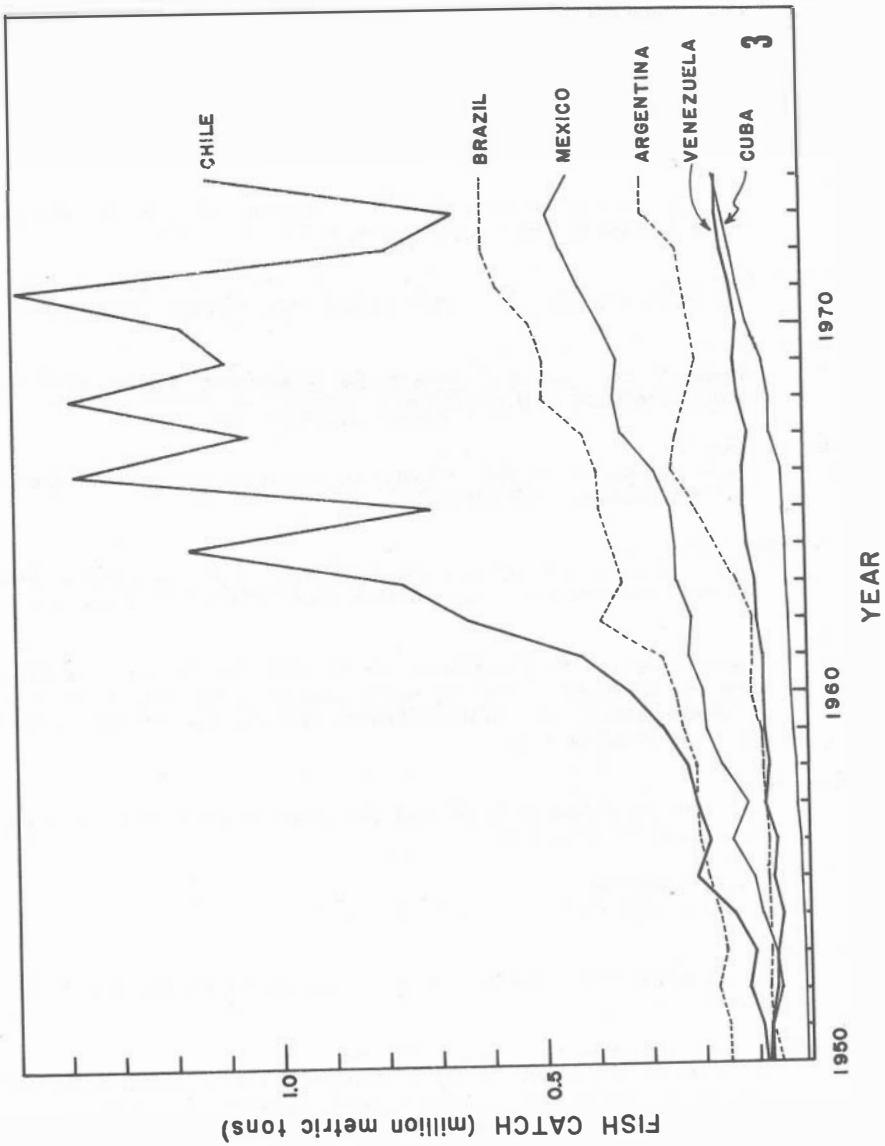
Fig. 3. Fish catches of six Latin American countries, 1950–1974. Along with Perú, these countries represent the leading seven Latin American fishing nations; in 1974 they contributed over 93% of the total Latin American fish catch. (Data from FAO Yearbooks of Fishery Statistics).


CHILE
BRAZIL
MEXICO
ARGENTINA
VENEZUELA
CUBA
3
1.0
0.5
1950
1960
1970
YEAR
FISH CATCH (million metric tons)

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