POTENTIAL FOR THE DEVELOPMENT OF AQUACULTURE IN THE INDO-PACIFIC REGION

by

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Summary

The paper describes those features of aquaculture which make it a more advantageous means of protein production than agriculture. In many countries a failure to understand the very considerable potential for aquaculture has been one of the main reasons for the failure of this form of food production to play a greater role in the regional economy. The paper indicates the favourable opportunities for aquacultural development in the Indo-Pacific area drawing attention to those species which are likely to yield the best results. The possibilities of bringing new areas under cultivation are discussed as well as methods of improving present cultural practices. The need for the better dissemination of information and improved institutional support is also discussed.

1. INTRODUCTION

A conservative estimate of the world population in year 2000 is between 6 - 6.5 billion people or double the present number. Over 80 per cent of this population will inhabit the so called developing countries, and among the many social pressures associated with overcrowding will be continuing demands for spatial freedom and particularly for food.

An extension of existing and improved agricultural practices, for example, better husbandry and the production of fast growing disease resistant strains of cereals and crops, will keep food production (if not distribution) in line with human protein intake requirements for some time to come. But as competition for the remaining available land increases, there will be a greater need to supplement these requirements with food from aquatic resources. Prominent will be the need for animal proteins which these aquatic resources can uniquely supply.

The natural resources of finfish and shellfish are finite. The total world catch presently fluctuates around 65 million metric tons per annum (Table 1), but there is no guarantee that the catch can increase annually. Estimated total sustainable yield from the seas varies widely but of the types of fish currently harvested, it is probably not much more than 100 million metric tons per annum. Of the present annual harvest of the seas only 75 per cent is used for direct human consumption, the remainder is processed into animal feeds, fertilizers or other products. However, the 75 per cent consumed directly represents about 15 per cent of the high quality animal protein required annually to sustain the world's present population.

Table 1

Total world nominal catch

Year	Million metric tons
1964	51.9
1965	53.2
1966	57.3
1967	60.4
1968	63.9
1969	62.6
1970	69.6
1971	69.7
1972	65.0
1973 prelim.	62.2

Bio-engineers visualize the production of a variety of acceptable protein concentrate for human consumption from other sources. Already a number are being produced or are bein developed. For example, the production of protein by the fermentation of low grade petroleum or the intensive culture of single cell yeast, algae or bacterial organisms, often in association with certain industrial processes, are all now recognized techniques. But natural protein is more desirable and culturally more acceptable than any artificially created meal, however nutritious or palatable. Intensive work is underway on upgrading

land animal husbandry in the tropics, but fish culture remains relatively neglected alth the majority of aquatic animal resources have a higher percentage of animal protein by weight than terrestrial resources, and religious and national customs frequently favour intensification of production of aquatic protein.

Agricultural production is also inhibited by the present high demands on the availa freshwater resources of the world. Rising household freshwater consumption, increased industrial demands and the loss of water resources through pollution, all contribute to a stabilizing if not lessening of land-based activity. The oceans of the world and particularly the brackish water coastal regions therefore offer advantageous prospects for developing new food resources.

2. THE IMPORTANCE OF AQUACULTURE

It is significant to note that finfish and shellfish are the most vital source of animal protein in the diet of the peoples of Southeast Asia, China, the Pacific Islands and India, and contribute extensively to that of the peoples of Africa and the Middle East.

Where the pressures of food shortage and malnutrition are the most acute, aquacultu is a tempting alternative to the intensive production of other animal proteins or aquati plants. Many indigenous peoples, particularly in Asia and the Pacific, have strong fish eating traditions and have practised farming in fresh and brackish waters for many centuries. These traditions offer an invaluable foundation for rapid food-programme development with the necessary financial and technical support. Unfortunately, the leve of skill and experience in these countries varies markedly. For example, the long established practices of Southeast Asia are in advance of all other developing regions but, in general terms, there exist many nuclei of indigenous people skilled in fish handling yet in need of further technical advice and scientific help.

The attributes of aquaculture that recommend it over other intensive animal production schemes under consideration for development in the regions are summarized below:

land marginal to or even unsuitable for agriculture can be brought under cultivation,

existing ponds and undeveloped swamplands can be used,

large areas of unutilized coastal mangrove are available,

many coastal areas are free from industrial pollution,

farming aquatic species is traditional,

labour intensive nature of the technology provides additional opportunities for skilled and unskilled labour,

The potential of aquaculture has long been recognized by established international development organizations, and effort and funds have been expended with individual national programmes throughout the world. The programmes have not been without success but also not without problems, and difficulties have been experienced both by the agencies concerned and by the nations involved. Most nations have received technical advice from foreign experts in desired fields and have been disappointed. The experts have not been oriented to the background of the peoples and to their problems and their recommendations have, in many instances, been too technical or scientific. Disregard of socio-economic factors, for example, a lack of local credit and low interest bank loans, have also contributed to the problems. Yet the international agencies, by their constitution, must consider each individual request for aid. Many nations within a region submit similar requests for programmes but the agencies experience difficulty in encouraging a united project as each wishes to take advantage of available funds.

Concerning research, in view of the similarity of problems, attempts have been made recently to encourage a regional programme. So far, progress in this respect has been rather limited, partly due to the site-specificity with regard to ecology and diseases as well as other problems which make the centralisation of research impracticable. In order to avoid duplication of effort, however, attempts are being made to strengthen work at particular centres on key problems concerning specie groups of wide regional interest.

3. THE INDO-PACIFIC REGION

Originating in China, and then spread by migrants through Southeast Asia and India, traditional fish culture practices based predominantly on the carp have become highly developed skills throughout the Indo-Pacific region. With the exception of India and Pakistan (about 5 per cent), fish is already the most important source (over 50 per cent) of animal protein in the diets of the peoples of the region, although the total animal protein consumed is, in many cases, well below the acceptable minimum requirement.

Fisheries production in Asia continues to lead that of all other continents (Figure 1) (FAO Yearbook of Fishery Statistics, 1971). In order to sustain this necessary position from capture fisheries most of the nations of the region have individually or jointly promoted and intensified fishing operations. However, the potentials of the vast brackish water coastal regions have not featured greatly in national priorities, and it is the exploitation of these coastal areas through aquaculture that will play the vital role in attempting to meet the necessary protein demands.

Fig. 1 World nominal catch by region and year

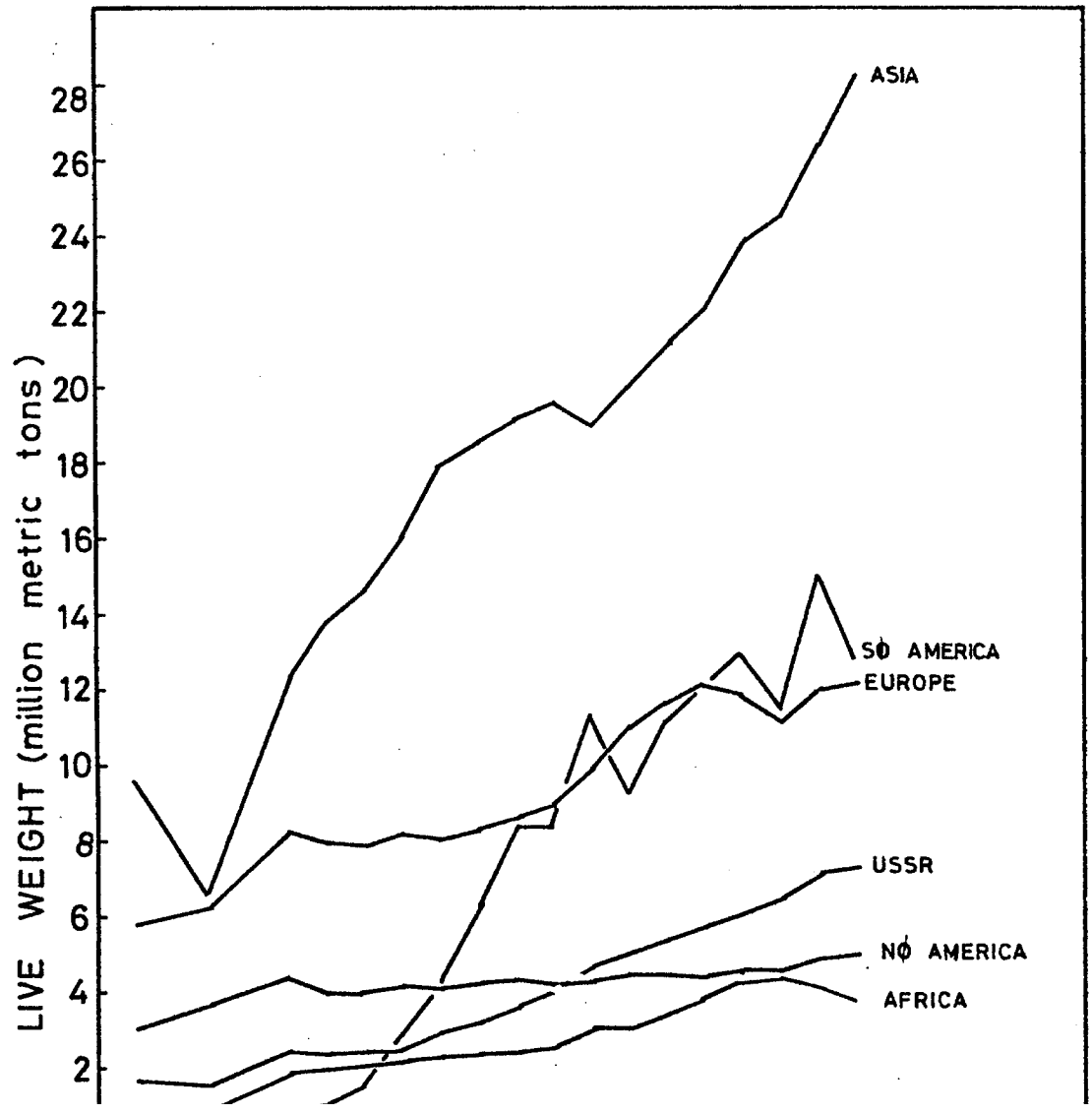

Table 2 - Estimated Area of Cultivable Inland Waters in the Indo-Pacific Region

hectares

	Fishponds						Wet rice fields						
	Fresh water	Brackish water	Natural lakes	Artificial lakes, reservoirs, tanks	Salt or mangrove swamps suitable for fish culture	Lagoons and estuaries suitable for fish culture	Without fish culture	With fish culture	Total inland waters	Area of arable land	Total area of country	Percentage of inland water to total area of country
he	-	-					510,000	-		8,754,000		
)	10,318	112,921	1,500	10,000			520,000	8,000				
	130	60	-	214	1,200	5,700	8,080	200		15,584	10,000	15.58
	337,980	2,671	725,783	179,943	121,166	264,444	5,762,792	1,619	7,396,398	123,820,000	316,100,000	2.34
	9,000	110,000	417,130	27,000	6,000,000	8,500,000	4,500,000	67,000	19,630,130	11,010,000	189,200,000	10.38
	617	-	21,000				2,991,100	8,500	3,021,217	5,992,000	38,200,000	7.90
	120,000	-	350,000	500		72,000	1,400,000	-				
							1,226,400	-		1,954,144		
id	105,000	24,600	30,100	68,500	305,200	424,000	43,400	12,000	1,012,800	21,000,000	94,300,000	1.18
			80,000	-	500,000	100,000	-	-				
	50	85,000		230,000		500,000					29,741,290	
		253	-	-	-	-	-	-	253		70,000	0.36
	-	-	-	8,000	-	117,000	350,000	-	547,000	1,469,000	6,600,000	8.29
	-	-	-	50	195,000		17,500	-	212,550		19,100,000	1.11
	100		25,700						6,161,000	4,751,000	50,000,000	12.37
	-	850	-		-							
p.	25,000	2,000	3,000	2,300	14,400	54,025	4,067,990	1,550	4,170,065	3,200,000	32,800,000	12.71
ia	150	-		500	300,000	-	314,500	45,500	660,650	2,129,000	13,530,000	4.88

Data from Hora & Pillay (1962) in Table 2 indicate the extent of the cultivable inla waters (including estuaries, salt and mangrove swamps, lagoons and rice fields) in the In Pacific region, of which the greater part could be developed for fish culture. The vast tracts of undeveloped mangrove regions in Indonesia and the Philippines alone (over 5 million hectares) could yield an estimated 400,000 tons of aquatic animal protein if only 20 per cent were utilized.

Although an extensive region of the world, the Indo-Pacific area has innumerable lin on which to forge regional fisheries programmes. Basically tropical and sub-tropical, th region is characterized by the same or closely related aquatic animal species, a natural dependence on rice and therefore already operating a water-based food production system, preference for fish in the diet, and large areas of similar aquatic habitations. By concentrating initially on a few species of finfish and shellfish throughout the region, and developing generalized but effective farming techniques, sufficient impetus can be given any food production programme to show positive results within five years.

4. WHICH SPECIES TO FARM

Systems of "total package" oriented research have led to the green revolution successes with man's three staple cereals, wheat, rice and maize, all within the last two decades. It is, however, important to note that in aquaculture development there is a wi range of organisms representing most of the animal phyla, the domestication of which, by and large, has not yet begun. It is clear, as a general guideline, that herbivorous and filter feeding finfish and shellfish offer the cheapest and most immediate prospects for producing high yields of animal protein. Many have already been reared successfully in l density on natural vegetation grown by natural fertilization in freshwater or tidal ponds and lagoons. But, it has also been demonstrated through intensive management methods and supplemental feeding with vegetable wastes (e.g. rice bran or soybean meal, etc.) and by careful use of both organic and inorganic fertilisers, that the production from the same volume of water can be dramatically increased.

Carnivorous aquatic animals, many of which are luxury fare when cultured and maintained in captivity, have high feed costs and require more elaborate facilities and advanced husbandry. Consequently they are expensive to produce and the need to introduce a higher technology to manage them are distinct disadvantages. The main asset of producii such desirable fish or crustacean species is their value in commerce, particularly in foreign exchange if the product has export value.

A significant factor to date in the failure of aquaculture to meet the early forecasts of success has been the great diversity of effort. This has been caused by the general reaction to a new technology, particularly by the lack of comprehensive national and international direction and the multitude of target aquatic species that had local commercial significance.

No aquatic animal species, with the possible exceptions of carp and trout, have the wide geographic distribution or universal acceptance of the domesticated cereal staples and traditional land animals. Incipient aquaculture schemes all over the world, again with the possible exceptions of carp and trout, rely on local species to achieve with aquaculture the success implicit in domestication. Any regional programme with aquacultu to provide protein for the future on a massive scale must concentrate initially on the production of a limited number of selected species. Selection must be based on several considerations, amongst which are:

the desirability and ready consumption by a wide variety of people,

wide geographic distribution,

feeding habits,

freshwater, brackishwater or seawater requirements for all or part of its natural life cycle,

suitability for polyculture,

a number of closely related sub-species for cross-breeding,

the length of its life cycle and growth rate,

the existence of farming techniques,

suitability for storage or preservation by both primitive and advanced methods,

association of cultural or regional objectives.

Few fish and shellfish come close to fulfilling all of these considerations satisfactorily, but there are a number of species which would be included in a final list from which to make priority selections. The headings under which these are listed below reflect not only their biological attributes but also indicate three basic development themes which regional programmes must consider.

Freshwater Species:

Chinese and Indian carp fishes
mussels
prawns
carp fishes
gorami fishes
catfishes

Brackishwater Species:

mullets
mussels
shrimps
milkfish

Marine Species:

bivalve molluscs
mullets

Marine species are least advanced toward domestication. It is believed nevertheless that they represent a substantial long-term development potential, particularly the cultur of mussels and oysters along the interface of the brackishwater and true marine environmen

Top priority among the fresh and brackishwater species must be given to the omnivores, herbivores and detritus feeders. Attention must be given to the several varieties of the omnivorus mullets and the milkfish. The mullets, Mugilidae, have an exceedingly broad geographic distribution, are highly desirable throughout all developing countries and can be commercially valuable. Their environment requirement covers both brackishwater and marine waters. The international Biological Programme in 1969 named the mullets first in a group of important organisms for worldwide study, and the Food and Agriculture Organization of the United Nations is presently encouraging scientists to co-operate in an unfunded programme on the species.

The milkfish, Chanos chanos, are the predominant species presently cultured in Southeast Asia, particularly in Indonesia and the Philippines. The production of this large and cheaply cultured fish can be increased considerably provided that the natural resources of juveniles can be guaranteed with supplies supplemented from hatcheries. Priority should also be given to the freshwater Indian and Chinese carps, Cyprinidae. A great deal of information on the vast carp family is available and some genetic programmes are well established. There are also considerable skills existing in farm management and animal husbandry.

Shrimp and prawns, Macrobrachium and Penaeus species, are very attractive for their commercial value but when reared in monoculture are expensive to produce. Reared in association with pelagic fish species as an ancillary crop will make their cultivation of considerable importance to almost every aquaculture programme.

24. The catfish, Clarias and Heteropneustes species, Lates species, eel, Anguilla species and mussels, Mytilus species all can contribute significantly to pond production. Many will be highly suitable for polyculture practices, providing the producers with a variety of both subsistence and commercial crops.

5. DEVELOPMENT OF FARMING PRACTICES

Concentration on a few high priority species alone is not sufficient to develop a satisfactory regional programme. Simple but effective farming practices have to be developed in order to establish production over a wide area in the shortest possible time through practical demonstration. Throughout the region there is a high degree of practical skill using long-tried and established techniques, but in order to increase its effectiveness considerable attention must be paid to the following.

5.1 Improving Present Practices

In general terms the average production of milkfish throughout the Indo-Pacific region is about 450 - 500 kg/ha. Recent experiments in China and elsewhere have doubled this production by simple expediencies; for example, improved pond design, controlling density of stock, limiting competitors and other general husbandry improvements. Such practices have induced others to follow suit, and increases in the production of catfish (threefold), shrimps (tenfold), eels (threefold), mullet (twofold) and mussels (150-fold) have been demonstrated at a number of locations throughout the world.

Simple demonstrations of polyculture have been made in Southeast Asia using a variety of prime crops within enclosed ponds. In the Chinese province of Taiwan experiments using the eel as the prime crop but with associated populations of carps and mullet, have demonstrated yields of 8,000 kg/ha. In Israel, mixed cultures of carp, tilapia and grey mullet yield over 2,500 kg/ha. The practice of polyculture can therefore give significant higher yields per hectare than the existing regional average under monoculture and, of course, considerably higher revenue.

Improved practices for shrimp culture have centred on attention to water quality, which is indirectly associated with improved enclosure design, maintaining water exchange, controlling density, reducing competitors, improving nutrition and avoiding disease or conditions which induce disease. By such practices, the Japanese have increased productic in ponds from 350 kg/ha/annum to 3,000 kg/ha/annum.

The last thirty years have seen a revolution in the practices used to culture bivalve molluscs. Using suspended culture methods to take full advantage of the full depth or water column, the culture of mussels and oysters has reached enormous proportions. Yields of 600,000 kg/ha/annum of mussels (wet weight) are common in areas of Spain and in parts of South America by constructing floating rafts from which are suspended the ropes contair ing the mussels. Oysters grown in the same way have been equally spectacular although considerably less in quantity. The new technique has rapidly demonstrated the inefficienc

of traditional bivalve farming methods using submerged tracts of coastal territory, regularly ravaged by weather and predators. Hanging baskets, floating cages and netted areas have all been effective demonstrating the need for additional engineering expertise to obtain the greatest production of aquatic products from the smallest volume of water in the most effective and controlled way.

5.2 Increasing the Available Areas for Culture

Good design and construction of enclosures is essential for improved production and, together with attention to maintaining water quality and limiting competitors, the new areas of ponds or enclosures which can and must be developed have to be planned and engineered correctly. Wholesale clearance of mangove swamps and the unplanned development of coastal areas without the necessary thought and planning will do irreparable damage. The natural productivity of the extensive brackishwater regions contributes significantly to the development of the offshore fisheries, and these cannot be impaired.

Specific areas for fish culture must be detailed and surveyed. Properly engineered clearances can then be started, probably constructing a number of ponds in series so that buffer zones of mangrove and untouched areas can be left to maintain the natural populations which contribute to the richness of the environment.

The magnitude of the undertaking should not be minimised and considerable investment in the right equipment is essential. It has been estimated that US$ 500 per hectare is required to clear the average type of swamp and mangrove area, and up to US$ 2,000 for tidal land. Considering that at least a million hectares can be developed in the Philippines and Indonesia alone without impairing the character of the region, a substantia development fund is needed.

Although extensive practices exist for the cultivation of fish in association with the cultivation of rice and other animals, there are opportunities for this to be increase Although rice is the prime crop and the associated culture of finfish or prawns takes seco place, the low density culture of a number of species in the rice paddies does and could contribute more to the subsistence requirements of the people of many inland settlements. The production of ducks on inland ponds has been demonstrated as another source of animal protein at little added cost. The holding of pigs and other domestic animals in buildings constructed over ponds and enclosures to fertilize the water has been practised for centuries, long before modern agricultural methods adopted a similar system for intensive rearing and concentrated fertiliser collection.

Regrettably, the development of improved rice production procedures and other intensive agricultural systems has brought the problems associated with widespread use of pesticides. The residuals of pesticides are transferred by water and accumulate in ponds and along the coastal regions adjacent to estuaries. Serious directives must be given by national governments to enforce a policy on the use of pesticides and to restrict their use only to those known to have a short effective life span. The development of mineral resources in the Indo-Pacific region has also contributed to an increase in pollution of rivers and coastal waters. The dangers from metallic ions on aquatic life cannot be over-stressed and controls must be enforced by local governments.

5.3 Dissemination of Information

Well-intentioned development programmes will never succeed without good dissemination of information and an understanding of local socio-economic and religious beliefs of the people. The most practical method of achieving instruction of farming techniques is by demonstration, observation and manual involvement.

Many facets of the technology of aquaculture still require pilot scale operations to permit their introduction on a commercial scale. It is believed that these pilot scale facilities can be focal points for instruction and demonstration. These centres will

therefore be the key to developing any new production programme. Individuals can then return to their homes and apply the methods modifying the techniques and selecting the species to suit their own local economic conditions and religious requirements. Extensio services will then be required to follow up on the basic instruction, giving advice on methods, the use of fertilizers, and water and soil quality problems peculiar to each location. Preferably, the extension service advisers will be nationals of the country and familiar with local social attitudes. In addition to trained personnel for extension services, programmes will require simple illustrated instruction manuals and brief information sheets on such things as techniques, parasites, diseases, suitable aquatic plants and prevention of pond erosion, to name a few.

5.4 Associated Technology and Research

Aquaculture production cannot be increased simply by the opening up of new territori selecting a few priority species, and then demonstrating what to do. Aquaculture has one fundamental stumbling block both for the commercial developer wishing to raise a high priced shellfish and for the subsistence farmer wishing to survive. The problem is obtaining sufficient resources of seed to grow on the farm and the magnitude of the problem can be seen from the following facts. For example, to conserve the yellowtail the Japanese government has limited the number of juveniles taken from the sea for farms to 31 million per annum. Commercial shrimp and flatfish farms are estimated to require respectively 200 million post-larvae and 25 million juveniles per annum to be economical. The existing milkfish seed collecting industry throughout Southeast Asia involves the distribution of literally hundreds of millions of fry each year.

The natural resources cannot bear any greater demands made on them, and the supplies for any species must be raised through extensive local hatchery operations parallel to those of the Pacific salmon hatcheries operated in the United States. Unfortunately, hatchery techniques are not as developed as those for Pacific salmon and a great deal of technical development has yet to be achieved to breed species in captivity and mass-propagate large numbers of juveniles ready for transfer to the farm.

Allied to this first domestication process of completing the life-cycle in captivity is the need for technical improvements and research in nutrition, the control of disease water quality control. These can then be followed by the first real steps in progressiv aquaculture which will be genetic improvement through selection, cross-breeding and lineage. Only then will aquaculture be initiating the first steps towards the real domestication of aquatic species following and emulating the long history of the culture of the Chinese carp.

Technological and research programmes must be directed for the species most importa to the success of the regional programme. For the most part they will have to be based within the region and used as centres from which the technical results can be disseminat to the pilot scale operations and to the extension advisers.

5.5 Preservation, Distribution and Marketing

Finally, increased attention is necessary to reduce the present wastage from spoila and bad preservation practices. The majority of aquatic products are traditionally drie cured or smoked which, for the most part, can all be highly successful. However, consid able spoilage does occur through neglect during storage and from vermin. It is essentia to establish satisfactory and cheap storehouses and improved methods in any development project.

Improved quality control regulations have to be established for wider distribution of farm produce and also for marketing. Present distribution of farm fish is mostly restricted to the local area as there are virtually no transportation mechanisms. These together with storage centres, packaging and marketing systems, have to be established a controlled by qualified personnel to establish the quality of the produce.

In addition to the need for credit and low interest bank loans to establish hatcheries and farms, the same socio-economic requirements will be necessary so that distribution and marketing infrastructures can be established.

6. SUMMARY

In summary, aquaculture has fallen short of predicted goals in the last decade for several reasons. Primarily, clearly defined priorities have been lacking because of the failure of nations or international organizations to consider aquaculture on the same level as agriculture, or to establish a programme orientating aquaculture to massive food production, or to encourage a limited number of commercial enterprises. For programmes which have been started development has been incomplete because of inadequate funding for the more expensive pilot test facilities. Independent research and development, which has been encouraged and funded in small increments in widely scattered parts of the developed and developing world, has tended to isolate technological discoveries from practical production and the people who would apply them.

In order to accelerate the transition of aquaculture from the laboratory to the field before the turn of the century, three requirements are crucial:

1. Flexible organization, which is target oriented to focus the widely generated academic and applied research, fill the research gaps, pilot the production process of a limited number of desirable food species at new field sites in selected regions, and train indigenous personnel for eventual large scale applications.

2. Concerted financial support to assure the necessary facilities and the development work for a decade and more.

3. Recognition of the need for unified effort by all nations in the target region or regions, and to have the agreement of these nations to participate in a programme.

The benefit of aquaculture to the developing world in terms of potential food production must not be under-estimated. Given the resources of seed stock, the area is certainly available to make aquatic farming extremely productive.

Preceding regional programmes with staple cereals indicate that international efforts applying modern technological methods to traditional practices are accepted and produce beneficial results. In the Indo-Pacific region subsistence aquaculture is probably as old as the farming of rice. An intensive aquaculture programme has therefore the greatest chance to succeed, however, for it to be effective meeting the anticipated animal protein demands within the next thirty years, time is short. Hence there is an acute demand for regional conceptualization, international effort, adequate and prolonged funding, capable direction, and an eagerness to see such a programme succeed.

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