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PROGRESS OF MODERN AQUACULTURE

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Contemporary times are witnessing a worldwide upsurge in aquaculture which made itself felt first about a decade and a half ago. A number of factors appear to have contributed to the upsurge. First and foremost perhaps was the shakening of faith in the inexhaustability of the marine stocks of demersal as well as pelagic fish, so destructive, intensive and extensive have methods of fishing become despite controllability of fishing effort, regulation of gear and mesh based on studies on dynamics of exploited marine fish populations. Next is the helplessness of man to control oceanic phenomena on which recruitment, survival and eventual abundance of different age-groups of marine fish and their migrations mainly depend. The case of 'El Nino', highlighting the 1972 crisis of Peruvian anchoveta, *Engraulis ringens* is a pointer to the unpredictability of continued natural abundance of onetime prolific fish. To these causes may be added to great oil spills exemplified by bursts of oil tankers *'Tory Canyon'* and *'Amoco Cadis'* which rendered vast oceanic areas into biological deserts, not to speak of apparently naturally occurring red tides discernible here and there time and again. This is notwithstanding the highly potent dangers of agricultural pesticides, more especially their aerial spray, to which aquaculture is unavoidably exposed and the unintended disharmony between modern agriculture and aquaculture. Finally, a positive factor for aquaculture is a desire on the part of man to acquire control on biological processes of fish reproduction, survival and growth and the encouraging results attained in artificial breeding and culture in hatcheries of some of the world's cultivable and cultivated species of fish inhabiting fresh, brackish and marine waters in different parts of the globe.

Chronologically, despite general recognition that the greatest potential for aquaculture lay in the tropical countries and realisation that China and India were perhaps the traditional cradles

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of the art of aquaculture of Chinese and Indian carps respectively, aquaculture research in the sixties largely remained focussed on the temperate and subtropical species of fish. This period saw the growth of very diverse and lucrative aquaculture industries of Japan; smaller but intensive growth of aquaculture in Israel and Taiwan and the Salmonid and the channel catfish industries of Europe and North America.

Aquaculture approach on tropical fish by and large remained artisanal and empirical in the aforesaid period. The first major international symposium on warmwater fish culture was held in Rome in 1966 under the auspices of the FAO which brought out that many of the problems hindering aquaculture development of warmwater fish could be attributed to inadequacy of research base, and, as a remedy, it was agreed that FAO should assume a leading role in promotion and coordination of research for aquaculture development. This lead to the establishment of regional limbs of the FAO, notably, the European Inland Fisheries Advisory Commission (EIFAC), the General Fisheries Council for the Mediterranean (GCFM), the Indo-Pacific Fisheries Council (IPFC) and the Committee for Inland Fisheries of Africa (CIFA) and a number of working groups and working parties on aquaculture and Cooperative Programmes of Aquaculture research (COPRAQ's). Other international funding agencies which were quick to lend support to a number of programs on aquaculture, research, training and development were the International Development and Research Centre (IDRC) of Canada, the International Foundation for Science (IFS) with financing from Sweden and Canada and later France. The Overseas Development Administration of the U.K. (ODA) and the United States Agency for International Development (USAID) also supported a considerable number of aquaculture projects concentrating on development and training.

In the S.E. Asiatic Region, in 1973, and then member nations of the Southeast Asian Fisheries Development Centre (SEAFDEC), viz. Japan, Malaysia, Philippines, Singapore, Thailand and Vietnam established a department for research, training and development of aquaculture and Inland Fisheries in the Phillippines.

A working party set up by FAO's Advisory Committee (TAC) of Experts on Marine Resources Research (ACMRR) in cooperation with the International Association of Biological Oceanography, broughtout that the Cooperative Programmes of Aquaculture Research (COPRAR) were inadequate and not commensurate with the research needs of aquaculture. They recommended greater financial and institutional support in aquaculture through;

(1) Consulative Group of International Agricultural Research (CGIAR) to fund research programs; (2) to strengthen FAO's aquaculture programs; and (3) hold a second world concerence on Aquaculture.

The Technical Advisory Committee (TAC) of the CGIAR set up its own working group which reviewed (Spoleto, July 1973) the culture systems and research priorities and, basing their recommendations on constraints and lacunae in knowledge of aquaculture which hinder effective fulfiment of aquaculture potential, indicated a wide range of critical problems in the various regions of the world, which, if solved, could contribute substantially to enhance production through aquaculture. Aquaculture of tropical species as a science lagged way behind agriculture and until and unless the critical technical problems facing cultivated warm water species were satisfactorily solved, commercial aquaculture was not possible. The more important problems related to : (1) fish breeding and seed production; (2) fish nutrition, food and feeds (3) genetic selection and hybridisation; (4) intensification of culture systems including polyculture; (5) aquaculture engineering; and (6) Aquaculture-farm management. To this may be added the important problem of selection and induction of new species into the fold of aquaculture, monoculture as well as polyculture.

While TAC of the CGIAR took stock of the then prevailing state of science of aquaculture, a further sub-committee of TAC reported in 1974 that due to shortage of trained personnel to carry out aquacultural research, CGIAR should make a limited start by tackling certain specific research problems on priority species. FAO requested for assistance from United Nations Development Programme (UNDP) to carry out an Aquaculture Development and Coordination Program (ADCP) which, through a series of regional workshops, highlighted the more acute regional problems of aquaculture, approaches to solving those problems and on the need for location-specific research on indigenous species of fish. Regional aquaculture research centres under ADCP were then established in Asia, Africa and Latin America to conduct multidisciplinary, systems-oriented research on a wide variety of regional species. Establishment of a Net-work of Aquaculture Centers in Asia (NACA) followed and China was later added as one of the regional centres. Intra-regional collaboration and sharing of experience within a network of regional centres and a series of outreach stations in every region is within the framework of the ADCP programme.

The FAO Technical Conference on Aquaculture held in

Kyoto, Japan, in 1976 has become a landmark towards taking stock of the then prevailing state of all technical aspects of science and economics of aquaculture on a global basis. The comprehensive recommendations of the conference, if and when followed, would tend to lead aquaculture to an ideal level of fulfilment to meet the needs of the human race.

As time marches, and research effort multiples, it is to be made clear that there are two aspects of research which need to be pursued - these are research basic to aquaculture on which mainly hinges applied research leading to development and commercialization of industrial aquaculture. The latter is variously termed as development - oriented - research; operational research (testing of operational hazards of large - scale aquaculture); problem - solving - research (Problems of commercial aquaculture) etc.

Present day aquaculture is generally described in knowledgeable circles as a high risk bio-industry. The high risk element of this bio-industry arises from chances of loss of crop at any stage of its progress (i.e., hatchlings, fry, fingerlings, table-sized fish or intermediate stages of development), at a slow or sudden rate of partial or total loss in a unit, due to incidence of disease and/or advant of adverse weather conditions and above all, not infrequently, by poaching or large-scale thefts. A contributory factor to high risk element also arises from the state of scientific and technical knowledge and its field application to individual steps that, in their totality, make aquaculture an industrial enterprise. By and large, carp culture so far is more a state of art with packages (Jhingran & Pullin 1988) of empirically developed practices going with the tag of one system or the other, e.g., the Chinese system, the Taiwanese system, Indonesian system, Indian system, etc. The impact of science has just begun to be felt but a great deal of headway still remains to be made to impart to aqauaculture the benefit of multidisciplinary systems oriented research which aquaculture urgently needs. Such systems approach has benefitted the poultry industry in the past with which aquaculture is generally compared. For example, hypophysation as a technique of breeding carps, through a big leap forward towards infusion of science into aquaculture, has fallen in a rut and is tending to remain at a hit and run level rather than a fool-proof, cause and effect based approach to carp breeding and multiplication. Similarly, pond manuring and fertilization and related production of natural food for the hatchlings and fry, its inevitable linkage with pond based soil and water chemistry have still not been fully done to give it the status of science and one is left again with package

of practices under one system or another.

There are usually several alternatives for practically any step of aquaculture that one can think of, with no one approach comprising a major break-through fully developed to fruition which could be considered as establishing a leading system for explosion of carp production like the high yielding dwarf varieties of certain cereal crops in the allied field or agriculture.

It must be stated here that fish are better food converters than birds and mammals, so much so that they have about double the amount of protein than chicken for the same amount of calories supplied as inputs. (National Academy of Sciences, Washington D.C. U.S.A., 1977). This relative advantage of fish over birds and mammals bases itself on the facts that fish have the same body temperature as their environment and no energy is expended in maintaining a constant body temperature regardless of that of the environment (i.e., fish are poikilothermic rather than homoiothermic which the birds and mammals are) and have a water-borne body i.e. water supports their mass. Also, perhaps most aquatic animals grow faster in warm waters than in the cold and, therefore aquaculture is more eminently suited for the tropics. In fact, 70% of the present day aquaculture produce comes from the tropics, especially South and S.E. Asia.

Pillay (1976) was the first to estimate aquaculture production on a global basis. Gulland (1971), among others, has furnished marine fish production of the world projecting it upto 2,000 A.D. These are shown in fig.1. In this figure, aquaculture production is also projected upto 2000 A D (National Acadamy of Sciences, Washington D.C. 1977).

According to Gulland (1971), aquaculture is divisible into two classes :

1. that in which cultivated fish feed entirely or mainly on natural production of the stocked area of the watermass and

2. that in which their food is especially provided.

Naturally, there are gradations between the two, from simple one when no feed from extraneous source is provided at all to most intensive form of aquaculture in which feeds constitute almost the entire bulk of the cost of production per kg of fish as in the Tanaka running water Fish Farm in Japan and several other places.

While stocking lakes and reservoirs is an age old practice in many parts of the world as practised by Russians, the Japanese have lead the world in developing culture-based capture fisheries in which even the seas (selected ones) are stocked with hatchery produced young notwithstanding dangers of predation. The approach has paid dividends galore. This approach, also followed by the west in more recent times, has lead to salmon ranching in the seas which is perhaps emerging as one of the world's leading lucrative fisheries in parts of temperate world. eg. in Norwegian fjords.

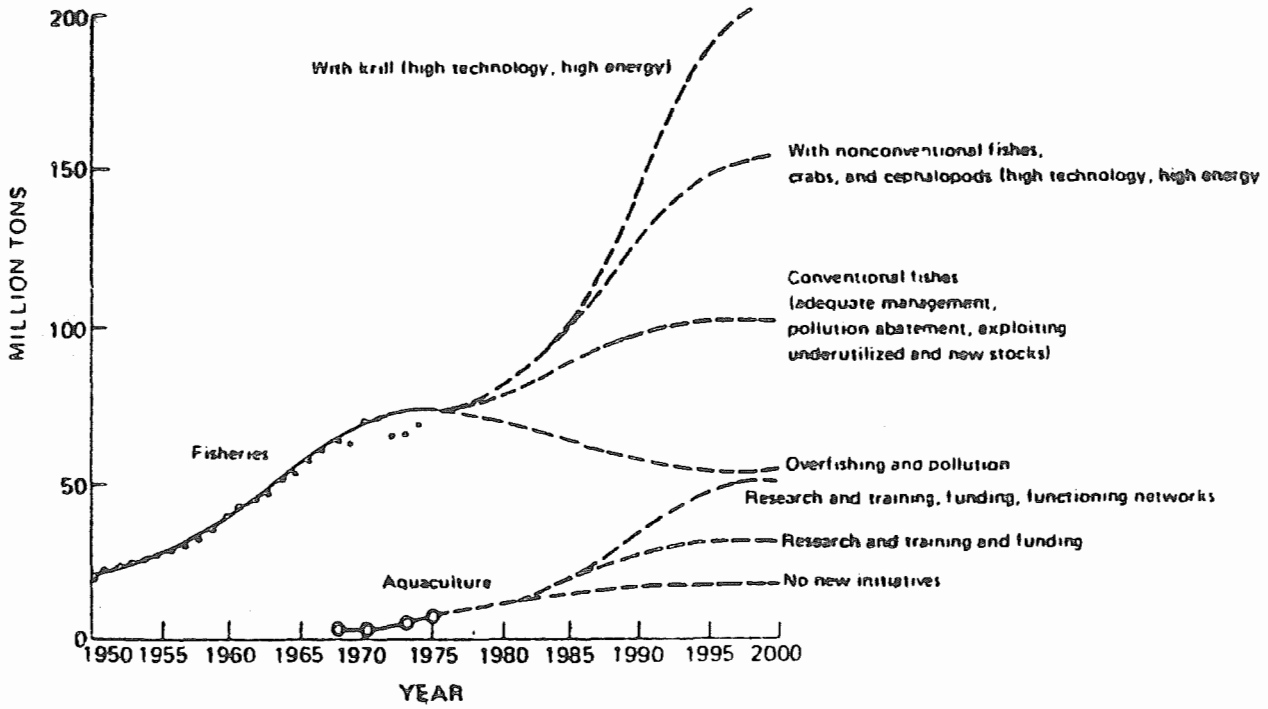

Fig.1 : Actual and projected world fish catch, 1950-2000.

SOURCES : Fisheries statistics, FAO (1950-1974); fisheries projections, FAO Technical Conference on Fishery Management and Development 1973; and acquaculture statistics and projections, Pillay (1976).

While the answer of the West (Beverton and Holt, 1957) to the conservation of capture fisheries, including that of seas, is control of mesh and effort (based on eumetric curve) with protection of the young, the Japanese and Russian answer is to massively aid natural recruitment with hatchery produced young in certain seas (prodigality of stocking) in which case conservation becomes secondary though not perhaps entirely so. With the coming into being of culture-based-capture fisheries, we tend to merge culture and capture fisheries as two processess of an integrated whole. A ridiculously exteme case of this system

is the pamperings of an angler in parts of the Western world by the hatchery men summedd up in the expression: "Stock-and-Take" inplying thereby that from the hatchery stock it so large as if you stock with one hand and capture with the other without the stocked mass having undergone any appreciable change between stocking and hooking.

Indian aquaculture has still to go a long way to be reckoned as aquaculture in the global scene.

Besides really commercialising sead production in hatcheries of cultivated fresh water fish, specific commercial feeds at reasonable price for monoculture must be found. Running freshwater aquaculture, essentially a feed based system, if developed would be a blessing to the country. We have a massive infrastructured of canals criss-crossing the country.

Brackishwater aquaculture has lagged way behind: even experimental success of prime fish like *Lates calcarifer* and *Pangasius pangasius* and thread fins has not been achieved. Mullet culture has been left half way through.

Mariculture of finfish has not even opened its account in the country. Seabreams of the family Sparidae and sand whiting are promising candidates to begin with.

Shrimp culture has progressed to some extent but its commercialisation is awaited with eagerness. *Macrobrachium* culture needs a break through most urgently.

Genetical research of all cultivated fish must be taken up forthwith since all over cultivated carps need genetic upgradation. Common carp can be taken as a model of sorts.

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