FAO Aquaculture Newsletter

August 1995 - Number 10

Inland Water Resources and Aquaculture Service
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EDITORIAL

Hatcheries and Fishery Enhancement

With approximately 60% of the world's capture fisheries overfished and a growing demand for increased fishery production for an expanding human population, the use of hatcheries in stock - enhancement of natural and man-made water bodies is seen by several international organisations, including FAO and the Consultative Group on International Agriculture Research (CGIAR), as a mechanism to contribute to future food security.

However, the use of hatcheries to create or augment fisheries has a history of controversy and mixed results. Hatchery enhancement of marine and anadromous fisheries has been criticized on the grounds that it is not effective, not cost effective, prevents alternative solutions from being implemented and that it endangers native aquatic resources. The use of hatcheries for enhancement of inland waters has not been as heavily criticized, but many of the same issues and concerns are involved.

One problem with many past stocking programmes was their simplistic approach to the problem of decreasing fish-stocks - simply dump large numbers of eggs or larvae into any convenient water body. Now, however, there is a greater appreciation of the complexities of stock enhancement. Size at release, disease control, release-habitat, feed preference, migrations, predator control, environmental carrying capacity, inbreeding and genetic structure of enhanced stocks are being addressed. Furthermore, stock enhancement is being considered as only one aspect of an overall fishery management programme that includes habitat protection, fishing regulation and socio-economic considerations.

These changes in the application of hatchery for the enhancement of fish stocks are indeed welcome. But hatchery enhancement will not be appropriate for all situations where stocks have been depleted or where increased production is desired. Conservation and development groups need to carefully assess each situation and take into account the reasons for stock depletion, the objectives of a stocking programme, the real beneficiaries, and how to assess the impacts. Hatcheries have a very important role to play and the Fisheries Department of FAO is anxious to help determine when and how they can be utilized in support of food security.

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AQUACULTURE FEEDS AND FEEDING IN THE NEXT MILLENNIUM : MAJOR CHALLENGES AND ISSUES

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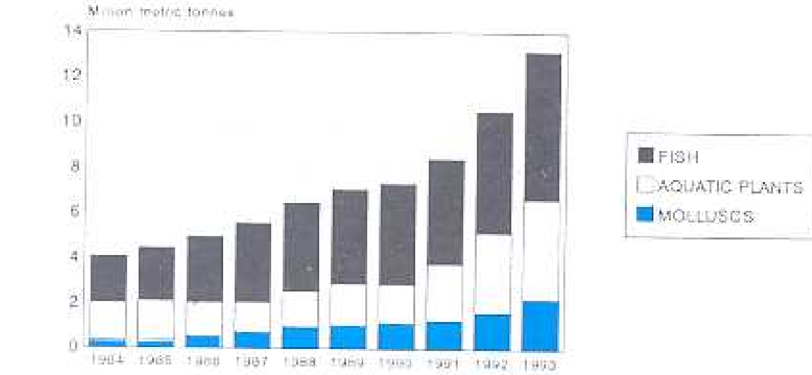
The dilemma : What approach

If aquaculture is to play a major role in the food security of low-income developing countries (LIDCs) as a much needed and affordable source of high-quality animal protein then it is essential that the farmed species be produced *en masse* using low-cost *sustainable* farming methods. In this respect China (an LIDC) stands out alone in that it has been producing *food fish* for home consumption for over *3000 years!*; China being the worlds largest producer of aquaculture products [58.7% of the world total of 22.63 million metric tonnes (mmt) in 1993], including farmed finfish (58.4% of the world total of 11.19 mmt in 1993; Figure 1). The Chinese finfish farming system is based on the polyculture of complementary freshwater herbivorous/omnivorous fish species (Figure 2) at low fish stocking densities within closed (ie. static water) *integrated* fish farms; aquaculture usually being the predominant farming activity and combined with the production of farm livestock and crops. Within these semi-intensive farming systems (SIFS) fish growth and production is achieved through the *integrated* use of low-cost locally available nutrient inputs in the form of pond fertilizers and low-protein agricultural by-products. India, the second largest aquaculture producer in the world (total aquaculture production of 1.44 mmt in 1993, including 1.39 mmt of finfish) also employs similar polyculture farming techniques. These two countries together producing over 65% of the total world aquaculture production. In fact, it is interesting to note that whereas only 46.2% of world meat production (ie. cattle meat, pigmeat, poultry meat, sheep meat, goat meat etc.) was produced within developing countries in 1993, over 85.0% of total world aquaculture production by weight (70.7% by value) was produced within developing countries, including 86.7% of all farmed finfish.

In marked contrast to China and India, Japan (the third largest aquaculture producer in the world, and the largest aquaculture producer among the *developed* countries with a total production of 1.43 mmt in 1993, Figure 3) employs high-cost intensive farming methods for the production of *food fish*. The farming system is based on the monoculture of high-value (in marketing terms) marine carnivorous fish species (Figure 4) at a high stocking density within open (ie. high water exchange) intensive pond, tank, raceway or cage-based farming systems. Japan produced 342,000 mt of finfish in 1993. Within these intensive farming systems (IFS) fish growth/production is achieved through the use of high-cost nutrient inputs in the form of high-protein *nutritionally-complete diets* or in the form of a natural foodstuff of high nutrient value such as fresh or frozen *trash* fish or shellfish.

Although both of the above mentioned farming systems operate as economically viable operations within their respective countries, they both have their share of advantages and disadvantages, depending upon one's viewpoint (ie. economic, socio-economic, environmental, technical, or biological) and position in society (ie. resource-poor farmer, resource-rich farmer, private investor, politician, government official, scientist, environmentalist, conservationist, angler, or layperson). However, whether these and other alternative farming strategies will continue to be sustainable in the coming decade or in the long-run is another matter. For example, due largely to population pressure and conflicting demands for resources (including land and water) there is now an emerging global trend in agriculture towards intensification of farming systems, and aquaculture is no exception to this. However, although the



Total aquaculture production in China was 13.29 mmt in 1993 or 58.7% of total world aquaculture production, including 0.12 mmt crustaceans, 2.22 mmt molluscs, 4.41 mmt aquatic plants, & 6.54 mmt fish. Total aquaculture production has increased by 224.9% from 4.09 mmt in 1984 to 13.29 mmt in 1993

Figure 1: Aquaculture production in China from 1984 to 1993 (Source FAO, 1985. Total value of aquaculture production in 1993 was US$8,359 million).

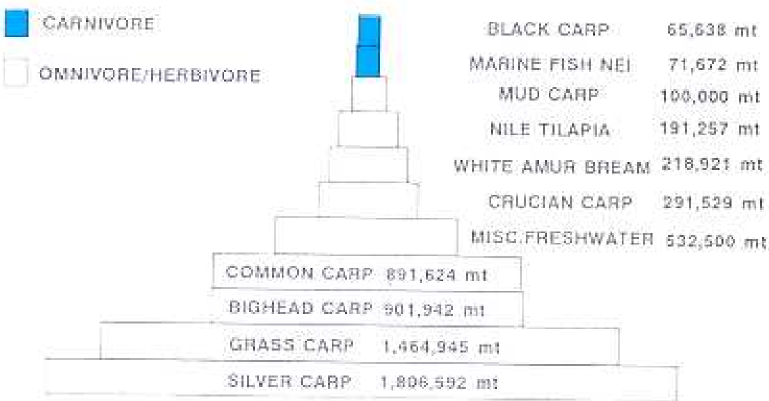
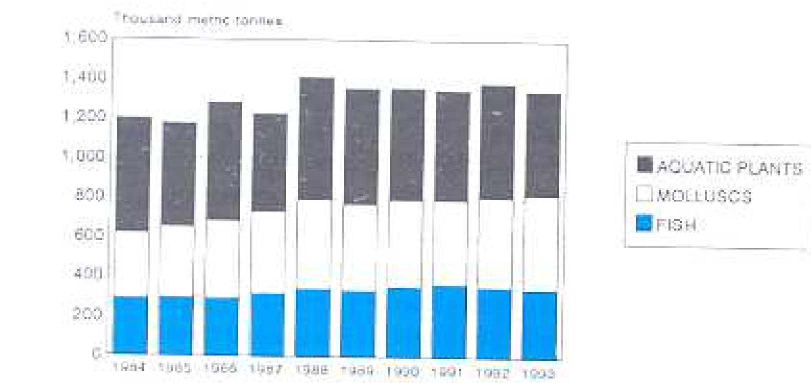


Figure 2: Pyramid of farmed fish production in China in 1993. (Total production : 6,536,620 mt; FAO, 1995).



Total aquaculture production in Japan was 1.43 mmt in 1993 or 6.3% of total world aquaculture production, including 1706 mt crustaceans, 0.48 mmt molluscs, 0.53 mmt aquatic plants, & 0.34 mmt fish. Total aquaculture production has increased by 12.1% from 1.28 mmt in 1984 to 1.43 mmt in 1993

Figure 3: Aquaculture production in Japan from 1984 to 1993. (Source: FAO, 1985. Total value of aquaculture production in 1993 was US$5,532 million).

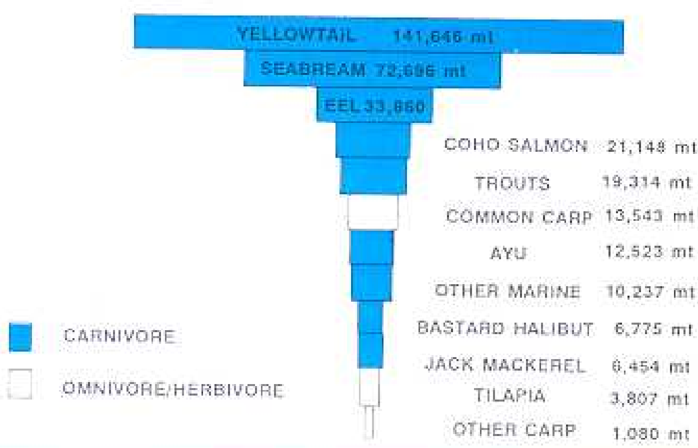


Figure 4: Pyramid of farmed fish production in Japan in 1993 (Total production : 343,714 mt; FAO, 1995).

intensification process may increase production per unit area and bring short term economic gains in terms of increased profits, intensification by its very nature is dependent upon increased resource inputs (including feed) and as such has its drawbacks and risks. The aim of this paper is to highlight some of the major issues and challenges related to aquaculture nutrition and feed development which will dictate sustainability of SIFS and IFS in developing countries.

Major issues and challenges

1. Dependency of aquaculture on agricultural and fishery resources as fertilizer and feed inputs

Availability and increased demand for feed resources

All finfish and crustacean farming systems are dependent upon the market availability of 'feed resources' for the provision of nutrient inputs, either in the form of fertilizers, agricultural wastes and by-products as supplementary feeds, or formulated pelleted aquafeeds. It follows therefore that if the finfish and crustacean aquaculture sector is to maintain its current growth rate (increasing by 11.2% from 10.90 mmt to 12.12 mmt from 1992 to 1993) then it will have to compete with other users (ie. humans and/or farm livestock) for these feed resources. Although the aquaculture sector may have been successful in the past in obtaining the necessary fertilizer and feed inputs, this may not be so in the future as farming systems intensify and the demand for a finite pool of valuable feed resources increases. It has been estimated that the total world production of manufactured compound animal feeds exceeded 550 mmt in 1994 (valued at over US$ 55 thousand million), of which poultry feeds constituted 32%, pig feeds 31%, dairy feeds 17%, beef feeds 11%, aquatic feeds 3%, and others 6%.

Dependency upon fish meal and other fishery resources as feed inputs

At present, the production of carnivorous finfish species (1.26 mmt or 11.3% of total farmed fish in 1993) and marine shrimp (0.80 mmt in 1993) is mainly dependent upon the use of fishmeal and fish oil as the sole or major source of dietary protein and lipid within farm-made or commercial aquafeeds. These two fishery products generally constituting about 70% by weight of compound aquafeeds for most farmed carnivorous fish species and about 50% (together with shrimp meals and squid meal) by weight of compound aquafeeds for marine shrimp (see previous article by author in FAN No.6).

Although the production of carnivorous fish species and shrimp species will continue to be profitable for those countries with ready access to fishery feed resources and/or international credit facilities. This will be only possible as long as fishmeal and fish oil stocks last and prices remain stable or within competitive limits. However, an unknown factor which could upset the balance is the growing global interest and demand for *health* foods (primarily within 'developed' countries) and the recognition that fish and fishery products (including fish oils) could play a key role in the diet of 'modern man'; the latter would either drive up the market price of fish and fishery products or divert the use of small pelagics for direct human consumption rather than for fishmeal production.

2. Need to sustain and further increase aquaculture production

Increasing raw material and farm production costs

Increasing raw material and farm operating costs, coupled with an often static and/or decreasing market value for many farmed species, particularly the high-value carnivorous fish and shrimp species, necessitates that the farmer reduce production costs so as to maintain profitability. Since food and feeding (including fertilization) usually represent the largest single operating cost item within SIFS and IFS, particular attention must be focused on the development of research and farming strategies aimed at reducing fertilizer/feed costs and improving on-farm fertilizer/feed management techniques. A logical step therefore is to make a detailed appraisal of the fertilizer and feeding strategies currently employed by the fish farming community within the country in question (through the use of farm questionnaires and field visits) so as to identify the fertilizer/feeding deficiencies and constraints. The results of such studies would identify the subjects of future on-farm field research investigations.

Furthermore, so as to ensure rapid transfer of research results to farmers it is recommended that wherever possible the fertilization and feeding/nutrition-based research trials be conducted *in-situ* on representative fish farms and that the data generated from these on-farm research studies be also evaluated from the viewpoints of economic, socio-economic, and environmental impact. Emphasis must be placed on trying to find local solutions for the existing problems of the aquaculture sector by supporting on-farm research (participatory systems approach) rather than just conducting pure or fundamental research within the laboratory. However, the key to the success of on-farm research is the participation of the farmers themselves, not only assisting in the identification of research needs and priorities but also in the actual implementation of on-farm research programmes. Sadly, in many instances the aquaculture R & D programmes of public agencies are selected on the basis of research interests of individual government scientists and/or donor agencies rather than on the needs of the farmers and the farming communities.

Choice of cultured species: herbivores, omnivores or carnivores?

At present, all IFS and SIFS for carnivorous finfish species (ie. salmonids, eels, marine fish species - seabreams, yellowtail, seabass, grouper etc.) and penaeid shrimp are net fish protein 'reducers' rather than net fish protein 'producers'; the total input of fish and fishery resources as feed inputs far exceeding the output of new fish protein by a factor of 2 to 5 depending upon the farming system and fishery resource used (ie. fishmeal-based diets or 'trash fish' as major feed inputs). This is in sharp contrast to the net fish protein producing status of the majority of SIFS and IFS employed by farmers for the production of herbivorous/omnivorous fish and prawn species; the culture of herbivorous/omnivorous fish species being generally realized by 'developing' countries (the two largest producers being China and India) and constituting 88.7% of total finfish aquaculture production in 1993. It is also of interest to note here that whilst the average increase in global production of cultivated carnivorous finfish species (ie. rainbow trout, Atlantic salmon, yellowtail, Japanese seabream etc.) was 9.37% from 1992 to 1993, the average increase in production of the non-carnivorous fish species (ie. silver carp, grass carp, common carp, bighead carp, milkfish, rohu, nile tilapia, catla, mrigal carp, crucian carp etc.) has remained higher at 13.35% from 1992 to 1993. On a country basis, it is of interest to compare the recent statistical data on aquaculture production from China and Japan; finfish production in China (97.9% of total being omnivorous/herbivorous fish species) reportedly *increased* by a staggering 21.4% from 5,387,107 mt to 6,536,620 mt from 1992 to 1993 and finfish production in Japan (94.5% carnivorous fish species) *decreased* by 2.7% from 353,140 mt to 343,714 mt from 1992 to 1993 (FAO, 1995).

It follows from the above that if aquaculture production is to maintain its current high growth rate and continue to play an important role in the food security of developing countries as an "affordable" source of high quality animal protein, then herbivorous or omnivorous finfish/crustacean species (feeding low on the aquatic food chain and therefore being less demanding in terms of feed inputs) should be targeted for production rather than high-value carnivorous fish/shrimp species; the latter being less energy efficient in terms of resource use and dependent upon the use of high-cost, protein-rich feed inputs. In this respect it is also high time that we learn from our terrestrial counterparts whose farming systems are based on the production of non-carnivorous animal species (ie. poultry, ducks, pigs, sheep, rabbits, goats, cattle).

Lack of information on nutrient requirements and importance of natural food organisms

Despite the fact that silver carp, grass carp, common carp, bighead carp, and the giant tiger prawn were the top five cultivated fish and crustacean species in the world in 1993 (totalling 5.97 mmt or 49.3% of total farmed finfish and crustacean production), and are all mainly cultivated within SIFS, little or no information exists concerning their dietary nutrient requirements under practical semi-intensive pond farming conditions; the majority of dietary nutrient requirement studies to date having been performed under controlled indoor laboratory conditions (these in turn only being restricted to common carp and the giant tiger prawn). Whilst the information generated from laboratory-based feeding trials maybe useful for the formulation of complete diets for use within IFS, this information cannot be applied for the formulation of diets for use within SIFS since the fish/shrimp also derive a substantial part of their dietary nutrient needs from naturally available food organisms; this is particularly true for those species which are capable of filtering fine particulate matter from the water column (ie. bacterial laden detritus, phytoplankton, zooplankton etc.), including silver carp, bighead carp, catla, rohu, mrigal, kissing gourami, Thai silver barb, milkfish, nilem carp, and last but not least marine shrimp.

For example, despite the dietary requirements of vitamins for *Tilapia* sp. under indoor laboratory conditions, field studies have shown no beneficial effect of dietary vitamin supplementation with *Tilapia* sp. in ponds, cages or concrete tanks at densities of 100 fish/m² with yields of up to 20 tonnes per hectare. Moreover, crustaceans researchers have recently been able to reduce feed costs by half using lower dietary protein and micronutrient levels with no loss in the growth and feed efficiency of shrimp within pond-based SIFS. Unfortunately, in the absence of published information on the dietary nutrient requirements of finfish/crustaceans within SIFS, almost all of the commercially available aquafeeds produced for these farming systems are usually over formulated as nutritionally complete diets, irrespective of fish stocking density and natural food availability. Clearly, this situation will have to be rectified if farmers are to reduce production costs and maximize economic benefit from their semi-intensive pond farming systems.

Polyculture and use of natural pond food resources

At present, the bulk of world finfish and crustacean aquaculture production within developing countries is realized from pond-based SIFS. Although the nutritional and economic importance of natural food organisms within the diet of pond raised finfish has been well recognized and utilized by farmers in China with the development and use of complex polyculture-based farming strategies, with the possible exception of India, such practices have not met with the same degree of success outside China. Polyculture-based farming systems are based on the stocking of a carefully balanced population of fish species with different (ie. non-competitive) and complementary feeding habits within the same pond ecosystem and so maximizing the utilization of natural available food resources (ie. phytoplankton, zooplankton, bacterial-laden detritus, macrophytes, benthic algae, invertebrate animals etc.) and available water resources (ie. surface, mid- and bottom-water) with a consequent increase in pond productivity and fish yield per unit area. For example, polycultures in China commonly include the use of filter feeding fish species (ie. silver carp, bighead carp; 26-52% of total fish stocking weight), herbivores (ie. grass carp; 30-37% of stocking weight), omnivores (ie. common carp, crucian carp, Chinese bream, tilapia; 18-25% of stocking weight), and carnivores (ie. black carp; 0-11% of stocking weight); stocking weights and patterns varying with the financial resources of the farmer. Thus, within low-productivity provinces (ie. low-income provinces/resource-poor farmers; net fish yields averaging 3.3 mt/ha/yr) fish stocking densities are low (initial stocking weights averaging 444 kg/ha) and the proportion of filter feeding fishes is high (52%), whereas in the high-productivity provinces (ie. higher-income/resource-rich farmers; net fish yields averaging 7.9 mt/ha/yr) fish stocking densities are about three times higher (initial stocking weights averaging 1,481 kg/ha) and the 'feeding fishes' (ie. herbivores, omnivores and carnivores) are the dominant species stocked.

Importance of farm-made aquafeeds within SIFS

As mentioned previously the bulk of world aquaculture production within developing countries is currently realized within SIFS and is small-scale in nature with nutrient inputs supplied in the form of fertilizers and supplementary 'farm-made' aquafeeds; the latter ranging from the use of fresh grass cuttings, cereal by-products, to sophisticated on-farm pelleted feeds. In contrast to industrially produced compound aquafeeds (more commonly used within IFS), farm-made aquafeeds allow the small-scale farmer to tailor feed inputs to their own financial resources and requirements, and facilitate the use of locally available agricultural by-products which would otherwise have limited use within the community. In addition to their ability to use locally available by-products and wastes, farm-made aquafeeds are also potentially much cheaper than commercial aquafeeds.

Need for increased environmental and social compatibility

Particular emphasis has been placed on the environmental compatibility and central role played by polyculture-based integrated farming systems in aquaculture development within developing countries, and the need to carefully balance exogenous supplementary feed inputs with the endogenous supply of natural food organisms (achieved through the use of fertilizers) within the pond ecosystem. Furthermore, as mentioned previously, in addition to their minimal effects on the environment, in terms of resource use SIFS are less dependent upon high-cost 'food grade' exogenous feed inputs (ie. fishery resources), facilitate maximum use of locally available agricultural resources (ie. by-products and wastes), have lower production costs, are less prone to disease problems, and are usually net fish protein producers and more energy efficient compared with IFS.

By contrast, the negative reported impacts of aquafeed usage within IFS on the aquatic environment have been largely due to the use of poor on-farm husbandry and management techniques (including on-farm feed management practices) and lack of appropriate aquaculture planning measures limiting the size of existing farms or groups of neighbouring farms to the 'environmental carrying capacity' of the water body or coastal area in question. Despite this, increasing attention is now being given by farmers, feed manufacturers, and researchers alike to the development of farming systems and feeding strategies which maximize nutrient retention by the cultured fish or shrimp and minimize nutrient loss and negative environmental impacts.

It is also important to mention here the critical role played by nutrition (ie. undernutrition) and farm management (ie. on-farm feed, water and pond management) on fish/shrimp health and the incidence of disease outbreaks within IFS (and to a lesser extent SIFS) and the need to satisfy not only the dietary nutrient requirements of the farmed species for maximum growth but also to satisfy their additional dietary requirements for increased immuno-competence and disease resistance.

Finally, the dietary value and importance of aquaculture products in human nutrition as a much needed source of 'affordable' animal protein should not be overlooked; fish being one of the cheapest sources of animal protein within rural and coastal communities. For example, at present, freshwater aquaculture (ie. mainly cyprinids and tilapia) offers one of the cheapest sources of high quality animal protein within the major rural inland communities of Asia, including China, India, Indonesia, Bangladesh and the Philippines.

Need for information and training

Last, but not least, one of the major factors limiting aquaculture development in most developing countries is the lack of ready access to up-to-date information, either through publications within libraries and electronic bibliographic databases, or through in-country training opportunities (ie. for farmers, extensionists, researchers, or the trainers) on aquaculture, and in particular concerning aquaculture nutrition and feed technology. Clearly, since information and training (ie. the dissemination of information and knowledge through education) are fundamental to any research, learning or development process, it is essential that this issue be addressed if farmers (the ultimate beneficiaries) are to improve their skills and farming operations. Sadly, information is often overlooked as being an integral part of the learning or research process; the net result being the re-invention of the wheel and the unnecessary duplication of research effort rather than building upon the knowledge base already available and learning from past mistakes and experiences.

Closing remarks

Despite the fact that China has the longest history and experience in aquaculture development, the sector has recently faced serious difficulties with the 'intensification' phenomenon and the shift of the more resource-rich provinces and farmers from traditional farming practices to more 'Developed country-style' market-oriented farming practices; farming practices shifting from the use of low-cost and low-input (and therefore low output) polyculture-based SIFS (aimed at the mass production of 'food fish' for local consumption) at one end of the spectrum to the production of high-cost and high input (and therefore high output) monoculture-based IFS (aimed at the production of high-value (in marketing terms) 'luxury food fish' (ie. carnivorous fish/shrimp) for export at the other end of the spectrum. The particular case in point is the spectacular 'rise and fall' of the shrimp farming industry, with shrimp production collapsing from a high of about 200,000 mt between 1988 and 1992 (China then being the largest producer of farmed shrimp) to under 50,000 in 1994. The collapse of the shrimp farming sector in mainland China was almost identical to that which had occurred in Taiwan five years earlier in 1988 and was largely due to the progressive degradation and deterioration of the aquatic and pond environment (due to pollution, poor feed and pond management, and inadequate planning and concern for the environment) and consequent massive disease outbreaks.

It is evident from the above economic and environmental disasters that although 'intensification' and modern 'high-tech' high-input and high-output IFS (ie. feedlot systems) can bring considerable economic gain to farmers with access to resources (ie. finance, land, water, trained manpower, feed and other off-farm inputs) these farming systems are highly 'stressed ecosystems' whose stability is entirely dependent upon 'human factors' and 'the farmers control and use of resources' rather than by natural 'ecological factors' as in the case of low-input polyculture-based SIFS. Despite this, whether we like it or not, intensification and IFS are here to stay and aquaculture (like all other forms of animal production) will increasingly be constrained by increasing competition for land, water and resources, including feed. For example, at present China's economy is one of the most dynamic and fastest growing economies in the world (GDP growth in 1993 being 13.4% and the highest amongst Asian countries), in which livestock and farmed fish production is increasing at double digit figures (mean annual growth rate for mutton and lamb 11.8%/yr, beef and veal 22.9%/yr, poultry meat 14.6%/yr, farmed fish 12.2%/yr, and pig meat 6.7%/yr from 1986 to 1993). By contrast, cereal and oilseed production (used as feed for humans and livestock) is only increasing at an average annual growth rate of 2-3% per year. Coupled with an average annual population growth rate of 1.3% per year and a huge population resource base of 1.2 billion people, it follows that if China (like the majority of other developing countries) is going to sustain and improve the nutritional and economic welfare of it's people the traditional farming systems will have to be improved and/or upgraded.

If the intensification process from extensive, semi-intensive to intensive farming systems is to proceed in a sustainable manner, it is essential that research be aimed at developing farming systems which produce more fish, but that the production be based on the use of sustainable ecological/environmental balances and the efficient 'integrated' use of resources rather than just on pure economics. It follows, therefore, that for the survival of the industry the overall efficiency of resource use is improved and that the aquatic environment be conserved for food production, thus ensuring that long term sustainability for food production prevails over the desire for rapid gains and short term profits.

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INTEGRATED RICE-FISH CULTURE IN ASIA WITH SPECIAL REFERENCE TO DEEPWATER RICE

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Based on a Paper submitted to the 18th Session of the International Rice Commission : 5-9 September 1994, Rome

Global fish production - present and future

Fish is an important source of animal protein, essential fatty acids, vitamins and minerals. Fish currently make up about 19% of total animal protein consumption in the world. However, in some developing countries such as Bangladesh, Indonesia, China, Myanmar, Philippines, Sri Lanka, Thailand etc. fish accounts for half or more of the animal protein supply. In Bangladesh, fish represents 80 percent of animal protein supply of the diet. If the rate of fish production is not substantially increased, severe strains on the nutritional status of the countries with high dependence on fish for their protein supply will appear. It is estimated that just to maintain the present level of consumption an additional 8.5 million t of fish will be required just for the East and Southeast Asia alone by 2010. Taking into account the present rate of population growth, it is estimated that by the year 2010 with a population of about 7 billion, maintaining the present level of 18 kg per caput, the production of fish will have to be raised to over 125 million t (FAO Agriculture towards 2010).

It is estimated that the capture fisheries may reach to its maximum production level of 90-110 million t by the year 2010. On the other hand, aquaculture production could be increased from 14 million t to 30 million t by 2010, through improved management, species diversification, development of new culture technologies and expansion of aquaculture in the marine environment (FAO Agriculture: towards 2010). However, the expected growth of aquaculture is not going to be very easy as sign of serious problems related to environment, disease and marketing have been surfacing.

Recognizing the constraints limiting the future increase in fish production from the marine and inland capture fisheries, aquaculture is seen as the major potential contributor. To achieve this, among other things, improvement in the existing culture technologies, development of new culture technologies, genetic improvement of culturable species will have to be made. In this context, improvement in the traditional system of integrated rice-fish culture and the development of new rice-fish culture technologies with a view to increasing food fish production in rural farm household level should be considered.

Traditional rice-fish culture

The practice of culturing fish in ricefields first started in China 2000 years ago and in India about 1500 years ago. Out of approximately 144 million ha of ricefields, 76.3 million ha (53%) are irrigated, 49 million ha (34%) are rainfed, and 18.7 million ha (13%) are classified as upland ricefields. Nearly all rice-fish culture practices are in irrigated and rainfed ricefields with less than 50 cm depth of water. Hora & Pillary (1962) reported that in the Indo-pacific Region only an estimated 136,000 ha or 0.65% of 21 million ha of wet ricefields were used for growing fish, and since then no reliable data on the area under rice-fish culture and the quantity of fish produced from there-in have been available. However, since sixties with the adoption of culture of High Yields Varieties (HYV) of rice which need much less water and higher quantities of fertilizer and pesticides, the overall environment of the ricefields became less conducive to fish culture; and as a result, the areas under rice-fish culture decreased steadily. Since early eighties, there has been a revival underway in Asia, especially in some countries like China

(Li 1992), Indonesia (Koesoemadinata et al 1992) and Thailand (Fedoruk et al 1992), the practice of integrated fish culture in the ricefields have been increasing. On the other hand, in industrialized countries such as Japan, Italy, Hungary etc., fish culture in ricefields is rarely practised mainly because of the facts that it is no longer economically attractive and that the cultivation of rice has been mechanized to such an extent that the ricefields in those countries are becoming unsuitable for fish culture (Fernando, 1993). In the everchanging scenery of rice-fish culture and in the absence of reliable data, it appears that no more than one percent of total irrigated ricefields in Asia is under rice-fish culture. Table 1 illustrates the paucity of data on the rice-fish culture in Asia.

The aquatic phase of the traditional ricefields creates a highly productive biological system that generates and sustains aquatic organisms (both plants and animals). The ricefield aquatic fauna includes, inter alia, birds, fish, molluscs, insects, crustaceans. Shallow water (less than 50 cm) with fluctuating temperature (20-30°C) makes the ricefields a kind of modified marshland. Filamentous algae grows abundantly. Also found are aquatic plants such as lotus (*Nelambo sp.*) arrowhead (*Sagitheria sp.*) and waterspinach (*Ipomea sp.*). Sometimes, other plants like *Azolla sp.* are grown in the ricefields to help increase soil fertility. *Ipomea* and *Wolffia* species are also grown as fish feed. The main fish species cultured in the ricefields are *Cyprinus carpio, Puntius gonionotus, Trichogaster pectoralis, Osphronemus goramy, Oreochromis niloticus, Oreochromis mossambicus, Ctenopharyngodon idella, Ophicephalus sp., Anabas testudinius, Barbus gonionotus, Clarias sp.* Also cultured are various species of freshwater and brackishwater shrimps.

For fish culture in ricefields, various simple modifications may include raising the dikes to accommodate higher water depth, digging trenches (0.5 - 1.0 m) along the periphery or at regular intervals within the ricefield, making one end of the ricefield lower to have higher depth of water, making a sump at the lowest end of the ricefield etc.

The system of culturing fish in ricefields can be classified into two main categories. In the rotational system fish (meaning fish and crustaceans) are cultured in the ricefields in between rice crops. Being cultured separately there is very little or no negative effect of one over the other. This production system allows deeper water in the ricefield and better fish culture management practices such as artificial fertilization of the water, providing supplementary feed, etc. This system therefore gives higher fish production per unit area under culture. The residues from fish culture makes the soil richer for rice cultivation; and the rice culture residues such as rice stubs encourage rich growth of fish food. Fish production under this system varies from 300-1000 kg/ha/crop depending on the intensity of management. Under the concurrent system, rice and fish are cultured together in the same field. Fish production under this system is much less as rice is the primary product and fish is the secondary or supplementary product. Fish culture therefore is adapted to the environment that is most suitable for rice culture.

Fish yield under this system, therefore, is much less (50-300 kg/ha/crop)). The advantages of this system are that i) fish excreta increases soil fertility and (ii) fish help control insect pests and aquatic weeds. The combined effects of these seem to help increase rice production by as much as 15% (lightfoot *et al.* 1990).

According to de la Cruz (1991) 20% of the irrigated ricefield areas in South and Southeast Asia are considered suitable for fish culture; and Lightfoot et al (1990) pointed out that even modest adoption of integrated rice-fish system could dramatically increase farm income and food supply (see Table 2).

It is estimated that Vietnam could increase by 150 times its fish production (from 0.5 to 79 thousand t) and income (from US$0.3 to 47 million) if she reached a target of harvesting 300 kg/ha/yr. of fish from just 5% of her rice lands. Similarly, Bangladesh could produce 140,000 t with a value of US$64 million. Theoretical potential for fish culture in ricefields is enormous, if only 5% of 76 million ha of irrigated ricefields and 49 million ha of rainfed ricefields (including nearly 9 million ha of deepwater ricefields) could be brought under some form of integrated rice-fish culture.

However, there remains many constraints to the development of integrated rice-fish culture. In an integrated rice-fish culture system rice is the primary crop and fish is the secondary crop. the ricefield agronomic condition must be prepared and maintained at optimum level for rice production. Fish, being the secondary crop, has to be adapted to the ricefield

TABLE 1: POTENTIAL AND EXISTING AREAS FOR RICE-FISH FARMING IN ASIA

Country		Ricefield area (1000 ha)	Potential/suitable (1000 ha)	Existing area (1000 ha)
Bangladesh	Total Irrigated Rainfed	10,229 1,227 9,002	615	Not known
China	Total Irrigated Rainfed	32,798 30,502 2,296	5,000	985.5(1986)
India	Total Irrigated Rainfed	40,991 14,349 26,642	2,000	Not known
Indonesia	Total Irrigated Rainfed	9,889 6,230 3,659	1,570	94.3(1985)
Korea	Total Irrigated Rainfed	1,229 1,118 111	127	0.1(1989)
Malaysia	Total Irrigated Rainfed	647 427 220	120	Not known
Philippines	Total Irrigated Rainfed	3,426 1,473 1,953	181	1.4(1982) 0.2(1986)
Thailand	Total Irrigated Rainfed	9,378 1,313 8,065	254	
Vietnam	Total Irrigated Rainfed	5,691 2,276 3,415	326	Not known

* Adapted from Lightfoot et al., 1992

TABLE 2*: TARGETS IN FISH PRODUCTION AND INCOME WHEN RICE-FISH FARMING IS ADOPTED IN 5% OF RICE LANDS

			Fish production in rice-fish area (t)		Incomes derived from rice-fish culture (000US$)	
Production target	Price per kg	Riceland(ha)** 1985-87	Actual 1983	Targets 5%	Actual 1983	Targets 5%
Indonesia (@511kg/ha)	@US$1.36/kg	8,504,540	49,544	217,291	67,380	295,516
Thailand (@1,044kg/ha)	@US$0.92/kg	9,096,660	2,944	474,846	2,708	436,858
India (@450kg/ha)	@US$0.46/kg	34,842,350	720	783,953	331	360,618
Vietnam (@300kg/ha)	@US$0.59/kg	5,292,630	465	79,389	274	46,840
Philippines (@300kg/ha)	@US$0.72/kg	3,014,880	0	45,223	0	32,561
Bangladesh (@300kg/ha)	@US$0.46/kg	9,308,390	0	139,626	0	64,228

*Adapted from Lightfoot et al. 1990
**Excludes upland rice area.

ecosystem. Most countries are now switching over to the cultivation of HYV rice which requires much less water than what is required for fish culture. Successful fish culture in ricefields requires at least 15-20 cm depth of standing water in the paddy and 50-60 cm in the ditches and sumps. Maintaining such a reliable supply of water throughout the fish growing season may become difficult. Moreover, the shorter duration (100-125 days) required for maturity of HYV does not allow enough time for fish to grow to marketable size. Also, the HYV requires the use of high doses of fertilizers and pesticides, most of which are toxic and slowly accumulate overtime in the fish tissue, thus making the fish unfit for human consumption. Other constraints relate to lack of appropriate technology and lack of inputs (such as fingerlings of desired species and size for stocking in time). Finally, in most developing countries the extension services are not geared for providing technical support to farmers. Lack of institutional credit facilities is also hindering progress. In some countries, land ownership, seasonal flooding and poaching are serious problems.

To resolve these problems, it will require strong political will, integrated development plan, institutional strengthening and long-term funding support. The technical problems could be resolved through national and regional research programmes in the priority areas such as development of appropriate production technology packages, ecology of rice-fish culture, engineering aspects of rice-fish culture, integrated pest management, bio-economic modelling. In this direction, the Asian Rice Farming Systems Network (ARFSN) together with International Rice Research Institute (IRRI) and International Centre for Living Aquatic Resources Management (ICLARM) are making collaborative efforts. The Integrated Rice-Fish Group (IRFG) supports national research and development activities in eight countries (Bangladesh, India, Indonesia, Malaysia, Philippines, China, Thailand and Vietnam) in the region. IRRI and ICLARM, in addition to their involvement in strategic research on rice-fish culture, assist national research programmes, when requested.

Rice-fish culture has had a chequered history during the last 150 years (Fernando, 1993). At present, the focus on rice-fish culture is on Asia, especially in China, Indonesia, Thailand and Vietnam. Even with many things favourable to rice-fish culture, it has not succeeded as one would expect. Many reasons such as changing rice cultivation practices, rising living conditions in some countries, ineffective research, extension and investment support can be cited for slow progress or demise of rice-fish culture in many countries. Fernando (1993) has pointed out that fish culture in rice fields will face many problems in establishing economically viable operation and that it is unlikely that these problems could be satisfactorily resolved in the near future. However, in many Asian countries where fish is in high demand in rural areas and where costs of labour and other inputs are relatively inexpensive, well-planned integrated rice-fish culture should have a good chance of success, as long as it is practised as an extensive/semi-intensive system and at subsistence level supplying badly needed animal protein for family consumption and providing additional family income.

DEEPWATER RICE - FISH CULTURE POTENTIAL

Fish culture in ricefields has always been carried out in irrigated and rainfed ricefields with less than 50 cm of water. Except a few experimental trials, there are no records of large scale integration of fish culture with deepwater rice cultivation. Deepwater rice is defined as cultivars that grows in areas which usually get flooded deeper than 50 cm for at least one month during the growing period. The cultivars which grow at depths of 50-100 cm are called Traditional Tall and the ones survive in more than 100 cm are called Floating rice. Some floating rice cultivars can withstand water depth of over 3.5 m. It is estimated that a total of 15.5 million ha or 10.8% of global total of 144 million ha of ricefields are rainfed with a flooding depth of over 50 cm (IRRI Ricefacts, 1988). However, according to the definition of deepwater rice there are a total of 8.33 million ha of deepwater rice in Asia and 0.47 million ha in West Africa as shown in Table 3.

In Asia, Deepwater rice is mostly grown in the backwaters of floodplains in the basins of major rivers such as the Ganges, Brahmaputra, Irrawaddy and Mekong. The floods in this region of the world comes from June to October and the water starts receding from October to December.

In Asia, over 90% of the deepwater rice areas are cultivated. The cultivation practices, in general, are as follows: the fields are ploughed and prepared in January - April period; sowing is carried out between April and May; planting is done in June, July and

Table 3: extent of deepwater rice in Asia and West Africa by country

Country	000 ha	Proportion in Asia (%)
Asia		
Bangladesh	2492	30
India	2470	30
Burma	1281	15
Thailand	763	9
Vietnam	567	7
Cambodia	405	5
Indonesia	128	2
Nepal	118	1
Philippines	76	1
China	30	<1
Sri Lanka	4	<1
Total for Asia	8334	
Africa		
Mali	161	
Guinea	151	
Nigeria	105	
Sierra Leone	20	
Niger	16	
Burkina Faso	6	
Togo	6	
Benin, Senegal and Gambia	5	
Total for Africa	470	
Grand total	8804	

From Rice in Deepwater, David Catling, IRRI (1992)

August; thinning and weeding are carried out in the months of August and September; and harvesting takes place in the period September to December. Most deepwater rice therefore grow for 2-4 months before the start of the main flood. This gives the plants enough time to establish themselves so that they would be in a position to withstand and adapt to the flood conditions. Most deepwater rice varieties grow for about 3-4 months under flood conditions. The general ecology of the deepwater ricefields has been described in details by Catling (1992). In general, the flood waters are slightly acidic with low dissolved salts. The water is usually well oxygenated and is fairly clear. Sedimentation in the deepwater ricefields are found to be low. The soils, in general, are fertile with upper layers consisting of sands and silts and the lower layers are composed of various types of clays. Some small areas in Vietnam and Thailand have acid sulphate soils.

The deepwater rice areas are generally very rich in algae. More than 150 species of algae that serve as fish food have been identified. Also, about 500 species of insects and spiders and over 30 species of fish have been found to inhabit deepwater ricefields. From the limited information available it seems that in general the deepwater ricefields are rich in fauna and flora that serve as fish food.

No fertilizer is used during the floodphase of the deepwater rice cultivation. Because of the difficulties in applying and also due to the uncertainties of their effectiveness under flooded conditions, most deepwater rice farmers do not use pesticides.

Average yield vary from country to country, with just over 1 t/ha/crop in Myanmar to over 2t/ha/crop in Bangladesh. In most countries, a second crop of modern cultivars are grown in the same fields in the dry season with irrigation. During the dry season, in Bangladesh and India, most of the deepwater ricefields are planted with crops such as peas, oil seeds (mustard), grains, vegetables, etc.

Another possibility of increasing productivity of the deepwater ricefields is to integrate fish culture with deepwater rice cultivation. Nearly all of the existing rice-fish culture is being carried out in irrigated and rainfed rice fields with water depth of less than 50 cm. Fish culture has not yet been integrated with deepwater rice cultivation mainly because of lack of appropriate technology. In the southern coastal districts of the state of West Bangal, India and in Bangladesh some deepwater rice farmers dike their ricefields and trap the wild species of fish and shrimps and keep them confined until the rice growing season. Some farmers even stock their ricefields without much consideration to stocking density or species composition. From such extensive culture system a harvest of 50-200 kg/ha/season is obtained.

In recent years, some research activities on the development of semi-intensive fish culture technology integrated with deepwater rice cultivation have been initiated in India and Bangladesh. An interesting study (Mukhopadhyay, 1992) on the ecology of the deepwater ricefields near Chinsurah, West Bangal revealed that the water depth in the deepwater ricefields increased from 20 cm in July to 144 cm in August. From September to mid-October a static water level condition prevailed. From then onwards, water receded and by end of November it was decreased to 21 cm. Large varieties of fish and a number species of freshwater shrimp were found in the ricefields, the most abundant species of fish were *Chanda sp., Puntius sp.* and *Colisa sp.* Freshwater shrimps represented 20% of the catch. Algae, Molluscs and Arthropod population was abundant. In addition, fifteen species of aquatic weed were found to grow in the deepwater ricefields. The study concluded that the physio-chemical characteristics of the water in the deepwater ricefield was found well-suited for fish culture and that the water contained rich flora and fauna as fish food. In India, *Datta et al* (1987) reported fish (*Catla catla, Labeo rohita, Cyrrhinus mrigala*) production of 1.1 t/ha in 7 months in deepwater rice plot containing maximum water depth of 160 cm. The same plot produced 2.1 t/ha of rice after 5 months. Under an IRRI/Government of India collaborative project on Deepwater Rice Pest Management and Rice-Fish Culture, based in Chinsurah, West Bengal, Roy et al (1990) reported very interesting results. In diked deepwater rice plots with water depth 0.5-1.5m semi-intensive polyculture of *Macrobrachium rosenbergii* (50%), *Puntius javanicus* (20%), *Cyprinus carpio* (20%) and Labeo rohita (10%), and monoculture of *macrobrachium rosenbergii* were carried out. Also, vegetables such as ridge gourd (*Luffa acutangula* L. Roxb), cowpeas (*vigna unquiculata* L. walp.) and french bean (*Phaseolus vulgaris L.*) were grown on the dikes. In comparison with traditional deepwater rice-fish culture where rice yield ranges from 1.0-1.5t/ha season and fish production varies from 50-200 kg/ha/season, semi-intensive fish culture integrated with deepwater rice cultivation produced 4.8t/ha/crop of rice and 1.2-1.9 t/ha/crop of fish and prawns (freshwater/brackishwater shrimp *M. rosenbergii*) with supplementary feeding. In addition, with the integration of vegetable farming on the dikes of the rice plot, 2.3 t/ha of ridge gourd, 0.3t/ha of cowpea and 0.6t/ha of French beans were produced. The study concluded that the deepwater rice cultivation integrated with fish culture and vegetable farming was highly advantageous because of synergistic effect of fish on rice and vice versa; control of weeds and pests by fish; increased efficiency in resource utilization and reduced investment risk through crop diversification, and improved family income and nutrition.

Concluding remarks

The traditional integrated rice-fish culture in irrigated/rainfed ricefields is declining. This trend must be reversed. To be able to do this the main technical constraints should be resolved by development oriented research on improving existing culture technologies, developing new culture technologies, integrating pest management, bio-economies modelling, etc. National governments and international organizations like IRRI, ICLARM and FAO should provide the needed technical support. And to ensure adoption and rapid expansion of integrated rice-fish culture in irrigated/rainfed ricefields with water depth of less than 50 cm, national governments should allocate development funds for extension, training and credit facilities.

The results of the pioneering research activities on integrated deepwater rice-fish culture in India has demonstrated its potential. The higher production of fish from integrated deepwater rice-fish culture (over 1.0 t/ha/yr against 50-200 kg/ha/yr from the traditional rice-fish culture in the irrigated ricefields) can be accounted for by (i) the presence of deeper water ensuring higher stocking density and better survival, (ii) the availability of abundant natural fish food, and (iii) the better quality of water, free from the toxic effects of pesticides and herbicides. However, very little information on the ecology of the deepwater ricefield is available and no technology packages are available for adaptation to various agro-climatic conditions. A lot of research and development work, therefore, will have to be carried out before large-scale adoption of integrated deepwater rice-fish culture becomes a reality.

Because of its potential socio-economic benefits, a global campaign should be launched for the integration of fish culture in ricefields. Within the next 10 years, at least 5% of the irrigated ricefields with a fish production target of 300 kg/ha/yr and 15% of the deepwater ricefields with production target of 600 kg/ha/yr should be brought under integrated rice-fish culture. It is estimated that the achievement of these modest targets would yield 3.2 million t of fish. In addition to contributing about 3% to the world fish production, successful integration of fish culture with rice cultivation would have lasting impacts on rural development efforts of many developing countries by producing affordable animal protein for local consumption, by creating additional employment opportunities and by generating additional farm family income.

Figure 1: Rice-cum-fish culture in Zambia

Figure 2: Rice-Azolla-Fish culture system - People's Republic of China

Figure 3: Rice-Azolla-fish culture. The ricefield is being prepared for Azolla inoculation and fingerling stocking

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MARKETING OF FARMED SEABASS SEABREAM AND TURBOT

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Seabass and seabream are usually traded in whole form, mainly fresh but sometimes frozen. In the wild, sizes of seabass Dicentrarchus labrax range up to 10-12 kg. Sizes above 700 g are sold filleted as well as whole. The culture industry concentrates on plate-sized fish, i.e., 300-500 g. The bream which are cultured are gilthead bream, Sparus aurata, commonly 0.5-3 kg reaching a maximum of 6 kg, and are usually sold whole. Other breams are captured from wild fisheries, notably the Spanish bream, (Pagellus bogaraveo 1-2 kg), red seabream, (Pagrus pagrus, 1-3 kg, maximum 6 kg) and black seabream, (Spondyliosama cantharus). Smaller seabream and seabass are usually cooked whole by poaching, grilling or baking. Larger fish are filleted or steaked and cooked in a similar manner.

SEABASS

Production of seabass doubled from 1986 to 1994 to 18 000 MT. This expansion was exclusively due to a sharp increase in farmed seabass production. The bulk of the world production of seabass is in the European Union, but in recent years farmed seabass production has expanded in the southern part of the Mediterranean. Strong growth was experienced in Turkey, Egypt and Tunisia.

Table 1 shows the impressive growth of production of cultured seabass. In 1994, some 13 800 MT of seabass was farmed and by 1995 the production is expected to reach 14 000 MT (figure 1). By 1998, some 21 000 MT of seabass will come from farms. Consequently, total production of seabass will exceed 26 000 t, more than fourfold the 1988 figure. Greece is by far the main seabass farming country with some 8 500 MT in 1994. Italy continues to be an important seabass farming country, but no growth has been experienced in recent years.

The year 1993 was critical for the seabass market, especially for Greek fish farms, for two reasons: a massive increase in cultured seabass output and the economic crisis in Italy, the main market for seabass. In 1993, estimated farmed seabass production in Greece was 3 500 t, threefold the 1990 production; while, in 1993, Italy experienced its worst economic crisis in recent history. Restaurant consumption fell, and in this sector, the consumer selected cheaper fish than seabass, a particularly high-priced species. As a result, seabass prices dropped sharply during 1993, sometimes below US$ 15.00/kg, while "normally" they sell above US$ 25.00/kg (figure 2). For seabream, the situation was substantially different. The increase was less pronounced, and in addition to Italy, there are other market outlets (France, Spain). Consequently, prices of seabream were about steady during 1993, sometimes ahead of the seabass price, which usually sells at about US$ 2-3/kg ahead of seabream. Since 1993, the seabass market has improved somewhat, but prices have not gone back to the pre-1993 level. The consequences of this for seabass farms in the whole Mediterranean area have been disastrous, and many farms that had made their cost/benefit analysis based on prices exceeding US$ 20.00/kg experienced big problems.

GILTHEAD SEABREAM

Gilthead seabream production has grown strongly during the past decade. In 1994, some 22 000 MT were produced, more than triple the 1986 production. The increase comes mainly from the booming aquaculture industry: in 1994 some 13 000 MT of seabream were cultured, double the 1991 production (figure 3). By 1998, the European mariculture industry expects production to reach 25 000 MT.

Italy used to be the world's main seabream producer with some 3 000-3 500 MT, but the strong growth in the Greek aquaculture industry made Greece the leader in seabream production with over 10 000 MT in 1994, of which 70% from aquaculture. Spain is a growing producer of cultured seabream. Egypt and Turkey also reported increase in seabream production (Table 2).

Italy is the main market for seabream, but this species has an established market also in France and Spain. Due to this diversification, the economic crisis in Italy did not have the same impact on price developments for seabream as it had for seabass. Prices went down, but not as dramatically as the seabass prices (figure 4). In 1994 and 1995, seabream prices were in fact ahead of seabass prices, while normally seabass is more expensive than seabream.

Market Prospects

Projections put the likely level of farmed seabass at around 14 000 MT by 1995. This represents an increase of 5 500 MT on 1992 supply. The impact on seabream is smaller. The 1995 seabream production is forecast at 14 700 MT, 5 000 MT more than the 1992 supply. Market predictions are difficult but prospects appear better than in 1993. The Italian economy is expected to improve soon; thus increased demand for seabass is likely in the coming years. Prices are expected to rise from their present low level, but it is unlikely that they will ever return to levels attained before 1993.

A number of cautionary points must however be made:

(a) Scheduling

Present experience with these species suggests that rapid seasonal and other short term changes in supply can cause dramatic changes in prices. Producers should thus discipline themselves to create a stable year-round market for these species to avoid such instabil'ties.

(b) Bass and Bream: The Contrasts

Prospects for bass are better than for bream. There is stronger demand for bass than for bream. Only the Italian market regards bream as highly as bass.

(c) Price Relationships with Other Species

Bass and bream prices are affected by the relative supplies of other high value species such as salmon, turbot and sole. Thus increasing supplies of salmon are likely to bring down bass and bream prices, unless active efforts are made to expand markets for them.

(d) Differential Market Prospects

Prospects at least in the short term are substantially better in Italy, Spain and France than in northern European markets. Demand in the north is limited in some cases to particular ethnic groups and the species are unknown to wider markets. These are good markets for limited volumes via specialist importers but any attempt to develop wider markets would require considerable marketing effort.

Turbot

Culturing of turbot is a relatively recent development. It started in Northern Europe (Norway, Scotland), but very soon it became evident that turbot culturing in these cold waters was not economically viable as the water used in grow-out tanks has to be heated. In contrast to the northern countries, Galicia in Spain offers excellent natural conditions (12-18°C range of seawater temperature). In addition, the development of turbot culture in Galicia has been further enhanced by Spain's entry into the European Union and funds from the Community played a crucial role in establishing the industry.

Spain has thus become the major turbot culturing country, but concentrates on growing-out importing juveniles from Norway, Denmark and the Netherlands. Spanish production of turbot has grown steadily from 40 MT in 1986 to 1 675 MT in 1993 (Table 3). The marketable size of the turbot cultured in Spain is 2-3 kg. The farmers avoid taking out smaller turbot as the biggest single element in the production cost is the cost of juveniles. On the other hand, it is not economically viable to grow out the turbot to a size larger than 3 kg.

Experience with turbot farming in other European countries has been rather disappointing, but positive developments are now becoming apparent, especially in France. In this country, production in 1993 reached 250 MT, from the 15 MT three years earlier.

Product forms

Turbot is generally sold fresh and gutted, and it is easy to handle. Transport is done in a variety of ways. The main problem is that turbot is a flatfish and is therefore not suitable for processing by existing machinery (fish transfer pumps, grades, counters, etc) without modifying them. Currently, the fish is graded with a newly designed machine when the weight is under 400 g/piece. Above 400 g it is generally graded manually. Counting is also carried out manually.

Prices

Turbot is high priced; generally costing US$ 10.00/ kg and above for fresh fish. Only in June/July, the spawning season, the price is much lower. During this period, the price of the small sized turbot falls to about US$ 8.00/kg. Brill (cophthalmus strombus), is turbot's main competitor on the European market. Its price is usually US$ 1.00/kg below that of turbot for the same size. In June/July, turbot prices normally remain the same as that of dover sole while in other months the price of small turbot (500-1 000g) exceeds that of a large dover sole (>400 g) by 50-70%. In Italy, turbot prices approach those of seabass, the highest priced fish of the Italian market. Bearing in mind the lower yield of turbot, it is the most expensive fish on the Italian market.

Price development

Wild turbot prices fluctuate widely during the year and are higher during the Christmas season. In the Netherlands, large sized turbot can reach US$ 21.00/ kg. In June-July, prices decline to about US$ 13.00/ kg. The price of fresh wild turbot from the Netherlands during the past 5 years shows a regular fluctuation. Cultured turbot started to have an influence on the market in 1992 and prices started to slip (figure 5).

Consumption

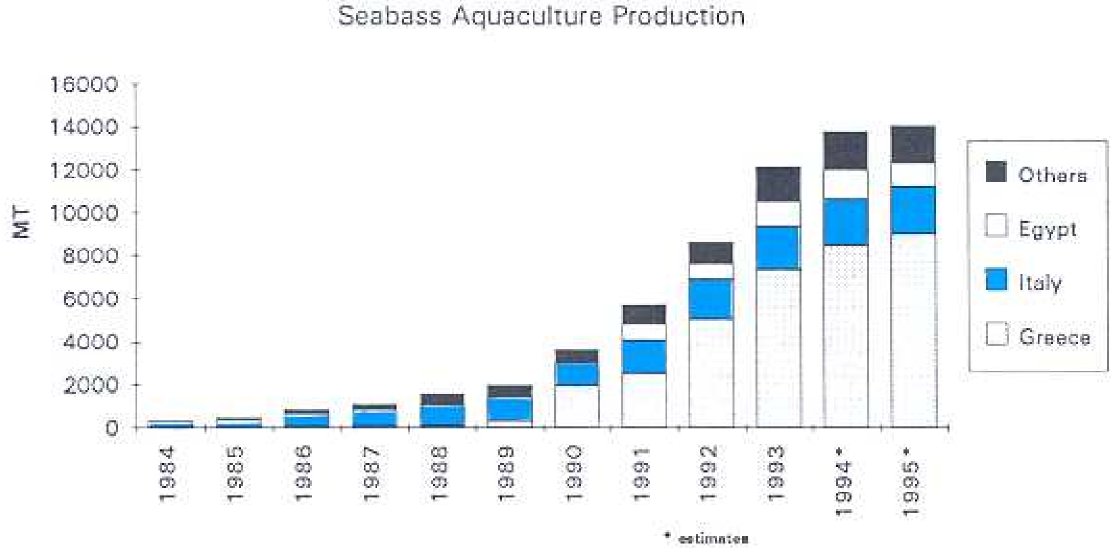
French imports of flatfish (excluding dover sole, plaice, halibut) are stable at 5 000 MT, of which about 3 000 MT are turbot. In 1994, the imports of cultured turbot, mainly from Spain, were estimated at 1 500 MT. France is thus the major market for turbot in Europe. The availability of fresh fish is very seasonal as production is highest in June-July. The French market appreciates the special taste of turbot, and is willing to pay a relatively higher price.

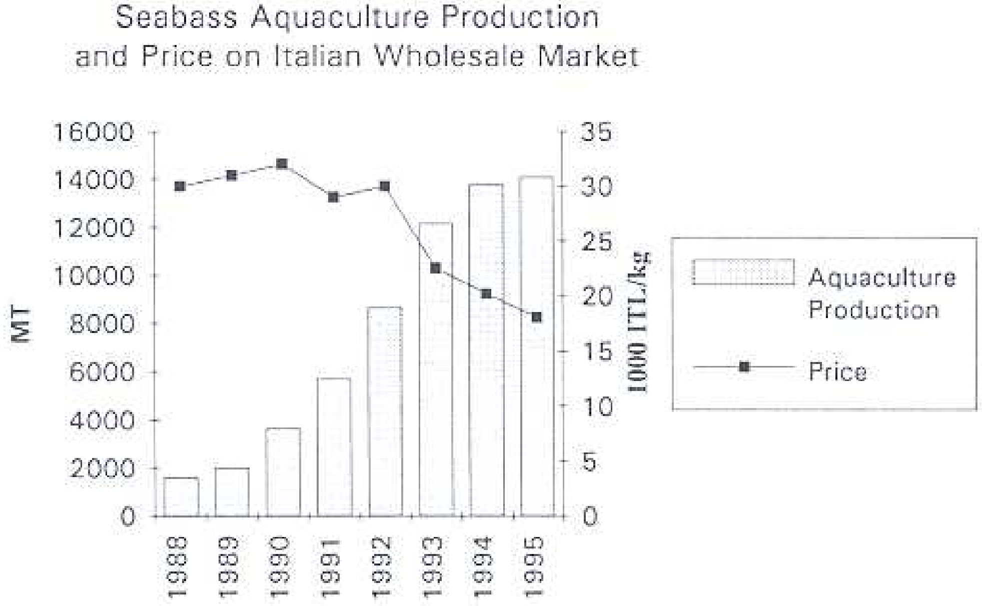
The Spanish market is somewhat smaller than the French, with about 3 000-4 000 MT. Due to the limited size of the market, the arrival of cultured turbot has an important effect on prices. Prices have dropped since 1991, sometimes below Ptas 1 000/ kg (US$ 8.00/kg), while the farms based their calculation on Ptas 1 400-1 800/kg. The price decline was caused by the increased production without corresponding marketing efforts. Promotion efforts have been nil, and now the Spanish turbot farmers realise that they will have to look for new markets inside and outside Spain.

Prospects

The Spanish market seems to be oversupplied with local products. Prices experienced a sudden decline, and farmers fear that they will face reduced returns. The main problem is the small size of the Galician market, while shipments to the Madrid and Barcelona wholesale markets have to compete with wild turbot imports from Netherlands, Denmark and the UK. Further, Spanish turbot farms present turbot as 'cultured' fish; while for cultured salmon, seabass and seabream, producers avoid selling them as 'cultured'1 fish. As a result, the Spanish consumers consider cultured turbot as a low quality item (like poultry).

Thus, the only lucrative market for turbot seems to be France. The present market size is 3 000 MT, absorbing almost all the turbot catch of the Dutch fishing fleet. In France, the good quality and flavour of turbot are fully appreciated and there are many different recipes on turbot. Prices are relatively high and have increased during the past five years. This market will soon start to absorb the domestic farmed production, and Spanish farmed turbots are likely to enter the market soon. French consumption of turbot can be forecast to grow by 2 000 MT in the next 2 or 3 years, with no significant decline in prices. Any quantity exceeding this figure may upset the market. The best period for selling turbot to the French market is before Christmas, when demand is strong and wild turbot supply is low.


Seabass Aquaculture Production
MT
16000
14000
12000
10000
8000
6000
4000
2000
0
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994*
1995*
Others
Egypt
Italy
Greece
* estimates


Seabass Aquaculture Production
and Price on Italian Wholesale Market
MT
16000
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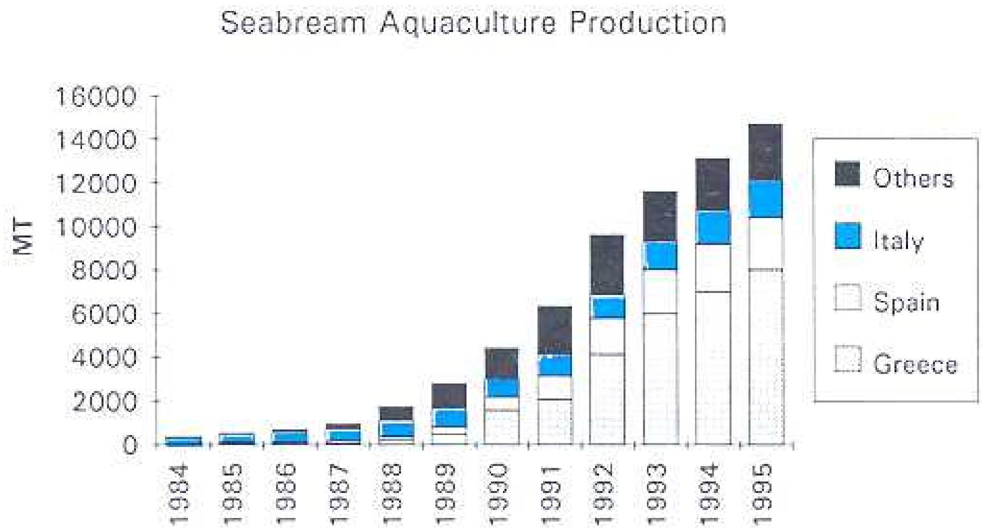
Aquaculture Production
Price


Seabream Aquaculture Production
MT
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Spain
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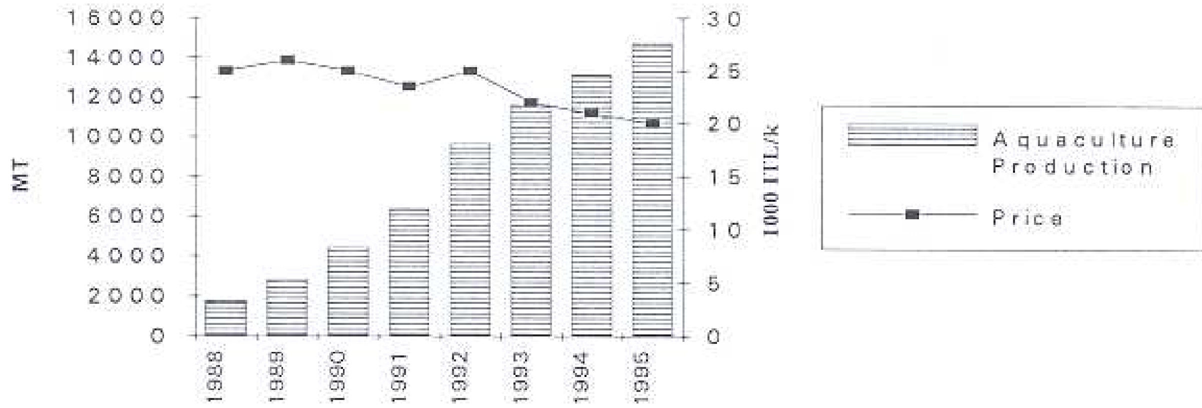
Seabream Aquaculture Production and Price on Italian Wholesale Market



Turbot Aquaculture Production and Price on French wholesale market

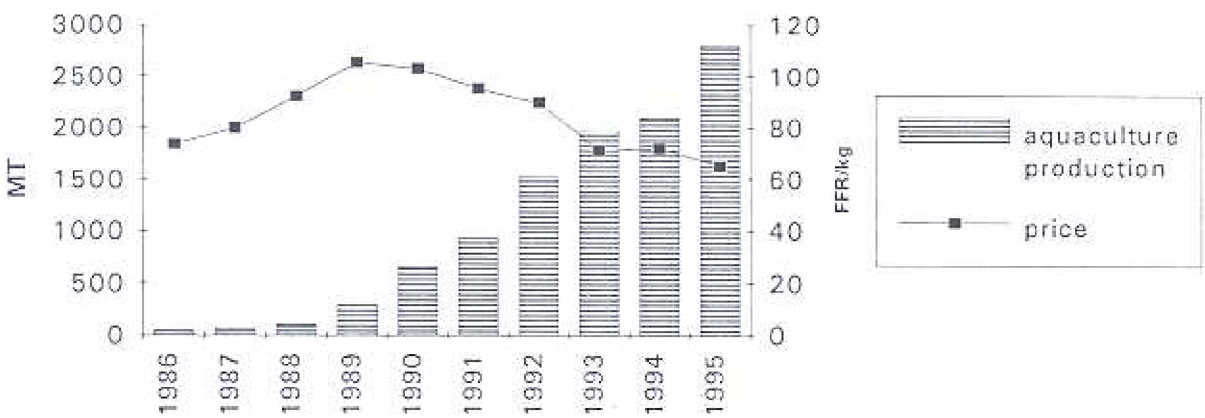


Table 1: World Seabass Culture Production (in mt)

COUNTRY	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Greece	0	0	30	70	110	300	1952	2530	5043	7345	8500	9000
Italy	280	340	550	750	930	1100	1050	1538	1826	2000	2150	2200
Egypt	0	0	0	0	0	0	0	720	720	1139	1350	1100
Tunisia	2	15	30	40	316	300	283	305	161	419	500	500
Malta	0	0	0	0	0	0	0	150	250	400	300	250
Spain	0	11	31	38	29	24	31	92	143	370	450	460
France	0	70	90	140	145	250	300	300	250	250	250	250
Morocco	0	0	0	0	0	0	0	56	121	120	120	150
Portugal	35	42	52	52	52	5	2	3	8	83	100	100
Cyprus	1	1	1	0	3	10	15	15	29	33	55	60
Algeria	2	4	5	6	7	5	2	4	4	4	5	5
TOT COUNTRIES	320	483	849	1096	1592	1994	3635	5713	8655	12163	13780	14075

Table 2: World Seabream Culture Production (in mt)

COUNTRY	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Greece	0	0	0	85	220	490	1536	2069	4125	6012	7000	8000
Spain	0	127	124	109	153	344	565	1073	1675	2007	2200	2400
Italy	320	360	450	550	750	850	850	865	1070	1300	1500	1700
Egypt	0	0	0	0	0	0	0	720	720	720	720	720
Turkey	0	0	34	65	100	798	1031	910	937	330	350	400
Portugal	35	45	67	67	69	19	105	296	369	289	350	400
Morocco	0	0	0	0	0	0	0	98	254	255	255	255
Malta	0	0	0	0	0	0	0	50	150	250	240	200
Israel	0	0	30	45	60	80	84	71	54	156	175	200
Cyprus	0	0	0	2	2	10	35	42	42	126	150	200
Tunisia	15	5	20	25	194	120	85	3	131	85	130	150
France	5	15	10	10	170	20	30	30	50	50	50	50
Croatia	0	0	0	0	0	0	0	0	45	30	20	50
Algeria	1	0	0	0	0	0	2	1	1	1	1	2
SFR of Yug	2	5	10	35	60	100	50	30	0	0	0	0
TOT COUN	378	557	745	973	1778	2837	4435	6358	9624	11630	13141	14727

Table 3: World Turbot Culture Production (in mt)

COUNTRY	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Spain	0	38	40	50	97	271	640	826	1626	1675	1800	2400
France	5	15	10	15	15	15	15	100	100	250	300	400
Chile	0	0	0	0	0	0	0	1	5	34	60	100
Norway	0	0	0	2	0	2	0	2	2	2	2	2
Germany	0	0	0	0	0	1	1	1	0	0	0	0
TOT COUNTRIES	5	53	50	67	112	289	656	930	1733	1811	2162	2902

NEWS ITEMS

NEWS ITEMS

NEWS ITEMS

NEWS ITEMS

Freshwater Fish Culture Extension Project - Vietnam

Under the ongoing economic reforms, the individual farm household is the main driving force of Vietnamese agriculture. Success in agriculture sector, including livestock and fisheries, is crucial to the achievement of Vietnam's national socio-economic goal - poverty alleviation. In this context it has been recognized that the agricultural support services and extension services are going to play a vital role in this process.

The estimated population of 70 million (1993) is expected to reach about 73 million by the end of 1995, given the annual growth rate of over 2 %. The annual per capita fish supply has gone down from 18 kg in early sixties to about 10 kg in 1993.

The country has 1.4 million ha of inland water area which is considered suitable for aquaculture. Of this, only 38 % (530,000 ha) is presently used for aquaculture purposes, with 61 % (325,000 ha) for freshwater culture and the remaining 39 % (205,000 ha) for coastal shrimp culture. It is estimated that more than 90 % of the 325,000 ha, used for freshwater culture, are under pond fish culture and the rest is under rice/fish culture and cage culture in reservoirs, lakes and rivers.

National fish production amounted to about 1.2 million tons in 1994, of which 878,000 tons were derived form marine fisheries and 333,000 tons from inland fisheries and aquaculture. It is estimated that the total yield of inland aquaculture would be in the region of 135,000 tons per annum, of which about 90 % was harvested from fish ponds and the rest from paddy fields and cages. Most of the aquaculture production is consumed domestically except for cultured shrimp destined for export markets.

Vietnam has a long tradition of culturing fish in village ponds. However, the real breakthrough in fish culture was made in the 1970s with the successful introduction of induced breeding of carps (mainly Chinese and Indian). Common carp, tilapia and catfish are also being cultured. Most pond culture practices are still traditional with a production of 50-500 kg/ha/yr. A small number of farmers are following the semi-intensive culture systems with a production 2 or 3 tons/ha/yr, especially in areas where the farmers can receive support from the government extension services. Intensive culture system with production of 7-10 tons/ha/yr has been demonstrated in government fish farms.

FAO involvement in aquaculture in Vietnam, started in early eighties with the implementation of an UNDP/FAO project for the development of marine shrimp culture. This was followed by a project on the development of brine shrimp culture under the FAO Technical Cooperation Programme (TCP). During the period 1989-1994, the FAO/UNDP projects assisted Vietnam in strengthening the country's aquaculture research capacity and in the production of hormones for induced fish breeding. The ongoing FAO/UNDP project -Freshwater Fish Culture Extension - started operation in early 1995 and is expected to last for 2 years.

The fisheries extension services, including aquaculture, are being reorganized in the light of the overall economic reforms. At the central level, the Department of Fisheries Management of the Ministry of Fisheries is responsible for the formulation of national fisheries extension policy and programmes and for providing guidance to provincial extension centres on the implementation of extension programmes. At the provincial level, the responsibilities for field coordination of extension activities lie with the agricultural extension centre of the provincial department of agriculture, forestry and fisheries. The provincial agricultural extension centres have a network of extension stations located in the districts.These extension stations maintain direct contact with the farmers through a network of communal extensionists. In addition to the regular extension system described above, various voluntary organizations also provide extension services.

The main objective of the ongoing project is to establish a sustainable aquaculture extension service in 17 provinces of northern Vietnam and 4 provinces of central Vietnam. The transfer of technology centre (TOTC) of the Research Institute for Aquaculture No. 1 (RIA No.1) of north Vietnam is the implementing unit. The RIA No.1 would provide the linkages between research functions and the technology transfer functions.

The project will provide:

- direct technical support to TOTC and its 4 SubCentres (SCs), 24 Demonstration Farms (DFs) and 12 Integrated Farming Systems sites (locally called VAC sites);
- develop a functional extension system network and an extension input delivery system;
- collect and analyse socio-economic base-line data/ information on 12 VAC sites;
- prepare training materials for extension work;
- establish a network of professional extensionists; etc.

The project is also designed to give special consideration to (i) poverty alleviation through generation of additional income for farm households; (ii) women participation by ensuring that at least 30% of the beneficiaries are women; and (iii) environmental integrity by implementing measures to minimize environmental impacts of aquaculture operations.

International Conference on Preventing Spread of Aquatic Animal Diseases Through International Trade, 07-09 June 1995, Paris, France.

Office International Des Epizooties (OIE) is an organization with a clear mandate to provide information on animal health, coordinate internationally the control of animal diseases, and to harmonize import and export regulations for animals and animal products. The fish Diseases Commissions (FDC) of the OIE recently prepared the International Aquatic Animal Health Code and the Diagnostic Manual for Aquatic Animal Diseases with the view to harmonizing health guaranties for international trade in aquatic animals (fish and shellfish) and aquatic animal products, and to guide Veterinary Administrations and/or other Competent Authorities in the preparation of appropriate health certificates. Since there is a growing concern about the recent moves to develop animal health rules governing trade in aquatic animals and animal products, OIE called for this international conference on Preventing Spread of Aquatic Animal Diseases Through International Trade.

The conference was attended by about 75 persons from over 30 countries and 24 papers were presented. The papers covered areas such as historical aspects, current characteristics, associated disease problems, and national and international legislation of the aquatic animal trade. Dr. Subasinghe of this service presented a paper entitled Historical Aspects of International Movement of Living Aquatic Species, which was jointly authored with Dr Devin Bartley of FAO/FIRI. Dr. Subasinghe also chaired the session on Characteristics of Current International Trade of Finfish.

The International Aquatic Animal Health Code and the Diagnostic Manual of the OIE provides detailed information on basic principles as regards definitions, notifications, ethics in connection with certification, import risk analysis and import/export procedures. This information is intended to facilitate the preparation of international health certificates based on a uniform approach to health control in aquatic animal populations, using the standardized techniques described in the Diagnostic Manual. Health certification in terms of the Code is generally required only for diseases notifiable to the OIE, which are listed in the Code. However, a list of other serious diseases that need consideration is also given in the Code. The listed diseases are recognised as serious transmissible diseases of socio-economic and/or public health importance and for which international trade of aquatic animals and aquatic animal products pose a significant risk of disease transfer between countries.

Discussions were also held on the applicability of OIE's Code and Manual and the ICES/EIFAC Codes of Practice in developing country situations, especially in Asia and Latin America. The latest version (1994) of the International Council for the Exploration of the Sea's (ICES) Code of Practice on the Introductions and Transfer of Marine Organisms and the European

Inland Fisheries Advisory Commission' s (EIFAC) Code of Practice consider the movement of a) new species that have not been previously used in international trade, and b) species that have been transferred and introduced as part of long-standing commercial practices.

It was concluded that considerable revision and infrastructure development is necessary to ensure effective implementation of the Codes in developing countries.

FAO/IAEA Consultants' Meeting on ***Identifying Support Areas for Nuclear Technologies in Aquaculture****, 12-15 June 1995, Vienna, Austria.*

The joint FAO/IAEA Division on Nuclear Techniques in Food and Agriculture, based in Vienna, Austria has a programme to support member countries in livestock production. They work with both state and private sector agencies to produce assay kits and other diagnostic tools for use in livestock. They also provide research grants to institutions to test these tools and technologies and promote technology transfer to developing countries. Recently, they have received requests from a number of member countries and agencies to explore the possibilities of using the above techniques to improve fish production. The FAO/IAEA programme has decided to address this need and requested FAO/FIRI to assist in organizing a Consultants' Meeting to identify support areas for nuclear technologies in aquaculture.

The main objective of the Consultants' Meeting was to identify and characterize research areas where the introduction and use of nuclear and related technologies are likely to have the most significant impact on improving aquaculture in the developing countries. The consultation was also expected to advise FAO/IAEA on the most appropriate mechanisms for the implementation of such research programmes in developing countries.

The consultancy team consisted of a group of scientists representing a wide range of disciplines relevant to utilisation of the aquatic environment for improving food production. They included expertise in areas of fish and shellfish culture, health management, nutrition, environmental toxicology, in both extensive and intensive farming systems. The consultants were Dr. J.R. Bonami (France), Prof. C. Aguis (Malta), Dr. R. Waagbø (Norway), Dr. L. Norrgren (Sweden) and Prof. R.J. Roberts (United Kingdom). Dr. Subasinghe represented FAO/FIRI.

Individual consultants reviewed the areas where nuclear technologies can be applied within their own disciplines. Lengthy discussions were held in order to finalise the most appropriate area to be supported in this initial phase. The group concluded that there was indeed an urgent need for the incorporation of modern technologies into the very rapidly developing aquaculture industry which is nowadays, in many developing countries, is of great economic importance. Further information on this meeting will be included in the next issue of the FAN.

Rohana P. Subasinghe
Fishery Resources Officer (Fish Health)

The Sixth Session of the Working Party on Aquaculture of the Commission for Inland Fisheries of Latin America (COPESCAL) was held in Tegucigalpa, Honduras, from 3-7 July, 1995. Representatives from 13 countries of the Region participated in the session. The main agenda items included review of intersessional activities; review of recommendations made by the last meeting of the Commission; presentations of papers and discussions on rural aquaculture; aquaculture in small water bodies; aquaculture feed and feeding; and culture of molluscs, algae, tilapia, marine shrimp, freshwater shrimp etc.

NEW PUBLICATIONS

Indo-Pacific Fishery Commission
FAO Fisheries Report No. 512, Rome, FAO, 1994. 48 p.

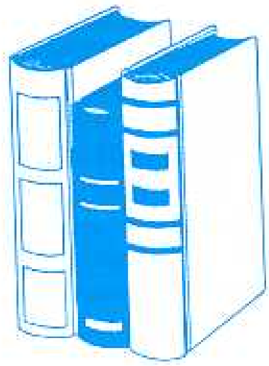
This report is now available in English. The sixth session of the Indo-pacific Fishery Commission (IPFC) Working Party of Experts on Inland Fisheries was held in Bangkok, Thailand, from 17 to 21 October 1994. It reviewed the activities in inland fisheries since the establishment of the Working Party in 1976, focussing especially on the last intersessional period (1991-1994). Among the topics discussed were fisheries in small water bodies (including culture based fisheries), in tropical rivers and in saline inland waters. The document also includes the report of the Regional Symposium on Sustainable Development of Inland Fisheries under Environmental Constraints, which was held during the sixth session of the Working Party. The edited proceedings of the symposium has been published as a supplement to the report.

J. M. Kapetsky. A strategic assessment of warm water fish farming potential in Africa. CIFA Technical paper No. 27. Rome, FAO. 1994. 67 p. Available in English.

Aquaculture in Africa is in its early stages of development. This study is a strategic assessment of the areal expanses and locations encompassing suitable to optimum potential for subsistence and commercial warm water fish farming in ponds.

Three temperature regimes were specified using the Nile tilapia as a model. In concert with each temperature regime, subsistence fish farming potential was assessed on the basis of availability of surface water for storage in ponds, suitability of topography and soil texture for pond construction, availability and variety of agricultural by-products as inputs, and local market potential. For commercial farming two criteria were added: perennial streams and rivers as independent or supplementary sources of water and availability of paved and motorable roads. Thresholds were established for each criterion corresponding to optimum, suitable and marginal conditions. A geographic information system (GIS) was used to evaluate the criteria on 10 minute (18 km x 18 km) grids and by country boundaries.

In all, there are some 9.2 million km², equivalent to 31% of the African surface, suitable for warm water fish farming at a subsistence level. The corresponding results for commercial fish farming indicate that there are 3.9 million km², equivalent to 13% of the African surface, potentially suitable for warm water fish farming.



Albert G.J. Tacon. Ictiopatología nutricional. Signos morfológicos de la carencia y toxicidad de los nutrientes en los peces cultivados. FAO Documento Tecnico de Pesca 330.

El presente document es una versión revisada del FAO/UNDP Field Document ADCP/REP/85/22, y forma parte de una serie de informes que la Dirección de Recursos y Ambientes Pesqueros de la FAO elabora de forma períodica para contribuir a satisfacer las necesidades de síntesis de información en el ámbito de la acuicultura de los trabajadores de este sector de los Estados Miembros. Este informe está basado en los textos del curso impartido por el autor a los asistentes del Curso International de Capacitación de la FAO sobre el Diagnóstico de Enfermedades de los Peces, organizado or el Proyecto GCP/INT/526/JPN en Coihaique (Chile) del 23 de noviembre al 5 de diciembre de 1992. La información contenida en el presente documento es un compendio de los datos publicados por fuentes muy diversas relativos a los signos morfológicos de la deficiencia y toxicidad de los nutrientes en las alimentación de los peces y, como tal, constituye un manual de consulta muy útil para las personas o equipos que se ocupan de la alimentación de los peces con dietas nutricionalmente completas en sistemas de piscicultur? intensive en aguas claras.

This document is also available in English and French.

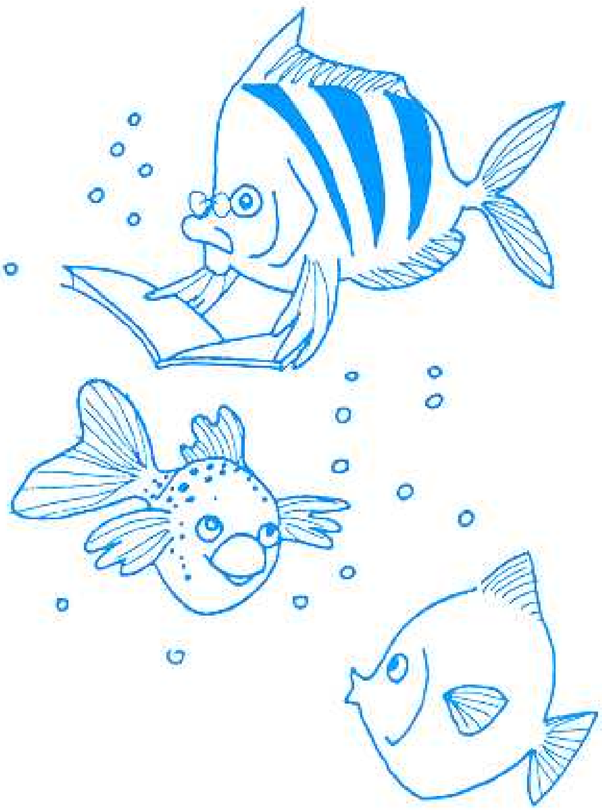
V. V. Sugunan. Reservoir Fisheries of India. FAO Fisheries Technical Paper No. 345, Rome, FAO. 1995. 423 p.

This first comprehensive review of reservoir fisheries of India covers more than 100 reservoirs located in various parts of the country. It includes an overview on fish stock enhancement through transfer of fish species, and culture-enhancement approaches such as regular stocking and establishment of cage and pen culture in some reservoirs. The policies hitherto adopted in Indian reservoirs mainly consisted of stocking fingerlings of a species or a combination of species without any definite density levels or ratios based on the biogenic capacity of the reservoir. Rate of stocking and the species mix are often determined by the availability of fingerlings, rather than on careful evaluation of the needs. The stocking of hatchery reared seed, initiated since 1970s, has gradually substituted the stocking of the natural spawn collected from rivers. Today, reservoir fisheries in India are largely based on carp fisheries. Development of endemic candidates as stocking material has not made much headway but it is recognized that diversification of the stocking material is essential for establishment of a multi-species fish stock that utilize all food niches of the ecosystem.

Achieving the most important objectives of stocking, i.e. to augment yield, and to recover this increment from the reservoir, are much easier in smaller reservoirs than in the larger ones. It has been also recognized that a stocking programme can be called successful only when the stocked fish start breeding in the new water body. In many cases, despite persistent stocking, the transplanted species did not show up in the catch. Indeed, only in a few instances the stocking operations were compensated by generation of income through recapture of the stocked fish. In small reservoirs, on the other hand, stocking has been more effective in improving the yield. The management of small reservoirs depends more on recapturing the stocked fish rather than on their building up a breeding population. The smaller water bodies have the advantage of easy stock monitoring and manipulation. In India, an imaginative stocking and harvesting schedule is the main theme of fisheries management in small, shallow reservoirs.

Cage and pen culture have not yet become very popular in India. Experiments on cage culture conducted in India have been exploratory in nature and the yields obtained, so far, are not impressive. The supplemental feeds (oilcakes, soybean flour and silkworm pupae) have great demand in cattle, and pig rearing and in other animal husbandry practices, and hence command a good price in the market. The food quotient obtained in the cage culture of various species has not been high, except in the case of tilapia, making conventional supplemental feeding unremunerative. One of the major constraints of the cage culture system is the lack of suitable cage designs to withstand severe wave action, common in Indian reservoirs. Floating cages are considered to be most appropriate for Indian conditions and all the experiments conducted so far in the country for seed rearing, grow-out, nutrition and biomonitoring have been in such enclosures. Pen fish nurseries have been used with remarkable success in Tungabhadra reservoir for some 15 years, and two other reservoirs in the northeastern India.

More details on stocking practices and cage and pen culture in Indian reservoirs are given on pages 38 to 62 of this publication.



H. R. Rabanal. Aquaculture Extension Services Review: the Philippines
FAO Fisheries Circular. No. 892 . Rome, FAO. 1995. 57p.

The Philippines is a major fish producing country in the world, ranking 11 among the world fisheries producers. In aquaculture, the Philippines holds the 5th position in the world. The country is a net exporter of fishery products, exporting US$468 million against an import value of US$96 million. Out of a total fish production of 2.6 million t, 28 % (736,000t) comes from aquaculture (1992).

In Philippines, aquaculture production comes mainly from six production system: brackishwater ponds, freshwater ponds, fish pens (mainly in freshwater), fishcages (mainly in freshwater), molluscs farming and seaweeds farming. The main species groups cultured are milkfish, tilapia, jumbo tiger shrimp, oyster, mussels and seaweeds.

The country has high potential for further growth in aquaculture, especially in mariculture of fish, molluscs and seaweeds. However, many technical, administrative and management problems must be resolved before further growth in the aquaculture industry is possible.

The government gives high priority to the development of fisheries, including aquaculture. Under the national Medium-term Economic Development Plan, a Medium-term Fisheries Development Plan is being implemented. The Department of Agriculture through its Regional offices carry out agricultural development activities including that of fisheries and aquaculture. The various specialized agencies under the Department of Agriculture, especially the Bureau of Fisheries and Aquatic Resources (BFAR), Bureau of Agricultural Research (BAR), Bureau of Agricultural Statistics (BAS) and the Agricultural Training Institute (ATI), cooperate and contribute towards the development of aquaculture.

The aquaculture extension services are provided by the Department of Agriculture through two nationwide programmes: (i) Fisheries Sector Programme (FSP), and (ii) National Fisheries Outreach Programme (NFOP). The former is an inter-agency programme to rehabilitate, conserve and regenerate fisheries/aquaculture resources while at the same time alleviating poverty amongst the marginal fishermen/fishfarmers. The latter programme, NFOP, is responsible for sustainable and equitable management of fisheries and aquaculture and is operated by the local government with full participation and cooperation of NGOs and Local Fishing Communities.

The aquaculture extension policies, plans and programmes are embodied in the Medium Term Fisheries Management and Development Plan (MTFMDP) of 1993-98. The plan envisages aquaculture production increase from 0.74 million in 1993 to 1.0 million t in 1998, at a cost of 5.396 billion pesos.

Aquaculture extension services cover brackishwater/freshwater pond culture, rice-fish culture, fish culture in pens and cages, and mariculture of molluscs and seaweeds. The extension methods applied are individual/group methods, demonstrations, training and visits, mass media, field trips/workshops, and training in extension schools and farmers training centres. The review also contains information on technologies, input supplies, subsidies, extension control mechanisms, extension and research linkages, part played by NGOs etc. Within the context of aquaculture extension services in the country, the subjects of aquaculture production, marketing of aquaculture products and the socio-economic benefits derived from aquaculture have been dealt with.

NEW COMER

Dr. Matthias Halwart has been appointed Fishery Resources Officer (Aquaculture and Farming Systems), Associate Professional Officer, in the Inland Water Resources and Aquaculture Service, effective 2 May 1995. He graduated in Agricultural Sciences from Hohenheim University (Germany) in 1990 and was awarded PhD in 1994 for his research on fish as bio-control agents in irrigated rice.

From 1990 to 1994 he was Collaborative Research Scientist in the Asian Rice Farming Systems Network of the International Rice Research Institute (IRRI) in the Philippines, where he coordinated and implemented a joint research project on the use and potential of fish in biological control programmes in irrigated rice.

Dr. Halwart will assist in the implementation of programmes for the incorporation of aquaculture into farming systems.

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