FAO Aquaculture Newsletter

April 1994 - Number 6

Inland Water Resources and Aquaculture Service
Fisheries Department
FOOD and AGRICULTURE ORGANIZATION
of the UNITED NATIONS
Viale delle Terme di Caracalla, Rome, 00100 Italy
Tel: 39-6-5225007 /Telex: 610181 FAO I/Fax: 39-6-52253020

Contents

EDITORIAL

There is an increasing trend throughout the world towards intensification of fisheries either for food or recreation. In inland waters this is manifested firstly through numerous programmes of stocking for enhancement of fish stocks in lakes, reservoirs and even in rivers and secondly through physical manipulation of the environment. Similar issues are now becoming common in the marine field with restocking and habitat enhancement being practised by an increasing number of countries. It is my belief that intensification of marine production systems is going to expand considerably in the foreseeable future. The possibility of enhancement of marine stocks through ranching is attracting a good deal of attention. Systematic conservation of diadromous stocks through artificial rearing and release into natural marine environments is a long established practice especially in the case of the North Temperate salmonids and sturgeons. Successes with such species has encouraged an extension to other species. Japan is undoubtedly the most advanced in this technology and is currently investigating 57 species as candidates for such management. At present salmon are dominant but several other species are part of current practice. Efforts are not limited to fish, as stocks of molluscs and crustacea are also enhanced by extensive stocking. Salmonid management programmes are also found in Russia, USA, Canada, Iceland, Norway and Finland. An increasing number of experimental releases of cod are being made in USA, Canada and Norway and a range of other fish species - red drum, turbot, sole and plaice are being investigated as candidate species. Maintenance of some mollusc stocks through seeding has long been established and systematic enhancement of crustacean fisheries particularly of lobster shows promise in North America and Europe. Theoretically enhancement of marine fisheries by release and recapture has a great potential to add to world fish production. The marine environment would seem to offer a greater area and a wider range of suitable species than inland environments and thus a greater potential before natural constraints appear. However, present return rates are, in most cases, such that the cost-benefit ratio of stocking is insufficient to warrant it being adopted as a major approach to management. As the cost of production per stocking unit falls and as fish supplies fail to keep up with demand causing changes in price structure the ratio may be forced towards a more favourable balance. However, it must be borne in mind that there are many interrelated technical, economic, management, environmental and sociological problems to be resolved before positive impacts of such efforts become a reality.

Robin Welcomme
Chief, Inland Fishery Resources and Aquaculture Service

THE POTENTIAL FOR WARM WATER FISH FARMING IN THE SADC COUNTRIES

James McDaid Kapetsky
Senior Firshery Resources Officer
Inland Water Resources and Aquaculture Service

A Cooperative Study of the FAO Inland Water Resources and Aquaculture Service (FIRI) and the Aquaculture for Local Community Development Project (ALCOM)

Introduction

Fish farming in Africa is still in its early stages of development. Inland fish farming production from the Southern African Development Community (SADC) countries (Angola, Botswana, Lesotho, Mozambique, Malawi, Namibia, Swaziland, Tanzania, Zambia, and Zimbabwe) amounts to approximately 2000 t/y, while the rest of Africa produces about 50,000 t/y. On the other hand, inland capture fisheries production from the SADC countries and the rest of Africa amounts to 0.5 million t/y and 1.3 million t/y respectively.

It is believed that there are much unrealized fish farming potential in most African countries. However, detailed studies for identifying and quantifying aquaculture opportunities at national levels have not yet been carried out. In the absence of basic information and a clear picture of the overall prospects and potentials for aquaculture development it is very difficult, of not impossible, for the national governments, funding institutions and international agencies to prepare long-term development plans and to allocate resources for national/regional aquaculture development programmes.

The objective of this study was to identify the areas with suitable to optimum potential for fish farming in ponds at subsistence and commercial levels in three temperature regimes corresponding to warm-water fish farming.

Materials and methods

Using *Oreochromis niloticus* and *Clarias gariepinus* as models, three temperature regimes were specified corresponding to two crops/y with good growth, two crops/y with fair growth and one crop/y with fair to good growth, the latter ensuring over-wintering without special care[1]. In connection 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 agriculture by-products as inputs, and local market potential[2]. In order to assess commercial fish farming two additional criteria were assessed: perennial streams and rivers as independent or supplementary sources of water and proximity of paved and motorable roads[3]. Thresholds were established for each criterion corresponding to optimum and suitable conditions for development. A geographical information system (GIS)[4] was created for the analysis. The GIS was used to evaluate the criteria on 10' (18 km x 18 km) grids and by country boundaries.

Results

The potential for warm water fish farming can be considered in several ways. The first is the land area of each country that is amenable to commercial and subsistence fish farming under each temperature regime (Map 1, Subsistence and Map 2, Commercial; Figs. 2 and 3). Map 1 shows that there are rather vast areas in Angola, Mozambique, Zambia, Tanzania, Zimbabwe and Malawi with opportunities for subsistence fish farming under conditions that range from suitable to optimum for the criteria mentioned above. Most of the areas favourable for two crops/y with good growth are in N Angola, E Tanzania and N and NE Mozambique. Areas favourable for two crops/y with fair growth are found in Northern Angola, N Zambia, NW and E Tanzania and N and E Mozambique. One crop/y opportunities are in Central Angola, in most of Zambia, Malawi and Swaziland, and in W and S Mozambique. In Botswana and Namibia the areas are relatively very small and Lesotho possesses no area apt for warm water fish farming.

Commercial farming opportunities follow a spatial distribution pattern similar to that for subsistence fish farming (Map 2, Commercial); but because additional criteria (primary or supplemental water supply from perennial streams and rivers and proximity of paved and motorable roads) were used, and because the threshold on local market demand for farm gate sales was more stringent than for subsistence farming, the areas apt for commercial fish farming (Fig. 3) are considerably smaller than for subsistence farming (Fig. 2).

Important from a national perspective is the percentage of the country that lends itself to fish farming development under each temperature regime. Country land areas apt for subsistence farming range from nearly 74% in Zambia to 49% in Zimbabwe (Fig. 4); however, only 1% of Botswana is amenable and less than 2% of Namibia. The greatest proportion of land apt for subsistence fish farming falls in the one crop/y temperature regime in Zambia (70%) and likewise in Swaziland (49%), Malawi (47%) and Zimbabwe (46%). In comparison, relatively large areas of Mozambique (41%), Tanzania (40%) and Angola (23%) are in the two crops/y-fair growth temperature regime. Four of the ten SADC countries (Zambia, Angola, Mozambique and Tanzania) include areas of two crops/y - good growth temperature regimes. In the last three of these countries, the two crops/y-good growth regime is found in vast areas ranging from 59,000 to 63,000 km^2 (Map 2, Commercial).

Surface areas amenable for commercial fish farming range from 34% in Malawi to 21% in Tanzania (Fig. 5). Most of the areas apt for commercial farming reside in the one crop/y temperature regime in Swaziland (32%), Malawi (31%), Zimbabwe (29%), Zambia (26%), and Angola(13%). But for Mozambique and Tanzania the greatest amount of area for commercial fish farming is in the temperature regime providing two crops/y with fair growth, 18% and 13% respectively. Commercial fish farming opportunities providing for two crops/y with good growth are in Tanzania, Mozambique and Angola with relatively large areas of 37,000, 27,000 and 24,000 km^2 respectively. In contrast, Zambia possesses little more than 300 km^2 in this category. Botswana has nearly 3900 km^2 apt for one crop/y, less than one percent of the national land area. Namibia has less than 1,000 km^2 apt for one crop/y.

Discussion

First, it has to be kept in mind that the results refer to potential for warm water fish farming in ponds. Countries may have other kinds of aquaculture potential and those are not included in this study. Second, because of the spatial resolution used, this was a strategic assessment rather than a tactical study. Thus, the results are indicative rather than definitive. third, this is a report on a study still in progress. However, the study does provide useful perspective on land surfaces and locations within which subsistence and commercial warm water fish farming development are likely to meet with a minimum of constraints as far as on the basic criteria dealt with in this study are concerned. It should be kept in mind that not all of the absolute area indicated in this study could be developed for fish farming. Apart from any errors in the data and in defining threshold limits for each criterion, much of the land could already be in other, competing uses. The value of this study is that it provides a comparative view of warm water fish farming potential among countries. From a national perspective, the results provide a jumping-off point for higher resolution, more detailed assessments of aquaculture potential at the province, district and ward levels.

Conclusions

Seven of the ten SADC countries possess large areas in which warm water fish farming could be further developed. These range from 49 to 74% of land areas apt for subsistence fish farming and from 21 to 34% ammenable to commercial fish farming. Therefore, lack of suitable areas is not a constraint to further development of aquaculture in these countries. However, farmers in suitable areas might not take up fish farming for reasons such as better alternative uses of the land or perceived lack of demand for fish. Aquaculture development efforts should be carefully targeted at those areas that are identified as suitable and where expected fish farming outputs are competitive with other land uses. In this context, GIS is a useful tool for initial planning of aquaculture development activities.

[1] The "good growth" regime is defined by t >= 26 C for 12 m/y, which is near to the optimum for both species. For tilapias in general, growth and reproduction are inhibited at t < 22 C. Thus, "fair growth" can occur when t >= 22 C for 12 m/y. The "one crop/y, fair to good growth" regime is t >= 22 C for 8 m/y and t >= 14 C for 4 m/y. In this regime the temperature range encompasses both the "fair" and "good" regimes above. Four months at t >= 14 C ensures over-winter survival without special care.

[2] The "model" subsistence fish farm has pond area of 0.04 ha, 2 t/ha/y output of which one-half is consumed by the farm family and the remainder goes to local sale, or barter at the farm gate or within a 2 km radius.

[3] The model commercial farm was of 0.4 ha pond area, 3 t/ha/y output of which 25% goes to farm gate sales made within a 4 km radius and the remainder to be transported to markets by paved or motorable roads, thus the importance of road proximity. Perennial streams and rivers can be an independent or supplemental source of water and allow for fish farming in areas otherwise too dry.

[4] A geographical information system is a collection of computer hardware, software and personnel to store, manipulate, analyze and report spatial data

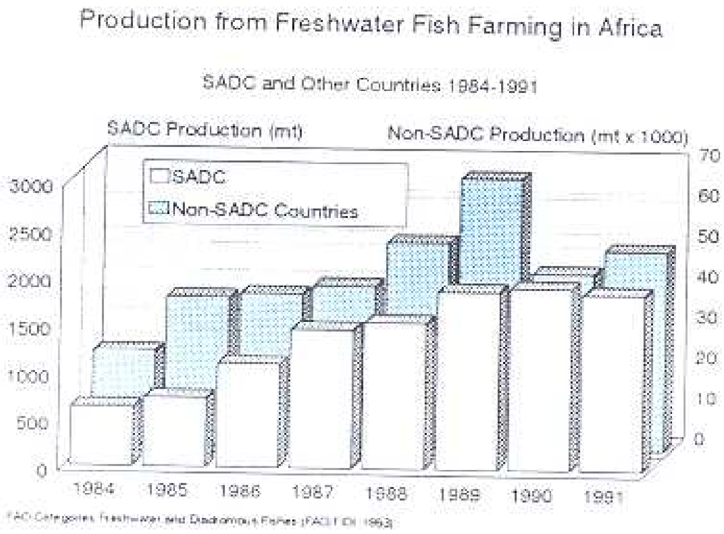


Figure 1

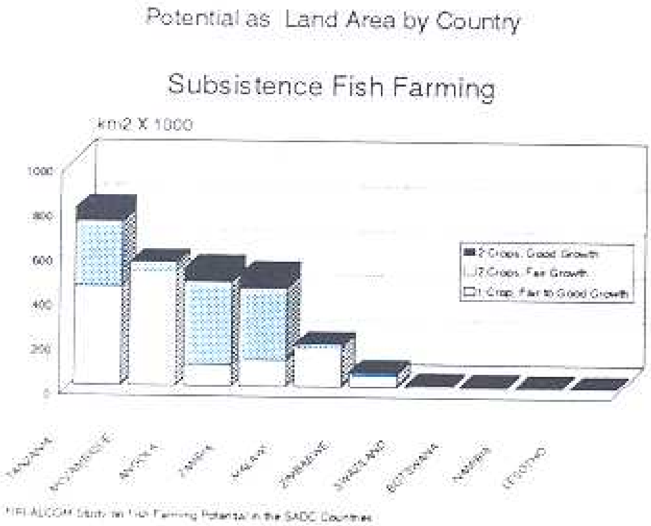


Figure 2

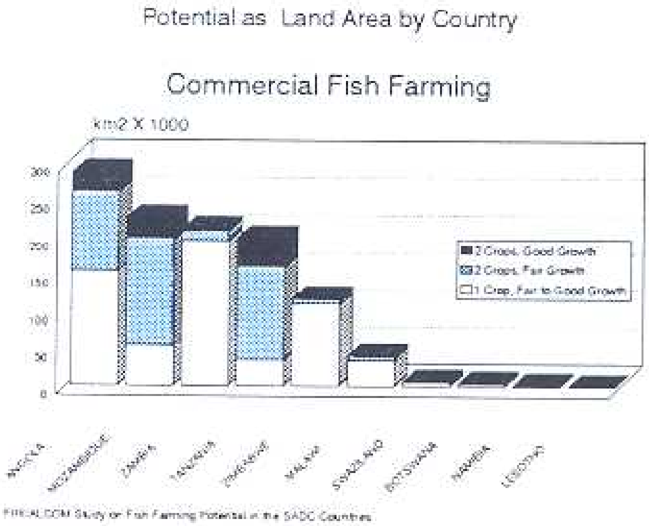


Figure 3

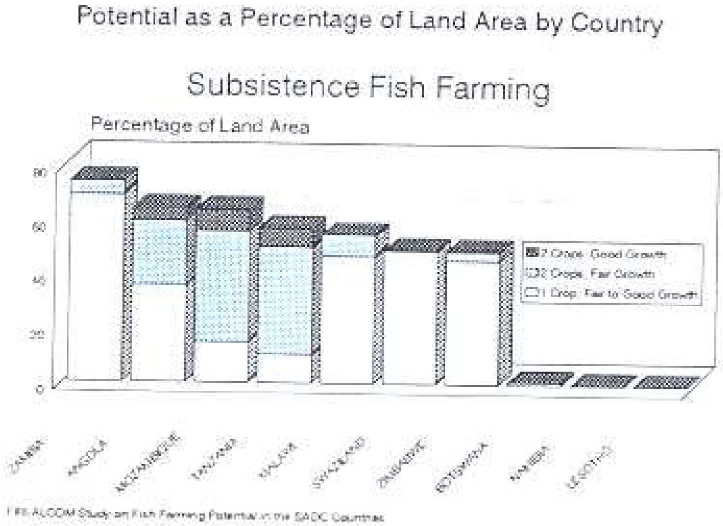


Figure 4

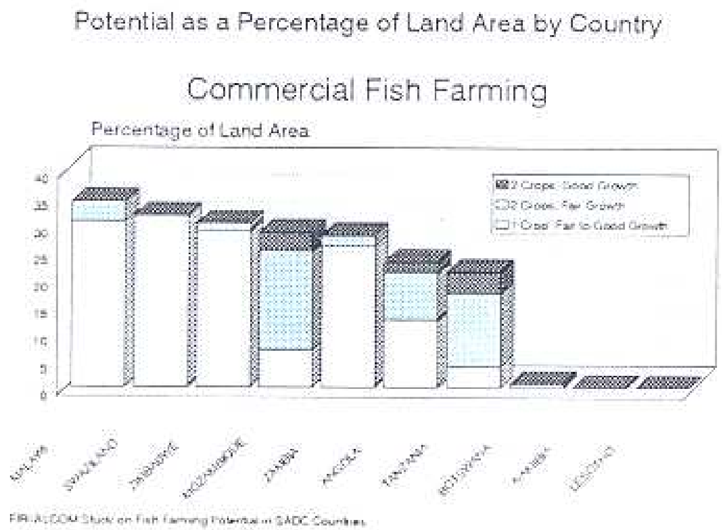
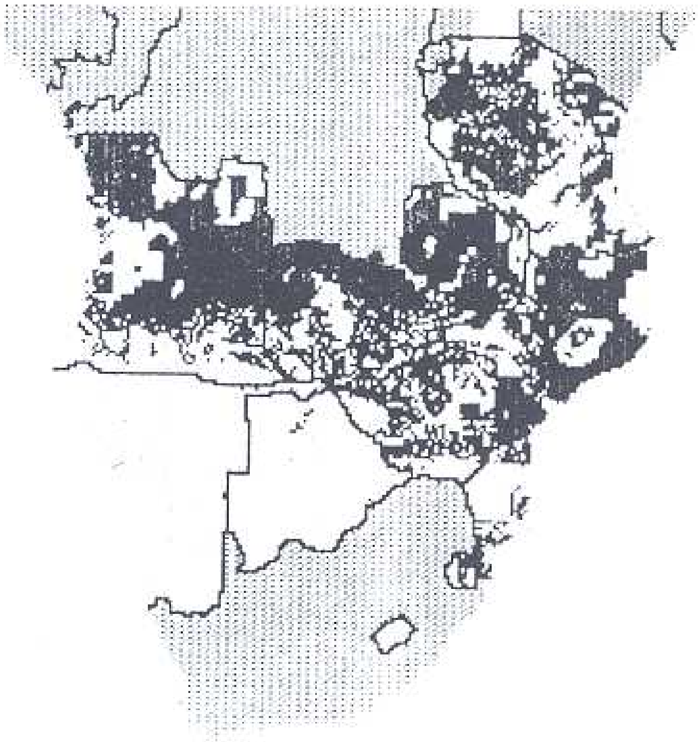
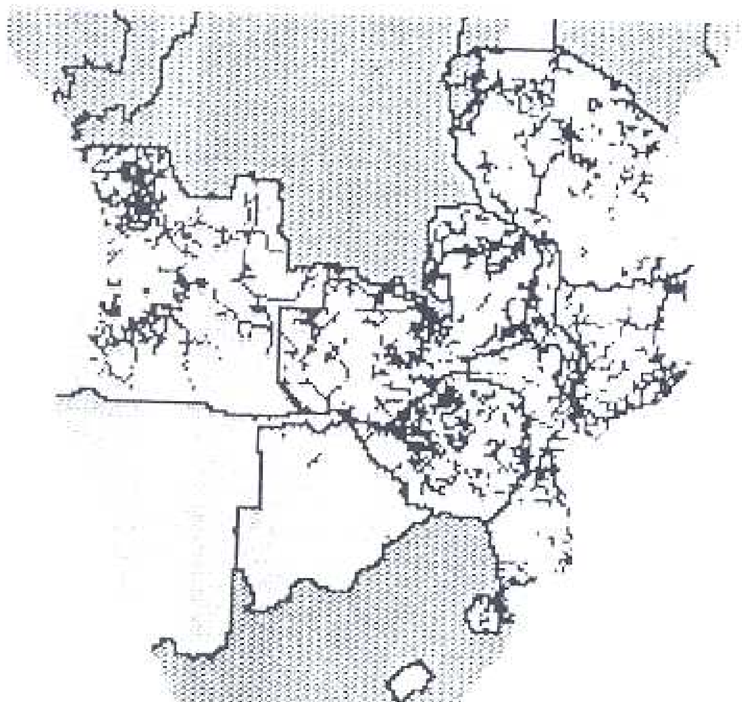


Figure 5

Map 1: Warm water fish farming potential at subsistence level



Map 2: Warm water fish farming potential at commercial level



FAO AND THE STRATEGY FOR INTERNATIONAL FISHERIES RESEARCH (SIFR) THE AQUACULTURE COMPONENT

Mario Pedini
Senior Adviser (Aquaculture Development)
Inland Water Resources and Aquaculture Service

THE STUDY ON INTERNATIONAL FISHERIES RESEARCH (SIFR)

The Study on International Fisheries Research (SIFR) was promoted by a consortium of eighteen bilateral and multilateral development agencies. The idea of such a study was conceived after the First Fisheries Donor's Meeting organized by the World Bank in 1986 and to which the same eighteen agencies participated. At that meeting the agencies felt that the fisheries development projects in general had lower performance rates than expected. There was also a general agreement that the performance of fisheries development projects could be improved through short and medium term development oriented research. A study was therefore launched to determine the needs and priorities for development oriented research for fisheries and aquaculture. Emphasis was put in the strengthening of national capacities and in the programme of regional nature.

The SIFR started in 1989 and it took two years to complete. Groups of consultants travelled to the various regions of the world, and meetings of experts were organized to gather opinions to prepare a sectoral diagnosis and an action plan. The final report was discussed at the Second Fisheries Donor's Meeting which took place in Paris in October 1991.

THE STRATEGY FOR INTERNATIONAL FISHERIES RESEARCH (SIFR)

At the Second Fisheries Donor's Meeting the agencies accepted the sectoral diagnosis but expressed strong reservations on the action plan, as it was not very clear from the report to which degree the recipient countries had participated in the determination of the priorities and in the design of the action plan. It was also felt that the action plan was not comprehensive enough to be used immediately by the donors for the reorientation of their aid programmes, and therefore the meeting requested the members of the Steering Committee of SIFR (World Bank, UNDP, EC, IDRC, NORAD and FAO) to revise it. The final report of the study as well as the various technical papers and the mission reports have been published by the World Bank. At the 1991 Paris meeting the final report was accepted. However, to ensure the necessary continuity, a new mechanism was created. Thus, the Strategy for International Fisheries Research was established, maintaining the same acronym and creating an Executive Secretariat, hosted by IDRC, Canada.

THE METHODOLOGY SELECTED FOR IMPROVEMENT OF THE ACTION PLAN

In early 1992, FAO initiated the design of a methodology to assist in the improvement of the action plan for aquaculture. The strategy tried to correct the following two major criticisms expressed by the agencies: (i) the lack of evidence of the participation of the recipient countries in the selection of research priorities and action plan and (ii) the lack of information about their capabilities to get involved in development oriented research. The methodology chosen by FAO was to carry out a series of national studies by national consultants, according to standard guidelines designed by FAO. A comparative analysis of these studies would then lead to the determination of regional and sub-regional priorities as seen by the countries, and on the basis of these priorities and taking into account the capabilities of national institutions in the regions, draft regional action plans would be formulated. These findings and the action plans would then be validated by the countries at meetings of the Working Parties of the FAO advisory bodies and the FAO Regional Fisheries Commissions.

These studies were initiated in Africa South of Sahara, the Northern African countries bordering the Mediterranean, and Latin America. A proposal is now being prepared for the donor community to fund a similar analysis in Asia. Although it is well known that Asia is the cradle of aquaculture and is the region contributing most to world aquaculture production, the complexity of the production systems in Asia is such that it requires much more detailed studies.

At an organizational meeting for the Asian study, held in Bangkok in February 1994, and in which representatives of the Asian Fisheries Society (AFS), Asian Institute of Technology (AIT), European Commission (EC), Network of Aquaculture Centers for Asia and the Pacific (NACA), the FAO Regional Office for Asia and the Pacific, and FAO Headquarters staff participated, it was recognized that it would be necessary to divide the continent in several sub-regions and that instead of national authors, national committees incorporating representatives of the public, academic and private sector should be put in charge of the national reports. Moreover, the deep involvement of several international, regional or sub-regional institutions (such as AIT, NACA, ICLARM, SEAFDEC, ESCAP and AFS) in aquaculture development and research makes the picture even more complex.

The interest of FAO in this matter is obvious as it would allow the Organization to better focus the needs of the member countries in designing their future aquaculture programmes. It has to be borne in mind that since the Technical Conference on Aquaculture, held in Kyoto, Japan, in 1976, the views of the member countries on aquaculture development and research have not been sought.

FAO has been deeply involved in the various stages of the SIFR regional studies especially in the coordination, design of the guidelines, organization of the missions and the regional meetings.

The methodology described above has been fully used in the studies on Africa South of Sahara, partially so in the case of Latin America (due to the lack of funds), and to a lesser extent in the African countries bordering the Mediterranean.

The study on Africa south of Sahara

The most comprehensive study carried out by FAO for promotion of development oriented research through the organization of specific regional networks is that concerning the countries of Africa South of Sahara. The study included 12 African countries (Cameroon, Central African Republic, Congo, Côte d'Ivoire, Kenya, Madagascar, Malawi, Nigeria, Rwanda, Tanzania, Zambia and Zimbabwe) which together produced about 50 percent of the total weight and about 85 percent of the total value of the 1990 aquaculture production in Africa. The national reports were prepared by national experts and briefed by a group of international consultants and ALCOM project staff. A synthesis and an Indicative Action Plan, based on a comparative analysis of the national reports, were then prepared. These two documents were discussed at the Second Working Party on Aquaculture of CIFA which took place in Harare, Zimbabwe, from 13 to 17 September 1993.

In summary, the major priorities identified for aquaculture development by the countries in Sub-Saharan Africa are :

- Reorganize and strengthen extension services
- Give access to credit to small-scale farmers
- Improve technology development and transfer processes
- Privatize juvenile fish production
- Reorganize public administration
- Promote specialized education of senior staff
- Establish a good aquaculture data base
- Promote education and training of medium-level staff

In terms of aquaculture research, the major priorities as identified are as follows:

- Improve supplementary feeding strategy
- Study biology and farming of new local species
- Improve organic fertilization strategy
- Improve farmed species genetically
- Establish research facilities
- Promote socio-economic research
- Intensify market research
- Improve broodstock management
- Study cage culture systems
- Improve and promote integrated farming systems.
- Enhancement of small water-body fisheries
- Integration of aquaculture in irrigation schemes
- Development of marine aquaculture
- Management practices in temperate areas of Africa.

The identified aquaculture development priorities, development constraints and research priorities were matched and classified into four broad development priority areas: (i) administration and management; (ii) aquaculture production; (iii) aquaculture information; and (iv) education of researchers. The research programmes which form the indicative action plan were then designed to help meet the identified aquaculture development priorities. The research programmes would be implemented through a network of existing national institutions which would be assisted by the international donor community. In each network there would be a lead center responsible for the overall coordination.

Nine regional research programmes have been elaborated; they are prioritized and grouped into short term (five years) and medium term (ten years) :- Table 1.

Table 1

Research Programmes	Duration	Priority
Information Centres	Short term	1
Socio-economics	Short term	1
Production indicators	Short term	1
Fertilization-Feeds	Medium term	1
Broodstock management	Medium term	1
Small-water bodies	Medium term	2
Irrigation schemes	Medium term	2
New indigenous species	Medium term	3
Marine aquaculture	Medium term	3

These programmes were validated by the countries at the Second Session of the Working Party on Aquaculture of CIFA. At present, they are in the form of project ideas only. In the course of 1994, further discussions with the donors community are envisaged within the framework of SIFR to raise funds for the detailed formulation of the programmes. A prior agreement on the cost sharing arrangements for these missions would be needed, and a special meeting for this purpose is being organized by the SIFR Executive Secretary.

The study on Latin America

Due to non-availability of funds for consultants, the entire study had to be carried out by the staff of AQUILA II. The study covers 19 countries of the Central and South America. A synthesis of the national reports were discussed at the Sixth Session of the Working Party on Aquaculture of COPESCAL, held in Cartagena, Colombia, from 12-16 July, 1993. Following the methodology used in the study on Africa south of Sahara, the priority theme for development oriented aquaculture research needs were identified along with the national capabilities. The proposed research programme would be implemented through the establishment of networks of national centres and lead centres as in the case of Africa south of Sahara. The prioritized research topics identified are as follows:

Marine shrimp culture. This topic include support to improve the bio-technical constraints related to pathology, feeds and feeding; economic analysis for improvement of profitability; marketing research; and research on the evaluation of environmental impact of aquaculture.

Diversification of production. This concerns with the identification of new species of seaweeds, mollusc and finfish with potential for farming in the area, as the Latin American production still depends on a few species.

Extensive forms of aquaculture. This refers to enhancement practices in inland waters as well as to the management of coastal lagoons. In the first case, research is required to monitor the impact of the enhancement practices on the communities exploiting the inland waters. In addition, limnological research is required to tailor the management practices to the specific characteristics of the small water bodies. For the second area, coastal lagoons, the research elements would consist of evaluation of the possibilities of inclusion of extensive forms of aquaculture to maintain the high ecological value of these areas and creating at the same time economic activities for the communities living around the lagoons.

Rural aquaculture. This is a topic to which a lower level of priority has been granted by the countries because of failures in the past years of many programmes to assist subsistence aquaculture. Research is now being carried out for the promotion of a form of rural aquaculture which is targeted at higher income rural farmers. This new form of artisanal aquaculture requires a focused analysis of the production packages to be practised within the socio-economic context of the new target groups.

Pathology and Nutrition. Although these themes have been given high priority in the context of marine shrimp culture, they have validity also in the context of the diversification of aquaculture production, as mentioned before.

Information. Although not a research area, it has been proposed by the countries as a priority area in support of overall research programmes because of the poor dissemination of aquaculture research information in the region.

The detailed definition of these six priority programmes are expected to be completed in 1994.

The study on the northern African countries

The study covering the Northern African countries is being conducted and is expected to be completed by the end of 1994.

In a future issue of the FAN additional information on the progress of these important studies will be provided.

DEPENDENCE OF INTENSIVE AQUACULTURE SYSTEMS ON FISHMEAL AND OTHER FISHERY RESOURCES
"TRENDS AND PROSPECTS"

Albert G.J. Tacon
Fishery Resources Officer (Feed Specialist)
Inland Water Resources and Aquaculture Service

Introduction

In contrast to world fish and shellfish catches, which have declined by 5.1% since 1989 (decreasing by 4,524,000 mt from 88,775,000 mt in 1989 to 84,251,000 mt in 1991), aquaculture production of fish and shellfish has increased by 10.9% over the same period (increasing by 1,242,000 mt from 11,433,000 mt in 1989 to 12,675,000 mt in 1991). However, if fish and crustacean aquaculture production is to sustain this growth rate into the next millennium then corresponding inputs of fertilizers and feeds will have to be provided (see previous articles by author in FAN # 3 & 4).

As with all farming systems the growth and production of farmed fish and shrimp is dependent upon the supply of food containing 40 or so essential dietary nutrients. In the case of extensive and semi-intensive pond-based farming systems these nutrients are supplied in the form of live food organisms endogenously produced within the pond (the production of which can be augmented through the application of fertilizers and manures) and/or exogenously supplied supplementary feeds; the latter ranging from dietary supplementation with live invertebrate foods, green fodder and aquatic macrophytes, kitchen scraps, processed single feed ingredient sources, farm-made aquafeed mixtures (in mash, dough ball or pelleted form) to commercial pelleted aquafeeds. By contrast, finfish and crustaceans reared at high stocking densities within intensive farming systems are totally dependent upon the exogenous supply of a nutritionally complete diet for the entire production cycle either in the form of a farm-made or commercial aquafeed, or the use of exogenous natural food items of high nutrient value such as 'trash fish' and *Artemia* as a complete diet.

Current feeding strategies

Of the above mentioned nutrient pathways by far the commonest at the farm level has been the use of a combined fertilization/supplementary diet-based feeding strategy within semi-intensive pond-based farming systems. This is perhaps not surprising since over 80% of world finfish and crustacean aquaculture production is currently realised within semi-intensive or extensive pond-based farming systems. With the exception of marine shrimp, these semi-intensive farming systems are usually based on the polyculture of warmwater omnivorous/herbivorous fish species feeding low on the aquatic food chain (Figure 1); freshwater cyprinids constituting 70.1% of total finfish aquaculture production and occupying the top four positions of the fish and crustacean aquaculture league production table in 1991 (Figure 2).

In marked contrast, the production of high-value (in marketing terms) carnivorous fish and shrimp species (ie. trout, salmon, yellowtail, eel, seabream, seabass and marine shrimp) is almost totally dependent upon the use of compound aquafeeds and is generally realised as a monoculture within intensive tank or cage-based farming systems. Carnivorous fish species representing 13.2% of total farmed finfish production (ie. 1,152,547 mt in 1991) and constituting 93.4%, 63.8% and 1.5% of the total production of farmed marine fish, diadromous fish and freshwater fish, respectively.

Global aquafeed production

Compound aquafeeds are considered here to include *all artificial diets compounded in pellet, ball or mash form and consisting of one or more processed feed* ingredients or feedstuffs. According to conservative estimates global aquafeed production in 1990 was about 3 million metric tonnes (mt) and valued at 1.5 thousand million US $. Of the total estimated aquafeed production approximately 70% was for carnivorous fish and shrimp species, and the remainder for omnivorous/herbivorous fish species. The major compound aquafeed consumers in 1990 were marine shrimp (810,000 mt), channel catfish (648,783 mt), trout (471,600 mt), salmon (429,000 mt), carp (170,300 mt), marine finfish (135,000 mt), and tilapia (70,349 mt) - (Chamberlain, 1993).

Fish meal and fish oil production

Approximately 31% of the total world fish and shellfish catch was reduced into fishmeals, oils and other industrial products in 1991 (Figure 3). Small pelagic fish species such as anchovy, jack mackerel, pilchard, menhaden, capelin, tuna, herring and sardine etc. forming the bulk of the fisheries catch used for this purpose. On a global basis, the production of fish meal and fish oil has remained relatively constant since 1984, fluctuating between 6.8 and 7.9 million tonnes and 1.4 and 1.7 million tonnes, respectively (Figure 4). However, only 52.1% of total fish meal and 47.6% of total fish oil production were available for export in 1991; export value exceeding 1600 and 200 million US dollars, respectively.

Essential feed ingredients

Fish meal and fish oil currently occupy the unique position of being essential feed ingredients for all industrially-produced aquafeeds for carnivorous fish and shrimp, and to a lesser extent, omnivorous freshwater fish and prawn species. For example, Chamberlain (1993) lists the dietary fishmeal and lipid levels normally used within compound aquafeeds for the major cultivated fish and shrimp species as follows: marine fish 60% and 12%, salmon 50% and 15%, trout 30% and 10%, shrimp 25% and 3%, carp 25% and 10%, tilapia 20% and 0.5%, and channel catfish 5% and 2%, respectively.

In addition to the use of fish meals and fish oils, there are also a wide variety of other marine by-product meals arising from the fishing and fish processing industry which are used within compound aquafeeds, *including shrimp meal, shrimp head meal, krill meal, squid meal, squid oil, fish protein hydrolysates, and* fish silage. For example, it is important to mention here the almost universal use of shrimp meals and squid meal within crustacean aquafeeds; the average inclusion levels for shrimp and squid meal within marine shrimp diets being 15-25% and 3-5%, respectively.

In general terms, fishery products (ie. fishmeal, fish oil, fish protein concentrates, squid meal, shrimp meal) make up about 70% of the total aquafeed for most farmed carnivorous fish species and about 50% of the feed for marine shrimp. The present use of high dietary inclusion levels of marine fishery products within aquafeeds has been due to their almost ideal nutritional composition and quality (ie. making the formulation of the aquafeed much simpler and easier), and ready availability throughout the year. More importantly, their use has been facilitated by the generally high market value of most cultured marine fish and shrimp species (as compared with the majority of warmwater omnivorous fish species) which makes the purchase and dietary use of these expensive feed ingredients by the aquafeed compounder and/or farmer economically possible.

Natural feeding habits

The fact that the above mentioned feedstuffs play such an important and central role within aquafeeds for carnivorous fish and shrimp species is perhaps not surprising since the natural diet of these species in the wild is normally composed of fish and/or shellfish. In terms of palatability, nutritional value, growth and food conversion efficiency, it has been repeatedly shown within feeding trials that the best food/feed ingredient to feed a carnivorous fish or shrimp species is another food fish/fish meal; the nutritional composition (ie. amino acid and fatty acid profile) of food fish and high quality fish meals approximating almost exactly to the known dietary nutrient requirements of the farmed species (fish meaning fish and shellfish).

For example, 'trash fish' based feeding regimes are still the most successful and economically preferred feeding method employed by the majority of marine fish cage farmers in Asia for culturing carnivorous fish species (ie. yellowtail, grouper, snapper, seabass, seabream etc). Similarly, fresh and frozen crustaceans have generally been found to be the preferred food item of farmed decapod crustaceans, including crayfish, lobster, crabs and marine shrimp. In addition to the use of fresh or frozen crustacean fishery products (ie. whole shrimps, shrimp head waste, crabs etc) as supplementary feed items for crustacean grow-out and maturation programmes, crustaceans are also an essential component of most crustacean hatchery operations in the form of *Artemia* nauplii as a live food organism for the developing larvae.

In fact, it is interesting to note that modern-day salmonid aquafeeds are mimicking more and more the natural composition of food fish; European salmon production diets being almost entirely based on the use of high quality fish meals and fish oil, having a high dietary protein and lipid content, and a low carbohydrate and fibre content. Being highly digestible, this kind of feed (if managed properly) causes less pollution problems in the aquatic environment.

Fishmeal and fish oil usage

It is estimated that between 816 and 873 thousand tonnes of fish meal and between 190 and 205 thousand tonnes of fish oil were used in aquafeeds in 1990 or the equivalent of 13 to 15% of the total world supply of fish meal and fish oil. As expected, the major consumers of fish meal and fish oil were marine shrimp and carnivorous marine/diadromous fish species (ie. salmon, trout, eel, yellowtail, sea bream), followed by omnivorous freshwater fish species. Latest estimates suggest that 1,078 thousand tonnes of fish meal were used within aquafeeds in 1992 (I.H.Pike, personal communication, Figure 5); 61.2% consumed by carnivorous fish species, 32.0% by marine shrimp, and only 6.8% by omnivorous/herbivorous fish species (ie. carp, tilapia, milkfish, channel catfish, etc.).

However, it must be stated that in 1990 over 86% of the world supply of fish meal was used within compound feeds for poultry, pigs and ruminants (Figure 6).

According to one source (Anon, 1993; Feed International, 14(1):4-8) total compound animal feed production in 1993 was estimated to be about 610 million tonnes (32% poultry, 31% pigs, 17% dairy cattle, 11% beef cattle, 3% aquaculture feeds, 6% others) and valued in excess of US $ 55 billion.

Future trends and prospects

According to the estimates of Chamberlain (1993) fish meal usage within aquafeeds is expected to increase by 50% from about 0.8 million tonnes in 1990 to 1.2 million tonnes by the year 2000, and fish oil usage by 77% from 0.2 to 0.36 million tonnes by the year 2000. Assuming that fish and crustacean aquaculture production will continue to increase at a modest rate of 5% per year and that global fish meal and fish oil production levels will remain at their present levels by the end the decade, this would mean that by the year 2000 about 20% of the total world supply of fish meal and fish oil would be consumed within aquafeeds. However, these assumptions are based on the following dietary fishmeal and fish oil inclusion levels within aquafeeds in the year 2000; marine shrimp 25% and 3%, salmon 45% and 15%, trout 30% and 10%, marine fish 45% and 12%, carp 20% and 10%, tilapia 20% and 0.5%, and channel catfish 3 and 2%, respectively. It is generally expected that compound aquafeed production will increase by about 5% per year to over 4.5 million mt by the year 2000.

Use of 'trash' fish in moist fish feeds

Although fish meal and fishery by-products will almost certainly remain as the main source of dietary protein used within compound aquafeeds for carnivorous fish and shrimp species by the end of the decade, it is anticipated that high quality fish meal replacers such as bacterial/fungal single cell proteins (SCP) and plant protein concentrates (ie. soya protein concentrates) will gradually gain prominence, and eventually reduce fish meal dietary inclusion levels within aquafeeds by half to about 25-30%. This trend will be more evident in the non-fishmeal producing countries than within the high fishmeal producing countries. For example, the top ten fishmeal producing countries in 1991 were Peru, Chile, Japan, Denmark, USA, the Russian Federation, Thailand, Norway, Iceland and China, in decreasing order.

By contrast, although only 73 thousand tonnes of fish meal was reportedly used within aquafeeds for non-carnivorous warmwater fish species in 1992, it is anticipated that by the end of the decade dietary fish meal inclusion levels will be reduced still further from 20-25% to about 5-10% within aquafeeds for intensive farming systems. This reduction will largely be achieved through the increased use of the lower priced plant oilseed meals (ie. soybean, rapeseed, cottonseed, linseed, mustard seed, sunflower seed), and to a lesser extent SCP, and by overcoming nutrient imbalances through the blending of complementary ingredient sources or by direct nutrient (ie. amino acid) supplementation. In fact, recent studies with warmwater omnivorous fish species such as tilapia and channel catfish have shown that cost-effective practical aquafeeds can be produced without the use of fish meal with no reduction in fish growth. This will be particularly true for semi-intensive pond farming systems where the cultured fish or shrimp, and in particular those filter-feeding fish species which feed low on the aquatic food chain (ie. Chinese and Indian major carps, Tilapia etc), can obtain a large part of their dietary nutrient needs from the consumption of naturally available food organisms.

Conclusion

Whilst there is no doubt of the high nutritional value of marine byproduct meals for farmed fish and shrimp, they represent an expensive and finite commodity; fishmeal (the largest source of animal protein available to the compound feed manufacturer) also being competitively purchased and used by the larger and therefore more powerful farm livestock production sector. Furthermore, increasing raw ingredient and feed manufacturing costs, coupled with an often static or decreasing market value for many cultured fish and shrimp species, necessitates that the farmer reduce production costs so as to maintain profitability. Since food and feeding usually represents the largest operating cost item of most intensive farming systems, clear emphasis must be placed on the development of feeding strategies aimed at reducing feed costs and improving on-farm feed management, either by 1) replacing or reducing the level of marine-based feedstuffs within aquafeeds with alternative less expensive protein sources, 2) by selecting omnivorous/herbivorous fish or crustacean species which feed low down on the aquatic food chain, and 3) by maximising the role played by natural food organisms in the overall nutritional budget of the pond-raised fish and shrimp species through improved pond fertilization and water management techniques. However, the latter can only be achieved by culturing fish or shrimp within semi-intensive pond-based farming systems.

As a concluding note, it must be made clear that if aquaculture is to play any significant role in food security then it is imperative that the species chosen for mass production have herbivorous or omnivorous feeding habits and so are not dependent upon high quality 'food grade' protein-rich feed inputs. For example, with the exception of mink farms, all land-based animal farming systems are based on the culture of omnivorous or herbivorous (ruminant) animal species, including poultry, ducks, pigs, sheep, rabbits, goats, beef and dairy cattle. In this respect it is important to remember that whereas the majority of aquaculture production within 'developed' countries is based on the culture of high value carnivorous fish or shrimp species within intensive farming systems, the bulk of aquaculture production within 'developing' countries is based on the culture of generally low value (from a marketing point of view) omnivorous/herbivorous fish or shrimp species within semi-intensive and extensive farming systems. The important point to learn from 'developing' countries (who not by chance also produce approximately 80% of total world aquaculture production) is that their farming systems are more energy efficient and net protein producers, are based on the polyculture of complementary fish species, and require only fertilizer or low-protein feed inputs. In the final analysis and within the context of food security, the real contribution of aquaculture products will be measured by its affordability as a much needed source of cheap animal protein in the diet of 'common man'.

FURTHER READING

Chamberlain, G.W., 1993. Aquaculture trends and feed projections. World Aquaculture, 24(1):19-29

FAO, Fishery Information, Data and Statistics Service, 1993. Aquaculture production 1985-1991. FAO Fisheries Circular No.815, Rev.5, Rome, FAO, 1993. 213p.

FAO, 1993a. FAO yearbook: Fishery statistics - catches and landings, Vol.72, 1992. FAO Statistics Series No. 111. Rome, FAO. 1993. 653p.

FAO, 1993b. FAO yearbook: Fishery statistics - commodities, Vol.72, 1992. FAO Statistics Series No. 113. Rome, FAO. 1993. 395p.

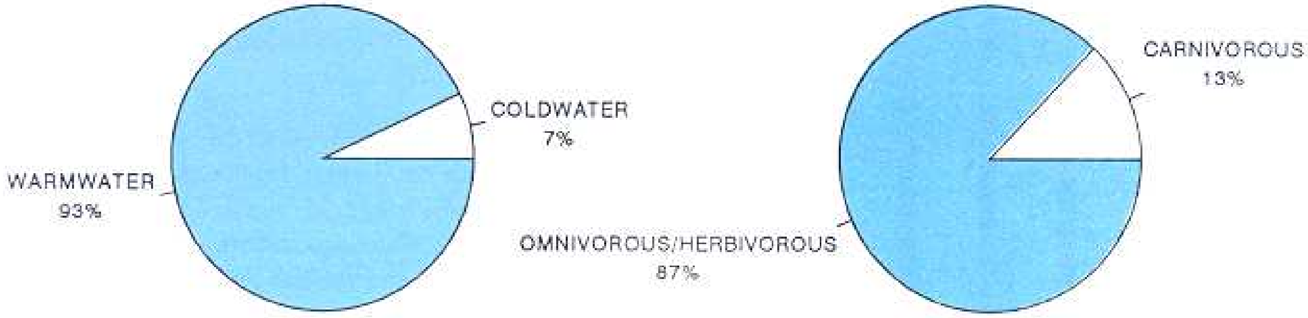
Tacon, A.G.J., 1993. Feed ingredients for warmwater fish: fish meal and other processed feedstuffs. FAO Fisheries Circular. No.856. Rome, FAO. April 1993. 64p.

Tacon, A.G.J., 1993. Feed ingredients for crustaceans: natural foods and processed feedstuffs. FAO Fisheries Circular. No.866. Rome, FAO. November 1993. 67p.

Watson, I. & B.F. Blake., 1993. Aquaculture can answer the fisheries dilemma - but how will we feed the fish? World Agriculture, 1993, (Stirling Publications, London), pp.104-105.

Wijkstrom, U.N. & M.B. New, 1989. Fish for feed: a help or a hindrance to aquaculture in 2000? INFOFISH International, 6/89:48-52.

Figure 1. Temperature and feeding habit of farmed fish in 1991



Production by temperature habit

Production by feeding habit

Coldwater fish species include salmons, trouts, smelts, cod and pike
Carnivorous fish species include the majority of marine finfish (except mullets), diadromous finfish (except milkfish), snakeheads, certain catfishes and mollusc eating freshwater fishes

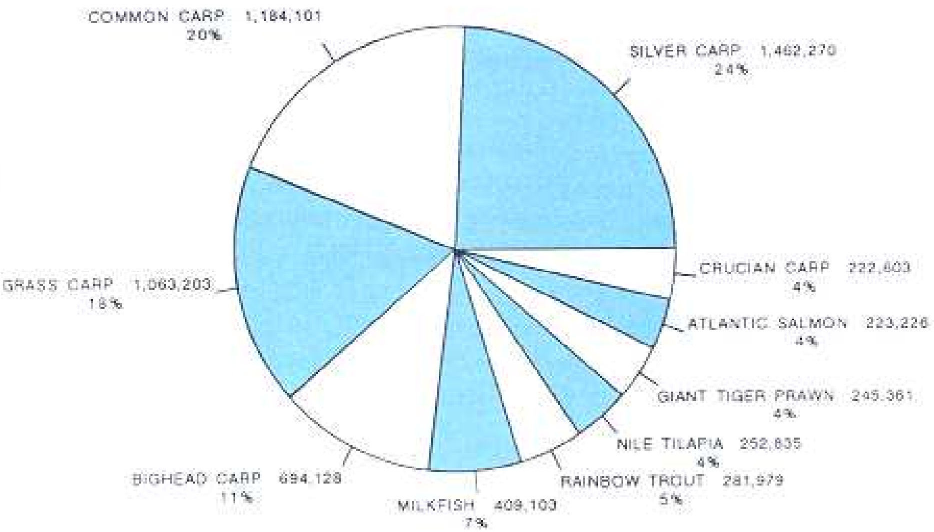


Figure 2. Top ten cultured fish and shrimp species in 1991

(values given in metric tonnes and as % of total).

Total production 6,038,809 mt or 63.2% of all cultured fish and crustaceans. (Source: FAO 1993)

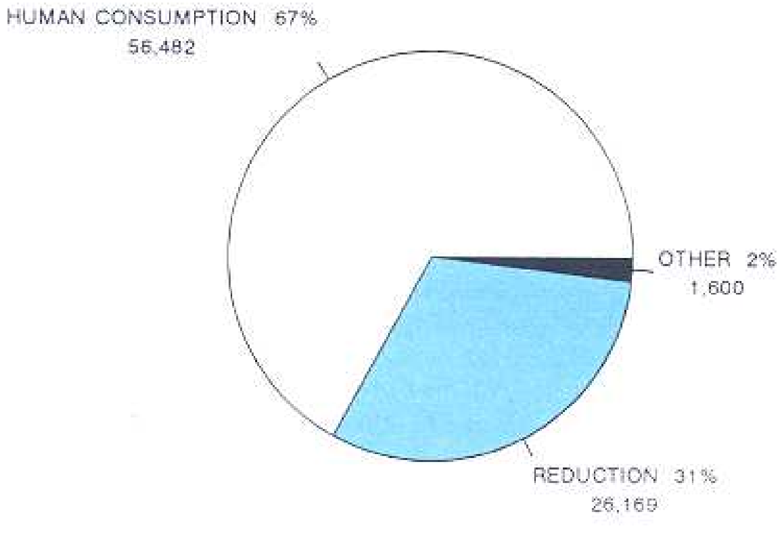


Figure 3. Utilization of the world fish and shellfish catch in 1991

(values given as % and '000 mt)

Reduction - includes only the use of whole fish destined for the manufacture of fishoils & fishmeals. Total world fish and shellfish catch in 1991 was 84,251,000 (Source: FAO 1993)

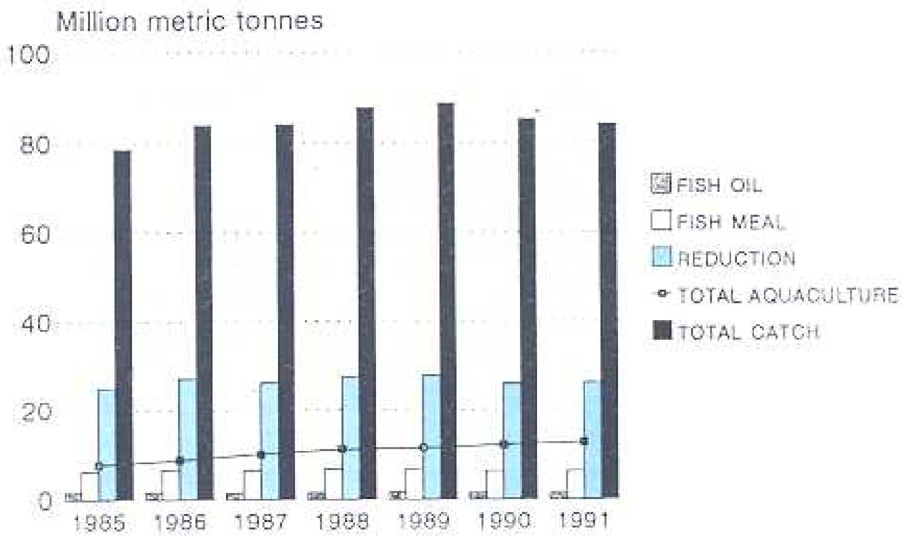


Figure 4. Utilization of the World fish & shellfish catch - Fish meal and fish oil production

(values given on a wet weight basis except for fish meal)

Reduction - includes only the use of whole fish destined for the manufacture of fish oils and fish meals (Source: FAO 1993). Total aquaculture - includes only fish and shellfish production

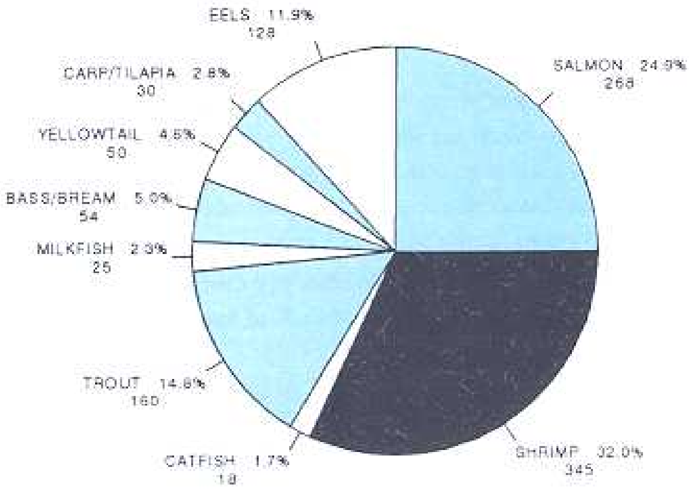


Figure 5. Fish meal consumption by aquaculture species in 1992

(values given as % and '000 metric tonnes)

Total reported fish meal used within aquafeeds 1,078,000 mt. Source: I.H.Pike, personal communication, IFOMA, March 1993

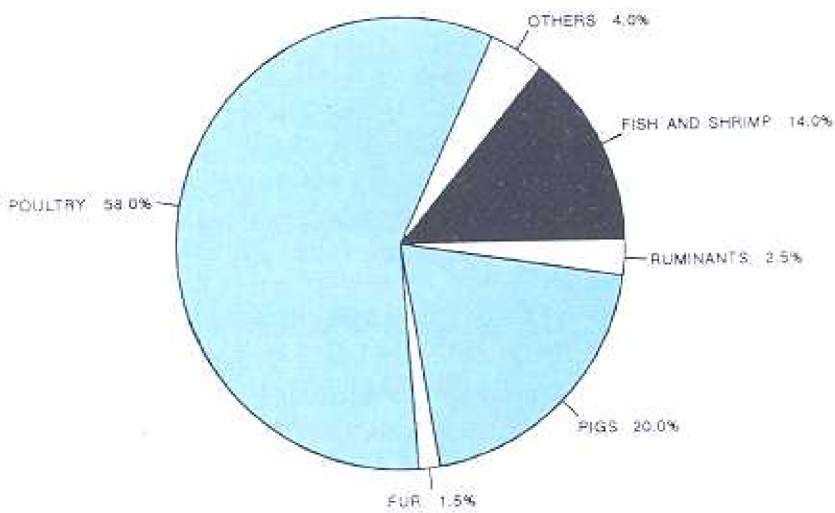


Figure 6. Global use of fish meal in livestock and aquafeeds

(values given as %)

Fish meal consumption by farm animal species in 1990

Fish meal used in aquafeeds in 1990 was 873,000 mt. Source: I.H.Pike - International Fishmeal & Oil Manufacturers Assocation (IFOMA)

CAN AQUACULTURE FILL THE MARKET GAP?

E. Ruckes
Senior Fishery Industries Officer
Fish Utilization and Marketing Service

The Gap

In the light of a world population which is growing faster than global fish production, it must be anticipated that current levels of product availability cannot be maintained in the future, at least not on a per caput basis. Past trends and the current situation of world fisheries indicate that a drastic increase in world catches of more than 2 or 3 percent per year cannot be expected and, in fact, for a variety of technological, environmental and political reasons, there is a distinct possibility of a decline in global landings, at least in the short term. All other things being equal, global demand will grow faster than supplies and a gap would develop between them. In reality , however, things will not remain the same, prices will go up resulting in reduced demand. Hence , there will be no gap but hidden or ineffective demand which cannot be satisfied at prevailing prices. Some if not all of this ineffective demand can possibly be made market effective by offering supplies from non- or under-utilized resources, from material now used for fish meal production or wasted so far or from newly developing resources. In the context of the latter, aquaculture is seen by many as a major potential for the future.

A Scenario for 2010

According to the FAO study "Agriculture: Towards 2010" total fish production from all sources could be in year 2010 between 10 % and 30% above present levels. Over the same period world population is expected to grow by 36 %. Therefore per caput fish supplies will likely fall and consumption by the poor may fall by more. These prospective developments can have serious nutritional consequences for the poor consumers in countries with high dependence on fish for protein supplies.

The potential of aquaculture

The contribution of aquaculture to the future availability of fishery products on national and international markets can be expected to be much more important than that of inland capture fisheries and even of marine products in some specific cases. Obviously, there will be differences between countries and regions. From a global point of view a good potential for an expansion of aquaculture output would appear to exist in Latin America and the Caribbean, Asia, Europe and the area of the former USSR. There are examples of traditional products from aquaculture which are also traded internationally, such as carp, trout and molluscs. Successful and relatively new arrivals like salmon and shrimp can be mentioned. Still small but increasing quantities from aquaculture enter the fresh fish trade in Hong Kong and Singapore. Shrimp and salmon are examples of aquaculture products having achieved sufficient weight to influence world market prices.

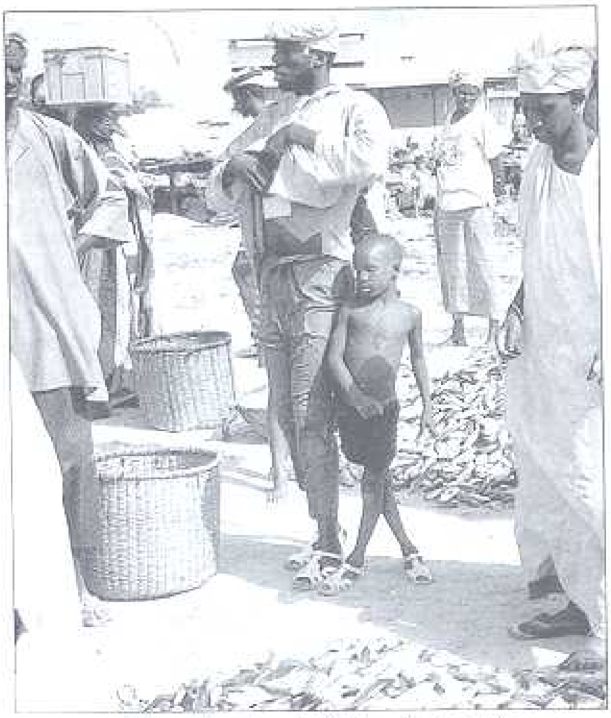
A summary calculation based on past trends (using 3-sliding averages 1984-1990; not a particularly strong methodology) indicates that for 1992-1994 the production level may be projected at 17 million t and for the turn of the century at 26 million t, equivalent to almost twice the 1991 production. However, such summary calculations have a rather restricted significance and caution is required in assessing the future contribution of aquaculture to the availability of fish supplies. A global analysis cannot achieve more than to provide general and provisional indications. For policy and development related analyses the investigations have to focus on national or regional situations which at the same time should coincide with the corresponding market or demand areas.

The FAO study mentioned earlier (Agriculture: Towards 2010) indicates aquaculture production levels at 12 million t for 1989/91 and 15-20 million t as possible for 2010.

Constraints for Aquaculture

Examples of constraints experienced in aquaculture expansion can be found in the cases of salmon and shrimp but they are not limited to these species. The European salmon-farming industry had to face a number of constraints in the technical and economic fields, such as the use of medicines and chemicals in feeds, release of nutrients to the environment, effects on wild stocks and, at times, severe marketing problems. Shrimp output from farms in Asia has suffered decreases several times due to the polluting and deleterious effects of shrimp farm effluents resulting in poor water quality and outbreak of diseases. Contamination with antibiotic residues and excessive harvesting levels have caused marketing problems. These examples may serve as illustrations of the complexity of some aquaculture operations and to caution against unrealistic expectations.

A major constraint may be seen in the restricted knowledge of the requirements for culturing only a relatively few species. Most notable is that finfish farming has mostly been restricted to freshwater herbivore species with a comparatively modest contribution from marine species. The further expansion of finfish supplies from freshwater aquaculture is likely to be constrained by the freshwater environment and to a significant extent also by the cost of inputs.



Fish sold on beach (Dakar, Senegal) to local traders

Outlook

In view of the limited possibilities for expanding world fish production in general and the likely continuation of competing uses and consumers it may be assumed that the importance of aquaculture in general is likely to grow. However it would be of particular interest to study and to report on specific cases, whether species, culture system or market area. There are also the aspects of consumer protection and product safety and related aspects of marketing technology which need to be looked at, mainly in respect of developed country markets. For the developing world a realistic, market oriented approach is required with a view to realizing economies of scale in the production and marketing of product accessible to a large section of the population.

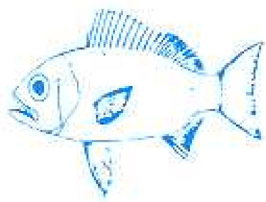
Sorting out prawns harvest to be sold in the market

The FAN would very much like to open a dialogue, and to share experience and ideas in these fields. Readers are encouraged to report on such specific cases referred to above since it is intended to regularly review developments in the fields of marketing and product quality in the FAN.

NEW PUBLICATIONS

Michael B. New, Albert G.J. Tacon and Imre Csavas: Farm-Made Aquafeeds.

This book is the proceedings of a meeting held in Bangkok in December 1992 on the use of farm-made feeds in Asia. It contains eleven country reviews (Bangladesh, Cambodia, China, India, Indonesia, Malaysia, Nepal, the Philippines, Singapore, Thailand and Vietnam). Nine technical papers are included. Also included are on-farm feed preparation and feeding strategies - for carps and tilapias, for catfish and snakehead, and for marine shrimp and prawns. Five other working papers are on economics, the selection of equipment, feed ingredients, formulation and on-farm management, and supplementary feeding in semi-intensive aquaculture, all concerned with farm-made, rather than commercial feeds. The ninth working paper is on regional overview of aquafeeds in Asia. An analysis of the eleven country papers is also presented. Emphasis is placed on the important role, hitherto not completely recognized, of farm-made aquafeeds to aquaculture production in Asia. While it was estimated that 50% of shrimp production from aquaculture comes from commercial feeds, only 10% of Asian finfish is currently produced in this way. Although statistical data is non-existent, it was speculated that over 1 million t of farm-made feeds are produced annually in Asia and that about one third of Asian finfish and crustacean production is achieved partially through their use. The proceedings also include the official report of the meeting, with recommendations aimed primarily at those concerned with research and development of aquafeeds and those organizations that fund such work. Commercial feedstuff manufacturers are generally able to fund their won research and development on complete feeds for use in intensive aquaculture. A strong plea is made for more attention to be paid to the needs of the small-scale farmers who are already using, or intend to use, farm-made feeds.



Gropps, J.M. and A.G.J. Tacon (eds.)

Report of the EIFAC Workshop on Methodology for Determination of Nutrient Requirements in Fish, Eichenau, Germany, 29 June - 1 July 1993.

EIFAC Occasional Paper. No. 29. Rome. FAO. 1994, 92 p.

The European Inland Fisheries Advisory Commission (EIFAC) organized a Workshop on methodology for determination of nutrient requirements in fish from 29 June to 1 July 1993 in Eichenau, Germany. There were nine consecutive technical sessions during which the various topics were introduced and discussed. These topics referred to energy, proteins and amino acids, digestion and utilization of protein and energy, lipids and essential fatty acids, carbohydrates, minerals and trace elements, vitamins, feed additives, and application of nutrient requirement data. A series of recommendations were made concerning each of these main topics and are presented in the report together with the abstracts of the papers and posters presented during the Workshop.

Devin M. Bartley. An application of international codes of practice on introductions of aquatic organisms: Assessment of a project on the use of Chinese carps in Mozambique.

FAO Fisheries Circular (863). Rome, FAO. 1993. 21 p.

International codes of practice on the use of exotic species were used to judge the desirability of utilizing Chinese carp for increased food production and control of aquatic vegetation in Mozambique. Resource managers, scientists, fishers, fish farmers, and local fish markets were surveyed to provide information on the feasibility of using Chinese carps. Although exotic species, such as common carp and black bass, have established reproducing populations and there is a high level of desire to raise Chinese carps in southern Africa, it was found that in Mozambique the culture of Chinese carps for increasing food production was not warranted given the status of indigenous fishery resources. However, grass carp could be used to control aquatic weed infestations. The international codes of practice provided a very usable framework to evaluate the proposed use of exotic species in Mozambique.

Devin M. Bartley. Expert Consultation on Utilization and Conservation of Aquatic Genetic Resources. Grottaferrata, Italy, 9-13 November 1992.
FAO Fisheries Report (491). Rome, FAO. 1993. 58p.
This report discusses the need and methodologies for the utilization and conservation of genetic resources of aquatic animals. More than a review of genetic principles and technologies, the report addresses the application of such principles and technologies in development and conservation projects and research. Specific recommendations are made with regard to the genetic resources contained in natural populations, fisheries stocks, and aquaculture. Recommendations concerning regulatory, policy and legal aspects of aquatic resources are also presented.

MEETINGS

Regional Workshop on Aquaculture and the Environment

The final workshop of the FAO regional project TCP/RAS/2253 "Regional Study and Workshop on Environmental Assessment and Management of Aquaculture Development in Asia-Pacific" was held during 21-26 February 1994 at the Regional Office for Asia and the Pacific (RAPA) of FAO. The workshop, organized in collaboration with the secretariat of the Network of Aquaculture Centres in Asia (NACA), was attended by 30 experts from countries participating in the TCP project, and 27 observers from various national and international organizations, agencies, programmes, producer groups, and institutions.

Prior to the workshop, a regional study, which included the preparation of country reports and detailed case studies, had been carried out by the National Environment Coordinators from 18 countries, assisted by the TCP team, consisting of an economist, an environmental management specialist and a legal expert. The workshop discussed the country reports and case studies, presentations by invited resource persons, and a synthesis document prepared by the TCP team containing an overview of major problems and suggestions for possible solutions. Working group meetings on environmental management aspects in inland and coastal aquaculture were held to identify options for environmental management and to formulate recommendations addressed to governments, farmers, supporting industries and international organizations.

The experts from the region expressed a general concern on the negative consequences of environmental interactions of aquaculture. The main areas of concern cover existing and potential problems including threats to aquaculture production; self-pollution problems; conflicts over resources used by aquaculture and other activities; social and economic consequences of insufficient management efforts at the farm level, district or community level, and by government authorities; and irreversible ecological impacts of aquaculture operations.

The participants emphasized their interest in promoting better farming practices, including improved use of aquaculture resources and inputs, and reduction of adverse effects, as well as in strengthening of institutional and legal arrangements to support, coordinate and regulate aquaculture development in their countries.

Many participants stressed that the interactions between aquaculture and the environment should be considered in a more general context. It was emphasized that many aquaculture development efforts are subject to increasing pollution and degradation of aquatic environments. Further, adverse ecological impacts resulting from aquaculture in many cases are not as severe as those resulting from other activities. Environmental management efforts at district and country levels should also be directed to protect resources that are required by aquaculture. Specific interventions, however, are necessary to prevent further degradation of wetland habitats and deterioration of water quality resulting from certain aquaculture practices. Precautionary approaches were advocated with regard to introductions of exotic species, collection of wild seed and use of chemicals.

The Eighteenth Session of The European Inland Fisheries Advisory Commission will be held in Rome, from 17 to 25 May 1994. The consultation will be on ***"Management Strategies for European Inland Fisheries and Aquaculture for the 21st century"***. The Working Groups on aquaculture, commercial fisheries and recreational fisheries will meet separately and will prepare reports on the issues covering their own sector. Four workshops will be held to define strategies for the integration of inland fisheries and aquaculture into national goals. One session will be devoted to the subject of collection of inland fisheries statistics in the EIFAC area.

M/T3420E/1/4.94/3000