

OUTLOOK

INTRODUCTION

A few years have passed since major quantitative studies were undertaken on the future of the fisheries sector and the results published in *The State of World Fisheries and Aquaculture*. How do the projections compare with recorded developments? It is, of course, too early to come to any definite conclusions even for the projections aimed at 2010. Nevertheless, a start can be made. The results are provided in the first part of this section.

During the past two years FAO has conducted a comprehensive study of the aquaculture sector. The study focused on establishing recent trends and on identifying challenges and opportunities for the sector. These were further discussed in a prospective study. The second part of this "Outlook" summarizes the most important findings of the prospective study. Naturally, a large part of these findings confirm observations and suggestions already made – some of which have been published in earlier versions of this report – but some are new.

REVISITING GLOBAL PROJECTIONS

Table 21 is taken from *The State of World Fisheries and Aquaculture 2004* – where it appeared as Table 16. An additional column (in blue) containing FAO statistical data for 2004 has been inserted in this updated table.

The table contains projections for 2010, 2015, 2020 and 2030, all based on information for the sector available around the year 2000. At the time of writing, information is available about what actually happened during the first part of the decade, including 2004. The four-year period is short and there is little reason to discuss in detail the validity of projections other than those for 2010.

There does not seem to be any reason not to expect that world fisheries and aquaculture production, four years into the decade, have moved some way towards the figures predicted for 2010. A rapid glance at the table indicates that this is so. Marine fisheries have reached a ceiling, in terms of output, while a growing aquaculture

Table 21

Fish production in 2004 and projections for 2010 and later

		Simulation target year						
	2000	2004	2010	2015	2020	2020	2030	
Information	FAO statistics ¹	FAO	SOFIA	FAO study⁴	SOFIA 2002 ³	IFPRI study⁵	SOFIA 2002 ³	
source		statistics ²	2002 ³					
Marine capture	86.8	85.8	86		87	_	87	
Inland capture	8.8	9.2	6		6	-	6	
Total capture	95.6	95.0	93	105	93	116	93	
Aquaculture	35.5	45.5	53	74	70	54	83	
Total production	131.1	140.5	146	179	163	170	176	
Food fish production	96.9	105.6	120		138	130	150	
Percentage used for	74%	75%	82%		85%	77%	85%	
food fish								
Non-food use	34.2	34.8	26		26	40	26	

Note: All figures - other than percentages - are in million tonnes.

¹ Based on the statistics available to the FAO Fishery Information, Data and Statistics Unit in 2000.

² Based on latest statistics of the FAO Fishery Information, Data and Statistics Unit.

³ FAO. 2002. The State of World Fisheries and Aquaculture 2002. Rome.

⁴ FAO. 2004. Future prospects for fish and fishery products: medium-term projections to the years 2010 and 2015. FAO Fisheries Circular FIDI/972-1. Rome.

⁵ International Food Policy Research Institute. 2003. *Fish to 2020: supply and demand in changing global markets*, by C. Delgado, N. Wada, M. Rosegrant, S. Meijer and M. Ahmed. Washington, DC.

sector is providing sufficient fish to permit per capita supplies of fish to remain almost constant. Only two features of the sector appear to have diverged from expectations: inland capture fisheries and the quantities of fish being used for non-food purposes. In both cases the quantities have exceeded the projections.

Marine capture fisheries

The image of stagnation provided by marine capture fisheries is false. The stagnation in terms of output in no way reflects a stagnating sector. Not only are landings increasing in some fisheries – exemplified by the fisheries in the Northwest Atlantic – and decreasing in others (see p. 10), but the sector is continuously adjusting to changing political, economic and social environments. In fact, considerable efforts are required by the sector to adjust to a situation of no – or very limited – growth in landings and more stringent management of fishing effort.

Some projections for marine fisheries production foresee an initial decline as stock recovery takes place, followed by an expansion of quantities captured, in some cases arriving at stable catches above those recorded prior to overfishing. While some stocks are recovering, there is no indication to date that landings for these stocks will expand to exceed the historical maximum sustainable yield levels.

Thus, it currently seems reasonable to expect that marine capture fisheries production will remain between 80 and 90 million tonnes per year, with an average somewhere in the middle of this range.

Freshwater capture fisheries

Contrary to projections, landings from inland fisheries have remained high and even increased somewhat. The projection for 2010 is that landings will have fallen to only two-thirds of the 2000 level. However, the projections were based on incomplete information; as information improves, the basis for past projections comes into question.

The freshwater fisheries sector is comprised of two subsectors: a large noncommercial, or subsistence, subsector, and a more formal commercial subsector. As mentioned on page 33, the landings of the subsistence fisheries are not usually included in official records of freshwater fisheries, generally because their magnitude is not known by the responsible fisheries administration. Similarly, catches destined for sale from many small-scale fisheries are not always fully documented. The catches from larger commercial freshwater fisheries are more often and more accurately included in the records.

The freshwater fisheries sector also suffers from a degraded aquatic environment and increased uses of freshwater for agriculture, hydropower and other purposes. Often, these activities take precedence over managing and reporting on freshwater fisheries, and this trend can be expected to continue as long as the real value of freshwater fisheries is unknown.

Efforts by FAO and others are under way to improve the official records of both commercial and non-commercial inland fisheries. In some cases, improved statistics now give a more accurate picture of freshwater fisheries, but because good baseline information on catch and numbers of commercial and subsistence fishers was not available previously, little can be said about trends. Information on freshwater fisheries and the numbers of fishers is improving.

Aquaculture

Aquaculture (excluding aquatic plants) production continues to grow both in China and in the rest of the world. Most noteworthy, perhaps, is that aquaculture production over the past four years has grown faster outside China (a combined increase of 37 percent) than in China (where expansion has been 24 percent). This means that as long as the annual rate of increase in production outside China remains at around 8 percent, the prediction of 53 million tonnes of aquaculture production for 2010 (see Table 21) will be met even if Chinese production remains at the level reported for 2004 (of 30.6 million tonnes). However, production in China is not likely to stagnate so suddenly; more importantly, conditions for the continued growth of aquaculture are favourable, particularly in South America and Africa. Thus, a first impression is that, at least during the rest of the current decade, aquaculture will contribute to future world fish supplies as was expected in 2000.

Fish utilization

The projections for the decade ending in 2010 were constructed on the expectation that quantities of fish used for non-food purposes would decline from about 35 million tonnes per year to 26 million tonnes per year. This does not seem to be happening. In 2004, the quantities used for non-food uses were as high as four years earlier. Why?

For the average consumer, some fish are more appetizing than others. Among those that are not valued as human food (e.g. menhaden and sand eel), some are available in large quantities and have no uses other than as animal feed or, in the past, fertilizer. These species are the backbone of the fishmeal industry. Unfortunately for this industry, the availability of these species can change dramatically from year to year.

Among the fish used by the fishmeal industry is the Peruvian anchoveta (*Engraulis ringens*). This species can contribute as much as one-third of the raw material used for fishmeal worldwide in a given year, but the standing biomass of the species usually fluctuates dramatically from one year to the next. Therefore, the fluctuation in anchoveta landings in Chile and Peru largely explains the fluctuations also in the amount of fish allocated to non-food uses worldwide. Any attempt to identify a trend in the use of fish for non-food purposes must somehow eliminate the random nature of the changes in quantities available in the sea and landed. One simple approach is to construct moving averages over a number of years.

The six-year moving average increased from about 29 million tonnes per year during the period 1994–99 to more than 32.5 million tonnes for the period 1999–2004. The increase is explained by a rapid expansion in China of the quantities used for non-food purposes – both for reduction to fishmeal and for other purposes. In China, the six-year moving average increased from 5 million tonnes per year of fish for non-food use during the period 1994–99 to 9.3 million tonnes for the period 1999–2004. For the rest of the world, the six-year average fell by 1.5 million tonnes, arriving at 23.4 million tonnes per year for 1999–2004.

Nevertheless, the increase in non-food uses has not prevented the expected increase in food use. In 2004, the amount of fish used as food had reached 105.6 million tonnes, 8.7 million tonnes more than four years earlier. It is aquaculture, and to some extent inland capture fisheries, that has made this possible. The growth in aquaculture output destined for human consumption (intermediary products excluded) has compensated for the proportion of capture fisheries landings that have been dedicated to fishmeal and other non-food uses. Of course, this has been possible because a large part of aquaculture production is not dependent on feeds fortified with fishmeal.

Fishmeal and availability of fish as food

It now seems unlikely, in the middle of the decade, that only 26 million tonnes of fish will be used for purposes other than food by 2010, but the extent to which this is unlikely this is difficult to establish. There are opposing forces at work.

On the one hand, aquaculturists – and other fishmeal users – will demand increasing quantities in the immediate future. These must come from capture fisheries, however, as aquaculture produce is generally too costly for uses other than human food.

On the other hand, the future demand for fishmeal in the aquaculture industry will be influenced by the results of research aiming to substitute fishmeal used in feed for fish and crustaceans. When the results of this research become technologically and economically feasible, the impact on fishmeal manufacturing could be rapid, and the quantities of fish demanded by fishmeal factories might well fall as projected in the past.

Halfway through the decade, however, such results do not seem to be forthcoming, so the demand for fishmeal will continue to grow. This will result in a rise in the real price of fishmeal (and fish oil), which in turn will contribute to increasing incentives

for using more fish as raw material in fishmeal plants. Such a development would lead to an increase in the real cost of some aquaculture produce, *ceteris paribus*, and production would expand more slowly than would otherwise have been the case.

As only part of the aquaculture sector is dependent on fishmeal in feeds, it seems unlikely that this scarcity of fishmeal will significantly hinder the overall growth of the sector, but there will be some reduction. Thus, in the absence of a "technological fix" that would make it possible to substitute significantly, if not fully, fishmeal in shrimp and fish feeds, the amount of fish available for human consumption in 2010 will probably be below 120 million tonnes, more likely in the range of 110–115 million tonnes. If freshwater fisheries production continues at present levels or expands, which may be the case during the rest of the decade, the availability of fish for human consumption will increase in a similar measure.

MEDIUM-TERM CHALLENGES AND CONSTRAINTS FOR AQUACULTURE

FAO recently concluded a prospective analysis intended to provide an insight into the future of aquaculture globally. The process was complex and included an assessment of demand and supply of fish and fish products. The analysis encompassed the preparation of national aquaculture sector overviews for more than 100 countries, five regional workshops in which participants discussed the aquaculture development status and trends in their region, the preparation of seven reports on regional aquaculture development status and trends¹ and a global expert survey on aquaculture development using the Delphi Technique. The material developed in this process, and other relevant documentation, was then synthesized to form a draft global review of the status and trends in aquaculture development.² Subsequently, this document was submitted to a group of experts, who were requested to reach consensus on the document and to craft the prospective analysis of future aquaculture development.³

The remainder of this section draws on the prospective analysis for a discussion of the possible behaviour of factors that are likely to influence significantly the development of aquaculture in the next decade or two. It starts with a few observations on the situation confronting aquaculture in sub-Saharan Africa.

The special situation of sub-Saharan Africa

In sub-Saharan Africa, per capita consumption of fish has lagged behind that of the rest of the world, decreasing from a high of 9.9 kg per capita in 1982 to the most recent estimate of 7.6 kg in 2003. The region can ill afford to see this trend continue or worsen. However, aquaculture can help also here as has been noted by the New Partnership for Africa's Development (NEPAD). In 2005, the NEPAD "Fish for All Summit" raised international awareness about the potential of aquaculture in the continent.⁴ Thus, for the coming years and decades, aquaculture is likely to become a priority for development. Indications are that assistance to Africa's aquaculture sector will be renewed in ways that are long-term in nature and favour private investment.

However, severe obstacles must be overcome. Most countries in sub-Saharan Africa have limited resources to deliver quality public goods and services for the aquaculture sector, and the private sector has not reached a level of development at which it could compensate for these deficiencies. So, the international community is likely to work increasingly in partnership with African development agents and institutions to ensure that aquaculture and fish production in the continent become part of its overall development process and that the public goods and services are provided.

Overarching conditions required for this to occur, identified during a recent FAO review,⁵ are political stability and good governance. More emphasis should also be placed on private-sector investment in aquaculture. Private-sector efficiency will be facilitated by the establishment of an enabling public-sector environment combined with a strategy to pursue development within the limits of available resources. The positive impacts of enhanced aquaculture development will be further complemented by the aggressive implementation of Poverty Reduction Strategy Papers, the

development of national aquaculture strategies and good legislation. The analysis also concluded that incentives and risk-reduction measures for foreign direct investment are necessary and that large-scale foreign-funded commercial aquaculture ventures could have trickle-down effects and boost the development of small- and medium-scale commercial aquaculture.

Conditions of particular relevance for the future of aquaculture in sub-Saharan Africa include the availability of quality inputs such as seed and feed and access to good quality information, affordable long-term investment capital, and land and water resources. Where these conditions prevail, sustainability will be enhanced and risks reduced. Given the importance not only of international assistance, but also of international markets, it is imperative that the image of African aquaculture is a positive one. This will permit benefits to accrue that include direct and indirect advantages to the most needy. The adoption of appropriate management practices for environmental protection and the sustainable use of aquatic resources will be vital in this regard, as will high standards for food safety. Finally, efficient communication and knowledge transfer using modern information technology will both improve overall global knowledge and skills and also link African aquaculturists with their counterparts in other continents.

Trends, opportunities and constraints

Of the many factors that determine the supply of aquaculture products and will, to a large extent, also determine the availability and consumption of fish, those outlined below are expected to play a lead role in the coming decades.

Access to land and water resources, and intensification

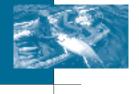
With a few possible exceptions, there is little new land available for fish farming in most countries around the world, especially in Asia, the leading aquaculture producer. Land shortage is, and is likely to remain, one of the major constraints to aquaculture expansion globally.

Governments have taken various measures to address the issue. These include the conversion of agriculture to aquaculture land where crops such as rice have failed to produce competitive returns. A further example is the integration of aquaculture into existing farming systems. Later aquaculture development in Southeast Asia, in the mid-1980s, took place in agricultural land, mainly sugar plantations. However, the possibility of using non-agricultural land for aquaculture is increasingly restricted. In the case of shrimp farming, most remaining mangroves are protected against encroachment. Because there is no possibility of increasing land area, one solution is to intensify land-based production, and intensification is becoming a growing trend in aquaculture worldwide. However, because production costs generally rise with the level of intensification, not all farmers are expected to intensify. Instead, many may choose to reduce intensity and produce less output, but lower the costs and/or their vulnerability to fish health and/or environmental problems.

The unavailability of freshwater could also limit future aquaculture development. In addition to its use for human consumption, agriculture and the farming of freshwater aquaculture species, freshwater is used in brackish-water culture of species such as shrimp as a means of reaching optimal salinity levels. Its use in aquaculture is frequently regarded as a loss for agriculture and, in many cases, agriculture has been given priority in the allocation of water. Yet the two sectors need not be mutually incompatible as policies can be put in place to encourage multiple uses of water. Nevertheless, in many countries, as aquaculture expands, access to clean water is increasingly likely to become a limiting factor.

Access to adequate feed: fishmeal, fish oil and "low-value/trash fish"

The use of aquafeeds will continue to play an important role in aquaculture development and production. The availability and cost of feed can be critical constraints to aquaculture. Irregularity or shortages of feed supplies add to risks and



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may jeopardize operations; such problems have occurred in many countries, especially in Africa and some parts of Asia.

There are mixed feelings about the reliance on fishmeal and fish oils in many countries. On the one hand, with the predicted global increase in aquaculture production, the demand for aquafeed will continue to grow, as will the demand for fishmeal and fish oil. According to the International Fishmeal and Fish Oil Organisation, the use of fishmeal in aquafeed is expected to rise by more than 5 percent (from 2.87 to 3.02 million tonnes from 2002 to 2012), while the demand for fish oil will increase by more than 17 percent (from 0.83 to 0.97 million tonnes) from 2002 to 2012.⁶ Considerable progress has been made in finding suitable alternatives to the fishmeal and fish oil from vegetable and terrestrial sources. However, the most promising results obtained so far are with omnivore/herbivore finfish and crustaceans, where total replacement of fishmeal has been possible.

On the other hand, as the production of fishmeal and fish oil is expected to remain stable over the next decade, the proportion of fishmeal use by the animal production sector is expected to fall and the use of vegetable-based protein and oil to increase. In addition, with technological advances, greater efficiencies in feeding are expected. It is therefore unlikely that the supply of fishmeal and fish oil will be a limiting factor in aquaculture feeding. However, this optimism should be considered with certain caution; the demand for fishmeal and fish oil from developing economies such as China may have a profound impact on overall supply and demand. In 2004, China imported 1 128 000 tonnes of fishmeal, or 29.6 percent of total global fishmeal imports, and accounted for more than one-third of world soybean imports.⁷

The use of low-value/trash fish in aquaculture is also an important factor for future development. Approximately 5–6 million tonnes of low-value/trash fish are used as direct feed in aquaculture (see pp. 118–119). Low-value/trash fish are primarily used for marine cage farming in China and in some Southeast Asian countries, including Cambodia, Indonesia, Thailand and Viet Nam, and to a lesser extent in tuna cage farming in the Mediterranean countries and in Mexico. It is projected that, by 2013, China alone would require 4 million tonnes of low-value/trash fish to sustain its marine cage culture. The requirement for Viet Nam has been estimated at around 1 million tonnes.⁸ It seems the use of low-value/trash fish in aquaculture feed is unlikely to be sustainable. There are concerns that its continued use may result in adverse environmental effects and biosecurity risks, and claims that the so-called low-value/ trash fish should be used as human food are mounting.

Greater capitalization and diversification of production systems and species

In spite of limited land and water resources, aquaculture entrepreneurs, attracted by high prices, are likely to find new ways (in addition to intensification) of producing sufficient fish to meet demand. One plausible way might be offshore cage culture and enclosure systems, probably with large corporations taking the lead because the economies of scale needed for farms to be profitable will require the production of enormous quantities of fish.

Greater production requires greater capitalization, that is, money invested in machinery, in sophisticated and expensive technologies and in training. Expansion in production will probably depress fish prices when, at the same time, companies will be competing for labour. This scenario implies that, in growing economies, real farm wages are likely to increase. Thus, in the long run, aquaculture employers will have to use less labour and more capital to maintain the profit margins needed to stay in business. Aquaculture, therefore, is likely to change from being labour-intensive to being capital-intensive. In other words, (labour) productivity is expected to be the key factor in the future of aquaculture.

Diversification is also expected to expand to new species or strains, especially of fish with a high commercial value. Generally speaking, an allocation of productive resources towards the production of high-commercial-value species, away from low-value species, can be expected. This development is already taking place in several parts of the world. Expansion of marine fish production in Southeast Asia is a good example; another is

found in the Philippines, where sea-cage culture of milkfish is replacing brackish-water ponds. In the United States of America, the government has already established a legal and regulatory basis for offshore aquaculture in the country's EEZ. The potential for offshore aquaculture is high worldwide, especially in Asia and the Pacific, North and Latin America, Europe and West and Southern Africa.

Aquaculture of non-food species such as ornamental fish farming is an industry full of promise for the future. In 2000, the global wholesale value of live freshwater and marine ornamental fish (live animals for aquaria) was estimated at US\$900 million, with an estimated retail value equivalent to US\$3 billion. Because of its growing potential for increasing rural employment and income and generating foreign exchange earnings, governments are increasingly promoting the culture and trade of ornamental fish. However, the outbreak of diseases is a threat to the development of this industry. It has been reported that a single strain of koi herpes virus has spread globally as a result of unregulated trade in ornamental fish. The continued spread of this virus could become a considerable problem for ornamental koi carp and for the common carp, both cultured and wild. It is hoped that the effective implementation of the measures adopted by countries to arrest the spread of fish diseases will prevent the future occurrence of such epidemics.

Ecotourism is an emerging industry and has the potential to spread throughout the world. A number of countries are promoting aquaculture-related ecotourism. Recreational fisheries in lakes and reservoirs play a significant role in Central and Eastern Europe, notably in Belarus, the Baltic States, Moldova, the Russian Federation and Ukraine. In Malaysia, there is a growing interest in integrating aquaculture operations with tourism, such as marine cage culture and "put and take" fishing ponds. Offshore sites are a potential area where aquaculture-related ecotourism could be further developed; for example, visits to cage culture sites could be promoted as part of coral reef expeditions.

The need to exploit further the potential of adding value to aquaculture products through the development of non-food uses, particularly in the context of increasing production costs, is widely accepted. The use of waste byproducts of processing, such as viscera (salmon), skins (tilapia), chitins (shrimp) and anti-arthritic compounds (green mussels) offers possibilities in this area. With the adoption of expensive machinery and technologies and more intensive production techniques combined with ever-rising energy costs, the costs of production are likely to increase further. Producers will need to explore every means possible for increasing revenues – including the expansion of marketing aquaculture byproducts for non-food uses.

In addition, in regions and countries where aquaculture is already well established, evidence shows that an increase in the number of farms for mariculture of high-value species has generally been accompanied by a reduction in the number of farms producing low-value (but high-volume) species such as cyprinids. China is one of the many examples. In the future, the reduction in freshwater aquaculture production may partly be offset by an expansion in marine production, particularly through the culture of relatively high-value commercial species. Whether it is lowvalue freshwater species or high-value marine species, the supply of high-quality seed will remain important.

Access to capital

With progressive intensification and diversification of aquaculture to systems and species requiring sophisticated technologies, access to capital will be a key factor for development. Capital will be needed not only for investment and operating costs, but also for aquaculture insurance as these high-tech investments will probably attract more risks than generally experienced in conventional aquaculture.

While access to capital might not be an issue in developed countries, it is certainly a stumbling block to aquaculture development in the developing world. With a few exceptions, the capital market is poorly developed and poorly accessible in Asia and the Pacific, Eastern Europe, Latin America and the Caribbean, and sub-Saharan Africa. As a consequence, in these regions the possibilities for developing and introducing new technologies are severely limited. Recourse to foreign investment is essential but, again, is severely limited. This problem is expected to persist, although there is room for some optimism. Provided that good governance and policies conducive to investment exist, the growing ease with which capital can be channelled from one country to another may enable capital-intensive farming systems to expand also in developing countries. Already, sizeable flows of foreign investments are reported in sub-Saharan African countries including the Gambia, Namibia, Nigeria, Senegal and Uganda for the culture of species such as shrimp, catfish and tilapia. There are also reports of significant capital inflows into Latin America, particularly Brazil and Chile, for the culture of salmon and other species. This trend is likely to continue for quite some time.

The farming of seaweed has expanded rapidly and offers new investment opportunities as demand has outstripped the supply from natural resources. The seaweed industry provides a range of products generating an annual production value of US\$5.5–6 billion. Of this, food products for human consumption contribute about US\$5 billion, substances extracted from seaweeds (carrageenan, agar and alginate) account for most of the remaining billion dollars, while smaller, miscellaneous uses, such as organic fertilizers and animal feed additives, make up the rest. This section of the industry is highly international and is an example of an activity where access to capital does not appear to be a limiting factor. There are indications that the seaweed industry is likely to expand in the coming decades.

Environmental management

Intensification may sustain the profitability of farming operations, but it does so at a cost. At times, it leads to farm management complications (especially with regard to water quality and health of culture animals). Also, concerns are often expressed about the environmental carrying capacity, which can be strained by increased numbers of farms and/or intensity of production systems. The production performance of the sector will depend on how well these issues are addressed.

Recent studies⁹ indicate that the output of nitrates and phosphates from aquaculture can be considered insignificant in terms of their contributions to nutrient loading in most regions of the world, although they may have local impacts on eutrophication and algal blooms. Great strides have been made over the past decade in mitigating nutrient and organic inputs from aquaculture. Notable advances and innovation in automated feeding technology have significantly reduced feed input while maintaining productivity and improving economic efficiency. These developments have been strengthened by the increased use of fallowing by fish farmers. Farmer and consumer associations, civil society and institutional buyers such as supermarket chains and other key stakeholder groups are actively promoting the development of standards and codes aimed at ensuring an environmentally and socially responsible aquaculture. Such improvements have been noticeable worldwide for a number of commodities, particularly salmon. They are likely to continue contributing to improving aquaculture's public image, thereby giving production an upward push.

Rising energy costs

Even before the current global energy crisis, energy costs represented an important share of the production costs in many commercial aquaculture operations. With further intensification and the use of more sophisticated technologies, it is likely that more energy will be needed, thereby exacerbating the energy cost problem. As for land and water, aquaculture must compete with other activities for energy. To alleviate this problem, researchers around the world are seeking low-cost energy sources. More efficient pumps have been suggested as one of the options. Another is the use of recirculating systems. While recirculation requires energy, it does not need water pumped from lower levels and so is energy-efficient. Wind-powered pumps are being used on a limited scale in freshwater aquaculture in many countries, but their capital cost is high. The inability to design a low-cost high-volume pump for saltwater shrimp farming has also restricted their use. Solar-powered pumps present the same difficulties.

In addition to seeking alternative sources, farmers are developing strategies and practices to reduce energy requirements. In certain culture practices, energy costs for pumping could be minimized with the combined use of bioremediation and low-discharge, or even zero-discharge, techniques. However, more research on these techniques is required.

Human resources development

Human resources development is pivotal to the future of aquaculture. The success of the sector will depend on whether progress in building the human capacity of the public and private sectors can keep pace with new developments in technology, international trade and legislation. Although this has been the subject of repeated debate in the past few decades, the need for human capacity to face the challenge of producing aquatic food to meet future demand is likely to remain an important issue in the next decade. Related issues, many of which are beyond the control of the aquaculture sector, include the so-called "brain drain", or migration of trained personnel from developing to developed countries, and the loss of human and social capital because of the effects of HIV and AIDS in many parts of the world, particularly in Africa. Natural disasters, such as the 2004 Asian Tsunami, also often result in heavy destruction of human capacity. These factors could still affect aquaculture for the foreseeable future.

Research and development

As aquaculture continues to feel the pressure to expand, research and development will be key. Research faces the challenge of providing policy-makers and practitioners with cutting-edge knowledge and innovations, ranging from genetic improvement of farmed fish to sophisticated cage designs for fish culture in offshore sites and improved feed, health and environmental management. Aquaculture development has been hampered, however, by three factors relating to the fundamental requirements of research and development, namely insufficient funds, lack of core research staff and weak research infrastructure. This situation again explains the need for more investment in the development of human resources; human capacity stands out as imperative for sustainable aquaculture development. An increase in the quantity and quality of human resources is needed in the search for aquaculture opportunities. Successful human resources development should trigger the development of more efficient aquaculture-related technology, legislation and management.

Information and communication technologies and networking

Continuous dramatic advances in information and communications technologies are creating new opportunities for communication, imparting learning and sharing knowledge in a timely and cost-effective manner. The challenge for governments and other stakeholders in aquaculture development is to seize and apply these opportunities for the benefit of the sector.

Information exchange through networking is likely to play an important role in the development of the sector. Although FAO has so far not been successful in creating self-sustaining aquaculture networks, with the exception of NACA, possibilities for networking are being explored in several regions. A Network of Aquaculture Centres in Central–Eastern Europe (NACEE) has been established and is eventually expected to become independent. Such networks, particularly in Latin America and sub-Saharan Africa, could contribute to more rapid development of the sector. In line with the 1995 Kyoto Declaration,¹⁰ and the recommendations of the COFI Sub-Committee on Aquaculture, there is a need for governments and international aid agencies to consider supporting the establishment of these networks.

Access to markets

Growing national and international markets and the ability to trade in these markets will continue to have a strong influence on the growth of aquaculture. International trade of farmed fish has been progressively increasing over recent decades. This

expansion in trade has induced some countries to apply high import tariffs on fish and fishery products as a way of protecting domestic aquaculture industries against foreign competition.¹¹

With the progressive liberalization of trade, tariffs have been lowered in many instances. However, non-tariff barriers (including technical and non-technical) have emerged as the main obstacle to trade and market access for exports to developed countries.¹²

In particular, domestic producers in importing countries have increasingly accused those selling products in their national markets (i.e. the exporters in other countries) of dumping and/or of benefiting from subsidies. These complaints have occasionally led importing countries to implement concrete measures against such imports, including the introduction of minimum import prices and countervailing duties to compensate for the alleged dumping or subsidy. Such disputes are increasingly being brought to the WTO for resolution by the WTO Dispute Settlement Mechanism; examples have included farmed species such as shrimp and salmon. As the industry grows and more aquaculture products move into international trade, the competition for market shares will become stiffer and an increasing number of such accusations and disputes can be expected.

Access to export markets has also become complicated by the need to comply with regulations concerning product quality and safety requirements on the part of importing countries (see pp. 136–143). It seems likely that market access could be improved through the development of certification systems for food safety and quality. Lack of compliance with these standards and regulations could have a serious impact on international trading of aquaculture products from developing countries. As a consequence, farmers, particularly the small-scale operators, are forming small associations or clusters and making efforts to implement better management practices and improve self-regulation. They view this as a means of both responding to demands for compliance with international trading standards and of increasing profits and minimizing production losses.

Given the significant contribution of developing countries to global aquaculture production, growing protectionism in developed countries would, of course, reduce aquaculture production in the developing world and thereby reduce the likelihood that aquaculture would be able to maintain the per capita supply of fish at its current levels. The impact of increased protectionism would be felt most keenly by small producers, who may not be able to bear the high costs of compliance – at least for internationally produced commodities – and who could eventually be pushed out of business.

In light of this situation, it seems that market diversification is likely to play an important role. The development of niche markets, such as for organic aquaculture products or aquaculture ecolabels, will go hand in hand with aquaculture of both established and novel species and products. Further liberalization of fish trade under new multilateral and/or bilateral agreements could provide new opportunities for the expansion of the aquaculture sector.

Additionally, in many developing countries, particularly in Asia, domestic aquaculture industries compete with imports for the domestic market shares of final products. In an attempt to overcome this problem, aquaculture producers and processors are slowly moving towards the development of processed products for both national and export markets. This value-addition strategy is an avenue for improving the profitability of aquaculture enterprises. There is also a trend towards targeting local urban markets with standardized, value-added "easy-to-cook" or "supermarkettype" products. As competition for markets increases, these trends are likely to grow and intensify.

Sound policies and governance

Good governance, including political stability, has a major influence on aquaculture development at all scales. It reduces the costs of doing business, attracts investment into the sector and enhances the industry's competitiveness both at home and globally.

Macroeconomic policies – such as fiscal policies, access to human resources and skills, and technology – play a similar, and equally important, role. Increased participation of stakeholders in the governance of the sector will become more important. Greater aquaculture sustainability will be achieved through the strengthening of farmer associations and by self-regulation in the aquaculture industry.

In many countries, there is no legislation specifically for aquaculture. Instead the sector is governed by a multiplicity of ad hoc laws, often subject to different interpretations. Where this is the case, sound governance means providing the sector with an "aquaculture legal act". Such acts do exist and it seems likely that during the coming decade public administrations will customize them to meet the needs of their particular countries, reflecting their varying levels of aquaculture development.

In countries with incipient aquaculture industries, governments are going to need to invest substantial sums in building institutions and establishing governance arrangements for aquaculture, in particular for industrial, export-oriented aquaculture ventures. As law enforcement is a constraint in many countries, strong emphasis will be placed on increasing self-regulation through farmer associations and by the sector as a whole. Self-regulation is likely to grow and become a norm.

Government support

Generally, a government's commitment to provide increased support to the aquaculture sector is a prerequisite for the sector's sustainable development. The commitment takes the form of clear articulation of policies, plans and strategies and the availability of adequate funding support. The challenge, and a potentially constraining factor, is the level of commitment of governments, particularly those of developing countries. Will it falter and shift as new global economic opportunities arise and the competition for scarce financial and natural resources increases? While the level of commitment will vary within and among regions, depending on the importance of aquaculture in national economies and well-being, it is nonetheless expected that in countries where aquaculture contributes substantially, or is seen as a potential contributor, to growth, poverty alleviation and food security, the commitment will hold and the level of support increase.



NOTES

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- 12. Ibid.

Please find enclosed a complimentary copy of the World Fisheries and Aquaculture Atlas CD-ROM. The Atlas, now in its fourth edition, presents a comprehensive and global view of marine and inland capture fisheries and aquaculture. It is currently available in English only.

For futher information please contact the FAO Fisheries and Aquaculture Department.

THE STATE OF WORLD FISHERIES AND AQUACULTURE

Several decades ago, the efforts of public administrations were concentrated on developing fisheries and aquaculture and ensuring growth in production and consumption. Then, in the 1980s, as many resources became fully or overexploited, the attention of policy-makers began to focus instead on fisheries management, in addition to development of aquaculture. Subsequent recognition of the many failures in management have now led FAO member countries and other relevant stakeholders to broaden the approach and governance, that is, the sum of the legal, social, economic and political arrangements used to manage fisheries and aquaculture in a sustainable manner is currently seen as a necessary context for management and is becoming the main concern.

Aquaculture continues to expand, while marine capture fisheries – when summed together worldwide – seem to have reached a ceiling. Reflecting the growing importance of aquaculture, *The State of World Fisheries and Aquaculture 2006* ends with a discussion of the challenges that aquaculture is facing as well as of the opportunities that are open to the sector. The discussion is based on a prospective analysis of the aquaculture sector worldwide, which was undertaken by FAO in the past two years.

Includes the fourth edition of the FAO *World Fisheries and Aquaculture Atlas* CD-ROM, a comprehensive and global view of marine and inland capture fisheries and aquaculture (available in English).

