CHAPTER 7

World fisheries

7.1 Introduction

The future of world fisheries[1] will be affected by fluctuations in the abundance of fish and living marine resources, along with factors such as technical developments, scientific discoveries, climate change and economic progress. But the dominant factor will be the critical issue of how capture fishing and aquaculture activities are managed.

The chapter starts by providing a summary of the status of world fisheries at the end of the 1990s, covering the main trends in supply (the status of stocks and fish production), demand (food consumption and other uses of fisheries) and employment. There follows a discussion of fisheries over the period to 2030.

Clearly, trying to depict world fisheries three decades from now is subject to many uncertainties. The discussion in this chapter is necessarily based on assumptions and analyses that include an element of subjectivity. The broad picture might be useful as a sketch of possible developments in production and consumption, even though fisheries in particular parts of the world may not conform to this picture.

7.2 World fisheries at the end of the 1990s

7.2.1 Fisheries production and stocks at the end of the 1990s

Capture fisheries. During the 1990s, the production of capture fisheries fluctuated between 80 and 85 million tonnes p.a. for the marine sector. Fish from the Pacific Ocean dominated world capture fisheries, accounting for almost two-thirds of total world supplies in 1999.

During the same period, the production from fisheries in inland waters expanded slightly, increasing from 6.4 million tonnes in 1990 to nearly 8.3 million tonnes in 1999. However, inland fishery catches are believed to be greatly underreported (FAO, 1999e). This is because of the dispersed and informal nature of many inland fisheries, and because many inland fish are bartered, sold or consumed locally without entering into the formal economy. For example, inland fisheries in Brazil, Ghana and several Southeast Asian countries may be twice to six times as productive, in terms of catch actually taken, as officially reported.

[1] The use of the term "fisheries" is in its broadest sense. It includes capture fisheries and aquaculture and sometimes associated handling, preservation, processing, marketing and trading activities, but excludes fishing for, and trade in, ornamental fish.

In several countries efforts are under way to improve the data on inland fisheries and on the range of services inland waters provide. One preliminary result is that it appears to be more profitable to use Brazilian floodplains for fisheries than to use cleared floodplains for cattle grazing.

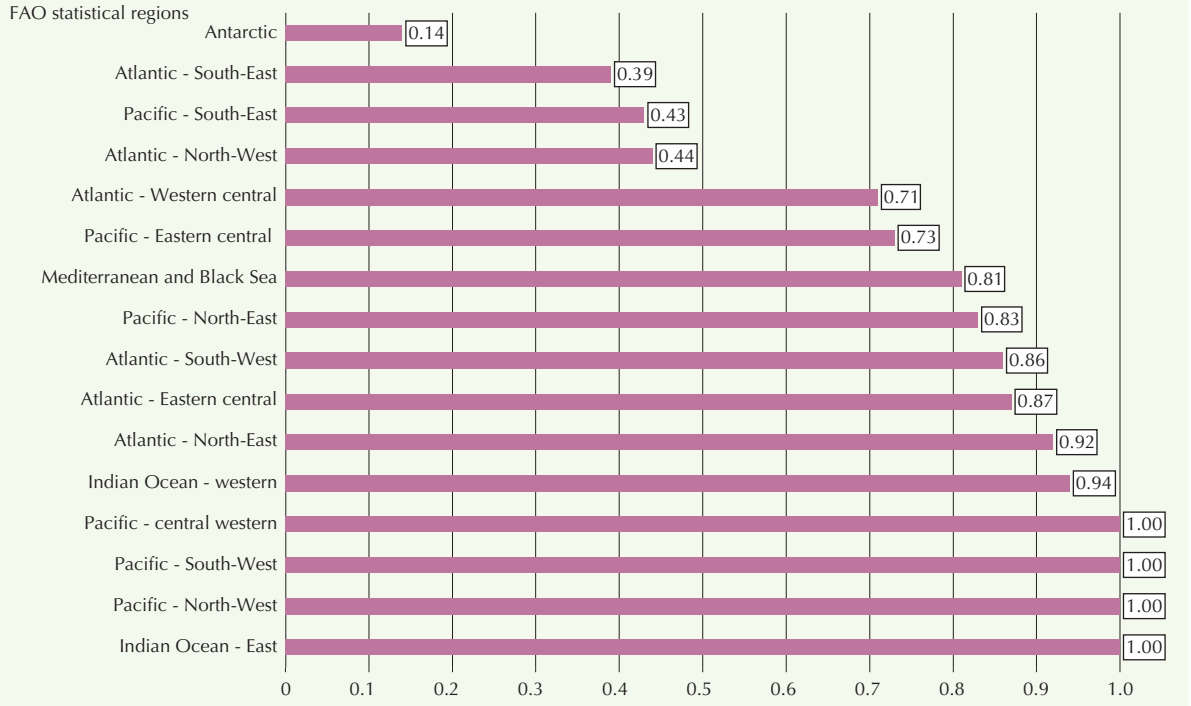
The gross volume of marine catches has fluctuated and does not show any definite trend. But the species composition of the catch has changed. High-value species – bottom-dwelling species (demersal) and large surface-dwelling species (pelagics) – are gradually being substituted by shorter-lived pelagic and schooling fish. FAO studies indicate many causes for this shift. These include the thinning out of (overfished) top predators; increases in natural production of small pelagics through nutrient enrichment of coastal areas, enclosed and semi-enclosed seas; and changes in fishing strategy and technology. The main force underlying such changes, however, is the change in harvesting costs as fishing technology has advanced and as various stocks have been depleted, and the impacts of these changing costs on operations.

During the second half of the twentieth century, capture technologies evolved rapidly. In the 1950s the invention of gear handling devices, such as the power block for purse seines, resulted in major improvements in the efficiency of fishing methods such as trawling, gillnetting, purse seining and lining. The development and introduction of synthetic fibres in fishing gear during the 1960s significantly increased the efficiency of such gears, thereby lowering that cost component of production. Also, new vessels were able to remain for longer periods in the fishing grounds and the introduction of freezing on board helped increase the autonomy of vessels.

Modern fishing fleets have also seen continued growth in efficiency over the last decades, thanks to improvements in navigation and fish-locating equipment, increased knowledge of fish behaviour during the capture process, and development of gear monitoring instruments. The growth of efficiency has contributed to increased exploitation rates and overexploitation in some fisheries, as well as to overcapacity in others.

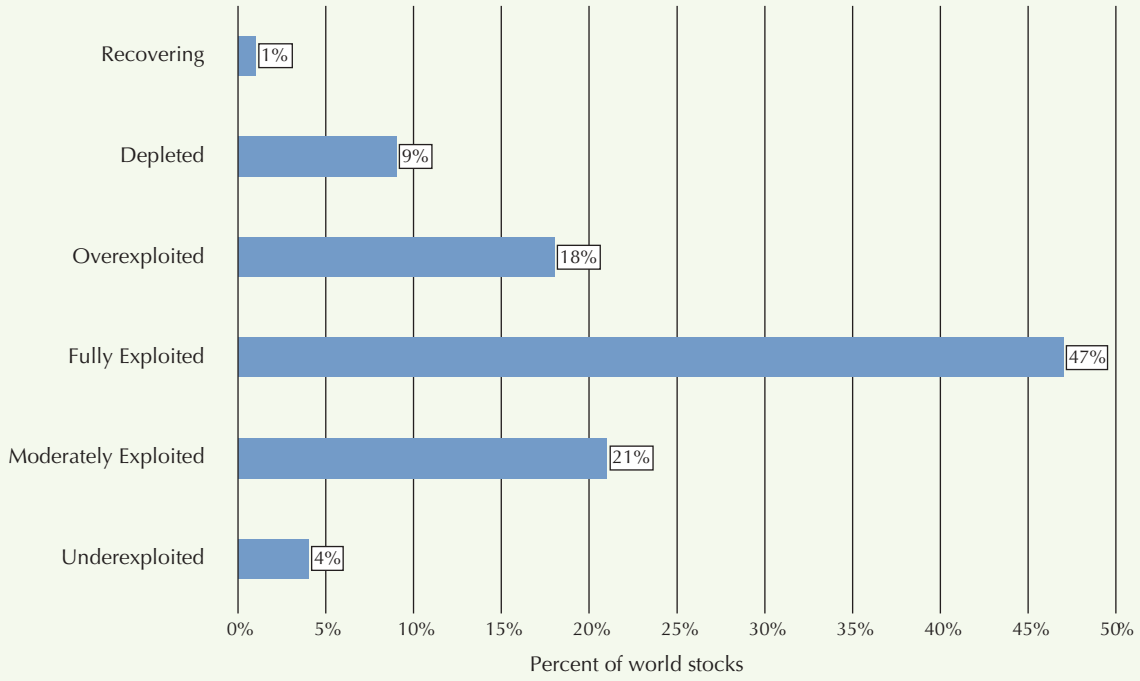
Status of fish stocks. In order to help organize its data, FAO distinguishes 16 statistical regions for the world's fishing areas. Figure 7.1 shows available

Figure 7.1 Ratio between the 1998 and maximum historical production, by region



Source: FAO (2000b).

Figure 7.2 The state of world fish stocks in 1999



Source: FAO (2000b).

data for these FAO statistical regions[2] of the world's oceans in 1998. Four regions (the Eastern Indian Ocean and the Northwest, Southwest and Western Central Pacific Oceans) were at their maximum historical level of production. Eight regions (the Western Indian Ocean, the Mediterranean and Black Sea, the Northeast and Eastern Central Pacific, and the Eastern Central, Western Central, Southwest and Southeast Atlantic) were slightly below maximum historical levels of production. The remaining four regions (the Antarctic, the Southeast and Northwest Atlantic and the Southeast Pacific) were well below maximum historical levels of production. While there may be some natural oscillations in productivity, the main factor responsible for the declines in production levels in most of the regions is overfishing.

Another useful indicator is the state of stocks of various fishery species (Figure 7.2). For the 590 "stock" items for which FAO had some information, 149 were in an unknown state. Among the 441 for which data were available, 9 percent were depleted,[3] 18 percent were overfished,[4] 1 percent recovering, 47 percent appeared fully exploited, 21 percent were moderately exploited, and only 4 percent were classified as underexploited, i.e. they could sustain catches higher than current levels.

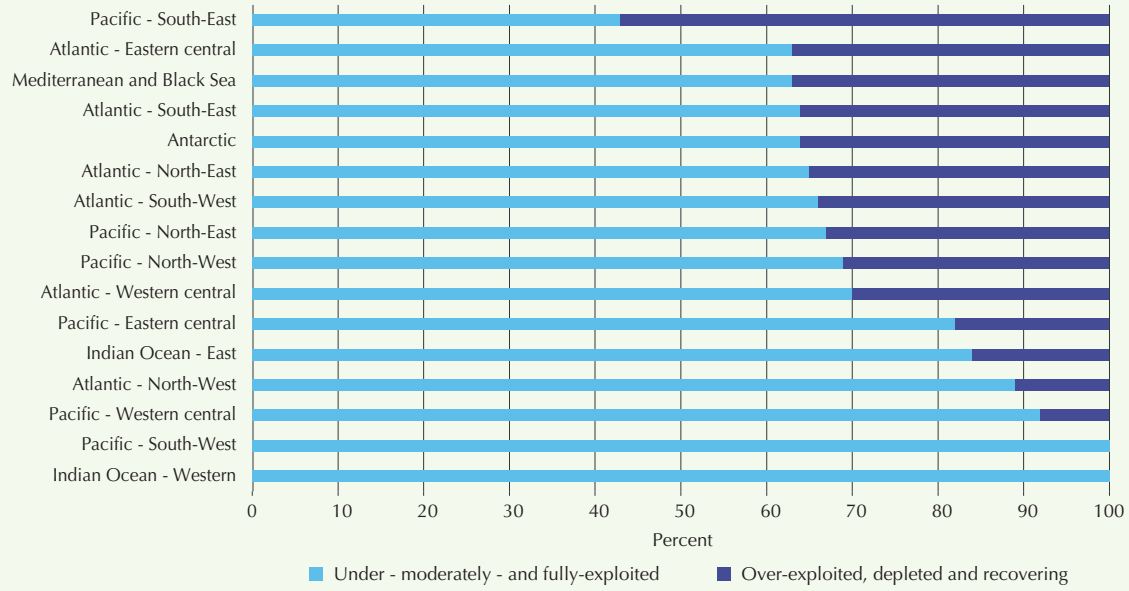
A more general assessment of the condition of world stocks depends on how one categorizes the stocks that at present are exploited close to the maximum sustainable yield (MSY) level. If the fully exploited stocks are accepted as being in good

2 The Pacific is divided into the northwest (PNW), northeast (PNE), eastern central (PEC), western central (PCW), southwest (PSW) and southeast (PSE) regions; the Indian Ocean into the eastern (IE) and western (IW) regions; the Atlantic into the northeast (ANE), northwest (ANW), eastern central (AEC), western central (ACW), southwest (ASW) and southeast (ASE) regions. The last two regions are the Mediterranean and Black Sea (MBS),and the Antarctic (ANT).

3 A "depleted" stock is one that is driven by fishing to a very low size (compared with historical levels), with dramatically reduced spawning biomass and reproductive capacity. Such stocks require rebuilding. The recovery time will depend on the current condition of the stock, the level of protection afforded to the stock, and environmental conditions.

4 A stock is considered "overfished" when exploited beyond the point at which the volume is considered "too low" to ensure safe reproduction. The term "overfished" is often used when biomass is estimated to be below a specified biological reference level such as the maximum sustainable yield (MSY).

Figure 7.3 Condition of stocks by FAO statistical region



Source: FAO (2000b).

condition because they comply with the United Nations Convention on the Law of the Sea (UNCLOS) requirement of being at or above the MSY level of abundance, then 72 percent of the stocks appear exploited at sustainable levels. However, this still implies that 28 percent of stocks are overfished or even depleted and therefore need rebuilding.

Similar conclusions arise by analysing the stock data by FAO statistical region. Comparing the total of fully, under- and moderately exploited stocks with the total of overexploited, depleted and recovering stocks, the data suggest that in each region more than 50 percent of stocks are being sustainably exploited, except in the Pacific Southeast (Figure 7.3).

Aquaculture. Until the 1950s, aquaculture involved a limited number of species: oysters, mussels, carp, trout and shrimps. This was largely because these were the species for which large volumes of young/spat could be easily obtained for production purposes, and such culture systems were generally extensive. Since the 1950s, scientists gradually solved the problem of artificial reproduction for different carp (e.g. common, Chinese and Indian carp), salmonids, oysters and shrimps, making it possible to stabilize and expand production of these species.

The bulk of aquaculture production comes from species that feed low on the food chain. Among the finfishes, carp, which generally feed on plankton and plants, accounted for nearly 70 percent of world production of cultured finfishes in 1999. Commanding low to moderate prices, such fish tend not to be traded internationally. Aquaculture currently provides a considerable share of the production of several high-priced species such as salmon, marine shrimps and oysters.

In general, efforts to culture other finfish and crustaceans implied protracted and costly research and development efforts. This has hampered greater aquaculture-based production of many of these types of species. As a result, even by the end of the 1990s, a relatively small number of species (less than 40) accounted for 90 percent of the volume of world aquaculture production.

During the 1990s, aquaculture production increased at the rapid rate of approximately 10 percent p.a., rising from a 1990 level of 13 percent of world fisheries production (excluding aquatic plants) to 26 percent nine years later. Currently, aquaculture production already far exceeds the year 2010 production level

projected as recently as in 1995 (Alexandratos, 1995).

Aquaculture's share of fish used in food consumption has risen in volume terms from 19 percent in 1990 to 34 percent in 1999. In value terms, this contribution is 39 percent – the ex-farm value of aquaculture (fish and shellfish) production was estimated in 1999 at approximately US$48 billion, compared with an estimated landed value of capture fisheries at approximately US$76 billion.

The growth of aquaculture has been unevenly distributed around the globe. Production has been heavily concentrated in Asia both in volume and value terms. At the beginning of the 1990s, Asia provided 83 percent of the world's total volume of aquaculture production, and by 1999 that share had risen to 89 percent. Most of the increase was attributable to China, whose share of the world's aquaculture production increased from 50 percent in 1990 to 68 percent in 1999.

There is a growing perception that much of aquaculture production leads to environmental damage. This is not correct for many aquaculture activities. Molluscs, seaweed and most forms of carp culture, for example, have only a very limited impact on the aquatic environment, and these species account for more than half of world aquaculture production.

However, it is generally recognized that the early rapid expansion of shrimp farming in countries around the Bay of Bengal, elsewhere in Asia, and in Latin America caused considerable environmental and social damage. This was in large part a result of unsuitable procedures for site selection, pond construction and pond management. Conversely, aquaculture itself has increasingly been negatively affected by coastal development, habitat loss, and non-point-source pollution, issues that are usually beyond the direct jurisdiction or control of fisheries management authorities.

7.2.2 Demand for fishery products at the end of the 1990s

Demand for fishery products consists of two components: direct consumption of fish as food and fish used for animal feeding. Increasingly, fishery resources are also in demand as a source of leisure activities.

Direct consumption of fish as food. Globally, fish provide about 16 percent of animal proteins consumed and are a valuable source of minerals and essential fatty acids. Regionally, these consumption figures vary, with fish accounting for an average of 30 percent of consumed animal proteins in Asia, approximately 20 percent in Africa, and around 10 percent in Latin America and the Caribbean.[5]

During the 1990s, global apparent consumption of fish increased.[6] In 1990, apparent direct food consumption of fish, crustaceans and molluscs amounted to 71.2 million tonnes (live-weight equivalent). This figure increased to 97.2 million tonnes in 1999, an increase of more than a third over a period of only nine years, faster than the growth of world population. Thus average apparent consumption of fish increased from 13.4 kg per capita in 1990 to 16.3 kg per capita in 1999.

This development was heavily dominated by events in China, which emerged as the world's largest fish producer during this period.[7] Growth in Chinese fish production was so rapid that it overshadowed developments elsewhere. In fact, excluding China, the apparent consumption per person in the rest of the world actually declined from 14.4 kg in 1990 to 13.1 kg in 1999.

However, it is important to note that such global figures mask the very wide differences among countries in the level of fish used in food consumption. This ranges from less than 1 kg per person p.a. in some countries to over 100 kg per person in others. Moreover, in recent years the form in which fish has been consumed has changed. The volume of fishery products marketed in their fresh state has increased not only in absolute terms, but also as a

5 In discussing food uses of fish, the term "fish" refers to fish, crustaceans and molluscs, excluding aquatic mammals and aquatic plants.

6 FAO does not obtain data from countries on consumption. Thus, when the term "consumption" is used it refers to "apparent consumption" which is the equivalent of domestic fish production plus fish imports minus exports and non-food uses of fish.

7 The accuracy of the Chinese figures for fish production and the utilization of fish for food and feed has been called into question by some scientists. FAO and China are examining this issue.

Box 7.1 Biodiversity and fisheries

Over 1 100 species of fishes, molluscs and crustaceans directly contribute to production of the world's major fisheries. There are many additional species contributing to smaller-scale fisheries. In aquaculture, although the majority of production comes from a few species, there are over 300 species, which do contribute.

Biodiversity as defined in the Convention on Biological Diversity – namely, the variability within species, among species, and of ecosystems, and the ecological complexes of which they are part – is a basic element necessary for sustainable fisheries and aquaculture. The biodiversity of natural populations provides the resource base for commercial fisheries and the means to adapt to environmental changes and fishing pressure, and the biodiversity of farmed fish allows for continued breed improvement to meet production and changing market demands.

Like most human activities that alter resources and the environment in which they are found, commercial fishing and aquaculture activities can have negative impacts on the environment and, hence, on biodiversity. For example, in capture fisheries practices such as the use of poison and dynamite are extremely harmful (especially in coral reefs) and have been generally banned. Similarly, the use of non-selective fishing gears can have negative impacts on biodiversity, particularly if the amounts of species harvested and impacted are unsustainable. This happens, for example, where there is a high bycatch of relatively scarce species, high discard rates, and where only high-valued catch is kept. There is growing concern that the practice of bottom trawling can have negative impacts on bottom-dwelling flora and fauna in sensitive areas such as coral reefs, seagrass beds, etc. Similarly, increased production of so-called reduction fisheries (i.e. fish being reduced to fishmeal and oil) have been increasingly criticized for their likely impact on the food chains of important aquatic species and birds.

Fishery administrations and Regional Fishery Management Bodies (RFMBs) are responding to stakeholders' concerns and are working to address the impacts of these activities through better regulations to minimize or mitigate their impacts on biological diversity. One approach has been the development and use of more selective fishing gears such as those that reduce the capture of marine mammals, undersized target species and unwanted bycatch. Additional efforts are being made to ensure that commercial exploitation does not result in the eradication of species or seriously harm genetic diversity.

Nonetheless, some currently targeted species such as the white abalone, the barn-door skate and large coral reef fishes are at risk. Genetic diversity and the related ability for species to adapt have been lost by intense fishing on susceptible populations such as spawning aggregations of the orange roughy in New Zealand, thereby eliminating this large, slowly reproducing species. In response, some stakeholder groups are working, through the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), to prohibit international trade of commercially caught species that may be at risk.

Inappropriate fisheries and aquaculture activities are but some of the threats to aquatic biodiversity. Additional threats, often more severe, include pollution, loss of habitat, habitat degradation and global warming. Unfortunately, aquatic biodiversity usually faces several such threats simultaneously, making the solution to such problems less amenable to relatively simple or quick remedies.

share of all uses of fish. In 1999 slightly more than a third of all fish was marketed fresh against only one fifth in 1987.

Fish used for animal feed. During the 1990s, between 28 and 33 million tonnes of fish were used each year for the production of fishmeal and oil. Almost all of this was landed by marine capture fisheries. When the capture of pelagic fish off the west coast of South America contracted as a result of the El Niño phenomenon, so did the production of fishmeal in the world: in 1998 only 23.9 million tonnes of fish were reduced to fishmeal and oil. By 1999 this figure increased again to 30 million tonnes or almost 24 percent of total world catch of fish, representing a return to a more normal level as a result of the recovery of fishing in South America.

Fishing as a source of leisure activities. Two types of users are increasingly using fisheries for leisure activities: active users such as recreational and sports fishers, and so-called non-consumptive and passive users such as tourists, sport divers and individuals who want to enjoy the environmental values of pristine marine environments (including fisheries). In many parts of the world, the number

of stakeholders who want to use fisheries for leisure purposes exceeds the number of commercial fishers. Because all stakeholders, commercial or otherwise, have valid claims for access to living aquatic resources and have a stake in influencing the use of world fisheries, the emergence of this group is an important development. Because of their numbers and the fact that they are increasingly well represented and organized, these stakeholders in affluent developed economies have a growing influence on how fisheries can be used, including the use of fisheries for food production.

This new category of stakeholders has developed various strategies for effecting its objectives. In some instances, stakeholders have moved to prevent or otherwise modify exploitation of some valued species, either because the exploitation of these species had the potential to directly threaten species (e.g. marine mammals) or because of the effects capture fisheries could have on associated species, e.g. seabirds or seals.[8] In other instances, they have asserted particular policy perspectives regarding the appropriateness of exploitation of certain environments or species and have worked to establish parks or protected areas in which certain fisheries activities are prohibited or limited. In some cases such efforts have resulted in fishing methods being significantly modified, restricted and even prohibited as, for example, under the 1989 UN Resolution 44/225 on Large-Scale Pelagic Driftnet Fishing and its Impacts on the Living Resources of the World's Oceans and Seas and the related 1989 Wellington Convention for the Prohibition of Fishing with Large Driftnets (and Protocols).

7.2.3 Trade in fishery products at the end of the 1990s

The gradual opening up of markets during the last decade has expanded international trade in fish and fish products in both volume and geographic coverage. Nearly 40 percent of all fishery production is now internationally traded. Around 80 percent of fish for human consumption ends up in three main markets (Japan, the United States and the EU).

Exporting countries increasingly see trade in fish and fish products as a powerful vehicle for earning foreign exchange, especially through the export of high-valued species. For example, in Indonesia the government is aiming for approximately three-quarters of all foreign exchange earned from fish and crustacean exports to come from high-valued cultured species (Purwanto, 1999). Globally, gross earnings from fish exports by developing countries grew rapidly from US$5.2 billion in 1985 to US$15.6 billion in 1999, a level that raised fish export earnings to a level on a par with the total value of exports of such commodities as bananas, coffee, cocoa and rubber.

International trade is particularly important in fishmeal and oil. Some 65 percent of the volume of world fishmeal production enters international trade. This reflects the fact that fishmeal is produced primarily in South America but is used as animal feed in feedlots in more wealthy economies elsewhere in the world. This growth in trade also reflects the global growth of the aquaculture sector, where fishmeal and oil are key feed ingredients.

The increase in trade in fish and fish products in the 1990s has not been without difficulty. Stringent standards for fish imports have been introduced, mostly in the markets of developed countries. Approaches such as HACCP methodology aim to ensure that consumers receive safe and hygienic quality food products. This has forced exporters to choose between finding new output markets, or introducing systematic procedures to meet the requirements of the markets to which they want to export. One effect has been that some countries saw their exports halted until they could introduce HACCP procedures.

7.2.4 Employment in fisheries

Employment policies in the fisheries sector are seldom explicitly elaborated. Where they are explicit, they frequently concern the participation of local fishers as crew in a joint venture or on foreign flagged, licensed vessels fishing in the national exclusive economic zones (EEZs).

[8] Stakeholder groups were key forces driving international efforts to set up the International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries, the International Plan of Action for the Conservation and Management of Sharks, and the International Plan of Action for the Management of Fishing Capacity.

Despite this, other developments in marine policy have had an impact on fisheries employment. For example, the introduction of the EEZs early in the 1980s affected fisheries employment. Employment in long-distance fishing fleets changed when countries lost access to fishing grounds. This affected both those that already existed, and those developed during the 1950s and 1960s by countries such as Japan, the former Soviet Union and several countries in Europe. Some countries, particularly Spain and Portugal, relocated much of their activities to other nations' fishing grounds through fishing agreements. Other countries, particularly developing countries in Asia, expanded employment in fisheries, in part through effective occupation of their own fishing grounds in their newly created EEZs, but also by engaging in high sea fisheries. Still other countries worked directly to reduce the numbers of those employed in high seas and other fisheries. For example, from 1980 to 1995, the number of active Japanese marine fishers was reduced from some 457 to 278 thousand.

Although information on fisheries employment is only fragmentary, the available data show that during the 1990s employment in capture fisheries and aquaculture continued to contract in the developed economies and to expand in the developing countries. Already in the early 1990s, more than 90 percent of those fully employed in the fishery sector were employed by either developing economies or economies in transition (FAO, 1997d). At the same time, fisheries employment in developed economies fell in capture fisheries, in part compensated by the slowly expanding employment in aquaculture. Overall, growth in employment in fisheries is slowing down significantly.

When fisheries are used as a means for providing social safety nets or for last-resort employment opportunities, such employment policies are rarely explicitly enunciated. For example, there has been an increasing tendency to allocate inshore areas with fish resources to small-scale fishers. This can be seen as an indirect way of preserving local employment opportunities and a source of food for local fishing communities. However, such policies rarely provide legal rules and mechanisms for controlling the inflow of fishers from other areas or communities. As a result, unrestricted catches by unregulated numbers of fishers mean that inshore fisheries are increasingly unable to render the benefits they were intended to provide, particularly when there are problems in other sectors that drive people into fisheries as an activity of last resort.

7.3 Plausible developments in world fisheries

Developments in the global fisheries picture will to a great extent be determined by developments in fisheries management, which will have to face problems such as the increasingly contentious issue of access rights allocation. In this section, developments in production, demand and trade will be discussed, leading up to a concluding discussion of management issues in fisheries.

7.3.1 Developments in fisheries production

Overall, production from wild capture fisheries is approaching its biologically sustainable limit for many fish species. The bulk of further production increases will therefore have to come from aquaculture. However, aquaculture is at present also constrained to the extent that it relies for feeding purposes on fishmeal and fish oil that come from capture fisheries. This constraint may be overcome when cost-effective substitutes for fishmeal and fish oil emerge.

Beyond these constraints, future fish production increases will depend on further development of post-harvest utilization technologies, and on successful resolution of various negative externalities such as habitat destruction, bycatch and pollution from intensive aquaculture.

The future for the *aquaculture* sector varies by region. In Asia aquaculture is long practised and well established. It is expected that aquaculture will continue to grow and supply important segments of fish markets in Asia, increasing its share in total fish production.

The aquaculture industry will respond to the growing demand for fish by increasing production of already domesticated species, by domesticating additional species, and by expanding marine ranching. In doing so, the industry will need to resolve issues such as how to maintain genetic diversity of domesticated species, how to develop technologies for new species, how to

Box 7.2 The use of genetically modified organisms (GMOs) in aquaculture

Traditional animal breeding, chromosome-set manipulation and hybridization have already made significant contributions to aquaculture production. Their contribution is expected to increase as aquatic species become more domesticated and as breeding and genetic technology continue to improve.

A relatively new form of genetic modification involves moving genes between species, thus producing "transgenics". Experimental and pilot projects on transgenic organisms have demonstrated that commercially important traits can be greatly improved. Growth hormone genes from a variety of fishes have been put into other species such as carp, catfish, tilapia and salmon to improve growth rates by increasing the production of the fishes' own growth hormone. A gene that produces an antifreeze protein in the Arctic flounder, thus allowing it to survive in subfreezing waters, has been put into Atlantic salmon in the hope of increasing this species' tolerance of cold waters.

At the end of the 1990s, no commercial aquaculture producer was marketing transgenic aquaculture species for human consumption. Consumer resistance and concerns about the protection of intellectual property rights are the main reasons for not marketing the animals at present being developed in research programmes. There is concern that new genetic technologies, and specifically transgenic technology, are poorly understood and that they may pose risks to the environment and human health. These concerns will be addressed, *inter alia*, in the biosafety protocols on the international movement of GMOs now being developed under the Convention on Biological Diversity. The EU has issued directives for the trade, transport and release of GMOs.

Many resource managers, aquaculturists and scientists believe that GMOs and transgenics will eventually become accepted in aquaculture and will contribute to increased production. Clear and accurate information on the benefits and risks of GMOs, and policy guidelines for their responsible use, are urgently needed in order to allow the field to progress.

resolve a looming shortage of feed for cultured fish and shrimps, and how to deal with pollution issues.

Aquaculture is an ancient activity that was usually carried out in harmony with other uses of the environment, but few of the old ways of raising aquatic animals and plants still prevail. Modernized technologies have resulted in substantial reductions in production costs for several species, but they have also created negative environmental externalities. Aquaculture will be increasingly subject to regulations ensuring judicious use of culture technologies and site selection. The development of technologies, and a reduction in the costs of dealing with the undesirable environmental effects of aquaculture installations and intensive feed regimes, will allow these problems to be much reduced, if not overcome. Environmental considerations may also lead to the shift of aquaculture installations away from the coastal zone into offshore and submergible installations at sea, and in densely populated areas inland, into intensive recirculating systems.

There is concern in the aquaculture industry that the limited availability of feeds could constrain the expansion of aquaculture production. Aquaculturists using semi-intensive and intensive culture systems for fish and marine shrimps are particularly dependent on feeds that incorporate fish oils. Fishmeal producers expect that within a decade or so, the aquaculture industry will use up to 75 to 80 percent of all fish oil produced, and about half of the available white fishmeal. Although considerable research efforts have been undertaken, a satisfactory replacement for fish oil has still to be found. The problem of finding new fish feeds will soon become more pressing, given that semi-intensive and intensive culture systems for shrimps, marine fish and increasingly for carp and other freshwater fishes will expand.

Despite boom-and-bust cycles of overexpansion, market gluts and falling prices in northern Europe and North America, it is likely that the culture of salmon, sea bass, bream and turbot will still continue to expand, particularly in Europe. But the rate of expansion is likely to decrease and stabilize, probably at a few percent per year in terms of the volume of production. The rate of expansion will depend on the intensity of market promotion efforts, particularly in non-traditional markets.

However, there are cultured species such as carp, tilapias and catfishes that have much larger "natural" markets. For example, carp account for about 70 percent of world cultured production of finfish although they are produced in only a few countries (China, India and Indonesia account for more than 90 percent of world production; FAO, 2001e). It is plausible to expect continued growth in traditional markets. Total production may well double by 2015, with growth slowing thereafter. If non-Asian markets could be found for Indian and Asian carp, production could grow more quickly.

After several decades of promotion, the culture of tilapia (mostly *Oreochromis nilotica*) took off at the end of the 1990s, not in its natural home of Africa, but in Asia, where it has found ready markets. It is also finding markets in Europe and North America. It seems most likely that tilapia culture will expand in Asia, intensify in Latin America and take off in Africa. The sector has been growing in volume by over 10 percent p.a. at the end of the 1990s, and it is likely to maintain that rate at least for the next two decades. Tilapia is a relatively inexpensive fish, and it can be used as an ingredient in processed products. By 2015, it is plausible that there will be a production volume in the order of 3 to 5 million tonnes p.a., increasing to possibly twice that amount by 2030.

Crustaceans account for about 5 percent of world production of fish and shellfish. While the culture of crustaceans has progressed steadily in volume, this has not always been the case for individual species. Given the growing demand for this luxury product and an increased ability to deal with disease (a severe problem in the culture of tropical marine shrimps), it would seem reasonable to expect that the culture of present domesticated crustaceans will expand as it did during the last few years of the 1990s.

Molluscs, foremost among them oysters, account for about one-third of world production of fish and shellfish. Recently, the production of mussels has stagnated. However, efforts are under way for these products also to find new markets and these are likely to be successful. Production of mussels can be expected to grow through new offshore technologies. Thus mollusc production is likely to resume its pace of growth.

Because of the high costs and long periods involved in achieving controlled reproduction and survival of the offspring of newly domesticated species, most recent domestications have been achieved in developed countries, in particular along the shores of the North Atlantic. This is likely to continue in the future. Production of species such as char, cod, halibut, coryphena and possibly large tunas and turbot is likely to grow and eventually stabilize. The level at which this will happen is largely determined by production costs vis-à-vis those in capture fisheries. For halibut, cod and tunas, which lately saw relatively high volumes in capture fisheries, cultured production will eventually be quite high. For Atlantic cod it may be several millions of tonnes. The technology is being developed for some types of halibut, production of which may increase quickly and reach hundreds of thousands of tonnes before the industry reaches serious market problems. Capture fisheries of char and turbot amount to only a few thousand tonnes per year. So, in terms of volume and number of producers, growth of aquaculture may be slow for these species.

Among the species mentioned above, Atlantic cod is perhaps the most interesting. Once this species has been domesticated and a commercially viable culture technology develops, the impact could be considerable not only on codfish fisheries and their markets but on the white fish industry as a whole. It took about 15 years for the Atlantic salmon industry to reach a yearly production of half a million tonnes and, as noted above, the marketing challenge was considerable. It is likely to take less time for the cod culture industry to reach that figure. It will start from a much better market position. Total capture fishery production of Atlantic cod is about 1.3 million tonnes p.a. Atlantic cod has a market also in southern Europe and in Latin America, and the species can be sold in many product forms. Thus, assuming that commercially viable technology for the culture of cod is developed soon, by 2015 cultured cod production could be at least 1 to 2 million tonnes p.a.

At present, of the major fishing nations, only Japan is engaged in sea (or ocean) ranching on a large scale. Over 80 species are being ranched or researched for eventual stocking in marine, brackish and fresh waters (Bartley, 1999) and, as a result, the population has increased for a number of species. Many other countries are also active in the enhancement and ranching of aquatic species, but most of

them stock only a few marine species. Salmonids are the most widely stocked group of fish.

The future of sea ranching will depend on a number of crucial issues. One of these is how to deal with the externalities of ocean ranching and the potential ecosystem-related imbalances that it could create (Arnason, 2001). Another is the ownership of the released animals. As long as ownership is not legally defined and technically impossible to defend, the private sector and governments will be reluctant to spend resources on maintaining ranching programmes. It is possible that new technology will permit the identification of released animals and their separation on capture. But, before sea ranching can contribute significantly to world fish supplies it must be integrated into an overall fishery management approach that includes habitat protection.

In inland fisheries, enhancement of fish stocks has been practised successfully in Asia, particularly in China. There is considerable potential for stocking and harvesting fish in both permanent and seasonal freshwater bodies in other parts of the world. The obstacle to rapid development of inland fish stocking is not technical, but rather financial and institutional. Most small freshwater bodies have a large number of users with long-standing traditional usage rights. Enhancement practices must be compatible with these rights and include mechanisms for perpetuating them. No doubt the practice of stocking fish in such bodies will spread, but the spread will be slow in Africa, and is not likely to receive priority in Latin America (with some notable exceptions). In Asia the practice will continue.

In summary, it is unrealistic to expect any sudden change or marked increase in the rate of aquaculture growth worldwide over the next decade or so, unless significant market shocks destabilize the production of other protein sources that currently serve as substitutes for fish in general and aquacultured fish in particular. Nevertheless, it seems possible that the growth in aquacultured fish and shellfish production will continue, at least until 2015, at close to the fairly high growth rates recorded recently (5 to 7 percent p.a.).

Wild *capture fisheries* production in the longer term will be influenced by advances in harvesting technologies and marketing developments. Estimates of total sustainable production still refer to the figure of approximately 100 million tonnes p.a. (National Research Council, 1999). This is higher than the annual catches of 80 to 85 million tonnes of the 1990s because it assumes efficient utilization of the stocks in healthy ecosystems where critical habitats have been conserved. Moreover, this estimated potential yield includes large quantities of living marine resources which thus far have been little exploited. Of these the best known are krill, mesopelagic fish and oceanic squids. The major factor affecting wild capture production is whether fisheries management can ensure that fish are harvested in a sustainable and economically efficient manner.

Clearly, technical developments will continue to increase the efficiency of fishing. Navigational technologies, electronic fish-finding devices, freezing technologies and gear improvements have already increased fishing productivity substantially. As international awareness increases about various fishing practices, more selective fishing gears that can reduce the catch of non-target species are being developed and spread. In addition, social pressures will continue to drive innovations to make use of unwanted but unavoidable catch. Nonetheless, technical gains will probably not fully compensate for management strategies where these are increasingly economically inefficient.

Market changes will also drive changes in technology. There is a growing trend to consume fresh fish instead of processed fish products. Increased access to markets, lower costs of the technology for delivering fresh fish, and price premiums paid for fresh fish are creating incentives to make this shift. The advent of labelling schemes further supports market changes. For example, labelling products by country of origin, and use of ecolabels recognizing sustainably harvested fish enable producers to differentiate their products and take advantage of changing consumer preferences. However, these developments will not necessarily alter total production, just the form in which fish are produced for food.

The increasing competition of fish substitutes will force wild capture fisheries to deliver products that enjoy price premiums. For example, at the beginning of the 1990s, imports of farmed tilapia (fillets) and supply of pond-cultured catfish were believed to depress prices of white fish in the United States market. Similar situations have been observed in south European countries with respect

Box 7.3 An aquaculture scenario for Africa

Africa's per capita fish consumption is relatively low (6.8 kg in 1999) and there is therefore ample scope for increases in per capita fish demand. There are however several reasons to expect at best a stagnation from now until 2015. Indeed it is not clear at present how per capita fish supply in Africa could be maintained even at its present low level.

Assuming that exports and imports remain at the levels of 1999, fish supply would have to expand by 46 percent over the period to 2015, and by 92 percent to 2030, simply to maintain present per capita supplies. It is not immediately obvious where the fish will come from. Local wild stocks are close to being fully exploited, both in inland and marine waters. Thus, it is unlikely that fishers can respond with higher production to an increase in demand. Export demand is likely to be supplied first, in response to prices that are higher than those affordable by African consumers. Imports of small pelagic species could grow, but it is all a matter of price. Supply for domestic consumption will probably decline and prices edge upwards. Consumers will therefore look for alternatives, which they are likely to find mostly in vegetables and, to a lesser degree, in red meats and poultry.

Recently aquaculture production has expanded rapidly in Africa, but it is essentially Egypt that has accounted for the expansion. In 1999 Egypt accounted for 80 percent of total African production, estimated at 284 thousand tonnes. Production in Egypt consisted of tilapia (46 percent), carp (33 percent) and mullet (19 percent). Conceivably, tilapia and carp could be sold in the rest of Africa, but this is not likely to happen for two reasons. Egypt depends on imports to keep up fish consumption and the average consumer is wealthier than most of the potential importers in the rest of Africa. Thus, future increases in aquaculture production of carp and tilapia are likely to enter the Egyptian market rather than being exported to other African markets. For Nigeria, the second largest aquaculture producer in Africa, the situation is similar.

Elsewhere in Africa aquaculture for local consumption is still small. The contribution to total fish supplies is less than 1 percent of apparent supply. Thus, even in the best of circumstances it will take at least a decade and probably longer before African aquaculture will have a significant impact on African fish supplies.

During the latter part of the projection period the supply situation might change somewhat in Africa as commercial aquaculture is likely to be introduced, initially mainly to supply export markets. Also, the purchasing power of the urban population could be large enough to absorb some of the production of local aquaculture entrepreneurs. African governments will have to put a number of remedial policies in place. These should include, but not be limited to, facilitating fish imports, stimulating aquaculture and the production of short-cycle terrestrial animals (in substitution for fish).

to European sea bass and sea bream. In 1991 some 3 800 tonnes of European sea bass came from culture, or just under 40 percent of the total supply. By 1999 aquaculturists produced more than 41 000 tonnes of the species, accounting for 85 percent of the total supply, and sea bass prices dropped. Similarly, the sheer volumes of cultured European sea bass, Channel catfish and Atlantic salmon that are now available have affected prices for these and other substitutable food sources.

7.3.2 Developments in demand for fishery products

Fish food products. Growth in food demand for fish will not be uniform, and there will be significant differences between regions and countries. As discussed in Chapters 2 and 3, per capita consumption of meat could by 2030 reach 37 and 89 kg per person in the developing and developed countries respectively. Delgado *et al*. (1999) suggest that this increase in meat consumption is expected to occur in parallel with a small decline in the real world market prices of both meat and grains. If these projections prove correct, fish consumption could still increase in developing countries where meat is not a common substitute for fish. Although consumption of poultry and pig meat is expected to continue to increase in the developed countries, this is unlikely to have a major effect on trends in fish consumption in these countries, where demand for fish is more influenced by variety and health considerations than for reasons of economy.

The world average per capita fish consumption grew from 9.4 kg in 1961/63 to 16.3 kg in 1999, or by over 70 percent. A study for FAO (Ye, 1999),

taking into account per capita income growth and trend factors, estimates that per capita fish consumption could reach 22.5 kg by 2030, an increase of almost 40 percent over 1999 consumption. Total world demand would then reach 186 million tonnes in 2030, or almost 90 million tonnes more than in 1999. However, the plausible developments in capture fisheries and aquaculture discussed above may limit the growth in fish supply. In view of this, total demand is more likely to lie in the range of 150-160 million tonnes by 2030, or between 19 and 20 kg per capita.

Ye (1999) suggests that per capita consumption in North America, Europe and Oceania will increase rapidly until 2015. Consumption will continue to increase thereafter, but at a slightly slower rate, reaching between 30 and 35 kg per capita in 2030.[9] However, in terms of total consumption, this increase is relatively small because populations in these regions are expected to grow only marginally. In Japan, the market is considered to be saturated, and it is likely that the total volume of fish consumption will decline slightly.

The picture in Asia is mixed. The 1999 average per capita consumption in the region was 17.4 kg. China's per capita consumption was much higher (25.6 kg). Demand is expected to continue to increase so that per capita demand in some countries in this region could reach about 40 kg by 2030. China's very rapid growth in per capita fish consumption will continue, as elsewhere in Asia, although this rate will begin to slow down over the next 30 years.

Since South Americans are large consumers of red meats, and are likely to remain so, per capita fish consumption is relatively low (9.6 kg in 1999), especially compared with North and Central America where per capita consumption is in the order of 16.5 kg. Furthermore, although per capita consumption in South America could grow slowly over the next 30 years, it is not likely to exceed 15 kg by 2030.

Demand for fish for animal feeding purposes. Small pelagic species and macro-algae have traditionally been used for animal feeding purposes and also as fertilizers. The use of fish and algae as fertilizer has almost ceased but vast quantities of small pelagic species and small volumes of fish offal are still regularly converted into fishmeal and oil, the bulk of

Box 7.4 Krill as a source of human food and animal feed

Krill is a large group of zooplankton found in all oceans, with the Antarctic stocks being the best known. Krill is the major source of food for large whales in southern oceans. It is estimated that the annual volume of these stocks is in the order of 300 to 400 million tonnes – four to five times the total present marine harvest of capture fisheries. Krill has been moderately harvested in the past, reaching a peak catch in 1982 (approximately 500 thousand tonnes). Annual catches dropped to about 100 thousand tonnes at the end of the 1990s.

Krill are small crustacean organisms dispersed in the water column. At present they can be captured only with fishing methods that filter water. To date, pelagic trawls with small meshes in the body of the trawl have been the most successful technology. Further improvement of krill capture technology is possible. Most likely this will involve increasing the volume of water filtered by the gear through use of stronger and thinner twine. Also the use of multiple trawls will increase efficiency. Development of technology permitting the easy spotting of the densest concentrations of krill would be a major advance in krill capturing.

Krill can be used for human food, as animal feed, and as a source of medical products. Such products have been developed and proven to have a market. In order to ensure quality, most processing of krill is done on board the fishing vessels. In the industry it is expected that more krill-based products will be developed, which is likely to spur future demand.

Japan, Poland and Ukraine have been the most active countries in exploiting Antarctic krill, and it is likely that they will continue this fishery. It is probable that international companies will also take an increased interest in this resource, and contribute to expansion. If catching efficiency improves significantly, krill resources in other oceans may also be exploited.

[9] The preliminary long-term projections based on FAO Food Balance Sheets (FAO, 2002b) suggest similar results, with the rate of increase in per capita consumption declining and per capita consumption in North America, Europe and Oceania reaching between 24 and 33 kg by 2030.

which is used as feed ingredient. Fish used as raw material in the manufacture of fishmeal accounted in 2000 for about a quarter of total fish production (30 out of 130 million tonnes). As discussed in Chapters 3 and 5, livestock production will continue to increase rapidly over the period to 2030, and with it demand for animal feeds, hence also for fishmeal and fish oil. To this should be added a growing demand for both fishmeal and oil used in feeds for intensive aquaculture systems.

Thus far, except for small volumes of offal, all raw material for fishmeal and oil has been supplied by capture fisheries. In all likelihood this will continue to be the situation over the projection period. However, the competition for pelagic fish, a limited and highly fluctuating resource, will become more intense, and it is unlikely that the fishmeal industry will have the economic means to continue to purchase the 30 million tonnes of fish p.a. for reduction. The industry will need to find other raw materials, the most plausible of which could be zooplankton or krill (see Box 7.4). Finally, the onboard processing of unavoidable bycatch and offal into fishmeal may expand.

Demand for fisheries in leisure activities. Recreational and sports fishers are becoming more numerous than commercial fishers in North America, northern Europe and Oceania, and the number of leisure fishers will continue to grow around the world. These stakeholders will increasingly obtain guaranteed access to particular stocks and fishing grounds, sometimes regulated by managing fisheries agencies and sometimes by purchasing access rights from commercial fishers. Their impact will be felt in both freshwater and marine fisheries. Indeed by 2030 the economic importance of recreational and sports fisheries could easily be greater than that of commercial fisheries for several species and waterbodies. This is a plausible scenario not only for developed countries, but also for "big game fishing" and similar activities occurring in tropical areas and on high seas. If access is reallocated in particular fisheries there will be an impact on revenues of the commercial fishing industry, even if the volumes captured in leisure fisheries are likely to remain comparatively small.

There is also a growing demand for "non-consumptive use" of living aquatic resources in developed countries. This demand for access to pristine and exotic resources has found indirect support in a number of United Nations conventions and agreements. The influence of non-consumptive user groups has also increased in less developed countries. It seems likely that demand for non-consumptive uses will continue to grow gradually. However, this is not expected to result in any significant reduction of commercial capture fisheries, particularly in developing countries, unless switching to such activities creates alternative livelihood opportunities that address local food security issues.

7.3.3 Developments in fishery trade.

In coming decades, the world's trading system is likely to be further liberalized under WTO auspices. Trade barriers for fisheries products will eventually be lowered or even dismantled. In anticipation of these developments, fish processors are investing in low-cost countries (e.g. China and the Baltic States) to take advantage of cost differences. Regional specialization in fish production means that some fish-processing industries will probably remain in industrialized countries, even if they have to rely on buying raw material from distant suppliers.

The expansion of international markets can be considered as useful but also problematic. For many communities, especially in developing countries, fish play a very important role in food security and constitute an important part of the diet. However, if fish producers or processors take advantage of access to distant markets for their fish in order to receive a higher net income, the local availability of fish may be reduced (see Box 7.4). Thus, increased trade can provide a mechanism for economic development, but local communities also need to change to accommodate it.

Carp production in China and India is very important but is not expected to expand greatly beyond existing markets in Asia, largely because the demand is limited by regional consumer preferences. In Africa and Latin America the situation is somewhat different in the sense that aquaculture constitutes a very small share of local fish supplies. In these regions abrupt increases of aquaculture fish production for local markets are not impossible, but at present seem unlikely. Thus, if a sudden increase in aquaculture production were to take place, it would most likely be directed at

Box 7.5 International agreements

The Code of Conduct for Responsible Fisheries (CCRF) was developed to address the management of all aspects of capture fisheries and aquaculture, fish processing and trade, including environmental issues and fishing on the high seas. The 1993 FAO Compliance Agreement (the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas), which addresses fishing on the high seas, is an integral part of the CCRF.

The application of the precautionary approach is a fundamental concept in the CCRF. It requires cautious aquatic resource management when information is uncertain, unreliable or inadequate, and should lead to reduced risks to the ecosystem. The precautionary approach has been enshrined in several other international initiatives, including the UN Convention on Biological Diversity and the UN Fish Stocks Agreement (i.e. the Agreement for the Implementation of the Provisions of the United Nations Convention of the Law of the Sea of 10 December 1982, relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks).

foreign markets. The direct effect on supplies in local markets would likely be small, with little competitive impact on local capture fisheries producing for local consumption.

7.3.4 Developments in fishery management

The management issues that are receiving increasing attention in the fisheries sector fall under the headings of maintenance of biodiversity, ecologically sustainable development and, more recently, ecosystem management. These are important considerations for many stakeholders, all of whom are increasingly vocal about what constitutes appropriate practices and acceptable uses of aquatic living resources.

However, there is a largely unaddressed, yet fundamental issue underlying these concerns. It is that in spite of their intrinsic renewable nature, capture fisheries resources are essentially finite. And, as finite resources, they can only be exploited so much in a given period, beyond which overexploitation will cause them to produce less in the longer term, if not entirely collapse. This simple fact means that total wild capture fisheries production cannot increase infinitely, that these exhaustible resources have to be treated with care, and that what is produced must be shared among those engaged in harvesting. The latter can either be done on an ad hoc free-for-all basis which probably is ultimately unsustainable, through administrative processes, or through the use of rights-based management systems.[10]

The single most important development for the future of wild capture production is how best to contain total catches at sustainable levels while allocating catches. To date, with only few exceptions, the matter of allocating resources among producers and other stakeholders has been addressed only indirectly, and not very successfully.

To achieve sustainable and equitable use, most fisheries stakeholders and administrators will eventually have to recognize the power of using instruments that create and enhance incentives, rather than administrative decisions. Fisheries management strategies based on explicit and well-defined access rights will have to become more common, or otherwise management entities will be overwhelmed by allocation conflicts. To facilitate decision-making, management responsibilities will need to be devolved to fishing interests and communities, with increased participation by stakeholder groups. As part of this, frameworks that control access to capture fisheries need to be strengthened, and created where they do not exist. This will not be a matter only for local or artisanal fisheries – the governance of high seas fisheries will also need to be more explicitly regulated.

In developing countries, the need to design management strategies that can cope with exit and entry issues in small-scale and artisanal fisheries will become more pressing. Although some countries

[10] The development of rights-based management systems to create and enhance incentives for sustainability does not equate to or preclude existing cultural, social and traditional arrangements in fishing communities. In fact, if well designed, rights-based management systems will reinforce and strengthen community arrangements while also strengthening rights for exploiting fisheries resources.

Box 7.6 Resource sharing

The sustainable harvest of natural resources in high demand is generally possible only if those resources are subject to explicit and well-defined property rights or rigorous administrative processes to regulate and enforce harvest levels. By contrast, wild fish stocks are often characterized by weak property rights, inadequate management regulations and ineffective enforcement. This situation has made it possible to exploit capture fish stocks beyond sustainable levels. In some instances, particularly for slow-growing demersal species, stocks have been reduced so seriously that the commercial fisheries activities causing the decline cease for lack of fish to catch.

Rights-based management systems create positive incentives for the rights holders and clarify their responsibilities. However, the allocation of rights where they have not explicitly existed before is a complicated matter. Most living aquatic resources are hidden from our view, fluctuate in their abundance, span jurisdictional boundaries and can occur jointly. One consequence of these characteristics is that creating or setting up rights systems can be extremely contentious, complex and expensive. This is particularly true in situations where policies have led to excess fishing capacity and overfishing and where the introduction of rights-based management includes concurrent reductions in fishing capacity (e.g. vessel buyout programmes and redeployment programmes for fishers). Finally, the initial enforcement of newly created rights can be difficult. The result is that rights-based management systems are not being rapidly adopted and implemented. Progress is slow, and excess fishing capacity continues to exist in many fisheries. The problem is severe and occurs in most parts of the world, including developing countries.

Because fisheries resources are becoming increasingly scarce, conflicts over the allocation and sharing of these resources are becoming more frequent. Most conflicts over fisheries resources arise when the resource is (or is perceived to be) so scarce that sharing it becomes difficult. When rights are well defined, understood and observed, allocation conflicts tend to be minimized. However, when rights to the use of a stock are not well defined, understood or upheld, divergent assumptions about what rights users may have often result in conflicts over scarce fisheries resources. Conflicts can be minimized by clarifying roles, responsibilities and the general management of a fishery, by following risk-based decision-making strategies and using conflict mitigation processes.

(for example, the Philippines and Sri Lanka) are working to confront this problem, the vast majority of countries are still struggling with how to do so. Not being able to cope with issues of mass entry and exit could have severe implications for the food security of the people involved. Eventually, it will become politically and socially imperative that alternative social safety nets are developed so that fisheries are not the sector of last resort.

Sustainability issues are also important in aquaculture. The early experience with modern semi-intensive and intensive methods showed that access to and use of water, seed, feed, etc. was perhaps not as low cost as initially envisioned. During the 1990s aquaculturists had to accept that access to sites on land and in water and feeding practices became increasingly regulated to reduce the negative externalities of some aquaculture technologies (e.g. intensive pond or cage culture). In many regions restrictions on species transfers, site selection and feed use have become quite severe, and this has increased production costs. Where profit margins are large, some of these regulatory changes have altered, but not eliminated, aquaculture production. However, in many developing countries the application of such regulatory concerns is difficult. There is little incentive to comply unless the consumers demand it and are prepared to pay a higher price for fish products. In addition, the very limited government budgets and the large number of aquaculture producers make compliance difficult to verify and enforce.

7.4 Concluding remarks

The preceding sections discussed many problems related to the fisheries sector, including how to increase productivity; how to maintain capture fisheries at sustainable levels; how to rebuild overexploited stocks; how to ensure adequate feed supplies to aquaculture; how to deal with aquaculture-induced environmental problems; how to guarantee user rights to various groups with inter-

ests in inland and marine fisheries; and how to strengthen the role of fisheries as a source of employment and foreign exchange earnings.

Views on what would be the appropriate policy responses to such problems differ considerably among the various stakeholder groups and jurisdictions (be they local, national, regional or global) and this makes it difficult to reach agreements on how to solve common concerns in fisheries. Moreover, the global picture is oversimplified as it masks the many possible local or regional specific situations and characteristics.

The most likely scenario to 2030 is that the management of and production from wild capture fisheries will continue much as it is today, and that aquaculture production will continue to grow. Fish will remain an important source of food and employment. The ongoing development and expansion of aquaculture and mariculture will likely continue to be the main source of increased fisheries production. Wild capture fisheries will also certainly remain an important source of food, but will be subject to production constraints.

It remains to be seen whether fisheries-related activities will be managed so as to allow expression of the full productive, economic and social potential that both aquaculture and wild capture fisheries have to offer. There are signs that the management of fisheries can address allocation and sharing issues. But to do so, some major policy and management challenges must be met. Adequate administrative processes and fisheries management capabilities must be developed to cope with issues of allocation of finite resources, in the absence of fully defined and explicit property rights in both the wild capture and aquaculture arenas. Perverse incentives must be removed, and incentive-enhancing management strategies must be created at local, national and international levels. And environmental, cultural and socio-economic concerns related to fisheries must be adequately addressed.