THE STATE OF WORLD FISHERIES AND AQUACULTURE

2004

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2004

FAO Fisheries Department

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FOREWORD

The State of World Fisheries and Aquaculture has changed its appearance – and we in the FAO Fisheries Department hope you agree that it is a change for the better. However, the way we present our view of the state of world fisheries and aquaculture remains almost unchanged. As in previous issues, the report begins by providing an overview of developments in world fisheries and aquaculture, followed by a review of issues confronting fishers and fish farmers, and a presentation of seven in-depth studies undertaken by FAO. The report concludes with some thoughts on the future of fisheries and aquaculture, from both short-term and longer-term perspectives.

Developments during the past two years confirm the trends already observed at the end of the 1990s: capture fisheries production is stagnating, aquaculture output is expanding and there are growing concerns with regard to the livelihoods of fishers and the sustainability of commercial catches and the aquatic ecosystems from which they are extracted. *The State of World Fisheries and Aquaculture 2004* reports on several of these issues.

It is not only fishers and fish farmers who have these concerns; they are increasingly shared by civil society at large. Moreover, the importance of international trade in fish and fish products, combined with the trend for major fishing and trading companies to operate on a multinational basis, means that such issues are becoming global in nature – affecting a growing number of countries, be they large fish producers or large consumers of fish. It is heartening to note that governments and other stakeholders have begun to collaborate with their neighbours and partners in trade in an effort to find shared solutions.

Concrete examples of positive outcomes of this "globalization of concerns" are the establishment of new regional fishery management organizations and the strengthening of existing ones. It is probable that ongoing discussions among intergovernmental organizations on topics such as trade in endangered aquatic species, the use of subsidies in the fishing industry, and labour standards in fisheries will also result in agreements of overall benefit to world society.

Given the nature and tone of the international discussion on fishery issues and the developments observed during recent years, I believe that fishers and fish farmers, in collaboration with governments and other stakeholders, will overcome the obstacles they face currently and will succeed in ensuring sustainable fisheries and continued supplies of food fish at least at their present levels.

Ichiro Nomura
Assistant Director-General
FAO Fisheries Department

CONTENTS

PART 3
HIGHLIGHTS OF SPECIAL FAO STUDIES

PART 4
OUTLOOK

TABLES

FIGURES

BOXES

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The preparation of Part 1, World review of fisheries and aquaculture, was the overall editorial responsibility of R. Grainger assisted by Z. Shehadeh (consultant), who coordinated the contributions made by L. Garibaldi (production, capture fisheries), A. Lowther (aquaculture production), J. Csirke (marine resources), A. Crispoldi (fishers and fishing fleets), A. Smith and K. Kelleher (consultant) (fishing fleets), D. Doulman (regional fisheries governance), N. Hishamunda (aquaculture governance), R. Subasinghe and N. Hishamunda (aquaculture), D.M. Bartley (inland fisheries), S. Vannuccini and G. Laurenti (consumption), S. Vannuccini (utilization and trade), and H. Josupeit (commodity trade). S. Montanaro, G. Laurenti, A. Lowther and S. Vannuccini prepared the figures and the tables.

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GLOSSARY

c&f
cost and freight

CBD
Convention on Biological Diversity

CBA
Capture-based aquaculture

CCFFP
Codex Committee on Fish and Fishery Products

c.i.f
cost, insurance, freight

CITES
Convention on International Trade in Endangered Species of Wild Fauna and Flora

COFI
Committee on Fisheries

CoP
Conference of the Parties

CPUE
catch per unit of effort

DEA
data envelopment analysis

DNA
deoxyribonucleic acid

EPA
Environmental Protection Agency (United States)

EU
European Union

FDA
Food and Drug Administration (United States)

FDM
Food Demand Model (FAO)

FFA
Forum Fisheries Agency

FIGIS
Fisheries Global Information System (FAO)

GDP
Gross domestic product

GRT
Gross registered tonnage

GT
Gross tonnage

HACCP
Hazard Analysis and Critical Control Point (system)

HIV
human immunodeficiency virus

IATTC
Inter-American Tropical Tuna Commission

ICCAT
International Commission for the Conservation of Atlantic Tunas

IFPRI
International Food Policy Research Institute

ILO
International Labour Organization

IMO
International Maritime Organization

IUU
Illegal, unreported and unregulated (fishing)

JECFA
Codex Joint Expert Committee on Food Additives

LIFDC
low-income food-deficit country

LMIS
Lloyd's Maritime Information Services

LOA
Length overall

NAFO
Northwest Atlantic Fisheries Organization

NDP
National development plan

OECD
Organisation for Economic Co-operation and Development

PCB
polychlorinated biphenyl

PRSP
Poverty reduction strategy paper

RFB
Regional fishery body

RFMO
Regional fisheries management organization

SADC
Southern African Development Community

SIDS
Small island developing states

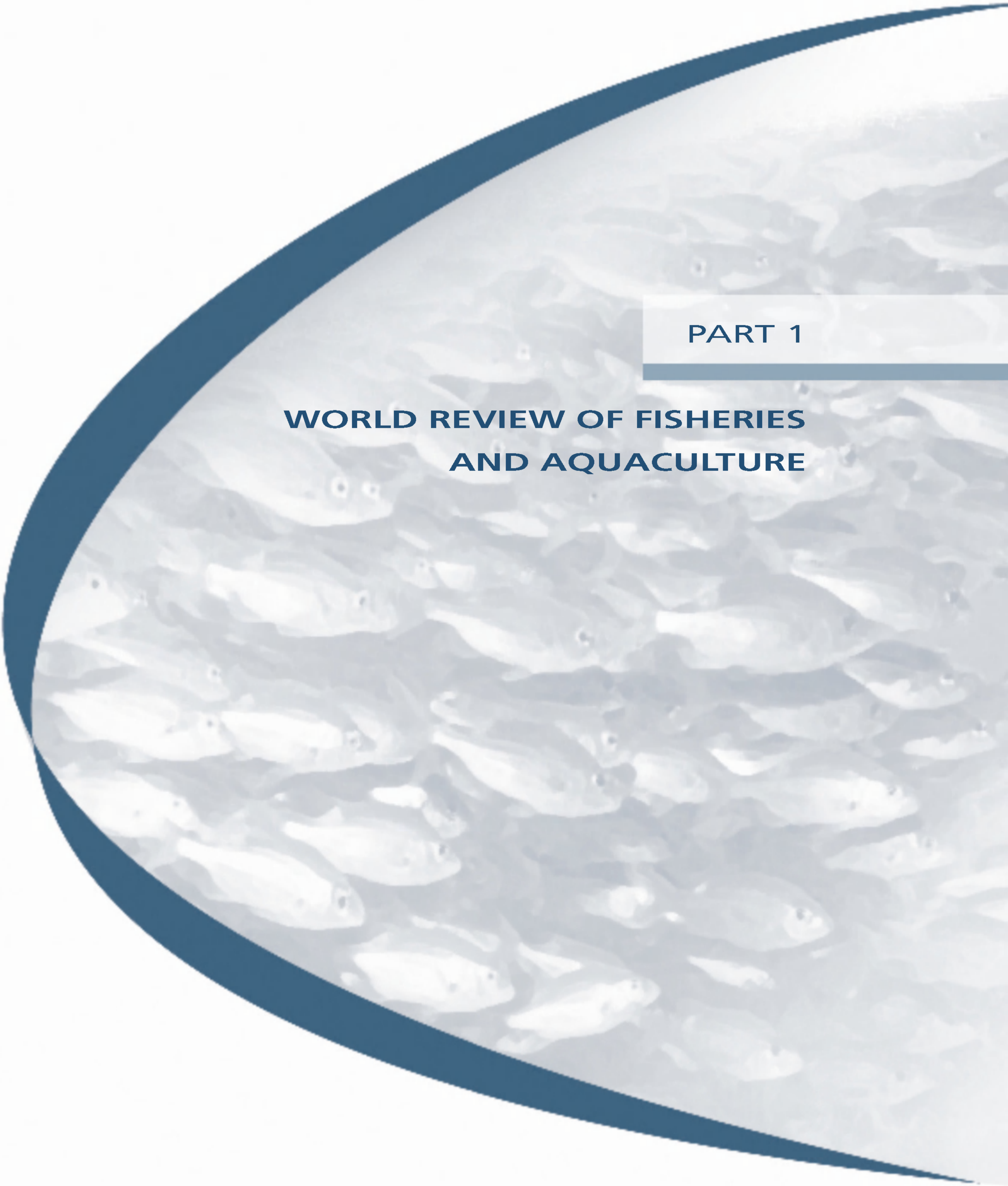
TAC
Total allowable catch

UN
United Nations

UNCED
United Nations Conference on Environment and Development

VPUE
Value per unit of effort

WTO
World Trade Organization



PART 1

WORLD REVIEW OF FISHERIES AND AQUACULTURE

WORLD REVIEW OF FISHERIES AND AQUACULTURE

Fisheries resources: trends in production, utilization and trade

OVERVIEW

Global production from capture fisheries and aquaculture supplied about 101 million tonnes of food fish in 2002, providing an apparent per capita supply of 16.2 kg (live weight equivalent), with aquaculture accounting for the growth in per capita supply since 2000 (Tables 1 and 2 and Figures 1 and 2). Outside China, the world's population has been increasing more quickly than the total food fish supply; as a result the average per capita fish supply outside China declined from 14.6 kg in 1987 to 13.2 kg in 1992 and has since remained stable (Figure 2). Overall, fish provided more than 2.6 billion people with at least 20 percent of their average per capita animal protein intake. The share of fish proteins in total world animal protein supplies grew from 14.9 percent in 1992 to a peak of 16.0 percent in 1996 and remained close to that level (15.9 percent) in 2001.

Preliminary estimates for 2003 based on reporting by some major fishing countries indicate that total world fishery production decreased slightly (–1 percent) compared with 2002. However, the total amount of fish available for human consumption increased to 103 million tonnes and, on average, the per capita supply was maintained. The decrease in capture fisheries resulting from the contraction of reduction fisheries in some major fishmeal-producing countries was partly compensated for by increases in other food fisheries and aquaculture.

Table 1
World fisheries production and utilization

	1998	1999	2000	2001	2002	2003[1]
			(million tonnes)			
PRODUCTION						
INLAND						
Capture	8.1	8.5	8.7	8.7	8.7	9.0
Aquaculture	18.5	20.2	21.3	22.5	23.9	25.2
Total inland	**26.6**	**28.7**	**30.0**	**31.2**	**32.6**	**34.2**
MARINE						
Capture	79.6	85.2	86.8	84.2	84.5	81.3
Aquaculture	12.0	13.3	14.2	15.2	15.9	16.7
Total marine	**91.6**	**98.5**	**101.0**	**99.4**	**100.4**	**98.0**
TOTAL CAPTURE	87.7	93.8	95.5	92.9	93.2	90.3
TOTAL AQUACULTURE	30.6	33.4	35.5	37.8	39.8	41.9
TOTAL WORLD FISHERIES	**118.2**	**127.2**	**131.0**	**130.7**	**133.0**	**132.2**
UTILIZATION						
Human consumption	93.6	95.4	96.8	99.5	100.7	103.0
Non-food uses	24.6	31.8	34.2	31.1	32.2	29.2
Population *(billions)*	5.9	6.0	6.1	6.1	6.2	6.3
Per capita food fish supply *(kg)*	15.8	15.9	15.9	16.2	16.2	16.3

Note: Excluding aquatic plants.
[1] Preliminary estimate.

China remains by far the largest producer, with reported fisheries production of 44.3 million tonnes in 2002 (16.6 and 27.7 million tonnes from capture fisheries and aquaculture, respectively), providing an estimated domestic food supply of 27.7 kg per capita as well as production for export and non-food purposes. However, there are continued indications that capture fisheries and aquaculture production statistics for China may be too high, as indicated in *The State of World Fisheries and*

Table 2

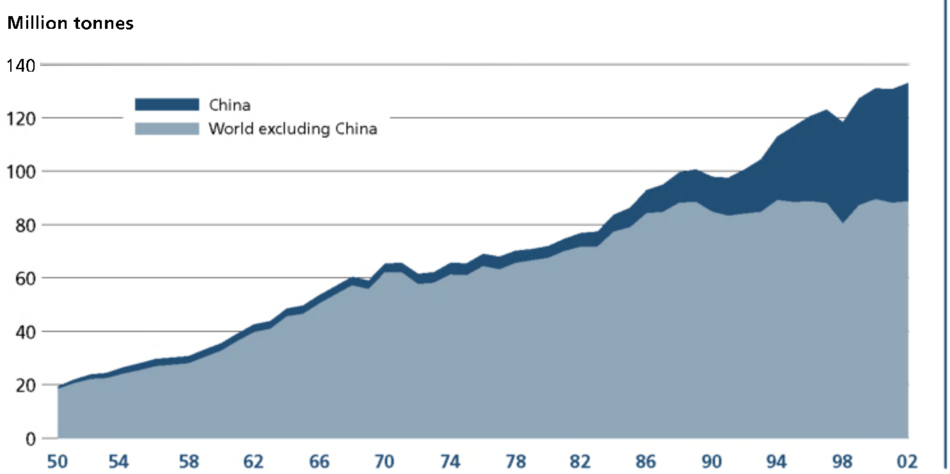
Fisheries production and utilization: world excluding China

	1998	1999	2000	2001	2002	2003[1]
		(million tonnes)				
PRODUCTION						
INLAND						
Capture	5.8	6.2	6.5	6.5	6.5	6.5
Aquaculture	5.3	6.0	6.1	6.6	6.9	7.5
Total inland	**11.1**	**12.2**	**12.6**	**13.1**	**13.4**	**14.0**
MARINE						
Capture	64.7	70.3	72.0	69.8	70.1	67.0
Aquaculture	4.4	4.7	4.8	5.1	5.1	5.5
Total marine	**69.1**	**75.0**	**76.8**	**74.9**	**75.2**	**72.5**
Total capture	70.4	76.5	78.5	76.3	76.6	73.5
Total aquaculture	9.8	10.7	10.9	11.7	12.0	13.0
Total fisheries production	**80.2**	**87.2**	**89.4**	**88.1**	**88.7**	**86.5**
UTILIZATION						
Human consumption	62.3	62.9	63.7	65.6	65.5	66.8
Non-food uses	17.9	24.3	25.7	22.5	23.2	19.7
Population *(billions)*	4.7	4.7	4.8	4.9	5.0	5.0
Per capita food fish supply *(kg)*	13.3	13.2	13.2	13.4	13.2	13.3

Note: Excluding aquatic plants.
[1] Preliminary estimate.

Figure 1

World capture and aquaculture production



Aquaculture 2002,[1] and that this problem has existed since the early 1990s. Because of the importance of China and the uncertainty about its production statistics, China, as in previous issues of this report, is generally discussed separately from the rest of the world.

Global landings from capture fisheries (Figure 3) remained relatively stable in the four years 1999–2002. World capture fisheries production in 2002 was 93.2 million tonnes (84.5 million tonnes marine and 8.7 million tonnes inland), slightly above production in 2001. After increasing from about 79 million tonnes in 1998 to 87 million tonnes in 2000, the world marine capture fisheries production decreased to about 84 million tonnes in 2001 and remained at that level in 2002. Inland capture fisheries production fluctuated slightly around 8.7 million tonnes during 2000–02.

There are considerable variations in marine catches among regions. Between 2000 and 2002, catches decreased in the Northwest and Southeast Pacific, and in the Eastern Central and Southwest Atlantic, but were still growing in the tropical regions

Figure 2

World fish utilization and supply, excluding China

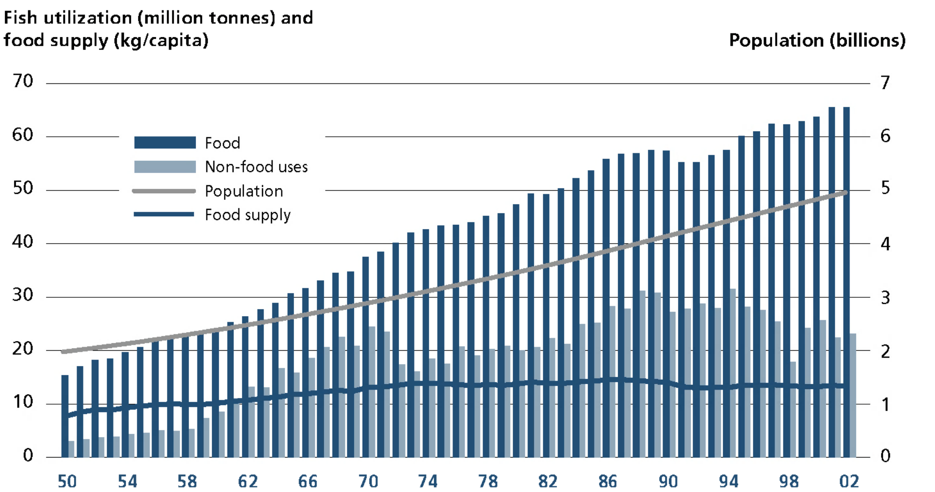
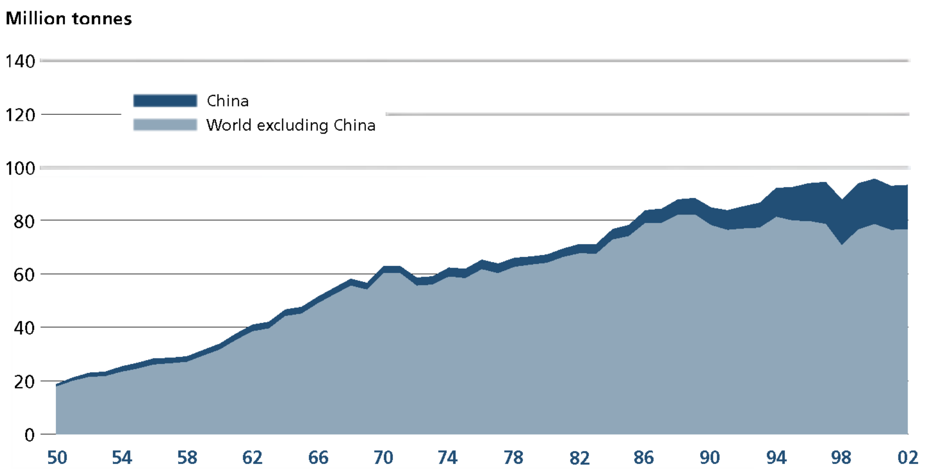


Figure 3

World capture fisheries production



[1] FAO. *The State of World Fisheries and Aquaculture 2002*. Rome, Box 2, p. 9.

of the Indian and Pacific Oceans. Catches in the temperate Northeast Atlantic and Mediterranean did not show significant variations, while in the Northwest Atlantic and in the Northeast Pacific, total catches increased in 2001 and remained stable in 2002. There has been a consistent downward trend since 1974 in the proportion of stocks offering potential for expansion, coupled with an increase in the proportion of overexploited and depleted stocks, from about 10 percent in the mid-1970s to close to 25 percent in the early 2000s (see Figure 19, p. 32). The percentage of stocks exploited at or beyond their maximum sustainable levels varied widely among fishing regions. Information available continues to confirm that, despite local differences, the global potential for marine capture fisheries has been reached, and more rigorous plans are needed to rebuild depleted stocks and prevent the decline of those being exploited at or close to their maximum potential.

By contrast, global production from aquaculture continues to grow, in terms of both quantity and its relative contribution to the world's supply of fish for direct human consumption. Production in 2002 (51.4 million tonnes,[2] with China accounting for 71 percent) was 6.1 percent higher than in 2000. The aquaculture sector, excluding China, contributed 12 million tonnes to food fish supplies[3] in 2002, compared with 53 million tonnes from capture fisheries (China produced 28 million tonnes from aquaculture and 7 million tonnes from capture fisheries). Aquaculture production of food fish continues to be mainly (57.7 percent) from freshwater. Developing countries accounted for 90.7 percent of production in 2002, consisting of predominantly herbivorous/omnivorous or filter-feeding species. All continents showed increases in production during 2000–02 with the exception of Europe, where production remained relatively unchanged. Growth in production of the major species groups continues to be rapid, although, with the exception of crustaceans, there were signs of a slowdown during 2000–02. The shift to sustainable culture practices and development strategies remains a work in progress and a key objective; some countries (mainly developed countries) have achieved significant advances in this respect, but in many others much still remains to be done.

In 2002, about 76 percent (100.7 million tonnes) of estimated world fisheries production was used for direct human consumption. The remaining 24 percent (32.2 million tonnes) was destined for non-food products, mainly the manufacture of fishmeal and oil, slightly (0.4 percent) above levels in 1999 but 5.8 percent below levels in 2000.

Total world trade of fish and fishery products increased to US$58.2 billion (export value) in 2002, up 5 percent relative to 2000 and showing a 45 percent increase since 1992. In terms of quantity, exports were reported to be 50 million tonnes in 2002,[4] a slight decrease (1 percent) from the 2000 level. The quantity of fish traded has been stagnant in the last few years following decades of strong increases, and it is unlikely that the increasing trends of pre-2000 years will be repeated in the short term.

The number of individuals earning an income from primary sector employment in fisheries and aquaculture in 2002 reached about 38 million (see Table 7, p. 22), a marginal increase over 2001. Of these, more than one-third were employed full-time and the rest were part-time and occasional workers. Together, this workforce represented 2.8 percent of the 1.33 billion people who were economically active in agriculture worldwide, compared with 2.3 percent in 1990. The highest numbers of fishers and aquaculture workers (85 percent worldwide) are in Asia, with China accounting for nearly one-third of the world total. The share of employment in capture fisheries is stagnating in the most important fishing nations and increased opportunities are being provided by aquaculture. Since 2000, however, in some developed countries, employment in aquaculture has started to level off, in parallel with the observed slowdown in the growth of production for some species.

The vast majority of the world fishing fleet is concentrated in Asia (about 85 percent of total decked vessels, 50 percent of powered undecked vessels and 83 percent of

[2] Includes aquatic plants.

[3] Finfish and shellfish products on a whole, live weight basis.

[4] Live weight equivalent.

total non-powered boats). In 2002, the number of large vessels increased to 24 406, but growth has halted as many nations have adopted capacity containment programmes. Records show that in 2002 about 13 percent of these large vessels were less than ten years old, and 28 percent were above 30 years of age (compared with 30 and 6 percent, respectively, in 1992). Indications are that the fleet size of some major fishing nations has continued to decrease.

A clear shift in the role of regional fishery bodies (RFBs) has occurred since the adoption of key international fisheries instruments following the 1992 United Nations Conference on Environment and Development (UNCED). Many RFBs have reviewed or amended their respective agreements or conventions in response to their strengthened post-UNCED role in conservation and management. Generally, they are taking innovative and cooperative action to implement international fisheries instruments, many of these in an effort to rebuild depleted stocks, prevent further decline and to combat illegal, unreported and unregulated (IUU) fishing. RFBs are constrained by the unwillingness of Member States to delegate sufficient decision-making power and responsibilities to the RFBs, and their reluctance to implement decisions taken by the RFBs. The movement of RFBs towards becoming bodies with fishery management functions is placing greater demands on their decision-making capacity.

CAPTURE FISHERIES PRODUCTION

Total capture fisheries production

In 2002, total capture fisheries production amounted to 93.2 million tonnes, slightly (0.3 million tonnes) above production in 2001 (Table 1). The first sale value of this catch amounted to around US$78 billion, representing a 1.6 percent decline compared with the value in 2000, partly caused by a decrease of catch and a decline of the unit value of landings for food consumption. Within the total value, reduction fisheries accounted for nearly US$3 billion. Global catches (Figure 3) remained stable during the last four years for which complete statistics are available (1999–2002), with the exception of 2000 when annual catches exceeded by over 2 million tonnes the level of preceding and subsequent years, a consequence of the remarkable increase in the environmentally driven recovery of stocks of Peruvian anchoveta. Preliminary estimates indicate that global marine catches decreased in 2003 by about 3 million tonnes compared with 2002. This decrease roughly corresponds to the drop in catches of Peruvian anchoveta and other reduction species in the Southeast Pacific.

The top ten capture fishery producing countries have not changed since 1992. In 2002, their cumulative catches represented 60 percent of the world total, with China and Peru still leading the ranking in both 2001 and 2002 (Figure 4). Capture production reported by China has remained fairly stable since 1998 (Figure 3), while trends in Peruvian total capture production are always strongly influenced by variations in anchoveta catches.

World marine capture fisheries production

Marine capture fisheries production in 2002 was 84.5 million tonnes, representing a decline of 2.6 percent with respect to 2000 and a minor increase of 0.4 percent in comparison with 2001 catches.

During the past decade, the reported landings of marine capture fisheries have fluctuated between 80 and 86 million tonnes (average 1993–2003, 84 million tonnes), a slight increase over the preceding decade (average, 77 million tonnes). It should be noted that, between the two periods, the quantity of marine fish caught and discarded has fallen by several million tonnes (see the section on discards in marine capture fisheries on pp. 122–127). This came about, *inter alia*, through improved gear selectivity and fishing practices (that reduced bycatch), fisheries management that decreased access to some stocks (by reducing allowable catches and including the closure of some fisheries), no-discard policies in some countries (that forced landings of all catches) and growing demand for fish combined with improved technologies and opportunities for utilizing bycatch. Despite the uncertainty regarding the total decrease in discards and the proportion of that decrease resulting from improved fisheries management, increased demand and improved processing, respectively, there is no doubt that marine capture fisheries are moving towards a more appropriate use of wild fish stocks.

The Northwest and Southeast Pacific are still the most productive marine fishing areas (Figure 5), although total catches in these two areas decreased by 1.8 and 2.0 million tonnes in 2002 compared with 2000 levels. Catches also decreased substantially from 2000 levels in the Eastern Central and Southwest Atlantic. In the former area, catches had increased in 2001 but decreased by more than 0.5 million tonnes in 2002, largely as a result of reduced small pelagic and cephalopod catches. In the Southwest Atlantic, cephalopod catches have declined even more dramatically, from 1.2 million tonnes in 1999 to 0.54 million tonnes in 2002. By contrast, catches were still growing in fishing areas that mostly lie in the tropical regions of the Indian and Pacific Oceans, where catches of large (mainly tuna) and small pelagic species continued to increase. Among the main fishing areas in temperate waters, total catches in the Northeast Atlantic and Mediterranean did not show significant variations, while in the Northwest Atlantic and in the Northeast Pacific, total catches increased in 2001 and remained stable in 2002.

After the high catches of 2000 (the third highest ever at 11.3 million tonnes), anchoveta decreased to 7.2 million tonnes in 2001 and recovered to 9.7 million tonnes

Figure 4

Marine and inland capture fisheries: top ten producer countries in 2002

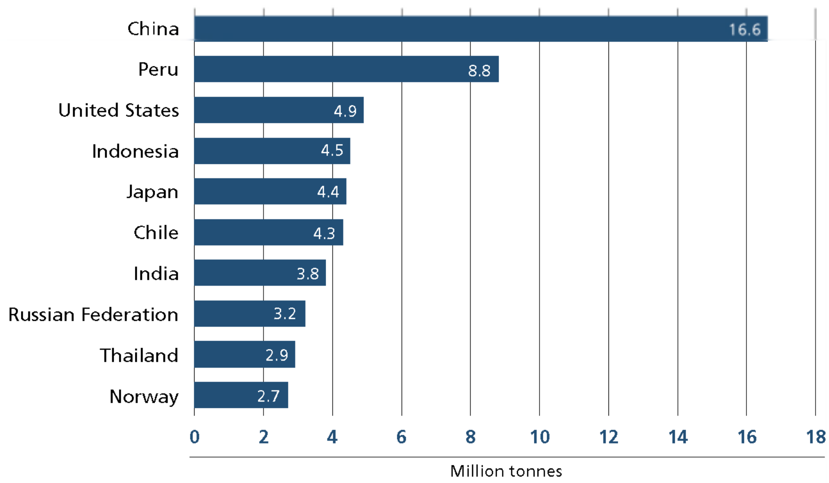
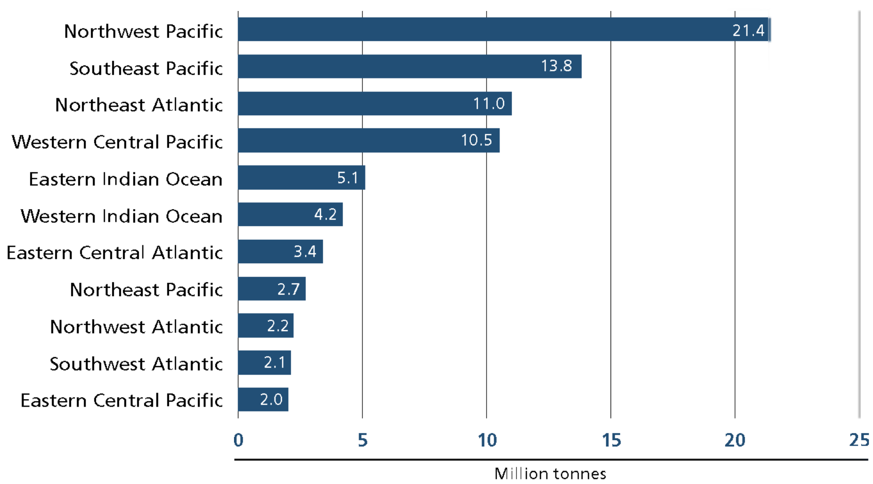


Figure 5

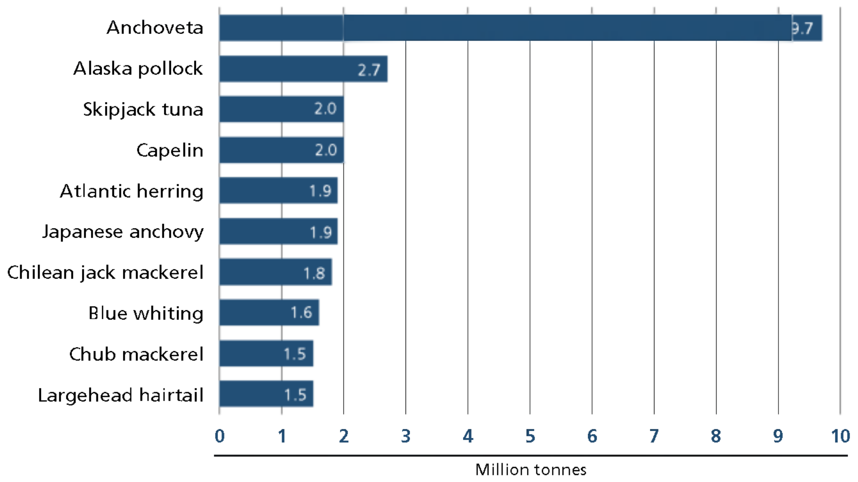
Capture fisheries production: principal marine fishing areas in 2002



Note: Fishing areas listed are those with a production quantity equal to or more than 2 million tonnes in 2002.

Figure 6

Marine capture fisheries production: top ten species in 2002



in 2002, ranking once again as the most caught marine species (Figure 6). Other major Clupeoid species (e.g. Atlantic herring, Japanese anchovy and European pilchard/ sardine) did not show a common catch trend in the latest years, as species belonging to this group are strongly influenced by the variability of local environmental conditions. Overall catches of the Gadiformes group of species (e.g. cods, hakes and haddocks) continued to decrease and by 2002 had reached their lowest levels since 1967. The value of these catches for food uses amounted to US$5.7 billion, representing 8 percent of the total value of landings for consumption. Alaska pollock and blue whiting, the two major species in terms of catches, but of low commercial value, also decreased in 2002 following a significant increase in 2001. After minor decreases in 2000 and 2001, total catches of tuna and tuna-like species exceeded 6 million tonnes for the first time in 2002, accounting for 11 percent of the total value of landings for consumption. Increased catches were also realized from tropical species such as skipjack (the third global species in 2002) and yellowfin tunas. Geographically, catches increased in the two central Pacific fishing areas and the Western Indian Ocean, while in the other fishing areas tuna catches were stable (e.g. the Eastern Indian Ocean) or decreasing (e.g. the Northwest and Southeast Pacific). Total catches of the three major small pelagic species (capelin, Chilean jack mackerel and chub mackerel) increased in 2001 by 33.2 percent in comparison with 2000 but decreased in 2002 by 13.5 percent from 2001 levels.

Catches of oceanic species occurring principally in high seas waters continued to increase (see Box 1).

Catches of the "sharks, rays, chimaeras" group have been stable since 1996 at about 0.8 million tonnes. However, a possible reduction of shark catches may be masked by the remarkable recent improvement in the species breakdown of reported catches (previously mostly combined under the generic item "Elasmobranchii" or even classified as "Marine fishes not identified") following the efforts of FAO and RFBs to improve shark statistics. In 1996, the FAO capture database included data for 45 species items in the shark group; this more than doubled to 95 species items in 2002 and now represents more than 7 percent of the total, at 1 347.

Total catch production of both marine crustaceans and molluscs declined slightly from their 2000 peak over the following two years. Production trends of cephalopods since the low catches recorded in 1998 have shown marked variation among the three major species: catches of the Eastern Pacific jumbo flying squid rose steeply (2002 catches were 15 times higher than those in 1998); catches of the Western Pacific Japanese flying squid grew markedly in 1999 and 2000 but have been decreasing since; and catches of the Argentine shortfin squid, which in 1999 had reached 1.1 million tonnes in the Southwest Pacific, dropped in the subsequent three years and by 2002 were half of the 1999 maximum.

Box 1

Catch and trade of oceanic species

Species items reported in the FAO capture production database were classified as oceanic, further subdivided into epipelagic and deep-water species, or living on the continental shelf.[1] A scrutiny of the new species included in the capture database in the latest three updates (2000–2002) showed that 35 more species items (mostly deep-water species) should have been added to those previously selected, reaching a total of 155 oceanic species. This considerable rise in reported deep-water species is probably a result of the growing awareness of deep-water fishing activities that has prompted flag states to improve their monitoring and reporting of deep-water catches, rather than a dramatic increase in deep-water fishing.

In 2002, the share of oceanic catches in global marine catches reached 11 percent. Catches of deep-water species decreased in 2002 after the highest catches ever in 2001, while catches of oceanic tuna decreased in 2000 and 2001 and reached a maximum in 2002 (Figure A). Catches of other epipelagic species, mainly oceanic squids, have been increasing steeply since a drop in 1998 and also reached a peak in 2002.

A significant proportion of the landings of oceanic species enters international marketing channels in various product forms. In 2002, exports of oceanic species accounted for 7 percent of the quantity and of 10 percent of the value of total exports of fish and fishery products. In recent decades, the marked increase in catches of oceanic species was paralleled by a growth in trade of oceanic species, which increased, in terms of live weight equivalent, from 0.6 million tonnes in 1976 to about 3.6 million tonnes in 2002, and in value terms from US$0.5 billion to US$5.9 billion over the same period (Figure B). Most of these exports consisted of tuna products, also a result of the inadequate identification of other oceanic species in international commodity classifications.

[1] For criteria adopted and further reading, see FAO. 2003. *Trends in oceanic captures and clustering of large marine ecosystems: two studies based on the FAO capture database*, by L. Garibaldi and L. Limongelli. FAO Fisheries Technical Paper No. 435. Rome (available at http://www.fao.org/DOCREP/005/Y4449E/y4449e03.htm; accessed September 2004).

Figure A

World catches of oceanic species (epipelagic and deep-water) occurring principally in high seas areas

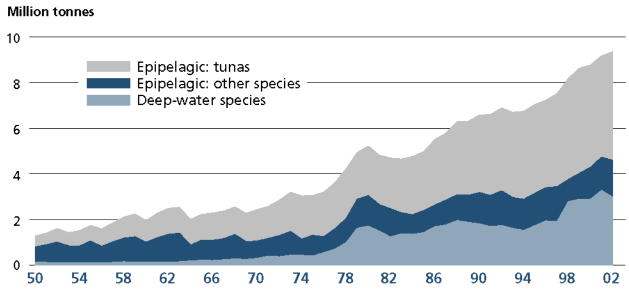
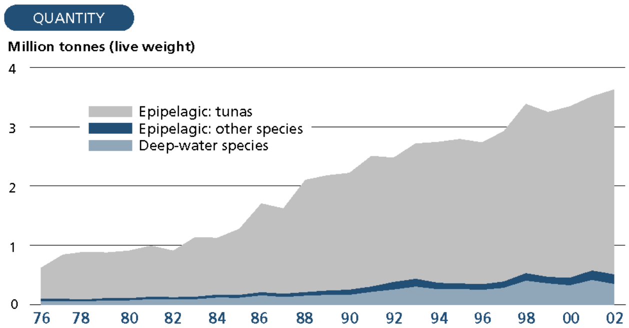
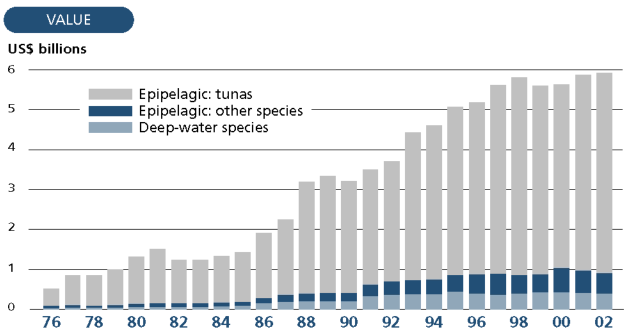


Figure B

World exports of oceanic species



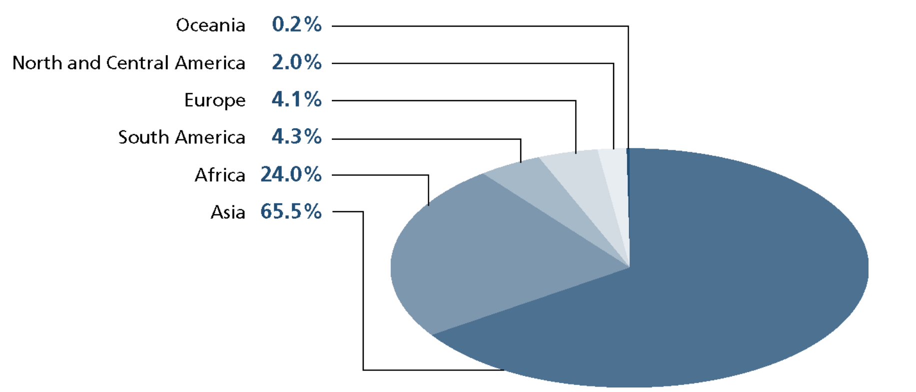


World inland capture fisheries production

Total catches from inland waters remained stable at around 8.7 million tonnes in the 2000–02 period. It should be noted, however, that reporting of global inland fisheries production continues to present problems owing to the lack of reliable information on catch quantities and species composition. In many countries, catches by rural communities, who are often the main users of the resource, are not reported in national statistics. Accordingly, the figures on total catch provided here should be considered indicative.

Figure 7

Inland capture fisheries by continent in 2002



Note: World inland capture fisheries production amounted to 8.7 million tonnes in 2002.

Figure 8

Inland capture fisheries: top ten producer countries in 2002

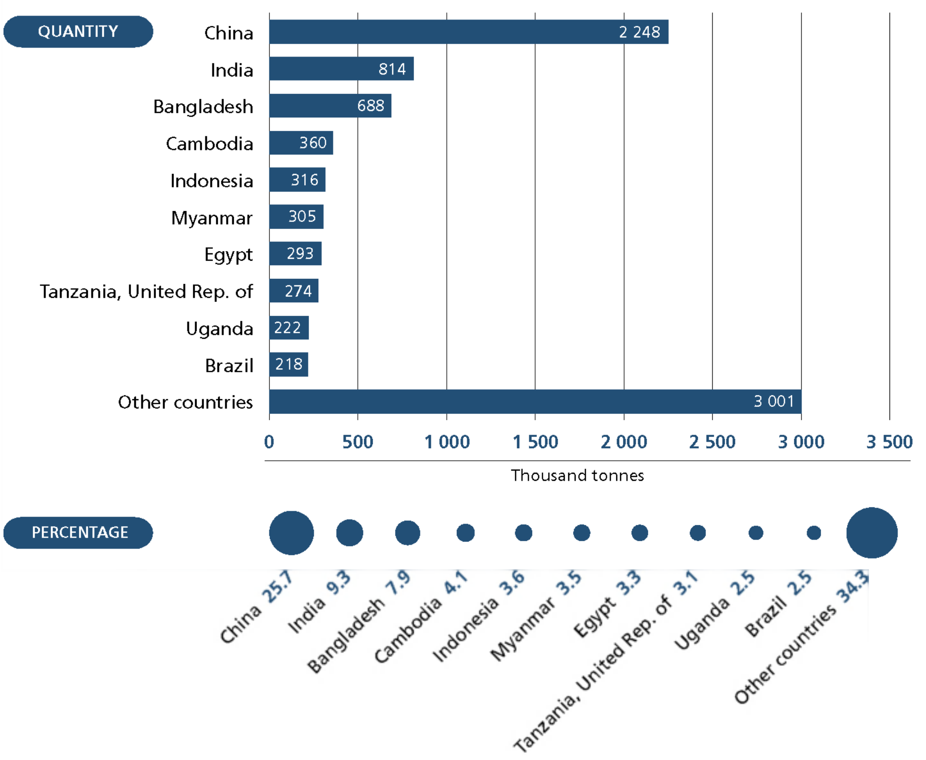
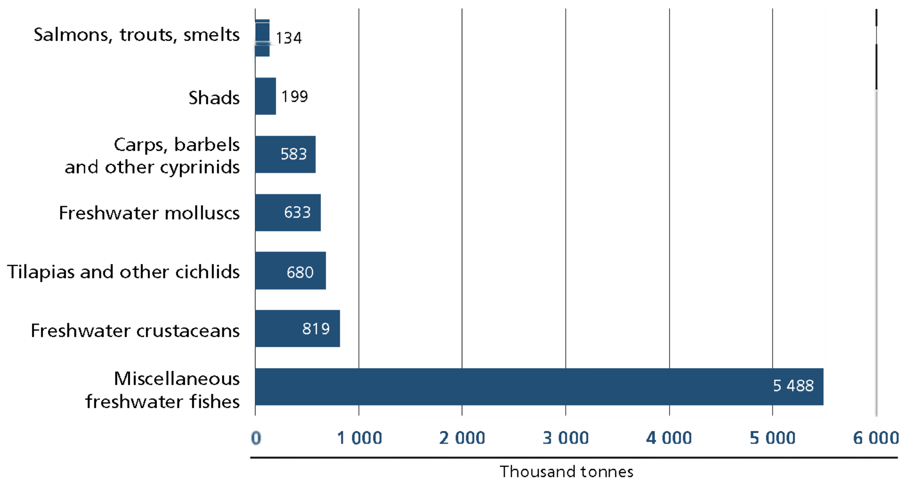


Figure 9

Inland capture fisheries: major species groups in 2002



Africa and Asia contributed about 90 percent of global inland capture production in 2002 (Figure 7). Compared with 2000, catches in 2002 have grown by about 0.6 percent in the Asia inland fishing area, 2 percent in Africa, and 9 percent in South America. Catches decreased in Europe (by 18 percent), North and Central America (by 9.8 percent) and Oceania (by 0.5 percent).

The principal ten producers accounted for about 66 percent of global production from inland capture fisheries in 2002 (Figure 8). China, the top producer, has reported stable inland catches since 1998 and still produces one-quarter of the global inland catches. The Russian Federation and Kenya, which ranked fifth and tenth respectively in 2000, dropped out of the top ten list in 2002 and were superseded by Myanmar and Brazil. The Russian Federation now ranks twelfth following a dramatic decrease in catch during the last two years.

The bulk of world production (68.1 percent) came from developing countries other than China and only 6.1 percent from developed countries, classified either as "Economies in transition" or as "Industrialized countries" (Table 3). The divergence between developed and developing countries in the importance of inland catches is further evidenced by the fact that, in 2002, not one developed country was among the top ten world producers (Figure 8).

Reporting of inland catch by species group remains very poor for many countries and does not permit detailed analysis of trends in catch composition given the unknown portion of catches that may have been reported at higher taxonomic levels or not identified at all. In 2002, about 50 percent of the global inland water catches were reported as "Freshwater fishes not elsewhere included" (Figure 9). China accounts for the great majority of reported world catches of freshwater crustaceans (94 percent)

Table 3
Inland capture fisheries production by economic class

Economic class	Production in 2002 *(million tonnes)*	Percentage of world production
China	2.25	25.7
Other developing countries or areas	5.95	68.1
Economies in transition	0.32	3.6
Industrialized countries	0.22	2.5
Total	**8.74**	

and molluscs (87 percent). Compared with 2000 levels, reported catches for 2002 of freshwater crustaceans were higher by about 44 percent, carps and other cyprinids by 3.7 percent and molluscs by 6 percent, while tilapia catches remained stable. Catches of the "shads" group were the highest ever in 2000 but more than halved in 2002.

AQUACULTURE PRODUCTION

According to FAO statistics, the contribution of aquaculture to global supplies of fish, crustaceans and molluscs continues to grow, increasing from 3.9 percent of total production by weight in 1970 to 29.9 percent in 2002. Aquaculture continues to grow more rapidly than all other animal food-producing sectors. Worldwide, the sector has grown at an average rate of 8.9 percent per year since 1970, compared with only 1.2 percent for capture fisheries and 2.8 percent for terrestrial farmed meat-production systems over the same period. Production from aquaculture has greatly outpaced population growth, with the world average per capita supply from aquaculture increasing from 0.7 kg in 1970 to 6.4 kg in 2002, representing an average annual growth rate of 7.2 percent, based largely on China-reported growth.

In 2002, total world aquaculture production (including aquatic plants) was reported to be 51.4 million tonnes by quantity and US$60.0 billion by value. This represents an

Table 4

Top ten producers in aquaculture production: quantity and growth

Producer	2000	2002	APR
	(thousand tonnes)		(percent)
Top ten producers in terms of quantity			
China	24 580.7	27 767.3	6.3
India	1 942.2	2 191.7	6.2
Indonesia	788.5	914.1	7.7
Japan	762.8	828.4	4.2
Bangladesh	657.1	786.6	9.4
Thailand	738.2	644.9	-6.5
Norway	491.2	553.9	6.2
Chile	391.6	545.7	18.0
Viet Nam	510.6	518.5	0.8
United States	456.0	497.3	4.4
Top ten subtotal	31 318.8	35 248.4	6.1
Rest of the world	4 177.5	4 550.2	4.4
Total	**35 496.3**	**39 798.6**	**5.9**
Top ten producers in terms of growth			
Iran (Islamic Rep. of)	40.6	76.8	37.6
Faeroe Islands	32.6	50.9	25.0
Lao People's Dem. Rep.	42.1	59.7	19.1
Brazil	176.5	246.2	18.1
Chile	391.6	545.7	18.0
Russian Federation	74.1	101.3	16.9
Mexico	53.9	73.7	16.9
Taiwan Province of China	243.9	330.2	16.4
Canada	127.6	172.3	16.2
Myanmar	98.9	121.3	10.7

Note: Data exclude aquatic plants. APR refers to the average annual percentage growth rate for 2000–02.

Table 5
World aquaculture production: average annual rate of growth for different species groups

Time period	Crustaceans	Molluscs	Freshwater fish	Diadromous fish	Marine fish	Overall
	(percent)					
1970–2002	**18.1**	**7.8**	**9.6**	**7.4**	**10.5**	**8.9**
1970–1980	23.9	5.6	6.0	6.5	14.1	6.3
1980–1990	24.1	7.0	13.1	9.4	5.3	10.8
1990–2000	9.9	5.3	7.8	7.9	12.3	10.5
2000–2002	**11.0**	**4.6**	**5.8**	**6.7**	**9.5**	**5.9**

annual increase of 6.1 percent in quantity and 2.9 percent in value, respectively, over reported figures for 2000. In 2002, countries in Asia accounted for 91.2 percent of the production quantity and 82 percent of the value. Of the world total, China is reported to produce 71.2 percent of the total quantity and 54.7 percent of the total value of aquaculture production.

Table 4 shows the top ten producers of fish, crustaceans and molluscs in 2002, together with the top ten producers in terms of annual growth in aquaculture production in 2000–02. All continents except Europe showed increases in production from 2000 to 2002; in Europe production remained relatively unchanged (0.1 percent annual decrease).

World aquatic plant production in 2002 was 11.6 million tonnes (US$6.2 billion), of which 8.8 million tonnes (US$4.4 billion) originated from China, 0.89 million tonnes from the Philippines and 0.56 million tonnes from Japan. Japanese kelp (*Laminaria japonica* – 4.7 million tonnes) showed the highest production, followed by Nori (*Porphyra tenera* – 1.3 million tonnes). An additional 4 million tonnes were reported by countries as "Aquatic plants" and not further specified.

The rapid growth in production of the different major species groups continues. However, in the period 2000–02 there were indications that the extraordinary growth rates seen in the 1980s and 1990s were slowing slightly (Figure 10, Table 5). Although the growth in production of crustaceans increased in the period 2000–02, growth rates for the other species groups had begun to slow and the overall growth rate, while

Figure 10

Trends in world aquaculture production: major species groups

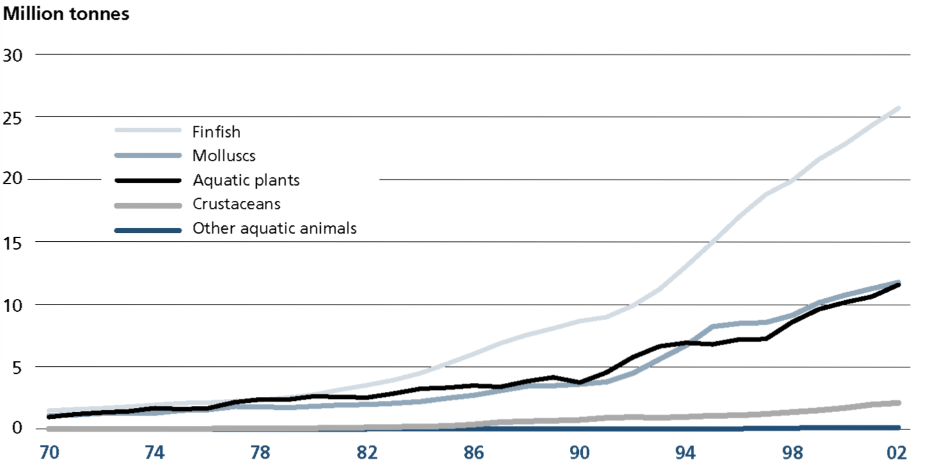
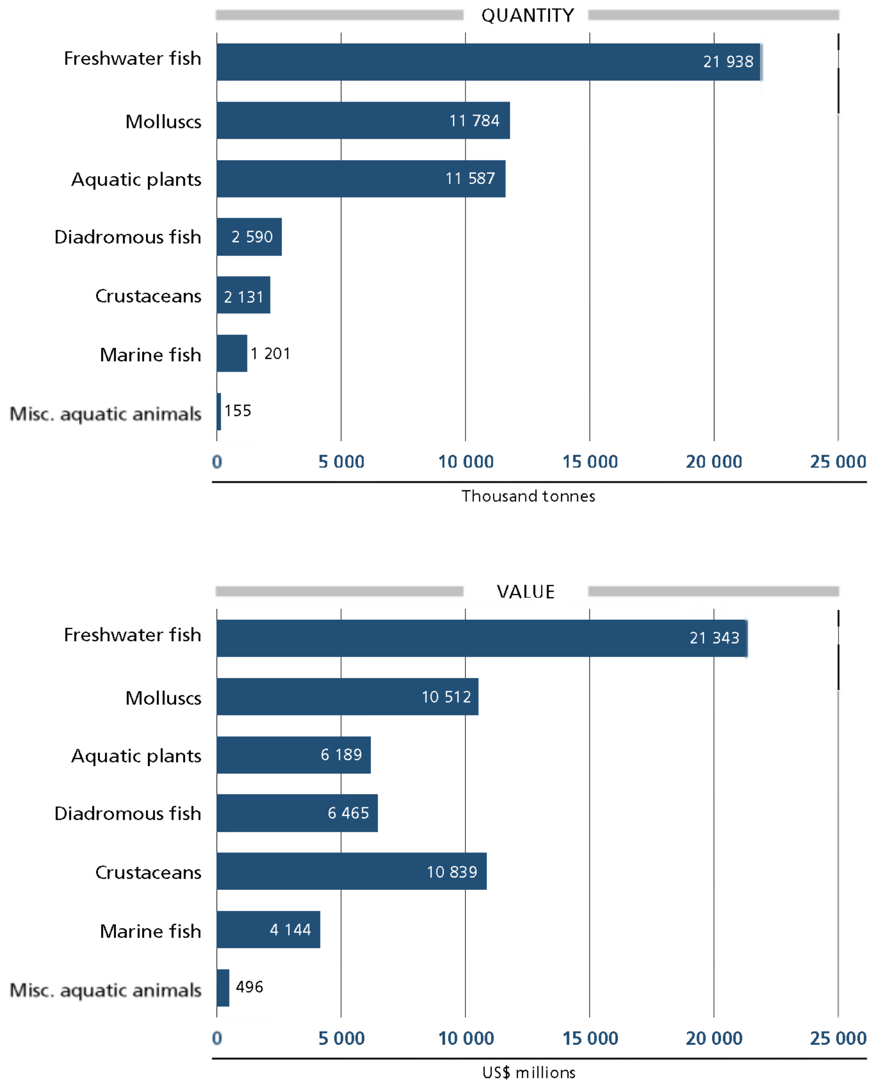


Figure 11

World aquaculture production: major species groups in 2002



still substantial, was lower than those experienced over the past 20 years. Aquaculture production in terms of quantity and value for major species groups in 2002 is presented in Figure 11.

The top ten species groups in terms of production quantity and percentage increase in production quantity from 2000 to 2002 are presented in Table 6. Production of carps and other cyprinids far exceeded that for all other species groups, accounting for nearly 42 percent (16.7 million tonnes) of total production of fish, crustaceans and molluscs. Combined, the top ten species groups accounted for 92.5 percent of the total aquaculture production of fish, crustaceans and molluscs. The largest production for an individual species was the Pacific cupped oyster (*Crassostrea gigas* – 4.2 million tonnes), followed by three species of carp – the silver carp (*Hypophthalmichthys molitrix* – 4.1 million tonnes), grass carp (*Ctenopharyngodon idellus* – 3.6 million tonnes) and common carp (*Cyprinus carpio* – 3.2 million tonnes).

Two high-value species of finfish appear in the top ten species groups in Table 6, with the largest percentage increases in production reflecting emerging activities. First, farming of Atlantic cod (*Gadus morhua*) has begun in Norway and Iceland. Second, the aquaculture of wild-caught tuna by fattening in sea-cages is an increasingly important

Table 6
Top ten species groups in aquaculture production: quantity and growth

Species group	2000	2002	Share of 2002 total	APR
	(tonnes)		(percent)	
Top ten species groups in terms of quantity				
Carps and other cyprinids	15 451 646	16 692 147	41.9	3.9
Oysters	3 997 394	4 317 380	10.8	3.9
Miscellaneous marine molluscs	2 864 199	3 739 702	9.4	14.3
Clams, cockles, arkshells	2 633 441	3 430 820	8.6	14.1
Salmons, trouts, smelts	1 545 149	1 799 383	4.5	7.9
Tilapias and other cichlids	1 274 389	1 505 804	3.8	8.7
Mussels	1 370 953	1 444 734	3.6	2.7
Miscellaneous marine molluscs	1 591 813	1 348 327	3.4	-8.0
Shrimps, prawns	1 143 774	1 292 476	3.2	6.3
Scallops, pectens	1 154 470	1 226 568	3.1	3.1
Top ten species groups in terms of growth				
Cods, hakes, haddocks	169	1 445		192.4
Misc. demersal fishes	8 701	15 302		32.6
Misc. marine crustaceans	34 202	52 377		23.7
Flounders, halibuts, soles	26 309	38 909		21.6
Tunas, bonitos, billfishes	6 447	9 445		21.0
Freshwater crustaceans	411 458	591 983		19.9
Crabs, sea-spiders	140 235	194 131		17.7
Freshwater molluscs	10 220	13 414		14.6
Misc. freshwater fishes	2 864 199	3 739 702		14.3
Clams, cockles, arkshells	2 633 441	3 430 820		14.1

Note: Data exclude aquatic plants. APR refers to the average annual percentage growth rate for 2000–2002.

activity in Mexico, Australia and the Mediterranean region and is now spreading to other areas. According to FAO statistical definitions, the net weight gain in captivity should be attributed to aquaculture, but few countries known to have fattening operations have reported any production from tuna farming as aquaculture. Thus the increase suggested by the official statistics is only a small part of the actual increase in production.

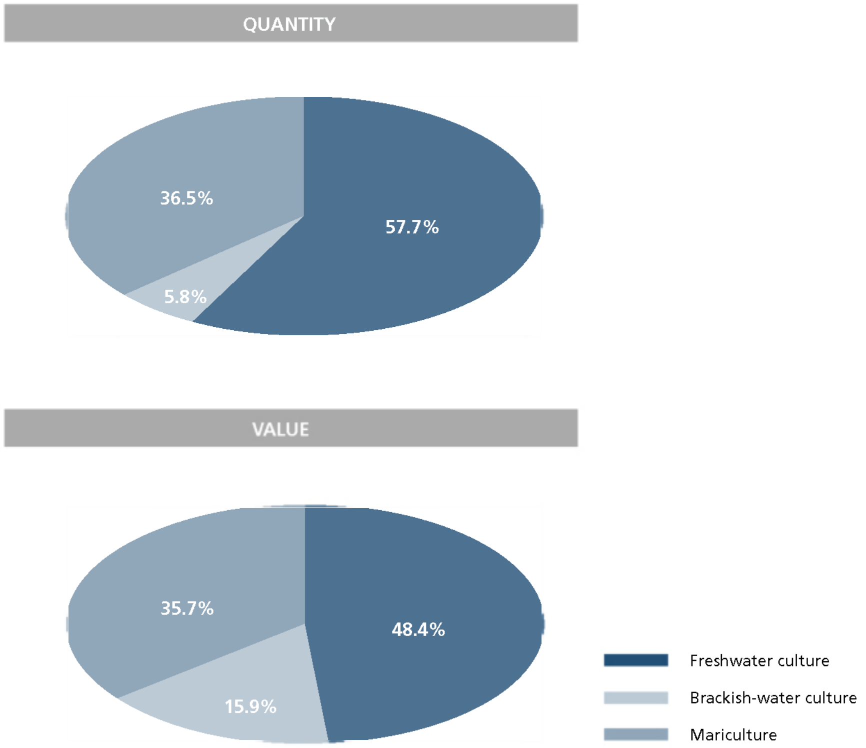
Most aquaculture production of fish, crustaceans and molluscs continues to come from the freshwater environment (57.7 percent by quantity and 48.4 percent by value) (Figure 12). Mariculture contributes 36.5 percent of production and 35.7 percent of the total value. Although brackish-water production represented only 5.8 percent of aquaculture production quantity in 2002, it contributed 15.9 percent of the total value, reflecting the prominence of high-value crustaceans and finfish. Aquaculture production trends for inland and marine waters over the period 1970–2000 are presented in Figure 13.[5]

During this period, reported Chinese inland water aquaculture production increased at an average annual rate of 11.1 percent, compared with 6.9 percent for the rest of the world. Similarly, reported Chinese aquaculture production in marine areas increased at an average annual rate of 10.9 percent compared with 5.5 percent for rest of the world.

[5] Brackish-water production is assigned to either marine areas or inland areas depending on the area reported by the country. Thus, production in inland areas and marine areas represents the total of aquaculture production.

Figure 12

World aquaculture production of fish, crustaceans and molluscs in 2002: breakdown by environment



Note: Data exclude aquatic plants.

Unlike terrestrial farming systems, where the bulk of global production is based on a limited number of animal and plant species, over 220 different farmed aquatic animal and plant species were reported in 2002. On the basis of aquaculture production statistics reported to FAO at the species level, the top ten species account for 69 percent of total production, and the top 25 species for over 90 percent.

It is noteworthy that the growth of aquaculture production of fish, crustaceans and molluscs in developing countries has exceeded the corresponding growth in developed countries, proceeding at an average annual rate of 10.4 percent since 1970. By contrast, aquaculture production in developed countries has been increasing at an average rate of 4.0 percent per year. In developing countries other than China, production has grown at an annual rate of 7.8 percent. In 1970, developing countries accounted for 58.8 percent of production, while in 2002 their share had risen to 90.7 percent. With the exception of marine shrimp, the bulk of aquaculture production in developing countries in 2002 comprised omnivorous/herbivorous fish or filter-feeding species. By contrast, 74 percent of the finfish culture production in developed countries was of carnivorous species.

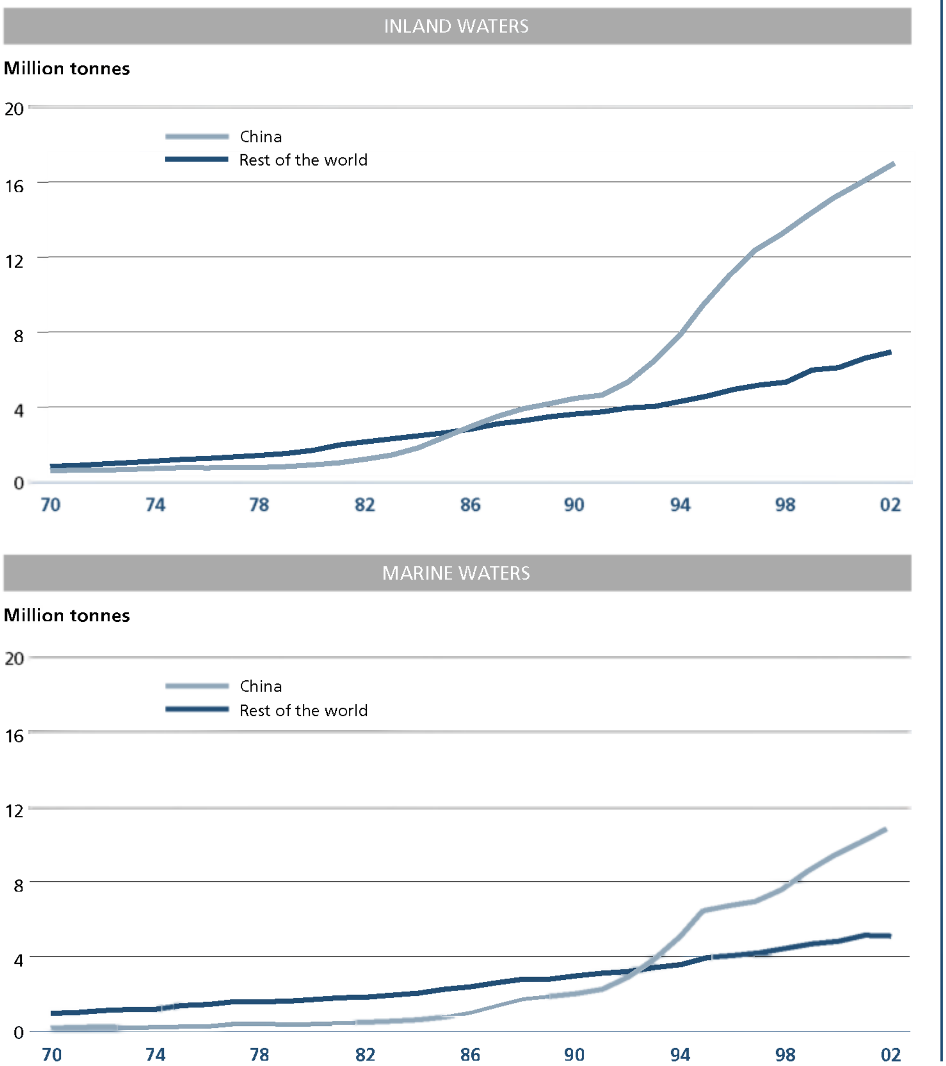
FISHERS AND FISH FARMERS

In 2002, fishery and aquaculture production activities provided direct employment and revenue to an estimated 38 million people (Table 7), a marginal increase compared with the previous year. The world number of fishers and fish farmers has been growing at an average rate of 2.6 percent per year since 1990.

Fishers and aquaculture workers represented 2.8 percent of the 1.33 billion people economically active in agriculture worldwide in 2002, compared with 2.3 percent in

Figure 13

Aquaculture production in marine and inland waters



Note: Data exclude aquatic plants.

1990. Most continents are close to the world average; exceptions are Africa, where the percentage of fishers and aquaculture workers is lower, at 1.3 percent of the total agricultural labour force, and North and Central America, where the share is 1 percent above the world average. Fishing in marine and inland waters accounted for 75 percent of the total number of workers, while aquaculture production provided employment for the remaining 25 percent. These figures are only indicative, as some countries do not yet collect employment data separately for the two sectors and some other countries' national systems do not yet account for fish farming.

The highest numbers of fishers and aquaculture workers are in Asia (87 percent of the world total) followed by Africa (7 percent), Europe, North and Central America and South America, (about 2 percent each) and Oceania (0.2 percent). These shares closely reflect the population shares of the different continents, the share of the population economically active in agriculture and the relative predominance of labour-intensive fisheries in some economies in Africa and Asia.

Fishing in marine and inland waters is often a part-time occupation (almost 60 percent of the total), as a result of the variations in seasonal resource availability and also because fishing is generally regulated through a series of

Box 2

Emergencies and fisheries

Natural hazards such as cyclones, floods, typhoons, sea surges, tidal waves, earthquakes and landslides can have a devastating effect on fishing communities – destroying fishing boats and equipment, or sweeping away their houses. A compelling example is the 1996 cyclone in the Bay of Bengal in which 1 435 fishers were reported as dead or missing and thousands of fishing crafts and other equipment were estimated to be lost or damaged.

When, following a disaster, fishing communities are no longer able to meet their basic survival needs and/or when there is a threat to their life and well-being, as in the case of armed conflicts, they face an emergency situation. Developing countries, especially the poorest, suffer disproportionately from emergencies because they lack the means to prepare for them and to deal with their aftermath. In view of the importance of fisheries in developing states (in terms of production, protein intake, employment and foreign exchange), there is a need to review the role that fisheries interventions can play in emergency relief operations.

In situations of emergency, fisheries interventions may be critical to help restore production and/or as a source of immediate income and food. Data gathered in the Sudan (northern sector) over a one-year cycle have shown that whatever the season and the location, fish commodities (mainly sun-dried fish) form the cheapest and most accessible source of animal proteins for the displaced and poor sections of the communities. Furthermore, sun-dried fish plays a crucial role in ensuring people's food security during the period between the first rains and first harvest (the "hunger gap") and during the active

measures that limit year-round activity (e.g. closures of selected fisheries at certain times of the year, limits on total annual catches of selected species so that commercial fishers may fish for only a few days of each month until the quota is reached) or limit the number of commercial licences and the number of fish caught per trip. Increasingly, operators have to turn to other activities for supplementary income.

Although the national statistics available to FAO are often too irregular and lacking in detail to permit a more in-depth analysis of the employment structure at world level, it is apparent that, in most important fishing nations that systematically provide this information, the share of employment in capture fisheries is stagnating and increased opportunities are being provided by aquaculture.

In China, where the combined numbers of fishers and fish farmers (12.3 million) represent nearly one-third of the world total, in 2002, 8.4 million people worked in capture fisheries and 3.9 million in aquaculture. However, existing fleet-size reduction programmes in China, aimed at reducing overfishing, are reducing the number of full-time and part-time fishers. The latter have decreased by almost 2 percent from two years before and there are plans to move 4 percent of the total number of fishers to other jobs by 2007. The policy tools to accomplish this include, among others, scrapping vessels and training redundant fishers in fish farming, where employment in 2002 increased by 6 percent compared with 2000 levels. A similar trend of increased agricultural planting season, when it is used to supplement wild indigenous foods.

A distinction between aquaculture and capture fisheries should be made here. The raising of fish through aquaculture requires both time and money. As a consequence, relief efforts should focus on restarting production where aquaculture operations had already been established and where the necessary skills are available. By contrast, the capture of wild fish can provide immediate income and food (animal proteins) as soon as the means of production are renewed. This can be crucial in times of conflict or acute crises. Furthermore, in the case of capture fisheries, entrance into the sector and access to the fishing ground are generally non-discriminatory. Fishing equipment such as nets and hooks are easy to transport, unlike livestock. Some fishing activities, such as the use of hooks and lines, do not require high levels of skills to be developed, and can thus provide children and women, who are the most vulnerable, with proteins soon after displacement.

Moreover, fisheries interventions offer multiple side activities and job opportunities such as net repair, boatbuilding, fish processing, trade and basket-making. Fisheries interventions can contribute to promoting the role of women through training in improved fish-processing and preservation techniques.

In spite of the significant role fisheries can and should play in relief and rehabilitation efforts, fisheries interventions do not always receive adequate attention in emergency operations. Until this situation is addressed and the potential impact of fisheries interventions is realized, the costs will continue to be borne by fishers and their communities.

employment opportunities in professions associated with culture practices is also evident in other countries.

In many industrialized countries, notably Japan and European countries, employment in fishing – and, as a consequence, in associated land-based professions – has been declining for several years. This is the result of several factors combined, including lower catches, programmes to reduce fishing capacity and the increased productivity brought about by technical progress. In the European Union (EU-15)[6] the decline in the number of fishers in recent years averaged about 2 percent per year.

In Norway, employment in fishing has been decreasing for several years (Table 8). In 2002, about 18 650 people were employed in fishing (excluding fish farming), representing a decline of 8 percent compared with 2000 and almost 20 percent compared with five years before. The largest decline has occurred in fishing as a main occupation, which accounts for more than 75 percent of the total. In Iceland, average employment in fisheries was fairly stable in the five years to 2002, although there were seasonal variations; however, the share of fishing and fish processing – where the majority of workers are women – as a source of employment, dropped to 8 percent in 2002 from 10 percent five years earlier. In Japan, the numbers of marine fishery workers

[6] The members of the European Union prior to 1 May 2004: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

Table 7
World fishers and fish farmers by continent

	1990	1995	2000	2001	2002
			(thousands)		
Total					
Africa	1 917	2 238	2 585	2 640	2 615
North and Central America	767	770	751	765	762
South America	769	814	784	760	770
Asia	23 654	28 552	30 770	31 493	32 821
Europe	654	864	821	796	746
Oceania	74	76	86	80	81
World	**27 835**	**33 314**	**35 797**	**36 534**	**37 795**
Of which fish farmers[1]					
Africa	...	105	112	115	111
North and Central America	53	74	74	69	65
South America	16	88	92	92	93
Asia	3 698	6 003	8 503	8 720	9 502
Europe	11	36	37	39	39
Oceania	neg.	1	5	5	5
World	**3 778**	**6 307**	**8 823**	**9 040**	**9 815**

[1] Data for 1990 and 1995 were reported by only a limited number of countries and therefore are not comparable with those for the following years.
neg. = negligible; ... = data not available.

has been falling yearly since 1991, reaching a low of 243 320 people in 2002. The vast majority (72 percent) of these fishers were self-employed workers, as is commonly the case in the fishery profession.

The fishing workforce in most developed economies is advancing in age, mainly because of the profession's decreasing attractiveness to younger generations. For instance, in Japan, 95 750 male fishers (or 47.2 percent of the total) were 60 years of age or older in 2002. The share of this age class has recently been increasing at a rate of 1 percent per year and in 2002 was nearly 25 percent above the figure of 20 years previously. By comparison, the younger group of workers (under 40 years of age), which represented one-quarter of the total number of marine fishery workers in 1982, had decreased to 12.1 percent of the 243 320 people engaged in marine fishery by 2002.

Complete data on the numbers of aquaculture workers worldwide are not available. The partial statistics that are available indicate an increase of about 8 percent per year since 1990, with part of the increase accounted for by improved reporting by countries. Since 2000, however, in many developed countries, figures on employment in aquaculture indicate that a levelling-off has started to occur, owing to a parallel slowdown of the rate of growth of farmed fish and shellfish production. After peaking in 1995, then decreasing for several years, employment in fish farming in Norway has been stable since 1998. In 2002, 3 457 people were employed, one-third of whom worked in hatcheries; men (accounting for 90 percent of the total) are employed mainly in salmon and trout production, while female workers, whose employment has been stable for many years, are largely employed in the production of fry and fingerlings rather than fish for consumption.

In countries where fishing and aquaculture are less prominent in the economy, comparative employment and income statistics at this level of detail are often not easily available. In many developing countries, which have the largest number of

Table 8
Number of fishers and fish farmers in selected countries

Country	Fishery		1990	1995	2000	2001	2002
WORLD	FI + AQ	(number)	**27 835 441**	**33 314 345**	**35 796 679**	**36 534 194**	**37 795 203**
		(index)	***78***	***93***	***100***	***102***	***106***
	FI	(number)	…	…	26 974	27 494	27 980
		(index)	…	…	100	102	104
	AQ	(number)	…	…	8 823	9 040	9 815
		(index)	…	…	100	102	111
China	FI + AQ	(number)	9 092 926	11 428 655	12 233 128	12 944 046	12 337 732
		(index)	74	93	100	106	101
	FI	(number)	7 352 827	8 759 162	8 510 779	9 097 276	8 377 036
		(index)	86	103	100	107	98
	AQ	(number)	1 740 099	2 669 493	3 722 349	3 846 770	3 960 696
		(index)	47	72	00	103	106
Indonesia	FI + AQ	(number)	3 617 586	4 568 059	5 247 620	5 477 420	5 662 944
		(index)	69	87	100	104	108
	FI	(number)	1 995 290	2 463 237	3 104 861	3 286 500	3 392 780
		(index)	64	79	100	106	109
	AQ	(number)	1 622 296	2 104 822	2 142 759	2 190 920	2 270 164
		(index)	76	98	100	102	106
Japan	FI + AQ	(number)	370 600	301 440	260 200	252 320	243 320
		(index)	142	116	100	97	94
Peru[1]	FI + AQ	(number)	43 750	62 930	66 361	66 382	66 502
		(index)	66	95	100	100	100
Norway	FI + AQ	(number)	27 518	28 269	23 729	22 637	22 105
		(index)	116	119	100	95	93
	FI	(number)	27 518	23 653	20 098	18 955	18 648
		(index)	137	118	100	94	93
	AQ	(number)	…	4 616	3 631	3 682	3 457
		(index)	…	127	100	101	95
Iceland	FI	(number)	6 951	7 000	6 100	6 000	6 000
		(index)	114	115	100	98	98

Note: FI = fishing, AQ = aquaculture; index: 2000 = 100; … = data not available.
[1] Data for Peru exclude inland fishers and fish farmers.

fishers, the spouses and families of fishers are occupied in coastal artisanal fisheries and associated activities. Reliable estimates of the number of people engaging in fishing on a part-time or occasional basis, or undertaking rural aquaculture as unpaid family workers, are difficult to obtain. As a consequence, the socio-economic importance of these activities is more difficult to measure, although their contribution to production and income, and to food security for coastal and rural communities, is substantial.

In the absence of other economic data, it is not possible to draw firm global conclusions on current trends from these numbers. Economics still makes fishing an attractive profession for many people in some areas. In China, where it is estimated that 25 million people work in the fish capture industry, in fish farming and in associated processing industries, the economic attraction is demonstrated by the fact that a large percentage of fishers are not local people but migrant workers from inland areas or neighbouring provinces. Part-time fishers might work seasonally in fishing and return to their village during the summer, or undertake a mix of agriculture and fish farming. The average earnings from fishing can offer higher incomes than those from agricultural farming, although jobs in manufacturing and other economic sectors, generally offer higher compensation than those in agriculture and fishing.

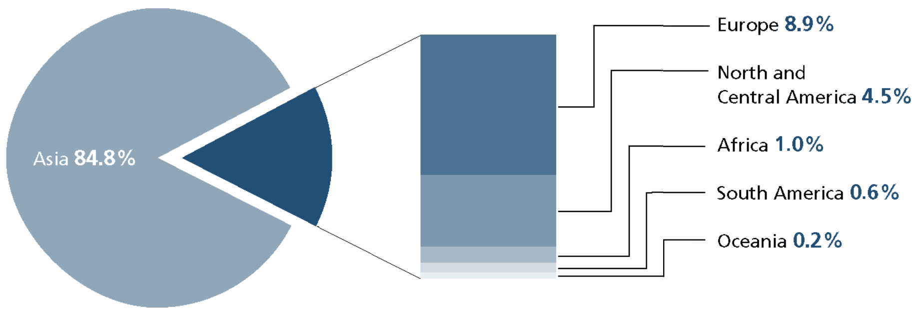
THE STATUS OF THE FISHING FLEET

After years of expansion of the world fishing fleet until the late 1980s and early 1990s, the number of decked vessels worldwide has remained fairly stable at around 1.3 million. In addition, the world fleet engaged in fishing in marine and inland waters comprised about 2.8 million undecked vessels, 65 percent of which were not powered. About 85 percent of total decked vessels, 50 percent of powered undecked vessels and 83 percent of total non-powered boats were concentrated in Asia. The remaining 15 percent of the world's total decked fishing vessels were accounted for by Europe (8.9 percent), North and Central America (4.5 percent), Africa (1 percent), South America (0.6 percent) and Oceania (0.2 percent) (Figure 14). Countries in North and Central America had 21 percent of the open fishing vessels with engines; Africa had 16 percent, South America 6 percent, and Oceania 3 percent.

The aggregate gross tonnage (GT) of large marine fishing vessels (considered to be those above 100 gross tons) increased to a peak of 15.6 million GT in 1992 (24 074 vessels) and has subsequently declined.[7] However, the number of these vessels increased gradually until 2001 and has remained relatively stable, at around 24 000 vessels, in recent years (Figure 15). In 2002, the number of large vessels increased slightly to 24 406 vessels; and has fluctuated around that number until 2004. However, since 1992 the total tonnage of this fleet has contracted as many countries began to adopt programmes of capacity containment. In 2003, the Russian Federation had the highest fleet capacity measured in GT (24 percent of the total GT), followed by Japan and the United States (7 percent each), Spain (6 percent), Norway (3.5 percent) and Ukraine (3 percent). Two open register countries, Panama and Belize, accounted for 6 percent and vessels of unknown flag made up 4.4 percent of the total GT.

Figure 14

Distribution of decked fishing vessels by continent



[7] Indicators of trends in the large marine fishing vessel fleet (above 100 GT) are based on data from Lloyd's Maritime Information Services (LMIS). It should be noted that only a small proportion (443 vessels) of the Chinese fleet of about 15 000 vessels over 24 metres length overall (LOA) reported by China to the International Maritime Organization (IMO) pursuant to the Torremolinos Agreement are included in the LMIS. It should also be noted that changes in the measurement of tonnage (from gross registered tonnage [GRT] to GT) requires caution in interpretation of trends in fleet tonnage.

The average age of the larger marine fishing vessel fleet segment has continued to increase. Whereas in 1992 about 30 percent of vessels were less than ten years old and 6 percent were more than 30 years old, in 2003 these percentages were 13 percent and 28 percent respectively. Figure 16 shows the age profile of the global fleet in 2003. Of the national fleets over 200 000 GT, the Japanese fleet is the youngest (average age 16 years), while the Republic of Korea's fleet is the oldest (average age 29 years). France and Vanuatu have relatively young fleets (average age 19 and 8 years, respectively), while the fleets of Ghana, the Philippines, Senegal and South Africa all have an average age of over 30 years.

Fishing is considered to be one of the most dangerous occupations. The aging fishing fleet raises concerns over the safety of both vessels and crew. Furthermore, standards of accommodation and other conditions for the crew on board these very

Figure 15

Global fleet above 100 GT recorded in the Lloyd's Maritime Information Services database

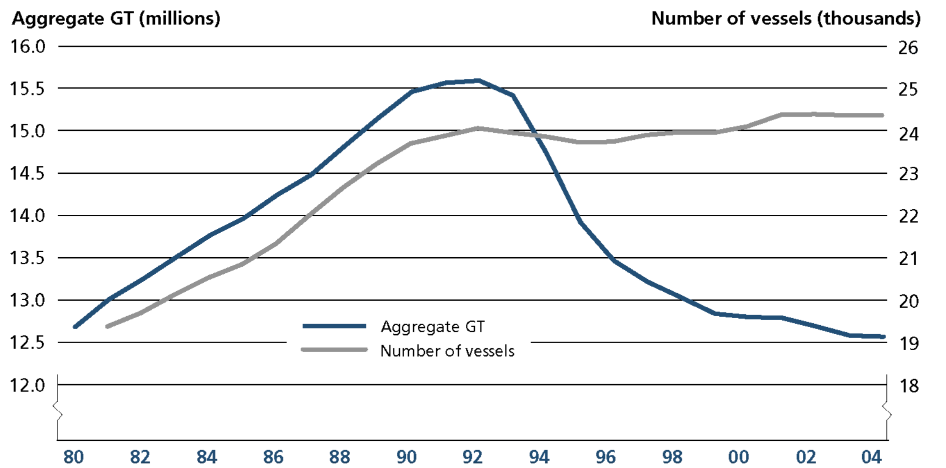
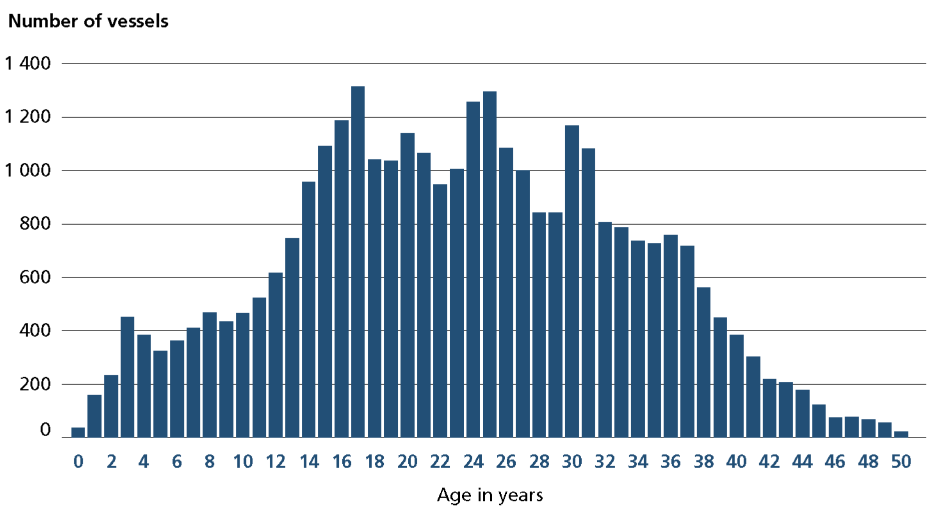


Figure 16

Age profile of global fleet above 100 GT in 2003



old vessels often do not conform to current minimum requirements for newly built vessels.

The slowdown in new construction of larger vessels suggests that improvements in safety and conditions may also be slow. While it is clear that capacity management plans may require some reduction in the fleet of large vessels, it is also clear that there will always be a need for larger vessels for fishing in distant waters and in bad weather conditions. In addition, many offshore pelagic fisheries tend to be more economically feasible when operating with larger vessels. It is expected that the construction of larger fishing vessels will increase over the next ten years, compared with the current low levels. In this context it may be noted that the International Labour Organization (ILO) is currently establishing a new Convention on labour conditions in the fishing industry (which includes accommodation standards for a new fishing fleet) (see Part 2, pp. 74–76). FAO, the ILO and the International Maritime Organization (IMO) are also finalizing a major revisions of the Code of Safety for Fishermen and Fishing Vessels and of the Voluntary Guidelines for the Design, Construction and Equipment of Small Fishing Vessels.

Although detailed indications of trends in the entire fishing fleet are not available on a global scale after 1998, the fleet size of some major fishing nations has continued to decrease. The European Union (EU-15) fishing fleet decreased from 96 000 vessels in 2000 to 88 701 in 2003. Of the total fleet, 13 percent were trawlers, 6 percent seiners, 33 percent gillnetters, 16 percent longliners, and the remainder operated other gear. Of the 87 833 vessels of known length, slightly over 80 percent measured less than 12 metres, the majority of these belonging to Greece, Italy and Spain. Some 15 percent of EU fishing vessels were between 12 and 24 metres in length, and fewer than 340 measured more than 45 metres (a decrease of 60 units compared with five years earlier). In December 2002, Norway had a registered fleet of 7 802 engine-driven decked fishing vessels and 2 847 open vessels. Comparative statistics indicate a further decrease of 628 units (8 percent) for the decked fleet since 2000, and a decrease of nearly 40 percent in the number of open vessels. At the end of 2003, the Icelandic fleet had 1 872 vessels on register, 50 percent of which were undecked; this implies 63 units fewer than in 2002 and a decrease of about 7 300 in GT. Nearly 40 percent of the trawlers (about 75 percent of all decked vessels) are more than 20 years old. In New Zealand, whose exclusive economic zone is one of the largest in the world, the number of domestic commercial fishing vessels numbered 1 700 in 2001 and these were complemented by 36 foreign chartered vessels; these figures represent a decrease of 1 102 domestic vessels and 43 chartered vessels compared with 1992.

Over 90 percent of the Japanese fleet are vessels below 5 gross tons. All segments of the fleet declined between 1997 and 2001; in particular, the number of vessels greater than 50 gross tons (fewer than 1 percent in 2001) decreased by over 20 percent.

Important advances have been made by several RFBs[8] through the establishment of lists of “positive” (authorized to fish in the area of the RFBs’ jurisdiction) and “negative” (unauthorized, or “non-cooperating”) vessels in order to improve the monitoring and control of fisheries on the high seas and transboundary stocks. Other RFBs[9] are in various stages of establishing such lists, and some countries and non-governmental organizations (NGOs) have initiated lists of vessels reported to be engaged in unauthorized fishing.

As of mid-2004, 5 517 vessels are recorded in the High Seas Vessels Authorization Record maintained by FAO. Only 19 countries[10] out of 30 parties to the Compliance

[8] These include the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Forum Fisheries Agency (FFA), International Commission for the Conservation of Atlantic Tunas (ICCAT), Indian Ocean Tuna Commission (IOTC), Inter-American Tropical Tuna Commission (IATTC), Northwest Atlantic Fisheries Organization (NAFO) and North East Atlantic Fisheries Commission (NEAFC).

[9] Sub-Regional Fisheries Commission (West Africa), Western Central Pacific Fisheries Commission, and Commission for the Conservation of the Southern Bluefin Tuna

[10] Benin, Canada, Japan, Namibia, Norway, United States and 13 EU countries (Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom).

Table 9
Fishing vessels of 100 GT and above: new building, flagging in and out of shipping registers and scrappings and losses in 2003

	New building	Flagging out	Flagging in	Scrappings and losses	Change
Selected country register					
Belize	5	178	81	0	–92
Equatorial Guinea	0	17	4	0	–13
Honduras	0	16	15	0	–1
Iceland	1	33	11	2	–23
Japan	0	138	1	3	–140
Namibia	1	10	16	0	7
Netherlands	9	22	1	13	–25
Norway	28	29	11	31	–21
Panama	2	21	33	0	14
Russian Federation	7	50	82	3	36
Saint Vincent and the Grenadines	0	38	7	1	–32
South Africa	2	3	29	1	27
Spain	64	13	1	25	27
United Kingdom	18	38	8	65	–77
United States	21	59	3	12	–47
Unknown	2	0	242	0	244
Subtotal	**160**	**665**	**545**	**156**	**–116**
All country registers	**384**	**916**	**916**	**347**	**37**

Note: Changes to the database of Lloyd's Maritime Information Services (for fishing vessels).

Agreement[11] have supplied FAO with the required information on vessels authorized to fish on the high seas.

Work in progress in FAO suggests that there is overcapacity in the world's industrial tuna fishing fleets.[12] In this context, a moratorium on construction has been considered in conjunction with the development of mechanisms for the smooth transfer of capacity from distant-water fishing nations to coastal developing states.

An analysis of the fishing vessels that changed their flag state in 2003 (Table 9) suggests continued high activity in "flag of convenience" countries, although there are indications that the number of such vessels are decreasing. Belize, Equatorial Guinea and Saint Vincent and the Grenadines had substantial fleet reductions, while the Honduras fleet remained relatively unchanged and the Panama fleet increased by 14 vessels, when new built vessels and scrapping is taken into account.

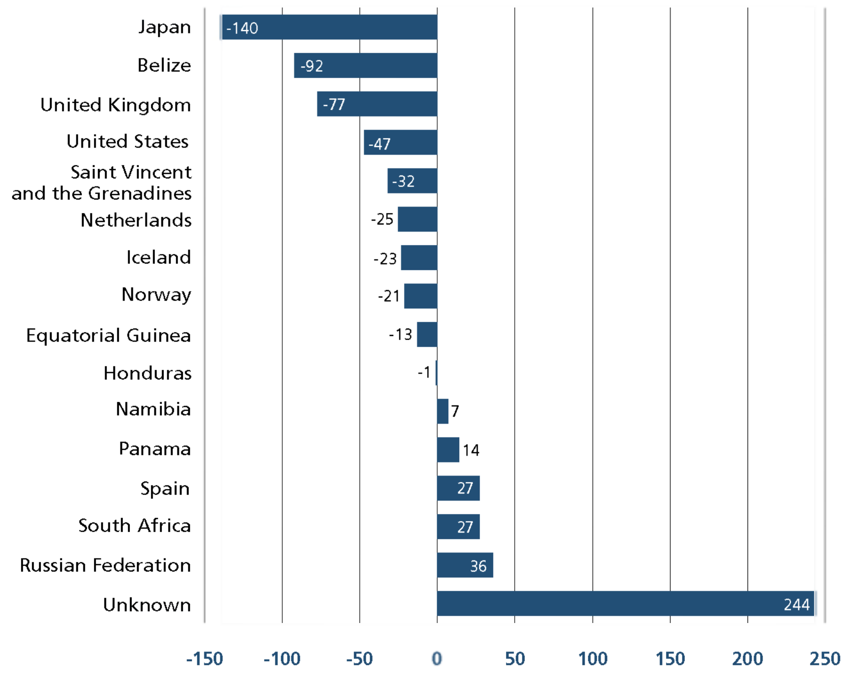
In 2003, several of the major fishing nations appeared to be substantially reducing their numbers of vessels of 100 GT and above by flagging out (Figure 17). Japan was foremost, with a total reduction of 140 vessels. Iceland, the Netherlands, Norway, and the United States all flagged out more vessels than they have flagged in. The United Kingdom has substantially reduced its fleet by scrapping older vessels and flagging out.

[11] The Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas was adopted by the FAO Conference in November 1993 and came into force in 2003. For further information, see http://www.fao.org/Legal/treaties/012t-3.htm; accessed September 2004.

[12] Management of Tuna Fishing Capacity: Conservation and Socio-economics. FAO Project GCP/INT/851/JPN.

Figure 17

Change in numbers of fishing vessels of 100 GT and above in selected fleets, 2002–03



Spain, on the other hand, has substantially increased its fleet by building new vessels. Vessels flagging out to the "unknown" category account for more that 25 percent of those reflagging.

The Lloyd's Register records 1 213 "unknown flag" vessels over 100 gross tons and considered to be still in operation in 2003 (records before 1970 excluded). Of the vessels for which records of the previous flag exists, 51 percent were flagged in one of the following countries: Belize, Equatorial Guinea, Honduras, Panama, Saint Vincent and the Grenadines, and Vanuatu, and 56 percent of these vessels were constructed either in Japan or Taiwan Province of China.

THE STATUS OF FISHERY RESOURCES

Marine fisheries

After increasing from around 79 million tonnes in 1998 to 87 million tonnes in 2000, world marine capture fisheries production decreased to around 84 million tonnes in 2001 and remained at that level in 2002. The decrease of around 2.5 percent in global catches between 2000 and 2002 is mostly due to the declines by 12 percent and 7 percent, respectively, in production from the Southeast Pacific and the Northwest Pacific.

The Northwest Pacific is the most productive fishing area of the world, with nominal catches oscillating between 20 and 24 million tonnes (including China) since the late 1980s (Figure 18). Large catch fluctuations in the area are mainly driven by fisheries for the abundant stocks of Japanese pilchard (or sardine) and Alaska pollock. Both stocks show a declining trend since the late 1980s as a result of the combined effects of overfishing and environmental factors affecting stock productivity. Although there has been an increase in catches of other species, including the Japanese anchovy, it was not enough to compensate for the decline in pilchard/sardine and pollock and to offset the consistent decline in fisheries production in the area of around 3 percent per year since 1998.

In the Southeast Pacific, three species account for around 80 percent of total catches: the Peruvian anchoveta, the Chilean jack mackerel and the South American pilchard (or sardine). Large catch fluctuations are common in the area as a consequence of periodic climatic events associated with the El Niño Southern Oscillation affecting fishing success and stock productivity. For instance, catches of Peruvian anchoveta dropped severely following the adverse El Niño environmental conditions in 1997–98. More favourable climatic conditions in 2000 led to one of the highest catches on record, of around 11 million tonnes, but in 2002 the fishery for Peruvian anchoveta declined to 9.7 million tonnes, causing a net decrease in total fisheries production in the area.

The remaining fishing areas of the Pacific have exhibited increasing trends in catches since 2000. In the Northeast Pacific, fisheries production had been declining since its peak of 3.6 million tonnes in 1987, but made a slight recovery to 2.7 million tonnes in 2001 and 2002. Alaska pollock is the single most important stock in the Northeast Pacific and accounts for most of the fluctuation in total catches. In the Western Central Pacific, fisheries production has been growing steadily since 1950, reaching close to 10 million tonnes in 2001. In the Eastern Central Pacific, total catches have fluctuated between 1.2 and 1.8 million tonnes since 1981. The recent production increase in the area has been influenced by the California pilchard (or sardine), which yielded about 670 000 tonnes in 2001 and 2002 – the highest recorded catch of the species since 1950. Nominal catches in the Southwest Pacific reached a peak of 917 000 tonnes in 1992 and gradually declined to 714 000 tonnes in 2000 before making a slight recovery.

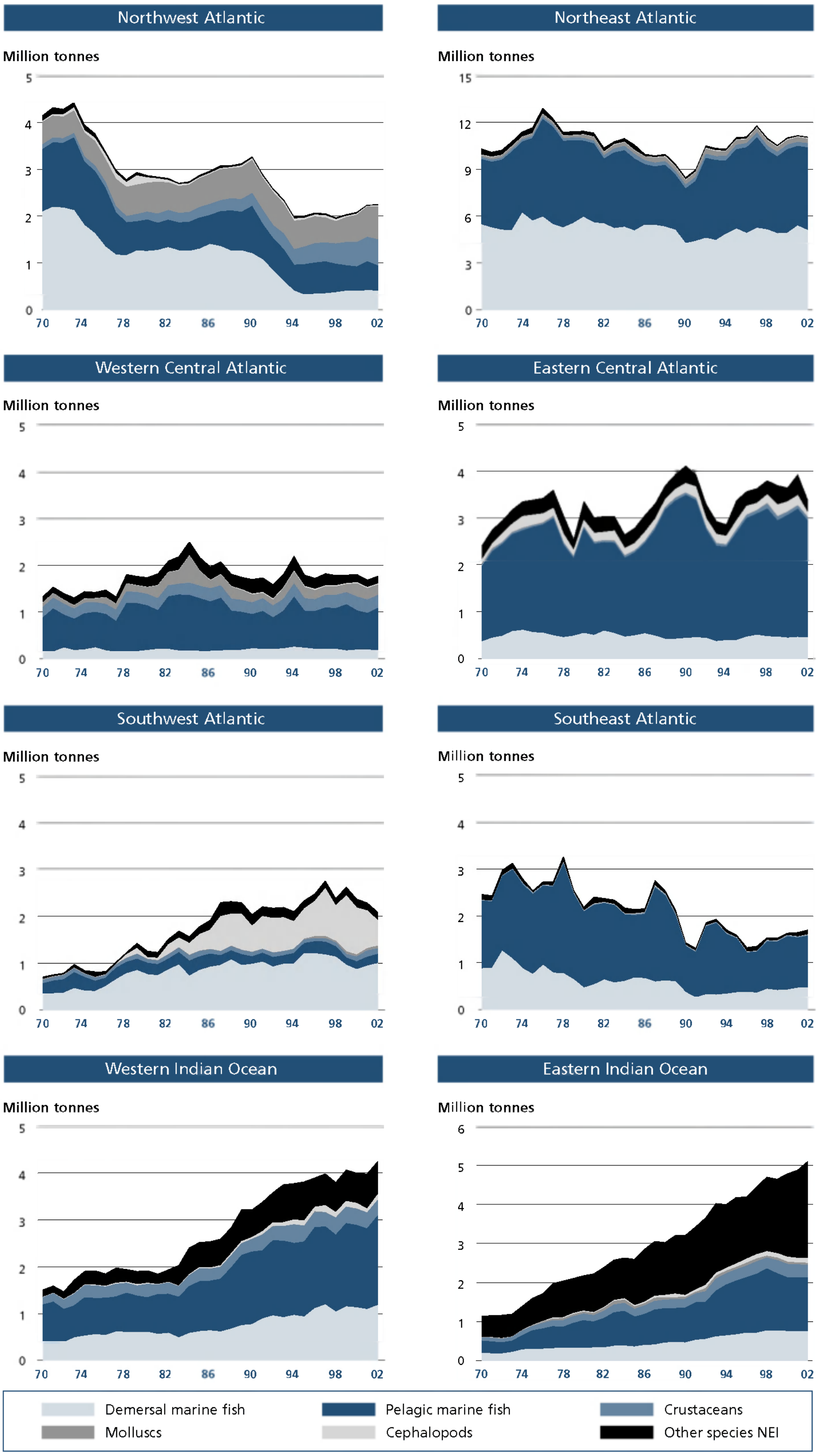
In the Atlantic, catches have increased in the Northwest and Southeast fishing areas. Northwest Atlantic fisheries production reached its lowest level in 1994 and again in 1998 with the collapse of groundfish stocks off Eastern Canada. Catches have since been increasing slowly, from close to 2 million tonnes in 1994 to 2.26 million tonnes in 2002. In the Southeast Atlantic, catches have followed an increasing trend since 1996, with the growth mostly accounted for by small pelagic fish, and reached close to 1.7 million tonnes in 2002. Fluctuations in catch are common in the area in response to the substantial environmental variability of the Benguela Current system. In other areas, such as the Southwest and Eastern Central Atlantic, there has been a noticeable decline in fisheries production since 2000. The 7 percent decrease in total catches in the Eastern Central Atlantic falls within the pattern of catch fluctuation from 2.9 to 4.1 million tonnes observed in the region since 1990. This is a consequence of the combined effect of changes in distant-water fishing effort and environmentally induced changes in the productivity of the abundant small pelagic stocks. In the Southwest Atlantic, the decline in catches can largely be attributed to the fall of around 45 percent in the catches of Argentine shortfin squid from 2000 to 2002. This species made up 33 percent of the total catches in the Southwest Atlantic in 2001 and squid catches have been declining since 1999, when around 1.1 million tonnes were reported.

Monitoring the status of fisheries in the Indian Ocean has been difficult because of a generally poor system of fisheries statistics collection in the region, reflected in the relatively high proportion of catches reported as "miscellaneous marine fishes" in the official statistics. This is also a significant problem in other areas, such as the Southwest, Eastern and Western Central Atlantic and the Northwest and Western Central Pacific. However, both the Western and Eastern Indian Ocean areas show a continuing increase in total reported catches, with fisheries production in 2002 being the highest on record for both areas.

Fisheries production in the high seas is considerably higher in the Pacific, followed by the Atlantic and the Indian Oceans. Tunas comprise the single most important resource exploited in the high seas. In some areas of the Atlantic and Pacific, straddling stocks of jack mackerel and squids and demersal fish on seamounts contribute significantly to production. The contribution of sharks to the total reported catches is minor compared with that of other oceanic resources; moreover, bycatch underreporting and discards are a source of concern when dealing with this species group. The world catches of the seven principal market species of tunas increased from less than 0.5 million tonnes in the early 1950s to a peak of 4 million tonnes in 2002,

Figure 18

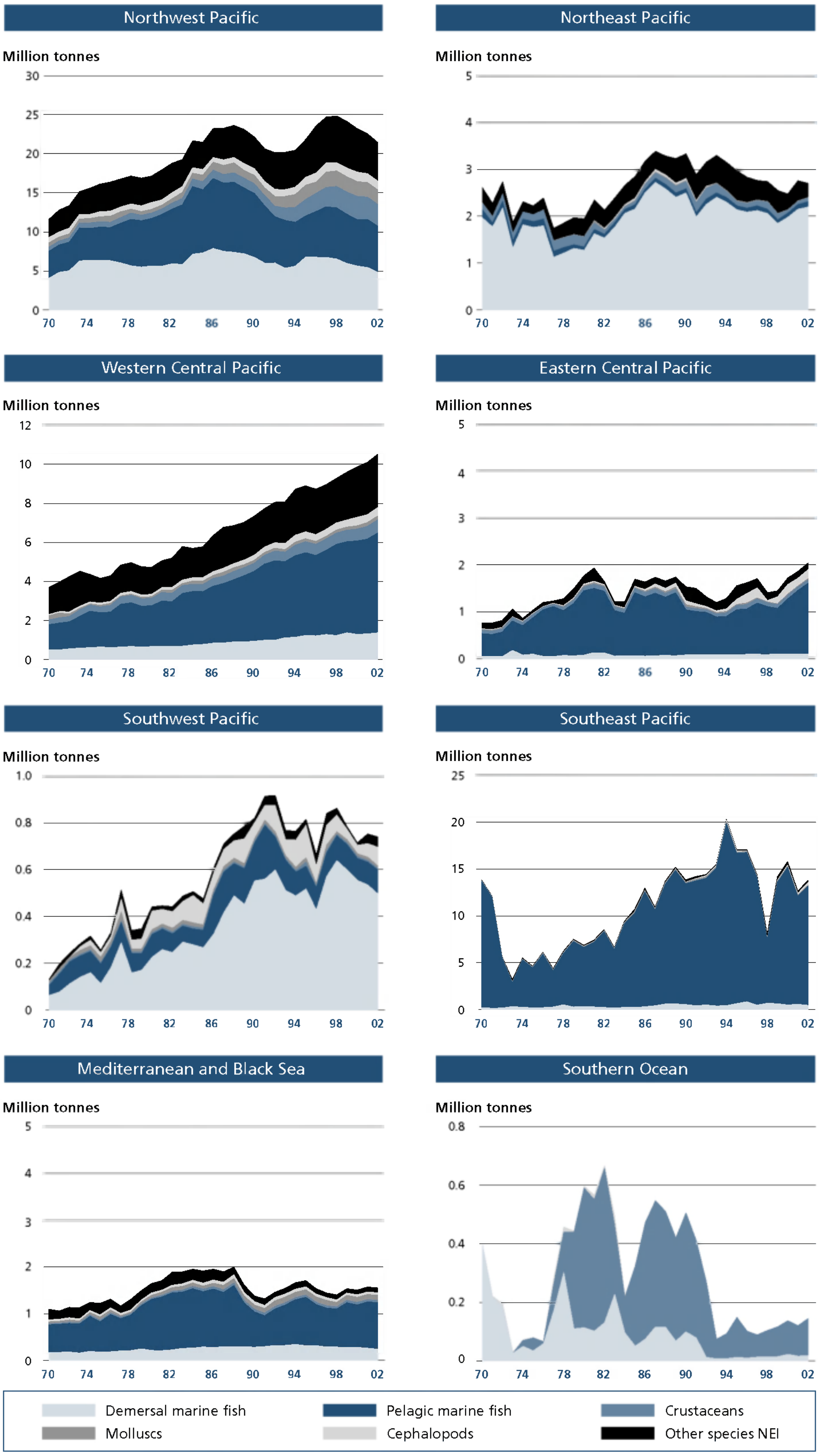
Capture fisheries production in marine areas



(Continued)

Figure 18 *(cont.)*

Capture fisheries production in marine areas



Notes: Data exclude aquatic plants and catches of marine mammals, sponges and corals, etc.
NEI = not elsewhere included.

with a tendency to stabilize since 1998. Skipjack tuna accounts for about 50 percent of this total, with a reported catch of 2 million tonnes, and remains one of the top species in world fisheries production.

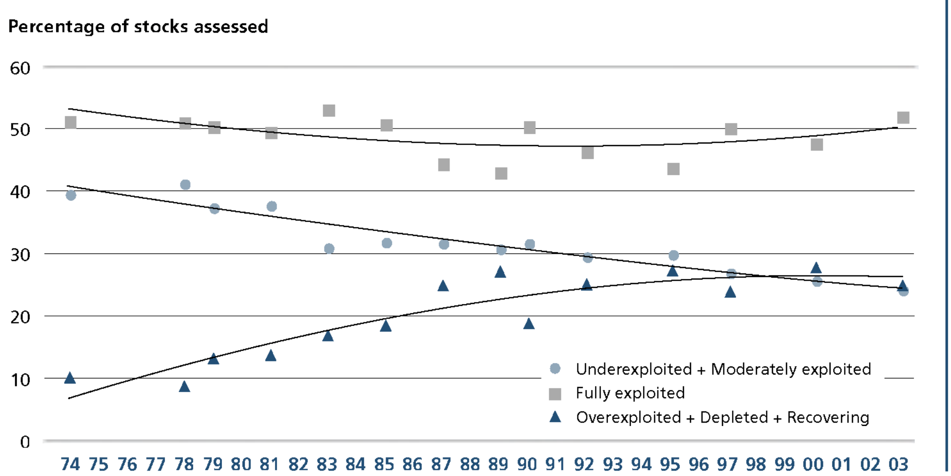
A recurring pattern in some areas is a long-term change in catch composition following the depletion of more traditional stocks and the targeting of other less-valuable and previously lightly exploited or non-exploited species (Figure 18). For instance, in the Northwest Atlantic invertebrate catches (molluscs and crustaceans) have increased and those of demersal fish have declined. In the Northeast Atlantic, the continuous decline in cod catches since the late 1960s has been counterbalanced by increasing catches of formerly low-valued fish species such as blue whiting and sand eels. In the Southwest Atlantic, the decline of the Argentine hake has been accompanied by an increasing trend in catches of shortfin squid. The decline in catches of pilchard (or sardine) and pollock in the Northwest Pacific has been partially compensated for by increases in catches of Japanese anchovy, largehead hairtail and squids. These changes in the species composition of fisheries catches can have different causes, including the adaptation of the industry and markets to resources previously considered as low-value, the effect of fisheries on the structure of marine communities, and changes in environmental regimes affecting the stock productivity. These effects are often difficult to discern, particularly in areas where research and monitoring of resources and environment processes are poorly developed.

FAO monitors the state of exploitation of the main fish stocks or groups of resources for which assessment information is available. The current global situation follows the general trend observed in previous years. It is estimated that in 2003 about one-quarter of the stocks monitored were underexploited or moderately exploited (3 percent and 21 percent respectively) and could perhaps produce more. About half of the stocks (52 percent) were fully exploited and therefore producing catches that were close to their maximum sustainable limits, while approximately one-quarter were overexploited, depleted or recovering from depletion (16 percent, 7 percent and 1 percent respectively) and needed rebuilding. From 1974 to 2003 there was a consistent downward trend in the proportions of stocks offering potential for expansion. At the same time there was an increasing trend in the proportion of overexploited and depleted stocks, from about 10 percent in the mid-1970s to close to 25 percent in the early 2000s (Figure 19).

Of the top ten species that account in total for about 30 percent of the world capture fisheries production in terms of quantity (Figure 6, p. 9), seven correspond to stocks that are considered to be fully exploited or overexploited (anchoveta, Chilean

Figure 19

Global trends in the state of world marine stocks since 1974



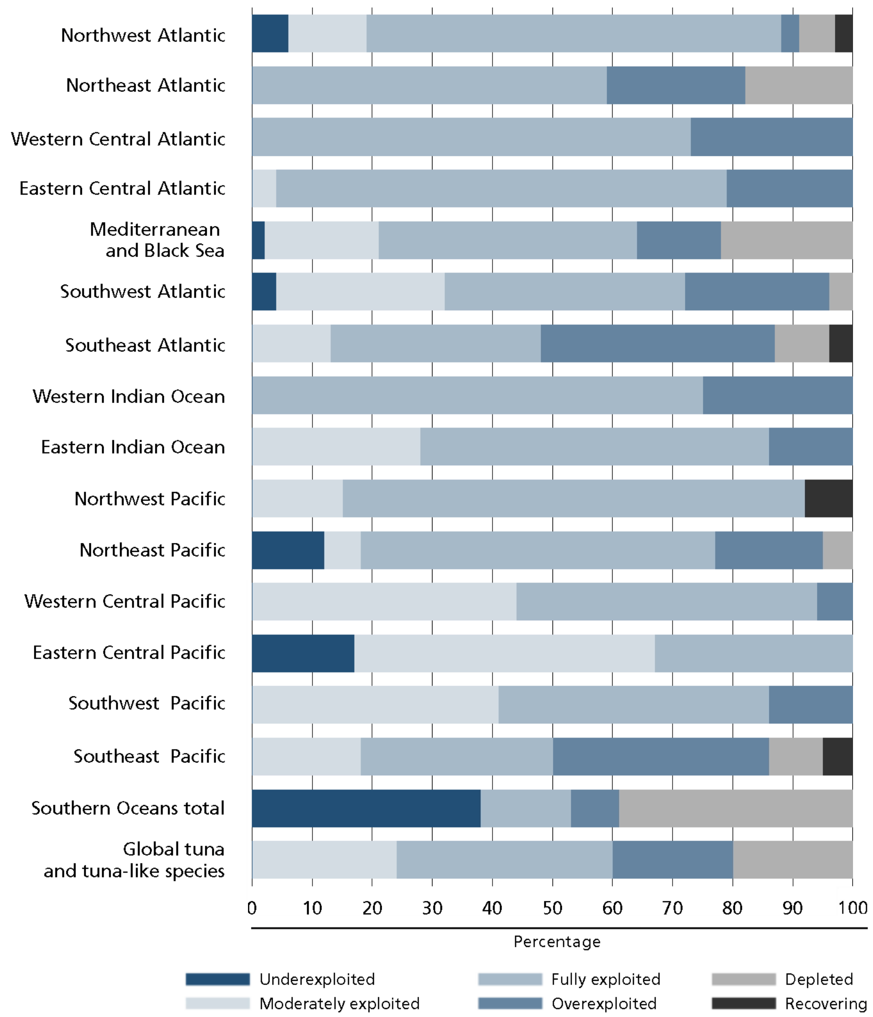
jack mackerel, Alaska pollock, Japanese anchovy, blue whiting, capelin and Atlantic herring). Major increases in catches cannot therefore be expected from these. Two species could probably support higher fishing pressure in some areas (skipjack tuna and chub mackerel) and the status of the remaining species (largehead hairtail) is unknown.

In the Southeast Pacific, a combination of high fishing pressure and adverse environmental conditions, including the severe El Niño event of 1997–98, led to a sharp decline in catches of the two leading species (anchoveta and Chilean jack mackerel) during the late 1990s. While the stock of anchoveta has shown signs of recovery, with catches in the order of 10 million tonnes since 2000, catches of Chilean jack mackerel totalled 1.7 million tonnes in 2002, representing less than 50 percent of the fishery's historical peak production reached in 1994. In the North Pacific large changes in catches occurred in response to heavy fishing and to natural decadal oscillations in the productivity of pilchard (or sardine), anchovy and pollock. Following record catches in the 1980s, the Japanese sardine (or pilchard) fishery collapsed in the mid-1990s and was followed by a strong rebuild of the anchovy population, which has been supporting catches of close to 2 million tonnes since 1998. This alternation between sardine and anchovy stocks follows a pattern observed in many other regions of the world and seems to be mainly governed by climatic regimes affecting stock production. The stocks of pollock in the Northwest Pacific are considered overexploited, while those in the Northeast Pacific are considered fully exploited. Pollock catches peaked in the late 1980s in both areas and have been declining since then, although a recent modest recovery is evident in the Northeast Pacific. In the Northeast Atlantic, catches of blue whiting reached record levels (1.8 million tonnes) in 2001 and declined slightly in 2002. The stock is currently under heavy fishing and requires more restrictive management measures. Capelin and herring are exploited to their full potential and are currently considered within safe biological limits. Catches of skipjack tuna have increased steadily since 1950 and reached their highest reported value of around 2 million tonnes in 2002, representing about half of the total capture of market tunas. The status of skipjack tuna stocks is highly uncertain but there are indications that some potential remains for increases in catches in the Eastern, Western and Central Pacific and in the Indian Ocean, provided that these increases in skipjack catches will not lead to parallel increases in catches of other species that are presently fully exploited or overexploited, for example bigeye and yellowfin tunas.

The percentage of stocks exploited at or beyond their maximum sustainable levels varies greatly by area. In the Eastern Central Pacific, only 33 percent of the stocks for which assessment information is available are recorded as fully exploited, with the remainder being either underexploited or moderately exploited, whereas in the Western Central and Northeast Atlantic and the Western Indian Ocean, all the stocks for which information is available are reported as being fully exploited (73 percent, 59 percent and 75 percent respectively) or as being exploited beyond this level (Figure 20). In 12 of the 16 FAO statistical regions at least 70 percent of stocks are already fully exploited or overexploited, suggesting that that the maximum fishing potential has been reached and that more cautious and restrictive management measures are needed. This conclusion is also supported by analysis of the trend in fisheries production of the regions. Four of the 16 regions are at their maximum historical level of production, while in 12 regions production has declined slightly and in four the declines have been sharper, including the Northwest Atlantic (50 percent decline from a peak in 1968), Southeast Atlantic (47 percent decline from a peak in 1978) and Southeast Pacific (31 percent decline from a peak in 1994). In most cases overfishing has been a main contributory factor and in some cases this has been associated with adverse or highly variable environmental conditions. All the information available tends to confirm the estimates made by FAO in the early 1970s that the global potential for marine capture fisheries is about 100 million tonnes, of which only 80 million tonnes are probably achievable. It also confirms that, despite local differences, overall, this limit has been reached. These conclusions lend support to the call for more rigorous stock recovery plans to rebuild stocks that have been

Figure 20

State of exploitation of marine fishery resources



depleted by overfishing and to prevent the decline of those being exploited at or close to their maximum potential.

In response to worldwide public concerns, countries have been promoting, through FAO and the World Summit on Sustainable Development held in Johannesburg, South Africa, in 2002, an extension of the usual policies and management focus from single fishery stocks to ecosystems. This implies an increasing demand for better understanding and monitoring of a wide range of processes affecting or affected by fisheries. Some of the most important management concerns today are the effects of fisheries on habitats, marine communities, and ecological interactions (such as predator–prey relationships), as well as the those of land-based activities and climatic changes on fisheries. The lack of selectivity in many fisheries, which leads to bycatch and discards (the unintended catch of non-targeted species and their subsequent discarding) is an additional management concern. Bycatch may increase fishing pressure on resources targeted by other fisheries, possibly aggravating overfishing, and can also have undesirable impacts on endangered and protected species such as sea turtles and certain species of marine mammals, sea birds and sharks. Discards of inedible, non-commercial, or undersized species and individuals represent collateral damage to the ecosystem, a waste of resources and an additional source of overfishing (see pp. 122–127).

Coastal development (including urban and industrial expansion and aquaculture) and industrial activities in the hinterland also pose many threats to the health of marine ecosystems when they pollute and degrade critical coastal habitats. These land-based and coastal alterations adversely affect the livelihoods of coastal fishing communities and industries, for example through a reduction of the sustainable yield of fish stocks; modification of the resource species composition, health and diversity; an increase in ecosystem instability and variability and a reduction of seafood quality and safety. Periodic climatic phenomena such as El Niño can have a drastic impact on fish populations and lead to the collapse of fisheries (e.g. the Peruvian anchoveta in the Southeast Pacific in the early 1970s). Over the longer term, many fish stocks follow decadal fluctuations that seem to respond to natural climatic cycles. The effect of climate on fisheries is exacerbated in a situation of overfishing, when both fish stocks and fishing industries become more vulnerable to the natural dynamics of the environment. The assessment of these and other ecosystem–fisheries interactions is still in its infancy and much more needs to be known about their effects on fishery resources, fishing communities and industries, their causes and trends, and how to deal with and adapt to them. The state of fishery resources and their ecosystems, however, allows little room for delay in the implementation of measures that should have been taken in the last three decades. Therefore the precautionary approach to fisheries, recommended by UNCED, the United Nations Fish Stocks Agreement[13] and the FAO Code of Conduct for Responsible Fisheries[14] needs to be implemented in practice.

Inland fisheries

Unlike the major marine fish stocks, inland fish stocks are less well defined and occur over much smaller geographical areas, such as individual lakes, rice fields or rivers, or over vast areas such as transboundary watersheds that are often situated in areas that are difficult to access. These factors make it costly to monitor the exploitation and status of fish stocks and, in fact, very few countries can afford to do so. As a result, the majority of countries report only a small fraction of their catch of inland fisheries by species, further compounding the problem of accurate assessment. Thus FAO is not in a position to make global statements on the status of these resources.

It was reported in *The State of World Fisheries and Aquaculture 2000* that inland fishery resources are undervalued and under threat from habitat alteration, degradation and unsustainable fishing activities. This trend unfortunately appears to be continuing. LARS 2, a recent symposium on managing the fisheries of large rivers,[15] noted that the availability of global information on river fisheries is poor, that over 50 percent of inland fish species occur in rivers and that rivers contain a higher proportion of organisms classed as endangered or threatened than do most other ecosystems. Many river basins, especially in developing countries, support intensive fisheries and in many cases catches have increased, although changes in their species composition have occurred as catches of large and late-maturing species have declined. River fisheries continue to provide substantial catches in developing countries, even in the face of intensive exploitation. However, in the Mekong River, for the first time, there is evidence that stocks are being overfished.[16] Numerous lake fisheries are also

[13] The Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks was adopted and opened for signature in 1995. For further information, see http://www.un.org/Depts/los/convention_agreements/convention_overview_fish_stocks.htm; accessed September 2004.

[14] Adopted by the 28th Session of the FAO Conference in October 1995. For further information, see http://www.fao.org/DOCREP/005/v9878e/v9878e00.htm; accessed September 2004.

[15] Second International Symposium on the Management of Large Rivers for Fisheries: Sustaining Livelihoods and Biodiversity for the New Millennium, Phnom Penh, Cambodia, 11–14 February 2003. For further information, see http://www.lars2.org; accessed September 2004.

[16] C. Barlow, Fisheries Unit, Mekong River Commission, personal communication, April 2004.

showing signs of overexploitation. In Lake Victoria, for example, the Nile perch fishery decreased from a record catch of 371 526 tonnes in 1990 to 241 130 tonnes in 2002. Sturgeon fisheries in the countries surrounding the Caspian Sea have also decreased, from approximately 20 000 tonnes in 1988 to less than 1 400 tonnes in 2002, owing to a combination of illegal fishing, overfishing and habitat degradation. Inland fishes in general have been characterized as the most threatened group of vertebrates used by humans.[17]

Nevertheless, the status of some inland fishery resources has been enhanced in many areas through stocking programmes, the introduction of alien species, habitat engineering and habitat improvement. In many developing areas, especially in Asia, rice fields and irrigated areas are enhanced to increase the production of aquatic biodiversity other than rice, and to improve the nutritional status of rural households.[18] Enhancement can make the resources more stable, easily harvested and valuable.

FISH UTILIZATION

In 2002, about 76 percent (100.7 million tonnes) of estimated world fish production was used for direct human consumption (Table 1, p. 3). The remaining 24 percent (32 million tonnes) was destined for non-food products, in particular the manufacture of fishmeal and oil. If China is excluded, the shares are 74 percent (65.5 million tonnes) and 26 percent (23 million tonnes), respectively (Table 2, p. 4 and Figure 2, p. 5). More than 79 percent (35 million tonnes) of China's reported fish production (44 million tonnes) was apparently used for direct human consumption, the bulk of which was in fresh form (75.5 percent). The remaining amount (an estimated 9.1 million tonnes) was reduced to fishmeal and other non-food uses, including direct feed for aquaculture.

In 2002, 70 percent (62 million tonnes) of the world's fish production, excluding China, underwent some form of processing. Sixty-three percent (39 million tonnes) of this processed fish was used for manufacturing products for direct human consumption and the rest for non-food uses. The many options for processing fish allow for a wide range of tastes and presentations, making fish one of the most versatile food commodities. Yet, unlike many other food products, processing does not generally increase the price of the final product and fresh fish is still the most widely accepted product on the market. During the 1990s, the proportion of fish marketed in live/fresh form worldwide increased compared with other products (Figures 21 and 22). Excluding China, live/fresh fish quantity increased from an estimated 17 million tonnes in 1992 to 26 million tonnes in 2002, representing an increase in its share in total production from 20 percent to 30 percent. Processed fish for human consumption (frozen, cured and canned) remained relatively stable at around 39 million tonnes. Freezing represents the main method of processing fish for food use, accounting for 53 percent of total processed fish for human consumption in 2002, followed by canning (27 percent) and curing (20 percent). In developed countries, the proportion of fish that is frozen has been constantly increasing, and it accounted for 42 percent of production in 2002. By comparison, the share of frozen products was 13 percent of total production in developing countries, where fish is largely marketed in fresh/chilled form.

Utilization of fish production shows marked continental, regional and national differences. The proportion of cured fish is higher in Africa (16 percent in 2002) and Asia (11 percent) compared with other continents. In 2002, in Europe and North America, more than two-thirds of fish used for human consumption was in frozen and

[17] M.N. Bruton. 1995. Have fishes had their chips? The dilemma of threatened fishes. *Environmental Biology of Fishes*, 43: 1–27.

[18] M. Halwart. 2003. Traditional use of aquatic biodiversity in rice-based ecosystems. *FAO Aquaculture Newsletter*, 29: 9–15.

Figure 21

Trend in utilization of world fisheries production, 1962–2002

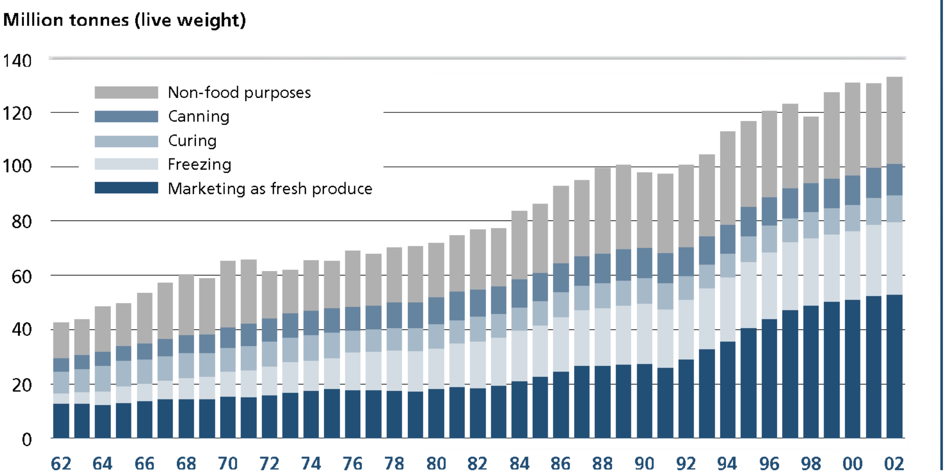
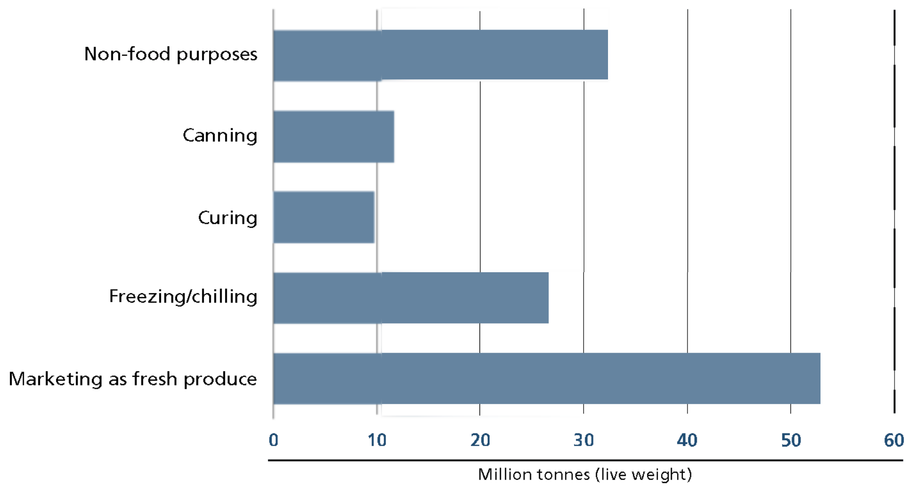


Figure 22

Utilization of world fisheries production (breakdown by quantity), 2002



canned forms. In Africa and Asia, the share of fish marketed in live or fresh forms was particularly high. Unfortunately, it is not possible to determine the exact amount of fish marketed in live form from available statistics. The sale of live fish to consumers and restaurants is especially strong in Southeast Asia and the Far East.

In 2002, almost all the fish products used for non-food purposes came from natural stocks of small pelagics, which represented 37 percent of total capture fisheries. Most of these fishery products were used as raw material for the production of animal feed and other products. Ninety percent of world fish production (excluding China) destined for non-food purposes was reduced to fishmeal/oil; the remaining 10 percent was largely utilized as direct feed in aquaculture and for fur animals. The quantity of pelagic fish used for animal feed (21 million tonnes) was slightly (3 percent) higher than that in 2001, when production was 13 percent lower than levels in 2000. But it is still well below peak levels of more than 29 million tonnes recorded in the mid-1990s.

Fish consumption

In 2002, average apparent per capita consumption of fish, crustaceans and molluscs worldwide was estimated to be about 16.2 kg, 21 percent higher than in 1992 (13.1 kg). This growth is largely attributable to China, whose estimated share of world fish production increased from 16 percent in 1992 to 33 percent in 2002. If China is excluded, the per capita fish supply would be 13.2 kg, almost the same as in 1992. Following a peak of 14.6 kg in 1987, world per capita fish supply, excluding China, showed a declining trend from the late 1980s to the early 1990s but has stabilized since then (Figure 2, p. 5). The declining trend was mainly caused by population growth outpacing that of food fish supply during the 1987–2002 period (1.3 percent per annum compared with 0.6 percent, respectively). For China, the corresponding annual increase since 1987 was 1.1 percent for population growth and 8.9 percent for food fish supply. In 2002, per capita fish supply in China was about 27.7 kg.

Fish represents a valuable source of micronutrients, minerals, essential fatty acids and proteins in the diet of many countries.[19] It is estimated that fish contributes up to 180 kilocalories per capita per day, but reaches such high levels only in a few countries where there is a lack of alternative protein foods, and where a preference for fish has been developed and maintained (for example in Iceland, Japan and some small island developing states). More commonly, fish provides about 20 to 30 kilocalories per capita per day. Fish proteins are a crucial dietary component in some densely populated countries, where the total protein intake level may be low, and are significant in the diets of many other countries. For instance, fish contributes to, or exceeds 50 percent of total animal proteins in some small island developing states and in Bangladesh, Cambodia, the Congo, the Gambia, Ghana, Equatorial Guinea, Indonesia, Japan, Sierra Leone and Sri Lanka. Overall, fish provides more than 2.6 billion people with at least 20 percent of their average per capita intake of animal protein. The share of fish proteins in total world animal protein supplies rose from 14.9 percent in 1992 to a peak of 16.0 percent in 1996, before declining slightly to 15.9 percent in 2001. Corresponding figures for the world, excluding China, show an increase from 14.3 percent to 14.7 percent in 2001 during the same period. Figure 23 presents the contributions of major food groups to total protein supplies.

In industrialized countries (Table 10), apparent fish consumption rose from 24 million tonnes (live weight equivalent) in 1992 to 26 million tonnes in 2001, with a rise in per capita consumption from 28.0 kg to 28.6 kg. The contribution of fish to total protein intake declined slightly from 8.0 percent in 1992 to 7.7 percent in 2001. In these countries, the share of fish in total protein intake rose consistently until 1989 (by between 6.5 percent and 8.5 percent), when it began a gradual decline as the consumption of other animal proteins began to increase; by 2001, its contribution was back at the levels prevailing in the mid-1980s. Since the early 1990s, consumption of fish protein has remained relatively stable at around 8.1–8.3 g per capita per day, while the intake of other animal proteins has continued to rise.

In 1992 the average per capita apparent fish supply in low-income food-deficit countries (LIFDCs) was 9.5 kg – only one-third of the estimated supply in the richest countries. The gap has been reduced progressively and by 2001 average per capita consumption (14.0 kg) had reached more than half that of the more affluent economies. However, if China is excluded, per capita supply in the other LIFDCs is still relatively low, at an estimated 8.5 kg in 2001, with a growth rate of less than 1 percent per year since 1992. Notwithstanding the relatively low fish consumption by weight in LIFDCs, the contribution of fish to total animal protein intake in 2001 was significant at more than 20 percent, and may be higher than indicated by official statistics in view of the unrecorded contribution of subsistence fisheries. However, the share of fish proteins in

[19] The term "fish" indicates fish, crustaceans, molluscs, excluding aquatic mammals and aquatic plants.

Figure 23

Total protein supply by continent and major food group (1999–2001 average)

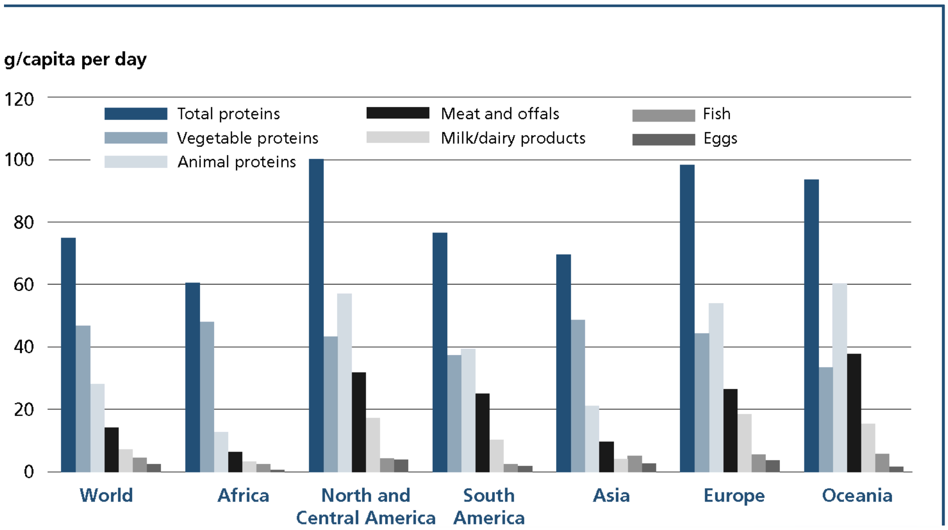


Table 10
Total and per capita food fish supply by continent and economic grouping in 2001

	Total food supply *(million tonnes live weight equivalente)*	Per capita food supply *(kg/year)*
World	**100.2**	**16.3**
World excluding China	**67.9**	**13.9**
Africa	6.3	7.8
North and Central America	8.5	17.3
South America	3.1	8.8
China	32.3	25.6
Asia (excluding China)	34.8	14.1
Europe	14.4	19.8
Oceania	0.7	23.0
Industrialized countries	26.0	28.6
Economies in transition	4.7	11.4
LIFDCs (excluding China)	22.5	8.5
Developing countries excluding LIFDCs	14.9	14.8

Note: Based on data available to FAO in December 2003. Some discrepancy may occur with other sections that quote data made available to FAO more recently.

animal proteins has continued unchanged over the past three decades as a result of the fast growth in the consumption of other animal proteins.

The role of fish in nutrition shows marked continental, regional and national differences as well as income-related variations (Figures 24 and 25). For example, worldwide, 100 million tonnes were available for consumption in 2001, but only 6.3 million tonnes were consumed in Africa (7.8 kg per capita); two-thirds of the total were consumed in Asia, of which 34.8 million tonnes were consumed outside China (14.1 kg per capita) and 32.3 million tonnes in China alone (25.6 kg per capita). Per capita consumption in Oceania was 23.0 kg, in North America 21.6 kg, in

Box 3

Mainstreaming fisheries into national development and poverty reduction strategies

The fisheries sector plays an important role in the alleviation of poverty and the achievement of food security in many parts of the world. Fisheries exports now generate more foreign exchange (either through export earnings or licence receipts) than the revenues earned from any other traded food commodity such as rice, cocoa, coffee or tea. Worldwide, more than 38 million people are directly engaged in fishing and fish farming as a full-time or, more frequently, part-time occupation, and fishery products account for 15–16 percent of global animal protein intake. Seventy percent of the fish for human consumption is presently supplied by developing countries. The fisheries sector is particularly important for 44 countries (15 small island developing states [SIDS], 12 African and 12 Asian countries, 3 transition economies and 2 Latin American countries) where the sector makes a significant contribution to both exports and domestic nutritional intake.[1] However, this contribution is generally not reflected in the national policies of these countries.

A recent study[2] showed that many national development plans [NDPs], poverty reduction strategy papers [PRSPs], World Bank Country Assistance Strategies and EU Country Strategy Papers only briefly acknowledge the fisheries sector. In general, national policy documents fail to integrate substantially the fisheries sector; nor do they recognize the causal linkages between fisheries and poverty. The sector has been most effectively mainstreamed in Asia (in the case of PRSPs and NDPs), closely followed by the African economies and the SIDS. By contrast, Latin America, which is home to two of the top six global fishing nations (Chile and Peru), scores extremely poorly in this regard.

In addition, an approach to fisheries mainstreaming that pays attention to gender roles is only apparent in a few national policy documents notwithstanding the marked demarcation of the sector in gender role terms. Moreover, despite FAO's wide-ranging efforts to promote the sustainable exploitation of aquatic living resources in harmony with the environment, through the Code of Conduct for Responsible Fisheries, just one NDP (Malaysia) makes explicit reference to the Code.

Further efforts should therefore be made to ensure the effective integration of fisheries into key national policy documents relating to poverty reduction and rural development, paying particular attention to gender issues and internationally recognized fishery development instruments such as the Code of Conduct for Responsible Fisheries.

[1] The sector was deemed to be significant in those instances where the contribution of fisheries to agricultural export trade and daily animal protein intake is greater than 10 per cent.

[2] FAO. 2004. *Mainstreaming fisheries into national development and poverty reduction strategies: current situation and opportunities*, by A. Thorpe. FAO Fisheries Circular No. 997. Rome.

Europe 19.8 kg, in Central America and the Caribbean 9.3 kg and in South America 8.7 kg.

In 2002, 60.5 percent of the world food fish supply originated from capture fisheries production; the remaining amount came from aquaculture (Figure 26). The contribution of inland and marine capture fisheries to per capita food supply declined slightly in the last decade and in particular since 1997, with a decrease of the per capita supply from almost 10.8 kg in 1997 to 9.8 kg in 2002. Worldwide, excluding China, per capita food fish supply from capture fisheries declined from 11.5 kg in 1997 to 10.8 kg in 2002. On the other hand, excluding China, the average contribution of aquaculture to per capita supply grew from 13.0 percent in 1992 to 18.4 percent in 2002, corresponding to an increase from 1.7 kg per capita in 1992 to 2.4 kg in 2002 (average annual growth of 3.5 percent). Corresponding figures for China indicate an increase from 55.5 percent in 1992 to 79.8 percent in 2002. The per capita supply from aquaculture in China is reported to have increased from 7.1 kg in 1992 to 21.8 kg in 2002, implying an annual average growth of 11.9 percent.

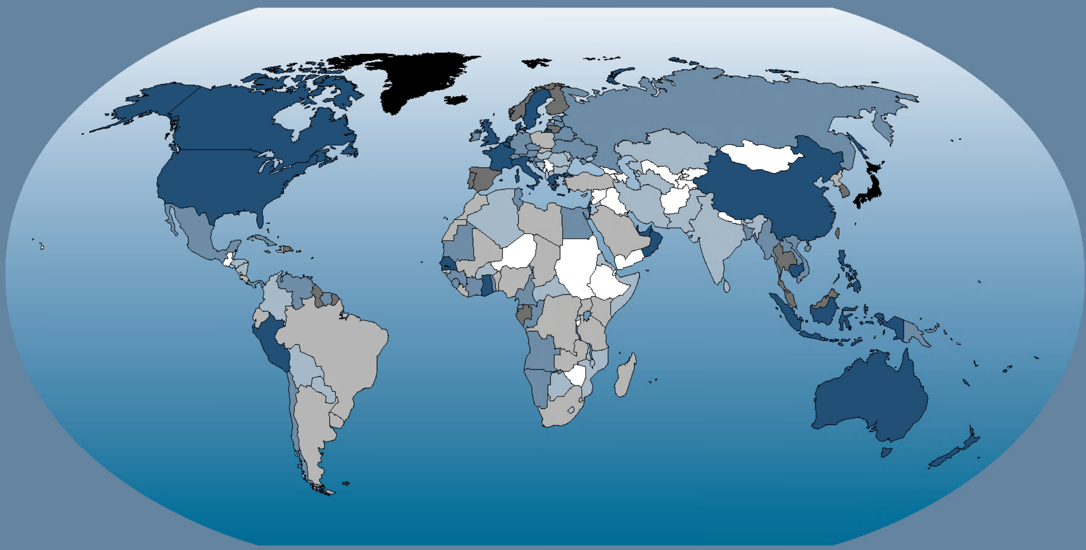
Fish consumption is distributed unevenly around the globe; there are significant differences among countries, with per capita apparent consumption ranging from less than 1 kg per capita to more than 100 kg. Geographical differences are also evident within countries, with consumption usually being higher in coastal areas. Dietary consumption patterns are influenced by complex interactions of several factors such as availability, income, prices, tradition and tastes, as well as demographic and lifestyle trends. Over the last few years, the consumption of fish and fishery products has been strongly influenced by improvements in transportation, in marketing and in food science and technology, which have led to significant improvements in efficiency, lower costs, wider choice and safer and improved products. The extent and range of these changes have varied among regions. In general, there has been a growth of fish and fishery products marketed in fresh form and in the production of ready-to-cook or ready-to-eat products, particularly in wealthy economies.

Differences in consumption patterns by species are even more marked. Demersal fish are preferred in northern Europe and North America, whereas cephalopods are consumed extensively in several Mediterranean and Asian countries, but to a much lesser extent in other regions. Despite the fast-growing contribution of aquaculture to food fish supplies and related reduction in the price of traded commodities, crustaceans are still high-priced commodities and their consumption is mostly concentrated in affluent economies. Of the 16.3 kg of fish per capita available for consumption in 2001, the vast majority (74 percent) comprised finfish. Shellfish supplied 25 percent – or about 4 kg per capita, subdivided into 1.5 kg of crustaceans, 2.0 kg of molluscs and 0.5 kg of cephalopods.

Freshwater and diadromous species accounted for 29 million tonnes of the total supply (about 4.7 kg per capita). Marine finfish species provided more than 45 million tonnes, of which almost 18 million tonnes were demersal species, 19 million tonnes pelagics and 9 million tonnes unidentified marine fish. The remaining share of the total food supply consisted of shellfish, of which 9.2 million tonnes were crustaceans, 3.3 million tonnes were cephalopods and 12.7 million tonnes were other molluscs. Historically, there have not been any dramatic changes in the share of most of the broader groups in average world consumption: demersal fish species have stabilized at around 2.9 kg per capita and pelagic fish at 3.0 kg. Crustaceans and molluscs are exceptions in that they showed a considerable increase between 1961 and 2001: the per capita availability of crustaceans increased more than three-fold, from 0.4 kg to 1.5 kg (mainly as a result of the increased production of shrimps and prawns from aquaculture), and the availability of molluscs (excluding cephalopods) increased from 0.6 kg to 2.1 kg per capita.

Figure 24

Fish as food: per capita supply (average 1999–2001)

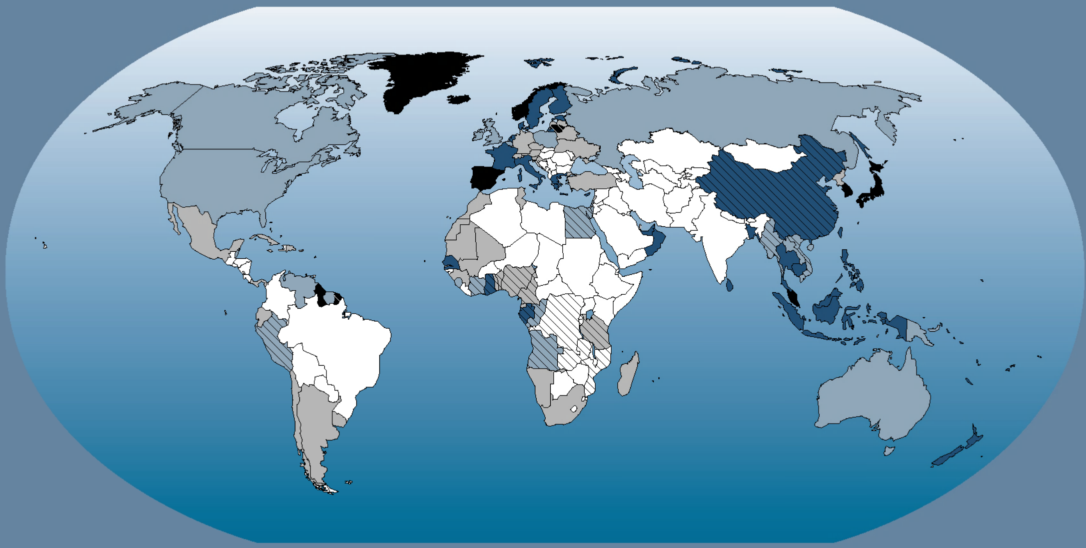


Average per capita fish supply (in live weight equivalent)

- 0–2 kg/year
- 2–5 kg/year
- 5–10 kg/year
- 10–20 kg/year
- 20–30 kg/year
- 30–60 kg/year
- > 60 kg/year

Figure 25

Contribution of fish to animal protein supply (average 1999–2001)



Fish proteins (per capita per day)

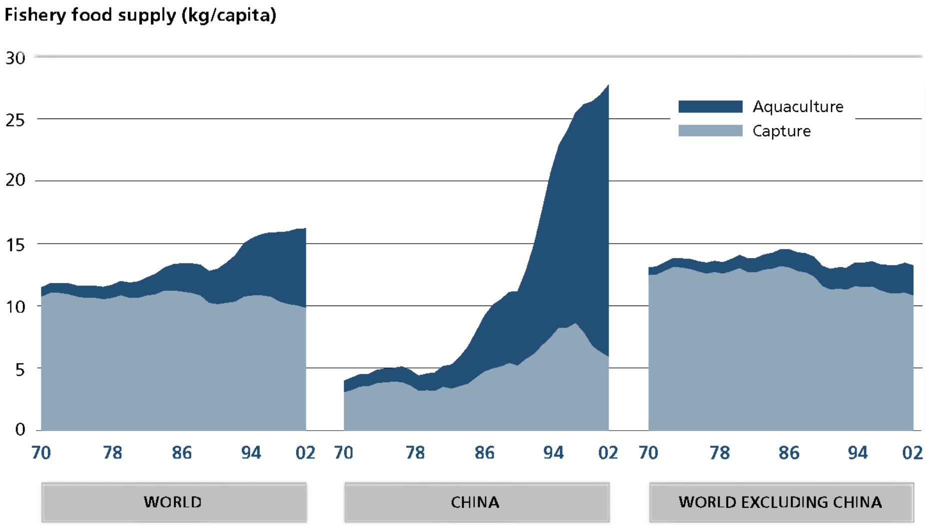
- < 2 g
- 2–4 g
- 4–6 g
- 6–10 g
- > 10 g

Contribution of fish to animal protein supply

- > 20%

Figure 26

Relative contribution of aquaculture and capture fisheries to food fish consumption



FISH TRADE

In 2002, total world trade of fish and fish products increased to US$58.2 billion (export value), representing a 5 percent increase relative to 2000 and a 45 percent increase since 1992 (Figure 27). In terms of quantity, exports were reported to be 50 million tonnes (live weight equivalent), having grown by 40.7 percent since 1992, but showing a slight decline (1.0 percent) compared with 2000 levels. The quantity of fish traded has remained stagnant over the last few years following decades of strong increases. Many of the economic factors responsible for the high growth in world fishery trade in the previous decade have now diminished in importance or are not strong enough to sustain past performance levels. While preliminary estimates for 2003 indicate a slight increase in the value of fishery exports, it is unlikely that the trends of pre-2000 years will be repeated in the short term, especially given setbacks resulting from geopolitical tensions.

In 2002, China overtook Thailand for the first time to become the world's main exporter of fish and fish products, with exports valued at an estimated US$4.5 billion. Notwithstanding this achievement, China's fishery exports represented only 1.4 percent of its total merchandise exports and 25 percent of its agricultural exports (excluding forestry products). China has experienced remarkable increases in its fishery exports since the early 1990s (average growth of 11 percent per year in the period 1992–2002) and in particular since 1999 (average growth of 24 percent in 1999–2002). These increases are linked to growing production, as well as to the development of China's fish-processing industry. The latter offers competitive labour and production costs. In addition to exports from domestic fisheries production, China also exports reprocessed imported raw material, creating a strong value-addition in the process. Imports of fish and fish products have increased significantly over the last decade, rising from US$0.7 billion in 1992 to US$2.2 billion in 2002, making China the world's eighth largest fish importer. The growth was particularly marked in the last few years, with a 94 percent increase in imports from 1999. With its accession to the World Trade Organization (WTO) in late 2001, China had to commit itself to lowering its import duties, which decreased from an average import tariff as high as 15.3 percent in 2001 to 11 percent in 2003 and 10.4 percent in 2004.

In 2002, Thailand, which had been the main exporter of fish and fish products since 1993, reported export values of US$3.7 billion, 9 percent lower than in 2001 and 16 percent below 2000 values. Norway was the third largest exporter with exports

Box 4

Fish contaminants

Introduction

Several organic and inorganic compounds can find their way into fish and seafood. These compounds can be divided into three major groups:

- **Inorganic chemicals:** arsenic, cadmium, lead, mercury, selenium, copper, zinc and iron.
- **Organic compounds:** polychlorinated biphenyls (PCBs), dioxins and insecticides (chlorinated hydrocarbons). This is a very diverse group with a wide range of industrial uses and a chemical stability that allows them to accumulate and persist in the environment.
- **Processing-related compounds:** sulphites (used in shrimp processing), polyphosphates, nitrosamines and residues of drugs used in aquaculture (e.g. antibiotics or hormones).

Many of the inorganic chemicals are essential for life at low concentration but become toxic at high concentration. While minerals such as copper, selenium, iron and zinc are essential micronutrients for fish and shellfish, other elements such as mercury, cadmium and lead show no known essential function in life and are toxic even at low concentrations when ingested over a long period. These elements are present in the aquatic environment as a result of natural phenomena such as marine volcanism and geological and geothermal events, but are also caused by anthropogenic pollution arising from intensive metallurgy and mining, waste disposal and incineration, and acidic rain caused by industrial pollution. This is in contrast with organic compounds, most of which are of anthropogenic origin brought to the aquatic environment by humans.

Increasing amounts of chemicals may also be found in predatory species as a result of *biomagnification*, which is the concentration of the chemicals in higher levels of the food chain. Similarly, they may be present as a result of *bioaccumulation*, when chemicals in the body tissues accumulate over the life span of the individual. In this case, a large (i.e. older) fish will have a higher content of the chemical concerned than a small (younger) fish of the same species. The presence of chemical contaminants in seafood is therefore highly dependent on geographic location, species and fish size, feeding patterns, solubility of chemicals and their persistence in the environment.

Risks from fish contaminants

But what are the risks to human health caused by these contaminants as a result of consuming fish and seafood?

Several studies indicate that in the open seas, which are still almost unaffected by pollution, fish mostly carry only the natural burden of these inorganic chemicals. However, in heavily polluted areas, in waters that have insufficient exchange with the world’s oceans (e.g. the Baltic Sea and the Mediterranean Sea), in estuaries, in rivers and especially in locations that are close to industrial sites, these elements can be found at concentrations that exceed the natural load.

Likewise, several studies have concluded that levels of these chemicals in fish intended for human consumption are low and probably below levels likely to affect human health. Nevertheless, they

can be of potential concern for populations for whom fish constitutes a major part of the diet and for pregnant and nursing women and young children who consume substantial quantities of oily fish. These concerns can only be clarified if updated and focused risk assessments are conducted.

While scientists and other experts recognize that certain of these elements are present naturally in fish and seafood, some consumers regard their presence even at minimal levels as a hazard to health. Consequently, food scares can be easily started and further amplified if communication is mismanaged – particularly given the growing speed of communication and information dissemination facilitated by the Internet. A number of such scares concerning fish contaminants have recently led to significant negative impacts on fish trade flows.

Example 1: Mercury in fish

In 2003, the Codex Joint Expert Committee on Food Additives (JECFA), administered by FAO and the World Health Organization (WHO), revised the guideline for mercury in fish to 1.6 micrograms of methyl mercury intake per day per kilogram of body weight, nearly half the original guideline of 3.3 micrograms.[1] At the same time, the JECFA review emphasized that people should continue to eat a normal diet of fish, pointing out its many health benefits. Included in its considerations was the recently released Seychelles Islands study, which analyzed mother and child pairs and fish consumption for almost ten years. That study determined that high levels of fish consumption led to no adverse effect to a foetus or child's neurodevelopment.

In order to translate the recommended weekly intake of mercury into national maximum mercury levels in fish it is necessary to take into account consumption patterns, other sources of mercury intake and other relevant information. However, public pressure often leads to consumer confusion between the maximal allowable levels necessary to protect human health and the limits recommended to protect the environment. The latter require that appropriate actions be taken consistently and for a significant period of time in order to reduce the environmental burden of the contaminant. In the case of mercury, for example, proper energy policies would be required to reduce reliance on coal-fired power stations and the reduction of waste incineration; these two factors combined account for 70 percent of new, human-made mercury emissions to the atmosphere.

Unfortunately, a number of media articles and public health warnings exacerbated the pre-existing consumer confusion and sent out conflicting messages regarding the health benefits of fish and seafood and the mercury risks from fish to the point that local authorities in California, the United States, instructed grocery retailers to display signs cautioning consumers about the dangers of mercury in fish and threatened to sue those that did not abide.

[1] FAO/WHO. 2003. *Summary and conclusions*. Joint Expert Committee on Food Additives, Sixty-first Meeting, Rome, 10–19 June (available at http://www.who.int/ipcs/food/jecfa/summaries/en/summary_61.pdf; accessed September 2004).

Box 4 *(cont.)*

Since then, the Food and Drug Administration (FDA) and Environmental Protection Agency (EPA) in the United States have released a consumer advisory document along the lines of the recent JECFA guidelines but stressing that fish and shellfish are an important part of a healthy diet. Despite this measure, the tuna industry considers that the damage already inflicted will be difficult to repair.

Example 2: Organic pollutants in salmon

A recent study published in the magazine *Science* reported on "Global assessment of organic contaminants in farmed salmon".[2] Concentrations of 14 chlororganic compounds in farmed and wild salmon were examined. Each of these compounds is thought to cause cancer. The study revealed that all the substances tested were present in higher concentrations in farmed salmon than wild salmon. This applied in particular to fish produced on European farms. Although the levels found were consistent with results from earlier surveys and official controls, the researchers concluded hastily that consumers should tightly limit their consumption of farmed salmon and suggested that anyone who does not want to additionally increase the risk of getting cancer should restrict consumption of one portion of farmed salmon to a maximum of once every two months.

On the basis of the identified concentrations of toxic substances, the authors of the study then calculated the portion sizes for wild and farmed salmon that could be consumed without increasing the risk of cancer. The recommended quantities fluctuate strongly depending on the salmon's origins. Whereas, for example, eight portions (227 g) of salmon from Kodiak (Alaska) could be consumed per month, consumers should not eat more than one portion of Chilean farmed salmon per month, no more than one portion of Norwegian farmed salmon every two months, or one portion of farmed salmon from Scotland or the Faeroe Islands no more than every four to five months.

It is these calculations that caused a big stir. The model used for the calculations is highly disputed among scientists and is not specifically intended for calculations on commercially produced fish; it had been developed by the EPA to estimate how much of their catches could be eaten by anglers who regularly fished in contaminated inland waters. By contrast, commercial products should be evaluated according to the FDA criteria. To refute the model, researchers calculated that on the basis of the PCB contamination levels cited in the study, after 70 years of regular consumption of 200 g of salmon per week the risk of developing cancer for the high-risk group (pregnant women, children, nursing mothers) would be one-hundred-thousandth higher – equal to a rise in risk of 0.0001 percent. By comparison, the risk of dying of a cardiovascular disease by eliminating fish completely from the diet can be as high as 30 percent![3]

[2] R.A. Hites, J.A. Foran, D.O. Carpenter, M.C. Hamilton, B.A. Knuth and S.J. Schwager. 2004. Global assessment of organic contaminants in farmed salmon. *Science*, 303(5665): 226–229.
[3] Does farmed salmon cause cancer? *Eurofish*, 2004/1: 62–65

It is therefore understandable that the recommendations made by the authors of the *Science* study to limit salmon consumption met with strong objections in Europe, the United States and elsewhere. Food control and health authorities reacted by announcing that its findings did not raise new food safety issues as the levels were consistent with results from other surveys and official controls. They encouraged consumers to continue eating salmon and other fish, the health benefits of which had been proven beyond all doubt in over 5 000 scientific studies. Unfortunately, the study had already alarmed the consuming public, and retail orders of farmed fish fell by 20–30 percent in countries such as Ireland, Norway and Scotland. A great deal of time and effort were required to restore consumer confidence.

Conclusion

Globalization and further liberalization of the world fish trade, while offering many benefits and opportunities, also present new safety and quality challenges. Fish safety regulators have been applying a host of control measures, from mandating the use of the Hazard Analysis and Critical Control Point (HACCP) system[4] to increasing testing, with varying degrees of success. Improved risk-based scientific tools must be adopted so that the fish safety standards reflect the most current and effective scientific methods available to protect public health.

In establishing maximum levels of fish pollutants, regulators need to ensure the highest level of consumer health protection, but they must also take into account the reality of the current background contamination of the environment in order not to endanger the food supply. Concurrently, strategies must be adopted to reduce gradually the background contamination of the environment and lower progressively the maximum levels in feed and foods to follow this downward trend. In addition, consumer information and awareness programmes will be necessary in order to improve transparency and consumer education.

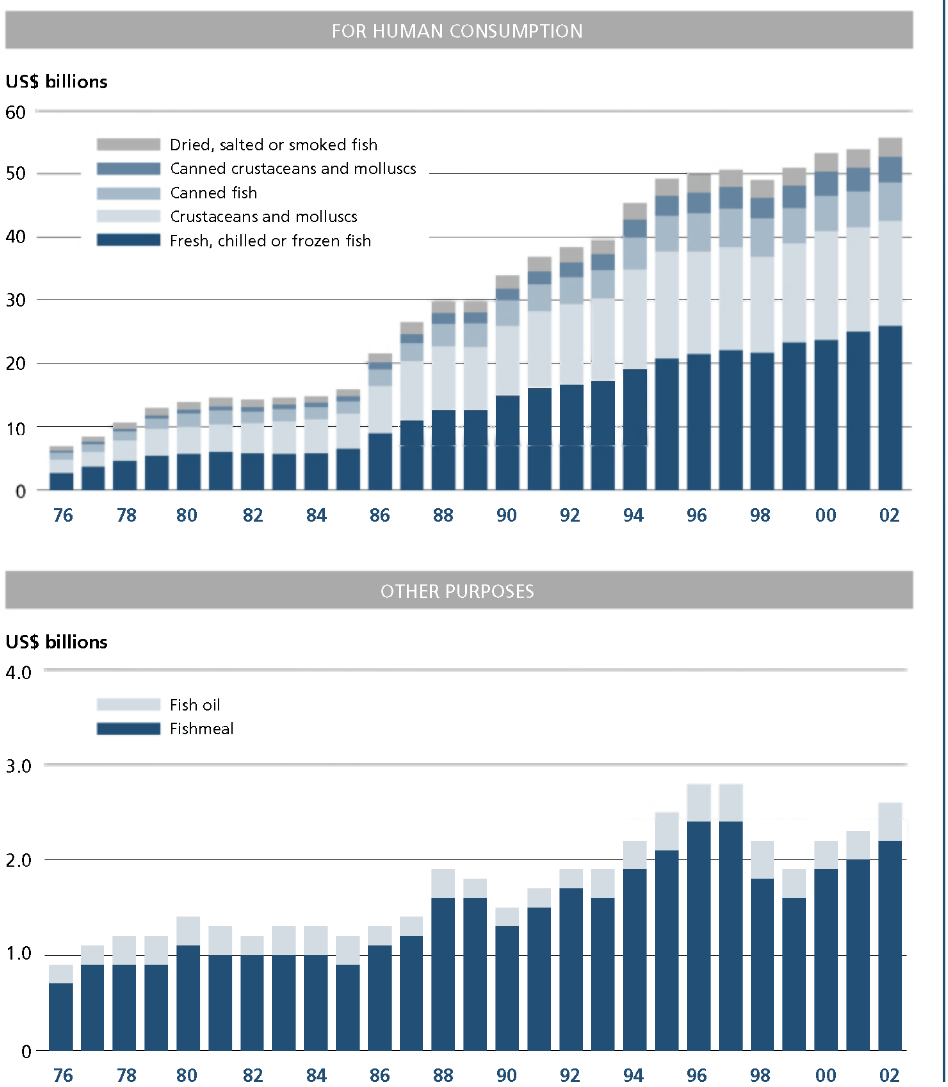
Progress in this area will require enhanced international cooperation in promoting scientific collaboration, harmonization, equivalency schemes and standard-setting mechanisms that are based on scientific principles. The World Trade Organization's Agreements on Sanitary and Phytosanitary Measures and Technical Barriers to Trade,[5] together with the benchmarking role of the Codex Alimentarius Commission, provide an international platform in this respect. Meeting these challenges will be of the utmost importance for fish trade, both in developed and developing countries, particularly as the latter contribute more than 50 percent (in value) of international fish trade.

[4] FAO. 1997. *Hazard Analysis and Critical Control Point (HACCP) system and guidelines for its application*. Annex to CAC/RCP 1-1969. Rev. 3 (available at http://www.fao.org/DOCREP/005/Y1579E/y1579e03.htm#bm3; accessed September 2004).

[5] For further information, see http://www.wto.org/english/docs_e/legal_e/legal_e.htm#agreements; accessed September 2004.

Figure 27

World fishery exports by major commodity groups

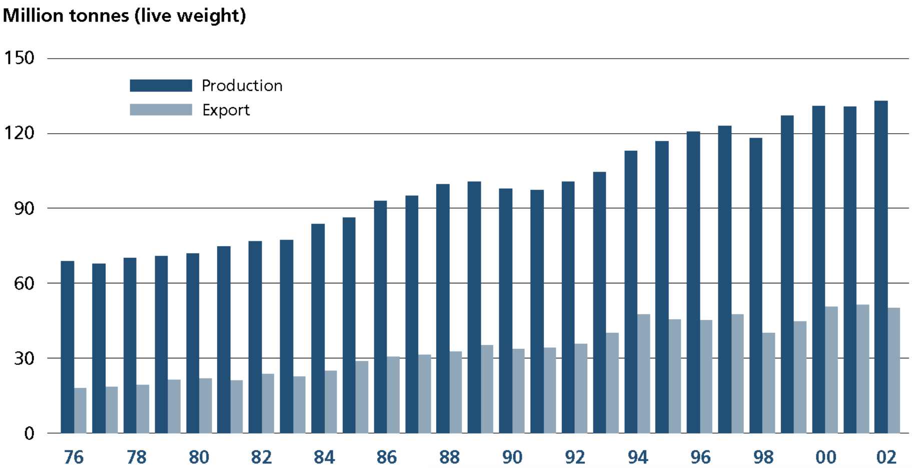


valued at US$3.6 billion, followed by the United States (US$3.3 billion), Canada (US$3.0 billion), Denmark (US$2.9 billion) and Viet Nam (US$2.0 billion). As a result of the growth in its aquaculture production, Viet Nam has significantly increased its exports of fish and fish products in the last decade (from US$0.3 billion in 1992 to US$2.0 billion in 2002), with a more accelerated growth (29 percent per year) since 1999. In 2002, the main target markets for Vietnamese exports were China, Japan and the United States. Forty-eight percent of the country's exports consisted of shrimps (mainly in frozen form).

World fish imports reached a new record of more than US$61 billion in 2002. Developed countries accounted for about 82 percent of the total value of imports of fish products. Despite the 12 percent decrease in imports from 2000 levels, Japan was once again the largest importer of fish and fish products, with a 22 percent share of the world import value in 2002. Japanese fishery imports (US$13.6 billion) accounted for 4 percent of its total merchandise trade. The United States, besides being the world's fourth largest exporting country, was the second largest importer, with imports remaining relatively stable at US$10 billion since 2000. In 2002, the EU further increased its dependency on imports for its fish supply by 10 percent since 2000. Spain, with

Figure 28

Share of world fisheries production destined for exports



US$3.9 billion, was the world's third largest importer of fish and fish products, followed by France (US$3.2 billion), Italy (US$2.9 billion), Germany (US$2.4 billion) and the United Kingdom (US$2.3 billion). Preliminary data suggest that in 2003 major importing markets increased their imports of fish and fish products by about 10 percent.

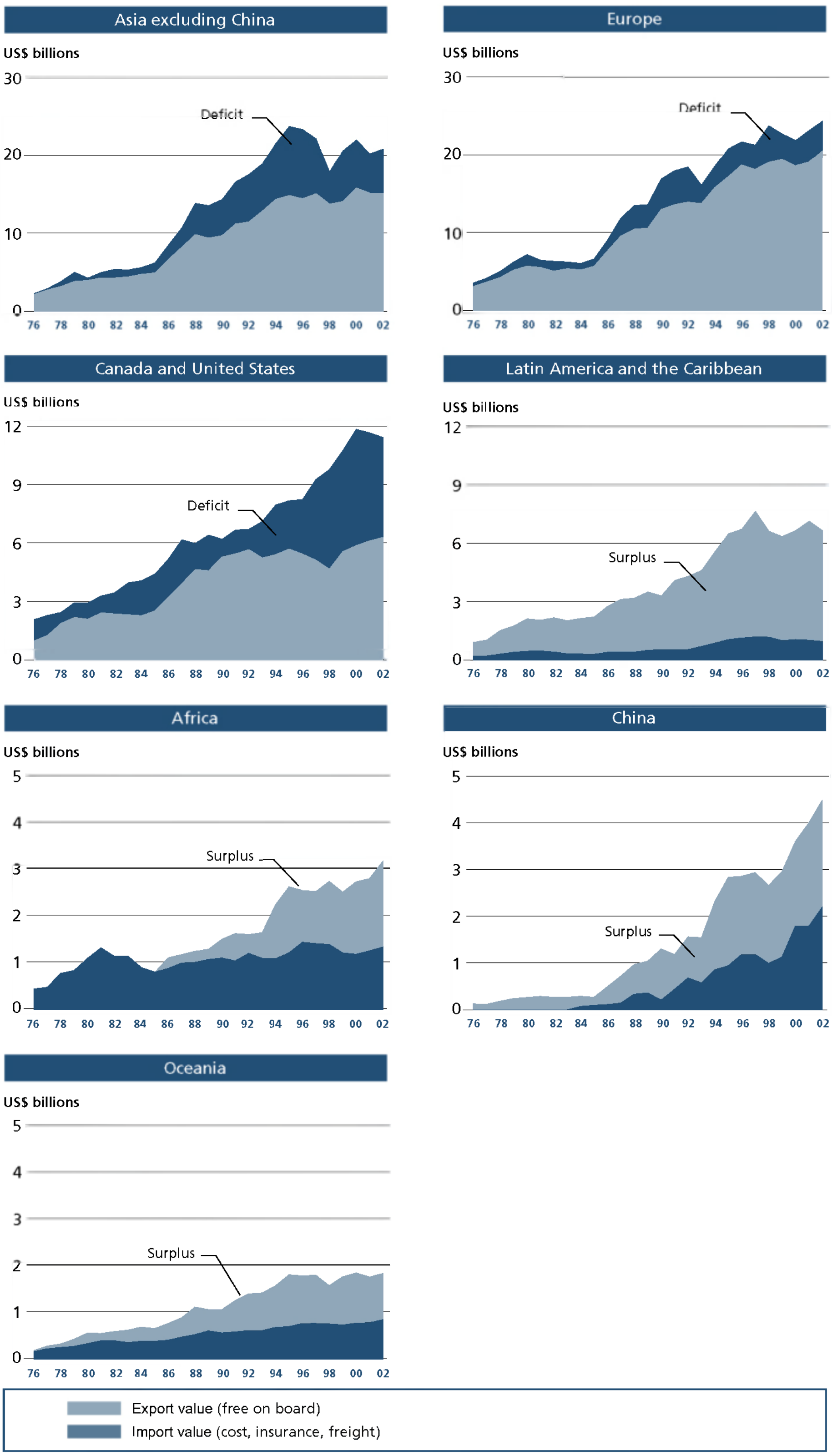
In 2002, a large share of fish production entered international marketing channels, with about 38 percent (live weight equivalent) exported as various food and feed products (Figure 28). Developed countries exported more than 22 million tonnes of fish (in live weight equivalent) in 2002; although a part of this trade may be re-exports, this amount corresponds to nearly 70 percent of their production. Exports from developing countries (28 million tonnes) were around one-quarter of their combined production. The share of developing countries in total fishery exports was 49 percent by value and 55 percent by quantity. A significant share of these exports consisted of fishmeal. In 2002, developing countries contributed about 66 percent, by quantity, of world non-food fishery exports. Developing countries have also significantly increased their share in the quantity of fish exports destined for human consumption, from 43 percent in 1992 to 49 percent in 2002.

In many countries there is considerable two-way trade in fish products. The trade surplus is significant in Africa, China, Oceania and Latin America and the Caribbean (Figure 29). In 2002, 95 countries were net exporters of fish and fishery products, with Canada, Chile, Norway, Thailand and Viet Nam reporting net export values of more than US$1.5 billion each and with Denmark, Iceland, India, Indonesia, Peru and Taiwan Province of China each having net exports worth more than US$1 billion. Although there is a strong trade in fish and fish products among the more developed economies (mostly demersal species, herring, mackerel and salmon), trade tends to flow from the less-developed to the more-developed countries (mainly tuna, small pelagics, shrimps and prawns, rock lobsters and cephalopods). In 2002, about 74 percent of the import value was concentrated in three main areas: the EU, Japan and the United States. In terms of quantity, developed countries imported over 32 million tonnes (live weight equivalent), of which 68 percent was fish for human consumption, while developing countries imported 19 million tonnes (live weight equivalent), of which 47 percent consisted of fish for food.

The maps shown in Figure 30 indicate trade flows of fish and fish products by continent for the period 2000–02. The overall picture presented by these maps, however, is not complete. Although the countries that reported their imports over this period (some 158 countries) account for 98 percent of the estimated world total, some continental groups are not covered completely (e.g. about one-third of African

Figure 29

Imports and exports of fish and fishery products for different regions, indicating net deficit or surplus



countries did not report their trade in fish products by country of origin/destination). In this case, the data indicated should not be taken to represent the total trade flow of the continental groups to which they refer.

Because fish is highly perishable, more than 90 percent of internationally traded fish and fish products are in processed form. In terms of quantity, the share of live, fresh or chilled fish has increased during the last decade from 9 percent in 1992 to 10 percent in 2002. This growth is a result of improved logistics and technology and increased demand. Live fish is particularly appreciated in Asia and in niche markets in other countries, mainly among immigrant Asian communities. In these countries, aquariums and tanks displaying live fish have become relatively common in seafood restaurants, supermarkets and retail outlets. Trade in live fish has increased in recent years due to technological developments. An elaborate network of handling, transport, distribution, display and holding facilities has been developed to support the live fish trade. New technological systems include especially designed or modified tanks and containers, as well as trucks and other transport vehicles equipped with aeration or oxygenation facilities to keep fish alive during transportation or holding/display.

Exports of frozen fish have increased during the last decade, rising from a share of 28 percent of the total quantity of fish exports in 1992 to 35 percent in 2002. Exports of prepared and preserved fish were 6.2 million tonnes (live weight equivalent) in 2002, representing a share of 12 percent of total exports (10 percent in 1992). Exports of cured fish accounted for 5 percent of total exports in 2002, but this share had declined slightly over the preceding decade. In 2002, exports of non-food products represented 36 percent of total exports in terms of quantity, a large share of which originated from Latin American countries.

Despite a slight decline in exports, shrimp continues to be the main fish commodity traded in value terms, accounting for about 18 percent of the total value of internationally traded fish products in 2002. The other main groups of exported species were groundfish (10 percent: e.g. hake, cod, haddock and Alaska pollock), tuna (9 percent) and salmon (8 percent). In 2002, fishmeal represented around 4 percent of the value of exports and fish oil less than 1 percent. Products derived from aquaculture production accounted for an increasing share of the total international trade in fishery commodities, with an estimated 22 percent of the export quantity. It is not currently possible to quantify the exact amount of fish trade originating from aquaculture because most countries do not specify the farmed origin in their fishery trade statistics.

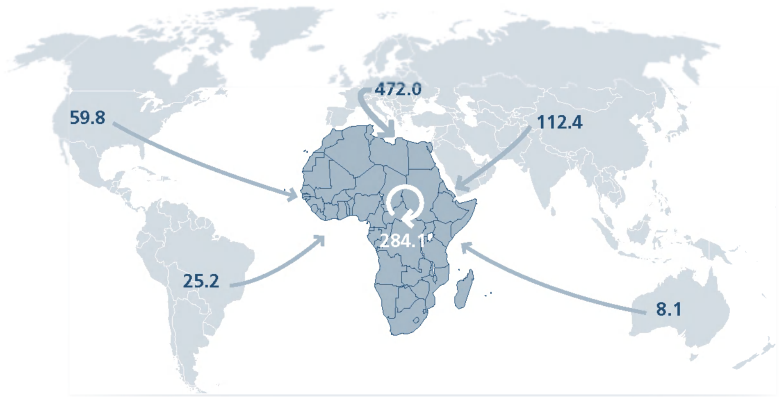
For many economies, and in particular for developing nations, trade in fish represents a significant source of foreign currency earnings, in addition to the sector's important role in income generation, employment and food security. In a few cases, fishery exports are crucial for the economy. For example, in 2002 they represented more than half of the total value of exported commodities in the Faeroe Islands, the Federal States of Micronesia, Greenland, Iceland, the Maldives and Saint Pierre and Miquelon. The net receipts of foreign exchange derived from fish in developing countries (i.e. the total value of their exports less the total value of their imports) increased from US$11.6 billion in 1992 to US$17.4 billion in 2002 (Figure 31), despite the 3 percent decline in net receipts since 2000 – these figures were significantly higher than those for other agricultural commodities such as rice, coffee and tea. LIFDCs play an active part in the trade of fish and fish products; in 2002, they accounted for more than 20 percent of the total value of fishery exports, with net export revenues estimated at US$8.2 billion.

Trade in developing countries is gradually evolving from the export of raw material for the processing industry in developed countries to high-value live fish or value-added products. Some countries are also importing raw material for further processing and re-export. Many developed countries have invested in processing facilities in developing countries, where costs are lower. Also, numerous projects have been assisting fish-processing companies in several developing countries to produce more sophisticated products through further processing in order to increase the companies' profitability and the contribution of the fisheries sector to the gross national product. The results

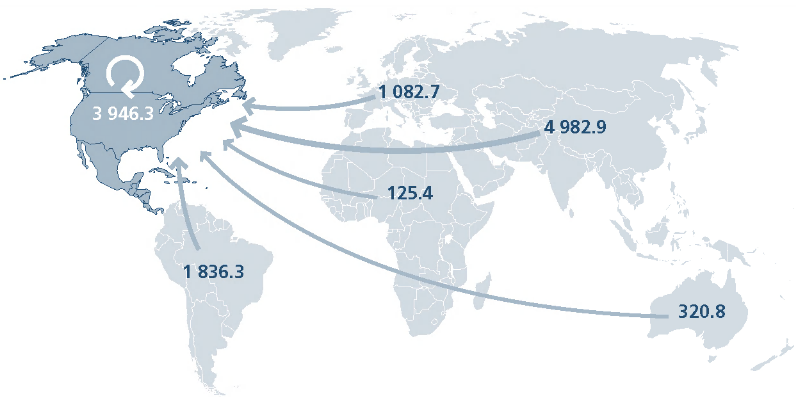
Figure 30

Trade flows by continent (total imports in US$ millions, c.i.f.; averages for 2000–02)

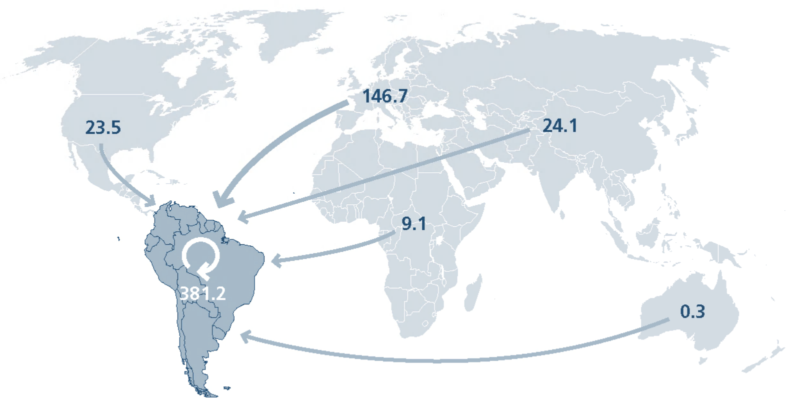
Africa



North and Central America



South America



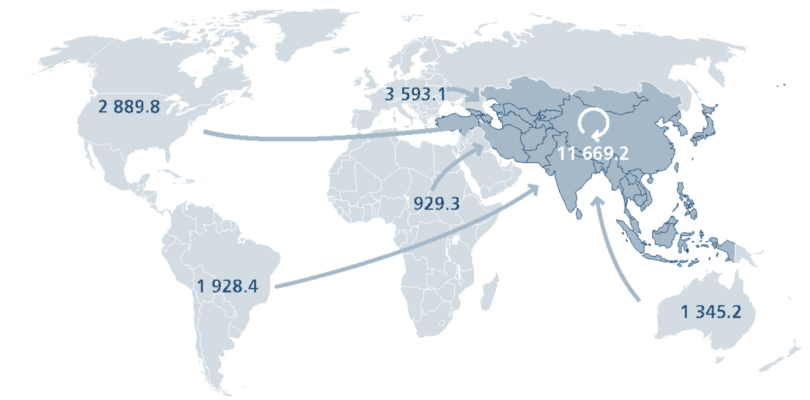
Intraregional trade

(Continued)

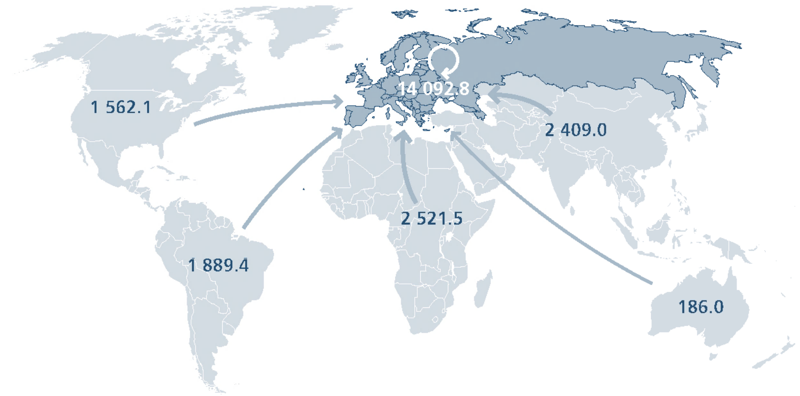
Figure 30 *(cont.)*

Trade flows by continent (total imports in US$ millions, c.i.f.; averages for 2000–02)

Asia



Europe



Oceania

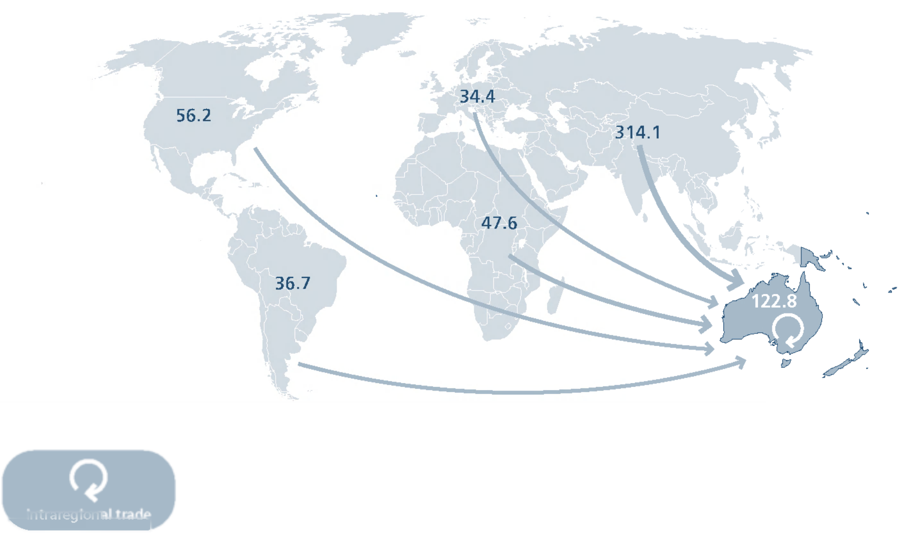
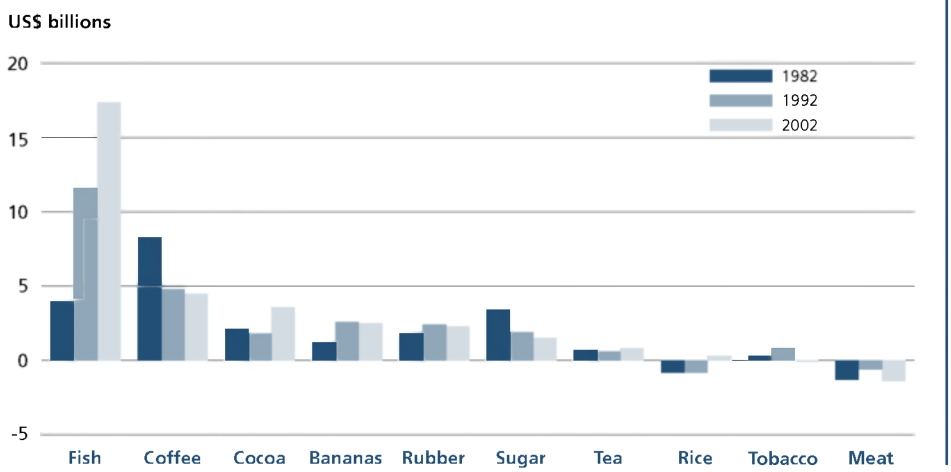


Figure 31

Net exports of selected agricultural commodities in developing countries



of these projects have often been unsatisfactory, largely because of inadequate importer–customer relationships, little or no advantage in terms of quality and price, and the failure of products to meet the needs of consumers – shortcomings resulting from inadequate market research. Experience has shown that the key to success lies in strong customer partnerships, sound market research, excellent quality of the product, reliability in supply, a constant drive for improvement, price competitiveness and attractive packaging.

In addition to value-addition and third-country processing in developing countries, other major issues concerning international trade in fish products that have been prominent in recent years include changes in quality and safety control measures in the main importing countries; the introduction of new labelling requirements and the concept of traceability in major markets in developed countries; chemical residues in aquaculture products; the general public's concern about overexploitation of certain fish stocks, especially groundfish; the sustainable development of aquaculture, including its future feed requirements; IUU fishing; international trade negotiations in the WTO; the expansion of regional trade areas and the increasing number of new bilateral trade agreements. With the entry of China into the WTO in 2001, all major fishery countries other than the Russian Federation and Viet Nam (which have started negotiations to become members) are now members of the organization. Parallel to the increase in the WTO's membership, a number of bilateral trade agreements with strong relevance to fish trade have been signed. The full impact and long-term effects of these agreements, in addition to or as a substitute for broader multilateral agreements, remain to be seen.

Salmon

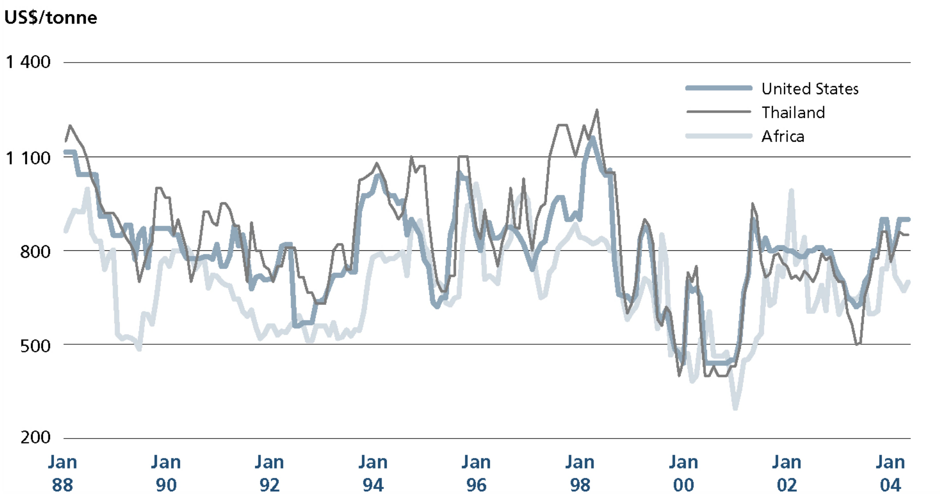
2003 was a positive year for salmon producers and traders worldwide. Increased prices particularly benefited European producers in Ireland and the United Kingdom. Chile and Norway enjoy a comparatively lower cost structure and can operate profitably at lower price levels. They were therefore profitable in earlier years when the European industry generally was experiencing heavy losses. Chile, however, was to some extent hurt by a weaker dollar in the United States, which is the major market for its fresh products.

Tuna

Japan is the top world market for *sashimi*-grade tuna. However, as in the case of shrimp, demand has declined in recent years or shifted to lower-priced species.

Figure 32

Skipjack tuna prices in Africa, Thailand and the United States



Notes: Data refer to c&f (cost and freight) prices for 4.5–7.0 pounds of fish. For Africa: ex-vessel Abidjan, Côte d'Ivoire.

The farming of bluefin tuna has had an important impact on the *sashimi* market in Japan, resulting in an overall decline of prices. The reduction of the EU canned tuna import tariff (from 24 percent to 12 percent) for a quantity of 25 000 tonnes from countries such as Indonesia, the Philippines and Thailand, was not welcomed by the main European tuna canners. On the other hand, Spanish canners are outsourcing and new canning plants have been installed by Spanish companies in Central America (El Salvador and Guatemala). The concentration of the world tuna industry in fewer hands is continuing. Canned tuna consumption is rising in European countries, which now represent the main outlet for canned tuna. By contrast, the United States market for canned tuna is declining, while that for pouch (as opposed to rigid plastic) packs is increasing. Prices of skipjack tuna in Africa, Thailand and the United States are shown in Figure 32.

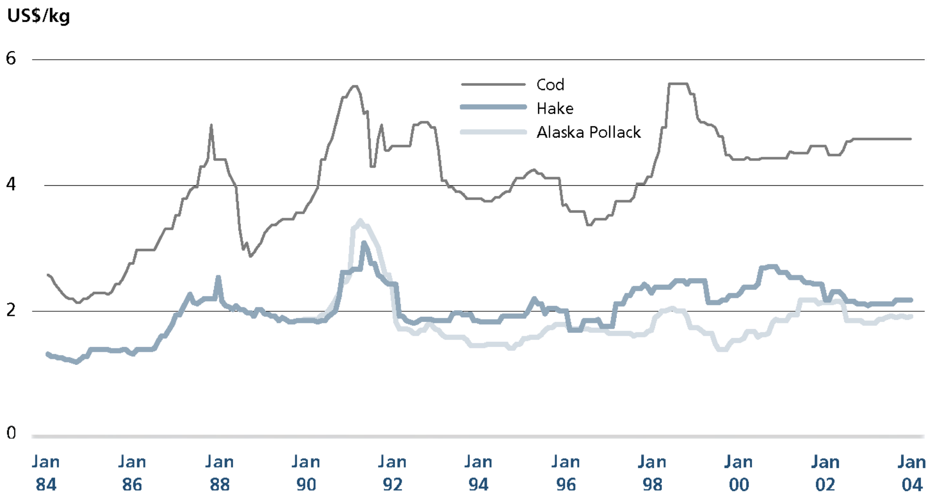
Other finfish

Relatively strong supplies of certain groundfish species (Alaska pollock and Argentinian hake) combined with resumed exports from China to EU markets and flat consumer demand had the effect of exerting downward pressure on frozen groundfish prices during 2003. Groundfish prices in the United States are shown in Figure 33. With somewhat reduced Alaska pollock supplies as well as strong Russian and Chinese demand during the first half of 2004, this negative trend came to an end and prices for certain groundfish products started to increase during the first quarter of the year. A continued scarcity of Alaska pollock during the second half of 2004 is likely to mean a general upward movement of groundfish prices in international markets despite flat demand in many key markets.

Continuous low prices, unsolved problems related to antibiotics and dumping allegations were all detrimental to groundfish exports from Asia. The *basa* (catfish) industry in Viet Nam was hit particularly hard: Vietnamese exports to the United States fell by 50 percent as a result of anti-dumping duties ranging between 37 and 64 percent that have been in force since June 2003. Consequently, *basa* fish swamped the Southeast Asian and Australian markets, creating difficulties in the markets for other freshwater fish.

Figure 33

Groundfish prices in the United States



Note: Data refer to c&f prices for blocks.

Shrimp

During 2003, shrimp imports in several key markets reached new highs. Sales to the world's largest shrimp market, the United States, exceeded 500 000 tonnes for the first time – 17 percent higher than imports in 2002. Annual imports of shrimp into Japan during 2003 declined by 6 percent compared with the previous year, continuing a long-term downward trend that is a consequence of the country's continued difficult economic situation. In Europe, shrimp imports increased in 2003, as a result of a strong euro and competitive international prices. Brazil, China, Ecuador, India, Thailand and Viet Nam are under investigation for dumping in the United States, which will create some problems for their sales there in the short term. Prices remained low during most of 2003, and there are no indications of an increase in 2004. Shrimp prices in the United States and Japan are presented in Figure 34.

Cephalopods

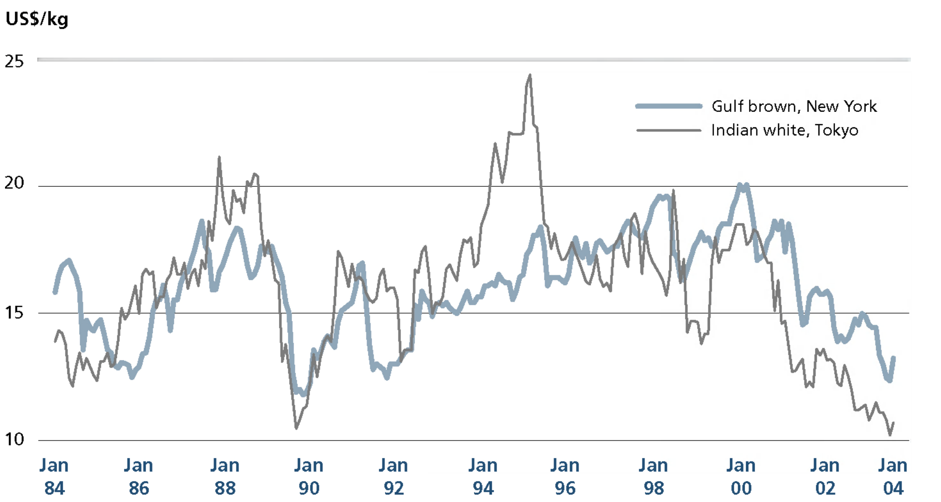
On the cephalopod market, lower *Illex* catches were offset by higher production of *Loligo* squid. Octopus catches were relatively low. The beginning of 2004 was marked by reduced squid landings, notably in the Southwest Atlantic. Spain remains the leading European squid market. During 2003, frozen imports (*Illex* and *Loligo*) increased by 7 percent over 2002 levels to almost 160 000 tonnes. This increase was the result of a 22 percent jump in *Loligo* imports that more than compensated for the 6 percent drop in frozen *Illex* imports. In 2003, the Italian squid market followed a similar trend to that of Spain, with a rise in frozen imports and a shift from *Illex* towards *Loligo*. Total imports into Italy reached 85 000 tonnes, 8 percent higher than in 2002. Japan continued to be the main market for cephalopods worldwide in 2003, but its imports were hit by low arrivals of octopus from Morocco. Imports by Japan in 2003 were 56 000 tonnes, down from 72 000 tonnes in 2002. The octopus resource in the Central East Atlantic is under stress, and no improvement to the supply situation is likely in the short term. Prices for all cephalopod products increased in 2004. Figure 35 presents cephalod prices in Japan.

Fishmeal

The bulk of fishmeal production – about 60 percent – is exported each year. In 2003, fishmeal production in the five major exporting countries amounted to 4.5 million

Figure 34

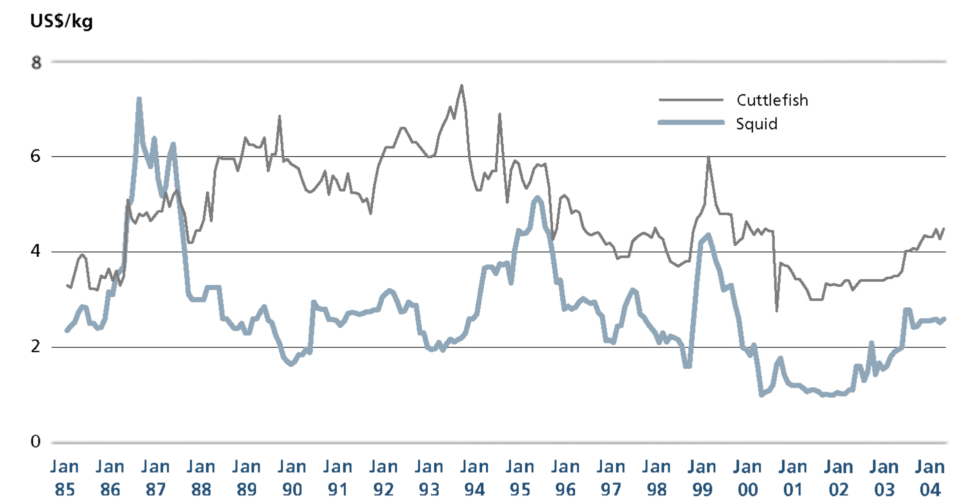
Shrimp prices in Japan and the United States



Note: Data refer to wholesale prices for frozen, headless, shell-on shrimps, 16–20 count.

Figure 35

Cephalopod prices in Japan

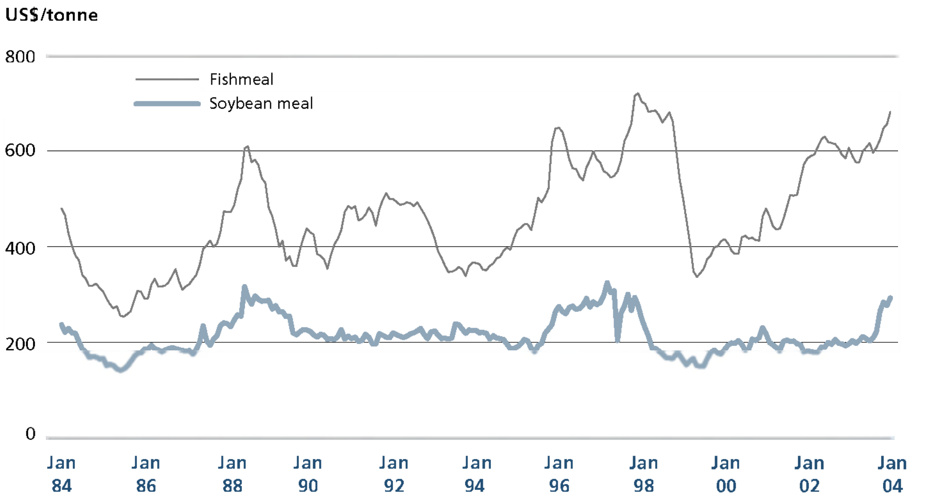


Note: Data refer to wholesale prices.
For cuttlefish: whole, 10 kg/block, 0.4–0.6 kg/pc;
for squid: whole 7.5 kg/block, 21-25 kg/pc.

tonnes, representing a 12 percent decrease from 2002. Catches of fish for reduction were low in all major fishmeal-producing countries. However, in the first six months of 2004, fishmeal production increased by 40 percent and it is likely that total production will return to normal levels. Fishmeal prices, which increased strongly in 2003, are expected to decline somewhat, but good demand, especially from China and other Asian countries, will keep them at attractive levels for the producing countries. Prices for Germany and the Netherlands are given in Figure 36.

Figure 36

Fishmeal and soybean meal prices in Germany and the Netherlands



Note: Data refer to c.i.f. prices.
Fishmeal: all origins, 64–65 percent, Hamburg, Germany
Soybean meal: 44 percent, Rotterdam, the Netherlands.

Source: OIL WORLD; FAO GLOBEFISH

THE CHANGING ROLE OF REGIONAL FISHERY BODIES IN DECISION-MAKING

Situation prior to UNCED

A clear shift in the role of regional fishery bodies (RFBs) has occurred over the past half-century – a trend that has intensified since the adoption of key international fisheries instruments following the 1992 United Nations Conference on Environment and Development (UNCED). Prior to the early 1980s, the mandates of many RFBs identified their role as research and advisory rather than decision-making and enforcement. The focus of decision-making in most RFBs was how best to serve as a forum for fisheries management rather than as a fisheries management body.

The 1982 United Nations Convention on the Law of the Sea prompted a sharp focus on the emerging role of RFBs.[20] A suite of new activities was envisaged by the Convention giving RFBs a greater role than had been intended previously. They would maintain their essential functions as fora for international cooperation; as vehicles for research, analysis and data repository and exchange; and as advisors on fisheries management in accordance with their mandates. In addition, however, the Convention foresaw new activities, such as:

- protecting stocks associated with harvested stocks from depletion;
- conserving stocks outside the 200-mile zone;
- providing advice to coastal states on the conservation of stocks inside the 200-mile zone;
- pursuing compulsory dispute settlement options;
- providing coastal states with all relevant information regarding fishing activities in high seas areas adjacent to their exclusive economic zones;
- the implementation by coastal states of appropriate minimum standards;

[20] The United Nations Convention on the Law of the Sea of was adopted and opened for signature on 10 December 1982. For more information, see http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm.

- providing a conduit through which coastal states could fulfil their obligation to give due notice of their relevant conservation and management laws and regulations and make information available on the outer limits of their exclusive economic zones;
- considering stricter regulations for marine mammals than those required for other species.

In response to these changes, many RFBs have reviewed or amended their respective agreements or conventions. However, the 1982 UN Convention, itself, can be considered inadequate as a mechanism for promoting effective fisheries management, in view of three interrelated factors:

- The Convention does not confer management authority on RFBs.
- The Convention ushered in an era of newly declared sovereign rights over extended areas of ocean space, which became a paramount consideration for many coastal states.
- The general state of the world fisheries resources at the time did not appear to be particularly worrisome. As a result, many RFBs remained virtually inactive with respect to effective fisheries management.

Post-UNCED

In the 1990s, fuelled by growing awareness of the scarcity of fishery resources, the absence of broad international agreement on the management authority of RFBs began to receive increasing attention. The need for strengthened fisheries governance through RFBs became a pressing issue and it was acknowledged that, to be effective, RFBs needed clear mandates to manage the fishery resources in their convention areas in full conformity with international law. In this connection, a number of post-UNCED fisheries instruments were adopted by the international community; these included the 1995 UN Fish Stocks Agreement, the 1993 FAO Compliance Agreement, and the 1995 FAO Code of Conduct for Responsible Fisheries.

The strengthened conservation and management roles of RFBs, foreshadowed by the post-UNCED instruments and accompanying public demands for accountability and transparency, brought with them the need for an effective decision-making process and authority. An FAO High-Level Panel of Experts in Fisheries concluded in a 1998 report that "... the last thirty years were essential to collect information and gain experience on the functioning of RFBs and that the next ten years would be to implement and enforce decisions so that world fisheries resources could be exploited and utilized in a responsible manner".[21] A few months later, in February 1999, FAO and non-FAO regional fishery bodies, at the first ever meeting of its kind to be convened, stressed that "regional fishery bodies must measure their success by results in the form of favourable trends in or status of stocks and human benefits".[22]

Generally, it has been observed that RFBs are taking innovative and cooperative action to implement the post-UNCED international fisheries instruments, many in an effort to rebuild the depleted stocks, prevent further decline and to combat IUU fishing. In addition, the stature of RFBs in fisheries governance is growing steadily, as is reflected in the expanding obligations on states to cooperate through RFBs, the number of new RFBs established in recent years and the institutional and constitutional reforms achieved by many RFBs in order to meet current and future needs. RFBs have made important contributions to fisheries governance, *inter alia*, in the following areas:

[21] FAO. 1998. *Report of the High-Level Panel of External Experts in Fisheries. Rome, 26–27 January* (available at http://www.fao.org/docrep/meeting/w9887e.htm; accessed September 2004).

[22] FAO. 1999. *Report of the Meeting of FAO and Non-FAO Regional Fishery Bodies or Arrangements. Rome, 11–12 February.* FAO Fisheries Report No. 597. Rome.

- promoting the development of national research and management capacity;
- improving and strengthening data collection, handling and dissemination;
- addressing new issues such as IUU fishing, the management of fleet capacity, the effect of the payment of subsidies and the reduction of bycatch and discards;
- adopting management measures and resolutions relating to such issues as fishing effort reduction, the use of gear, minimum fish sizes, mesh restrictions;
- adopting rules and procedures for boarding, inspection and enforcement;
- taking measures to enable the implementation of recent international instruments.

Regrettably, assessments show that strengthened governance of RFBs does not always translate into more effective fisheries management. One of the main constraints faced by RFBs is a lack of willingness on the part of member countries to delegate sufficient decision-making power and responsibilities to RFBs, combined, in some cases, with an inability or reluctance to implement decisions taken by them.

Increased emphasis on decision-making

Article 10 of the UN Fish Stocks Agreement includes the obligation for states to "agree on decision-making procedures which facilitate the adoption of conservation and management measures in a timely and effective manner".[23] In this context, decision-making procedures are not confined to a voting formula but could involve considerations of a variety of elements. These might include, for principal bodies, clear and timely procedures for a number of actions, the entry into force of recommendations and decisions within an appropriate time period and the inclusion of an objection procedure that is consistent with the criteria of timeliness and effectiveness; for the subsidiary bodies, they might also include timely procedures for making recommendations and giving advice.

Several RFBs have taken concrete action on a wide range of decision-making objectives, functions and processes (the IATTC, for example, see Box 5). Specific areas include:

- the adoption of criteria that determine the nature or extent of participatory rights for new members, that facilitate the adoption of conservation and management measures and may encourage objectivity;
- the adoption of clear decision-making procedures both for the parent body, usually included in the constitutive instrument, and for the subsidiary bodies, generally detailed in the rules of procedure, to ensure that the recommendations or advice will be timely and effective;
- the institution of an objection procedure, the length of time and specific procedure for which varies among RFBs;
- placing greater emphasis on transparency by adopting, *inter alia*, procedures for observers that may specify qualifications, application procedure and attendance at meetings;
- focusing on related areas of dispute settlement, particularly the prevention of disputes.

However, it is important to note that, in the absence of agreed performance indicators for self-evaluation, which could conceivably include the evaluation of decision-making authority and process, it is difficult to establish a correlation between strengthening governance in terms of decision-making and effective fisheries management. This issue is further complicated by the fact that decision-making is only one of many interrelated elements of governance by RFBs.[24] The three

[23] Op. cit., footnote 3, p. 35.

[24] Others include institutional arrangements, mandate and functions, membership, members' data provision, budget and finance, capacity, enforcement mechanisms, non-parties undermining measures, cooperative management, partnership/stakeholder participation, collaboration with other RFBs, political will to implement decisions, acceptance of international instruments and dispute settlement mechanisms.

main elements in decision-making are political will, legal obligations and institutional mechanisms.

That greater demands in terms of decision-making are being placed on RFBs as they move towards becoming bodies with fishery management functions is evidenced by the requirements of post-UNCED international fisheries instruments. While RFBs have not, on the whole, actively reviewed this area of governance, the current decade, which represents a period of consolidation following the adoption of the post-UNCED instruments, could provide a platform for further elaboration of RFB decision-making procedures.

AQUACULTURE DEVELOPMENT POLICY AND GOVERNANCE

Sustainable development

Market forces are exerting a strong influence on aquaculture development, particularly that of commercial and industrial aquaculture. Middle-class consumers in many developed and developing countries are becoming increasingly influential and concerned about what they eat and at what cost food is produced, especially in the case of internationally traded products. Major importing regions and countries have begun to set stringent standards and regulations to ensure quality and safety and to reduce the social and environmental impacts of production. Aspects covered by these standards include trade in endangered species, labelling for origin, traceability, the chain of custody and zero tolerance for certain veterinary drug residues. In 2002, fish and fishery products represented the largest category (over 25 percent) of food safety and quality alerts in the EU. Aquaculture products were particularly targeted for veterinary drug residues and monitoring resulted in the banning of imports from several countries. Also, considerable progress has been made in the development and adoption of a range of market strategies – such as product certification, ecolabelling, ethical or fair trade and organic produce – aimed at improving the sector's public image and gaining consumer confidence.

Progress has also been made in addressing sustainability problems through improved technology – and further progress is expected in the future. For example, improved management practices have successfully limited the spread of pathogens from cultured to wild stocks and made it possible to reduce the use of veterinary drugs in aquaculture production. Nevertheless, there is still a need to regulate access to veterinary drugs in many developing countries. There have also been some advances in establishing effluent standards, improving feed and feeding efficiency and reducing the nutrient output of farms. Research to reduce the dependency on fishmeal in aquafeeds has been ongoing since the 1970s and the results are now being tested with varying degrees of success. Long-term solutions, such as genetic engineering to propagate plants with more suitable profiles of amino acids and fatty acids, are also being considered.

Aquaculture appears to be expanding into offshore marine areas in some parts of the world. Several countries have been proactive in developing appropriate offshore aquaculture and ocean policies, including the control of off-site impacts associated with the discharge of effluent and solid wastes and escapees, even prior to embarking on large-scale development. Pilot projects have also been initiated to gather information to guide policy and development. Operating farms in a more socially and environmentally responsible manner and making a tangible contribution to rural development and poverty alleviation in coastal areas are important challenges for the future, especially in developing countries. Many large-scale industrial production systems are becoming more sustainable, while small-scale practices and integrated systems are continuously adapting to the changing perceptions and demand.

The shift to sustainable practices and development strategies remains a work in progress and a common objective. It requires the concerted support of the public sector through the provision of an enabling environment to attract investment in responsible development and encourage innovation. Inadequate resources, the relatively low importance accorded to aquaculture compared with other priority areas in national

Box 5

The 2003 Antigua Convention and the strengthening of the Inter-American Tropical Tuna Commission

On 27 June 2003, at its 70th meeting, held in Antigua (Guatemala), the IATTC adopted the Convention for the Strengthening of the Inter-American Tropical Tuna Commission established by the 1949 Convention between the United States of America and the Republic of Costa Rica ("Antigua Convention"), bringing to a successful conclusion five years of negotiations.[1] These negotiations were open, from the outset, not only to the parties to the 1949 Convention[2] but also to all those that might become parties to or members of the Commission under the existing Convention or a revised one.[3] Interested intergovernmental organizations and NGOs were also welcome to participate and contribute as observers.

Based on the "Chairman's text" technique, the negotiating process was initially aimed at amending the 1949 Convention in order to bring it in harmony with the principles of international law as reflected in the 1982 UN Convention of the Law of the Sea and the provisions of other international instruments such as the 1992 Agenda 21, the 1993 FAO Compliance Agreement, the 1995 FAO Code of Conduct for Responsible Fisheries and the 1995 UN Fish Stocks Agreement.[4] However, the gap was so great between these instruments and the letter of the 1949 Convention that very little could be preserved from the original text.

The institutional continuity of the IATTC is stressed both in the title and the body of the Antigua Convention, but the new instrument has transformed the Commission into a true management organization, in addition to filling a number of gaps and uncertainties. Thus the area covered by the Antigua Convention in the Eastern Pacific is now defined precisely. It is also vast, since it is bounded, on the east, by the coastline from Canada to Chile between the 50 °N and 50 °S parallels and, on the west, by the 150 °W meridian, thus encompassing part of French Polynesia and reaching the waters of Kiribati and Hawaii, United States. The Commission has been institutionally strengthened with the establishment of a Committee for the Review of Implementation of Measures Adopted by the Commission and of a Scientific Advisory Committee. The functions of the Commission have been updated and expanded to enable it to perform its tasks and adopt conservation and management measures, "giving priority to tunas and tuna-like species". These tasks and measures cover a broad range of areas, such as scientific research, data collection, allowable catch, fishing capacity or effort, new entrants, species belonging to the same ecosystem, waste and discards, gear, allocation, application of the precautionary approach, and implementation of the Code of Conduct for Responsible Fisheries and its international plans of action. Its decisions, which must be adopted by consensus, are binding. In its decision-making processes and other activities, the Commission must promote transparency. Provisions have been included on the settlement of disputes. The rights and obligations of the Commission members concerning implementation, compliance and enforcement have been specified, as have the duties of those members in their character as flag states.

In the same spirit of openness that characterized the negotiating process, the condition of "Party" to the Antigua Convention, either through signature followed by ratification or through accession, may be aquired by the Parties to the 1949 Convention, by the coastal states of the region (states with a coastline bordering the Convention area) and by the states and regional economic integration organizations whose vessels fish for fish stocks covered by the Convention. Moreover, and most innovatively, the Antigua Convention makes full use of the concept of fishing entity introduced in the 1995 UN Fish Stocks Agreement to enable Taiwan Province of China to participate fully in the work of the IATTC. To this end, throughout the provisions of the Convention, a distinction is made between two categories: on the one hand, the "members" of the Commission and, on the other, the Parties to the Antigua Convention. The members of the Commission are defined as including the Parties and "any fishing entity" that has expressed its "firm commitment to abide by the terms of the Convention".[5]

This means that states and the regional economic organizations (e.g. the EU), are necessarily both Parties and members while the fishing entity can only be a member. The specific competences of each one of these two categories are also clearly and precisely stipulated (for instance, all members are entitled to take decisions under Article IX, except those decisions related to the adoption of amendments to the Convention, which are the exclusive competence of Parties).

The Antigua Convention was opened for signature in Washington on 14 November 2003. By the end of May 2004, 11 states had signed it and the fishing entity had also signed its respective instrument. The Antigua Convention will enter into force once seven of the Parties to the 1949 Convention have deposited their instrument of ratification, approval, acceptance or accession.

[1] In June 1998 the IATTC adopted a resolution establishing a working group to review the 1949 Convention. The working group met 11 times from October 1998 to June 2003. The full text of the Convention is available at http://www.iattc.org/PDFFiles2/Antigua%20Convention%20Jun%202003.pdf; accessed September 2004.

[2] All parties participated in the negotiating process. Their number grew during the negotiations. They totalled 13 in June 2003: Costa Rica, Ecuador, El Salvador, France, Guatemala, Japan, Mexico, Nicaragua, Panama, Peru, the United States, Vanuatu and Venezuela.

[3] Canada, China, Colombia, the Republic of Korea as well as the fishing entity that will have the possibility of becoming a member of the Commission (but not a Party to the Antigua Covention) under the name "Chinese Taipei".

[4] Op. cit., see footnotes 11, 13 and 14, pp. 27 and 35; for Agenda 21, see http://www.un.org/esa/sustdev/documents/agenda21/index.htm; accessed September 2004.

[5] The Parties are themselves legally "bound" by the Convention; they are not merely committed to abide by its terms.

development plans, conflicts between sustainable aquaculture development and efforts to improve food security and alleviate poverty, and the high cost of compliance for small enterprises number among the possible reasons for slow progress in the development of an enabling environment for responsible aquaculture in many developing countries.

Policy and governance

The aquaculture sector continues to expand, diversify, intensify and advance technologically, and still dominates all other animal-producing sectors in terms of growth. The shift in the perception and objectives of aquaculture development is probably one of the important factors behind this growth. Aquaculture is now perceived not only as an activity for meeting producers' food needs, but also as part of the engine for economic growth and achieving diverse societal and environmental goals. As the thinking shifted from aquaculture development to aquaculture for development, so did the laws and policies governing the sector.

In the past, development policies focused mainly on production; in contrast, recent global aquaculture governance and policies have tended to target both the supply and demand side of the sector, with sustainable development (economic, social, environmental, legal and institutional) as the desired outcome. On the supply side, it is now recognized that sustainable aquaculture development must be adequately regulated and protected by integrated and effective legal and administrative frameworks, and that enabling public policies and legislation granting investors, *inter alia*, legal rights to land supporting the farm and to good-quality water are of the highest priority.

A common feature of emerging aquaculture regulations is the obligation to acquire permits or licences to establish a farm. These give farmers the right to establish and operate aquaculture facilities and at the same time allow governments to monitor the environmental sustainable development of aquaculture and to impose conditions that compel farms to be operated towards this end. Many countries, particularly developed countries, are making efforts to simplify the process of obtaining permits, particularly where several agencies are involved. While permits are often mandatory in developed countries, developing countries have introduced permit requirement policies only recently, probably in response to the emergence of industrial commercial farms.

The FAO Code of Conduct for Responsible Fisheries, although voluntary, is having significant influence on aquaculture governance and policy. Several mandatory international instruments also have an impact on aquaculture at the national level, particularly with regard to traded aquaculture products and the movement of live organisms and germplasm. For example, the international Convention on Biological Diversity (CBD) could restrict the exchange of germplasm and movement of genetically modified organisms.[25] Additionally, part of the CBD Programme of Work assesses the consequences of mariculture for marine and coastal biodiversity and promotes techniques that minimize adverse impacts. The WTO has a number of binding agreements which, *inter alia*, define minimum quality and safety standards for traded aquatic organisms and establish a list of notifiable diseases (the Agreement on Sanitary and Phytosanitary Measures).[26] Matters of concern to aquaculture in the WTO Agreement on Trade-related Implications of Intellectual Property Rights include the extent to which the agreement allows for the transfer of environmentally sound technology and the patenting of living organisms. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) calls for certificates of

[25] For further information, see http://www.biodiv.org/convention/articles.asp; accessed September 2004.

[26] Summaries and legal texts of the WTO Agreements are available at http://www.wto.org/english/docs_e/legal_e/legal_e.htm#agreements; accessed September 2004.

Box 6

Microfinance in fisheries and aquaculture

Microfinance can be defined as the provision of a broad range of financial services, including loans, savings and insurance, to segments of the population who may lack access to traditional financial services. Most microfinance programmes aim to promote and protect income and empower these population segments. More specifically, the development objectives of microfinance for poor fishing communities are to enable fishing households to increase their income, smooth consumption, develop microenterprises, manage risks better and enhance their earning capacities, thus reducing their economic and social vulnerability. Because women constitute a significant proportion of poor fishing households, microfinance can also serve as an effective tool to assist and empower women in fishing communities.

The demand for financial services in the fisheries sector is diverse and requires differential products and services. Microfinance is just one means in the continuum of financial services provision to cater to that demand. Characterized by small loans, microfinance has inherent limitations in terms of financing the capital investment needs of the fishing industry. It should therefore supplement, not replace, traditional lending products from mainstream financial institutions, as the latter are still required to finance medium- and large-scale investment needs and priorities necessary for the growth and development of fisheries.

Microfinance programmes can be a powerful tool also in poverty alleviation. In the case of fishing and fish-farming communities, the alleviation of poverty is an important precondition for their participation in efforts to rehabilitate and conserve the aquatic environment and fisheries resources.

The mechanics of microfinance operations basically involve three levels:

1. the borrowers who take out loans that they invest in microbusinesses;
2. the loan delivery and recovery system;
3. the institution or organization that manages the delivery system.

The successful operation of these levels is premised on the twin principles of client discipline (where borrowers take responsibility for their decisions and agreements made with the lending institution) and institutional discipline (where the lending institution offers and provides products and services that are characterized by quality, efficiency and commitment).

A core principle that has been proved by successful microfinance programmes is that the poor have the capacity to repay loans, pay the real cost of loans and generate savings.

Source: FAO. 2003. *Microfinance in fisheries and aquaculture: guidelines and case studies*, by U. Tietze and L.V. Villareal. FAO Fisheries Technical Paper No. 440. Rome.

origin for cultured species on the endangered list, issued by the competent national authority, before they can be traded.[27]

At the national level also, aquaculture policies are being established to stimulate development. Many governments have intervened at the macro level by designating aquaculture as a priority area in their economic agendas, defining goals and targets and establishing guiding strategies to achieve them. They have also facilitated reasonable access to credit, provided fiscal incentives and removed institutional constraints (e.g. by establishing effective aquaculture administrative frameworks) (see Box 6). In many instances, however, aquaculture administration still falls under more than one agency, which often hinders progress. At the micro or farm level, governments have intervened with start-up policies such as financing research, providing stocking material and extension and advisory services, and, in some instances, providing loans. The inability of potential entrepreneurs in infant industries to afford the initial investment through their own equity or to obtain private funding, and their lack of absolute and competitive advantage, are often cited as justifications for government intervention at the farm level. Once aquaculture has taken off, farmers have often found it difficult to expand, forcing governments to intervene through expansionary and export promotion policies such as those targeting the lack of availability and/or high costs of essential inputs (feed, seed and capital).

Governments have also encouraged the aquaculture sector through market promotion policies, the development of new value-added products and the regulation of aquatic food safety. In addition to the regulations relating to the drugs and feed used in aquaculture, special regulations have also been issued on the processing and packaging of aquaculture products to prevent health hazards and safeguard consumers.

[27] For further information, see http://www.cites.org; accessed September 2004.

PART 2

SELECTED ISSUES FACING FISHERS AND AQUACULTURISTS

SELECTED ISSUES FACING FISHERS AND AQUACULTURISTS

Capture-based aquaculture[28]

THE ISSUE

Capture-based aquaculture (CBA) has been defined as the practice of collecting "seed" material – from early life stages to adults – from the wild, and its subsequent on-growing to marketable size in captivity, using aquaculture techniques. This category of farming includes the rearing of some species of finfish, most molluscs, and certain forms of the extensive culture of marine shrimp. The scale of CBA activity is difficult to quantify because statistical records do not differentiate between production from capture-based and other forms of aquaculture in which hatchery-reared juveniles are stocked. However, it has been estimated that it accounts for about 20 percent of the total quantity of food fish production through aquaculture. Using FAO data from 2001, this is equivalent to over 7.5 million tonnes per year, principally molluscs. The production of finfish, especially carnivorous species (including milkfish, groupers, tunas, yellowtails and eels), through CBA, is currently receiving the most attention.[29]

Production data deriving from statistical returns provided to FAO for some of these species groups are believed to be underestimates; higher estimates for eels, groupers, bluefin tunas and yellowtails are provided in Table 11. The value of the CBA output of these groups in 2000, using FAO data, exceeded US$1.7 billion. The output of bluefin tuna alone is expected to surpass 25 000 tonnes in 2004. Although Japan is the primary market for bluefin tuna, it is estimated that demand in the United States is around 45 000 tonnes, mainly for *sushi* and *sashimi*, but also for grilling.

CBA is an interface between capture fisheries and true aquaculture and provides an alternative livelihood for local coastal communities in developing countries and several industrialized countries. However, a number of important issues have yet to be resolved relating to the impacts on third parties of management practices that are environmentally questionable – especially the use of wild seed and the use of raw fish as feed. In addition, a practical method for monitoring the aquaculture production contributed by CBA has yet to be found. The sector has also created popular new market segments; it has successfully filled the gap between the two extreme categories (high-quality/expensive and low-quality/inexpensive) of bluefin tuna in the Japanese market and has provided a source of groupers that is cheaper than the wild-caught equivalent. CBA also provides opportunities for developing low-hazard, good-quality products that satisfy codes of conduct and practice.

Use of wild seed

By definition, CBA relies on the use of wild-caught "seed" (a term that covers fry, juveniles and, in some cases, larger fish) for stocking on-growing facilities such as tanks

[28] The information in this section has been derived from FAO. 2004. *Capture-based aquaculture*, by F. Ottolenghi, C. Silvestri, P. Giordano, A. Lovatelli, and M.B. New. Rome; and several other sources (Anonymous, 2004. Burris tuna diet "extends shelf life". *Fish Farming International*, 31(4): 42; FAO. 2003. *FAO Yearbook of Fishery Statistics 2001: Aquaculture Production.* Volume 92/2. Rome; C.W. Laidle and R.J. Shields. 2004. Amberjack culture progresses at Oceanic Institute. *Global Aquaculture Advocate*, 7(1): 42–43; M. Rimmer, S.-Y. Sim, K. Seguma and M. Phillips. 2004. Alternatives for reef fishing: can aquaculture replace unsustainable fisheries? *Global Aquaculture Advocate*, 7(1): 44–45; V. Scholey, D. Margulies, J. Wexler and S. Hunt. 2004. Larval tuna research mimics ocean conditions in lab. *Global Aquaculture Advocate*, 7(1): 38; I.Q. Tan. 2003. Success with formulated feeds for groupers. *Asian Aquaculture Magazine*, September/October: 16–18; T. Wray. 2004. The rise and rise of tuna. *Fish Farming International*, 31(4): 11.

[29] See, for example, R.L. Naylor, R.J. Goldburg, J. Primavera, N. Kautsky, M.C.M. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney and M. Troell. 2000. Effect of aquaculture on world fish supplies. *Nature*, 405: 1017–1024.

Table 11
Estimates for capture-based aquaculture production of eels, groupers, bluefin tunas and yellowtails in 2000

Species group	Estimated production (thousand tonnes)
Eels	288
Groupers	15
Bluefin tunas	10
Yellowtails	136

or cages. This source of seed will be unsustainable in the short term and inadequate in the long term because the catch per unit of effort of seed – whether juveniles or adults – appears to be in decline. Nursery and adult habitats (e.g. mangrove, seagrass and coral) are increasingly being damaged by pollution, destructive fishing practices and other environmental impacts. Moreover, accurate information is not always available on the status of these resources. Overfishing of the target resources frequently occurs during normal fishing activities, but is exacerbated by the demand created by CBA. The collection of seed for CBA can also lead to mortalities in non-target species and the destruction and disturbance of habitats; it also generates discards, contributing further to the depletion of other resources. In addition, the transfer of seed to CBA farms is characterized by high mortality rates (and thus wastage of resources) and conflicts with other resource users (e.g. the obstruction of waterways caused by the towing of cages containing bluefin tuna).

Use of raw fish as feed

Many forms of CBA use raw fish as feed (sometime referred to as "trash fish"). To date, assessment of the related environmental impacts, such as the depletion of the stocks used and the potential transfer of disease vectors to farmed fish and possibly to fish sharing the same water body, has been inadequate. The transfer of human pathogens is also possible. Even when the use of raw fish is replaced with formulated compound aquafeeds, the reliance on marine resources as feed ingredients tends to remain, as high levels of fish oil and fishmeal are used in these feeds.

Effects of CBA management

The siting and operation of CBA farms can be problematic. Significant among the environmental and safety issues still to be addressed by the CBA sector is the lack of adequate, cost-effective environmental assessment systems that would ensure good site selection. The latter is essential in order to minimize sediment build-up, thereby preventing eutrophication and avoiding the risk of contaminating farmed products (e.g. with dioxins and PCBs).

Farm operations sometimes involve inadequate technologies such as unsuitable feeding regimes, poor mooring systems and deficient cage structures. Limited knowledge of the optimum conditions for on-growing facilities and a lack of trained personnel (with many operations being undertaken at an artisanal level, resulting in poor performance and loss of fish) also affect the sustainability of CBA. Also, any untreated farm-generated waste harms the coastal environment and imposes a cost on local populations.

Monitoring CBA production

Substantial difficulties are experienced in quantifying the output from CBA. Fish caught from the wild for stocking purposes are considered as having been produced by capture fisheries and thus only the weight added through fattening is considered as aquaculture production. For CBA activities that depend on juveniles caught in the

wild this is not an issue, as their weight is negligible. In the case of tuna, however, the fish caught for fattening are already adults and their weight must be assessed using a reliable method.

POSSIBLE SOLUTIONS

Seed supply and transshipment

Hatchery-rearing technology is being researched and developed for species that are currently stocked in CBA as fry. Provided that these technologies prove economically viable, hatchery-reared fry will ultimately replace wild-caught fry (at which time the rearing of these species will become true aquaculture, not CBA). However, it is unlikely that it will become commercially viable to rear seed under controlled conditions when, instead of being small fry, the seed consists of large juvenile or adult fish (such as those often used for bluefin tuna). It is expected that the need for supplies of wild-caught seed will continue, not only for species cultured at present, but for others that may be cultured in the future in response to market forces.

Improvements in the management of fisheries for species used in CBA are key to solving these seed-related problems. To this end, further studies on the biology of the species concerned and specific research on more selective fishing gears should be undertaken. New technologies for the transshipment of wild fish to farms are also needed in order to reduce mortalities. Moreover, there is a need to develop specific policies and legal frameworks for CBA that incorporate and create interactions between the fishing and farming sectors.

Replacement of raw (“trash”) fish as CBA feed

An important breakthrough will occur when specific cost-effective formulated diets are developed for each species and accepted by farmers. The substitution of raw fish by compound feeds will reduce the existing dependence on capture fisheries, thus indirectly protecting marine resources. It will also reduce the pollution caused by waste feed, promote a favourable ecological equilibrium, enable diet quality to be controlled and guarantee more efficient feed conversion ratios, thus reducing handling and feeding costs (although the ultimate economic gain through such improvements depends on the relative unit costs of the alternative feeds as well as feed conversion ratios). The use of formulated diets will also eliminate the health risks (to the cultured fish) associated with the uncontrolled quality of raw fish. Other factors also need to be taken into account in order to achieve a successful transition to specific formulated diets. These include the final consumer acceptability, and therefore the value, of the products produced using alternative feeds. Such factors are important, because they heavily influence the willingness of farmers to change from current feeding practices.

Improved site availability

Further developments in equipment and technology for offshore farming in cages will result in improved water quality and fish health. The use of offshore locations will necessitate improvements in feeding systems, require larger boats for servicing and call for new techniques for the repair and cleaning of nets and the maintenance of mooring systems. Increased automation, electronic monitoring and the use of tension leg mooring systems are examples of possible solutions.

Waste management

Controlling and reducing wastes would be beneficial to the CBA sector. Sustainable practices would not only preserve the environment and reduce the potential for conflicts with other coastal users; they would also provide products that are perceived as safe by the consumer (thus improving marketability). An integrated and multidisciplinary approach is needed to achieve sustainability. The development of rapid and innovative low-cost environmental impact assessment programmes, together with regular monitoring based on key environmental performance indicators, would be highly beneficial for CBA.

Legal and institutional control of CBA activities

The application of responsible production methods must become the norm in CBA. In many cases, CBA represents the first (but sometimes, as in eel production, very lengthy) step towards true aquaculture. However, this evolution will not affect the characteristics of certain forms of CBA as currently practised, such as the stocking of large bluefin tuna. Furthermore, the CBA of new species will emerge. It is therefore essential that governments explore and develop legal and institutional instruments that recognize CBA as a distinct sector. CBA also needs to be integrated into resource use and development planning. International agreements for specific actions in the CBA sector need to be drafted and signed by all the countries that share common resources. The management of CBA, particularly where the practice is currently unsustainable, needs to be improved. Governments should also actively promote CBA, as it is likely that it will lead to the rearing of new aquaculture species and thus reduce the pressure on existing wild stocks.

Monitoring CBA production

For more than a decade FAO has been refining the questionnaires on aquaculture production that it sends to member countries. These initiatives have been designed to assist in defining which production activities result in aquaculture output (from a statistical point of view) and which should be regarded as capture fisheries production. In 2001, the Coordinating Working Party on Fishery Statistics addressed the specific issue of tuna CBA and decided that the weight of the captured fish should be recorded as capture fishery production and that subsequent incremental growth in captivity should be recorded as aquaculture production. This would avoid double counting.[30]

Although this solution is ideal in theory, there are practical difficulties in weighing the fish both at the start and at the end of the culture activity. The matter is therefore still under discussion and awaits a satisfactory resolution.[31] Until this has been reached, some difficulties will remain in interpreting the statistical data relating to species of tuna that are raised by CBA. Cooperation between FAO and the tuna CBA industry is essential for developing appropriate rates for measuring increments over time so that the correct proportions of the total production can be assigned to the statistical returns for capture fisheries and aquaculture production.

The CBA of eels, groupers and yellowtails does not currently present similar statistical problems because the negligible weight of the fish caught from the wild for stocking into rearing units means that the total production is recorded as aquaculture. However, they may arise in reporting the output from the on-growing of other species that may be caught as large fish and reared by CBA in the future.

RECENT ACTIONS

Hatchery-reared seed

Great strides are being made towards the hatchery production of several species currently reared through CBA. As a result, some portions of the sector will move closer to true aquaculture, thereby limiting the ecological impacts of wild seed capture. Progress in this area may also ultimately facilitate fisheries enhancement programmes.

In Japan, technologies have been developed for sustaining bluefin broodstock in offshore cages and in barrier net/closed cove systems for fisheries enhancement, leading to the first closed-cycle breeding of bluefin tuna in 2002; similar efforts are proceeding in Australia and the Mediterranean. Captive bluefin tuna broodstock are also being maintained in a number of other locations, including California, United

[30] FAO. 2001. *Report of the Nineteenth Session of the Coodinating Working Party on Fishery Statistics.* FAO Fisheries Report No. 656. Rome.

[31] For example, this topic forms part of the deliberations the General Fisheries Commission for the Mediterranean/ICCAT Ad Hoc Working Group on Sustainable Tuna Farming Practices in the Mediterranean.

States. The IATTC has maintained a spawning broodstock of yellowfin tuna (*Thunnus albacares*) on an experimental scale in Panama since 1996, and experimental work on optimizing the conditions for larval tuna rearing is ongoing.

Natural spawning of wild-caught greater amberjacks (*Seriola dumerili*) and the longfin or Almaco jack (*S. rivoliana*) was achieved in Hawaii, United States, in 1999; since then, domesticated F1 and F2 stocks have been used as broodstock.

The survival of hatchery-produced fingerlings of various marine finfish species cultured in Asia, including groupers, has until recently been low and variable. However, there has been a significant expansion of grouper fingerling production in Indonesia, for example, mainly from "backyard hatcheries" in Bali; the principal output of these hatcheries had formerly been another species that was once stocked with wild seed, namely milkfish (*Chanos chanos*). It is estimated that 15–30 percent of the farmed groupers in Indonesia now come from hatchery-reared seed.

There appears to be little immediate hope that seed for eel CBA can be provided through a commercially feasible closure of its life cycle. However, it has been reported that research success, at least for *Anguilla anguilla*, is within sight.[32]

Feed developments

CBA producers are usually reluctant to change feeding practices; the possible failure of alternatives when so much is at stake economically (especially in bluefin tuna production) means that many fear to take the risk. Despite this, there are moves towards the partial substitution of raw fish by manufactured diets.

Research on tuna diets has been ongoing in Australia since 1997 but has been hampered by the difficulties of conducting controlled experiments with such valuable fish. High feed production costs and the suboptimal acceptance of pelleted feeds by tuna have also proved problematic. In addition, a degree of consumer resistance to tuna (and other species produced by CBA) that have been fed using "artificial" feeds has been encountered.

In 2004, at the World Aquaculture Society exposition in Hawaii, United States, an American feed company exhibited a tuna feed being used in Mexico as a supplement at 25–50 percent of the diet; moreover, some farmers were said to be "looking at feeding a 100 percent dry diet to their tuna".

Intensive eel farms, while continuing to use small aquatic worms and fish flesh for the first few days of elver rearing, move through a transitional phase of feeding an artificial moist paste feed subsequently followed by steam-pressed or extruded pellets for on-growing purposes.

Raw ("trash") fish remains the most commonly used type of feed for groupers, despite decades of research aimed at producing pelleted substitutes. Nevertheless, attempts at marketing commercial grouper feeds continue; for example, following a successful commercial-scale experiment with the orange-spotted grouper (*Epinephelus coioides*), one aquafeed manufacturer began selling a grouper feed in the Philippines in 2002.

Raw fish is still used in the CBA of yellowtails in Japan but, since farmers became aware of the environmental damage caused by this practice in the early 1990s, its substitution by moist, semi-moist and "soft-dry" pellets and extruded pellets has been increasing. By 1998, over 120 000 tonnes of artificial feeds were being used. A suitable artificial feed for yellowtails that exceed 3 kg in weight has yet to be identified; these fish exhibit a strong preference for raw fish over extruded pellets.

The need for the partial or complete replacement of marine resources as aquafeed ingredients is not restricted to CBA but is relevant to the rearing of all carnivorous fish and crustacean species.[33]

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[32] Anonymous. 2003. Dana Feed Research Project: reproduction of European eel is almost within reach. *Eurofish*, 2/2003: 36.

[33] FAO. 2002 *Use of fishmeal and fish oil in aquafeeds: further thoughts on the fishmeal trap*, by M.B. New and U.N. Wijkström. FAO Fisheries Circular No. 975. Rome.

FUTURE PERSPECTIVE

CBA is an economic activity that is likely to continue to expand in the short term, both with finfish species currently under exploitation and probably with others that will be selected for rearing in the future. In the case of non-finfish species, such as a variety of bivalves (e.g. mussels), CBA is certain to continue indefinitely in view of the very large number of gametes released. However, the CBA of selected species of finfish is more uncertain; where it becomes a direct competitor of capture fisheries there will be many who will argue, at least, for strict limits to this activity. It is therefore critically important that economically viable means be found to rear the species concerned throughout their full life cycle. When that goal is achieved, not only will the future aquaculture production of those species be assured, but the feasibility of restocking programmes may be explored to enhance their capture fisheries.

While opportunities exist for market expansion for species currently reared through CBA, there is a tendency (as has occurred in the aquaculture of salmon, sea bass, and sea bream, for example) for farm-gate prices to decline as the supply increases. Thus, expansion will only be feasible if farmers are able to reduce costs. The main technical constraint to expansion is seed supply. In the case of tuna CBA, future expansion will be constrained by limited fishery quotas. Eel farming is already constrained by the shortage of seed and future expansion is likely to be limited by controls over elver capture. Damage to the environment (e.g. by the collection of grouper seed) may also result in controls that will limit expansion. There is enhanced interest in yellowtail farming but, again, seed supply is a limiting factor.

The potentially positive long-term benefits of CBA should not be ignored. As grouper culture metamorphoses from CBA to true aquaculture in Indonesia, the supply of hatchery-reared juveniles is causing fishers to replace the cyanide harvesting of aquarium fish with aquaculture of reef fish. This development has positive implications for the future of reef fish culture as an alternative to destructive capture fisheries practices – not only in Indonesia but globally.

More research, development and capacity building in the private and public sectors are essential for success in this area. Researchers worldwide have been working for many years on the reproductive cycles of many species, achieving results that range from a hint of success in the case of eels to partially successful ones in the case of bluefin tunas and selected species of groupers. These studies will become even more important if capture fisheries for the species used as wild seed for CBA become threatened, as has happened in the case of eel fisheries. A ban on the capture and export of elvers may result; if this occurs, the farming of eels will cease unless a feasible means of rearing them artificially to the required stocking size becomes available.

In conclusion, critical issues for the future are the development of fry production in hatcheries on an economically viable commercial scale and the refinement of environmentally acceptable grow-out technologies. Failure to address these could have severe consequences for the future of both aquaculture and some capture fisheries.

Labour standards in the fishing sector

THE ISSUE

One of the most significant changes in marine fishing over the last 40 years has been the changing status of fisheries resources. Burgeoning demand for fish, in conjunction with technological innovations in fishing and navigation, especially in the absence of effective fisheries management, has led to a situation where there is little scope for increasing fish production from capture fisheries. This has serious implications for employment in the fishing sector. The emphasis, according to the ILO, is now changing from maximum employment to sustainable employment. At the same time, the global fleet is aging – with consequent effects on the occupational safety and health of crews.

The oldest labour instrument in fishing is the Hours of Work (Fishing) Recommendation, adopted in 1920, just one year after the founding of the ILO.[34] The existing ILO fishing labour standards that apply to persons working on board fishing vessels are the Conventions on minimum age, medical examination, articles of agreement, accommodation and competency certificates, and the Recommendations on vocational training and hours of work. Two of the existing labour standards – competency certificates and accommodation of crews – also explicitly exclude small-scale fishing vessels from their scope. In practical terms, the scope of the existing labour standards in fishing, in general, does not include people who work on artisanal and small-scale fishing vessels. New issues that are not covered by existing instruments include identity documents, repatriation, recruitment, medical care at sea, occupational safety and health, social security protection, and compliance and enforcement.

Although it is almost 40 years since the last ILO fishing labour standard was adopted, the ratification levels of these Conventions have been very low. Moreover, these instruments are no longer fully relevant and need to be updated to reflect the changing nature of fishing operations in today's world. The ILO is therefore in the process of revising them in order to update and strengthen the Organization's standard-setting system to reflect the changes in the sector.

POSSIBLE SOLUTIONS

In March 2002, the 283rd Session of the Governing Body of the ILO decided to place on the agenda of the session of the forthcoming International Labour Conference an item concerning a comprehensive standard – a Convention supplemented by a Recommendation – on work in the fishing sector. The new standard was to revise the seven existing ILO instruments. Issues hitherto not addressed in relation to people working on board fishing vessels would be taken up, namely, occupational safety and health, and social security.

The ILO also intends to provide protection for people working on both large and small fishing vessels in all its fishing labour standards. The Organization believes that the objectives of the new instruments should be to extend coverage to reach as many people working on board fishing vessels as possible; minimize obstacles to ratification; achieve a more widespread ratification; enable the provisions to be implemented in practice and minimize the risk of the Convention becoming outdated in a short period of time.

The new comprehensive standard on work in the fishing sector would take into account the provisions of the 1995 FAO Code of Conduct for Responsible Fisheries and would try to integrate the work of the ILO with that of other international organizations concerned with fisheries and the operation of fishing vessels. This, the ILO believes, would result in the standard being clearly understood and found more acceptable by the ministries responsible for labour issues as well as those responsible for fisheries management and vessel safety, and by fishing vessel owners and individuals who work on fishing vessels.

RECENT ACTIONS

A Committee on the Fishing Sector was set up by the 92nd Session of the International Labour Conference, held in Geneva in June 2004, to adopt provisions on a number of substantive issues related to fishing labour standards. The Conclusions adopted by the Committee, after 20 sittings, aim to reach the majority of the world's fishers, including those on board small fishing vessels. This coverage will provide protection also to the self-employed, especially those who are paid in a share of the catch.

The Conclusions also provide sufficient flexibility to ensure wide ratification and implementation. Such flexibility is particularly important in view of the complex nature

[34] The texts of all ILO Recommendations and Conventions are available on the ILO Web site at http://www.ilo.org.

of the fishing sector, which stretches from small vessels in territorial waters to bigger vessels in the high seas. The Committee sought to achieve flexibility without any dilution of the protection provided to fishers working on vessels of different sizes and in various fishing operations.

The ILO broadens the definition of "commercial fishing" in the new standard to include all but subsistence fishing and recreational fishing (including fishing operations on inland lakes and rivers). The definition of "fisher" includes every person employed or engaged in any capacity on board any fishing vessel, including persons working on board who are paid on the basis of a share of the catch.

Certain categories of fishers and fishing vessels are exempted from the requirements of the Convention where the application is considered to be impracticable. However, such exclusions could occur only after consultation with the representative organizations of fishing vessel owners and fishers.

The instrument will include, for the first time, provisions that will address safety and health in the fishing sector, and thus help reduce the rate of injuries and fatalities in the sector. This is significant, considering that fishing is considered one of the most hazardous occupations. Finally, the instrument will include new provisions on compliance and enforcement, especially those promoting intervention by port states in relation to conditions on board fishing vessels visiting their ports.

OUTLOOK

The International Labour Conference has approved the report of the Committee on the Fishing Sector and adopted the proposed Conclusions concerning the fishing sector. Much work, however, remains to be concluded at the forthcoming Second Discussion during the 93rd Session of the International Labour Conference in June 2005. A new section concerning additional requirements for vessels above a certain, as yet unspecified, length is to be developed by the International Labour Office for examination at the Conference. Provisions concerning longer fishing vessels and accommodation on board fishing vessels are yet to be finalized, and are considered to be "complex and controversial" by the Chairperson of the Committee. There has to date been only limited discussion on social security, which needs to be addressed in the Convention, given that fishers are excluded from the ILO Social Security (Minimum Standards) Convention, 1952. The area of fishers' work agreements also remains outstanding.

While the Employers' Group looks forward to sufficiently broad and flexible standards, the Workers' Group is seeking the adoption of a balanced approach that would be global in scope and provide the flexibility necessary for the progressive extension of standards to the small-scale subsector, and that would ensure that the protection afforded to the larger vessels by current ILO instruments is retained and not eroded. As the proposed Consolidated Maritime Convention would exclude fishers from its scope, the Workers' Group is concerned that the fishing standards should also make provisions to retain protections under existing maritime conventions that are currently extended to fishers.

While addressing the Fishing Committee, the Director-General of the ILO observed: "It is clearly important that no fisher slips inadvertently through the protective net of the Convention … For this to be achieved, the mesh of this net must be just right: not too large that everything is exempt, but not so small that it would stifle ratification and implementation."

The International Labour Conference in 2005 is expected to adopt the revised labour standards for the fishing sector.

Source: S. Mathew, International Collective in Support of Fishworkers (ICSF)

Fisheries management and CITES

THE ISSUE

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) entered into force on 1 July 1975.[35] It is an international agreement and, at the time of writing, included 166 signatory countries, referred to as Parties. CITES aims to assist in the conservation of species threatened with extinction or species that, although not necessarily threatened with extinction now, may become so unless trade in them is subject to strict regulation so as to avoid utilization that would otherwise threaten their survival. It does this by controlling international trade in specimens of species of concern. The species are listed in one of three appendixes, according to the degree of protection they are considered to require.

- *Appendix I* includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances.
- *Appendix II* includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization that is incompatible with their survival.
- *Appendix III* includes species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade.

The criteria for deciding whether or not a species qualifies for listing are contained in CITES Resolution Conf. 9.24. This provides detailed criteria, with accompanying definitions, guidelines and notes, for listing species in Appendix I as well as more general criteria for listing species in Appendix II. Appendix II has a dual function as it can include species, as described above, for which there is concern over their conservation status (covered by the Annex 2a criteria), but it can also include species that must be subject to control so that trade in specimens of other species listed because of concern for their conservation status can be effectively controlled. This is the so-called "look-alike provision" covered by the Annex 2b criteria. As discussed in the next section, both of these Appendix II criteria are cause for some concern and the source of differences of opinion among FAO Members.

Any Party can submit a proposal to CITES for listing, down-listing or de-listing a species. Typically, such a proposal would be submitted to a Conference of the Parties (CoP) meeting, where it would be voted upon. All CITES Members are eligible to vote on all listing proposals and a majority of two-thirds is required for acceptance. While this mechanism is designed to achieve international cooperation in protecting species of conservation concern, it can also create problems; in practice, achieving a two-thirds majority has frequently proven difficult, leading to frustrations for Parties trying to get a species listed, down-listed or de-listed. Naturally, voting is often preceded by intense lobbying. Critics of the present system maintain that, at times, votes will therefore be decided not by considerations that are inherent to the CITES agreement but by arguments that are extraneous to the issues under discussion.

At the time of writing, there were 827 species listed in Appendix I, over 32 500 species in Appendix II and 291 species in Appendix III. Each appendix also contains a number of subspecies and populations. Appendix II largely comprises plant species (28 074) but also includes mammals (369 species), fish (68 species) invertebrates (2 030 species) and species from other major taxonomic groups. Until fairly recently, CITES had paid little attention to species that are important to fisheries, but at the 10th Session of the Conference of the Parties (CoP 10), held in Harare in 1997, a proposal was tabled for the creation of a working group for marine fisheries. The proposal was motivated by concerns that some fish species exploited on a large scale and subject to international trade might qualify for listing in CITES appendixes. At the same meeting,

[35] See footnote 27, p. 66.

however, caution was also expressed that the CITES criteria might not be appropriate to deal with exploited and managed fishery resources.

Following CoP 10, the matter was brought to FAO on the occasion of the Sixth Session of the Committee on Fisheries (COFI) Sub-Committee on Fish Trade at Bremen, Germany, in June 1998. There it was proposed that FAO should consider the suitability of the CITES listing criteria for commercially exploited aquatic species and explore the need for amendments to, or appropriate interpretation of, the criteria in relation to such species. This marked the start of an intense, frank and fruitful engagement by FAO with CITES, which has led to greater cooperation and mutual understanding between the two organizations and to the formulation of recommendations by FAO for significant changes to the listing criteria. These recommendations were accepted by CITES at CoP 13 in Bangkok in October 2004 as part of a broader revision of the previous criteria.

POSSIBLE SOLUTIONS

The FAO process

The issue of CITES in relation to commercially exploited aquatic species has been discussed at three sessions of COFI (1999, 2001 and 2003) and three sessions of the COFI Sub-Committee on Fish Trade (1998, 2000 and 2002) and has also been the subject of two technical consultations (2000 and 2001) and two expert consultations (both in 2004). In addition, an ad hoc Expert Advisory Panel for Assessment of Listing Proposals to CITES was convened in July 2004 to consider the technical merits of the proposals to CoP 13 for listing commercially exploited aquatic species. Although the work by FAO has focused on the listing criteria and the process for evaluating listing proposals, the administrative and monitoring implications for countries of the listing of a commercially exploited aquatic species and the legal implications and implementation of CITES have also been examined.

In relation to the criteria, the first FAO Technical Consultation on the Suitability of the CITES Criteria for Listing Commercially-exploited Aquatic Species (Rome, 28–30 June 2000) quickly came to the conclusion that the existing (Res. Conf. 9.24) criteria, were not entirely suitable. Discussion of the Appendix I criteria has always been largely technical and at the Consultation included issues such as the need to provide sound technical guidelines on the processes and methodologies for quantifying threshold levels; the need for, and problems associated with, verification and validation of population numbers (Criterion A); and problems associated with the estimation and significance of changes in geographic area of distribution and fragmentation of populations (Criterion B).

In contrast, consideration of the more general criteria for listing under Appendix II, especially the Annex 2a criteria, generated wider disagreement on the intent of the criteria. The Annex 2a criteria stated:

A species should be included in Appendix II when either of the following criteria is met.

A. It is known, inferred or projected that unless trade in the species is subject to strict regulation, it will meet at least one of the criteria listed in Annex 1 in the near future.

B. It is known, inferred or projected that the harvesting of specimens from the wild for international trade has, or may have, a detrimental impact on the species by either:

i) exceeding, over an extended period, the level that can be continued in perpetuity; or

ii) reducing it to a population level at which its survival would be threatened by other influences.

Concern was expressed about the wording in this paragraph, including the interpretation of terms such as “extended period” and “in perpetuity”. In particular, FAO Members could not agree on the intention of the criteria and a key conclusion of the Consultation was that “there were differences of opinion as to whether it relates to reducing the risk of extinction and/or promoting sustainable use.” These differences of opinion are also found within CITES – they have yet to be resolved and constitute a major cause of controversy over the role of Appendix II.

The Consultation also discussed potential problems concerning the implementation of listing a commercially exploited aquatic species in relation to the Annex 2b criteria – the "look-alike" clause. Annex 2b, Paragraph A states that species should be included in Appendix II if they "resemble specimens of a species included in Appendix II under the provisions of Article II, paragraph 2 (a), or in Appendix I, such that a non-expert, with reasonable effort, is unlikely to be able to distinguish between them". As many fish products are traded in processed form, for example as white fillets, implementation of this paragraph has potentially widespread ramifications for fisheries and fish trade. Furthermore, there were concerns among FAO Members that the references to the precautionary approach, as applied in Annex 4 of Res. Conf. 9.24, could be subject to extreme interpretations.

The 24th Session of COFI in 2001 agreed that a further technical consultation should be held to develop the formal FAO input to CITES on the criteria. Subsequently, a small group of high-level experts was convened in June 2001 to prepare a working document for the Consultation. The group referred to the most recent work on extinction risk in aquatic species, in particular the work undertaken by the United States National Marine Fisheries Service.[36]

A report and recommendations were prepared and submitted to the Second Technical Consultation on the Suitability of the CITES Criteria for Listing Commercially-exploited Aquatic Species.[37] Using these as a basis, the Consultation agreed on some substantial revisions and additions to the CITES listing criteria for application to commercially exploited aquatic species. The FAO recommendations were based on the following fundamental principles:

- In general, it is considered that taxonomic characteristics are less important to risk of extinction than life history characteristics and that population resilience (the ability to rebound after perturbation) is the demographic variable generally considered to be of greatest relevance to the risk of extinction.
- There is no reliable way of measuring resilience, but it is thought to be closely related to population productivity, with more productive species likely to have greater ability to rebound from low numbers.
- Productivity is a complex function of fecundity, growth rates, natural mortality, age of maturity and longevity; more productive species tend to have high fecundity, rapid individual growth rates and high turnover of generations.
- Populations that are low relative to the environmental carrying capacity can give rise to concern about their risk of extinction because they may be susceptible to "depensation", where depensation is defined as a negative effect on population growth that becomes proportionately greater as population size declines.
- Populations experiencing depensation are prone to further reductions in size, even in the absence of exploitation, and therefore have a greater risk of extinction.

Based on these fundamental principles, the Consultation put forward a series of recommendations on biological criteria for consideration for listing commercially exploited aquatic species in Appendixes I and II. Central to the recommendations was the importance of declines in determining extinction risk, where declines can be considered either as a historical extent of decline (the current population size in relation to some historical baseline size) and the recent rate of decline (the observed rate of decline of a population or species over recent time). Criteria were developed for both Appendix I and Appendix II based on these types of decline. This quantitative approach to the interpretation of the Appendix II criteria is considered by FAO to be

[36] NMFS. 2001. Report of the NMFS CITES Criteria Working Group. Preliminary Draft 16 May 2001. Woods Hole, USA, National Marine Fisheries Service; J.A. Musick. 1999. Criteria to define extinction risk in marine fishes. *Fisheries*, 24(12): 6–13; C.S. Holling. 1973. Resilience and stability of ecological systems. *Annual Rev. Ecol. Systematics*, 4: 1–23.

[37] Details of the recommendations are available in FAO. 2001. *Report of the Second Consultation on the Suitability of the CITES Criteria for Listing Commercially-exploited Aquatic Species. Windhoek, Namibia, 22–25 October 2001*. FAO Fisheries Report No. 667. Rome.

an important contribution to the implementation of Appendix II for commercially exploited aquatic species.

In addition to its recommendations on the criteria, FAO emphasized the importance of using the best scientific information available when preparing listing proposals. This information should be subjected to comprehensive analyses, quantitative where possible, in order to integrate the available relevant data. This is the most reliable means of obtaining the best estimates of important indicators such as population size and production rates. FAO also expressed concerns about the process normally used by CITES for scientifically evaluating the proposals because it did not ensure a rigorous evaluation and provided little opportunity for reconciling conflicting views. It was recommended that FAO assist in the evaluation of proposals for relevant species.

After formal approval, the FAO recommendations were sent to CITES for consideration.

The CITES process

When the Res. Conf. 9.24 criteria were adopted by the 9th Conference of the Parties to CITES in 1994, it was recommended by the Parties that the text and annexes of that Resolution be reviewed, in terms of their scientific validity, before CoP 12. CITES therefore began to review the criteria in 2000, after CoP 11. The CITES process included holding two meetings of a specially constituted Criteria Working Group, constant consultation with Parties and interested organizations, extensive review and discussion at CoP 12, testing the draft revised criteria against a number of species from different taxonomic groups and finalization at CoP 13. The FAO Fisheries Department was invited by CITES to serve on the Criteria Working Group and participate in most of the other discussions and consultations. A number of other fish and fishery specialists were also closely involved. Throughout the process, CITES recognized the concerns of FAO, national fisheries authorities and regional fisheries management organizations (RFMOs) about the Res. Conf. 9.24 criteria and was receptive to recommendations and inputs from fishery experts and from FAO. CITES considered it desirable to retain a single set of criteria that is applicable to all species and therefore the definitions and criteria that have been included specifically to address commercially exploited aquatic species have largely been included in Annex 5 of the revised criteria (containing definitions, guidelines and notes). This decision has not, however, weakened these considerations and the revised criteria are now considered suitable, if not ideal, for application to commercially exploited aquatic species.

RECENT ACTIONS

In addition to ensuring that the CITES criteria would be suitable for application to commercially exploited aquatic species, FAO also recommended improvements to the process for scientific evaluation of proposals for listing, down-listing or de-listing species. This has now also been addressed. In terms of the CITES Convention text on proposals for marine species (Article XV, paragraph 2b), the CITES Secretariat is required to consult intergovernmental bodies having a function in relation to those species for the purposes of "obtaining scientific data these bodies may be able to provide" and "ensuring coordination with any conservation measures enforced by such bodies".

Prior to CoP 13, FAO had declined to respond to requests from CITES for information under Article XV on the grounds that the FAO Secretariat did not have a mandate to do so. This situation changed after the 25th Session of COFI in 2003 and the 9th Session of the COFI Sub-Committee on Fish Trade in 2004, where terms of reference for an FAO ad hoc Expert Advisory Panel for the Assessment of Listing Proposals to CITES were approved and it was agreed that such a panel should be convened to evaluate listing proposals to CoP 13 for commercially exploited aquatic species.

The panel, consisting of a group of high-level experts from around the world, met in July 2004 and considered the following proposals to CoP 13:

- *Carcharodon carcharias* (white shark) to be included in Appendix II with a zero annual export quota;
- *Cheilinus undulatus* (humphead wrasse) to be included in Appendix II;
- *Lithophaga lithophaga* (Mediterranean date mussel) to be included in Appendix II;
- Helioporidae spp., Tubiporidae spp., Scleractinia spp., Milleporidae spp. and Stylasteridae spp.; an amendment of the annotation to these taxa to exclude fossils from the provisions of the Convention.

The panel's recommendations were forwarded to the CITES Secretariat and made available to the Parties to CITES in accordance with Article XV. The recommendations were noted by CoP 13 although they were not consistently adhered to in the final decisions, in which it was agreed to list white sharks (without the constraint of a zero quota), humphead wrasse and Mediterranean date mussel in Appendix II.

FAO Members have also been concerned about the implications for exporting, re-exporting and importing states of the listing of commercially exploited aquatic species. An expert consultation was therefore held in May 2004 to consider the following issues:

- the fundamental principles of CITES Article II, especially paragraph 2(b), the "look-alike" clause;
- Annex 3 of CITES Res. Conf. 9.24, which deals with split-listing and aquaculture issues;
- the administrative and monitoring implications of listing and down-listing, including the implications of Annex 4 of Res. Conf. 9.24 in this context. Consideration of this issue included an analysis of the socio-economic impact of listing on selected commercially exploited aquatic species.

In addition, a second expert consultation was held to address a number of legal issues related to CITES and fisheries. These included:

- the application of the phrase "introduction from the sea" used in the definition of trade in Article I of the CITES Convention, including consideration of the administrative costs associated with the various interpretations of this term.
- an analysis of the legal implications of the existing CITES listing criteria and the CITES Convention itself in relation to the UN Convention on the Law of the Sea and related international law covering fisheries.

GLOBAL PERSPECTIVE

Many, if not most, of the world's fisheries are currently caught in a dilemma. A number of the resources on which they depend are overexploited and it is widely accepted that there is considerable excess capacity in the fishing fleets of the world – but fisheries are still important sources of food security, employment and other economic benefits. The fishing nations of the world are attempting to address these problems in a responsible manner. In terms of its mandate, CITES clearly has a role in solving some of the problems confronting fisheries, although countries differ in their views on the extent of that role.

When FAO first became involved in working with CITES, the fisheries agency or agencies and the CITES agency in individual countries were frequently located in different departments and did not communicate with each other to a meaningful extent. Arguably, the most significant progress that has been made over the last five to six years has been the breaking down of such barriers in many countries, thus encouraging the greater involvement of the fisheries agencies in CITES regarding matters of relevance to them. In addition, revision of the criteria so as to bring them further into line with the best practices in fisheries science and stock assessment, coupled with a rigorous and transparent review process, should result in better-informed decisions on commercially exploited aquatic species being made by CITES Parties, thereby contributing to the improved effectiveness of CITES in fulfilling its role and mandate.

Trade implications of fish species and fish product identification

THE ISSUE

Developments in food preservation and processing technologies and liberalization of trade have contributed significantly to the globalization of fish trade and the diversification of seafood, in terms of both species and products. It is currently estimated that more than 800 fish species are traded internationally in many different forms, shapes, brands and preparations.

As prices differ depending on the product/species and consumer preferences and perceptions, it is important that market forces and the market environment provide for the protection of consumers from fraudulent and deceptive practices whereby low-value species or products are substituted for high-value similar ones. At the national level, food legislation generally indicates that the label must not mislead consumers, but international trade and the use of similar terms for different products make this complicated when a product from one country is introduced to another in which the market niche already exists.

Seafood companies and exporting countries are increasingly seeking to sell their products using commercial names with established international repute so as to derive maximum value and recognition. The matter is exacerbated by the fact that different species may have the same common name in different countries (or even regions of the same country). On the other hand, sometimes the same species has different names in the same language in different locations within the same country. For example, in Nordic countries, canned *Sprattus sprattus* is labelled "sardiner" or "ansjos" and is called brisling if not canned, while in other countries sardine refers to *Sardina pilchardus* and anchovy to Engraulidae species. A market name such as "seabass" is frequently used in international trade, but it refers to very different species from various families; the same observation can be made for the name "catfish". This factor may be a source of misleading information.

On the other side, food companies, trade associations and even entire countries can be protective of market niches for given fish species and products. They consider that establishing such market niches often requires significant investment in research and development, publicity, promotion and consumer sensitization towards the claimed attributes of the specific product they are trying to protect. Therefore, the successful companies or countries are unwilling to accept that other similar products may use the same commercial denominations and compete in the same marked niches. Such occurrences may be a source of trade disputes between countries.

Recent examples of international trade disputes (scallop muscles, canned sardines – arbitrated by the WTO) show that the implications of fish species identification represent a recurrent and worldwide issue. Although such disputes generally involve a limited number of countries, they have a direct impact on international fish trade.

In the sardine case, the dispute arose from the fact that the name "sardine" was exclusively reserved for *Sardina pilchardus* in certain countries whereas other countries were intending to develop trade in different clupeid species labelled as "sardine" products. The dispute was taken to the WTO Appellate Body, which looked into the Codex Standard for Canned Sardine and Sardine-type Products.[38] The labelling provisions of the standard state that the name of the product shall be:

(i) "Sardines" (to be reserved exclusively for Sardina pilchardus *[Walbaum]); or*

(ii) "X sardines" of a country, a geographic area, the species, or the common name of the species in accordance with the law and custom of the country in which the product is sold, and in a manner not to mislead the consumer.

"X" refers to sardine-type species listed in the "Product definition" section of the standard, which include small pelagic fish such as anchovies or herring.

[38] CODEX STAN 94 –1981 Rev. 1-1995 (available at http://www.codexalimentarius.net/web/standard_list.do?lang=en; accessed September 2004).

As an outcome of the dispute on the trade description of preserved sardines, the WTO Appellate Body concluded that the labelling provisions of Codex standards are relevant, effective and efficient in pursuing the legitimate objectives of promoting market transparency, consumer protection and fair competition. Consequently, countries will have to modify their labelling regulations in such a way that they are consistent with Codex provisions.

Other implications of fish species identification may be pointed out in CITES provision implementation. Annex 2b of the Convention establishes two conditions under which a species may be included in Appendix II in accordance with Article II, paragraph 2(b).

A. The specimens resemble specimens of a species included in Appendix II under the provisions of Article II, paragraph 2(a), or in Appendix I, such that a non-expert, with reasonable effort, is unlikely to be able to distinguish between them.

B. The species is a member of a taxon of which most of the species are included in Appendix I under the provisions of Article II, paragraph 2(a) or in Appendix I, and the remaining species must be included to bring trade in specimens of the others under effective control.

Criterion A addresses the 'look-alike' problem by providing a mechanism for including in Appendix II all species that closely resemble in appearance any species included in either Appendix I or Appendix II in accordance with the provisions of Article II, paragraph 2a.

Some countries are concerned that these criteria have the potential for interpretation in a manner that could result in the inclusion in Appendix II of an economically important marine fish species. Another concern is the difficulties experienced by customs officers in identifying – readily and accurately – imported commodities derived from species included in Appendix II, whether or not they are accompanied by appropriate export documents.

The development of procedures for fish species identification based on sound scientific methods should allow for a more accurate management of protected species and look-alike species and mitigate the economic impact of precautionary principle implementation.

POSSIBLE SOLUTIONS

FAO's Code of Conduct for Responsible Fisheries calls for the liberalization of trade in fish and fishery products and for the elimination of unjustified barriers, in accordance with the principles laid down in the agreements of the WTO.[39] But such liberalization can only take place in a framework of transparency and enhanced information to consumers, particularly with regard to product labelling.

Reconciling the interests of those seeking to protect commercial denominations and those seeking to use these denominations for "similar" species requires an international undertaking using a reliable approach and methodology. The principles depicting the environment to achieve this are embodied in the WTO's binding Agreement on Technical Barriers to Trade. The objective of the Agreement is to prevent the use of national or regional technical requirements, or standards in general, as unjustified technical barriers to trade. It includes numerous measures designed to protect the consumer against deception and economic fraud. In essence, the Agreement provides that all technical standards and regulations must have a legitimate purpose and that the impact or cost of implementing the standard must be proportional to the purpose of the standard. It also states that, if there are two or more ways of achieving the same objective, the least trade-restrictive alternative should be followed. The Agreement also places emphasis on international standards, with WTO Members being obliged to use international standards or parts of them except where the relevant standards would be ineffective or inappropriate in the national situation. The aspects of food standards that are covered specifically are

[39] In section 11.2, "Responsible international trade"; see footnote 14, p. 35.

quality provisions, nutritional requirements, labelling, packaging and product content regulations, and methods of analysis.

Labelling the product so as to indicate exact nature and characterization is considered the most appropriate and transparent method in international trade. Doing so should enable consumers to make choices in full knowledge of the facts and thus should protect them from deceptive practices. Likewise, verifying that a fish product conforms to the claims made on its label requires reliable authentication techniques.

It is therefore important that scientific criteria be developed for listing species under a given denomination and a reliable methodology for verifying the authenticity of labelling claims. In this respect, the Codex standards have become an integral part of the international regulatory framework within which international trade is being facilitated through harmonization. Already, they have been used as the benchmark in international trade disputes, and it is expected that their role will increase in the future.

Fish-exporting countries are increasingly seeking recognition of their fishery products in the Codex standards and it is perfectly understandable that a country would want to derive maximum benefit from its resources and expertise. The potential reward from including additional species or families of species in a Codex standard is, of course, linked to international recognition of the derived products of this species. This recognition is associated primarily with the commercial name of the product; authorization to use a name with established international repute is therefore an important asset and a declared objective. However, value-enhancing appellations are being sought for many species, but such appellations are relatively few. Labelling provisions therefore need to be sufficiently clear to avoid consumers being misled and the creation of conditions of unfair competition in international trade.

Because Codex standards are used as reference documents in trade disputes, discussions within the Codex Committee on Fish and Fishery Products (CCFFP) tend to be tough and lengthy, in particular when considering the definition and labelling sections of new draft standards. The inclusion of additional species in existing standards is also a sensitive issue, to the extent that the Committee has embarked on work to develop an improved methodology for this purpose.

The species proposed for inclusion in a Codex standard need to be identifiable. The present procedure requests that biological information be supplied in order to place the species within a classification, although additional information should also be provided to improve the effectiveness of this procedure. With the prospect of growing international trade and an increasing number of potentially marketable species, reliable methods for verifying product authenticity are essential. The country requesting the inclusion of an additional species in a standard should therefore be in a position to provide biochemical references that will permit the identification of the species in the products covered by the standard, for example, protein electrophoretic profiles or DNA sequences.

The same reasoning may be applied for inclusion of additional species in CITES lists. The development of procedures based on sound scientific methods for fish species identification should allow for a more accurate management of protected species and look-alike species and mitigate the economic impact of precautionary principle implementation.

RECENT ACTIONS

Since the mid-1960s, FAO has developed a programme to clarify and improve, on a national, regional and global scale, the identification of species of actual or potential interest to fisheries;[40] more recently, conservation criteria are also being considered. This programme has produced world catalogues, regional identification sheets and national field guides, used for four decades by many fish trading companies as the

[40] FAO Species Identification and Data Programme (SIDP) (available at http://www.fao.org/fi/sidp; accessed September 2004).

authoritative source of scientific and vernacular names and characteristics. During the last decade, information regarding bony fish and cartilaginous fish has progressively been included in FishBase.[41] FAO has recently established a list of species of interest to the international fish trade and compiled current information on the authentication of fish species using techniques such as electrophoresis and DNA sequencing. This work supports the deliberations of the CCFFP on the identification of fish species for the standardization of fish and fishery products and on facilitating fish trade, especially exports from developing countries.

Based upon available information, in particular in FishBase, the corresponding common names have been indicated, where available, in the different languages used in the different countries classified according to the regions: Africa, Asia, Europe, Latin America and Caribbean, Near East, North America and the Southwest Pacific. It is to be noted that, according to most Codex standards for fishery products, "the name of the product declared on the label shall be the common or usual name applied to the species in accordance with the law and custom of the country in which the product is sold, and in a manner not to mislead the consumer". FAO names and taxonomic codes are also indicated, based upon the Aquatic Science and Fisheries Information System (ASFIS). Nevertheless, this list is to be considered as a starting list which needs to be improved and taken forward to completion. FAO has called upon the collaboration of the member countries of Codex Alimentarius in undertaking this work. The list of species needs to be corrected and updated, in particular to verify whether all species are genuinely of commercial interest, to remove species that have no or little such interest and insert additional species as necessary.

FUTURE PERSPECTIVE

Molecular biology has made considerable progress in the identification of processed fishery products, including products that have undergone extensive technological treatment. It would be interesting to draw up an inventory of the analytical protocols used to identify species used in fishery products and to collate available reference data in the Codex member countries. A compilation or database of internationally recognized references of this nature could be useful for applying the inclusion procedures and for verifying product conformity with the labelling requirements of standards.

Correct identification of the species and their origin requires the collaboration of the scientific community at an international level. During the first Trans-Atlantic Fisheries Technology (TAFT) meeting held in Reykjavik, Iceland, in 2003, the creation of an international network of institutions to provide authentic reference samples was proposed; indeed, the main problem in authenticating a sample is often the lack of reference material at the location where the analysis is required. A useful way forward might be to construct a database or Web page containing a list of each species being used as food and providing the common names for each species, the location where each common name is indeed common, the scientific name, a description of the analyses performed on the species and a link to the results. The results page might present a graphic of how the results look (e.g. a photograph of the gel, or the scan) and, if possible, a table providing the values corresponding to the graphic. For each species, it would also be helpful to include a link to an institution from which samples of authentic material might be obtained

The support of an internationally recognized institution such as FAO would be beneficial in establishing the infrastructure and the contacts among the relevant institutions in each country. FAO is currently examining the possibilities of assuming this responsibility in relation to the Aquatic Food Programme being developed under the direction of FAO Fishery Industries Division, keeping in mind the need to ensure improved access to scientific information on the part of developing countries.

[41] Available at http://www.fishbase.org; accessed September 2004.

By fostering collaboration among international institutions and individual scientists, FAO expects that this programme will generate a peer-reviewed and multidisciplinary aquatic food safety and quality knowledge base. Its long-term goals are to support member countries in the areas of safety and quality (including authenticity) of food produced from aquatic species. Under this programme, the use of information technologies will be maximized to facilitate information dissemination and to enhance capacity-building initiatives in developing countries.

A list of common names linked to the Aquatic Food Programme knowledge base containing scientific data could be useful for preparing and implementing a new Codex inclusion procedure and, more generally, for further work on species identification and for enhancing international fish trade transparency.

Depleted stocks recovery: a challenging necessity

THE ISSUE

During the eighteenth and nineteenth century, thinkers such as Jean-Baptiste de Lamarck and Thomas Huxley assumed that the size of the oceans and the high fecundity of commercially exploited fish and shellfish meant that, under the conditions prevailing at that time, the risk of extinction of fishery resources was low. These scientists overestimated the ocean's resilience to fishing and underestimated both the future demand and the potential progress in fishing efficiency. However, the fact that local natural renewable resources could be depleted through wasteful competition and lack of ownership has been known literally for centuries,[42] and by the end of the 1960s the "tragedy of the commons" was already common knowledge.[43] The problem of overfishing was already recognized by the first FAO Fisheries Technical Committee in 1946 and was flagged recurrently in the successive FAO fisheries conferences, for example in Vancouver (1973), Rome (1984) and Reykjavik (2002), to cite just a few major events. The depletion issue was flagged again at the start of the twenty-first century in *The State of World Fisheries and Aquaculture 2002*, which indicated that "An estimated 25 percent of the major marine fish stocks … are underexploited or moderately exploited … About 47 percent of the main stocks or species groups are fully exploited … 18 percent of stocks or species groups are reported as overexploited … The remaining 10 percent have become significantly depleted, or are recovering from depletion." Among the stocks considered depleted, the Northeast Atlantic and the Mediterranean and Black Seas are the areas with stocks having the greatest need for recovery, followed by the Northwest Atlantic, the Southeast Atlantic, the Southeast Pacific and the Southern Ocean areas.

The depletion of stocks contravenes the basic conservation requirement of the 1982 UN Convention on the Law of the Sea and of sustainable development. It is also contrary to the principles and management provisions adopted in the 1995 FAO Code of Conduct for Responsible Fisheries. It affects the structure, functioning and resilience of the ecosystem, threatens food security and economic development, and reduces long-term social welfare. The demand for fish as human food may reach around 180 million tonnes by 2030 and then neither aquaculture nor any terrestrial food production system could replace the protein production of the wild marine ecosystems.

The Plan of Implementation of the World Summit on Sustainable Development specifically urges the need to "Maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015." Considering the trends since 1946, this time-frame certainly represents a high-order challenge.

[42] S.M. Garcia and J. Boncoeur. 2004. *Allocation and conservation of ocean fishery resources: connecting rights and responsibilities.* Paper presented at the 4th World Fisheries Congress, Vancouver, Canada, May 2004, as an opening to the session on Allocation and Conservation.

[43] G. Hardin. 1968. The tragedy of the commons. *Science*, 162: 1243–1248.

ACTION REQUIRED

While stock recoveries from stocks driven to 10 percent of their unfished biomass level have been documented, it is advisable to develop an explicit recovery plan before they fall below 30 percent of that level and, preferably, as soon as resources appear to be clearly below their long-term maximum average yield.

The measures needed for stock rebuilding are no different, in essence, from those needed to avoid its depletion, namely:

- the reduction of mortality through more or less abrupt reduction of effort, including moratoria when they are unavoidable, and bycatch reduction;
- the reduction or elimination of environmental degradation;
- the enhancement of factors of growth, for example through stock enhancement and habitat rehabilitation.

Under the ecosystem approach to fisheries, stock rebuilding is a prerequisite for ecosystem rehabilitation. In the last issue of this report it was stated that "recovery usually implies drastic and long-lasting reductions in fishing pressure and/or the adoption of other management measures to remove conditions that contributed to the stock's overexploitation and depletion". The explicit adoption of a rebuilding strategy, however, implies that rebuilding be adopted as an explicit objective in a formal stock rebuilding plan, including target reference values, specific management measures and performance assessment. It emerges from available examples that a successful recovery plan needs most, if not all, of the following basic components, in some order of priority:

1. A "rule-based" precautionary management framework providing non-discretionary measures incorporated into overriding legislation.[44] Subsidies and other measures that allow participants to continue to fish a depleted stock will compromise recovery.
2. A proper institutional set up with: (i) teams of experts to take responsibility for recovery plans; (ii) a participatory process involving fishers in all operations to promote transparency; (iii) public information and education programmes; and (iv) integration of goals, strategies, measures and data among jurisdictions. In the case of shared resources a cooperative management regime would be needed in most situations.
3. Mandatory limitation of access to the resource and reduction of capacity and exploitation rates to levels compatible with recovery conditions. This may involve closing all or critical parts of the stock range and allocation of explicit fishing rights. In multi-species fisheries, tradeoffs may arise between attaining recovery of the depleted stock and continued harvesting of other, healthier, stocks.
4. Provisions for compensation for definitive or temporary loss of rights and livelihood in the form of alternative employment. These may not be required if alternative resources are available but may be essential in the case of poor, rural or disenfranchised communities.
5. *Ex-ante* assessment of the consequences of the planned measures, for example in terms of bioecological as well socio-economic impacts, the transfer of excess capacity to other areas or resources, and a likely time-frame for recovery. This assessment should offer an analysis of cost–benefits of various options with different grades of severity for the people involved.
6. A system for monitoring stock, people's/communities' status and fleet activities using indicators of fishing pressure, economic well-being, recruitment and environmental conditions and, if affordable, a fishery-independent monitoring of stock biomass by regular research vessel surveys.
7. A system of indicators with target reference points and limit reference points representing agreed "dangerous" stock conditions, unsustainable levels of exploitation of the stock, or deterioration of critical habitats for the resources in question.

[44] As provided for in the Magnuson-Stevens Fishery Conservation and Management Act of the United States Congress.

8. Tight enforcement of the recovery plan until there is a high probability that the stock spawning biomass is above the level corresponding, at least, to the one that provided the maximum sustainable yield or equivalent prior to collapse. In particular, the occurrence of a good year class should be seen as a rare opportunity to rebuild stock biomass and not an excuse to increase quotas or prematurely terminate a rebuilding plan.
9. The elaboration of post-recovery management plans avoiding significant new increases in effort and incorporating aspects of recovery planning into routine, post-recovery management.

Even the best planned recovery may be inhibited by one or more of the following factors:

- unfavourable climate conditions,[45] which, combined with overcapacity, may contribute to the failure of recovery plans, either through delaying the stock recovery response to management or providing incentive (pressure) to curtail management action as soon as a good recruitment is observed;
- a change in species composition, such as replacement by a competitor or depletion of its main prey;
- continued and surreptitious high mortality, for example inflicted through bycatch in another fishery;
- environmental degradation;
- interference in the life cycle, for example through the interruption of migration routes or destruction of spawning or nursery areas.

All of the above factors could be aggravated by loss of genetic diversity.

Because of the costs involved and the essentially uncertain nature of the recovery process, the number of fisheries to be included in recovery plans and the time-horizon for recovery will need to be carefully considered. Recovery times vary according to the resource, the scale of the intervention and the socio-economic and climatic environments. If a large proportion of stocks are depleted and overcapacity is high, the process may need to be drastic, and hence costly, if any impact is to be made in a reasonable time. The reproduction of depleted stocks consisting of young fish is unlikely to give optimal results,[46] and rebuilding the older age groups requires that the recovery time extends beyond a single generation to rebuild the stock capability to "bridge" across medium-term climatic oscillations.[47] Impacts may be felt in the target fishery as well as in other fisheries connected to it, for example through bycatch or predator–prey relationships.

Because of their potential social costs, the development of recovery plans needs the close involvement of the communities concerned.[48] The plans may not be very popular but, as shown by past examples, the cost of *laissez-faire* policies is likely to be much higher in the medium to long term.[49] Rebuilding may require a permanent reduction

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[45] Experience shows that environmental fluctuations may delay or accelerate recovery and climate regime shifts produce effects comparable to those of fishing and predator–prey interactions. See, for example, J. Jurado-Molina, and P. Livingston. 2002. Climate-forcing effects on trophically linked groundfish populations: implications for fisheries management. *Can. J. Fish. Aquat. Sci.*, 59: 1941–1951.

[46] See, for example, E. Kenchington. 2001. *The effects of fishing on species and genetic diversity.* Paper presented at the Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem. Reykjavik, 1–4 October 2001; R. Law. 2000. Fishing, selection, and phenotypic evolution. *ICES J. Mar. Sci.*, 57: 659–890. A. Longhurst. 2002. Murphy's Law revisited: longevity as a factor in recruitment to fish populations. *Fish. Res.*, 56: 125–131.

[47] Recovery times for short-lived tropical and small pelagic fish will, in principle, be shorter than for long-lived demersal resources of high latitudes, for which recovery times upwards of 15 years may be expected, subject to the climatic vagaries mentioned above. As much as a half century may be needed to restore very long-lived resources such as sturgeons, ocean perch or orange roughy.

[48] In the yet unsuccessful cod fishery moratoria in Canada, rights-based comanagement has been used as a means to assist in rebuilding and the industry plays an active role in monitoring closed areas and formerly productive grounds, reducing conflicts between managers and stakeholders.

[49] The collapse of the Canadian Atlantic cod fishery caused a yearly expense of Can$50 million in assistance to individuals and communities in addition to the earlier government expenditures associated with the moratorium. See Fisheries and Oceans Canada. 2003. *Closure of the cod fisheries and action plan to assist affected individuals and communities.* In Focus – Archive, 24 April (available at http://www.dfo-mpo.gc.ca/media/infocus/2003/20030424_e.htm; accessed September 2004).

in fishing capacity and may also lead to the displacement of fishing crew. In most countries, some form of compensatory measures will be needed for both the vessel owners (e.g. vessel buy-back) and the fishing crew (e.g. unemployment insurance, soft loans, retraining, alternative employment). Buy-back programmes have led to mixed results and care must be taken that the financial support provided is not reinvested in more powerful vessels.

During the recovery plan, enforcement and monitoring are of key importance. When recovery begins to be obvious, pressure from the sector to resume or increase fishing rises drastically and strict management will be needed to avoid a repetition of the problem.

ACTION TAKEN

Curbing fishing effort has been the main measure for recovery when the stock has been depressed by overfishing – combined or not with unfavourable climatic conditions. The progressive reduction of fishing, for example through a reduction in total allowable catches, has generally been the first choice in order to limit the need to address social and economic consequences. However, because of the cost and difficulty of reducing fishing capacity to the level of harvest compatible with stock recovery, the action has often been "too little and too late". Allocating the residual effort among the artisanal, industrial and recreational segments of the fishery is a difficult task and rarely attempted. In addition, the fact that catchability tends to increase exponentially with some stocks as abundance decreases seriously complicates the control of fishing pressure. Effort may therefore have to be eliminated abruptly, for ecological or economic reasons; indeed, most of the abrupt fishing closures in the past have been forced by the economic collapse of the fishery.

Seasonal closures (e.g. "biological rest") have also often been proposed as "soft" rebuilding measures. These have been shown to be ineffective if the overall fishing capacity remains excessive.

Moratoria have generally been called for following failed attempts to curb fishing pressure progressively. They have often been imposed as a result of the economic demise of the fishery. No-take sport fisheries may have a similar effect if all individuals caught and released survive. Moratoria were relatively successful in restoring herring fisheries in the North Atlantic and Northeast Pacific. Such closures are more easily implemented and hence acceptable for selective pelagic fisheries than for demersal multispecies multigear fisheries; the latter require an integrated recovery plan that addresses all segments of the fisheries affecting the resource in the area and pose a more complex challenge to a wide range of interest groups. There is no guarantee that the success of total closures will be rapid or even certain, as evidenced by the very slow recovery of the Canadian cod fishery after a decade of efforts.

Areal closures, either permanent (sanctuary), temporary or seasonal, aimed at protecting nursery or spawning habitats and concentrations of spawners or juveniles, have also been used for some time. They may be introduced to protect critical habitats in rivers and streams, mangroves, seagrass meadows, algal beds and coral reefs. Their efficiency depends on the level of overcapacity and degree of enforcement or compliance. Marine protected areas, if adequately located, may be useful in this respect. The closure of a 17 000 km^2 reserve on the United States side of George's Bank to haddock and flounder trawl fisheries demonstrated, after five years, a significant recovery of the two target species as well as some recovery of cod and a large-scale build-up of scallop stocks. However, the results of a closed area or closed fishery are not always entirely predictable, as demonstrated by the rise of lobsters, snow crabs and shrimp landings in the Northwest Atlantic and Scotian Shelf following the cod fishery closure. The high value of these landings might generate pressures against the original recovery plan objective.[50]

[50] Fisheries and Oceans Canada. 2003. *Current state of the Atlantic fishery.* Backgrounder – Archive, 24 April (available at http://www.dfo-mpo.gc.ca/media/backgrou/2003/cod-1_e.htm; accessed September 2004).

Although not uniformly successful, experience shows the importance of a "harvest control rule" specifying the conditions under which rebuilding is obligatory and its strict enforcement for as long as rebuilding is not completed. A rule-based approach requires precautionary or limit reference points to be defined (e.g. for spawning biomass and fishing capacity) and non-discretionary action must be decided in advance and taken if and when these limits are reached. Action should continue until the spawning stock is restored to some predetermined level – possibly higher than that formerly supporting the maximum sustainable yields. A lack of capacity control will then result in the fishery oscillating dangerously around the boundary of the overfished condition.

Results obtained

Proactive recovery planning is recent. The majority of proper recovery plans relate to waters adjacent to developed countries and have less than 10–20 years of track record. Their success has been limited and many plans are still underway. If such a plan is considered successful when an upward trajectory of biomass is registered some time after a plan has been initiated, past experience shows that recovery has been successful in 12 (46 percent) of the cases for groundfish, 8 (67 percent) of them for pelagic fish and 10 (71 percent) for invertebrates, possibly related to reduced predation by collapsed groundfish stocks.[51] These statistics suggest that groundfish stocks recovery has been less successful than for other resources, except for some local area closures in the tropics. It has also been shown that many small pelagics recovered five years after the major decline, while 40 percent of the groundfish stocks continued to decline even 15 years after the period of largest decline in the stock history was over.[52]

OUTLOOK

Can we meet the Johannesburg directive?

The review provided above and the results experienced to date illustrate both the major scale of the task called for in the Plan of Implementation of the World Summit on Sustainable Development, the time frame of which results from political bargaining more than any scientific analysis of recovery times. Recovery will inevitably have a high cost, although the alternative (taking no action) can only be more costly. From the few successful recovery plans located, restoring demersal stocks is a much more difficult task than for pelagic fish and invertebrates, especially on high-latitude fishing grounds. Rapid recovery will also be compromised if environments are unfavourable, or stocks reduced to much below 30 percent of the unexploited stock size. Local recoveries of mainly tropical shallow shelf resources have been achieved relatively rapidly by closing areas to fishing, but it is expected that recovery of high-latitude demersal stocks will require rebuilding periods of 15 years or more, and will probably need to be supplemented by large closed areas and technical measures. Unfortunately, relatively few large-scale closures of demersal fisheries have been attempted in temperate zones, although this mechanism seems to offer chances of success over a decadal time frame.

A negative sign is given by the slow progress achieved in adjusting fishing capacity to biological productivity since the problem was first recognized at least 50 years ago. Awareness is now extremely high and pressure from both fisheries and environmental quarters is growing. However, capacity to fulfil this task is still very unequal and often insufficient, particularly in developing countries. In addition, the concept that without allocation there will be no conservation – a concept reaching back to Greek civilization – has still to be accepted in the modern political arena, jeopardizing the process in many areas.

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[51] J.F. Caddy and D. Agnew. 2003. *Recovery plans for depleted fish stocks: an overview of global experience.* International Council for Exploration of the Sea Doc CM 2003/Invited lecture 2 (available at http://www.ices.dk/products/CMdocs/2003/INVITED/INV2PAP.PDF;accessed September 2004).

[52] J.A Hutchings. 2000. Collapse and recovery of marine fishes. *Nature*, 406: 882–885.

Governance and management of deep-water fisheries

THE ISSUE

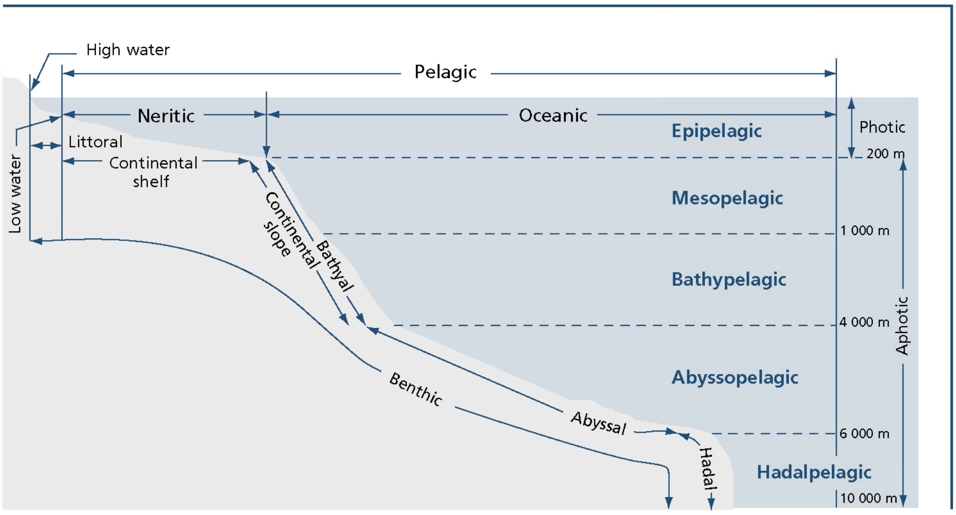
An unequivocal definition of a deep-sea fish is difficult. The recent Deep Sea 2003 Conference, held in New Zealand,[53] took the view that such fish, characteristically, would not be found above the continental shelf or in epipelagic waters (see Figure 37). The Deepsea Fisheries Working Group of the International Council for the Exploration of the Sea takes a limit of 400–500 m as defining their upper-depth range. The behaviour of many deep-sea fishes complicates such definitions – several species undergo extensive daily vertical migrations, moving from the mesopelagic zone into the epipelagic zone to feed; other species move between the continental shelf and slope waters.

In the past, the great depths where these fishes are found prevented, or inhibited, fishing operations in such regions, but technological development has brought possible solutions, albeit with associated management problems. Developments have been rapid during the last 50 years. From a low of 1.2 percent in 1952, reported deep-water landings (excluding China) had risen to a share of 4.7 percent of total marine landings by 2002. China’s reported landings of deep-water fishes are almost entirely represented by largehead hairtail (*Trichiurus lepturus*), which accounted for 1.5 percent of total world marine fish landings in 2002.

Today, commercially exploited deep-water species include orange roughy (*Hoplostethus atlanticus*), oreos (*Allocyttus* spp., *Neocyttus* spp., *Pseudocyttus* spp.), alfonsinos (*Beryx* spp.), cusk eels and brotulas (Ophidiidae), Patagonian toothfish (*Dissostichus eleginoides*), pelagic armourhead (*Pseudopentaceros wheeleri*), sablefish (*Anoplopoma fimbria*), Greenland halibut (*Reinhardtius hippoglossoides*), morid cods (Notocanthidae and Moridae) and various species of Scorpaenidae. Away from seamounts, Gadiformes such as Macrourids predominate – these are also slow-growing species but less “extreme” in their population characteristics than, for example, the roughies (Trachichthyidae) caught in the vicinity of seamounts. Several species of deep-water snappers (*Etelis* spp.) and jobfish (*Pristipomoides* spp.) are found above

Figure 37

Ocean biogeographic depth zones



[53] Papers presented at the Deep Sea 2003 Conference are available at http://www.deepsea.govt.nz/; accessed September 2004.

Box 7

Deep-water fisheries: some history

The development of deep-water fisheries has been most extensive in the North Atlantic, and this area dominates global landings of deep-water species (see Figure below). Landings from the Pacific Ocean have been important, although development in this region has lagged behind that of the Atlantic Ocean. During the 1970s and 1980s much of high seas fisheries operations were poorly recorded as many of the nations fishing at that time lacked the legal power, or the interest, to document carefully the catches and fishing efforts of their high seas deep-sea trawling fleets. One such fishery was that for the Pacific pelagic armourhead. In this case, trawling on the Emperor Seamount chain and in the Northern Hawaiian Ridge areas by Russian and Japanese vessels began in 1969. The total catch is unknown but has been estimated at between 36 000 tonnes and 48 000 tonnes per year for the period 1967–1977; 90 percent of the catch comprised pelagic armourhead. Total catches fell to between 5 800 and 9 900 tonnes per year between 1977 and 1982 – and today the fishery no longer exists.

Reported deep-water species landings by oceans and major seas

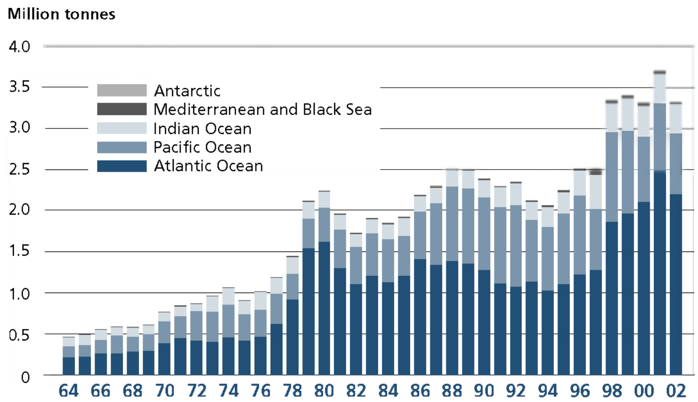


Table 12
Global data on reported landings of deep-water fishes

	1952	1962	1972	1982	1992	2002
Deep-water catch, world excluding China *(tonnes)*	232 574	360 125	870 693	1 726 181	2 348 990	3 325 006
Decadal increase *(percent)*	–	54.8	141.8	98.3	36.1	41.6
Fraction of total marine catch excluding China *(percent)*	1.2	1.0	1.7	2.8	3.3	4.7
Deep-water catch, world including China *(tonnes)*	468 174	759 125	1 366 193	2 219 554	2 971 233	4 613 684

the continental slope in depths of 100–400 m in low latitudes of the Pacific and Indian Oceans. These valuable fish are harvested by small-scale line fishers and, because of their slow growth, are highly vulnerable to depletion.

The drop-line fishery for black scabbard fish (*Aphanopus carbo*) in Madeira is one of the few traditional deep-water fisheries; most commercially important deep-water fisheries today are harvested by trawl in regions of seamounts and seafloor ridges.

The rapid development of deep-sea fisheries has, in many cases, outpaced the acquisition of the knowledge needed for successful resource management. The population biology of many species is not yet fully understood and, despite the widespread nature of these fisheries, little information exists about the impact of fishing on bycatch species (e.g. deep-water elasmobranchs). In the case of benthic effects, the information from the few studies that have been done indicates cause for concern – as in the case of deep-water corals.

In addition to problems encountered in traditional fisheries, deep-water fisheries face other problems that are specific to their industry. These include the low sustainability of long-lived fish resources, discarded bycatch, and the impact of fishing operations on benthos habitats – especially those providing nursery habitats for commercially exploited species. Moreover, because most deep-water fishing occurs on the high seas, an additional concern has been the ability (or inability) of international legal regimes and instruments to provide a satisfactory framework for the effective management of these fisheries' resources.

POSSIBLE SOLUTIONS

Management of deep-water fisheries – the need for more and better data

The management of deep-water resources requires strategies to deal with a variety of species, many of which have an unusual population biology. Among the various types of fish behaviour encountered are: fishes with strong diurnal migrations; pelagic larval phases that may be extended (e.g. oreos and Pentacerotidae); groups that have one, or a few, global spawning populations; those with highly localized spawning populations (e.g. orange roughy, whose eggs quickly become negatively buoyant to facilitate retention near their spawning habitat); and those with behavioural phases of acute aggregation for, at times intermittent, annual spawning. Some deep-water populations are geographically restricted while others have extensive distributions. Many deep-water species have relatively high longevity (around 100 years) and relatively late maturity (15–20 years), while others have life histories that are not dissimilar to those of shelf-bound fish stocks.

Given these challenges, not unsurprisingly, the management success of deep-water resources has been little better than that for many shelf-based fisheries. Even when a precautionary approach has been pursued, total allowable catches set in the absence of definitive information, have initially tended to overestimate the productivity of deep-sea resources. In such cases, fisheries theory predicts that recovery from the effects of overfishing of long-lived species with low growth rates and episodic recruitment will take generations. This underlines the need for resource managers – where they exist and have a mandate and capacity for action – to pay specific attention to the implications of insufficient scientific information, poor or unavailable catch and effort data,[54] little if any information on bycatches and the unknown past development trajectories of the deep-water fisheries. What is known is that the productivity of many such fisheries (but not all) will be low, a consequence in part of the lack of food in mid- and deep-water habitats. Providing operational meaning for management paradigms such as the "ecosystem approach" for the management of deep-water fisheries will require explicit consideration of the conservation of benthic biodiversity and sustaining of minimum spawning biomasses of what may be small fish populations subject to reproductive isolation.

[54] A major obstacle is that historic catch data often do not distinguish between the related product forms, e.g. whole fish, headed and gutted or fillets.

Box 8

The deep sea and its environment

The environment inhabited by deep-sea fishes is large (comprising more than 50 percent of the earth's surface) and its ocean dynamics, fisheries biology and ecosystems are poorly understood. However, over the last two decades, studies of these regions have begun to describe their often astonishing physical and biological nature. While many of these areas are flat with silt and mud-covered bottoms, others are characterized by chains of seamounts and bottom ridges and knolls. Across the continental shelves, turbidity currents have excised submarine canyons, whose importance as links to the deep seas is only beginning to be understood. Other features, such as seafloor seeps and hydrothermal vents, have produced bizarre and complex chemosynthetic communities with highly evolved and unusual faunas.

Diverse and long-lived benthic fauna, most notably the deep-water corals, are associated with seamounts and similar seafloor features. Cold-water corals have longevities potentially in excess of 10 000 years. Their structure, proud of the bottom, and brittleness make them vulnerable to destruction by trawls when inexpert skippers allow their trawls to encounter the surface of seamounts. Also of concern is the apparent high level of endemism of the species in those seamounts that have been researched; thus recruitment of many species from other seamounts may be less than would be expected.

Seamounts have oceanographic features that are important for fisheries. First, commercially important species form spawning aggregations in association with seamounts resulting in profitable catch rates, while those distant from seamounts may produce far lower rates. Second, currents flowing over seamounts bring nutrient-rich waters into the photic zone, enhancing biological production. Then, when Taylor's Columns (named after the scientist who discovered these phenomena) form over the top of the seamount, zones are created that retain fish larvae in the region of the adult fish habitat. Further enhancement occurs when plankton migrate into the surface layers at night and are unable to descend when advected over seamounts, thus providing biomass that can be "captured" by the seamount-based ecosystems.

Successful resource assessment and harvesting strategies for these resources will need:

- *Accurate catch data* – complemented by log books and observer programmes, particularly for areas where no management protocols have been agreed, or satisfactory means have not yet been established that ensure that such information will be made available for resource management purposes.
- *Time series of abundance indices and physical parameters*. Some important deep-water fisheries developed and expired before any protocols for capturing fisheries-related data came into effect. Additionally, vessels that were under no obligation to record information needed for management may not have done so.
- *Stock identity and distribution information*. Deep-water fisheries, especially those of the high seas, tend to be mobile; vessels may remain at sea for several months

and move large distances before discharging their catches. Thus knowledge of the port of discharge may provide little useful information for resource management purposes.

- *Key life-history information* (maximum ages, fecundity, growth and maturity data). When the fish populations targeted are small, the financial and human resources are not usually available to undertake the necessary analyses, and even where they are, it is not always cost-effective to do so.
- *Population biology statistics and age-frequency data*. This information is often unavailable. In such cases, resource management may be possible based on meta-population analyses – the aggregating of information across all relevant species or population groups.

Such considerations will require inventiveness and an ability to make best use of the most recent developments in fisheries resource management. These will include:

- the use of several models to capture alternative hypotheses concerning the available fisheries data and the underlying population dynamics that encompass space and spatial structures;
- an ability to undertake assessments based on analyses of auxiliary information when few pre-specified model parameters are available;
- the use of Bayesian inference to quantify uncertainty in point estimates and the sensitivity of the results to changes to data weightings.
- judgement methods to determine many resource management parameters based on meta-analyses. Assessments for which little data are available will depend on *a priori* expectations about the state of the resources in preference to the commonly used, but often overly simple and optimistic, traditional models.

Additionally, efforts are needed to prevent inexperienced skippers or risk-prone operators from entering deep-water fisheries, where inexperience can result in considerable damage to bottom fauna and its biodiversity. Industry-organized certification of vessel officers who participate in these fisheries may help ensure that they can be carried out with minimum damage to bottom fauna.

Governance of deep-water fisheries

In spite of the adoption of several international instruments building upon the development of the international law of the sea and the international law of the environment, as well as advances in good practices in the ambit of regional fishery bodies or arrangements, numerous shortcomings remain. In fact, most of the world's deep-water fishery resources and the high seas areas where they are found could currently be considered as "unregulated". As the Deep Sea 2003 Conference demonstrated, there appears to be no single view on how best to proceed in regulating and ensuring good governance for these resources. Developing and implementing new binding instruments or modifying existing agreements would probably take too much time to allow for the adoption of the urgent measures that are often required. There are other difficulties to be addressed, such as uncertainty regarding the level of acceptance of these instruments and the need to avoid undermining through this process some of the key elements contained in the existing instruments. Many fear that the conservation, and perhaps even survival, of many threatened deep-water ecosystems would be forgone. Hence, as many believe, the best way to manage high seas deep-water fisheries resources may be to make full use of the existing legal framework and ensure its implementation by all stakeholders. In some instances, the broadening of the competences of existing RFBs or arrangements might be considered; in others, it might be necessary to create new competences.

A regional or fishery-by-fishery approach will probably not be sufficient. It is essential to ensure that problems are not merely exported from one marine area to another. A global approach is also necessary, as in the FAO Compliance Agreement, for example, which seeks to ensure that there is effective flag state control over all fishing vessels used, or intended, for fishing on the high seas. In addition to the action taken by the flag state itself, the Compliance Agreement contains provisions related to port states, allowing a port state "to promptly notify the flag state" if it "has reasonable grounds for believing that a fishing vessel has been used for an activity that undermines the effectiveness of international conservation and management measures". Other high seas monitoring activities, such as vessel monitoring systems and future catch documentation systems will also stand a better chance of success if embraced in a global manner.

RECENT DEVELOPMENTS

Perhaps first among the developments that have enabled deep-water fisheries to develop have been the satellite-based geographical positioning systems. These allow fishing vessels to set their trawls within tens of metres of open-ocean seafloor features and replicate successful trawls "on a shackle pin" when fish distribution is highly localized. Thus, while this technology has rendered deep-water species available to capture, they have also enabled skippers to locate with greater accuracy where they will set their gear and avoid areas where fishing is impossible or undesirable.

Matching this above-sea technology have been developments in acoustic telemetry of trawls. These enable the net, often a kilometre aft of the ship, to be precisely located in vertical and plane coordinates, so avoiding bottom "hang ups" and allowing gear to be positioned accurately to catch deep-water fish shoals. Supplementing these developments have been the advances in fish detection – the traditional echo sounders and sonars used to locate the fish ahead of the trawl.

Seabed swath mapping systems represent another acoustic development that facilitates the targeting of deep-water resources found within narrowly defined, and often highly irregular, areas. These methods provide highly defined images of bottom profiles and assist aimed trawling so that skippers can avoid areas where the gear might be lost or where bottom contact might occur (Figure 38). Swath mapping provides the equivalent of terrestrial topographic mapping, to the benefit of the fishing skipper.

Successful deep-water demersal fisheries require a suite of particular abilities. First, aimed trawling in deep waters requires skills in vessel manoeuvring and gear control if damage to bottom fauna is to be avoided and the gear not lost. As for any marine resource, the productivity of deep-water fisheries is finite, though usually unknown, and careful management is required to ensure that harvests and resource biomasses are sustained. However, data show that reported landings from the deep seas continue to increase, presumably in some cases through fishing down of resource biomasses and also through gains in fishery productivity.

OUTLOOK

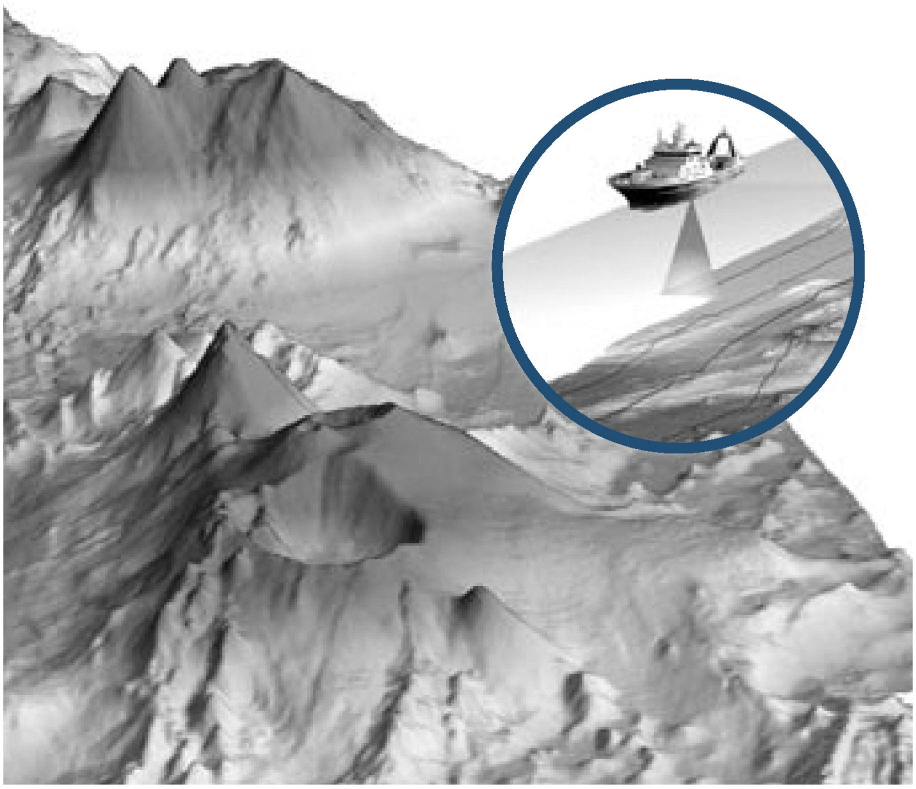
Technology will continue to evolve. Future developments may benefit those who try to control deep-water fisheries on the high seas; they may also benefit those who conduct those fisheries. In view of this uncertainty, there is likely to be a continued effort to strengthen the governance of high seas fisheries in general, and of deep-water fisheries in particular.

Some thought that the provisions of the United Nations Convention on the Law of the Sea, including the qualified freedom to fish on the high seas, would provide comprehensive answers for problems related to the management of the fishery resources of the high seas, where many deep-sea fisheries occur. However, in practice, the freedom to fish on the high seas and the open access to fishery resources this permits have resulted in many problems, most notably the lack of incentives for individuals to constrain fishing effort and comply with conservation measures.

High seas conservation and management regimes under the Convention are limited to transboundary stocks, marine mammals and the use of driftnets. A further continuing problem is how to achieve, through RFMOs, effective enforcement of their conservation and management measures, especially the enforcement of catch quotas. This is discussed further in Box 9.

Figure 38

Bottom imaging has transformed skippers' ability to target demersal tows



Source: National Institute of Water and Atmospheric Research, New Zealand

Despite the broadening of the high seas fisheries conservation and management regimes through such hard- and soft-law instruments, their effectiveness in promoting and facilitating management and conservation of high seas fisheries resources remains to be seen. Effective governance of high seas fisheries will build on the application of relevant conservation and management measures whether a state is a member of an RFMO or not. In this regard, the FAO Compliance Agreement and, more importantly, relevant provisions of the UN Fish Stocks Agreement build on, and give support to, the provisions of the Convention.

Box 9

Governance and fisheries in the high seas

The freedom to fish on the high seas, where most deep-sea fisheries occur, can be traced back to the work of Grotius in the seventeenth century, but its roots can be traced back even earlier – to the time of Roman law. Its continued acceptance in the ensuing centuries resulted in its incorporation into customary international law and subsequently into its codification during the second half of the twentieth century. Thus, the United Nations Convention on the Law of the Sea, which entered into force in 1994, 12 years after its adoption and opening to signature in 1982 and providing the cornerstone of the current high seas legal regime, strongly reaffirms in its Article 87 the principle of "freedom of the high seas". Among the freedoms listed in that article is the "freedom of fishing". It must be stressed that this freedom is not unlimited or unqualified; rather, it is "subject to the conditions laid down in the articles under Section 2 [of Part VII]", which establish a number of obligations that states fishing on the high seas must respect. Additionally, as noted in Article 87 (2), all "these freedoms shall be exercised by all States with due regard for the interests of other States in their exercise of the freedom of the high seas".[1]

It is important to stress that these provisions apply to all countries – to the Parties to the Convention, and also to non-Parties in respect of its requirements that reflect the existing customary international law. Thus, the rights of states fishing on the high seas are qualified by: (a) their treaty obligations (Art. 116 [a]); (b) their duty to adopt measures for the conservation of living resources (Art. 117); (c) their duty to cooperate with other states in the conservation and management of living resources in the areas of the high seas (Art. 118); and (d) their duty to take measures to maintain or restore populations of harvested species [to] produce the maximum sustainable yield (Art. 119 [a]).

It could be expected that these provisions of the Convention would provide a framework sufficiently comprehensive and strict to allow for an efficient management of the fishery resources of the high seas, where many deep-sea fisheries occur, and in particular to avoid the problems that might arise from an unqualified regime of freedom. However, in practice, the establishment of this set of obligations has not been followed by their development and implementation, and freedom to fish on the high seas combined in most cases with a *de facto* open access to fishery resources has resulted in a serious and problematic situation, characterized most notably by the lack of incentives for individuals to constrain fishing effort and comply with conservation measures.

One of the persisting problems is how to achieve, through RMFOs, the adoption and effective enforcement of conservation and management measures, especially catch quotas. Additionally, conservation and management issues are often overshadowed by those related to maximizing benefits from high seas fisheries resources and solving the allocation problems that are commonly experienced in fisheries management arrangements. Countries that already belong to an RFMO might argue that the resource is effectively managed

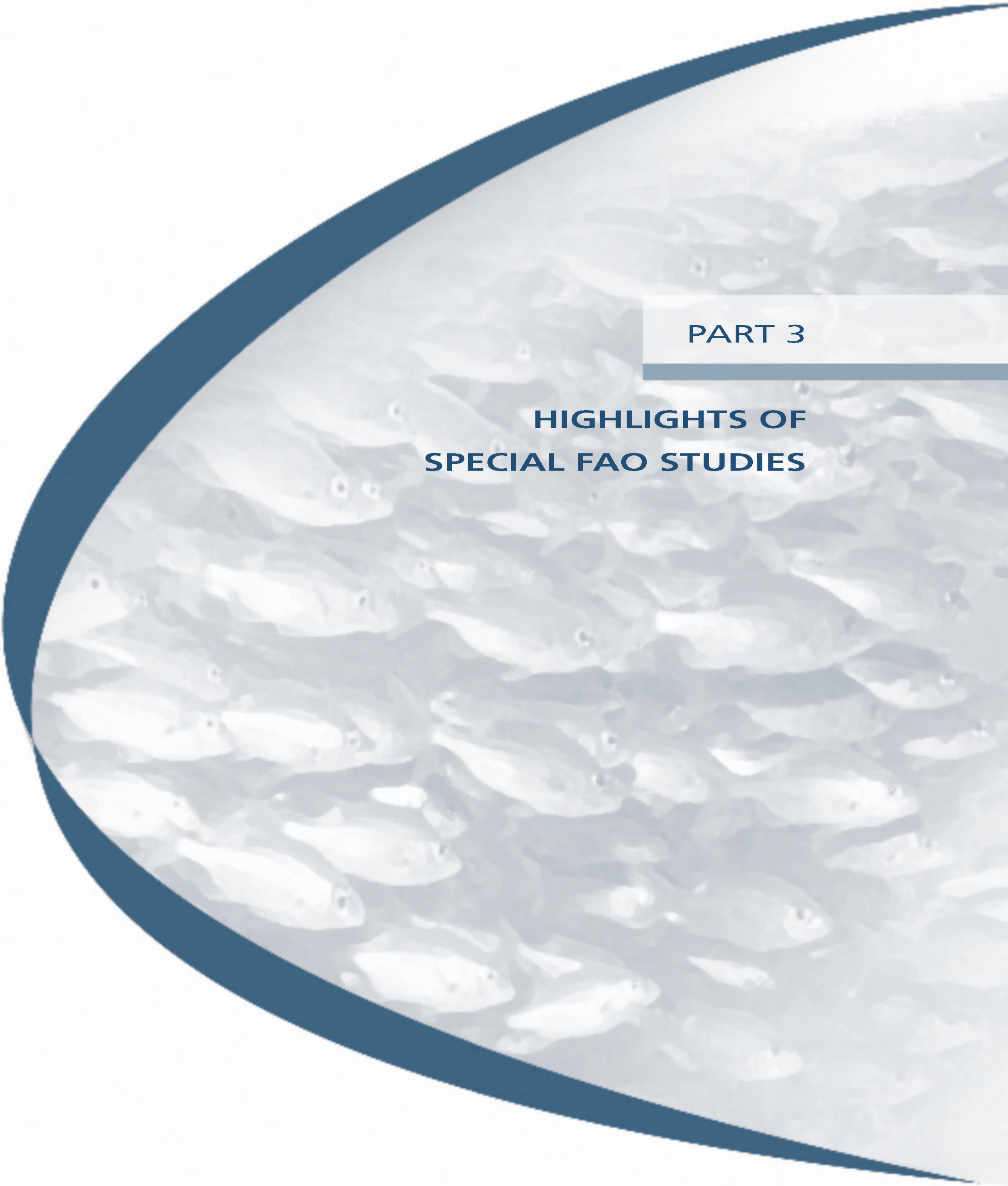
under a common-property arrangement, i.e. the resource is harvested in common among those who have accepted the rules of the RFMO or management arrangement. However, the expectation of new entrants when becoming members of an RFMO is that they will participate in harvesting the allowable catch. If no provision is adopted to regulate this situation and control access to the resource or the total fishing effort, particularly where there is flexibility in allowing for membership of the RFMO, then, operationally, there is no distinction between this and a truly open-access situation.

The 1990s brought the problems in managing high seas stocks into sharp relief. To address issues of high seas fisheries management raised in the Convention on the Law of the Sea, a series of international instruments have been negotiated and adopted, including Chapter 17 of the 1992 Agenda 21, the 1993 FAO Compliance Agreement, the 1995 UN Fish Stocks Agreement, the 1995 FAO Code of Conduct for Responsible Fisheries,[2] and several international plans of action including the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing.[3] While the FAO Compliance Agreement and the UN Fish Stocks Agreement are treaties that bind states that are Parties to them, the Code of Conduct and its Plans of Action are voluntary in nature. However, while differing in scope, nature and contents, these hard- and soft-law instruments were largely negotiated over a similar period and represent significant steps in the development of principles and standards applicable to the conservation and management of high seas fisheries.

Beyond the need to ensure the widest acceptance of these instruments and their effective implementation, the issue still remains of the applicability of the agreed international regimes to non-Parties. Effective governance of high seas fisheries resources requires the application of relevant conservation and management measures by all states whose nationals fish these resources, whether they are members of the competent RFMO or not. In recent years, a number of RFMOs have developed their practice in this respect in order to ensure compliance by non-members (for instance through establishing a category of "cooperating non-Parties"). In addition to the relevant provisions of the FAO Compliance Agreement, it is interesting to note that the UN Fish Stocks Agreement has attempted to go beyond the traditional exclusiveness of the flag state responsibility in several of its provisions on compliance and enforcement, although this effort met with the strong reservation of a number of countries.

[1] The full text of the Convention is available at http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm; accessed September 2004.
[2] Op. cit., see footnotes 11,13 and 14, pp. 27 and 35; for Agenda 21, see Box 5, footnote 4, p. 63.
[3] The text of the Plan of Action is available at http://www.fao.org/DOCREP/003/y1224e/y1224e00.HTM; accessed September 2004.

PART 3



HIGHLIGHTS OF SPECIAL FAO STUDIES

HIGHLIGHTS OF SPECIAL FAO STUDIES

Scope of the seaweed industry

INTRODUCTION

The seaweed industry provides a wide variety of products that have an estimated total annual production value of US$5.5–6 billion. Food products for human consumption contribute about US$5 billion to this figure. Substances that are extracted from seaweeds – hydrocolloids – account for a large part of the remaining billion dollars, while smaller, miscellaneous uses, such as fertilizers and animal feed additives, make up the rest. The industry uses 7.5–8 million tonnes of wet seaweed annually, harvested either from naturally growing (wild) seaweed or from cultivated (farmed) crops. The farming of seaweed has expanded rapidly as demand has outstripped the supply available from natural resources. Commercial harvesting occurs in about 35 countries, spread between the northern and southern hemispheres, in waters ranging from cold, through temperate, to tropical.

CLASSIFICATION OF SEAWEEDS

Seaweeds can be classified into three broad groups based on pigmentation: brown, red and green. Botanists refer to these broad groups as Phaeophyceae, Rhodophyceae and Chlorophyceae, respectively. Brown seaweeds are usually large, ranging from the giant kelp that can often be as long as 20 m, to thick, leather-like seaweeds from 2 to 4 m long, to smaller species 30–60 cm long. Red seaweeds are usually smaller, generally ranging from a few centimetres to about a metre in length. Red seaweeds are not always red in colour; they are sometimes purple, even brownish-red, but they are still classified by botanists as Rhodophyceae because of other characteristics. Green seaweeds are also small, with a similar size range to that of the red seaweeds. Seaweeds are also called macro-algae. This distinguishes them from micro-algae (Cyanophyceae), which are microscopic in size, often unicellular, and are best known by the blue–green algae that sometimes bloom and contaminate rivers and streams. Naturally growing seaweeds are often referred to as wild seaweeds, in contrast with seaweeds that are cultivated or farmed.

SOURCES AND USES OF COMMERCIAL SEAWEEDS

Seaweed as food

The use of seaweed as food has been traced back to the fourth century in Japan and the sixth century in China. Today, those two countries and the Republic of Korea are the largest consumers of seaweed as food. However, as nationals from these countries have migrated to other parts of the world, the demand for seaweed for food has followed them, as, for example, in some parts of the United States and in South America. Increasing demand over the last 50 years has outstripped the ability to supply requirements from natural (wild) stocks. Research into the life cycles of these seaweeds has led to the development of cultivation industries that now supply more than 90 percent of the market’s demand. In Iceland, Ireland and Nova Scotia (Canada), a different type of seaweed has traditionally been eaten, and this market is being developed further. Some government and commercial organizations in France have been promoting seaweeds for restaurant and domestic use, with some success. An informal market exists among coastal dwellers in some developing countries where there has been a tradition of using fresh seaweeds as vegetables and in salads.

Kombu from Laminaria *species*

China is the largest producer of edible seaweeds, harvesting about 5 million wet tonnes annually. The greater part of this is for kombu, produced from hundreds of hectares of the brown seaweed *Laminaria japonica*. *Laminaria* was originally native to Japan and the Republic of Korea, and was introduced accidentally to China, in 1927, at the northern city of Dalian (formerly Dairen), probably by shipping. Prior to that, China had imported its needs from the naturally growing resources in Japan and the Republic of Korea. In the 1950s, China developed a method for cultivating *Laminaria*; sporelings ("seedlings") are grown in cooled water in greenhouses and later planted out in long ropes suspended in the ocean. This activity became a widespread source of income for large numbers of coastal families. By 1981, 1 200 000 wet tonnes of seaweed were being produced annually. In the late 1980s, production fell as some farmers switched to the more lucrative but risky farming of shrimp. By the mid-1990s, production had started to rise again and the reported annual harvest in 1999 was 4 500 000 wet tonnes. China is now self-sufficient in *Laminaria* and has a strong export market.

In the past, *Laminaria* was in plentiful supply in Japan, mainly from the northern island of Hokkaido, where several naturally growing species were available. However, demand grew as Japan became more prosperous after the Second World War, and by the 1970s cultivation became necessary. Today, the supply comes from a combination of natural and cultivated harvests. In the Republic of Korea, the demand for *Laminaria* is much lower and most is now provided from cultivation.

Wakame from Undaria pinnatifida

The Republic of Korea grows about 800 000 wet tonnes annually of three different species of edible seaweed, of which about 50 percent is for wakame, produced from the brown seaweed *Undaria pinnatifida*, which is cultivated in a similar fashion to *Laminaria* in China. Some of this is exported to Japan, where production is only about 80 000 wet tonnes per year. *Undaria* is less popular than *Laminaria* in China; by the mid-1990s China was harvesting about 100 000 wet tonnes per year of *Undaria* from cultivation, compared with 3 million wet tonnes per year of *Laminaria* at that time.

Hizikia from Hizikia fusiforme

Hizikia is popular as food in Japan and the Republic of Korea. Up to 20 000 wet tonnes were harvested from natural beds in the Republic of Korea in 1984, when cultivation began. Since then, cultivation has steadily increased, on the southwest coast, such that in 1994 about 32 000 wet tonnes were farmed and only 6 000 wet tonnes were harvested from the wild. A large proportion of the production is exported to Japan, where there is little activity in *Hizikia* cultivation.

Nori from Porphyra *species*

Japan produces about 600 000 wet tonnes of edible seaweeds annually, around 75 percent of which is for nori – the thin, dark, purplish seaweed found wrapped around a rice ball in *sushi*. Nori is produced from species of *Porphyra*, which are red seaweeds. *Porphyra* has been cultivated in Japan and the Republic of Korea since the seventeenth century; there are natural stocks, but even at that time they were insufficient to meet demand. Cultivation was developed intuitively, by observing the seasonal appearance of spores, but the complex life cycle of *Porphyra* was not properly understood until the 1950s. Since that time, cultivation has flourished, and now accounts for virtually all the production in China, Japan and the Republic of Korea. In 1999, the combined annual production from these three countries was just over 1 000 000 wet tonnes. Nori is a high-value product, worth approximately US$16 000/dry tonne, compared with kombu at US$2 800/dry tonne and wakame at US$6 900/dry tonne.

Extracts from seaweeds – hydrocolloids

Agar, alginate and carrageenan are three hydrocolloids that are extracted from various red and brown seaweeds. A hydrocolloid is a non-crystalline substance with very large molecules, which dissolves in water to give a thickened (viscous) solution. Agar, alginate and carrageenan are water-soluble carbohydrates used to thicken aqueous solutions, to form gels (jellies) of varying degrees of firmness, to form water-soluble films, and to stabilize certain products, such as ice-cream (they inhibit the formation of large ice crystals, allowing the ice-cream to retain a smooth texture).

The use of seaweeds as a source of these hydrocolloids dates back to 1658, when the gelling properties of agar, extracted with hot water from a red seaweed, were first discovered in Japan. Extracts of Irish moss, another red seaweed, contain carrageenan and were popular as thickening agents in the nineteenth century. It was not until the 1930s that extracts of brown seaweeds, containing alginate, were produced commercially and sold as thickening and gelling agents. Industrial uses of seaweed extracts expanded rapidly after the Second World War, but were sometimes limited by the availability of raw materials. Once again, research into life cycles has led to the development of cultivation industries that now supply a high proportion of the raw materials for some hydrocolloids. Today, approximately 1 million tonnes of wet seaweed are harvested annually and extracted to produce the above three hydrocolloids. Total hydrocolloid production is in the region of 55 000 tonnes per year, with a value of US$585 million.

Agar

Agar production (valued at US$132 million annually) is principally from two types of red seaweed, one of which has been cultivated since the 1960s, but on a much larger scale since 1990. Two genera, *Gelidium* and *Gracilaria*, account for most of the raw material used for the extraction of agar, with *Gelidium* species giving the higher-quality product. All *Gelidium* used for commercial agar extraction comes from natural resources, principally from France, Indonesia, the Republic of Korea, Mexico, Morocco, Portugal and Spain. *Gelidium* is a small, slow-growing plant and, while efforts to cultivate it in tanks and ponds have been biologically successful, they have generally proved uneconomic. *Gracilaria* species were once considered unsuitable for agar production because the quality of the agar was poor. In the 1950s, it was found that pre-treatment of the seaweed with alkali before extraction lowered the yield but gave a good-quality agar. This allowed expansion of the agar industry, which had been previously limited by the available supply of *Gelidium*, and led to the harvesting of a variety of wild species of *Gracilaria* in countries such as Argentina, Chile, Indonesia and Namibia. Chilean *Gracilaria* was especially useful, but evidence of overharvesting of the wild crop soon emerged. Cultivation methods were then developed, both in ponds and in the open waters of protected bays. These methods have since spread beyond Chile to other countries, such as China, Indonesia, the Republic of Korea, Namibia, the Philippines and Viet Nam, usually using species of *Gracilaria* native to each particular country. *Gracilaria* species can be grown in both cold and warm waters. Today, the supply of *Gracilaria* still derives mainly from the wild, with the extent of cultivation depending on price fluctuations.

Alginate

Alginate production (valued at US$213 million annually) is by extraction from brown seaweeds, most of which are harvested from the wild. The more useful brown seaweeds grow in cold waters, thriving best in waters up to about 20 °C. Brown seaweeds are also found in warmer waters, but these are less suitable for alginate production and are rarely used as food. A wide variety of species are used, harvested in both the northern and southern hemispheres. Countries producing alginate include Argentina, Australia, Canada, Chile, Ireland, Mexico, Norway, South Africa, the United Kingdom (Scotland and Northern Ireland) and the United States. Most species are harvested from natural resources; cultivated raw material is normally too expensive for alginate production. While much of the *Laminaria* cultivated in China is used for food, when there is surplus production this can also be used in the alginate industry.

Carrageenan

Carrageenan production (valued at US$240 million annually) was originally dependent on wild seaweeds, especially *Chondrus crispus* (Irish moss), a small seaweed growing in cold waters, with a limited resource base in France, Ireland, Portugal, Spain and the east coast provinces of Canada. As the carrageenan industry expanded, the demand for raw material began to strain the supply from natural resources. However, since the early 1970s the industry has expanded rapidly following the availability of other carrageenan-containing seaweeds that have been successfully cultivated in warm-water countries with low labour costs. Today, most raw material comes from two species originally cultivated in the Philippines, *Kappaphycus alvarezii* and *Eucheuma denticulatum*, but which are now also cultivated in other warm-water countries such as Indonesia and the United Republic of Tanzania. Limited quantities of wild *Chondrus* are still used; attempts to cultivate *Chondrus* in tanks have been successful biologically, but it has proved uneconomic as a raw material for carrageenan. Wild species of *Gigartina* and *Iridaea* from Chile are also being harvested and efforts are being made to find cultivation methods for these.

Other uses of seaweed

Seaweed meal

The production of seaweed meal, used as an additive to animal feed, was pioneered in Norway in the 1960s. It is made from brown seaweeds that are collected, dried and milled. Drying is usually by oil-fired furnaces and costs are therefore affected by the price of crude oil. Approximately 50 000 tonnes of wet seaweed are harvested annually with a yield 10 000 tonnes of seaweed meal, which is sold for around US$5 million.

Fertilizers

The use of seaweeds as fertilizers dates back at least to the nineteenth century. Early usage was by coastal dwellers, who collected storm-cast seaweed, usually large brown seaweeds, and dug it into local soils. The high fibre content of the seaweed acts as a soil conditioner and assists moisture retention, while the mineral content is a useful fertilizer and source of trace elements. In the early twentieth century, a small industry developed based on the drying and milling of mainly storm-cast material, but it dwindled with the advent of synthetic chemical fertilizers. Today, with the rising popularity of organic farming, there has been some revival of the industry, but not yet on a large scale; the combined costs of drying and transportation have confined usage to sunnier climates where the buyers are not too distant from the coast.

Liquid seaweed extracts are the growth area in seaweed fertilizers. These can be produced in concentrated form for dilution by the user. Several can be applied directly onto plants or they can be watered in, around the root areas. Several scientific studies have proved the effectiveness of these products, and seaweed extracts are now widely accepted in the horticultural industry. When applied to fruit, vegetable and flower crops, improvements have included higher yields, increased uptake of soil nutrients, increased resistance to certain pests such as red spider mite and aphids, improved seed germination, and greater resistance to frost. No one is really sure of the reasons for their effectiveness: the trace element content is insufficient to account for the improved yields, for example. Most of the extracts contain several types of plant growth regulator, but in this respect also there is no clear evidence that these alone are responsible for the improvements. In 1991, it was estimated that about 10 000 tonnes of wet seaweed were used annually to make 1 000 tonnes of seaweed extracts with a value of US$5 million. However, since that time the market has probably doubled as the usefulness of these products has become more widely recognized and organic farming has increased in popularity.

Cosmetics

Cosmetic products, such as creams and lotions, sometimes show on their labels that the contents include “marine extract”, “extract of alga”, “seaweed extract” or similar. This usually means that one of the hydrocolloids extracted from seaweed has been added. Alginate or carrageenan could improve the skin moisture retention properties of the product. In thalassotherapy, seaweed pastes, made by cold-grinding or freeze-crushing, are applied to the person’s body and then warmed under infrared radiation.

This treatment, in conjunction with seawater hydrotherapy, is said to provide relief for rheumatism and osteoporosis.

Fuels

Over the last 20 years a number of large projects have investigated the possible use of seaweeds as an indirect source of fuel. The idea was to grow large quantities of seaweed in the ocean and then ferment this biomass to generate methane gas for use as fuel. The results have indicated that the process is not yet economically viable and that further research and development will be needed over the longer term.

Wastewater treatment

There are potential uses for seaweed in wastewater treatment. For example, some seaweeds are able to absorb heavy metal ions such as zinc and cadmium from polluted water. The effluent water from fish farms usually contains high levels of waste that can cause problems for other aquatic life in adjacent waters. As seaweeds can often use much of this waste material as a source of nutrients, trials have been undertaken to farm seaweed in areas adjacent to fish farms.

Antiviral agents

Antiviral activity has been reported for extracts from several seaweeds, although the tests have been either *in vitro* (in test tubes or similar) or on animals, with few advancing to trials involving people. A notable exception is Carraguard – a mixture of carrageenans similar to those extracted from Irish moss. Carraguard has been shown to be effective against human immunodeficiency virus (HIV) *in vitro* and against herpes simplex 2 virus in animals. Testing has advanced to the stage where the international research organization, the Population Council, is supervising large-scale HIV trials of Carraguard, involving 6 000 women over four years. Extracts from the brown seaweed, *Undaria pinnatifida*, have also shown antiviral activity; an Australian company is involved in several clinical trials, in Australia and the United States, of such an extract against HIV and cancer. The Population Council's trials against HIV involve the vaginal application of a gel containing carrageenan.

Because antiviral substances in seaweeds are composed of very large molecules, it was thought they would not be absorbed by eating seaweed. However, it has been found in one survey that the rate of HIV infection in seaweed-eating communities can be markedly lower than it is elsewhere. This has led to some small-scale trials in which people infected with HIV ate powdered *Undaria*, with a resulting decrease (25 percent) in the viral load. Seaweeds may yet prove to be a source of effective antiviral agents.

Global aquaculture outlook: an analysis of production forecasts to 2030

INTRODUCTION

Population growth, urbanization and rising per capita incomes have led the world fish consumption to more than triple over the period 1961–2001, increasing from 28 to 96.3 million tonnes. Per capita consumption has multiplied by a factor of 1.7 over the same period and in many countries this trend is expected to continue in forthcoming decades. In the context of stagnant production, or slow growth from the capture fisheries, only aquaculture expansion can meet this growing global demand. Acknowledging the challenges that this relatively new industry may face in coming years and the need to prepare for the sustainable growth of the sector, FAO carried out a study on the global aquaculture production outlook to evaluate its potential to meet projected demand for food fish in 2020 and beyond.[55]

[55] This article is a summary of FAO. 2004. *Global aquaculture outlook in the next decades: an analysis of national aquaculture production forecasts to 2030*. FAO Fisheries Circular No. C1001. Rome. (In press)

One of the means of assessing whether forecasts of aquaculture expansion are achievable is to examine national aquaculture plans. With their expected aquaculture output, national plans can provide insights into future directions. Production targets can be aggregated and compared with existing general equilibrium forecasts. This approach was used to answer two questions: do individual countries have the ambition to expand to meet global demand forecasts, and are their projections realistic? Is the "sum" of national production forecasts compatible with projected increases in demand for food fish?

Major aquaculture producers were requested to provide their aquaculture development strategies and plans, with quantitative production targets if available.[56] Information on global supply and demand forecasts was compiled from three sources (Ye in FAO, 1999; IFPRI, 2003; Wijkström, 2003).[57] This information was subsequently used as a benchmark against which the realism and relevance of national projections were measured.

GLOBAL FORECASTS

Global fisheries production reached 130.2 million tonnes in 2001, having doubled over the previous 30 years.[58] However, a significant part of the increase came from aquaculture. While output from capture fisheries grew at an annual average rate of 1.2 percent, output from aquaculture (excluding aquatic plants) grew at a rate of 9.1 percent, reaching 39.8 million tonnes in 2002. This growth rate is also higher than for other animal food-producing systems such as terrestrial farmed meat.[59] Much of this expansion in aquaculture has taken place in China, whose reported output growth far exceeded the global average. However, if figures for China are excluded, world aquaculture output growth during the last 30 years was more moderate, showing declining rates of expansion (6.8, 6.7 and 5.4 percent annual growth rates for the periods 1970–80, 1980–90 and 1990–2000, respectively).[60]

Future global aquaculture production

Table 13, which presents three global forecasts of food fish demand, demonstrates that even if output from capture fisheries continued to grow at 0.7 percent annually, it alone would be incapable of meeting projected demand for food fish. This table also highlights the impact of price assumptions on the projections. Two forecasts, made by Wijkström (2003) and Ye (in FAO, 1999), assume constant relative fish prices. Their projections of world fish consumption are based on demand variables (population growth and per capita consumption) and exclude variations in real and relative prices. One forecast by Ye assumes that even if per capita consumption of food fish remains at its 1995/96 level of 15.6 kg per person, population growth will generate a demand for food fish (126.5 million tonnes) that exceeds the 99.4 million tonnes available in 2001.

Prices, and their effect on consumer demand and aquaculture supply, are an integral part of the International Food Policy Research Institute (IFPRI) equilibrium model. The baseline forecast predicts an increase in the real price of both high-value and low-value food fish by 2020, and also an increase in its relative price (compared with substitutes). This increase has a dampening effect on demand in two ways. First, given the high price elasticity of demand for fish, an increase in real price will reduce

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[56] Many countries replied to the request. However, only 11 documents (from Bangladesh, Brazil, Canada, Chile, China, Egypt, India, Indonesia, the Philippines, Thailand and Viet Nam) were ultimately used as they were obtained within the time limit of the study and contained quantitative production targets.

[57] FAO. 1999. *Historical consumption and future demand for fish and fishery products: exploratory calculations for the years 2015/2030*, by Y. Ye. FAO Fisheries Circular No. 946. Rome; IFPRI. 2003. *Fish to 2020: supply and demand in changing global markets*, by C. Delgado, N. Wada, M. Rosegrant, S. Meijer and M. Ahmed. International Food Policy Research Institute (IFPRI), Washington, DC.; U.N. Wijkström. 2003. Short and long-term prospects for consumption of fish. *Veterinary Research Communications*, 27(Suppl. 1): 461–468.

[58] 2001 is the most recent year for which fisheries production figures are available in FAOSTAT.

[59] FAO. 2003. *Aquaculture production statistics 1988–1997*. Rome.

[60] Source: Fishstat Plus (v. 2.30) of 21.06.2004.

the quantities demanded. Second, an increase in the relative price of fish, with positive cross-elasticity coefficients (at least for poultry), will encourage substitution towards cheaper alternatives. In spite of these factors, global per capita consumption of fish in the baseline scenario is projected to continue rising (to 17.1 kg per year). An extreme scenario is a negative growth in production for all capture fishery commodities, including fishmeal and fish oil.[61] This would have such significant effects on reduction fisheries, fishmeal and food fish prices that demand would be dampened. Under this scenario, per capita consumption in 2020 would actually be less than in 2001. However, increases in the real price of fish do provide an incentive to aquaculture, given that its supply elasticity coefficient is higher than that of capture fisheries. If higher prices spur technological innovations and needed investment, aquaculture could expand more quickly than the baseline, with a possible output of 69.5 million tonnes by 2020.

To visualize the consequences of all three forecasts on aquaculture output, two scenarios are considered. In the first case, "growing fisheries", output of food fish from the capture fisheries is assumed to increase at IFPRI's 0.7 percent rate until the forecast horizon date. Under this assumption, the food fish derived from the capture fisheries is deducted from the projected demand, and the residual is the amount required from aquaculture. All results require a higher aquaculture output than the 2001 total of 37.9 million tonnes. If food fish output from the capture fisheries does not increase at the rate projected, the demand gap to be filled by aquaculture will be higher than shown. This is explored in the "stagnating fisheries" scenario, which assumes that the output of food fish from capture fisheries does not increase beyond 2001. Quantities

Table 13
Projections of food fish demand

Forecasts and forecast dates	Price assumption	By the forecast date		Required from aquaculture by the forecast date[4]				
				Growing fisheries		Stagnating fisheries		
		Global consumption (kg/year/capita)	Food fish demand (million tonnes)	Total output (million tonnes)	Growth rate (percent)	Total output[5] (million tonnes)	Growth rate (percent)	Average annual increase (million tonnes)
IFPRI (2020)								
Baseline	Flexible real and relative prices	17.1	130	53.6[3]	1.8	68.6	3.5	1.7
Lowest[1]		14.2	108	41.2	0.4	46.6	1.4	0.6
Highest[2]		19.0	145	69.5[3]	3.2	83.6	4.6	2.4
Wijkström								
(2010)	Constant	17.8	121.1	51.1[3]	3.4	59.7	5.3	2.4
(2050)	Constant	30.4	270.9	177.9[3]	3.2	209.5	3.6	3.5
Ye (2030)								
	Constant	15.6	126.5	45.5[3]	0.6	65.1	2.0	1.0
	Constant	22.5	183.0	102.0[3]	3.5	121.6	4.2	2.9

[1] Assumes an "ecological collapse" of the capture fisheries.
[2] Assumes technological advances in aquaculture.
[3] Assumes a growth of output of food fish from the capture fisheries of 0.7 percent per year to the forecast date.
[4] From 2000, 35.6 million tonnes, three-year average of aquaculture output.
[5] Assumes zero growth in food fish from the capture fisheries after 2001.
Source: Calculated from IFPRI (2003); Wijkström (2003) and Ye in FAO (1999).
Full source details are given in footnote 57, p. 108.

[61] This scenario was labelled as "ecological collapse" under the IFPRI projections. Although suggesting a dramatic decline and pessimistic outlook for capture fisheries, technically, it is not a complete collapse.

required from aquaculture under this scenario may, however, be overstated as price increases will reduce demand. Were the capture fisheries to stagnate after 2001 rather than grow until 2020, food fish prices would increase more than estimated. Because of own-price elasticity and cross-price elasticity, this increase would have a dampening effect on demand for food fish.

REGIONAL PERSPECTIVES

An analysis of country plans in a regional context has also been undertaken. In 2001, Asia produced 88.5 percent of world aquaculture output (excluding aquatic plants). Europe's output, during the same year, represented 3.4 percent. Norway is Europe's largest producer and has ambitious forecasts for expansion. However, the future of the 15 members of the EU pre-2004 is less promising as growth rates are projected to fall. Latin America and the Caribbean, on the other hand, has experienced rapid expansion of its aquaculture output (16.4 percent per year during the 1990s). Despite its total output remaining much smaller than Asia's (2.9 percent of global aquaculture output excluding aquatic plants) in 2001, the region's share of global value was higher at 7 percent.

All regions are forecast to experience continued expansion (Table 14) but, according to the baseline and IFPRI's highest forecast, Asia will continue to produce the bulk of aquaculture output by 2020.

Contrasting these results with goals set in national plans and strategies, projections for China and Latin America and the Caribbean appear low, whereas those for

Table 14
Food fish from aquaculture: actual and forecast, by region

	Actual in 2001		IFPRI output forecast for 2020[a]				Alternative forecast	
			Baseline		Highest			
	Output *(million tonnes)*	Share of global output *(percent)*	Output *(million tonnes)*	Growth rate 2001–20[b] *(percent)*	Output *(million tonnes)*	Growth rate 2001–20[b] *(percent)*	Output *(million tonnes)*	Growth rate 2001–20[b] *(percent)*
China	26.1	68.8	35.1	1.6	44.3	2.8		
Europe[c]	1.3	3.4	1.9	2.0	2.3	3.0	1.5[d]	0.8
India	2.2	5.8	4.4	3.7	6.2	5.6	4.6[e]–3.3[f]	8.5[e]–8.2[f]
Latin America and the Caribbean	1.1	2.9	1.5	1.6	2.1	3.5	24.8[g]	18
South Asia (excl. India)	0.7	1.8	1.2	2.9	1.7	4.8		
Southeast Asia	2.9	7.7	5.1	3.0	7.3	5.0		
Sub-Saharan Africa	0.06	0.1	0.1	4.6	0.2	8.1		
Global	37.8	100	53.6	1.9	69.5	3.3		

[a] IFPRI, 2003; [b] Annual average growth rate 2001–20; [c] the fifteen countries of the EU in April 2004; [d] Failler in FAO, 2003; [e] period 2001–10, Gopakumar, 2003; [f] period 2000–05 for freshwater aquaculture, Gopakumar, *et al*., 1999; [g] Wurmann, 2003.
Sources: IFPRI, 2003 – see note 57 on p. 108.

C. Wurmann. 2003. *Acuicultura en América Latina y el Caribe: ¿Una industria con futuro?* AquaNoticias al día (available at http://www.aqua.cl/puntosvista.php).
FAO. 2003. *Fish consumption in the European Union in 2015 and 2030*, by P. Failler. Fisheries Circular 792/2. Rome. (In press)
K. Gopakumar. 2003. Indian aquaculture. *Journal of Applied Aquaculture*, 13(1/2): 1–10.
K. Gopakumar, S. Ayyappan, J.K. Jena, S.K. Sahoo, S.K. Sarkar, B.B. Satapathy and P.K. Nayak. 1999. *National Freshwater Aquaculture Development Plan*. Central Institute of Freshwater Aquaculture, Bhubaneswar, India.

countries from Southeast Asia and the EU pre-2004 seem to have been overestimated. China is clearly critical to regional (and global) forecasts. However, while historic growth rates cannot be maintained, an expected output growth rate of 2 percent per year until 2020 is plausible. Aquaculture plans for the two main Latin American producers (Brazil and Chile) strongly emphasize the promotion of the sector, which has been demonstrated in China as being key to successful aquaculture expansion.[62] This suggests that IFPRI's projections underestimate expected aquaculture output. Expansion by China and Latin America and the Caribbean would be sufficient to offset the slower than anticipated expansion in the EU and Southeast Asia.

NATIONAL FORECASTS: THE "SUM" OF NATIONAL PRODUCTION TARGETS

Based on the information extracted from the 11 national documents received on anticipated annual growth rates for the aquaculture sector, individual projections were calculated for the years 2010, 2020 and 2030 to allow summing-up projections from individual countries. A second step was to compare the "sum of the targets set in national plans" with projected requirements from aquaculture in 2010, 2020 and 2030 under the "growing fisheries" and "stagnating fisheries" scenarios set out in Table 13. Table 15 shows the results obtained, using, in addition to the above scenarios, two simulations for China: one that assumes an annual growth rate of aquaculture production of 3.5 percent, and a second of 2 percent.[63]

Based on the 11 country plan projections, the average annual growth rates for the aquaculture sector for the period 2010–30 (adjusted figure for 2030) will be:

- with China's growth assumed at 3.5 percent per year: 4.8 percent.
- with China's growth assumed at 2 percent per year: 4.5 percent.

Under the "stagnating fisheries" scenario and with China maintaining a growth rate of 3.5 percent, the countries studied would largely meet the projected requirements from aquaculture (115 percent) in 2020. In the case of Chinese aquaculture experiencing a slower growth rate, food fish requirements from aquaculture would only be met at 102 percent. Using the adjusted – and more realistic – annual growth rates for the period 2020–30 under Simulation 2, aquaculture may just provide the quantities of fish required in 2030 (97 percent of the requirements met). This highlights the continued dependence on China to supply the bulk of production. However, if Brazil and Chile fulfil their aquaculture production targets, they will increasingly weigh on the world aquaculture scene, particularly in relation to China and other Asian countries (Figure 39).

CONSTRAINTS TO GROWTH

Despite these encouraging results, it is wise to remain cautious as there may be limits to the expected growth of the sector. These limits may apply to both demand (consequences of variations in prices and international trade, compliance with HACCP standards and traceability regulations, consumer confidence) and supply (disease, social opposition such as that experienced in Canada[64] and Chile[65] impeding macroeconomic context and political instability, fishmeal availability – the latter being a much debated issue). Although more environmentally friendly approaches and environmental issues were placed high on national agendas, these issues may result in rises in costs

[62] FAO. 2003. *Aquaculture development in China: the role of public sector policies*, by N. Hishamunda and. R. Subasinghe. FAO Fisheries Technical Paper No. 427. Rome.

[63] These assumptions were based on our estimate that aquaculture in China would continue to grow but at a slower pace for the next 8–10 years, at an anticipated rate of 2–4 percent per year.

[64] Union of British Columbia Indian Chiefs. 2004. *Fish farms: zero tolerance – Indian salmon don't do drugs* (available at http://www.ubcic.bc.ca/UBCICPaper.htm; accessed September 2004).

[65] G.Barrett, M. Caniggia and L. Read. 2002. There are more vets than doctors in Chiloé: social and community impact of globalization of aquaculture in Chile. *World Development*, 30(11): 1951–1965.

Table 15

Comparison of the sum of national aquaculture production forecasts with quantities required from aquaculture to fulfil demand (Table 13) in 2010, 2020 and 2030

	2010	2020	2030	2030 adjusted[2]
	(thousand tonnes)			
1. OPTIMISTIC SCENARIO (capture fisheries growth rate = 0.7 percent/year)				
Simulation 1: using China growth rate = 3.5 percent/year				
Sum of national aquaculture production forecasts[1]	52 604	96 487	234 494	133 457
Quantities required from aquaculture	51 100	69 500	102 000	102 000
Percentage fulfilled by national forecasts	103%	139%	230%	131%
Simulation 2: using China growth rate = 2 percent/year				
Sum of national aquaculture production forecasts[1]	49 007	85 009	210 495	117 569
Quantities required from aquaculture	51 100	69 500	102 000	102 000
Percentage fulfilled by national forecasts	96%	122%	206%	115%
2. STAGNATING FISHERIES SCENARIO (capture fisheries growth rate = 0 percent/year from 2001)				
Simulation 1: using China growth rate = 3.5 percent/year				
Sum of national aquaculture production forecasts[1]	52 604	96 487	234 494	133 457
Quantities required from aquaculture	59 700	83 600	121 600	121 600
Percentage fulfilled by national forecasts	88%	115%	193%	110%
Simulation 2: using China growth rate = 2 percent/year				
Sum of national aquaculture production forecasts[1]	49 007	85 009	210 495	117 569
Quantities required from aquaculture	59 700	83 600	121 600	121 600
Percentage fulfilled by national forecasts	82%	102%	173%	97%

[1] Projected aquaculture quantities for the years 2010, 2020 and 2030 are the sum of national production targets, obtained for each country studied by applying their forecast annual growth rates linearly to their current aquaculture output to the year 2030. Forecasted annual growth rates (calculated on the basis of production target figures provided in national aquaculture development plans or expert opinion in the case of China and Egypt) were: Chile: 5.9%, Indonesia: 11.1%, India (freshwater subsector): 8.2%, Philippines: 15.1%, China: 3.5% and 2%, Egypt: 5.5%, Brazil: 22%, Canada: 11.5%, Vietnam: 10%, Bangladesh: 3.5% and Thailand: 1.7%.
[2] 2030 adjusted: national annual growth rates (taken from individual country plans) were reduced by 40 percent over the period 2020–30 to account for declining growth rates over time.
Source: Calculated from national documents and Table 13.

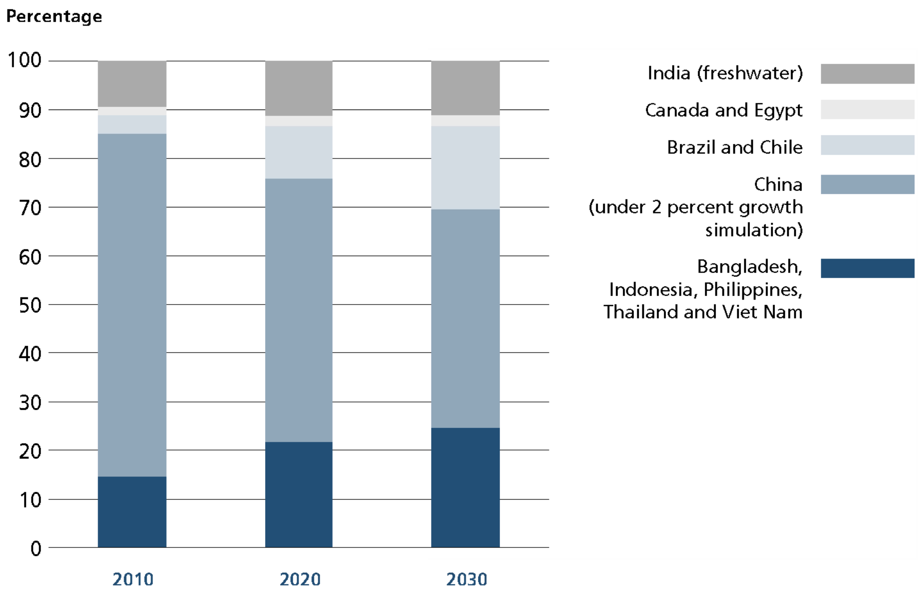
of production and initiate a decline in growth rates, necessitating a re-orientation of production.

While the above analysis looked strictly at the quantities of fish required, it is also necessary to consider the *species* that will constitute the bulk of future aquaculture production. Two species, namely carp and salmon, deserve a mention as they are among the most commonly produced fish and represent the two ends of the fish value spectrum.[66] In China, most of the carp production is consumed domestically. However, with an expected slowdown in demand for low-value fish products as a consequence

[66] IFPRI (op. cit., footnote 57, p.108) classified carps among the "low-value" species. This categorization has, however, to be nuanced to account for regions (in particular in some parts of Asia) where this species is highly valued.

Figure 39

Contribution of countries studied to aquaculture output forecasts



Note: Forecasts based on national aquaculture development plans (with adjusted growth rates for the period 2020–30).

of diet diversification and increased purchasing power, new markets will have to be found. These could be in locations where either consumer tastes are acquired and/or capacity to pay exists. Carp, however, was not considered as a strategic export by this country, despite foreseen increases in demand in South Asia and sub-Saharan Africa that are unlikely to be met by projected increases in production.[67] Carp is an important species in the diets of the poor but the lack of uniformity in markets and preferences, even within regions, should not be overlooked (Box 10).

Although carp supply is expected to continue its expansion (Bangladesh, China and Egypt have explicitly indicated their intention to boost their production), future demand for carp is likely to be constrained to specific geographical areas, mainly in developing countries. In contrast, the versatility of tilapia may prove more useful in targeting developed country markets.

A threat to the forecasted expansion plans of Latin America and the Caribbean is the future profitability of salmon farming. In 2001, salmonids were the principal species cultivated in the region, and this was almost exclusively accounted for by Chile. However, Canada and Norway have also planned to expand their production, which will put pressure on prices. The Chilean plan does acknowledge the need for new markets; of particular interest are Brazil and China, where increasing incomes and urbanization are creating new demand for high-value species. It is nevertheless questionable whether these expected increases in demand will be sufficient to maintain prices. Average costs have fallen appreciably as a result of selective breeding, but the most rapid gains may have already been made, resulting in decreasing profit margins.[68] These, in turn, would affect incentives to continue investing in the industry.

[67] Op. cit.; footnote 62, p.111; and IFPRI (2003), op. cit., footnote 57, p.108.

[68] Aerni, P. 2001. *Aquatic resources and technology: evolutionary, environmental, legal and developmental aspects.* Science, Technology and Innovation Discussion Paper No. 13. Cambridge, MA, USA, Center for International Development, Harvard University.

Box 10

Demand for carp

In India, for example, although annual fish expenditure was lowest among the poor and the very poor, most of the amount spent went on two Indian major carps, catla and rohu, indicating that increased production and improved access to this fish would benefit the poor.[1] This contrasted with Bangladesh, where rohu, catla and mrigal fetched higher prices and consequently, were bought by higher income groups.[2] In Europe on the other hand, consumers are not used to carp and this trend is not expected to change: a 0.1 per cent growth in consumption in low-value fishes to 2020 is indicated by IFPRI.

[1] R. Bhatta. 2001. Production, accessibility and consumption patterns of aquaculture products in India. *In* FAO. 2001. *Production, accessibility, marketing and consumption patterns of freshwater aquaculture products in Asia: a cross-country comparison*. FAO Fisheries Circular No. 973. Rome.
[2] M.F. Alam. 2002. Socioeconomic aspects of carp production and consumption in Bangladesh. *In* D.J. Penman, M.G. Hussain, B.J. McAndrew and M.A. Mazid, eds. 2002. *Proceedings of a Workshop on Genetic Management and Improvement Strategies for Exotic Carps in Asia, 12–14 February 2002, Dhaka, Bangladesh*. Mymensingh, Bangladesh, Bangladesh Fisheries Management Institute.

CONCLUSIONS

Findings suggest that answers to the two questions raised at the beginning of the study, namely: (1) do individual countries have a "realistic" ambition to expand their aquaculture production and (2) is the sum of national forecasts likely to be compatible with projected increases in demand for food fish, are generally positive. Countries do wish to expand aquaculture output and, with some exceptions, their assumptions were realistic. The examination of national plans and strategies has provided a valuable insight into the ambition and commitment of governments with regard to developing aquaculture, and most have appeared to endorse the sector's growth. National priorities for development, in particular with regard to the role of aquaculture in contributing to food security (often cited as one of the three reasons underlying a country's will to develop the sector, along with foreign exchange earnings and economic growth) were indicative of the realization that aquaculture can be an innovative motor of growth with many additional benefits, while revealing growing concerns over the overexploitation of capture fisheries and the motivation to find alternatives to declining catches.

As for the second question, the aggregation of national plans indicates that global forecasts may underestimate the supply of food fish coming from aquaculture. China's future expansion is critical, but using a modest 2 percent growth rate and without increases in food fish output from capture fisheries, results suggest that most of the demand projections will be met. From these findings, a conclusion, although sanguine, may be that the aquaculture sector could replicate the expansion of agriculture. However, much will depend on the realism of assumptions used to support projected targets, and countries formulating development plans for their aquaculture sector are encouraged to place a stronger emphasis on the rationale supporting their production forecasts. Such an emphasis will contribute to improved sector development planning, at an international scale, and to progress monitoring. Many factors affect the evolution of an activity such as aquaculture and setting realistic production targets is a difficult task. The sector is susceptible to unforeseen shocks – meteorological, pathological or economic – when countries compete in marketing a commodity and expand their production simultaneously.

While macro projection models used to estimate future supply were based on commodity prices, per capita incomes, rates of population growth and landings from capture fisheries, population density could be another factor to take into consideration in the setting of future production targets. This is apparent in the examples of Brazil and Norway, for which low population densities are seen as an asset to the further development of aquaculture while avoiding conflicts over resource use and social opposition typically encountered in more densely populated areas. Technological developments could bring answers to immediate concerns over resource use: for example, self-maintained offshore cages for intensive production, alleviating pressure from coastlines and inland waters, could significantly contribute to increases in aquaculture outputs and stabilization of fish prices. However, concerns may be voiced over the real motives behind this type of production and its market allocation. Targeting developed country markets with high-value fish exports is often a prime aim for many developing countries. Balancing both domestic needs for extra protein provision in LIFDCs, and foreign income generation from the same activity, is likely to involve delicate and politically challenging decisions.

Impacts of trawling on benthic habitats and communities

BACKGROUND

The effects of fishing and other anthropogenic activities on the marine environment have always been a source of great concern to fishers. Over the last two decades this concern has increased, with interest mainly focusing on the impacts of towed fishing gears such as trawls and dredges on benthic habitats and organisms. The rationale for this is multiple. On the one hand, benthic habitats provide shelter and refuge for juvenile fish and, on the other, the associated fauna provide food sources for several important demersal fish species. This means that negative impacts on benthic communities may cause a decline in marine resources, including those exploited commercially. Therefore, knowledge of the responses of these communities to disturbance from fishing gears is of great importance also to fishery managers.

Numerous investigations have been conducted on the impact of towed fishing gears on benthic communities during the last decade, but still little is known and few clear conclusions can be drawn. There are several reasons for this. First, benthic communities are complex and their large temporal and spatial variations may mask anthropogenic disturbances. Second, the studies show that the impacts of – or responses to – trawl gear vary greatly and depend on habitat type and disturbance regime (intensity and gear type). Consequently, considerable differences in responses to trawl impact can be expected when trawling is undertaken on virgin, unknown fishing grounds. Third, different methodologies have been used in the studies and many of those employed have serious limitations. This last point is of particular significance and means that the methodology used for any study should be reviewed and the results interpreted with caution.

However, the fact that the conclusions that can be drawn from such studies of benthic communities can be limited by methodological deficiencies is not always considered. (In fact, several recent review studies have been published without taking these caveats into account.)

A recent FAO study has attempted to remedy this situation by presenting a critical evaluation of the scientific approach and methodologies used in trawl impact studies.[69] It assesses the current knowledge of the physical and biological impacts of otter trawls, beam trawls and scallop dredges. Highlights of the study are provided below.

METHODOLOGIES

The methodology applied in impact studies should ideally:

- permit a study of trawling disturbance at a spatial and temporal scale representative of commercial fishing;
- include a comparison of the disturbed area with undisturbed control sites;
- use quantitative tools to sample benthic organisms.

To date, most impact studies have failed to meet one or more of the three requirements for an ideal study.

Two different approaches have been applied to investigate physical and biological impacts of trawl fisheries on benthic habitats and communities. One is to conduct experimental trawling on a site and compare the physical and biological parameters before and after the disturbance and/or with those at an adjacent and undisturbed control site. The second approach is to compare commercial fishing grounds that have been heavily fished with areas that are lightly fished or not fished at all.

The main problem with the first approach is that experimental trawling is commonly conducted along narrow corridors and completed within a short period of time. This means that this approach does not replicate the large-scale and long-term disturbances that occur in commercial fishing activities. The problem with the second approach is that commercial trawling effort is usually distributed erratically within fishing grounds and sampling under impact studies is not usually extensive enough to reveal the actual level of disturbance as there will be patches of low fishing effort within high-effort areas and vice versa. In addition, untouched control sites seldom exist at commercial fishing grounds. Unfortunately, both approaches to conducting impact studies depend on access to control sites because the lack of appropriate control sites may lead to overestimation of the effects of trawling on the benthic habitat.

PHYSICAL IMPACTS

Otter trawls, beam trawls and scallop dredges incorporate in their design different catching principles and therefore have different physical impacts on the seabed. Demersal otter trawls are designed to target fish and shrimps close to the seabed. They are rigged with different types of ground gear (e.g. bobbins, rock hoppers) and trawl doors, all of which are intended to keep the active part of the gear just above the seabed. The most noticeable physical effect of otter trawling is the creation of furrows (up to 20 cm deep) by the doors, whereas other parts of the trawl create only faint marks. Changes in sediment surface characteristics have also been demonstrated in some studies. On hard bottoms, the trawl gear may displace large boulders in its path. Studies have shown that trawl door marks disappear within five months in areas with strong currents, whereas in sheltered coastal areas faint marks can still be seen 18 months after trawling. The penetration depth and persistence of trawl marks depend on the weight and performance of the gear, sediment type and natural disturbance (e.g. current and wave actions).

Beam trawls and scallop dredges are used to catch species that stay on the bottom or are partly buried in the seabed. Accordingly, beam trawls have tickler chains and dredges with teeth that are designed to disturb the seabed surface and penetrate the upper few centimetres of the sediment. The most noticeable physical effects of beam trawling and scallop dredging are a flattening of irregular bottom topography and the elimination of natural features such as bioturbation mounds and faunal tubes. The penetration depth of the tickler chains of beam trawls varies between 1 and 8 cm, whereas scallop dredges show a slightly lower penetration depth. These marks may last from a few days in tidally exposed areas to a few months in sheltered bays.

[69] FAO. 2004. *Impacts of trawling and scallop dredging on benthic habitats and communities*, by S. Lokkeborg. FAO Fisheries Technical Paper No. 472. Rome. (In press)

BIOLOGICAL IMPACTS

The most serious effects of otter trawling have been demonstrated for hard-bottom habitats with vertical structures. In such habitats, the abundance of large sessile organisms such as sponges, anthozoans and corals has been shown to decrease considerably as a result of the passage of ground gear. Habitats dominated by large sessile fauna may thus be severely affected by trawling.

A few studies have been conducted to determine the impacts of experimental trawling on sandy-bottom (offshore) fishing grounds. These studies showed declines in the abundance of some benthic species. However, they seemed to recover within a year or less. They also indicated that trawling does not produce large changes in the benthic communities studied. The habitats, however, showed considerable temporal and spatial variability in the numbers of species and individuals. Such habitats may be resistant to trawling because they are subjected to a high degree of natural disturbances such as strong currents and large temperature fluctuations.

The impacts of shrimp and nephrops trawling on soft bottoms (i.e. clay, silt) have been thoroughly studied through numerous investigations, but clear and consistent effects were not demonstrated in these studies. Although changes in several benthic species were observed during the course of the research, few consistent and unambiguous effects could be attributed to trawling disturbance. However, these soft-bottom habitats showed pronounced temporal changes in many benthic species as a result of natural variability; changes caused by trawling may be masked by this variability and therefore difficult to demonstrate.

The relatively few studies carried out to determine impacts of beam trawling were conducted mainly in the North Sea and the Irish Sea, where certain areas of the seabed have been intensively trawled for many decades. These studies demonstrated a considerable decrease in abundance of several benthic species (sometimes by as much as 50 percent). Also, clear evidence of the short-term effects of intensive beam trawling was demonstrated. The long-term effects were not studied owing to the lack of undisturbed areas suitable for use as control sites.

Studies on scallop dredging are far more numerous than those on beam trawling. The effects of scallop dredging seem to be similar to those for beam trawling, with a considerable decrease in abundance of several benthic species. However, reductions in population density caused by dredging were often small compared with reductions arising from temporal and spatial changes. Disturbances by scallop dredging or beam trawling were found to cause no effects in areas exposed to natural disturbances (e.g. wave actions and salinity fluctuation), confirming the general trend that exposed habitats seem to be resistant to disturbances imposed by towed gears.

CONCLUSIONS

Knowledge of how towed fishing gears affect different habitat types is still rudimentary. In fact, few, other than general, conclusions can be drawn on the responses of benthic communities to trawling disturbances. This lack of knowledge can mainly be attributed to the complexity and natural variability of benthic communities, and to the fact that the methodology applied in most studies conducted to date has limitations and deficiencies. Moreover, it can be both difficult and demanding to conduct these types of studies.

Hard-bottom habitats dominated by large sessile organisms are most severely affected by otter trawling, whereas only subtle effects have been demonstrated on soft bottoms. Also, beam trawling and scallop dredging have been shown to cause changes in benthic communities.

The documentation of the impacts of trawling on certain habitat types gives rise to an interesting and challenging management issue: how are associated fish populations and other exploited marine resources affected by changes in the benthic community structure? Our knowledge of the linkage between benthic habitat complexity and the dynamics of fish populations is weak, and the potential impacts of trawling can thus not be fully established until this linkage is better understood.

Measurement of fishing capacity

THE FISHING CAPACITY MANAGEMENT PROBLEM

Declining yields, shrinking stock biomass and uncertain profitability are characteristics common to many commercial fisheries. In those that are unmanaged or managed as *de facto* open-access fisheries, the race for fish soon tends to create a fishing capacity that is larger than that needed to catch the sustainable yield. Overcapacity develops in the form of overexpanded harvesting (and processing) capacity. If this is uncontrolled, this capacity generally leads to overfishing.

The problems of overcapacity and capacity management have become key issues for fisheries management in the new millennium. Overcapacity and overfishing are really symptoms of the same underlying management problem – the absence of well-defined property or user rights. If fishers enjoyed exclusive and more secure rights, they would be able to adjust their harvesting capacity to the quantity of fish available and not be stimulated to invest in excessive capacity in order to catch the fish before someone else does.

It can be argued that if rights-based management systems were to be introduced, then the problem would largely be solved and there would be little need to consider fishing capacity as an issue.

In recent years, governments in many countries have strengthened use rights in fisheries. Change is slow, however. There are political, social and economic reasons for this. Concerns about food security and the economic and financial impacts of adjustment on fisheries and fishing communities are also important considerations for fisheries managers. These impacts are not confined to the commercial sector, but affect all consumptive and non-consumptive users of living marine resources, including recreational fisheries and the general public.

The trend towards providing stronger use – or property – rights in fisheries will probably continue. Nevertheless, it is likely that for some fisheries, exclusive use rights will not be considered feasible for technical, social or political reasons. In such situations, capacity management must occur through a combination of input and output controls so that excessive levels of fishing effort do not develop and cause both total yields of fish and economic benefits to fall well below their potential levels.

To manage capacity, managers need to know how much fishing capacity exists and then determine for each fishery the level of capacity (i.e. the target level of capacity) that best meets the management objectives. FAO has reviewed various methods for measuring fishing capacity.[70] A definition of fishing capacity and different ways to measure it are described below.

WHAT IS FISHING CAPACITY?

Different groups of people generally have a different understanding of capacity. Fishing technologists often consider fishing capacity as the technological and practical feasibility of a vessel achieving a certain level of activity – be it days fishing, catch or processed products. Fisheries scientists often think of fishing capacity in terms of fishing effort, and the resultant rate of fishing mortality (the proportion of the fish stock killed through fishing). Fisheries managers generally have a similar view of fishing capacity, but often link the concept directly with the number of vessels operating in the fishery. Many managers express fishing capacity in measures such as gross tonnage or as total effort (e.g. standard fishing days available). Most of these ideas reflect an understanding of capacity primarily in terms of inputs (an input perspective).

[70] FAO. 2000. *Report of the Technical Consultation on the Measurement of Fishing Capacity, Mexico City, 1999*. FAO Fisheries Report No. 615. Rome; FAO. 2003a. *Measuring and assessing capacity in fisheries: issues and methods*, by S. Pascoe, J.E. Kirkley, D. Gréboval and C.J. Morrison-Paul. FAO Fisheries Technical Paper. No. 433/2. Rome; FAO. 2004. *Measuring and assessing capacity in fisheries: basic concepts and management options*, by J.M. Ward, J.E. Kirkley, R. Metzner and S. Pascoe. FAO Fisheries Technical Paper No. 443/1. Rome. (In press); FAO. 2003b. *Measuring capacity in fisheries*, by S. Pascoe and D. Gréboval, eds. FAO Fisheries Technical Paper No. 445. Rome.

Box 11

Additional fishing capacity terminology

Capacity utilization. The degree to which the vessel is utilized. From an input-based perspective, capacity utilization may be expressed as the ratio of the number of days actually fished to the number of days the boat could potentially fish under normal working conditions. From an output-based perspective, capacity utilization is the ratio of the actual catch to the potential catch (if fully utilized).

Excess capacity. A common, essentially short-term, phenomenon in all types of industry. In general, excess capacity may be defined as the difference between what a production facility could produce if fully utilized during a given period and what has actually been produced in that same period. In fisheries, lower prices or temporarily higher costs (e.g. fuel price increases) may result in boats operating less frequently than expected under average conditions. If the prices and costs return to normal levels, then this form of excess capacity is self-correcting. Excess capacity can also be caused by fisheries management. Stock recovery programmes may impose restrictions on catch or effort that result in the vessels being underutilized during the recovery process, but allow vessels to be fully utilized when the stocks have increased. In such circumstances, the existence of excess capacity is not problematic. However, if the effort or catch restrictions are likely to persist into the future, then it is likely that excess capacity is an indicator of overcapacity in the fishery.

Fishing effort. The amount of time and fishing power used to harvest fish.

Fishing power. Fishing power is determined *inter alia* by gear size, boat size and horsepower.

Overcapitalization. Overinvestment in assets (capital). In its simplest form, overcapitalization exists if the fleet size is greater than that required to harvest a particular yield.

Overfishing. Normally expressed in terms of fishing mortality levels, that is, in terms of how many fish are killed. If total fishing mortality (harvesting) is at a rate that exceeds the maximum level that the stock can withstand on a sustainable basis (i.e. the maximum sustainable yield), then there is overfishing.

In contrast, economists tend to consider capacity as the potential catch that could be produced if the boat were to be operating at maximum profit or benefit (an output perspective).

To reflect these different views of fishing capacity, an FAO technical consultation developed a definition of fishing capacity that is both input (e.g. effort, boat numbers, etc.) and output (catch) based:

> *[Fishing capacity is] the amount of fish (or fishing effort) that can be produced over a period of time (e.g. a year or a fishing season) by a vessel or a fleet if fully utilized and for a given resource condition.*[71]

[71] Op. cit., see FAO (2000) in footnote 70.

Indicators will generally be used, to monitor and measure fishing capacity, ranging from vessel characteristics (gross tonnage, horsepower) to potential effort or potential catch (adjusting for full utilization).

The term "overcapacity" conveys the fact that fishing capacity is greater than some desirable level of fishing capacity (the target capacity). This may be either a long-term target sustainable yield – reflected in the short term in a total allowable catch (TAC) – or a related long-term target for fixed inputs employed in the fishery.

MEASURING CAPACITY

Quantitative capacity measures

Measuring excess capacity or the degree of capacity utilization is relatively easy as it does not require any knowledge of the state of resources *per se*. It is sufficient to estimate actual levels of fishing inputs use (using indicators for vessels, gear or effort) or output (using catch as indicator) and to compare these actual levels with potential ones, under the assumption of unrestricted but normal full use of the available inputs (actual levels of capacity).

In order to measure overcapacity quantitatively in any particular fishery two numbers are needed: the actual level of capacity[72] and the target level of capacity. The extent of overcapacity is established by comparing these two numbers. Establishing a target level of exploitation (target catch, corresponding effort level and minimum corresponding fleet size) is required to set a target level of capacity. Except for simple fisheries, quantitative estimation of capacity is relatively difficult.

Given the complexity of estimating potential catch (e.g. for multispecies fisheries), several techniques have been developed to assist in the quantitative measure of excess fishing capacity and overcapacity. These include data envelopment analysis (DEA), stochastic production frontiers (SPF), and peak-to-peak (PTP) analysis.[73]

Overcapacity measures that utilize DEA have been developed to measure overcapacity levels in fisheries relative to a biological target level of yield[74] or to an economic target level of yield such as maximum economic yield (MEY).

Bioeconomic models have also been used to estimate input-based measures of overcapacity or overcapitalization. Using such models, the fleet size and configuration that best conform to the management objectives can be estimated and compared with current fleet sizes and configurations to derive an estimate of the level of overcapacity and overcapitalization.[75]

All of these approaches have both strengths and weaknesses, and the choice of the appropriate method will vary depending on the nature of the fishery, the data available, and the intended use of the capacity measure.

Subjective capacity measures

Quantitive data is needed to develop quantitative estimates of fishing capacity. As quantitative data may not be readily available, managers will need to develop non-quantitative estimates of fishing capacity. Subjective measures and qualitative indicators of capacity levels are also needed.

[72] When potential catch is used as an indicator of actual capacity, adjustment will be required to reflect changing resource conditions (catch rates).

[73] Details on how these measures are estimated are presented in J. Kirkley and D. Squires. 1999. Measuring capacity and capacity utilization in fisheries. *In* FAO. *Managing fishing capacity: selected papers on underlying concepts and issues,* edited by D. Greboval. FAO Fisheries Technical Paper No. 386. Rome; and in FAO (2004), op. cit., see footnote 70, p.118. Examples of applications using these techniques are also presented in FAO (2003b), op. cit., see footnote 70, p.118.

[74] J. Kirkley, J. Ward, J. Waldron and E. Thunberg. 2002. *The estimated vessel buyback programme costs to eliminate overcapacity in five federally managed fisheries.* Final contract report to the National Marine Fisheries Service, Silver Spring, Maryland. Gloucester Point, Virginia, USA, Virginia Institute of Marine Science.

[75] An example of the application of a bioeconomic model for that purpose is presented in FAO (2004), op. cit., see footnote 70, p.118.

Rapid appraisal techniques and expert knowledge (e.g. the Delphi method) have been used to derive subjective estimates of a wide range of indicators. However, such techniques should only be employed when the analyst has access to individuals or organizations that have a profound knowledge of the concerned fisheries and that are able to provide information on historical change.

Qualitative capacity indicators

Qualitative assessments of overcapacity can be based on verifiable indicators, although, clearly, no single indicator can be sufficient to determine overcapacity in a fishery. A combination of indicators, each indicating change over time, will be needed to determine qualitative capacity levels in fisheries and may include:

Biological status of the fishery. If signs of overfishing are observed for the target species in a directed fishery, it is probable that overcapacity exists – especially against a background of increasing capacity.

Harvest/target catch ratio. Overcapacity is likely to exist when harvest levels regularly exceed the target catch – with a harvest-to-target catch ratio significantly exceeding one. However, this indicator must be considered in the context of the management of the fishery. If a fishery is closed before the target catch is exceeded, the harvest level will not exceed the target, and no apparent overcapacity will be observed. Also, this indicator is not sensitive to any discarding that may take place in a fishery managed through quotas and is therefore not a good indicator of overcapacity in fisheries that are managed through TACs or quotas. In addition, if the fishery has been overfished, and the harvest level is below the target level, the measure may be less than one in spite of the presence of overcapacity.

TAC/season length. Using the ratio of the TAC level to the season length, an increase over time of this ratio indicates overcapacity.

Conflict. Controversies surrounding the setting of the TAC and the suballocation of TACs among different user groups may also indicate overcapacity in a fishery.

Latent permits. A relatively large number of latent permits, or a low ratio of active to total permits, indicate overcapacity in a fishery, and if this ratio declines, the likelihood increases that overcapacity exists in the fishery.

Catch per unit of effort. A decline over time in catch per unit of effort (CPUE) against a background of stagnating catches generally implies overfishing and, most likely, overcapacity. However, fluctuating TACs under a constant fishing mortality management strategy could mask this effect, and CPUE trends may remain constant or increase for schooling species even though overall stock abundance is declining.

Value per unit of effort. The value of catches per unit of effort (VPUE) may be a potential indicator of overcapacity in multispecies fisheries, especially if the VPUE decreases as overall CPUE stagnates or decreases. VPUE is a useful capacity indicator in fisheries where it is impractical to record the catch of each species separately, but recording the total value of sales is feasible.

Re-estimating discards in the world's marine capture fisheries

BACKGROUND

UN General Assembly resolutions, the Kyoto Declaration[76] and the Code of Conduct for Responsible Fisheries are among the international instruments that have highlighted the need to reduce or minimize discards. FAO is mandated to report periodically to the UN on the implementation of the resolutions and has been at the forefront of efforts to draw attention to wastage of fishery resources as a result of discarding, and to promote efforts to reduce or minimize discards.

Changes in the patterns of fishing activities throughout the world have influenced discarding practices. An FAO study was therefore undertaken to update the previous FAO estimates of discards in the world's marine capture fisheries and to review trends and issues related to discards.[77]

The quantification of discards and knowledge of trends in discarding practices are of value in the design of fisheries management regimes and initiatives to promote responsible fishing operations and catch utilization. Discarding also raises a range of issues with regard to the interpretation, application and monitoring of the Code of Conduct, and to promoting both sustainable fisheries and food security.

Previous estimates[78]

The previous FAO assessment (1994) estimated global discards to be 27 million tonnes (ranging from 17.9 to 39.5 million tonnes). It was based on data from the 1980s and early 1990s. A subsequent FAO estimate, presented in *The State of World Fisheries and Aquaculture 1998*, suggested a reduced estimate of 20 million tonnes. A further study by Alverson (1998) indicated that the 1994 assessment was an overestimate.

Method

Discards are defined as being "that portion of the catch which is returned to the sea" for whatever reason.[79] Aquatic plants and animals are excluded from the estimate.

The study is based on the premise that discards are a function of a fishery, defined in terms of an area, a fishing gear and a target species. An inventory of the world's fisheries and associated catch and discard information was compiled in a "discard database". The information on catches and discards was obtained from published national and regional fisheries reports and statistics, from papers published in scientific journals, from "grey" literature and Internet sources, and through direct contacts with national and regional fisheries institutions. The discard database references the sources of the information for each fishery. Records can thus be checked, updated, or replaced as further information on each fishery becomes available.

It is assumed, that for a given fishery, there is a linear relationship between landings and discards at the aggregate level. In other words, the discard rate calculated in a study of a fishery (a sample) was applied to the total landings of the fishery to calculate the total quantity of discards. In the absence of information to the contrary, artisanal fisheries were generally assumed to have a low (1 percent or less) or negligible discard rate.

As most discard studies focus on fisheries with high discard rates, the results may be biased in favour of such fisheries. However, this potential bias is partially offset by the inclusion of numerous artisanal fisheries.

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[76] The Kyoto Declaration and Plan of Action were adopted at the International Conference on the Sustainable Contribution of Fisheries to Food Security, held in Kyoto, Japan, from 4 to 9 December 1995.

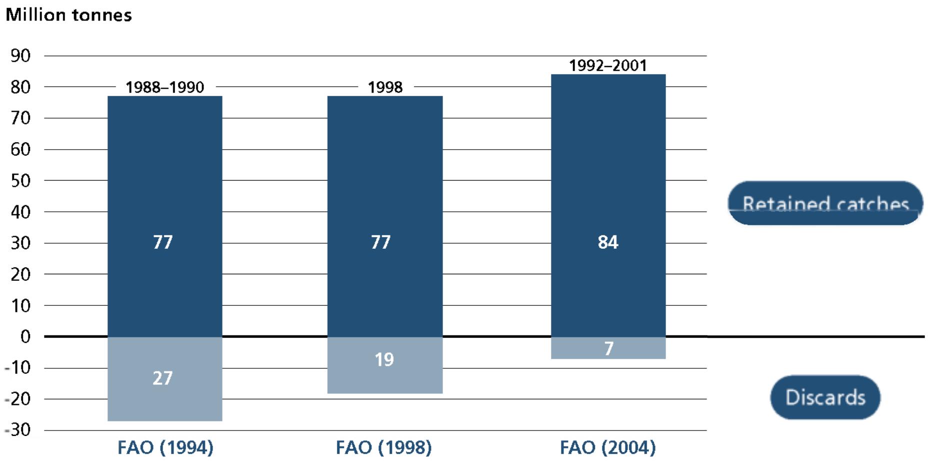
[77] FAO, 2004. *Discarding in the world's fisheries: an update*, by K. Kelleher. FAO Fisheries Technical Paper No. 470. Rome. (In press)

[78] Sources of the estimates referred to in this paragraph are, respectively, FAO. 1994. *A global assessment of fisheries bycatch and discards*, by D.L. Alverson, M.H. Freeberg, S.A. Murawaski and J.G. Pope. FAO Fisheries Technical Paper No. 339. Rome; FAO. 1998. *The State of World Fisheries and Aquaculture 1998*. Rome; and D.L. Alverson. 1998. *Discarding practices and unobserved fishing mortality in marine fisheries: an update.* Report prepared for the NMFS. Washington Sea Grant Publication WSG 98-06. Seattle, USA, Washington Sea Grant.

[79] FAO. 1996. *Report of the Technical Consultation on Reduction of Wastage in Fisheries.* Tokyo, Japan, 1996. FAO Fisheries Report No. 547. Rome.

Figure 40

Comparison of discard estimates and retained catches



Source: Full source details are given in footnotes 77 and 78.

MAIN FINDINGS

The global estimate

The global summed discard rate is 8 percent (quantity of discards as a percentage of the total catch).

Applying the 8 percent global aggregate discard rate estimated in the study to a ten-year (1992–2002) average of the global nominal catch reported in FAO Fishstat,[80] the total extrapolated discards is calculated to be 7.3 million tonnes. Some caution is required in extrapolating to the total global catch, as some major fish producer countries[81] are underrepresented in the discard database.

Discards by area

The highest quantities of discards are in FAO Areas 27 (Northeast Atlantic) and 61 (Northwest Pacific), which jointly account for 40 percent of the discards. Areas with low discards include Southeast and East Asia, small island nations in the South Pacific and Caribbean, and countries with a "no discards" policy.

Discards by type of fishery

Trawl fisheries for shrimp and demersal finfish account for over 50 percent of the total estimated discards while representing approximately 22 percent of total landings in the discard database. Tropical shrimp trawl fisheries have the highest discard rate and alone account for over 27 percent of the total estimated discards. Penaeid shrimp fisheries in Indonesia, South America and the United States jointly account for approximately 1 million tonnes of discards. Coldwater shrimp trawl fisheries have considerably lower discard rates. However, the rates can vary from over 80 percent for some *Nephrops* trawl fisheries to less than 6 percent for many *Pandalus* fisheries.

Demersal finfish trawls account for 36 percent of the estimated global discards. In particular, trawlers targeting flatfish and deep-water species may discard more than 50 percent and 39 percent of their catches, respectively.

Most purse seine, handline, jig, trap and pot fisheries have low discard rates. If the carcasses of finned sharks are considered as discards, then the summed discard rate in tuna longline fisheries is 29 percent.

[80] Fishstat Plus (v. 2.30) of 24.07.2003. The nominal (or retained) catch excludes marine animals and plants.

[81] These include New Zealand, the Philippines, the Republic of Korea and the Russian Federation. The EU member countries and India have only partially been covered. A number of smaller fish-producing countries are not included.

Figure 41

Estimated average yearly discard quantities and discard rates in major ocean areas, 1992–2001

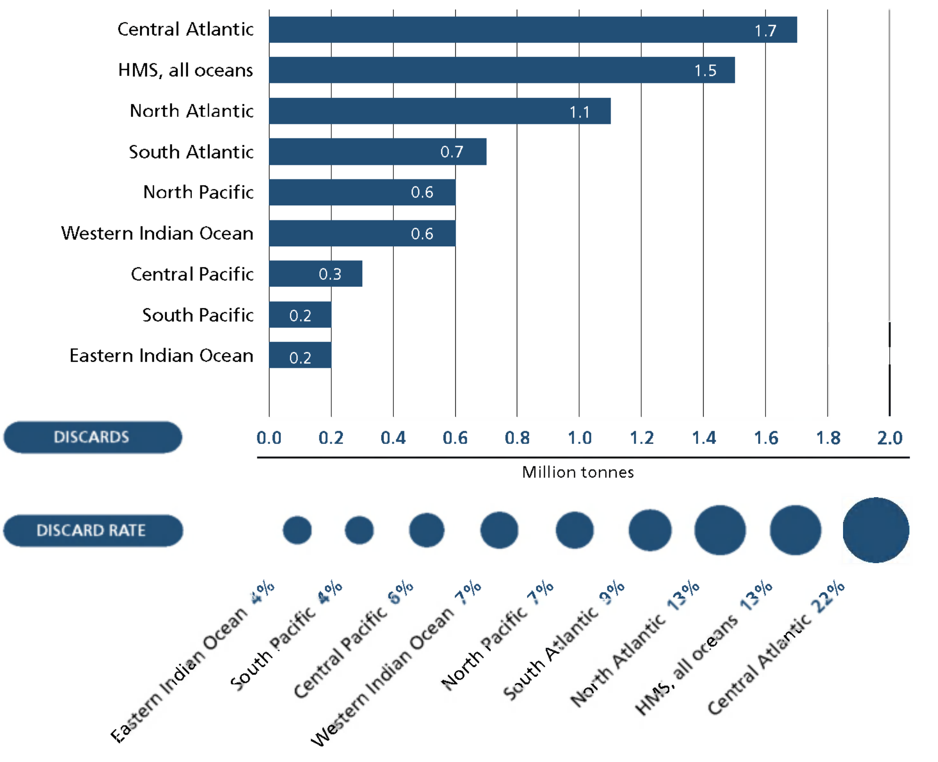
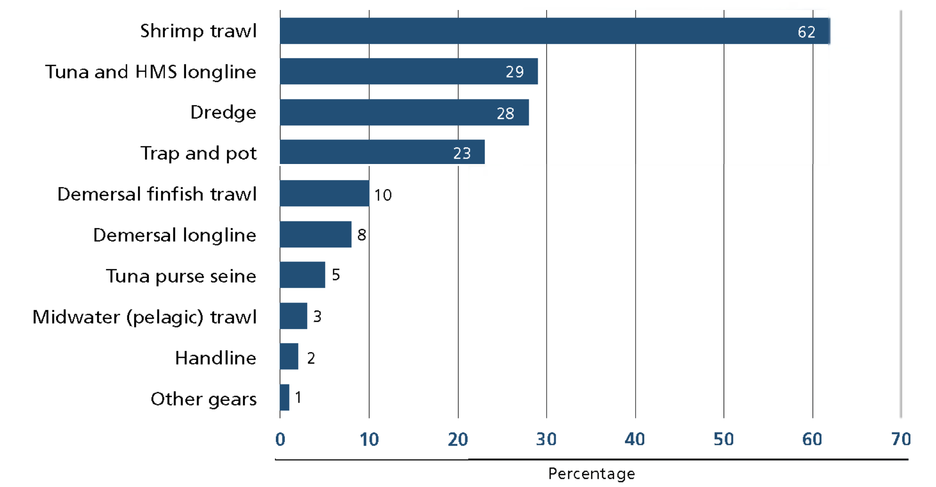


Figure 42

Discard rates by major gear type



Note: HMS = highly migratory species.

Small-scale fisheries generally have lower discard rates than industrial fisheries. The small-scale fisheries account for at least 11 percent of the discard database landings and in aggregate have an estimated discard rate of 3.7 percent.

Major trends

Two discard estimates have been made with respect to the periods 1988–90 and 1992–2001. A number of factors complicate direct comparisons between the estimates: (1) the methodology has changed to a more robust fishery-by-fishery estimate; (2) the first estimate had a range of 17.9 to 39.5 million tonnes with a mean of 27 million tonnes, while the second had a range of 6.9 to 8.0 million tonnes; (3) the landings data used in the extrapolations needed to estimate global discards in both periods were affected by uncertainty related to IUU fishing and by possible overestimation of landings by China. But, although a time series at the global level is not available, evidence from numerous fisheries clearly indicates that there has been a substantial reduction in discards since the 1994 assessment was made. There are two major reasons for this: a reduction in bycatch due to the use of more selective fishing gears, the introduction of bycatch and discard regulations and improved enforcement of regulatory measures; and the increased retention of bycatch for human or animal food, as a result of improved technologies and expanding market opportunities.

Bycatch reduction

Many factors have contributed to bycatch reduction. In particular, the promotion of the Code of Conduct for Responsible Fisheries has increased public and international awareness of discards as being morally unacceptable waste. Scientific concerns over the unaccounted mortalities of juvenile fish and fishers' concerns over the impact of unsustainable fishing practices on ever-scarcer fish resources have resulted in a broad range of bycatch and discard reduction initiatives. Economic factors such as the costs of sorting catches, crew shortages, efforts to comply with ecolabelling requirements and the introduction of quotas on bycatch species have all contributed to reductions in unwanted bycatch. Improvements in fisheries management and improved enforcement of regulations have also played an important role. In several countries, the common concerns of government and industry have led to the joint formulation of bycatch reduction strategies and implementation of mutually agreed measures. Major fisheries in which discards have significantly declined include the Gulf of Mexico shrimp trawl, Alaskan groundfish fisheries, Canadian fisheries, fisheries in the NAFO area, a number of Australian fisheries and fisheries in countries with a "no discards" regime (e.g. Iceland, Namibia and Norway).

However, some fisheries have contributed to increases in discards, notably deep-water fisheries and fisheries where severe quota restrictions have resulted in more discarding of smaller specimens (highgrading). Overfishing has also contributed to increases in discards, particularly where an increasing proportion of the target species is composed of juveniles. Certain regulations, such as those on minimum landing size, or more effective enforcement of such regulations, have also contributed to increases in discards.

Bycatch retention

Many species and types of fish that were previously considered to be bycatch are now included in a broader range of target species. The extent to which increases in retained catches may be attributed to increased landings of previously discarded species requires further analysis. Lack of time series again preclude empirical assessment at a global level, but evidence strongly suggests the increased utilization of bycatch in many fisheries, particularly in:

- South, Southeast and East Asian fisheries, which (with some exceptions) have very low or negligible discard rates. The increased utilization can partly be attributed to increased demand for aquaculture feed and innovations in product development;

- African industrial trawl fisheries, which are marketing increasing quantities of bycatch, particularly on African urban markets;
- factory vessels involved in at-sea processing to produce *surimi* and related products.

The following count among the numerous reasons for increased bycatch utilization:

- population and income increases leading to greater demand for fish products, particularly in developing countries;
- the development and transfer of technologies for the use of small-sized fish to produce value-added products;
- the development of consumer markets for unfamiliar or previously discarded species;
- reductions in quotas or target species catches as a result of overfishing, which frees up hold capacity and allows increased retention of lower-valued bycatch;
- the trend towards shorter fishing trips to improve fish quality, which may also create "spare" hold capacity that can be used for bycatch;
- increased at-sea collection of bycatch, particularly in tropical shrimp trawl fisheries in Africa and in Central and South America;
- changes in management regimes that encourage, facilitate or even oblige landings, or at-sea collection of bycatch;
- changes in regulations, e.g. a decrease in minimum landing size to ensure compatibility with trawl mesh sizes, and the issue of permits to transfer target, or bycatch, quotas between vessels or fishers;
- economic incentives to maximize returns from the catch.

Further efforts to promote bycatch utilization are likely to reduce discards further, particularly in LIFDCs, in Africa and in Central and South America.

In contrast to the trend towards full utilization of almost all harvested species in many Asian countries, many Western fisheries focus on increasing selectivity and on bycatch reduction.

IMPLICATIONS AND ISSUES

Policy implications

The "no discards" approach

A number of countries have instituted fisheries policies and management regimes based on the principle of "no discards". A "no discards" policy implies a paradigm shift in approaches to fisheries management. It moves the focus of management measures from landings to catches and from fish production to fish mortality. Fishers are obliged to make efforts to avoid catching unwanted fish. Such a policy is also in conformity with the precautionary approach: by regarding "no discards" as the norm, any discarding then requires adequate justification. Complementary measures are necessary to apply a "no discards" regime successfully. Minimum landing size regulations must be removed and provisions made to market all landings.

Balancing bycatch reduction and utilization

The biological and social principles upon which an appropriate balance between bycatch reduction and utilization can be based require further analysis and the development of decision frameworks. A more precise interpretation of the "ecosystem approach" in relation to bycatch reduction and utilization is required, with particular regard to the relative merits of selective and non-selective fishing. The conservation implications of a strategy of "total utilization" of bycatch also require further attention.

Endangered species

The incidental catch and subsequent discard of charismatic, protected or endangered species, such as turtles, marine mammals and seabirds, are likely to have an increasing impact on fishing activities and trade in fish products. The absence of a neutral and internationally accredited mechanism for the compilation of information on incidental catches of many of these species, and for the examination and promotion of best practices in mitigation measures, may impede rational discussion and the development of solutions. The impact of discards on biodiversity and ecosystem change remains poorly understood.

Technical implications

Measuring discards

A complex of biological, economic and regulatory factors determine the decisions of fishers to discard. These factors are generally specific to each fishery and the decision to discard may vary by fishing trip, fishing operation, season or fisher. Consequently, discard information has a high level of inherent variability, often requiring extensive discard sampling to generate accurate assessments of quantities. On-board observer reports are considered indispensable for accurate estimation of discards. Relationships between discard rates and other variables (e.g. landings, duration of trip, length of trawl tow, market prices) tend to be weak. Accordingly, raising or extrapolating discard estimates derived from samples to the level of the fleet, or the fishery, may have a high degree of error, particularly if the sampling protocol is inadequate.

National fisheries statistics are not generally collected, compiled and presented on a fishery-by-fishery basis, so that extrapolation of discards to the level of the fishery may also be problematic. There are several advantages in compiling national fisheries statistics on a fishery-by-fishery basis. In particular, it may focus attention on the definition of coherent management units, link trends in landings to fishery-specific management measures and facilitate consideration of bycatch and discards in resource assessments.

Use of discard estimates

Discards may account for a significant mortality in fisheries. For numerous reasons, discard estimates may not be included in stock assessments, in determination of TACs, or in quota management. In general, the fisheries management "accounting toolkit" for discards is deficient.

Development of guidelines

The development of guidelines, or a review of best practices, should be considered, particularly with regard to the following:

- discard sampling;
- raising discard sample estimates to the fleet or fishery level;
- the use of discard estimates in stock assessments;
- the inclusion of discard estimates in fishery management plans and accounting for discards in TACs and quotas;
- the development of bycatch management plans;
- the introduction and adoption of bycatch reduction and mitigation technologies.

Future discard estimates

Future compilations of discard estimates at a global level can be closely linked to the developing FAO Fisheries Global Information System (FIGIS) inventory of fisheries. Cross-linkage with Fishstat may help identify trends in landings of hitherto discarded fish. The closer involvement of member countries and RFBs in verifying and updating the information in the discard database can give a broader "ownership" base to the discard data. Further efforts to obtain discard information from countries and fisheries where such information is lacking can help focus attention on discard- and bycatch-related issues. Complementary periodic reviews of information on the survival of discards, non-discard sources of unobserved fishing mortalities and the impact of discards on ecosystems will further contribute to the knowledge required to manage fisheries sustainably.

Fisheries subsidies

INTRODUCTION

Fishery subsidies were recognized by FAO as a stimulus to overcapacity and overfishing in *Marine fisheries and the law of the sea: a decade of change*.[82] That 1992 document helped to focus attention on the depleted state of many of the world's major commercial marine fish stocks. The most shocking aspect of the report was its emphasis on the substantial deterioration of the situation since the halcyon days when, having reached agreement at the Third United Nations Conference on the Law of the Sea, most coastal states assumed control over fisheries to 200 nautical miles from their shores. The report concluded that the existence of subsidies had negated the desired, and anticipated, role of extended fisheries jurisdiction in developing and maintaining sustainable fisheries.

Interest in fishery subsidies has grown during the last dozen years, with such intergovernmental agencies as the World Bank, the Organisation for Economic Co-operation and Development (OECD), the United Nations Environment Programme (UNEP) and FAO[83] focusing on fishery subsidies and publishing documents to bring the problem to the attention of the public. The Fourth Ministerial Meeting of the WTO, held in Doha in 2001, resulted in an explicit directive to the negotiators in the subsequent round of international trade talks to improve WTO discipline to control fishery subsidies. The Plan of Implementation of the 2002 World Summit on Sustainable Development, held in Johannesburg, re-emphasized the Doha Declaration's call for the WTO to act with respect to fishery subsidies.

DEFINITION

But what are fishery subsidies? They can be defined as narrowly as government financial transfers to the industry and as broadly as any government action that modifies the potential profits earned by the firm in the short, medium or long term. Regardless of the definition used, subsidies can alter the actions of firms in ways that interfere with international trade and affect fishing effort and, ultimately, the sustainability of the fish stock. They are introduced for presumably socially beneficial reasons and are not inherently evil. Those that violate the conditions of the international Agreement on Subsidies and Countervailing Measures are clearly actionable under current WTO rules and are inherently in violation of international standards. But not all subsidies fall into this class. The problems of non-actionable subsidies arise when the context in which they were implemented has changed to the extent that they become a threat to stock sustainability. For instance, with the extension of fisheries jurisdiction to the 200-mile limit, a coastal state might have wanted to replace a foreign distant-water fleet with a domestic fleet which, among other things, it would find easier to control for purposes of fishery management. Society might view favourably a subsidy with that objective. Over time, however, the subsidy might become so embedded in the thinking of the operators of fishing enterprises that it becomes difficult to eliminate it once the goal, in this case the development of a domestic fleet, has been reached. Pursuing the example a little further, because the subsidy encourages the building of domestic vessels, if it is not removed at the appropriate time, boatbuilding will embed excess capacity in the industry and the existence of that excess capacity will lead to overfishing.

After the declaration of the 200-mile limit in the United States and Canada, for instance, government policies (subsidies) were adopted that encouraged the

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[82] FAO. 1992. *Marine fisheries and the law of the sea: a decade of change*. Special Chapter of *The State of Food and Agriculture 1992*. FAO Fisheries Circular No. 853. Rome.

[83] FAO. 2003. *Introducing fisheries subsidies*, by W.E. Schrank. FAO Fisheries Technical Paper. No. 437. Rome.

development of domestic fishing fleets. These were long-lasting and, by the early 1990s, Canada was forced to close its major Atlantic cod fisheries to commercial fishing because the stocks had been decimated. Similarly, by 1999, one-third of the stocks controlled by the United States Government whose status was known were considered to have been overfished. Subsidies no doubt played their role in these events.

JUSTIFICATION AND HISTORY

There are at least three potential justifications for subsidies. First, there is the infant industry concept wherein the government must provide seed capital if a domestic industry is to take hold in the face of existing foreign competition. Second, a large and important firm may encounter temporary financial difficulties which, if the firm went out of business, could spill over and damage other, healthy, aspects of the economy. By temporarily offering subsidy protection, the government might protect the entire economy. Third, subsidies can be used to encourage firms to behave in environmentally friendly ways.

Forty years ago, subsidies were generally seen as being socially useful, largely under the infant industry argument. With the passage of years, and changing views of the role of government in the economy, subsidies are less often seen as socially useful – although many find the environmental justification of subsidies to be compelling. Subsidies have to be judged in the social context in which they are embedded. Will they accomplish their purpose? If they do ultimately accomplish their purpose, will it be possible to abolish them before the point at which they may start to do harm? Are there alternative ways for the government to accomplish its goals?

Regardless of whether these questions have been asked and suitably answered in specific cases, the history of fishery subsidies is a long one, as will be seen from the following examples.

Within 20 years of the establishment of the Massachusetts colony in 1620, fishermen were being subsidized by exemptions from military duty and from certain taxes. In the seventeenth century, England granted monopolies to stimulate the fisheries of what is now Atlantic Canada. In the middle of the nineteenth century, Norway engaged scientists to investigate fluctuations in fish catches, marking the beginning of a long programme of government support to Norwegian fisheries. The modernization of Icelandic fisheries received a stimulus when, towards the end of the nineteenth century, a government bank extended loans for the purchase of fishing vessels. Peru, in the early 1970s, introduced a plan to develop its fisheries for the purpose of supplying fresh and frozen fish products to the domestic market. This plan included a government-financed investment programme in fisheries infrastructure and equipment. In the 15 years following 1960, the Chilean Government used a subsidy programme of income tax and import duty exemptions to develop its fisheries. For a quarter of a century beginning in the mid-1960s, Brazil developed its fisheries through a variety of tax exemptions. The list can go on and on, including subsidies in developed and developing countries, and from hundreds of years ago to this day.

MEASUREMENT OF SUBSIDIES

The measurement of subsidies has been complicated by the diversity of subsidy definitions, a lack of data and, when international bodies have undertaken subsidy measurements, inconsistencies generated by the variety of concepts the individual countries are prepared to consider as subsidies. When subsidies are measured, the cost to government of financial transfers, or of waived receipts, usually provides the basis for the computations. There have been several major attempts to measure fishery subsidies in this way; in particular, a book on the subject by M. Milazzo published by the World Bank is the seminal work in the field.[84] In addition, the OECD has compiled and published a list, by country, of government financial transfers to the fishing

[84] M. Milazzo. 1998. *Subsidies in world fisheries: a re-examination.* Washington, DC, World Bank.

industry; the Asia-Pacific Economic Co-operation group of countries have published a study of the nature and extent of subsidies in the fisheries sector of its member countries; and FAO has prepared a detailed guide to help countries to measure their fisheries subsidies. The gathering of the data constitutes an important first step, but is only a first step. Subsidies themselves are not of primary interest. What is of primary concern is their effect on the behaviour of people and firms. Do the subsidies negatively affect international trade? Do the subsidies encourage firms and fishers to take actions that are detrimental to the stocks of fish that they catch?

Certain subsidies, for instance a boat bounty whereby government pays a certain share of the cost of building and equipping a fishing vessel, theoretically would lead to overfishing. After all, the costs facing the fisher or fishing firm are reduced, the firm's anticipated profits rise, and there would be a double stimulus for overfishing: first, with positive unit profits from catching fish, profits would increase as more fish are caught; and, second, the firm would want to keep its capital employed. Unless scientists were able to make an airtight case for limiting fishing, owners of this excess capital would try to convince fishery managers not to limit fishing. Because scientists are immersed in a world of uncertainty, they cannot offer such an airtight case and often fishing continues at an excessive level until it is too late – the fish stock has approached the state of commercial extinction. While this is the theoretical argument, there are cases, such as that of Newfoundland's northern cod stock, where it has clearly happened. There are, of course, additional factors that lead to the decline of a fish stock: scientific error (as opposed to uncertainty), political pressure from communities that depend on the fishery for their economic livelihood, IUU fishing, and environmental factors such as climatic conditions, excessive predator numbers and insufficient prey, among others. The empirical questions are: to what extent do subsidies actually affect overfishing? What is the contribution of the subsidy to the firm's anticipated profits (it is, after all, the anticipation of profits that will lead the firm to take action)? To what extent does the anticipated change in the firm's profits lead it to overfish? Such analysis is at an early stage.

INTERNATIONAL CONFERENCES

The year of *decade of change*, 1992, was a watershed in the history of fisheries management. In May of that year, an International Conference on Responsible Fisheries met in Cancún, Mexico. Concerned with maintaining fish as a major source of human nutrition, the importance of preserving the marine environment, and problems of excess capacity in fisheries, the conference asked FAO to prepare what was to become the International Code of Conduct for Responsible Fisheries, approved by FAO member countries three years later. Later in the year, the Earth Summit was held in Rio de Janeiro. Although no direct mention of fisheries or fishery subsidies was made, the Rio Declaration on Environment and Development was broad enough to encompass problems of fisheries. In December 1995, the Kyoto Conference on the Sustainable Contribution of Fisheries to Food Security strengthened the call for responsible fisheries. The Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem, in 2001, reinforced the urgency of the need for improved fishery science and monitoring to continue the implementation of the International Code of Conduct for Responsible Fisheries. Finally, the Doha Ministerial Conference in the same year explicitly brought fishery subsidies to the forefront of consideration.

THE POLITICAL DEBATE

There has been great frustration with the apparent inability of existing international arrangements to control overfishing. Because of the existence of strong enforcement procedures under the WTO, there has been interest by a number of nations to find a legitimate way for the WTO to become involved in sustainability issues. As early as 1999, five nations presented a submission to the WTO's Committee on Trade and the Environment urging governments to pursue work with the WTO to achieve the gradual elimination of environment-damaging and trade-distorting fishery subsidies. These discussions continued until the Doha Declaration in 2001 intensified the urgency of the matter. The issue subsequently came under the purview of the WTO's Negotiating Group on Rules. Eight nations – Australia, Chile, Ecuador, Iceland, New Zealand, Peru, the Philippines and the United States – made a submission that started by noting that commercial fisheries are often exploited or potentially exploited by more than one nation. As a result, the argument continued, fishery subsidies have implications for trade far beyond the distortion of competitive relationships. In most industries, subsidies that encourage production impinge on trade only at the market level; they have no effect on the trading partners' ability to produce the goods. With shared fishery resources, a trading partner's ability to produce fish products may be hindered if one country subsidizes the fishery to the extent that the resource is diminished. Thus, the eight countries supported the Doha Declaration's appeal for strengthening the WTO's disciplines with regard to fisheries.

Opposition to the proposal came from countries that, among other arguments, suggested that the new UN Fish Stocks Agreement should be given time to see if it will prove effective. This Agreement was intended to solve exactly the problems that the eight nations raised. From October 2002 to July 2003 there was a second flurry of correspondence addressed to the WTO's Negotiating Group on Rules. The United States proposed a "traffic light" system whereby a certain category of subsidies would face a red light (i.e. they would be forbidden) and a second category of subsidies would face an amber light (where the subsidy would be considered as presumptively harmful). The European Communities presented an alternative proposal which stressed a simple dichotomy of subsidies into "prohibited" and "permitted" classes. The discussion is continuing via correspondence, so far, from Argentina, Chile, Iceland, Japan, the Republic of Korea, New Zealand, Norway and Peru. In addition, a group of "small vulnerable coastal states" has sought differential treatment on such matters as access fees, development assistance, fiscal incentives to domestication and fisheries development, and artisanal fisheries. Only time will tell whether or not the WTO "disciplines" will be adapted to the special problems of fisheries.

African freshwaters: are small scale-fisheries a problem?

INTRODUCTION

During the last decade fisheries comanagement has often been proposed as a means of moving away from the failures of past management approaches. Although it is presented as an alternative, comanagement continues to share with more conventional management the fundamental assumption that increased fishing effort causes biological and economic overfishing and therefore represents the major challenge in terms of achieving the sustainability of fisheries. The regulation of fishing effort thus remains the essential means to avoid "tragedies" and improve efficiency and peoples' living conditions. However, comanagement differs from conventional management in its assumption that once people have been convinced of the positive effects of effort reduction, fisheries will arrive at some form of community-based regulation.

Recently, ecologists and social scientists in the fields of African pastoralism and forestry have started to challenge such assumptions and question the extent of anthropogenic impact on the regenerative capacity of tropical pastures and forests.[85] They have shown how abiotic variables related to climate variability and change may

[85] See, for example, I. Scoones, ed. 1995. *Living with uncertainty: new directions in pastoral development in Africa.* London, Intermediate Technology Publications; and J. Fairhead and M. Leach. 1996. *Misreading the African landscape: society and ecology in a forest-savanna mosaic.* Cambridge, UK, Cambridge University Press.

be much more important to the dynamics of the ecosystem than has been generally assumed. The effects of such variables may even outweigh anthropogenic impacts, and the resulting dynamics, at the very least, make it difficult to perceive trends resulting from human activity. Similar questions are now being raised in relation to African fisheries and in 2003 FAO published the findings of a group of African and European researchers,[86] whose work focused mainly on fisheries in medium-sized water bodies in Malawi, Zambia and Zimbabwe, although it also drew upon material from the other fisheries in the region. The principal questions asked were:

- How have catches and fishing effort changed in the Southern African Development Community (SADC) freshwater fisheries over the last 50 years?
- What are the main causes behind these changes?
- How does fishing effort influence the regeneration of the stocks?
- To what extent are existing and proposed management regulations in fisheries consistent with the conclusions derived from the answers to the three previous questions?

CHANGES IN CATCHES AND FISHING EFFORT OVER THE LAST 50 YEARS

According to FAO, freshwater catches in 12 SADC countries steadily increased from 168 000 tonnes in 1961 to 598 000 tonnes in 1986. Since then catches have stabilized between 600 000 and 700 000 tonnes. The increases over time have resulted partly from exploitation of new water bodies (e.g. Lakes Kariba and Cabora Bassa) and partly from fishing previously untouched stocks, especially small pelagics. Fishing effort on already exploited stocks has continued to increase during the same period although with large variations among water bodies. In Lake Mweru, for example, the number of fishers has steadily increased, while in the nearby Bangweulu swamps, it has remained fairly stable over a long period. In Lake Kariba, fishing effort on the inshore stocks has fluctuated considerably and is probably not much higher today than it was just after the lake was filled in the late 1950s. In Lake Malombe, the number of fishers steadily increased through the 1970s, but stabilized in the 1980s and 1990s and has decreased in recent years.

Large differences in effort dynamics are apparent with reference to "population-driven" and "investment-driven" changes of fishing effort. The first concept refers to changes in the number of harvesters while the latter relates to changes in investments and technology. All fisheries have elements of both types of change, but their relative importance varies considerably, and in SADC freshwaters population-driven changes have dominated during the last 50 years. This means that harvest technology and overall production costs per fishing unit have often remained relatively stable or declined, while the number of harvesters has grown or fluctuated. Lake Malombe and other cases connected to the (unsuccessful) development of "modern" fisheries by foreign entrepreneurs are exceptions in that investment-driven changes have dominated and technological changes have constituted the most important element of development.

The variation in effort levels may be dramatic. For instance, in Lake Kariba the number of fishers decreased by 75 percent in less than five years after 1963, but increased by 150 percent in the course of seven years during the 1980s. The fisheries are dominated by simple and inexpensive technologies that entail low entry costs and facilitate human mobility in and out of the fisheries. From an economic stance, anyone can become an independent fisher within a few years. This mobility may be the reason for Daniel Pauly's argument that the entry of people marginalized in terms of other

[86] FAO. 2003a. *Management, co-management or no management? Major dilemmas in southern African freshwater fisheries. 1. Synthesis report,* by E. Jul-Larsen, J. Kolding, R. Overå, J. Raakjær Nielsen and P.A.M. van Zwieten. FAO Fisheries Technical Paper No. 426/1. Rome; and FAO. 2003b. *Management, co-management or no management? Major dilemmas in southern African freshwater fisheries. Case studies,* by E. Jul-Larsen, J. Kolding, R. Overå, J. Raakjær Nielsen and P.A.M. van Zwieten, eds. FAO Fisheries Technical Paper No. 426/2. Rome.

resources or occupations causes the biggest worries in small-scale fisheries all over the world.[87] He argues that small-scale fisheries have become a “last resort” and that the accumulation of destitute people in the sector ultimately leads to what he terms “Malthusian overfishing”.

Fishers exploiting SADC freshwaters demonstrate an even greater mobility. As described above for Lake Kariba, people not only move into most fisheries – they also move out of them. People even leave those fisheries where effort is steadily growing. In Lake Mweru, for example, more than 3 000 fishers left the fisheries in a period where the total number of producers grew by 2 300. Fisheries in SADC freshwaters do not function as a last resort, but as a temporary safety valve – they provide an occupation that people can join and leave according to their needs.

CAUSES BEHIND THE PATTERNS OF CHANGE IN FISHING EFFORT

Growth of effort is often considered inevitable because it is related to demographic growth (population-driven) and to increased demand for fish (investment-driven). However, these explanations neither account for variations over time, nor do they explain the differences between water bodies. Furthermore, investment-driven growth seems to be the exception, despite a general increase in demand for fish in the region as a whole.

Changes in population-driven effort are mainly induced by a combination of variations in ecological productivity and opportunities in other sectors. The sudden reduction in productivity after Lake Kariba was filled, combined with good opportunities in other sectors, led to the dramatic reduction in fishers after 1963. Similarly, the crisis in the Zambian economy after 1974 led many people to join the Kariba fisheries. More than 80 percent of fishers who arrived in Kariba in the 1980s had previously worked in Copperbelt Province or in Lusaka. The same crisis led people who had lost their jobs in Copperbelt to introduce the new fishery for chisense in Lake Mweru. There is little doubt that the SADC freshwaters serve as an important safety-valve for numerous people in times of economic distress – but entering the fisheries is not irreversible.

Local access-regulating mechanisms based on ethnic or community identity are found everywhere, although they may differ in how effectively they control the recruitment of new fishers. In Malombe, such mechanisms have, for many years, excluded owners originating from outside the fishery. In Lake Kariba it was only in the early 1960s and during the last decade that local access regulations have been successful in excluding outsiders; elsewhere they seem to have been of little relevance.

In contrast, when important investment-driven changes in the form of more capital-intensive harvesting methods occur, this seems to reduce population-driven growth. In Lake Malombe, the shift from gillnets to various seining methods that are much more capital-intensive, have substantially increased the costs of entry and thereby reduced the number of potential operators.

Access to financial capital is the major constraint affecting investment-driven growth of effort. Fishing activities are not in themselves sufficient to trigger expensive technological development: financial resources from outside always seem to be needed. In Lake Mweru, the financial needs of the Mpundu (*Labeo altivelis*) fishery initiated in the early 1950s were met by European entrepreneurs. In Lake Malombe, money to buy seines was found through surpluses generated from international labour migration.

The lack of financial resources and of investment-driven growth in the SADC freshwaters is a reflection of much more basic aspects of the societies, both at central

[87] D. Pauly. 1994. On Malthusian overfishing. *In* D. Pauly, ed. *On the sex of fish and the gender of scientists: essays in fisheries science*, pp. 112–117. London, Chapman and Hall; and D. Pauly. 1997. Small-scale fisheries in the tropics: marginality, marginalization and some implications for fisheries management. *In* K. Pikitch, D.D. Huppert and M.P. Sissenwine, eds. *Global trends: fisheries management*, pp. 40–49. Bethesda, Maryland, USA, American Fisheries Society Symposium 20.

and local levels. Analyses of the existing institutional landscape in SADC fisheries also demonstrate how difficult it is, at the local level, to identify institutions with well-defined social rules and with underlying norms that are commonly shared. Such difficulties are seen in the relationship between gear owners and active fishers in Malombe: this is often believed to be a straight employee/employer relationship, but the underlying norms that may serve to stabilize this relationship appear to be far from commonly shared and rules therefore continuously appear to be ambiguous and even contradictory. As a result, the owners experience great difficulty in controlling their crews and the fishers often feel betrayed and/or exploited by the owners.

EFFECTS OF FISHING EFFORT AND ENVIRONMENT ON THE REGENERATION OF FISH STOCKS

In all management approaches, a major role is given to fishing effort in explaining and predicting changes in the regeneration of individual fish stocks. However, efforts to set limits on fishing mortality based on classical stock assessment models have met with limited success in many African fisheries. A number of reasons intrinsic to ecosystem variability contribute to this failure. In the lakes studied, environmental drivers are often more significant than changes in effort in explaining changes in fish production. Although total yields in multispecies and multigear fisheries are surprisingly stable over a large range of effort, considerable changes in species and size composition take place, both as a result of fishing and of environmentally driven processes. Many stocks appear to be resilient, with a large capacity to bounce back after release of pressure. As a consequence, variations in effort levels, to some extent, are a reflection of variations in the productivity of the ecosystems (Figure 43), rather than vice versa as the classical models assume.

As environmental fluctuations significantly influence productivity, biological management of fish stocks must be based upon knowledge of long-term system variability and the responses of both fish and fishers to those dynamics. The information base containing that knowledge is composed of three elements: system variability, susceptibility of species to fishing, and selectivity and scale of operation of fishing patterns.

System variability

Long-term changes in water levels, associated with climate change, are significant in explaining stock changes. This is immediately clear for intermittent lakes like Mweru Wa Ntipa, and Chilwa/Chiuta, where, after refilling, fast regeneration and increase in productivity takes place. But such effects are not restricted to extreme cases. In all lakes catch rates prove to be significantly and positively related toπ water levels. In Lake Kariba, differences in size composition and catch rates among fished and unfished areas in the lake can be attributed to fishing, but here also overall fish production and lake levels indices strongly suggest that the environment is a dominant factor affecting stock fluctuations.[88] In Lake Tanganyika, large changes in catch rates of clupeid species over 40 years seem to be mainly environmentally driven with wind stress as a dominant driver.[89]

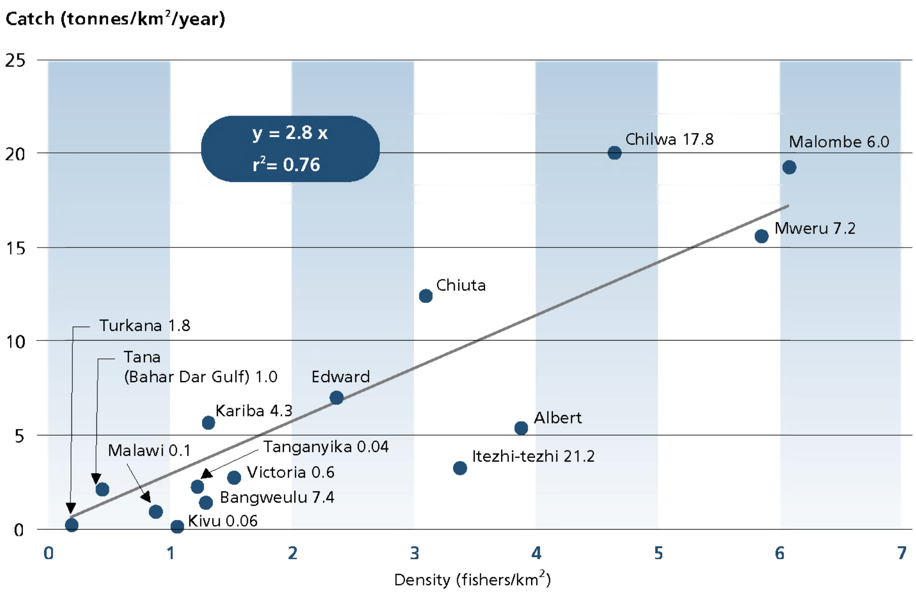
Freshwater lakes and rivers can be classified over a range from pulsed to constant environments. Where changes in water levels are the dominant environmental driver,

[88] L.P. Karenge, and J. Kolding. 1995. On the relationship between hydrology and fisheries in Lake Kariba, central Africa. *Fisheries Research*, 22: 205–226.

[89] P.A.M. van Zwieten, F.C. Roest, M.A.M. Machiels, and W.L.T. van Densen. 2002. Effects of inter-annual variability, seasonality and persistence on the perception of long-term trends in catch rates of the industrial pelagic purse-seine fisheries of Northern Lake Tanganyika (Burundi). *Fisheries Research* 54: 329–348; and P. Verburg, R.E. Hecky and H. Kling. 2003. Ecological consequences of a century of warming in Lake Tanganyika. *Science*, 301: 505–507.

Figure 43

Catch rates plotted versus effort density in 15 African lakes
(data from the period 1989–92)



The trendline indicates an average yield of about 3 tonnes/fisher/year irrespective of water body and country. The number shown alongside 12 of the lakes is the "stability" index in terms of relative lake lake-level fluctuations (RLLF) (mean annual lake–level amplitude/mean depth x 100). Excluding Itezhi-tezhi and Tana, the explained variation between annual catch rates (tonnes/fisher) and RLLF is 45 percent.

this can provide information on the relative stability of the system that can be related to both stock size fluctuations and overall productivity (Figure 43).

Susceptibility of species to fishing

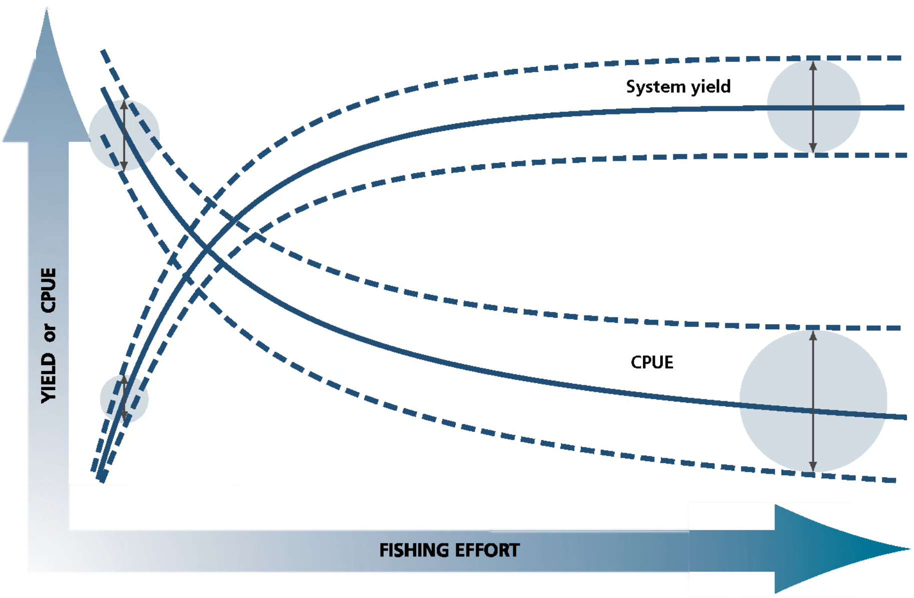
Underneath the apparent stability in system yields of the SADC freshwaters a bewildering array of changes can take place (Figure 44). While examples of serious declines of single stocks can be found, many fluctuate independent of effort. Biological characteristics play a role here, and some species are particularly "susceptible" to fishing: for instance large, slow-growing species such as the large, predatory *Lates* species in Lake Tanganyika clearly declined as a result of fishing; or species with particularly vulnerable stages such as the large cyprinid species that are easily caught during spawning migrations in Lakes Mweru, Malawi, Victoria and Tana. Most species, however, are remarkably resilient to increased effort and this characteristic is related to the system variability. The more a species is adapted to pulsed environments, the less relevant management becomes from a biological perspective. "Resilient" species such as tilapias have long dominated many African freshwater systems. Recently, however, shifts towards pelagic fast-growing, short-lived and "highly resilient" species, such as freshwater clupeids, have taken place in many lakes.

Selectivity and scale of operation of fishing patterns

Small-scale fisheries are able to adapt rapidly to changing circumstances, through change and diversification of fishing methods. In Lake Mweru, in response to the disappearance of large-sized *Oreochromis mweruensis* in the 1970s, the complete gillnet fishery decreased its mesh size in just a few years. Strong year-classes formed after years with high flood-pulses, and large-sized *O. macrochir* reappeared despite the increased effort. Not being caught by the dominant smaller mesh sizes, they formed

Figure 44

Generalized development of fishing yield and catch rate of a fishery with increasing effort



The broken lines represent increasing variation around the mean yield and catch rates over time (vertical arrows). The six characteristics set out below change with increased effort as indicated (High/Low). They refer to total fish biomass system (a, b, c and f) and to the fishery (d, e and f).

(a) Annual carry over of biomass	High	→	Low
(b) Target species susceptibility to fishing	High	→	Low
(c) Resilience to perturbations	Low	→	High
(d) Uncertainty(ies)	Low	→	High
(e) CPUE (mean return to the household)	High	→	Low
(f) Inter-annual variability	Low	→	High

the base of a renewed seine fishery. Many fishing methods, although sometimes forbidden formally, are selective (but invariably multispecies) and may even catch species that otherwise remain unexploited. Increased diversification of small-scale fishing patterns like the ones found in most SADC freshwaters seem to present only limited dangers. By hedging the inherent variability in a relative abundance of multispecies stocks, and opting to target many species and sizes simultaneously, an overall unselective fishing pattern emerges that appears to be ecosystem-conserving. The fish community structure will remain unchanged if all components are removed in proportion to their productivity. As system productivity and average catch rates seem to determine overall effort (Figure 43), the environment, to a large extent, appears to regulate small-scale fisheries. The danger would lie in an increase in the scale of operations arising from either investments in better technology or from more intensive use of existing technology when attempting to override the inherent variability in stocks.

CONCLUSIONS

Since the beginning of the 1900s, fisheries regulations in Africa have built up management systems based on an accepted wisdom regarding the relationship between fishing effort and biological productivity.

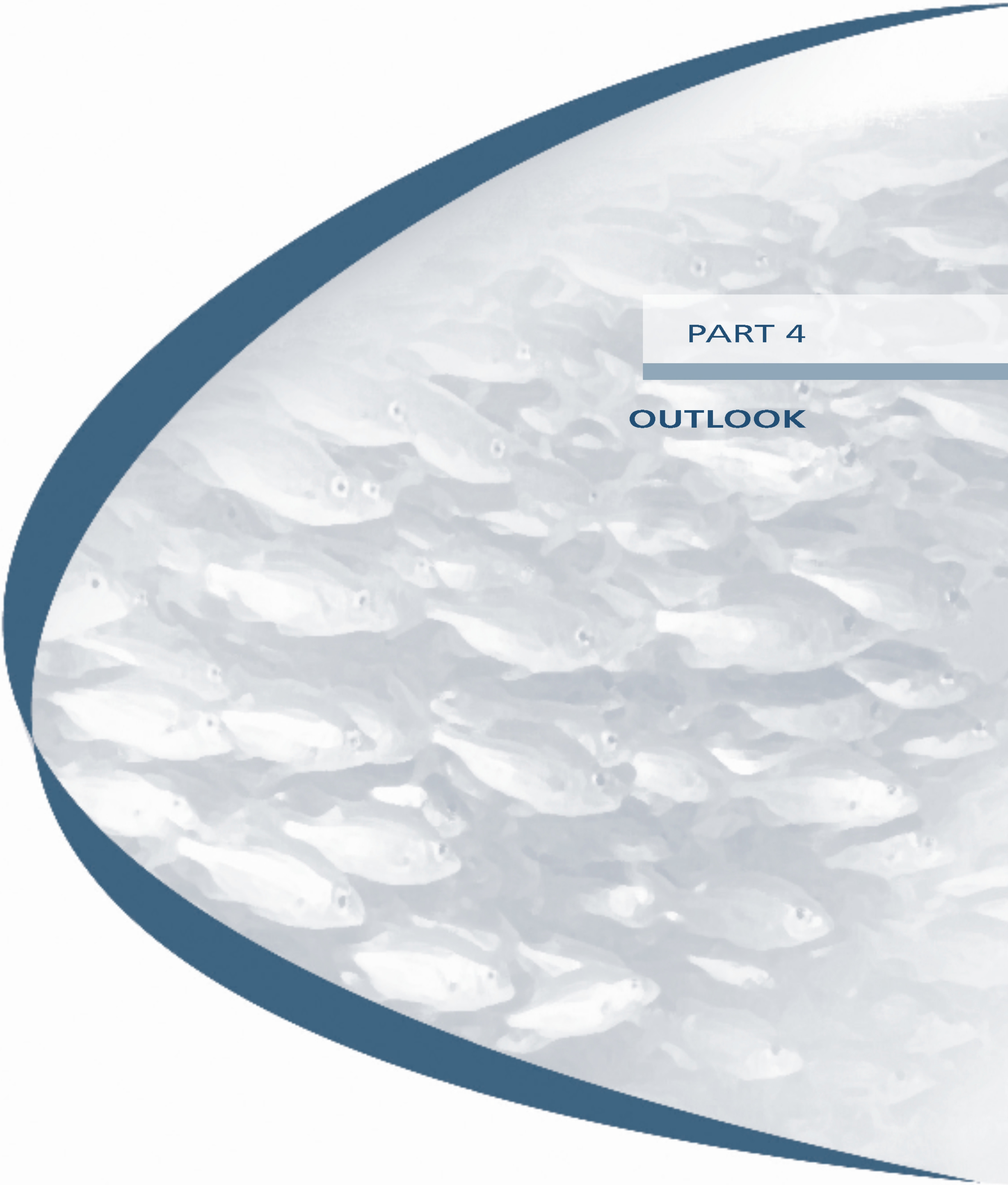
However, the ecological dynamics are complex and population-driven growth in effort may be less damaging than is generally considered. An increased perception of the natural variability, with vulnerable stages during periods of low productivity and uncertainties connected to the emergence of more efficient technologies, indicates a need for “early warning systems”, in line with the elements outlined above.

The finding that effort dynamics depend as much on the general economic and social development in the region as they do on the fishing economy, implies the need for a much broader focus for monitoring fisheries. Economic analyses based on how people react and respond to macroeconomic changes are as important to understanding fisheries development as those based on current biological monitoring.

As long as changes in effort remain population-driven and the fishing pattern is small-scale and multigear, general regulations relating to effort are problematic. It will be difficult to show that reduced effort leads to improvements in both catch rates and total yield. Adaptive effort reduction may nevertheless be of local importance, either in particularly vulnerable periods, or as a means of coping with natural variations that occur under any type of management system. However, if effort dynamics become more investment-driven, the need for regulations will increase considerably. It should not be too difficult to decide how to answer the question of whether the SADC freshwaters should continue to serve as an economic safety-valve and a buffer for the people of the region, or whether its fisheries should develop into more industrial enterprises (and thereby exclude many of these people). In a situation characterized by serious and long-lasting macroeconomic recessions, it would appear essential that the buffer function be upheld. Besides, the freshwater fisheries will hardly become a driving force in the process for much needed economic reforms.

PART 4

OUTLOOK



OUTLOOK

INTRODUCTION

Will capture fisheries suffer from "implosion" – a drastic reduction in the quantity and quality of fish harvested – because fishers cannot be sufficiently restrained in their search for and capture of wild fish? Or will governments, fishers and other stakeholders manage to stop the race for fish where it still continues? Will aquaculture be stopped in its tracks because society as a whole considers its repercussions on the environment too damaging? Or, on the contrary, will "technology fixes" by aquaculture entrepreneurs and scientists remove these adverse impacts and ensure a continued rapid spread and growth of aquaculture?

No one has the exact answers. No one can predict with precision what will happen to capture fisheries or aquaculture, particularly when the question is projected several decades into the future. But, as there is inertia in human activities and evolution in nature is marked by recognizable patterns, reasonable predictions can be made – at least for the short term. In fact, those who are interested in the sector continue to produce predictions and scenarios for the future of both capture fisheries and aquaculture.

This outlook section will first discuss the next decade (the short term) and then what might happen thereafter (the medium-to-long-term perspective).

For the short term, we will review global changes in attitudes towards the production and consumption of fish and discuss their influence on the known short-term trends set by growth in population and income and by the state of marine resources.

The discussion concerning the medium-to-long term will be anchored in two computer-based simulations of the future for global fisheries and aquaculture towards the years 2010, 2015 and 2020.

THE COMING DECADE: CONSTRAINTS AND OPPORTUNITIES

Capture fisheries and aquaculture develop as fishers and fish farmers react to a continuous evolution of commercial and technical opportunities, on the one hand, and of legal and environmental constraints, on the other. The opportunities evolve as a result of modifications, *inter alia*, in the demand for fish, access to natural resources, the state of living aquatic resources, and governance and sector policies. The reactions of fishers and fish farmers will be displayed in aquaculture development strategies and in adaptations developed in a maturing capture fisheries sector. Possible trends in opportunities, constraints and the way in which fishers and fish farmers respond to them are discussed in some detail below.

Demand for fish

Demand expands as the number of consumers grows and as their incomes increase. However, demand is also modified – either increased or decreased – as consumers change their view of fish as food and modify their fish consumption patterns. Such changes occur for different reasons: they may be stimulated by commercial advertisements or occur as a result of increased knowledge of the characteristics of fish as food, or because the consumer may link consumption with environmental sustainability.

It is clear that in the short-to-medium term, demand for fish will expand as populations and incomes grow. However, this increase will be relatively slow in developed countries, probably less than 1 percent per year (in terms of quantity of fish), because populations stagnate or increase only very slowly, per capita consumption is already relatively high and consumption does not increase significantly as disposable income increases.

In developing countries, the growth will be faster because populations increase more quickly and in some countries per capita consumption figures are very low.

Growth – again in terms of quantity – could easily be double or triple that projected for the developed countries.

These trends in demand for and consumption of fish imply stability. However, this image of stability is false. The moment "fish" is no longer considered as a homogenous product, but broken down into species and types of product, records show that there have been – and are likely to continue to be – considerable short-term changes in demand for and consumption of individual species and products (see p. 38 in Part 1). Most of these changes constitute responses to short-term modifications in the availability of the fish on the market, following changes in the quantity of fish biomass available for fishing.

Discerning shifts in demand in what constitutes a complex picture of year-to-year fluctuations is complicated. However, there seems to be a consensus that some consumers, particularly in developed countries, are changing their attitudes to fish. New perceptions of the value of fish include: (i) fish is not only something to eat but something that can improve your health – a health food; (ii) eating the "correct" fish can help preserve the aquatic environment – it is an "environmentally safe" food; and (iii) fish is a luxury worth eating occasionally, in small quantities and at high prices.

These shifts in consumer attitudes do not all lead to an overall increase in the quantity of fish consumed. Their effects on consumption are not one-way. For example, new attitudes may result in an increase in the demand for fish that is considered environmentally safe, or healthy, but at the same time may also lead to reduced demand for fish that are not considered as such.

In this context modifications in the conditions governing international trade in fish are important. The progressively greater liberalization of the market is likely to add significantly to the pressure exerted on developing countries' wild fish stocks, particularly of species for which there is a high demand in the international market. As exports of such species increase, the exporting countries are likely to resort to imports of cheaper fish; as a result there will be increasing pressure not only on high-value species, but also on lower-value species in both tropical and temperate waters – globally in fact.

Access to natural resources

The trend is reasonably clear with respect to access. For fishers, access is being reduced as limitations are imposed. Imposing access limitations takes several forms in capture fisheries. Among those that are becoming increasingly common are the development and allocation of use rights (which are useful when there is not sufficient room to fish for all who want to), the imposition of access fees or equivalent, the creation of marine protected areas or equivalent, and a shift from commercial to non-consumptive users in the granting of access.

Access limitations are spreading also in aquaculture and will continue to do so. Licensing requirements, including environmental impact assessments for new facilities, will become common also in developing countries. Commercial farms for high-value finfish and crustaceans, no matter where they are located, will increasingly be faced with the limitations imposed by an almost fixed supply of low-value fish (for fattening operations), fish oil and fishmeal.

Aquatic resources

The increase, albeit slow, in the percentage of stocks recovering (whether due to improved management or climatic conditions) is encouraging, but the phenomenon is too recent for any reliable conclusions to be drawn. Improvements in governance during the last decade and the decline in long-range fleets have not yet been reflected in the global state of stocks, even though local signs in some countries indicate that improvement is possible.

Observed trends of many exploited stocks suggest a grim picture, yet the pressure on fishery resources continues to intensify (see also the section on the status of marine

fisheries in Part 1, p. 28). Analysis of trends in the average trophic levels of FAO capture fisheries production statistics revealed declining trends in most regions of the world, especially in the Northwest Atlantic. The same trends were also reflected in inland capture fisheries. Examination of the ratio of landings of predatory fish (piscivores) to landings of fish that feed on plankton (planktivores), to detect similar changes, identified the Northeast Atlantic as an area of major concern and, with the possible exception of the Eastern Indian Ocean and the Western Central Pacific, the indicators showed fully exploited ecosystems with little room for manoeuvre in all areas. It cannot be excluded that, in the coming decade, the already notable pattern of "fishing down the food chain", may worsen also in other areas of the oceans.

With regard to the potential of non-conventional species, it is evident that unless new energy-efficient methods are found to catch oceanic squid (or the international ban on large-scale pelagic driftnet fishing is lifted), most oceanic squid will remain inaccessible. It is also apparent that unless there is a substantial and sustained increase in the world price of fishmeal and fish oil, a fishery for mesopelagic species will not develop. The deliberate strategy of exploiting the lower levels of the ecosystem's trophic chain (including krill) for further fisheries expansion (to provide a doubling of the world potential harvest) implies high technology development costs and faces public concern about human competition with large cetaceans. Deep-water demersal resources, whether in exclusive economic zones or on the high seas, are unlikely to contribute substantial and sustainable catches.

Monitoring and diagnosis of the state of stocks and elaboration of management advice will continue to be blurred by exacerbated natural oscillations and climate change. Management systems will become increasingly competent in predicting change over time but, except in a few leading countries, the industry does not seem to be developing the type of responsiveness needed to adjust to systematic forecasts. As a consequence, until the ability to tune fishing capacity and removals to an oscillating environment is acquired, a proportion of stocks is bound to be accidentally overfished at all times unless management systems become highly precautionary – which represents a costly and unlikely scenario, at least in the coming decade.

The officially declared marine fisheries landings total around 80–90 million tonnes, a volume that was reached some time ago (see also the section on the status of fishery resources in Part 1, p. 28). There has been widespread agreement for some time that, taking into consideration the estimated discards (presently less than 7 million tonnes per year), the amount likely to be caught by IUU fishing and the impossibility that the production of all species can be optimized simultaneously, the most likely potential of conventional marine species remains at the same figure of 80–90 million tonnes. Recent records of catches and aquatic resource assessments do not indicate that this consensus needs to be revised.

Governance and specific sector policies

During the next five to ten years, policies specific to the fisheries sector will probably result in the continued spread of individualized use rights of fish stocks, leading to the elimination of marginal fishing enterprises. This will occur mainly in the developed economies. In addition, economic policies *vis-à-vis* the fisheries sector will become less lenient: subsidies directly linked to fisheries capacity and effort will be severely curtailed and an increasing proportion of fishers will be asked to pay for government services and possibly also to pay specific fees for the right to fish.
The costs of fishing will thus increase. This will tend to eliminate marginal fishing enterprises, contribute to increases in the real price of fish and stimulate aquaculture production.

In tropical small-scale fisheries, use rights will tend to be communal – rather than individual – and associated with comanagement arrangements. This situation will constitute a governance structure that should permit the control of access in the fisheries concerned and therefore provide the legal foundation for an increase in labour productivity (without increasing overall catches), which is needed for the sector to progress at the same pace as other sectors of the economy. Small-scale fisheries in South and Southeast Asia, and China, are likely to experience significant changes, with decreasing employment and fewer fishing vessels but increased productivity (in economic terms) for those fishers that remain. Similar developments will also start to take place during the coming five to ten years in those parts of Africa that do not suffer from civil strife.

RFBs are likely to be strengthened through the gradual delegation of members' decision-making powers in an effort to strengthen governance for the purpose of rebuilding depleted stocks, containing the overcapacity of fishing fleets and, most importantly, combating IUU fishing. They are also likely to become prime movers in extending the conventional fisheries management focus from single stocks to ecosystems (by applying the "ecosystem approach"), particularly for shared or high seas resources. Management bodies will need to understand, *inter alia*, the effects of fisheries and climatic changes on habitats and marine communities and to develop a clearer understanding of ecological interactions and the effects of discarding. As meeting these requirements will expand the need for monitoring and research, the RFBs that deal with high-value stocks, high-value fisheries or particularly vulnerable resources (e.g. coral reefs, endangered species) may be those for which the issue will take the highest priority.

Aquaculture producers worldwide will have to adjust to an increasing number of standards. These will have two principal aims: to ensure that products are good for the health of the consumer and to minimize the environmental impacts of the production technologies used. The rules, or guidelines, will be harmonized in order to facilitate international trade. In return, the aquaculture sector will obtain stronger legal recognition.

With regard to a legal framework for controlling and limiting environmental impacts, the coming decade will probably see increasing and stronger attempts to limit the introduction of exotic species. Also, stakeholders will develop policy frameworks to guide the use of genetically modified aquatic organisms. As aquaculture becomes more prevalent, countries will find that they need to develop integrated aquatic animal health programmes that are able to provide routine fish health services to the aquaculture industry.

Adaptations to obstacles and opportunities in capture fisheries

Capture fisheries are no longer expanding in terms of number of fishers and vessels. The industry is consolidating and maturing as obstacles grow and opportunities diminish. For many fishers, the main obstacle is reduced access to resources. Most countries have completed the domestication of fisheries in their exclusive economic zones, which means that there are now few new frontiers to conquer for fishery entrepreneurs. High seas fisheries are capital-intensive and, for species other than pelagic species, their sustainability is far from certain. So most fishers and fishing enterprises are faced with fisheries that have reached exploitation levels at, or even beyond, what is sustainable. In order to improve their earnings, therefore, they need to catch the same quantity of fish but incurring lower costs or selling to markets that pay better; alternatively, they need to catch more fish, but by doing so will then displace other fishers.

At the same time, the industry is aging – particularly in developed countries. In OECD economies, the average age of fishers is increasing, largely because old fishers are leaving the profession more quickly than they are being replaced. There seem to be several reasons for this: unattractive working conditions, the high level of exploitation of stocks and the associated possibility that the authorities will enforce policies leading to fewer actively employed fishers.

However, a declining number of fishers, coupled with growth in productivity per fisher, are in fact preconditions for the continued economic viability of capture fisheries in advanced economies. So although the average age of fishers and vessels may still remain high and may even increase further, the continued viability will make possible an inflow of new vessels and younger fishers (an increasing share of these will be migrant labour), permitting fisheries to continue producing at present levels also in developed economies during the coming decade. In number terms, this inflow of new fishers and vessels will not compensate for the decommissioning of old vessels and existing fishers going into retirement.

This development is illustrated by what is happening to the fleet above 100 GT (or 24 metres LOA), which totals 24 000 vessels. In 2004, the vessels that were more than 30 years old accounted for 35 percent of the fleet, or slightly more than 8 700 vessels, up from 6 percent or 1 400 vessels in the early 1990s. Most of these 8 700 vessels are likely to cease operating within the next ten years (an average of 870 vessels per year). Constructions of new large vessels were taking place at the rate of 300 vessels per year at the beginning of this decade. If vessels lost in accidents are also taken into account, it seems likely that the fleet of vessels larger than 100 GT could decrease by some 600 vessels per year in the short term. However, because new vessels, even at equal size, are so much more efficient than the vessels they replace, it is certain that the fishing capacity of the fleet will not decline at the same rate.

In developing economies, economic growth will create an opportunity for artisanal and small-scale fishers to specialize and graduate from a subsistence mode of operation to one that is entrepreneurial. This will occur as markets and employment opportunities change. Economic growth will generate more urban and third-sector employment, which will lead to a reduction in the number of individuals who engage in part-time and occasional fishing, so leaving more resources for the full-time fishers to exploit. As comanagement develops and becomes increasingly common, the incidence of overexploitation will decrease and fisheries will become sustainable. Urban growth will generate a larger market for fish. This will lead to increased internal sales, growing imports of cheaper frozen and canned products, as well as imports of highly priced fish.

Adaptations to opportunities and obstacles in aquaculture

As real wages increase in China, and in South and Southeast Asia – where some 90 percent of world aquaculture output (in terms of quantity) is now produced – aquaculture production, and associated capital and technical know-how, will spread to Africa and Latin America in search of lower overall costs of production.

Fish constitute a significant part of world food supplies, accounting for some 16 percent of all animal protein consumed. However, as mentioned earlier, fish is made up of a very large number of species and products. This presents both opportunities and obstacles for aquaculture development.

It is an opportunity for the entrepreneur who is willing to develop a new "aquaculture" product. As so many markets exist for different fish products, all he or she has to do is to select one of these and produce the product through culture rather than through capture. The obstacle in this case is that once the entrepreneur has entered the market there will be natural limits to that market. It will be difficult to sell cultured quantities that are several times those of the traditional capture fisheries market without having an impact on price.

Thus the search for new – preferably high-value – species to culture will continue and no doubt some successes will be achieved before 2015.

Strategies aiming to promote offshore aquaculture will also continue. It is natural that such culture methods will be developed in industrialized economies where labour is costly and environments strongly protected. In those developing countries that do not already have well-established aquaculture sectors it is likely that aquaculture will start, as it has in most countries, by the spread of inland fish culture subsequently followed by coastal aquaculture.

2015 AND BEYOND: FUTURE SCENARIOS FOR WORLD FISHERIES AND AQUACULTURE

This section will briefly describe and compare two recently completed studies of the future for world fisheries and aquaculture. The two studies, undertaken by FAO and by IFPRI,[90] use quantitative computer-based simulations to project the future in 2015 and 2020. These quantitative projections will then be compared with projections reported in *The State of World Fisheries and Aquaculture 2002*.

Future prospects for fish and fishery products: medium-term projections to the years 2010 and 2015 (FAO study)

The FAO study has three analytical steps: it projects demand for fish based on specific assumptions for population and macroeconomic growth and assumes constant relative prices among substitutive commodities; it projects supply also on the basis of unchanged real prices; and it then makes world supply and demand meet by modifying prices.

Demand for fish as food and feed

World total demand[91] for fish and fishery products is projected to expand by almost 50 million tonnes, from 133 million tonnes in 1999/2001 to 183 million tonnes by 2015. This represents an annual growth rate of 2.1 percent compared with 3.1 percent during the previous 20 years. Demand for food would account for 137 million tonnes. The world average per capita demand for all seafood could amount to 18.4 kg in 2010 and 19.1 kg in 2015, compared with 16.1 kg in 1999/2001. This increase in demand implies an 18 percent increase over the next 15 years compared with a 40 percent increase over the previous 20 years. Per capita demand for finfish would account for 13.7 kg in 2010 and 14.3 kg in 2015, respectively, while demand for shellfish and other aquatic animals would be 4.7 kg and 4.8 kg, respectively.

Of the total increase in demand for food (some 40 million tonnes) about 46 percent would result from population growth, while the remaining 54 percent would be caused by economic development and other factors.

World fishmeal and oil demand is projected to grow by only 1.1 percent (from 2000 to 2010) and 0.5 percent (from 2010 to 2015) annually.[92] While the demand for fishmeal in developed countries is projected to decrease annually by 1.6 percent, the yearly growth of demand for fishmeal in developing countries would be 2.6 percent until 2010 and 1.4 percent thereafter. The amount of fish required to meet the global demand for fish for reduction to meal and for other non-food uses would total some 45 million tonnes in 2015.

[90] 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. (In press); IFPRI. 2003. *Fish to 2020: supply and demand in changing global markets*, by C. Delgado, N. Wada, M. Rosegrant, S. Meijer and M. Ahmed. International Food Policy Research Institute (IFPRI), Washington, D.C.

[91] Owing to a generalized lack of data, it was not possible to include prices directly in the determination of future demand levels because medium/long-term price projections for fish and other competing commodities are not available. The FAO Food Demand Model (FDM) was used to make projections on the initial assumption of constant relative prices. Implications for price changes were derived by comparing the constant-price projections of supply and demand using a simple market-clearing model. The FDM makes projections of per capita and total demand for all commodities entering a country's diet, starting from basic assumptions on the growth of population and the gross domestic product (GDP), as a proxy for disposable income. The population forecasts for individual countries are based on the latest UN population projections (medium-fertility variant). The assumptions on GDP growth are those used for the FAO study *Agriculture: towards 2015/2030*, which, in turn, are based on the latest UN economic forecasts extrapolated to the year 2015. It should be noted, however, that the currently prevailing international conditions may slow down the rates of economic growth for many countries at least during the initial years of the projection period.

[92] Demand projections for fishmeal are based on the foreseen expansion of aquaculture and of the broiler and pig weaning industries (derived from the most recent FAO projections) as well as on expected change in the price ratio between fishmeal and its close substitutes.

Prospects for fish production
Total world fish production would increase from 129 million tonnes in 1999/2001 to 159 million tonnes by the year 2010 and to 172 million tonnes by the year 2015.[93] This means that growth in global world fish production is projected to decline from the annual rate of 2.7 percent of the past decade to 2.1 percent per year between 1999/2001 and 2010 and to 1.6 percent per year between 2010 and 2015. World capture production is projected to stagnate, while world aquaculture production is projected to increase substantially, albeit at a slower rate than in the past.

Out of the expected increase of 43 million tonnes in global fish production from 1999/2001 to 2015, 73 percent would come from aquaculture, which is projected to account for 39 percent of global fish production in 2015 (up from 27.5 percent in 1999/2001).

The share of pelagic species in total fish output would decline from 30.8 percent in 1999/2001 to 24.5 percent by 2015. Similarly, the share of demersal fish would shrink from 16.2 percent to 12.7 percent. By contrast, the share of freshwater and diadromous fish would increase from 23.7 percent in 1999/2001 to 29.3 percent by 2015, and that of crustaceans, molluscs and cephalopods would rise from 20.5 to 25.6 percent during the same period.

Prospects for trade and implications for prices
A comparison of the supply and demand projections for fish and fishery products shows that demand would tend to exceed potential supply. The deficit for all types of fish combined would amount to 9.4 million tonnes by 2010 and to 10.9 million tonnes by 2015. The deficit will not materialize as the market will be re-equilibrated, on the one hand through relative price rises and shifts in demand among different types of fish and fish products and, on the other, through shifts in demand towards alternative protein foods.

To simulate the market-clearing effect of price changes, the World Price Equilibrium Model was applied.[94] According to the projections, the prices for all types of fish would increase in real terms by 3.0 percent and 3.2 percent by the years 2010 and 2015, respectively. Increases in real prices will have severe effects on low-income consumers. As a result of the price rise, world consumption of all types of fish would be 165.2 million tonnes by 2010, which is 3.1 million tonnes lower than the projected demand at constant relative prices. Similarly, overall consumption of fish by 2015 would be 179.0 million tonnes, corresponding to a reduction of 3.8 million tonnes in demand. On the other hand, world supply of all types of fish, stimulated by higher prices, would increase by 6.3 and 7.1 million tonnes, respectively, at the end of the two projection periods.

The study indicates that developing countries as a whole would increase their net exports of fish and fishery products from 7.2 million tonnes in 1999/2001 to 10.6 million tonnes by 2010, but they would slightly reduce their net exports to 10.3 million tonnes by 2015, mainly in response to increased domestic demand. On a regional basis, Latin America and the Caribbean would continue to be large world net exporters of fish and Africa, which was a marginal net importer of fish in 1999/2001, would become a net exporter by 2010. Asia is expected to reduce slightly its net imports from 5.1 million tonnes in 1999/2001 to 4.8 million tonnes by 2015. In contrast with this trend, China, projected to be a net importer at constant relative prices, is expected to become an exporter of fish by 2015, mainly because of the continuing expansion of its aquaculture output.

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[93] The production projections were made for each country or group of countries fitting different types of regression functions to the historical data for 1980–2001 separately for capture fisheries and aquaculture and for major species groups.

[94] The model assumes that a world average market price exists for all types of fish and that its movements are transmitted to domestic prices. This effect is simulated through the application of selected price elasticities of supply and demand for each country or group of countries. The model eliminates imbalance between supply and demand through a market-clearing iteration process (Newton method), which determines the price level at which supply and demand are in equilibrium. At the country level, the difference between supply and demand represents net trade. Changes in world market prices are in turn transmitted to domestic prices.

Developed countries would reduce their current net imports of fish and fishery products from 11.3 million tonnes in 1999/2001 to 10.6 million tonnes by 2010 and to about 10.3 million tonnes by 2015. On a regional basis, North America is likely to increase its net imports from 1.7 million tonnes in 1999/2001 to 2.4 million tonnes by 2015. Western Europe is predicted to reduce its net import from the current level of 2.6 million tonnes to about 0.2 million tonnes by 2015. Other developed countries, notably Japan, are projected to maintain approximately their current level of fish imports.

Conclusions: supply and food consumption

According to the projections there would be a global shortage of supply of fish in future. Although the severity of the shortage would differ among countries, the overall effect would be a rise in the price of fish. Prices for all types of fish would increase in real terms by 3.0 and 3.2 percent by the years 2010 and 2015, respectively.

At world equilibrium prices, growth in world fish production is projected to slow down from the rate of 2.9 percent per year recorded during the past two decades to 2.1 percent per year between 1999/2001 and 2015. Global fish production in developing countries is projected to grow at 2.7 percent per year during the projection period, which is at half the rate recorded, on average, during the past two decades. In these countries, capture fisheries are expected to grow at only 1 percent per year. Therefore, most of the increase would come from aquaculture, which is expected to grow at 4.5 percent per year. The share of developing countries in world fish production is expected to increase from 75 percent in 1999/2001 to 81 percent by 2015. Total fish production in developed countries would only grow at 0.3 percent per year; this, however, represents an improvement with respect to the negative growth experienced during the past two decades. As a result, the share of developed countries in total world fish production is expected to fall from about 25 percent to 19 percent by 2015. Capture fisheries production in developed countries is expected to stagnate or even decline in absolute terms during the projection period.

On average, people will be consuming more fish in 2015, but increases henceforth are likely to accrue more slowly than in the past two decades. At equilibrium prices, global per capita fish consumption would increase at an annual compound rate of 0.8 percent from 1999/2001 to 2015, down from the rate of 1.5 percent achieved over the past 20 years. Developing countries would lead with per capita demand growth projected at 1.3 percent per year, while per capita demand would decrease yearly, on average, by 0.2 percent in developed countries.

Fish to 2020: supply and demand in changing global markets (IFPRI study)

The IFPRI study projects supply, demand and trade of fish from 1997 to 2020 in response to different policy and environmental scenarios for the fish sector. The study, which draws on FAO statistical databases, was carried out under six scenarios,[95] using IFPRI's IMPACT model[96] modified to deal with food fish. This summary discusses two of these scenarios: the baseline scenario and the one described as "ecological collapse".

Fish production

Food fish production is projected (under the base scenario) to increase globally by 40 percent to 130 million tonnes by 2020, at an average annual rate of 1.5 percent (1.8 percent in developing countries, including China, or 1.6 percent excluding China; 0.4 percent in developed countries). The average annual growth rate for capture

[95] (1) Base scenario with most plausible assumptions about population and income, policy decisions, technology, and other factors; (2) aquaculture expansion 50 percent faster than baseline scenario; (3) lower Chinese production; (4) fishmeal/oil conversion efficiency increasing twice as fast as in base scenario; (5) slower aquaculture growth (technological advance 50 percent of baseline scenario); (6) ecological collapse (exogenous declining trend of 1 percent applied to wild commodities, including fishmeal and fish oil).

[96] International Model for Policy Analysis of Agricultural Commodities and Trade.

fisheries and aquaculture are projected to be 0.7 and 2.8 percent, respectively, with a lower rate of growth (0.7 percent) for capture fisheries in developed countries, compared with developing countries (1.0 percent). About 73 percent of the total increase in food fish production by 2020 will come from developing countries (compared with 73 percent in 1997). Aquaculture will contribute 41 percent of food fish supplies (54 million tonnes), and the share of low-value food fish in total food fish production will remain stable at 48 percent. Increased investment in aquaculture and its accelerated pace of expansion will significantly increase production. Under the ecological collapse scenario, increased aquaculture production moderates the decline in production of food fish to 17 percent.

Fish consumption
Consumption of low- and high-value commodities will increase in developing countries (in the baseline scenario) by 1.9 percent annually, or by 2.0 percent if China is included, while remaining static in developed countries (0.2 percent) and sub-Saharan Africa. In this scenario, the global annual rate of increase in consumption, during the period 1997–2020, is projected to be about 1.5 percent. Per capita consumption of molluscs and crustaceans would increase most rapidly (1.0 and 0.7 percent annually, respectively), while that of high-value finfish is projected to decrease. Lower production by China reduces consumption by 1 kg, mainly due to the impact within China, with little effect on consumption and world prices of fish outside the country. Faster expansion of aquaculture would increase per capita food fish consumption by 1.9 kg in the baseline scenario. Under the ecological collapse scenario, per capita consumption would decline only from 17.1 kg (with the baseline scenario) to 14.2 kg, due to the moderating influence of higher prices on demand pressure, and of increased aquaculture production on supply.

Fish prices
The study indicated that fish prices would probably continue to increase during the coming two decades. Under the more likely baseline scenario, increases of 15 percent are projected for high-value finfish and crustaceans and 18 percent for fishmeal and fish oil, while molluscs and low-value fish are forecast to have significantly lower but still positive (4 percent and 6 percent, respectively) real price appreciation. This is in contrast with other food commodities, which show almost uniform price declines. Fish is projected to become 20 percent more expensive than other meat sources. Fishmeal and fish oil prices increase under several of the scenarios, more than doubling (+134 and 128 percent, respectively) under combined ecological collapse and increased demand from aquaculture. Rapid aquaculture expansion, while putting pressure on fishmeal and fish oil prices (+42 percent), is projected to reduce real prices of low-value food fish (–12 percent), suggesting that investment in the efficiency of related production systems would put these commodities within the reach of more poor people. Predictably, improved conversion efficiency would reduce the price of fishmeal (–16 percent) and fish oil (– 6 percent), implying that the culture of carnivorous species would benefit from research to this end. Slower aquaculture growth would lead to significant price increases for all food fish commodities (+19–25 percent range), underlining the market impact of aquaculture in the face of level supplies from capture fisheries.

World trade
With regard to net international trade, the growth rate of consumption (under the base scenario) will exceed that of production by 0.2 percent per year to 2020 in developing countries (0.3 percent excluding China), resulting in reduced net exports from developing countries (excluding China) to developed countries (5 percent of food fish production, compared with 11 percent in the late 1990s). China, India and Latin America are projected to be net exporters, but only Latin America will export a significant portion of its production. Developing countries will continue to be net

importers of low-value food fish and net exporters of high-value food fish, although many will begin to import high-value commodities also, thus driving a likely increase in South–South trade.

Conclusions

The quantitative outlook developed in the IFPRI study reinforces five major structural shifts that are already underway, but will become more pervasive between now and 2020.

1. Developing countries (particularly Asian countries) will dominate food fish production, from both capture fisheries and aquaculture. Stocks that are not fully exploited will be fished more heavily.
2. South–South trade will increase with the emergence of urban middle classes. Domestic producers in developed countries will gradually leave the sector, and policy in these countries will probably come to favour import-friendly regimes for fish. Fish will become an increasingly high-value commodity and the shift, in traded products, from frozen low-grade whole fish to value-added products will continue.
3. Environmental controversy will continue: sustainability concerns will increase and motivate environmental regulations and institutions, first in developed countries and then in developing countries. Overfishing will remain a major

Box 12

Fish consumption to 2030[1] in the European Union

FAO has commissioned a study on the long-term projections for fish consumption in the EU. The study indicates that, compared with 1998, per capita fish consumption[2] in the EU-25 countries[3] during the period 2005–30 will show an increasing trend (varying from 1 to 12 percent) in 19 countries[4] and a decreasing trend (from 1 to 4 percent) in 6 countries.[5]

General consumption trends for the pre-2004 EU-15 countries reflect an increase in the consumption of seafood products. This rise is supported by an increase in the consumption of convenience products. Frozen products tend to be on a downward trend, while the consumption of fresh fish will stagnate or decrease. The rising share of supermarkets in the retail of seafood products will also increase their availability, leading to increased consumption, while growing consideration of the health benefits of seafood may further fuel the positive trend in consumption.

Improvement of economic conditions is the main force behind the increased per capita consumption in the new member countries. Frozen fish still represents the bulk of fish consumption but the variety of species in this group will increase, with small pelagic species losing ground to demersal or other more exotic species such as crustaceans, molluscs or cephalopods. Freshwater fish will gradually be replaced by marine species, as the latter are often easier to prepare, offer wider variety in terms of taste and are becoming increasingly available owing to the spread of supermarkets.

The increase of the net supply will be possible because of a rise in imports from third countries (mainly Asian, African and South American countries) and an increase of aquaculture production in some countries concern, and the use of pelagic stocks for fishmeal and fish oil will become an important policy issue. The link between pollution and food safety in the fish sector, including pollution sources outside the sector, will receive more attention worldwide.

4. Fisheries and aquaculture technology will address new challenges in both the North and South: reducing fishmeal and fish oil requirements in aquaculture; reducing and mitigating the environmental impacts of intensive aquaculture; finding alternatives to food safety regulations requiring capital-intensive, scale-sensitive approaches to compliance; and utilizing information technology for improved fisheries management.
5. Institutional development in the sector will be necessary for reducing poverty through fisheries and aquaculture development, as it will be for improving environmental sustainability and food safety.

Comparison of the IFPRI and FAO studies and earlier projections

Do the two studies discussed above point towards the same future for fisheries and aquaculture? The answer is yes, but there are significant differences.

The differences relate to the total volume produced and consumed, to the relative roles of capture fisheries production and aquaculture and to the trend in real prices for fish.

(Greece, Spain, Norway and the United Kingdom). The addition of new countries to the EU will increase intra-European trade: firstly, because a large proportion of external European trade is currently between Western countries and Eastern and Northern countries; secondly, as a consequence of the relocation of Western plants to newly joined Eastern countries such as Poland or the Baltic States; and, thirdly, because of a reduction of re-export mechanisms among Western countries. In the same vein, decreasing trade barriers and improvements in the quality of processed fish products from developing countries will lead to restructuring within the European processing industry.

[1] The projections of future fish consumption are based on assumptions derived from past trends, literature review and expert consultations. More than 1 200 assumptions were made for growth rates in capture fisheries, aquaculture, commodity production, and imports and exports of commodities. For capture fisheries, it is likely that the European vessel production will face zero growth up to 2030. Aquaculture is growing at a substantial rate for salmon, sea bass and sea bream, but environmental constraints, coastal zone occupation choices by civil society and health regulations will not allow fish farming to continue its exponential trends in the future.

[2] Total apparent consumption (net supply for human consumption) divided by the number of inhabitants of a country.

[3] Austria, Belgium-Luxembourg, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

[4] Austria, Belgium-Luxembourg, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Malta, the Netherlands, Poland, Slovakia, Slovenia and the United Kingdom.

[5] Cyprus, Estonia, Ireland, Portugal, Sweden and Spain.

The FAO study is more optimistic in terms of fish supplies and consumption. It foresees total production to have reached 179 million tonnes in 2015, while the IFPRI study in its base scenario foresees a lower production – 170 million tonnes – by 2020. It is only to be expected, therefore, that the FAO study foresees a lower increase in real prices (about 3.2 percent by 2015) than does the IFPRI study (between 4 and 15 percent, dependent upon species category, by 2020).

Also, the IFPRI study expects capture fisheries landings to expand significantly, while the FAO study is much more cautious in this respect. The IFPRI study foresees capture fisheries production amounting to 116 million tonnes in 2020, while the FAO study only expects capture fisheries to contribute some 105 million tonnes in 2015.

The most dramatic difference, however, is with respect to aquaculture production. IFPRI expects only about half the growth foreseen in the FAO study. By 2020, IFPRI expects aquaculture to contribute – under its base scenario – 54 million tonnes (an increase of 18 million tonnes over the amount provided in 2000), while the FAO study expects a contribution of 74 million tonnes already by 2015 (38 million tonnes more than produced in 2000).

The models used by FAO and IFPRI to simulate future scenarios have important similarities. They both use international trade as the mechanism through which to equalize world supply and demand for fish, and they both consider plausible developments in industries producing close food substitutes. The fundamental reasons for the differences in results, therefore, are most likely to be found in the basic assumptions used. Three seem to be of particular importance: they concern sensitivity to prices, the physical possibility of increasing capture fisheries production and the "reactivity" of aquaculture to developing opportunities.

The FAO study assumes that consumers will respond immediately (elastic demand) to small increases in real prices by reducing their consumption. However, as aquaculturists are quick to respond to the opportunities created by price increases – and growing demand even at unchanged prices – in the FAO study, consumers will not be forced by the market to reduce their fish consumption much below the quantity they would have wished to consume under unchanged real prices. The study does not assume that capture fisheries will be in a position to deliver major increases in output.

The IFPRI study is much more cautious about the possibility of aquaculture increasing production rapidly. Therefore, it also does not expect that the fisheries sector as a whole will be able to expand output as rapidly as does the FAO study, in spite of the fact that the IFPRI study is much more optimistic about the increase in landings from capture fisheries.

The forecast contained in *The State of World Fisheries and Aquaculture 2002* (SOFIA 2002) falls within the range of forecasts of the IFPRI study. The SOFIA 2002 production forecasts for 2020 (total, used for human consumption, and aquaculture) are at the high end of the forecasts contained in the IFPRI study, that is the SOFIA 2002 forecasts fall between those of the FAO study (summarized and commented on above) and the IFPRI study. As can be expected, SOFIA 2002 is also more pessimistic regarding capture fisheries production than is the IFPRI study (Table 16).

A common denominator for these studies is that the world should not have to face any shortage of fish supplies in the next three decades and the impact on prices will be minimal. In concrete terms, this means that per capita supplies will be maintained, and are even likely to grow. Supplies will increase substantially thanks to sustainable aquaculture development combined with sustained capture fisheries production, mainly from the oceans.

The simulations provide an image of gradual and uniform evolution of the sector. Unfortunately, this is not likely to be an accurate reflection of the future for world fisheries and aquaculture. Despite the tendency of globalization to lead to uniformity, the future fisheries world could be expected to remain diversified in terms of performance, within the range outlined below.

1. Areas of significant progress in countries with sufficient economic and institutional capacity (policy-reformed countries). Fishing capacity will be

Table 16
Comparisons of simulation results

Information source	Simulation target year: 2000 — FAO statistics[a]	2010 — SOFIA 2002[b]	2015 — FAO study[c]	2020 — SOFIA 2002[b]	2020 — IFPRI study[c]	2030 — SOFIA 2002[b]
Marine capture	86	87		87	–	87
Inland capture	9	6		6	–	6
Total capture	95	93	105	93	116[2]	93
Aquaculture	36	53	74	70	54	83
Total production	131	146	179	163	170[3]	176
Food fish production[1]	96	120		138	130	150
Percentage used for food	73%	82%		85%	77%[4]	85%
Non-food use	35	26		26	40[5]	26

Note: All figures – other than percentages – are in million tonnes and rounded.
[1] Aquatic animals other than reptiles or mammals, excluding quantities reduced in fishmeal and oil.
[2] Calculated by the authors from total production minus aquaculture.
[3] Calculated by the authors by adding food fish to fishmeal production.
[4] Calculated by the authors by comparing food and non-food use.
[5] Calculated by the authors by multiplying fishmeal production forecasts by five.
Sources:
[a] Based on latest statistics of the FAO Fishery Information, Data and Statistics Unit.
[b] FAO. 2002. *The State of World Fisheries and Aquaculture 2002*. Rome.
[c] Op. cit., footnote 90, p. 146.

reduced significantly, stocks will rebuild (although not always as planned) and environmental impacts will be reduced. Catches will decline in weight but increase in value. A number of fishers will be redirected to other forms of livelihood.

2. Areas of stagnation or “controlled” degradation, where economic means and political will follow the “too little, too late” principle. Rebuilding will be uncertain and chaotic, and strongly dependent on natural oscillations. Overcapacity will remain rampant. Catches will stagnate or drop progressively (with some possible collapses) and the catch quality and value will continue to decrease. Fishers’ livelihoods will hover around non-sustainability, with acute crises and temporary periods of remission.
3. Areas of governance collapse, where for reasons largely external to fisheries (e.g. droughts, wars) pressure on resources will escalate, pushing more fisheries towards rapid decline and, possibly, collapse. Catches will definitively decline in quality and value. Fishing communities will face repeated crises and the disappearance of their livelihoods.

THE STATE OF WORLD FISHERIES AND AQUACULTURE

2004

Fisheries continue to receive increasing attention not only because they represent an important source of livelihoods and food but also because of their contribution to increasing our understanding of the vast aquatic ecosystem – a strong concern of civil society at large. *The State of World Fisheries and Aquaculture 2004* considers that developments in world fisheries and aquaculture during recent years have continued to follow the trends that were already becoming apparent at the end of the 1990s: capture fisheries production is stagnating, aquaculture output is expanding and there are growing concerns with regard to safeguarding the livelihoods of fishers and the sustainability of both commercial catches and the aquatic ecosystem from which they are extracted.

The report provides a comprehensive overview of these developments and discusses several issues confronting fishers and fish farmers worldwide: the recovery of marine fish stocks, the management of deep-water fisheries and the sustainability of capture-based aquaculture. Other questions of global significance are raised in the report, *inter alia*, the impact of trawling on benthic habitats, the amount of fish discarded in marine fisheries globally and the measurement of fishing capacity. Consideration is also given to how freshwater fisheries in southern Africa could be managed sustainably while respecting the social and economic importance of these fisheries. *The State of World Fisheries and Aquaculture 2004* concludes with some views on the potential for fisheries and aquaculture as a source of food in the coming three decades.

Includes the third release of the FAO World Fisheries and Aquaculture Atlas CD-ROM, a comprehensive and global view of both capture fisheries and aquaculture (available in English)