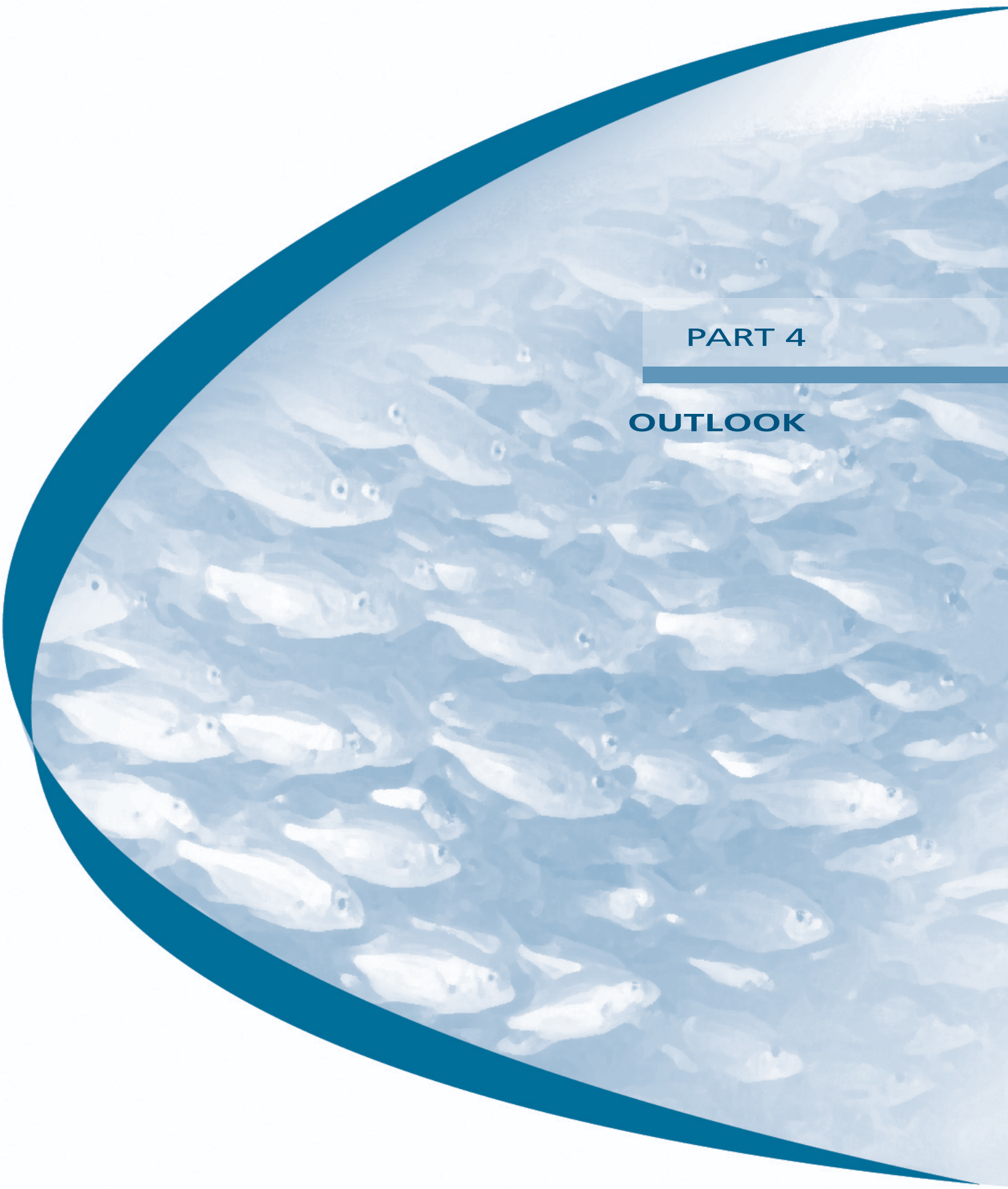


PART 4

OUTLOOK

What future for inland fisheries?

ANCIENT ORIGINS, CURRENT ISSUES

Origin, importance and nature of inland fisheries

Fisheries[1] had their origin in inland waters. Long before people started to grow crops or raise livestock, they went fishing, initially in rivers, ponds, wetlands and lagoons. Many decades passed before people ventured onto the open waters of large lakes, or onto the sea, in purpose-built craft.

Several centuries ago, marine fisheries overtook inland fisheries as the major supplier of fish protein on a global scale. Since FAO started collecting fisheries statistics in 1950, inland fisheries have contributed between 5 and 10 percent to annual capture fisheries production globally as reported by FAO. However, this apparently low proportion can be misleading and this share does not reflect adequately the importance of inland fisheries in today's society.

Inland capture fisheries are rooted in socially and culturally complex societies (Box 16), operate in a large variety of environments and are characterized by an

Box 16

The many uses of inland fish: food, currency, religion and mythology

In ancient Egypt, the fish of the Nile River was an important part of people's diet; fish was used as a means of payment, a reward and considered as part of national revenue. The connection of fish with the cyclical life-giving forces of the Nile River became an image in the Egyptian conception of the world. Mullets, having travelled from the Mediterranean Sea to the first cataract, were honoured as heralds of the flood god, Hapi. The mouth-brooding habits of certain cichlids were associated with the god Atum, who took seed into his mouth and spat out the world. The Nile catfish, *Clarias* sp., which favours muddy waters, was believed to guide the solar boat through the dark river of the underworld at night.[1]

Fish and fisheries were central to life in the ancient Khmer Empire. Bas-reliefs showing fish and other aquatic animals and fisheries-related activities are found on centuries-old temples in Cambodia. The local currency, the riel, is probably named after the most abundant fish species, trey riel, and an indication of its traditional importance to the economy.

In the Lao People's Democratic Republic, giant catfish have traditionally been associated with spirits, royalty and sacrifice. Near Vientiane, every February, people used to gather to catch giant catfish. The first one caught belonged to the spirits and to the old man who was in contact with them.[2]

[1] I. Feidi. 2001. Gift of the Nile. *Samudra*, 28: 3–7.
[2] Mekong River Commission. 2003. Lao legends. *Catch and culture*, 9(1): 11.

extremely diverse range of gear. Inland fisheries are generally labour-intensive and, in most cases, do not easily lend themselves to mechanization and industrialization. They are thus typically driven by individual human effort and the overall number of people in the fishery. As a result, they are typically not great wealth creators for individual fishers, but may in their aggregate sense be massive suppliers of food and income. As such, inland fisheries can be considered significant contributors to rural food security and income generation, providing a diverse set of livelihood benefits to some of the poorest households in the rural sector. However, they do not usually provide an opportunity for taxation and levies and, hence, awareness of their socio-economic importance is often lacking in government development programmes. There are some notable exceptions, such as sturgeon fisheries in the Caspian Sea, lot and dai fisheries in the Tonle Sap, and Nile perch fisheries in Lake Victoria (see below).

Today, there are probably more individuals involved in inland fisheries than ever before. While fishing provides working opportunities and income in less affluent societies, relatively few people in richer countries fish to make a living but millions go fishing for fun.

Major issues in inland fisheries

Inland fisheries often appear to be undervalued and inadequately addressed in national and international policies or priorities for development. There is a critical need to improve the information on inland fishery resources and on the people that use and depend on them.

Another major issue is how to maintain ecosystem integrity and mitigate impacts on aquatic ecosystems. These ecosystems, so essential for inland fisheries, suffer as hydroelectricity generation and abstraction of freshwater resources for agriculture and other purposes are often given higher priorities. These other sectors, combined with growing populations and ease of travel and trade, are putting pressures on inland fisheries resources that are stronger and more widespread than at any time in history. Inland capture fisheries are also being affected by developments within the sector itself, such as increasing fishing pressure and illegal fishing. However, the majority of the impacts originate from outside the fisheries sector (see below).

Rich economies can mitigate influences on inland fish resources through legislation and technical measures to protect aquatic environments. Developing countries have fewer resources for such tasks, or have other priorities to invest resources in. Thus, those who have most need of inland fisheries, in particular rural populations in developing countries, are particularly at risk from these pressures and a lack of policies.

In a changing world, it will be a major challenge to sustain the different functions of inland fisheries, such as their role in food security and poverty alleviation and other ecosystem services.

THE STATUS OF INLAND FISHERIES

Inland waters and global landings

The waters

Globally, lakes, reservoirs and wetlands important for inland fisheries cover a total area of about 7.8 million km^2 (Table 17). Relatively high proportions of land are covered with surface waters in Southeast Asia, North America, east and central West Africa, the northern part of Asia, Europe and South America.

Global production

In 1950, inland fisheries produced about 2 million tonnes in terms of fish landings. The figure was about 5 million tonnes in 1980, and, after steady growth of 2–3 percent per year, 10 million tonnes in 2008 (Figure 44). This growth occurred mainly in Asia and Africa, with Latin America making a small contribution. Asia and Africa regularly account for about 90 percent of reported landings. The remaining 10 percent is split between North and South America and Europe. However, much uncertainty surrounds both the trend in and the level of production (see below).

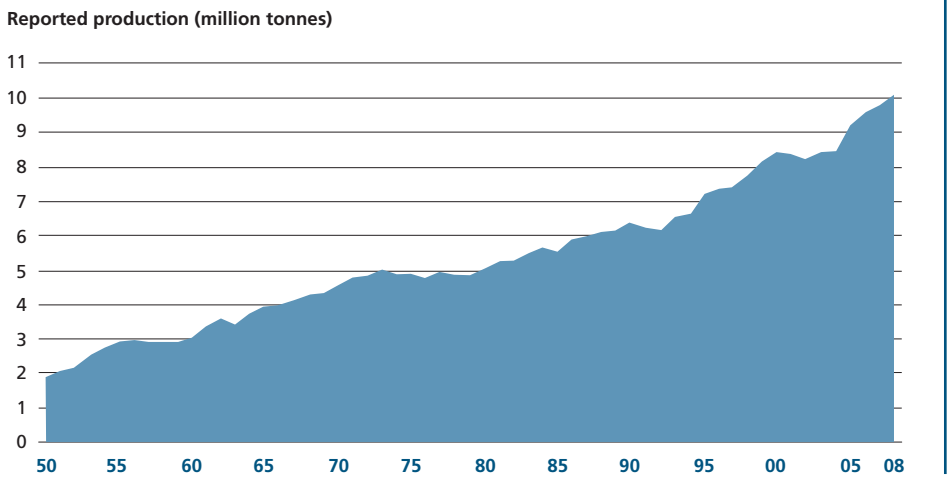
Table 17
Distribution by continent of major surface freshwater resources

	Surface area								Share of total
	Lakes	Reservoirs	Rivers	Floodplain	Flooded forest	Peatland	Intermittent wetland	Total	
	(km²)								(Percentage)
Asia	898 000	80 000	141 000	1 292 000	57 000	491 000	357 000	**3 316 000**	42
South America	90 000	47 000	108 000	422 000	860 000	–	2 800	**1 529 800**	20
North America	861 000	69 000	58 000	18 000	57 000	205 000	26 000	**1 294 000**	17
Africa	223 000	34 000	45 000	694 000	179 000	–	187 000	**1 362 000**	17
Europe	101 000	14 000	5 000	53 000	–	13 000	500	**186 500**	2
Australia	8 000	4 000	500	–	–	–	112 000	**124 500**	2
Oceania	5 000	1 000	1 000	6 000	–	–	100	**13 100**	0
Total	**2 186 000**	**249 000**	**358 500**	**2 485 000**	**1 153 000**	**709 000**	**685 400**	**7 825 900**	**100**

Source: B. Lehner and P. Döll. 2004. Development and validation of a global database of lakes, reservoirs and wetlands. *Journal of Hydrology,* 296(1–4): 1–22.

Figure 44

Production in inland fisheries reported by FAO since 1950



Source: FAO. 2010. FishStat Plus – Universal software for fishery statistical time series (online or CD–ROM) (available at: www.fao.org/fishery/statistics/software/fishstat/en).

Trends and role

Characteristics of the sector

The inland fisheries sector is extremely diverse. It deploys a wide variety of fishing techniques, ranging from simple hand-held gear to small trawls or purse seines operated by commercial fishing vessels. Moreover, the term "fisheries" means not only the harvesting of fish[2] – the actual fishing operations – but also includes processing and other post-harvest and supporting activities. These related activities add further layers of complexity to the sector.

Inland fisheries include commercial and industrial fisheries, small-scale fisheries and recreational fisheries, each with a different economic and social structure. Commercial, small-scale and recreational fisheries are difficult to define at the global level. Still, some general attributes can be used to give a broad definition.

Commercial and industrial inland fisheries. Income is a primary motivation for many fishers, including at the small-scale level. This group is thus not limited to the commercial and industrial sector, as modern small-scale fisheries can be economically efficient and produce high-value products, also for international markets.

Commercial inland fisheries produce significant quantities of fish at localized sites. They often require specialized catch preservation and distribution, usually involving high-capital-input gear and often using significant inputs of professional labour. Commercial fisheries are usually found where resource availability and access to markets justify significant investment (financial, human resources and/or in the construction of gear) and where access can be controlled. Key fishing sites or opportunities are often allocated through well-developed licensing and auction systems. Commercial and industrial inland fisheries are mainly known from lake fisheries in developed countries, from the Great Lakes in Africa and from sturgeon fisheries in the Caspian Sea. However, some impressive commercial and industrial river fisheries occur in Southeast Asia, such as the "fishing lots" and the dai or bagnet fisheries of Cambodia, the "fishing inns" of Myanmar and reservoir marketing concessions. In Latin America, industrial fisheries for migratory catfish are carried out in the Amazon and for sábalo (*Prochilodus* spp.) in the Plate River.

Small-scale inland fisheries.[3] These constitute a dynamic and evolving sector employing labour-intensive harvesting, processing and distribution technologies to exploit the fisheries resources. The activities are conducted: full time,[4] part time, often targeted on supplying fish and fishery products to local and domestic markets, or occasionally. Occasional fishers are a complex group. They fish for cash when the opportunities are there and for subsistence home consumption; they often outnumber full-time and part-time fishers. However, pure subsistence fisheries are rare as excess production would be sold or exchanged for other products or services even in the smallest fishery. When referring to subsistence fishing, a more household-centred rather than commercial activity is implied. The definition "subsistence fisher" is more often concerned with lack of opportunity to derive income rather than a deliberate livelihood strategy. Even where fish is not sold but consumed locally, it has a value because it contributes to family, local or regional welfare and food security. Subsistence fisheries are a subset of occasional small-scale fisheries.

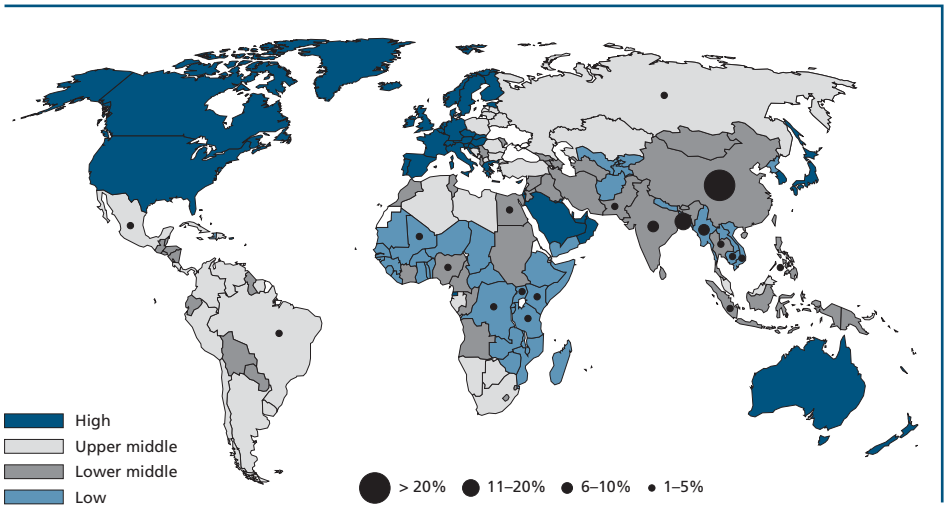
Recreational fisheries. These exist where fishing is for pleasure or competition, with a possible second objective to catch fish for own consumption. Recreational fishing is a popular activity and pastime in many developed countries around the world (e.g. Western Europe, Australia, Canada, New Zealand and the United States of America) and also occurs in countries such as Argentina, Botswana, Brazil, Chile, Mexico, South Africa and Thailand (in some of which it has started to develop recently). Recreational fishing is by definition not a commercial activity – the catch is usually not sold. The fish may be returned to the water, used as a trophy, eaten or sold, but the latter two are not the main motivation for capture. However, the subsector can contribute substantially to local and national economies through employment in secondary sectors.

Inland fisheries in developing countries

Small-scale fisheries. The bulk (about 90 percent) of inland fish is caught in developing countries and 65 percent is caught in low-income food-deficit countries (LIFDCs) (Table 18 and Figure 45). In most rural areas of many developing countries, especially landlocked ones, inland fisheries are more important than marine fisheries for food security and income generation. A recent study[5] estimates that about 1 million people are employed in larger-scale commercial inland fisheries and 60 million in small-scale inland fisheries, and the majority of them (41 million) live in Asia (Table 19). It thus seems that a total of 61 million people (of whom more than 50 percent are women) are involved in fishing and associated post-harvest activities, such as fish processing and trading, in the inland fisheries sector in developing countries. This is more than the 55 million people who are engaged in the marine fisheries sector in developing countries.

Figure 45

Distribution of global inland capture fisheries production in relation to development status of countries



Country	World Bank development status	Percentage of global inland fish production
China	Lower middle	22
Bangladesh	Low	11
India	Lower middle	9
Myanmar	Low	8
Uganda	Low	4
Cambodia	Low	4
Indonesia	Lower middle	3
Nigeria	Lower middle	3
United Republic of Tanzania	Low	3
Thailand	Lower middle	2
Brazil	Upper middle	2
Democratic Republic of the Congo	Low	2
Russian Federation	Upper middle	2
Egypt	Lower middle	2
Philippines	Lower middle	2
Viet Nam	Low	1
Kenya	Low	1
Mexico	Upper middle	1
Pakistan	Lower middle	1
Mali	Low	1

Note: Values for countries accounting for less than1 percent of global inland fish production are not shown.

Table 18

Distribution of inland fisheries catch in developing and developed countries

	Production 2008	Production	Water area	Water surface
	(Tonnes)	*(Percentage)*	*(km²)*	*(Percentage)*
LIFDCs[1]	6 528 000	65	1 967 000	25
Non-LIFDCs	3 557 000	35	5 862 000	75
World Bank income status				
Low	4 175 000	41	1 222 000	16
Lower middle	4 903 000	49	1 589 000	20
Upper middle	812 000	8	3 493 000	45
High	194 000	2	1 516 000	19
World Bank development status				
Developing	9 078 000	90	2 811 000	36
Developed	1 006 000	10	5 009 000	64

[1] Low-income food-deficit countries.

Sources: FAO FishStat Plus 2010 (available at www.fao.org/fishery/statistics/software/fishstat/en); FAO list of LIFDCs 2010 (available at www.fao.org/countryprofiles/lifdc.asp); World Bank country list 2010 (available at data.worldbank.org/about/country-classifications/country-and-lending-groups).

Inland fishers catch less fish per individual and year than do small-scale fishers employed in marine fisheries. This is because a large number of rural households, although living close to waterbodies, engage in fishing activities for only a few weeks or a few months in the year. The use of passive gear (traps, gillnets, etc.) allows the fishers to spend most of their time on other activities, which explains why fishing in inland waters is often, if not predominantly, a component of a mixed livelihoods strategy.

It is clear that for millions of households in developing countries, small-scale inland fisheries play an important role in their livelihood (Box 17). The bulk of inland fisheries production is usually consumed locally, and it is important to rural populations for food and nutritional security, cash income, alternative livelihoods and as a safety net for the poor. There are, however, large differences in the characteristics at the local, national or regional levels.

Commercial fisheries. Where commercial inland fisheries are licensed, licence fees can be significant sources of income at a local or even national level. For example, in the 1990s, the Government of Cambodia collected US$2 million in licence fees from dai and lot leases. This subsequently decreased to US$1.2 million after the fisheries reform in 2001.

Products from inland fisheries can also be important export commodities. For example, in the recent past, more than 90 percent of the world's caviar production came from the Caspian Sea at a value of US$90 million per year. In Argentina, sábalo was once the fourth-most-exported fish – 40 000 tonnes per year (with a value of US$40 million). Catch limits have since been reduced to protect the stocks, and production is about 10 000 tonnes. The Nile perch fisheries in Lake Victoria are valued at US$250 million per year.

Commercial inland fisheries can be a significant source of employment on a seasonal basis both in the primary industry and in the post-harvest sector. In large-scale operations, the owners do not usually do the fishing themselves but rely on a number of labourers.

Commercial inland fisheries in rivers often target migratory fish either on their path towards the spawning grounds or on their way to their dry season refuges when the floodwaters recede. In lakes and reservoirs, commercial inland fisheries usually target schooling pelagic species.

The development of commercial fisheries depends *inter alia* on possibilities of marketing the products. This can be a major challenge as infrastructure is poorly developed in many rural areas. High-value fish are usually bought by intermediaries

Table 19
Employment in inland fisheries in developing countries

	Inland small-scale		Inland commercial		Total
	Fishers	Other employment	Fishers	Other employment	
	(No. of people)				
Africa	5 634 000	11 832 000	213 000	85 000	17 764 000
Americas	519 000	1 091 000	34 000	14 000	1 658 000
Asia	13 146 000	27 607 000	534 000	216 000	41 503 000
Oceania	9 000	19 000	500	500	29 000
Total by category	**19 308 000**	**40 549 000**	**781 500**	**315 500**	**60 954 000**
Total employment by subsector	**59 857 000**		**1 097 000**		**60 954 000**
Total female employment by subsector	**32 921 000**		**342 000**		**33 263 000**

Source: World Bank, FAO and WorldFish Center. 2010. *The hidden harvests: the global contribution of capture fisheries.* Washington, DC, World Bank.

Box 17

Livelihood strategies that include inland fisheries

In rural markets, fish can readily be converted into cash or bartered and, importantly, the cash can be obtained for as long as the fishing season lasts, sometimes all year round. For example, data suggest that in the Zambezi floodplain the contribution of inland fisheries to household cash income is greater than cattle rearing and sometimes crop production (see table).

Floodplain fisheries in Bangladesh are dominated by part-time and subsistence fishers, catching about 75 percent of the production (about 8–20 kg/fisher/year).[1] Fish is one of many resources that become relatively more important during the flood season when other sources of income are at their annual low.

Fishing households at the Great Lake of the Tonle Sap in Cambodia obtain more than half their household income from fishing. People fishing mainly in the Mekong mainstream acquire about one-fifth of their total income from fish sales. A wide range of factors (including market access) decides how much of the income is derived from fish.

Contribution of fishery to households' income in different parts of the Zambezi Basin compared with other activities

Category	Barotse floodplain		Caprivi-Chobe wetlands		Lower Shire wetlands		Zambezi Delta	
	(US$/household/year)							
Cattle	120		422		31		0	
Crops	91		219		298		121	
Fish	**180**	**43%[1]**	**324**	**28%**	**56**	**13%**	**100**	**39%**
Wild animals	6		49		1		0	
Wild plants	24		121		48		29	
Wild foods	0		11		7		4	
Clay	2		0		8		0	

[1] Percentage of total household income.

Source: J. Turpie, B. Smith, L. Emerton and J. Barnes. 1999. *Economic valuation of the Zambezi basin wetlands.* Report prepared for IUCN Zambezi Basin Wetlands Conservation and Resource Utilization Project. Harare, IUCN – The World Conservation Union Regional Office for Southern Africa.

In a survey of upland fisheries of Luang Prabang, a rugged mountainous province in the north of the Lao People's Democratic Republic, 83 percent of households were engaged in capture fisheries, although rice and livestock farming were the most important activities. Ninety percent of the catches came from rivers and small streams, 7 percent from rice fields and 3 percent from ponds. Fish and other aquatic animals provided about 20 percent of total animal protein intake, ranking equally with beef and pork.[2]

In the Brazilian Amazon, floodplain households obtain about 30 percent of their income from fishing.[3]

[1] G.J. de Graaf, B. Born, K.A. Uddin and F. Marttin. 2001. *Floods fish and fishermen*. Dhaka, The University Press Limited.

[2] J.G. Sjorslev, ed. 2000. *Luangprabang fisheries survey*. Vientiane, AMFC/MRC and LARReC/NAFRI.

[3] O. Almeida, K. Lorenzen and D. McGrath. 2002. *Impact of co-management agreements on the exploitation and productivity of floodplain lake fisheries in the Lower Amazon.* Paper presented at the Ninth Biennial Conference of the International Association for the Study of Common Property IASCP at Victoria Falls, Zimbabwe, 17–21 June 2002.

and transported to urban centres where they can be sold at a high price or exported – one example is the catfish fisheries in the Amazon. Low-value products may be sold locally to the extent that the local market can absorb the fish. In the peak season, most of the fish will be processed and stored for use later in the year (this is the case with the riel [*Henicorhynchus* spp.] caught in the dai fisheries in Cambodia).

Inland fisheries in developed countries

Small-scale and commercial fisheries. About 1 million tonnes of fish is caught in the inland waters of developed countries by 100 000 fishers (Table 20), where the total number of people employed in the sector is estimated at 307 000. Most of these people are involved in small-scale fisheries. However, the small-scale sector is technologically more advanced and obtains higher catches per fisher than in the developing countries. Women make up about 44 percent of the workforce, employed mainly in the post-harvest sector.

Recreational fisheries. In the last century, the number of commercial fishers has decreased considerably, and recreational fishing has become a major activity in the inland waters of developed countries. This move away from food fisheries towards recreational fisheries has been accompanied by a shift in economics and interests, and recreational interests have become a major driver of habitat and water use (Box 18).

In countries such as Belarus, Bulgaria, Georgia, Republic of Moldova, Romania, Turkey and Ukraine, recreational fishing is often not just a hobby activity. Many people go fishing after work and at weekends to help their households meet their food security needs.

Although only partially covered in the FAO statistics, there is today a realization that sport and recreational fishing is important in many developed countries. In 2004, the Government of Mexico and the National Commission of Aquaculture and Fishing developed an action plan, partly based on the FAO Code of Conduct for Responsible Fisheries (CCRF), that stresses the importance of recreational fisheries as environmental stewards for the sustainable conservation of fish habitats. In 2008, the FAO European Inland Fisheries Advisory Commission developed the European Code of Practice for Recreational Fisheries.

Recreational fishers can contribute to fish and habitat conservation through their desire to protect the particular fisheries and environments they value. However, recreational fisheries can also have serious impacts on natural habitats through the introduction of non-native species that may become invasive. Moreover, conflicts may arise between recreational and commercial fishers over catch allocations and access to fishing grounds

Utilization of inland captures

In developing countries, most of the catch from inland fisheries goes for domestic consumption, and most of the processing is done in small-scale or medium-scale units,

Table 20
Estimated employment in inland fisheries in developed countries

Category	Small-scale	Commercial/ industrial	Total
Number of fishers	98 000	2 000	100 000
Post-harvest employment	206 000	1 000	207 000
Total employment	**304 000**	**3 000**	**307 000**
Share of women in total workforce (*percentage*)	44	29	41

Source: World Bank, FAO and WorldFish Center. 2010. *The hidden harvests: the global contribution of capture fisheries.* Washington, DC, World Bank.

where handling and hygienic practices often are inadequate. Trade in inland fish and products is constrained by lack of infrastructure (e.g. hygienic landing centres, roads, electric power supply, potable water) and facilities needed to establish and operate cold chains (e.g. ice plants, cold rooms, refrigerated trucks). This often results in high post-harvest losses, especially quality losses, that can amount to up to 40 percent of the landings. Owing to the remoteness and isolated nature of many inland fishing

Box 18

Recreational fisheries

Recreational fisheries have grown to involve millions of people and generate billions of dollars in developed countries; the activity is also emerging in developing countries.

A change to recreational fishing

Fishing by commercial and sport fishers in the inland waters of the Netherlands changed structurally after 1900. At the beginning of the 1900s, there were about 4 500 active commercial inland fishers. Today, they number only a few hundred. Seining, previously done intensively by about 300 crew, is now carried out by a crew of 15. In the same period, the number of sport fishers has increased from a few thousand to 1.5 million.[1]

A popular pastime

Recreational fishing is the most important activity in nature for the people of Finland. About 40 percent of the Finnish population, more than 2 million people, fish at least once a year. The catch from recreational fishing accounts for about one-third of the total catch of fish in Finland; in inland waters, its share in the catch is almost 90 percent. The annual catch of recreational fishing totals about 50 000 tonnes consisting mostly of perch, pike and roach. However, almost half of the landings are caught by nets, and thus probably the fish is also used for significant home consumption.[2]

A source of income and jobs

In the European Union, more than 3 000 companies (manufacturers and wholesalers) trade in recreational fishing tackle, providing 60 000 jobs. It is estimated that the total expenditure by recreational fishers in Europe on their hobby and related lodging and transportation add up to more than US$33 billion annually.[3]

In Queensland, Australia, fishers are estimated to spend about US$870 each per year on fishing activities, including tackle, boats, travel and accommodation. Using these estimates, the contribution to the Queensland economy is about US$766 million per year.[4]

[1] B. Steinmetz. 1983. Developments in fishery management in the Netherlands. *Aquatic Ecology,* 17(1): 67–69.
[2] Ministry of Agriculture and Forestry. *Recreational fishing* (available at www.mmm.fi/en/index/frontpage/Fishing,_game_reindeer/Recreational_fishing.html).
[3] B. Dillon. 2004. *A bio-economic review of recreational angling for bass (*Dicentrachus labrax*).* UK, Scarborough Centre for Coastal Studies, University of Hull.
[4] J. Robinson. 2001. *The economic value of Australia's estuaries: a scoping study*. Australia, University of Queensland (available at www.ozcoasts.org.au/pdf/CRC/economic_value estuaries.pdf).

communities and the high abundance of fish on a seasonal basis, large amounts of fish from inland capture are cured. However, given the localized demand and relatively limited post-harvest industries in inland fisheries, as compared with marine fisheries, most of the operations are on a small or medium scale and most of the post-harvest operators are self-employed.

In Africa, the fish processing methods vary according to region and even subregion. Drying and smoking, and to a very small extent fermenting, are the main methods. Some processed freshwater products are considered a delicacy in some countries and are higher priced than similar products prepared using marine fish, e.g. in Ghana, where fresh and salted dried tilapia as well as smoked catfish or perch (*Lates*) are highly preferred. Fish smoking has been under scrutiny for the past few years owing to the occurrence of the carcinogenic compounds belonging to the group of polycyclic aromatic hydrocarbons, e.g. benzo(*a*)pyrene, which are process-related human health hazards.

In Asia, a significant proportion of inland fish goes into fish sauce and fish paste. In Cambodia for example, the bulk of the fish caught from the Mekong River in the dai fishery is used for making fish paste (prahoc) and fish sauce. Here, there are food safety issues involved with the presence of parasites in raw or lightly fermented fish or fish products, or in products that have been improperly frozen. Live parasites are rare in well-fermented fish, and parasites do not usually survive when fish are well frozen.

Addressing the above deficiencies requires more capacity building and training in good hygienic practices, focusing more effort on research work (e.g. in systematic loss assessment for sustainable loss-reduction strategies and aspects related to [live] fish handling, post-mortem attributes and technological processes) for the development of value addition of fish from inland capture. With a reduction in the losses, more fish would be available for human consumption and/or some pressure could be taken off the aquatic resource.

The role of women

Fishers are most commonly portrayed as men going out on boats to catch the fish while women work as fish sellers and processors on land. This generalization of the professional roles of men and women is largely correct, but a closer examination of gender in fisheries reveals a more complex situation depending on the cultural context. In some countries, such as Benin, Cambodia, Congo, Mali, Nepal and Thailand, women actively fish or collect fish. In other countries, such as Uganda, it is taboo for women to be on board a fishing vessel, but they can own boats and hire men as crew. As fish buyers, it is not unusual for women to provide the working capital for fishing trips against a guaranteed supply of fish when the catch is landed. In Bangladesh, fishing was traditionally a low-caste Hindu occupation and only the men in fishing communities engaged in catching fish. While still relatively few women work in fisheries today – an estimated 3 percent of the total female workforce is involved in the fisheries sector – shrimp fry is caught in coastal areas by significant numbers of poor women, irrespective of their religion, age or marital status. In Lake Liangzihu (China), some of the small-scale fishing vessels are operated by women.

Worldwide, there are more women (33 million) than men employed (28 million) in the inland fisheries sector when post-harvest activities are included (Tables 19 and 20).

Statistics, information and data collection

Since 1950, FAO has requested its Member States to report inland fisheries capture statistics as a separate part of their fisheries reporting in order to enable the tracking of trends in global inland fisheries production. From these reported data, there is an apparent increasing trend in the production from global and regional inland fisheries in the period 1950–2008. In 2003, FAO Member States committed themselves to improving such statistics by adopting the Strategy for Improving Information on the Status and Trends of Capture Fisheries, and this strategy was subsequently endorsed by the United Nations General Assembly.

The significance of current reported trends in catches is difficult to assess. In most countries, it is assumed that actual catches have been at a maximum level for some

time. Analyses of reported catches in Southeast Asia indicate that large year-to-year increases in reported catches are a relatively common occurrence and are due to the deliberate revision of statistics rather than a sudden change in the status of a fishery.[6] Owing to the high contribution of Asian countries to global inland fisheries landings, improved reporting at the national level can influence also the global trends. The implications of this are that for the world as a whole the baseline is being re-adjusted while in some countries a possible decline in one or more fisheries is being masked (in the reporting to FAO) by the aggregation of catches from several fisheries.

The individual catch per fisher may well be declining, but the aggregate catch can still increase because, overall, the total number of fishers may be increasing. Therefore, an increase in total capture production is not a contradiction to decreasing individual catches. For example, the catch in the Tonle Sap (Cambodia) approximately doubled between 1940 and 1995, but at the same time the number of fishers tripled.[7] Thus, the catch per fisher in 1995 was lower than it was in 1940 although the overall landings were higher. Nevertheless, among fishers, the impression is that resources are declining, although this may not be the case.

In addition, it has frequently been reported, by those working closely with inland fisheries, that catches of individual species or species groups are declining, e.g. in the sturgeon fisheries of the American Great Lakes and the Caspian Sea, the Murray cod fisheries of Australia and the large species of the Mekong River. Often, such details are difficult to obtain from the information on reported landings that countries provide to FAO.

Coates[8] noted that national inland fisheries statistics for a number of countries in the Asia-Pacific region did not show the variations typically expected for inland fisheries as a result of variations in the annual monsoon rains, seasonal effects and dry versus wet years, all of which are known to affect fisheries productivity through year-on-year variations in the areas inundated that influence primary productivity, migration, breeding and recruitment success. In well-monitored fisheries, these significant annual variations in catch as a result of seasonal and climate factors are clearly observed. National fisheries statistics reported to FAO tend not to show these variations.

Estimating the yield from the inland fisheries by using the same approaches as in marine fisheries is extremely difficult. The majority of inland fisheries are not licensed; they operate at commercial, semi-commercial and subsistence levels and are widely dispersed along the lengths of all rivers and streams as well as in a variety of waterbodies and wetlands. There are often no centralized landing ports or major markets where data can be easily collected, and a large part of the catch is bartered locally or consumed by the fishers and their households. Catch size and composition, gear used and the number of fishers vary greatly seasonally. Ideally, data should therefore be collected several times per year, but poorly developed infrastructure in remote areas makes data collection time-consuming and expensive.

Furthermore, as few fees or taxes can be levied on these fisheries, there is little incentive to invest already scarce human and financial resources in collecting the data. The institutional capacity to collect and analyse the data remains low in many countries, and one of the results is that trends in catches become suppressed because data are aggregated across basins and species. Often, landings are recorded for some indicative fisheries and these are subsequently extrapolated up to a national figure, with large errors occurring if structural data (numbers of gear, fishers and households involved) are unreliable.

To improve the situation, alternative approaches to data collection are needed that, in addition to the traditional catch and effort surveys, should include population censuses (for structural data), agriculture surveys, consumption studies (including household surveys), market surveys, georeferenced information, habitat classification and measurement, and establishment of comanagement or fishery user groups.

Freshwater aquatic resources: species and stocks and their environment

The ecosystem services provided by inland waters include food and water supply, water purification, biodiversity habitat, fibre and raw materials, climate regulation, flood protection, and recreational opportunities. Biodiversity has an important role in

aquatic habitats, a large number of aquatic plants and animals are important ecosystem components, essential in sustaining fisheries and other uses of aquatic ecosystems. Where biodiversity is maintained and ecosystem processes remain largely undisturbed, also the adaptive capacity of the ecosystem is retained, meaning, *inter alia*, that it retains its ability to buffer or absorb perturbations, including exploitation by the fishery.

Fish assemblages of tropical floodplain rivers and waterbodies with a floodpulse are highly dynamic as a result of seasonal shifts in availability of food, habitats and mortality. Nutrient pulses induced by the floods lead to cycles of explosive population growth followed by high mortality when the aquatic environment contracts. Fish populations in these environments are therefore adapted to high mortality and

Box 19

Atlantic salmon: disappearance and rehabilitation – an example from the Rhine Basin

Atlantic salmon (*Salmo salar* L.) were abundant in the Rhine River and its tributaries until the middle of the nineteenth century and provided the basis for a valuable fishery. The decrease in the salmon population was triggered mainly by the construction of weirs and dams, loss of spawning habitat and water pollution. Since ancient times, people have built water diversion structures, canals and aqueducts to provide drinking-water and water for irrigation, to fill public baths and to harness water power. With the intensification of agriculture that also involved clearing forests, increased silt runoff led to greater alluvial deposits and clogging of gravel river bottoms. During the Industrial Revolution, the use of land and water along the Rhine River intensified even more dramatically. River channels were straightened and deepened, and vast canal networks were constructed together with dams and weirs to serve navigation and hydropower production. Vast floodplains, side arms and backwaters were lost and, thus, valuable aquatic habitat was destroyed. In addition, increasing amounts of industrial and domestic wastes poured into rivers as towns and factories proliferated and grew. However, unsustainable fishing also contributed to the decline of the Rhine salmon.

In an attempt to remedy the situation, intensive stocking with salmon fry and fingerlings was carried out in the second half of the nineteenth century. In Germany alone, several million were released annually.[1] Even an international "salmon treaty"[2] was concluded that led to the first international stocking programme for the Rhine River from 1886 onwards. However, stocking alone failed to maintain the stock and the salmon, together with the sea trout (*Salmo trutta trutta* L.), disappeared from the Rhine Basin. The last salmon was caught in the late 1950s.

When the water pollution in the Rhine River became critical in the 1960s and 1970s, sewage stations for treating industrial and domestic wastewater were built throughout the basin. Old smokestack industries like steelworks and tanning factories shut down because of the radical restructuring of Europe's industry and cleaner technology was applied. In addition, better pollution monitoring was implemented. As a consequence, the water quality in the Rhine River and its tributaries improved remarkably, and sea trout returned to the Sieg River (a tributary of the Rhine River in North Rhine–Westphalia) in the early 1980s. However, it was only after a chemical

are extremely resilient to exploitation by fisheries, and capable of persevering even under extreme exploitation levels. However, the pressure on the fish stocks exerted by the fishery does not act in isolation. Impacts on the aquatic environment and habitats arising from non-fishery uses reduce the adaptive capacity of the fish populations. Therefore, decisions on the management of the fishery should consider any activity that, directly or indirectly, may affect the ecosystem and thus the fish stocks of concern.

The estimated global trend of increasing global production may encourage an immediate conclusion that inland fisheries have not yet been fished to their fullest extent. However, overfishing may be taking place in inland fisheries but is often

accident in Switzerland in 1986, when toxic water spilled into the Rhine River and killed tonnes of fish, that the riverine states initiated a comprehensive programme for the rehabilitation of the Rhine River and its tributaries. The aim was to improve the Rhine Basin ecosystem to such an extent that sensitive species like salmon and other migratory species could live and reproduce there again.[3]

Within the framework of the "Rhine Action Programme" under the control of the International Commission for the Protection of the Rhine, assessments of potential salmon spawning and feeding habitats were carried out and the accessibility of such habitats evaluated in the entire Rhine Basin. This showed that the basin was still suitable for salmon. *In-situ* tests to evaluate the potential success of natural spawning were carried out, and salmon fry and fingerlings were released. Where possible, aquatic habitat was protected and, where appropriate and feasible, actively restored. Atlantic salmon eggs were imported from trusted and certified sources that provided material that was genetically the closest to that originally present in the Rhine Basin. A programme for constructing fish passage facilities was intensified and monitoring programmes initiated.

The first record of returning salmon in the Rhine Basin since the species disappeared was in 1991, and in 1994 natural reproduction occurred again in the Sieg River.[4] Since then, hundreds of salmon have come back into the Rhine River and migrated far upstream, as is documented by monitoring results from the fish passes in Iffezheim and Gambsheim. Salmon are now again reproducing successfully in the Rhine Basin system.

[1] P.F. Meyer-Waarden. 1970. *Aus der deutschen Fischerei: Geschichte einer Fischereiorganisation*. Berlin, H. Heenemann.
[2] F. Bürger. 1926. Die Fischereiverhältnisse im Rhein im Bereich der preußischen Rheinprovinz. *Zeitschrift für Fischerei*, 24: 217–398.
[3] Internationale Kommission zum Schutz des Rheins (HG.). 1987. *Aktionsprogramm "Rhein"*. APR-Bericht No. 1. Strasbourg, France and Koblenz, Germany.
[4] J. Lehmann, M. Schenk, G. Marmulla, F. Stürenberg and A. Schreiber. 1995. Natural reproduction of recolonizing Atlantic salmon, *Salmo salar*, in the rhenanian drainage system (Nordrhein-Westfalen, Germany). *Naturwissenschaften*, 82(2): 92–93.

masked by the fact that total catches remain stable over a range of fishing pressures. This is referred to as "assemblage overfishing" and is related to the resilience of inland fish communities and the opportunistic behaviour of the fishers. In healthy inland multispecies fisheries, a small part of the fish community consists of large fish, with a high value. These species grow slowly and start to reproduce when they are three to four years old or even older. The majority of the fish consist of small rapid-growing fish reproducing early in their life. With increasing fishing pressure, the large fish will be reduced by fishing and may ultimately suffer recruitment

Box 20

Changes in fish communities in the Danube Delta Biosphere Reserve and their relation to nutrient loads

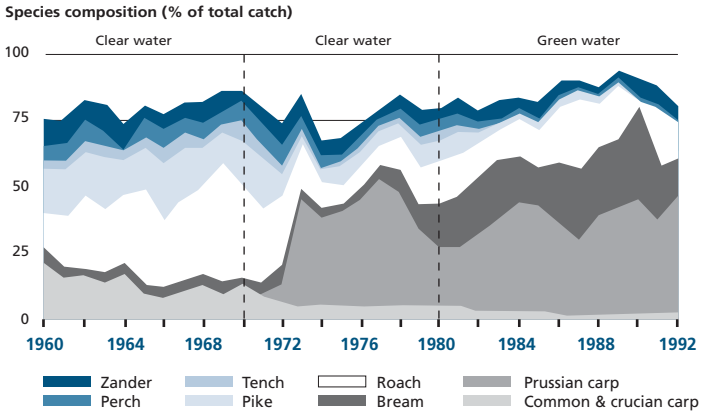
The degree of eutrophication (phosphorus and nitrogen content) is an important factor in deciding which fish species can be found in a waterbody. The evolution of the species composition of the fish catch and eutrophication in the Danube Delta (Romania) in the period 1960–1992 is shown in the accompanying figures.

From 1960 until the mid-1970s, the nutrient load in the Danube Delta was rather low, the water was clear, and macrophytes were frequent and provided shelter for the predatory pike. The vegetation near the embankments provided breeding and nursing places for tench and pike. The abundance of common and crucian carp was in decline, but species like pike, perch and tench were abundant.

In the mid-1970s, the phosphorus load increased gradually until it reached a very high level of 0.1–0.15 mg/litre, the water turned green due to algae growth, and the submerged vegetation disappeared. The habitat favoured by pike and tench was destroyed, and bream, roach, zander and stocked Prussian carp became dominant in the system.

From 1980 onwards, owing to, *inter alia,* reduced water clarity, changes in zooplankton composition and intensive stocking programmes, the Prussian carp stock increased rapidly, partly replacing the roach. Pike, which is a visual

Trends in species composition in the Danube Delta

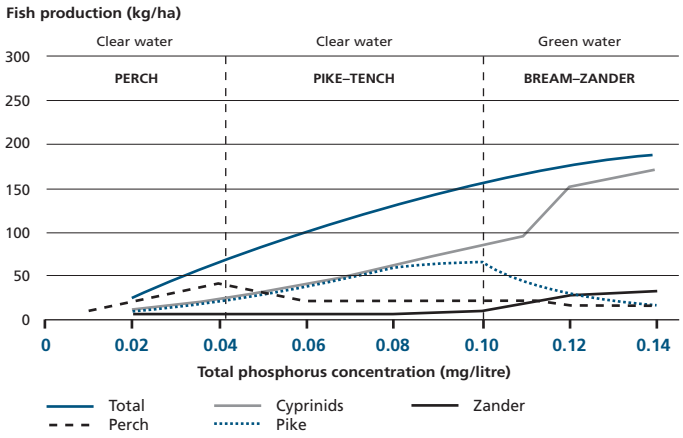


failures. In response, the fishers will gradually shift their effort to other species of the assemblage by using different gear. As the mean size of individuals and species in the assemblage becomes smaller, the fishers will reduce the mesh size of gear they use. This will result in a fishery mainly consisting of the smaller species, with a more rapid life cycle, and often based on the young of the year, but it will remain very productive, at least for a while.

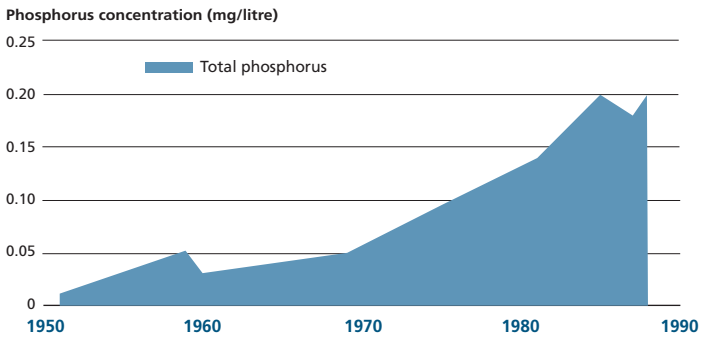
The fishing-down process is illustrated in Figure 46, which shows the trend in catch composition in the Tonle Sap (Cambodia). In 1940, the total catch from the Tonle Sap

predator, was replaced by zander (which are less reliant on vision). With the disappearance of pike (the largest predator in the system), the abundance of bream and other cyprinids increased substantially.

Fish production and phosphorus concentration



Total phosphorus concentration in the Danube Delta



of 125 000 tonnes consisted mainly of large and medium-sized fish, while the 1995–96 catch of 235 000 tonnes contained hardly any large fish and was dominated by small fish.

Assemblage overfishing is most common in tropical areas with high species diversity and where local communities depend on a diverse inland fish harvest. It is an indication of the resilience of inland fisheries, but it also creates the misleading impression that inland fisheries resources are limitless. This is especially the case if catches are not reported by species or species groups and internal processes in the fisheries are masked.

In Asia, most inland fisheries are heavily fished to a degree that substantially alters species size and composition, and also the abundance and ecology of the fish communities. In these situations, there is probably little room for any substantial increases in catch. Fishing pressures in South America and parts of Africa do not appear to have reached these levels, as catches usually still include large species, and here there is probably some room for increases.

Where fish resources in lakes or rivers are reserved for recreational purposes, it is common for the fish assemblages to remain reasonably pristine, except where alien sport fish have been introduced and become established or where habitats have been modified to suit particular species. Nevertheless, many recreational fisheries exist in highly modified habitats, e.g. urban parks or specially constructed waterbodies where native and alien species provide food and recreation. In these fisheries, conservation of biological diversity is not an objective.

However, also in the developed world, inland fisheries resources have changed considerably in recent decades, mainly owing to developments outside the sector. Well-known examples are the decline of many salmon populations and the disappearance of clear water systems in Europe because of eutrophication. Considerable resources have been, and continue to be, invested in reversing this trend, with some success (Box 19).

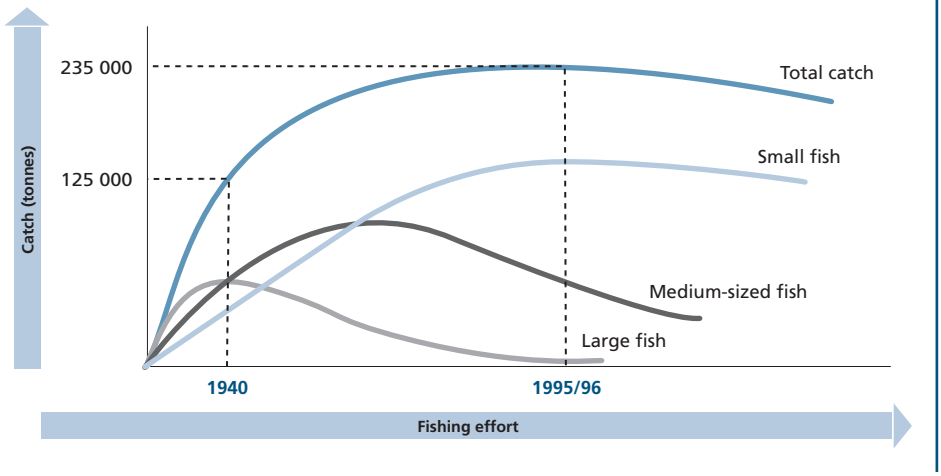
Where overfishing exists, alien species are introduced and habitats are degraded, in particular through changes in water- and land-use practices, the species composition of inland fishery catches will continue to change (Box 20).

Threats

Major threats to inland fisheries come from outside the sector. Environmental degradation and increasing land and water scarcity in most regions of the world are threatening inland fish production. Industrialization, urbanization, deforestation,

Figure 46

Catch composition in the Tonle Sap, Cambodia



Source: FAO. 2003. *New approaches for the improvement of inland capture fishery statistics in the Mekong Basin. Ad-hoc expert consultation.* RAP Publication 2003/01. Bangkok, Erewan Press. 145 pp.

mining and agricultural land and water use often cause degradation of aquatic environments, which is the greatest threat to inland fish production. Some major threats from outside the sector and their impacts are summarized below.

Agriculture is responsible for draining wetlands, abstracting a tremendous amount of water through irrigation and disrupting the connectivity between rivers and floodplains. Floodplains are some of the most productive inland fishery habitats, especially in tropical areas. Agricultural expansion is leading to a progressive modification of floodplains. For example, more than 40 percent of the floodplains of Bangladesh, which themselves cover more than 69 percent of the country, have been modified and impoldered for rice growing, and more than 60 percent of the water flow of the Ganges Basin is abstracted for irrigation and other purposes, and while some water is returned, its quality has suffered.

Excessive agricultural effluents, e.g. agrochemicals and harmful waste, can cause pollution and eutrophication of inland waters and affect growth and mortality of aquatic species, or toxins may accumulate in fish and be passed on to consumers. To a lesser extent, effluents from irresponsible aquaculture may pose some of the same threats to inland waters. Introduction of pathogens and alien species are two potential threats of irresponsible aquaculture that could also affect inland fisheries.

Hydropower generation through the creation of dams changes the quality and quantity of water available to inland fisheries. The dams often create impassable barriers to fish that result in fragmented habitats where access to critical areas is unavailable to the fish.

Development, land clearing and deforestation cause increased erosion and siltation in the watershed. Trees often provide shade and even habitat and food for many inland fisheries. Rivers are often "channelized" to suit the needs of urban populations. Increased human populations require more water to be used for industrial and municipal uses rather than being available for fish.

The effects of climate change are hard to predict but are expected to result in an increase in the variability of environmental conditions, including temperature, precipitation and wind patterns. Rising sea levels and increased temperatures will change the distribution and composition of inland fishery resources (see below).

The above threats are not new. In the past, they have together had a variety of impacts on inland fisheries. Their combined effects have resulted in changes in the natural flow patterns of inland waters, which in turn have caused the species composition to change. Where species cannot adapt, they simply disappear. It seems that these threats will continue to have serious impacts on the viability of inland fishery resources. Eutrophication and increased temperatures may initially increase production of some species, but beyond thresholds production will decline. However, habitat fragmentation, direct loss of fish through pollution or entrapment at water and turbine intakes, predation by introduced species and loss of critical habitat for spawning or feeding will result in a reduction in inland fishery resources.

Policies and regulatory environment[9]

In light of the external threats cited above, there exists a great need for policies on inland fisheries to be closely integrated with those of other stakeholders and sectors. In general, these policies are lacking, or where present they may not be easily enforced. Policies and regulations are more developed concerning access to fishing grounds and fishing practices than for regulation of other threats to fish resources and their ecosystems. However, these will be insufficient if the quantity and quality of water necessary to sustain inland fisheries are not ensured.

There are a number of international agreements that can guide governments towards improving governance of natural resources, and the focus in all of these is on sustaining benefits to people. In addition to the CCRF, they include the Ramsar Convention, the Convention of Biological Diversity, the Convention on Migratory Species, and the World Heritage Convention.

As reported on in *The State of World Fisheries and Aquaculture 2006,*[10] a range of regional frameworks provide advice on, or deal directly with, the management of inland waters and living aquatic resources. However, the governance system remains incomplete as only 44 percent of international basins are subject to one or more agreements. Many of these do not focus on fishery resources but on water as a resource, i.e. the allocation of water for irrigation, flood protection, navigation or hydropower generation. Nevertheless, the agreements normally have a mandate in environmental matters, which could be extended to include fisheries, although these are often not specifically mentioned.

A wide range of different access regimes and fishing rights systems are observed in inland fisheries. In most cases, inland fisheries remain public resources, but the responsibilities of the management and the access rights to the resource are increasingly being devolved to private individuals or groups and local communities in recognition of the limited capacities of the central state (in particular in developing countries) to enforce management regulations.

It is frequently stated that small-scale fisheries in the developing world are "open access". However, very few inland fisheries are de facto open access; the right to fish is usually linked to some form of formal or informal, symbolic or substantial management system generally established at the local or community level. In Africa, these community-based arrangements are still largely under the influence and/or control of local traditional authorities. However, in Asia and Latin America, decentralization reforms have led to situations where the control of access to inland fisheries has been increasingly devolved to local government or decentralized institutions, often in collaboration with fishers organizations, under what are known as fisheries comanagement systems. While the top-down approach to fisheries management has largely failed, comanagement, to be effective, requires that local communities and other partners be given greater influence over the management of the environment upon which the fishery is based.

Comanagement is not the only major type of reform that has been introduced in inland fisheries in recent years. In some countries where reservoirs and lake fisheries are mainly managed through leasing systems, the central government has decided to abolish the existing arrangement that favoured local fishing cooperatives, and instead to allow individual private "entrepreneurs" to bid during the leasing process. The basis for this reform is frequently the assumption that these waterbodies are likely to be more effectively managed and exploited by private investors than by local collective groups or cooperatives. In India, one factor driving this policy reorientation is the hope that these privately exploited waterbodies will increase the capacity of the sector to produce a fish surplus and, thereby, to respond to the increasing demand generated by the country's growing urban population. Experiences elsewhere have shown that sustainability is closely linked to the length of the lease periods – a long lease period creates an incentive to manage the fishery sustainably.

Production-oriented policies to increase fish production through aquaculture development and culture-based fisheries in waterbodies that previously sustained capture fisheries have been introduced in a number of countries. Although fish production *per se* may in many cases have increased as a result of this type of intervention, the benefits may not be socially and environmentally sustainable if the intervention overly restricts access and creates conflicts among the different stakeholders.

In most developed countries, policies governing inland fisheries have evolved from an initial emphasis on food production, through a growing interest in recreation, and with aesthetic and nature conservation interests emerging last. In many areas, however, the main uses of inland waters continue to be for non-fishery related development.

Sustainable fisheries require that key habitats be protected. For species with strict ecological requirements, their spawning grounds and nursery areas are especially sensitive. However, most importantly, ecosystem processes and functions must be maintained or restored where they have been lost, and ecosystem connectivity

throughout the basin must be ensured and habitat fragmentation avoided. By maintaining biodiversity, the ecosystem stands the best chance of being able to adapt on its own to the changes that are already happening. Sustaining biodiversity and habitats is equivalent to sustaining ecosystem services and, therefore, sustaining human well-being.

Biodiversity loss has seriously inequitable outcomes – usually greatly disadvantaging inland fishers. To achieve a more balanced and sustainable development, an "ecosystem services" approach to policy and decision-making needs to be adopted, instead of sector-based approaches, which tend to lead to disparities in service delivery and inequities in benefits. For this to happen, greater awareness of the role of biodiversity

Box 21

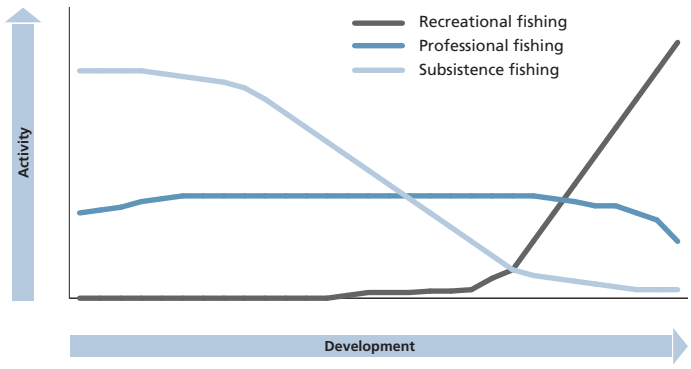
Economic development and its influence on inland fisheries – some relationships

Economic growth will generate improved employment opportunities outside the fisheries sector as well as leading to increasing income levels and purchasing power for rural populations. Most likely, this will mean that fewer households will need to rely on subsistence fisheries for the supply of food, and some occasional or subsistence and part-time fishers will abandon the fishery (see figure).

Professional inland fishing may continue over a long period. Transport and communication infrastructure will improve, as will fishing technology, leading to a strengthening of the sector's competitive position in fish markets. However, economic and social development will increase the threats from outside the sector and may lead to reduced ecosystem services and degradation of water resources, and reduction in income opportunities from fishing.

Aquaculture and fisheries enhancements will increase fish supply globally and will partly meet the demand for fish. With increased development, people in developing countries will become less dependent on supply from wild inland fisheries except in productive and profitable inland fisheries supported by appropriate policies and regulations. As living standards improve, recreational fisheries will become increasingly common also in developing countries.

Evolution of inland fisheries



is necessary, together with more transparent, informed and impartial decision-making processes involving the rural people who depend directly on the biodiversity resources.

THE OUTLOOK

In spite of the trend of gradually increasing inland catches, it is reported that the abundance of inland water species populations declined by 28 percent between 1970 and 2003.[11] Action is required to secure conservation of aquatic ecosystems and safeguard the resources that form the basis for inland fisheries. A range of factors will directly or indirectly drive the development of the sector. However, there is the possibility to mitigate some negative impacts through technological advances, wealth creation and better management.

Drivers of inland fisheries

A general scenario

For inland fisheries to have a future, there must be fish resources that can be exploited to satisfy people's needs for food, income and/or recreation.

Those now engaged in inland fisheries have fundamentally different reasons to be involved. Commercial, full-time and part-time fishers pursue fisheries because they see the activity as one of their best possibilities to secure a livelihood for themselves and their families. Occasional and subsistence fishers go fishing for additional income or to add fish to their meals, and recreational fishers do so because it is for most of them a leisure-time occupation. However, the sector is highly dynamic with possibilities for people to enter or leave it or increase or decrease their participation in response to developments and available opportunities inside and outside fisheries.

The status of the fisheries resources depends to some extent on the number of fishers and how they are regulated. However, the threats coming from outside the fisheries sector are often more important and can lead to fishers being deprived of their resources and their livelihoods. General social and economic development is a major force influencing the drivers within and outside the fisheries sector, in both a positive and negative manner (Box 21).

Need for more food

According to the projections by the United Nations Population Division,[12] the world population will increase from 6.8 billion today to 9 billion by 2050. As stated above, 65–90 percent of the inland capture fish production takes place in the developing and low-income food-deficit countries. The World Bank's forecast for 2020 suggests that 826 million people, or 12.8 percent, of developing country citizens will be living on US$1.25 a day or less and that there will be almost 2 billion poor people living at or below the US$2 a day poverty line.[13] The growing population will need significant increases in food production at affordable prices.

More land (including wetlands) will be used, and some will be used more intensively, as agricultural food production expands during coming decades. This will result in increased use of agrochemicals with serious negative consequences for inland fisheries.

The demand for water for both irrigation and domestic purposes will continue to increase, leading to reduced water availability for fisheries, especially during the dry season. There will be attempts to transfer water between separate basins, with unpredictable consequences for biodiversity. There are also already plans to connect large rivers and transform them into shipping lanes linking distant cities, provinces and countries in areas with poorly developed rail and road infrastructure. There is expected to be increased demand for energy, including hydropower – leading to further damming of rivers.

The need for animal protein, including fish, will increase. Most marine fish stocks are already fully exploited. Notwithstanding increases in aquaculture production, fishing pressure will increase on inland fish stocks, and there will probably be a rise in unsustainable fishing methods, such as the use of explosives and poison, electrofishing and dry pumping of small natural waterbodies. These methods are all capable of killing large amounts of fish indiscriminately.

Aquaculture will continue to grow, and high-value species and products will increasingly come from farms rather than wild stocks. This may reduce capture fishing pressure. In developing countries, improvements in aquaculture technology will allow more fish to be sold more cheaply but, in some markets, cultured species will have problems competing with wild fish because of the need for feed based on fishmeal and fish oil. However, progress is being made on developing feed alternatives derived from locally available animal-waste products or using plant-based proteins instead of animal protein. Where water is available, culture-based and enhanced fisheries will become increasingly important in poor countries with rapidly growing populations because of the lower levels of investment and running costs, but they will require hatcheries to provide the seed. This development will tend to concentrate access to fishing among fewer groups, and the role of fishing as a safety net for the poorest of the poor is likely to be threatened.

Economic development

In an economic growth scenario, income per capita is expected to increase. In order to achieve such an increase in income from fisheries, it is necessary to achieve either a higher price per kilogram of fish or a higher catch per unit of effort. In most countries, the majority of inland fisheries products are low-priced compared with other sources of animal protein and there is little reason to expect this situation to change. For high-value products (e.g. caviar), there will be increased competition from aquaculture. As economies develop and diversify, more jobs will be created in cities, causing a migration from rural areas to urban ones, and fishing for food will become a less important source of employment. Reduced fishing pressure – as fishers leave the industry – may lead to a growth in the standing biomass of commercial species and higher catches per unit of effort, provided that the habitat remains viable. This may slow the decline of the industry provided it is possible to increase the landings or their value with the available technologies. In some inland fisheries, the cost of inputs such as fuel and gear will also increase. However, the low level of technology in most cases is likely to continue, as the return on any investment to improve technology will be comparatively low.

At the same time, with the increasing amount of leisure time, the tendency of recreational fisheries to become more important will continue. This will change the visibility of the recreational fishery subsector. Government income from the subsector will rise and so will its political leverage. The dynamics of the fishery will change and the management requirements will be fundamentally different from a fishery geared to providing food. The transition from a fishery for food towards "fishing for fun" has already occurred in developed countries around the world, and many transition economies are now following a similar course. Development should ensure that recreational fisheries are conducted responsibly.

With increased economic development, people are freed from the fear of starvation and can devote more time to activities other than the pursuit of food. Better-educated people often have the leisure time and opportunities to become more aware of the general value of biodiversity and ecosystems, and "environmental ethics" and conservation issues tend to take a higher priority. Consequently, there will also be a higher demand for the protection of natural ecosystems for recreation as well as sustainably produced food.

Technological development

Most inland waters require labour-intensive methods to fish them efficiently and, apart from in the largest lakes and reservoirs, there is limited scope to apply labour-saving technologies. Recreational fisheries will continue to develop new gear, tackle, baits and methods.

Technological advances have the potential to reduce pollution from both agriculture and industries. In the future, pesticides will, for example, target particular pests much more specifically and so be used in smaller amounts. Pollution from

industries can be reduced with technologies that treat or recycle water and prevent pollution.

There will also be new techniques to mitigate the impacts of water-using sectors on aquatic habitats, and new methods to rehabilitate already-affected aquatic environments, e.g. fish pass technologies, ecological engineering, and reconnection of rivers and floodplains. Although these technologies may initially be available mainly in developed countries, they will increasingly be adopted by other countries driven by the move towards conservation.

Climate change and climate variability

Climate change has the potential to become the most important driver of change in inland aquatic ecosystems. It will affect societies and economies, and increase pressures on all livelihoods and food supplies. Inland water ecosystems and, thus, inland fisheries are affected by more or less regular natural variations in the physical environment. However, an expected characteristic of global climate change is a probable increase in the variability of environmental conditions, including temperature, precipitation and wind patterns.

Inland fisheries have a strong reliance on resources harvested from natural ecosystems. How climate change affects these fisheries will depend on the capacity of the ecosystem to adapt to change, which in turn is heavily dependent on the extent of degradation of the ecosystem from other human activities. Therefore, while climate change will almost certainly influence inland fisheries in significant ways, both directly, e.g. as a result of changes in rainfall patterns and rising sea levels, and indirectly, e.g. through shifts in the demand for and trade in commodities, the exact nature of these changes cannot be easily established.

Impacts will occur as a result of both gradual warming and associated physical changes as well as from changes in the frequency, intensity and location of extreme events. Wetlands and shallow rivers are susceptible to changes in temperature and precipitation, and prolonged periods of drought will reduce available habitat to fish, especially during the dry season. Overall, a global temperature increase of 1 °C is associated with a 4 percent increase in river runoff. However, rainfall will not be evenly distributed geographically, and while river runoff is expected to increase at higher latitudes, it is predicted to decrease in parts of West Africa, southern Europe and southern Latin America.[14] In rivers with reduced discharge, up to 75 percent of local fish biodiversity could be headed towards extinction by 2070 because of combined changes in climate and water consumption. Fish-loss in these scenarios would fall disproportionately on poor countries.[15] Measures implemented to ensure continuous water supply for irrigation and domestic purposes by storing more water will further escalate impacts on aquatic ecosystems.

The melting of glaciers and changed rainfall patterns will potentially affect river flows and flood hundreds of kilometres downstream in large catchments, leading to changes in flood areas, timing and duration. As the life cycles of fish species are closely adapted to the rhythmic rise and fall of the water level, changes to this pattern may cause fish to spawn at the wrong time of the year, with loss of eggs and fry as a result. Flash floods may wash eggs and fry out of their normal habitats, thereby increasing the chances that they will die from starvation or predation.

Variations in temperature and wind could affect stratification of waterbodies and circulation of water masses in large lakes and reservoirs. They may also lead to changes in productivity and shifts in the relative abundance of species throughout the foodchains and cause deoxygenation in bottom layers. To date, there has been no global assessment of warming of inland waters, but many lakes have shown moderate to strong warming since the 1960s. There are particular concerns regarding Africa, where temperatures are predicted to rise and rainfall to decrease.

Increased temperatures will affect fish physiological processes and, thus, their ability to survive and reproduce. Increased temperatures will therefore also change the distribution of species. Unlike the marine environment, where many species can move

to more suitable water conditions, many inland fish species are constrained by physical boundaries that would prevent them changing their distribution. There could also be an increased risk of species invasions and of the spread of vector-borne diseases.

Lack of information

In most cases, the information available on inland fisheries is insufficient to allow an assessment of the potential for future development and the elaboration of the necessary policies and strategies. To create the necessary awareness for inland fisheries to be taken seriously into account when planning, better data on the size and importance of the fisheries are required. The failure to understand how inland ecosystems work and how many people depend on them has greatly affected inland fisheries throughout the world. Appropriate management must be guided by data on which to base an assessment of the status and trends for the stocks concerned.

New approaches to gathering and analysing information are needed that include individual fishers, households and communities, and proxy measures of fishery yield. In addition to the traditional catch and effort surveys, approaches to improve information on inland fisheries include: population censuses (for structural data), agriculture surveys, consumption studies (including household surveys), market surveys, georeferenced information, habitat classification and measurement, and the involvement of comanagement or fishery user groups in data collection.

Geographic information systems (GIS) constitute a very powerful analytical tool for inland fisheries managers because they can incorporate a variety of information from different sources at the same time, thereby revealing patterns that may otherwise be difficult to discern. For example, they can be used to analyse and illustrate migration patterns, fish occurrences and spawning grounds in relation to physical data such as water quality, substrates, current and the presence of physical obstacles. By combining environmental data with population statistics, a GIS can also yield information about the status of fisheries, people's dependence on aquatic resources and their vulnerability to environmental change.

There are encouraging signs that information on inland fisheries can improve.[16] The implementation of the FAO Strategy for Improving Information on Status and Trends of Capture Fisheries[17] is making progress, and proxy measures for yield, such as fish consumption measures, are being developed. Regional and subregional mechanisms for exchange of information, especially for the small-scale sector, are also making progress. An analysis of inland fishery statistics from key countries in Africa is under way. Its aim is to help identify data needs and shortcomings.

As the special information needs of inland fisheries are being realized, it can be expected that the new approaches mentioned above, the development of fisheries information systems and easier Web-based communications will generate improved information.

CONCLUSIONS

Inland fisheries are an important source of cash and high-quality protein, particularly in poorer countries where their products are readily available to the population. Ninety percent of inland fishery production comes from developing countries, and 65 percent comes from LIFDCs. As shown above, inland fisheries provide employment for some 60 million people, especially women, in both developed and developing countries. Although the figures given are only best estimates, it is clear that the inland fishery sector involves a tremendous workforce, producing food where it is greatly needed.

In a changing world, it will be a major challenge to sustain the different functions of inland fisheries, such as their role in food security and poverty alleviation and other ecosystem services. It is apparent that many of the drivers of inland fisheries originate from outside the sector. Many of them are associated with the economic development and industrialization that compete for water resources and can negatively affect inland waters and the living aquatic resources therein. Therefore, fisheries need to be taken

into due consideration, and integrated basin planning needs to be brought forward. However, development may also provide alternative livelihoods for fishers, technology to mitigate negative impacts, and improved food security that will allow people to fish for recreation rather than for livelihood. Technological interventions that will help maintain ecosystem function and biodiversity (e.g. wetland rehabilitation, pollution control, and construction of well-designed fish passes) can accompany development and thereby maintain viable inland fisheries. Thus, the future of the inland fishery sector depends very much on responsible development in other sectors.

However, also within the sector, changes are needed. Improved fish-processing technologies and investment in post-harvest infrastructure can help reduce post-harvest losses and increase the quality of inland fish and fish products for better market access (as is the case for marine fisheries and aquaculture). Considering the importance of inland fisheries for the rural poor, reduction of fishing pressure where the resources are threatened by overexploitation, although extremely difficult, is often the only option. Ways to reduce the fishing pressure should be developed with all stakeholders involved.

The shift away from fisheries as a food source to providing recreation in developed countries may also be followed in developing countries as they develop economically. This shift will depend on the level of food security, education, economic development and available infrastructure to support conservation and recreational activity. In addition, there will be increased competition from aquaculture as that sector continues to grow. However, aquaculture is not commonly an activity or source of food for the poorest of the poor – for these people, inland fisheries will continue to be important.

While many impacts resulting from development or climate change appear unavoidable, countries have options on how to respond if the political will is present and resources are made available. In many developed countries, the desire to protect inland waters and fisheries exists and the necessary resources will be available. However, in other areas, economic considerations of the more influential sectors that are perceived to be more profitable are expected to take precedence.

It is often the case that policies and strategies for the management and development of the water sector are formulated, and water development projects implemented, with incomplete information on the extent of inland fishery production, the number of people involved and the significance of inland fisheries for their livelihoods. This usually results in serious negative consequences for aquatic ecosystems and, hence, inland fisheries. If the inland fishery sector can become better integrated with other users of inland waters and food production sectors, it will facilitate the collection and exchange of the information necessary to help protect inland waters and to assess and manage the status of inland fisheries. This information should be used to develop and implement holistic land-use policies that emphasize user participation and an ecosystem-based approach to management in order to conserve biodiversity and ecosystem services, and so ensure the continued availability of aquatic resources for the benefit of human populations. Thus, economic development of the water sector should include measures that maintain viable fisheries that serve local populations as a source of food, money and/or recreation, or measures that provide alternative economic opportunities for those displaced from inland fisheries.

NOTES

1 This "Outlook" section does not deal with aquaculture, except as it interacts with inland fisheries. Inland fisheries take place in inland waters existing inland of the coastline, including lakes, ponds, streams, rivers, wetlands, artificial watercourses and reservoirs, coastal lagoons and artificial waterbodies.

2 The term "fish" includes finfish, crustaceans and molluscs. Unless stated otherwise, aquatic plants are not included.

3 Although the term "small-scale fisheries" is commonly used in international fisheries literature and discussions, this classification is rarely explicitly defined. This could be considered a significant oversight that relates to the fact that the conceptualization in one place could be considered large scale in another. While there are common attributes, there is hence no all-encompassing global definition.

4 Full-time fishers receive at least 90 percent of their livelihood from, or spend at least 90 percent of their working time on, fishing. Part-time fishers receive at least 30 percent but less than 90 percent of their livelihood from fishing, or spend at least 30 percent but less than 90 percent of their working time in that occupation. Occasional fishers receive less than 30 percent of their income from fishing or spend less than 30 percent of their working time on fishing. (Definition from the FAO Fisheries and Aquaculture Department, available at www.fao.org/fishery/cwp/handbook/K/en).

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THE STATE OF WORLD FISHERIES AND AQUACULTURE

2010

Against a backdrop of global economic uncertainty, this issue of *The State of World Fisheries and Aquaculture* highlights the major role and challenges facing fisheries and aquaculture worldwide. With a steadily rising demand for fish and fish products, the supply of fish as human food hit a record high in 2008, underlining its significance in contributing to food security and nutrition as a source of high-quality, affordable animal protein in particular. International trade in fish also topped previous values, pointing to the sector's continued important contribution to economic expansion and human well-being. Aquaculture, despite a falling growth rate in recent years, remains the fastest-growing animal-food-producing sector and is set to overtake capture fisheries as a source of food fish. Overall production of the sector continues to grow.

This publication analyses and reviews the latest available global statistics and trends in fisheries and aquaculture. It explores the important, yet often underestimated, role of inland fisheries, particularly in many small communities where they make a vital contribution to poverty alleviation and livelihood security. A broader look at the issues affecting fisheries and aquaculture emphasizes the growing need to focus on the many facets of policy and governance and examines the impacts of climate change, biodiversity loss, quality certification and product traceability on the sector.

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