Fishing for Answers

Making Sense of the Global Fish Crisis

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CONTENTS

BOXES

FIGURES

TABLES

FOREWORD

Fishing and the places where fish live hold a special place in each of our lives. We are recreational fishermen and environmentalists who get joy from simply being on the water — sparkling brook or the restless ocean. We have each seen waters we love damaged by overuse, too little care, and the effects of pollution. We have seen the conflicts among recreational fishermen, commercial fishermen, conservationists, regulators, and scientists grow. No aquatic ecosystem is immune from the forces that contribute to overfishing and degradation of habitat.

Given our personal experience we found *Fishing for Answers: Making Sense of the Global Fish Crisis* compelling. This report is a much needed contribution to the ongoing debate about the scale of and response to the "global fisheries crisis." The current alarming rates of fish stock depletion and degradation of aquatic ecosystems serve none of those who has a stake in the fate of the oceans, rivers, and lakes, and the vast resources that they contain. None of us wants to contemplate a time when our world's rivers and seas are drained of the richness and abundance of life that sustains not only our fishing pastime, but more importantly the lives of millions of people who depend upon fisheries for their food source and livelihood.

Many of those involved in fishing — fishers, industry, policy-makers, and environmental organizations — are already acutely aware of the rapid depletion of key fish stocks and the serious disruption and degradation of the marine and freshwater ecosystems they live in. The exploitation pattern in marine fisheries has existed since the end of World War II, as the capacity and range of boats increased, and the technology for locating and catching fish improved. Since 1992, overfishing has become one of the major natural resource concerns for coastal nations. Seventy-five percent of commercially important marine and most inland water fish stocks are either currently overfished or are being fished at their biological limit, putting them at risk if fishing pressure increases or the marine habitat degrades. Overharvesting and habitat degradation are the main causes driving fish stock declines in marine waters, while habitat loss and environmental degradation are the principal factors threatening fisheries in inland waters.

From a consumer's point of view, however, the depletion of fish stocks is not always obvious. Fish is still abundant in markets and restaurants, although the types may have changed and the prices may be higher. Therefore consumers might ask, are we really running out of fish? Are coastal and freshwater ecosystems nearing collapse? How can you, the consumer, help reverse this trend? *Fishing for Answers: Making Sense of the Global Fish Crisis*, helps answer these and other similar questions that will foster support for the needed policies and measures to achieve sustainable fishing.

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The Authors

EXECUTIVE SUMMARY

For millennia, harvesting resources from the seas, lakes, and rivers has been a source of sustenance and livelihood, and a mainstay of local culture. That is nearly as true today as it was a century ago. Fishing remains key to food security for millions of people, a bulwark of local employment, and a significant factor in the global economy. In fact, about 1 billion people—largely in developing countries—rely on fish as their primary animal protein source and an estimated 35 million people are directly engaged, either full- or part-time, in fishing and aquaculture. In terms of income generation, fisheries are extremely important as well, generating over US$55 billion in international trade.

Yet, the nature of the fishing enterprise and the condition of the marine and freshwater resources it relies on could hardly have changed more radically over the last 100 years. During that time, the increase in the world's population and the need for economic development has brought a rapid expansion of commercial fishing and an overwhelming upsurge in our capacity to exploit fish stocks. In the last half century, a tide of new technology—from diesel engines to driftnets—has swept aside the limits that once kept fishing a mostly coastal and local affair. The result has been a rapid depletion of key stocks, and serious disruption and degradation of the marine and freshwater ecosystems they live in—what many have termed a "global fisheries crisis."

The exploitation pattern in marine fisheries began to change at the close of World War II, when the increased commercial potential of fishing became more obvious as the capacity and range of boats increased. Since 1992, overfishing— the action of fishing beyond the level at which fish stocks can replenish through natural reproduction—has become one of the major natural resource concerns in the industrialized world, and increasingly in developing nations as well. Seventy-five percent of commercially important marine, and most inland water fish stocks are either currently overfished, or are being fished at their biological limit, putting them at risk if fishing pressure increases or the habitat degrades. In marine waters, overharvesting and habitat degradation are the main causes driving fish stock declines, while in inland waters, the principal factors threatening fisheries are habitat loss and environmental degradation.

As ocean catches have dwindled, aquaculture—the practice of farm-raising fish and shellfish—has burgeoned and diversified to take up the slack to meet food and income needs in developing and developed countries. In fact, over the past three decades, aquaculture has become the fastest growing food production sector in the world, accounting for 37.9 million metric tons of fishery products in 2001—nearly 40 percent of the world's total *food* fish supply.

It was once thought that commercial fish species that were widely distributed and abundant were unlikely to be threatened with biological extinction even if heavily fished. But in recent years it has become clear that this is not the case. A small number of commercial fish species have now joined endangered whales and sea turtles on the *IUCN's Red List of Threatened Species*. Scientists warn that when fish populations become severely depressed, a threshold can be breached making recovery questionable even if fishing effort is reduced or stopped. In May 2003, Canadian biologists declared the Atlantic cod an endangered species after concluding that some stocks face imminent extinction—this in spite of the fact that the Canadian cod fishery is closed.

Unfortunately, pressure on fish stocks is primed to increase even as stock conditions continue to worsen. Demand for seafood products has doubled over the last 30 years and is projected to continue growing at 1.5 percent per year through 2020 as global population grows and per capita fish consumption rises. The number of fishers and fish farmers is growing markedly as well, having doubled in the last 20 years with most of the increase occurring in developing countries as people turned to fishing for an alternative or supplemental source of income.

Despite these troubling statistics, most people have little idea of what the "fisheries crisis" is, or what it means to them. From a consumer's point of view—at least in most developed nations—the sad condition of fish stocks is not obvious. There are still plenty of fish available in markets and restaurants, although the types may have changed and the prices may be higher. So are we really running out of fish? Are coastal ecosystems nearing collapse? The answers to these questions are not widely understood outside of the circle of fish experts and others in the fishing industry. That is unfortunate, because solutions to the problem may require decisions to regulate fishing in politically unpopular ways—measures that will need strong public support to be successfully implemented.

The purpose of *Fishing for Answers: Making Sense of the Global Fish Crisis* is to answer some of these questions and help consumers, environmental organizations, and policy-makers deepen their understanding of the issues surrounding global fisheries and find their potential roles in creating a political and economic environment that will foster sustainability in fishing.

Achieving sustainable fishing practices and maintaining healthy fish stocks will not be easy. It will require action at many levels: changes in national economic development plans and structural government reforms; changes in how fishing rights are allocated to both small-scale fishers and industrial fleets; changes in international cooperation and international trade negotiations; and better compliance with international norms. It will also require a more concerted effort by nations to address the management and monitoring of small-scale and inland fisheries sectors, which are largely unregulated and ignored today.

But the fishing sector is far too important to allow its continued downward spiral through inaction, particularly when some initial steps toward sustainability are possible today. Here we summarize some of these key measures and highlight some known trends in global fisheries.

Who Are the Key Players?

Prior to the 1950s, only a handful of countries had industrial fishing fleets harvesting more than 1 million metric tons of fish per year. Today, more than 20 countries regularly exceed this quantity and more of the top fish-producing nations are from the developing world. In fact, developing nations now produce more than 70 percent of the fish we consume. In 2001, the top ten producers were Chile, China, the European Union, India, Indonesia, Japan, Peru, the Russian Federation, Thailand, and the United States. The main markets are the European Union, Japan, and the United States, who together consume about 80 percent of all the fishery products traded internationally. Developing countries consume about one third of all fish imports by quantity, but these are often lower-priced items, so they only account for 17 percent of the total value of the international fish trade.

The Forgotten Fisheries: Freshwater and Small-Scale Fishing

Small-scale fishing—characterized by small-capacity fishing craft with non-mechanized propulsion, or low-horsepower engines—is by far the dominant form of fishing in the world today, at least in terms of the number of people involved. But small-scale, and especially freshwater fisheries have been historically marginalized and routinely ignored when multiple development demands and conflicting interests compete over the use of water bodies and coastal resources. Dam construction, water withdrawal for irrigation, land conversion, and the presence of industrial fleets in coastal areas can have tremendous impact on small-scale coastal and freshwater fishers. Large industrial trawlers that fish the waters close to shore, for example, often degrade the sea bottom habitat and change the species composition of coastal ecosystems to a point where the local fish catch can drop precipitously. Such conflicts between foreign industrial fleets and small-scale coastal fishers are becoming increasingly prevalent in Asia and Africa, with small-scale fishers gradually losing ground.

This lack of attention puts small-scale fishers at a disadvantage compared to industrial fleets, and leaves the inshore and freshwater bodies they frequent inadequately managed. Policies aimed at developing management programs that involve fishing communities in the decision-making process would go a long way in incorporating this sector into national development plans. Co-management programs that devolve control over certain fishing grounds to local communities not only give local people a stake in maintaining the resource in the long-term, but can also contribute to poverty alleviation. However, this control must be integrated into the wider coastal and basin management regimes and coordinated with industrial fishing and other development activities such as irrigation and tourism.

The Role of Aquaculture: Can it Save Wild Fisheries?

Aquaculture is the fastest growing food production sector in the world. It has become so by expanding, diversifying, and intensifying its operations. But the heavy dependence of intensive systems on human inputs—water, energy, chemicals—and on wild fish for feed and seed, as well as the effects on ecosystems and species are major constraints to the sustainability and future growth of this industry.

In general, aquaculture products fall into two distinct groups: high-valued species that mainly target export markets, and low-valued species that are primarily consumed locally. Most large-scale, intensive aquaculture operations target high-value species, such as shrimp and salmon, which are commercialized in developed countries—mainly Europe, Japan, and the United States—and require large capital investments. Extensive or rural aquaculture on the other hand usually targets low-valued species, such as carp, requires low capital investment, and often provides affordable fish for local consumption.

Although much of the world's aquaculture production comes from small- and medium-scale operations, the tendency is toward intensification and higher reliance on wild fish for fishmeal and seed fish. The wild juveniles used as seed in aquaculture are largely unaccounted for in capture statistics, and are therefore not taken into consideration in management decisions, such as setting catch limits or assessing stocks, making the management of wild fisheries even more challenging. Furthermore, the last few years have seen an unprecedented trend in the transfer of wild-caught juvenile fish, especially high-valued tuna, to open-ocean pens for fattening without these individuals being reported as part of the catch. This practice can seriously hinder stock assessment and misinform the setting of harvest quotas, with grave consequences for some already depleted wild stocks.

Developing more sustainable aquaculture practices, and streamlining the monitoring and reporting of new sea-farming methods in order to avoid negative impacts on wild stocks are key steps to achieving sustainability in the sector. In recent years, some aquaculture practices have achieved significant results in increased production and efficiency. However, most operations still have a long way to go to reach the environmental standards being set by numerous national authorities and international aquaculture associations. In addition, regulatory structures need to progress in parallel with rapidly developing technological advances before widespread adoption of these technologies takes place. Developing countries in particular face enormous challenges to support responsible aquaculture practices because of lack of financial resources and many times, local capacity.

International Trade Increasingly Influences Fishing

Trade has become a driving force in the global fishing enterprise, influencing the species of fish targeted and farmed, the intensity of fishing pressure, and, in many cases, the incentives for fishing either sustainably or destructively. Whether trade encourages overfishing or is part of its solution can't be answered with certainty. However, it is likely that trade simply magnifies the environmental effects of existing fishing practices. Where those practices are harmful, the effects of trade will be compounded by for example, expanding the market for fish caught in this way, or by providing easier market access to illegally harvested products.

Part of the problem is that the World Trade Organization (WTO) trade rules are often in conflict with trade restrictions that aim to promote sustainable fishing practices. Some steps to reconcile environment and trade rules would require granting observer status at the WTO to the UN Environment Programme and to the secretariats of international environmental treaties, incorporating the precautionary approach into WTO and other trade rules, and reducing environmentally harmful fisheries subsidies through negotiations within the WTO and other trade bodies.

Another important and damaging feature of the growing international trade is the rise in illegal, unreported, and unregulated (IUU) fishing, which is especially prevalent in fisheries of high commercial value, such as sashimi-grade tuna. The products are often exported to Europe, Japan, and the United

States. Responsible fishing nations should no longer keep open registers for fishing vessels, which too often are used to facilitate illegal and irresponsible fishing. The increased use of other measures such as "blacklisting" (disallowing known illegal vessels from landing their catch), and "white-listing" (allowing only registered and compliant vessels to land their catch) are also good ways to combat IUU fishing.

Sustaining Ecosystems is Key to Fisheries Management

The harm that fishing can cause to target fish is substantial, but the damage does not end there. The world's fleets harvest a large number of fish and other animals besides the particular species being targeted—animals that are generally referred to as bycatch. Some of this bycatch is retained for sale, but a portion of it—often a large portion—is returned to the sea, usually dead or dying (so-called "discards"). Bycatch and discards, and the associated high mortality of species, such as marine turtles, present one of the major challenges facing sustainable fisheries today. The latest FAO estimate of total marine discards is at least 10 million metric tons of animals—but this figure underestimates the number of marine mammals, turtles, and seabirds caught as bycatch, which can be substantial in certain fisheries.

Ecosystems can also be damaged physically, either by some fishing practices or by particular fishing gear. Bottom trawling, in which a trawling rig is dragged across the seafloor, for example, is a significant source of pressure on the biodiversity of sea bottom ecosystems. In inland waters, the introduction of non-native fish species for aquaculture or for re-stocking lakes and rivers also causes damage by displacing and threatening native species. Together, this sums to major ecosystem change and impact—impact so severe that it jeopardizes the very resource base upon which the fishing community depends.

Conventional management approaches have focused on individual stocks rather than maintaining the health of marine and freshwater ecosystems—the basis for current and future production. Only recently have governments officially recognized the breadth of the problem, and the necessity to look beyond individual fish stocks as they address fisheries management. The idea of an ecosystem approach to fisheries management has been gaining ground slowly. At its heart, it calls for limiting fishing's impact on ecosystems as much as possible and sustaining the ecological relationships between the species being fished and other ecosystem inhabitants. Therefore reorienting fisheries management to account for ecosystem interactions and damages is a key step in achieving sustainable fisheries.

The FAO Code of Conduct provides the key principles for sustainable fishing and is being used by many nations to introduce hundreds of management plans. Nonetheless, the Code's potential is far from being realized, partly because of its relatively recent adoption and because nations have implemented its guidelines in a piecemeal fashion. New incentives and support mechanisms for countries to fully implement and enforce the principles set forth in the Code of Conduct and the associated International Plans of Action are urgently needed.

Can Fisheries Be Managed Sustainably?

The net effect of the UN Convention on the Law of the Sea (UNCLOS) has been that the rich resources of coastal waters—where some 90 percent of commercial fish are harvested—are now controlled by national governments, who may restrict or sell off fishing rights within these waters as they choose. This puts the responsibility to sustainably manage coastal fisheries squarely in the hands of coastal nations. Managing straddling stocks and safeguarding them from overfishing, however, requires the collaboration of all the relevant nations. Effective bilateral and multilateral agreements on how to manage shared fish stocks are still the exception rather than the rule and the regional fisheries bodies, which have historically dealt with management of shared stocks, frequently suffer from inadequate mandates, funding and staffing difficulties, and lack of political commitment by its members.

Although the conventional measures to control fishing pressure are useful, they do not eliminate the underlying cause that leads to overfishing: the innate desire to catch more and higher-valued fish before others do. The bottom line is that there are too many fishers trying to catch too few fish. Even if some were to give up fishing, those who remain can develop additional capacity by buying new vessels or upgrading existing ones, and others who leave one fishery may simply move on to another one that is also depleted.

There is no question that the world's fisheries can be managed to produce a significant harvest of fish without depletion. But how large this harvest can be, and how fishing operations must be managed to produce this harvest sustainably is still a topic of much debate and experimentation in most parts of the world. Some exceptions do exist—some fisheries are being managed sustainably today, and these numbers are slowly growing. The ecosystem approach to fisheries management put forward by the FAO and supported by many countries provides the framework and principles needed to achieve the goal of sustainability in the fisheries sector. As mentioned above, it aims to reduce the impact of fishing activities on aquatic ecosystems and maintain the ecological relationships between the species being harvested and other inhabitants of the ecosystem, trying not to disturb the relative balance of species by overharvesting a given stock. Protecting the coastal and inland water environments from other human-induced threats, such as pollution and infrastructure development, is another key element of this approach.

Using an ecosystem approach also has a socioeconomic dimension. It starts from the assumption that fisheries management should not only sustain the fishery resource itself, but should contribute to the sustainable development of communities and nations, including food security and economic growth. It therefore realizes that managing fisheries must do more than just satisfy the commercial fishing industry, it must also accommodate the wide array of economic and social benefits that people derive from marine and freshwater ecosystems, such as recreation, livelihoods, cultural identity, and so on. The practical effect of this is that it widens the group of users who have a legitimate say in how fisheries should be managed. Setting up appropriate institutional structures and legal frameworks that will allow wider stakeholder participation in resource management is therefore essential for the successful implementation of more concrete management strategies.

Of course, translating the ecosystem approach into concrete management policies is not easy. There is no "one-size-fits-all" management approach suitable to all nations and fish stocks. However, there are a variety of strategies that, when combined, can clearly contribute to more sustainable fishing practices. These include such steps as:

- improving licensing and monitoring regimes;
- developing refined fishing gears that reduce damaging impacts and unintended catches;
- establishing marine protected areas that act as refuges for recovery of fish stocks;
- managing river basins as integrated units with water allocation schemes to sustain river flows and the natural ecosystem functions and processes;
- supporting better stock assessments that yield more accurate catch quotas;
- pursuing stricter enforcement of fishing regulations and tighter international cooperation to improve compliance with international fishing treaties;
- establishing new institutional arrangements that can adopt an integrated or ecosystem approach to resource management;
- creating national policies that incorporate fisheries into development and poverty reduction strategies; and
- putting in place economic policies that give fishers incentives to reduce fleet sizes and that reward responsible fishing practices.

All of these strategies are currently being applied in various nations and with various stocks, but the specifics and the level of coordination are what count. Finally, a sustained political commitment to reorient fisheries subsidies will also be needed to shift our current way of managing fisheries to a more holistic and ecosystem-based approach.

CHAPTER 1

WHY CARE ABOUT FISH?

Fishing is fundamental to coastal and riparian societies—an ancient activity that predates even agriculture. For millennia, harvesting resources from the seas, lakes, and rivers has been a source of sustenance and livelihood, and a mainstay of local culture. That is nearly as true today as it was a century ago. Fishing remains a bulwark of local employment in many communities, a key to food security for millions, and a significant factor in the global economy. Yet, the nature of the fishing enterprise and the condition of the marine and freshwater resources it relies on could hardly have changed more radically in the last 100 years.

During that time, the increase in the world's population and the need for economic development has brought a rapid expansion of commercial fishing and an overwhelming increase in our capacity to exploit fish stocks worldwide, largely under open-access conditions. In the last half century a tide of new technology—from diesel engines to driftnets—has swept aside the limits that once kept fishing a mostly coastal and local affair. Greatly enlarged fleets, fish-tracking sonar, and factory ships that can catch and process in any waters mean that fish can be targeted with greater accuracy and deadly dispatch. The result has been a rapid depletion of key stocks, and serious disruption and degradation of the marine and freshwater ecosystems they live in—what many have termed a "global fisheries crisis."

At the same time, the revolution in fishing practice and technology has not been uniformly shared. A great number of fishers in the developing world still ply their trade at a smaller, more traditional scale, using small craft and equipment and either consuming their catch themselves, or selling it locally. In addition, as ocean catches have dwindled, aquaculture—the practice of farm raising fish and shellfish—has burgeoned in recent years to take up the slack to meet food and income needs in developing countries, or to meet demand for high-priced seafoods such as shrimp and salmon. As a result, fishing today is not one but many different activities, pursued at different scales, by different groups of fishers, and with differing equipment and economic returns.

This complexity can make it difficult to understand the dimensions of the problems that global fish stocks and fishers face, or how the actions of consumers play into these problems. The contrast between large-scale commercial and small-scale community-based fishing, between the global seafood trade worth billions of dollars and local consumption of fish for subsistence by fishers earning less than $1 per day, between high-end shrimp aquaculture for export and low-end carp production in farm ponds in rural China, can be hard to reconcile. What is the condition of the world's fish stocks? What are the environmental and social costs of our current fishing practices, and who pays the price? Will aquaculture relieve the pressure on ocean fish stocks? Are we making progress toward curbing overfishing and managing fish stocks for long-term productivity?

The purpose of *Fishing for Answers: Making Sense of the Global Fish Crisis* is to address these and similar questions and to give non-technical readers a sense of the condition of fisheries today, exploring the dimensions of the fishing enterprise, and the environmental and socioeconomic problems related to fisheries management. Chapters 2–4 provide background information on commonly used terms in fisheries management, as well as descriptive statistics on types and status of the world's fisheries. These chapters are meant to aid the reader in untangling the complexity and confusion surrounding policy and management problems that are discussed later in the report. Chapters 5–10 examine some of the major issues such as the role of aquaculture, the differences and conflicts between large-scale and small-scale fishing, the impact of fishing on ecosystems, and the effects of global trade policies on fisheries management. These chapters also highlight the importance of those fishing sectors that comprise the majority of the world's fish-dependent people, but are routinely ignored by policy-makers and consumers alike in developed countries—namely small-scale and inland water fisheries in developing countries. We quantitatively describe the importance of these sectors, identify data gaps, and compare the relative significance of small and large scale fisheries in terms of resource pressure and management issues. Finally, Chapters 11 and 12 examine the management strategies currently in play—from international treaties to modern approaches to fleet monitoring and stock assessment—and recommend modest steps toward more sustainable fishing.

Box 1-1: What is a Fishery?

The term "fishery" can be confusing, because it is used differently by fisheries experts and in the technical literature, and by the media and in non-technical literature. From a technical point of view the term exclusively refers to the commercial activity of harvesting fish. In reality, however, "fishery" is often used to refer to the fish resource itself by non-technical audiences.

Technical definition: A fishery consists of the *fishing activity focused on certain fish, shellfish species, or a group of species*, often in a certain geographic area. For example, the Pacific halibut fishery refers to the commercial fishing industry centered on Pacific halibut. Likewise, the Bluefin tuna fishery refers to the commercial exploitation of Bluefin tuna, either on the high seas or in national waters.

In the non-technical literature and in the media, the term "fishery" is often used in reference to the *actual stocks—or populations within a certain geographic area—of a particular fish or shellfish species (or group of species)* that are the subject of fishing activities. For example, the Pacific halibut fishery is used in the popular media to refer to the stocks of Pacific halibut that are fished commercially. In this sense, the media can refer to a fishery (in reality they mean the stock) as being healthy or depleted, overfished or underexploited, reflecting the condition of the resource.

This report is not meant to cover all aspects of fish biology and management as these have been covered in numerous textbooks and reference materials, such as *Marine Fisheries Ecology* by Jennings et al. (2001) and *Handbook of Fish Biology and Fisheries* by Hart and Reynolds (2003). Neither does this report replace authoritative sources of updated fisheries statistics, such as *The State of World Fisheries and Aquaculture* series, published by the Food and Agriculture Organization of the United Nations (FAO) every two years. Readers who are interested in more technical studies of fisheries and their management are strongly encouraged to refer to these and other publications cited throughout the report.

We hope that *Fishing for Answers* will help consumers, environmental organizations, and policy-makers deepen their understanding of the issues surrounding global fisheries, and find their potential roles in creating a political and economic environment that will foster sustainability in fishing. The goal is to get consumers to understand how their seafood choices and purchases affect global fish stocks and ecosystems, and that this understanding and awareness will encourage them to support the growing market for "sustainably managed" fish and shellfish products. Finally, we hope that the report will educate the broader public on fisheries issues and related policies in order to build support for some of the difficult policy choices needed to sustainably manage fish stocks and fishing effort around the world.

HOW IMPORTANT IS FISHING?

Fishing and the activities surrounding it—processing, packing, transport, and retailing—are important at every scale, from the village level to the level of national and international macroeconomics. For one, fishing generates significant revenue. In 2000, the global fish catch was worth US$81 billion when landed at port; aquaculture production added another US$57 billion (FAO 2002a); and the international fish trade totaled over US$55 billion (FAO 2002a).

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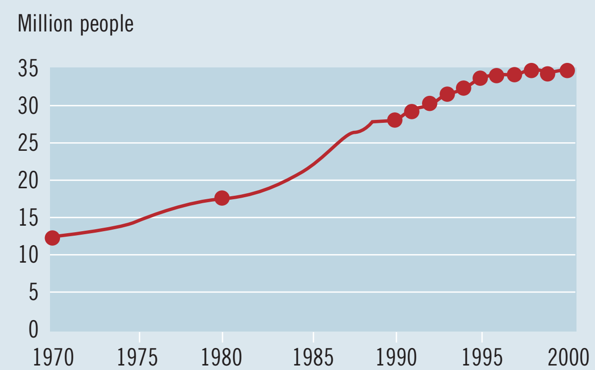
Income from fishing is particularly important to developing economies, which often depend heavily on revenues from natural resources such as timber, mining, oil, and fish. Fisheries (the collective term for fishing and the fish resource, see Box 1.1 for definition) are a major foreign exchange earner for developing countries, which produce more than half of all internationally traded seafood (Sabatini 2001). Fishery export revenues in developing countries increased rapidly from US$10 billion in 1990 to US$18 billion in 2000—a growth rate of 45 percent when corrected for inflation (FAO 2002a).

Fishing is also a crucial source of livelihoods in developing nations, particularly for low-income families in rural areas where job options are limited. In fact, small-scale and subsistence fishing often acts as the employment of last resort when more lucrative labor opportunities cannot be found. FAO estimates that some 35 million people are directly engaged, either full- or part-time, in fishing and aquaculture, and this may be a substantial underestimate (*See Figure 1-1*). Over 95 percent of them live in developing countries, and the majority are small-scale fishers (FAO 2002a; WRI et al. 2003). In some countries, these subsistence fishers contribute more to the national economy than large-scale commercial operators—because of their larger numbers and in spite of their lack of high technology (see *Chapter 5* for further discussion on the small-scale fishing sector).

The contribution of fisheries to the global food supply is also significant. In 2000, fish constituted 15.3 percent of the total animal protein (or 5.7 percent of all dietary protein, including grains) consumed by people worldwide (FAO 2003a). More importantly, about 1 billion people—largely in developing countries—rely on fish as their primary animal protein source (calculation based on Laurenti 2002). Among the countries most dependent on fish for food security are small island states such as Maldives and Kiribati, and sub-Saharan African states such as Ghana and Malawi, many of which depend on fish for more than 50 percent of their animal protein (Laurenti 2002). Residents of Solomon Islands, for example, consume some 51 kilograms of fish per person each year—about 83 percent of their animal protein. By comparison, people in the United States, Canada, Australia, France, and Germany get less than 10 percent of their animal protein from fish (Laurenti 2002).

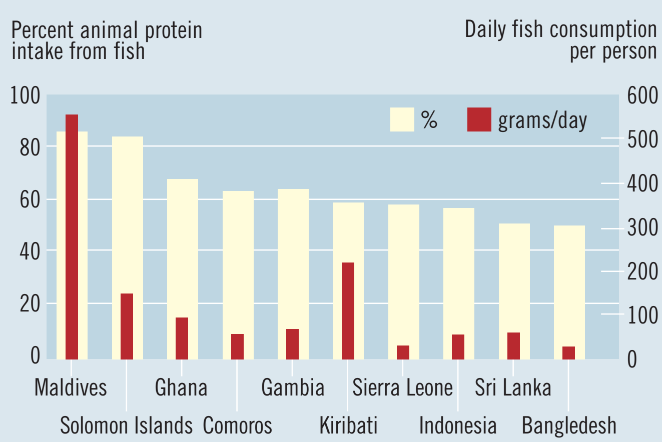
Because of their importance as a food and income source for the poor, managing the world's fisheries resources wisely is a crucial element in national strategies to reduce poverty. But the challenge of attaining fisheries management that is environmentally and socially sustainable is becoming more formidable every day. Demand for fish is growing and will likely continue to grow over the next three decades, while current management practices cannot even maintain today's catch (FAO 2002a).

Figure 1-1: Number of Fishers and Fish Farmers



Source: Earth Trends, WRI 2003.

Figure 1-2: Nutritional Importance of Fish



Source: Laurenti 2002.

IS THERE REALLY A FISHERIES CRISIS?

The world's wild fisheries are in desperate need of better management. Over the last two decades, overfishing has become one of the major natural resource concerns in the industrialized world, and increasingly in developing nations as well (FAO 1997a; Berril 1997; FAO 1999a; FAO 2000a; FAO 2002a). The FAO estimates that 75 percent of commercially important marine fish stocks are either currently overfished, or are being fished at their biological limit, putting them at risk if fishing pressure increases or the marine habitat degrades (see *Boxes 1-1* and *1-2* for definitions). One recent analysis made an attempt to measure the magnitude of global fisheries decline. Researchers estimated that the quantity of large predatory fish such as cod, tuna, swordfish, and salmon—those most commercially desirable—has dropped more than 90 percent in the world's oceans since large-scale industrial fishing began (Myers and Worm 2003). While the methods and results of this analysis have generated considerable controversy among marine fishery experts, there seems to be broad consensus that many key commercial fish stocks have declined significantly as fishing has increased. Chapter 3 explores the question of the status of fish stocks in greater detail.

Unfortunately, pressure on fish stocks is primed to increase even as stock conditions continue to worsen. Demand for seafood products has doubled over the last 30 years and is projected to continue growing at 1.5 percent per year through 2020 as global population grows and per capita fish consumption rises (Delgado et al. 2003). The number of fishers and fish farmers is growing markedly as well, having doubled in the last 20 years (1980-2000) (FAO 2002a). That is a growth rate nearly three times faster than general population growth (UN Population Division 2003). Most of the increase in the number of fishers has occurred in developing countries as people turned to fishing for an alternative or supplemental source of income.

Recognizing the important role that fisheries play in employment and food security, and confronted with their perilous biological state, governments have reacted to the crisis, at least in writing. At the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002, nations publicly committed to maintain or restore depleted fish stocks to levels that can produce their maximum sustainable yield[1] by 2015—one of the most challenging targets to emerge from this meeting.

Despite this urgency, most people have little idea of what the "fisheries crisis" is, or what it means to them. From a consumer's point of view—at least in most developed nations—the sad condition of fish stocks is not obvious. There are still plenty of fish available in markets and restaurants, although the types may have changed and the prices may be higher. So are we really running out of fish? Are coastal ecosystems nearing collapse? The answers to these questions are not widely understood outside of the circle of fish experts and others in the fishing industry. That is unfortunate, because solutions to the problem may require decisions to regulate fishing in politically unpopular ways—measures that will need strong public support to be successfully implemented.

Perhaps people would better understand the threat to global fisheries if they likened it to defor-

Box 1-2: Taking Stock: Fully Fished, Overfished, or Collapsed?

A fish stock is considered to be *fully fished* when increases in fishing effort do not significantly increase the amount of fish harvested, but substantially increase the risk of overfishing. *Fully fished* stocks are said to be exploited at their biological limit—a reference point below which the spawning stock is too low to ensure safe reproduction.

The term *overfishing* refers to the action of fishing beyond the level at which a fish stock can replenish itself through natural reproduction. In other words, if too many fish are harvested because of excessive fishing pressure, the stock reaches a point where there are not enough fish of spawning age to reproduce and sustain the stock.

Continued overfishing of a stock can result in removal of a high proportion of fish of all age classes—juvenile to mature adult. When few mature adults remain to spawn and few juveniles remain to grow to a harvestable size (a process called recruitment), such a stock is known as *depleted*.

Prolonged overfishing of a depleted stock can lead to its *collapse*, that is, the reduction in fish abundance to levels at which the harvest is negligible compared to historical levels. Depleted or collapsed stocks may require a long time to recover, even if fishing pressure has been reduced or eliminated entirely. Indeed, they may never recover their former productivity, due to changes in population dynamics, habitat conditions, and other biological factors that influence reproduction.

Source: Definitions based on FAO Fisheries Glossary (2003) and adapted for a non-technical audience.

[1] Maximum Sustainable Yield (MSY) or sustainable catch is defined as the largest average catch or yield that can continuously be taken from a stock under existing environmental conditions (Ricker 1975). MSYs are estimated through models (e.g., surplus production models) but, both "the MSY and the level of effort needed to reach it, are difficult to assess" (FAO Fisheries Glossary 2003).

Artisanal fisher with net, Brazil.

estation—an environmental problem that the public has come to be quite familiar with in general terms. Fish and trees are both renewable resources that can be sustainably harvested over the long term if managed wisely. However, these resources are currently being exploited faster than they can regenerate in many parts of the world. This exploitation has also caused widespread destruction of ecosystems, which threatens the whole basis of future productivity. In both cases, economic incentives still largely favor continued exploitation rather than sustainable management. A substantial amount of illicit harvesting—pirate fishing and illegal logging—also adds to the difficulty of managing the resources properly.

Of course, there are important differences between fish stocks and forests that make the fisheries crisis in some ways even more difficult to tackle than deforestation. One is that many fish species are not static like forests, but move freely across territorial boundaries and thus have to be managed jointly by more than one country. This requires coordination in policies, monitoring, and enforcement—a significant challenge.

Another difference is that it is much more difficult to monitor and assess fish than forests. They can't be measured to a high level of accuracy using helicopters, satellite imagery, or even boats. As a consequence, fisheries data are notoriously poor, obscuring the true dimensions of the "deforestation of the seas." We do not really know how many fish remain in the world's oceans, lakes, and rivers today, nor do we know exactly how many fish we remove from them every year, nor the condition of their habitats. All of this is vital information if we expect to manage fisheries wisely.

CAN FISHERIES BE MANAGED SUSTAINABLY?

There is no question that the world's fisheries can be managed to produce a significant harvest of fish without depletion. But how large this harvest can be, and how fishing operations must be managed to produce this harvest sustainably is still a topic of much debate and experimentation in most parts of the world. Exceptions to this statement exist, with some fisheries being managed sustainably today, and their numbers slowly increasing. Before the advent of large-scale commercial fishing, marine resources were managed and marketed on a more local basis. Many indigenous coastal communities developed well-elaborated rules for exploiting local fish and shellfish stocks, including restricting the number of community members who could fish a given area, and imposing harvest seasons and closed seasons to let stocks recover—some of the same strategies used today to manage fisheries. In this sense, traditional small-scale fisheries have a long history of sustainable use. Indeed, overfishing only became a real problem in the last century or so with the expansion of the fish trade into a truly global market.

We do not really know how many fish remain in the world's oceans, lakes, and rivers today, nor do we know exactly how many fish we remove from them every year, nor the condition of their habitats.

But as maritime and fishing technology changed, increasing the range and intensity of fishing, fisheries management has become infinitely more complex. Authority over fisheries is no longer the province of local chieftains or community elders, but generally a state function, and more and more, an international effort. Fishing fleets now range over great expanses, increasing the difficulty and expense of monitoring and enforcing fishing regulations. Even the science of assessing fish stocks and setting quotas that will maintain or restore fish populations to viable levels remains notoriously imprecise because of its inherent level of uncertainty (see *Annexes A* and *B* for discussion on stock assessment and data limitations).

Answering the question 'how many fish can we responsibly catch?' is not only difficult, but—as author Michel Berrill (1997) very suitably put it—is an attempt to "predict the unpredictable." Fisheries biologists work with models and assumptions, many of which are often inaccurate because of lack of information on the species or group of species, or because of information that is intentionally misreported by fishers. Fisheries experts have come to accept the inherent limitations of their calculations, realizing that their estimates of the number of fish in a given stock may be off by as much as 30 percent (Berrill 1997). Politicians, and the public, on the other hand, do not like uncertainty and demand accuracy in these predictions, unaware of the limits of current science.

The task of managing fisheries sustainably is made still more challenging because fisheries must simultaneously meet many different demands—national development, local food security, poverty alleviation, market demand, and global trade—each with its own set of pressures. Solutions to the problem of sustainable management must therefore be pursued as interlocking actions at different levels, addressing different user communities—small-scale fishers, commercial fishers, industry, recreational fishers, and many others. Conventional, centrally-lead fisheries governance has often proven to be poor at reconciling these conflicting demands. This is reflected in the inequitable allocation of rights and access to the fishery resources and fishing environments.

In recent years, the international community (NGOs, academia, policy makers, etc.) has generally accepted and begun to promote a framework for the sustainable management of fisheries. This framework revolves around the central importance of managing fisheries as an integral part of the ecosystem, rather than just as a collection of fish stocks to be exploited without regard to the system which nurtures them. This has come to be known as the "ecosystem approach" to fisheries management. Ecosystems consist of a dynamic complex of organisms—fish, mammals, vegetation, coral, and other bottom-dwelling organisms—and the physical environment in which they live, interacting as a functional unit (Millennium Ecosystem Assessment 2003). Current understanding recognizes that maximum production of fish stocks cannot occur where marine or freshwater ecosystems have been degraded, since these environments affect the reproduction and survival rates of fish.

Applying the "ecosystem approach" to fishing activities means, for example, reducing the impact of fishing activities on aquatic ecosystems by limiting disturbance of the sea-bottom community by bottom-trawling equipment. It also entails trying to maintain the ecological relationships between the species being harvested and other inhabitants of the ecosystem, trying not to disturb the relative balance of species by overharvesting a given stock. Protecting the coastal and inland water environments from other human-induced threats, such as pollution and infrastructure development, is another key element of the ecosystem approach.

Using an ecosystem approach also has a socioeconomic dimension. It starts from the assumption that fisheries management should not only sustain the fishery resource itself, but should contribute to the sustainable development of communities and nations, including food security and economic growth. It therefore realizes that managing fisheries must do more than just satisfy the commercial fishing industry, but must accommodate the wide array of economic and social benefits that people derive from marine and freshwater ecosystems, such as recreation, local livelihoods, cultural identity, and so on. The practical effect of this is that it widens the group of users that have a legitimate say in how fisheries should be managed (FAO 2003b). Setting up appropriate institutional structures and legal frameworks that will allow wider stakeholder participation in resource management is essential for the successful implementation of more concrete management strategies.[2]

Of course, translating the ecosystem approach into concrete management policies is not easy. There is no "one-size-fits-all" management approach suitable to all nations and fish stocks. However, there are a variety of strategies that, when combined, can clearly contribute to more sustainable fishing practices. These include such steps as improving licensing and monitoring regimes; developing refined fishing gears that reduce damaging impacts and unintended catches; establishing marine protected areas that act as refuges for recovery of fish stocks; supporting better stock assessments that yield more accurate catch quotas; pursuing stricter enforcement of fishing regulations and tighter international cooperation to improve compliance with international fishing treaties; and putting in place economic policies that give fishers incentives to reduce fleet sizes and that reward responsible fishing practices. All of these strategies are currently being applied in various nations and with various stocks, but the details of the applications and their coordination are what count. Chapter 11 discusses these management approaches—what has worked and what has not.

Lastly, there are external factors that influence how well any of these natural resource management efforts can succeed, from political stability and corruption, to poverty and economic development priorities, especially in developing countries. However, detailed coverage of these broader issues is outside the scope of this report.

[2] This report focuses on those strategies that are specific to fisheries resources, rather than fully exploring the broader theoretical and practical approaches to common property resource allocation and management. There are numerous published sources that cover issues such as common property resource and fisheries, terrestrial wildlife, and water resources, to name a few (Berkes et al. 2001; Hulme and Murphree 2001; Le Moigne et al. 1992).

CHAPTER 2

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THE COMPLEX WORLD OF FISHING

The world of fisheries is complex. The terms *fishing* and *fisheries* are used to describe a diverse group of activities from catching fish, to processing fish products and managing fish stocks. These and other common terms are often used interchangeably by different sectors of the industry, leading to public confusion about what fishing is, the relative importance of the different kinds of fishing, and how they affect fish stocks and ecosystems.

Here we provide a brief overview of the different aspects of fishing as background for the chapters that follow. We look at the major fishing sectors; the environments in which fishing takes place; the kinds of fish that are generally caught; and the kinds of fishing gear that are widely used. The category descriptions outlined below are not strict technical definitions; instead these definitions are an attempt to help the readers differentiate amongst broad types of fishing activities that are not always distinct or mutually exclusive. With this information, readers can begin to better understand the dimensions of modern fishing, and to interpret news of the global fishing crisis and questions of fishing policy in more real terms.

FISHING SECTORS

In looking at the world's fish production, a basic distinction must be made between *capture* fisheries and *aquaculture*. The term *production*, which is used frequently throughout this report, refers to the output of both capture fisheries and aquaculture. *Capture* fisheries is the activity that most people think of as true fishing: using traps, lines, nets, or other gear to harvest wild fish, shellfish, and a variety of other aquatic animals. *Aquaculture* is the use of tanks, ponds, pens, or other structures or enclosures to raise fish and shellfish in captivity. Although these seem like very different activities, they often target the same species and aim for the same consumer markets, and are therefore indistinguishable to most consumers. However, the issues regarding management, condition, and policies surrounding these two sectors are quite different. As consumers, the public has an impact with purchasing choices that favor wild-caught, farmed fish, or both; therefore, understanding the differences and policy implications of these two activities is essential.

Increasingly, the distinction between these two sectors, capture and aquaculture, is becoming more blurred and confusing. Some capture fisheries for instance, are now culture-based, meaning the fish are raised in pens but then released into the wild for later capture by fishers—counting as capture fisheries in the statistics. On the other hand, some aquaculture operations are capture-based, meaning that juvenile fish are captured at sea, and then transferred to pens for fattening and sale as aquaculture products.

Haitian fishermen deploy an illegal fish trap.

In this report, much of the discussion concerns capture fisheries, since this is the activity that employs most fishers and presents the most pressing challenges in terms of sustainable management. But, as discussed above, aquaculture increasingly intersects and influences capture fisheries: ocean-caught fish are used in fishfeed formulations in shrimp and salmon aquaculture, while in the new sea ranching techniques wild-caught juvenile fish (mostly tunas) are fattened up with formulated feed in open sea pens. (See *Chapter 6* for a full discussion of aquaculture and its implications.)

CAPTURE FISHERY CATEGORIES

Fisheries fall into a few major categories depending on the size and sophistication of the fishing vessel used, its crew size, how close it operates to the shore, and what it does with its catch. Each category has its own implications for fishery resources, ecosystems, management, and policies. This report uses the terms described below. In practice, however, definitions vary among countries and there are always some exceptions, particularly regarding small-scale and artisanal fishing. For example, in Taiwan, only fishers using unpowered boats are considered "small-scale," while in a developed country such as the United States, use of a 20-meter trawler might be considered artisanal if it is individually owned and used to fish near-shore waters. This variation in definitions makes it hard to standardize data, make regional or national comparisons, and analyze trends in fishing capacity and employment in the fishing industry.

Industrial Fishery. This is a general term for the kind of mechanized, high-volume fishing we associate with modern commercial fishing fleets, financed and operated by a large commercial enterprise. It is typified by large fishing vessels with high technological input (i.e., sonar technology, satellite navigation systems, and highly mechanized gear such as trawls). These boats frequently employ a large crew and are capable of fishing far from the coast, often in the high seas and for extended periods of time. This term is often used interchangeably with *large-scale* or *commercial fishery*, especially in the popular media, and sometimes used specifically to refer to fisheries that target small pelagic fish for fishmeal production.

Artisanal Fishery. This term is the opposite of industrial fishery, and is often used interchangeably with *small-scale* in the non-technical literature. The FAO defines an artisanal fishery as a traditional fishery involving fishing households, as opposed to commercial companies. Artisanal fishing typically takes place using small vessels that make short trips close to shore, with the catch used mainly for local consumption (FAO Fisheries Glossary 2003). Artisanal fishers usually rely on inexpensive (paying very low or no wages), but labor-intensive fishing methods. Most have low and irregular incomes, and many make use of sharing or barter systems rather than fixed wages (Tietze et al. 2000).

Small-Scale Fishery. The term "small-scale" applies to a broad range of smaller fishing vessels with less sophisticated fishing technology. A small-scale fishery is characterized by small-capacity fishing craft with non-mechanized propulsion or low-horse-power engines and the absence of fish-finding and navigation devices. Small-scale fishers often use traditional fishing gear, operated by hand (rather than diesel winch), and tend to fish closer to the shore. The International Labour Organization defines small-scale fishers as "people of both genders who usually operate their own fishing craft and equipment, and go to sea themselves, either alone or with a few crew members (preferably their own relatives)" (Ben-Yami 2000). Nonetheless, in many places small-scale fisheries are populated by small boat owners employing hired hands as crew. In other cases, small-scale fishers may rent boats and gear from local boat owners. (See *Chapter 5* for further discussion on small-scale fisheries).

Commercial Fishery. A commercial fishery is any fishery that sells its catch in the marketplace, either for export or for local consumption. With the exception of subsistence fishers, all modern fisheries are commercial, including most small-scale or artisanal fisheries. However, the term commercial fishery is most often applied to larger-scale operations, marked by at least modest technology and crew size, and capable of venturing into the open seas.

Subsistence Fishery. A subsistence fishery is one where the fish caught are shared and consumed directly by the families of the fishers rather than being bought by middlemen and sold at market. Very few fisheries are truly "subsistence fisheries" because the products are often used for barter. Subsistence fishing is usually a very small-scale activity, undertaken with low-technology—and often traditional—boats and gear (FAO Fisheries Glossary 2003).

Recreational or Sport Fishing. This term refers to fishing or shellfish collection done primarily for pleasure. Recreational fishing takes place in both freshwater and marine environments, encompassing everything from flyfishing or surf fishing with a hook and line, to motorized trolling, skindiving, and clam digging. Recreational fishing is more significant in size and economic impact than most people realize. In many countries, such as the Australia, Canada, Chile, Europe, New Zealand, the United States, and many small island states, it provides an important source of income through the sale of fishing gear, guide services, lodging, and other tourist services. For example, freshwater sport fishers in the United States numbered approximately 30 million in the mid-1990s, generating some $24.5 billion in sales of equipment and services (Revenga et al. 2000). An additional 15-17 million sport anglers fished the U.S. coastal waters (as of 2001), harvesting nearly 190 million marine fish (approximately 120,000 metric tons) (NMFS 2001a).

FISHING ENVIRONMENTS

Fishing activities take place in several distinct environments, which are populated by different fish and shellfish species, and call for different fishing gears and fishing techniques. Although the general public is, for the most part, unaware of this, where the fish they consume comes from is of key importance from an ecosystem and policy perspective, given that different gears and policies impact certain fisheries and environments more than others. The most obvious distinction is between *marine capture fisheries* and *freshwater or inland capture fisheries*. Both are critical to global food security and livelihoods. Marine fishing accounts for some 90 percent of global fish catch, while the freshwater harvest contributes to almost 10 percent of the total catch (FAO 2002a).

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MARINE FISHING ENVIRONMENTS

Marine fishing environments can be categorized by distance from the shore, water depth, and other physiographic characteristics. The following are the major categories that often differentiate the pattern of marine fishery exploitation.

Coastal Waters. Coastal waters extend to the outer edge of the continental shelf, or to a depth of 200 meters. This is the zone where most fishing occurs, and it typically lies within the Exclusive Economic Zone (EEZ) of a given nation—the 200 nautical miles zone within which international law recognizes a nation's right to manage and exploit the marine resources. Fish harvested in coastal waters typically fall into a few groups: groundfish, such as flounder, redfish, cod, and pollock; molluscs, such as octopus, scallops, clams, and mussels; crustaceans such as shrimps, crabs, and lobsters; and also small pelagic species such as mackerel and herring.

Within coastal waters, we can distinguish between different resource systems:

- ***Near-shore waters***, including estuaries and lagoons. Subsistence, artisanal, and small-scale fishing generally takes place in near-shore waters, often in waters at a depth of 10 meters or less. A variety of habitat types occur in these waters, including coral reefs and seagrasses. Coral reefs thrive in tropical waters, populated by a wide array of specialized species, and are often subject to intensive small-scale fishing.
- ***Soft-bottom shelves***. These are the relatively shallow (10-200 m) productive areas of the continental shelf that sustain most marine fisheries. In the shallower, near-shore areas (10-50 m in depth) strong conflicts can arise between small-scale fishers and large-scale fishing operations.
- ***Upwelling shelves***. These continental shelf regions are marked by an influx—or upwelling—of cold, nutrient-laden water from the ocean depths that fertilizes the sea, allowing it to support large populations of certain fish species such as anchovies, sardines, bonitos, and mackerels. These in turn support substantial populations of sea birds and mammals.


FAO/19158/M. MARZOT

Dugout canoe used for fishing and transport in Congo.

Open Oceans. The open ocean refers to the waters above the sea bottom that extends beyond the edge of the continental shelf or is deeper than 200 meters. These waters often extend beyond national EEZs into the high seas, and are thus subject to fishing by the commercial fleets of many nations, increasingly regulated by international treaties or regional fishing organizations. Fish caught in the open oceans frequently spend part of their life cycles in coastal waters, and are therefore affected by coastal conditions, land-based activities, and pollution. Typical species fished in open oceans include blue whiting, cod, deep sea crabs, merluccid hakes, orange roughy, sablefish, sauries, shark, squid, swordfish, toothfish, and tuna.

Within open ocean waters, two distinct resource systems can be distinguished:

- ***High Seas*** is a legal term used to describe the areas of water outside of a country's EEZ.
- ***Deep Seas*** is the water columns below the depth of 200 meters. Some biologically productive habitats such as seamounts and deep-sea coral reefs are typically found in these areas. Seamounts are undersea mountains, usually cone shaped and of volcanic origin. These habitats are often targeted for commercial trawl fishery of high-valued demersal species, such as orange roughy and oreo dory.

FRESHWATER OR INLAND ENVIRONMENTS

The importance of freshwater fisheries as a major source of the world's fish catch is often underappreciated, partly because their production is severely underestimated. With a few notable exceptions—such as caviar from river sturgeon or Nile Perch from Lake Victoria—freshwater fish production does not figure significantly in the global fish trade. But fish and shellfish from rivers, lakes, ponds, and even rice paddies are a crucial factor in local food security and livelihoods in many parts of Asia, Africa, and South America, often providing a low-cost source of protein. Even in developed nations in North America and Europe, recreational fishing for trout, carp, pike, and other freshwater species has become an important source of revenue in many communities.

Freshwater environments are very vulnerable to human degradation from dams, water diversions, and pollution. Fish production in inland environments is also subject to considerable human manipulation through fish stocking of lakes and streams, the introduction of new fish species, and construction of artificial environments for freshwater aquaculture. The freshwater harvest consists mostly of finfish such as carp, catfish, salmon, shad, tilapia, and trout. It also includes a significant amount of molluscs, crustaceans, and even reptiles that are of local and regional importance.

Freshwater environments fall into three major categories:

Rivers, Streams, and Wetlands. These natural waterways are subject to seasonal changes in water flow such as flooding, as well as seasonal fish migrations. Dams and water diversions have altered the natural flow regimes of all but a few of the world's major rivers, often damaging river fisheries in the process. Riverine fisheries may not be as productive as lake fisheries, but are significant in many countries and regions. Carp, catfish, characin, salmonid, shad, and trout are common target fisheries.

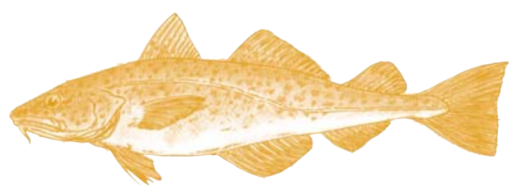
Lakes and Reservoirs. As major dams have increased in number over the last century, reservoirs have become a more common freshwater environment. However, these water bodies and their fisheries have been widely impacted by nutrient and chemical pollution from agriculture and industrial effluent. Nevertheless, fisheries in lakes and reservoirs are the most productive inland fisheries. They are often restocked with introduced species, such as tilapia, Nile perch, and carp, in addition to a variety of native finfish, molluscs, and crustaceans.

Ponds and Rice Fields. These artificial freshwater environments are now a major source of fish production, with aquaculture production of carp, catfish, and other species surpassing production from freshwater capture fishing. Small fishpond areas in China increased by 71 percent between 1984 and 2000 (Miao and Yuan 2001). Diversification is also occurring. High-value species such as freshwater crab and prawns are now also cultured in paddies in China, in addition to traditional species such as carp (Miao and Yuan 2001).

FISH TYPES

The global fish catch includes hundreds of species, but they fall into just a few major groups. These groups have different vulnerabilities to fishing activities, and therefore require different management policies to protect them. Greater awareness of these variations can help fish consumers reduce their contribution to unsustainable fishing.

Demersal Fish or Ground Fish. Demersal fish are bottom-feeding fish, found on or near the seabed. Thus, they are often referred to as "ground fish." This group includes many of the most commercially valuable marine species, prized for direct human consumption, such as cod, croaker, flounder, grouper, hake, halibut, pollock, seabream, and some deepwater sharks and skates. The wild catch of demersal fish accounts for approximately 35 percent of the world's marine finfish capture[3] by weight, but about 62 percent of the total value of that catch (Fishstat 2003). There is also some aquaculture production of demersal fish, but in relatively small quantity.



Demersal or ground fish: Atlantic Cod, *Gadus morhua*

Pelagic Fish. These ocean fish spend most of their life swimming in the water column with little contact with or dependency on the sea bottom. They often travel and feed in large groups or schools. The catch of pelagic fish represents about 65 percent of the total marine finfish catch[3]. *Small pelagics*, such as anchovies, sardines, mackerels, herrings, and pilchards, are low in commercial value, and are often used as raw material for fishmeal and fish oil rather than for direct human consumption. In contrast, *large pelagics*, such as tunas, swordfish, and other billfish, command high prices from consumers. Some shark species also have substantial commercial

[3] Excludes the catch of molluscs, crustaceans and other invertebrates and marine animals.

value as large pelagics, as their fins are considered delicacies in Asian countries.

Pelagic fish: Tuna, *Thunnus thynnus*; and European anchovy, *Engraulis encrasicolus*; above.

Deep Sea Fish. These are normally found in waters deeper than 400 m. Large-scale exploitation of deepwater species is relatively recent, but has quickly attained commercial importance. Among the more valuable deepwater species are angler fish, blue ling, orange roughy, Patagonian toothfish (often marketed as Chilean sea bass) and some deep water sharks. Deepwater species tend to be long-lived and slowly maturing fish, with low fecundity rates relative to other fish. Orange roughy, for example live longer than 100 years and take up to 25-30 years to reach maturity and start reproducing (Stevens 2003). These species are therefore highly susceptible to overfishing and slow to recover once overfished.

Deep sea fish: Patagonian toothfish, *Dissostichus eleginoides*

Freshwater Fish. These species spend their entire lives in freshwater. They include barbell, black bass, carp, catfish, perch, pike, snakehead, tilapia, trout, and many others. Although freshwater fish account for less than 10 percent of world capture, they contribute about 90 percent of all aquaculture production (FAO 2002a).

Freshwater fish: Brown trout, *Salmo trutta fario*

Diadromous Fish. Species that spend part of their life in freshwater and part in saltwater are known as diadromous. They fall into two groups:

Semi-industrial fishing boat in Indonesia.

Anadromous fish, such as salmon and sturgeons, spend their adult life in the open oceans or inland seas but swim upriver to freshwater to breed and spawn. In contrast, *catadromous* fish, such as eels, spawn in seawater but feed and spend most of their adult life in estuarine or freshwater environments.

Diadromous fish: Sturgeon, *Acipenser sturio*

Shellfish. This is a general term for a variety of edible invertebrates. These include both *molluscs*, such as clams, oysters, scallops, squids, cuttlefish, octopuses, and mussels; and *crustaceans*, such as lobster, shrimp, crayfish, and crabs. Crustaceans and molluscs represent 7 and 8 percent respectively of the world's marine catch by volume; but 26 and 11 percent respectively in terms of value (Fishstat 2003). Shell-less animals such as sea cucumbers, sea urchins, or jellyfish are sometimes included in the category of shellfish.

Shellfish: Japanese flying squid, *Todarodes pacificus*

2

FISHING GEARS

Commercial fishing gears are classified into two main categories—active gears and passive gears. Active gears involve a vessel or a group of people towing a net or dredge in pursuit of one or more fish species. Passive gears consist of nets or traps set in one location or drifting with the current, with the target species entangling themselves in the net or swimming into the trap. Below are some of the most common fishing gears used on a commercial scale (FAO Fisheries Glossary 2003; Morgan and Chuenpagdee 2003).

All types of fishing gear are associated with some level of bycatch—the accidental harvest of untargeted species, such as marine mammals, seabirds, or other fish species. But the level of bycatch and the species affected vary greatly by gear type used. Chapter 7 presents further discussion on bycatch.

ACTIVE GEARS

1 **Trawls.** A trawl is a bag-like net with a large mouth, tapering to a narrow end. The mouth is held open by a solid beam or steel doors. Bottom trawls are towed by a trawler along the sea bottom to catch demersal species such as flounder, sole, cod, rockfish, and shrimp. As they make contact with the sea floor, bottom trawls can seriously disturb the habitat, damaging or removing vegetation and organisms such as sea sponges, worms, and other bottom-dwelling species. Midwater trawls target species such as pollock, herring, hake, and mackerel that live higher in the water column.

2 **Dredges.** Dredges are specifically designed to harvest bottom-dwelling species such as scallops, clams, oysters, and sea urchins using a metal frame lined with a metal net. Because the dredge occasionally digs into the sediments as it is dragged along, it can disturb and damage the sea bottom ecosystem, in the same way as the bottom trawls.

3 **Surrounding or Encircling Nets.** Surrounding or encircling nets are large netting walls used for surrounding fish both from the sides and from underneath. *Purse seines* are a widely used type of surrounding net requiring one or two boats to deploy; one of the boats or a buoy remains stationary while the other encircles a school of fish. Purse seines are used to target schooling pelagic fish such as anchovies, sardines, mackerel, herring, salmon, and tuna.

PASSIVE GEARS

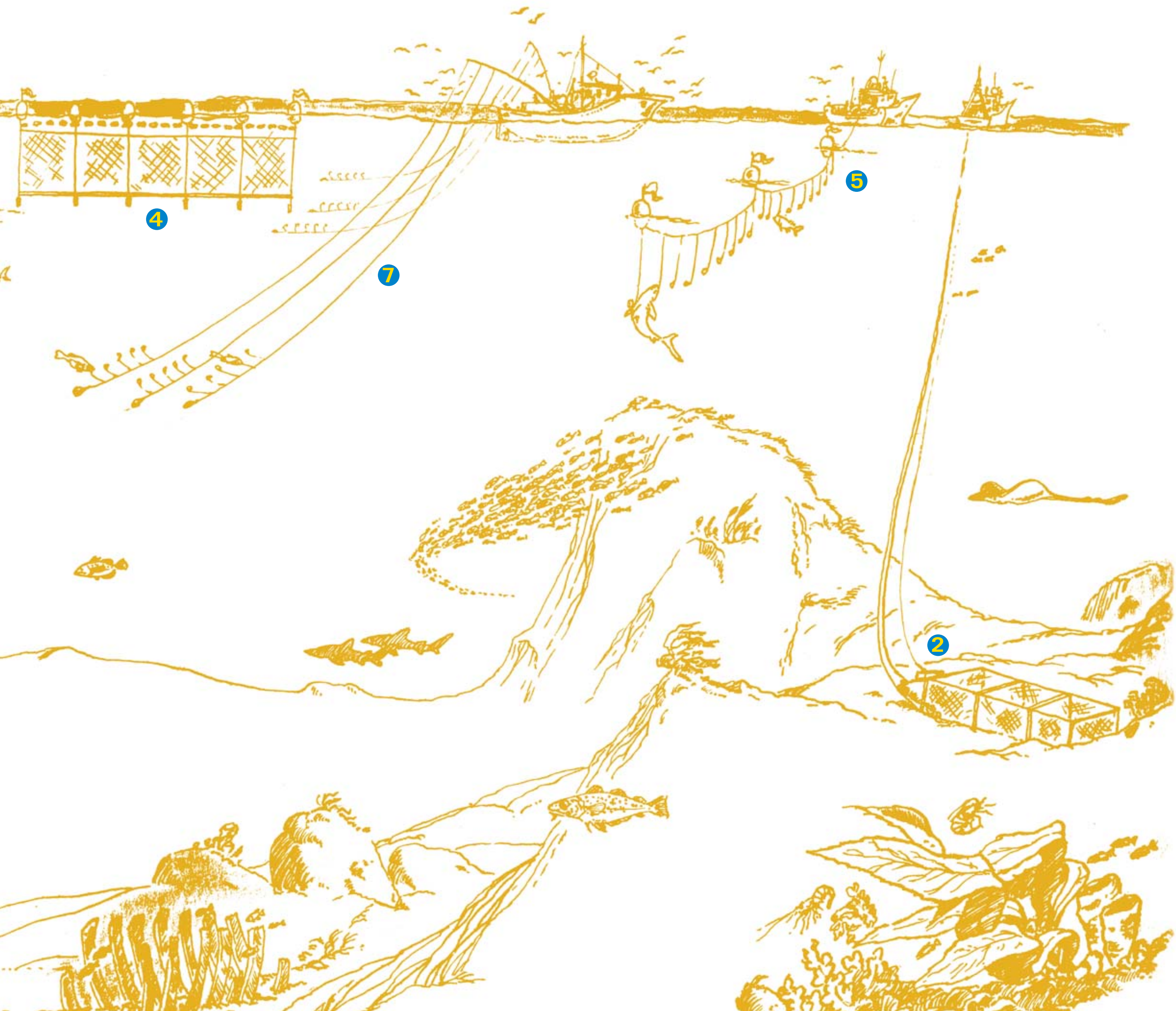
4 **Gillnets.** Gillnets consist of large panels of nearly transparent monofilament netting that hang vertically from floats like a curtain in the water. Because they can't see the netting, fish swim into the gillnet, entangling themselves. Bottom gillnets target demersal fish like cod, flounder, and pollock, while midwater gillnets target pelagic fish like mackerel, herring, swordfish, salmon, and sharks. Gillnets frequently entangle many non-target animals such as marine mammals and seabirds. *Driftnets* consist of many panels of gillnets strung together to make extensive walls of netting. Because of the high mortality rate of nontarget animals in driftnets, the use of large-scale driftnets (in excess of 2.5 km) in the high seas was banned by a United Nations resolution in 1992 (FAO 1998).

2

5 Longlines. Longlines use a stationary mainline to which are attached as many as 12,000 hooks on shorter branching lines. Longlines, which may be several miles in length, may be left in place from hours to days, and can be deployed on the sea bottom to catch demersal fish or in midwater to catch large pelagic species such as swordfish and tuna.

6 Traps and Pots. Traps and pots that rest on the sea bottom are used to catch crustaceans such as lobsters, crabs, prawns, and whelks, as well as some fish species such as Pacific cod and black sea bass, and even some tunas in the Mediterranean.

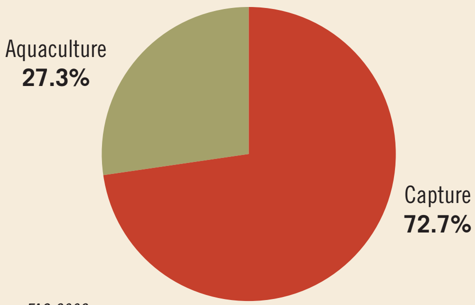
7 Hook and Line. Individual lines with baited hooks are still used in commercial fishing for a variety of pelagic and demersal fish, especially in small-scale and sport-fishing operations.



Box 2-1: Key Fishing Contrasts

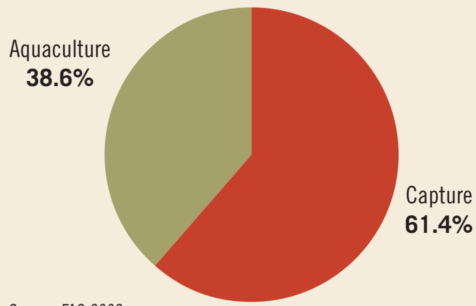
Global Production: Capture Fishing vs. Aquaculture

Figure 2-1a: Production by Volume from Capture Fisheries and Aquaculture
(World Total 130.4 million metric tons, 2000)



Source: FAO 2002a

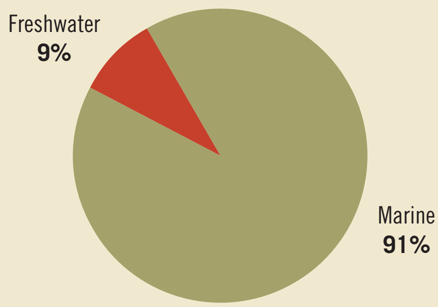
Figure 2-1b: Production by Value from Capture Fisheries and Aquaculture
(World Total US$130.1 billion, 2000)



Source: FAO 2002a

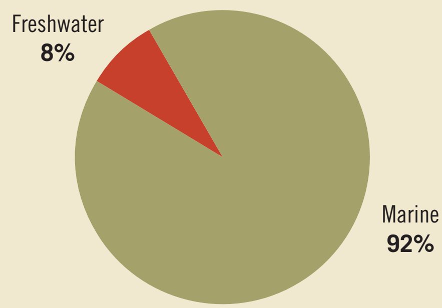
Global Catch: Marine vs. Freshwater

Figure 2-2a: Global Catch by Volume from Marine vs. Freshwater Environments
(World Total 93 million metric tons, 2001)



Source: Fishstat 2003

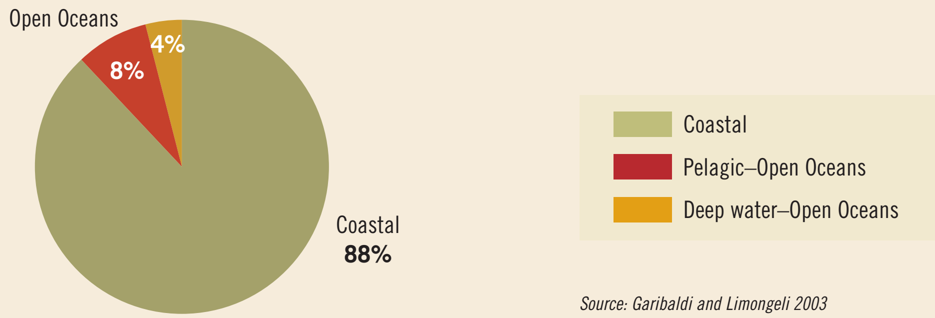
Figure 2-2b: Global Catch by Value from Marine vs. Freshwater Environments
(World Total US$79 billion, 2001)



Source: FAO Yearbook of Fisheries Statistics 2003

Global Catch: Coastal Waters vs. Open Ocean

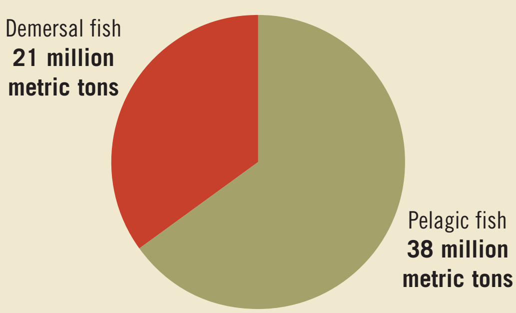
Figure 2-3a: Catch by Volume from Coastal Waters (Continental Shelf) vs. Open Oceans, 2002



Source: Garibaldi and Limongeli 2003

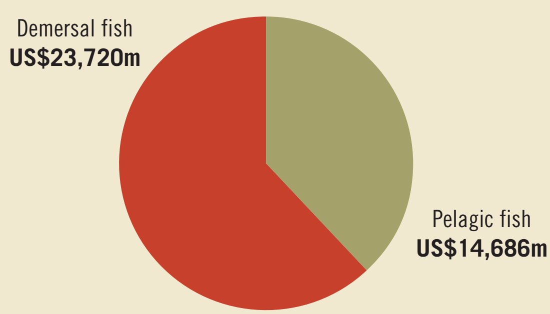
Global Catch: Pelagic vs. Demersal Fish

Figure 2-4a: Pelagic vs. Demersal Marine Fish Catch by Volume (metric tons, 2001)



Source: Fishstat 2003

Figure 2-4b: Pelagic vs. Demersal Marine Fish Catch by Value (million US$, 2001)



Source: Fishstat 2003

FAO /18298/ P. CENINI

ARE WE RUNNING OUT OF FISH?

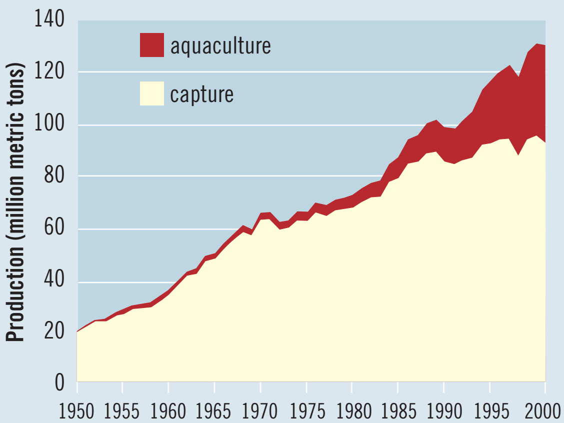
Historically, oceans were considered an inexhaustible source of fish. While fishing rights in near shore waters were often locally controlled, waters beyond easy boating distance from the shore were open to everyone. Open access resources, as they are called, are those that are owned by no one, and as such are particularly difficult to govern, precisely because no one individual has an exclusive right to use them, yet each person's use can diminish the remaining resource (WRI et al. 2003). Although open access resources are often subject to heavy and unsustainable use, over the last 35 years research has shown that degradation is not always inevitable (Feeny et al. 1990; Ostrom et al. 1999).

In 1968, author Garrett Hardin highlighted the vulnerability of open access resources when he popularized the concept of the "tragedy of the commons" arguing that these resources will inevitably be overexploited (Hardin 1968). The state of global fish stocks is perhaps the purest modern expression of Hardin's thesis. As new technology made fishing more productive and lucrative, the open accessibility of ocean and coastal waters was an invitation to overfishing—the action of excessive harvesting that leads to the depletion of the fish stock. This was fueled by the growth in human population with its increased demand for fish as food, as well as the growing demand for economic opportunities. Even as overfishing of traditional stocks became apparent, the economics of the fishing enterprise rewarded continuous expansion of activities into new fishing grounds and unexploited stocks—the birth of today's fisheries crisis.

Overfishing was formally recognized as a localized problem as far back as the early 1900s (FAO 1997a; Engesaeter 2002). According to historical documents from the International Council for the Exploration of the Sea (ICES), there were concerns about overfishing of North Sea plaice as early as 1912, and then over the stocks of Atlantic cod and haddock (Engesaeter 2002). The first multinational meeting to discuss fish size and mesh limits, known as the "Overfishing Conference," was held in London in 1936, with participants from 12 European countries (Engesaeter 2002). But until the 1950s, the problem was confined to a few regions such as the North Atlantic, the North Pacific, and the Mediterranean Sea, and to specific stocks which were heavily fished, while the majority of global fish stocks were not extensively exploited.

The exploitation pattern began to change at the close of World War II, when the increased commercial potential of fishing became more obvious as the capacity and range of boats increased. Throughout the 1960s and 1970s the global fish catch recorded impressive annual growth, allowing the yearly harvest to more than double during this period. But by the 1980s the costs of intensive fishing were becoming clear. Even though the total world catch continued to grow, catches in traditional fishing grounds had long since reached their maximum and declined. One of the clearest examples of decline was the heavy depletion of groundfish stocks in the North Atlantic, including Atlantic cod, haddock, flounder, and plaice. These species historically supported much of the commercial fish catch in northern Europe and the East Coast of Canada and the United States.

Figure 3-1: Increasing Proportion of Aquaculture in Fish Production



Source: Fishstat 2003.

By the 1990s, the fisheries crisis was receiving major media coverage. One of the most dramatic and public occurrences was the collapse of Canadian cod stocks and the closure of the fishery in 1992—an event that idled some 30,000 people employed in or affiliated with the industry (Milich 1999). The cod fishery had been a key source of employment and one of the most productive fisheries in the world for hundreds of years. In 1620, the fleet on the eastern coast of North America numbered more than 1,000 vessels with the average landing of cod for each vessel being around 125,000 fish (Mowat 1984). According to accounts from an English fisher at the time "cods are so thick by the shore that we hardly have been able to row a boat through them" (Mowat 1984 citing John Mason).

Not only was the abundance of fish impressive, but the average size of the cod was larger than in the last 40 years (Mowat 1984). This abundance continued for centuries until the 1960s when factory freezer trawlers from the former Soviet Union, Poland, Iceland, Norway, and the United Kingdom arrived in the region. After that Atlantic cod catches began a precipitous decline (Berril 1997; Fishstat 2003) ending in the closure to groundfishing of Newfoundland waters, the Grand Banks, and most of the Gulf of St. Laurence by the Canadian government in 1992 (Kurlansky 1997).

Fishery analysis makes it clear that the conditions that led to the collapse of Canadian cod stocks are spreading to other areas and commercially important fish stocks. Overfishing has become one of the major natural resource concerns in developed countries and, increasingly, in the developing world. While industrial fisheries are more visible in terms of their expansion, level of catch, and overcapacity, small-scale fishers have also proliferated throughout the world in the last two decades, particularly as a result of increased technology and access to markets. In some areas small-scale fishers are as capable and responsible for overfishing as the industrial sector (Verdin, pers. comm. 2004).

HOW WIDESPREAD IS THE CRISIS?

Global fish production from today is near its historical maximum—some 130 million metric tons in 2001 (Fishstat 2003). This hardly seems like a "crisis" situation. But just looking at statistics on the annual global fish harvest does not tell the whole story. For one, aquaculture now accounts for nearly one third of global fish production—a proportion that has steadily increased over the last decade as production from capture fisheries has stagnated (see *Figure 3-1*).

Even so, the harvest from capture fisheries—the catch of wild fish from boats and nets—is still impressively high, in spite of the fact that many major fish stocks are in decline. That is because the impact of overfishing has been masked by steady expansion of the fishing enterprise into new fishing grounds, intensification of fishing effort using new technologies, and rapid exploitation of alternative fish stocks as traditional species are fished out.

Continuous geographic expansion of fishing effort. The last 50 years have seen an unprecedented geographic expansion of fishing effort by industrial fleets. They have ventured far from their "core" fishing areas in the North Atlantic and North Pacific to areas unexploited or underexploited prior to the 1960s—areas such as the Indian Ocean and the southern waters around Antarctica. At the same time, the fishing intensity in traditional grounds continued to increase as improved fishing gear and fish-finding technology came into wide use and as governments subsidized the growth of their fishing fleets.

Together, these factors set in motion a pattern of systematic overexploitation common throughout the world's fishing regions. First, production levels increase, then fishing continues at high intensity even after peak production levels have passed. Catch data from around the world show that many ocean fishing areas have already passed their peak harvest, and that production has subsequently declined (see *Map 3-1*).

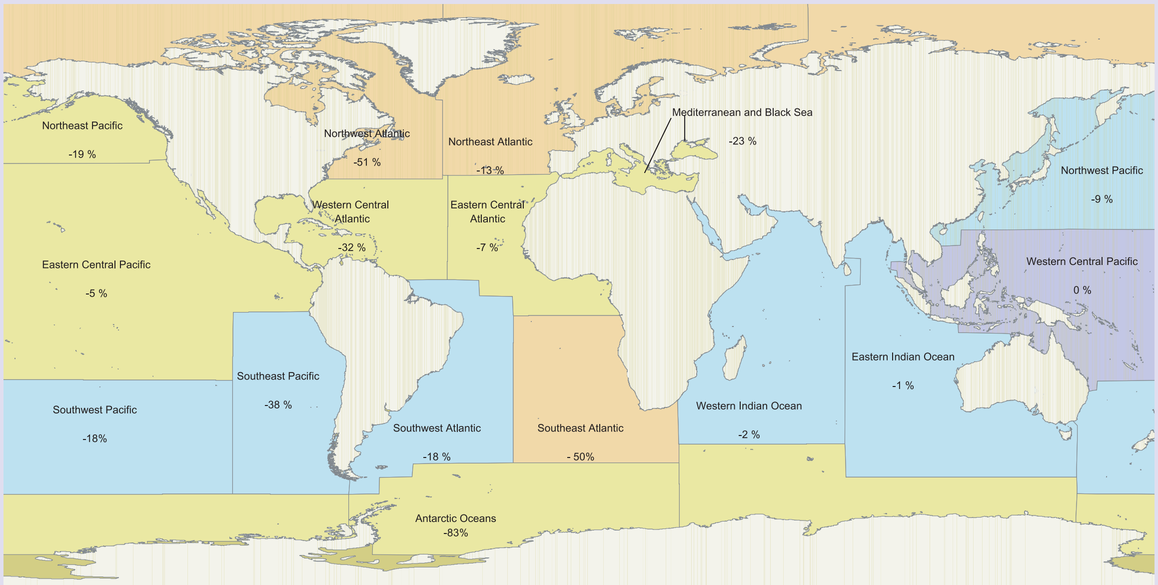
As Map 3-1 shows, fish landings (or catches) peaked in the Northern and the Southeast Atlantic regions between 1968 and 1980. In the Central Atlantic, the Eastern Pacific, and the Mediterranean, landings reached their maximum between 1981 and 1990; in the South Pacific, the Southwest Atlantic, and the Indian Ocean, peak harvests occurred between 1991 and 2001. So far, only the Western Pacific has continued to produce at its historical maximum (Burke et al. 2001; Caddy et al. 1998; Fishstat 2003). Most fishing areas, even those more recently exploited from a commercial point of view, show fully fished and overfished stocks (see *Table 3-1*). Fisheries experts warn that few ocean regions now remain underexploited, signaling that the cycle of relentless fisheries expansion is nearing an end. In a very real sense, greater production has led to greater depletion.

Substituting new stocks for old. In addition to expanding to new fishing areas, fishers have also turned to new species to keep their nets full. Traditionally, most industrial fishers focused their efforts on a relatively small number of highly abundant and valuable demersal species, such as Atlantic cod, flounder and haddock. However, thousands of

Table 3-1: Key Overfished Species by Major Fishing Area

Major Fishing Area	Key depleted (d), overfished (o), and fully fished (f) species
Northwest Atlantic	Atlantic cod (d), haddock (d), flounders (f), hakes (f), shrimps (f)
Northeast Atlantic	Atlantic cod (f/d), capelin (f/d), European plaise (o), European pilchard (o), Atlantic redfishes (o), Atlantic mackerel (o)
Western Central Atlantic	Groupers (f/o?)* croakers/drums (f/o?)* Stromboid conchs (f/o), manhadens (f)
Eastern Central Atlantic	Bigeye tuna (o), tropical spiny lobsters (o), croakers and drums (f/o), squids and octopuses (f/o)
Mediterranean and Black Sea	Shads (d), Northern bluefin tuna (d), albacore tuna (d), European hake (f/o), red mullets (f/o)
Southwest Atlantic	Brazilian sardinella (o), Argentine hake (f/o), Argentine shortfin squids (f/o)
Southeast Atlantic	Kingklip (o), Southern bluefin tuna (o), Cape rock lobster (o), Southern African pilchard (f)
Western Indian Ocean	Indian oil sardine (f), Penaeus shrimps (f), Bombay-duck fish (f)
Eastern Indian Ocean	Croakers and drums (f), Indian oil sardine (f), skipjack tuna (f)
Northwest Pacific	Yellow croaker (f/o), Alaska pollock (f), Pacific cod (f), red fish, basses and congers (f)
Northeast Pacific	Chinook salmon (f/o), coho salmon (f/o), Pacific ocean perch (d), king crabs (f/d), Pacific shrimps (f/o/d)
Western Central Pacific	Bali sardinella (f), yellowfin and skipjack tunas (f)
Eastern Central Pacific	Shrimps & prawns (f/o)
Southwest Pacific	Southern blue whiting (f), Southern hake (f), orange roughy (f), red fishes (f)
Southeast Pacific	South Pacific hake (f/o), Patagonian grenadier (f/o), South American pilchard (d/f/o)
Antarctic	Mackerel icefish (d), Patagonian toothfish (f)
Source: FAO 1997a.	* *A question mark indicates that there is significant uncertainty in the assessment.*

Map 3-1: Period of Peak Catch and Percentage Decline Since Peak Year

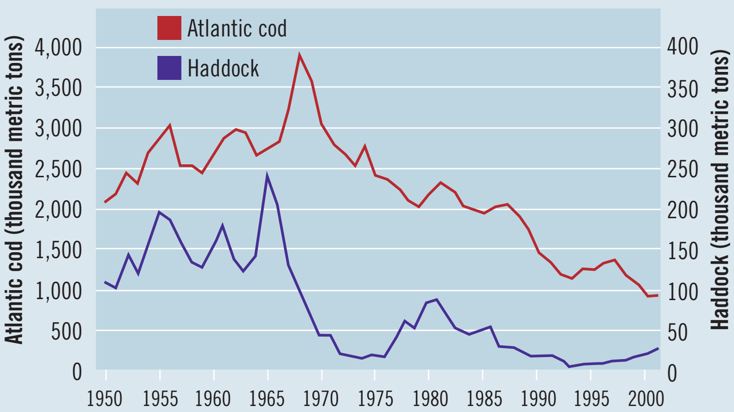


1968 - 1980
1981 - 1990
1991 - 2000
2001

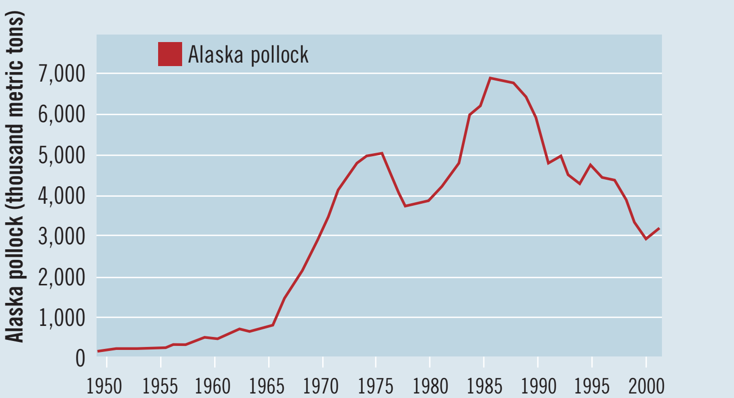
Note: The percentage reflects the decline in the catch from the peak year to 2001. Zero indicates that the fishing area experienced the maximum catch in 2001.

Source: FISHSTAT 2003

Figure 3-2a and 3-2b: As Atlantic Cod and Haddock Catch Declines, the Alaska Pollock Fishery Expands

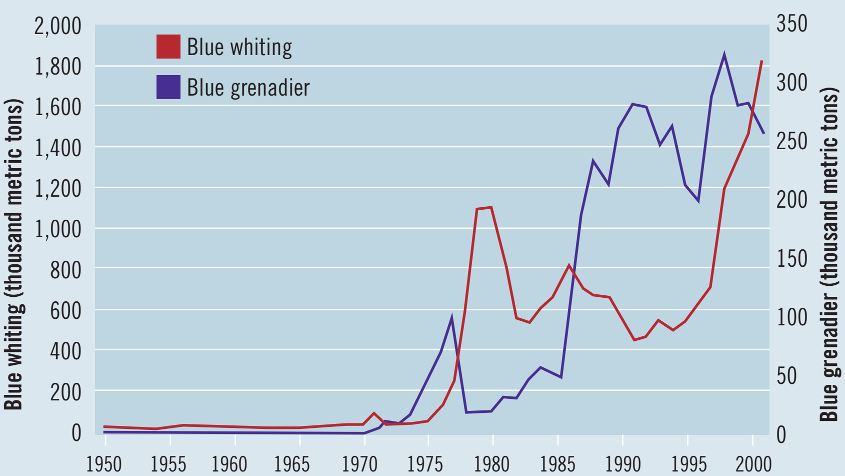


Source: Fishstat 2003.



Source: Fishstat 2003.

Figure 3-3: Species in the Cod Family Increasingly Exploited Since the 1970s, as More Traditional Cod Stocks Decline



Source: Fishstat 2003.

fish species are known to exist in the world's oceans. Improvements in fishing gear and on-board storage technology have allowed many new species to become commercially viable—even species found in remote locations and in deep waters. Many of these new species have acted as effective substitutes for over-fished species, helping to fuel fisheries growth over the last three decades (Grainger and Garcia 1996).

Catch statistics show discernable cases of the commercial replacement of a depleted fishery with a previously underexploited one. For example, the Alaskan pollock fishery dramatically expanded in the 1970s and 1980s as the Atlantic cod and haddock fisheries were in decline (see *Figures 3-2a and b*). Another substitute for depleted white fish such as cod, flounder, hake, and haddock are deep-water fish such as orange roughy and Patagonian toothfish. Although these species were commercially unknown only a little more than a decade ago, they are now widely sold in supermarkets and restaurants. A similar pattern can be seen with small pelagic fish targeted for fishmeal production. Species such as blue whiting, blue grenadier, and Chilean jack mackerel, which were virtually unexploited before the 1970s, are now among the top ten species harvested (*see Figure 3-3*).

Limits of the boom and bust cycle. Once they are targeted for industrial exploitation, fish stocks follow a predictable pattern of boom and bust. Fishing effort rapidly intensifies as more fishermen join in to fish the new resource; the fishery generates high yield until it reaches peak production; the stock begins to be depleted; and the fishery subsequently collapses. This cycle may not take long to run its course. One recent analysis—disputed by some[4]—estimated the effects of industrial fishing in 13 different fisheries around the world and suggested that substantial depletion—defined as an 80 percent reduction in the original fish biomass—typically occurred within 15 years of initial exploitation (Myers and Worm 2003).

For some vulnerable stocks the cycle may be shorter. For example, deep sea species such as deep water sharks, orange roughy and Patagonian toothfish are susceptible to more rapid depletion due to their slow growth and low reproduction rates (FAO 2002a). It took only a few years of intense fishing of orange roughy and Patagonian toothfish before some of the initial fishing grounds were depleted and had to close (Smith 2001).

Once stocks have collapsed, recovery may take years or may never fully occur. The Atlantic cod and haddock that were heavily exploited in the 1950s and 1960s have never recovered and today yield only 30 percent of the peak catch in 1969. Other cod-

[4] Details on the points of contention on this analysis can be found on-line at: http://www.soest.hawaii.edu/PFRP/large_pelagic_predators.html.

3

related species targeted in the 1970s with flagging yields have also not recovered since being heavily depleted. Catches of Alaskan pollock, Argentinean hake, Norway pout, and silver hake have all declined 40-90 percent from their peak production levels (Fishstat 2003).

If overfishing of a stock continues long enough, it can put the fishery at risk of commercial extinction. It was once thought that commercial fish species that were widely distributed and abundant were unlikely to be threatened with biological extinction even if heavily fished. But in recent years it has become clear that this is not the case. A small number of commercial fish species have now joined endangered whales and sea turtles on the *IUCN Red List of Threatened Species* (see *Table 3-2*). Scientists warn that when fish populations become severely depressed, a threshold can be breached making recovery questionable even if fishing effort is reduced or stopped. In May 2003, Canadian biologists declared the Atlantic cod an endangered species after concluding that some stocks face imminent extinction, in spite of the fact that the Canadian cod fishery is closed (COSEWIC 2003). Canadian cod populations have declined more than 99 percent from historic levels (Schiermeier 2002).

Compounding the problem of stock depletion is the likelihood that we cannot keep replacing depleted species with newly-discovered ones indefinitely. In fact, we may already have run out of species that can be used as substitutes for today's declining stocks. FAO statistics from the last decade or so suggest that production of the world's capture fisheries has reached its maximum potential, with the majority of the stocks that can be economically harvested being fully exploited (FAO 2001a). Experts warn that without serious efforts to combat overfishing and restore depleted stocks the harvest from capture fisheries will plateau and eventually decline, perhaps precipitously (Pauly et al. 2002).

WHAT IS THE CURRENT STATUS OF MARINE FISH STOCKS?

Global Status

A comprehensive and accurate assessment of the majority of the world's marine fish stocks is not really possible given today's fisheries data. Only a portion of commercially exploited fish stocks are scientifically and routinely monitored, and even these assessments suffer from many shortcomings (see *Annex A: What Is a Stock Assessment?* and *Annex B: Limitation of Global Fisheries Production, Capture, and Trade Statistics*). As a result, it is hard to determine exactly the condition of all marine fish stocks, and whether they are depleted or not, especially those in tropical waters.

Nonetheless, data collected by FAO and national and regional fishery agencies provide a general picture of the state of marine fisheries. As of 2002, FAO reported that 75 percent of the 441 fish stocks for which information was available are in urgent need of better management. Of these, 28 percent are currently being overfished or are already depleted from past overfishing. Another 47 percent are being fished at their biological limit and cannot sustain increased fishing pressure without risk of collapse (Garcia and De Leiva Moreno 2000; FAO 2002a).

Table 3-2: Selected Fish and Shark Species Threatened by Commercial Exploitation

Common Name	Scientific Name	Red List Status*
Southern Bluefin Tuna	*Thunnus maccoyii*	Critically endangered
Harrison's Deepsea Dogfish	*Centrophorus harrissoni*	Critically endangered
Giant Catfish	*Pangasianodon gigas*	Critically endangered
Brazilian Guitarfish	*Rhinobatos horkelii*	Critically endangered
Pondicherry Shark	*Carcharhinus hemiodon*	Critically endangered
Atlantic Halibut	*Hippoglossus hippoglossus*	Endangered
Borneo Shark	*Carcharhinus borneensis*	Endangered
Common Skate	*Dipturus batis*	Endangered
Freshwater Sawfish	*Pristis microdon*	Endangered
Knifetooth Sawfish	*Anoxypristis cuspidata*	Endangered
Smalltooth Sawfish	*Pristis pectinata*	Endangered
Smoothback Angel Shark	*Squatina occulta*	Endangered
Whitefin Topeshark	*Hemitriakis leucoperiptera*	Endangered
Angel Shark	*Squatina squatina*	Vulnerable
Atlantic Cod	*Gadus morhua*	Vulnerable
Basking Shark**	*Cetorhinus maximus*	Vulnerable
Bigeye Tuna	*Thunnus obesus*	Vulnerable
Giant Freshwater Stingray	*Himantura chaophraya*	Vulnerable
Great White Shark	*Carcharodon carcharias*	Vulnerable
Grey Nurse Shark	*Carcharias taur*	Vulnerable
Gulper Sharks	*Centrophorus granulosus* *Centrophorus squamosus*	Vulnerable Vulnerable
Haddock	*Melanogrammus aeglefinus*	Vulnerable
Sharptooth Lemon Shark	*Negaprion acutidens*	Vulnerable
Smoothtooth Blacktip	*Carcharhinus leiodon*	Vulnerable
Tope Shark	*Galeorhinus galeus*	Vulnerable
Whale Shark	*Rhincodon typus*	Vulnerable
Yellowtail Flounder	*Pleuronectes ferrugineus*	Vulnerable

* Species with a Red List status of Critically Endangered, Endangered and Vulnerable are all considered threatened with extinction.
** The Northeastern Atlantic population is considered Endangered.

Source: IUCN 2003.

Nor is the status portrayed by these numbers likely to remain stable for long. Analysis reveals that of the 200 fish stocks that are commercially most valuable, 35 percent show declining yields, indicating that the state of these fisheries continues to deteriorate (FAO 1997b).

The conventional goal of a fishery is to exploit the stock at its biological limit, but this means that any increase in fishing pressure also increases the risk of overfishing. This makes expansion of the fishery difficult to achieve in a sustainable manner, particularly when our knowledge of fishery conditions is incomplete.

Regional and National Status

In some cases, assessments conducted by national and regional fishery agencies provide a more detailed, although fragmented, picture of how fish stocks in particular regions are doing. One note of caution here is that countries use different methods of assessment and different criteria for categorizing the status of fish stocks, sometimes generating conflicting results. For example, members of the Commission for the Conservation of Southern Bluefin Tuna (CCSBT)—namely Australia, New Zealand, and Japan—undertook separate assessments of the bluefin tuna stock and arrived at different conclusions, resulting in disagreement on what the total allowable catch should be (Foster 2001).

National data reveal that stock assessments are regularly conducted for only a small fraction of species that are commercially exploited. In the United States, for example, only 304 out of 959 commercially fished stocks have been assessed, and this represents a relatively high rate of assessment compared to most countries (NMFS 2001a). Of the 304 assessed stocks, 175 are major stocks representing a considerable portion of the US fish landings. Of the remaining 655 stocks, whose status is unknown, 18 percent are major commercial stocks (NMFS 2001a). In the 2001 assessment of fish stocks in United States waters, a total of 27 percent were found to be overfished (NMFS 2001a).

In Japan, catch statistics on about 600 species are reported to the FAO database. Of the 81 Japanese stocks assessed in 2002, more than 50 percent (42 stocks) are considered to be at a "low" abundance level or a "mid" abundance level with a declining trend (JFRA 2002).

In European Union (EU) waters, about 70 stocks are assessed annually. Approximately 40 percent of the stocks assessed in 2000 were found to be depleted (European Commission 2000).

Together, these estimates give a good sense of the severity of commercial stock depletion in the Northern Hemisphere and the challenges that face fishery managers as they try to find ways to reduce fishing pressure and allow stocks to recover.

In the Southern Hemisphere, summary information on the condition of fish stocks is not as readily available, with many countries only assessing a few of their commercial stocks on a regular basis. Argentina, for example, commercially exploits about 99 species (Fishstat 2003), of which a few key stocks are regularly assessed. Several of these stocks, including Argentinean hake, Southern blue whiting, Patagonian toothfish, seatrout, and flathead are all currently being overexploited (Prado and Drew 1999). In Chile, which fishes about 131 species (Fishstat 2003), pelagic resources including horse mackerel, anchovy, and sardine are all heavily exploited (Prado and Drew 1999).

In Australia, about 600 marine and freshwater species are caught and marketed (FRDC 2003). The Australian Commonwealth manages 19 fisheries outside the 3-nautical-mile limit of which 67 species or stocks have been assessed (Australian Bureau of Rural Science 2004; AFFA 2003). Most known species are at or near full exploitation, and several, such as southern bluefin tuna, school shark, tiger prawn, and Torres Strait lobster are overfished (Australian Bureau of Rural Sciences 2004).

Namibia exploits 55 species, including hake, pilchard, horse mackerel, monkfish, orange roughy, rock lobster, and tuna (Fishstat 2003). With the exception of pilchard and orange roughy, catch quotas for commercial species have been increasing in the past 5 years, in response to government policies to rebuild stocks that were put in place after independence in 1990. According to Namibia's Ministry of Fisheries and Marine Resources (2002), the general status of all but one of the main commercial stocks in Namibian waters is promising.

Finally, in India, which exploits 121 species (Fishstat 2003), including the Indian oil sardine, Indian mackerel, anchovies, cephalopods, and perch, most major stocks are fully exploited (FAO 2000f).

These estimates show that our knowledge about the condition of fish stocks in the Southern Hemisphere is partial, and that many are not regularly assessed. This is particularly true in developing countries, where capacity and resources are limited. From the few countries for which information is available, most monitored stocks are being exploited at their biological limit, and a few important stocks are being overfished.

The conventional goal of a fishery is to exploit the stock at its biological limit, but this means that any increase in fishing pressure also increases the risk of overfishing. This makes expansion of the fishery difficult to achieve in a sustainable manner, particularly when our knowledge of fishery conditions is incomplete. These estimate also show, that government policies to rebuild stocks in Namibia and Australia are for the most part working.

WHAT ABOUT THE CONDITION OF FRESHWATER FISH STOCKS?

Determining the status of freshwater fish stocks is even more problematic than assessing marine stocks. Despite the importance of inland fisheries to the livelihood and nutrition of the rural poor in many developing countries, the level of knowledge about freshwater fish stocks is quite dismal. The use of catch statistics to assess stocks, which is common practice with marine species, is difficult because much of the inland catch is underreported—by a factor of 3 or 4 according to FAO (FAO 1999a; FAO 2000a). And although recent efforts have focused on developing easier survey methods, such as electronic fish counters and echo-sounding equipment (Hickley 1996) that can count migratory fish in rivers, these are applicable to only a small number of fish species and localities. Indeed, FAO considers its data on freshwater harvests and stock conditions so uncertain that it declined to give a comprehensive analysis of inland trends in its latest report on the state of world fisheries and aquaculture (FAO 2002a).

Nevertheless, there is little dispute that major increases in the harvest of freshwater fish have occurred over the last two decades. Much of this increase is the product of enhancement efforts such as fish stocking and the introduction of non-native fish species in lakes and rivers. As in the case of marine fish stocks, increased freshwater harvests do not indicate healthy freshwater fish stocks or healthy aquatic ecosystems. In fact, evidence indicates that most freshwater systems are stressed by habitat loss and degradation, the introduction and presence of invasive species, pollution, overfishing, and the disruption of river flows by dams and other water diversions (Revenga et al. 2000). FAO's last major assessment of inland fisheries (FAO 1999a) reported that most inland capture fisheries that rely on natural reproduction of the stocks are overfished or are being fished at their biological limit and that the principal factors threatening inland capture fisheries are fish habitat loss and environmental degradation.

Lake Fisheries Status

Some large lakes have been systematically studied because of their importance as a fishery resource. The North American Great Lakes are a case in point. The USGS Great Lakes Science Center conducts annual fish stock assessments for commercially important salmonoid species, such as lake trout and Pacific salmon, and their prey species (e.g., alewife, rainbow smelt, bloater, sculpin and lake herring), using bottom trawl and hydroacoustic surveys (USGS 2003). The prey population assessments for the five lakes show that with the exception of Lake Superior, whose status is mixed, but improving, prey species in the other four lakes are all deteriorating (USGS 2003).

With respect to predator species in the lakes, many native species like lake trout and sturgeon are found in vastly reduced numbers and have been replaced by introduced species, while others such as coho and chinook salmon are only maintained by hatchery-reared fish (Great Lakes Atlas 2003). Important commercial species, such as blue pike and Lake Ontario Atlantic salmon are believed to be extinct (Great Lakes Atlas 2003) and in 19 of the 20 states within its original range, lake sturgeon are listed as either threatened or endangered under the U.S. Endangered Species Act (USFWS 2003).

Fish market in Thailand.

FAO/18568/ R. FAIDUTTI

Other regularly assessed lakes include Lake Victoria and Lake Tanganyika in Africa. These lakes also show a decline in native fisheries and their replacement with exotic species.

One of the faces of the fisheries depletion in inland waters is the collapse of native fish stocks even as overall fish production rises—a biodiversity crisis more than a fisheries crisis.

River Fisheries Status

Rivers are more diverse in their characteristics than large lakes and reservoirs, and consequently fish stock assessments require more complex methods. Some migratory species, such as salmon and trout are relatively well studied in developed countries, but even these assessments tend to be difficult because of the widespread distribution of life stages of migratory species and the lack of biological information about them.

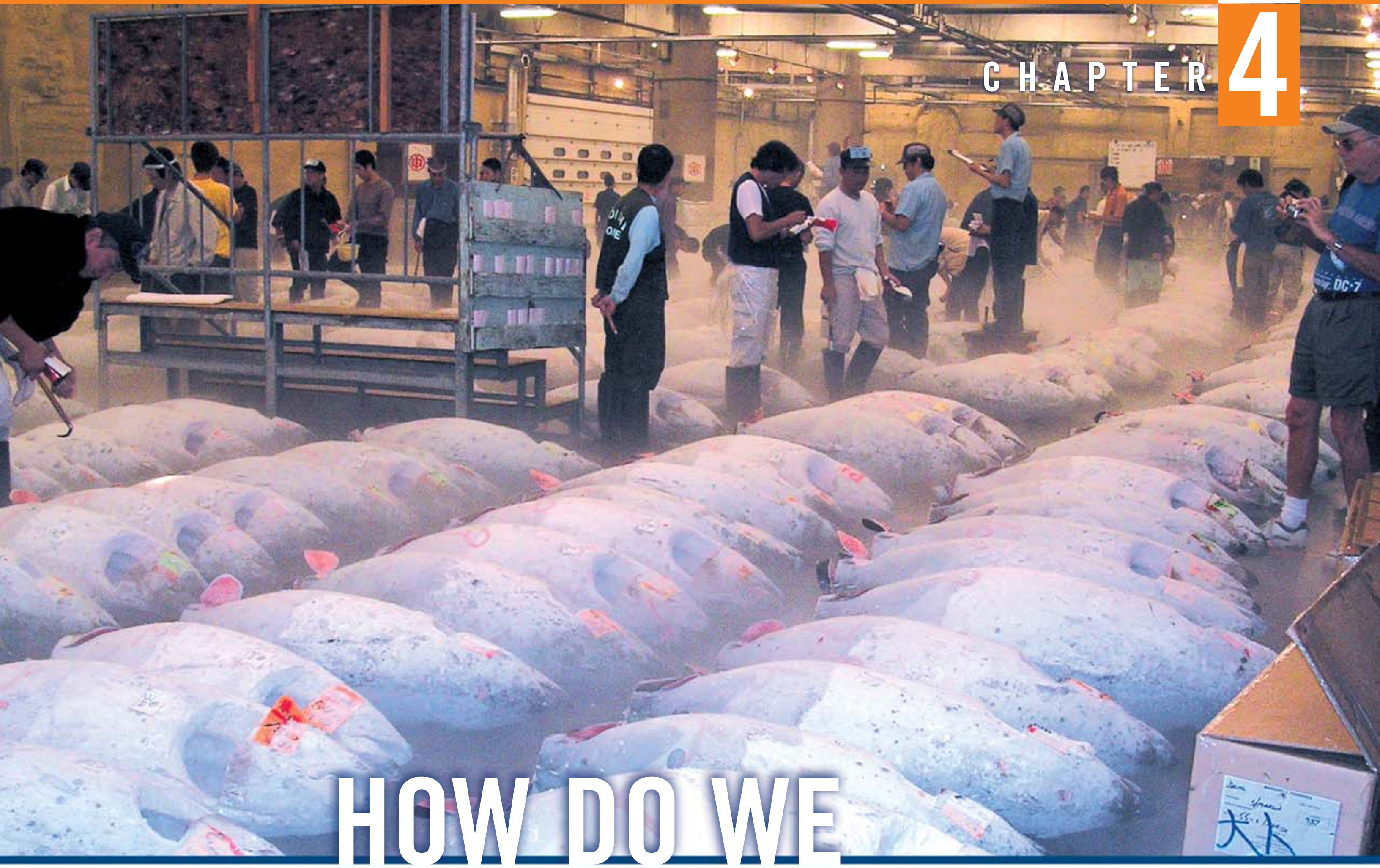
The few examples of freshwater fish assessments show that many inland fisheries of traditional importance have declined precipitously. The European eel fishery, for example, has steadily declined over the last 30 years with important socioeconomic and biological implications. According to the International Council for the Exploration of the Seas (ICES), the European eel fishery maintains 25,000 fishermen and is the most widespread fishery under the ICES management area (Dekker 2003). In the mid-1980s, the number of new glass eels (eel juveniles) entering European rivers declined to 10 percent of former levels. Recent figures show that this has now dropped to 1 percent of traditional level, putting this important fishery "dangerously close to collapse" (Dekker 2003). Some of the causes contributing to this drastic decline include overfishing, freshwater habitat loss and degradation, pollution, diseases, and changes in climate and ocean currents. Because of the gravity of the situation, ICES and FAO's European Inland Fisheries Advisory Commission have initiated new international management measures for this shared stock (Dekker 2003).

Other fish stocks for which there is longer-term catch and status information include Pacific and Atlantic salmon in North America, fisheries of the Rhine and Danube Rivers in Europe, and fisheries of the Pearl River in China. All of these have declined to just a fraction of their former levels due to overexploitation, river alteration, and habitat loss, putting some of these species at serious risk of extinction (Bacalcaça-Dobrovici 1989; Lelek 1989; Liao et al. 1989; WDFW and ODFW 1999).

Finally, even fisheries that until recently were reasonably well managed, such as the caviar-producing sturgeons in the Caspian Sea, and fisheries from relatively intact rivers such as the Mekong in Southeast Asia are rapidly declining. For example, while almost all the 25 species of sturgeon in the world have been affected to some degree by habitat loss, fragmentation of rivers by dams, pollution, and overexploitation, much of the recent decline in the catch of caviar-producing sturgeon is a direct result of overfishing and illegal trade (De Meulenaer and Raymakers 1996; WWF 2002). Ninety percent of the caviar consumed in the world comes from just four species of sturgeon in the Caspian Sea (De Meulenaer and Raymakers 1996). Experts believe that major sturgeon populations have already declined up to 70 percent (WWF 2002). The decline has been so drastic that the five Caspian States agreed to establish the first unified system for surveying and managing sturgeon stocks (UNEP 2002a). Unfortunately, illegal harvesting and unregulated domestic consumption continue to threaten the long-term survival of Caspian Sea sturgeon species (UNEP 2002a).

In the Mekong two important fish species—the giant catfish and Jullien's golden carp—are threatened with extinction according to *IUCN's Red List of Threatened Species* (2003). The giant catfish in particular has recently been upgraded from endangered to critically endangered (IUCN 2003), and the giant barb (*Catlocarpio siamensis*), an endemic species in the Mekong considered one of the world's largest cyprinid fish, is becoming increasingly rare (Mattson et al. 2002).

These examples show that inland fisheries are under pressure in most parts of the world, even though catches of selected species continue to grow. In many instances, harvests of introduced species—such as tilapia, carp, or Nile perch—mask this serious decline by substituting for wild or native species. In most cases, however, these introductions have actually hastened the decline of indigenous fish. In Africa's Lake Victoria, the introduction of Nile perch and Nile tilapia in the 1950s has led to near extinction of more than half of the native species of cichlid fish—the basis of the lake's traditional subsistence and commercial fishery (Witte et al. 1992; Kaufman 1992). Thus, one of the faces of the fisheries depletion in inland waters is the collapse of native fish stocks even as overall fish production rises—a *biodiversity crisis* more than a fisheries crisis.



CHAPTER 4

HOW DO WE CATCH, USE, AND TRADE FISH?

E. HOSHINO, WRI 2003

This chapter traces the world's "fish flows" to give readers some insight into the real globalization of fishing as well as some perspective on the geographic impacts of the purchasing choices they make. We address the issues of who produces and consumes fish, which fish consumers prefer, what is done with the fish once it is caught, and how the global fish trade figures into this balance.

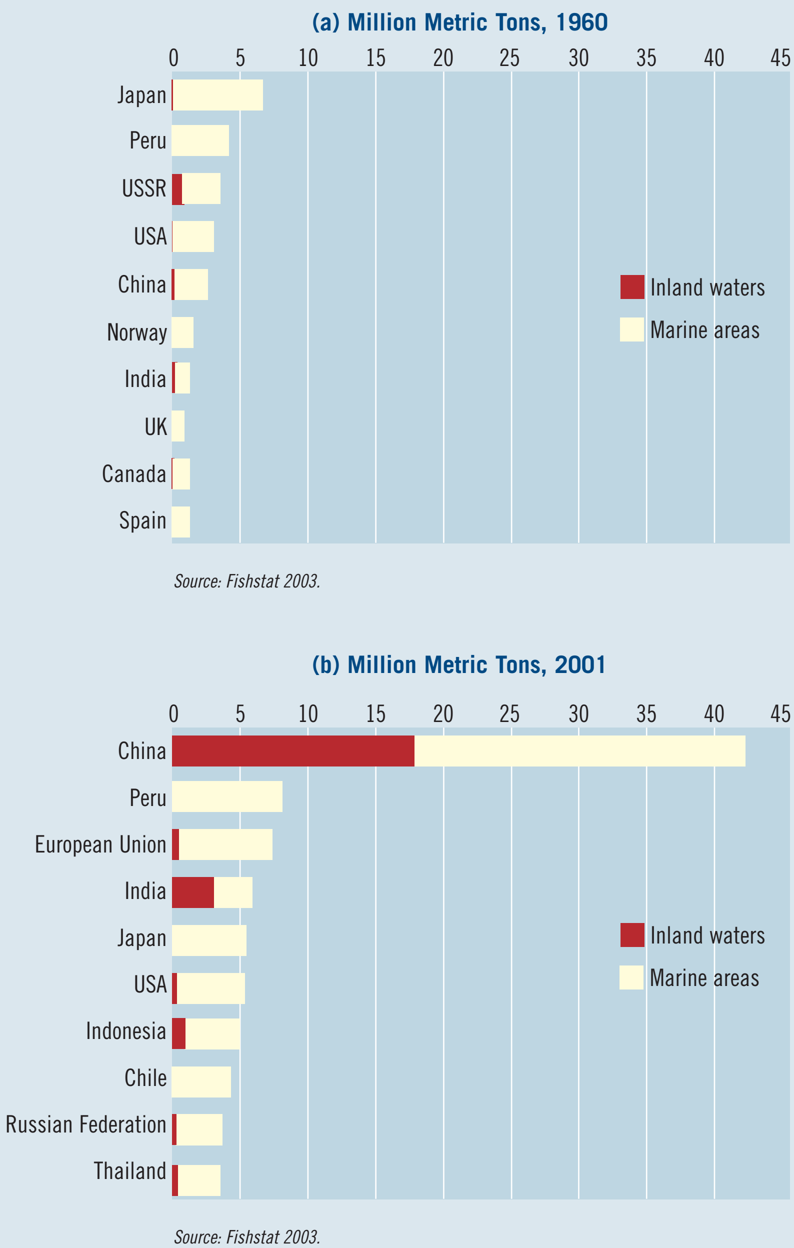
To facilitate the reader's understanding of this chapter, the differences between the terms fish production and fish capture are explained. Within the fisheries context *production* refers to marine and inland capture fisheries as well as aquaculture; while *capture or harvest*, refers exclusively to wild caught fish. Top fish producing nations, therefore are those with the highest tonnage of capture and aquaculture fish combined; while the top marine fishing nations are those countries that have the highest tonnage from marine capture fisheries alone. The chapter highlights the change over time in the ranking of fishing nations from both a production and wild harvest perspective.

WHO ARE THE TOP FISH PRODUCING NATIONS AND WHAT TYPES OF FISH ARE PRODUCED?

Prior to the 1950s, only a handful of countries had industrial fishing fleets. They operated mostly in the North Atlantic and the North Pacific, and only a few harvested more than 1 million metric tons (MT) of fish per year. Today, more than 20 countries regularly produce 1 million MT or more per year, either through wild harvest of fish or aquaculture (Fishstat 2003).

While in 1960 only three developing nations—Peru, China and India—made the list of top ten fish-producing countries (see *Figure 4-1a*), developing nations now account for half of the top producers. This is a measure of the profound shift in fish production that occurred through the 1970s and 1980s: developing nations now produce more than 70 percent of the fish consumed by humans (Delgado et al. 2003). In 2001, the top ten fish-producing nations were China, Peru, the European Union (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, The Netherlands, Portugal, Spain, Sweden, and UK), India, Japan, United States, Indonesia, Chile, the Russian Federation, and Thailand (see *Figure 4-1b*).

Figure 4-1a and 4-1b: Top Ten Fish Producing Nations (marine and inland, wild capture and aquaculture), 1960 and 2001



Changes in national fish production over the years reflect a variety of influences, from changes in international maritime law to national investments in fleet expansion. For example, in 1960 and up until the late 1980s, Japan caught and farmed by far the largest quantity of fish in the world (see *Figure 4-1a* for 1960s production figures). This reflected its strong cultural, dietary, and economic reliance on fish, and a substantial "distant water" fleet that fished well beyond Japanese coastal waters, off other nations' coasts and in the high seas. But by 1990, the Japanese catch started to drop, due in large part to adoption of the United Nations Convention on the Law of the Sea (UNCLOS) (see *Chapter 9* for discussion on UNCLOS and its effect on distant water fleets). This treaty gave coastal nations exclusive rights to exploit the resources in waters within 200 nautical miles[5] of their coast, a zone where Japanese distant water fleets had formerly operated extensively but were now increasingly displaced by local fleets.

As Japan's wild catch declined, other countries filled the gap (see *Figure 4-1b*). The most notable increase in production has occurred in China over the last 15 years. In 1960, China's fisheries production totaled less than 5 million MT; by 2002, that had skyrocketed to some 43 million MT, mostly on the strength of a huge surge in inland aquaculture production. Recent analysis shows that China's fish production data are probably somewhat overestimated, but no one disputes that the country's fisheries expansion far exceeds that of other nations, allowing it to greatly increase both its internal consumption of fish as well as its fish exports (Watson and Pauly 2001; FAO 2002b). Other nations also made quantum leaps to join the top ranks of fish producers. Both Chile and Indonesia, for example, have quadrupled their fish catches since 1970 (Fishstat 2003).

Although all the top fishing nations produce millions of tons of fish, the types of fish that dominate production varies (see *Tables 4-1 and 4-2*). For example, freshwater fish, primarily carp and other pond-raised fish, dominate production in China and India. The Chilean and Peruvian catch, on the other hand, depends mostly on the harvest of anchoveta—a small pelagic fish used to make fishmeal. Because the anchoveta population can swing widely depending on natural conditions, the harvest from these nations varies widely as well. Fish production from Japan, the United States, Norway, and the European Union relies more heavily on demersal species including groundfish from the cod family, but also on a variety of small pelagics (e.g., herring), and migratory and diadromous species such as tunas and salmonids (see *Table 4-1*).

[5] One nautical mile equals 1.85 kilometers or 1.15 miles.

4

WHAT FISH DO THE TOP FISHING NATIONS HARVEST FROM THE WILD?

The majority—about two thirds—of the world's fish production comes from marine capture fisheries or wild harvest. In 2001, the top marine fishing nations were China, Peru, the European Union, the United States, Japan, Indonesia, Chile, the Russian Federation, India, and Norway—all the same nations, with the exception of Norway, that dominate total fish production (including inland fishing and aquaculture). (See *Table 4-1*).

Whereas production from marine capture fisheries seems to have reached its maximum potential, production from inland capture fisheries and inland aquaculture has dramatically increased in recent years. As mentioned in Chapter 3, this is partly due to extensive enhancement efforts such as stocking and introduction of new fish species in lakes and rivers, and an increase in aquaculture production (see *Chapter 6*).

In terms of inland capture fisheries, China is the modern powerhouse, accounting for about one quarter of the world's inland catch. However, it is important to note the prevalent underreporting of inland catch in many developing and developed countries.

Other countries with significant inland catches are India, Bangladesh, Cambodia, Indonesia, Egypt, Tanzania, Myanmar, Uganda, and Thailand—all developing or transition economies where production has rapidly increased over the last 10-15 years. Table 4-2 presents the top ten countries in terms of inland capture and inland aquaculture. In both cases, "inland" refers to both inland and brackish waters.

WHICH NATIONS CONSUME THE MOST FISH AND WHAT FISH DO THEY EAT?

Once caught, fish are used in a variety of ways. A portion—some 77 percent in 2001—are directly consumed by humans, while most of the remaining 23 percent are processed into fishmeal and fish oil that are primarily used for livestock and aquaculture feed (FAO 2002a). Nearly all the fish used for fishmeal and oil come from small pelagics such as anchoveta and pilchard.

Of the fish consumed directly by humans, 54 percent are marketed as fresh fish and the rest are processed—through freezing, canning, or curing—to preserve them. The percentage of preserved fish has been falling in recent years as the desire for fresh fish has surged. Between 1990 and 2000, the quantity of fresh fish sold rose 85 percent, driven by the popularity of seafood for its health benefits, particularly in developed countries (FAO 2002a).

According to FAO (2003c), the countries that consume the most fish in terms of total quantity are China, Japan, United States, India, Indonesia, the Russian Federation, South Korea, Philippines, Thailand, and the European Union (particularly Spain) (see *Figure 4-2*). But comparing per capita fish consumption tells a different story. Among the countries on the top 10 fish-consuming list, each Japanese eats 2.5 times as much fish as each Chinese does, and three times as much as an American or a Russian does. In fact, if countries are ranked by per capita fish consumption, many of the top fish-consuming countries are small island nations, such as Tokelau, Maldives,

Table 4-1: Top Marine Fishing Nations, 2001

	Country/Region	Marine Capture (metric tons)	Share of Total %	Top Species Caught
1	China	14,379,457	17.2	Miscellaneous marine fishes, molluscs and crustaceans*, large head hairtail, Japanese anchovy
2	Peru	7,950,450	9.5	Anchoveta, Chilean jack and chub mackerel, anchovies, South Pacific hake
3	European Union	6,031,308	7.2	Sandeels, Atlantic herring, Atlantic mackerel, European sprat, blue whiting
4	USA	4,915,128	5.9	Alaska pollock, Gulf and Atlantic manhaden, Pacific cod, pink salmon
5	Japan	4,659,716	5.6	Chub mackerel, Japanese anchovy, Japanese flying squid, Yesso scallop, skipjack tuna
6	Indonesia	3,898,271	4.7	Marine fishes nei*, scads, skipjack tuna, kawakawa, Indian mackerels
7	Chile	3,797,143	4.5	Chilean jack mackerel, anchoveta, chub mackerel, Araucanian herring, Patagonian grenadier
8	Russian Federation	3,422,117	4.1	Alaska pollock, blue whiting, Pacific herring, Atlantic cod, capelin
9	India	2,787,940	3.3	Marine fishes nei*, Indian oil sardine,croakers, drums, giant tiger prawn, hairtails, scabbardfishes
10	Norway	2,686,733	3.2	Atlantic herring, blue whiting, capelin, Atlantic cod, sandeels
	Other	29,153,771	34.8	
	Total	83,682,034	100.0	

* Much of the catch by some countries is not reported at the species level, but grouped in a general class of "marine fish nei.," which stands for "not elsewhere included."

Source: Fishstat 2003.

Kiribati, and the Seychelles, along with other traditional fishing nations in the developed world such as Iceland, the Faeroe Islands, Japan, Norway, Portugal, and Spain (Laureti 1999; Laurenti 2002).

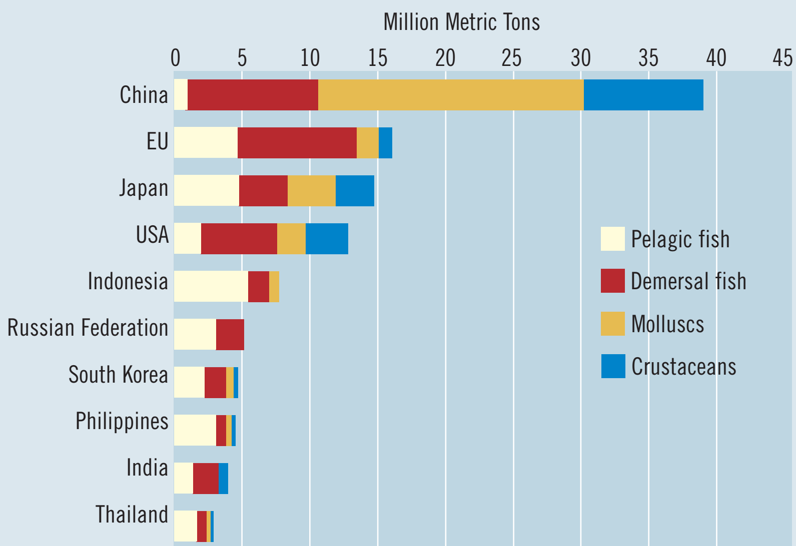
Market studies and household surveys provide a glimpse of the kinds of fish consumed in many countries. In Asia, freshwater fish play a large role in the national diet, comprising over 50 percent of the fish eaten in India and around 40 percent in China (as of 1997) (Laureti 1999). Almost all the fish—freshwater and marine—consumed in China used to be entirely domestically produced, but that may be changing as personal incomes rise. A recent survey in Shanghai indicates an increasing demand for high-value imported seafood, such as salmon, among more affluent households. Overall, the market for imported high-value seafood in China is still "in the initial stages of growth," according to analysts (Zhang 2002).

On the other hand, Japan now imports almost 50 percent of the fish it consumes as food—a figure that increased from less than 20 percent in the early 1980s. A wide variety of fish species are still consumed in Japan, but preferences have changed over the last 40 years. Consumption has shifted from relatively low-value species like scad, mackerel, and squid that were domestically produced to high-value fish including tuna, salmon, shrimp, and crab that are largely imported (JMAFF 1999 and 2002a).

Spain consumes a relatively balanced list of fish species as food. These include white fish such as hake and whiting (18%), pelagics such as sardine and anchovy (14.4%), cephalopods such as octopus and squid (9.1%), flat fish such as flounder (7.5%), shrimp (5.4%), and salmon (3.5%). Farmed mussels are a popular item for domestic consumption and are also the top seafood for export (World Fishing Companies 2002).

For the last 30 years the United States has imported almost 50 percent of the fish it eats. According to the U.S. National Fisheries Institute, the ten most popular seafood species are almost all high-value fish, including shrimp, tuna, salmon, pollock, and catfish.

Figure 4-2: Top Ten Food Fish Consuming Nations and Regions, 2001



Source: FAOSTAT 2003.

Table 4-2: Top Inland Fish Producing Nations, 2001

	Country/ Region	Inland Capture* (MT)	Share (%)	Country/ Region	Inland Aquaculture (MT)	Share (%)	Top Cultured Species
1	China	2,149,932	24.7	China	15,949,588	73.3	Grass, silver, common, and bighead carps
2	India	974,710	11.2	India	2,098,447	9.6	Roho labeo, Catla, Mrigal, grass, and common carp
3	Bangladesh	670,000	7.7	Bangladesh	598,500	2.8	Roho labeo, silver carp, Catla, common carp
4	Cambodia	360,000	4.1	Indonesia	401,029	1.8	Milkfish, common carp, Mozambique and Nile tilapia
5	Indonesia	306,560	3.5	Viet Nam	390,000	1.8	Unspecified freshwater fish and crustaceans
6	Egypt	295,422	3.4	USA	331,957	1.5	Channel catfish, rainbow trout, red swamp crawfish, tilapias, cyprinids
7	Tanzania	283,000	3.3	Thailand	289,631	1.3	Nile tilapia, catfish hybrid, Thai silver barb, snakeskin gourami, giant river prawn
8	Myanmar	235,376	2.7	EU	250,505	1.2	Rainbow trout, common carp, European eel.
9	Uganda	220,726	2.5	Taiwan	184,338	0.8	Tilapias, milkfish, Japanese eel, Asian clam, giant river prawn
10	Thailand	209,977	2.4	Brazil	164,000	0.8	Common carp, tilapias, cachama, characins
	Other	2,987,055	34.4	Other	1,089,558	5.0	
	Total	8,692,758	100.0	Total	21,747,553	100.0	

* Top species caught in inland waters are not included in this table because wild-caught inland fisheries are rarely reported at the species level. They are usually reported as "freshwater fish," "freshwater crustaceans," etc. The European Union catch does not appear in the production statistics that are shown in the first 3 columns of this table because the majority comes from recreational fishing.

Source: Fishstat 2003.

Of all fish consumed, demersal fish account for over 40 percent. Shrimp consumption is also climbing rapidly—increasing by more than 50 percent per person in the last 10 years—making shrimp the most popular seafood in the United States (National Fisheries Institute 2002).

HOW IMPORTANT IS THE INTERNATIONAL FISH TRADE?

More than one third of all the world's fish production now enters international trade—more than three times the percentage of global meat production that is traded (Delgado et al. 2003; FAO Yearbook of Fishery Statistics 2003). For this reason, understanding the trade flow of key fish products is essential to understanding the dynamics of the fishing industry, and ultimately the pressures on fish stocks. Global trade in fish products has expanded considerably in the last two decades, both in terms of quantity and value. Improvements in preservation and refrigeration technology, transport, and communication, as well as a sustained growth in demand, have made this possible.

Japan, the United States, and the European Union are the "Big Three" consumer markets for internationally traded seafood, consuming about 80 percent of all the fishery products traded (Sabatini 2001). The fish most popular in these three markets inevitably account for a large proportion of the total value of the trade.

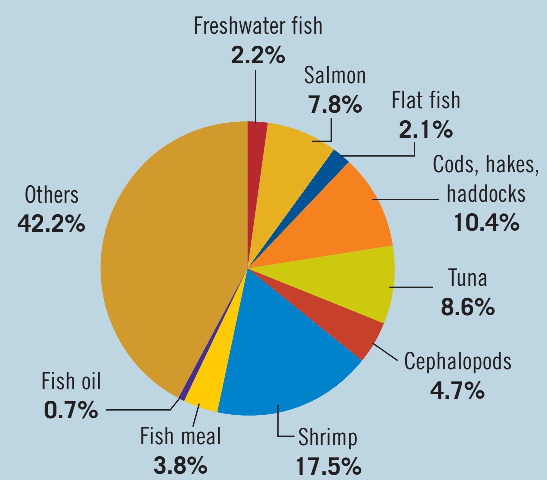
In terms of supply, developing countries as a whole generate around 50 percent of total fish exports, in both value and quantity. Thailand and China are the top exporters of fish by value, exporting respectively US$4.4 and US$3.7 billion worth of fishery products in 2000 (Fishstat 2003). Developing countries also consume about one third of all fish imports in terms of quantity, but these are often lower-priced items, so these imports only account for 17 percent of the total value of the international fish trade (Sabatini 2001). This means that the majority of internationally traded seafood is destined for developed countries and consists largely of high-priced products, such as frozen shrimp and prawns.

An important factor in the growth of the fish trade has been the advances made in freezing technology, allowing exporters to deliver a fresher, tastier product. In the past, due to its highly perishable nature, fish had to be canned, dried, cured, or otherwise preserved before it could be traded. Today, fish and shellfish for human consumption are traded mostly as a frozen food, although canning and curing are still important. Trade of live, fresh, or chilled fish—about 15 percent of fish exports—has also increased as the capacity for air shipment has grown (Sabatini 2001).

Until recently, developing countries primarily exported raw materials for processing in developed countries. Their role in producing value-added products—such as canned fish and frozen fillets—was limited partly because of the high energy requirements; inability to meet quality control and hygiene standards required by developed country markets; and in the view of some, because of protectionism of developed country markets. However, with upgraded facilities now available, developing countries are increasingly exporting semi-processed products, especially to Europe, for further value-added processing there (Sabatini 2001).

The commodities that are traded in largest quantities are fish meal, frozen fish fillets, frozen shrimp, frozen squid, and canned tuna and bonito. In terms of value, however frozen shrimp rank the highest, by far, although they are not traded in as great a quantity as fish meal and fish fillets (Fishstat 2003) (see *Figure 4-3*).

Figure 4-3: Most Traded Species by Value, 2001



Source: Vannuccini 2003.

OVERVIEW OF THE TOP TRADED FISH PRODUCTS

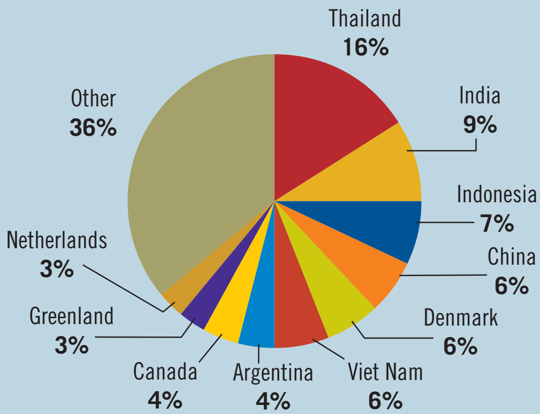
Among the top traded fish products are shrimp, tuna, and fish meal. The top producers and consumers for each are listed below.

Shrimp. Shrimp are one of the most popular seafood items in developed countries, and an important source of revenue for many developing countries. Although traded in smaller quantity than ground fish or tuna, shrimp bring in over US$12 billion per year in trade revenue—about 20 percent of the total import value of the international seafood trade (Fishstat 2003). In fact, shrimp—whether wild caught or farmed—are mainly produced for export and, on average, 90 percent of the global harvest is exported. The top producers are centered in South and Southeast Asia, while the top markets for shrimp are Japan, the United States, and Europe (Sabatini 2001) (see *Figures 4-4a and 4-4b*).

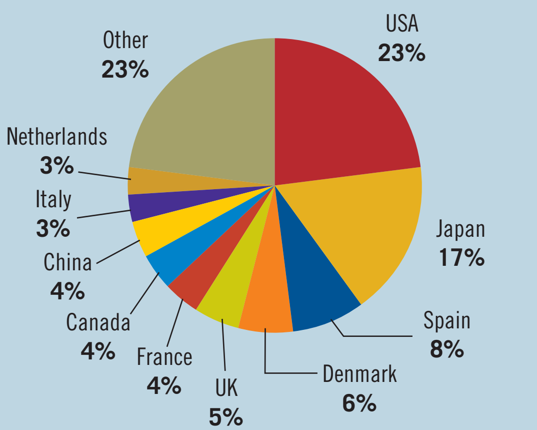
World shrimp production reached 4.2 million MT in 2000, including both wild capture and farmed. China remains the world's largest producer by far, harvesting some 1.2 million MT annually. Other top producers include India, Thailand, and Indonesia, each averaging over 300,000 MT throughout the 1990s. Thailand is the world's leading shrimp exporter, commanding 16 percent of the export market in 2001 (Fishstat 2003) with exports more than tripling over the last 10 years. India and Indonesia are also major exporters, each with around 7-9 percent of the export market (Fishstat 2003).

Figure 4-4a and 4-4b: Top Shrimp Exporters and Importers, 2001

(a) Top 10 Shrimp Exporters by Weight, 2001



(b) Top 10 Shrimp Importers by Weight, 2001



Source: Fishstat 2003.

The United States is the largest import market, importing over 80 percent of the shrimp it consumes. That means U.S. shrimp imports make up nearly one quarter of the world's shrimp trade. The second largest market is Japan, with a 17 percent share. Spain and Denmark follow, with much smaller shares. The European Union as a whole, however, accounts for roughly one third of the shrimp import market (Sabatini 2001; Fishstat 2003).

Tuna. Tuna, another widely consumed seafood, is a cornerstone of the global fish trade. The world tuna market can be divided into two distinct types: the high-priced "sashimi" market, which is consumed fresh and uncooked; and the low-priced canned tuna market. The sashimi market relies on bluefin, bigeye, and yellow fin tuna, while the canned tuna market uses mostly skipjack, albacore, and bonito.

Global capture of tuna was about 3.6 million MT in 2000 (Globefish 2002a). Japan remained the world's top producer in 2000, harvesting 630,000 MT—a slight decline from its peak in the late 1980s. Eighty percent of the tuna imported by Japan is used for sashimi (OPRT 2002) and it consists mainly of fresh or frozen bigeye, yellow fin, and bluefin tuna flown in from Indonesia, one of Japan's major suppliers. The Japanese also import a large quantity of frozen skipjack tuna that is processed primarily into canned and dried products (Heibonsha 2000). In contrast, Taiwan and Indonesia, who are also top producers, more than doubled their production during the 1990s (Globefish 2002a) (see *Figures 4-5a and 4-5b*).

During the 1980s and 1990s, Thailand grew into a leading producer of canned tuna, second only to the United States. But Thailand does not always catch all the tuna that it cans. Much of its canned production originates as imported, frozen skipjack tuna, which it then cans and re-exports, primarily to the United States (see *Figure 4-5a*). The United States and the European Union are the largest markets for canned tuna. In fact, the United States accounts for about one third of the world's canned tuna consumption, although this figure has dropped in recent years (FAO 2000a).

Fish Meal. Fish meal and fish oil are increasingly valued trade commodities, largely because of their importance to the ever-expanding aquaculture industry. The source of these protein and fat-rich commodities is generally the small pelagic species that are oily and bony, and therefore less desirable for human consumption—species such as herring, sardine, mackerel, anchovy, pilchard, sand eel, and menhaden. Low-value bycatch species and waste from fish processing plants are also important source materials. Fishmeal and oil are used mainly as feeds for poultry, pigs, and in aquaculture operations for carnivorous species, such as salmon and shrimp.

Around 29.4 million MT of fish—nearly one third of the world's total capture fisheries production—were reduced to fish meal and fish oil in 2001 (FAO 2002a). This yielded some 6.5 million MT of fish meal after processing. Peru ranks as the world's top fishmeal processor, producing more than 1.5 million MT in 2001. Chile and China followed, each producing close to 800,000 MT (Fishstat 2003).

Peru is also the top exporter of fish meal, commanding almost half of the global export market in 2001 (Fishstat 2003). Chile, Denmark, and Iceland are also major exporters. Peruvian fish meal exports are directed mainly to China for animal feed production and to other countries for aquaculture. More than one third of the world's fish meal exports now end up in the Far East (Globefish 2001).

WHAT ARE THE MORE RECENT ADDITIONS TO THE FISH TRADE?

As traditionally marketed fish dwindle due to overfishing, several non-traditional species have been introduced into world trade to accommodate rising demand for fresh or frozen fillets. Typically, these fish are targeted at high-end markets in developed countries.

Some of these are fast-growing exotic species introduced to freshwater environments. Others are deep-sea fish that, until recent technical advances, were not economically viable to harvest. Unfortunately, commercial exploitation is often accompanied by significant environmental impacts, including displacement of native species by exotic species, and rapid depletion of vulnerable fish stocks.

Nile Perch: The Nile perch is a large freshwater fish found in the rivers and lakes of Africa. It is also known as Lake Victoria perch, *capitaine, mputa,* or *sangara*. The introduction of this species to Lake Victoria in the 1950s is a good illustration of a trade-off between economic gain and biodiversity loss. The perch soon established itself in Lake Victoria, the world's largest tropical lake, and a commercial fishery developed. Production of Nile perch increased dramatically in the 1980s, giving rise to a robust export market for the delectable white-fleshed fish.

The Nile perch fishery in Lake Victoria produced an average of 320,000 MT in the 1990s (Fishstat 2003), generating between US$280 and US$400 million in export earnings (Kaufman, pers. comm. 2000). Kenya, Tanzania, and Uganda account for over 90 percent of total production. Their success in tapping export markets is a result of efforts to develop domestic processing capacity so that the exported fillets meet the quality standards of markets in Europe, Israel, Australia, the United States, and Japan. Europe has become a particularly good market for perch. The export of fresh or frozen fillets to Europe expanded rapidly to average around 18,000 MT in 1994-1996. Nile perch prices compare favorably with other white fish such as cod and haddock, which have become scarcer and more expensive (Megapesca 1997).

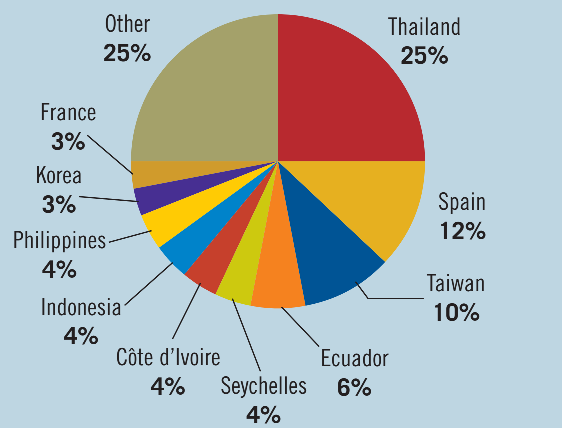
As production of Nile perch rose, it became apparent that some of the victims of the exotic perch's success were the native fish species known as cichlids, which the carnivorous perch preyed on. More than 350 species of cichlids were endemic to Lake Victoria and had been one of the mainstays of the traditional subsistence and commercial fishery. After the introduction of the perch and another exotic species, the Nile tilapia, more that half of the cichlid species have gone extinct or are found in very small populations (Witte et al. 1992). Furthermore, the impacts of the "success" of the Nile perch fishery can be seen in the deforested landscapes surrounding Lake Victoria. Unlike the cichlid fish, which can be air-dried to preserve their flesh, the oily Nile perch requires firewood, which has led to increased deforestation in areas surrounding the lake, and, in turn, has created more siltation and eutrophication of the lake's waters furthering the ecosystem's imbalance (Kaufman 1992).

Unfortunately, local communities and fishers who had depended on the native fish for decades did not benefit from the Nile perch fishery either. Nile perch fishing requires more advanced gear that local fishermen cannot afford. In addition, because most of the perch's catch is destined to the export market, the availability of fish for local consumption has actually declined; in fact local communities now show signs of protein malnutrition (Kaufman pers. comm. 2000).

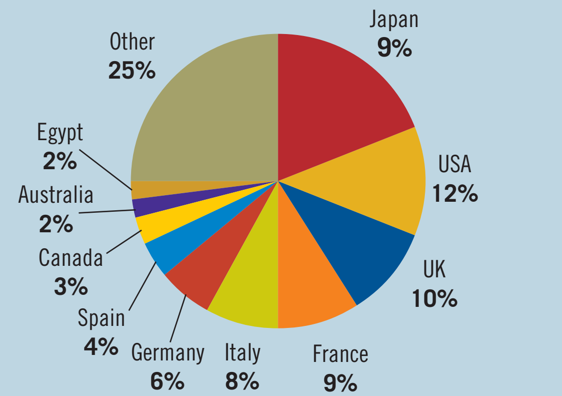
In addition to the ecological destruction and the impact on local communities caused by this introduced species, the economic sustainability of the Nile perch fishery is now in question. According to the Lake Victoria Environmental Management Project—an intergovernmental initiative by Kenya, Tanzania, and Uganda—stocks of Nile perch have declined over 30 percent between 1999 and 2001, and fishers are increasingly catching immature fish (LVEMP 2001). The average weight of a commercially caught fish has dropped from over 50 kg in 1980 to less than 10 kg in 1996. Fisheries scientists believe that the Nile perch fishery is now being sustained by cannibalism

Figure 4-5a and 4-5b: Top Tuna Exporters and Importers, 2001

(a) Top 10 Tuna Exporters by Weight, 2001



(b) Top 10 Tuna Importers by Weight, 2001



* Thailand has a large tuna cannery that contributes to its large percentage of exports. Unlike other countries in the top exporter list, which catch their share of tuna, Thailand imports much of its tuna for processing and re-export.

Source: Fishstat 2003.

E. HOSHINO, WRI. 2003

Tsukiji fish market in Tokyo, Japan.

of young perch by larger individuals, due to the decline in native cichlids—the perch's original prey (Megapesca 1997). In order to combat the decline in perch catches, regulations such as seasonal fishing bans, gear specifications, and minimum size limits for fish are now beginning to be adopted (AllAfrica Global Media 2002).

Tilapia: Tilapias, consisting of several species of fast-growing, white-fleshed fish, are one of the world's major groups of farm-raised freshwater species. Tilapia readily adapt to new environments and have high rates of reproduction. Until a few years ago, most tilapia were grown and consumed locally in Africa and Asia. In recent years, improved tilapia strains and better aquaculture techniques have made large-scale production of tilapia possible and fueled an international trade in the fish. The price of tilapia makes it very competitive as a substitute for ocean fish that are in short supply, and some experts predict that the biggest growth in tilapia production is still to come (Sabatini 2001).

China is the world's top producer of tilapia, followed by Egypt, and Thailand. These three producers have rapidly ramped up their production over the last decade: China's harvest has increased sixfold, Egypt's eightfold, and Thailand's has tripled (Fishstat 2003). The environmental implications of such rapid expansion and intensification of tilapia farming have become a cause for concern (see *Chapter 6* for a discussion of the environmental impacts of aquaculture). First, over-application of feeding mixtures often acts as a source of water pollution. Second, non-native tilapias that are intentionally introduced, or that escape from culture facilities into the wild, tend to re-establish and quickly proliferate in the adopted environment, preying on and outcompeting native fish species. These impacts can significantly alter the ecosystem structure (McKaye et al. 1995) and put native species at risk of extinction.

The United States is the single major market of fresh and frozen tilapia fillets, with China and Taiwan supplying three quarters of this amount, and smaller quantities coming from Ecuador, Costa Rica, and Indonesia (NMFS 2003). European countries are emerging as new markets for tilapia, although European imports are small in comparison to United States imports.

Orange Roughy: The orange roughy fishery provides a textbook example of the "boom and bust" pattern of overfishing. Orange roughy is a deepwater marine species of the southern oceans that is particularly vulnerable to overfishing due to its biology. It typically lives for 100 years, does not sexually mature until it is 25 years old, and probably doesn't spawn every year even when mature (Lack et al. 2003). With such a low reproductive rate, scientists believe that, to be sustainable, annual harvest levels for orange roughy should be low—probably not exceeding 1-2 percent of the stock's biomass (Lack et al. 2003). Unfortunately, catches are currently far above this level.

Commercial fishing for the species began in the early 1980s, when New Zealand and the former Soviet Union targeted stocks in the Southwest Pacific. Exploitation rapidly expanded to the East Indian Ocean when Australia became a major producer at the end of the 1980s, and to the Southeast Atlantic when Namibia joined the top producers in 1995. Orange roughy has become a popular export, with nearly half the catch going to the United States in 2001.

The exact status of orange roughy stocks is difficult to determine due to a lack of accurate assessments for most stocks. However, available data and a continuing drop in orange roughy landings make it clear that the species is being overfished. One recent analysis found that nearly half of 30 orange roughy stocks assessed had been fished below 30 percent of the original biomass of the stock. In other words, less than one third of the original stock remained (Lack et al. 2003). Total global production of orange roughy peaked at 91,500 MT in 1990 but has sharply declined since, falling to some 25,000 MT in 2001, in part because New Zealand has set catch quotas. Namibia's catch reached 18,000 MT in 1997 and dropped by over 90 percent to 1,600 MT in 2000. Catches of newly discovered stocks often decline within a few years of their discovery, in some cases resulting in the closing of the fishing grounds (Smith 2001).

Patagonian Toothfish (Chilean Sea Bass): The Patagonian toothfish has gained the attention of a number of conservation groups in recent years because of its vulnerability to stock depletion and the prevalence of illegal fishing, which has greatly aggravated the overfishing problem. Patagonian toothfish is a deepwater species that has become popular since the 1980s as a restaurant-quality white fish. It is subject to the same biological vulnerabilities as orange roughy: it is relatively slow-growing, slow maturing, and has a low reproductive rate. The responsibility for the conservation and management of Patagonian toothfish in international Antarctic waters falls to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), an international organization created by the Antarctic treaty. CCAMLR, however, depends on member organizations to enforce its regulations and combat illegal fishing—an effort that is proving much harder than anyone imagined.

The overfishing and illegal fishing problem is partly masked by the fact that the fish is marketed under different names in order to make it sound more attractive to consumers: as Chilean seabass in the United States and Canada, as Chilean or Antarctic sea bream in the United Kingdom, as *merluza negra or bacalao de profundidad* (deep-sea cod) in Spain, and as *Magellan ainame, ginmutsu,* or *mero* in Japan. An added problem is that the countries where the fish is caught, landed, and consumed all differ. Toothfish is commonly exported from the country where it is landed to an intermediate country for processing into different derived products (e.g., fillets), and then re-exported to its final consumer market (Willock 2002). For example, while China is the major importer and processor of toothfish, it is almost all re-exported and consumed in the United States, Japan, and the European Union (Willock 2002).

Large-scale production of Patagonian toothfish rapidly increased in the early1990s to replace overfished stocks from the northern hemisphere, as well as collapsed stocks of Austral hake and golden kingclip (Lack and Sant 2001). Chile, Ukraine, and Russia were the top toothfish producers in the 1980s, but Argentina and France have replaced the latter two since 1994 as exploitation spread from the stocks in the southeast Pacific and southern Atlantic to the Indian Ocean. Total production peaked in 1995 with over 40,000 metric tons (Fishstat 2003). Since then the catch has declined slightly (Fishstat 2003), but it is still seen as a very profitable fishery, especially because of its high market value—informally referred to by fishermen as "white gold" (Lack and Sant 2001). Patagonian toothfish is heavily traded internationally, with a global import value exceeding US$200 million in 2000 (Fishstat 2003). By far the largest markets for toothfish are Japan and the United States, but Canada and the European Union are also significant consumers.

The high demand and profitability of this fishery has also encouraged a robust illegal fishing enterprise. In 1999, CCAMLR estimated that "in most areas 30 to 100 percent of the toothfish [catch] is taken by illegal and unregulated longliners." (ENS 2002). In 1997 alone, the total illegal catch of Patagonian toothfish was valued at over US$500 million— around 100,000 metric tons of fish (ENS 2002). Currently the estimated illegal catch accounts for half of the toothfish traded internationally (Lack and Sant 2001).

The level of illegal fishing is putting this fishery at serious risk. Some stocks have reportedly declined to 25 and 30 percent of their original levels (Lack and Sant 2001) and according to the Australian government, "if illegal and unregulated fishing continues at the current level the population of Patagonian toothfish will be so severely decimated that within the next two to three years the species will be commercially extinct. Some areas are already showing signs of this." (ENS 2002).

The member countries of CCAMLR, especially Chile and Argentina, have made significant strides in reducing the illegal fishing activity of their nationally-flagged vessels, and Australia and France have signed a maritime cooperation agreement to strengthen actions against illegal fishing in the Southern Ocean (ENS 2003). CCAMLR members have also established a document system to track catches and monitor trade. For example, the United States no longer allows Chilean sea bass imports without proper documentation and a valid dealer permit issued by its National Oceanic and Atmospheric Administration (NOAA). However illegal fishing by non-CCAMLR member countries continues (Lack and Sant 2001) (see *Chapter 7* for further discussion on illegal, unregulated and unreported [IUU] fishing). Because of the prevalence of illegal fishing and the vulnerability of the toothfish stocks, some groups suggest that the species be included under the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)—a treaty designed to prevent trade from contributing to global biodiversity loss and species extinction (Willock 2002).

The Growing Trade in Shark Fins

While certainly not a recent addition to the fish trade, the rapid increase in trade of shark fins is noteworthy because of its contribution to the threatened status of many shark species. Sharks are long-lived, slow-maturing species with relatively low reproductive rates, making them more vulnerable to excessive fishing pressure. Shark fin is a traditional delicacy among Chinese communities the world over. Consumption dates back thousands of years as a key ingredient in shark fin soup, a dish associated with high social status. Shark fins are also one of the most expensive seafood products in the world—a powerful incentive for their harvest and trade.

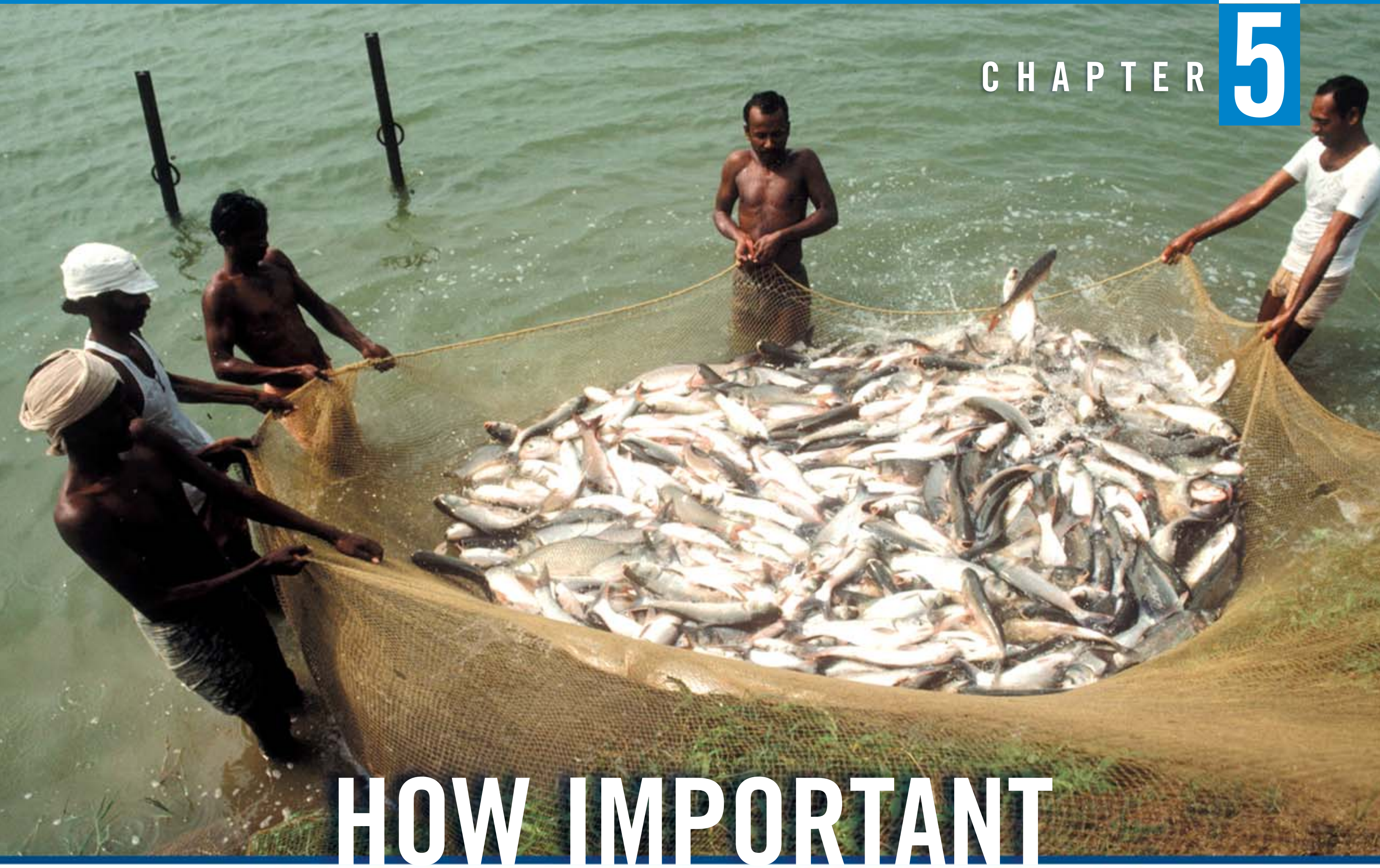
After the shark fins are cut off and retained for sale, the rest of the animal is usually thrown overboard to die.

In the last 15 years trade in shark fins has risen dramatically because of the increased affluence associated with economic growth in China, as well as the reduction in Chinese tariffs on the import of shark fins (Vannuncini 1999). Statistics submitted to FAO show that trade has doubled from approximately 3,000 MT in 1985 to more than 7,000 MT in 1997. But this figure is certainly an underestimate, given the high level of underreporting in shark fin trade (Vannuncini 1999). For instance, research comparing FAO statistics with customs trade data from Hong Kong—the world's center for shark fin trade—shows that the FAO figures are at least two orders of magnitude lower than those reported in Hong Kong (Clarke 2002). If one adds the customs data for internationally traded shark fins from China, Hong Kong, Singapore, and Taiwan, the major centers of trade, for the year 2000, the total amount is higher than 11,500 MT—and this is still considered an underestimate (Clarke 2002). This same research also shows that shark fin imports into Hong Kong are growing exponentially at a rate of 5.3 percent per year (Clarke 2002).

One explanation for the high level of underreporting is that many sharks are caught as bycatch in regular fishing operations (Bonfil 1994; Vannuncini 1999) (see *Chapter 7* for further discussion on bycatch). Since the commercial value of shark meat is very low, there is an incentive to cut off the fins, retaining them for sale, and throwing the dying shark back into the sea—a practice known as shark finning. The Hawaii long-line fishery that traditionally targets tuna and swordfish is an example of the recent increase in this practice. Records show that finning in this particular fishery has increased from less than 2 percent in 1991 to 65 percent in 1999 (NOAA 2001). Shark finning is not only inhumane, but also wasteful since practically the entire animal is thrown overboard and not utilized. The proliferation of this practice, its wastefulness, and the pressure on shark populations has led some countries, such as Australia, Brazil, Canada, and the United States to adopt legislation that bans finning or at least the landing of shark fins without carcasses (WildAid 2001). However, the growing purchasing power in China will most certainly continue to fuel demand for this commodity (Clarke 2002).

The major suppliers of shark fin to Hong Kong between 1998 and 2000 include Spain, Indonesia, the United Arab Emirates (UAE), and Taiwan. The UAE and Singapore do not domestically harvest shark fins but are believed to serve as transshipment points for shark fins from Africa, India, and Sri Lanka (Clarke 2002). The majority of shark fins imported to Hong Kong are exported to mainland China for further processing at lower labor costs, and re-exported back to Hong Kong for sale (Clarke 2002).

Direct and indirect (i.e., bycatch) fishing pressure for shark fins, meat, and other shark-derived products (e.g., liver oil, cartilage extracts), have placed 22 shark species on IUCN's *Red List of Threatened Species* as of 2002 (see *Table 3-2 in Chapter 3* for partial listing of threatened species). In addition, the basking shark and the whale shark were listed under Appendix II of the CITES in 2002. This listing requires trade permits and monitoring of these species to avoid their endangerment through international trade (Clarke 2002).



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HOW IMPORTANT IS SMALL-SCALE FISHING?

Small-scale fishing is much more significant—as a source of livelihoods, food security, and national income—than most people realize. Like small-scale agriculture, small-scale fishing is widespread and crucial to employment and food supply in innumerable communities in developing nations, where some 95 percent of all fishers ply their trade (FAO 2002a).

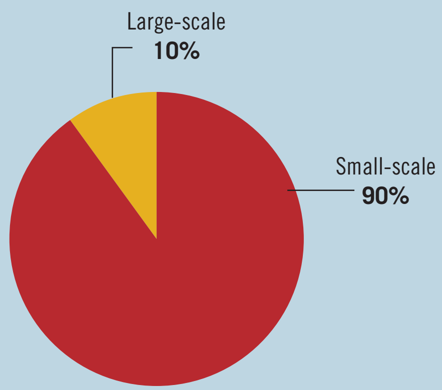
The FAO estimates that over 90 percent of the 15 million people engaged in coastal and ocean fishing are small-scale operators—people who use small fishing vessels with a relatively low level of capital investment (see *Figure 5-1*). That number does not include the many millions of freshwater fishers and fish farmers also working at the small or artisanal level. These fishers catch or farm fish primarily for household consumption or to sell in local markets, and their incomes are usually very low. There are an estimated 5.8 million fishers in the world earning less than $1 a day (FAO 2002a).

Because of the sheer numbers of small-scale and artisanal fishers, their vulnerability to competition from industrial fleets, and their potential impacts on marine and freshwater ecosystems, it is essential to factor this sector into fisheries management policies. Unfortunately, just the opposite has happened. For decades, policy-makers and consumers have ignored the importance of small-scale fishing. Since large-scale industrial fishers generally produce the fish consumed in developed countries and marketed through the international trade, most of the attention of fisheries managers has focused squarely on them. Only recently is the need for appropriate management and protection of small-scale fisheries slowly gaining recognition (Berkes et al. 2001; Drammeh 2000; FAO 2000b; FAO 2002a.).

Several factors have contributed to the lack of attention to small-scale fishing. One of the most potent is the dearth of information. Data on this sector are notoriously poor, with the number of small-scale fishers—and especially subsistence level freshwater fishers—grossly underestimated by national governments. An accurate picture of small-scale fishing at the global level is also hard to assemble, because the definitions of small-scale and artisanal fishing vary by country. Indeed, the fish caught by small-scale fishers frequently go unreported in official government statistics and the impact of these fishers on fish stocks and ecosystems is rarely monitored. This means that the economic importance of the sector remains hidden from official view, and the implications for national fisheries policy remain unclear.

In addition, small-scale fishers tend to inhabit the political margins. Fishing communities are often remotely located, and therefore isolated from decision-making centers, increasing the likelihood that their interests will be marginalized (Le Sann 1998, Berkes et al. 2001). As a consequence, the aquatic environments and resources upon which small-scale fishers depend frequently suffer from poor management, competition from industrial fishing, and degradation from land-based activities, such as deforestation, pollution, and coastal development.

Figure 5-1: Number of Fishers in Marine Capture Fisheries



Source: FAO 2002a

HOW LARGE IS THE SMALL-SCALE FISHING SECTOR?

Because there is no universal definition of small-scale fishing and no accurate census of those who practice it, the exact number of fishers engaged in this sector is impossible to pin down. In fact, few governments know with precision how many people are occupied in the various sectors, whether industrial, small-scale, or aquaculture.

A few experts have attempted to estimate the number of small-scale fishers worldwide, including subsistence and artisanal fishers. These estimates vary widely, ranging from 12 million to as many as 50 million men and women directly involved in catching fish—and the number could be higher still (Berkes, et al. 2001; Le Sann 1998; Misund et al. 2002; Weber 1995; World Bank et al. 1992). The lower end of this range is very likely an underestimate. After all, based on national level statistics, FAO (2002a) estimates that 90 percent of the 15 million fishers occupied in marine capture fishing alone use vessels less than 24 meters in length—a relatively small-scale operation. And that does not begin to factor in those who fish inland rivers and lakes, or operate in small ponds or rice fields where they raise fish.

Certainly, inland fishing accounts for a large proportion of the world's fish production, and it is almost entirely dominated by small-scale operations. In China alone, more than 80 percent of the 12 million reported fishers are engaged in inland capture fishing and aquaculture (Miao and Yuan 2001). Moreover, in the Lower Mekong river basin of Southeast Asia (covering Thailand, Laos, Cambodia, and Vietnam) a recent study estimated that 40 million rural farmers are also engaged in fishing, at least seasonally (Sverdrup-Jensen 2002). In Laos, over 70 percent of all farm households also fish to augment their family food supplies and incomes (Sverdrup-Jensen 2002).

Simply adding together these estimates—the 13 million fishers involved in marine capture worldwide, 10 million inland fishers in China, and the 40 million Mekong basin part-time fishers—makes it clear that even the high-end estimate of

Table 5-1: Range of Estimates of Number of Fishers and Fish Farmers in Selected Countries and Regions (1996-2000)

		Small-scale or Artisanal	Medium to Large-scale or Industrial	Small (including subsistence fishers) and Large Scales Combined
Marine	World	13.5 million[a]	1.5 million[a]	> 15 million[a]
	Nigeria	272,000[b]		
	Senegal	90,000[c]	10,000	
	Chile	45,764[d]		
Inland	World			> 2.7 million[a]
	China			10 million[e]
	Lower Mekong Basin			40 million[f]
Marine and inland combined	World	12 million[g] – 50 million[h]		> 34.5 million[a]
	Philippines	675,677[i]	56,715[i]	

Sources: a. FAO 2002a; b. Horemans 1998; c. UNEP 2002b; d. SERNAPESCA 2001; e. Miao and Yuan 2001; f. Sverdrup-Jensen 2002; g. Misund et al. 2002, LeSann 1998; h. Berkes et al. 2001; i. PBFAR 2000.

50 million fishers no longer seems exaggerated as a world total for the small-scale sector. (See *Table 5-1* for the comparison of estimates in number of fishers in selected countries and regions).

In addition to the actual fishers, there are many other people who rely on small-scale fisheries for their livelihoods. Small-scale fishing is a labor-intensive activity and it is estimated that each fisher's job creates at least two other jobs in processing and distribution (Le Sann 1998). Including these ancillary workers, the total number of people who rely on small-scale fishing for income could be well over 100 million (Berkes, et al. 2001; World Bank et al. 1992).

Therefore, in terms of employment, small-scale fishing is a bigger factor in many national economies than large-scale industrial fishing, even though industrial fishers are usually responsible for a larger share of the catch. In Chile, one of the world's top producers of marine fish, large industrial fleets catch more than 80 percent of the country's total marine catch, but small-scale fishers represent 60 percent of the country's population of fishers (SERNAPESCA 2001). In general, although industrial fleets are more efficient at catching fish, and therefore more profitable, they generate much less employment than small-scale fishing.

Although the growth in industrial fishing is clearly putting pressure on small-scale fishing in many regions, the number of small-scale fishers continues to grow in many countries. In Chile, there was nearly a 50-percent increase in the number of artisanal fishers between 1993 and 1998 (SERNAPESCA 2001). In West Africa, the number of artisanal fishers appears to have increased by over 8 percent in the three years between 1993 and 1996.

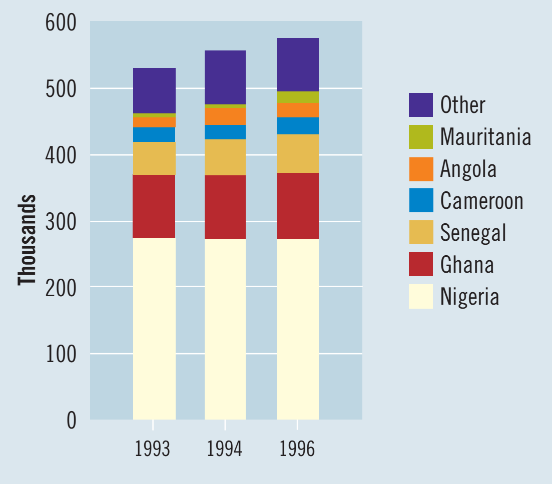
An influx of migrants looking for employment may be one factor in the increase in small-scale fishers in West Africa (see *Figure 5-2*). For example, 75 percent of the fishers in Gabon are foreigners; 65 percent in Togo; and 80 percent in Cameroon. Unfortunately, such migrant fishers tend to have even more of a marginalized social and political status than local small-scale fishers, making their voices even less heard by policy-makers (Horemans 1998).

Globally, the number of *part-time* fishers has increased much more rapidly than *full-time* fishers. While the number of full-time fishers nearly doubled between 1970 and 1990, the number of part-time fishers increased by 160 percent to 17 million, according to one FAO analysis (FAO 1999b). In Indonesia—the largest marine fish producer in Southeast Asia—the number of part-time fishers increased by more than 50 percent in ten years, from nearly 740,000 in 1989 to more than 1.1 million in 1998 (Indonesian Department of Fisheries 2000). These figures seem to indicate that people in developing countries continue to turn to fishing as an employment alternative or to supplement income from other activities, especially farming (see *Figure 5-3*).

HOW MUCH DO SMALL-SCALE FISHERS CATCH?

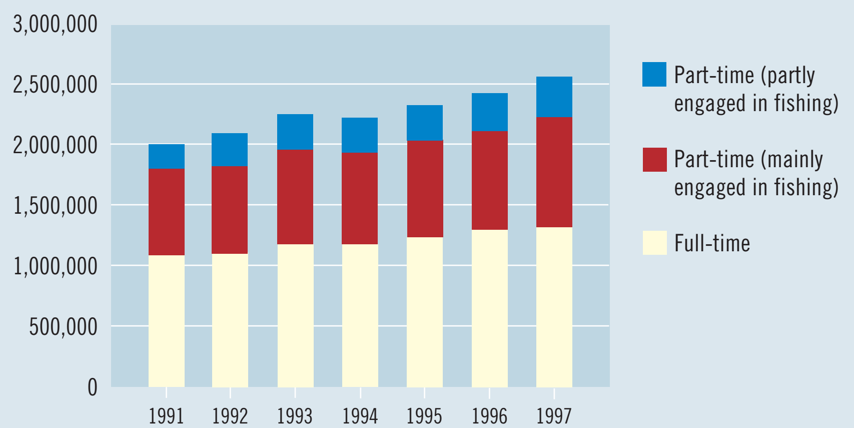
Mechanized industrial fleets are far more efficient at catching fish than small-scale fishing boats (see *Figure 5-4*). So it is easy to underestimate the collective production of the many small-scale fishers or their contribution to national economies. Some experts estimate that, as a whole, small-scale fishers produce as many fish for direct human consumption

Figure 5-2: Artisanal Fishers in West Africa



Source: Horemans 1994, 1995, 1996 and 1998.

Figure 5-3: Growth in Number of Fishers in Southeast Asia



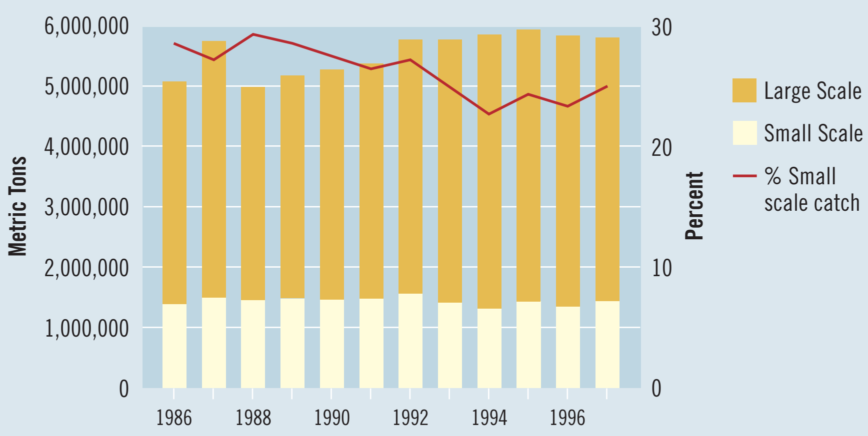
Source: SEAFDEC 2001b.

as industrial fishers (Berkes et al. 2001; Misund et al. 2002; World Bank et al. 1992). If so, that would equate to at least 30 million metric tons of fish per year—half of the 60 million tons of fish that FAO reports are annually consumed as food (small-scale fishers do not participate substantially in the harvest of small pelagic fish for the fishmeal trade, which is dominated by industrial fleets). If this is indeed the case, then small-scale fishers are just as capable of overfishing as the industrial sector.

It is also possible that the small-scale harvest could be much higher than 30 million metric tons, depending on how much of the harvest falls outside the global catch figures reported to FAO. Of course, these figures are estimates only. As indicated earlier, fish harvested by small-scale fishers often go unreported, and there are no global statistics on the size of the aggregate small-scale catch. This is particularly true for inland fisheries, where much of the catch is consumed locally and does not enter into the formal fish trade (FAO 1999a).

The structure of the small-scale fishing sector and its relation to industrial fishing differs from country to country, from region to region, and between inland and coastal waters. Freshwater fishing, for instance, is almost entirely a small-scale operation, except in large lakes such as Africa's Great Lakes, the North American Great Lakes and some operations in Cambodia's Tonle Sap.

Figure 5-4: Large- vs. Small-Scale Catch in Malaysia, Philippines, Thailand, and Taiwan



Source: SEAFDEC 2001b.

Freshwater fisheries produced almost 9 million metric tons worldwide in 2000—about 7 percent of the world's total fish production (FAO 2002a).

Small-scale fishers are also a major contributor to the marine catch. In Southeast Asia, for example, the majority of fishers are still small-scale, usually working in family-run operations with low-technology boats and fishing gear (SEAFDEC 2001a). Their production comprises a significant proportion of the region's total fish catch. For example, during the period 1986-1997, the combined annual production of small-scale fishers in Malaysia, the Philippines, Thailand, and Taiwan was around 1.4 million metric tons, or 25 percent of the total marine fishery production in these countries (see *Figure 5-4*). In terms of its economic value, the small-scale catch in these four countries was even more significant, reaching nearly US$2 billion in 1997 or over one third of the total value of fish production in these nations (SEAFDEC 2001b).

ARE INDUSTRIAL FLEETS DISPLACING SMALL-SCALE FISHERS?

As fishing technology advances and developing nations continue to support the growth of industrial fishing, the face of small-scale fishing is changing. Marine fishing in Southeast Asia is gradually becoming modernized, and industrial fleets are expanding rapidly. In Indonesia, the region's largest marine capture producer, the number of powered fishing vessels larger than 30 metric tons—a moderately sized industrial vessel—increased five-fold between 1989 and 1998 (Indonesian Department of Fisheries 2000). In response to increasing competition from industrial operators, some small-scale operators are attempting to move toward more profitable forms of fishing, targeting high-value species, such as crab, prawn, redfish, and molluscs destined for export (SEAFDEC 2001b). Some fishers have even turned to coral reef fishing, catching live reef fish which are served as a restaurant delicacy or sold as aquarium fish, often at great harm to the reefs because of the destructive fishing practices employed, such as using cyanide to stun the fish (Burke et al. 2002).

Compared to Southeast Asia, industrialization of the fisheries sector in West Africa seems slower, although nations in the region differ considerably in this regard. In Mauritania, for example, some 90 percent of fishing vessels are motorized, compared to just 3 percent in Liberia (Horemans 1998). In general, in West Africa, small-scale fisheries still play a dominant role in terms of fish production and employment, especially for domestic fish supply (see *Figure 5-5*). Small-scale fishing in West Africa produces around 75 percent of the region's total fish catch (Horemans 1998). In fact, the artisanal catch in the region increased by 25 percent from 1992 to 1996 (Horemans 1998).

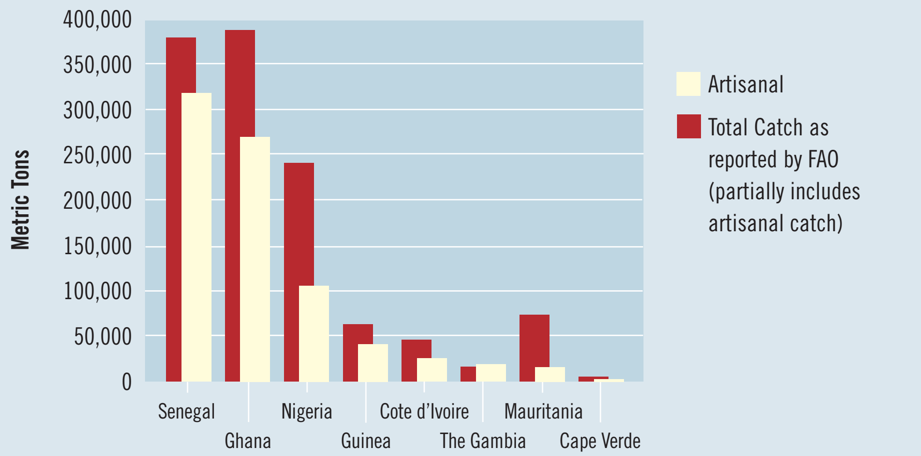
Even though industrial fishing does not yet play the same dominant role in the West Africa region that it does in other areas, it is nonetheless a considerable source of competition for small-scale producers. One reason is that many West African nations without significant industrial fleets have historically opted to sell fishing rights in their coastal waters to foreign vessels, typically European fleets. The access fees that these foreign vessels pay governments to fish in their waters are often an important source of foreign income, although this rarely trickles down to the coastal fishing communities.

The presence of industrial fleets can have a tremendous impact on small-scale fishers. Small-scale operators traditionally catch a variety of fish species for domestic consumption, including small, low-valued pelagic species as well as more valuable demersal species. Large industrial fleets tend to concentrate on the most profitable species only, such as shrimp and demersal fish suitable for export (Horemans 1998). Where this brings them close to shore, they are often in direct conflict with small-scale fishers. When large industrial vessels, particularly trawlers, fish the coastal waters close to shore, they can degrade the sea bottom habitat and change the species composition of coastal ecosystems to a point where the local fish catch may drop precipitously.

Such conflicts between industrial fleets and small-scale coastal fishers are becoming increasingly prevalent in Asia and Africa alike, with small-scale fishers gradually losing ground. Industrial trawlers are often reported to have encroached into fishing grounds as close as a few miles from the coast—the prime fishing area for most small-scale fishers—sometimes destroying the nets set by these small-scale operators (see *Chapter 10* for further discussion on small- vs large-scale conflicts). The resulting drop-off in local catches can be dramatic. Surveys off the west coast of Africa show that fish resources in the shallow inshore waters where small-scale operators ply their trade dropped more than half from 1985 to 1990 due to increased fishing by commercial trawlers (FAO 1995a; Koranteng 2002). Unfortunately, local fishers cannot simply move on to another fishing ground when nearby waters are depleted like industrial vessels can.

Any shortfall in fish supplies due to competition with industrial fleets is bound to have a wide array of negative effects on small-scale fishers, their families, and the communities that are highly dependent on the local supply of fish for food and livelihood. Small-scale fishers are extremely vulnerable to problems such as stock depletion, and local employment alternatives may be few if fishing becomes unviable. In many cases, artisanal fishers are tied to a certain fishing ground, with their fishing methods or fishing gears tailored to catch particular species. This makes it difficult to switch locations or to target another type of fish when their preferred species are depleted or their traditional methods become unprofitable (FAO 2000a). Even if they are successful at switching to more profitable forms of fishing targeted for export—an increasingly common response to competition from industrial fleets—this may adversely affect local communities by leaving fewer fish available for consumption in local markets.

Figure 5-5: Artisanal and Total Catch for Selected West African Countries, 1996



Source: Horemans 1998; Fishstat 2003.

In order to forestall the negative effects of encroachment by industrial fleets, nearly all West African countries now legally grant small-scale fishers exclusive fishing rights in near-shore waters, prohibiting industrial trawlers within a fixed distance from the shore (1 to 12 nautical miles, depending on the country) or a set depth of water (Horemans 1998; Bortei-Doku Aryeetey 2002). Asian countries such as India, Indonesia, and Thailand also have banned or limited the access of industrial trawlers to coastal waters along some parts of their coasts (Vijayan et al. 2000; FAO 2000c; FAO 2000d). Although their enforcement is a challenge, such regulations are an important step toward protecting the livelihood of small-scale fishers (Bortei-Doku Aryeetey 2002).

Despite some failures, co-management is generally considered the way forward in small-scale fisheries management and continues to spread around the world. The existing body of experiences is encouraging, and provides a glimpse of the challenges and opportunities for the future generation of co-management projects.

CAN CO-MANAGEMENT HELP SUSTAIN SMALL-SCALE FISHERIES?

In small-scale fisheries, particularly in developing countries, the idea of shared power and responsibilities between the government and fishing communities has emerged as an alternative framework for managing fish stocks. This management approach is referred to as "co-management"—management where government and local resource users are each given specific decision-making and monitoring rights and responsibilities. Co-management by definition includes active participation by both government and fishing communities, as well as other stakeholders such as nongovernmental organizations (NGOs) and local businesses (Wilson et al. 2003; Viswanathan et al. 2003).

The rationale behind co-management is that conventional management approaches have often failed to manage small-scale fisheries effectively or in a manner that is fair to local fishers. In pre-colonial times, local fisheries were managed by traditional authorities such as chiefs or village councils. But during colonial times these traditional arrangements in developing countries were replaced by more centralized governance regimes (Berkes et al. 2001; Wilson et al. 2003). Such centralized governing systems have continued in modern societies, where fisheries resources are usually considered state property (instead of the property of local communities), often resulting in their *de facto* treatment as open access resources (Brown and Pomeroy 1999; Berkes et al. 2001).

Unfortunately, centralized and top-down management measures have often failed at the village level (Wilson et al. 2003). One primary difficulty is that small-scale artisanal fisheries are often spread across remote rural areas, making it difficult to enforce compliance. Another problem is that these centralized systems take little heed of the different conditions or needs of local communities and often fail to ensure that local communities have equitable access to fisheries resources in the form of a legally recognized right to fish.

Co-management offers an alternative. Research shows that when communities participate in the governance of local resources, they are more likely to support management decisions about how those resources should be used, and these decisions are more likely to be successfully implemented. On the other hand, when local people are left out, it is often a recipe for conflict, inequity, and environmental harm (WRI et al. 2003). By granting local communities specific rights to use fishery resources, co-management acts as a bridge between traditional forms of community management and modern state management.

The potential of local management can be seen today in several communities where customary systems of local fishery management survive (Berkes et al. 2001). For example, in the Maluku Islands of Indonesia, the "Sasi-Laut" system, based on rules evolved by the local fishing community, regulates the use of marine resources. It includes rules on permissible fishing gear, access to the fisheries, and designation of fishing seasons and areas closed to fishing (Novaczek et al. 2001). In Japan, local fishing villages and fishermen's guilds, now formally organized into over 1,700 Fisheries Cooperative Associations (FCAs), have managed inshore fisheries for centuries (Lou and Ono 2001). The FCAs are organized geographically or around a specific fishery, for which they regulate activities using a variety of conventional measures (described in *Chapter 11*), from catch quotas to closed seasons. The Japanese government plays a supporting role, primarily providing a legal and administrative mechanism for this community-based resource management, and by supporting stock assessments and research, capacity building, and evaluation (Lou and Ono 2001).

Similar examples can also be found in Europe, such as the Cofradías (fishermen's association) system in Spain, and the Lofoten Island system in Norway (Jentoft 2003). These and other examples of traditional community-based management show that the rate of compliance with regulations tends

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The catch is meager at the end of the fishing season in Tonle Sap Lake, Cambodia.

to increase where local users take ownership of the management objectives and collectively self-police their implementation (Brown and Pomeroy 1999; Pomeroy et al. 2001; Hauck and Sowman 2003; Viswanathan et al. 2003).

What are the conditions that lead to good community management of common resources? Research on thousands of cases of community-based management shows that key factors to success include a community-wide understanding of the value and scarcity of the resource; good communication among community members; an effort to monitor whether rules are being followed; a credible system of sanctions when rules are broken; and a mechanism to resolve disputes. Government recognition of the community's right to manage the resource itself, ensuring that local authority is not undermined, is also a crucial precondition for success (Ostrom 1990; Ostrom et al. 1999; Jensen 2000).

It's important to note that while co-management schemes can bring about more effective fisheries management, they do not ensure that this management will always foster sustainable fishing practices. The strong points of co-management are that it enables greater fairness in decision-making and a wider participation of stakeholders in the management process. But that does not always translate into an emphasis on the long-term health of local fish stocks. Much depends on the community's level of awareness about sustainable fishing practices, its economic situation, and the availability of employment alternatives to fishing. In some instances, the community may choose to prioritize short-term economic development over long-term sustainability. On the other hand, there are numerous examples where communities have chosen to prioritize conservation (Johannes and Hickey 2002; Viswanathan et al. 2003; Begossi and Brown 2003; Harris et al. 2003).

Transitioning from state-dominated management to a co-management approach can be challenging. Factors influencing a successful transition include the community's history and its economic and cultural needs, the condition of the local resources, and the details of the existing management arrangement. Therefore, there is no universally applicable guide to establishing a successful co-management regime (Pomeroy et al. 2001; Hara and Nielsen 2003). However, some lessons can be drawn from existing examples.

One important element is how power, rights, and responsibilities are shared and transferred to communities. If the decision-making power remains with the government, and communities are merely used as a local body to implement government policies that have not been cooperatively developed, the co-management program may not be successful. The main reason is that the community will not feel a sense of ownership for the management objectives (Viswanathan et al. 2003; Hara and Nielsen 2003). This is also the case if donors such as development agencies or outside conservation groups have played too central a role in the co-management scheme. For example, several co-management projects in Africa failed to reach their potential because local communities felt that conservation goals developed by outside funders were imposed on them in a top-down fashion (Hara and Nielsen 2003).

On the other hand, in countries such as the Philippines, where the central government has encouraged decentralization of power to local governments, transition to co-management has been smoother (Pomeroy and Viswanathan 2003). In San Salvador Island in the Philippines, for instance, a group of local stakeholders successfully set up a marine protected area and regulated destructive fishing practices within the area, resulting in the recovery of reef fish species (Pomeroy and Viswanathan 2003; Viswanathan et al. 2003).

The participation of local NGOs in organizing communities and building partnerships can also contribute to the success of co-management projects. In Bangladesh, where an estimated 80 percent of rural households are engaged in inland fishing, co-management projects have evolved in some 270 water bodies since the late 1980s (Pomeroy and Viswanathan 2003). Although the level of success has varied among these projects, NGOs have played a key role in the more successful examples.

Careful planning and support from legal authorities and funders can also be key to the success of some projects. The tribal Sokhulu community in KwaZulu Natal province, South Africa, has recently gained legal access to harvest mussels from a nearby national park after a long-standing conflict between the community and park officials over illegal harvests. After a two-year period of working together and building trust, the community entered into a co-management arrangement with the park in which they have been given the legal right to harvest mussels. As part of the arrangement the community must monitor the harvest to determine if it is sustainable, and adjust the harvest level if it is too high (Harris et al. 2003; WRI 2003).

In sum, for a co-management project to be successful it should at least adhere to the following general principles:

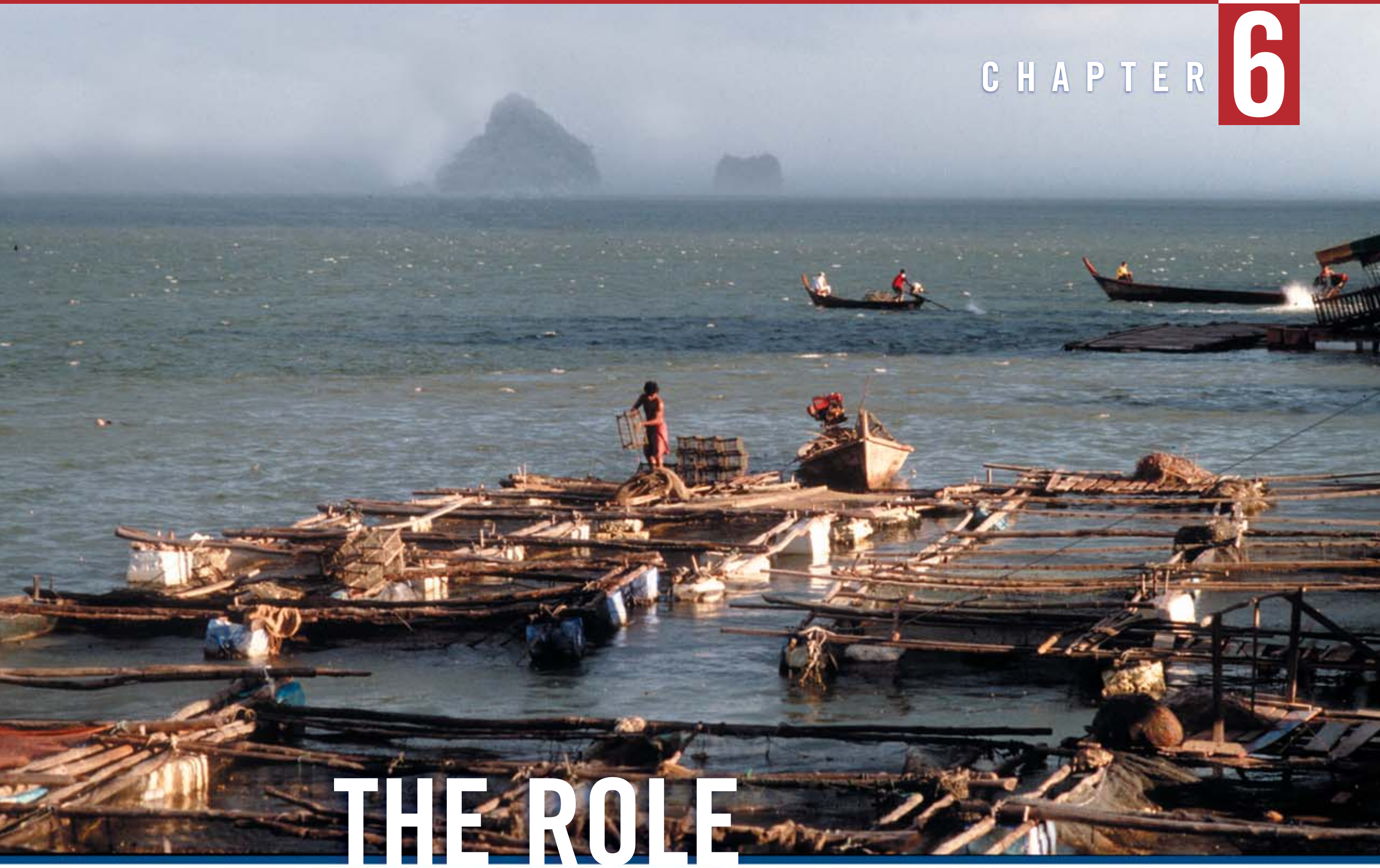
- Policies and legislation should ensure the recognition of property rights and resource access for fishing communities;
- Local responsibilities and authorities should be well defined;
- Communities should be well organized, well represented, and aware of the issues and stakes involved;
- Government and local communities should have the capacity and the willingness to work with an array of local stakeholders, and to balance their needs;
- There should be incentives both for communities and governments to continue to participate in the scheme over a protracted period, such as guaranteed equitable sharing of costs and benefits.

Despite some failures, co-management is generally considered the way forward in small-scale fisheries management and continues to spread around the world (Wilson et al. 2003). This is partly because co-management presents one of the few alternatives to the centralized approaches that are currently the norm and are often unsuccessful. The existing body of experiences is encouraging, and provides a glimpse of the challenges and opportunities for the future generation of co-management projects.


FAO/17088/M. MARZOT

In developing countries, children often participate in fishing activities.

CHAPTER 6



FAO/18557/R. FAIDUTTI

THE ROLE OF AQUACULTURE:
IS IT HELPING TO SUSTAIN FISHERIES AND FEED THE POOR?

WHAT IS AQUACULTURE?

The practice of aquaculture—the farming of fish and shellfish—dates back 3,000 to 4,000 years in China and Mesopotamia. In those times, fish farming was mostly carried out by farmers who raised fish in small ponds to supplement their diet. Since then, aquaculture has evolved considerably, and today comprises a broad spectrum of systems, practices, and operations ranging from simple small-household ponds to large-scale, highly intensive, commercially oriented practices (see *Box 6-1*).

The term "aquaculture[6]" entails the controlled farming of aquatic species such as molluscs, crustaceans, aquatic plants, and finfish; or interventions in aquatic systems that will enhance their production, such as stocking lakes, rivers and oceans with hatchery-born juveniles to increase the wild stock; or taking wild-caught juvenile fish or hatchery-raised fish and raising them in enclosed facilities in open sea waters. Land-based aquaculture operations include ponds, paddies, and other artificial facilities built on dry land, while water-based systems include pens, cages, and rafts, commonly found in sheltered coastal or inland waters (FAO 2000b). Aquaculture products fall into two general groups if evaluated from an international market perspective: high-valued species that mainly target export markets, and comparatively low-valued species that are primarily sold locally in developing countries. Most large-scale, intensive aquaculture operations target high-value species, such as shrimp and salmon, which are commercialized in developed countries, mainly the United States, Japan, and Europe, and require large capital investments.

[6] The specific farming of marine fish and shellfish is also referred to as "mariculture".

Extensive or rural aquaculture on the other hand usually targets species for local or domestic consumption, such as tilapias and cyprinids, which require low capital investment and often provide affordable fish for local markets.

HOW SIGNIFICANT IS AQUACULTURE IN GLOBAL FISHERIES PRODUCTION?

Aquaculture produced 37.9 million metric tons of fishery products in 2001, nearly 40 percent of the world's total *food* fish supply and valued at US$55.7 billion (FAO 2002a; Vannuccini 2003). Over the past three decades, aquaculture has become the fastest growing food production sector in the world; it has increased at an average rate of 9.2 percent per year since 1970—an outstanding rate compared to the 1.4 percent rate for capture fisheries or the 2.8 percent rate for land-based farmed meat products (FAO 2002a). Aquaculture has achieved this rapid growth by expanding, diversifying, and intensifying production, as well as by introducing technological improvements in its operations. In comparison, capture fisheries production has been stagnant with increasingly larger quantities of fish being caught to produce fishmeal and fish oil—about 31 million metric tons in 2001, or one third of capture fish production (Vannuccini 2003).

According to the most recent survey, at least 300 fish, crustacean, and mollusc species are cultured worldwide (FAO 2000b). In 2001, freshwater finfish accounted for the largest share (50.5 percent) of the global aquaculture production in terms of quantity, followed by molluscs (23.3 percent) and aquatic

Box 6-1: Basic Types of Aquaculture Systems and Practices

In general, aquaculture systems fall into three major groups with some degree of overlap: extensive to semi-intensive or rural aquaculture; intensive or industrial aquaculture; and culture-based fisheries, e.g. stocking and sea-ranching (Le Sann 1998).

Extensive to semi-intensive aquaculture systems take advantage of the natural environment and try to increase production with minimum external inputs. Extensive systems commonly raise species groups that are lower in the food chain (herbivores/omnivores), such as carp. These systems use simple technology and rely on natural food (algae, plankton, etc.) which can be supplemented by livestock waste and agricultural residues, or processed fish feed in the case of semi-intensive operations. Usually only the adult part of the species' life cycle is controlled—wild-caught juvenile fish are raised until they reach full growth, as opposed to hatchery-raised juveniles that are more commonly used in intensive systems. The most significant example of extensive aquaculture is the traditional or artisanal operation widely practiced in Asia and in rural Central Europe (FAO 2000b). These aquaculture systems are often integrated with crops and livestock production; typically use rice fields, ponds, and cages; and involve polyculture (i.e., the practice of raising more than one species in the same pond). Despite very high yields—16.4 million MT of carp, barbel, and other cyprinids in 2001—and its critical contribution as protein to the human diet, especially in Asia, the importance of these "low-tech" aquaculture practices are under-appreciated at the global level because of the relatively low export value of the farmed products. For instance, the average price of one metric ton of cultured carp, barbel, and other cyprinid fish is US$973, while a metric ton of aquaculture produced salmonids is US$2,908, and one metric ton of shrimp and prawn is US$6,635 (Fishstat 2003).

Intensive aquaculture practices try to maximize output from a given production unit. These practices are carried out in a controlled environment with a higher level of technological inputs and management over the entire life cycle of the cultured animal/plant. Compound, manufactured pellet feed is regularly used, along with antibiotics to prevent diseases in facilities with higher stocking densities. This level of input and management requires considerable investment; hence, production is primarily targeted toward the monoculture of species with high commercial value, which are generally oriented to the export market. Common intensively farmed fish include carnivorous species such as shrimp, salmon, trout, seabream, yellowtail, and eel. Shrimp and salmon, in particular, require large amounts of high-protein fishmeal and fish oil as feed, and are in terms of value, the most significant sectors in aquaculture. Farmed Atlantic salmon, for example, represents 99.5 percent of all Atlantic salmon production (capture and aquaculture), while cultured shrimp and prawn represent 30 percent of all shrimp and prawn production in 2001 (Fishstat 2003).

Culture-based fisheries, such as stock enhancement[a] or stocking, are aquaculture practices that fall somewhere between farming and capture fisheries. The practice consists of releasing juvenile fish or invertebrates raised in hatcheries or captured elsewhere in the wild into a sea, lake, or river for subsequent fishing when they have reached a larger size (Munro and Bell 1997). The most commonly stocked freshwater and diadromous fish include common carp, rainbow and brook trout, Atlantic salmon, and Nile tilapia (FAO 1999a). Stocking is also used to increase production of some marine species such as abalone, scallop, lobster, cod, and flounder (Svåsand et al. 2000; Jennings et al. 2001). Japan is the leading country in the use of marine stocking, with ongoing commercial and experimental programs for numerous species, such as scallops, Japanese flounder, and red and black seabream, among others (Bartley 2002; Fushimi 2001). Success of these stock enhancement practices varies. For some species like scallops and chum salmon, stocking seems to have worked; for other species, particularly finfish, results are not as clear because of high mortality rates of juvenile fish once they are released into the wild, and because of inadequate methodologies to assess effectiveness and track released juveniles (Kitada 1999; Svåsand et al. 2000).

Sea ranching (or sea farming) is also considered a form of aquaculture, and the term is many times used interchangeably with stocking of marine fish, and recently with the term open ocean aquaculture. For the purpose of this report, we limit the term sea ranching to the practice of raising wild-caught juvenile fish within controlled boundaries in the open ocean, where they grow using natural food supplies or formulated feed. Once the fish reach a certain size they are harvested, and production is therefore reflected in aquaculture figures, instead of capture statistics.

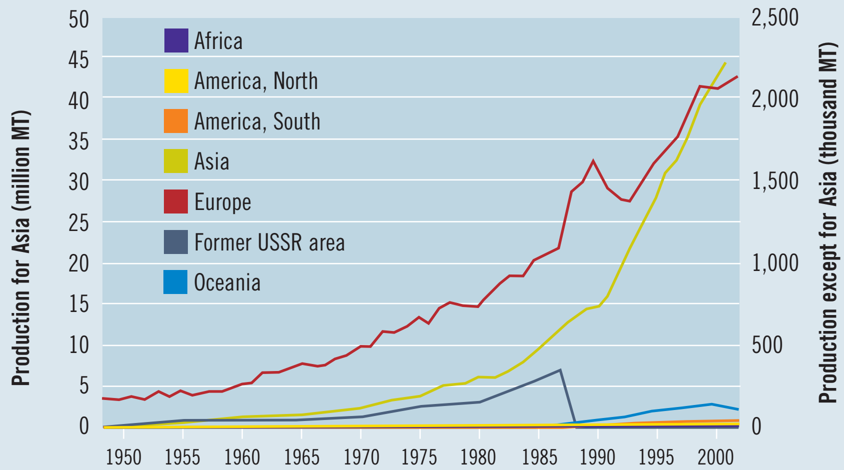
[a] Some authors use a broader definition of the term "stock enhancement" to include a variety of practices used to increase harvests including habitat rehabilitation, the introduction of exotic species, etc. (Bartley, pers. comm. 2004).

plants (21.8 percent) (Fishstat 2003). And although crustaceans accounted for only 4 percent of the share in terms of quantity, in terms of value they reached nearly 19 percent, mostly from shrimp production for the export market (Fishstat 2003).

Asia is the leading region in aquaculture production, with China producing 70 percent of the global total (Sabatini 2001), although recent reviews of Chinese production statistics show an overestimation of figures during the 1990s (FAO 2002a). Much of China's increased aquaculture production is attributed to carp culture (12 million metric tons in 2000, or one third of the world's aquaculture), destined mostly for domestic consumption. Significant increases can also be observed in South and Southeast Asia, Europe, and North America. Whereas production in Latin America and Africa is still relatively low, but increasing, and Chile is now the world's top producer of farmed salmon (FAO 1997a; Fishstat 2003) (see *Figure 6-1*).

Much of the world's aquaculture production comes from small-scale, extensive to semi-intensive systems. These systems dominate the production of many farmed species, including 70-80 percent of tilapia and shrimp production; 80-90 percent of carp, catfish, and milkfish, and 90-100 percent of freshwater prawn and crayfish (Tacon 1996). However, as demand for fish and the associated incentives for cash income increases, extensive systems are shifting toward more intensive operations that require higher levels of inputs. The use of compound feeds, for example, appears to be increasing in China, where extensive fish ponds have been the norm for decades (Tacon 1997). This intensification is more common in coastal provinces, where larger-scale farms account for 40 percent of production, while in remoter Chinese provinces traditional integrated extensive systems still predominate (FAO 2000b). The number of cultured species in China has also increased dramatically in the last 20 years, from about 10 fish species being commonly farmed in the 1970s to over 40 indigenous and exotic species introduced to inland aquaculture today (Miao and Yuan 2001). The newly introduced species include high-valued fish, crab, prawn, and soft-shelled turtles (Miao and Yuan 2001). This shift to more input-dependent aquaculture practices is also reflected in China's import of fishmeal, which increased by 51 percent since 1999 and almost three times since 1990 (Globefish 2001).

Figure 6-1: Growth in Aquaculture Sector by Continent



Source: Fishstat 2003.

THE AQUACULTURE DILEMMA: IS IT POSITIVE OR NEGATIVE FOR BOTH PEOPLE AND ECOSYSTEMS?

There are many different kinds of aquaculture and each system has its own strengths and weaknesses, which may positively or negatively affect the environment and people's livelihoods. Small-scale, extensive aquaculture has become widely recognized as a significant contribution to local economies and diets, as well as being associated with a lower degree of environmental impacts, although the cumulative impact of a large number of small farms can be just as damaging as a large-scale operation.

The trend in most countries is to intensify aquaculture operations toward more input-dependent practices. And while aquaculture products have certain advantages over wild-caught fish, such as a more regular supply, job security, and income generation, there are often negative environmental implications. Some of the major concerns surrounding aquaculture today include the use of wild-caught fish as aquaculture feed, which consequently places additional stress on already depleted wild stocks; social concerns that aquaculture is taking considerable amounts of fish—to make fishmeal—from the poor; and that aquaculture operations are destroying natural habitat—especially mangroves—and contaminating vast expanses of coastal and inland waters. While these are legitimate concerns, they are not as clear-cut and straightforward as these statements imply. Below, we briefly discuss the main advantages and disadvantages of aquaculture and then assess some of the key disputed concerns.

Aquaculture operations, especially intensive production systems, pose serious environmental concerns. The heavy dependence of intensive systems on human input—feed, water, chemicals—and the effects on ecosystems and species are major constraints in the sustainability and future growth of this industry.

In general, the advantages of aquaculture include:

- ***Regular supply and lower prices.*** Controlled production makes it possible to meet market demand regardless of natural fluctuation in wild stocks and seasonal changes. Technical advancements—including genetic improvements—allow for industrial operations where mass production can reduce costs and hence lower the price for the consumer. The price of farmed salmon for example, has consistently declined as aquaculture production expanded and consumption increased in the last 15 years (Globefish 2002b). Stocking of reservoirs and rice fields can also improve the supply of fish from these waterbodies.
- ***Income generation.*** Aquaculture is an income-generating activity and can provide considerable foreign exchange revenue for developing countries. For example, in 1997, shrimp aquaculture production in Thailand was valued at nearly US$1.6 billion (SEAFDEC 2001a).
- ***Food Security.*** Aquaculture's contribution to food security and livelihoods is of enormous significance, especially in remote and resource-poor areas. Small-scale, low input aquaculture that is done in combination with rice cultivation can "increase household resilience through diversification of income and food sources" (FAO 2000b). Extensive aquaculture of carp, for example, increases the amount of dietary protein that is available to the rural poor—needed protein that otherwise these communities cannot afford. China is a good example: per capita consumption of fish in the country has increased four-fold in the last 20 years, as its inland aquaculture has expanded (Laurenti 2002).
- ***Improvement in water quality.*** According to some aquaculture proponents, certain types of aquaculture, such as mollusc and seaweed farming can help clean water supplies. Shellfish, such as oysters and mussels, serve as natural filters, by removing nutrients, toxins, and sediment from the water column while feeding on microscopic plants and animals. Scientists estimate that each American oyster, for example, is capable of filtering up to 50 gallons (190 liters) of water per day (NCDMF 2003). Some scientists believe that the Chesapeake Bay's once flourishing oyster populations could have filtered the estuary's entire water volume of excess nutrients in 3 to 4 days (Newell 1988); of course, natural oyster populations are much better at filtering water into a bay, than randomly placed aquaculture structures. In addition, complex-structured oyster reefs can serve as nursery grounds for a variety of fish, crabs and other marine invertebrates, that can potentially enhance fisheries.

But aquaculture operations, especially intensive production systems, pose serious environmental concerns. The heavy dependence of intensive systems on human input—feed, water, chemicals—and the effects on ecosystems and species are major constraints in the sustainability and future growth of this industry. Nonetheless, recent technological advancements in some modern, efficient aquaculture operations, particularly in the more developed regions of the world, are helping to lessen the environmental impacts of these practices.

Below are some of the disadvantages arising primarily from, but not limited to, intensive aquaculture operations:

- ***Dependence on wild fisheries.*** Modern aquaculture operations use high-tech facilities and often depend on processed feed made from fishmeal and fish oil from wild-caught fish. Intensive aquaculture of high-valued

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An oyster farm just off the coast of Malaysia.

carnivorous species (e.g., salmon and shrimp) in particular, requires large quantities of artificial feed derived from lower-value fish (e.g., anchovies and mackerels) from capture fisheries. Raising one kilogram of shrimp for instance, requires about 2 kg of high-quality fishmeal (New and Wijkström 2002), or an equivalent of up to 10 kg of pelagic fish assuming a pelagics-to-fishmeal conversion factor of 5:1 (Tacon 1997)—a rather high feed conversion rate. It is important to note that the conversion rates of high-quality feed to protein in efficient salmon aquaculture operations in particular, has improved considerably in recent years.

Wild fish are not only used for feed, but also as juvenile stock or as seed fish for aquaculture practices, especially in the highly profitable and rapidly expanding sea ranching operations. Eel aquaculture, for example, relies completely on wild-caught juveniles—called glass eels—for seed, causing a complete collapse of the wild stocks in Europe, where most of the juvenile catch comes from (Dekker 2003). Many shrimp farmers in South and Central America, Bangladesh, and India also depend on wild-caught post larvae shrimp (shrimp fry), usually harvested by local fishermen (World Bank 2002).

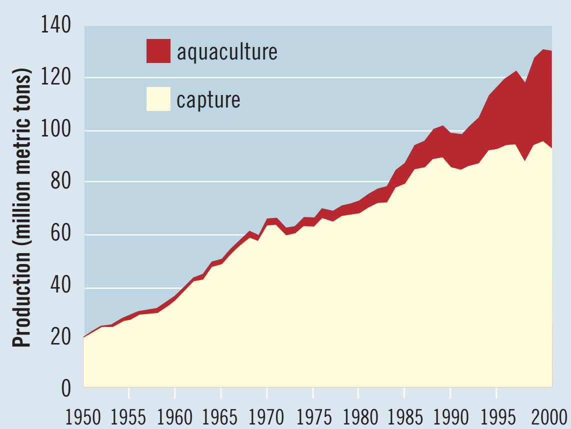
- ***Resource intensive.*** Intensive aquaculture operations maintain high densities of fish and shellfish under stressful conditions, often requiring the use of antibiotics, pesticides, hormones, vitamins and other chemicals to control diseases or to improve production. In the United States alone, between 204,000 and 433,000 pounds of antibiotics are used annually in the production of seafood sold for domestic consumption (Benbrook 2002). In addition, these systems may require other energy dependent resources such as the mechanical addition of oxygen to the water, and frequent water exchanges (up to 30 percent per day) to aerate and filter the ponds, although the rate of water use is much improved in recent years (Boyd and Clay 1998; World Bank 2002).
- ***Destruction of natural habitat and vegetation.*** To set up aquaculture facilities natural vegetation is often cleared, especially along the shore where brackish species, such as shrimp, are raised. As of 1998, Asia had 1.2 million hectares of shrimp ponds (Boyd and Clay 1998), and in Central and South America the creation of new farms continues unabated. Although precise estimates of the area cleared for aquaculture is not globally documented, one estimate is that some 40 percent of small shrimp farms in Asia displaced mangroves (Boyd and Clay 1998). Other important nursery and spawning grounds that disappear when vegetation is cleared for aquaculture are inland and coastal wetlands and seagrass beds.

- *Water pollution.* Discharge from aquaculture facilities can be loaded with pollutants, including excess nutrients from uneaten fish feed and fish waste; antibiotic drugs; and other chemicals including disinfectants, such as chlorine and formaline; antifoulants such as tributyltin; and inorganic fertilizers such as ammonium phosphate and urea (GESAMP 1997). These chemicals can significantly degrade the surrounding environment, particularly at local scales. In the North American Great Lakes, for example, rainbow trout aquaculture operations have increased phosphorous levels, reduced water transparency, lowered dissolved oxygen, and caused algae blooms (Great Lakes Fishery Commission 1999). Such water quality degradation can cause fish kills, odor problems, and reduce the productivity of some fisheries, as well as impair the water supply quality for neighboring communities.

  The use of antibiotics and other man-made drugs can also have serious health effects on humans, the ecosystem and other species. For instance, the transfer of antibiotics to wild fish and benthic microbial communities may influence natural bacterial decomposition in bottom sediments, impacting the ecological structure of the surrounding environment (World Bank 2002). The use of the antibiotic chloramphenicol, for example, can cause human aplastic anaemia, a serious blood disorder which is usually fatal. And while many countries have banned the use of chloramphenicol in food production, the level of enforcement varies considerably from one country to another (GESAMP 1997; Health Canada 2004). Another risk from antibiotic use is the spread of antibiotic-resistance in both human and fish pathogens. This resistance can hamper the effectiveness of treatments and further decrease the number of available drugs that can be used during disease outbreaks (Harper 2002). The U.S. Center for Disease Control and Prevention reported that certain antibiotic resistance genes in *Salmonella* might have emerged following antibiotic use in Asian aquaculture (Angulo 1999 as cited in Goldburg et al. 2001).

- *Introduced species and "genetic contamination".* Farmed fish are often genetically different from local wild populations. Sometimes the farmed species are exotics, other times they are genetically distinct varieties of the same species that occurs in the wild. These farm-raised fish often escape from aquaculture facilities or are intentionally released into the wild to boost stocks. Once in the wild, farm-raised fish breed with native populations of the same, or closely-related species causing loss of unique genetic fish varieties among the wild population, interbreeding problems, and consequently altering the species composition and the structure of native ecosystems.

Figure 6-2: Increasing Proportion of Aquaculture in Fish Production



Source: Fishstat 2003.

At a global scale, aquaculture seems to have been making up for the slowed growth in capture production over the last 15 years, rather than reducing the pressure of overfishing on wild stocks.

Inbreeding is of great concern, especially among salmon populations, where it can potentially reduce the fitness, productivity, and characteristics of local salmon varieties and runs (McGinnity et al. 1997; Doubleday 2001). In the Pacific coast of the United States, scientists have documented that between 1987 and 1996, at least a quarter million Atlantic salmon escaped from farms (McKinnell and Thomson 1997), putting in jeopardy the already depleted native Pacific salmonids. Experience in Ireland has shown that offspring of farmed salmon grow faster and out-compete native young Atlantic salmon in rivers, but are likely to have lower survival rates at sea than native salmon (McGinnity et al. 1997; Doubleday 2001).

The concern is that a relatively large number of farmed fish will replace the native spawners, who will then be unable to sustain themselves in the long term (Doubleday 2001). Escapees can also impact the wild populations by competing with them for food and habitat, acting as predators, or by spreading disease and parasites.

- ***Disease and Parasites***. Infectious disease is currently the single most devastating problem in shrimp culture and presents ongoing threats to other aquaculture sectors (FAO 2003c). In addition, when infected farmed fish escape from aquaculture facilities, they can transmit these diseases and parasites to wild stocks, creating further pressure on them. Infectious Salmon Anemia (ISA), a deadly disease affecting Atlantic salmon poses a serious threat to the salmon farming industry. ISA was first detected in Norwegian salmon farms in 1984, from which it is believed to have spread to other areas, being detected in Canadian salmon (1996), in Scotland (1999) and in U.S. farms (2001) (Doubleday 2001; Goldburg et al. 2001). Norwegian field studies observed that wild salmon often become heavily infected with sea lice (parasites that eat salmon flesh) while migrating through coastal waters, with the highest infection levels occurring in salmon-farming areas (Goldburg et al. 2001). Wild Norwegian salmon stocks have also been impacted by another parasite, *Gyrodactulus salar*, that probably originated from Swedish salmon used in stocking programs (Bakke et al. 1990).

IS AQUACULTURE HELPING TO REDUCE THE PRESSURE ON WILD STOCKS?

At a global scale, aquaculture seems to have been making up for the slowed growth in capture production over the last 15 years, rather than reducing the pressure of overfishing on wild stocks. As seen in *Chapter 3* it is obvious that capture fisheries alone cannot keep up with the world's increasing demand, and that much of the increase in annual global fisheries production now comes from aquaculture (see *Figure 6-2*).

However, the question of whether farmed products of one fish species can reduce the pressure on the wild stock of the same species is less clear. In theory, aquaculture products in the market can outcompete wild capture products of the same species group, and hence reduce the demand for the wild fish. However, the market response is not as simple. There are certain characteristics of wild-caught fish and farmed fish that differentiate the demand for each product—in general, captured fish is considered more "healthy" because of its lower fat content and finer flavor than farmed fish; hence, consumers are willing to pay more for the capture products (Brigante 2001). For example, a study of sea bream and seabass markets in Italy shows that wild-caught and farmed fish occupy different niches in the market, and that one does not affect demand for the other (Brigante 2001). Another important factor is that while most seafood products have several substitutes, these substitutes tend to come from other species (Asche and Bjørndal 1999), not from farmed varieties of the same fish. For example, new farmed species, such as tilapia, have carved out market share in the United States and Europe as a substitute for traditional white fish such as cod and haddock which are overfished and consequently more expensive and harder to find in the market (Alceste and Jory 2002).

Nevertheless, a few exceptions do exist. One condition under which a farmed product may displace the demand for wild fish is when supply from aquaculture rapidly increases and saturates the market, lowering the price, as in the case of salmon and catfish, or of seabass in the Mediterranean. The price of salmon has declined and is now at a record low, as more salmon became available from successful aquaculture production operations in Norway and Chile in the last 15 years (Globefish 2002b). Another example is when the characteristics of the cultured product are actually favored over that of wild fish. Farmed Norwegian Atlantic salmon, for example, is out-competing wild Alaskan salmon in the Japanese market—the world's leading importer of frozen salmon—because of its higher fat content which is preferred by Japanese consumers (Globefish 2002b).

FAO/19901/G. GREPIN

Shrimp fry collectors on the Passur River, Bangladesh.

Wild stocks are used for feed

As mentioned earlier in this Chapter, aquaculture is increasingly using more wild-caught fish to produce processed fish feed. In 2001, aquaculture used 35 percent of the global fishmeal supply and 57 percent of the global fish oil supply (Nautilus Consultants Ltd. 2003)—most of it for just salmon and shrimp production (Delgado et al. 2003). Herbivorous and omnivorous species, such as carp and tilapia, which do not need to consume fishmeal because they can process plant protein better than carnivorous species, are now being fed artificial feeds in order to boost growth. This is particularly true in China, where most carp production has not utilized fish feed until recently.

A future concern for fishmeal producers, and for fisheries managers, is that because most of the stocks currently used as feed have already reached their maximum production levels, market pressure to harvest relatively unexploited species may increase. One of these relatively unexploited fisheries that has excellent nutrient potential for fish feed (New and Wijkström 2002), but at the same time could have devastating ecosystem-wide effects is krill—a microscopic crustacean living in Antarctic waters. According to the FAO, the use of krill as an aquaculture feed is likely to increase in the coming years (FAO 1997d). This usage, however, requires special monitoring because increased harvesting of krill—which forms the base of the Antarctic food chain—could alter entire food webs and potentially harm numerous species and ecosystem structures. In the Antarctic Ocean krill fisheries operate during periods when many species—from whales to fish—are directly or indirectly dependent on this resource (Parkin 2003); a drastic change in available krill, could affect the survival of these species.

Wild stocks are used for seed

Similarly, the use of wild-caught juveniles as seed fish in aquaculture operations can have a serious impact on wild fish stocks. Such is the case with the declining population of European eel, whose juveniles are collected from the wild in European waters for aquaculture operations elsewhere in the world—mostly in Japan (see *Chapter 3* for further discussion on the condition of the European eel stock). Another serious and more recent concern is the sea ranching of tuna species, especially the highly valuable bluefin tuna, one of which usually sells for thousands of US dollars in the Japanese sashimi market. Tuna ranching or fattening is the practice of capturing wild juvenile tuna and placing them in open-ocean pens where they are fattened with formulated feeds to improve their oil content. This is done to produce the expensive, but very flavorful "fatty tuna" so much in demand by sushi and sashimi lovers the world over. The tuna farming industry is rapidly expanding. Total production of "fattened" tuna increased from 5,000 metric tons in 1997 to over 20,000 metric tons in 2001 (Ukisu 2001). The major producing countries include Spain, Croatia, Malta, Italy, Australia, and Japan, with production in the Mediterranean making up more than half of the world total and almost all exported to, and consumed in Japan (Tudela 2002).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Offshore fish ranching pen.

This faming method, however, is raising concerns with fisheries managers, fishers, environmentalists, the FAO, and the various International Tuna Commissions. Fishermen catch the juvenile tuna before they have had a chance to reproduce and renew wild stocks, thereby increasing fishing pressure on the already depleted wild populations and putting long-term yields and any hope for sustainability at risk.

In addition, fish caught by Mediterranean purse seiners are now being transferred directly to pens and cages for fattening, without landing them at port and reporting the catch so it can be integrated into catch statistics to guide quota allocations and fisheries management rules (Tudela 2002). The International Commission for the Convention of Atlantic Tuna (ICCAT) has not only expressed serious concern on this matter, but has gone further by approving a recommendation on bluefin tuna farming in 2003 that, among other things, requires all ICCAT members to report all transfers of tuna to fattening facilities (ICCAT 2003a).

FAO/20044/ H. ZHANG

Mulberry field with fish ponds in the Taihu Lake area of Jiangsu province, China.

Reporting requirements include number of fish transferred, dates, names of vessels involved in the transfers, as well as locations where the tunas were caught and the names of the fattening facility operators (ICCAT 2003a). ICCAT has also approved recommendations that require imports of "fattened" tuna to have the appropriate documentation for tracking and monitoring these operations and facilities (ICCAT 2003a).

As with other forms of aquaculture, increasing farmed tuna stock may make more high-valued tuna available year-round and lower the prices, resulting in increased demand and more pressure on the wild stocks. Measures to monitor and track these practices, as well as strict enforcement of regulations, and willing collaboration from member states that are involved in these operations is not only needed, but essential if we are to sustain these fisheries in the long term.

IS AQUACULTURE HELPING TO FEED THE POOR?

As mentioned earlier, aquaculture operations can be divided into two general categories: large scale or intensive operations that target export markets, and small-scale or extensive operations that target local consumption. Intensive operations often require large financial investments and therefore tend to be owned by large companies. Developing-country producers certainly benefit from these operations through overall revenue and employment generation, but the local people who actually live in areas where the farming takes place do not always enjoy all the benefits. In addition, local communities also have to cope with a number of environmental and social problems arising from the operations such as polluted water and the reduction in wild fish for local consumption. In India and Bangladesh for example, local farmers and fishermen who depended on coastal resources were unable to access beaches and creeks due to shrimp farming activities—a significant factor contributing to the Supreme Court's ban on shrimp farming in India (World Bank 2002).

On the other hand, extensive, rural, or small-scale aquaculture tends to benefit local people and have lower environmental impacts. These operations supply food to local markets and support local livelihoods. Inland water carp aquaculture production, for instance, provides significant cash income to farming households in rural China and animal protein to much of the population. In China, per capita availability of fish and fishery products increased from less than 6 kg in the early 1980s to about 33 kg in 1999—40 percent of which came from inland fisheries and aquaculture (Laurenti 2002). More than 80 percent of the employment in the fisheries sector is estimated to be in inland fisheries and aquaculture in rural areas (Miao and Yuan 2001). In terms of cash income, the average income of people engaged in fisheries and aquaculture is nearly twice as much as the average income in the agricultural sector in general. In China, fish-culture related activities provide over 90 percent of the income to small-scale carp farming households in rural areas (Miao and Yuan 2001). For these reasons, a number of fisheries development and research agencies are now promoting more research and investment in developing small-scale or rural aquaculture (NACA and FAO 2000; FAO 2000b).

Despite its success in Asia, rural aquaculture development has not been as successful elsewhere. Attempts to introduce aquaculture practices to rural Latin America, for instance, have often failed partly because in some regions there is no strong tradition of a fish-based diet and fish farming, or because aquaculture was not introduced as an integral part of existing farming systems (FAO 2000b). In parts of Africa, competition from inexpensive capture fisheries, inappropriate aquaculture extension programs, low population densities, and lack of appropriate infrastructure have contributed to poor results at developing rural aquaculture (Harris 1993).

Women participate in fishing activities, by feeding pond-raised fish, cleaning, drying, salting, and preparing the fish for local consumption and export, Cambodia.

IS AQUACULTURE TAKING FOOD FISH AWAY FROM THE POOR?

One of the concerns surrounding aquaculture is the belief that intensive aquaculture is consuming vast amounts of processed feed derived from wild-caught fish that could be used to feed the poor. But the argument that industrial fishmeal production competes with domestic demand for small pelagic fish for food, has not been substantiated, at least for the moment. First, fishmeal and fish oil are primarily made of waste from fish processing factories, and of surplus production of small pelagic fish for which there is limited demand for direct human consumption. Second, the largest fishmeal and fish oil producers are in Peru, Chile, and the European Union, where small pelagic fish are so abundant that production more than surpasses domestic demand. Third, even in developing countries where a food deficit exists, much of the high-quality fishmeal used in intensive aquaculture is imported from Northern Europe, Japan, or Chile (World Bank 2002), rather than relying on domestic supplies of small pelagic fish.

Over the past three decades, the aquaculture sector has grown at an unprecedented pace and it seems that it will continue to do so. The challenge is to maintain the balance between support for further development of the sector and regulation to prevent potential adverse environmental and social impacts.

There are however, some isolated cases, where locally caught "trash" fish—fish that impoverished populations actually rely on—are used as aquaculture feed (Edwards and Allen 2003; World Bank 2002). In addition, a recent study of the industrial pelagic fishery in Peru that caters to the fishmeal industry shows that a large portion of the catch—more than 20,000 metric tons in 2003—is bycatch of fish such as sculpin and drum, which affects the stocks of important white fish that provide food to local markets (Segura et al. 2004). The destination of the bycatch is unclear, but this is certainly an example of the fishmeal industry indirectly taking food away from the poor.

CHAPTER 6

The Role of Aquaculture: Is It Helping to Sustain Fisheries and Feed the Poor?


FAO/18558/R. FAIDUTTI

Aquaculture pens in Thailand.

While overall it may not directly take fish away from the poor, the fishmeal industry as a whole may want to review the environmental costs of its production processes. Untreated sewage from fishmeal factories in Peru for instance, has deposited a thick layer of fat on the bottom of the Bay of Paracas, rendering 18 km^2 or 95 percent of the Bay's seafloor a biological dead zone—decimating local traditional fisheries (Mundo Azul 2004).

There is little doubt that dependence on fishmeal can pose financial constraints to aquaculture (as well as to poultry and livestock) in the future if the demand for fishmeal keeps increasing while the overall global supply is static (World Bank 2002). Global production of fishmeal and fish oil combined has averaged 8 million MT in the last 15 years. It is unrealistic to believe that the increase in capture fishery can increase the supply of fishmeal since most of the fishmeal-grade fish are already managed by some kind of total allowable catch system to prevent overfishing. Peru and Chile, the top fishmeal producers, apply strict catch regulations to protect their fish stocks. For now, the growing demand for fishmeal in the aquaculture sector might be offset by declining usage in the other agricultural sectors (poultry and livestock). The share of global fishmeal production being used for aquaculture has increased from 10 percent in 1988 to 35 percent in 2000 while usage for poultry declined from 60 percent to 24 percent (Barlow 2001). However, there are concerns that in the near future more fish species currently being consumed as food may be "downgraded" to become fishmeal material in order to meet the demand. If the price of fishmeal keeps increasing (Globefish 2001), the fishmeal market may start taking small pelagic fish away from people. However, this can be avoided by substituting vegetable oil and protein for fish oil, improving the efficiency of aquaculture facilities, and making better use of fish waste and capture fishery discards in the fishmeal production process (Barlow 2001).

TOWARD SUSTAINABLE AQUACULTURE

Over the past three decades, the aquaculture sector has grown at an unprecedented pace and it seems that it will continue to do so. The challenge is to maintain the balance between support for further development of the sector and regulation to prevent potential adverse environmental and social impacts. Because the aquaculture industry has expanded so rapidly, the legal and political frameworks for maintaining it as a sustainable business have lagged behind. Article 9—Aquaculture Development—of the FAO Code of Conduct for Responsible Fisheries (the Code) adopted in 1995, sets principles and guidelines for the sustainable development and management of aquaculture. (See *Chapter 9* for further discussion on the FAO Code of Conduct.) A brief overview of the key principles of Article 9 that relate to the environmental impacts of aquaculture and some of the progress in these areas follows.

Establishing Legal and Administrative Frameworks for Responsible Aquaculture

Under Article 9.1 of the Code, countries are encouraged to establish "legal and administrative frameworks that facilitate the development of responsible aquaculture" (FAO 1997c). Following these principles, many countries have started to implement national regulatory guidelines that address the environmental and social impacts from aquaculture in order to ensure its sustainability. A total of 140 codes or instruments to promote responsible aquaculture have been put in place in FAO-member countries both by government and industry (FAO 2003d). Canada, for example, has developed a comprehensive Aquaculture Action Plan, which provides clear guidelines for applying regulatory responsibilities to aquaculture under the existing legislation (DFO 2001). Canada has also implemented strict controls on the introduction of non-native species by establishing a National Code on Introductions and Transfers of Aquatic Organisms (DFO 2002a). Brazil, Malaysia, and Sri Lanka have made progress in establishing legal and regulatory frameworks for aquaculture (Emerson 1999), and the state of Tamil Nadu in India has enacted an Aquaculture Regulation Act, which calls for the establishment of an "Eco-Restoration Fund" for remedying environmental damages caused by aquaculture operations (FAO 1997d).

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Offshore fish ranching pen.

The seafood industry has also taken steps in this area. The Australian Seafood Industry Council has developed a voluntary Code of Conduct for a Responsible Seafood Industry (ASIC 2003), while the Australian Aquaculture Forum has developed a similar Code of Conduct for Australian Aquaculture (AAF 1998).

Encouraging the Use of Environmentally Sound and Sustainable Practices in Aquaculture

Despite such progress, aquaculture-producing countries still face enormous challenges to support responsible practices. While there are examples of environmentally sound practices, one of the limiting factors is the lack of financial resources for some countries to take advantage of the advanced technology that lessens the impact of aquaculture on the surrounding environment (Emerson 1999). Some of the more promising areas for lessening the environmental impacts of aquaculture practices include the following.

Closed or low-discharge systems

A recirculation or closed-cycle system is an innovative system of culturing fish in tanks using water that constantly recycles. It is considered more environmentally friendly than traditional open systems, because it conserves water and fishmeal, avoids wastewater discharges, and minimizes the use of land. A notable example is the expansion in tilapia production using indoor closed-recirculation systems in the U.S. freshwater farming sector (FAO 2003c). Multilateral and bilateral organizations financing aquaculture operations in developing countries should invest in aiding technology transfer, or at least request the agencies or NGOs implementing the projects to ensure the use of technological measures that will diminish the potential impacts of aquaculture operations on the surrounding ecosystems and communities.

Lessening the dependence on wild fisheries

Aquaculture can also help to lessen dependence on fishmeal from wild-caught fish. The use of plant protein in feeds has considerable potential, with some success to date. For example, some research shows the successful replacement of 33 percent of fishmeal-based protein with soybean meal and pea protein concentrate for Atlantic salmon feed (Carter and Hauler 2000). There are also a number of research activities investigating alternative sources of protein for shrimp, molluscs, and fish feed (FAO 2003c). Conversely, other studies have shown lower growth rates and higher mortality in several aquatic species when vegetable meal was substituted for fishmeal (Lim et al. 1998 as cited in Delgado et al. 2003). The complete replacement of fish oil is even more difficult than the replacement of fishmeal, because replacing more than 50 percent of the fish oil in feed for carnivorous fish (especially salmon species) may affect their growth, survival rate, as well as the fat content and therefore the flavor of the product (Wada pers. comm. 2003).

Nevertheless, there is ongoing research on protein feeds and biotechnological techniques that seem to increase the opportunities for developing non-fish based alternatives. For instance, improving of the dietary value of *Artemia nauplii* (brine shrimp, the most widely used live feed in shrimp aquaculture) through bioencapsulation (enrichment) has shown positive results in improving quality, survival, growth, and stress resistance of shrimp larvae (Merchie et al. 1995 as cited in FAO 2003c). Plant-based protein also has significant potential for lessening the problem of phosphorous pollution, because plants contain less phosphorous than animal protein, therefore diminishing the overall phosphorous levels in water discharges (FAO 2003c).

Advances in hatchery technology

It is widely felt that advances in hatchery technology, especially for the culture of marine species, has great potential to replenish wild fisheries. Unfortunately, much of the research into stocking marine species is still at the experimental stage (Bartley 1999). But despite the absence of adequate

Box 6-2: Use of Genetic Technologies in Aquaculture

The application of genetic biotechnologies in the farming of aquatic organisms has gained significant attention in recent years because of its potential to increase production. Gjedrem (1997) stated that by simply using selective breeding on more aquatic species, aquaculture could more than keep up with the rising demand for aquatic products. Chromosome set manipulation to make sterile animals has been used to keep animals from wasting energy on developing gonads, and to reduce the chance of animals breeding in the wild in the event they escape from culture facilities. Studies have shown that the growth of transgenic salmonoid species is, on average, 3 to 5 times larger, than those of non-transgenic salmonids under controlled conditions (Devlin et al. 1994). Similarly, studies on the use of hybrids in the culture of numerous species show considerable potential for improving yields (FAO 2003c, Bartley et al. 2001).

However, the use of Genetically Modified Organisms (GMOs)—the term applied to animals or plants that have been genetically altered to improve growth, yields, or disease resistance by means of gene-transfer or other modern genetic technologies—has become especially controversial (Bartley 2000). The use of GMOs in agronomy is more prevalent with over 60 million hectares planted with transgenic crops worldwide (Beardmore and Porter 2003).

Despite increases in production and yields, the use of GMOs raises concerns regarding their impact on human health and ecosystem integrity. Indeed, the impacts of genetically altered farmed fish on ecosystems and species are not well documented (NACA/FAO 2001). The high level of uncertainty regarding impacts mandates that a precautionary approach should be adopted as suggested by the FAO Code of Conduct for Responsible Fisheries, and the Convention on Biological Diversity. Some countries promote GMO projects while others vehemently oppose their use.

However, GMOs are just one category of genetic alteration and at present there are no GM aquatic species available on the market or available to the consumer. All genetically altered organisms should be evaluated as to their advantages and risks. Article 9.3 of the FAO Code recommends member states to "undertake efforts to minimize the harmful effects of introducing non-native species or genetically altered stocks." (FAO 2003d); and useful guidelines and mechanisms exist to regulate the use of GMOs and introduced species in aquaculture. These include the International Council for the Exploration of the Seas's Code of Practice on the Introduction and Transfers of Marine Organisms, the USA's Nuisance Species Protection Act, the U.S. Department of Agriculture Performance Standards for safely conducting research with genetically modified fish and shellfish, and the EU's Directive on the deliberate release into the environment of genetically modified organisms.

These guidelines are also detailed in the FAO Technical Guidelines for Responsible Fisheries. However, a survey conducted by FAO revealed that only a limited number of countries have actually introduced measures that encompass risk management, environmental impact assessment, or the application of the precautionary principles regarding the introduction of non-native species and the use of genetically altered stocks (FAO 2003d).

scientific information, there is a growing expectation amongst the aquaculture industry that hatchery technology and the farming of marine species could rescue the depleted wild stocks. Recent advancements in hatchery technology, for example, are making cod farming—the raising of juvenile codfish in ocean net pens—a promising enterprise. In Norway, cod farming is expanding rapidly. The Norwegian industry claims that by 2013, cod farms in the country will be producing five times the volume of the current cod catch harvested by the British fleet (*The Economist* 2004). Genetic technologies have also been successful at creating selectively bred varieties, e.g. carp and tilapia, producing useful hybrids and creating sterile animals that grow well and do not breed with the wild population if they escape (Bartley 2000; Bartley et al. 2001).

One advantage of improving the science of stock enhancement and hatchery technology is that it may help reduce the demand on wild-caught fish that are used as seed in aquaculture operations. The majority of the shrimp seed used in the world, for example, no longer relies on wild-caught larvae but comes from hatcheries and nurseries (World Bank et al. 2002). And even farmers in countries such as Ecuador who used to favor the use of wild seed for shrimp farms, are now shifting to hatchery-reared seed because they are perceived to contain fewer diseases (World Bank et al. 2002). Replacing wild-caught seed with hatchery-reared seed however, requires some transition, since the livelihood of many poor communities, such as those in Bangladesh, still depends on the collection of wild seed (World Bank et al. 2002).

Regardless of the positive impact that these technological advancements may have, the fast development of the sector underscores the need for a precautionary approach. This is particularly true given that information on the long-term impacts of these technologies on wild stocks (such as disease transfer, genetic contamination, predation, and competition) are not well documented or available, and the consequences of their use could prove devastating to wild species and ecosystems. For this same reason, the use of genetic engineering—creation of transgenic organisms or genetically modified organisms (GMOs)—in aquaculture, is especially controversial (see *Box 6-2*).

Use of best practices to mitigate impacts

It is important to recognize and promote the use of best practices that increase efficiency and productivity, and reduce impacts. Fish farmers can mitigate water pollution from aquaculture facilities by reducing the amount of feed they apply or by collecting sediments and solids prior to discharge. Farmers may also reduce the mortality of fish by reducing the fish density in a pond and in turn increase productivity. Research shows that careful management in combination with quality feeds, well designed culture systems, and a solids collection area can reduce nutrient discharges by as much as 50 percent (Miller and Semmens 2002). In Australia, the use of settlement ponds reduced total suspended solid loads by 60 percent, total phosphorous discharge by 30 percent, and total nitrogen discharge by 20 percent (World Bank et al. 2002). The use of biofiltration, including the use of molluscs, seaweed, and marsh plant species, is also being applied for effluent treatment (World Bank et al. 2002). These and other best practices should be promoted and disseminated among farmers for their adoption based on individual farm characteristics.

Integrating Aquaculture Operations into Rural Agriculture Practices to Support Livelihoods

The integration of aquaculture practices into agriculture practices, such as cultivating fish together with rice, should be supported, since it generates income for the poor with minimal negative impact on the surrounding ecosystem. In fact, integrated aquaculture systems can provide some positive environmental benefits (NACA/FAO 2001). For example, rice-fish systems reduce the amount of fertilizer needed, reduce the frequency of insect infestations, while increasing rice yields and providing farmers with extra income from fish sales (International Development Research Center Canada 1998). This integrated approach is now being used for environmental rehabilitation, such as the rehabilitation of former mangrove areas that have been cleared and converted to shrimp ponds.

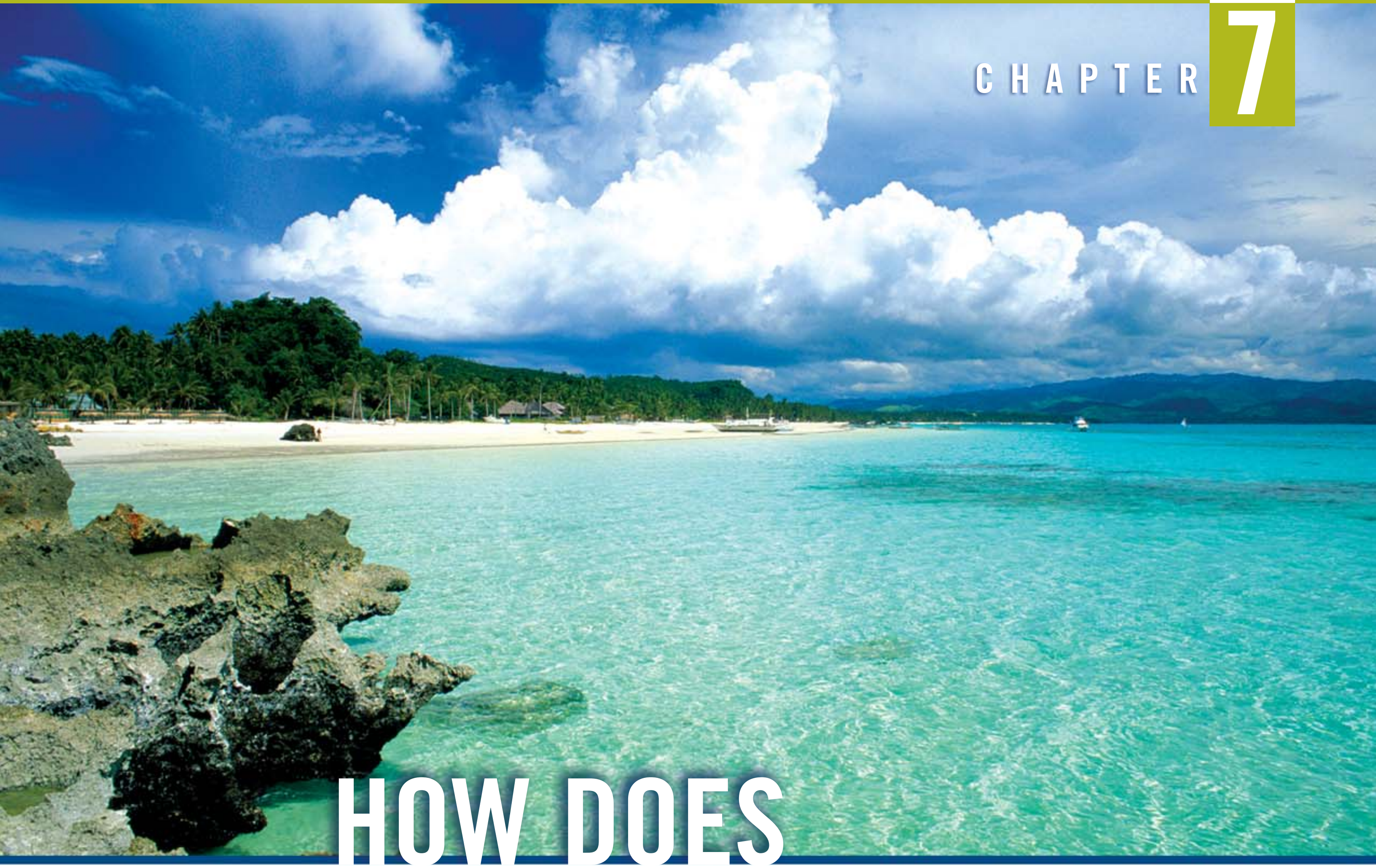
In Vietnam, the Mekong Delta Master Plan integrates shrimp farming into mangrove rehabilitation projects to relieve land-use conflicts and reduce incentives to build illegal shrimp ponds (Primavera 2000). In Indonesia, a modern version of the traditional fish ponds farming systems in mangrove areas relying on natural food and seed (known as Tambak or Empang Parit) is now being promoted (Primavera 2000). Both examples allow for the use and development of aquaculture for food and income generation, while conserving mangrove forests.

FAO/19341/R. FAIDUTTI

Fishermen bringing in tilapia, Lake Victoria, Uganda.

Providing Positive Economic Incentives

Finally, market incentives, such as certification for sustainably farmed products needs to be expanded to developing countries, because the existing certifying bodies are primarily restricted to a handful of organizations in developed countries, mainly Europe, North America, Australia, and New Zealand (See *Box 11-1 Seafood Certification: Incentive for Sustainability*). Price premiums for certified products not only give producers incentives to generate environmentally sound products, but also help consumers use their purchasing power to encourage such practices (FAO 2003c). Encouraging news indicates that market incentives are being considered and put in place in the developing world. For example, Thailand is considering a "certification" process for marketing shrimp aquaculture products that are produced in environmentally sound ways (NACA/FAO 2001).



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CHAPTER 7

HOW DOES FISHING AFFECT ECOSYSTEMS?

Both the quantity of fish we catch and the manner and frequency with which we harvest them affect marine and freshwater ecosystems. Overfishing a particular stock, for instance, affects not just the population of that particular species, but can also change the composition—the population balance among the various species—of a given habitat. Thus, the potential impacts from fishing go well beyond the targeted fish and often include substantial collateral damage to non-target animals as well as freshwater and marine habitats, such as coral reefs and seagrass beds. The cumulative effect of these impacts is, according to some scientists, the leading cause of current changes in the structure and functioning of coastal and marine ecosystems—more influential than climate change or water pollution (Jackson et al. 2001). To mitigate these harmful effects we not only have to *fish less*, we also have to *change the way we fish* by using alternative fishing methods and modified gear that lessens the impacts on habitats and non-target species.

The impacts of capture fisheries on ecosystems can be broadly categorized into four types:

(1) overfishing of target animals;

(2) mortality of non-target species (bycatch, discards, and "high-grading");

(3) alteration of community structure; and

(4) habitat degradation from fishing gear and fishing practices.

Overfishing is discussed in detail in Chapter 3, so this chapter will focus on the three other negative impacts listed above. In Chapter 6 we look at the environmental impacts of aquaculture, a related issue.

BYCATCH, DISCARDS, AND HIGH-GRADING

What is Bycatch?

The world's fishing fleets harvest a large number of fish and other animals besides the particular fish species they are targeting. These non-target fish and animals, accidentally caught in fishing gear along with the intended species, are called *bycatch* or *incidental catch*. Some of this bycatch is retained for sale, but a portion of it—often a large portion—is returned to the sea, usually dead or dying. The animals and fish returned to the sea are known as *discards*. At times, even some of the target species are discarded if they are damaged, do not meet the minimum legal size for landing, or fall short of other legal and economic yardsticks.

Bycatch or the incidental catch of non-target species is a key contributor to the depletion of fish stocks, and can have a significant impact on endangered species of fish, mammals, and seabirds.

One particular profit-driven practice that involves commercially valuable fish is called *high-grading*—discarding smaller fish of the target species to make room for larger, more valuable fish caught later in the day. Imposition of strict catch quotas may create incentives for high-grading as fishers struggle to maximize the value of each kilogram of the quota (Gills et al. 1995). The result of high-grading for the fisher is a higher return on the day's fishing effort, but the ecological price is high, since the discarded fish are often juveniles of the target species that will not reach maturity. Discarded species tend to have very low survival rates by the time they are returned to sea, so juveniles that are discarded will not go on to reproduce, thus harming the development of future stocks of the species. Discarding commercially viable undersized fish is therefore not only wasteful but biologically and economically unsustainable. Scientists believe that the present level of bycatch is a key contributor to the biological depletion of fish stocks and changes in the species composition of the marine environment (Alverson et al. 1994). It can also have a significant impact on endangered species of fish, mammals, and seabirds.

How Much Bycatch and Discarded Catch is there?

Bycatch and discards, and the associated high mortality of non-target species, such as marine turtles, is one of the major challenges facing sustainable fisheries. The latest FAO estimate of total discarded catch is considerable, but reflects quite an improvement over previous numbers (Kelleher 2004). World marine fisheries today discard less than 10 million metric tons of animals (Kelleher 2004), whereas previous estimates, although not directly comparable because of different methodology used, placed this figure at around 20 million metric tons (FAO 1999c). This estimate does not include discards from inland fisheries (lakes and rivers), marine mollusc fisheries, or releases and discards from marine recreational fishing. Lower discard rates reflect better utilization of the catch, adoption of more selective gear (particularly in Europe, North America, and New Zealand), reduced effort in some major trawl fisheries, and application of policies to reduce bycatch (Kelleher 2004). Yet, to some extent, these figures still underestimates the discard of marine mammals, turtles, and seabirds which can be substantial in certain fisheries. Hundreds of thousands of marine mammals are estimated to be caught worldwide each year (Read et al. 2003). Unfortunately, discard estimates are highly uncertain. Lack of uniform data on discard quantities and species composition acts as a barrier to the development of more selective fishing gear, improved estimates of species mortality, and better fisheries policies.

To many people the terms bycatch and discards are synonymous with "waste." However, this is only partially true, since much bycatch is commercially exploited, particularly in Asia where all species are considered to be targets and the entire catch is utilized. Bycatch that is retained is often sold for human consumption or, particularly in Southeast Asia, used as aquaculture feed (Alverson 1998). And as the new estimates for discarded catch show, utilization of the retained bycatch has improved considerably (Kelleher 2004). The Northwest Pacific, Northeast Atlantic, and the Western Central Atlantic continue to be the areas with the highest discard rates (Alverson et al. 1994, Kelleher 2004). Incentives for fishers to implement measures to avoid unwanted bycatch, or to create markets for currently discarded species, can reduce wastage. However, simply making better use of bycatch does not necessarily address some key issues, such as the impact of fishing on endangered marine mammals, birds, and other marine species, or changes in fish population structures that may impact future stocks.

Which Fisheries Have the Largest Bycatch?

In some fisheries, the bycatch rates are so high that there are more non-target animals than target species in each net. The catch, and therefore the bycatch, depends on many factors including the type of gear used, as well as how and where it is used. All fishing gears are to a certain degree selective; however, fishing gear that is towed along the ocean floor, such as trawls tend to be less selective than lines or purse seines. Such less selective gears tend to have higher discard rates. The top highest

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Some fishing gear catch more non-target species in each net: shrimp bycatch, eastern Florida, USA.

discard rates (the proportion of the total catch discarded) are dominated by shrimp trawl fisheries; bottom-trawl fisheries for finfish such as cod, flounder, halibut, and sole; and the tuna and other highly migratory species longline fisheries that have a considerable discard rate for sharks (Alverson et al. 1994, Kelleher 2004). Crustacean and other bottom-trawl fisheries jointly account for approximately 50 percent of estimated global discards, while representing about 25 percent of global landings (Kelleher 2004). A recent review of the fishing gears used in the United States and their impact on ecosystems confirms that bottom-trawls, bottom gillnets, and dredges have substantial ecological impacts on marine biodiversity (Morgan and Chuenpagdee 2003).

Shrimp trawling continues to be the major source of discards worldwide, accounting for close to 35 percent of discards from commercial fisheries in the 1980s and early 1990s (Alverson et al. 1994). However, there has been some improvement in certain regions of the world due to stricter enforcement of gear-use regulations and better catch utilization (Alverson 1998; Kelleher 2004). U.S. shrimp fishers in the Gulf of Mexico, for instance, used to discard more than 5 kilogram of fish, such as red snapper, and other animals for each kilogram of shrimp they caught (Alverson 1998). Since 1998, the use of certified Bycatch Reduction Devices (BRDs)—a device installed in shrimp nets that provides a small opening to allow red snapper and other finfish to escape—has been required for most offshore shrimp trawlers in the Gulf of Mexico in order to reduce the severe bycatch of juvenile red snappers (NMFS 1998). It is estimated that BRD usage has reduced bycatch of red snapper in the Gulf by 40 percent (NMFS 2004).

The United States example shows, that in some cases, discard rates can be significantly reduced by modifying gear and fishing methods, if that is accompanied by incentives for, and enforcement of, gear regulations. However, there is still considerable debate on the effectiveness of many of these devices and gear modifications, especially as it relates to the loss or potential loss of target catch. If gear regulations have a high impact on fishery profits, the implementation of their use becomes very challenging. In the case of the Gulf of Mexico, the financial losses incurred by shrimp fishers in an effort to restore snapper stocks far outweigh the commercial value of the snapper fishery, making the use of BRDs unpopular. Therefore, while the use of BRDs have helped to mitigate the problem, they are not as effective as is necessary for recovery of the red snapper stock (Gallaway and Cole 1999).

The fisheries with the lowest discard rates tend to be pelagic trawls, mid-water trawls, some high seas driftnet fisheries, and purse seines targeting menhaden, sardine, and anchoveta. In these cases, the placement of the net in the water column and the schooling behavior of the targeted fish combine to reduce bycatch. Small-scale and subsistence fisheries also have practically no discarded catch, since most of these fishers sell or consume everything they catch (FAO 1999a; Jennings et al. 2001).

BYCATCH OF DOLPHINS, SEABIRDS, TURTLES, AND SHARKS

The current debate, research, and regulations concerning bycatch tend to focus on the negative effects of bycatch on well-known species such as dolphins, turtles, and seabirds, which are profiled below. However, it is important to remember that many other organisms besides these charismatic species are killed as bycatch, and usually in far larger quantities. Of particular importance for the sustainability of fisheries is the bycatch of non-target fish of commercial value and juveniles of target species. When these fish are killed, it jeopardizes the reproductive potential—and thus the future commercial viability—of the stocks.

How Does Bycatch Affect Dolphins?

Dolphins are fished commercially in many places, including Japan, Greenland, and India, but they are also a significant bycatch in some tuna fisheries (Fishstat 2003; Reeves et al. 2003). Unintended dolphin mortality during tuna fishing has been a prominent issue among civil society since the dimensions of the problem became public knowledge in the 1980s. Public awareness campaigns by environmental groups showing dolphins caught and killed in tuna nets triggered a long-standing "dolphin-tuna" debate, particularly in the United States.

In the early years of the tuna purse seine fishery in the eastern tropical Pacific, hundreds of thousands of dolphins were killed each year in tuna nets. Fishermen knew that tuna are often associated with schooling dolphins and would set their nets intentionally around the dolphins in order to catch the tuna. This "dolphin-set" technique contributed to a major dolphin population decline until the late 1970s. Estimates of dolphin mortality from tuna fishing during the 1950s and 1960s place the mortality rate as "very high," although actual data is limited (Hall 1998; Alverson et al. 1994). The available information at the time, however, led to considerable concern among scientists and environmental groups that bycatch mortality was depleting dolphin populations.


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Separating shrimp from bycatch, North Carolina, USA.

Public outrage from media images of dead dolphins put pressure on governments and the tuna industry to adopt practices that reduced dolphin mortality. Some of the measures included releasing dolphins from nets and using alternative purse seining methods. In the United States, where public reaction was strongest, the 1972 Marine Mammal Protection Act was amended in 1994 to include regulations governing the incidental taking of marine mammals in the course of commercial fishing operations. The intention was to reduce the "incidental serious injury and mortality of marine mammals to insignificant levels approaching a zero rate" (NMFS 2002a). In addition, a total annual dolphin mortality limit for tuna-related bycatch in the Eastern Pacific was set by the International Dolphin Conservation Program (IDCP) at 5,000 individuals, although this was a voluntary limit. Stock-specific limits are also established under the IDCP to ensure that no individual dolphin stock is adversely impacted.

Thanks to these efforts, dolphin mortality from tuna fishing has dropped considerably. In the eastern tropical Pacific Ocean, bycatch mortality of dolphins dropped by 99 percent, from 133,000 dolphins in 1986 to 1,636 in 2000—a level considered to be non-threatening to dolphin stocks (NMFS 2002a).

Unfortunately, there may be a darker side to this successful reduction in dolphin bycatch. Some scientists and fishermen claim that the current standard of "dolphin safe" labeling of commercial tuna is so strict that it has encouraged purse seine fishermen to use methods that may be dolphin-friendly, but detrimental to other species (see *Table 7-1*). For example, a common alternative to the "dolphin-set" technique is to set a net around a floating object, such as a log. These objects are known to attract tuna, but other fish species such as mahi-mahi, wahoo, sea turtles, and several shark species are also attracted and subsequently caught along with the tuna, in some cases increasing the bycatch of these species 10 to 1,000 times (Hall, 1998; Norris et al. 2002). Use of the "log set" technique also increases the bycatch of undersized, juvenile tuna by 10-100 times, and the total bycatch of all species combined is much higher than experienced with the "dolphin set" technique (see *Table 7-1*). This has led some scientists to conclude that the ecological price of using this "dolphin-safe" method is still inappropriately high (Norris et al. 2002).

Another tuna purse seine method that has lower levels of bycatch of juvenile tunas and other fish than the log-setting method, but also has very little dolphin bycatch is the location of the tuna school by surface activity (see *Table 7-1*). When schools of fish swim close to the surface of the water they create ripples and water movement that can be identified from a vessel or helicopter (CLS 1992). Once the school is detected, the purse seine is set. Unfortunately, this method takes more time and is not as reliable or as easy to put into practice; therefore it is not a preferred method for fishers.

How Does Bycatch Impact Seabirds?

There are numerous reported incidents of seabirds captured and drowned in fishing gears. In general, bird mortality related to bycatch is highest where fishers use driftnets, longlines, and set nets (Jennings et al. 2001). Up until the 1990s, driftnets on the high seas were the greatest source of seabird bycatch. Driftnet fisheries in the North Pacific, for instance, killed about 416,000 seabirds in the 1990 season alone; 80 percent of these were in the Japanese squid fishery (Johnson et al. 1993). Due to this high bycatch rate, the United Nations brokered an international treaty in 1992 that banned the use of large-scale driftnets in international waters (FAO 1998). According to the U.S. National Oceanic and Atmospheric Administration (NOAA), the implementation of the large-scale driftnet ban has been "generally successful" at the global level. In 2002, no cases of unauthorized large-scale high seas driftnet fishing were reported in the world's oceans and seas (NOAA 2002).

Today, longline gears, such as those used to catch swordfish, represent the greatest bycatch threat for seabirds such as albatrosses and petrels. These birds often get entangled in the nets as the lines are being baited at the surface, and drown as the nets sink to fishing depth. The Global Seabird Conservation Programme estimates that as many as half a dozen seabird species may be threatened with extinction due to mortality associated with longline fishing (Birdlife International 2003). Fortunately, a number of strategies—such as baiting fishing lines at night when birds are not present or using noisemakers to scare birds off—can enable longline fishermen to reduce seabird bycatch by up to 90 percent (Løkkeborg 1998). On the other hand, seabirds can sometimes adapt to these techniques, and bird bycatch remains a significant concern. The true dimensions of the problem are hard to quantify, since bird mortality is often not monitored in national waters.

Table 7-1: Bycatch by Tuna Purse Seine Method, 1998 (per 1,000 MT of tuna caught)

Species Caught as Bycatch	Type of Purse Seine Set Method		
	Dolphin-Set (no. of individuals)	Log-Set (no. of individuals)	Locating the Tuna School (no. of individuals)
Dolphins	19	0	0-1
Sea turtle	0-1	0-1	0-1
Billfish	6	11	10
Sharks and ray	35	236	134
Other large bony fish	15	5,444	751
Tuna discards (in tons)	6	146	38

Source: Norris et al. 2002.

How Does Bycatch Affect Marine Turtles?

Sea turtles are mainly caught in longline, set net, and trawl fishing gears. Since the early 1980s, shrimp trawls were recognized by U.S. scientists as a significant source of sea turtle mortality (Alverson et al. 1994). To address this, the U.S. National Marine Fisheries Services (NMFS) developed Turtle Excluder Devices (TEDs), a contraption that allows trapped turtles (and other by-catch animals) to escape. The NMFS required commercial fishermen in the United States to use the devices and any country wishing to export trawled shrimp to the United States must make sure its fleet uses TEDs or other similar measures.

Just how effective TEDs are is not immediately clear. A carefully designed TED can allow turtle escape rates of 95 percent (Epperly et al. 2002). However, other factors such as compliance and proper equipment use are important as well. In the United States, the effectiveness of the TED policy is hard to determine. The number of annual strandings of Loggerhead and Kemps Ridley turtles has actually grown since the TED requirement was put in place, but this is quite possibly due to an increase in the turtle population in general, an increase in shrimp trawling, or increased monitoring and reporting (Lewison et al. 2003). No one knows how high the turtle bycatch would be in the absence of the TED policy.

More certain is the fact that TEDs are not popular among fishers in developing countries in particular. Many shrimp fishers remain reluctant to use the devices, claiming that they reduce their catch. In developing countries, where government funding is limited and fishermen often cannot afford to replace equipment, TED regulations are difficult to enforce. Furthermore, in countries where sea turtles are used for food and other commercial purposes—mostly through illegal operations—experts argue that investment to encourage local people to stop consuming turtles, or penalizing the consuming and marketing of them, may yield similar or even better results in terms of turtle conservation rather than simply enforcing the use of TEDs (Chokesanguan 2001a).

How Does Bycatch Affect Sharks and Similar Species?

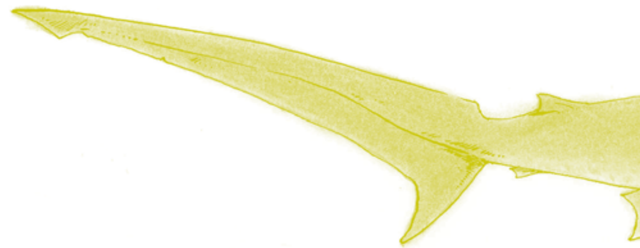
Shark fishing is common throughout the world and constitutes a substantial part of the commercial fishing industry. Sharks are caught in industrial and artisanal fisheries mainly by gillnet, hook, or trawl (FAO 2000e). However, in addition to this directed fishing effort, a great number of shark species are caught as bycatch in multispecies fisheries and in fisheries targeting highly valued fish, such as tuna, swordfish, shrimp, and squid (Vannuncini 1999). For instance, in the Canadian tuna and swordfish fishery, the bycatch of blue sharks often exceeds the amount of tuna and swordfish caught, with blue sharks accounting for 47 to 152 percent of the landings (DFO 2002). Longline fisheries in the high seas appear to be the most important source of shark bycatch, contributing about 80 percent of the estimated total shark and ray bycatch in terms of weight, and about 70 percent in terms of number of individuals caught (Bonfil 1994). The number of sharks caught each year in large-scale high seas fisheries during the period 1989-1991 was estimated at between 11.6 and 12.7 million animals. Shark species are considered to be a long-lived, slow maturing species with low reproduction rates, and are therefore highly susceptible to overfishing. Indeed many shark species are joining the list of threatened species of the world due to overexploitation (IUCN 2003) (see *Chapter 3: Table 3-2*).

Additional pressure on shark populations comes from an increase in commercial fishing efforts caused by a recent upswing in the international trade in shark fins and other related products (FAO 2000e). FAO reports that total world landings of sharks, rays, and chimaeras in 2000 reached approximately 856,000 metric tons (Fishstat 2003). Annual shark landings exceed 10,000 metric tons per year in 18 nations (IUCN/SSC and Traffic 2002). The true value of this catch, however, is likely to be much higher, given that there is a large underreporting problem in shark fisheries. In some cases, only the fins are retained and their weight reported on, while the rest of the shark—which may still be alive—is discarded at sea to die (Rose 1996). (See *Chapter 4* for further discussion on the trade in shark fins). According to several studies, the actual annual catch in shark species seems to be at least twice as high as that reported to the FAO (Bonfil 1994, Vannuccini 1999, Clarke 2002).

BYCATCH CONCLUSIONS

What Are the Ecological Impacts of Bycatch?

The additional mortality caused by bycatch and discards harms both targeted fish stocks and non-targeted animals. However, it is difficult to ascertain the overall effect of bycatch on the marine ecosystem because the impact of bycatch mortality differs depending on the life history of the species that is caught. For



example, incidentally killing a school of highly abundant small pelagic fish, such as mackerel and herring, may have less of an impact on their overall population than killing several individuals of a much less abundant and long-lived species such as loggerhead turtles.

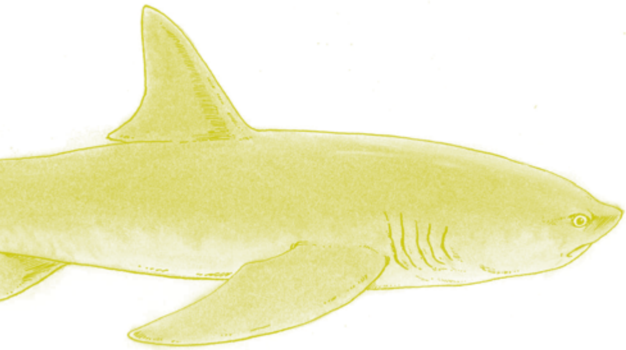
Until recently, much of the focus of policies meant to reduce bycatch has been on species such as dolphin, shark, albatross, and sea turtle. These animals are less abundant, have lower reproduction rates, take longer to reach maturity, and hence are more susceptible to extinction from fishing-related mortality. Although bycatch from commercial fishing is not the only threat these animals face, many of them have declined to the point where they are listed as threatened in the *IUCN Red List of Threatened Species* (IUCN 2003). The harbor porpoise (*Phocoena spp.*), the black-footed albatross (*Phoebastria nigripes*), the wandering albatross (*Diomedea exulans*), several species of dolphin (*Stenella spp.*), several species of shark, and six of the seven living species of sea turtle[7] are all classified as threatened with extinction by IUCN (IUCN 2003). (See *Box 7-1.* on ghost fishing for additional pressures on endangered species as an indirect result of commercial fishing operations).

Commercially important fish species are also severely affected by bycatch and discards. For example, since the 1960s, bycatch has risen to account for as much as 69 percent of the total commercial catch of halibut in peak years. Moreover, half of this bycatch is made up of juvenile fish, threatening the future of the halibut fishery itself. At present, the International Pacific Halibut Commission reduces the annual halibut quota by the amount of adult halibut caught as bycatch in other fisheries—such as shrimp trawls and crab pots—to offset the added mortality (Clark and Hare 1998).

How Should We Address Bycatch and Discards?

Definitive solutions to the problem of bycatch and discards are elusive. Better utilization of the incidental catch can reduce discards and make fisheries

[7] The seventh species of sea turtle, the flatback turtle is considered data deficient, therefore its conservation status has not been assessed.



When the bycatch of non-target fish of commercial value and juveniles of target species are killed, it jeopardizes the reproductive potential—and thus the future commercial viability—of the stocks.

less wasteful, but non-target species, some of them endangered, may still be caught unintentionally. Clearly, modifications to fishing gear and methods that reduce bycatch are and have been an important part of the solution, driven by well-elaborated bycatch policies. A number of national and international regulations are already in place to protect some of the species seriously affected by commercial fisheries bycatch. These species have been mostly marine mammals, birds, and turtles. In the United States alone there are three pieces of legislation that provide the foundation for the U.S. National Bycatch Strategy: the Marine Mammal Protection Act, the Endangered Species Act, and the Migratory Bird Act. The United Nations ban on large-scale driftnets in high seas was also enacted to specifically address the bycatch issue of these same animals. In addition and as part of the elaboration of the Code of Conduct for Responsible Fisheries, FAO has developed two International Plans of Action: one on seabird bycatch and one on shark fisheries (FAO 1999d).

Unfortunately, all these regulations tend to protect only a few species. This narrow species-based approach is not enough to address the complex issue of bycatch because it ignores broader ecological considerations and trade-offs among different conservation goals. Focusing too much on a single charismatic animal can simply replace one problem with another. For instance, "dolphin-safe" tuna fishing methods may come close to eliminating dolphin bycatch, but can create a higher bycatch for sea turtles, sharks, and several fish species (Hall 1998). Adding to the complexity of the issue is that, according to a number of studies in European waters, millions of seabirds rely on discarded fish as a source of food. Reducing the discard may thus affect some seabird populations (Megapesca 1999).

Part of the problem with current approaches to bycatch is that our scientific understanding is still inadequate to appreciate its full ecological implications (Hall and Donovan 2002). Further research is urgently needed, especially in tropical multispecies fisheries, where the ecological impacts of bycatch have barely been studied. A better understanding and more data collection on bycatch itself will help inform and shape management plans, gear specificity, and other regulatory measures such as fishing seasonality. Meanwhile, the "precautionary approach" would argue for reducing pressure on those fisheries where the effects of bycatch have the greatest impact or where they are most uncertain, until there is a sound basis in science for bycatch-specific policies for each of these fisheries.

Even though the science of bycatch is still incomplete, some countries have taken decisive action to deal with potential effects. Countries such as Canada, Iceland, and Norway are the current leaders in addressing the bycatch problem. One concrete example is their 'no discard' policy, which means that fishing vessels engaged in specific fisheries are required to land all their catch—including the bycatch. This has created an incentive for fishers to minimize bycatch by improving the selectivity of their fishing gear and their fishing methods (Clucas 1997; OECD 1997). After all, if a vessel has a lot of bycatch that it cannot discard, it will have less space to store the higher-value commercial species it is actually targeting. Norway introduced the policy barring discards in all its fisheries in 1983 (FAO 1997b) and the policy is generally considered a success (Nordic Council of Ministers 2002; Megapesca 1999; also see *Chapter 11* for further discussion on management issues).

Coupled with adequate monitoring, surveillance, and technical advances, such discard ban policies can contribute to reducing bycatch rates in some fisheries. Yet, the effectiveness of these bans relies heavily on enforcement, usually accomplished by placing observers on fishing vessels to ensure compliance. Unfortunately, observer coverage, except on very large vessels, is still limited and costly (Morgan and Chuenpagdee 2003), making a discard ban an impractical approach in many countries, and the opportunities for noncompliance very great (Megapesca 1999).

ALTERATION OF COMMUNITY STRUCTURE: ARE WE "FISHING DOWN THE FOOD WEB?"

For millennia, humans have focused their fishing efforts on some species more than on others, but the rise in large scale industrial fishing has greatly magnified the biological impacts of the practice of selective fishing. The result is a profound shift in the community structure of marine ecosystems. Historical data suggest that removal of certain target fish from the oceans by overfishing can have potentially irreversible effects on the balance of the ecosystem and its biodiversity (Jackson et al. 2001).


PETER AUSTER. USED WITH PERMISSION.

Seafloor communities are severely affected after a dredge has swept the area.

In many fisheries, the most prized fish are large predatory species high in the food web— fish such as tuna, cod, or hake that feed on smaller fish. Once a desirable species at the top of the food chain has been overfished, fishing effort will expand to new species, often lower in the food chain—those fish that feed on plankton or small invertebrates, for example. This pattern of exploitation is known as "fishing down the food web," and was described by Pauly et al. (1998). The pattern implies that overfishing the top predators in the ocean food web allows expansion of fish stocks lower in the food chain, thus changing the species composition of the fish community.

The mechanism of such a change in the fish community is generally understood, but there is no comprehensive biological data that can reveal the full scope of the problem worldwide. Nonetheless, analyzing data from commercial fish catches over time can provide clues to how widespread are the effects of this practice in major fishing regions.

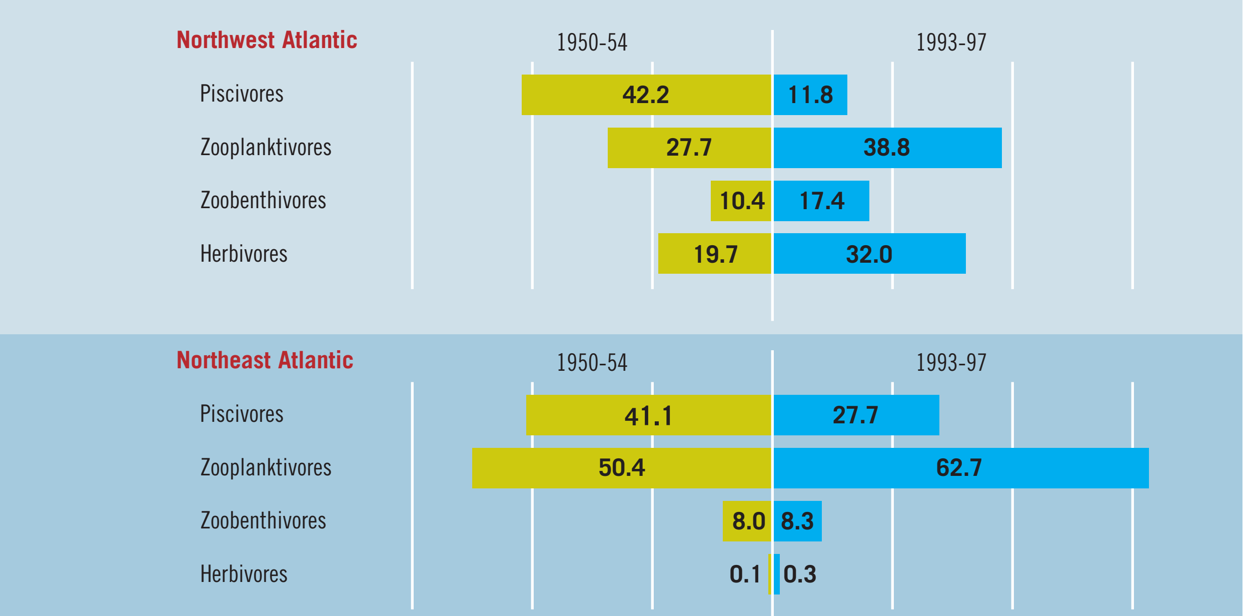
Results of such an analysis conducted by the FAO in 1999 (Caddy et al. 1999) show that the strongest evidence of the biological effects of fishing down the food web is found in the Northern Atlantic—a fishing area with the longest historical record of industrial fishing. There commercial landings show a progressive decline in the ratio of predatory fish high on the food chain (called piscivores) to those lower on the food chain (zooplanktivores) such as herring and mackerel, after a peak in the mid-1960s (see *Figure 7-1*). This correlates well with the overfishing of cod, hake, and other piscivores during this period and the subsequent collapse of these fish stocks. While top-of-the-food-web fish made up over 40 percent of the North Atlantic fish catch in 1950-1954, they comprised less than 12 percent of the catch in 1993-1997 (see *Figure 7-1*) (Burke et al. 2001).

The FAO analysis did not find as clear-cut evidence for fishing down the food web in other ocean regions as it did for the North Atlantic. This may be because overfishing has a shorter history in these areas, or its effects may be obscured by other factors such as changes in fishing technologies. Therefore, the results may not show up in catch statistics for some time (Burke et al. 2001).

HABITAT DEGRADATION BY FISHING GEAR AND PRACTICES

Some fishing practices and fishing gears significantly disturb seafloor and other marine habitats. For instance, bottom trawling, in which a trawling rig is dragged across the seafloor, is a significant source of pressure on the biodiversity of sea bottom (benthic) ecosystems in shallow as well as in deep-sea waters. Among the deep-sea habitats most affected by trawling are cold-water coral communities (Baker et al. 2001; Roberts 2002). Damage to seabed habitats from bottom trawling may be light, with effects lasting only a few weeks, or severe, with impacts on corals, sponges, and other bottom-dwelling species lasting decades or even centuries (Watling and Norse 1998). The degree of damage depends on a number of factors, including the frequency and intensity of trawling, and the type of seabed habitat. Habitat destruction is a factor in the decline of some fishing stocks in heavily trawled areas, since the carpet of

Figure 7-1: Catches by Trophic Level for the North Atlantic, 1950-54 and 1993-97



Source: Caddy et al. 1999.

vegetation and animals on the sea bottom normally acts as a refuge for the fry of fish species such as cod (Watling and Norse 1998).

Based on a review of scientific literature, expert consultation, and public meetings in North America and Europe, a 2002 study by the United States National Research Council (NRC) on the impact of bottom trawling and dredging on the marine environment concluded that repeated trawling causes considerable damage to the sea floor ecosystem. The study found that repeated trawling can shift marine species composition toward small opportunistic species—such as sea stars and small short-lived clams—while reducing the overall biomass of the area by removing aquatic vegetation and bottom-dwelling animals. The impact of prawn trawling in the Great Barrier Reef Marine Park in Australia, for example, shows that a single trawl removes 5-25 percent of the bottom-dwelling organisms, and that repeated trawling has a cumulative impact (Poiner et al. 1998). An accurate account of the geographic extent, intensity, and effects of bottom trawling operations worldwide does not exist, but one rough estimate puts the area affected by trawling at 14.8 million km^2 (Watling and Norse 1998). However, this estimate fails to capture the impacts of repeated trawling over the same area.

Poison fishing and blast fishing are other examples of highly destructive practices. The aim of poison fishing is to stun and capture live fish, which are then sold in the ornamental fish trade primarily in the United States and Europe, or cooked and served at high-end restaurants in China and Taiwan. The use of dynamite and sodium cyanide is especially prevalent among coastal and reef fishermen in Southeast Asia, but the practice is rapidly spreading east to the island nations in the Western Pacific (Barber and Pratt 1997).

Commercial use of poisons such as sodium cyanide to capture live reef fish began in the Philippines in the 1960s and soon spread to Indonesia, Vietnam, and parts of Malaysia. Many nontarget species and corals are damaged or killed by poisons. Dynamite used in blast fishing kills most nearby fish and damages reefs, often permanently. Over two-thirds of the coral reefs in the Philippines, Malaysia, and Taiwan, and over half of the reefs in Indonesia are threatened by these destructive fishing practices (Burke et al. 2002).

The use of cyanide and dynamite for fishing has been banned by governments in virtually all countries in Southeast Asia for some time. However, implementing and enforcing such laws remains a challenge (Barber and Pratt 1997; Cesar, pers. comm. 2003). For example, Indonesian fishermen are barred by law from using cyanide for fishing, but they are allowed to carry cyanide on their boats. This makes it virtually impossible to monitor and suppress the improper use of the poison (Cesar, per. comm. 2003).

Box 7-1: Impacts of Derelict Fishing Gear (Ghost Fishing)

What Is Ghost Fishing?

Modern fishing gear is often composed of durable, synthetic materials that are meant to last for years and even decades. When these fishing gears are lost or discarded at sea, they can entangle, trap, or kill fish and other aquatic animals. This phenomenon is called *ghost fishing*. Abandoned fishing gear also degrades marine and coastal ecosystems and sensitive habitats, and may even damage propellers and rudders of small vessels and recreational boats, at times endangering boat crews and passengers when vessels capsize. While the extent and impact of ghost fishing is only anecdotally documented, entanglement in, or ingestion of human-caused debris (including fishing gear and many other items) has been reported as a mortality factor for over 250 marine species (Laist 1997).

How Much Gear Is Lost and What Are the Impacts?

Information on how much fishing gear is lost or abandoned in the ocean is very poor. However, there are a few documented cases. In northwestern Hawaii, where ocean currents seem to bring a variety of marine debris from throughout the Northern Pacific—and possibly the entire Pacific basin—ghost fishing has become a serious problem. Between 1996 and 2000, over 78 tons of derelict fishing gear and other debris were recovered from the shallow coral reefs in northwest Hawaii mostly trawl nets and gillnets. Drifting gillnets, in particular, were the most dominant form of derelict fishing gear (Brainard et al. 2000).

Because they are left unattached in the water for relatively long periods of time, static gears such as traps, pots, and gillnets are subject to high accidental loss caused by bad weather or interactions with towed fishing gears. Although little is known about the frequency of net or pot losses, the few available estimates of gear loss indicate that it can be substantial in some fisheries (Jennings et al. 2001). Along the coast of Maine in the United States, an estimated 100,000-200,000 traps, or 5-10 percent of the 2 million lobster traps in use were lost in 1992 alone (Carr and Harris 1997).

Equally scarce is information on how many aquatic animals these derelict gears actually entangle and kill. Since 1982, beach surveys conducted by field crews at the National Marine Fisheries Service have reported more than 200 entangled Hawaiian monk seals—an endangered species with a population size of only about 1,400—including six animals that died from their entanglement (NMFS 2002b). From an economic standpoint, it is estimated that lost and abandoned gillnets in the Canadian Atlantic waters killed about 3,600 metric tons of fish of various species, valued at more than $3 million Canadian dollars (Brothers 1992).

Because governments often provide financial compensation for lost gear there is little incentive for fishers to try to recover their gear or not discard damaged gear over board. However, where ghost fishing is recognized as a problem, voluntary clean-up efforts are sometimes made. For example, when ghost fishing was highlighted as a threat to commercial stocks of Greenland halibut, commercial fishers led a voluntary clean-up program (Bech 1995). Because of the increasing problem with ghost fishing and its threats to species, commercial fisheries, and at times small-scale vessels and artisanal fishers, some policy measures are being considered. The International Marine Debris Conference on Derelict Fishing Gear and the Marine Environment has recommended that all states contributing to, or affected by, derelict fishing gear should encourage and fund the development of an International Plan of Action to Control and Minimize Fishing Vessel Gear Loss (Stewart and Koehler 2000). Such a plan of action could be coordinated jointly by the International Maritime Organization (IMO), FAO, and the Regional Fisheries Organizations (Stewart and Koehler 2000). Other conference recommendations encourage members of the IMO to take a hard look at the implementation of Annex V of MARPOL (i.e., the International Convention for the Prevention of Pollution from Ships). Annex V specifically covers the Prevention of Pollution by Garbage from Ships, including plastics. Finally the conference recommendations ask for the establishment of a mechanism for monitoring derelict fishing gear (Stewart and Koehler 2000). No international action plan has yet been established but some countries and states that have been heavily affected by lost gear have already established proactive measures to control and reduce the amount of derelict fishing gear. For example, the Washington Department of Fish and Wildlife in the United States has produced guidelines for the removal of derelict gear, an online form to report lost fishing gear, and has engaged several organizations to assist with derelict gear cleanups (WDFW 2003).

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Fur seal entangled in fishing gear.

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CHAPTER 8

HOW DOES THE GLOBAL FISH TRADE AFFECT SUSTAINABILITY?

The international trade in fish and fish products is worth over US$55 billion per year (FAO 2002a). Fish-related trade has expanded rapidly in the last three decades, with the value of fish imports increasing nearly seven-fold between 1976 and 2001 (Fishstat 2003). Trade has become a driving force in the global fishing enterprise, influencing the species of fish targeted by industrial fleets and aquaculture businesses, the intensity of fishing pressure, and, in many cases, the incentives for fishing either sustainably or destructively.

Indeed, the international fish trade has become one of the frontiers of economic globalization. This raises important issues about whether trade exacerbates the current problems with unsustainable fishing practices or provides an avenue for gradual improvement as fishers are pushed to meet environmental requirements in importing countries.

DOES INCREASED TRADE ACCELERATE THE DEPLETION OF FISH STOCKS?

The rapid rise in the quantity and value of the global fish trade puts it near the center of the debate regarding sustainable fisheries management. Some see increased trade as a driver of fish stock depletion. The reasoning behind this argument is that higher demand for certain fish products translates into greater economic incentive to continue fishing. In many cases, these are the very species already in decline—the high-value demersal, deep-water, or migratory species that consumers prefer, such as cod, Patagonian toothfish, or bluefin tuna. There are a number of instances where this argument appears to hold true. One example is the increasing demand for Patagonian toothfish (Chilean sea bass) in Japan and the United States, which continues to fuel a booming illegal fishing business in the southern oceans that is causing severe declines in this species population.

Increased market access through trade can also drive severe environmental damage to habitats and ecosystems. For instance, demand for shrimp in developed countries—particularly the United States—contributed to the accelerated expansion of shrimp farms in many developing countries such as India, Thailand, and Ecuador, along with its significant environmental consequences.

Trade also has the effect of further insulating consumers from the environmental impacts of their fish choices and consumption (WRI et al. 2000). Consumers often know little about where the fish they are buying comes from, how it was caught, or what the effects on the fish stock and ecosystem might be, unless the fish is labeled as "sustainably managed." (See *Box 11-1 Seafood Certification: Incentive for Sustainability*). On the other hand, if destructive practices are involved, or the stock is poorly managed and in a depleted state, consumers won't know unless adequate labeling is required. In addition, consumers in developed countries will not suffer in the same way that a local community of small-scale fishers might when local fish supplies are depleted. In fact, the nature of trade markets is such that consumers of traded fish will usually have the option of turning to other imported fish species as substitutes for depleted stocks, so there is little incentive to insist on sustainable fishing practices.

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Menhaden being off-loaded to fishmeal factory, Southport, North Carolina, USA.

On the other hand, trade advocates argue that trade revenue is an essential element of economic growth, particularly in developing nations, and may thus be one foundation of better government management of natural resources such as fish stocks. The hope is that significant foreign earnings derived from the fish trade will translate into greater investment in fisheries management by governments wishing to preserve this income stream. That, in turn, will gradually support more sustainable fishing practices. So far there are only a few examples where this holds true. For instance, when major fish buyers such as Unilever start requesting stricter management standards and measurable sustainable harvest practices from their fish suppliers, countries may strengthen national rules or enforcement practices to keep or attract such a large client (Unilever 2003). Small-scale fisheries can also benefit from increased international trade and access to new markets. A small well-managed fishery that has traditionally been marketed for local consumption can see its market share increase through up-scale niche markets in foreign countries where consumers may demand sustainably harvested fish (MSC 2004).

In some cases, trade can act as a conduit for the spread of better fishing practices. For example, when consumers in the United States became concerned about the high dolphin mortality associated with the tuna catch, fishing practices began to change to satisfy the consumer demand for "dolphin safe" canned tuna. This change affected not only United States tuna fishers, but those from other nations as well, since canned tuna is one of the most heavily traded fish products (Sabatini 2001; Fishstat 2003). Likewise, when the United States adopted a policy requiring the use of turtle excluder devices for all shrimp fishing destined for that country's substantial shrimp import market, it triggered the adoption of this technology by some shrimp fishers in Southeast Asia (Chokesanguan 2001a; Choudhury 2003).

In the end, the question of whether trade encourages overfishing or is part of its solution cannot be answered with certainty (Dommen 2000). The fish trade is complex, involving numerous fish stocks and fishing practices, governed by an array of trading policies. Empirical evidence tells us that trade is one factor exacerbating some instances of overfishing, as in the case of Patagonian toothfish. But there are no systematic studies supporting the conclusion that trade is inherently harmful to fisheries.

It is likely that trade simply magnifies the environmental effects of existing fishing practices. Where those practices are harmful, as with some types of trawling or deep water fishing, trade will intensify these effects by expanding the market for fish caught in this way or by providing easy market access to illegally harvested products. But when trade opens new markets for sustainably managed fisheries, it can magnify the benefits of such enlightened management as well. National and international trade policies can be crucial in distinguishing between beneficial trade and trade that harms fish stocks (OECD 2003).

DO INTERNATIONAL TRADING RULES UNDERMINE SUSTAINABLE FISHERY MANAGEMENT?

Trade measures can, in theory, be designed to promote the sustainable use of fish resources. For example, a country can enact trade regulations barring the import of fish that have been illegally harvested or caught in an unsustainable manner. In practice, however, it is not easy to put such restrictions in place without provoking controversy. International trade rules often interpret trade restrictions as barriers to free trade, even when they are imposed for reasons of environmental protection.

The World Trade Organization (WTO) is the main international body regulating the flow of goods such as fish across national borders. A primary goal of the WTO is to facilitate world trade on a fair and equal basis by removing barriers such as import quotas and regulations that favor a country's domestic products. These "protectionist" measures are often set by importer countries to shield their domestic industries from competition with imported goods. Some government subsidies to the domestic fishing industry are also considered protectionist measures (see *Box 8-1* on fishing subsidies).

In order to discourage protectionism, WTO trade rules are built around the principle of "nondiscrimination," which means that countries are not allowed to "discriminate" against imported products on the basis of where they were produced, as long as the end product looks and performs acceptably. In the case of fish and fishery products, this performance is measured in terms of taste, nutrition, and product safety according to agreed-upon international food standards.[8] In other words, the nondiscrimination principle says, for instance, that a salmon or shrimp from any country is considered equivalent no matter how it is caught or raised, as long as it looks and tastes right and is safe to eat. This principle however, runs counter to the premise of many national trade policies meant to promote sustainable fishing practices, because the very point of such policies is to discriminate between products that harm fish stocks and marine ecosystems and those that minimize such harm. For example, a country that wants to encourage environmentally sound fishing practices would probably like to impose trade barriers impeding the imports of fish not caught or processed in this manner; under WTO rules this would be considered trade discrimination, and therefore sanctioned under the nondiscrimination principle.

The idea of promoting environmentally sound practices is also the basis of "ecolabeling" programs, which certify as "sustainable fish" products that meet certain environmental standards, allowing marketers to cater to consumers who want to support sustainable fisheries (Downes and Van Dyke 1998). (See *Box 11-1* on seafood certification).

Fortunately, WTO rules contain a safeguard clause (GATT Article 20) that nations may invoke to "protect human, animal or plant life or health, and to conserve exhaustible natural resources" (WTO 2003a). In effect, this clause allows nations to discriminate against trade products in certain circumstances—through process requirements or product bans—in order to protect the environment. Unfortunately, the conditions under which this clause may be applied are very restrictive, making trade regulations with an overtly environmental purpose contentious and sometimes the subject of trade disputes among nations. Since 1995, some eight cases involving

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[8] There are two key agreements related to the food trade that acknowledge the importance of harmonized international standards so as to minimize the risk of sanitary and other technical standards becoming barriers to trade. These are the Agreement on the Application of Sanitary and Phytosanitary measures(SPS), which ensures proper sanitary measures to protect human health, and the Agreement on Technical Barriers to Trade (TBT), which ensures that technical regulations and standards, including packaging, marking, and labeling requirements do not create unnecessary obstacles to trade. Both agreements were annexed to the 1994 Marrakech Agreement that established the Word Trade Organization (FAO/WHO 1999).

fish products have come before the WTO's Dispute Settlement Body—the official panel responsible for resolving international trade disputes (Helland 2000).

Two of the most notable examples of these disputes involve restrictions on harmful fishing methods enacted by the United States. The first dispute was filed by Mexico, challenging a requirement that canned tuna imported into the United States be caught using "dolphin safe" methods that reduce the dolphin mortality associated with tuna harvesting. The second dispute was filed jointly by India, Malaysia, Pakistan, and Thailand against a United States import ban on shrimp caught without the use of turtle excluder devices (TEDs) (Downes and Van Dyke 1998). Initially, the ruling in both cases went against the United States, with a determination that these trade restrictions constituted unfair practices. The U.S.-Mexico tuna dispute is being resolved bilaterally under the International Dolphin

Box 8-1: Examining Fishing Subsidies

Government subsidies of the fishing industry have received much attention by both free trade advocates and environmentalists. Many trade proponents hold that fishing subsidies provide an unfair advantage to the fishing industry in those countries where subsidies are high, reducing the costs of fishing and allowing fishers to charge lower prices for traded goods. This, in turn, helps them out-compete unsubsidized fishers from other countries.

Environmentalists consider many government fishing subsidies to be a leading factor in the excessive size or capacity of the world's fleets, and thus a key driver of overfishing. A 1996 analysis by FAO estimated that 30–40 percent more fishing capacity exists in the world's fishing fleets than the oceans' fish stocks can withstand (Garcia and Grainger 1996), and subsidies have played a large role in financing fleet expansion.

While the arguments for curbing "excessive" fishing subsidies have been around for some time, progress in tackling the problem has been slow. In part this reflects the political difficulties that governments frequently face when they attempt to curtail benefits to politically powerful groups. In addition, several basic questions about the nature and effect of subsidies remain unresolved, the answers to which are critical to effective action on subsidies. These questions include the following:

- What defines a fishing subsidy?
- Which subsidies are detrimental to sustainable fishing?
- Which subsidies are harmful from a trade perspective and what is the WTO's role in the subsidies debate?

What Defines a Fishing Subsidy?

Despite years of discussion, there is no universal agreement on what defines a fishing subsidy (FAO 2002a). In general, subsidies can include a variety of forms of government assistance, ranging from direct payments to the fishing industry to indirect aid such as building harbor facilities for fish handling, or supporting research on new fishing gears. One useful classification scheme adopted by the Asia Pacific Economic Cooperation (APEC), a regional development and trade organization, divides fishing subsidies into six categories:

- *Direct assistance to fishers and fishery workers*, such as supplemental income support payments, unemployment insurance, and support for training in alternative employments.
- *Lending support programs*, such as government-funded loans, loan guarantees, or lower interest rates on loans to purchase boats or equipment.
- *Tax preference and insurance support programs*, such as fuel tax exemptions, income tax deferrals, and government-funded vessel insurance.
- *Capital and infrastructure support programs*, such as grants to purchase or modernize vessels, access fees to the fishing waters of other nations, bait services, and the construction of harbor facilities and other port infrastructure.
- *Marketing and price support programs*, such as export marketing support, advertising and promotion of seafood products, and minimum price supports for certain species or products.
- *Fisheries management and conservation programs*, such as vessel buy-back programs, stock enhancement efforts, general fisheries management and enforcement actions, and research and development.

While useful, APEC's classification scheme is not universally adopted, and other definitions and accounting systems for quantifying subsidies are currently in use. Consequently, it is difficult to say exactly how much governments spend on subsidies to the fishing industry. One rough estimate is that global fishing subsidies total at least US$15 billion per year (WWF 2001). Japan reports by far the largest figure, spending over US$2 billion annually, according to an OECD study (OECD 2000).

Which Subsidies Are Detrimental to Sustainable Fishing?

Not all fishing subsidies damage ecosystems or contribute to overfishing. It is often unclear which specific subsidies are harmful, or how harmful they may be, particularly in the case of indirect subsidies like port improvements or government-sponsored trade promotions. And some subsidies can be highly beneficial to small-scale fishers. In Japan, for instance, government subsidies since the 1950s have helped raise the level of income of small-scale fishers in coastal communities.

But there are a few types of subsidies that clearly contribute to overfishing. One is the group of subsidies that encourages continued growth of fishing fleets, even when fish stocks are already overexploited by existing capacity. These subsidies

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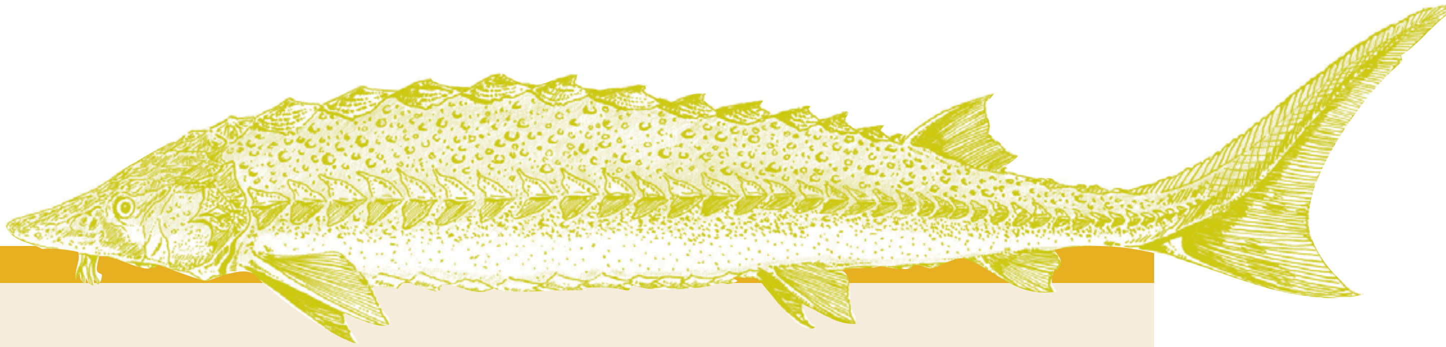

often consist of grants or low-interest loans to purchase or upgrade fishing vessels. They were originally conceived by governments as incentives to develop their industrial fishing sectors, but have not been withdrawn even though most national fleets in the developed world suffer from overcapacity. Some fishing subsidies doled out in developed countries actually have a negative effect on small-scale fishers in developing countries (see *Chapter 10* for further discussion on conflict between large and small-scale fleets).

Another questionable subsidy is fishing access payments. These are fees that one government pays to another for access to its Exclusive Economic Zone (EEZ). The best known example is the access fees that European governments pay to allow European boats to fish in West African EEZs (see *Box 10.1* on the fishing conflict between EU fleets and West African fleets). The European fleets have been criticized for depleting West African fish stocks, but proponents of the fees claim that they provide much-needed revenue to the governments of many West African countries (WWF 2001; Kaczynski and Fluharty 2002).

In contrast to these harmful subsidies, some government-subsidized programs clearly contribute to better fisheries management. For example, well-designed "vessel buy-back" programs, where the government pays fishermen to retire fishing vessels, can help shrink the size of the fishing fleet and reduce pressure on fish stocks. And government-sponsored research on fishing gear and methods can improve the selectivity of the gear and refine how best to deploy it to cut down on bycatch and waste (see *Chapter 11* for further discussion on management practices). Government support is also essential for many other aspects of advanced fishery management and conservation, such as research into better stock assessment methods.

How Do Trade and the WTO Figure Into the Subsidies Debate?

When WTO member nations opened the current round of trade negotiations in Doha, Qatar in 2001, they agreed to try to clarify the WTO rules with regard to fishing subsidies (WTO 2001). By taking on this subject, the trade negotiations could play a significant role in changing how national fisheries are managed. Action at that level could simultaneously meet both a WTO goal—removal of trade barriers—and a fishery management goal—a decrease in fishing overcapacity.

But the WTO's role in addressing the problem of fishing subsidies should not be exaggerated. Not all fishing subsidies are relevant to international trade, and so only a subset of them fall within the WTO's mandate. Only those that create conditions of trade distortion can be challenged through the organization's Dispute Settlement Body, and are likely to be subject to elimination through trade negotiations (WTO 2003c; OECD 2003). For instance, grants to upgrade vessels fall within WTO's definition of a trade-distorting fishing subsidy, while government-to-government payment of fishing access fees may not (WWF 2001).

From the perspective of sustainable fishing, some types of trade-related subsidies should be removed right away, such as loans to expand boat capacity. But other subsidies that benefit the environment may actually need to be shielded from WTO action, such as loans to reconfigure boats to use environmentally friendly fishing gear. Finding the balance between removing trade-distorting subsidies and preserving subsidies that help manage the resource sustainably will be a major challenge.

Certainly WTO cannot be the only venue where the discussion about modifying fishing subsidies takes place, given the organization's limited mandate. Other intergovernmental groups can also provide appropriate forums for action. The WTO has already held meetings with such organizations as FAO, the United Nations Environment Programme (UNEP), OECD, APEC, and the United Nations Conference on Trade and Development (UNCTAD) to coordinate their work on subsidies (FAO 2002c). The FAO's International Plan of Action (IPOA) on fishing capacity already calls on FAO member governments to eliminate subsidies that create excess fishing capacity (FAO 1999e), but the voluntary nature of the IPOA limits its implementation. In the final analysis, decisions regarding how to apply subsidies to fisheries rest with national governments, but these decisions are influenced by international organizations, environmental groups, and other interest groups.

Conservation Program. (See *Chapter 7* for further discussion on dolphin bycatch).

The dispute concerning shrimp imports was ultimately settled in favor of the United States after this country clarified its regulation to make sure that it was applied broadly to all nations, and not targeted to just a few nations selectively (USTR 2001). In the meantime, a number of countries have implemented programs to introduce the use of TEDs in shrimp trawlers to accommodate the U.S. requirement (Chokesanguan 2001a), a testament to the potential impact that environmental trade policies can have when they are allowed to stand.

While the shrimp/turtle case shows that trade and environmental rules can sometimes be compatible, it should not be interpreted too broadly. In general, the WTO's mandate only deals with environmental matters tangentially, and many nations still see environmental trade restrictions as thinly veiled protectionism, and actively discourage them. In addition, the international trading system provides an awkward platform for making and enforcing fisheries policies. While there are international standards to ensure that the world's food supply is sound, free from adulteration, and safe to eat,[9] the existing standards do not address fishery resource exploitation, nor does any panel of experts exist to advise the WTO on fisheries-related policies. This makes it difficult to interpret WTO rules and resolve disputes as they relate to sustainable fishing practices.

Another possible source of conflict between trade and environmental policies revolves around the status of international environmental treaties such as the Convention on Trade in Endangered Species of Wild Fauna and Flora (CITES), or the United Nations Fish Stocks Agreement. These treaties, negotiated and signed by the international community, explicitly include trade restrictions designated to achieve environmental ends, with sustainable fisheries being one of those ends. Nonetheless, their implementation is not harmonized with WTO's international trading rules. In fact, they could be challenged as unfair trade practices within the WTO system by WTO member countries who have not signed these environmental agreements.

To date, this has not occurred, and there is little indication as to how the Dispute Resolution Body might rule if they were challenged. The surest way around this potential difficulty would be for the WTO to explicitly recognize the authority of these international agreements and clarify how they fit into or conflict with WTO rules. Steps to begin this process are supposed to take place as part of the current round of international trade negotiations (called the "Doha round") (WTO 2003b).

The current round of trade talks also includes a discussion of national fisheries subsidies, which many see as unfair government support for the fishing industry, and thus an unfair trade practice (Dommen 2000). Action to eliminate some subsidies could be a significant step toward both fairer trade and more sustainable fisheries—an example of trade and environment in alignment. However, (as of 2004) the Doha round of trade talks is stalled, and the fishery subsidies discussion has been curtailed for the time being (see *Box 8-1*).

E. BOS, IUCN, 2003

Fish from all over the world are sold at the Tsukiji fish market in Tokyo, Japan.

[9] The Codex Alimentarius Commission (Codex) or food code was established in 1963 as a joint FAO/ World Health Organization commission to protect the health of consumers and ensure fair practices in the food trade. The Codex Committee on Fish and Fishery Products in particular seeks to ensure that the world's fish supply for food is sound, wholesome, free from adulteration, and correctly labeled. The SPS and TBT agreements, have adopted the Codex standards as scientifically justified norms for international trade (FAO/WHO 1999).


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CHAPTER 9

MANAGING FISHERIES AT THE INTERNATIONAL LEVEL

Since the first regional fishing treaties were forged in the eighteenth century, nations have understood that managing ocean fish stocks often requires international cooperation. That realization has strengthened over the years as commercial fishing has grown in scale and national fishing fleets have extended their reach far from their native coastlines. The widespread decline in the status of fish stocks in the last 30 years has also served to underscore the importance of cooperative action and has prompted the negotiation of a number of international agreements to help manage marine resources more intelligently and sustainably.

WHAT IS THE UN CONVENTION ON THE LAW OF THE SEA?

The United Nations Convention on the Law of the Sea (UNCLOS) was adopted in 1982 with the goal of balancing the right to exploit marine resources with the duty to manage and protect the marine environment (Stokke and Thommessen 2002). The effect of UNCLOS on fisheries management has been revolutionary, since it fundamentally changed the international norm on how much authority nations have to control the exploitation of resources off their coasts. Under UNCLOS, coastal countries can claim complete sovereignty over the marine resources within 200 nautical miles of their coast—the area now known as an Exclusive Economic Zone, or EEZ.

Formerly, international custom recognized national sovereignty only within a territorial zone extending 12 nautical miles from the coast. Waters beyond 12 miles—and the fish and other resources they contained—were considered international waters and thus free for exploitation by other nations. Now the rich resources of coastal waters—where some 90 percent of commercial fish are harvested—are controlled by national governments, who may restrict or sell off fishing rights within these waters as they choose. This puts the responsibility to sustainably manage coastal fisheries squarely in the hands of coastal nations. National governments are not only responsible for controlling fishing within their EEZs, but also for the operations of fishing fleets that carry their national flag regardless of where they fish, including in the open oceans or the EEZs of other countries.

The net effect of establishing sovereign rights over coastal resources has been to reduce the area of productive fishing grounds that are treated as "open access" resources—areas where there is no restriction on who can fish or how they can fish. Unfortunately, not all countries have adequate fisheries management plans and laws in place. Even when they do, implementation and enforcement often fall short, and overfishing is still a problem.

Although UNCLOS did not become international law until 1994 (it took 12 years for enough nations to ratify the agreement to bring it into effect), discussions and negotiations over the provisions of such a law, including the establishment of sovereign rights over coastal resources, began 20 years earlier, in the mid-1970s. In the late 1970s and 1980s, some countries, such as the United States and the United Kingdom adopted national laws establishing rights over their coastal resources based on provisions outlined under UNCLOS, changing the dynamics of global fisheries production and trade significantly.

Many countries used to depend heavily on their distant water fleets (DWFs)—fleets from one nation fishing within the coastal waters of another country or in the high seas—for a significant proportion of their fish catch. The establishment of sovereign rights over fishing grounds meant that these nations had to negotiate access to the foreign EEZ and abide by the laws and regulations of the coastal state. Consequently, production from DWFs around the world declined (partly due to reasons other than UNCLOS, such as the collapse of the Soviet Union), and some formerly self-sufficient nations have had to turn to international trade to meet their demand for fishery products. From 1972-1991, DFW catches fluctuated at around 8 million metric tons annually, but dropped to about 4.5 million metric tons per year through the late 1990s. As a proportion of the global total, DWF catch peaked at 15.5 percent in 1972 and has declined to about 5 percent per year since 1993. Over half of the DWF catch is now from open ocean fisheries—those fishing areas beyond the EEZs (Galibardi and Limongelli 2003).

The net effect of national and international laws (i.e., UNCLOS) on establishing sovereign rights over coastal resources has been to reduce the area of productive fishing grounds that are treated as "open access" resources—areas where there is no restriction on who can fish or how they can fish. Open access resources such as high seas fisheries are vulnerable to overexploitation because there is no incentive for individual fishers to limit their harvest. Since no one has responsibility for the long-term care of the common property resource, the incentive is to fish until the stocks are depleted—a phenomenon called the "tragedy of the commons." (See *Chapter 3* for further discussion.)

While the intent of UNCLOS is clearly to help nations avoid the tragedy of the commons, realizing this goal depends heavily on the ability of coastal states to manage their coastal resources competently. Unfortunately, not all countries have adequate fisheries management plans and laws in place. Even when they do, implementation and enforcement often fall short, and overfishing is still a problem. Thus, acceptance of the basic UNCLOS treaty is only one of many necessary steps on the path to effective fisheries management over the long term. In fact, the treaty is considered only a basic framework that should be augmented by other legal agreements on specific aspects of marine management, such as ways to manage high-seas fisheries or fish stocks that migrate across the waters of more than one coastal nation.

WHAT IS THE UN FISH STOCKS AGREEMENT?

One fundamental problem with the concept of the EEZ is that many fish stocks, such as cod, do not confine themselves to a single EEZ, but migrate between political jurisdictions along the coast, and sometimes venture beyond the EEZs into the high seas. Such fish stocks are referred to as "straddling stocks" because they straddle one or more jurisdictional boundaries. Obviously, managing straddling stocks and safeguarding them from overfishing requires the collaboration of all the nations whose waters they pass through. Unfortunately, collaborative management is challenging and often contentious. Effective bilateral and multilateral agreements on how to manage shared fish stocks are still the exception rather than the rule (Hannesson 2002). Negotiations among neighboring countries over the use of shared stocks can be complicated if there are territorial and EEZ disputes, as is the case with Russia, Japan, and South Korea (Kim 2002; JMAFF 2001).

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Sorting and recording the catch is key to monitoring fisheries.

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In addition to straddling stocks, there are many other highly migratory fish species that travel well beyond national EEZs into international waters where they are subject to open exploitation. Tuna and swordfish, for instance, may swim thousands of kilometers in the open ocean, and a single stock may be harvested by fleets from many nations. In order to manage and exploit these shared fisheries, the international community has negotiated numerous international agreements and conventions. One key example is the UN Fish Stocks Agreement, which was negotiated as a separate treaty under the framework of UNCLOS. The Agreement is formally known as the Agreement for the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. By establishing criteria for good management and specific obligations for fishing nations to achieve them, and primarily by encouraging countries to collaborate through the establishment of Regional Fisheries Bodies (RFBs), the Agreement is an attempt to prevent the unbridled exploitation of the marine commons. (For discussion on the role of RFBs in fisheries management see the section on *Regional Fisheries Bodies* in this chapter.)

Nations ratifying the UN Fish Stocks Agreement consent to manage migratory and straddling stocks using the best scientific information available, and to monitor these stocks methodically through the RFBs. These countries also agree to apply the "precautionary principle" in their management, using a conservative approach to setting fishing quotas when there is uncertainty about the condition of a fish stock. In an important nod to the impact of fishing on marine biodiversity, the agreement calls for preserving the health of the marine ecosystem as a whole—rather than just the target fish stocks—by minimizing pollution and bycatch, and monitoring the effects of fishing on nontarget species (United Nations 1995).

The Agreement was adopted by the international community in 1995 but it was not until 2001 that enough countries ratified the agreement so that it could enter into force. As of August 2003, 36 of 59 signatories had ratified it. Unfortunately, a number of important fishing nations have not yet accepted the treaty. Of the world's top 10 fishing countries, India, Norway, Russia, and the United States have ratified it, while China, Indonesia, and Japan have signed but not ratified the treaty (UNCLOS 2002). Chile, Peru, and Thailand—also top 10 fishing nations—have not signed the treaty at all.

WHAT IS THE FAO CODE OF CONDUCT FOR RESPONSIBLE FISHERIES?

One of the main roles of the Food and Agriculture Organization of the United Nations (FAO) is to promote the key principles of sustainable fisheries management and to help nations implement these principles within their EEZs and in international waters (see *Box 9-1*). FAO's Code of Conduct for Responsible Fisheries is an important tool in this task. It contains recommendations and guidelines aimed at national policy-makers and fisheries managers on a wide range of topics, from how nations should register and monitor their fleets, to how they should conduct fishing operations and develop aquaculture sectors. Although the guidelines are voluntary in nature, more than 150 countries have formally embraced the Code since its introduction in 1995 (FAO 1995b).

The Code's principles are consistent with those of the UN Fish Stocks Agreement and are meant to add specificity to them and guide their practical implementation. Key principles include:

- Manage stocks using the best available science;
- Apply the "precautionary principle," using conservative management approaches when the effects of fishing practices are uncertain;
- Avoid overfishing; prevent or eliminate excess fishing capacity;
- Minimize waste (discards) and bycatch;
- Prohibit destructive fishing methods;
- Restore depleted fish stocks;
- Implement appropriate national laws, management plans, and means of enforcement;
- Monitor the effects of fishing on all species in the ecosystem, not just the target fish stock;
- Work cooperatively with other states to coordinate management policies and enforcement actions;
- Recognize the importance of artisanal and small-scale fisheries, and the value of traditional management practices.

To augment the general provisions of the Code, FAO has issued a number of "technical guidelines for responsible fisheries" that look at certain important subjects in depth and interpret the Code with greater specificity. For example, FAO has issued guidelines on applying the precautionary principle, integrating fisheries management into coastal area management, developing aquaculture responsibly, and applying an "ecosystem approach" to fisheries, among other topics (FAO 2001a).

In addition, FAO has overseen the development of four International Plans of Action (IPOAs) on selected areas of concern to the international community. These consist of a set of recommendations on how nations should cooperate to track a given problem, assess its magnitude, and develop individual national plans of action to address the problem. So far, IPOAs on reducing seabird bycatch; conserving shark fisheries; reducing fishing capacity; and reducing illegal, unreported, and unregulated fishing (IUU fishing) have been approved by FAO member nations.

Beyond these efforts, nations often need further elaboration and refinement of the Code's principles to reflect national or regional fisheries structures, ecosystems, and socioeconomic factors. The Southeast Asian Fisheries Development Center (SEAFDEC), for example, has been developing regional guidelines for implementing certain aspects of the Code in Southeast Asia that

Fishing harbor at Madras, India.

FAO/19583/G. BIZZARRI

incorporate the needs of the Association of Southeast Asian Nations (SEAFDEC 2003; Chokesanguan 2001b). In Europe, a reform of the European Common Fisheries Policy has also taken place in an effort to shift the focus of the policy so that its principles are fully compatible with the Code, and it becomes an instrument for conservation and management of fisheries and aquaculture, rather than simply a policy of exploitation (European Commission 2003).

The elaboration of the principles in the Code and their general acceptance as norms by nations represents an important step toward more sustainable fishing. But it does not imply that fishing operations worldwide are now based on the Code. One reason is that, unlike a treaty, the Code of Conduct and the IPOAs are all voluntary agreements, free of legal mandates or enforcement mechanisms. This means that member countries are solely responsible for incorporating the Code's principles into their national fishery policies, or following the Plans of Action as they see fit. Another reason is that many developing countries simply lack resources or capacity to do so, or have other pressing needs they consider higher priority such as basic infrastructure development. For nations with the will and capacity to apply them, voluntary agreements (often called "soft law") such as the Code and the IPOAs can be important tools, but they can also be easily undermined by nations that fail to fully implement or enforce them.

One urgently needed step is to create incentives and support mechanisms for countries to truly implement and enforce the recommendations and principles set forth in the Code of Conduct and associated IPOAs. This is particularly necessary in the developing world, where resources are limited. In these countries, a step forward would be to help them integrate the principles of sustainable fisheries into their economic development and poverty reduction strategies given that many nations will continue to rely on fishery resources as a source of food, employment, and income.

Independent oversight to monitor progress in implementing and enforcing the Code and IPOAs, which does not depend on, and is not influenced by the member countries would increase transparency and accountability in international fisheries management and would go a long way in helping to achieve the 2002 World Summit on Sustainable Development (WSSD) targets of maintaining or restoring depleted fish stocks by 2015.

HAS THE FAO CODE OF CONDUCT BEEN EFFECTIVE?

Since the adoption of the Code, there are indications that it is beginning to have an effect on fisheries management in some countries. In surveys conducted by FAO in 2000 and 2002, most member countries and regional fisheries bodies indicated that their policies and legislation conform at least in part to the norms and principles set forth in the Code. Member countries also reported the development of some 700 fishery management plans tailored to different stocks or geographic areas, with over 70 percent of these plans being implemented to date. However, not all the plans have specific targets or reference points, such as fleet capacity reduction. Even when they do, many governments noted that fishers in their waters often fail to meet these targets (FAO 2002e). In addition, the performance of these management plans in protecting fish stocks has not been comprehensively evaluated. Relying on countries to report on their own progress can result in biased conclusions. More objective, independent oversight mechanisms to track progress—whether by NGOs, civil societies, or international bodies—would help to improve transparency in reporting and the associated government accountability.

In terms of implementing the IPOAs, several countries report that they have developed their own national plans of action for sharks or seabirds, while many others have formulated plans

Box 9-1: FAO's Role in Global Fisheries Management

The Food and Agriculture Organization (FAO) is a specialized agency of the United Nations with a crucial role in promoting sustainable fishing at the international level. No other organization has such a breadth of responsibility for assessing global fisheries, developing sound management policies, and providing the 180 member countries with technical advice on sustainable fishing in both national and international waters. Its program areas cover virtually every aspect of fishery management:

Global fisheries assessment and analysis. FAO compiles and analyzes fisheries information reported annually from member governments to give a global-scale view of the fisheries resource base, discern trends in catches, track trade in fisheries products, monitor the condition of marine ecosystems, track illegal fishing activities, and identify emerging management issues. FAO makes its fisheries data available through its FISHSTAT database, and puts these data and trends in context in its biennial report *State of the World's Fisheries and Aquaculture.*

Policy development and treaty monitoring. FAO coordinates the drafting and implementation, and monitors the progress of many international agreements on fisheries policy and management practices, such as the Code of Conduct for Responsible Fisheries. The agency does not have a formal enforcement role, and cannot hold member countries accountable for their performance in implementing or complying with these agreements. For the most part FAO focuses on providing recommendations and assistance to its members upon request, including help in formulating national fisheries policies.

Coordination and technical assistance. FAO provides a number of services to help member countries adapt the principles and practices it recommends to their national circumstances. The agency offers technical assistance in all aspects of fisheries and aquaculture management, particularly to developing countries, where it runs a large number of field projects. It also facilitates international meetings (for example, the periodic meetings of the Committee on Fisheries—FAO's formal body for negotiating policy among member countries), and organizes working groups on topics of particular concern.

to reduce the fishing capacity of their national fleets. Since one of the fundamental purposes of the IPOAs is to stimulate nations to craft action plans tailored to their particular national needs, this represents initial progress. Of the four existing IPOAs put forward by FAO, the one concerning Illegal, Unreported, and Unregulated (IUU) fishing seems to be of highest priority in most countries. Surveys show that 70 countries have developed or are in the process of developing a national plan to address IUU (FAO 2002e). Of course, preparing a national plan does not guarantee implementation. Developing countries, in particular, tend to have limited resources and capacity to implement such plans. Incentives and support to integrate them into national development and poverty reduction strategies are urgently needed.

WHAT ROLE DO REGIONAL FISHERIES BODIES PLAY IN MANAGING FISH STOCKS?

One of the principal goals of the Code of Conduct, the UN Fish Stocks Agreement, and the Compliance Agreement (see section below on Illegal, unreported and unregulated fishing for discussion on the Compliance Agreement) is to enhance the work currently being done by the regional fisheries bodies (RFBs), which have historically dealt with management of shared stocks. RFBs, such as the Northeast Atlantic Fisheries Commission and the International Pacific Halibut Commission, are typically given the job of monitoring and managing specific fish species, stocks, or geographic regions. Some RFBs are key players in the decision-making process that determines overall catch quotas and the allocation of these quotas among member countries, while others play more of a scientific and advisory role. Currently, there are 33 active marine and inland RFBs, including five focusing on management of various tunas stocks, and two on marine mammals (Lugten 1999; Swan 2000). Of the 33 bodies, 9 were established under FAO's Constitution, while the remaining 24 were set up by international agreements among 3 or more parties (Swan 2000). FAO RFBs are open to all member countries, including non-coastal nations, whereas some non-FAO RFBs restrict the involvement of non-coastal states (Lugten 1999). A list of these RFBs, together with their main roles is presented in Annex C: Regional Fisheries Bodies.

In developing countries, where resources and capacity are limited, incentives and support to integrate the principles of sustainable fisheries into national development and poverty alleviation strategies are needed.

Because international arrangements for fisheries management change over time, the mandate, regulations, and defined roles of RFBs should keep pace with these changes in order to meet the needs of new legal frameworks and address emerging issues. In reality, this has not been the case for all RFBs. FAO's 1999 review of the current mandates and roles of RFBs concluded that, "very few bodies have started to implement the conservation and management measures" put forward in the contemporary fishing agreements named earlier (FAO 1999e based on Lugten 1999). However, FAO also noted that most RFBs are limited by "inadequate mandates or terms of reference, incongruent fishery interests of members, funding and staffing difficulties, and lack of political commitment" (FAO 1999 based on Lugten 1999). Since the 1999 review, the RFBs that are under the auspices of FAO have undergone reviews and evaluations to update their

roles and mandates. Annex C provides an overview on implementation of contemporary fishing agreements by RFBs.

RFBs vary widely in their levels of institutional development and accomplishment. Some of these bodies, such as the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the Inter-American Tropical Tuna Commission (IATTC) have been in existence for decades and are quite advanced in achieving some of their mandates such as compiling tuna production data, assessing stocks, making regulatory recommendations, or setting catch quotas. In addition, IATTC and ICCAT, along with the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), are making progress in monitoring unregulated fishing activities by fleets that are registered in non-member countries but exploit the same fisheries resources that the organization is mandated to manage and protect. (See section on *Tackling Illegal, Unreported, and Unregulated Fishing.*) On the other hand, other newer RFBs such as the Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) have yet to establish regular stock assessment programs for the species they aim to manage, or to gain the full participation of key countries that exploit the same resources (IOTC 2003; CCSBT 2003; Swan 2003).

FAO/19340/R. FAIDUTTI

Daily arrival of fishing boats at Lake Victoria, near Entebbe, Uganda.

TACKLING ILLEGAL, UNREPORTED, AND UNREGULATED FISHING

Measures to control overfishing and curb destructive fishing practices are hampered by the widespread incidence of illegal, unreported, and unregulated (IUU) fishing. The term "IUU fishing" encompasses a wide range of practices that do not respect applicable laws and regulations, or the standards set forth by international agreements such as UNCLOS. Examples include fishing in a nation's EEZ without government authorization, misreporting or failing to report catches, fishing in 'no-fishing' areas, fishing stocks during closed seasons when fishing is forbidden, and reflagging fishing vessels to evade laws or regulations (FAO 2002b).

IUU fishing occurs to some degree in virtually all capture fisheries, whether they are located within national EEZs or on the high seas. However, it is most prevalent in fisheries of high commercial value, such as sashimi-grade tunas (bluefin and bigeye) and other restaurant-quality species such as cod, redfish, and Patagonian toothfish (i.e., Chilean Sea bass).

Information on the dimensions of IUU fishing is limited. A number of national fishery agencies and regional fisheries management bodies have documented the incidence or estimated the quantity of fish caught by IUU fishing in their respective jurisdictions. However, information from developing country EEZs is mostly anecdotal. These include reports of Japanese, South Korean, and Taiwanese fleets fishing tuna illegally, and Spanish vessels taking hake in Namibian waters while bearing flags of neighboring countries—an example of the "flags of convenience" practice (Bray 2000a). (See below for more on this practice).

Northern and Southern bluefin tuna, and Patagonian and Antarctic toothfish are the best documented examples of fisheries with high IUU incidence. Each of these species is managed by a regional fisheries body, such as the IOTC, ICCAT, CCSBT, and CCAMLR. Unfortunately, not all countries whose tuna and toothfish operations fall under the jurisdiction of these bodies are members of the respective RFBs; they are therefore not subject to quota management (see *Table 9-1*). One urgent and key measure is to get these non-member countries to join the respective RFBs and to enforce the management rules on their own vessels.

Table 9-1: Member and Non-Member States of Selected Tuna Commissions

Tuna Commission	Parties Harvesting Tuna Species in Areas under the Jurisdiction of Tuna Commissions		Managed Species
	Member Parties	Non-Member Parties	
Commission for the Conservation of Southern Bluefin Tuna (CCSBT)	Australia, Japan, New Zealand, South Korea, Taiwan[1]	Indonesia[2], Philippines[2], South Africa[2], Belize, Honduras, Equatorial Guinea, Cambodia, Seychelles	Southern bluefin tuna
Inter-American Tropical Tuna Commission (IATTC)	Costa Rica, Ecuador, El Salvador, France, Guatemala, Japan, Mexico, Nicaragua, Panama, Peru, Spain, U.S.A., Vanuatu, Venezuela	China, South Korea, Honduras, Indonesia, Taiwan, French Polynesia	Yellowfin, albacore, skipjack, bigeye, and bluefin tuna; swordfish, striped marlin
International Commission for the Conservation of Atlantic Tunas (ICCAT)	Algeria, Angola, Barbados, Brazil, Canada, Cape Verde, China, Côte d'Ivoire, Cyprus, Croatia, Equatorial Guinea, EU, Gabon, Ghana, Guinea, Conakry, Honduras, Iceland, Japan, South Korea, Libya, Marta, Mexico, Morocco, Namibia, Panama, Philippines, Russia, Sao Tomé & Principe, South Africa, Trinidad & Tobago, Tunisia, Turkey, UK., U.S.A, Uruguay, Vanuatu, Venezuela	Taiwan[3], Costa Rica, Senegal, Singapore, Togo, Thailand, Georgia, Indonesia, Seychelles, Belize, St. Vincent, Grenadines, Cambodia, Bolivia, Sierra Leone	Atlantic bluefin, yellowfin, bigeye, skipjack and albacore tuna; Atlantic bonito; swordfish, white and blue marlin; etc.
Indian Ocean Tuna Commission (IOTC)	Australia, China, EU, Eritrea, India, Japan, Rep. of Korea, Madagascar, Mauritius, Malaysia, Oman, Pakistan, Seychelles, Sudan, Sri Lanka, Thailand, UK., Vanuatu, Philippines	Indonesia, Iran, Maldives, Taiwan, Belize, Equatorial Guinea, Honduras, Panama, Vanuatu, Cayman Islands, Cote d'Ivoire, Liberia, Malta, Netherlands Antilles	Yellowfin, albacore, skipjack, bullet, and bigeye tuna; kawakawa, Indo-pacific blue marlin, swordfish.

[1] The Fishing Entity of Taiwan is a member of the Extended Commission.
[2] Parties indicated their desire to become cooperating non-members and were invited to apply for admission in 2004.
[3] Cooperating Party

Source : ICCAT 2002; IOTC 2002; CCSBT 2003; IATTC 2003.

9

According to estimates by CCAMLR (1998), over 50 percent of the global harvest of toothfish on the international market in 1997-1998 was caught by IUU fishing. Vessels with flags from Seychelles, the Faroe Islands, and Belize were sighted taking part in this illegal activity, while landings of illegal catch are known to have taken place at ports in Namibia and Mauritius (Bray 2000a). None of these countries was entitled to fish for toothfish under the CCAMLR legal catch quota allocation. By 2000-2001, the unreported catch of toothfish within CCAMLR's jurisdiction had declined significantly, but was still estimated at 39 percent of the total catch (CCAMLR 2001).

IUU fishing of tuna is also widespread. In 2000, the IOTC and ICCAT estimated that at least 10 percent of all landings of tuna and tuna-like species in their respective jurisdictions came from IUU fishing (Bray 2000a). The CCSBT also estimated that at least 5,000 metric tons of southern bluefin tuna—nearly 30 percent of the estimated total catch—was caught by countries that are not members of the Commission, mainly South Korea, Taiwan, and Indonesia (CCSBT 2002). Reporting of catch statistics, and therefore monitoring of stocks, is expected to improve now that South Korea and Taiwan have become members of CCSBT (in 2001 and 2002, respectively).

FLAGS OF CONVENIENCE AND IUU FISHING

Illegal, Unreported, and Unregulated fishing (IUU) is often conducted by fleets that carry a "flag of convenience" (FOC). This term describes vessels that are officially registered in one nation, but whose owners and operators reside in another nation. This may be done to take advantage of low registration fees, or favorable taxation and labor laws in a given country. It may also be done to avoid trade embargoes that apply to certain nations (FAO Fisheries Glossary 2003). Some countries intentionally allow the practice of FOC registration—a practice known as keeping an "open register." Countries with large open registers include the Bahamas, Belize, Cyprus, Honduras, Liberia, Marshall Islands, Panama, Saint Vincent and the Grenadines, and Vanuatu. These countries are characterized by having the majority of their registered ships owned abroad.

FOC vessel owners are often persistent in their effort to evade controls on their fishing practices. For example, when South Korea and Taiwan recently joined the CCSBT—requiring that the vessels registered in these countries comply with international standards—many vessel owners re-registered their

Table 9-2: FOC Countries and Countries Reportedly Engaged in IUU

Country	Fish Targeted[1]	Problems and Status of Sanction by RFBs and Japan
Belize	tunas	Sanction imposed by ICCAT as of 2000. Implemented Japanese port ban on tuna longline vessels as of 2003.
Bolivia	tunas, toothfish	ICCAT identified IUU vessels registered, export substantially increased, as of 2001. In July 2003 Japan implemented a port ban on tuna longline vessels from the country.
Cambodia	tunas	Sanction imposed by ICCAT as of 2000. Implemented Japanese port ban on tuna longline vessels as of 2003.
Cote d'Ivoire	tunas	IOTC reported catches of non-reporting purse seiners by 2000.
Equatorial Guinea	tunas	Sanction imposed by ICCAT as of 2000. Implemented Japanese port ban on tuna longline vessels as of 2003.
Ghana	toothfish	IUU activities reported by CCAMLR, 2002.
Grenadines	tunas	Not cooperating with IATTC.
Guinea	tunas	ICCAT identified IUU vessels registered, 1999.
Honduras	tunas	Imposition of sanction decided by ICCAT, 2001. Removal of some IUU vessels. In July 2003 Japan lifted the port ban on tuna longline vessels.
Indonesia	tunas	ICCAT Identified IUU vessels registered and export substantially increased, as of 2001.
Kenya	tunas	ICCAT Identified IUU vessels registered, 1999.
Liberia	tunas	IOTC reported catches of non-reporting purse seiners by 2000.
Malta	tunas	IOTC reported catches of non-reporting purse seiners by 2000.
Mauritania	toothfish	IUU activities reported by CCAMLR, 2002.
Netherlands Antilles	toothfish, tunas	IUU activities reported by CCAMLR, 2002.
Panama		ICCAT identified export substantially increased, catch and landing reported, IUU vessels registered and returned, as of 2001.
Philippines	tunas	ICCAT identified IUU vessels registered, 1999.
Russian Federation	toothfish	IUU activities reported by CCAMLR, 2002.
Seychelles	tunas	CCSBT agreed to suspend further action on the basis of undertaking cooperating framework, 2003.
Sierra Leone	tunas	ICCAT identified IUU vessels registered, export reported as of 2001. In July 2003 Japan implemented the port ban on tuna longline vessels.
Singapore	tunas	ICCAT identified IUU vessels registered, 1999.
St. Vincent	tunas	Sanction imposed by ICCAT as of 2000, lifted in 2003.
Taiwan	tunas	IOTC reported catches of IUU tuna longliners by 2000.
Trinidad & Tobago	tunas	ICCAT identified IUU vessels registered, 1999.
Uruguay	toothfish	IUU activities reported by CCAMLR, 2002.
Vanuatu	tunas	ICCAT identified IUU vessels registered, export substantially increased, as of 2001. IOTC reported catches of IUU longliners by 2000.

[1] "Tunas" include: yellowfin, bigeye, bluefin, albacore, and other tuna species, billfish (swordfish, marlin), and other small tunas and tuna-like species.

Source: Transport International 2000; CCAMLR 2002; IOTC 2002; IATTC 2003; ICCAT 2003b; JFA 2003.


E. BOS, IUCN 2003

The high value of sashimi-grade tuna makes it a target for IUU fishing. This photo shows legal tuna being auctioned at Tsukiji market, Tokyo.

ships in another FOC country, in a practice called "reflagging," in order to continue to side-step international laws and restrictions. Of 240 tuna vessels blacklisted by ICCAT as FOC vessels in November 2000, almost all are owned by Taiwanese companies. Of these, 96 are registered in Belize, 83 in Honduras, 50 in Equatorial Guinea, and 17 in Saint Vincent. Tuna vessels are also increasingly being registered in China, raising concerns that China may become the next popular open register country (Japan Tuna 2002). Table 9-2 shows the FOC nations engaged in IUU fishing.

IUU REGULATIONS AND MONITORING: FAO'S COMPLIANCE AGREEMENT

In order to deal with IUU fishing, FAO initiated the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (also referred to as the Compliance Agreement) in 1993. The agreement entered into force in April 2003 when the 25th nation accepted the treaty. FAO's Compliance Agreement and other international agreements primarily address the IUU fishing issue on the high seas, rather than in national Exclusive Economic Zones. These treaties specify that a flag state—the nation in which a ship is registered—holds legal jurisdiction over the operation of the ship whether the ship is operating in that nation's waters or abroad. These agreements also make it clear that the flag state is responsible for monitoring the activities of ships carrying its flag, and can be held accountable for any IUU fishing practices they undertake. Since the Compliance Agreement so recently entered into force, its effectiveness in terms of reducing IUU fishing is still unknown.

New technologies such as satellite-linked vessel monitoring systems (VMS) are gradually being adopted to reduce IUU fishing activities. VMS provides monitoring agencies with accurate locations of participating fishing vessels, so that the vessels cannot operate in illegal waters (FAO1998). Regional fisheries bodies are also trying to counter IUU fishing by compiling more accurate information on the extent of the IUU catch and trade, blacklisting known IUU vessels, and encouraging more fishing nations to join these regional and international bodies. In some cases, regional fisheries bodies have started granting Taiwan and other non-member countries an official status that allows increased cooperation by these "fishing entities" without having to become an official Party to the various international fishing treaties. Until now, Taiwan, which is not officially recognized by the UN system as a "country," has been unable to join UN-related international bodies, and therefore was not legally bound by the rules set by these institutions.

Another new strategy by regional fisheries bodies to address IUU fishing is to establish "white lists" (or positive lists) of approved vessels—a complement to the current practice of "blacklisting" certain vessels known to engage in IUU fishing. Ports in nations that agree to use the white- listing strategy only allow vessels that are on an approved list of registered vessels to land or export their catches. The intent is to prevent IUU vessel owners from avoiding blacklisting by simply changing their names or reflagging their vessels. Both the ICCAT and IOTC began to implement the white-listing approach in July 2003 (ICCAT 2004; IOTC 2004).

FAO/19609/G. BIZARRI

CHAPTER 10

CONFLICTS BETWEEN SECTORS: RIGHTS TO FISH AND THE FISHING ENVIRONMENT

Fisheries have been the direct and indirect cause of international and sectoral conflicts for decades, but especially since the advent of the Exclusive Economic Zones (EEZs), which drastically reorganized access rights in marine fisheries (see *Chapter 9* for further details on EEZs) (Le Sann 1998). In addition, the open-access nature of many coastal fisheries has meant that the rights and responsibilities of resource users are not well defined, and competition among fishers intensifies as the resource becomes scarcer. Even where clear laws and regulations defining rights exist, enforcement is a challenge for industrial nations and developing countries alike, often resulting in conflicts among different user groups.

Fisheries-related conflicts range from basic competition among fishers over the same fish stock to international trade disputes over fishing rules and regulations (see *Chapter 8* for examples of international trade disputes). But in general, most fisheries-related conflicts arise from disputes over fishing rights within territorial seas and EEZs; disputes over the use of fishing environments between fisheries and other industrial sectors (i.e., tourism, coastal development); and disputes between different fishing sectors, such as industrial and small-scale, or sport and commercial fishing. This chapter describes a few examples of these three major types of conflicts.

EEZ and other territorial disputes. Fisheries disputes related to territorial boundaries have been widespread for decades. However, they have intensified in many parts of the world, sometimes invoking violence, as countries have established sovereign rights within their EEZs—200 nautical miles of their coast—under UNCLOS (see *Chapter 9*). Instead of freely accessing fish stocks in these formerly open-access waters, governments now have to negotiate access to fishing grounds in other countries' EEZs and abide by the laws and regulations of the coastal state.

Encroachment by fishing vessels into another country's EEZ continues to cause numerous international fisheries disputes. The most famous examples are the so-called "cod wars" between Iceland and the U.K.There have been three since Iceland extended its jurisdiction over offshore waters to 12 nautical miles in 1958—the first cod war; from 12 to 50 miles in 1973—the second cod war; and finally from 50 to 200 nautical miles in 1975-76—the third cod war (Berrill 1997). Although these are the best known of the cod wars, they are by no means the only ones. Disputes over Atlantic cod—historically, a highly prized fish in Europe, and North America—occurred as early as 1532 between England and Germany (Kurlansky 1997), and more recently in 1991 between Spain and the U.K (Benseler 1996).

The open-access nature of many coastal fisheries has meant that the rights and responsibilities of resource users are not well defined, and competition among fishers intensifies as the resource becomes scarcer. Even where clear laws and regulations defining rights exist, enforcement is a challenge for industrial nations and developing countries alike, often resulting in conflicts among different user groups.

Spain has been involved in several disputes over fishing access, quotas, or gears. Recent incidents include the 1991 dispute between Spain and Namibia when Spanish fishing boats were seized by the Namibian government for illegally fishing within its territory, the 1992 and 1995 disputes between Spain and Morocco over fishing in Moroccan waters, and the 1995 dispute over the turbot catch and the use of illegal nets by Spanish fleets just outside Canadian waters (Benseler 1997; Martin 1998).

Fisheries disputes related to territorial jurisdiction also occur in inland water bodies. For instance, Lake Victoria, which is bordered by Kenya, Tanzania, and Uganda, has been the subject of conflict with fishers crossing into each other's territorial waters. The problem intensified recently when Kenyan fishers were detained by both Ugandan and Tanzanian authorities for illegally fishing beyond Kenyan waters (AllAfrica Global Media 2003). Dwindling stocks of Nile perch (LVEMP 2001; Balirwa et al. 2003)—the most prized fish in the lake—only fuels competition among the fishermen who share the lake's resources.

International dispute settlement bodies, including the International Court of Justice, the International Tribunal for the Law of the Sea, the World Trade Organization, or regional fisheries organizations officially record these disputes, and will often settle them if bilateral negotiations are not successful (ICJ 2003; ITLS 2003). However, fishery disputes related to EEZ boundary violations and other territorial issues are controversial and can take years to settle. The prevalence of illegal, unreported, and unregulated (IUU) fishing fleets often exacerbates the problem (see *Chapter 9* for further discussion on IUU fishing).

Conflicts between fisheries and other sectors. When multiple development goals and conflicting interests compete over the use of the same water body or coastal zone, fisheries can often be marginalized in favor of other development sectors such as agriculture or energy. Dam construction, for instance, alters the flow regime of the rivers; inundates riverine fish spawning grounds; and blocks the migratory paths of anadromous fish; all of which affect inland, floodplain, and delta fish resources downstream (Adams 2000; Jackson and Marmulla 2000; Pringle et al. 2000). Conflicts involving transboundary rivers, such as the Mekong River in Southeast Asia, can be especially volatile. The construction of numerous hydroelectric dams in the upper Mekong River by China and Laos caused widespread outcry from the downstream countries who fear the loss of fisheries, especially in the Tonle Sap—the bread (or fish) basket of Cambodia. Numerous local and international NGOs have called attention to this problem and highlighted the food security risk of populations downstream if the dams go ahead as planned (NGO Forum on Cambodia 2000; Probe International 2003; International Rivers Network 2003; Mekong Watch Japan 2003).

This problem is reflected in key messages from the World Commission on Dams report (2000), which stresses the need to assess the impact of dam development within a basin-wide context according to seven strategic principles: gaining public acceptance; comprehensive options assessment; addressing existing dams; sustaining rivers and livelihoods; recognizing entitlements and sharing benefits; ensuring compliance; and sharing rivers for peace, development and security (WCD 2000). The report specifically calls for attention to the impact of dams on downstream fisheries and the livelihoods of the people who depend on them. (see *Chapter 11* for discussion on Integrated River Basin Management.)

Large-scale versus small-scale fisheries. Disputes between large and small-scale fisheries are common in many parts of the world, both in inland and marine waters and usually arise where these two very different sectors compete over the same fish stocks and fishing grounds. In Cambodia's Tonle Sap large-scale, commercial fishing operations can severely limit access of small-scale fishers to the most productive fishing grounds in the lake. This is reflected in the number of complaints filed with the Cambodian Department of Fisheries—more than doubling between 1998 and 1999 (Gum 2000; Stockholm Environment Institute 2000).

In marine environments the most documented conflict between large and small-scale fishers occurs when industrial trawlers encroach into near-shore fishing grounds where small-scale fishers operate (see *Box 10-1*). Industrial bottom trawlers not only can destroy the nets set by small-scale and local artisanal fishers, but also may overexploit commercially valuable fish, and degrade the fishing grounds upon which local people depend. Artisanal fishers plying their trade in coastal waters can experience severe drops in their catch for several days after an industrial bottom trawler has swept the area. Where small-scale fishers are organized as a sector and have a political

Box 10-1: European Union Fishing Access Agreements—How do they affect small scale fishers in Africa?

Europe's overcapacity in the fishing sector and the depleted and overfished condition of many North Atlantic stocks has driven industrial nations to redeploy their fishing fleets to new fishing grounds. Many of these grounds are off the coasts of developing countries, where traditional coastal communities ply their trade. While European and other developed nations sign agreements and pay for the rights to fish in the coastal waters of these countries, the payments do not trickle down to coastal communities. The impact of fishing activity by foreign vessels however, does—by encroaching into grounds within a few miles of the coast where local fishers operate and creating conflicts between foreign fleets and local fishers.

Between 1992 and 2000, the European Union (EU) spent an average of 270 million ECU (European Currency Unit – the predecessor to the Euro) annually to purchase fishing rights in non-member countries, mainly through bilateral agreements with African and European nations (European Commission 2001; IFREMER 1999). Before the mid-1990s, such agreements were purely "commercial transactions" with a goal to bring back as much fish to Europe for as little cost as possible. However, in recent years access agreements have a stronger element of development assistance through joint ventures, where the financial compensation can include funding for fisheries research, training for fishery managers, and grants to small-scale fishing (Kaczynski and Fluharty 2002).

These agreements help supply the EU fish market with 8 percent of its total fish supply and support the employment of tens of thousands of European fishers. However, the costs and benefits to developing countries have become a matter of controversy. The agreements are criticized for depleting fish stocks; marginalizing the local artisanal fishers; putting local populations at risk of food security; and for not returning an equitable share of the benefits to the developing countries. For instance, the compensation Guinea-Bissau received for issuing licenses to French and Spanish fleets in 1996 was less than 1 percent of the estimated market value of the tuna harvested from Guinea Bissau's waters. Moreover, although European vessel owners pay the license fee to their respective governments, these fees account for at most one-third of the total compensation paid to the West African country. The remaining amount is made up by EU government subsidies, mostly for the benefit of companies in Spain, Italy, Portugal, and France (Kaczynski and Fluharty 2002). Such subsidies lower the costs for EU fleet owners and make it much harder for West African fishers to compete with EU fleets in the market.

In addition, West African nations, for the most part, continue to sign access agreements and allocate fish catches without monitoring or taking into account changes in the number of local or national vessels actively involved in fishing. Neither do most of these agreements contain catch quotas for EU vessels (Kaczynski and Fluharty 2002). Therefore, a country can continue to sign the same agreement over and over even if its local fleet has increased substantially and the catch is declining due to overcapacity from both, national and foreign vessels.

Declines in demersal fish stocks have been reported in Mauritania, Ghana, and Senegal—three countries where European fleets have targeted demersal species for some time (CNROP 2002; Koranteng 2002; UNEP 2002b). The National Oceanographic and Fisheries Research Centre of Mauritania (CNROP 2002) reported that, in Mauritania, the catch of octopus—the most important fishery export product shipped primarily to Japan—fell by more than 50 percent in less than four years because of increased competition from EU vessels. Consequently, the number of fishers employed in Mauritania's non-industrial octopus fishery who use pots fell sharply (CNROP 2002).

Finally, although the fishing access fees paid to West African governments are intended to help develop domestic capacity for fishing and fisheries management, tracking how the governments actually use these fees is another matter (IFREMER 1999). An analysis of the EU's fishery agreements with West African countries observes that the financial compensation received from the EU in most cases goes to the central government as a single lump sum and is "seldom used to benefit the development of the domestic fisheries sectors" (Kaczynski and Fluharty 2002).

In response to criticisms of the prevailing practices, and as part of the reform of the EU Common Fisheries Policy, the European Commission has announced plans to move its fishing access agreements with developing countries toward what they call "partnership agreements" that integrate sustainable fisheries objectives with national development strategies (European Commission 2002).

voice, negotiations with the national government requesting fair allocation of fishing rights and protection from the encroachment of industrial fleets is possible. However, enforcement of these measures usually falls short. For example, in West Africa, nearly all countries have passed laws giving artisanal fishers exclusive fishing rights to coastal waters within a fixed distance from the shore (1–12 nautical miles, depending on the country), and have prohibited industrial trawlers from operating in these waters (Horemans 1998; Bortei-Doku Aryeetey 2002). Unfortunately, foreign and national industrial vessels do not usually adhere to these laws, and enforcement by national governments is weak and limited by lack of adequate funding, staffing problems, and corruption. Asian countries such as India, Indonesia, and Thailand have also banned or limited access of industrial trawlers to coastal waters in some part of the country (Vijayan et al. 2000; FAO 2000c; FAO 2000d).

In most cases, however, because many small-scale fishers are marginalized, their political leverage is minimal so they tend to shift to exploiting less valuable species, or pursue different niches in the industry, such as catching ornamental coral reef fish often using environmentally destructive methods.

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Artisanal fishermen ply their trade at sunset in southern Laos on one of the many tributaries of the Mekong River.

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CHAPTER 11

WHAT DO WE KNOW ABOUT FISHERIES MANAGEMENT?

SUCCESSES, FAILURES, AND PROMISING APPROACHES

In 2002, nations attending the World Summit on Sustainable Development (WSSD) promised to make substantial progress toward recovering depleted fish stocks by 2015. But how will they make good on this promise? Over the years, national governments and regional fisheries organizations have used a variety of regulations and other measures to try to curb overfishing and manage fish stocks more sustainably. Some of these measures have been effective in achieving specific goals. Others have simply substituted one set of problems for another rather than solving the overfishing issue. This chapter describes some successes, failures, and promising approaches to sustainable fisheries management.

Fisheries management options generally fall into three broad categories: those that manage fishing effort by limiting the number of fishers or the gear they can use (so-called "input controls"); those that manage the level or size of the permissible catch (so-called "output controls"); and technical measures, such as the designation of limited fishing seasons, restricted zones, or limits on fish size. All these measures restrict when, where, and how fishing takes place or how many fish can be harvested in order to protect fish stocks and maximize economic output. Some of these approaches also restrict who can participate in a fishery.

As mentioned in earlier chapters, most fisheries are managed as open access resources, that is, there is no restriction on who can use the fishery. However, as these regimes show their weaknesses, managers turn to approaches that are more restrictive. These include limiting entry to the fishery through the sale of licenses, limiting particular uses in certain areas (zoning), or limiting the amount of fish that one can harvest (quotas). Some systems have even granted "property rights" or exclusive access to a portion of the harvest in hopes of giving fishers a stake in the health of the fishery (see the section on *Individual Fishing Quotas* below).

This chapter also considers the merits of using an ecosystem-based approach to recovering fish stocks, and includes a brief overview of integrated river basin management approaches for freshwater fisheries, and the establishment of marine reserves as part of the wider range of management tools.

Over the years, national governments and regional fisheries organizations have used a variety of regulations and other measures to try to curb overfishing and manage fish stocks more sustainably. Some of these measures have been effective in achieving specific goals. Others have simply substituted one set of problems for another rather than solving the overfishing issue.

MANAGING FISHING EFFORT

Limited Licensing

Licensing—the allocation of licenses to fishers or fishing vessels, entitling them to harvest from one or more stocks—is the most widely used system for controlling the fleet capacity (Cunningham and Gréboval 2001). The theory is that by limiting the number of licenses issued, fisheries managers can limit the effort focused on a particular stock and so prevent overfishing. However, licensing programs are insufficient on their own to control a fleet's overcapacity. They do not prevent fishers from expanding the capacity of their vessels or adding new technology to increase their catch. And, as fish become scarcer because of overfishing, that is exactly what many licensed fishers do to remain profitable—they increase their capacity by investing in larger, more powerful boats or improved technology to target fish more accurately. The net effect is, usually, an increase in the fleet's ability to overfish even when the number of licenses remains constant (Cunningham and Gréboval 2001).

Licensing schemes also suffer from other problems, particularly when they are being set up. The initial allocation of licenses, for example, can be difficult (OECD 1997). Fishers with a history of harvesting a given stock are usually given preference, but it is often difficult to establish who was fishing before and who was not, and therefore who should be given preference. Also, if a bidding process is involved, many of the licenses may end up in the hands of a few large, well-financed fishing companies, at the expense of smaller and poorer operators.

Once licenses are issued, managers may try to reduce the pressure on a stock by slowly reducing the number of licenses issued. This can happen through buy-back programs or by retiring licenses as fishers die or move on.

Gear and Vessel Restrictions

Gear and vessel restrictions aim to reduce the fishing power of vessels by limiting boat dimensions, crew size, or the type and number of gears used. These measures can be quite successful in reducing fishing pressure in the short run. In the long run, however, they tend to lose their effectiveness because they are often easy to circumvent with new technology (Jennings et al. 2001). Fishers adapt by developing new gear or switching to other unrestricted gear, and fishing regulations generally cannot keep up with the fast pace of adaptation.

Buy-Back Programs

Buy-back programs offer governments a quick and direct means to reduce pressure on fish stocks by purchasing licenses or vessels from active fishers and retiring them. By lowering the total number of boats, governments can reduce the industry's overcapacity problem. The idea behind these programs is to provide a financial incentive so fishers move to other occupations, while increasing the profitability of the remaining fishers by reducing competition.

Buy-back programs have been carried out in many countries, including Australia, Canada, Japan, the Netherlands, Norway, Taiwan, and the United States (Holland et al, 1999). Results have been mixed. Some programs have been successful in reducing fleet size and capacity, but these reductions are often offset by the increased capacity of the remaining fishers, who continue to invest in new technology, modernizing their vessels. In the United States, for example, the National Marine Fisheries Service reported that the ability of remaining fishers to increase their rate of harvest was so large that the impact of the buy-back program was muted (NMFS 1999).

Buy-back programs can be very expensive and can go awry in other ways as well. The cost of the program in the Australian northern prawn fishery in the late 1980s, for example, was $43 million (Holland et al. 1999). Sometimes fishers who have been "bought out"—and in theory have quit fishing—use their government buy-out payment to purchase a new vessel, often a larger or more modern one and return to fishing. Sometimes, they even return to fish the same stock they had been paid to retire from. A survey of 240 fishers who participated in the buy-back program in the British

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Unloading a 16,000 pound catch of pollock in Alaska. Only fish brought into port are counted against the established catch quotas.

Columbia salmon fishery found that 47 percent of them purchased another vessel and license and re-entered the fishery (Kurt and Muse 1984, cited by Holland et al. 1999). In the Washington State salmon fishery, nearly 40 percent of the participants in the buy-back program sold an unwanted license or vessel, only to then upgrade their vessels and gear and re-enter the industry soon after (Kurt and Muse 1984, as cited by Holland et al. 1999).

Another common practice is that retired vessels from one country may be sold to fishers in another country and find a second life, sometimes re-entering the very same fishery under a new flag. In the first round of tuna fleet reduction efforts in Japan (1981-1982), many of the retired vessels instead of being scrapped were sold to the Taiwanese who began to fish the same tuna stocks using the "retired" vessels. Hence, the overall pressure on tuna stocks remained high (Komatsu 2000). A comprehensive analysis of buy-back programs published in 1999 concluded that they had generally been ineffective in addressing the overcapacity problem due to the lack of restrictions on re-use of retired vessels (Holland et al. 1999).

In order for buy-back programs to be truly effective, they must include rules that limit the ability of remaining licensees to expand their fishing capacity, and prohibit vessels that have been retired from being reactivated. For example, current buy-back programs in the United Kingdom and Japan require participating vessels to be scrapped. This increases the cost of the program but ensures that the vessels are truly eliminated from the fleet (Cunningham and Gréboval 2001).

MANAGING THE LEVEL OF CATCH

Total Allowable Catch

Catch controls limit the amount of a given species, by weight that fishers can catch and keep. The most common application of this type of control is the Total Allowable Catch (TAC). The TAC sets the maximum tonnage that can be extracted from a given fishery within a specific period—usually a year (FAO Fisheries Glossary 2003). If set at the right level, TACs can effectively reduce the direct pressure on a fish stock. The "right level" should be no higher than the fishery's maximum sustainable yield—the maximum harvest that still allows the fish stock to remain biologically healthy and able to replenish itself indefinitely. However, TAC systems have many flaws. Perhaps the worst is that they give fishers a big incentive to fish as quickly and intensively as possible to maximize their share of the allowable catch. This competition for the limited pool of fish has many negative consequences. Fishers tend to invest in larger and more powerful vessels and gears, leading to overcapacity. It also leads to higher bycatch rates, and encourages fishers to operate in inclement weather, which leads to more accidents and increased gear loss. Shorter fishing seasons also result as fishers race to catch as much fish as possible before the TAC is reached. A shorter fishing season can also reduce profits by flooding the market with fish over a short time thus lowering fish prices—a bad outcome for both fish and fishers (OECD 1997; NRC 1999).

Finally, setting the TAC at the proper level is a major challenge. Sometimes TACs are based on recent catch records, rather than on a scientifically estimated maximum sustainable yield. Even when managers do their best to refine their estimates, the calculation is complex and full of uncertainty because it is based on catch statistics and information on population dynamics, both of which may be flawed or not fully understood (see *Annex A* and *B* for further discussion on stock assessments and data limitations). In developing countries, the considerable data and analyses necessary to establish a maximum sustainable yield are often limited or not available at all so setting a legitimate TAC is even more difficult.

Further, some fisheries experts question the whole concept of "maximum sustainable yield" and its use in fisheries management (Caddy and Mahon 1995). Instead, they encourage the precautionary approach, which implies that when managers are uncertain about the accuracy of stock assessments or the intricacies of particular fish dynamics they should set the TAC at a lower level than the maximum yield, leaving a substantial margin for error.

Individual Fishing Quotas

One variation on the TAC that has become increasingly common is the individual fishing quota, where a specific proportion of the TAC may be allocated to individual fishers to harvest at their own pace. In many instances, fishers are allowed to treat these individual transferable quotas (ITQs) as personal assets, with the legal right to buy or sell them. Since the late 1970s, many countries have implemented ITQ programs, including Australia, Canada, Iceland, New Zealand, and the United States. Although they represent a significant innovation in managing stocks, such quota systems are still only used in a small fraction of the world's fisheries.

The theory behind ITQs is that fishers are more likely to use sustainable practices if they hold a long-term interest in the fishery in the form of a guaranteed percentage of the harvest. Their incentive to overfish is less because that diminishes the value of their asset—their quota—while conservative fishing increases its value. And because they do not directly compete with other fishers, they can adopt a more reasonable schedule.

The introduction of ITQs has indeed brought benefits in some fisheries. In Alaska these programs have eliminated the traditional "race for fish," improved safety, and considerably reduced ghost fishing—the accidental entanglement of fish by abandoned or lost gear (NRC 1999). (See *Box 7.1* on ghost fishing.) Iceland and New Zealand both have comprehensive ITQ programs that are generally considered successful in reducing overall fishing effort and improving the efficiency of the industry as a whole (Hannesson 2002).

But ITQs have disadvantages too. For one, they still rely on setting a TAC, and suffer from the same scientific difficulties in determining a reliable estimate of sustainable yield. For instance, the TAC for New Zealand's orange roughy fishery was set too high because of pressure from the industry, resulting in high immediate profits for the quota holders but serious depletion of the stock (Copes 2000). Another problem is that ITQs give fishers an incentive to "high-grade," or substitute larger (and more valuable) fish caught later in the day for smaller fish caught earlier. The smaller fish are usually discarded overboard—dead or dying. Only fish brought into port are counted against the quota, so high-grading maximizes the value of the catch even as it depletes the fish stock. A related practice is when fishers dump their catch at sea when prices are too low—again, so that the fish they have caught will not count against their quota.

From a management standpoint, quota systems are also rather inflexible, making it difficult for fisheries managers to follow the precautionary approach to protect fish stocks. The stability of the quota system is built on setting the TAC in advance of the fishing season, and not altering it as the season progresses (Copes 2000), therefore, managers have little flexibility to change if they realize mid-season that the TAC is too high, and overfishing can result.

In addition to the ecological issues associated with ITQ systems, they have also engendered some social and equity problems. A primary goal of most fishing quota programs is to reduce the overall amount of fishing by apportioning the resource among a limited number of people. That means that some fishers ultimately lose their jobs, and communities dependent on fishing can become vulnerable. In Australia's southern bluefin tuna fishery, the number of quota holders was consolidated from 143 to 63 in the first four years of ITQ management (Muse and Schelle 1989, cited in Grafton 1996). This consolidation also represents another difficulty with ITQ programs: the danger that over time, quota prices will increase and will be monopolized by a small number of efficient, well-capitalized, and usually larger fishing companies, putting small-scale operators and smaller fishing communities at a disadvantage. In Iceland, for instance, since 1990, when the ITQ system was extended indefinitely, there has been a shift in the composition of the fleet toward fewer, but larger vessels, thus increasing the overall fleet capacity (NRC 1999). During the consolidation of fishing quotas, Icelandic communities of less than 500 people lost a much larger share of their quota than larger communities, leaving them with unemployment problems and an eroding tax base (Eythórsson 2000). In order to avoid this, New Zealand, for example, caps the maximum percentage ownership of the total quota by any one company or individual (Grafton 1996).

RESTRICTIONS ON SIZE, SEASON, AND FISHING ZONES

Size and Sex Selectivity

In order to keep a fish stock biologically viable, it must retain its ability to reproduce. Fisheries managers sometimes try to help by forbidding the catch of mature or egg-bearing females. They may also designate the minimum mesh size of nets and the minimum size or maturity of fish caught, so that immature fish are not harvested before they can reproduce.

These measures can be particularly useful where the target species can be returned to the sea alive, as with lobsters or scallops. But with many other species, they have not proven to be effective conservation measures (OECD 1997). A review of 50 fisheries which employed size and sex-selective measures found that they are particularly ineffective in cases where the stock has been in poor condition for some time, or where more than one type of fish is targeted at the same time. Enforcement of these measures has also proven costly and difficult, because they depend mostly on observer programs requiring many qualified staff (OECD 1997).

On the other hand, managers can sometimes provide incentives to fishers to increase the effectiveness of gear selectivity requirements. When Norway introduced a ban on discards in 1983 (FAO 1997a), it created an economic incentive for fishers to modify their gear and methods to improve catch selectivity and minimize bycatch, leaving more room in their holds for the targeted species. The policy is generally considered a success; however, the effectiveness of such bans relies heavily on enforcement (Nordic Council of Ministers 2002; Megapesca 1999). (See *Chapter 7* for more detailed discussion on discard ban policies.)

Time and Area Closures

Time and area closures, in which fishing is barred during certain periods or in certain fishing grounds, are standard management approaches that have been

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Harvesting juvenile fish is harmful to the health of the fish stock.

used in both small-scale and industrial fisheries for decades, if not centuries (Ward et al 2001). They can be effective management tools, but are usually combined with other regulations because, on their own, neither will reduce the overall pressure.

Closed seasons are used to protect stocks at critical times in their lifecycle—such as when they are spawning—or as a way of lowering the total catch. A major disadvantage of establishing a closed season is that fishers will have an incentive to race for fish during the open season. In the Northern Pacific halibut fishery, fishing is restricted to several 24-hour periods per year, resulting in a hectic competition. This causes high processing and storage costs, frequent injury or death to fishers, and large amounts of wasted fish (Anderson 1995).

Closed areas are used to help depleted stocks recover, or to protect biologically critical areas such as spawning grounds or juvenile nurseries. The problem with this approach is that it does not necessarily decrease the overall fishing pressure. Boats that usually operate in the closed area often simply move to an adjacent open space, increasing fishing pressure there.

"Certified" Sustainable Fishing

A relatively recent approach to better managed fishing is the "ecolabeling" of seafood that has been certified as "sustainably harvested". (See *Box 11.2* Seafood Certification: Incentive for Sustainability.) Fish that are caught within the given criteria of "sustainability" can be labeled and marketed as being

Box 11-1: Seafood Certification: Incentive for Sustainability

Government regulations on where and when to fish and what gear to use are not the only factors affecting the behavior of fishers, and thus the pressure on fish stocks. Fishers also respond to the marketplace, taking note of the preferences that consumers show for one product over another. This is the idea behind "certifying" some seafood and marine products as "sustainable." The intent is to capitalize on some consumers' desire to buy marine products that do not contribute to overfishing or other destructive practices, providing an economic incentive for sound fisheries management.

Generally speaking, a certification is an officially sanctioned label or designation guaranteeing—through inspections or other verification methods—that a given product has met certain standards in its growth, harvest, or handling. The most common environmental certifications—or ecolabels as they are often called—are those applied to organic foods. The "certified organic" label has demonstrated its market value over many years. Certification of marine products is a more recent phenomenon, driven by growing concern over the status of fish stocks worldwide and the commitment of some companies to sustainable fish supplies. In the last decade, both public and private organizations have started to develop standards that can be used in the marine industry, and to design programs to apply these standards in a credible manner (Wessells et al 2001; Pickering et al. 2002).

Organizations that are actively involved in certifying marine products today include the Marine Aquarium Council, the Global Aquaculture Alliance, and the Marine Stewardship Council. The Marine Aquarium Council (MAC) is a nonprofit organization formally established in 1999 that certifies the collection, husbandry, and handling of ornamental aquarium marine organisms including fish, corals, and other invertebrates. The MAC standards are intended to assure that populations of aquarium fish and their habitats are maintained in optimal health, and harvested fish are well treated. Since developing the standards in 2001, MAC has certified the practices of two fishermen associations and four fish exporters in the Philippines (MAC 2003a; MAC 2003b).

The Global Aquaculture Alliance (GAA), a nonprofit aquaculture industry organization, has developed the Responsible Aquaculture Program, which certifies products that are farmed in an environmentally and socially responsible manner (GAA 2003). The program currently focuses on shrimp aquaculture and has certified four shrimp farms in Central America (Aquaculture Certification Council 2003). GAA's *Code*

Table A Marine Stewardship Council: Selected Principles and Criteria for Sustainable Fishing

Principles	Criteria
Protection of Target Fish Stock: Fishing operations must be conducted in a manner that does not lead to over-fishing, or in a manner that demonstrably leads to the recovery of depleted populations	• Catch levels are set to maintain high productivity of target populations • Where the exploited populations are depleted, stock recovery is allowed to occur based on the "precautionary approach" • Fishing operations do not alter the age, sex, or genetic structure of the exploited stocks
Protection of Surrounding Habitat and Ecosystems: Fishing operations must maintain the productivity, functioning, diversity, and community structure of the ecosystem on which the fishery depends	• Fishing operations do not alter the biological structure of the ecosystem of which the target stock is a part • Fishing operations do not threaten marine biodiversity and avoid, or minimize damage to, endangered species
Presence of Institutional and Operational Framework to Implement the Principles: The fishery must be subject to an effective management system that incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable	• Fishing operations comply with local, national, and international laws and standards • Fishing operations respect the cultural context and the long-term interest of fishing-dependent communities • Appropriate procedures are in place for effective compliance, monitoring, control, and surveillance of fishing operations • Periodic assessments are undertaken of the status of the target stock and the impact of fishing operations on the stock and the ecosystem • A mechanism for settlement of disputes is in place

Source: MSC 2002.

more ecologically responsible. The theory behind this approach is that obtaining the certification—which is usually granted after inspection by an independent, nonprofit organization—would add value to the product by either allowing it to be sold at a higher price or to attract consumers who demand products with minimal environmental impacts. If the business case is proven, this can act as a powerful economic incentive for fishers to harvest in ways that minimize their impacts on ecosystems and species.

APPLYING THE ECOSYSTEM APPROACH

The fishery management measures evaluated in this chapter are typically administered by national government agencies and supported by multilateral and bilateral agreements between nations. But alternative institutional arrangements that actively involve resource users also play an important role in improving compliance rates with norms and regulations, especially in small-scale fisheries. (See *Chapter 5* for discussion on co-management approaches to small-scale fisheries.)

The ecosystem approach framework is based on the central concept of managing fisheries as integral parts of the ecosystem, rather than just as a collection of fish stocks to be exploited without regard to the system that nurtures them. But applying an ecosystem approach may require different legal and institutional frameworks that include not only governments, but also a multitude of other stakeholders. Under this approach, fisheries management must do more

of Practice in Shrimp Aquaculture is intended to assure that GAA-certified shrimp are not contaminated by pathogens, chemicals, and drugs that pose human health concerns. It also ensures that certified shrimp farms do not destroy mangroves and wetlands, and that they minimize the waste load they release to the environment. In addition, the code provides some general guidelines for harmonious relations with aquaculture laborers and the local community (GAA 2003).

The Marine Stewardship Council (MSC) is the most widely known example of an independent organization certifying capture fisheries based on standards for sustainable management. Since 1997, MSC has elaborated standards for sustainable fishing practices in seven fisheries, and certified fishers using these practices. Table A lists some of the key principles and criteria used by the council. There are 219 MSC labeled products in the market (as of August 2004), mostly sold in Europe (MSC 2004). Fish stocks for which certification has been completed include Alaska salmon, cockles from the Burry inlet in Wales, hand-line caught English Southwest mackerel, Loch Torridon Nephrops (a Norwegian lobster fishery in Scotland), New Zealand hoki, Red Rock lobster in Baja California, South African Hake Trawl Fishery, South Georgia Patagonian toothfish longline fishery, Thames herring, and Western Australia rock lobster. In addition, as of August 2004, 16 more fish stocks were under review for certification (MSC 2004).

A major challenge for MSC is the time-consuming nature of the certification processes partly because they involve broad multi-stakeholder negotiations. Since only a tiny proportion of the world's fisheries has been certified so far, MSC-labeled products are not yet available in sufficient quantities to influence consumer preference in a major way. As a result, certification hasn't yet achieved its potential as an economic incentive for better fisheries management. However, the council is currently assessing several large fisheries for possible certification. These include Alaska Pollock—the world's largest whitefish fishery—and North Sea herring (MSC 2004). If certified, these widely circulated products could make the MSC certification scheme much more visible and economically relevant worldwide.

One benefit that is already emerging from MSC's program is that it can help small-scale fishers carve out a market niche and give them a comparative advantage against large industrial fishing operations. Until now, the products from small-scale fishers tended to be out-competed by lower-priced products provided by larger companies. Certification is starting to shift this dynamic in some places. The majority of the MSC-certified fisheries so far are dominated by small-scale fishers: The Thames herring fishery, for example, only produces 120 metric tons per year and the Burry Inlet cockles fishery has just 55 license holders. With the MSC certification to distinguish them, these smaller operations are able to reach a more sophisticated and better-priced market through a new set of seafood retailers across the world who have signed on to purchase the certified products (MSC 2004).

The success of some environmentally friendly consumer products and organic foods in general suggests a great potential for seafood certification schemes (Pickering et al. 2002). However, a detailed study of consumer preference in the United States shows that the preference for ecolabeled seafood will likely differ by species, geographic region, consumer education, and certifying agency (Wessells et al. 1999). The survey also revealed a lack of awareness about the declining status of many of the world's fisheries. For example, two thirds of the survey respondents were unsure of the state of Pacific salmon and Atlantic cod stocks, indicating that building consumer awareness of the need for better fishing practices will be a crucial step in making certification programs more effective.

One example of a successful seafood certification effort is the "dolphin-safe tuna" label that identifies tuna caught using methods that minimize dolphin mortality. Evidence from the United States shows that these labels have been effective in altering consumer behavior (Teisl et al. 2002), and have consequently promoted the adoption of "dolphin-safe" fishing methods. (See *Chapter 7* for further discussion on dolphin bycatch and dolphin-safe tuna labeling).

However, there are a few potential problems associated with these seafood certification schemes. Establishing and maintaining the credibility of such a program is a significant and costly effort, in part because there are no internationally recognized standards for certifying sustainable seafood. Adding to the challenge is the fact that several different schemes may arise independently and compete or be in conflict with each other, leading to possible confusion among consumers. In addition, fishers in some developing countries are resistant to the idea of certification. They worry that such schemes could be misused as trade barriers, effectively shutting them out of lucrative markets because they cannot afford to fund or participate in the certification process. In the case of MSC, financial resources are now available to encourage such small-scale fisheries to go through with the process (MSC 2004).

Aside from ecolabeling, other general labeling requirements can be important tools to encourage more sustainable fishing practices. For example, simply requiring that seafood labels show the origin of the fish can help deter illegal, unreported, and unregulated (IUU) fishing (see *Chapter 9*). Several regional fisheries bodies, such as CCAMLR and ICCAT, now require fishers to supply certain catch or trade documentation in order to help prevent illegally caught fish from entering the market (Wessells et al. 2001; FAO 2002f).

than just satisfy the commercial fishing industry, it must accommodate the wide array of economic and social benefits that people derive from aquatic environments, such as recreation and tourism, transportation, local livelihoods, cultural identity, and so on. The practical effect of this is that it widens the group of users that have a legitimate say in how the fishing environment is managed (FAO 2003b).

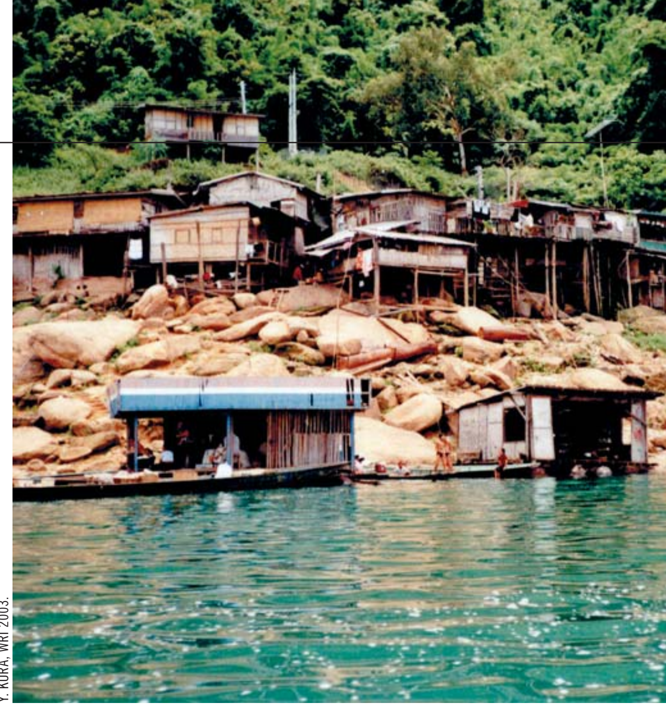
A perfect example is the increasing shift toward, and acceptance of, the integrated river basin management (IRBM) approach—an approach that advocates managing a river and its entire catchment as a single system, and coordinating all the user group activities that take place within this geographic unit. Another example is the establishment and integration of marine reserves into traditional fisheries management approaches.

The following section provides a brief overview of the role that IRBM has played in sustaining inland fish and water resources and a more detailed discussion on the role of marine reserves in rebuilding fish stocks and conserving marine biodiversity.

INTEGRATED RIVER BASIN MANAGEMENT: AN ECOSYSTEM APPROACH TO FRESHWATER RESOURCES AND THEIR FISHERIES

Inland fisheries, water for irrigation, flood control, and hydropower are among the goods and services that people derive from freshwater ecosystems. Current approaches to managing water continue to be mostly fragmented, favoring single uses, such as water withdrawal for irrigation, at the expense of the wider array of goods and services, including fisheries. As population grows, human society will become more dependent on irrigation for food supply and hydropower for electricity, placing extraordinary stress on already altered freshwater ecosystems, particularly in arid and semi-arid regions of the world.

Inland fishery resources are often overlooked when assessing river basin development plans—usually taking a back seat to dam and irrigation development schemes. The price that farmers pay for irrigation water, for instance, does not account for impacts associated with excessive water withdrawn for crops, such as lower water flows to sustain fish populations. As the previous chapters have shown, local communities, especially the poor, depend heavily on inland fishery resources for their livelihoods. Assessing



Y. KURA, WRI 2003.

Rural fishing communities displaced by dam construction often live under precarious conditions, Laos.

development plans at the basin scale and their impacts on inland fisheries, therefore needs to come to the forefront of policy agendas in many nations. Applying the ecosystem approach to managing water would ensure, at least in theory, that all goods and services derived from ecosystems, including inherent ecological functions, are taken into account when assessing development plans for a given river or lake—the integrated river basin management (IRBM) approach.

But despite the commitment by many countries to implement IRBM approaches, such plans are still in their infancy. In most river basins around the world, allocation of water for irrigation and hydropower continues to take precedence over other water uses, as countries prioritize food and electricity production. Many times, these products—food and electricity—are not made available to local or national populations, but exported to neighboring countries as a source of foreign currency. The ecosystem is, for the most part, routinely ignored in water allocation priorities, with negative consequences for inland fishery resources.

In order to implement an IRBM approach, new institutions are required, such as river basin organizations (RBOs), which link adjacent states along the river corridor in a legal framework allowing them to cooperatively manage water resources within a single basin. RBOs can provide a forum for dialogue where the wide array of stakeholders can participate. As a result, development plans and water-use strategies can become more balanced, minimizing environmental and social impacts. For RBOs to be effective, however, they need to be given the authority, funding, and legal mandate to implement long-term

policies. They must also have the wide participation of riparian states.

Effective RBOs are still the exception around the world, but some countries such as South Africa and Australia are making considerable progress in changing the way water is managed and allocated. South Africa is one of the best examples of a concerted national effort to monitor, assess, and conserve the country's inland native fisheries. One of its most prominent and innovative pieces of legislation is the National Water Act of 1998. The fundamental guiding principles of the Act are sustainability and equity in the "protection, use, development, conservation, management and control of water resources." The Act also establishes that the national government, acting through the Minister, is responsible for the achievement of these fundamental principles in accordance with the Constitutional mandate for water reform (National Water Act 1998).

One of the most progressive aspects of South Africa's National Water Act is the establishment of the *Reserve*, which consists of two parts: the basic human needs reserve, and the ecological reserve. The basic human needs reserve provides for "the essential needs of individuals served by the water resource in question and includes water for drinking, for food preparation and for personal hygiene" (National Water Act 1998). The ecological reserve relates to both the quantity and quality of the water required to protect the aquatic ecosystems; that is the minimum amount of water necessary for the environment to function naturally. To establish this reserve, river basin authorities have to calculate the flow required for all the natural cycles to be sustained. This would include, for example, the water flows required for the spawning of sensitive fish species such as largemouth yellowfish (de Villiers, pers. comm. 2004).

The Snowy River in SE Australia provides a striking example of what can be achieved if there is a real commitment to sustaining river flows. The river, a tributary of the Murray, has two large dams to provide both irrigation water and electricity to much of southeastern Australia. The dams have had devastating effects on the fisheries of the Snowy River for over half a century. Stream flow in parts of the river was reduced to only 1 percent of its original flow at critical periods of the year (Rose and Bevitt 2003). In 2000, the state governments of New South Wales and Victoria signed an agreement to restore the Snowy to 15 percent of its original flow in 7 years, 21 percent in 10 years, and to an eventual target of 28 percent (Commonwealth of Australia 2000).

These examples show that, although not easy, implementing IRBM approaches that allocate water to the ecosystems can be done, and can go a long way in ensuring the sustainable management of water resources and their fisheries. However, the success of such approaches depends heavily on cooperative governance and political commitment (de Villiers, pers. comm. 2004).

CAN MARINE RESERVES HELP MARINE FISH STOCKS RECOVER?

Within the last decade or so, marine scientists and conservation groups have begun to suggest that establishing marine reserves—sanctuaries where fishing and other human activities are restricted—is one way to help battle the long-term depletion of fish stocks. These reserves are just one type of the broader "marine protected area" concept—that is, marine areas that have some level of legal protection from exploitation. While some marine protected areas may allow limited fishing and other extractive uses, marine reserves generally do not; they are often known as "no-take zones" or "marine sanctuaries" where fishing is barred.

Research on marine reserves leaves little doubt about the conservation benefits they offer. A recent review of 73 reserves around the world showed that the density, size, diversity, and overall biomass of fish inside these sites was significantly higher than at control sites outside the reserves (Halpern 2003).

Given the proven ability of marine reserves to nurture stocks within their boundaries, there is a growing expectation that they will also enhance commercial stocks in surrounding waters and beyond. The theory is that reduced mortality within a new reserve will first allow depleted fish populations to recover within the reserve. With time, these populations will grow in size and density, allowing adult and juvenile fish to migrate from the reserve into adjacent waters—a "spillover effect" that will help replenish nearby fishing grounds. In addition, as the fish populations within the reserve continue to grow, so does their reproductive capacity. This allows a net export of eggs and larvae from the reserve, some of which may even drift to more distant waters, where they can replenish fish stocks there as well. So, in theory, reserves can have both a local and long-range beneficial effect.

Evidence of Fisheries Benefits

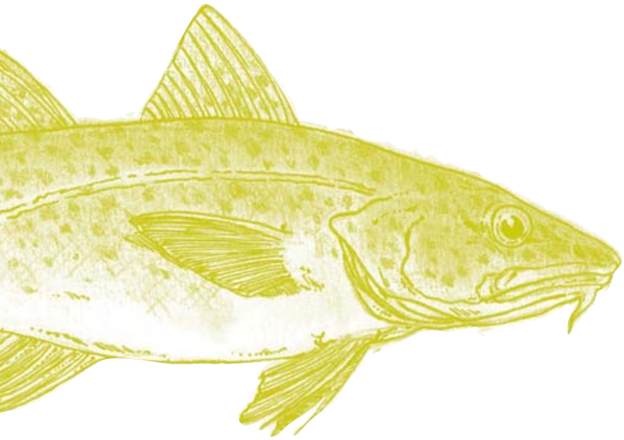
The biological benefits of marine reserves for organisms and ecosystems within the reserves are well documented. But their benefits to commercial fisheries outside the reserves are poorly known so far and are still the subject of debate (Ward et al. 2001). Part of the problem is that few marine reserves have been strictly protected and monitored for long enough to determine the effect of potential benefits in surrounding waters. Even fewer reserves have been set up specifically to enhance a commercial fishery. In addition, monitoring and demonstrating the spillover effect is no easy matter, and documenting benefits to distant waters is even more difficult.

Lack of proof that marine reserves can enhance commercial fisheries feeds into fishers' resistance to the creation of new reserves. Designating a reserve involves relinquishing rights to access fishing grounds currently in use to achieve a benefit sometime in the future. The more uncertain and nebulous the future benefit appears the less likely fishers are to give up their present benefits—however meager—to support the planned reserve. When a marine reserve is proposed, fishers want to know up front, when, and to what extent the surrounding fish stocks will be enhanced.

That kind of predictive ability will probably not be available for some time. Nonetheless, there is some evidence to support the idea that reserves can benefit fish stocks outside their borders. For example, a study of the oldest fully protected marine reserve in the United States, the Merritt Island National Wildlife Refuge in Florida, shows that large trophy fish have spilled over into nearby waters where they are taken by recreational fishers (Roberts et al. 2001). Case studies and research in localized reef systems also show that the recovery that comes from establishment of a reserve can affect areas immediately adjacent to the reserves (Ward et al. 2001; Polunin 2003).

Additional support comes from the recuperation of fishing grounds that have been closed for extended periods. The complete closure of fishing areas in the North Sea during the two World Wars, for instance, led to a substantial increase in groundfish, which translated into higher catch rates and greater production immediately after the wars, when commercial operation resumed (Polunin 2003). A more recent example is the closure in 1994 of a large portion (17,000 km2 or about 25 percent) of the Georges Bank—once the most productive area for harvesting groundfish in the eastern coastal waters of North America. After a 5-year closure, stocks of several species have increased, including scallop, haddock, and flounder (Murawski et al. 2000). These improvements are now beginning to spill over into waters outside the closed areas (P. Howard, New England Fishery Management Council, pers. comm., cited in Gell and Roberts 2003).

These results seem to indicate that in order for any substantial spillover to develop, the reserve must be strictly protected from fishing for several years at a minimum (Ward et al. 2001). Even then, results are not assured. Cod stocks within the Georges Bank closure, for example, have been much slower to recover than other species. Some experts suggest the reason for this is that cod are more mobile than haddock and flounder, and may migrate out of the protected area where they are then harvested, rather than gradually building up their numbers within the reserve (Gell and Roberts 2003). Others suggest that prior overfishing of cod in the Georges Bank has radically shifted the structure of the fish community, with that niche now filled by other species, making it harder for cod stocks to regain their former dominance in the ecosystem (Chamut 2003). In any case, it is clear that the rate and nature of recovery of fish species within reserves may vary considerably.



Within the last decade or so, marine scientists and conservation groups have begun to suggest that establishing marine reserves—sanctuaries where fishing and other human activities are restricted—is one way to help battle the long-term depletion of fish stocks.

Making Marine Reserves Successful

According to current research, the effectiveness of marine reserves in helping fish stocks recover is influenced by a number of conditions, including the design and the location of the reserve, the life history and behavioral pattern of target fish species, how depleted the fish stock is when restoration begins, how much fishing has contributed to the decline of the fish stock, and how long the reserve remains closed to fishing (Ward et al. 2001). The size of the reserve is also clearly a large factor in its success. Modeling studies indicate that as much as 20-50 percent of the range of a target fish population might have to be protected from all exploitation in order to sustain the stock over the long term. This implies that reserves will probably have to cover large areas of former fishing grounds in order to produce significant recovery results (Ward et al. 2001).

Unfortunately, there is still much we do not know about marine reserves or how to maximize their benefit. We do not yet know if it is feasible to establish a network of reserves sufficient to recharge stocks and sustain the modern fishing industry at the same time. With this level of uncertainty, it will undoubtedly be very difficult for many politicians and fishers to support the kind of large and long-lasting closures in heavily fished waters that fish recovery via a marine reserve system would call for. On the other hand, conventional fishery management approaches, such as quota systems and seasonal closures, also do not guarantee fish recovery and require concessions from fishers too. Moreover, the commitment to restore stocks that nations made at the Johannesburg Summit is too ambitious to rely on these traditional approaches alone, adding pressure to further explore the marine reserve option.

An understated strength of marine reserves is that they provide a clear example of one type of ecosystem-based approach to fisheries management, since they protect both fish and the ecosystem where they live. In marine reserves, all species—regardless of their commercial value, sex, or size—are protected. That means reserves can retain older and larger individuals with high reproductive rates that otherwise would be fished out by commercial fishers (Berkeley et al. 2004; Hixon, pers. comm. 2004). Reserves can also maintain the structure of marine communities intact, allowing important interactions among species to function unimpeded. This can provide a good complement to typical fishery management approaches that focus on maintaining a single species and may be especially useful in the tropics, where many species may be commercially exploited in one fishery. In this case, a marine reserve approach is probably easier to implement and enforce than trying to regulate the fishing effort or catch quota of each species separately (Ward et al. 2001; Roberts and Hawkins 2000).

Recognizing the wide ranging benefits of an ecosystem approach to managing fisheries, some countries have started testing the concept of a marine reserve with a commercial fisheries goal in mind. The first no-take zone in the United Kingdom was established in 2003 at Lundy Island Marine Nature Reserve at the joint request of local fishermen and English Nature, a government agency responsible for wildlife conservation (English Nature 2003).

One problem that hinders the effectiveness of marine reserves is non-compliance. The enforcement of closures and no-take regulations is fraught with difficulty. For example, repeated incidents of shrimp poaching have been reported in the Dry Tortugas Marine Reserve in the United States (Florida Keys National Marine Sanctuary 2002a, 2002b, 2003). Effective management of fishing in the waters just outside reserves is also a key to success (Ward et al. 2001). Close stakeholder involvement throughout the process of establishing and managing reserves can increase fishers' understanding of the problems and benefits of these sites, and hence strengthen enforcement and compliance (Roberts and Hawkins 2000; Berkes et al. 2001).

SOME MANAGEMENT CONCLUSIONS

With the exception of marine reserves and IRBM plans, the measures described in this chapter illustrate the basic approaches that countries have used for decades to manage their fisheries. Each has met with moderate success in some situations, but all have weaknesses that limit their overall effectiveness. Even in combination they frequently fail to adequately protect stocks. In addition, their performance varies greatly from one fishery to the next, depending on the configuration of fleets, technologies, and underlying regulations. Past experience shows that there is no perfect combination of these measures that will guarantee sustainability in every fishery—no "one-size-fits-all" approach that nations can rely on.

In addition, as useful as these conventional measures are, many of them still operate under *de facto* open access regimes, where the rights and obligations of individual resource users are not clearly defined or allocated. And therefore the driving force behind overfishing persists: the economic incentive to catch more and higher-valued fish before others do. This incentive, combined with the inherent difficulty of limiting access to the oceans, drives growth in the number of fishers and the sophistication of their gear. The bottom line is that there are too many fishers for the available supply of fish, and they are too efficient at their jobs. Reducing fishing capacity globally by 30 percent, for example, would have a huge systemic effect on today's overfishing problem.

Alternative employment opportunities and food security for fishers—especially in developing countries—are desperately needed in order to reduce the overall fishing pressure.

Other problems plague the effective management of fish stocks as well. Even where the allocation of rights are well defined, enforcing compliance with any of these conventional measures is a major challenge. In most cases, national budgets for enforcement are small compared to the scale of the task, with thousands of fishing vessels dispersed over large areas. In addition, stock assessments and models are often inadequate to allow management measures to be accurately calibrated to individual fish stocks (see *Annexes A* and *B*). Nor are most management measures well-suited for the multispecies fisheries common in many tropical waters.

Another difficulty is that, historically, fishery management actions have been primarily aimed at industrial fleets in coastal or open oceans, where commercial interests were focused. Comparatively little attention has been paid to the special needs of small-scale fishers, especially in developing countries, or the special challenges of managing freshwater fishing. By and large, policy-makers and regulators have ignored these sectors, resulting in management that is inadequate and underfunded. (See *Chapter 5* for discussion on co-management of small-scale fisheries.)

Although more work is required to refine the ecosystem-based method of managing fisheries, new institutional frameworks that take an integrated approach to resource management, such as IRBM, can provide a platform for balancing competing interests and supporting the fair allocation of rights. And while the establishment of marine reserves is not a panacea for recovering fish stocks—at least in a systemic manner—they offer the potential to augment traditional fisheries management approaches at the local level and help meet the urgent need to restore stocks. Marine reserves and Integrated River Basin Management plans are examples of an ecosystem approach to resource management—conveying potential benefits to both small-scale and industrial fishers, and offering recognized conservation benefits.

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HOW DO WE PRODUCE FISH SUSTAINABLY?

FINDINGS AND RECOMMENDATIONS

World fish stocks—and world fishing—face an uncertain future. Globally, fishing has never been a more important source of human nutrition nor a greater source of livelihoods and national income. But neither have fish stocks been more threatened nor the global fishing enterprise been in greater flux. Stock assessments, ecological studies, and commercial harvest data tell us that the fisheries crisis is real and global in scope. Harvests from capture fishing have peaked and only growth in aquaculture keeps overall fish production from declining. Larger fleets and more robust technology—as per today's trends—have the opportunity to either hasten the current fisheries decline or increase the efficiency of the fish harvest and lead the way toward sustainable fisheries management.

Achieving sustainable fishing practices and healthy fish stocks will not be easy. It will require action at many levels: changes in national economic development plans and structural government reforms; changes in how fishing rights are allocated to both small-scale fishers and industrial fleets; changes in international cooperation and international trade negotiations; and better compliance with international norms. It will also require a more concerted effort by nations to address the management and monitoring of small-scale and inland fisheries sectors, which are largely unregulated and ignored today.

The fishing sector is far too important to allow its continued downward spiral through inaction, particularly when some initial steps toward sustainability are possible today. These include employing fishing practices that reduce bycatch and waste, adopting policies that emphasize ecosystems, eliminating damaging subsidies, reducing fleet size, and expanding markets for sustainably harvested fish. These and similar actions are crucial steps on the road to sustainability. In turn, sustainability equates to recovered fish stocks and a fishing industry that can both survive economically and continue to make important social and nutritional contributions to national development.

Below we list some principal findings from Chapters 1-11, and recommend priority actions that governments, fishers, and consumers can take in response.

Findings and Recommendations

1. Ecosystems are Key

WHAT WE KNOW: *Current inappropriate fishing practices don't just deplete stocks, they often significantly alter the ecosystems that sustain them. Conventional management approaches have focused on managing individual stocks rather than maintaining the health of marine and freshwater ecosystems—the basis for current and future production.*

The harm that fishing can cause to targeted fish species is substantial, but the damage does not end there. Bycatch and discards spread fishing's impacts widely among other species and ecosystems. Physical damage from trawling disturbs sea-bottom communities and crucial fish habitat, and the introduction of non-native commercial fish species into freshwater lakes and rivers displaces and threatens native species. Together, this sums to major ecosystem change and impact—impact so severe that it has put in jeopardy the very resource base the fishing community depends on. Only recently have governments officially recognized the breadth of the problem, and realized the necessity to look beyond individual fish stocks as they manage the fishing enterprise.

WHAT WE NEED TO DO: *Reorient fisheries management to account for ecosystem interactions and damages, and make sustaining the vitality of marine and freshwater ecosystems a primary goal.*

The idea of an ecosystem approach to fisheries management has been gaining ground slowly, promoted by FAO and accepted by many at a theoretical level. At its heart, it calls for limiting fishing's impact on ecosystems as much as possible and sustaining the ecological relationships between the species being fished and other ecosystem inhabitants. Unfortunately, progress in incorporating an ecosystem perspective into management measures is challenging. The principles of the ecosystem approach to fisheries management need to be further elaborated into concrete goals and measures that can be applied to daily fishing operations and management decisions. While some steps and priority actions listed below are currently being implemented to some degree, progress is still needed.

Priority Actions:

- ***Shift the focus*** of management approaches and fisheries research from managing single species or single stocks to managing many interacting species and the habitats they require.

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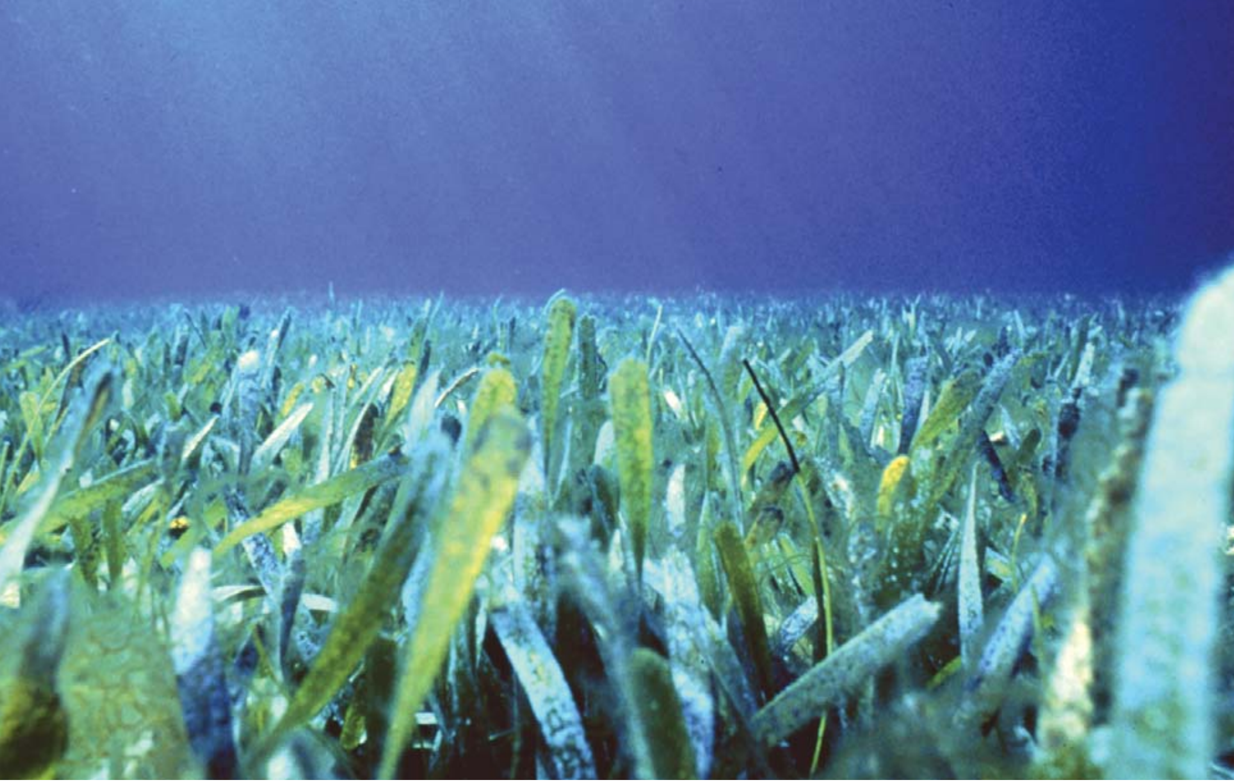
Kelp forests are important habitats for fish and other animals.

- ***Gather data*** specifically on ecosystem impacts of fishing, such as bycatch, disruption of aquatic community interactions, and habitat destruction, as well as the impact of other human activities on the fishing environment, such as water withdrawals, dam construction, pollution, and coastal development.
- ***Create incentives*** to minimize discards and other ecosystem impacts through discard bans, certification schemes, and other practices that create greater access to markets for sustainably harvested fish.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Healthy seagrass beds form important nursery and breeding habitats for fish.

12

- ***Strengthen compliance*** with agreed-upon national and international fishing norms and regulations (e.g., strengthened observer programs by placing independent observers on fishing vessels to increase compliance).
- ***Take a regional and international approach*** to managing straddling stocks and migratory species. Fish that cross from one country's waters to another or transit the high seas require the combined management efforts of many countries.
- ***Pursue research*** on management approaches that will enhance an ecosystem approach, such as the use of marine reserves to help restore and maintain depleted stocks.
- ***Build capacity*** and provide support so that these priority actions can be adopted and implemented in developing countries.

2. The FAO Code of Conduct Must Be Applied

WHAT WE KNOW: *The FAO Code of Conduct for Responsible Fisheries has become well accepted at the broad conceptual level, but implementation is still in its infancy in most nations.*

The FAO Code of Conduct provides the key principles for sustainable fishing. It has become the international standard in this area, formally accepted by more than 150 countries since its introduction in 1995. But the Code is an entirely voluntary measure. FAO, as its steward and author, acts as a consultant and promoter of the Code's practices and approaches, but has no authority for enforcement at the national level. Its success depends entirely on national governments and their willingness to implement and enforce national legislation adapted to reflect the Code's guiding principles. Many nations have begun to take heed of these guidelines and principles, putting in place hundreds of management plans tailored to various fisheries. Nonetheless, the Code's potential has been far from realized to date, in part because nations have adopted its guidelines in a piecemeal fashion. In many cases, countries have not fully amended their fishery laws and management practices to conform with the Code, or, if they have, these laws are not yet totally implemented. The net result has been modest change, rather than the more far-reaching reorientation of fishery approaches needed to make fishing sustainable.

WHAT WE NEED TO DO: *Adapt national fishery laws to embody the concepts and provisions of the Code of Conduct and elaborate these laws into concrete fishing regulations and research agendas. Monitor and report on the progress of nations to implement the Code in order to bring public pressure to affect change.*

Priority Actions:

- ***Create incentives and support mechanisms*** for countries to truly implement and enforce the recommendations and principles set forth in the Code of Conduct and associated International Plans of Action (IPOAs), particularly in the developing world, where resources are limited.

Small-scale and inland fishing are far more significant than most people realize, but the importance of these sectors to rural livelihoods has been greatly underestimated and neglected by policy-makers for decades. Instead, management attention and funding has been largely devoted to address issues concerning large commercial fleets.

- ***Provide support*** to developing countries so that the principles of sustainable fisheries management are integrated into their economic development and poverty reduction strategies.
- ***Encourage objective*** oversight and evaluation mechanisms—whether by NGOs and other civil society organizations, or international bodies—to increase transparency in fisheries reporting and promote government accountability regarding how nations have:
  - Adapted the Code of Conduct and IPOAs into national law;
  - Reflected these laws in national regulations;
  - Implemented and enforced these regulations.

3. Small-Scale Fishing is Overlooked

WHAT WE KNOW: *Small-scale fishing is far more significant than most people realize, but this sector has been neglected for years by policy-makers who have devoted management attention and funding to larger commercial fleets.*

Small-scale and artisanal fishing is, in terms of the number of people involved, the dominant fishing sector at the global level. It is particularly important as a source of livelihood for the poor, and in developing nations may contribute more to the national economy than industrial fishing. This sector is also the most diverse, and the least monitored and regulated. The lack of attention that small-scale fishers have received puts them at a disadvantage relative to industrial fleets, and leaves the inshore waters and freshwater bodies they frequent inadequately managed. It also leaves small-scale fisheries subject to conflicts between large- and small-scale fishers, and even between the fishing sector and other sectors such as agriculture.

WHAT WE NEED TO DO: *Focus greater management attention on small-scale fishing, and target specific policies and assistance programs at the sector.*

Greater attention at the national level can help small-scale fishers retain control of, and better manage their local resources, thereby safeguarding a crucial source of rural livelihoods. Policies should be aimed at developing management programs that involve fishing communities in the decision-making process. This will include policies to reduce conflicts with industrial fishers and with other economic sectors (e.g., tourism, agriculture); programs that improve monitoring and assessment of the sector so that it can be better integrated with the national economy; plans oriented to develop gears and technologies that are appropriate to local conditions and customs; and regulations that open local and regional markets to small-scale fishers.

Priority Actions:

- ***Promote co-management*** programs that devolve control over certain fishing grounds to local fishing communities. Such management can take advantage of indigenous and traditional knowledge and give local people a stake in maintaining the resource. The authority that is devolved should be well-defined and legally recognized, and should include the responsibility to harvest sustainably. Local control must also be integrated into the wider coastal management regime and coordinated with industrial fishing and other development activities.
- ***Support local control*** with technical and management help at the state level. State support should look beyond the fishing sector. Integrated programs that support fishing along with other rural employment options and social services may be more effective.
- ***Take advantage of traditional knowledge*** and customary management techniques that have been successfully adapted to particular stocks or local conditions.
- ***Support alternative economic development paths*** for fishing communities and prevent and reduce overcapacity in the sector.

4. Inland Fisheries are Underestimated

WHAT WE KNOW: *The importance of inland fishing to rural livelihoods in many developing countries has been greatly underestimated for decades. Habitat degradation is threatening the capacity of freshwater systems to support wild fish stocks in almost all regions of the world. Increasing conflict over water resources is exacerbating the already stressed freshwater ecosystems, putting inland fisheries and the livelihoods of the millions of people dependent on them at risk.*

Inland fishing, which is primarily small-scale, is a significant component of global fish production. It is particularly important to the national economy and food security of many developing countries, especially in Asia and Africa. Because this sector is largely underappreciated, it is all but forgotten when decisions over water resources are made. As a result, dam construction, irrigation diversions, and other water uses tend to take precedence over inland fishery resources and have impacted the capture fisheries to such an extent that many are only maintained through fish stocking and other enhancements.

WHAT WE NEED TO DO: *Encourage a more integrated river basin approach to water management that takes inland fishing and the maintenance of ecosystem functions into account.*

Integrated River Basin Management (IRBM) refers to an ecosystem approach to managing rivers, lakes, and wetlands. The concept has been largely recognized as the most appropriate way to manage inland water bodies in a sustainable manner. In practice, however, inland fishery resources are often overlooked when assessing river basin development plans. An integrated or ecosystem approach to water resources management requires allocating water in a more balanced way between the ecosystem and other uses such as hydroelectric power production or irrigation. To achieve this, greater monitoring and data collection on inland fishery resources will be needed, both to highlight the importance of the sector and its link to human well-being, and to set realistic water allocations at the basin scale.

Priority Actions:

- ***Establish functional institutional structures***—such as river basin management authorities—that manage water basins in their entirety, and with the participation of all interested stakeholders.
- ***Emphasize the importance of maintaining healthy river ecosystems*** and their fisheries and strengthen the mandate of river basin authorities to incorporate social, economic, and ecosystem considerations into river basin planning.
- ***Integrate inland fisheries*** in river basin development plans by ensuring that water is allocated in a more balanced way between the ecosystem (e.g., water to sustain fish communities and ecological functions) and other sectors (e.g., agriculture, hydropower generation, tourism).
- ***Increase reporting and assessment*** of inland fisheries and the level of dependence of local communities on these resources. Reporting of catch statistics should be at the species level, and ideally catch data should be collected and reported at the basin level, in order to incorporate this information into basin-wide management plans.
- ***Improve capacity to assess the condition of aquatic ecosystems***. Because the major threat to inland fisheries is environmental degradation, information on land-use change, water quality, water withdrawals, and species introductions is critical for assessing the current and future condition of a particular fishery.
- ***Compile information*** on recreational fisheries and fishery enhancements, especially stocking and introduction programs that can be incorporated in a systematic way into fisheries statistics. The consequences of enhancement practices should also be assessed more closely to ensure that the integrity of the ecosystem and its capacity to provide other goods and services is maintained.

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It is essential to provide alternative economic development paths to fishing communities and integrate the communities needs into poverty reduction strategies.

5. Aquaculture Cannot Save Wild Fish Stocks But Can Feed More People

WHAT WE KNOW: *Aquaculture is the fastest growing food production sector in the world, producing nearly 40 percent of the world's total food fish supply. It has become so by expanding, diversifying, and intensifying its operations. But the heavy dependence of intensive systems on human inputs—water, energy, chemicals—and on wild fish for feed and seed, as well as the effects on ecosystems and species are major constraints to the sustainability and future growth of this industry.*

Although much of the world's aquaculture production comes from small- and medium-scale operations, the tendency is toward intensification and higher reliance on fishmeal made from wild fish. In addition, wild juvenile fish are still extensively used in aquaculture as seed fish. These juveniles are largely unaccounted for in capture statistics, and are therefore not taken into consideration in management decisions, such as setting catch limits or making stock assessments. Furthermore, the last few years have seen an unprecedented trend in the transfer of wild-caught juvenile fish, especially high-valued tunas, to open-ocean pens for fattening without these individuals being reported as part of the catch. This practice can seriously hinder stock assessment and misinform the setting of harvest quotas, with grave consequences for some already-depleted wild stocks.

What We Need to Do: *Support and encourage more sustainable aquaculture practices, and streamline the monitoring and reporting of new sea-farming methods in order to avoid negative impacts on wild stocks.*

In recent years, some aquaculture practices, particularly in developed countries, have made considerable progress in increasing production and improving their efficiency. For instance, many salmon aquaculture operations have made substantial reductions in water use and waste generation, and have improved protein conversion rates from fishmeal. However, most operations still have a long way to go to reach the environmental standards being set by numerous national authorities and international aquaculture associations. Regulatory structures need to progress in parallel with rapidly developing technological advances before widespread adoption takes place.

Priority Actions:

- ***Support research*** that focuses on alternative protein sources to manufacture fish feed and reduces the heavy dependence on other human inputs—water, energy, and chemicals.
- ***Invest in research*** to improve small-scale or rural aquaculture while discouraging unnecessary intensification of practices, such as wasteful use of fishmeal.
- ***Promote practices and recent technological advancements*** that lessen the environmental impacts of aquaculture operations and increase their efficiency. Special focus should be placed on facilitating technology transfer and supporting capacity building in developing countries.
- ***Provide market incentives*** for consumers including commercial fish purchasers, such as certification for sustainably farmed products and proper labeling of aquaculture products.
- ***Enforce reporting*** of wild-caught juveniles for sea-farming operations so that management decisions take these individuals into account when assessing stocks and setting harvest quotas. Variables to be reported include: the number of fish transferred, the dates and names of the vessels involved, the location where the fish were caught, the name of the sea-farming facility operators, and the country of ownership of the operation.
- ***National governments should adopt and enforce legislation*** that requires appropriate documentation for the import and export of "fattened" tuna products.

6. Fisheries Data are Poor, Management Uncertainty is High

What We Know: *Lack of sufficient data on the real status of fish stocks, their response to fishing pressure, or the impact of fishing pressure on ecosystems and other species, is a significant obstacle limiting the effective management of fisheries. As a result, scientific uncertainty about what are the correct levels for fishing quotas, and how to design appropriate management plans is high.*

Fisheries data and our understanding of fisheries science is slowly improving, but is still far from adequate to manage stocks with any precision, or to account for the complex workings of aquatic ecosystems and their relation to fish production. Even our knowledge of the status of the most commercially important stocks is fragmented, and often disputed among fisheries biologists and fishers. Our understanding of tropical and inland water fisheries, where many different species may be harvested at once using a single gear type, is especially poor. Yet, in spite of this dearth of information, fisheries managers continue to manage stocks for the highest possible yield, leaving little margin for error if their estimates are incorrect—a strategy that has aggravated the effects of overfishing.

What We Need to Do: *Base fisheries management on sound science and data. Follow the precautionary approach when fisheries data and forecasts are highly uncertain. Greatly improve collection, analytic capacity, and sharing of information, particularly in developing countries. Refine and improve fisheries models and knowledge of fisheries biology to increase the reliability of stock assessments. Improve the communication of scientific information so that it can directly inform policy decisions.*

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Creating incentives for fishers to accurately report their catch and discards is essential for managing fisheries sustainably.

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The need for better data is an often-cited complaint, and one that requires persistent and collaborative efforts to address. Nonetheless, poor science and lack of data should never become an excuse for inaction or a reason to disregard caution. More investment in primary data collection and research are clearly needed, especially in the developing world. FAO member countries have recognized this need, and in 2003 adopted the FAO *Strategy for Improving Information on Status and Trends of Capture Fisheries*, which is a framework, strategy, and plan of action to improve the knowledge base and increase and understanding of fishery status and trends (FAO 2003e). The strategy emphasizes small-scale and multi-species fisheries—including inland fisheries—and the need for capacity building in developing countries.

Improved communication of fisheries data and analyses is essential, especially as it increases the understanding of fisheries issues by those outside the circle of professional fisheries managers—the politicians, businesses, and public who may exert substantial influence on fishery policy. In addition, fisheries managers must begin to take the precautionary approach as their guiding principle in situations where data are poor, opting for conservative quotas and tighter harvest controls unless more liberal measures can be soundly justified.

Priority Actions:

- ***Implement the FAO Strategy*** for Improving Information on Status and Trends of Capture Fisheries.
- ***Increase data collection and research*** in key areas, including: small-scale and inland fisheries; impacts of fishing on ecosystem structure and on aquatic habitats and species, especially deep-sea environments and sea-bottom habitats; managing mixed-species fisheries; and understanding the effects of non-fisheries policies—such as trade and subsidies—on global fisheries.
- ***Create incentives for fishers*** to accurately report their catch and discards. At the government level, encourage more systematic and timely data collection and regular monitoring of catch, as well as obtaining additional information on the environmental impacts of fishing practices.
- ***Increase capacity in developing countries*** to improve data collection, reporting, and analysis of important stocks, focusing on those fisheries with the greatest information deficiencies.
- ***Compile and assimilate*** existing data in digital format, in order to increase its accessibility and dissemination.
- ***Encourage analysis*** and presentation of fisheries information in a more policy-relevant and user-friendly format, so that it can inform non-fishery policies such as trade, development assistance, and environmental conservation.
- ***Insist on using the precautionary approach***, especially in data-deficient situations and for mixed-species fisheries. This means:
  - Making more effective use of the best available science while taking uncertainties into account, in order to optimize output rather than maximize it.
  - Applying conservative principles based on long-term sustainability, and ensuring that conservation and other management measures do not counteract each other.

7. International Cooperation Must Grow

WHAT WE KNOW: *Managing fisheries sustainably requires a sustained effort on the part of all fishing nations to coordinate management strategies and enforcement. Limited international cooperation to date has greatly undermined the success of many management efforts.*

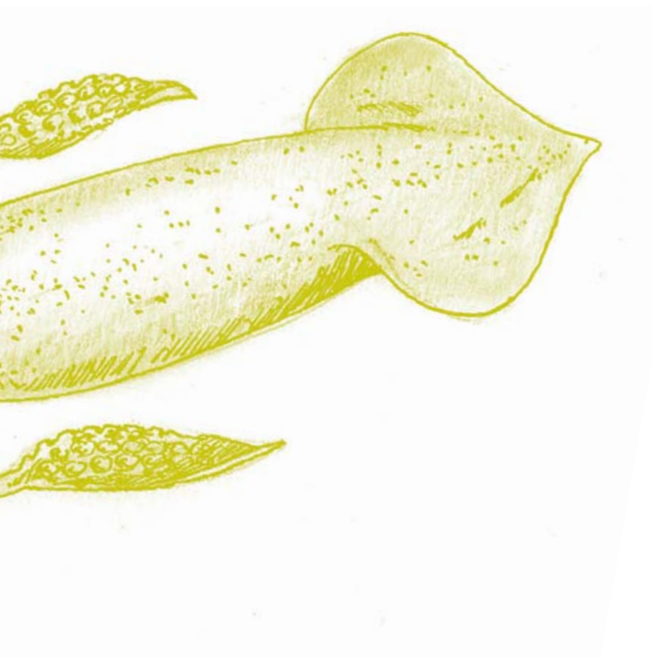
The oceans are a global common. Although coastal nations have nominal control over their Exclusive Economic Zones, in reality they cannot adequately manage many of the stocks within their waters without the help of other fishing nations. In international waters, the problem of joint management of fish stocks is even more pressing, as no one nation can assert legal authority. Realizing their interdependence, fishing nations have crafted treaties to formalize common responsibilities and establish ground rules for managing fleets. They have also created institutions—Regional Fisheries Bodies—to jointly manage high seas and straddling stocks. These regional organizations and the actions taken under international treaties have become the first line of defense against illegal fishing and non-compliance with fishing regulations. But, like other measures in global fisheries management, they are undermined by half measures on the part of many nations, or outright disregard for these international commitments by some countries.

WHAT WE NEED TO DO: *Increase compliance of fishing nations with international fishing treaties and strengthen the mandates of Regional Fisheries Bodies. Discourage countries from keeping open vessel registers, which facilitate irresponsible fishing and the use of "flags of convenience."*

The international fishing treaties now in place, especially the Law of the Sea, the UN Fish Stocks Agreement, and the Compliance Agreement, provide an adequate framework for international cooperation. The task now is to increase willing compliance with these, and active oversight of whether nations are fulfilling their commitments. In the case of Regional Fisheries Bodies, more groundwork needs to be done to strengthen the charters of these organizations, resolve conflicts among members, and increase performance oversight.

Responsible fishing nations should no longer keep open registers for fishing vessels, which too often are used to facilitate illegal and irresponsible fishing. Illegal fishing—often under the cover of a flag of convenience—is so widespread that many countries consider it their highest management priority.

Achieving sustainable fishing practices and healthy fish stocks will require action at many levels, from changes in national economic development plans, to changes in how fishing rights are allocated, and better compliance with international norms. It will also require a more concerted effort by nations to adopt and implement policies that reduce bycatch, emphasize ecosystem functioning, and expand markets for sustainably harvested fish.



Priority Actions:

- ***Strengthen the mandates and terms of reference*** of Regional Fisheries Bodies (RFBs), so that they specifically incorporate concepts put forward in contemporary fishing agreements, such as the ecosystems approach under the FAO Code of Conduct for Responsible Fisheries.
- ***Strengthen the capacity*** (staffing and funding) of recently established RFBs so they become more apt to press for compliance among member nations.
- ***Discourage nations from keeping open vessel registers*** and allowing "flags of convenience." At a minimum, discourage nations that have signed the Compliance Agreement or the FAO Code of Conduct from keeping such registers.
- ***Increase the use of "blacklisting"*** (disallowing known illegal vessels from landing their catch), and "white-listing" (allowing only registered and compliant vessels to land their catch) to combat illegal, unreported, and unregulated fishing.
- ***Reconcile environment and trade*** by granting observer status at the WTO to the UN Environment Programme and to the secretariats of international environmental treaties (e.g., Convention on Biological Diversity [CBD]).
- ***Incorporate the precautionary approach*** into WTO and other trade rules (particularly regional agreements) by harmonizing these rules with the implementation of international environmental treaties, such as the CBD.
- ***Reduce environmentally harmful subsidies*** through negotiations within the WTO and other trade bodies, especially as they relate to fisheries.

8. Consumer Awareness Can Boost Sustainable Fishing

WHAT WE KNOW: *Consumer demand is a key driver of overfishing, but it can be an equally powerful force for adopting sustainable practices. Public awareness of the fisheries crisis is growing, but the connection between what consumers purchase and consume, and how fish are caught, raised, and processed is not well known. Changes in consumer behavior can influence and drive demand for sustainably harvested fish and fishery products.*

Consumers seek low prices, quality, and convenience, but they also value environmental responsibility. Unfortunately, unless they are explicitly told—through labeling or public awareness campaigns—they are usually ignorant of the environmental impacts of their consumption patterns. However, once made aware of their choices, they can provide an economic incentive for fishers to adopt sustainable practices by purchasing products certified as sustainably harvested.

WHAT WE NEED TO DO: *Make fish consumers aware of the dimensions of the fisheries crisis and their part in it. Encourage them to take an active role in supporting sustainable fisheries. Educate consumers on which seafood products are sustainably harvested, and which should be avoided because of their high environmental impacts.*

NGOs, scientific organizations, and even government agencies have an important role to play in educating the public on the plight of world fisheries and informing them on how they can become responsible consumers. Civil society groups needs to build capacity and understanding so that they can hold governments accountable to their international fishery commitments and elevate the status of fisheries management on the political agenda. Informed civil society groups can also generate stronger political support for better management and can play a more active role in influencing the performance of both government and the fishing industry.

Priority Actions:

- ***Support ecolabeling programs*** that identify—and certify, based on sound science —which seafood products have been sustainably harvested, and that reflect the origin of the product and the species.
- ***Support efforts to define*** in a detailed manner what sustainable fishing practices mean for each fishery.

- ***Encourage governments*** to communicate objective information to the public about the state of fish stocks.
- ***Encourage NGOs and other groups*** to mount consumer awareness campaigns on the state of fish stocks, and provide guidance on which products are more ecologically sustainable.
- ***Encourage capacity building*** and support NGOs and other civil society groups so that they can independently monitor and evaluate progress by their governments in managing fisheries sustainably.

Y. KURA, WRI 2003

Sustainable fishing is key to food security of future generations in developing countries.

IN SUMMARY, Accommodating competing demands for fish and aquatic ecosystems while sustaining the fishing environment is quickly becoming one of our greatest environmental challenges. As reported here, the world's fisheries suffer from severe overcapacity, with too many boats chasing fewer and fewer fish. At the same time, global demand for fish and fishery products is growing and will continue to do so for the foreseeable future. As the resource declines, competition over fish intensifies, as do conflicting demands on fishing environments, particularly in inland waters and coastal zones. Today, competing interests such as hydropower development, tourism, and water for agriculture are, for the most part, taking precedence over fisheries. Conventional management institutions and approaches, designed originally to deal with single-sector activities, are no longer suited for resolving conflicts among the various players, and rarely allow for wider stakeholder participation.

New institutional arrangements that can adopt an integrated or ecosystem approach to resource management are urgently needed. This report has presented different institutional structures and legal frameworks that can help us achieve this goal—from international commitments through established fishing agreements such as the Code of Conduct, to national strategies that incorporate fisheries into development and poverty reduction strategies. The need for industry, fishers, aquaculturists, and consumers to participate in shaping the way we manage fisheries in the future has also been highlighted. *Fishing for Answers* has especially stressed the need to pay attention to small-scale and inland fisheries, both in terms of monitoring and management. Finally, a sustained political commitment to re-orient fisheries subsidies will also be needed to shift our current way of managing to a more holistic and ecosystem-based approach.

ANNEX A

WHAT IS A STOCK ASSESSMENT?

The term, *stock assessment*, is used to describe the processes of collecting and analyzing biological and statistical information to determine the effects of fishing on fish populations and to predict their future condition (NMFS 2001c; FAO Fisheries Glossary 2003). Stock assessments aim to provide fisheries managers with the best possible scientific information so they can calculate the volume of fish that can be harvested without depleting the stock for the following year's catch.

Conducting a stock assessment, however, is much harder than it may seem. Fisheries biologists and managers must predict not only how many fish there are in a particular stock, but their size; the juvenile recruitment rate (i.e., the numbers of juvenile fish that come into the population and develop to adults); how the particular target fish interact with other species; and how many can be fished at a safe level, while taking into account the impact of external environmental factors, such as currents, climate pattern changes, and so on. The task becomes even more complex when we look at the quality and sources of the data available to these managers.

Data availability drives the current use of stock assessment methods—ranging from expert judgment-based estimates to sophisticated statistical and mathematical models. Simpler models that do not take into account the size or age structure of the fish stock are less data-dependent and therefore more widely used. Unfortunately, these estimates tend to depend on the catch per unit of effort reported by fishers, which can sometimes lead to inaccurate assumptions about fish abundance, recruitment, etc., especially given the high level of misreporting and unreported catch (e.g., bycatch that is returned to the ocean and not landed is not reported).

More sophisticated models that incorporate age/size structure and recruitment rates require more data, such as information on the life history of the species, and the size and age composition of the stock. These data are often only available from research surveys and are therefore limited to a few fisheries. Age-structured models, however, are being applied to the management of many commercially important fisheries. For example, 40 percent of the U.S. commercial fish species managed by the National Marine Fisheries Service, including yellowfin tuna and Alaskan Pollock, use this sort of model (NRC 1998).

Most assessment methods, such as the ones described above, focus on a single species or stock at a time (i.e., single-species assessments). In reality, fish populations do not live in isolation, but interact with other species and share the same environment. These interactions affect the abundance of a particular stock depending on their role within the fish community or ecosystem. For instance, when competitors and predators are abundant, the natural mortality of the fish may be higher than usual. A single-species approach therefore may underestimate the natural mortality rate and may overestimate the stock biomass available for harvest. Single-species assessments also ignore the fact that we rarely catch one species at a time—even when the most selective fishing gears are used. This is particularly problematic in managing tropical fisheries, where most of the catch is multi-specific. Models that incorporate the prey-predator relationships of several species require massive data collection efforts, making them prohibitive for most tropical fisheries (Jennings et al. 2001).

Finally, relatively simple ecosystem models are also being considered to assess multi-species stocks. Rather than simulating precise species-to-species relationships, ecosystem models incorporate interactions among broader components within the food web. The data requirements for these models are relatively simple, and are generally available from stock assessments, ecological studies, or the literature. Although these models are promising and useful in ecological studies, their application to actual fisheries management is limited. Multispecies stock assessment in tropical waters is in its infancy, but the limitations of single-species approaches are well understood. The use and refinement of the multispecies approach, along with the relatively simple ecosystem models are expected to grow in the near term, making stock assessments more widely used in tropical fisheries.

ANNEX B

LIMITATION OF GLOBAL FISHERIES PRODUCTION, CAPTURE, AND TRADE STATISTICS

This report relies heavily on the Food and Agriculture Organization's (FAO) fisheries database and its published technical papers and reviews. Since 1950, FAO's mandate, as agreed by member parties, has been to monitor the exploitation and condition of the world's fishery resources, including capture fisheries, aquaculture, trade in fish and fishery products, fish consumption, fishing fleets, and level of employment in the fishing sector. Current information on fisheries and the people who depend on them is far from complete, however, and the general availability of fisheries data has not really improved in the last two decades (FAO 2002b). This annex provides an overview of the quality and limitations of the existing fisheries data.

How Does FAO Compile Its Fisheries Statistics?

Fish production data includes information on capture fisheries and aquaculture, production of processed fishery commodities, the size and type of the fishing fleet, and the number of people employed in the sector. These figures are provided annually—although some countries always report with a 1–2 year delay—to the FAO Fisheries Department by national fishery offices, regional fishery commissions, and national statistical offices.

The level of detail and accuracy of the information varies from country to country. Once the data has been received by FAO, it must be incorporated into a single database. This is already a major challenge because each country uses its own definitions and data collection protocols which must all be standardized according to international classification schemes in order to ensure that the collected statistics are comparable across countries. If no data are submitted, FAO uses previous year's figures or makes estimates based on other relevant information from regional fishery organizations, project documents, industry magazines, or from statistical interpolations. On occasion, FAO will question a country's reported estimates if it seems to differ from FAO's estimates and knowledge of the fish resources.

Annual production data are then organized by approximately 1,300 "species items"—species groups separated at the family, genus, or species level—by country of capture, and location of the capture. The location of the capture refers to FAO's designated 27 major fishing areas (19 marine and 8 inland) that divide the world oceans and inland water bodies into geographic units. The production data are also divided into marine capture, inland water capture, and aquaculture.

While there are many limitations to the FAO's fisheries data, as expressed below, its database on fishery resources is still the most comprehensive at the global level. The FAO Fisheries Department staff should also be credited for the level of effort that they have consistently invested into improving the database itself, its usability and its access for the general public. Some areas that still need strengthening, and that FAO is addressing, are small-scale fisheries, inland fishery resources, fleet size and type, and employment statistics in the fishing sector.

What Are the Main Limitations of FAO's Capture Fisheries Statistics?

Catch and Landings are not Identified at the Species Level

A major limitation of the production statistics, especially in tropical multi-species fisheries and in inland fisheries is the lack of proper identification of the catch at the species level. Except in the North Atlantic and the Northeast and Southeast Pacific, only 50 to 70 percent of the catch in the rest of the world is reported by species (Caddy and Garibaldi 2000). For the Indian Ocean and the West Central Pacific, only 20-35 percent of landings and harvests are reported by species—the rest being included in higher taxonomic categories or as unidentified mixed fish (Caddy and Garibaldi 2000). FAO has also noted that as large stocks are depleted and fisheries diversify into a number of smaller stocks, the percentage of "unidentified fish" is increasing (FAO 2002b).

This lack of species-level reporting is even more critical in inland fisheries where nearly 45 percent of all the catch is reported as "freshwater fish not elsewhere included (nei)" (FAO 1999a). This makes assessments of inland fisheries particularly difficult. The large diversity of freshwater fauna that support fishery is not represented in FAO statistics; although there are 11,500 identified species of freshwater fish, the FAO lists only 100 of these species or species groups in its catch statistics categories (FAO 1999a). In Asia, the region with the largest inland fisheries production, up to 80 percent of the landings can be reported as "freshwater fish nei" (FAO 1995c).

Lack of Monitoring Capacity

The quality of the fisheries data varies because many countries lack the resources to adequately monitor landings within their borders. To record the catch landed by every single fisher or fishing boat that participates in a fishery is almost impossible. Therefore, only a proportion of the total landings are recorded and used to extrapolate to the rest of the fishery.

Again, inland fisheries are even harder to monitor because they are usually dispersed over large areas, which makes data collection difficult and very expensive. National reporting offices, particularly in developing countries, are poorly funded and justifying expensive data collection is increasingly difficult, adding to the underreporting problem (FAO 1999a).

In addition, fishers sometimes underreport their catch for a variety of reasons: for example, they have not kept within harvest limits established to manage the fishery, or the catch comes from IUU vessels. In other cases, production estimates are inflated by district or regional level administrations to increase the apparent importance of their fishing industry to the national economy. China is a perfect example where overestimation of catch has occurred: during the 1990s China consistently overestimated production statistics until 1998, when a policy of zero growth for capture fisheries was declared by the Chinese authorities (Watson and Pauly 2001).

Port sampling, log books, on-board data input systems, and observer records are also used to monitor catch data, fishing location, and fishing effort. On-board data collection system and satellite tracking can be used for larger vessels (Jennings et al. 2001), however, the cost of such data collection systems can be prohibitive for fisheries that involve a large number of small vessels or for many developing countries where the resources are limited.

Another area for which there is practically no monitoring or recording is for the level of bycatch and discards at sea. Monitoring bycatch and discards would require a much larger presence of observers on fishing vessels, something that many countries cannot afford. Some policies to reduce discards, such as Norway's discard ban, are making it easier to estimate bycatch, but this is still a drop in the bucket at the global level.

The Small-scale Sector is Overlooked

Subsistence and small-scale fisheries constitute a crucial information gap in the FAO fisheries production database as well as in national statistics because they are often overlooked in data collection efforts. Inland water fisheries statistics are notoriously poor because much of the inland fish catch comes from subsistence and recreational fisheries.

For instance, none of the countries in the Mekong River basin (Cambodia, China, Laos, Thailand, and Vietnam) derive their inland capture statistics from actual measurements or direct observation, but from estimates based on indirect methods (Coates 2002). And because much of the subsistence catch is consumed locally, products do not always enter the market and therefore landings are not recorded at ports or by vendors (FAO 1995c). This situation is so prevalent in many developing countries that recent evaluations carried out by the FAO show that actual catches are probably twice as large—and in some countries, three times as large—as the reported landings (FAO 1999a). Finally, data collection on recreational fisheries and fishery enhancements, especially stocking and introduction programs, are also missing from many data collection protocols.

Trade Data: Even More Limitations

Trade data on fish and fishery products may be the most problematic of all the fisheries data. FAO's import and export trade statistics are obtained primarily from reports provided to them by member countries. Data for non-reporting countries are estimated using published national reports, information from industry associations, and other relevant material, including the economic returns of major trading partners. As in the production statistics, the quality of these data varies depending on each country's ability to collect and compile such statistics. FAO evaluates data accuracy and completeness whenever possible, using industry and commodities reports, and communicates with the countries when data are questionable.

However, the mechanisms of international trade are not straightforward. Fish can be harvested by one vessel in one region and landed and sold at a foreign port, or off-loaded to another vessel at sea, and landed at a third country. These are considered exports and imports, but a number of countries do not categorize these transactions as foreign trade, or even keep track of them. All information on illegal fishing that is traded in this way is excluded from the FAO database, even though the rate of illegal activities is high for some species.

Because fish are perishable, most of the products are traded as processed items, such as fillets or canned products. When products are traded in this way, species identification is often dropped or renamed with a more general term such as "frozen white fish fillet". Information on where this fish was produced, whether it was wild or farmed, country of origin, and country of processing, may be completely lost by the time the product reaches the supermarket shelf. Improved catch documentation and product labeling are beginning to be implemented in some countries for some fishery products; however, this is still the exception rather than the norm. Progress in documenting the fisheries trade is becoming increasingly important as countries try to combat illegal, unreported, and unregulated fishing.

ANNEX C

REGIONAL FISHERIES BODIES

Regional Fisheries Bodies (RFBs) are divided into 3 broad categories, depending on their key mandates: management bodies (M) that directly establish management measures for fish stocks, including catch quotas; advisory bodies (A) that provide members with scientific and management advice; and scientific bodies (S) that provide scientific and information advice. The following table lists the FAO and non-FAO RFBs, the year each body was established or entered into force, their role (Management, Advisory, or Scientific), where their headquarters are located, and how each body has adapted to, or is implementing the three most pressing contemporary fishing agreements: the Compliance Agreement, the UN Fish Stocks Agreement, and the FAO Code of Conduct. This table has been adapted in part from FAO (1999e) and it indicates if the particular agreement is being implemented, under consideration or discussion, or not considered by each of the RFBs. A (—) indicates that the information is not available. Other information presented in this Annex is from Lugten (1999) and FAO (2004).

FAO Regional Fisheries Bodies
Name
Asia-Pacific Fishery Commission (APFIC)
Commission for the Inland Fisheries of Latin America (COPESCAL)
Committee for Inland Fisheries of Africa (CIFA)
Coordinating Working Party on Fishery Statistics (CWP)
European Inland Fisheries Advisory Commission (EIFAC)
Fishery Committee for the Eastern Central Atlantic (CECAF)
General Fisheries Commission for the Mediterranean (GFCM)
Indian Ocean Tuna Commission (IOTC)
Regional Commission for Fisheries (RECOFI)
Western Central Atlantic Fishery Commission (WECAFC)

Non-FAO Regional Fisheries Bodies
Name
Advisory Committee on Fisheries Research (ACFR)
Atlantic Africa Fisheries Conference (AAFC)
Bay of Bengal Programme Inter-Governmental Organization (BOBP-IGO)
Comisión Permanente del Pacífico Sur (CPPS)
Comisión Técnica Mixta del Frente Marítimo (COFREMAR)
Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)
Commission for the Conservation of Southern Bluefin Tuna (CCSBT)
Forum Fisheries Agency (FFA)
Inter-American Tropical Tuna Commission (IATTC)
International Baltic Sea Fishery Commission (IBSFC)
International Commission for the Conservation of Atlantic Tunas (ICCAT)
International Council for the Exploration of the Sea (ICES)
International Pacific Halibut Commission (IPHC)
International Whaling Commission (IWC)
Lake Victoria Fisheries Organization (LVFO)
Mekong River Commission (MRC)
Network of Aquaculture Centers in Asia-Pacific (NACA)
North Atlantic Marine Mammal Commission (NAMMCO)
North Atlantic Salmon Conservation Organization (NASCO)
North Pacific Marine Science Organization (PICES)
Northwest Atlantic Fisheries Organization (NAFO)
Organización Latinoamericana de Desarrollo Pesquero (OLDEPESCA)
Pacific Salmon Commission (PSC)
Regional Fisheries Committee for the Gulf of Guinea (COREP)
Secretariat of the Pacific Community (SPC)
South East Atlantic Fisheries Organisation (SEAFO)
Southeast Asian Fisheries Development Center (SEAFDEC)
Sub-Regional Commission on Fisheries (SRCF)
The North Pacific Anadromous Fish Commission (NPAFC)
The North-East Atlantic Fisheries Commission (NEAFC)
Western Indian Ocean Tuna Organization (WIOTO)

Year Established	Main Role	Headquarters	Compliance Agreement	UN Fish Stocks Agreement	Code of Conduct
1948	A	Bangkok, Thailand	Under Discussion	Implemented	Not Considered
1976	A	Santiago, Chile	—	—	—
1971	A	Accra, Ghana	—	—	—
1959	S	Rome, Italy	Not Applicable	Not Applicable	Not Applicable
1957	A	Rome, Italy	—	—	—
1967	A	Accra, Ghana	Under Discussion	Under Discussion	Under Discussion
1949	M	Rome, Italy	Not Considered	Not Considered	Under discussion
1993	M	Victoria, Seychelles	Under Discussion	Implemented	Under Discussion
1999	A	Dokki, Egypt	—	—	—
1973	A	Barbados	Under Discussion	Under Discussion	Implemented

Year Established	Main Role	Headquarters	Compliance Agreement	UN Fish Stocks Agreement	Code of Conduct
1993	S	Rome, Italy	—	—	—
1995	A	Rabat, Morocco	—	—	—
2003	A	Tamil Nadu, India	—	—	—
1952	A	Guayaquil, Ecuador	Not Considered	Under Discussion	Under Discussion
—	A	Montevideo, Uruguay	—	—	—
1982	M	Tasmania, Australia	Implemented	Implemented	Under Discussion
1994	M	Deakin, Australia	Under Discussion	Implemented	Implemented
1979	A	Honiara, Solomon Is.	Under Discussion	Under Discussion	Under Discussion
1950	M	California, USA	Under Discussion	Implemented	Under Discussion
1973	M	Warsaw, Poland	Not Applicable	Not Applicable	Implemented
1969	M	Madrid, Spain	Implemented	Implemented	Under Discussion
1964	S	Copenhagen, Denmark	Not Applicable	Not Applicable	Under Discussion
1923	M	Seattle, USA	Not Applicable	Under Discussion	Under Discussion
1946	M	Cambridge, UK	Under Discussion	Implemented	Under Discussion
1994	A	Jinja, Uganda	—	—	—
1995	A	Phnom Penh, Cambodia	—	—	—
—	S	—	Not Applicable	Not Applicable	Not Applicable
1992	A	Tromsø, Norway	—	—	—
1983	M	Edinburgh, UK	Under Discussion	Not Applicable	Under Discussion
1992	S	Br. Columbia, Canada	—	—	—
1949[1]	M	Nova Scotia, Canada	Under Discussion	Under Discussion	Under Discussion
1982	A	Lima, Peru	Under Discussion	Under Discussion	Under Discussion
1985	M	Vancouver, Canada	—	—	—
1984	A	Libreville, Gabon	Under Discussion	Under Discussion	Under Discussion
—	S	—	Under Discussion	Under Discussion	Under Discussion
2001	M	Windhoek, Namibia	—	—	—
1967	A	Bangkok, Thailand	—	—	—
1985	A	Dakar, Senegal	—	—	—
1992	M	Vancouver, Canada	Not Considered	Not Applicable	Not Applicable
1982	M	London, UK	Under Discussion	Implemented	Implemented
1994	A	Victoria, Seychelles	—	—	—

[1] Prior to 1979 it was the International Commission of the Northwest Atlantic Fisheries.
Note: The Indian Ocean Fishery Commission (IOFC) established in 1967 was dissolved in February 1999 by the FAO Council (Resolution 1/16).

ANNEX D

LIST OF ACRONYMS

ADB: Asian Development Bank
CBD: Convention on Biological Diversity
CCAMLR: Commission for the Conservation of Antarctic Marine Living Resources
CCSBT: Commission for the Conservation of Southern Bluefin Tuna
CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora
CNROP: National Oceanographic and Fisheries Research Centre of Mauritania
COP: Conference of the Parties (for a given Convention)
CSIRO: Commonwealth Scientific and Industrial Research Organisation of Australia
DFO: Department of Fisheries and Oceans Canada
DWF: Distant Water Fleet
EC: European Commission
EEZ: Exclusive Economic Zone
EU: European Union
FAO: Food and Agriculture Organization of the United Nations
FOC: Flag of Convenience
GATT: General Agreement on Tariffs and Trade
GEF: Global Environment Facility
GESAMP: Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GIS: Geographic Information System
IATTC: Inter-American Tropical Tuna Commission
ICCAT: The International Commission for the Conservation of Atlantic Tunas
ICES: International Council for the Exploration of the Seas
ICJ: International Court of Justice
ICLARM: WorldFish Center
IDAF: Programme for the Integrated Development of Artisanal Fisheries in West Africa
IFREMER: French Research Institute for Exploitation of the Sea
IOTC: Indian Ocean Tuna Commission
ISSCAAP: International Standard Statistical Classification of Aquatic Animals and Plants
ITQ: Individual Transferable Quota
IUCN: The World Conservation Union
IUU: Illegal, Unreported, and Unregulated fishing
IWC: International Whaling Commission
JMAFF: Japanese Ministry of Agriculture, Forestry, and Fisheries
LVEMP: Lake Victoria Environmental Management Project
MAC: Marine Aquarium Council
MARPOL: International Convention for the Prevention of Pollution from Ships
MHLC: Multilateral High Level Conference on the Convention and Management of Highly Migratory Fish Stock in the Western and Central Pacific
MPA: Marine Protected Area
MRC: Mekong River Commission
MSC: Marine Stewardship Council
MSY: Maximum Sustainable Yield
NACA: Network of Aquaculture Centres in Asia Pacific
NAFO: International Commission for the Northwest Atlantic Fisheries
NEAFC: North-East Atlantic Fisheries Commission
NGO: Non-Governmental Organization
NMFS: US National Marine Fisheries Service
NOAA: US National Oceanic and Atmospheric Administration
NPAFC: Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean
NRC: US National Research Council
OECD: Organisation for Economic Co-operation and Development
OPRT: Organization for Promotion of Responsible Tuna Fisheries
PBFAR: Philippines Bureau of Fisheries and Aquatic Resources
SEAFDEC: Southeast Asian Fisheries Development Center
SERNAPESCA: National Fisheries Service of Chile
SPC: Secretariat of the Pacific Commission
TAC: Total allowable catch
TED: Turtle Exclusion Device
UNCLOS: United Nations Convention on the Law of the Sea
UNEP: United Nations Environment Programme
USGS: United States Geological Survey
USTR: United States Trade Representative
VMS: Vessel Monitoring System
WCPOC: Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean
WRI: World Resources Institute
WSSD: World Summit on Sustainable Development
WTO: World Trade Organization

ANNEX E

GLOSSARY

Active gear
Active gear usually involves a vessel towing a net or dredge in pursuit of target species, while passive gear is set statically to trap or entangle the target species that move toward or into them.

Anadromous fish
Fish that spend their adult life in the sea but swim upriver to freshwater spawning grounds in order to reproduce.

Aquaculture
The farming of aquatic organisms including fish, molluscs, crustaceans, and aquatic plants with some sort of intervention in the rearing process to enhance production.

Artisanal fisheries
Traditional fisheries involving fishing households (as opposed to commercial companies), using relatively low technology and small fishing vessels (if any) and making short fishing trips close to shore.

Beach seine
A light-weight, encircling net deployed parallel to the shore and then drawn in to the beach by long ropes attached to the wingends of the net.

Beam trawl
A bottom trawl that is kept open laterally by a rigid beam.

Benthic
Refers to the bottom of water bodies, such as the sea floor.

Biodiversity
The variability among living organisms from all sources including, among others, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species and ecosystems.

Biomass
The total weight of a group (or stock) of living organisms (e.g. fish, plankton) or of some defined fraction of it (e.g. spawners), in an area, at a particular time.

Bottom trawl
A trawl net that is towed across the sea floor rather than through a water column. They are also referred to as demersal trawls and include both beam trawls and otter trawls.

Brackish waters
Water bodies with a salinity intermediate between seawater and freshwater, usually showing wide salinity fluctuations.

Bycatch
Fish and other animals besides the primary target species that are caught incidental to the capture of the primary target species. Bycatch may be retained or discarded.

Capture fishery
The sum (or range) of all fishing activities on a given resource. It may refer to the activities of a single type of fishing, such as location, the target species, and the technology used.

Catadromous fish
Fish that spawn in seawater but feed and spend most of their life in estuarine or fresh water.

Catch
(1) Any activity that results in killing any fish or bringing any live fish onboard a vessel. (2) The total number (or weight) of fish caught by fishing operations. Catches that are not landed are called discards.

Catch controls—see output controls

Catch per unit effort (CPUE)
Catch per unit of fishing effort. The total catch divided by the total amount of effort used to capture the fish. For example, CPUE can be expressed as weight of fish captured per fishing trip, per hour spent at sea, or number of fish taken per 1,000 hooks per day.

Cephalopods
Invertebrate animals (molluscs) with tentacles converging at the head, around the mouth (e.g., squids, cuttlefish, and octopus).

Cetaceans
Marine mammals of the order Cetacea. Includes whales, dolphins, and porpoises.

Closed season
A period during which fishing for a particular species, often within a specified area, is prohibited.

Coastal waters
Areas of ocean that extend from the shore to the outer edge of the continental shelf, or to a depth of 200 meters.

Collapsed fish stock
Prolonged lack of annual recruitment of juvenile fish due to excessive fishing pressure that leads to the reduction of stock abundance to levels at which production is negligible compared to historical levels.

Co-management
A process of management in which government shares power with resource users, with each given specific rights and responsibilities relating to information and decision-making.

Common property resource
A term that indicates a resource owned by the public. It can be fish in public waters, trees on public land, and the air.

Continental shelf
The part of the continental margin which is between the shoreline and the shelf break or, where there is no noticeable slope, usually to a water depth of between 100 and 200 meters.

Crustaceans
Invertebrate animals in the group Crustacea, which includes crabs, lobsters, and shrimp.

Demersal fish
Fish that live and depend on the bottom of a water body, marine or freshwater, during their adult life (e.g., groupers, cods). They are often referred to as ground fish.

Depleted stock
A fish stock where a high proportion of one or all age classes of individuals are harvested because of excessive fishing pressure that leads to a reduction in the spawning stock, limiting the natural reproduction or annual recruitment levels.

Diadromous
Fish that spend part of their life in freshwater and part in saltwater; e.g., anadromous salmon and catadromous eels.

Discards
Fish and other animals that are disposed of, usually at sea, after being caught.

Distant water fleet
Fishing fleet that operates far outside of the Exclusive Economic Zone of the home country.

Dredges
Gear dragged along the bottom, usually to collect molluscs such as mussels, oysters, scallops, and clams, that live either on the surface of the seabed or within the sediment down to depths of 100 cm.

Drift nets
Curtains or sheets of netting that hang vertically in the water, either at the surface or lower in the water column.

Effort control
A system of fishery management that focuses on limiting the quantity of fishing gear or the duration of its deployment rather than on limiting the quantity of catch that can be taken. (See also TAC and quota.)

Endangered—see threatened

Endemic
A natural or naturalized population that is normally found in a particular area.

Eutrophic
Water bodies or habitats with high concentrations of nutrients, particularly phosphorus and nitrogen. Excessive nutrient enrichment may result in the depletion of dissolved oxygen and eventually to species mortality and replacements.

Exclusive Economic Zone (EEZ)
A zone of water up to 200 nautical miles from the boundary of a coastal State declared in line with the provisions of the 1982 United Nations Convention on the Law of the Sea, within which the coastal State has the right to explore and exploit, and the responsibility to conserve and manage, the living and non-living resources.

Exploited stock
Any stock of fish that is subject to commercial fishing activity.

Fish stock
Scientifically, a population of a species of fish that is isolated from other stocks of the same species and does not interbreed with them and can, therefore, be managed independently of other stocks.

Fishing effort
The amount of fishing gear of a specific type used on the fishing grounds over a given unit of time: e.g., hours trawled per day, number of hooks set per day, or number of hauls of a beach seine per day. At its most basic, it is the total number of boats engaged in a fishery and/or the number of days they were fishing.

Fixed gear
Any fishing gear that is anchored or attached in some other way to the seabed so that it does not drift or move while it is in fishing mode, e.g., crab pots, and bottom set gill nets .

Flag of convenience (FOC)
The term pertains to cases where a boat is registered in a different country than that of ownership, for reasons of convenience.

Fully fished stock
A stock is considered to be fully fished when increases in fishing effort do not significantly increase the yields, but substantially increase the risk of overfishing. These stocks are said to be exploited at their biological limit—an upper limit of the stock biomass which marks a threshold that, if surpassed, causes a substantial decline in recruitment.

Ghost fishing
The continued capture of animals by fishing gear that has been lost or abandoned at sea. Such gear can continue to capture fish until it is retrieved, destroyed (by time and weather), or otherwise ceases to function, e.g., from being weighed down with weed, debris, and/or cadavers.

Gill nets
Gill nets and entangling nets are strings of single, double, or triple vertical netting walls, placed near to the surface, in midwater, or on the bottom of the water column in which fish will entangle or enmesh themselves.

Groundfish
A species or group of fish that live most of their life on or near the sea bottom. See also demersal fish.

Habitat
Particular 'living space' or environment in which an animal or plant lives, eats, and breeds.

High grading
A profit-driven practice that involves discarding smaller fish of the target species to make room in the fish hold for larger, more valuable fish caught later in the day.

High seas
High seas is a legal term used to describe the areas of water outside of a country's EEZ.

Highly migratory species or stocks
Species or stocks that carry out extensive migrations through out the oceans, usually crossing territorial boundaries such as EEZs and between EEZs and the high seas. This term is usually used to describe tuna and tuna-like species such as marlins, and swordfish.

Illegal, unreported, and unregulated fishing (IUU fishing)
A wide range of fishing practices and activities that: do not respect applicable laws and regulations, or the standards set forth by international agreements; have not been reported, or have been misreported to the relevant authority; or for which there are no applicable conservation or management measures.

Incidental catch—see bycatch.

Individual quotas
An individual quota is the maximum amount of fish that an individual can catch, where 'individual' may be a person or a legal entity. A catch quota is the maximum amount of fish that can be caught in a certain period.

Individual transferable quota (ITQ)
A type of quota management system that typically entails the allocation of a part of the Total Allowable Catch to individual fishermen or vessel owners. The quota, once distributed, can be sold to others.

Input control—see effort control

Introduced species
Any species that occurs outside its normal geographic range as a direct or indirect result of human activity and one that has not been found to occur naturally in the area within historic time.

Juvenile
A young animal that has not reached sexual maturity.

Keystone species
A predator at the top of a food web, or discrete sub-web, capable of consuming organisms of more than one trophic level beneath it.

Landings
The number or weight of fish unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen for personal use. Landings are reported at the locations where fish are brought to shore.

Limited entry
A program that restricts the participation of individuals in a fishery, virtually changing a common property resource into private property for individual fishermen. License limitation and the individual transferable quota (ITQ) are two forms of limited entry.

Longline
A type of fishing gear consisting of a mainline with evenly spaced baited hooks, which is kept near the surface of the water or at a certain depth by means of regularly spaced floats.

Mangrove forest
A shoreline ecosystem dominated by mangrove trees, with associated mud flats.

Marine protected area (MPA)
An area of seabed and the water above it that has some level of legal protection from exploitation. The level of protection varies depending on its purposes and many allow limited fishing and other extractive uses, as well as recreational activities.

Marine reserve
A marine protected area that is semi-permanently protected from all forms of resource exploitation and direct destructive activities. Also referred to as a "no-take zone" or a "marine sanctuary."

Maximum sustainable yield (MSY)
The largest average catch or yield that can continuously be taken from a stock under existing environmental conditions, without significantly affecting the reproduction capacity of the stock.

Minimum landing size
The smallest size at which it is legal to retain a fish or offer it for sale.

Minimum mesh size
The smallest size of mesh that can be used legally in any given type of net.

Molluscs
A group of freshwater and saltwater animals with no skeleton and usually one or two hard shells made of calcium carbonate. Includes the oyster, clam, mussel, snail, conch, scallop, squid, and octopus.

Nautical mile
Unit of distance equivalent to 1 minute latitude of the great circle of earth (=1852 meters or 1.1508 miles).

Open access
The condition where access to the fishery is unrestricted. The right to catch fish is free and open to all.

Open ocean
Waters above the sea bottom that extend beyond the edge of the continental shelf, or are deeper than 200 meters.

Output controls
The management measures that limit the weight of catch fishers can take. These options include the Total Allowable Catch (TAC), and individual quotas (IQ) which permit each fisher to take a percentage of TAC for a certain species during the fishing season.

Overfished stock
A fish stock is considered to be overfished when it is exploited beyond an explicit limit considered "too low" to ensure safe reproduction. A stock may remain overfished (i.e., with a biomass well below the agreed limit) for some time even though fishing pressure might be reduced or suppressed, because it takes time for the fish population to recover.

Overfishing
The action of exerting fishing pressure beyond an agreed optimum level that allows for replenishment of the fish stock through natural reproduction.

Pelagic fish
Fish that spend most of their life swimming in the water column with little contact with, or dependency on, the sea or lake bottom. They often travel and feed in large groups or schools. Common pelagic fish include anchovies, sardines, and tuna.

Predator
A species that feeds on other species. The species being eaten is the prey.

Quota
Amount of catch allocated to a fishing license.

Recreational fishery
Harvesting fish for personal use, fun, and challenge. Recreational fishing does not include sale of catch.

Recruitment
A measure of the number of fish that enter a class—such as the spawning class or fishing-size class—during some time period.

Sashimi
Japanese term for a dish with sliced fish and shellfish served and consumed in raw form.

Sea ranching
In general, sea ranching (or sea farming) is the practice of raising wild-caught juvenile fish within controlled boundaries in the open ocean, where they grow using natural food supplies or formulated feed. Once the fish reach a certain size they are harvested, and production is therefore reflected in aquaculture figures, instead of capture statistics. Sea ranching is a form of aquaculture, and the term is many times used interchangeably with stocking of marine fish stocks.

Shellfish
General term for crustaceans and molluscs.

Species
A population or a group of animals or plants having common characteristics, able to breed together to produce fertile offspring, and reproductively isolated from all other populations.

Species richness
The number of species in an area or biological collection.

Stock enhancements
A range of practices carried out to enhance or increase the size or growth of the fishery resource. Enhancements can consist of releasing juveniles raised in hatcheries or captured elsewhere in the wild, into a sea, lake, or river for subsequent fishing when they have reached a larger size. Other enhancement practices involve the introduction of new or non-native species to an aquatic system, where it reproduces and grows using natural food supplies.

Stocking
The practice of putting artificially reared young fish into a sea, lake, or river. These are subsequently caught, preferably at a larger size.

Straddling stocks
Any stock that migrates regularly across one or more international jurisdictional boundaries, such as EEZs.

Surrounding nets
Large netting walls set for surrounding groups or schools of fish, both from the sides and from underneath. An example of this type is the purse seine, which is used to target pelagic species such as anchovies, tuna, and mackerel.

Threatened
A species, stock, or population is considered threatened if it is facing a high risk of extinction in the wild in the near future. According to IUCN-The World Conservation Union, species with a *Red List* status of Critically Endangered, Endangered, and Vulnerable are all considered to be threatened with extinction.

Total Allowable Catch (TAC)
The annual recommended catch for a species or species group. Usually a regional council or similar administrative body sets the TAC based on the range of the allowable biological catch.

Trawl
A large, funnel-shaped net that is towed through the water by single or paired boats.

Trolling
A method of hook-and-line fishing where the lines with baits or lures are dragged by a vessel. It is used to catch surface swimming pelagic species such as mackerel and tuna.

Trophic level
Classification of natural communities or organisms according to their place in the food chain.

Undersize fish
Any fish that is less than the legal minimum landing size.

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ABOUT WRI

World Resources Institute is an environmental research and policy organization that creates solutions to protect the Earth and improve people's lives.

Our work is concentrated on achieving progress toward four key goals:

- Protect Earth's living systems
- Increase access to information
- Create sustainable enterprise and opportunity
- Reverse global warming

Our strength is our ability to catalyze permanent change through partnerships that implement innovative, incentive-based solutions that are founded upon hard, objective data. We know that harnessing the power of markets will ensure real, not cosmetic, change.

We are an independent and non-partisan organization. Yet, we work closely with governments, the private sector, and civil society groups around the world, because that guarantees ownership of solutions and yields far greater impact than any other way of operating.