

## Part IV

### Assessment of Marine Biological Diversity and Habitats

One of the main services provided by the oceans is food for human consumption, resulting in benefits for human health and nutrition, economic returns, and employment. These benefits can be enjoyed sustainably, but only if the intensity and nature of harvesting and culture are appropriately planned and managed, and access to the potential benefits is made available.

Part IV of the WOA reviews these issues under the headings of the Ocean as a source of food (Chapter 10), Capture fisheries (Chapter 11), Aquaculture (12), Fish stock propagation (13), Specialized marine food sources (14), and Social and economic aspects of fisheries (15). Chapter 10 summarizes the contributions of seafood<sup>1</sup> to human nutrition and alleviation of hunger, discussing both patterns at regional and sub-regional scales and their trends over time. Chapter 11 looks in more detail at capture fisheries, presenting trends over time both globally and regionally in overall harvest levels and fishing gear used. It also looks at major species harvested at these scales, and the sustainability of use of the harvested species. It also looks at the ecosystem effects of fishing, considering the nature, levels, and, where information is available, trends, in effects on bycatch species, marine food webs, and habitats. Chapter 12 reviews the same types of information for aquaculture, considering overall production and production of key species at global and regional scales, and, with regard to ecosystem effects, considers issues such as introduction of alien species, local degradation and conversion of habitats, use of antibiotics, genetic manipulations, and other similar factors in this form of production. Chapters 13 and 14 address focused issues of artificial propagation of fish and use of marine plants and species other than fish and invertebrates as food. Chapter 15 then assesses the magnitude of economic and social benefits from fisheries and aquaculture. The assessment again looks at trends both globally and regionally, and in addition at differences in the nature, scales, and distribution of social and economic benefits of large-scale and small-scale fisheries. The role of trade, hunger, poverty, worker safety and related issues are all addressed, with particular attention to the interactions of trade, hunger, and poverty alleviation in how benefits may be taken and distributed.

The synthesis in Chapter 16 brings these aspects of the ocean as a source of food together. It integrates the perspectives of the sustainability of harvested and cultured stocks and the impacts on marine ecosystems from fishing and aquaculture, with the perspectives of economic benefits and social / livelihoods benefits.

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<sup>1</sup> Both the terms “seafood” and “fish” are used to include a variety of marine sources of food, depending on the source being consulted. In Part IV both terms are used generically to refer to all types of fish (including both bony and cartilaginous species) and invertebrates consumed as food. When information is presented on a subset of these taxa, the text is explicit about the intended group of species.

## **Chapter 10. The Oceans as a Source of Food**

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### **1. Introduction**

One of the main services provided by the oceans to human societies is the provisioning service of food from capture fisheries and culturing operations. This includes fish, invertebrates, plants, and for some cultures, marine mammals and seabirds for direct consumption or as feed for aquaculture or agriculture. These ocean-based sources of food have large-scale benefits for human health and nutrition, economic returns, and employment.

A major challenge around the globe is to obtain these benefits without compromising the ability of the ocean to continue to provide such benefits for future generations, that is, to manage human use of the ocean for sustainability. In effect, this means that capture fisheries and aquaculture facilities must ensure that the supporting stocks are not overharvested and the ecosystem impacts of the harvesting or aquaculture facilities do not undermine the capacity of a given ocean area to continue to provide food and other benefits to society (see Chapter 3). Further, the social and economic goals of the fisheries and aquaculture should fully consider sustainable use in order to safeguard future benefits.

### **2. Dimensionality of the oceans as a source of food**

Capture fisheries and aquaculture operate at many geographical scales, and vary in how they use marine resources for food production. Here, “small-scale” refers to operations that are generally low capital investment but high labour activities, relatively low production, and often family or community-based with a part of the catch being consumed by the producers (Béné et al., 2007; Garcia et al., 2008). Large-scale operations require significantly more capital equipment and expenditure, are more highly mechanized and their businesses are more vertically integrated, with generally global market access rather than focused on local consumption. These descriptions are at the ends of a spectrum continuum of scales with enormous variation in between.

The geography of harvesting and food production from the sea is also important. Williams (1996) documents that until the mid-1980s, developed countries dominated both harvesting and aquaculture, but thereafter developing countries became

dominant, first in capture fisheries and later in mariculture. A general division of large-scale fisheries and mariculture in the developed world and small-scale operations in the developing world was never absolute. Small-scale operations were present in all areas, but highly mobile large-scale fisheries are increasingly operating around the globe (Beddington et al., 2007; World Bank/FAO, 2012), and large aquaculture facilities for export products are increasing in the developing world (Beveridge et al., 2010; Hall et al., 2011).

### **3. Trends in capture fisheries and aquaculture**

According to FAO statistics reported by member States, production of fish from capture fisheries and aquaculture for human consumption and industrial purposes has grown at an annual rate of 3.4 per cent for the past half century from about 20 to above 162 mmt by 2013 (FAO, 2014a; FAO, 2015). Over the last two decades though, almost all of this growth has come from increases in aquaculture production. Chapters 11 and 12 of this Assessment describe the time course of capture fisheries and aquaculture development over the last several decades.

Globally aquaculture production has increased at approximately 8.6 per cent per year since 1980, to reach an estimated 67 mmt in 2012, although the rate of growth has slowed slightly in recent years. Of that total, however, more than 60 per cent is from freshwater aquaculture. In addition nearly 24 million tons of aquatic plants (mostly seaweeds) were cultured on 2012. Total marine aquaculture production is growing slightly faster than freshwater aquaculture in all regions, but, like freshwater aquaculture, over 80 per cent of production is concentrated in a few countries, particularly China, as well as some other east and south Asian countries (FAO, 2014a).

Some of the fish taken in capture fisheries are used as feed in aquaculture, fishmeal, fish oil and other non-human consumption uses. Thus the total harvest from capture fisheries and production from mariculture is not all available for human consumption. This use of fish is debated with regard to the best use of production from capture fisheries (Naylor et al., 2009; Pikitch et al., 2012). The total amount of fish used for purposes other than direct consumption has been declining slowly since the early 2000s from about 30 per cent to just over 20 per cent of total capture fishery harvest in 2012 (FAO 2014a). Consequently, fish for human consumption has been increasing slightly faster than the human population, increasing the importance of fish in meeting food security needs (HLPE, 2014).

Finally, fishing is also undertaken for recreational, cultural and spiritual reasons. Even though fish taken for these purposes may be consumed, they are addressed in chapters 8 and 27, and will not be considered further here.

#### 4. Value of marine fisheries and mariculture

Fish harvested or cultured from the sea provide three classes of benefits to humanity: food and nutrition, commerce and trade, and employment and livelihoods (see Chapter 15 for additional detail). All three classes of benefits are significant for the world.

##### 4.1 *Food and nutrition*

According to FAO (2014a) estimates, fish and marine invertebrates provide 17 per cent of animal protein to the world population, and provide more than 20 per cent of the animal protein to over 3 billion people, predominantly in parts of the world where hunger is most widespread. Asia accounts for 2/3 of the total consumption of fish. However, when population is taken into account, Oceania has the highest per capita consumption (approximately 25 kg per year), with North America, Europe, South America and Asia all consuming over 20 kg per capita, and Africa, Latin America and the Caribbean are around 10 kg per capita. Per capita consumption does not capture the full importance of the marine food sources to food security, however. Many of the 29 countries where these sources constitute more than a third of animal protein consumed are in Africa and Asia. Of these, the United Nations has identified 18 as low-income, food deficient economies (Karawazuka Béné, 2011, FAO, 2014b). Thus fish and invertebrates, usually from the ocean, are most important where food is needed most.

Table 1. Total and per capita food fish supply by continent and economic grouping in 2011<sup>1</sup>

	Total food supply (million tonnes live weight equivalent)	Per capita food supply (kg/year)
<b>World</b>	<b>132.2</b>	<b>18.9</b>
World (excluding China)	86.3	15.3
Africa	11.0	10.4
North America	7.6	21.7
Latin America and the Caribbean	5.9	9.8
Asia	90.3	21.5
Europe	16.4	22.1
Oceania	0.9	25.0
Industrialized countries	26.4	27.0
Other developed countries	5.6	13.7
Least-developed countries	10.3	12.1
Other developing countries	89.9	18.9
LIFDCs <sup>2</sup>	21.2	8.6

<sup>1</sup> Preliminary data

<sup>2</sup> Low-income food-deficit countries.

Source: FAO Information and Statistics Branch, Fisheries and Aquaculture Department, 2015.

Not only are marine food sources important for overall food security, fish are rich in essential micronutrients, particularly when compared to micronutrients available when meeting human protein needs from consumption of grains (WHO 1985). Compared to protein from livestock and poultry, fish protein is much richer in poly-unsaturated fatty acids and several vitamins and minerals (Roos et al., 2007, Bonhan et al., 2007). Correspondingly, direct health benefits relative to reducing risk of obesity, heart disease, and high blood pressure have been linked to diets rich in fish (Allison et al., 2013).

It should be noted, however, that there are also potential health risks from consumption of seafood, particularly as fish at higher trophic levels may concentrate environmental contaminants, and there are occasional outbreaks of toxins in shellfish. Substantial effort is invested in monitoring for these risks, and avoiding the conditions where probability of toxin outbreaks may increase. More broadly, food safety is a key worldwide challenge facing all food production and delivery sectors including all parts of the seafood industry from capture or culture to retail marketing. This challenge of

course faces subsistence fisheries as well. In the food chain for fishery products, risk of problems needs to be assessed, managed and communicated to ensure problems can be addressed. The goal of most food safety systems is to avoid risk and prevent problems at the source. The risks come from contamination from toxins or pathogens and the severity of the risk also depends on individual health, consumption levels and susceptibility. There are international guidelines to address these risks but substantial resources are required in order to continue to build the capacity to implement and monitor safety protocols from the water to the consumer.

Because of the several limiting factors affecting wild fish catch today (see Chapter 11), it is forecasted that aquaculture production will supply all of the increase in fish consumption in the immediate future. Production is projected to rise to 100 million tons by 2030 (Hall et al., 2011) and to 140 million tons by 2050, if growth continues at the same rate.

Estimates by the World Resources Institute (Waite et al., 2014), assuming (a) the same mix of fish species, (b) that all aquaculture will go to human consumption and (c) that there will be a 10 per cent decrease in wild fish capture for food, indicate that the growth in aquaculture production cited above would boost fish protein supply to 20.2 million tons, or 8.7 million tons above 2006 levels. This increase would meet 17 per cent of the increase in global animal protein consumption required by 9.6 billion people for 2050 (Waite et al. 2014).

#### 4.2 *Commerce and trade*

The total value of world fish production from capture fisheries and marine and freshwater aquaculture was estimated to be 252 billion USD in 2012, with the “first-sale” value of fish from capture fisheries at approximately 45 per cent of that value (FAO 2014a). Consistent accounting for “value” has been elusive, providing alternative value estimates that are as much as 15-20 per cent greater (e.g., Dyck and Sumalia, 2010). The different possible accounting schemes make it correspondingly difficult to estimate the growth rate of economic value of fisheries, but all approaches project the value to have increased consistently for decades and likely to continue to increase. This increase in economic value is attributable to several factors, including increased production (primarily from aquaculture), an increasing proportion of catches directed to human consumption, improvements in processing and transportation technologies that add to the product’s value, and changing consumer demand (Delgado et al 2003). Several factors contribute to increasing consumer demand. The factors include increasing awareness of health benefits of eating fish, increasing economic consumer power in developed and developing economies, and market measures such a certification of sustainably harvested fish and aquaculture products (FAO 2014a).

Just as total per capita consumption of fish underestimates the importance of fish to food security in many food-deficit countries, the total economic value of fish sales underrepresents the value of fish sales to low-income parts of the world. There is a

“cash crop” value to fish catches of even small-scale subsistence fishers. Most of this “value” is not captured in the formal economic statistics of countries, and probably varies locally and seasonally (Dey et al., 2005). However studies have shown that the selling or trading of even a portion of their catch represents as much as a third of the total income of subsistence fishers in some low income countries (Béné et al., 2009).

#### 4.3 *Employment and livelihoods*

These differences between large-scale and small scale fishers are particularly important in considering employment benefits from food from the ocean. Estimates of full-time or part-time jobs derived from fishing, vary widely, with numbers ranging from 58 million to over 120 million jobs being available (BNP 2009, FAO 2014a). All sources agree that over 90 per cent are employed in small-scale fisheries. This includes jobs in the processing and trading sectors, where opportunities for employment of women are particularly important (BNP 2009). The value-chain jobs are considered to nearly triple the employment benefits from fishing and mariculture, compared to direct employment from harvesting (World Bank 2012). All sources report that more than 85 per cent of the employment opportunities are in Asia and a further 8 per cent in Africa, largely in income-deficit countries or areas. It is even harder to track direct and value-chain employment from small-scale aquaculture production and break out the portion that is derived from marine aquaculture (Beveridge et al., 2010), but recent estimates for employment from aquaculture exceed 38 million persons (Phillips et al., 2013).

Of the 58.3 million people estimated to be employed in fisheries and aquaculture (4.4 per cent of total estimated economically active people), 84 per cent were in Asia and 10 per cent in Africa. Women are estimated to account for more than 15 per cent of people employed in the fisheries sector (FAO, 2014).

When full- or part-time participants in the full value-chain and support industries (boat-building, gear construction, etc.) of fisheries and aquaculture and their dependents are included, FAO estimated that between 660 and 820 million persons derive some economic and/or livelihood benefits (FAO 2012, Allison 2013). Direct employment in fishing is also growing over 2 per cent per year, generally faster than human population growth (Allison, 2013). However, there has been a shift from 87 per cent in capture fisheries and the rest in aquaculture (primarily freshwater) in 1990, to approximately a 70:30 division in 2010, with slightly faster growth in employment in mariculture than in freshwater aquaculture (FAO, 2012).

Trade in fishery products further complicates efforts to evaluate trends in the contribution of the oceans to human well-being. Fish is one of the most heavily traded food commodities on the planet, with an estimated 38 per cent of fishery production by 2010, up from 25 per cent in 1976 (FAO, 2012). This represents about 10 per cent of international agricultural exports. The direct value of international exports was over 136 billion USD in 2012, up 102 per cent in just 10 years (FAO, 2014a. <http://www.fao.org/3/a-i4136e.pdf>); European Union (EU) countries alone imported

more than 514 billion in fish products in 2013, although slightly over half of that was from trade among EU Member States (<http://www.fao.org/3/a-i4136e.pdf>). Fish trade is truly global, with FAO recording fish and fishery products exported by 197 countries, led by China, which contributes 14 per cent of the total exports.

Developing countries contribute over 60 per cent by volume and over 50 per cent by value of exports of fish and fish products. Although this trade generates significant revenues for developing countries, through sales, taxation, license fees, and payment for access to fish by distant water fleets, there is a growing debate about the true benefits to the inhabitants of these countries from these revenue sources (Bostock et al., 2004; World Bank 2012). The debate centres on whether poor fishers would benefit more from personal or community consumption of the fish than from sales of the fish to obtain cash or credit. The issue is complicated by the leasing of access rights for foreign vessels which may compete for resources with coastal small scale fishers. With small-scale and large-scale fisheries each harvesting about half of the world's fish, resolving the relative importance of large-scale and small-scale fisheries to food security, in an increasingly globalized economy, is complex. Reviews found the issue to be polarized in the early 2000s (FAO 2003; Kurien, 2004), and there has been little convergence of views over the ensuing decade (HLPE, 2014).

## **5. Impacts of fisheries and mariculture, on marine ecosystems**

Harvesting or culturing marine fish, invertebrates or plants necessarily has at least direct and immediate, and often indirect and longer-term impacts on marine ecosystems. For over a century fisheries experts have sought ways to evaluate the short-term and long-term sustainability of varying levels of fish harvests (Smith 1994), and to manage fisheries to keep these harvests within sustainable bounds (Garcia et al., 2014). Assessing and managing the wider ecosystem impacts of fisheries and aquaculture is even more challenging (Garcia et al., 2014). These impacts may range from loss of habitat due to destructive fishing practices to impacts on the structure of marine food webs by selectively harvesting some species that play a key role in the integrity of a given ecosystem. The fact that these effects may be difficult to quantify in no way diminishes their importance in sustaining the capacity of the oceans to provide food and other benefits to human society. Moreover, the scope of assessments of impacts continues to expand, as life cycle analyses are introduced into fisheries (Avadí and Fréon, 2013). Results indicate that, for example, the carbon footprint of a kg of fish at market depends greatly on modes of capture and transport. However, the carbon footprint is often substantially lower than the footprint of a kg of poultry or livestock (Mogensen et al., 2012). Other chapters in this Assessment, primarily in Part VI, consider a broad range of impacts on the ocean of human activities. Since food production from the ocean is such an important benefit, particular care must be taken to ensure that sustained capacity to produce food from fisheries and aquaculture is not diminished.

## 6. Conclusions

This chapter sets the stage for assessing the role of the oceans as a source of food. The chapters to follow will assess in depth the ways that food is taken from the sea. Each chapter will consider the trends in yields, resources, economic benefits, employment, and livelihoods, the interactions among the trends, and their main drivers, on global and regional scales as appropriate. They will also look at the main impacts of the various food-related uses of the ocean on biodiversity – both species and habitats. Some of these interactions will also be considered, from the perspective of the affected components of biodiversity, in Part VI of the World Ocean Assessment. Each chapter will also consider the main factors that affect the trends in benefits, resources used and impacts. Together a picture will emerge of the importance of the ocean as a source of food, and of fisheries and mariculture as sources of commerce, wealth, and livelihoods for humankind, with a particular focus on the world’s coastal peoples.

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