Chapter 11. Capture Fisheries

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1. Present status and trends of commercially exploited fish and shellfish stocks

Production of fish from capture fisheries (Figure 1) and aquaculture for human consumption and industrial purposes has grown at the rate of 3.2 per cent for the past half century from about 20 to nearly 160 million mt by 2012 (FAO 2014).

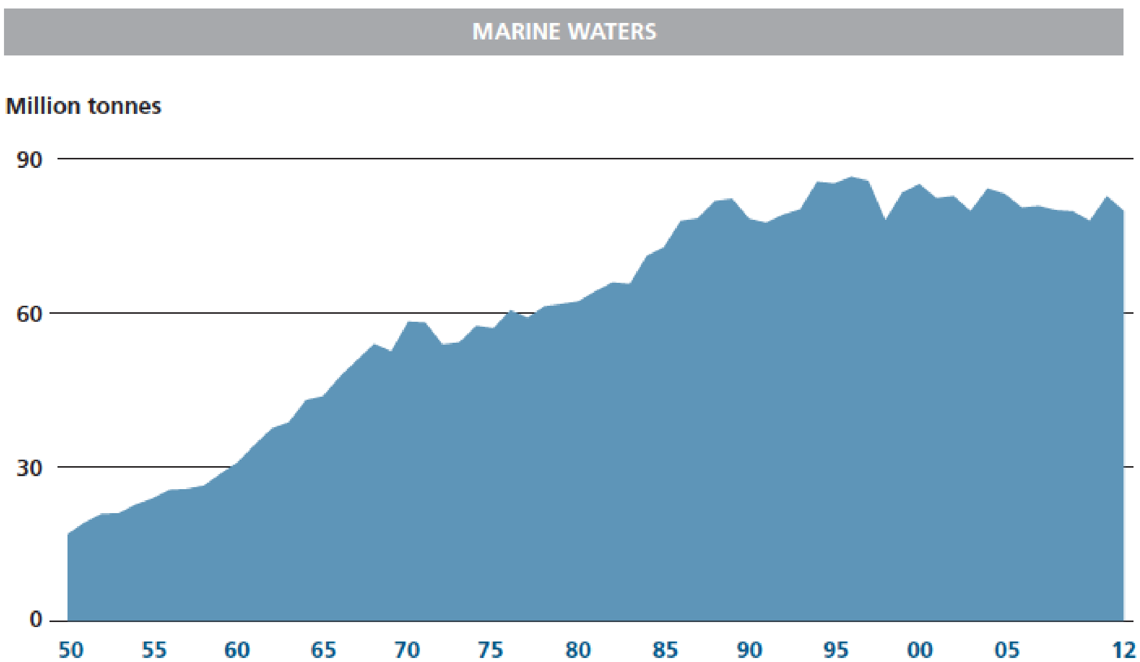

Figure 1. Evolution of world's capture of marine species. From SOFIA (FAO 2014).

Globally, marine capture fisheries produced 82.6 million mt in 2011 and 79.7 million mt in 2012. The relatively small year-to-year variations largely reflect changes in the catch of Peruvian anchoveta, which can vary from about 4 to 8 million tons *per annum*.

In 2011 and 2012, 18 countries accounted for more than 76 per cent of global marine harvests in marine capture fisheries (Table 1). Eleven of these countries are in Asia.

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Table 1. Marine capture fisheries production per country. From SOFIA (FAO, 2014).

Marine capture fisheries: major producer countries

2012 Ranking	Country	Continent	2003	2011	2012	Variation 2003–2012	Variation 2011–2012
				(Tonnes)		(Percentage)	
1	China	Asia	12 212 188	13 536 409	13 869 604	13.6	2.4
2	Indonesia	Asia	4 275 115	5 332 862	5 420 247	27.0	1.7
3	United States of America	Americas	4 912 627	5 131 087	5 107 559	4.0	–0.5
4	Peru	Americas	6 053 120	8 211 716	4 807 923	–20.6	–41.5
5	Russian Federation	Asia/ Europe	3 090 798	4 005 737	4 068 850	31.6	1.6
6	Japan	Asia	4 626 904	3 741 222	3 611 384	–21.9	–3.5
7	India	Asia	2 954 796	3 250 099	3 402 405	15.1	4.7
8	Chile	Americas	3 612 048	3 063 467	2 572 881	–28.8	–16.0
9	Viet Nam	Asia	1 647 133	2 308 200	2 418 700	46.8	4.8
10	Myanmar	Asia	1 053 720	2 169 820	2 332 790	121.4	7.5
11	Norway	Europe	2 548 353	2 281 856	2 149 802	–15.6	–5.8
12	Philippines	Asia	2 033 325	2 171 327	2 127 046	4.6	–2.0
13	Republic of Korea	Asia	1 649 061	1 737 870	1 660 165	0.7	–4.5
14	Thailand	Asia	2 651 223	1 610 418	1 612 073	–39.2	0.1
15	Malaysia	Asia	1 283 256	1 373 105	1 472 239	14.7	7.2
16	Mexico	Americas	1 257 699	1 452 970	1 467 790	16.7	1.0
17	Iceland	Europe	1 986 314	1 138 274	1 449 452	–27.0	27.3
18	Morocco	Africa	916 988	949 881	1 158 474	26.3	22.0
Total 18 major countries			**58 764 668**	**63 466 320**	**60 709 384**	**3.3**	**–4.3**
World total			**79 674 875**	**82 609 926**	**79 705 910**	**0.0**	**–3.5**
Share 18 major countries (percentage)			**73.8**	**76.8**	**76.2**		

In 2011-2012, the top ten species (by tonnage) in marine global landings were Peruvian anchoveta, Alaska pollock, skipjack tuna, various sardine species, Atlantic herring, chub mackerel, scads, yellowfin tuna, Japanese anchovy and largehead hairtail. In 2012, 20 species had landings over a half a million tons and this represented 38 per cent of the total global marine capture production. Many of these top species are small pelagic fishes (e.g. sardines, chub mackerels) and shellfish (squids and shrimp) whose abundance is highly sensitive to changing climatic conditions, resulting in significant interannual variability in production.

Tuna harvests in 2012 were a record high, exceeding more than seven million tons. Sharks, rays and chimaera catches have been stable during the last decade at about 760,000 tons annually. Shrimp production from marine capture fisheries reached a record high in 2012 at 3.4 million tons; much of this catch was from the Northwest and Western Central Pacific, although catches also increased in the Indian Ocean and the Western Atlantic. Cephalopod catches exceeded 4 million tons in 2012.

1.1 Regional Status

Significant growth in marine capture fisheries has occurred in the eastern Indian Ocean, the eastern central Atlantic and the northwest, western central and eastern central Pacific over the last decade, but landings in many other regions have declined. Thus, even though overall landings have been quite stable, the global pattern is continuing to adjust to changing conditions and regional development of fishing capacity (Table 2).

Table 2. Fishing areas and captures (from SOFIA, FAO, 2014)

Marine capture: major fishing areas

Fishing area code	Fishing area name	2003	2011	2012	Variation 2003–2012	Variation 2011–2012
		(Tonnes)			(Percentage)	
21	Atlantic, Northwest	2 293 460	2 002 323	1 977 710	–13.8	–1.2
27	Atlantic, Northeast	10 271 103	8 048 436	8 103 189	–21.1	0.7
31	Atlantic, Western Central	1 770 746	1 472 538	1 463 347	–17.4	–0.6
34	Atlantic, Eastern Central	3 549 945	4 303 664	4 056 529	14.3	–5.7
37	Mediterranean and Black Sea	1 478 694	1 436 743	1 282 090	–13.3	–10.8
41	Atlantic, Southwest	1 987 296	1 763 319	1 878 166	–5.5	6.5
47	Atlantic, Southeast	1 736 867	1 263 140	1 562 943	–10.0	23.7
51	Indian Ocean, Western	4 433 699	4 206 888	4 518 075	1.9	7.4
57	Indian Ocean, Eastern	5 333 553	7 128 047	7 395 588	38.7	3.8
61	Pacific, Northwest	19 875 552	21 429 083	21 461 956	8.0	0.2
67	Pacific, Northeast	2 915 275	2 950 858	2 915 594	0.0	–1.2
71	Pacific, Western Central	10 831 454	11 614 143	12 078 487	11.5	4.0
77	Pacific, Eastern Central	1 769 177	1 923 433	1 940 202	9.7	0.9
81	Pacific, Southwest	731 027	581 760	601 393	–17.7	3.4
87	Pacific, Southeast	10 554 479	12 287 713	8 291 844	–21.4	–32.5
18, 48, 58, 88	Arctic and Antarctic areas	142 548	197 838	178 797	25.4	–9.6
World total		**79 674 875**	**82 609 926**	**79 705 910**		

An estimated 3.7 million fishing vessels operate in marine waters globally; 68 per cent of these operate from Asia and 16 per cent from Africa. Seventy per cent are motorized, but in Africa only 36 per cent are motorized. 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 are 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).

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2. Present status of small-scale artisanal or subsistence fishing

The FAO defines small-scale, artisanal fisheries as those that are household based, use relatively small amounts of capital and remain close to shore. Their catch is primarily for local consumption. Around the world there is substantial variation as to which fisheries are considered small-scale and artisanal. The United Nations Conference on Sustainable Development (Rio+20) emphasized the role of small-scale fisheries in poverty alleviation and sustainable development. In some developing countries, including small island States, small-scale fisheries provide more than 60 per cent of protein intake. Its addition to the diets of low-income populations (including pregnant and breastfeeding mothers and young children) offers an important means for improving food security and nutrition. Small-scale fisheries make significant contributions to food security by making fish available to poor populations, and are critical to maintain the livelihoods of vulnerable populations in developing countries. Their role in production and its contribution to food security and nutrition is often underestimated or ignored; subsistence fishing is rarely included in national catch statistics (HLPE, 2014). Anyhow, the key issues in artisanal fisheries are their access both to stocks and to markets (HLPE, 2014).

Significant numbers of women work in small-scale fisheries and many indigenous peoples and their communities rely on these fisheries. The “Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security” (FAO 2012) are important in consideration of access issues. FAO also notes the linkage to international human rights law, including the right to food. Most of the people involved in small-scale fisheries live in developing countries, earn low incomes, depend on informal work, are exposed to the absence of work regulations and lack access to social protection schemes. Although the International Labour Organization adopted the Work in Fishing Convention, 2007 (No.188), progress towards ratification of the Convention has been slow.

FAO continues to encourage the establishment of fishers’ organizations and cooperatives as a means of empowerment for small-scale fishers in the management process to establish responsible fisheries policy. They have also highlighted the need to reduce post-harvest losses in small-scale fisheries as a means of improving production. Two special sections discuss these issues in SOFIA. Besides the “Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security”, FAO also adopted the “Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication” in June 2014.

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3. Impacts of capture fisheries on marine ecosystems

The effects of exploitation of marine wildlife were first perceived as a direct impact primarily on the exploited populations themselves. These concerns were recognized in the 19th and early 20th centuries (e.g., Michelet, 1875; Garstang, 1900; Charcot, 1911) and began to receive policy attention in the Stockholm Fisheries Conference of 1899 (Rozwadowski, 2002). In 1925, an attempt to globally manage "marine industries" and their impact on the ecosystems was presented before the League of Nations (Suarez, 1927), but little action was taken. Only following WWII, with rapid increases in fishing technology, was substantial overfishing in both the Atlantic and Pacific Oceans (Gulland and Carroz, 1968) acknowledged. Establishment in 1946 of FAO, with a section for fisheries, provided an initial forum for global discussions of the need for regulation of fisheries.

Capture fisheries affect marine ecosystems through a number of different mechanisms. These have been summarized many times, for example by Jennings and Kaiser (1998) who categorized effects as:

(i) The effects of fishing on predator-prey relationships, which can lead to shifts in community structure that do not revert to the original condition upon the cessation of fishing pressure (known as alternative stable states);

(ii) Fishing can alter the population size and body-size composition of species, leading to fauna composed of primarily small individual organisms (this can include the whole spectrum of organisms, from worms to whales);

(iii) Fishing can lead to genetic selection for different body and reproductive traits and can extirpate distinct local stocks;

(iv) Fishing can affect populations of non-target species (e.g., cetaceans, birds, reptiles and elasmobranch fishes) as a result of by-catches or ghost fishing;

(v) Fishing can reduce habitat complexity and perturb seabed (benthic) communities.

Here these impacts are discussed first for the species and food webs being exploited directly, and then for the other ecosystem effects on by-catches and habitats of fishing. Part VI of this Assessment provides additional detail regarding impacts on biodiversity and habitats.

3.1 Target species and communities

The removal of a substantial number of individuals of the target species affects the population structure of the target species, other species taken by the gear, and the food web. The magnitude of these effects is highly variable and depends on the species considered and the type and intensity of fishing. In general, policies and management measures were instituted first to manage the impact of fisheries on the target species, with ecosystem considerations being added to target species management primarily in the past two to three decades.

If the exploited fish stock can compensate through increased productivity because the remaining individuals grow faster and produce more larvae, with the increase in productivity extracted by the fishery, then fishing can be sustained. However, if the rate of exploitation is faster than the stock can compensate for by increasing growth and reproduction, then the removals will not be sustained and the stock will decline. At the level of the target species, sustainable exploitation rates will result in the total population biomass being reduced roughly by half, compared to unexploited conditions.

The ability of a given population of fish to compensate for increased mortality due to fishing depends in large part on the biological characteristics of the population such as growth and maturation rates, natural mortality rates and lifespan, spawning patterns and reproduction dynamics. In general, slow growing long-lived species can compensate for and therefore sustain lower exploitation rates (the proportion of the stock removed by fishing each year) than fast growing shorter lived species (Jennings et al. 1998). In addition, increased exploitation rates inherently truncate the age composition of the population unless only certain ages are targeted. This truncation results in both greater variability in population abundance through time (Hsieh et al. 2006) and greater vulnerability to changing environmental conditions, including climate impacts. Very long-lived species with low rates of reproduction may not be able to truly compensate for increased mortality, and therefore any significant fishing pressure may not be sustainable on such species. Of course there are many complicating factors, but this general pattern is important for understanding sustainable exploitation of marine species.

The concept of “maximum sustainable yield” (MSY), adopted as the goal of many national and international regulatory bodies, is based on this inherent trade-off between increasing harvests and the decreasing ability of a population to compensate for removals. Using stock size and exploitation rates that would produce MSY, or other management reference points, FAO has concluded that around 29 per cent of assessed stocks are presently overfished (biomass below the level that can produce MSY on a continuing basis; Figure 2 below). That percentage may be declining in the more recent years, but has shown little overall trend since the early 1990s. FAO estimates that if overfished stocks were rebuilt, they would yield an additional 16.5 million mt of fish worth 32 billion United States dollars in the long term (Ye et al., 2013). However, significant social and economic costs may be incurred during the transition, as many fisheries would need to reduce exploitation in the short term to allow this rebuilding.

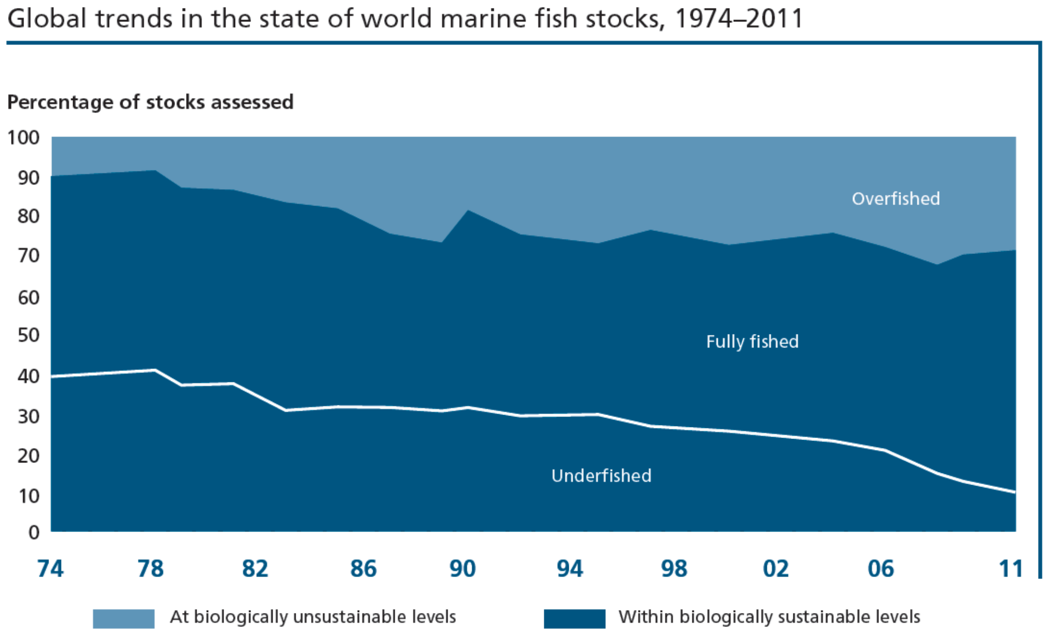

Figure 2. State of world marine fish stocks (from SOFIA, FAO 2014)

Anyhow, for many ecological reasons, the MSY is an over-simplified reference point for fisheries (Larkin, 1997; Pauly, 1994). For example, declines in productivity can result as fewer fish live to grow to a large size, because larger, older fish produce disproportionately more eggs of higher quality than younger, smaller individuals (Hixon et al. 2013). Long-term overfishing may even change the genetic pool of the species concerned, because the larger and faster-growing specimens have a greater probability of being removed, thereby reducing overall productivity (Hard et al., 2008; Ricker, 1981). Interactions between species may also mean that all stocks cannot be maintained at or above the biomass that will produce MSY. Strategies for taking these interactions into account have been developed (Polovina 1984, Townsend et al. 2008, Fulton et al. 2011; Farcas and Rossberg 2014, http://arxiv.org/abs/1412.0199), but are not yet in routine practice.

3.2 Ecosystem effects of fishing

The FAO Ecosystem approach to Fisheries (FAO 2003) has detailed guidelines describing an ecosystem approach to fisheries. The goal of such an approach is to conserve the structure, diversity and functioning of ecosystems while satisfying societal and human needs for food and the social and economic benefits of fishing (FAO 2003). There are ongoing efforts around the world to implement an ecosystem approach to fisheries that encompasses the aspects considered below, among others.

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3.3 Ecosystem effects of fishing – food webs

Marine food webs are complex and exploiting commercially important species can have a wide range of effects that propagate through the food web. These include a cascading effect along trophic levels, affecting the whole food web (Casini et al., 2008; Sieben et al., 2011). The removal of top predators may result in changes in the abundance and composition of lower trophic levels. These changes might even reach other and apparently unrelated fisheries, as has been documented, for example, for sharks and scallops (Myers et al., 2007) and sea otters, kelp, and sea urchins (Szpak et al., 2013). Because of these complexities in both population and community responses to exploitation, it is now widely argued that target harvesting rates should be less than MSY. No consensus exists on how much less, but as information about harvest amounts and stock biology is more uncertain, it is agreed that exploitation should be reduced correspondingly (FAO, 1995).

The controversial concept of "balanced harvesting" refers to a strategy that considers the sustainability of the harvest at the level of the entire food web (see, for example, Bundy, A., et al. 2005; Garcia et al., 2011; FAO 2014). Rather than harvesting a relatively small number of species at their single-species MSYs, balanced harvesting suggests there are benefits to be gained by exploiting all parts of the marine ecosystem in direct proportion to their respective productivities. It is argued that balanced harvesting gives the highest possible yield for any level of perturbation of the food web, On the other hand, the economics of the fishery may be adversely affected by requiring the harvest of larger amounts of low-value but highly productive stocks.

3.4 Other ecosystem effects of fishing by-catches

Fisheries do not catch the target species alone. All species caught or damaged that are not the target are known as by-catch; these include, *inter alia,* marine mammals, seabirds, fish, kelp, sharks, mollusks, etc. Part of the by-catch might be used, consumed or processed (incidental catch) but a significant amount is simply discarded (discards) at sea. Global discard levels are estimated to have declined since the early 1990s, but at 7.3 million tons are still high (Kelleher, 2005).

Fisheries differ greatly in their discard rates, with shrimp trawls producing by far the greatest discard ratios relative to landed catches of target species (Table 3).

Table 3. Discards of fish in major fisheries by gear type. From Kelleher, 2005.

Fishery	Landings	Discards[1]	Weighted average discard rate (%)	Range of discard rates (%)
Shrimp trawl	1 126 267	1 865 064	62.3	0–96
Demersal finfish trawl	16 050 978	1 704 107	9.6	0.5–83
Tuna and HMS longline	1 403 591	560 481	28.5	0–40
Midwater (pelagic) trawl	4 133 203	147 126	3.4	0–56
Tuna purse seine	2 673 378	144 152	5.1	0.4–10
Multigear and multispecies	6 023 146	85 436	1.4	n.a.
Mobile trap/pot	240 551	72 472	23.2	0–61
Dredge	165 660	65 373	28.3	9–60
Small pelagics purse seine	3 882 885	48 852	1.2	0–27
Demersal longline	581 560	47 257	7.5	0.5–57
Gillnet (surface/bottom/trammel)[2]	3 350 299	29 004	0.5	0–66
Handline	155 211	3 149	2.0	0–7
Tuna pole and line	818 505	3 121	0.4	0–1
Hand collection	1 134 432	1 671	0.1	0–1
Squid jig	960 432	1 601	0.1	0–1

[1] The sum of the discards presented in this table is less than the global estimate, as a number of discard database records could not be assigned to particular fisheries.

Very few time series have been found that document trends in by-catch levels for marine fisheries in general, or even for particular fisheries or species groups over longer periods. Although both Alverson et al. (1994) and Kelleher (2005) provide global estimates of discards in fisheries that differ by a factor of three, the latter source (with the lower estimate) stresses that the methodological differences between the two estimates were so large that two estimates should not be compared (a warning confirmed in the Kelleher report by the authors of the earlier report).

When even rough trend information is available, it is for particular species of concern in particular fisheries, and is usually intended to document the effectiveness of mitigation measures that have been implemented already. As an illustration, in the supplemental information to Anderson et al. (2011), which reports a global examination of longline fisheries, of the 67 fisheries for which data could be found, two estimates of seabird by-catches were available for only 17 of them. Of those, the more recent seabird by-catch estimates were at least 50 per cent lower than the earlier estimates in 15 of the fisheries, and reduced to 5 per cent or less of the earlier estimates in 10 of the fisheries. Several reasons were given, depending on the fishery; they included reduction in effort and the use of a variety of technical and occasionally temporal and/or spatial mitigation measures. These can be taken as illustrative of the potential effectiveness of mitigation efforts, but should not be extrapolated to other longline fisheries.

The more typical case is reflected in FAO Fisheries and Aquaculture Department (2009) and the report of a FAO Expert Consultation (FAO, 2010), which call for efforts to monitor by-catches and discards more consistently, in order to provide the data needed to document trends. Even the large initiative by the United States to document by-catches in fisheries (National Marine Fisheries Service, 2011) considers the reported estimates to be a starting point for gaining insight into trends in by-catch and discards.

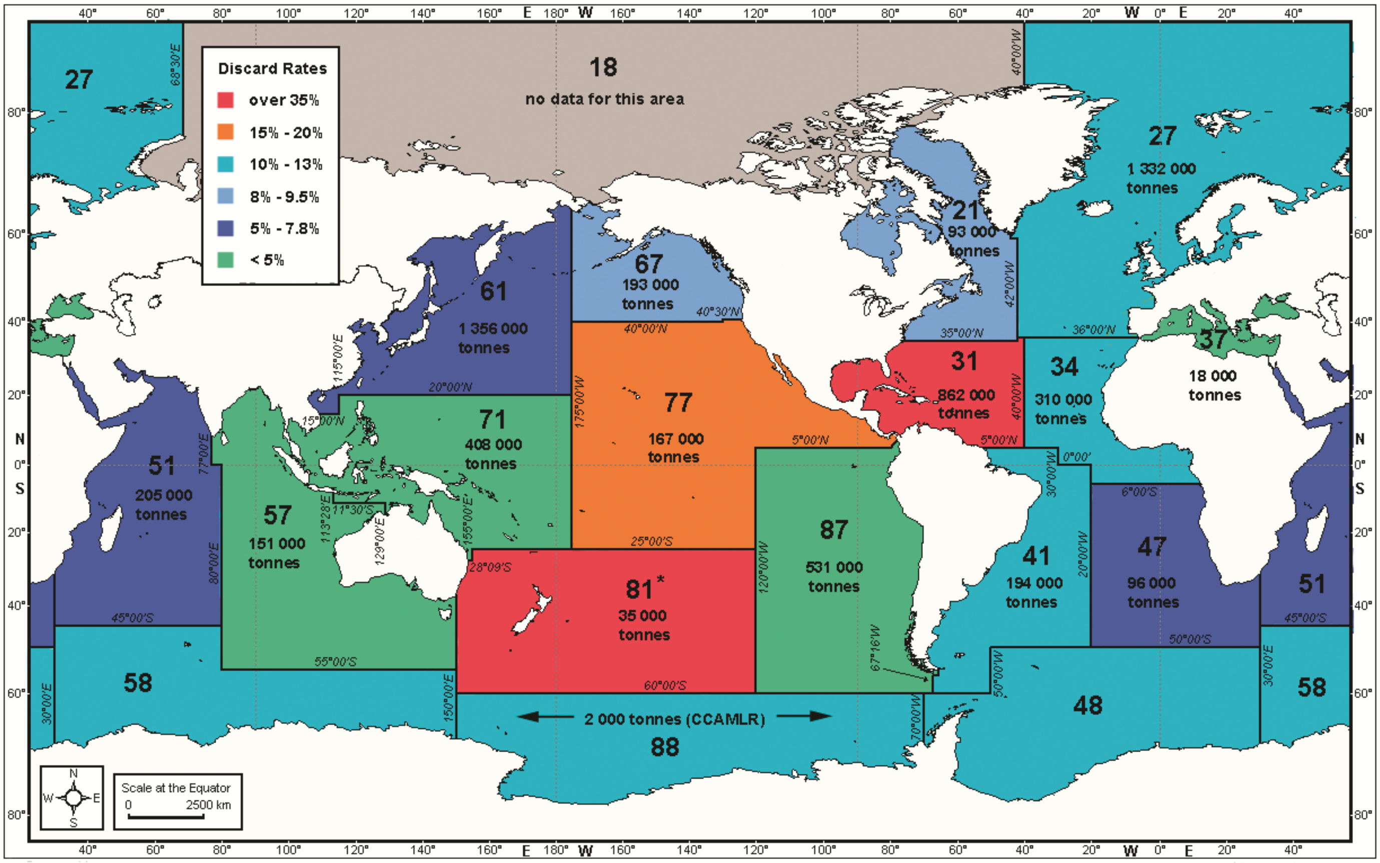
It documents the very great differences among fisheries within and among the United States fisheries management regions, but has neither tables nor figures depicting trends for any fishery.

By-catch rates may result in overfishing of species with less ability to cope with fishing pressures. The biological impact of by-catches varies greatly with the species being taken, and depends on the same life-history characteristics that were presented above for the target species of fisheries. By-catch mortality is a particular concern for small cetaceans, sea turtles and some species of seabirds and sharks and rays. These issues are discussed in the corresponding chapters in Part VI on marine mammals (Chapter 37), seabirds (38), marine reptiles (39) and elasmobranchs (40). In general, long-lived and slow-growing species are the most affected (Hall et al., 2000). Thus, the benchmarks set for a given fishery also consider by-catch species.

The geographic distribution of discard rates is shown in Figure 3 (from Kelleher, 2005).

The numbers in bold are the FAO Statistical Areas and the tonnages are of by-catch. By-catches are clearly a global issue, and can be addressed from local to global scales. The review by Kelleher (2005) reports a very large number of cases where measures have been implemented by States, by international organizations, or proactively by the fishing industry (especially when the industry is seeking independent certification for sustainability), and by-catch and discard rates have decreased and in a few cases been even eliminated.

A recent global review of practices by regional fisheries management organizations and arrangements (RFMO/As) for deep sea fisheries found that all RFMO/As have adopted some policies and measures to address by-catch issues in fisheries in their regulatory areas. However, almost nowhere was full monitoring in place to document effectiveness of these policies (UNEP/CBD/FAO, 2011). Nevertheless, extensive evidence exists that by-catches can be mitigated by changes in fishing gear, times, and places, and the incremental cost is often, but not always, small.



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 3. Distribution of discards by FAO statistical areas (numbers in bold are FAO statistical areas, catches in tons). * Note: the high discard rate in FAO Area 81 is a data artefact. Source: Kelleher, 2005.

At the global level, calls for action on by-catch and discards have been raised at the United Nations General Assembly, including in UNGA resolutions on sustainable fisheries and at the Committee on Fisheries. In response, FAO developed International Guidelines on Bycatch Management and Reduction of Discards; these were accepted in 2011 (FAO, 2011).

3.5 Ecosystem effects of fishing – benthic and demersal habitats

Fishing gear impacts on the seafloor and other habitats depend on the gear design and use, as well as on the particular environmental features. For example, in benthic habitats, substrate type and the natural disturbance regime are particularly important (Collie et al., 2000). Mobile bottom-contacting gear (including bottom trawls) also can resuspend sediments, mobilizing contaminants and particles with unknown ecological effects on both benthic and demersal habitats (Kaiser et al., 2001).

A very large literature exists on habitat impacts of fishing gear; experts disagree on both the magnitude of the issue and the effectiveness of management measures and policies to address the impacts. In the late 2000s, several expert reviews were conducted by FAO and the Convention on Biological Diversity in cooperation with UNEP. These reports (FAO, 2007; 2009) provide a recent summary of the types of impacts that various types of fishing gear can have on the seafloor. Most conclusions are straightforward:

- All types of gear that contact the bottom may alter habitat features, with impacts larger as the gear becomes heavier.
- Mobile bottom-contacting gear generally has a larger area of impact on the seabed than static gear, and consequently the impacts may be correspondingly larger.
- The nature of the impact depends on the features of the habitat. Structurally complex and fragile habitats are most vulnerable to impacts, with biogenic features, such as corals and glass sponges, easily damaged and sometimes requiring centuries to recover. On the other hand, impacts of trawls on soft substrates, like mud and sand, may not be detectable after even a few days.
- The nature of the impacts also depends on the natural disturbance regime, with high-energy (strong current and/or wave action) habitats often showing little incremental impacts of fishing gear, whereas areas of very low natural disturbance may be more severely affected by fishing gears.
- Impacts of fishing gears can occur at all scales of fishery operations; some of the most destructive practices, such as drive netting, dynamite and poisons, although uncommon, are used only in very small-scale fisheries (Kaiser 2001).

All gear might be lost or discarded at sea, in particular pieces of netting. These give rise to what is known as “ghost fishing”, that is fishing gear continuing to capture and kill marine animals even after it is lost by fishermen. Assessment of their impacts at either a global or local level is difficult, but the limited number of studies available on its incidence and prevalence indicate that ghost fishing can be a significant problem (Laist et al., 1999, Bilkovic et al. 2012).

Quantitative trend information on habitat impacts is generally not available. Many reports provide maps of how the geographical extent and intensity of bottom-contacting fishing gear have changed over time (e.g. Figure 4 from Gilkinson et al., 2006; Greenstreet et al., 2006). These maps show large changes in the patterns of the pressure, and accompanying graphs show the percentage of area fished over a series of years. However, these are individual studies, and broad-scale monitoring of benthic communities is not available. Insights from individual studies need to be considered along with information on the substrate types in the areas being fished to know how increases in effort may be increasing benthic impacts. Furthermore, the recovery potential of the benthic biota has been studied in some specific geographies and circumstances but broadly applicable patterns are not yet clear (e.g., Steele et al. 2002, Claudet et al. 2008).

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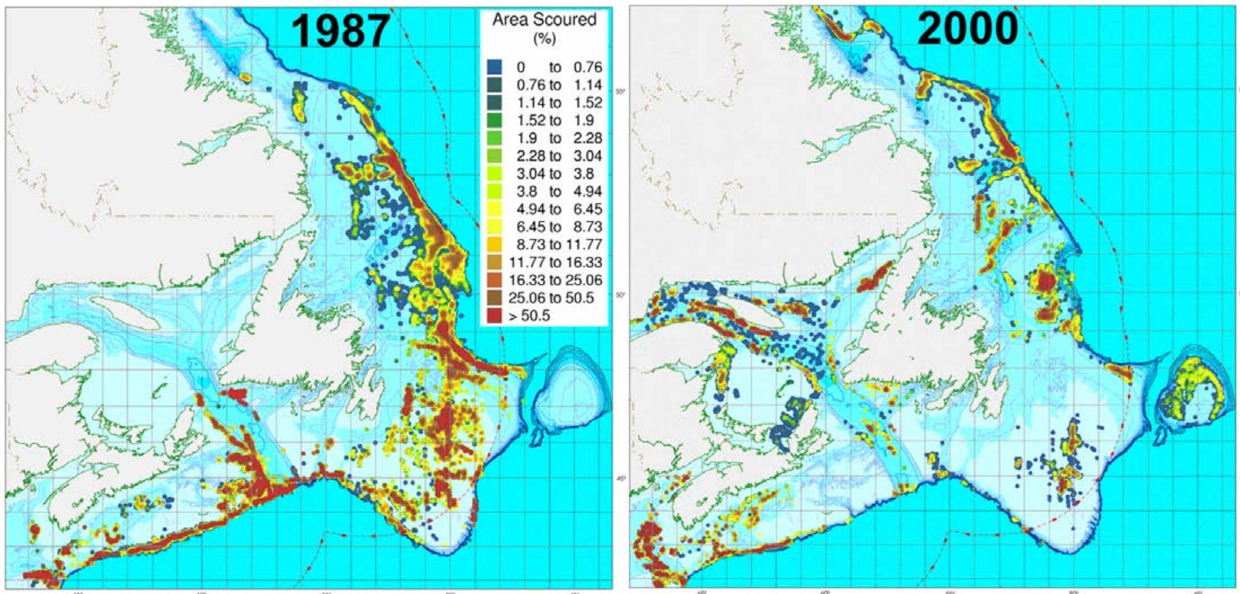

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 4. Distribution of trawling effort in Atlantic Canadian waters in 1987 and 2000, based on data of bottom-trawl activity adjusted to total effort for <150 t. From Gilkinson et al., 2006.

Even without quantitative data on trends in benthic communities, however, marine areas closed to fishing have increased. Views differ on what level of protection is actually given to areas that are labelled as closed to fishing, but the trend in increasing area protection is not challenged (c.f. CBD, 2012; Spalding et al., 2013). Moreover, the size of the areas being closed to fishing that are not already affected by historical fishing is unknown, as is the recovery rate for such areas, and high-seas fisheries continue to expand into new areas, although probably at a slower rate as RFMO/As increase their actions to implement United Nations General Assembly Resolution 61/105 (FAO, 2014). Hence the pressure on seafloor habitats and benthic communities from bottom-contacting fishing gear may be decreasing slightly, but has been very high for decades on all continental shelves and in many offshore areas at depths of less than several hundred meters (FAO, 2007).

4. Effects of pollution on seafood safety

Fish and particularly predatory fish are prone to be contaminated with toxic chemicals in the marine environment (e.g., organochlorines, mercury, cadmium, lead); these are found mostly in their liver and lipids. Because many sources of marine contamination are land-based (Chapter 20), freshwater fish may contain higher concentrations of contaminants than marine species (Yamada et al., 2014). Furthermore, contamination of the organisms found there is highly variable at the regional and local levels.

Processing methods might significantly reduce the lead and cadmium contents of fish (Ganjavi et al., 2010) and presumably those of other contaminants, whose concentrations generally increase with size (age) of fish (Storelli et al., 2010).

Some species of fish might be toxic (venomous) on their own, such as species of the genus *Siganus* and *Plotosus* in Singapore, which are being culled to reduce their presence on beaches (Kwik, 2012) and *Takifugu rubripes* (fugu), whose properties are relatively well known, such that it is processed accordingly (Yongxiang et al., 2011). However, in extreme situations, human consumption of the remains of fugu processing resulted in severe episodes (Saiful Islam et al., 2011).

Fish, mussels, shrimp and other invertebrates might become toxic through their consumption of harmful algae, whose blooms increased due to climate change, pollution, the spreading of dead (hypoxic/anoxic) zones, and other causes.

Harmful algal blooms are often colloquially known as red tides. These blooms are most common in coastal marine ecosystems but also the open ocean might be affected and are caused by blooms of microscopic algae (including cyanobacteria). Toxins produced by these organisms are accumulated by filtrators that become toxic for species at higher trophic levels, including man. Climate change and eutrophication are considered as part of a complex of environmental stressors resulting in harmful blooms (Anderson et al., 2012). The problem has prompted research to develop models to predict the behaviour of these blooms (Zhao and Ghedira, 2014). Since the 1970s, the phenomenon has spread from the northern hemisphere temperate waters to the southern hemisphere and has now been well documented at least in Argentina, Australia, Brunei Darussalam, China, Malaysia, Papua New Guinea, the Philippines, Republic of Korea and South Africa, but the expansion might also be due to increased awareness of the phenomenon (Anderson et al., 2012) The impact of toxic algal blooms is mostly economic, but episodes of severe illness, even with high mortality rates, might occur, which prompt regulations closing the affected fisheries.

One of the best-known risks in this category is ciguatera, a well-known toxin ingested by human consumption of predatory fish in some regions of the world. The toxin comes from a dinoflagellate and is passed along and concentrated up the food chain (Hamilton et al., 2010). Processed foods are usually safer from the standpoint of contamination. Thus, processing results in added value to the raw food (Satyanarayana et al., 2012). However, inadequate harvest and postharvest handling and processing of the catches might result in contamination with pathogenic organisms (Boziaris et al., 2013).

The general trend expected is an increase in the frequency of harmful algal blooms, in the bioaccumulation of chemical contaminants and in the prevalence of common food-borne pathogenic microorganisms (Marques et al., 2014), although the occurrence of catastrophic events seems to be diminishing.

5. Illegal, unreported and unregulated (IUU) fishing

The FAO International Plan of Action for IUU fishing (FAO 2001) defines IUU fishing as:

- Illegal fishing refers to activities conducted by national or foreign vessels in waters under the jurisdiction of a State, without the permission of that State, or in contravention of its laws and regulations; conducted by vessels flying the flag of States that are parties to a relevant regional fisheries management organization but operate in contravention of the conservation and management measures adopted by that organization and by which the States are bound, or relevant provisions of the applicable international law; or in violation of national laws or international obligations, including those undertaken by cooperating States to a relevant regional fisheries management organization;

- Unreported fishing refers to fishing activities which have not been reported, or have been misreported, to the relevant national authority, in contravention of national laws and regulations; or undertaken in the area of competence of a relevant regional fisheries management organization which have not been reported or have been misreported, in contravention of the reporting procedures of that organization;

- Unregulated fishing refers to fishing activities in the area of application of a relevant regional fisheries management organization that are conducted by vessels without nationality, or by those flying the flag of a State not party to that organization, or by a fishing entity, in a manner that is not consistent with or contravenes the conservation and management measures of that organization; or in areas or for fish stocks in relation to which there are no applicable conservation or management measures and where such fishing activities are conducted in a manner inconsistent with State responsibilities for the conservation of living marine resources under international law.

Notwithstanding the definitions above, certain forms of unregulated fishing may not always be in violation of applicable international law, and may not require the application of measures envisaged under the International Plan of Action (IPOA). FAO considers IUU fishing to be a major global threat to sustainable management of fisheries and to stable socio-economic conditions for many small-scale fishing communities. This illegal fishing not only undermines responsible fisheries management, but also typically raises concerns about working conditions and safety. Illegal fishing also raises concerns about connections to other criminal actions, such as drugs and human trafficking. IUU fishing activity has escalated over the last two decades and is estimated to take 11-26 million mt of fish per annum with a value of 10-23 billion United States dollars. In other words, IUU fishing is responsible for about the same amount of global harvest as would be gained by ending overfishing and rebuilding fish stocks. It is an issue of equal concern on a global scale.

International efforts by RFMO/As, States and the European Union are aimed at eliminating IUU fishing. FAO notes that progress has been slow and suggested (FAO 2014) that better information-sharing regarding fishing vessels engaged in illegal activities, traceability of vessels and fishery products, and other additional measures might improve the situation.

6. Significant economic and/or social aspects of capture fisheries

Capture fisheries are a key source of nutrition and employment for millions of people around the world. FAO (2014) estimates that 800 million people are still malnourished and small-scale fisheries in particular are an important component of efforts to alleviate both hunger and poverty.

Growth in production of fish for food (3.2 per cent *per annum*) has exceeded human population growth (1.6 *per annum*) over the last half century. Recently the growth of aquaculture, which is among the fastest-growing food-producing sectors globally, has formed a major part of meeting rising demand and now accounts for half of the fish produced for human consumption. By 2030 this figure will rise to two-thirds of fish production.

Per capita consumption of fish has risen from 9.9 kg *per annum* to 19.2 kg in 2012. In developing countries this rise is from 5.2 kg to 17.8 kg. In 2010, fish accounted for 16.7 per cent of the global population's consumption of animal protein and 4.3 billion people obtained 15 per cent of their animal protein from fishery products.

Employment in the fisheries sector has also grown faster than the world population and faster than in agriculture. However, of the 58.3 million people employed in the fishery sector, 83 per cent were employed in capture fisheries in 1990. But employment in capture fisheries has decreased to 68 per cent of total fishery sector employment in 2012 according to FAO (2014) statistics.

7. The future status of fish and shellfish stocks over the next decade

World population growth, together with urbanization, increasing development, income and living standards, all point to an increasing demand for seafood. Capture fisheries provide high-quality food that is high in protein, essential amino acids, and long-chain poly-unsaturated fatty acids, with many benefits for human health. The rate of increase in demand for fish was more than 2.5 per cent since 1950 and is likely to continue (HPLE, 2014).

Climate change is expected to have substantial and unexpected effects on the marine environment as detailed throughout this Assessment. Some of these impacts may not negatively impact fisheries and indeed may result in increased availability for capture fisheries in some areas. Nevertheless, there will certainly be an increase in uncertainty with regard to effects on stock productivities and distributions, habitat stability, ecosystem interactions, and the configuration of ecosystems around the globe. Whether these effects on the resources will be “mild” or “severe” will require prudent fisheries management that is precautionary enough to be prepared to assist fishers, their communities and, in general, stakeholders in adapting to the social and economic consequences of climate change (Grafton, 2009).

Small-scale, artisanal fisheries are likely to be more vulnerable to the impacts of climate change and increasing uncertainty than large-scale fisheries (Roessig et al. 2004). While small-scale fisheries may be able to economically harvest a changing mix of species, varying distribution patterns and productivity of stocks may have severe consequences for subsistence fishing. Further, the value of small-scale fisheries as providers not only of food, but also of livelihoods and for poverty alleviation will be compromised by direct competition with large-scale operations with access to global markets (Alder and Sumaila, 2004).

The data clearly indicate that the amount of fish that can be extracted from historically exploited wild stocks is unlikely to increase substantially. Some increase is possible through the rebuilding of depleted stocks, a central goal of fisheries management. Current trends diverge between well-assessed regions showing stabilization of fish biomass and other regions continuing to decline (Worm and Branch, 2012).

In Europe, North America and Oceania, major commercially exploited fish stocks are currently stable, with the prospect that reduced exploitation rates should achieve rebuilding of the biomass in the long term. In the rest of the world, fish biomass is, on average, declining due to lower management capacity. Many fisheries may still be productive, but prospects are poor (Worm et al., 2009).

The growing demand for fish products cannot be met from sustainable capture fisheries in the next decade. On the other hand, the potential for sustainable exploitation of non-traditional stocks is not well known. Particularly in light of the growth of the aquaculture sector with a need for fishmeal for feed, the pressure to exploit non-traditional resources will increase even if the impacts on marine ecosystems are not well understood.

8. Identify gaps in capacity to engage in capture fisheries and to assess the environmental, social and economic aspects of capture fisheries and the status and trends of living marine resources

Rebuilding overfished stocks is a major challenge for capture fisheries management. Another key challenge is making better, more sustainable use of existing marine resources while conserving the ecosystem upon which they depend. From a global perspective this will require filling a number of gaps, both scientific and in management capacity (Worm et al., 2009):

- The transfer of fishing effort from developed to developing countries is a process that has been accelerating since the 1960s. Almost all of the fish caught by foreign fleets is consumed in industrialized countries and will have important implications for food security (Alder and Sumaila, 2004) and biodiversity in the developing world. In many regions there is insufficient capacity to assess and manage marine resources in the context of this pressure;

- The increase in IUU fishing operations is a major challenge for management that will require increased management capacity if it is to be controlled;

- Recovery of depleted stocks is still a poorly understood process, particularly for demersal species. It is potentially constrained by the magnitude of the previous decline, the loss of biodiversity, species' life histories, species interactions, and other factors. In other words, the basic principle for recovery is straightforward – fishing pressure needs to be reduced. But the specific application of plans to promote recovery of the stock once fishing pressure is reduced requires significant scientific and management capacity;

- Addressing the challenges of spatial management of the ocean for fisheries, conservation and many other purposes, and the overall competition for ocean space, will depend upon greater scientific and management capacity in most regions.

The average performance of stock-assessed fisheries indicates that most are slowly approaching the fully fished status (*sensu* FAO). On the other hand, recent analyses of unassessed fish stocks indicate that they are mostly in poorer condition (Costello et al., 2012). The problem is severe because most of these stocks sustain small-scale fisheries critical for the food security in developing countries. Better information and the capacity to manage many of these stocks will be needed to improve the situation.

Debates among fisheries specialists have been more concerned about biological sustainability and economic efficiencies than about reducing hunger and malnutrition and supporting livelihoods (HLPE, 2014). It is necessary to develop the tools for managing small-scale fisheries efficiently, particularly in view of the competing long-distance fleets. The fishing agreements allowing long-distance fleets to operate in developing countries had not yielded the expected results in terms of building the capacity to administer or sustainably fish their resources. IUU fishing becoming more prominent has exacerbated the situation (Gagern and van den Bergh, 2013). It is necessary for developing countries to build the capacity to develop sustainable industrial fisheries and to develop stock assessment capabilities for small-scale fisheries balancing food security and conservation objectives (Allison and Horemans, 2006).

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