Executive Summary

In recent decades landings of commercial fisheries have fallen in most fishing areas. Although most experts agree that human over-fishing is responsible for the decline of commercially relevant fish stocks and have discussed various strategies for the realization of a precautionary approach, recently a new hypothesis has been introduced: Whales have been accused to directly compete with commercial fisheries.

This report critically analyses the reasons for the crisis in commercial fisheries. An overview of the industrialization of fisheries and consequences for target and non-target species is given. To examine whether the hypothesis of a competition between whales and fisheries is justified, special emphasis is given to the current situation of five representative fish species – cod, herring, haddock, capelin and sandeel – as well as past and present stock size of whales. The paper shows that the role of whales regarding the breakdown of commercially relevant fish stocks is negligible in comparison to the tremendous impact of commercial fisheries. Furthermore, a culling of whales would obviously not result in increasing volumes in commercial landings. In conclusion, the argument that whales compete with commercial fisheries should be rejected as an attempt to justify the resumption of commercial whaling.

Content

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1. Introduction

Commercial fisheries are in crisis. As recently as 1997, the Food and Agriculture Organisation of the United Nations (FAO) classified 40% of commercially-relevant fish stocks as developing (stocks that still have potential for commercial fishery) and 60% of stocks as over-exploited or harvested at a maximum yield. By 2000, the share of developing stocks had dropped to 25-27% and stocks for which strong management was needed increased to 73-75% (FAO 2000, 1997). The percentage of fish stocks classified as over-exploited has been increasing continuously since 1960, even as worldwide landings have, since the late 1980s, stagnated (Safina 1996). In some areas fish stocks of commercial interest fell in size by fifty per cent over the course of just one or two decades (AAAS 2002, Fisheries Agency of Japan 2001; Kemf *et al.* 1996).

Effective fishing techniques and high-tech equipment in modern commercial capture fisheries initially led to significant increases in landings: from 18 million tonnes in 1950 to 56 million tonnes in 1969, an average growth of 6% per year. But this rate declined to 2% per year in the 1970s and 1980s and dropped to almost zero in the 1990s (FAO 2000a). Since then, annual marine fisheries production has fluctuated in the range of 85-90 million tonnes (Garcia & de Leiva Moreno 2001). Clearly, marine fisheries production has reached its peak – not from the technical aspect, which is still capable of development, but from the ecological capacity of stocks to compensate for fishery-induced losses. According to FAO (2000), it is unlikely that substantial improvements in total catches can be obtained, as there are only a few areas remaining with the potential for increases in production.

One response to the alarming declines of many commercially-valuable fish stocks was the development of a "precautionary approach" to fisheries (e.g. FAO Code of Conduct for Responsible Fisheries, adopted in 1995): an approach in which parameters such as catch quotas, fishing techniques, and fleet capacities are analysed to reduce commercial fisheries to a sustainable level and to enable the recovery of fish stocks. Recently, however, some have proposed an alternative solution: the "culling" of whale populations -- which, it is claimed, are competing directly with commercial fisheries (Fisheries Agency of Japan 2001; JWA 1999; Institute of Cetacean Research 1999a, b). The Japanese Institute of Cetacean Research (undated), closely related to the Japanese Government, claims that: "*Whales are consuming five times more fish resources than humans… Thus utilization of whales could lead to an increase of fish catches for human consumption*".

The aim of this paper is to examine whether the consumption of marine resources by whales is really responsible for dwindling fish stocks. The analysis reviews the industrialization of commercial fisheries (section 2), corresponding landing volumes, and the development of stocks of both whales and some fish over the last century (sections 3, 4 and 5). Finally, responsibility for the collapse of fish stocks, and appropriate management strategies, are addressed in section 6.

2. Industrialisation of Commercial Fisheries

Since 1948 world marine fisheries production has officially increased from 20 million tonnes to about 90 million tonnes per year (FAO 2000, see figure 1). However, considering discards, which are estimated to account for an additional 20 to 27 million tonnes, and an unknown catch volume of insufficiently recorded small-scale fisheries, the total volume annually removed from the ocean must exceed 150 million tonnes (Hubold 2000).

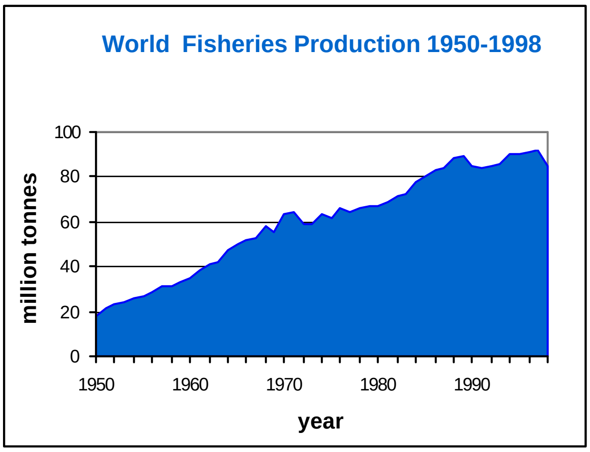


Figure 1: Increase of world capture fisheries production between 1950 and 1998, data based on FAO (2000)

The increase in world fisheries production was a result of the industrialisation of fishing fleets in the 1950s and 1960s, when techniques originally developed for military purposes were adapted to the needs of capture fisheries. (Between 1970 and 1990 the size of the global fishing fleet increased twice as rapidly as landings). A large proportion of the world's fish catch is landed by these large-scale commercial fisheries, which are highly mechanised and very effective (FAO 2000b) – so effective, in fact, they take 80-90% of some stocks annually (Safina 1996). However, most small-scale commercial fisheries are poorly documented and controlled, and may also contribute to possible over-exploitation of fish stocks (FAO 2000b).

2.1. Technical Innovations in Commercial Fisheries

Although large industrial ships account for only 1% of the global fishing fleet, they are responsible for about 50% of total landings (Hubold 2000). Equipped with modern navigation and communication techniques these ships are able to locate shoals of fish from great distances and to co-ordinate fishing activities within their fleet. Additionally, nets of enormous size are used – for example, up to 3.5 kilometres length and 150 meter height for pelagic cod trawling (Anon. 1997). Longlines of up to 130 kilometres length are also in use (Safina 1996). Many technological innovations have had tremendous effects on the efficiency of commercial fisheries, e.g. electronic aids for navigation and fishing (satellite communication, Global Positioning System (GPS), echolot, ultra-sonic and radar), new net fibres and the introduction of multirig trawling (FAO 2000a; Safina 1996).

Developed countries in particular now frequently must contend with the fact their favoured fish stocks are fully or overexploited (FAO 2000a). The situation is exacerbated by increasing overcapitalisation. Despite the fact that stocks of many target species are in decline, hundreds of new vessels have been registered within the last few years, with Spain (99), other countries of the EU (82), USA (75), Japan (56), Belize (47), and Norway (43) being the dominant nations (FAO 2000a). Although in total some nations reduced their fleets by numbers, registration of new well-equipped vessels may increase landing capacities. As a consequence, stock rebuilding and capacity reduction are the most relevant aspects for management of marine fisheries (see section 6.2.)

Fish stocks of commercial interest are classified in fish for consumption ("food fish" as Alaska pollock, cod, herring etc.) and fish for industrial processes to produce fishmeal and fish oil (e.g. sandeel, capelin, anchoveta).

2.2. Fishmeal and Fish Oil

Fishmeal and oil are commonly produced from small pelagic fish species. According to the FAO (2000), fishmeal production for 1999 is estimated at 6.6 million tonnes, which is close to the annual average from 1976 to 1997. More than 50% is used in poultry production, 20% in pig production, and 25% in aquaculture.

In 1999, world fish oil production reached 1.2 million tonnes, up from 0.8 million tonnes in 1998 (FAO 2000a). Fish oil is consumed by the food industry and aquaculture (Hubold 2000; FAO 2000).

2.3. Causes of Over-exploitation

Although recent technical innovations led to increased catches by marine fisheries, fishermen's knowledge of fish stocks and biology is still mainly based on personal observation and experience, with little understanding of biological and ecological considerations (Hubold 2000). Management of marine fisheries is mainly conducted on a "species-by-species" basis: Complexity in the dynamics of fish stocks – and even more of fish communities – in their highly variable environments is difficult to assess. The natural high variability of fish populations may hide effects of overexploitation and consequently contribute to the biological uncertainty which is inherent to fisheries management (Butterworth & Punt 2001; Cochrane 2000). Interspecific relationships, for example between predator and prey species, are often neglected or even ignored (see section 4.2), even though fundamental knowledge on those interdependencies is vital for long-term sustainable fisheries.

Several factors contribute to commercial over-fishing, including the setting of quotas that are too high, high

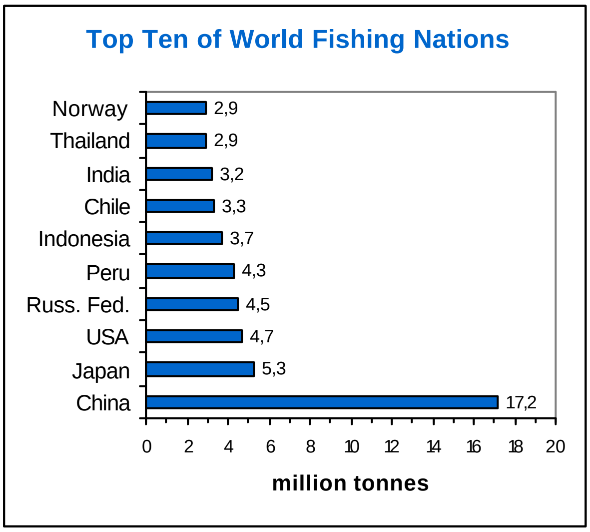


Figure 2: Landing volume of top ten of world fishing nations, according to FAO (2000)

percentage of discards (section 4.1), highgrading (the waste of legal landing that contains specimens with suboptimal size enables fishermen to go for another catch), underreporting (unallocated catches), illegal fishing activities (exceeding quota, fishing in closed areas, use of undersized meshes), registration of fishing fleets under flags of convenience to escape from stronger fisheries management measures, and insufficient national and international controls and enforcement. Whole sections of commercial fisheries are almost unregulated, e.g. the rapidly growing shrimp fisheries: Although the total number of fishing vessels is limited, as are mesh size and the amount of nets, the absence of catch limits means fishermen may go for hauls as often as they like (Neudecker 2000).

In recent decades, several management bodies for fisheries, including the *International Commission for the Conservation of Atlantic Tunas* (ICCAT) and the *Convention of the Conservation of Antarctic Marine Living Resources* (CCAMLR), have been founded to address the depletion of commercial fish stocks. However, enforcement of agreements and national restrictions is weak.

3. Impact of Commercial Fisheries on Target Species

Although more than 13,000 marine fish species are known and 9,000 species are exploited in some way (Gaski 1993), landing volumes mainly consist of about 200 species (Hubold 2000). A significant impact of commercial fisheries on the structure of fish stocks has been proven for many target-species, which show a wide age and size range in reserves due to a lower adult mortality compared to exploited stocks (Bergstad & Hoines 2001; Mosquera *et al.* 2000). Imbalances in target stock populations and erosion of genetic diversity lead to a long-term decline in target stocks (de Fontaubert *et al.* 1996).

3.1. Bony fishes

For several species of different trophic levels recent publications have claimed direct competition between commercial fisheries and whales (e.g., Folkow *et al.* 2000; Sigurjonsson *et al.* 2000; Schweder *et al.* 2000; Neve 2000). However, an analysis of their population trends indicates that although all of them are partially consumed by whales, only stocks of high trophic levels that are especially relevant for commercial fisheries have collapsed due to over-exploitation:

- Cod (piscivorous): Fishery-induced mortality is the outstanding parameter that influences this species' negative population trends (Hubold 2000). Stocks of cod in most relevant fisheries areas have dramatically collapsed due to intensified fishery activities and are still far outside biological safe limits (more details in Annex A).
- Herring (piscivorous): In the late 60s herring stocks in the North Atlantic collapsed (IMF 2002). Due to local over-fishing, stocks in several areas have been drastically decimated, and a reduction of landings is overdue (more details in Annex B).
- Haddock (piscivorous): Stocks in several commercially exploited areas have been seriously decimated and are below biological safe limits (Hammer 2001a). For more details see Annex C.
- Sandeel (bottom prey): Conditions of stocks are comparatively stable. Nevertheless ICES recommends not exceeding present landing volumes and distributing fishing grounds to different areas (Hammer 2001b). For more details see Annex D.
- Capelin (bottom prey): In general, stocks of capelin are comparatively stable at present and biomass is above safe biological limits (Hammer 2001a), although stocks are susceptible to local over-exploitation (more details in Annex E).

Additionally, the collapse of many other fish stocks of commercial interest has been documented in the recent past, e.g.:

- Landings by volume of Northern Bluefin Tuna fell by 87% over the last two decades (Kemf *et al.* 1996; Gaski 1993). Western Atlantic populations are now classified as "critically endangered", eastern Atlantic as "endangered" (IUCN 2000).
- Landings of Southern Bluefin Tuna declined from a high of more than 80,000 metric tonnes in 1961 to less than 15,000 metric tonnes in 1990 (Kemf *et al.* 1996). The species is now classified as "critically endangered" (IUCN 2000).
- Patagonian toothfish only recently has become a high-value target species in Antarctic waters, but stocks sharply declined within a short period and commercial extinction must be feared. Pirate fisheries take more than 80% of toothfish catches (Clark & Hemmings 2001; Hubold 2000).
- Catches of Alaska Pollock in the Northern Pacific have continuously decreased since the mid 1980s, when landings exceeded 6 million tonnes (FAO 2000a; Hubold 2000).
- Stocks of Argentine shortfin squid and Argentine hake in the Southwest Atlantic have recently become seriously depleted (FAO 2000a).
- Anchoveta and horse mackerel in the Southeast Pacific have also undergone severe declines (FAO 2000a).

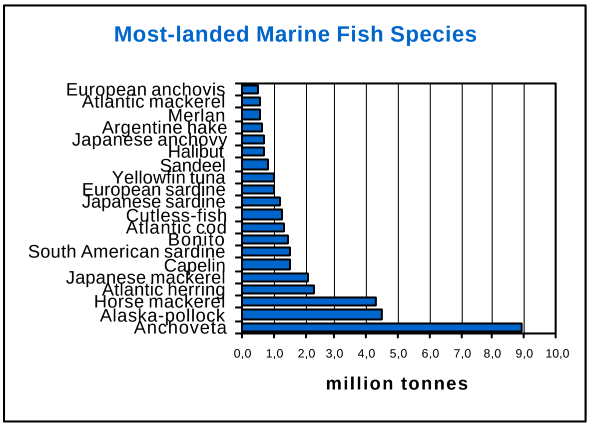


Figure 3: Most landed marine fish species (based on FAO 1998)

3.2. Cartilaginous fishes

Species with a high reproduction rate, rapid growth, and high ecological plasticity are less susceptible to over-fishing than others. These traits do not apply to species such as sharks and rays, which are ill-suited for commercial fisheries exploitation (FAO 1994b). Nevertheless, landings of sharks (400 species), rays (500 species) and chimeras (35 species) have dramatically increased since 1950: From 272,000 tonnes? to 760,000 tonnes? in 1996 (Hubold 2000). Add levels of shark by-catch in fisheries worldwide, which may reach as much as 50% of official landings, and the actual total may, according to FAO (1994b), reach 1-1.35 million tonnes per year. As a consequence, more than 20 sharks species are classified as over-fished, including spiny dogfish in the North Sea and Northwest Atlantic (Hubold 2000).

3.3. Other Invertebrates

A variety of invertebrates are increasingly targeted by commercial fisheries. Invertebrates have long been considered resistant to over-fishing, but populations of some species that have been exploited for centuries have recently undergone severe declines as a result of over-exploitation. Within the last 30 years the population of white abalone off California and Mexico has collapsed to less than 0.1% of its estimated pre-exploitation size (Hobday *et al.* 2001). Declines have also been documented for, among others, queen conches (Mulliken 1996), sea cucumbers (Jenkins & Mulliken 1999), giant clams (Sant 1995), and Red and Brown King Crab (Orensanz *et al.* 1998).

Antarctic krill (*Euphausia superba*), is a key component of the Southern Ocean ecosystem (Atkinson *et al.* 2001). Its annual recruitment strongly varies, depending for example on the length and strength of winter. Since 1973 commercial fisheries have increasingly exploited krill (Clark & Hemmings 2001; Siegel 2000). Shortly after the onset of a commercial fishery catches reached a maximum of 500,000 tonnes annually, stabilised around 100,000 tonnes in recent years, but are expected to again increase in the near future (Clark &

Hemmings 2001; Siegel 2000). Krill fishing has changed from products oriented toward human consumption to products that are primarily destined for aquaculture (see also section 2.2), with krill meal as a substitute for fishmeal (Siegel 2000; Anon. 1999a). Nevertheless, the market for human consumption is still relevant. The principal krill fishing nations are Japan, Poland, Uruguay, Korea, and Ukraine. Russia, South Africa, the United Kingdom, and the United States have recently indicated their intention to launch krill fishing (Clark & Hemmings 2001). Previous estimates of a total krill biomass of 500 million tonnes have been corrected downwards to 62-137 million tonnes (Anon. 1999a). The *Commission on the Conservation of Antarctic Marine Living Resources* (CCAMLR) has expressed concern at the rapid escalation of fisheries for krill over the last two decades (Clark & Hemmings 2001).

4. Impact of Fisheries on Non-Target Species

The present extent and techniques of industrialized fisheries have severe consequences for target species but also second order and cumulative effects on biodiversity because of destructive and unselective harvesting methods and depletion of certain stocks and species (de Fontaubert *et al.* 1996). Shrimp trawling, which is mainly conducted using bottom trawls, is known as one of the most destructive fishing techniques. Bottom trawling scrapes and plows up to 30 cm into the sea bed, suspending sediments and destroying benthic organisms. As a consequence, the ability of sea-bed organisms to adapt to environmental changes is reduced, in the process also impacting those species that prey on them (de Fontaubert *et al.* 1996).

4.1. By-catch, Discards & Waste

One of the most severe problems caused by commercial fisheries is the by-catch of non-target species and undersized specimens of target species. Unwanted and discarded by-catch is estimated at between 20 and 30 million tonnes, or approximately 25% of landings by commercial marine fisheries (Münkner 2001; Alverson *et al.* 1994). In general, the condition of by-catch organisms after discarding is poor, and mortality often reaches 100% (Münkner 2001; FAO 1994).

Shrimp trawling has one of the highest rates of by-catch: In tropical shrimp fisheries it frequently includes large numbers of sharks and sea turtles and be ten times the size of landings (Münkner 2001; Safina 1996; de Fontaubert *et al.* 1996).

By-catch of dolphins was frequently observed in drift-net fishery and purse seine fisheries (Safina 1996; Kemf *et al.* 1996; FAO 2000a). Until 1973, in the eastern tropical Pacific 350,000-654,000 dolphins were annually killed in the yellowfin tuna fishery; annual dolphin mortality declined to around 50,000 by the end of the 1970s, increased to 130,000 by 1986, and as a result of international agreements and monitoring measures has now been reduced to approximately 3,000 (Hall 1996). Tens of thousands of seabirds such as albatrosses are killed as by-catch in longline fisheries each year (Hubold 2000; Safina 1996).

The extent and volume of by-catch, and the species involved, vary according to geography and fishing methods. Trawls, for example, are especially unselective, resulting in a high portion of by-catch. This has been described in detail for, among many other examples, cod fisheries in the East Sea, where in just one season the German cod trawl fishery discarded almost seven million juvenile and undersized cod (Ernst *et al.* 2000). In Arctic regions, the percentage of undersized individuals of target fish species was reported to reach up to 77% (Hanly 1997).

Several trawl fisheries now use selective grids and square meshes to reduce by-catch (Münkner 2001). Furthermore, fishing techniques that depend on behavioural differences between shrimp and fish have been introduced in tropical shrimp fisheries (FAO 2000a).

However, true reduction or elimination of by-catch requires substantial improvements in the selectivity of fishing gear and methods, and the introduction and implementation of strict legal restrictions. In Norway for example, fishermen must leave their fishing grounds if undersized specimens account for 15% of their total catch (Münkner 2001). Corresponding regulations are absent in other fishery management authorities, in the EU or elsewhere (Hubold 2000).

Additionally, a significant portion of fish is wasted during processing. Two thirds of fish for consumption undergo some form of processing (FAO 2000a). On average processing waste comes to 60%, but in modern processing methods like “deep skinning” or “defatting” may be only 20% (Hubold 2000).

4.2. Impact of Commercial Fisheries on Marine Food Webs

Predator-prey interactions are influenced by several factors, including season, maturity of predators, and complexity of community. Larvae and eggs of predator species, such as cod, halibut and haddock, are an essential prey for species of lower trophic level. Food availability is a vital factor that affects larval survival, fish recruitment and ultimately stock abundance (Cury *et al.* 2001). Causes for extensive shifts in the abundance and composition of species in an ecosystem – so-called regime shifts – may be the result of natural, periodic changes in water temperature and ocean currents, but often are anthropogenic. Commercial fisheries may, in some cases, be a contributing factor: certainly they can have a tremendous impact on marine food webs. Fisheries not only change the abundance of target-species but also species interactions and as a result effect broader ecosystem change (Gislason 2001; Rosenberg 2001). For example, trawling in the Gulf of Thailand resulted in the decline of most fish species, but simultaneously in the increase of abundance of others, such as squids, *Logilo* spp. (Cochrane 2000). Cephalopod stocks obviously benefit from the decline of predatory groundfish species, tuna and toothed whales (Caddy & Rodhouse 1998). Negative correlations of predator and prey abundance have also been documented for lobster and sea urchin, herring and capelin, cod and sprat as well as cod and capelin

(Gislason 2001). Similar relationships exist between krill and copepods (with the former a main predator of the latter) as well as capelin and krill (Atkinson *et al.* 2001; Folkow *et al.* 2000).

The density of prey may also be relevant: Whereas whales need dense aggregations of krill for energy efficient feeding, smaller predators, such as penguins, are able to exploit krill over much more diffuse areas (Reid *et al.* 2000).

Interspecific relationships within marine ecosystems are highly complex, and the consequences of the reduction of one component, -- for example by culling or directed fishing -- are hardly predictable (Stefansson 2001; Butterworth & Punt 2001; NOAA 1999). Accordingly, in a multi-species fishery it is impossible to maximise or optimise the yield from all fisheries simultaneously (Cochrane 2000; Mace 2001). The stability of an ecosystem is directly related to the number of species involved; longer food chains are associated with stable environments (Trites 2001). Heavily exploited fishing grounds are therefore especially prone to other factors, such as natural climatic changes.

4.3. Fishing Down the Food Chain

As a consequence of decreasing catches of the most desirable target species, some commercial fisheries have at least partially shifted towards landings of fish from lower levels in the food web (Gislason 2001; Caddy 1999; Hutchinson 1996), giving cause for concern that continued heavy fishing may lead to more widespread changes within the ecosystem (Jackson 2001; FAO 2000a; Safina 1996):

- Booming industrialised fisheries are mainly targeted to species of a lower trophic level, such as capelin, sandeel, and sprat, to produce fishmeal and fish oil (see section 2.2). Removal of such essential components can have serious impacts; for example, an intense sprat fishery conducted at present catch levels might inhibit recovery of cod stocks in future (Rechlin 2000b).
- According to the IUCN *SSC Sustainable Use Specialist Group* (2002) deep-sea fisheries are continuing to increase, despite the fact that some deep-sea species are already considered vulnerable and there is not enough data available for proper management. Declining stocks have already been observed for a variety of species, including *Molva dypterygia, Brosme brosme*, and orange roughy, *Hoplostethus atlanticus* (Hammer *et al.* 2000).

5. Whales and Humans – Is there a Conflict?

5.1. Past and Present Abundance of Whales and Dolphins

There is no dispute that most stocks of whales were dramatically decimated by past commercial whaling operations; in many cases, they have not recovered to anything like their initial level (Reeves & Leatherwood 1994, Reid *et al.* 2000; Jackson *et al.* 2001). Between 1930 and 1980 547,463 fin whales, 199,188 blue whales, 198,117 sperm whales, 31,937 sei whales, 31,114 humpback whales, and 69,048 minke whales were recorded as being caught in Antarctic waters alone (Ishida undated). Faced with declining rates of larger species, whaling in the 1970s shifted to smaller species such as minke whales until in 1986 a moratorium on commercial whaling came into force.

Confident estimates of pre-whaling levels for whale stocks are almost non-existent, and often catch statistics are used to assess original population sizes (Kasuya 1999b; Moore *et al.* 2000), although catch statistics are known to be unreliable or even prone to manipulations (Kasuya 1998). Recently, abundance estimates of several species have been corrected downwards. It has been suggested that sperm whales, for example, may number as few as 360,000 (Whitehead, cited in WDCS 2002), not the one to two million animals that was previously estimated. The often-quoted figure of 760,000 minke whales in the Southern hemisphere was officially abandoned by the IWC Scientific Committee in 2000, and recent data suggest the population may number only 270,000 or even fewer (Government of New Zealand 2002).

Although some stocks like Southern right whales or humpback whales are increasing, they are still far below estimated pre-whaling levels (Young 2001). Very few populations, notably grey whales in the Northeast Pacific, have recovered to their assumed initial stock size. For others, such as minke whales, pre-whaling estimates are lacking and comparison of past and present stocks is not possible. Despite all the above, some pro-whaling interests have stated unequivocally that, e.g. *"There is substantial evidence that whale populations are robust and increasing"* (JWA 1999) or *"…The population of minke whales is far beyond its original population level. If this situation continues, any effort to reduce fishing capacity becomes useless*" (Institute of Cetacean Research 1999a).

5.2. Diet of Whales

Whales' diets frequently reflect regional and seasonal variations of feeding behaviour as well as availability of prey species: Shares of planktonic organisms, capelin, herring and cod in the stomachs of whales may vary significantly, indicative of the flexibility of feeding patterns and adaptation to local prey availability (Neve 2000; Folkow *et al.* 2000; Fisheries Agency of Japan 2001; Hutchinson 1996).

In general, some whales do partially feed on fish, but often on species that are of no commercial interest, such as deep sea squid or deepwater fishes, or unsuitable for human consumption.

Depending on the species, the locality, and the season, the diet of baleen whales varies from almost exclusively plankton-based to consisting primarily of small schooling fish. Blue and sei whales subsist almost entirely on planktonic organisms – principally euphausiids and copepods, respectively. The stomach contents of examined Bryde's whales, depending on local populations and seasons, vary from almost only fish, including anchovies and pilchards, to almost exclusively krill (Best 2001; Young 2001). The diet of fin whales is mainly composed of krill, but also may include fish from low trophic levels, such as capelin (Stefansson *et al.* 1995). Humpback whales are generalist feeders, eating primarily small schooling fish such as capelin in the northern hemisphere, and euphausiids in the Antarctic (Stefansson *et al.* 1995). The diet of minke whales varies geographically and seasonally (Lindstrom *et al.* 1998, Tamura *et al.* 1998): Whereas in some areas of the North Pacific and North Atlantic several fish species are the more dominant prey, in other areas krill comprise up to 100% of stomach content (Lindstrom *et al.* 1998; Folkow *et al.* 2000). For Antarctic minke whales, krill is significantly more important than for the common minke whales of the northern hemisphere, and is the species' near-exclusive prey (Young 2001; Sigurjónsson *et al.* 2000). In some northern waters, capelin and sandeel are the principal prey fish species for minke whales and other marine mammals (Neve 2000; Vikingsson & Kapel 2000). Both are of low interest for human consumption but are intensely caught for the production of both fishmeal and fish oil (Bergstad & Hoines 2001; Münkner & Kuhlmann 2001).

Toothed whales: The cephalopod-dominated diet of sperm whales, covering different genera and deep-water species, has been well documented (e.g. Smith & Whitehead 2000; Young 2001). Differences in the variety of prey species and diving behaviour may correlate with changes in oceanographic conditions, such as El Nino (Smith & Whitehead 2000).

5.3. Saving Fisheries by Culling Whales?

Some recent publications have argued that the decline in commercially relevant fish species could be combatted by increased exploitation of predators, specifically whales (e.g. Tamura 2001; Folkow *et al.* 2000; Vikingsson & Kapel 2000). The Institute of Cetacean Research (undated), closely related to the Japanese Government, claimed: "*Whales are consuming 5 times more fish resources than humans… Thus utilization of whales could lead to an increase of fish catches for human consumption*". In another publication the consumption of cetaceans was estimated to account for 66 to 144% of commercial fisheries catches, with slight variations in different oceans (Tamura & Ohsumi 2000). Schweder *et al.* (2000) even calculated that for each extra [minke] whale in the ocean the yearly mean catch of cod would be reduced by some 5 tonnes, that of herring by 4.5 tonnes, and that of capelin by some 2.8 tonnes.

Table 1: Initial and current population status of whales (based on IUCN 2000; WDCS 2002; Young 2001; *Kemf et al. 2001; WWF 2000a*)

Species	Stock	Current population	Initial population	IUCN status
Blue whale *Balaenoptera musculus*	1) Antarctic stock 2) North Atlantic stock 3) North Pacific stock	1) 400 - 1,400 2) 1,000 - 2,000 3) 2,000 - 4,000	1) 250,000 2) 12,000 3) 14,000	Endangered 1) Endangered 2) Vulnerable 3) Lower Risk
Bowhead whale *Balaena mysticetus*	1) Davis Strait 2) Bering, Chukchi 3) Hudson Bay 4) Okhotsk 5) Svalbard-Barents	1) < 400 2) 7,500 3) 350 4) < 300 5) < 100 total: < 8,650	1) 12,000 2) 16,000 3) 600 4) 8,000 5) 25,000 total: 61,600	1) Endangered 2) Lower risk 3) Vulnerable 4) Endangered 5) Critically endangered
Northern right whale *Eubalaena glacialis*	1) North Atlantic 2) North Pacific	1) 300 - 350 2) < 1,000	No estimates, but tens of thousands have been killed	Endangered 1) Endangered 2) Endangered
Southern right whale *Eubalaena glacialis*		7,000	70,000	Lower risk
Gray whale *Eschrichtius robustus*	1) Northwest Pacific 2) Northeast Pacific 3) Atlantic	1) No estimates 2) 21,000 3) Extinct	1) No estimates 2) 22,000 3) No estimates	1) Critically endangered 2) Lower risk
Fin whale *Balaenoptera physalus*	1) North Atlantic 2) Mediterranean 3) Southern hemisphere	1) 27,700 - 82,000 2) 3,000 - 7,400 3) 12,000 total:42,700 - 101,400	1) No estimates 2) No estimates 3) 300,000-650,000	Endangered
Sei whale *Balaenoptera borealis*		39,000 - 65,000	No estimates	Endangered
Bryde's whale *Balaenoptera edeni*		40,000 – 112,000 (?)	No estimates	Data deficient
Common minke whale *Balaenoptera acutorostrata*	1) Northeast Atlantic 2) Central Atlantic 3) North Pacific stock 4) West Greenland 5) Southern hemisphere	1) 67,000 - 118,000 2) 21,600 - 31,400 3) 12,000 - 48,600 4) 1,790 - 5,950 5) 12,000 - 48,600 total: 114,390 – 252.550	No estimates	Lower risk
Antarctic minke whale *Balaenoptera bonaerensis*		270,000 - < 760,000	No estimates	Lower risk
Humpback whale *Megaptera novaeangliae*	1) Pacific stock 2) North Atlantic Stock	20,000 - 28,000	150,000	Vulnerable
Sperm whale *Physeter catodon*		< 1-2 million, maybe only 360,000 animals	2-3 million (?)	Vulnerable

Although at first sight the arguments for a competition may look convincing, a critical analysis of such statements is necessary. This is done in the following by analysing the calculations of Tamura & Ohsumi (2000), who claimed that all cetaceans together consume 63-78 million tonnes of fish, 78 to 1222 million tonnes of cephalopods, and 108-235 million tonnes of crustaceans:

- The total volume of food consumed by whales, as presented by Tamura and Ohsumi, is questionable (Young 2001; Johnston & Santillo undated). Their calculation of whale biomass is based on population estimates for many whale species far in excess of more precautionary estimates published elsewhere (e.g. as used in table 1). For example, they assume a world population of around 600,000 sperm whales, whereas recent estimates only suggest about little more than half of this number (see section 5.1.). This use of exaggerated population statistics results in consumption estimates that are probably exorbitant.
- The calculation of total food consumption is based on body weight, which significantly varies according to species, developmental stage, and sex. For example, the figures for sperm whales use the average weight for males, whereas females are much smaller and lighter and correspondingly consume much smaller volumes.
- According to Tamura & Ohsumi baleen whales annually consume 101-225 million tonnes of crustaceans. However, these calculations are quantitative and do not take into account – or conceal – that baleen whales eat primarily krill and copepods, while the most important crustaceans for commercial fisheries are crabs, prawns, and lobsters. Similarly, the figure of 78 to 122 million tonnes of cephalopods, said to be the amount consumed annually by toothed whales, does not reflect that a very large portion comprises deep-sea squid that is not commercially relevant by fishing fleets.
- Misleadingly, total odontocete food consumption figures also include estimates for consumption by small cetaceans. But in most cases, the population sizes of the small cetaceans included in the calculations are not known, and information on diet composition is scarce.

There are several other issues that raise doubts about the "whales vs. fisheries" hypothesis:

- Differences in feeding behaviour (for example fish species that are consumed by whales mainly belong to low trophic levels of little or no commercial interest) and migration patterns largely preclude direct competition between whales and coastal and pelagic fisheries (Young 2001, NOAA 1999).
- The collapse of commercially-exploited fish stocks has not been shown to correspond with a concomitant increase in whale populations. For example, according to a paper from the Fisheries Agency of Japan, over the last two decades landings of Japanese pilchard from the Pacific stock have decreased from 4 million tonnes to 100-150,000 tonnes. Catches of chub mackerel have crashed to just 10% the level of landings in the late 1970s (Fisheries Agency of Japan 2001). The thesis of the publication of the Japanese Fisheries Agency is that whales are in competition with commercial fisheries, but at no point does it demonstrates that the above fish stock collapses are in any way related to an increase in regional cetacean populations.
- Indeed, in some cases fish stocks have collapsed in a region even as commercial whaling in that same region has been at its height. For example the collapse of herring in the North Atlantic occurred in the late 1960s (IMF 2002) – the same time that Norwegian minke whaling was at a historically high level (HNA 2002, see figure 4).
- Whereas the consumption of fish and invertebrates by cetaceans is in the focus of such publications, the role of piscivorous fish or sea birds is ignored, even though their consumption volume is comparable or even higher. The calculated annual consumption of sea birds in the Barent Sea is remarkably close to that of cetaceans – 1.4 vs. 1.8 million tonnes (Bogstad *et al.* 2000; Schweder *et al.* 2000) -- but no one would seriously call for a culling of sea birds to promote commercial fisheries, as this does neither justice to inter-specific relationships nor to the complexity of the food web as a whole.

Clearly, the competition hypothesis is based on scientifically poor grounds, and the question for the motivation of those statements arises. In this regard, it is worth noting that the publications advocating the existence of competition between whales and fisheries are all written by authors from whaling nations.

Several nations have conducted culls of cetaceans in the past, including Canada, Japan, Denmark (Greenland), and Iceland (Reeves & Leatherwood 1994). The argument that routine culling of cetaceans would be integral to ecosystem management was introduced in the context of Norway's resumption of commercial whaling (Reeves & Leatherwood 1994). In practice, however, ecosystem management is very difficult to implement in view of the complexity and dynamics of the marine ecosystem. The diet of whales includes predatory species that prey on fish species of

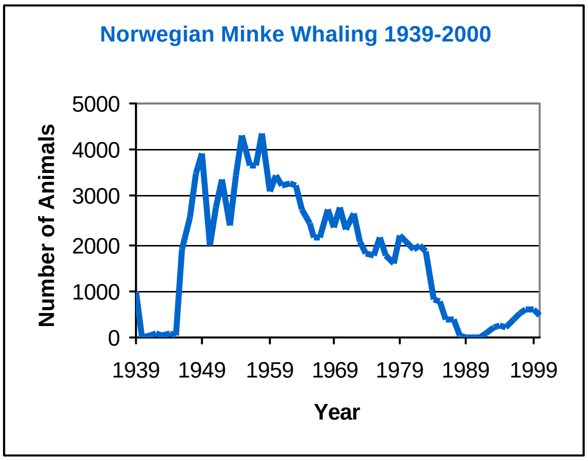


Figure 4: Number of minke whales killed in Norwegian waters between 1939 and 2000 (based on HNA 2002)

commercial interest. For example, cephalopods heavily feed on juvenile fish. Accordingly, the consequences for commercial fisheries after culling of whales are not predictable (Johnston & Santillo undated; Young 2001; NOAA 1999). Anyway, there is no scientific evidence that the culling of large marine predators has ever benefited a commercial fishery (IFAW 2001). For example the effect of a seal cull on the hake fishery was assessed to be minimal and detrimental consequences could not be excluded (Young 2001).

In conclusion, the argument that culling whales can save commercial fisheries can be shown to instead be a strategy to justify whaling interests.

5.4. Threats to Marine Ecosystems Besides Fisheries

Over-fishing by far exceeds all other pervasive human-induced factors which damage coastal ecosystems, including pollution, degradation of water quality, and anthropogenic climate change (Jackson *et al.* 2001; Rosenberg 2001; Mosquera *et al.* 2000). Nevertheless, these factors are frequently also considerable, and growing, and must be additionally considered. In the following, an overview on serious environmental changes in marine ecosystems is given.

There is growing evidence that global climate change is having a serious impact on marine food webs: for example, increasing sea surface temperatures are affecting the productivity of phyto- and zooplankton, and the stability of food webs and marine communities (Hanly 1997; MacGarvin & Simmonds 1996). As a consequence of global warming sea levels may rise, with possible consequences for the migration of marine species and significant impacts on fishery resources and coastal habitats.

Ozone depletion and a resulting increase in UV radiation have been reported from several regions, including the Arctic and Antarctic. This may severely harm planktonic organisms that are the basis of marine food webs, as well as fish species (Zagarese & Williamson 2001). In particular, developmental stages of pelagic fish embryos are very sensitive to UV damage (Dethlefsen *et al.* 1996).

The severe medium- and long-term effects of pollutants such as organochlorines, including polychlorinated biphenyls (PCBs), the persistent insecticide DDT, and heavy metals, on the vitality and fertility of fish and marine mammals are well documented (Krahn *et al.* 2001; Richardson 2001; Reijnders 1996).

The introduction of alien marine species is playing an increasing role, as it can upset predator-prey relationships, or introduce diseases and pathogens (de Fontaubert *et al.* 1996).

6. Conclusions

6.1. Responsibility for the Breakdown of Fish Stocks

As a consequence of the industrialization of commercial fisheries, which began in the 1950s, many fish stocks have been over-fished to the point that over 75% of world fisheries are now fully or over-exploited (FAO 2000a). Experts warn that the present tendency of "fishing down the food chain" will have fatal consequences for the stability of marine ecosystems (see section 4.3.).

Whaling nations have tabled several arguments to justify a resumption of whaling, especially in the context of “small-type coastal whaling”. However, these arguments have been challenged (e.g. Palmer 1997), and catch quotas regularly refused by the IWC.

New arguments for the resumption of whaling are now being put forward, particularly by attempting to create a causal connection between the decline of commercially relevant fish stocks and the diet of cetaceans. Critical analysis of these arguments show that such alleged competition is over-simplified and statements promoting the competition hypothesis are politically rather than biologically motivated.

- Far more cetaceans inhabited the ocean in the past than is the case today; and yet, during that time, stocks of fish and other marine resources were healthy – obviously sufficient to satisfy both the needs of marine mammals and humans.
- Over-exploitation by humans is the major cause for the collapse of fish stocks (e.g. Pauly 2001, for more details see section 3).
- Whereas stocks of capelin and sandeel in the northern hemisphere, which are among the most significant fish prey species for Northeast Atlantic minke whales but are not fished for human consumption, are still comparably stable, stocks of the most commercially desirable species, such as cod or haddock, have undergone drastic declines (section 3).
- Piscivorous fish species are more significant predators of target species of commercial fisheries than are cetaceans (Bogstad *et al.* 2000; Bax 1998, 1991).
- To a very great extent the diet of many cetaceans is based on species that are not the target of human fisheries, e.g. deep-sea squid (Young 2001).
- Feeding grounds of cetaceans often do not overlap geographically with commercial fishing grounds (Young 2001; NOAA 1999).
- Fish species found in the stomachs of cetaceans caught incidentally in commercial fisheries were in most cases different from the target species of the fisheries (Hartmann *et al.* 1996).
- Primary producers play the dominant role in determining the abundance of various marine populations, while removal of large predators does not have a significant impact on other species (Cury *et al.* 2001).

In conclusion, the notion that exploiting certain species to compensate for existing damage to an ecosystem – damage caused by over-exploitation of other species – is at best naive, at worst a manipulative attempt to forward such goals as the resumption of commercial whaling. Accordingly, many governments and organizations have rejected this argument (e.g. Young 2001; IFAW 2001, Johnston & Santillo undated).

In the interest of a long-term conservation of the oceans' biodiversity the depletion of fish stocks should be recognised as a signal to reduce production of commercial fisheries and to enable fish stocks to recover from over-exploitation – not as an excuse to extend harvesting to other components of an ecosystem that is increasingly susceptible to a breakdown.

6.2. Management Strategies for Commercial Fisheries

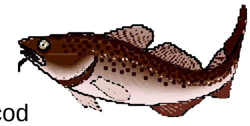
The crisis in commercial fisheries is mainly caused by over-capacity of fishing fleets, overcapitalisation in combination with subsidies, and institutional weakness (Garcia & de Leiva Moreno 2001; Cochrane 2000).

Traditional management models were based on the *Maximum Sustainable Yield* (MSY), which could not prevent fish stocks from over-exploitation. Many experts are in accord that world fisheries production must be reduced by 23 to 30%, to guarantee landing volumes that are economically and ecologically sustainable (FAO 1994a). In 1998, the EU Commission called on ICES to base their recommendations for a *Total Allowable Catch* (TAC) on the rules of a precautionary approach. This precautionary approach considers two components: Is the Spawning Stock Biomass (SSB) within limits that are biologically safe? And does the catch volume exceed the production of offspring? The precautionary approach therefore is understood as proactive rather than reactive (Mace 2001). Nevertheless, defined TACs are often exceeded by European fishery management, often leading to further reductions of TACs in the following years: Sixty-one of 74 TACs were reduced from 1999 to 2000, some of them even set to zero (Hammer 2001a; Hammer *et al.* 2000).

Only a large-scale restructuring of fishery management worldwide will make a reduction of commercial fisheries to a sustainable level possible. The *American Association for the Advancement of Science* (AAAS 2002) recommended substantial reduction in fishing fleets, phasing out of subsidies, and the development of sizable "no-take zones" that would allow fish populations to recover. The benefit of reserves for the restoration of fish stocks has been documented (Malakoff 2001; Mosquera *et al.* 2000). Besides no-take zones the benefit of fishery closures that limit specific types of activities, such as gear restrictions, has been emphasized (Rosenberg 2001).

7. ANNEXES

ANNEX A: Cod



Role in ecosystem: Atlantic cod (*Gadus morhua*) primarily feeds on smaller schooling fish such as capelin, sprat, herring, and sandeel, but also on crustaceans (Bogstad *et al.* 2000). Cod matures at about 8-12 years with a body size of at least 60 cm and can reach 100 cm. It is extremely fertile, capable of producing several million eggs per female per year (Hubold 2000). Its spawn is an important prey for herring and sprat, but also for adult cod. Besides predation, climatic conditions also cause natural mortality of offspring, which may significantly fluctuate from year to year (Beentjes & Renwick 2001; Hammer 2001a).
Role in fisheries: Cod is mainly caught by bottom trawl, long line and gillnet and usually at depths of 100 to 250 meters. In the rank of the world's commercial fisheries Atlantic cod comes ninth (see figure 3). Between 1986 and 1992 pelagic fleets in the Northwest Atlantic exceeded quotas for several species, including cod, sixteen fold (Safina 1996). By-catch of cod, either in haddock fisheries or as undersized by-catch in directed cod fisheries has a serious impact (Hammer 2001a; Ernst *et al.* 2000; Hubold 2000). Reduction of recruitment not only hampers the restocking of future cod generations but also means a future economic loss of cod that would have grown up to maturity (Münkner 2001). The artificial enhancement of cod stocks by releases of juvenile cod failed and no significant increase of cod stocks or landings could be achieved (Svasand *et al.* 2000).

Trends in stocks:

- In the North Sea, landings of cod continuously declined from 1983 until stabilising in the 1990s at a level similar to the 1960s (Hubold 2000). The current stock status is very critical, with the estimated stock size in 2000 at a historical minimum. This led to a temporary closure of different fishing areas by the European Commission in spring 2001 (Hammer 2001b). According to ICES this step is only a first aid measure and should be complemented by a recovery plan.
- An economic collapse of cod stocks was experienced in the Northwest Atlantic Sea, mainly in Canada: In 1994, it was decided to bring cod fishing to an almost total halt – a consequence of a reduction in cod landings by 75% since 1988 (Hubold 2000).
- As shown in figure 5 Greenland stocks have collapsed, stocks from coastal and pelagic areas are far under safe biological limits, and Spawning Stock Biomass (SSB) is at its lowest level (Gröhsler & Zimmermann 2001; Hammer *et al.* 2000). In 1998 incoming yearclasses have been comparably low and gonad development was abnormal (Dornheim & Wegner 1998). ICES recommends a temporal closure of cod fisheries in this area (Gröhsler & Zimmermann 2001).
- Icelandic cod stocks declined to only 200,000 tonnes in 1993, but are now slowly recovering, with increasing recruitment (Hammer *et al.* 2000). However, although present trends are positive, biomass remains far below its level of 1950, as shown in figure 6; and catches in recent years

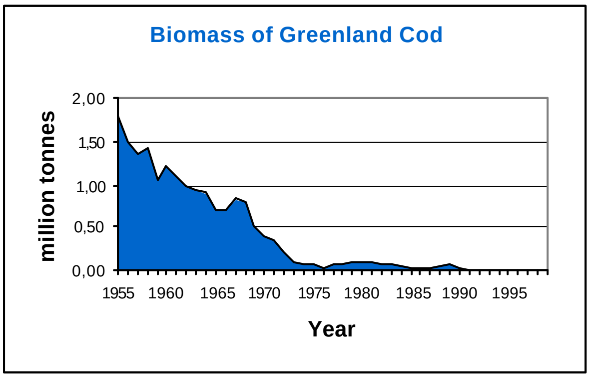


Figure 5: Decline of biomass of Greenland cod (according to Hammer et al. 2000)

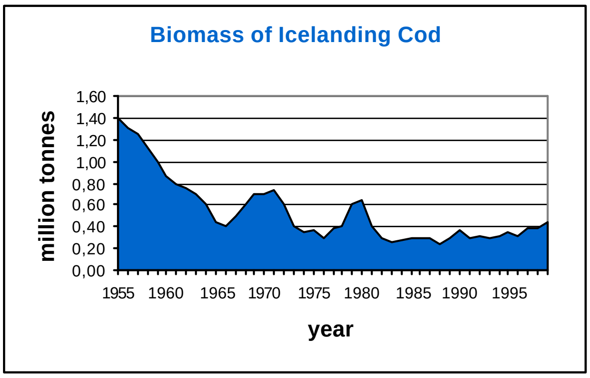


Figure 6: Decline of biomass of Icelandic cod (according to Hammer et al. 2000)

have again exceeded sustainable levels (Gröhsler & Zimmermann 2001).

- As Northeast Arctic stocks of cod comprise only little more than half of a precautionary biomass, the situation for this stock is critical. Fishery management licenses have repeatedly and extensively exceeded precautionary recommendations of ICES, while total landings have been higher still (Gröhsler & Zimmermann 2001; Hammer 2001a; Hammer *et al.* 2000). ICES has called for the development of a recovery plan for the stock.
- Western East Sea stocks of cod have strongly varied in size in recent years, landings are above the precautionary approach, and TACs have been reduced. In eastern East Sea stocks, over-fishing is even higher, resulting in an ICES recommendation for a closure of fisheries and establishment of a recovery plan (Gröhsler & Zimmermann 2001).
- The Kattegat stock is outside safe biological limits, biomass is much below the volume of the 1970s, and landings of 6,600 tonnes as in 1999 are far above a sustainable level. Accordingly, for 2001 ICES recommended a reduction of catches by at least 40%, and for 2002 even called for a closure of cod fisheries in this area (Gröhsler & Zimmermann 2001; Hammer *et al.* 2000).
- The mean body length of Atlantic cod from the coastal Gulf of Maine has fallen from 100 cm to 30 cm within the last two centuries, reflecting the collapse of this stock as a consequence of overfishing (Jackson *et al.* 2001).

ANNEX B: Herring

Role in ecosystem: Atlantic herring (*Clupea harengus*) and Pacific herring (*Clupea pallasii*) are pelagic, shoaling fish that feed on plankton and young fry, mainly from capelin and cod. Specimens mature at about three to four years with a body size of 23 to 24 cm and can grow up to 40 cm. Their spawn is a vital prey for jellyfish and starfish. Haddock, mackerel, tuna, cod, sharks and many other predatory fish, seabirds, and marine mammals consume mature herring. Herring in the East Sea shows a complex population structure, due to a mixing of herring of different origin and differences in individual growth (Rechlin 2000a).

Role in fisheries: It is caught by seine and pelagic trawl in depths up to 250 m. It is the fourth most important species in the world's commercial landings (see figure 3).

Trends in stocks:

- Following record landings of nearly 2 million tonnes between 1969 and 1990 landings of herring from the Scandinavian Atlantic were sharply reduced (Toresen & Ostvedt 2000). After the collapse of the commercial fishery the stock had a chance to recover and the SSB increased from 250,000 tonnes in 1980 to 10 million tonnes in 2000. Recruitment from offspring in productive years may contain 3 to 100 billion individuals (Hubold 2000).
- Herring populations in the western East Sea are comparably low, with decreasing SSB (Gröhsler & Zimmermann 2001). In the central East Sea catch statistics and estimation of biomass are reported to be unreliable (Hammer *et al.* 2000). Total landings in 1999 reached a historical minimum, reflecting a decline of biomass from 850,000 tonnes in 1992 to 450,000 tonnes in 1999.
- In the North Sea stocks are still outside biologically safe limits: Although in 1997 the stock recovered to 750,000 tonnes, only a stock size of 1.3 million tonnes would meet the precautionary approach for sustainable fishing (Dornheim & Wegner 1998). TACs, as set by ICES, are regularly exceeded and landing volume has decreased (see figure 7). ICES stresses that in compliance with the precautionary approach fisheries should be closed. However, for practical reasons a reduction of catches and stronger controls are recommended (Gröhsler & Zimmermann 2001).

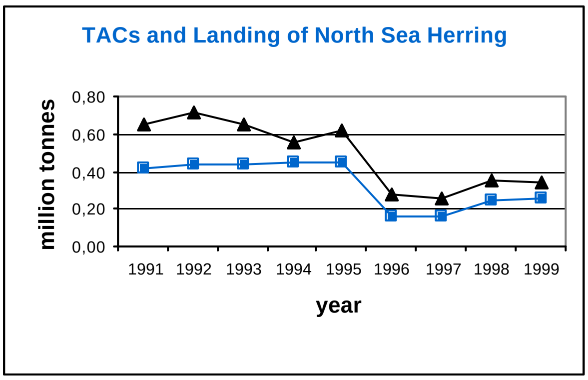


Figure 7: TACs (blue) and landing volumes (black) of herring in the North Sea (Hammer et al. 2000)

ANNEX C: Haddock

Role in ecosystem: The diet of haddock (*Melanogrammus aeglefinus*) is dominated by young cod, herring, sandeel, rays and other fish species, but also includes squid, molluscs and lobster. Younger individuals of about 11 cm prefer shallow waters of 35-70 m, whereas mature specimens with up to 1 meter body size live in depths of 700-1,000 m.
Role in fisheries: Haddock is mainly caught by bottom trawl, longline and gillnet at depths of 10 to 200 meter.

Trends in stocks:

- Northeast Arctic stocks are in sharp decline: Whereas biomass in 1999 reached 118,000 tonnes, in 2000 it was estimated at only 90,000 tonnes. Stocks have been over-exploited for several years, and recruitment is low. As a consequence ICES recommended a reduced catch quota of less than 66,000 tonnes for the year 2001 (Hammer 2001a; Hammer *et al.* 2001). Haddock is a frequent victim of by-catch in cod fisheries. Compared to total landings of 112,299 tonnes in 1999 ICES recommended a reduced TAC of 60,000 tonnes for 2001 (Hammer 2001a).
- Stocks in the North Sea have shown a low incoming yearclass in 1998 (Dornheim & Wegner 1998). Although stock size is presently within biological safe limits, exploitation exceeds sustainable levels and the stock suffers from by-catch of undersized individuals, which can reach as much as one third of total catches (Hammer 2001a).
- The Faeroese stock is outside biological safe limits, and the situation has worsened due to low recruitment in recent years. ICES now recommends this stock be closed to fisheries (Gröhsler & Zimmermann 2001).
- The Icelandic stock has continuously decreased since the early 90s and, at 41,000 tonnes, is at a historically low level due to constant over-fishing (Gröhsler & Zimmermann 2001). Landings of haddock in Icelandic fisheries have decreased (see figure 8).

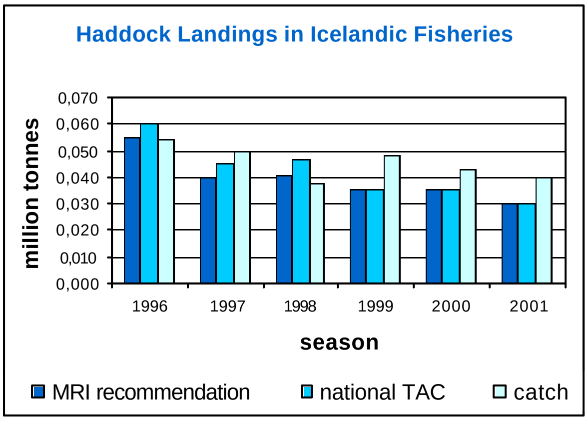


Figure 8: Landings of haddock in Icelandic fisheries (based on data of Icelandic Ministry of Fisheries 2002)

ANNEX D: Sandeel

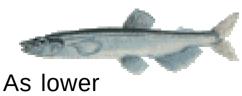
Role in ecosystem: The lesser sandeel (*Ammodytes marinus*) is a small shoal fish. With a body size of less than 20 cm it is a key prey species for other fish, sea birds and marine mammals. Breeding success of common guillemot, kittiwake, and European shag was found to depend strongly on sandeel availability (Rindorf *et al.* 2000).

Role in fisheries: Its fourteenth rank in world landings reflects the importance of sandeel for industrial fisheries (see figure 3). Since the 1950s it has become the subject of the largest fisheries in the North Sea, and now accounts for one third of total fish landings. Sandeel is used for the production of fishmeal (Münkner & Kuhlmann 2001; Bergstad & Hoines 2001).

Trends in stocks:

- While in 1999 the stock size in the North Sea was 1.2 million tonnes and within biologically safe limits, it has subsequently been estimated at only 700,000 tonnes (Hammer 2001a). Due to the central role of sandeel as prey for other fish and sea birds a closure of sandeel fisheries in the North Sea has been proposed (Anon. 1999b).
- Impacts of commercial fisheries on age structure and size distribution of sandeel have been proven: In unexploited areas a wider age and size range in populations is a consequence of a lower rate of adult mortality (Bergstad & Hoines 2001).

ANNEX E: Capelin



Role in ecosystem: Capelin matures at an age of 2-4 years and a body size of 15-20 cm. As lower trophic level prey, capelin (*Mallotus villosus*) provides a vital link in the food chain between plankton and larger animals (Schweder *et al.* 2000). It feeds on small crustaceans among the plankton and is a vital prey for cod, saithe and many other fish species. Capelin, a pelagic schooling species, inhabits depths of 0-300 m.

Role in fisheries: Capelin has become one of the most important target-species of industrial fisheries for the production of fishmeal (Münkner & Kuhlmann 2001). It is the sixth largest of the world's commercial fisheries (see figure 3).

Trends in stocks:

- Between 1993 and 1998, the biomass of Northeast Arctic capelin fell to a dangerously low level, and fisheries were closed. Subsequently, the stock has recovered to levels within biologically safe limits (Hammer 2001a).
- Stocks off Eastern Greenland are within biological safe limits. Nevertheless, ICES recommends temporarily closing commercial fisheries in areas with high shares of juvenile capelin (Gröhsler & Zimmermann 2001).

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