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Fisheries Depletion and Collapse

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The scope of human dependence on marine life is significant, both in terms of the nutritional value provided by fish and other seafood to populations (especially in the developing world) and in terms of the level of economic security the fishing industry provides for coastal communities. Marine biodiversity, in itself, also offers tangible benefits to society, via revenues earned from tourism as well as by providing useful ecosystem services, such as the maintenance of water quality [Stokstad, 2006]. Currently, however, about 25% of world fish stocks are overexploited or fully depleted and overcapacity in fishing fleets is the norm rather than the exception [FAO, 2007:29]. Indeed, many experts agree that the exploitation limit of marine resources has been reached, if not exceeded, and that this overcapacity of fleets, excessive fishing quotas, illegal fishing practices and the generally poor management of most fisheries are to blame [Rebufat, 2007:5-6]. The complete collapse of large, profitable fisheries such as the Californian sardine fishery in the 1950s, the Atlanto-Scandian herring fishery in the late 1960s, the Peruvian anchovy fishery in 1972, the Northern cod fishery off the East coast of Canada in 1992 and the North Sea cod fishery over the last decade have acted as clear warning signs that fishing practices in many parts of the world are unsustainable and that there are serious governance deficits evident in the management of fish stocks.

Although we concentrate here on overfishing as a cause of fisheries depletion and collapse, the depletion of global fish stocks cannot be attributed to fishing alone. Habitat destruction, pollution, climate change and invasive species also have an impact upon fish populations. Also, a changing environment affects stock abundance, and some stocks experience collapse from environmental causes alone. In many instances, it is quite difficult to determine the main causes of the depletion of fish stocks.

Overview of the risk issue

Until the late 19th century, the fish resources of the world's vast oceans were thought to be essentially inexhaustible, even by the most prominent biologists [Smith, 1994]. As the fishing industry expanded and technology made larger catches possible and more areas of the ocean exploitable, the received wisdom that fisheries were inexhaustible soon became discredited. FAO estimates that 25% of the world's fish stocks are currently being fished at an unsustainable level [FAO, 2007:29], thus risking collapse.

Fish are a common pool resource, meaning that it is difficult to exclude users and that exploitation by one user reduces the resource availability for others [Ostrom et al. 1999]. Common pool resources are found when a system of individual property rights is insufficient for sustainability or too costly to implement [Bromely, 1991]. Furthermore, in many cases, especially in long-distance fisheries and in developing countries, they are effectively an open access resource, meaning that a system of property rights is completely absent and thus the fish can be caught by anyone. When common pool resources are valuable and open access, overexploitation is inevitable because users have no incentive to conserve when the fruits of such conservation can simply be

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taken by another user. The outcome of such a situation is overfishing and eventual collapse. This is why management is required if fish are to be harvested in a sustainable and economically efficient manner. Because fisheries are common pool resources they are often owned and managed as “common property” by governments or other collective entities. These entities seek to avoid the commons dilemma by granting conditional rights of access, for example a fishing license or a rule that only certain fishing techniques can be used. Although it is a common mistake, common property should never be confused with open access because common property regimes involve these access rights. However group-level management arrangements are challenging and costly, and often require the development of complex management systems.

Over the past century, the management of fisheries commons has developed around the central concept of maintaining a sustainable yield of fish stocks [Hannesson, 2008:14]. The sustainable yield of fish stocks has important implications well beyond fisheries. Capture fisheries are one of the most environmentally benign sources of animal protein in the human food supply system, and they have a very important potential for shrinking the overall environmental footprint [Wilson, 2009]. Fish have the highest protein content in their flesh of all food animals, and no other food animal converts feed to body tissue as efficiently as fish [Smil, 2000]. Capture fisheries have the potential to have the lowest ecological impact of all sources of animal protein because they do not generate the waste and disease problems found in both terrestrial and aquatic animal husbandry. If the dilemma described in the last paragraph is resolved through effective management, the rate of fishing would slow to allow stocks to recover and produce new fish at a higher rate than they do in their currently depleted state. This would mean higher catches from a lower fishing effort. The lower effort implies lower energy use and other environmental impacts from fishing. The higher catches imply a reduction of the price of fish products and a shifting of protein consumption to capture fisheries from more environmentally damaging sources. This in turn would mean a reduction in the overall human pressure on the environment.

Risks related to overfishing:

- ***global food security***

Fish provide more than 20% of the animal protein consumed by 2.6 billion people in developing countries (up to 50% for some nations) and is an important source of micronutrients, essential fatty acids, proteins and minerals. Due to this nutritional importance of fish for so many people, a large-scale collapse of fisheries or a significant increase in the price of fish products (likely to be the result of smaller catches) could seriously affect the nutritional status and the food security of many populations [World Bank 2005:6]. Overfishing does not only reduce the source of food today. If overfishing and other negative human impacts on the oceans continue, ecosystems can be driven to irreversible states of decline and this may affect the food supply for future generations.

- ***economic security***

Harvesting fish in an unsustainable manner also means harvesting them inefficiently. When we put fish stocks at risk we also put at risk the economic welfare of millions of people dependent on marine products.

Tourism is an important source of income in some countries, where the vibrant aquatic life (around coral reefs, for example) attracts divers, sports fisherman and other visitors. Income generated by tourism could be lost if fisheries are depleted and marine biodiversity is lost.

More substantial, however, is the importance of fish exports for developing economies. Indeed, there is a direct link between overfishing and poverty. Approximately half of the total export value of the world trade in fish and fisheries products (US$71.5 billion in 2004) comes from developing countries. Poverty among coastal communities in developing countries is often high (especially in Asia and Africa), and fishing industries help alleviate this, employing 150 million people and

providing a last resort livelihood for the poor. The collapse of fisheries can thus have devastating economic impacts for developing countries, as well as for countries whose trade in fishery products makes up a large percentage of their total merchandise exports (Greenland and Iceland, for example) [World Bank, 2005:4-5 and 7].

- ***coastal settlement***

Excess fishing capacity and depleted fish stocks cause problems for coastal communities that depend on the fishing industry and eco-tourism. Such devastation of coastal settlements can also result in the loss of cultural value. Problems can be fortified in cases where rights to fish can be traded and quota shares become concentrated in fewer hands. The introduction of individual transferable quotas in Iceland contributed to the marginalisation of fisheries dependent coastal communities, due to quota concentrations [Pálsson & Helgason, 1995].

- ***biological diversity and ecosystem stability***

Overfishing poses serious risks as the loss of marine biological diversity can have serious consequences for the stability of marine and coastal ecosystems. Biological extinction from a directed fishing effort is extremely rare because economic extinction (i.e., the fish becoming too rare to fish profitably) usually happens well before biological extinction. However, overexploitation of the target fish population can lead it to become depleted to the point where it cannot recover because the depletion of the fish stock often involves other ecological changes. Fishing can also change trophic relationships through changing the relative abundance of predators, prey, and competitors as well as the genetic make-up of populations [ICES 2006]. Research on the Scotian Shelf in Canada has documented a vast general change in the ecosystem that seems to have been driven by the removal of a huge number of fish [Choi et al. 2004] and resulted in the emergence of a completely different set of dominant species, mainly invertebrates. The failure of the Northern cod stock to recover following its depletion (in spite of a sustained fishing moratorium) can be explained by overfishing, the effect of which was amplified by environmental changes, which altered the ecosystem structure [Frank et al., 2005]. Similar conclusions can be drawn in the cases of the Black Sea [Daskalov, et al., 2007] and the Baltic Sea [Möllmann et al., 2008], and Daan et al. [2005] discuss whether the changes in the North Sea fish community were caused by overfishing . Other suggested effects of overfishing are evolutionary effects [Jørgensen et al., 2007] and changes in fish behaviour, for example migration patterns, due to loss of learning from older fish, which have basically beenremoved from the population [Fernö et al., 2006]. Overfishing may also further amplify any effects brought about by global warming on the ocean environment, the structure of its ecosystems and of invasive species.

Loss of biological diversity and changes in ecosystem stability can also result from bycatch of non-target species. Bycatch[2], especially in mixed fisheries that target several stocks, is perhaps the single greatest fisheries management challenge. The problems of catching undersized fish can also be a great problem. For example, even when the depleted North Sea cod stock manages to produce abundant offspring, the majority is discarded at a very early age and only a small percentage of the cod manage to reach maturity to produce more offspring [ICES, 2008]. Bycatch problems extend to marine mammals, sea turtles, seabirds and sharks.

Fishing activities can also damage marine habitats. Some types of fishing, intensive trawling in particular, cause damage to the sea bed and may reduce the number of marine fauna living in the deep seas or in the benthic zone (sediment and sub-surface layers of sea-beds) by between 20-80% [Nellemann et al., 2008:10].

[2] Sometimes a distinction is made between bycatch, which is discarded, and by-product, which is landed and sold. It is more common to simply used the term bycatch for both, which is the convention we follow here.

- ***coastal water quality***

The loss of biodiversity in coastal waters that can result from overexploitation of fisheries can make these coastal waters much more susceptible to other human and environmental disturbances. Harmful algae blooms and oxygen depleted areas may arise more frequently once the marine ecosystem has been disturbed by overfishing and species loss [Jackson et al., 2001].

Risk Governance in Fisheries

To maintain sustainable use, all commons require proper management. This usually involves the implementation of a tailored governance regime with two distinct elements – firstly, a way to **restrict access** to the resource and, secondly, a way to **create incentives** for users of the resource to conserve it and invest in it rather than overexploiting it [Ostrom et al., 1999: 279]. Such governance regimes incorporate biological, ecological, social and political aspects, and they rely strongly on cooperation between stakeholders, be they at the local, national, international, or all three, levels.

The difficulty of devising governance regimes

Unfortunately, the nature of fisheries as a common pool resource makes devising an effective governance regime particularly difficult, and thus increases the probability that some of the systemic risks listed above may eventuate. This is because:

- *the number of stakeholders involved in managing fish stocks is usually very large, with stakeholders sometimes being far apart geographically*
  This makes cooperation, agreeing on and enforcing rules, more difficult;

- *the size and carrying capacity of the resource system (the oceans) is extremely large*
  The larger the size of the commons, the more complicated it is to implement and enforce regulations;

- *many fish and marine animals migrate over large distances*
  Fish stocks often do not remain within the jurisdiction of any one state. This means that clearly defined property rights cannot be easily assigned to fish stocks;

- *the rate of regeneration of fish stocks varies*
  Therefore the type of governance regime required will depend on the type of fish stock in question, plus other local environmental factors;

- *environmental factors and natural oscillations also affect the size of fish populations*
  Exogenous factors may cause fish populations to decline or fisheries to collapse because they influence the survival rate of offspring. These need to be identified and taken into account by any management regime;

- *the fishing technologies used affect ecosystems in different ways*
  The type of ecosystem, how fish species assemble and mix plus the type of fishing technology employed will partly determine the best governance regime for sustainability of fish stocks;

- *fish stocks can be hard to measure and assess accurately*
  Inaccurate measurement of stocks can lead to catch quotas being set too high, compared to precautionary means, or too low, compared to what is acceptable for the fishermen. Discards and/or illegal fishing in several fisheries deteriorate data and assessments.

These characteristics of the risk system have meant that the process of regulating to achieve sustainable yields in many of the world's fisheries has usually been inefficient and ineffective. Nevertheless, the nature of this commons problem, the particular difficulties faced, and the severity and systemic nature of the risks posed by fisheries depletion are well recognised. In fisheries management, the problem has, in general, not been not knowing what needs to be done in a technical sense. Rather, the problem has been not knowing how to build the institutions that make people *willing* or *able* to implement the necessary measures.

Regulation to try to solve the commons problem of fisheries has been gradually evolving since at least 1956, when the first United Nations Conference on the Law of the Sea (UNCLOS I) was held. UNCLOS I included a convention on 'Fishing and Conservation of Living Resources of the High Seas' [UN, 1958], and the following UNCLOS conferences (see key events timeline below) took further steps towards creating property rights for fish stocks, at least within coastal waters, via the establishment of the exclusive economic zone (EEZ) [UN, 1982][3] – this move has been called "one of the most far-reaching distributional and institutional changes in the history of the world", as it brought over 20 % of the world's oceans and 90 to 95 % of world fisheries under the national jurisdiction of coastal states [Ebbin et al., 2005]. This begins the process of solving the commons dilemma, as such rights allow the state to implement and enforce fishing regulations (within the EEZ) at the national level in order to maintain sustainable fish stocks. Governments frequently manage their fisheries via the imposition of direct restrictions as well as biological limits:

- Biological limits = governments can cap the total catch, close a fishery during spawning season or when bycatch rates are too high; monitor fish catches with technology; and employ expensive enforcement mechanisms.
- Direct restrictions = the government restricts various inputs into the fishing industry, by limiting the number of boats, limiting the number of days the boats can go to sea, fishing time, investment in fishing technology, engine size and processing capacity [Deligiannis, 2000].

National fishery management regimes are not without their problems – subsidies, enforcement failures, insufficient knowledge, capacities or clashing policy priorities, as we will see when looking at the risk governance deficits below, have contributed to numerous failures. But even if they were largely successful, greater international regimes would still be necessary due to the migratory nature of fish stocks and the remaining fisheries in the high seas. A number of intergovernmental fisheries commissions have been created to manage shared fish stocks within more than one state jurisdiction. Regional Fisheries Management Organisations (RFMO) are intergovernmental organisations that have the authority to establish fisheries conservation and management regimes on the high seas, outside any state jurisdiction. Their purpose is to facilitate cooperation between fishing nations in order to prevent the depletion of migratory and high seas fish stocks, and several stocks are under management by one or more RFMOs [Chatham House, 2007]. At the global level, too, there have been attempts to ensure long term conservation of these and other migratory or widely distributed fish stocks, as evidenced by the UN Fish Stocks Agreement of 1995 and the FAO Code of Conduct for Responsible Fisheries.

Over the last two decades, there have also been considerable efforts made at both the national and international levels to broaden the traditional management of fisheries resources (often focussed on single or multiple fish species) to an ecosystem-based approach. Ecosystem-based fisheries management (EBFM) aims to sustain healthy marine ecosystems and the fisheries they support, essentially reversing the order of traditional management priorities so that the ecosystem, rather than the target species, becomes the starting point [Pickitch et al., 2004: 346].

[3] The EEZ stretches for 200 nautical miles from the baseline (low water line of the shore), within which the coastal state has sole exploitation rights over all natural resources, including fish populations. See Part V of the UNCLOS, full text of the convention available online at **http://www.un.org/Depts/los/convention_agreements/texts/unclos/unclos_e.pdf**

According to the FAO, an EBFM "strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries" [FAO, 2000-2008]. Such a multi- and inter-disciplinary approach requires a new governance approach; an active and open process involving input and support from the public, plus effective cooperation between the government agencies involved in various aspects of environmental management [Busch et al, 2003: 3]. The basic tension, indeed the central institutional issue within EBFM is this: it requires strong legislation and a comprehensive, inter-agency, decision-making process that can make practical decisions related to the whole ecosystem; it also requires more cooperation from more groups in society operating at multiple scales [Wilson, 2009]. To succeed, governance must be top down and bottom up simultaneously. Implementation is thus very difficult, and despite the need for EBFM having been stressed in many international agreements,[4] much progress remains to be made [FAO, 2000-2008].

Overall, it is clear that national, regional and EBFM regimes all have their shortcomings and continue to struggle with commons-related problems, such as managing large numbers of stakeholders, excess capacity in the world's fishing fleets, illegal or unreported fishing and fair allocation of high seas fishing opportunities. Good intentions and some degree of progress is evident such that, according to the FAO's most recent report on the state of world fisheries (2007), the increasing trend in the proportion of depleted or overexploited fisheries evident over the period 1974-1990 (from 10% to 25%) has now levelled off – from 1990 to 2004, the proportion of overexploited stocks remained quite constant at around 25%. However, at the same time, negative trends are also present, as the proportion of underexploited fish stocks has been consistently decreasing, and most of the stocks of the top ten fished species are currently fully exploited or overexploited. Fish stocks exploited partly or wholly in the high seas, as well as stocks that straddle boundaries between countries' EEZs and the high seas, are in particularly bad shape [FAO, 2007].

Stakeholders involved

Fishing and related industries: On the one hand, fishing industries are under strong short term pressure to maintain high quotas, long fishing seasons, and government subsidies in order to pay the high costs that excess capacity, poor management and, effectively open access have imposed on them. Industry stakeholders often lobby hard for these interests and put significant pressure on governments to prioritise their economic well-being. On the other hand, they also have a strong interest in maintaining fish stocks at healthy levels in order to keep their jobs in the long run. Fishers are often committed to sustainability and reducing environmental impacts from fishing. However, the short term pressures, for example to pay the loans on their boats, can often be overwhelming.

Governments: For governments, maintaining fish stocks is about fostering a profitable industry (which, for some countries, is a major export earner); creating employment in coastal communities; providing food security; looking after coastal and marine ecosystems, or some combination of these aims. Some countries are quite reliant on the fishing industry for foreign income or food, while others subsidise it so much that it is a net economic loss, but keeps people employed and coastal communities thriving. It is the responsibility of national governments to manage fish stocks within their EEZs sustainably, however, the amount of effort and level of success of national fisheries management depends on where policy priorities lie.

[4] For example, the 1995 FAO Code of Conduct for Responsible Fisheries; the 1995 UN Fish Stocks Agreement; the 2001 Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem; or the 2002 world Summit on Sustainable Development (among others)

International and regional organisations: The FAO and UNEP are both concerned with fisheries management at the global level. The FAO, in particular, is very active in monitoring the state of world fisheries and promoting the development of fisheries management. Intergovernmental UN conventions and agreements also play a critical role in fisheries management (see key events below). At the regional level, there are more than 30 RFMOs worldwide. A list of these RFMOs as well as other international organisations and NGOs involved in fisheries governance can be found here: http://www.fao.org/fishery/rfb/search/en and http://www.fao.org/fishery/topic/2897/en. With the push towards EBFM in recent decades, the influence of environmental NGOs, in particular, has grown in the domain of fisheries management policy. As industry and government become more interested in the environmental aspects of fisheries management, these stakeholders enjoy greater legitimacy and more influence in the policy-making process.

Science and advisory bodies: These bodies support fisheries management councils and institutions such as RFMOs, international organisations or national governments. Most RFMOs have their own scientific advisory committees. Broadly, their role is to prepare and review fishery management plans and provide *independent* advice on the technical and scientific bases for decisions concerning fisheries conservation and management, including biological, economic and societal aspects. The accuracy of advice given by these bodies, or how uncertainty is accounted for, can be very important to how well fish stocks are managed.

Marine Conservation Non-governmental Organisations: NGOs have played a critical role in fisheries and marine management over the last three decades. The US was the first country to implement fisheries co-management in the 1970s. Co-management is an approach to management where the fishing industry works with the government on management tasks and it has proved to be an important component of most effective management regimes [Wilson et al. 2003]. The NGOs were mainly excluded from these processes. The US co-management system failed for two decades to conserve fish stocks until the NGOs began to put pressure, mainly legal pressure, on the system to reform. Now NGOs have a far greater influence on marine management, and the US is one of the leaders at promoting the successful recovery of fish stocks.

In addition to these major stakeholders, members of the public are also implicated in, and affected by, the decline of global fish stocks. For consumers, the choices made when purchasing fish can affect global demand for endangered and overfished species and, in general, declining stocks could mean higher prices or even shortages. Agents like the Marine Stewardship Council have developed standards for sustainable fisheries, and together with concerned consumers they put pressure on national and international supermarket chains not to buy and sell non-certified fish. For inhabitants of coastal fishing communities or citizens of countries where fishing is an important export earner, collapse of fisheries could lead to an economic downturn affecting the general population. For conservationists and tourists, marine species and habitats have an aesthetic and intrinsic value that, once destroyed, cannot be replaced.

Key events in the (global) management of fisheries

1956	United Nations Conference on the Law of the Sea I (UNCLOS I)
29 April 1958	United Nations Convention on Fishing and Conservation of Living Resources of the High Seas opened for signature
1960	UNCLOS II
Early 1960s	Collapse and closure of California Sardine fisheries (USA)

Late 1960s	The entire stock of the Atlanto-Scandian Herring fisheries collapses from overfishing (Iceland, Norway, Russia)
1970s	Many countries begin imposing exclusive economic zones extending up to 200 miles from their coastlines to keep foreigners out in the face of a competitive fishing 'free for all'
1972	Collapse of the Peruvian Anchovy fishery (Peru)
1973-1982	UNCLOS III
10 Dec 1982	United Nations Convention on the Law of the Sea is signed
1992	Collapse and closure of the Northern cod fisheries (Newfoundland, Canada)
16 Nov 1994	United Nations Convention on the Law of the Sea comes into force (60th state ratifies the treaty) – this *officially* establishes the *Exclusive Economic Zone* (EEZ) of 200 nautical miles from the coast. A state has exclusive fishing rights within its EEZ.
1995	UN FAO Code of Conduct for Responsible Fisheries. Includes the concept of the precautionary approach.
4 Dec 1995	The United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Laws of the Sea of 10 December 1982. Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement) is opened for signature. It legally binds countries to conserve and sustainably manage fish stocks by a precautionary approach and to settle peacefully any disputes that arise over fishing on the high seas. The agreement is accompanied by guidelines on how to operationalise the precautionary approach, which many fisheries around the world follow today.
11 Dec 2001	UN Fish Stocks Agreement comes into force.

Several more recent initiatives and developments provide reasons to be optimistic about the future. An increasing number of fish stocks are regulated, more bottom habitat and coral reefs are protected and more environmentally friendly fishing gear is being developed and utilsed. International bodies, like FAO, have developed risk and indicator frameworks to facilitate an ecosystem based approach to fisheries management, and several nations are about to adopt such frameworks. Canada uses a risk framework to categorise the risks to fish and fish habitats as a decision support tool for reducing risks and for spatial planning of human uses[5]. The Australian Fisheries Management Authority has put in place an ecological risk management framework as a tool for an ecosystem approach to fisheries management[6]. Hand in hand with these developments goes a trend to include stakeholders in prioritising objectives and developing frameworks for decision making. Serious fisheries management reform is getting support from many representatives of science, the conservation community and the fishing industry. In many places the risks and uncertainties associated with fishing are being pushed to the centre of the discussion.

[5] See: http://www.dfo-mpo.gc.ca/oceans-habitat/habitat/policies-politique/operating-operation/index_e.asp Access: 08.04.2009

[6] See http://www.afma.gov.au/environment/eco_based/eras/risk.htm. Last access: 08.04.2009.

Risk governance deficits illustrated by fisheries depletion

B1 Responding to early warnings

A positive example of how previous failures led to improved risk governance is the case of the North Sea herring fishery. This fishery suffered a severe collapse in 1975-6 following failures by regulators to act on early warning signs that fish stocks were unhealthily low (rapid declines in spawning stock biomass and catches composed of 80% juvenile fish were observed throughout the 1960s). The fishery was therefore closed in 1978 and it took 19 years for the stock to recover. Upon reopening of the herring fishery in 1981, efforts were made to improve the management of fish stocks [CEFAS, 1999] and, in 1995, when early warning signs once again showed that fish stocks were becoming dangerously low, quick and drastic action - including an EU/Norway agreement on fishery management in 1997 - was taken to avoid another collapse. By 2003, the stock had recovered without requiring even temporary closures of the fishery [Simmonds, 2007]. An important reason for the success was the support from the fishing industry. Why the herring industry in particular has been more supportive of precautionary management actions than many other fisheries can partly be explained by the memory of the earlier collapse [Simmonds, 2007]. But perhaps more importantly, the number of fishing vessels and companies involved in the fishery is small, and the fleet has lately been well enough capitalized to benefit from long-term planning.

A2 Factual knowledge about risks

What makes fisheries management particularly susceptible to knowledge-related governance deficits is that, on the one hand, it relies heavily on scientific knowledge for the formulation of policies and regulations, but, on the other hand, scientific information in this domain often comes with a significant degree of associated uncertainty. Scientific knowledge about the life cycles of many fish species is limited, as is knowledge of how the oceans and marine ecosystems respond to pressures (changes may not be noticed by scientists because they are occurring too slowly and are thus “not on the radar screen of human perception”) [Nellemann et al., 2008:56]. The combination of these two uncertainties leads to a third: scientific knowledge about how fish stocks will react to pressures, both human and environmental, is also somewhat lacking [Richards and Maguire, 1998]. A consequence of this is that the thresholds representing limit, precautionary or target measures used for obtaining management objectives are also associated with uncertainty [Hauge et al., 2007]. Indeed, there is even a degree of uncertainty involved in measuring and assessing existing fish stocks [Pattersen et al., 2001; Reeves and Pastoors, 2007]. In fisheries with unreported catches (discards and illegal catches) the incomplete catch data makes the assessment even less accurate.

Further examples of sources of uncertainty are the problems involved with sampling fish populations to estimate their size. Because fish tend to congregate in schools, some areas within the fishing grounds will have much higher concentrations of fish than others. As a result, even if overall stocks are very low, sampling can give the opposite impression if a rare, high density area is sampled. Estimates of the Northern cod populations made by sampling in the late 1980s were controversial for this reason, with the fishing industry, in particular, insisting that sampling had been done in areas of low density, thus leading to quotas being set too low [Watkins, 2007]. Modern technology, such as acoustic surveying, has made the task of estimating fish stocks somewhat more accurate, although uncertainties have not been and, cannot be, eradicated. The International Council for the Exploration of the Sea, which provide quota advice for the Northeast Atlantic, considers stock estimates in data rich cases to be associated with an average uncertainty (coefficient of variation) in the order of 20% [ICES, 2008:3].

Overall, lack of scientific information and difficulties related to observation of marine environments have allowed fishing and other pressures to progress, intervention free, much further than would have been permitted on land [Nellemann et al., 2008:58]. Intractable uncertainties in scientific

knowledge have also (as exemplified above by the Northern cod case) been used by the fishing industry as justification for objections to regulations and quotas and for non compliance with governance regimes [Beverton & Anderson, 2002; Rosenberg, 2007].

A7 Understanding complex systems

"Most scientists and managers may not be aware of the true magnitude of change in marine ecosystems, because the majority of declines occurred during the first years of exploitation" [Myers & Worm, 2003].

The responsibility of fisheries managers is to maintain fish stocks at their most productive state over the long term. For fish stocks a theoretical "virgin" state in not the ideal management target because it is when a stock is growing rapidly that it is at its most productive level. The great challenge is to maintain the fish stock at its most productive level while maintaining this productivity in the long term. Too often managers have erred on the side of greater fishing, and this has meant that fish populations have been fished to the point of collapse. In some cases, this collapse can be so severe that the fish population in question does not recover, or takes many decades to recover. However, some scientists argue that the problem of fisheries depletion, and its related risks, exists on a much larger scale than that of single fish populations (see above under "biological diversity and ecosystem stability"). A study found "general, pronounced declines of entire communities across widely varying ecosystems" and a loss of more than 90% of large predatory fishes from the global ocean [Myers & Worm, 2003].

If we are facing global warning, with impacts on the ocean environment, overfishing may further fortify effects of changes in the ecosystem structure and of invasive species. The above evidence suggests that, instead of managing the risks related to fisheries depletion predominantly on a species by species, or a population by population basis, there needs to be a greater emphasis on ecosystem level measures that guard the overall productivity of the ecosystem. The North Pacific Fishery Management Council has responded to some of the problems with single stock management by adding specific regulations. One is that a cap is set for total catches in each of two defined ecosystems in federal waters off Alaska. The cap for the Eastern Bering Sea has restricted the single stock quotas several times; each time when the added single stock quota limits have exceeded the cap. Another response to ecosystem concerns is that it is generally forbidden to catch fish that are prey for other fish in these waters [Witherell et al, 2000].

The scaling problem can also be the opposite; that the scale is defined too broadly. Normally fisheries are regulated by stock - an independent, self-reproducing unit of a certain species - but in reality few stocks are fully independent, and there is a continuum of levels of connectedness. When a quota is set for a stock, a fisherman is often relatively free to decide where to catch the fish from that particular stock. Defining a stock too broadly can therefore result in depleted subpopulations. A possible mismatch between the biological and management "stock" is addressed in advice for about one third of the ICES stocks [Stephenson, 2002], but scientific methods and analyses are often inconclusive. North Sea sandeel and cod are two depleted stocks that may have suffered less if spatial management had been put in place to account for possible independent subpopulations.

A8 Recognising fundamental or rapid changes in risk systems

Atlanto-Scandian herring fishery: Sudden improvements in fishing technologies in the 1950s and 60s significantly increased the size of herring catches and thus constituted a fast change in the overall risk system of the Atlanto-Scandian herring fishery. Mechanical winches made it possible to use bigger boats and sonar made it easier to locate shoals of fish, leading to rates of extraction that were far greater than rates of population replacement. The absence of new regulations to take into account the power of these technologies led to the sudden collapse of the fishery in the

late 1960s [Hannesson, 2008:17].[7] Many fisheries scientists at the time believed that depleted fish stocks could quickly be rebuilt. The origin of this idea was the fact that a single herring can produce hundred thousands of eggs and cod, millions. Around the beginning of the 1970s, more and more scientists supported the idea that the number of spawning fish actually mattered. In the case of Atlanto-Scandian herring, the role of the scientists up until the 1970s had been to locate the largest concentrations of herring to assist the fishermen [Dragesund et al., 2008]. This explains why it took a couple of extra years after the depletion to get a fishing moratorium in place. It took more than 20 years for the fishery to recover. Advances in fishing technologies without accompanying regulation played a similar (though less prominent) role in the collapse of the Northern cod fishery in 1992.

In the 70s, the Barents Sea capelin stock maintained an annual fishery with catches up to 3 million tons [Gjøsæter & Bogstad, 1998]. Then the stock began to decline and in 1985 scientists recommended no fishing be allowed in 1986 [ICES, 1986]. The Mixed Soviet-Norwegian Fisheries Commission found itself unable to follow this advice of political reasons, and a quota was set for 1986 [Hønneland, 2006]. But the fishermen were not even able to catch this quota because there were so few fish. The collapse was an inescapable fact, and the fishery was closed until 1991, when it was partially reopened.

Although possible ecological mechanisms had been hypothesised before the collapse [Hamre. 1984; ICES, 1986], these were far from established. The collapse was later explained by a combination of fishing and environmental conditions. One was the unforeseen importance for capelin of the Norwegian Spring Spawning herring stock, which has its nursery area in the Barents Sea. Since the herring stock had been depleted in the late 60s, its role in the Barents Sea ecosystem had only been rarely studied. The increased inflow of Atlantic water to the Barents Sea in 1983 provided favourable environmental conditions and resulted in an outstanding number of herring and cod larvae in the Barents Sea. What the scientists did not fully realize was the extent that the young herring would graze on the young capelin, and that cod would consume a significant part of the maturing capelin stock. The combination of massive predation and fishing led to the depleted capelin stock [Tjelmeland & Bogstad, 1993]. The lack of capelin as prey fish then led to poor growth and high mortality among the fish, marine mammals and marine birds that depend on them, resulting in a more or less collapsed ecosystem [Hamre, 2003].

As a consequence, an extensive stomach-sampling scheme was conducted to map the interrelationships between the species in the Barents Sea [Gjøsæter et al., 2002]. Now the managers are warned when the observed abundance of herring larvae is high, the assessment of capelin takes the predation of cod into account and uncertainties are better addressed.

A9 The use of formal models

Between the late 1960s and the late 1980s, industrial over-fishing managed to wipe out the Northern cod fishery, once considered one of the greatest in the world, to the point that biological extinction of the fish stock was considered a real possibility [McCay and Finlayson, 1995]. This occurred in spite of the fact that the government had been employing mathematical models to set total allowable catches (quotas). While models can be very useful and have an important place in fisheries management, this example demonstrates that models, and what they represent, are complex and that models can be fallible. How models are used is thus crucial to their usefulness and potential success

Reassessments of the abundance of Northern cod indicate in hindsight that the abundance was overestimated by as much as 100% [Walters & Maguire, 1996]. A range of explanations for these overly optimistic assessments has been discussed and analysed in the scientific literature:

[7] However, a cold period in the NE Atlantic, which naturally causes herring populations to decline, may have disguised the severity of the situation.

- The model treated Northern cod as a unit stock. In reality, it was comprised of more or less distinct populations, each having different migratory patterns and different spawning grounds. The neglect of this fact may have contributed to an overestimation of biomass and an overly optimistic prediction of recruitment (survival of offspring) [Walters & Maguire, 1996; deYoung & Rose, 1993];
- The risk of having a recruitment failure was not taken sufficiently into account [Walters & Maguire, 1996];
- Natural mortality was treated as a constant in the model, but there are indications of increased predation of marine mammals and decreased survival due to environmental conditions the years before the collapse [Shelton & Lilly, 2000];
- The data from the fishery was distorted by the practice of discarding undersized fish, resulting in underestimates of mortality from fishing [Shelton & Lilly, 2000; McCay & Finlayson, 1995];
- The catch rate of the offshore fleet was used as an index of abundance to 'tune' the stock assessment model. The ongoing technical improvements made it easier to catch the fish so that the index turned out not being able to reflect the decline in abundance. Furthermore, the offshore fleet continued to get good catches because the stock was concentrating in smaller and smaller locations before the collapse. [Walters & Maguire, 1996; Shelton & Lilly, 2000; deYoung & Rose, 1993; McCay & Finlayson, 1995; Shelton, 2005].
- The optimistic forecasts contributed to the build-up of overcapacity in the fishing fleet [Walters & Maguire, 1996; Finlayson, 1995].

There is broad agreement that the assessment model failed to represent nature and the impact of fishing in a way that was adequate for policy support. However, several scientists have concluded that given the data, the knowledge and the managers' dependence of a number from the fisheries scientists to set quotas, the collapse could not have been foreseen earlier [McGuire, 1997; Shelton & Lilly, 2000; Shelton, 2005]. In spite of the model's shortcomings and warning voices from parts of the inshore fleet and the scientific society [Finlayson, 1995; Rose, 2007], the mathematical model was a convenient tool for policy-makers who wanted more than anything to avoid making the politically disastrous decision to halt or significantly decrease fishing [Pilkey & Jarvis-Pilkey, 2007]. Two years before the collapse, the scientists became confident that the stock had been severely overestimated. Yet, the managers chose to listen to the still optimistic representatives from the offshore fleet and set a quota twice the level recommended by the scientists [Rose, 2007].

Finally, the collapse became evident. There was a complete closure of the Northern cod fishery in 1992 and, since then, the fishery has only been reopened sporadically and on an experimental basis. Cod stocks have still not recovered sufficiently to allow the fishery to reopen on a permanent basis [Hannesson, 2008]. The overfishing, with a fortified effect from environmental changes, may have changed the ecosystem structure [Frank et al., 2005] so that a recovery in the near future cannot be taken for granted.

B11 Dealing with commons problems and externalities

With regards to global fisheries management, it is not a case of *no* strategy or norms to deal with the commons dilemma, but rather of a strategy with many imperfections. A solution to a commons dilemma begins with some form of access rights that limit exploitation. This can be done, *inter alia*, through a common property regime, an individual property regime, or direct government management. One challenge is that fish often migrate over large distances and between jurisdictions, and the number of users of the resource is very high. Nevertheless, the international community did manage to agree upon a scheme for access rights on a large scale – the establishment of the Law of the Sea created jurisdiction for many fisheries, effectively creating many separate national government property regimes. Fish stocks within states' exclusive economic zones (EEZ) came under the control of national governments. The creation of RFMOs was intended to solve the problem of fish stocks migrating through more than one EEZ by

creating a sort of group property regime between the 'owner' states. Fish stocks on the high seas and those that migrate between the high seas and national EEZs, however, remain problematic. Even the EU's collective approach has thus far failed to solve the problem of distant-water fishing fleets poaching fish from near the EEZ of its coastal states and undermining its efforts to manage fish stocks in its waters. The lack of policies and protected areas covering deeper waters and sea mounts on the high seas is currently of critical concern [Nellemann et al., 2008:58].

B2 Designing effective risk management strategies

Policy objectives related to fisheries management will usually fall into one of three categories: economic, food security, or conservation and environmental protection. In practice, the first two have tended to outweigh the third. The challenge is how to balance the need for a healthy and environmentally sound source of protein that supports a healthy fishing industry, with making sure that fish stocks and marine ecosystems remain healthy and productive. The short term economic pressures on the fishing industry, which themselves result from poor management and overcapacity, and the fact that they have until recently been the best organized and most focussed stakeholders in fisheries management, have meant that the balance has fallen too often toward short term economic concerns and therefore continued high exploitation. The challenge now is to restore this balance without such draconian measures that fishers are unnecessarily deprived of their livelihoods.

Northern cod: The Fishing industry in Newfoundland was very important to the local economy and a key means of keeping people employed in the province. Government subsidies to the fishing industry were also considerable and many rural communities were nearly totally dependent on cod fishing. Furthermore uncertainty about the conditions of the cod stocks was very high, and high catches were continuing even after the cod stocks were becoming dangerously low. As a result the Canadian government did not take fast or drastic enough action in cutting fishing quotas. Because it feared the political fallout of taking drastic action to reduce fishing, especially in the face of uncertain information, the government failed to save the fishery from collapse. The fishing industry, and the local economy and population more generally, suffered harsh losses as a result and the government ended up facing far worse problems than the political fallout it had initially feared [Hannesson, 2008:19].

Overall, "the crisis in the world's marine fisheries is not only a fisheries problem, but one of the political economy of reform. Fisheries reform requires broad based political will" [World Bank/FAO, 2008:xv]. Finding ways of dealing with uncertainty and risk is one of the key factors in mobilizing this political will. Several more recent initiatives and developments give reasons for some optimism for the future. An increasing number of fish stocks are regulated, more bottom habitat and coral reefs are protected and more environmentally friendly fishing gears are being developed and put into practice. International bodies, like FAO, have developed risk and indicator frameworks to facilitate an ecosystem based approach to fisheries management, and several nations are about to adopt such frameworks. Canada uses a risk framework to categorise the risks to fish and fish habitat as a decision support tool for reducing risks and for spatial planning of human uses[8]. The Australian Fisheries Management Authority has put in place an ecological risk management framework as a tool for an ecosystem approach to fisheries management[9]. Hand in hand with these developments goes a trend to include stakeholders in prioritising objectives and developing frameworks for decision making. Serious fisheries management reform is getting support from many representatives of science, the conservation community and the fishing industry. In many places the risks and uncertainties associated with fishing are being pushed to the centre of the discussion.

[8] See: http://www.dfo-mpo.gc.ca/oceans-habitat/habitat/policies-politique/operating-operation/index_e.asp Access: 08.04.2009

[9] See http://www.afma.gov.au/environment/eco_based/eras/risk.htm. Last access: 08.04.2009.

B3 Considering a reasonable range or risk management options

In the case of fisheries management, there have been examples of both failure and relative success in regulation. Success depends on the specified objectives for economically and ecologically sustainable fisheries. Examples of policy instruments that restrict access are: closed areas for fishing, for the whole year or certain seasons, limiting the number of fishing licenses (in order to stop the expansion of the fishing fleet) and the imposition of total allowable catches per species per year (quotas). For such measures to be effective there must be a sufficient control and enforcement system in place. Every fisher knows that there is no point in following regulations that are not enforced; he would only be hurting himself while doing nothing for sustainability. Two classes of management tools also serve particularly well in providing incentives for responsible fisheries: rights-based management and participatory governance.

Whenever it is important to divide a fish stock among different nations or other groups, and this is often the case, then setting a divisible quota is usually required because other approaches, such as limits on fishing effort are so difficult to measure for distribution. Even when an overall quota is set that guarantees ecological sustainability, economic waste is created when fishermen lack secure rights to the resource. In this case their incentive is to catch as many fish as possible as quickly as possible, before the quota is reached. This competitive 'race to fish' can lead to excessive harvests, industry lobbying for larger quotas and generally poor stewardship of fish stocks. Therefore, blunt industry-wide quotas are often not the most effective policy instruments for the sustainable management of fisheries.

Rights-based management is a regulatory tool to prevent these drawbacks. It can take many forms, depending on the prioritised objectives for the fishery, but in common they provide a rights holder a certain share of the fishery. The rights holder can i.e. be an individual, a cooperative or a community. The greatest economic efficiency is achieved when these rights are permanent, secure, and transferable. Individual transferable quotas (ITQs) allocate each fisherman a certain portion of the overall catch quota, which he can then sell or trade. This creates incentives to increase economic efficiency in a fishing fleet. While it has been shown that ITQs can smooth the transition to a lower fishing capacity, the relationship between ITQs and conservation, however, remains suggestive but unproven. Examples of rights-based management where the objective is to protect fishing communities are territorial use rights in fishing (TURFs), which specify the right to specific fishing locations and community quotas, where fish quotas are allocated to fishing communities.

Iceland was among the very first countries that introduced ITQs. The ITQ system has led to substantial increases in economic efficiency [Arnason, 2006], but also to quota concentrations, causing a concentration of wealth and marginalising fisheries dependent coastal communities [Pálsson & Helgason, 1995]. ITQs have often the consequence of driving small fisherman out of business and concentrating the wealth in the hands of a few, large companies [World Bank, 2005:12].

The pollock fishery in Alaska is certified as sustainable by the Marine Stewardship Council. The fishery is formed by cooperatives with preset quota shares. Although these rights have been an incentive to increase economic investments and gains, they do not provide sustainability on their own. The North Pacific Fishery Management Council, which also set regulations for the pollock fishery, provides a precautionary fisheries management with relatively low harvest rates and strict bycatch regulations. Also, each pollock vessel has 100% observer coverage so that there are no compliance problems [Witherell et al., 2000].

As the examples illustrate, rights-based management needs to be accompanied with diverse management measures in any real-world fisheries to improve sustainability.

For fisheries management to be truly sustainable, policy instruments must consider the whole context (local conditions and industry) as well as the entire marine ecosystem, not just the situation of the target fish species. Also, as illustrated above, policy makers must think about possible unintended consequences their policy instruments may have on marine environments or on the fishing industry. Another policy that had unintended consequences was implemented in the US in the 1990s, when the National Marine Fisheries Service encouraged fisherman to focus on underutilised species, to give over fished species a chance to recover. This led to the harvesting of squid in large quantities and the removing of a crucial food source for many other marine creatures, thus severely interrupting the marine food chain [Russell, 1996].

A policy instrument that has acquired a bad reputation with regard to the protection of fish stocks is the subsidy. The provision of subsidies to the fishing sector by the government is often justified as a means to protect fledgling industries; to ensure national food security; to preserve traditional livelihoods; or to reduce poverty. However, subsidies often prove to be inappropriate policy instruments to achieve any of the above aims, and especially those that rely on the maintenance of fish stocks. Commonly, subsidies in the fishing sector take the form of fuel price support (or fuel tax exemption), vessel construction, modernisation and buyback schemes, surplus fish purchases, financing of fishing access agreements, grants or concessional credit and insurance [World Bank/FAO, 2008:18]. In 2000, governments worldwide provided over US$10 billion in fishing subsidies, almost 80% of which were provided by developed countries. Subsidies for fuel are by far the most frequently provided, by both developing and developed nations, and are estimated to be worth in the range of US$4.2 to 8.5 billion per year [Sumaila et al., 2008]. Unfortunately, because subsidies reduce the cost of fishing – which is already lower than it should be due to the inherent lack of property rights for many fish stocks – they create perverse incentives for continuing, and even expanding, fishing in the face of falling catches. Subsidies thus foster overcapacity and the overexploitation of fish stocks. Their use as a policy instrument is often meant to be short term, but entrenchment of subsidies is not uncommon and often subsidies are primarily employed due to their political expediency – it is easier to placate the stakeholders in the fishing industry than to address unpopular alternatives such as “the challenge of helping fisher households to take up other gainful economic activities” [World Bank/FAO, 2008:38].

B10 Dealing with dispersed responsibilities

Because fish stocks are transboundary in character and the same fish stock may migrate through the waters of more than one state and even into international waters, the problem of dispersed responsibility between institutions is a common one. If management is devolved to a local level, these institutions will exist within national fisheries management arrangements, which themselves exist as sets of rules within a greater global system of governance, for example the Law of the Sea plus RFMOs. Since 1945, at least 30 subregional or regional fisheries management organisations have been established. While the division of responsibilities between the local, national and international levels is complicated enough, it is sometimes the case that there are multiple institutions *within* each of these levels. For example, in Peru in the 1960s and 70s there was no single office responsible for coordinating fishing policy. The Ministry of Finance, the Ministry of Agriculture, IMARPE (Instituto del Mar del Peru), the Ministry of Navy, the Ministry of Labour and the Congress all had various responsibilities to make decisions that affected the fishing sector [Tran, 2003]. Peru now has a Ministry of Fisheries.

B9 Organisational capacity

The effectiveness of fisheries governance depends on the suitability of the implied institutions and regulatory frameworks. In many countries, the basic regulatory framework for fisheries management is weak or non-functional [World Bank, 2005:8]. Developing countries often have new and untried institutions and tend to lack the financial and technical capacity for the good management of fish stocks, while in developed countries it is often the case that sufficient resources exist, but are just not employed efficiently or effectively. Difficult issues are often

sidestepped, not for lack of institutional capacities to deal with them, but rather because they could cause political or economic tensions (deficits B1 and B2 may be more relevant for developed countries). Developing countries thus have the greatest need for institutional capacity building, although developed countries' institutions could also, in most cases, be significantly improved.

For one thing, fisheries management institutions need to broaden their policy frameworks and make sure they possess a full range of analytical skills – biological, economic, social, etc. Building institutional capacities for consensus-building, conflict resolution and negotiation will become increasingly important, as will improving the capacity to communicate and cooperate effectively with all stakeholders and all levels of fisheries governance [SIFAR/World Bank, 2003]. For example, at the international level, one of the greatest problems facing RFMOs is currently the lack of cooperation between members. This occurs due to a lack of coordination and common standards between national-level institutions and the RFMO; the prioritisation of national over regional interests; and also a lack of technical capacities for cooperation [FAO, 2006].

B5 Implementing and enforcing risk management policies

Despite the existence of national legislation on fisheries management in many countries, as well as the existence of regional fisheries management organisations which are meant to foster improved cooperation and coordination between nations, management failures have not been an uncommon occurrence. One recent example concerns the Mediterranean Tuna fishery. This fishery has one of the highest levels of over fishing in the world. It is fished by 11 Mediterranean coastal states, some of which are also bound by the rules of the EU's Common Fisheries Policy. Despite the many regulations in place and the quotas assigned to each fishing nation, blue-fin tuna stocks are now dangerously low as a result of over-fishing. While many criticise the International Commission for the Conservation of Atlantic Tuna (ICCAT) and its member states for setting quotas far higher than the sustainable limits recommended by scientists [Black, 2008], another major problem is that these quotas are not respected, along with rules on reporting catches, bans on using tuna spotting planes, etc. – enforcement of policies is seriously lacking [WWF, 2008a]

Italy, for example, is known to be one of the worst offenders as far as over-fishing and violating fishery management rules are concerned: in 2007 it overshot its quota by at least 38% (approximately 1,653 tonnes); despite the EU's early closure (in June) of the fishery in 2008, it had already overshot its quota by 724 tonnes; it has used spotter planes (a banned activity) to help direct purse seiners to their catch; and has also underreported catches in recent years [WWF, 2008b]. The EU's Joint Deployment Plan launched in March 2008 (under the auspices of the EU Community Fisheries Control Agency, CFCA) aims to coordinate and step up joint control and enforcement activities to try and rectify this problem [CFCA, 2009]. Resources of seven main EU-member fishing states will be pooled to carry out enforcement operations involving inspections at sea and in ports [EC, 2008]. It is hoped that these efforts to improve enforcement of policies (along with parallel efforts to reduce fleet capacity) will help the fishery to recover.

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Another example of an implementation and enforcement failure is the EU fisheries, as the EU waters are more overfished than globally. The Common Fisheries Policy is claimed to have failed in all its dimensions, in spite of agreed general objectives and a whole set of existing regulations [Sissenwine and Symes, 2007]. Two central reasons for this failure are the year to year negotiations between member states on quotas and the lack of enforcement [Sissenwine and Symes, 2007]. Indeed, a meta-study indicate that the fisheries managers have followed the direction of advice from ICES, but that TAC regulations do not actually limit the catches due to compliance problems [Patterson & Résimont, 2007].

While the European Commission can develop fisheries objectives and policies, the Member States have the responsibility to implement regulations and to provide enforcement schemes. The

European Court of Auditors points to problems concerning catch recordings, inspections and sanctions, both at the national level and the European Commission [ECA, 2007], indicating that there has been a reluctance to taking responsibility.

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