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Consequences of climate change for some segments of the Norwegian Fishing Fleet

by

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Abstract

This paper identifies the possible effects of climate change on fish stocks important for the Norwegian fishing fleet along with information on the Norwegian harvest pattern in the past can tell us something about the consequences of a changing climate for the fishing fleet. A survey the Directorate of Fisheries's landings and settlement register are performed on a subsample of the Norwegian fishing fleet consisting of factory trawlers, other trawlers, large conventional fishing vessels and small inshore fishing vessels. The relative importance fish stocks and harvest areas are described for the period 2000-2006. We combine the information retrieved in the previous sections and try to say something about the fishing fleet's ability to cope with change. The trawlers and the large conventional vessels specialize in targeting the large fish stocks, such as cod, saithe and haddock, and as the stocks are expected to gain from higher ocean temperatures and expand their area of distribution, the ocean going vessels will also benefit from this. The inshore fishing fleet also target the same fish stocks, but are more limited in their ability to take advantage of expansions off shore. However, the coastal fishing fleet is a very diverse group, harvesting a number of alternative species living in different coastal areas and can be expected to take advantage of new species entering the ecosystem following a warmer climate.

Keywords: Climate change, Norwegian fishing fleets, Barents Sea, Norwegian Sea, adaptability.

JEL Classification: Q22, Q54.

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1 Introduction

The ecosystem of the Norwegian Sea and the Barents Sea is one of the world's richest, purest, and most productive marine areas, and where the climate, both in the sea and the atmosphere, is expected to change[1] in response to global warming (Stenevik and Sundby, 2007). Although the prevailing view seems to be that these waters will become warmer over the next 50-70 years, to the extent that the Arctic Ocean could become ice-free during the summer, there is also the possibility that the Gulf Stream and the termohaline circulation will be weakened, leading to a colder climate in northwestern Europe, despite global warming (ACIA, 2004).

Higher ocean temperatures could lead to greater plankton production and, because of ice melting, even production in previously inaccessible areas. Changes in prey availability will influence the distribution of fish stocks which seasonally migrate into such areas. Furthermore, higher abundance of plankton could lead to an increased production of plankton feeding fish, and as plankton feeding fish typically serve as important prey for other fishes, this could spill over on the higher trophic levels as well. However, the predator-prey relationship makes it difficult to predict how exactly these changes will affect a specific species, and is further complicated by the fact that individuals of the same species may be at different trophic levels depending on the current stage of their life cycle. Younger and smaller fish, to a large extent, feed on plankton, but as they become older and bigger they prefer larger organisms as prey; and even smaller individuals of their own species.

This paper identifies the possible effects of climate change on fish stocks important for the Norwegian fishing fleet, which we hope, along with information on the Norwegian harvest pattern in the past, can tell us something about the consequences of a changing climate for the fishing fleet. We focus on the effects in the Norwegian Sea and Barents sea, because this is where the largest fish stocks live, and it is also where the change in climate is expected to have most pronounced effects within the area of interest of the Norwegian fisheries.

Modelling studies show that it is difficult to simulate and project changes in climate resulting from the response to forces that can be and have been measured and even monitored on a regular basis for considerable periods and on which the models are built. Furthermore, current climate

[1] Climate change is usually linked to changes in temperature, but also other climate parameters such as salinity, ocean currents, ice conditions, light (which depends, among other things, on the cloud cover and season), and turbulence (which changes with the wind conditions) affects the ecosystem (Anon., 2008).

models do not include scenarios for ocean temperatures, water mass mixing, upwelling, or other relevant ocean variables such as primary and secondary production, on either a global or regional basis. As fisheries typically depend on such variables, any predictions concerning fisheries in a changing climate can only be of a very tentative nature.

Commercial fisheries in Arctic regions are based on a number of species belonging to physically different ecosystems. The dynamics of many of these ecosystems are not well understood and therefore it is often difficult to identify the relative importance of fishing and the environment on changes in fish populations and biology. Moreover, current fish populations differ in abundance and biology from those in the past due to anthropogenic effects, *i.e.*, exploitation rates. As a result it is unclear whether current populations will respond to climate change as they may have done in the past. Thus the effects of climate change on marine fish stocks and the eventual socioeconomic consequences of those effects for Arctic fisheries cannot be accurately predicted.

The paper is organized as follows. Section 2 identifies the most important fish stocks and describes how they have responded to changes in the climate in the past. Next, Section 3 surveys the Directorate of Fisheries's landings and landings slips register for a subsample of the Norwegian fishing fleet consisting of factory trawlers, other trawlers, large conventional fishing vessels and small inshore fishing vessels. The relative importance of fish stocks and harvest areas are described for the period 2000-2006. In Section 4 we combine the information retrieved in the previous sections and try to say something about the fishing fleet's ability to cope with change. The trawlers and the large conventional vessels specialize in targeting the large fish stocks, such as cod, saithe and haddock, and as the stocks are expected to gain from higher ocean temperatures and expand their area of distribution, the ocean going vessels will also benefit from this. The inshore fishing fleet also targets the same fish stocks, but is more limited in its ability to take advantage of expansions offshore. However, the coastal fishing fleet is a very diverse group, harvesting a number of alternative species living in different coastal areas and can be expected to take advantage of new species entering the ecosystem following a warmer climate. Finally, Section 5 concludes.

2 Possible impacts of climate change on fish stocks

Arctic or Arctic-influenced waters are inhabited by more than 150 species of fish. Few are endemic to the Arctic, unlike the situation in the Southern Ocean where endemic species predominate. Most fish species found in the Arctic also live in boreal (northern) and even temperate regions. Arctic fish communities are dominated by a small number of species. The most abundant are Greenland halibut (*Reinhardtius hippoglossoides*), polar cod, Atlantic and Pacific cod (*Gadus morhua* and *G. macrocephalus*), Greenland cod (*G. ogac*), walleye pollock (*Theragra chalcogramma*), capelin (*Mallotus villosus*), long rough dab, also known as American plaice (*Hippoglossoides platesoides*), yellowfin sole (*Pleuronectes asper*), Atlantic and Pacific herring (*Clupea harengus* and *C. pallasi*), and redfish (*Sebastes spp.* e.g., *S. mentella*, *S. marinus*). Greenland halibut, polar cod, and capelin have a circumpolar distribution. Greenland cod is a predominantly Arctic species that is restricted to Greenland waters (ACIA, 2005).

There are few records of marine biota showing interannual and longer-term variability in the Arctic Ocean, but records of the abundance of commercial fish species for the Labrador, Greenland, Iceland, Norwegian, and Barents Sea go back to the start of the twentieth century and even earlier in some cases. Within these areas capelin, cod, and herring populations have undergone very large fluctuations in biomass and distribution.

The period of warming from the mid-1920s to the mid-1960s, which affected Greenland and Iceland in particular, had a profound effect on the major commercial fish species and also on most other marine life. A number of species, which had been rare or nonexistent in offshore areas west of Greenland, in particular Atlantic cod and Atlantic herring, became abundant at this time, and population biomass increased by several orders of magnitude. Other species, previously absent, such as haddock (*Melanogrammus aeglefinus*), tusk (*Brosme brosme*) and ling (*Molva molva*), appeared off West Greenland from 1920 onwards, while saithe (*Pollachius virens*), previously rare, became more common and extended its range. These changes were not related to fishing and are probably due to climate variability. Boreal species such as cod are likely to respond strongly to temperature variability and so show greater variability in recruitment at the extremes of their range. However, for the period over which records are available, most populations have been reduced to low levels as a result of fishing pressure and may therefore show high variability throughout their distribution.

The Arctic Climate Impact Assessment (ACIA) working group on Arctic fisheries (ACIA, 2005) came to the following general conclusions regarding the main commercial fish stocks of the North Atlantic: A warming of the magnitude predicted is more likely than not to be beneficial to the fisheries of the North Atlantic. Important species that would probably benefit are: Cod, haddock, saithe, herring, blue whiting and several species of flatfish. Important species that would probably decline are: Shrimp, capelin, Greenland halibut and some species of flatfish. To a certain extent, ocean warming will induce a northward shift in the range of some species. Less ice cover may offer increased access to fish stocks.

3 A survey of the landings and landings slips in the fisheries

The following is based on information obtained from the Norwegian Directorate of Fisheries record of landings and landings slips in the fisheries, 2000-2006. The records contain information about quantity and payment of landings of fish, specified as to year, vessel, county of origin, fish species, gear type and harvest area. The vessels in the data set are selected on the grounds that they appear in the Norwegian Directorate of Fisheries profitability surveys of the Norwegian fishing fleet for vessels over 8 metres length operating year round. The period covered is 2000 to 2006. The data set is divided into four subsamples: Factory trawlers, *i.e.*, trawlers with onboard fish processing facilities, other trawlers, fishing vessels over 28 metres length using conventional gear, *i.e.*, passive fishing gear that is characterized by the absence of gear movements and/or the pursuit of the target species; such as, but not limited to, hook and line, fish pots, traps and gill nets across the migration path of the fish, and fishing vessels less than 15 metre length.

Although the vessel data set is a sample and does not include all vessels in each group, the samples consisting of the trawlers and conventional vessels can be regarded as fairly representative of the respective subpopulations. The numbers of vessels in the said groups are relatively small and a significant number are represented each year in the profitability surveys. For the coastal vessels, *i.e.*, the vessels less 15 metre length, the diversity is great, and the number of vessels included in the survey is small compared to the total number of vessels in the group, so the same degree of representability is not achieved within this group.

Therefore, in an effort to explore the data in order to find out what characterizes each group with respect to landings and value of different target species and harvest area, the relative

Table 1: Factory trawlers. Vessels with cod trawling license and possibly shrimp trawling license: Fish Species, % of total landings and values, averaged over 2000-2006

Fish Species	Landings	Value	Fish Species	Landings	Value
Other Skate/Ray	0.00	0.00	Spotted Wolf-Fish	0.06	0.05
Greater Argentine	0.01	0.00	Northern Wolf-Fish	0.02	0.00
Tusk	0.02	0.01	Wolf-Fish	0.00	0.00
Cod	24.71	37.28	Mackerel	0.00	0.00
Ling	0.17	0.15	Red-Fish	2.92	2.12
Blue Ling	0.00	0.00	Deep Water Red-Fish	10.99	7.68
Haddock	8.96	10.67	Halibut	0.01	0.04
Saithe	42.12	25.87	Plaice	0.01	0.01
Pollack	0.05	0.05	Greenland Halibut	3.87	8.33
Whiting	0.00	0.00	Long Round Dab	0.00	0.00
Hake	0.01	0.01	Other Flatfish	0.00	0.00
Onion-Eye Grenadier	0.01	0.00	Angler Fish	0.00	0.00
Grenadier	0.01	0.00	Shrimp	5.99	6.42
Atlantic Wolf-Fish	0.05	0.03	Unspecified Fish	0.00	1.26

importance of species and areas is presented for one vessel group at a time, aggregated over the years from 2000 to 2006.[2] We start by the factory trawlers, continue with the other trawlers and the conventional vessels, and end with the coastal vessels.

3.1 Factory trawlers. Vessels with onboard processing holding cod and haddock quotas, and possibly shrimp trawling license

Table (1) shows the fish species landed by the sample of Norwegian Factory Trawlers participating in the Norwegian Directorate of Fisheries profitability surveys of the Norwegian fishing fleet, covering vessels over 8 metres length, from 2000 to 2006. The table also shows the importance of each species relative to the total amount landed and the total value of the landings. Quantity-wise the landings are dominated by saithe (42%), cod (25%), red fish (14%, including deep water red fish), haddock (9%), shrimp (6%) and Greenland halibut (4%). A peculiarity with shrimp (except that it is not a fish species), which is a significant species in both quantity and value terms is that only eight of the 23 vessels in the sample fished shrimp, and there were no landings of shrimp in the 2006 sub-sample. In value terms the order is cod (37%), saithe (26%), haddock (11%), red fish (10%, including deep water red fish), Greenland halibut (8%) and shrimp (6%).

Table (2) shows the areas and fishing grounds where factory trawlers caught fish, from 2000

[2]See the Appendix, Tables (A-1) and (A-2) for landings and values of species and harvest area, respectively.

Table 2: Factory Trawlers. Vessels with cod trawling license and possibly shrimp trawling license: Harvest Areas, % of total landings and values, averaged over 2000-2006

Harvest Area	**Landings**	**Value**	**Harvest Area**	**Landings**	**Value**
Westfjord (Lofoten)	0.20	0.27	Hopen	2.26	3.12
Kanin Bank	1.40	1.79	Great Bank	1.48	1.78
Coast of Murmansk	0.04	0.04	Northwest Spitsbergen	0.09	0.12
East Finnmark	4.14	5.37	Southwest Spitsbergen	0.13	0.24
West Finnmark	8.45	8.63	Viking Bank	3.82	2.48
Røst Bank to Malang Ground	22.57	23.09	Southern Norwegian Sea	0.08	0.06
Helgeland Bank	2.90	2.26	Eastern Norwegian Sea	0.76	0.58
Storegga - Frøya Bank	1.67	1.10	West of the Tromsø Bank	1.26	2.43
Eigersund Bank	2.97	1.95	Central North Sea	0.48	0.32
Skagerrak	0.01	0.01	Shetland Islands	15.91	10.37
Skolpen Bank	0.31	0.43	Outside Cornwall	0.00	0.00
Goose Bank	1.35	1.75	Southwest Norwegian Sea	0.00	0.00
Nordkapp Bank	4.76	5.75	Northwest of Iceland	0.02	0.05
Thor Iversens Bank	1.24	1.41	Skjoldungen Bank	6.80	5.24
Britvin Ground	0.25	0.33	Denmark Strait	0.59	0.97
Central Bank	1.10	1.08	Gammelock	0.00	0.01
Northeast Area	0.01	0.02	Fyllas Bank	0.98	2.03
Bear Island	7.18	10.50	Reykjanes Ridge	2.41	1.60
West Spitsbergen	0.19	0.32	Flemish Cap	2.00	2.26
Storfjord/Hinlopen Strait	0.16	0.22			

to 2006, along with harvest and revenue in each area relative to total quantity and value. Most productive is the coastal area from Røst to the Malang Ground with 23% of the landings from the trawlers, providing 23% of the revenue too. The most important fish species caught in this area are cod, saithe, haddock, red fish and Greenland halibut, making up 99.7% of the total quantity caught and 97.5% of the total value. The second most productive fishing ground is the area around the Shetland Islands with 16% of the total landings, but only 10% of the revenue originates from this area. The fishery around the Shetland Islands is dominated by saithe, which makes up 96.9% of the factory trawlers' total catches in the area and 90.8% of the total value. The third most important harvest area is the waters off the coast of West Finnmark in northern Norway (8%), where saithe is the most dominant fish species with 50% of the quantity. However, in the Barents Sea, for example, in the waters surrounding the Bear Island the harvest is dominated by cod and haddock, making up 92.2% of the harvest and 92.0% of the total value from this area. In the North Sea and along the coast of Norway saithe is an important commercial species, but in the Barents Sea it is not. Here the harvest is dominated by cod and haddock; in particular, haddock seems to gain importance the farther north and east you get along the Norwegian coast towards sub-Arctic waters.

3.2 Other trawlers with cod and haddock quotas and possibly shrimp trawl licence

Table (3) shows the importance of the different fish species with regard to both quantity and value for the Norwegian trawlers without onboard processing. In terms of quantity, saithe is the most important fish species, while in value terms cod is responsible for more than 50% of these vessels' income. Other important species are shrimp, haddock and red fish. Together these five species constitute about 93% of both quantity and value.

The trawlers without onboard processing are almost as dependent on cod, haddock, saithe, shrimp, red fish and Greenland halibut as the factory trawlers. However, Table (3) shows that they fish a variety of species in addition to the ones landed by the factory trawlers. Moreover, in addition to several species of flat fishes, these trawlers fish pelagic species such as capelin and Norwegian spring-spawning herring.

While shrimp appeared only to be fished by a few individual factory trawlers, 40 vessels out of a total of 88 vessels in the sample of trawlers without processing fished shrimp in at least one of the seven years between 2000 and 2006. Most of the shrimp is harvested in the Barents Sea/Spitsbergen areas, with the Flemish Cap as the only significant exception.

The ranking of the important harvest areas for trawlers without onboard processing shown in Table (4) is similar to the ranking of areas with regard to factory trawlers shown in Table (2), where the most important harvest areas are along the Norwegian coast from 62° N to the boarder between Norway and the Russian Federation in East Finnmark.

3.3 Fisheries with conventional gear. Vessels over 28 metres length

Table (5) shows the catches and landings values by vessels over 28 metres length, fishing with conventional gear. The catches in question are for the most part caught by the auto line system, a highly mechanized system for handling long lines, which among other features hook the bait automatically. Some vessels use gill nets, targeting mainly saithe. Moreover, Table (5) shows that although cod is the most important catch for these vessels, the second most important species are ling and tusk, in contrast to the trawlers. Moreover, wolf fish is also among the important species, along with saithe, haddock and Greenland halibut. Together, these species provided about 95% in terms of both quantity and value for these vessels. They also fished a

Table 3: Other Trawlers: Fish Species, % of total landings and values, averaged over 2000-2006

Fish Species	**Landings**	**Value**	**Fish Species**	**Landings**	**Value**
Spurdog	0.00	0.00	Red-Fish	1.90	1.74
Other Sharks	0.00	0.00	Deep Water Red-Fish	1.28	0.96
Blue Skate	0.00	0.00	Halibut	0.02	0.07
Other Skates/Rays	0.00	0.00	Plaice	0.39	0.55
Argentine	1.30	0.60	Greenland Halibut	1.66	3.59
Conger Eel	0.00	0.00	Witch	0.00	0.00
Tusk	0.02	0.02	Long Round Dab	0.00	0.00
Cod	31.50	45.22	Common Dab	0.02	0.02
Ling	0.14	0.14	Lemon Sole	0.00	0.01
Blue Ling	0.01	0.01	Flounder	0.00	0.00
Greater Forkbeard	0.00	0.00	Other Flatfish	0.00	0.00
Haddock	10.97	10.82	Sole	0.05	0.38
Saithe	35.36	20.15	Other Soles	0.01	0.01
Pollack	0.10	0.08	Brill	0.00	0.03
Blue Whiting	0.01	0.00	Turbot	0.02	0.12
Whiting	0.01	0.01	Angler Fish	0.03	0.08
Hake	0.01	0.00	*Calanus finmarchicus*	0.01	0.01
Onion-Eye Grenadier	0.00	0.00	Shrimp	12.36	14.37
Grenadier	0.01	0.00	Norway Lobster	0.00	0.01
Atlantic Wolf-Fish	0.09	0.06	Minke Whale	0.01	0.03
Spotted Wolf-Fish	0.10	0.08	Other Marine Fish	0.00	0.01
Northern Wolf-Fish	0.00	0.00	Unspecified Fish	0.01	0.03
Wolf-Fish	0.00	0.00	Rat-tail	0.00	0.00
Sandeel	0.00	0.00	Herring	2.19	0.77
Atlantic Cutlassfish	0.00	0.00	Capelin	0.41	0.04
Mackerel	0.00	0.00			

Table 4: Other Trawlers: Harvest Areas, % of total landings and values, averaged over 2000-2006

Harvest Area	**Landings**	**Value**	**Harvest Area**	**Landings**	**Value**
Westfjord (Lofoten)	2.66	1.53	Hopen	3.11	4.00
Kanin Bank	0.67	0.72	Great Bank	3.25	3.59
Coast of Murmansk	0.16	0.18	Northwest Spitsbergen	0.67	0.77
East Finnmark	11.76	12.41	Southwest Spitsbergen	0.01	0.01
West Finnmark	13.89	14.41	Viking Bank	4.56	2.75
Røst Bank to Malang Ground	22.12	22.32	Southern Norwegian Sea	0.43	0.63
Helgeland Bank	5.19	3.92	East of the Faroe Islands	0.00	0.00
Storegga - Frøya Bank	5.18	3.69	South of Jan Mayen	0.00	0.01
Eigersund Bank	0.79	0.48	Eastern Norwegian Sea	1.23	1.04
Skagerrak	0.04	0.05	West of the Tromsø Bank	0.07	0.13
Skolpen Bank	0.17	0.20	Southern North Sea	0.01	0.03
Goose Bank	0.69	0.79	Central North Sea	0.64	1.17
Nordkapp Bank	1.39	1.66	Shetland Islands	5.84	3.87
Thor Iversens Bank	1.96	2.28	Outside Cornwall	0.01	0.00
Britvin Ground	0.26	0.26	Northwest of Iceland	0.02	0.06
Central Bank	2.62	2.89	Skjoldungen	0.00	0.01
Admiralty Ground	0.00	0.00	Denmark Strait	0.37	1.03
Bear Island	7.58	9.48	Fyllas Bank	0.37	0.78
West Spitsbergen	0.17	0.24	Reykjanes Ridge	0.00	0.00
Storfjord/Hinlopen Strait	0.11	0.16	Flemish Cap	1.99	2.42

Table 5: Fisheries with conventional gear. Vessels 28 metres over all length and over: Fish Species, % of total landings and values, averaged over 2000-2006

Fish Species	**Landings**	**Value**	**Fish Species**	**Landings**	**Value**
Porbeagle	0.00	0.00	Grenadier	0.01	0.01
Spurdog	0.01	0.01	Atlantic Wolf-Fish	0.20	0.12
Other Dogfish	0.12	0.05	Spotted Wolf-Fish	1.84	1.53
Leafscale Gulper Shark	0.00	0.00	Northern Wolf-Fish	4.94	1.22
Portuguese Dogfish	0.00	0.00	Wolf-Fish	1.54	0.39
Other Sharks	0.01	0.00	Red-Fish	1.11	0.84
Blue Skate	0.01	0.00	Deep Water Red-Fish	0.00	0.00
Roker	0.00	0.00	Blue Mouth	0.00	0.00
Other Skates/Rays	0.33	0.11	Halibut	0.56	2.05
Conger Eel	0.00	0.00	Plaice	0.00	0.00
Moras	0.14	0.11	Greenland Halibut	4.34	7.85
Tusk	14.48	10.84	Long Round Dab	0.02	0.01
Cod	28.37	36.02	Other Flatfish	0.00	0.00
Ling	14.49	17.20	Turbot	0.00	0.00
Blue Ling	0.52	0.41	Angler Fish	0.04	0.07
Greater Forkbeard	0.99	0.46	Minke Whale	0.02	0.05
Haddock	11.81	12.48	Other Marine Fish	0.00	0.05
Saithe	13.47	6.98	Unspecified Fish	0.02	0.17
Pollack	0.17	0.09	Rabbit Fish	0.12	0.04
Whiting	0.01	0.00	Ratfish	0.01	0.00
Hake	0.01	0.00	Antarctic Toothfish	0.18	0.76
Onion-Eye Grenadier	0.14	0.06			

number of sharks and skates species along with several species of flatfish.

Table (6) shows where the conventional oceangoing vessels fished from 2000 to 2006. The most important area was the Nordkapp Bank in the Barents Sea, in contrast to the trawlers, which had the area from Røst to the Malang Ground as their most important harvest area. Besides the waters surrounding Bear Island, other areas in the Barents Sea are of minor importance to these vessels. Important species fished in the Barents Sea are cod, haddock, wolf fish and Greenland halibut. On the coastal banks between 62° N and the Russian boarder saithe, cod, tusk and ling dominate the landings; as you go further north the occurrence of haddock and Greenland halibut increases. A third important harvest area is the waters surrounding the Shetland Islands, in addition to significant harvest in adjacent areas, *i.e.*, the banks west of Scotland/The Hebrides and around Rockall. Except for saithe and cod in the Shetland area, ling and tusk are dominant species in these areas. The same can be said about the waters surrounding the Faroe Islands, the fourth main harvest area of the conventional off shore fishing fleet. Finally, the areas in the North Sea, the Norwegian Sea and other areas of the North Atlantic are of minor importance compared to the ones mentioned earlier.

Table 6: Fisheries with conventional gear. Vessels 28 metres over all length and over: Harvest Areas, % of total landings and values, averaged over 2000-2006

Harvest Area	**Landings**	**Value**	**Harvest Area**	**Landings**	**Value**
Westfjord (Lofoten)	0.45	0.45	Western Norwegian Sea	0.00	0.01
Kanin Bank	0.08	0.07	Eastern Norwegian Sea	0.70	0.62
Coast of Murmansk	0.28	0.28	Northwestern Norwegian Sea	0.08	0.07
East Finnmark	5.19	5.55	West of the Tromsø Bank	0.38	0.53
West Finnmark	1.83	1.81	Cental North Sea	0.55	0.63
Røst Bank to Malang Ground	4.54	4.24	Shetland Islands	13.10	11.01
Helgeland Bank	8.70	6.61	West of Scotland/The Hebrides	3.53	3.49
Storegga - Frøya Bank	6.22	4.54	Rockall	2.73	2.61
Eigersund Bank	0.04	0.05	West of Ireland	0.40	0.43
Skagerrak	0.02	0.01	Southwest Norwegian Sea	0.04	0.05
Skolpen Bank	1.51	1.45	Southeast of Iceland	0.09	0.09
Goose Bank	0.48	0.38	Southwest of Iceland	0.49	0.51
Nordkapp Bank	29.33	31.80	North of Iceland	0.02	0.03
Thor Iversens Bank	1.27	1.20	West of the Faroe Islands	1.93	1.96
Central Bank	0.12	0.13	Faroe Bank	1.34	1.35
Northeast Area	0.00	0.01	East of Iceland	0.00	0.00
Bear Island	6.68	6.77	Skjoldungen Bank	0.35	0.75
West Spitsbergen	0.17	0.20	Denmark Strait	1.40	3.00
Storfjord/Hinlopen Strait	0.03	0.04	Gammelock	0.03	0.06
Hopen	0.39	0.53	Baffin Island	0.37	0.56
Great Bank	0.04	0.05	Hellefisk Bank	0.04	0.04
Northwest Spitsbergen	0.02	0.02	Banana Bank	0.06	0.07
Southwest of Spitsbergen	0.02	0.02	Fyllas Bank	0.10	0.14
Viking Bank	0.76	0.73	Reykjanes Ridge	0.58	0.83
Southern Norwegian Sea	0.06	0.06	Cap Farewell	0.11	0.18
East of the Faroe Islands	2.99	3.04	Flemish Cap	0.01	0.02
Central Norwegian Sea	0.16	0.15	Area outside the North Atlantic	0.18	0.76

3.4 Coastal vessels less than 15 metres in length

The group, coastal vessels less than 15 metres in length is much more heterogenous than the vessel groups described above. As can be seen from Table (7), the smaller coastal fishing vessels target a number of species, in addition to demersal fishes (*i.e.*, a near-bottom fish), such as cod, haddock, saithe, angler-fish *etc.*; pelagic fish, such as herring and mackerel; cartilaginous fishes, such as sharks, skates and rays; crustaceans, such as crabs and lobsters; and molluscs, such as scallops, cockles and whelks. Although some of these species appear to be insignificant if we aggregate over all vessels and years, the marginal species can be highly important for the vessels that target them and for local fisheries. The diversity is high when it comes to gear types applied. While the trawlers of course use trawls and the conventional vessels over 28 metres long for a large part use long line, the coastal vessels use a number of gear types, not just passive fishing gear, such as anchored sink gill nets, hand lines, long lines *etc.*, but active gears too, such as trawls, purse seines and Danish seine.

Table (8) shows that the number of harvest areas are small compared to the other vessel groups. The harvest areas is for the most part the coastal areas along the Norwegian coast, except for a few insignificant catches in various adjacent ocean areas. Many of these coastal vessels are small and do not travel far. Therefore, we must assume that many of them do not operate outside the coastal area closest to their home port. We do not know the home port, but are informed about to which county each vessel belong.

Table (9) shows the importance of the harvest areas depending on the vessels county of origin. The counties in question are, from the Russian boarder in the north to the Oslo Fjord area in the southeast, Finnmark (F), Troms (T), Nordland (N), Nord-Trøndelag (NT), Sør-Trøndelag (ST), Møre og Romsdal (M), Sogn og Fjordane (SF), Hordaland (H), Rogaland (R), Vest-Agder (VA), Aust-Agder (AA), Telemark (TK), Vestfold (V), and Østfold (Ø). We see that the vessels in the sample originating from the eastern part of southern Norway exclusively fish in their home waters, which is denoted here as Skagerrak. For vessels from the other counties, Vest-Agder to Finnmark, the most important harvest areas are the ones closest to home. However, many vessels from these counties participate in fisheries in areas other than their home waters as well. Vessels from Vest-Agder to Nordland have a significant part of their activity in the Westfjord/Lofoten area. This is due to the large fishery on the Northeast Arctic cod that spawns in this area.

Table 7: Coastal vessel shorter than 15 metre length: Fish Species, % of total landings and values, averaged over 2000-2006

Fish Species	Landings	Value	Fish Species	Landings	Value
Bass	0.00	0.00	Other Red Fish	0.00	0.00
Porbeagle	0.01	0.02	Red-Fish	2.89	2.37
Basking Shark	0.16	0.02	Deep Water Red-Fish	0.00	0.00
Spurdog	0.80	0.58	Halibut	0.26	1.04
Other Dogfish	0.00	0.00	Plaice	0.32	0.35
Other Sharks	0.00	0.00	Greenland Halibut	2.11	3.29
Blue Skate	0.03	0.01	Witch	0.00	0.01
Other Skates/Rays	0.17	0.11	Common Dab	0.00	0.00
Herring	0.00	0.00	Lemon Sole	0.01	0.02
Atlantic Salmon	0.00	0.00	Other Flatfish	0.02	0.01
Argentine	0.00	0.00	Sole	0.00	0.00
Eel	0.01	0.05	Other Soles	0.00	0.00
Garpike	0.00	0.00	Brill	0.00	0.01
Tusk	1.93	1.17	Turbot	0.01	0.04
Cod	42.18	53.53	Angler Fish	3.05	8.05
Ling	1.76	1.66	Shrimp	0.12	0.27
Blue Ling	0.04	0.02	Edible Crab	1.82	1.43
Greater Forkbeard	0.00	0.00	King Crab	0.43	2.87
Haddock	8.86	7.35	Norway Lobster	0.01	0.07
Saithe	16.73	7.48	Lobster	0.01	0.10
Pollack	1.51	1.27	Scallop	0.02	0.05
Whiting	0.01	0.01	Iceland Scallop	0.00	0.00
Hake	0.29	0.74	Spiny Cockle	0.00	0.00
Onion-Eye Grenadier	0.01	0.00	Other Cockles	0.01	0.01
Grenadier	0.00	0.00	Whelk	0.03	0.01
Other Cod Fish	0.00	0.00	Other Molluscs	0.00	0.00
Horse Mackerel	0.00	0.00	Minke Whale	0.01	0.04
Sea Bass	0.00	0.00	Other Marine Fish	0.00	0.00
Ballon Wrasse	0.00	0.00	Unspecified Fish	0.00	0.02
Atlantic Wolf-Fish	0.24	0.13	Rat-tail	0.00	0.00
Spotted Wolf-Fish	0.10	0.08	Herring	6.17	1.42
Wolf-Fish	0.00	0.00	Sprat	0.13	0.06
Mackerel	6.47	3.57	Lumpfish	1.25	0.64

Table 8: Coastal vessel shorter than 15 metres in length: Harvest Areas, % of total landings and values, averaged over 2000-2006

Harvest Area	Landings	Value	Harvest Area	Landings	Value
East Finnmark	12.23	14.71	Skagerrak	0.94	1.00
West Finnmark	15.50	15.78	Nordkapp Bank	0.05	0.07
Røst Bank to Malang Ground	16.64	18.03	Central Bank	0.01	0.01
Westfjord (Lofoten)	23.87	21.88	Bear Island	0.02	0.04
Helgeland Bank	7.99	6.79	Viking Bank	4.01	3.90
Storegga - Frøya Bank	13.03	13.61	Eastern Norwegian Sea	0.05	0.08
Eigersund Bank	5.62	4.03	Central North Sea	0.04	0.06

The relative importance of the Westfjord/Lofoten area is small for vessels from Finnmark and Troms compared to their own home waters. However, it is not surprising that the closest fishing grounds are more important for local vessels than banks farther away, but more so for the small coastal vessels than for the larger, more mobile, offshore fishing fleet.

Although the smaller coastal fishing vessels have a more limited area of operation compared to larger ocean going fishing vessels they appear be very well adapted to local conditions. In addition, they target different species, many of which have a more limited distribution and abundance than the large fish stocks that the larger, more specialized vessels target, such as cod, haddock and saithe. This flexibility compensates for the rigidities they face when it comes to seaworthiness and range.

4 Possible effects of climate change on the fishing fleets

An increase in water temperature of 1 to 2 °C in the Atlantic part of the Norwegian and Barents Sea is very likely to result in a change in distribution for several species of fish. However, in both seas there are fronts between the warm Atlantic water and the cold Arctic water masses, whose position is partly determined by bottom topography. Previous experience of how fish react to changes in water temperature in the Barents Sea may be used to speculate about future changes. The most likely impact of an increase in water temperature on some commercial fish species is shown in Figure (1). Capelin is very likely to extend its feeding area north and northeastward. During summer it might feed in the Arctic Basin and migrate to the Kara Sea. Whether the capelin maintain their spawning ground along the coast of northern Norway and the Kola Peninsula is unknown. They may possibly move eastward, and may even spawn along the west coast of Novaya Zemlya. Cod is also likely to expand its feeding area eastward, especially as capelin is its main food source. As cod is demersal, it is not likely to migrate north of the Barents Sea and into the deep Arctic Basin. Haddock will probably follow the same track as cod, but as at present is likely to remain further south than cod. In the Norwegian Sea, herring is likely to return to the feeding and overwintering area used before 1964, but, maintain the same spawning areas along the Norwegian coast. Mackerel (*Scomber scombrus*) and blue whiting (*Micromesistius poutassou*) are likely to migrate northeast to the Barents Sea. The mackerel and blue whiting will then compete with the other pelagic species in the Barents

Table 9: Coastal vessel shorter than 15 metres in length: Harvest Areas, by county. % of total landings and values, averaged over 2000-2006

	County													
Harvest Area	F	T	N	NT	ST	M	SF	H	R	VA	AA	TK	V	Ø
East Finnmark	53.34	8.20	6.61	1.70	2.71	3.13	1.14	4.53	0.53	0.00	0.00	0.00	0.00	0.00
	59.49	9.21	7.45	2.11	3.88	3.89	1.01	5.72	0.68	0.00	0.00	0.00	0.00	0.00
West Finnmark	38.97	40.52	4.75	3.00	4.21	6.91	3.98	3.50	1.47	1.80	0.00	0.00	0.00	0.00
	35.27	38.83	5.51	3.63	5.14	8.29	3.62	4.89	2.06	2.27	0.00	0.00	0.00	0.00
Røst Bank to Malang Ground	2.83	44.17	23.65	9.62	3.27	2.51	10.20	6.92	4.81	7.67	0.00	0.00	0.00	0.00
	2.89	46.49	27.61	11.51	4.23	3.20	10.90	8.98	6.91	10.29	0.00	0.00	0.00	0.00
Westfjord (Lofoten)	3.67	6.56	48.15	21.55	23.62	13.75	15.75	13.54	7.04	19.97	0.00	0.00	0.00	0.00
	1.52	4.96	46.16	19.24	26.14	14.21	15.37	14.70	9.64	22.25	0.00	0.00	0.00	0.00
Helgeland Bank	0.17	0.10	14.08	58.34	15.43	0.96	4.61	0.74	0.00	0.00	0.00	0.00	0.00	0.00
	0.03	0.07	11.21	59.90	13.28	0.46	3.78	0.46	0.00	0.00	0.00	0.00	0.00	0.00
Storegga - Frøya Bank	0.00	0.05	0.65	1.38	45.21	60.22	27.28	4.72	14.47	1.39	0.00	0.00	0.00	0.00
	0.00	0.02	0.42	1.10	44.38	62.57	24.93	4.72	11.59	1.46	0.00	0.00	0.00	0.00
Viking Bank	0.29	0.00	0.61	1.84	2.93	5.22	35.67	38.43	4.61	5.68	0.00	0.00	0.00	0.00
	0.16	0.00	0.38	1.22	1.59	3.39	39.65	37.99	3.22	3.65	0.00	0.00	0.00	0.00
Eigersund Bank	0.51	0.32	1.10	2.57	1.99	6.97	0.61	25.35	67.05	45.76	0.00	0.00	0.00	0.00
	0.35	0.27	0.72	1.30	0.94	3.79	0.24	21.74	65.87	35.57	0.00	0.00	0.00	0.00
Skagerrak	0.00	0.01	0.19	0.01	0.62	0.32	0.75	2.29	0.01	16.17	100.00	100.00	100.00	100.00
	0.00	0.02	0.11	0.01	0.41	0.20	0.50	0.81	0.02	21.77	100.00	100.00	100.00	100.00
Nordkapp Bank	0.13	0.08	0.06	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.19	0.13	0.09	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central Bank	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bear Island	0.04	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.05	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eastern Norwegian Sea	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central North Sea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.57	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.73	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

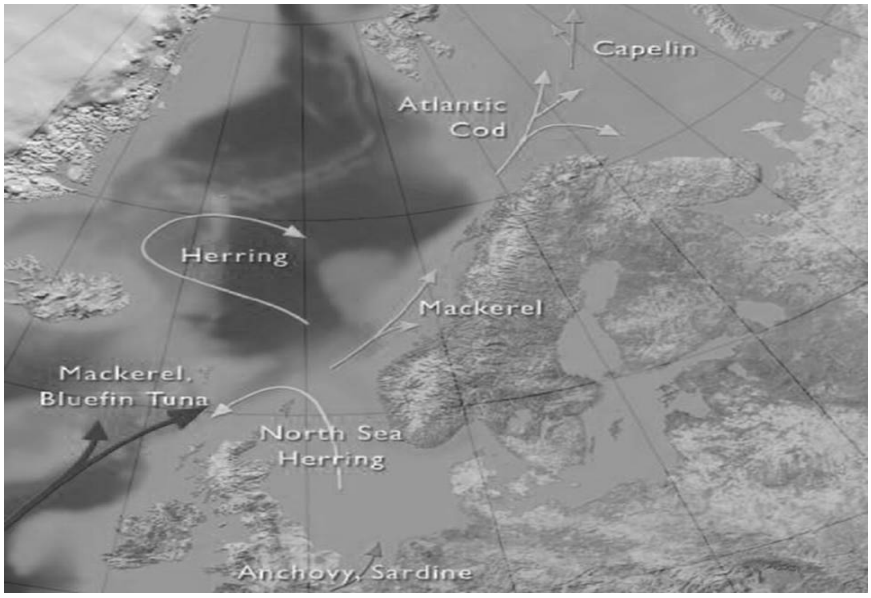

Figure 1: Likely extension of the feeding area for some of the main fish populations if sea temperature increases. Modified after Loeng (2001).

Sea for a limited supply of food. It is also likely that new species will enter the Norwegian Sea (ACIA, 2005).

From the warming of the waters around Iceland and Greenland in the 1920s and 1930s we know that saithe, ling and tusk are also able to change their area of distribution in response to changing climatic condition. It is therefore possible that the said species will become more numerous in the Barents Sea if the anticipated temperature increase should occur.

What, then, could be the effects of a future warming of the Norwegian Sea and Barents Sea? How might the anticipated changes in the fish species migration, distribution and abundance affect the behaviour of the groups of fishing vessels described in the previous section?

Starting with the trawlers, both factory vessels and the ones without onboard processing facilities, the large demersal fish stocks, cod, haddock and saithe, as well as red fish, Greenland halibut and shrimp have been particularly important target species. Greenland halibut and shrimp, which are important for the trawlers without onboard processing, are expected to become rare due to a warmer ocean climate. However, the other fish stocks are expected to gain from a warmer climate and expand their distribution in a northeastward direction, such that the Barents Sea will become an even more important harvest area than it already is. The trawlers, being large ocean going vessels, will have few difficulties in following the new paths of

migration and take advantage of any possible increase in production of the fish stocks for which the effect of a warmer climate is expected to be benevolent with regard to recruitment and growth. How the distribution of fish stocks will change and how this will affect the productivity of the fish stocks involved, is difficult to quantify, but cod being as dominating as it is today, both in terms quantity as well as value, it is likely that any changes in this stock will dominate changes in others.

For the vessels over 28 metre length using conventional gear, cod, haddock, saithe and Greenland halibut, along with various wolf fishes, tusk and ling, are important fish species, and the effects of a warmer climate will be similar to that of the trawlers. Cod, haddock, and saithe are expected to adapt well to the change by inhabiting new waters. This will be the case also for tusk and ling, which under the warmer period in the 1920s-30s became common in areas where they previously were unknown.

When it comes to the coastal vessels less than 15 metre in length, the picture could be a bit different. These are not large ocean going vessels, but vessels with a limited range that cannot be expected to follow the offshore migrations of the fish stocks. As a larger part of important fish stocks, in particular cod, is distributed northeastward, outside Norwegian coastal waters, either into Russian coastal waters or spending more time on the banks of the Barents Sea, the coastal vessels will have less access to these stocks. However, if an increase in the distribution area is accompanied by a great stock abundance, the fish will be available and plentiful in the old areas as well as in the new areas of habitation. A problem with this change in distribution is that it might lead to a dispute over how to divide the total allowable catch (TAC); when the stocks enter into new areas and spend more time in other waters than previously, the sharing rule between Norway and Russia might have to be changed in favour of Russia. Another problem is that cod might become more available and exposed to the fishery in the high seas portion of the Barents Sea known as "the loop hole" where it can be harvested, legally, by vessels from any third country, not just Norwegian and Russian or foreign vessels licensed by either one of these two countries. In this respect a change in distribution might lead to a lower share of the TAC for all Norwegian fishing vessels, not just the coastal vessels.

Table (9) shows that local waters are important harvest areas for the coastal vessels. Furthermore, many coastal vessels travel north to participate in the large seasonal fisheries in

other areas, especially in the spawning cod fishery in the Westfjord area every winter, but also the saithe fishery on Møre and the spring time fishery on juvenile cod as it follows the spawning migration of the capelin to the coast of Finnmark or the haddock fishery in the summer. However, if the climate changes the fish migrations might change too, and the coastal vessels will have to follow if they want to continue harvesting these stocks. As mentioned earlier, some of the stocks previously harvested by the coastal fishing fleet may become inaccessible because they are not able to follow the fish stocks on their extended migration routes.

Traditionally, there has been an important spring time cod fishery on juvenile cod coming in from the Barents Sea to feed on the dense shoals of spawning capelin. The importance of the cod fishery in East Finnmark to the Norwegian fishing fleet gives an indication of the possible consequences should this fail because higher sea temperature makes the capelin, and consequently the cod, shift its distribution northeastward and appear on the coast of the Kola Peninsula in the Russian zone instead of East Finnmark. The importance of the cod fishery in East Finnmark 2000-2006 can illustrate the potential loss[3]. To the coastal fleet the East Finnmark cod fishery made up 7.6% of their total harvest and 9.1% of the total value. The loss to the local fishing fleet would be even bigger, not to mention other unfortunate consequences should the capelin abandon the coast of Finnmark completely. To the other fleet segments included in this survey the cod fishery on the coast of East Finnmark is also important, 2.7% in quantity and 3.2% in value for the conventional fleet, the equivalent for the factory trawlers and others trawlers is 2.9% and 6% in quantity and 4.2% and 8.3% in value, respectively; but because these vessels are ocean going they are able to compensate for this loss by harvesting the cod when it returns to the Barents sea.

Then there is the fishery on the spawning cod in the Westfjord/Lofoten area, important for the coastal vessels, not just for the locals, but also coastal vessels from many other counties come to Lofoten to participate in this rich fishery. However, the Westfjord/Lofoten area is not so important for the ocean going fleet, in particular, the trawlers catch the spawning cod on its migration to Westfjord/Lofoten in the area from Røst to the Malang ground, which is important for the coastal vessels as well. The cod is very particular with regard to temperature and salinity in its choice of spawning location, and a radical warming of the ocean might lead the spawning

[3]See Appendix, Table (A-2) for the cod harvest in the respective areas.

cod to abandon the traditional spawning grounds altogether and spawn farther north and east, if this is where it would find optimal condition for its offspring to start their lives. Should this happen, it could potentially have dire consequences for the coastal vessels dependent on the spawning cod fishery. Of course the consequences would be less grave if the cod chose to spawn some other place on the Norwegian coast rather than in the Russian EEZ, but still an abrupt and radical displacement of the cod's spawning grounds would mean trouble for many fishermen and communities dependent on its annual arrival in waters close to them.

However, if the coastal vessels suffer a disadvantage because of fish stocks moving out of their reach, they show great flexibility and adaptation in that they are able to exploit new species entering their home waters and finding previously unexploited species to fish in response to a changing environment. Our listing of the coastal vessels of both targeted as well as by-catch species in Table (7) show that they harvest a large number of species, many of which may seem unimportant relative to the larger stocks, but important to the vessels that catch them and which might gain in importance, if not on a national level then at the local level. An example is sea bream, which was extremely rare in Norwegian waters, but has now become a more frequent visitor, especially in the Oslo Fjord/Skagerrak area. It is easy to imagine that this species along with other previously uncommon species will become more abundant in Norwegian waters as the sea temperature increases and the more traditional species adapt to the new conditions by moving northwards.

Will the consequences of climate change occur gradually over time, or will, for example, the temperature cross some critical threshold level which triggers qualitative changes in the ecosystem (such that the capelin suddenly stops spawning in Finnmark, for example)? According to ACIA (2005) the projected changes are very likely to happen gradually, but these are changes in climate indicators, such as air temperature, wind, precipitation *etc*, and not directly linked to fish stocks. However, other indicators seem to be changing more rapidly than anticipated; this relates especially to the ice cover in the polar sea, which seems to be melting faster than what was predicted by the models. Should changes in the fish stocks behaviour and growth occur quickly, society would be much less prepared, and the fishermen and the communities dependent on fishing would be faced with great difficulties. In the longer run these difficulties could be solved, but the solution chosen, development and the final outcome will be highly dependent

on whether the changes occurred suddenly or more gradually. If the changes happen gradually, the adaptations will also be gradual. Besides, such gradual changes will probably follow a trend with significant fluctuations around this trend, such as there have always been.

The trawlers and the conventional vessels over 28 metre length are able to follow the fish as long as they stay within Norwegian waters. What if the climate change results in increased production of the fish stocks? Would it require an increase in the harvest capacity, or is there enough harvest capacity as it is today? Steinshamn (2005) showed that a restructuring the fishing fleet and investing in only the most efficient vessels within each group, scrapping the old and redundant vessels, the 2002 Norwegian harvest could have been caught more economically with only half of the number of vessels and labour actually used. This indicates that there exists a large overcapacity in the fishing fleet and any realistic increase in the fish stocks could easily be accommodated. Should it be necessary to invest in more appropriate vessels, this could be accomplished gradually and simultaneously with natural renewal of the fleet, as it takes some time for the changes in fish stocks to materialize.

5 Concluding comments

In this paper we use postulated effects of a warmer North Atlantic on important fish stock to try to say something about how this climate change will affect certain segments of the Norwegian fishing fleet with regard to species harvested and harvest areas.

The Arctic Climate Impact Assessment (ACIA) working group on Arctic fisheries (ACIA, 2005) came to the general conclusion that a warming of the magnitude predicted, *i.e.*, an increase in water temperature of 1-2 °C in the next 50-70 years, is more likely than not to be beneficial to the fisheries in the North Atlantic, important fish species, such as cod, haddock, saithe, herring, mackerel and blue whiting would probably benefit from this, and ocean warming will to a certain extent induce a northward shift in the range of some species.

The species said to probably benefit from the warming are all important target species for the Norwegian fishing fleet. In particular, cod, haddock and saithe are the dominant ones in the fleets segments under investigation here, namely the offshore trawler fleet, both factory vessels and others, the offshore conventional fleet, and the coastal vessels less than 15 metre length. The offshore vessels are easily capable of taking advantage of the anticipated expansion in the fish

stocks. The coastal vessels, on the other hand, have a more limited range and cannot operate at will outside waters close to the shore. However, the coastal vessels harvest a diverse range of species, adapted to the marine fauna in their home waters. This diversification could make up for their limitations in their ability to follow stocks that move out of their reach by switching other existing species or starting to exploit new species moving in from the south as the oceans get warmer.

It is important to have in mind that change in fishermen's behaviour are driven by other forces than the environment alone. Other human activities are important drivers of change, through social, economic and political processes. It is extremely difficult to isolate the relative impact of the various drivers of change. In addition, societies have the capacity to adapt to change. Changes in fish stocks, for example, are met by adjustment in fisheries management and the way fisheries are performed.

If the changes are gradual, the consequences are expected to be less severe. The fishing fleets will have time to adapt along with the changes in the fish stocks caused by a changing climate. The management agreement on the sharing of the stocks between nations will have time to adapt too. However, the consequences will be larger if there are threshold values that are important for the fish stocks' response to climate change. The problem is to know what to expect. Temperatures above the previously observed are virtually unknown territory. How are we then supposed to know what will happen? And if we don't know, there is perhaps little we can, or should do. A trend with fluctuations around it is very much what we always have had. Variations in the environment decide to a large degree how much we can harvest from nature at any point in time, and we have to manage the fish stocks accordingly.

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Appendix

Table A-1: Fish species landed (tonnes) and values (thousand 2006 NOK), by fleet group 2000-2006

Fish Species	Conventional	Coastal	Factory	Trawlers
Bass		0		
		0		
Porbeagle	2	24		
	23	401		
Basking Shark		268		
		373		
Spurdog	53	1320		6
	565	9813		1
Other Dogfish	481	0		
	2873	2		
Leafscale Gulper Shark	1			
	14			
Portuguese Dogfish	13			
	196			
Other Sharks	40	0		4
	254	1		21
Blue Skate	26	45		0
	71	127		0
Roker	1			
	6			
Other Skates/Rays	1377	284	3	14
	6125	1576	10	22
Conger Eel	2			0
	6			0
Moras	571			
	5253			
Herring		0		
		2		
Atlantic Salmon		0		
		0		
Argentine		0	29	8224
		0	103	35945
Eel		20		
		911		
Garpike		0		
		0		

Continued on next page

Fish Species	Conventional	Coastal	Factory	Trawlers
Tusk	60155	3163	66	154
	573940	19404	471	1028
Cod	93553	4146	75214	14437
	1495086	57557	1165143	209609
Ling	60154	3087	662	933
	910521	29052	5881	8486
Blue Ling	2146	71	9	58
	21523	435	81	418
Greater Forkbeard	4091	0		1
	23814	0		2
Haddock	39031	2059		8938
	532356	18959		90129
Saithe	56029	29244	167883	239675
	375490	137296	1002130	1259870
Pollack	694	2572	222	638
	4558	22522	1725	4606
Blue Whiting				42
				0
Whiting	39	17	0	74
	204	85	2	492
Hake	29	528	41	40
	169	13776	229	296
Onion-Eye Grenadier	563	13	31	17
	2940	36	116	55
Grenadier	59	2	28	56
	401	0	122	240
Other Cod Fish		0		
		0		
Horse Mackerel		1		
		0		
Sea Bass		0		
		0		
Ballon Wrasse		0		
		0		
Atlantic Wolf-Fish	818	378	207	623
	6605	2225	1348	4047
Spotted Wolf-Fish	7643	173	275	715
	79372	1389	2094	5121
Northern Wolf-Fish	20511		68	1
	64328		173	2
Wolf-Fish	6483	1	8	22

Continued on next page

Fish Species	Conventional	Coastal	Factory	Trawlers
	21340	3	66	57
Sandeel				3
				0
Atlantic Cutlassfish				0
				0
Mackerel		11126	6	0
		66468	5	0
Red-Fish	4623	4732	11335	11913
	44557	40453	90105	101853
Deep Water Red-Fish	21	0	41913	7771
	132	1	290999	55730
Other Red Fish		0		
		1		
Blue-Mouth	6			
	12			
Halibut	2325	477	56	144
	107078	19784	1615	4366
Plaice	1	539	54	2319
	14	5986	520	31132
Greenland Halibut	18036	3753	14591	11108
	412760	61336	312881	225445
Witch		6		0
		88		9
Long Round Dab	64		4	0
	417		24	0
Common Dab		0		100
		2		1190
Lemon Sole		24		11
		415		367
Flounder				7
				36
Other Flatfish	2	25	14	8
	11	169	93	60
Sole		0		273
		34		20101
Other Soles		0		40
		0		587
Brill		3		26
		144		1439
Turbot	0	16		94
	2	719		6477

Continued on next page

Fish Species	Conventional	Coastal	Factory	Trawlers
Angler Fish	177	5351	3	162
	3523	144710	33	4514
Calanus finmarchicus				41
				442
Prawn		188	23204	84758
		4349	229410	872468
Edible Crab		1385		
		10979		
King Crab		781		
		51404		
Norway Lobster		13		16
		1165		594
Lobster		9		
		1752		
Scallop		35		
		714		
Iceland Scallop		1		
		9		
Spiny Cockle		0		
		13		
Other Cockles		23		
		117		
Whelk		66		
		330		
Other Molluscs		1		
		0		
Minke Whale	97	23		70
	3101	702		1811
Other Marine Fish	0	6		15
	2718	45		343
Unspecified Fish	66	7	10	38
	9333	274	47614	1492
Rabbit-Fish	487	0		0
	1963	0		0
Ratfish	42			
	99			
Antarctic Toothfish	774			
	43938			
Norwegian Spring-spawning Herring		10963		14643
		25706		47951
Juvenile Herring		3		

Continued on next page

Fish Species	Conventional	Coastal	Factory	Trawlers
		0		
North Sea Herring		183		
		583		
Skagerrak Herring		0		
		1		
Fjord Herring		171		
		640		
Sprat		220		
		1038		
Capelin				2720
				2247
Farmed Salmon		0		
		0		
Spawning Cod	375	18493		99
	7042	251074		1179
Northeast Arctic Cod	23786	51753	19653	199063
	383553	669318	293978	2602721
Farmed Cod		0		
		0		
Northeast Arctic Haddock	10312	13401	7392	66666
	138813	112228	85289	591238
Lumpfish		2096		
		10806		
Edible Crab (Male)		580		
		4295		
Edible Crab (Female)		1190		
		10063		
Total	415757	175064	391880	676779
	5287097	1813869	3876801	5912460

Table A-2: Landings and values of cod and all other species, 2000-2006.
Landings and values in thousand tonnes and million 2006 NOK, respectively.

	Conventional		Factory trawlers		Other Trawlers		Coastal Vessels	
Harvest Area	Cod	All Species	Cod	All Species	Cod	All Species	Cod	All Species
Westfjord (Lofoten)	0.4	1.9	0.6	0.9	2.6	18.0	20.7	41.6
	6.6	24.1	8.2	10.2	33.0	89.7	282.8	393.8
Kanin Bank	0.1	0.3	1.7	6.0	1.1	4.7	0.0	0.0
	1.3	3.7	26.0	71.7	15.7	42.1	0.0	0.0
Coast of Murmansk	0.6	1.1	0.1	0.1	0.5	1.1	0.0	0.0
	10.1	12.9	0.8	1.6	6.4	10.5	0.0	0.0
East Finnmark	11.2	21.4	11.3	15.1	40.9	78.0	13.4	22.0
	170.8	278.5	164.5	199.2	488.5	703.6	164.9	274.1
West Finnmark	3.0	7.5	11.3	32.8	48.0	92.5	15.8	26.8
	44.7	92.2	177.0	335.7	586.1	841.3	203.2	284.6
Røst Bank to the Malang Ground	3.5	19.0	24.5	84.8	56.0	152.0	16.9	29.6
	56.1	230.3	378.7	854.9	721.1	1313.9	226.2	336.4
Helgeland Bank	1.9	36.4	1.4	12.7	3.2	35.0	2.7	14.4
	29.6	359.5	21.5	102.1	42.6	230.5	34.1	121.6
Storegga - Frøya Bank	0.8	25.8	0.2	7.0	1.5	32.9	3.5	22.7
	12.6	236.9	2.3	46.9	20.5	202.9	46.5	241.2
Eigersund Bank	0.1	0.2	0.2	12.2	0.1	5.2	0.6	9.1
	1.0	2.7	2.2	70.4	1.7	27.1	8.5	70.1
Skagerrak	0.0	0.1	0.0	0.0	0.0	0.3	0.1	1.7
	0.0	0.8	0.0	0.2	0.2	3.0	2.4	17.6
Skolpen Bank	2.2	6.2	1.0	1.2	0.5	1.1	0.0	0.0
	38.3	71.8	13.5	16.3	6.8	11.0	0.0	0.0
Goose Bank	0.4	2.0	2.6	6.2	1.0	4.9	0.0	0.0
	5.6	21.1	42.8	86.4	14.4	50.8	0.0	0.0
Nordkapp Bank	64.3	121.9	7.9	17.5	4.7	9.2	0.0	0.1
	1026.8	1677.7	126.7	230.5	58.8	97.0	0.0	1.5
Thor Iversens Bank	2.1	5.4	0.7	5.0	0.5	12.8	0.0	0.0
	35.3	68.2	11.4	52.0	6.4	121.3	0.0	0.0
Britvin Ground	0.0	0.0	0.5	1.1	0.0	1.8	0.0	0.0
	0.0	0.0	9.4	15.0	0.0	16.5	0.0	0.0
Central Bank	0.2	0.5	0.2	3.9	0.9	17.8	0.0	0.0
	4.4	7.6	4.0	39.1	14.0	170.4	0.2	0.2
Admiralty Ground	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Northeast Area	13.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
	216.1	0.6	1.2	1.2	0.0	0.0	0.0	0.0
Bear Island	0.3	28.1	22.0	30.0	35.9	53.9	0.0	0.0

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	Conventional		Factory trawlers		Other Trawlers		Coastal Vessels	
Harvest Area	Cod	All Species	Cod	All Species	Cod	All Species	Cod	All Species
	5.3	368.9	337.4	442.1	464.1	634.4	0.2	0.7
West Spitsbergen	0.1	0.7	0.2	0.8	0.5	1.2	0.0	0.0
	1.9	11.5	3.5	12.4	6.3	12.9	0.0	0.0
Storfjord/Hinlopen Strait	1.4	0.1	0.4	0.6	0.1	0.7	0.0	0.0
	22.9	1.9	6.7	7.7	1.7	8.4	0.0	0.0
Hopen	0.2	1.6	5.0	8.9	9.7	22.1	0.0	0.0
	2.3	27.5	76.6	117.4	120.8	246.8	0.0	0.0
Great Bank	0.0	0.2	1.8	5.3	4.3	22.9	0.0	0.0
	0.3	2.5	27.8	63.9	57.4	226.8	0.0	0.0
Northwest Spitsbergen	0.0	0.1	0.0	0.3	0.0	4.6	0.0	0.0
	0.0	1.4	0.0	4.5	0.0	44.3	0.0	0.0
Southwest of Spitsbergen	0.0	0.1	0.2	0.5	0.0	0.0	0.0	0.0
	0.0	1.2	2.6	9.7	0.0	0.8	0.0	0.0
Viking Bank	0.5	3.1	0.2	15.1	0.6	29.4	0.6	7.0
	8.3	39.5	3.1	93.7	8.0	154.5	7.8	69.3
Southern Norwegian Sea	0.0	0.3	0.0	0.3	0.2	2.6	0.0	0.0
	0.1	2.5	0.0	2.4	2.5	32.4	0.0	0.0
East of the Faroe Islands	1.3	12.3	0.0	0.0	0.0	0.0	0.0	0.0
	22.4	154.0	0.0	0.0	0.0	0.0	0.0	0.0
Central Norwegian Sea	0.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0
	2.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0
South of Jan Mayen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Western Norwegian Sea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Eastern Norwegian Sea	0.1	2.9	0.2	2.5	0.1	7.1	0.0	0.1
	2.3	33.4	3.5	20.5	1.1	52.6	0.0	1.4
Northwestern Norwegian Sea	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0
	1.1	4.5	0.0	0.0	0.0	0.0	0.0	0.0
West of the Tromsø Bank	0.9	1.6	0.1	5.5	0.1	0.5	0.0	0.0
	15.4	27.7	0.9	96.5	1.0	8.5	0.0	0.0
Southern North Sea	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0
Cental North Sea	1.6	2.3	0.0	2.1	0.1	4.0	0.1	0.1
	23.8	33.1	0.6	11.8	2.1	59.8	1.2	1.3
Shetland Islands	3.3	54.4	0.4	62.9	0.4	40.9	0.0	0.0
	53.8	587.5	6.1	401.2	5.5	239.5	0.0	0.0
West of Scotland/The Hebrides	0.3	14.5	0.0	0.0	0.0	0.0	0.0	0.0
	4.2	185.4	0.0	0.0	0.0	0.0	0.0	0.0
Outside Cornwall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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	Conventional		Factory trawlers		Other Trawlers		Coastal Vessels	
Harvest Area	Cod	All Species	Cod	All Species	Cod	All Species	Cod	All Species
	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Rockall	0.3	11.3	0.0	0.0	0.0	0.0	0.0	0.0
	5.0	138.9	0.0	0.0	0.0	0.0	0.0	0.0
West of Ireland	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0
	0.1	24.2	0.0	0.0	0.0	0.0	0.0	0.0
Southwest Norwegian Sea	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0
	1.8	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Southeast of Iceland	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0
	1.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0
Southwest of Iceland	0.3	2.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.5	26.7	0.0	0.0	0.0	0.0	0.0	0.0
Northwest of Iceland	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0
	0.0	0.0	0.0	1.8	0.0	4.2	0.0	0.0
North of Iceland	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0
West of the Faroe Islands	0.6	8.1	0.0	0.0	0.0	0.0	0.0	0.0
	10.1	104.1	0.0	0.0	0.0	0.0	0.0	0.0
Faroe Bank	0.2	5.5	0.0	0.0	0.0	0.0	0.0	0.0
	3.3	69.7	0.0	0.0	0.0	0.0	0.0	0.0
East of Iceland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Skjoldungen Bank	0.1	1.5	0.0	27.1	0.0	0.0	0.0	0.0
	1.1	39.8	0.0	207.3	0.0	0.0	0.0	0.0
Denmark Strait	1.4	5.8	0.0	2.1	0.1	0.0	0.0	0.0
	22.6	156.9	0.0	35.2	1.4	0.7	0.0	0.0
Gammelock	0.0	0.1	0.0	0.0	0.0	2.6	0.0	0.0
	0.3	3.1	0.0	0.3	0.0	64.4	0.0	0.0
Baffin Island	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	25.7	0.0	0.0	0.0	0.0	0.0	0.0
Hellefisk Bank	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
	1.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Banana Bank	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
	2.6	2.9	0.0	0.0	0.0	0.0	0.0	0.0
Fyllas Bank	0.1	0.4	0.0	3.6	0.0	2.5	0.0	0.0
	0.7	7.9	0.0	74.7	0.0	49.6	0.0	0.0
Reykjanes Ridge	0.0	2.4	0.0	9.6	0.0	0.0	0.0	0.0
	0.1	43.2	0.0	59.5	0.0	0.1	0.0	0.0
Cap Farewell	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0
	5.5	9.9	0.0	0.0	0.0	0.0	0.0	0.0
Flemish Cap	0.0	0.1	0.0	7.9	0.0	14.1	0.0	0.0

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	Conventional		Factory trawlers		Other Trawlers		Coastal Vessels	
Harvest Area	Cod	All Species	Cod	All Species	Cod	All Species	Cod	All Species
	0.0	0.9	0.0	81.2	0.0	137.4	0.0	0.0
Area outside the North Atlantic	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	44.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	117.7	415.8	94.9	391.9	213.6	676.8	74.4	175.1
	1885.7	5287.1	1459.1	3876.8	2688.1	5912.5	977.9	1813.9