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D3.31 – Market responses to climate change

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RE	Restricted to a group specified by the consortium (including the Commission Services)	
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Contents

Foreword

This report constitutes the deliverable D3.31 from the ACCESS task 3.3 "Climate change effects on factor and product markets for capture fisheries". Another offspring from the work has been a more designated and focused article, published in the 2015 February issue of the *Marine Policy* journal (Isaksen, Hermansen & Flaaten, 2015).

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1. Introduction

Fossil fuels are renewable solar fuels; it just takes tens or hundreds of millions of years for the used fuels to be replaced.
Hodas (2004: 607)

The study of climate change is mainly a biophysical one where the physical and biological changes, as a result of human action (anthropogenic) on climate, are assigned with probabilities for occurring.

The leading reference work when it comes to climate change is the work synthesised and provided by the IPCC – the Intergovernmental Panel on Climate Change – whose Fifth assessment report(s) was published in 2013/2014. Three working groups – “The Physical Science Basis", "Impacts, Adaptation, and Vulnerability" and “Mitigation of Climate Change" respectively – gave their report each, together with a synthesis report with a summary for policy makers.

The main conclusions from the Synthesis Report (IPCC, 2014d) are the following:

- The human influence on the climate system is clear
- The more we disrupt our climate, the more we risk severe, pervasive and irreversible impacts
- We can limit climate change and make the future sustainable and prosperous.

The ACCESS-project, which evaluates climatic impacts in the Arctic on different industries, has focused on environmental sensitivities and sustainability. One of the industries under scrutiny has been the Arctic fisheries industry, including aquaculture, scrutinized from different angles of attack in ACCESS’ work package 3. One angle is that of task no. 3.3. “Climate change effects on factor and product markets for capture fisheries”, led by Nofima, which objective is to “*assess the effect from climate change on input and output markets of the Arctic fishing industry”.* According to the ACCESS description of work, Nofima “*…will elucidate knowledge on how climate changes will spur governmentally or consumer induced price changes in factor or product markets. How these may alter the activity at sea, and the catch composition of the fishing fleet will also be investigated. Earlier work at Nofima has suggested that changes in fishing activity are heavily impacted by the level of input costs in the industry, and how they change. Further, the market price of fish determines the relative attractiveness of specific species. Examples of such changes can be how increased fuel oil taxation can make some specific fisheries unprofitable or how consumer awareness on the climate friendliness of single fisheries can shift demand from one species to another. In order* *to address these issues, we will study fishing vessels' input structure and analyze which are likely to be climate affected. We will employ forecasting methodology to develop relevant development scenarios in relation to the climate scenarios selected. Analysis of vessel responses will be undertaken through interviews with vessel owners and economic models of vessel operations. Analysis of consumer responses will be done by reviewing the available literature on environmental awareness and consumer decisions. Supporting these, we will carry out own consumer surveys. Along with foresight techniques, these will form the basis of scenarios. The effects of these on fisheries operations will be studied in the aforementioned economic vessel models. Input from WP1 will guide the scenarios to be discussed. Expected key output from this task is improved understanding of the consequences of climate change induced shifts in demand and supply structures, as well as their responses to these changes. Especially government taxation/subsidy policy on fuel may benefit from better knowledge in these fields. Results will input in task 5.7.*"

This report represents an attempt to consider yet another side of climate change on Arctic capture fisheries. That is how climate change might mediate through factor and product markets and impact the behaviour of fishers. Hence, under the influence of climate change, the fishing industry (and individual fishers and seafood producers) will not only take into consideration the direct impacts from climate change (be it increasing frequency of bad weather, sea temperature and level increase leading to increased migration for some stocks) but might also have to consider altered input prices and product prices when making decisions regarding their daily duties. It is a well-established fact that economics has a central role in explaining the effects of climate change and also point to the remedies to reverse it and abate the effects, by the ways of markets, transactions and the human incentive structure (Neuhoff, 2011; Helm & Hepburn, 2009: Stern, 2007).

The remainder of the report is therefore built up as follows: In section two a background is given regarding expected (biophysical) climate changes the coming 50-100 year period in the Arctic, and the effect these will have on fisheries. As part of this we present the magnitude of Arctic fisheries today, their main markets and the importance of this industry – in a global, regional and national context. In section three we address the most important factor market of the fishing industry – fuel – taking into account how price movements in factor markets might alter the adaptation fishers make in their day-to-day business. And a main cause for dramatic fuel price changes, in the wake of climate change, would be found if national authorities were to impose ordinary taxes on fuel consumption (or cut fuel subsidies) in this industry. In section four, product markets are addressed. If climate change and its consequences was better penetrated throughout the population, it might alter the preferences of consumers in a more environmental friendly way, giving products form sustainable fishing with low carbon footprints the benefit of achieving a price premium in end markets. Foreseeable demographic changes, together with consumer trends, might spur and increase this effect. A global population – increasing from todays 7.3 billion, to 8.1 billion in 2025 and 9.6 billion in 2050 – populating urban and coastal areas will increase the demand for seafood products, and – most probable – the prices achieved in the market place. If markets for seafood prices function correctly, giving economic actors the right incentives, this should contribute to making Arctic fishers more environmental friendly in their behaviour at sea. Finally some conclusions are drawn from this work, emphasising implications for authorities, fisheries management and Arctic fisheries.

2. Background

Limiting global temperature increases to 2ºC and reducing the risks associated with climate change demand large-scale reduction of carbon emissions. The reductions can only be achieved if all sectors of the economy are integrated into climate policy – to increase efficiency, find substitutes for carbon-intensive products and services and access low-carbon energy sources. The objective is not only marginal reduction of carbon emissions but the low-carbon development of our societies.
Nalebuff (2011: 237)

Defining the limits of Arctic fisheries is not straight forward. In utilising the definition brought forward by IPCC, the Arctic is the areas of the northern hemisphere above the Arctic Circle, i.e. above 66° 33' N. Capture fisheries in marine areas include fisheries in all Arctic and sub-Arctic waters: The Arctic Ocean/Sea, the Northeast and Northwest Atlantic. The Northeast Pacific falls without Arctic area since the Bering Strait (serving as the border between this and the Arctic Sea) is just south of the Arctic Circle. The figure below shows both the marine Arctic areas and also different definitions of the Arctic.

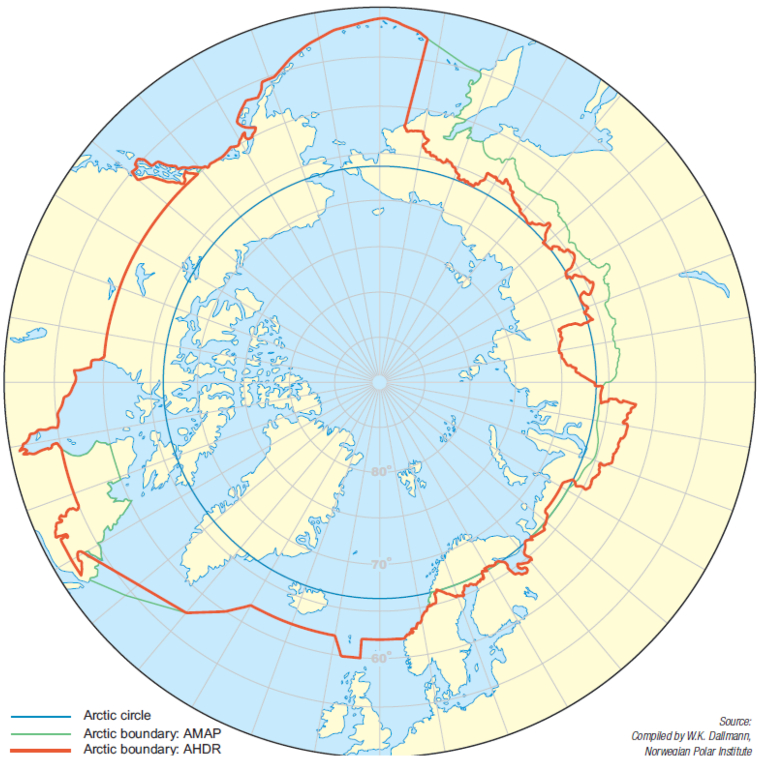

Figure 1 The Arctic – different definitions. Source: Young & Einarsson (2004: 18)

Different definitions of the Arctic is used, however when narrowing the area to above the Arctic Circle the Barents Sea becomes predominantly the most important area when it comes to fisheries quantities – one of the most productive ocean areas world-wide. However, Icelandic waters also have high fishing activity – and also in Northwest Atlantic (Greenland and Canadic waters).

The fisheries areas then that cover the Arctic, according to FAO fishing area codes[1], are the Arctic Ocean (Area 18), the Northeast Atlantic (27) and Northwest Atlantic (21). According to State of the World Fisheries and Aquaculture (SOFIA) (FAO, 2014) the capture fisheries in these areas constituted 16 percent of the total world catch of 79 706 thousand tonnes in 2012. The Northeast Atlantic is by far the most important area - with more than 10 per cent - with the Arctic Ocean being the least important where only 1 tonne of diadromous fish was caught in 2012. However the Northeast Atlantic covers much more than only the Arctic area, extending as far south as to the Gibraltar peninsula. If we constrain the Arctic catch to be that belonging to only the Barents Sea, the Norwegian Sea, Svalbard, the Bear Island, Northeast Greenland, Iceland and Faroese Grounds (Area I, II, V and XIVa in the Northeast Atlantic), and areas 0A and 1A and 1B (north of 66°15’ N) in the Northwest Atlantic the share of world marine catches caught in these waters in 2012 was 6 per cent (4,5 mill tonnes) - with 96 per cent of the total caught in the Northeast Atlantic. The figure below shows the Northeast and Northwest Atlantic areas in question.

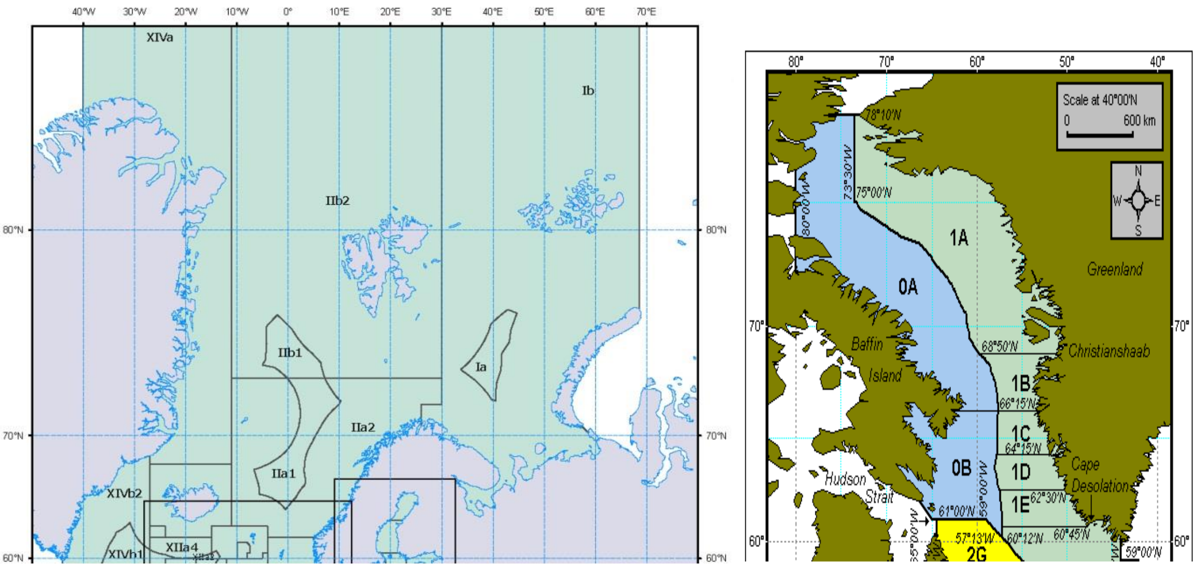

Figure 2 FAO fishing regions Northeast Atlantic (27) and Northwest Atlantic (21) above the Arctic Circle. Source: FAO; http://www.fao.org/fishery/area/search/en

[1] See http://www.fao.org/fishery/area/search/en

The table below show the quantities caught in Arctic fishing areas in 2012, according to SOFIA (FAO, 2014) and catch statistics from FAO.

Table 1 Capture fisheries in tonnes by Arctic areas in 2012. Sources: FAO, ICES, NAFO[2] and Eurostat.

FAO area n°:	Area	Tonnes	Share of world catch
18	Arctic Ocean	1	-
21	Northwest Atlantic	1 977 710	2,5 %
	- Area 0A, 1A and 1B*	*4 886*	*0,01 %*
27	Northeast Atlantic	8 103 189	10,2 %
	- Areas I (Barents Sea)	*536 015*	*0,7 %*
	- Area II (Norwegian Sea, Spitzbergen and Bear Island)	*2 279 526*	*2,9 %*
	- Area Va (Iceland Grounds)	*1 282 197*	*1,6 %*
	- Area XIVa (Northeast Greenland)	*1 230*	*0,002 %*
	- *Total "Arctic" Northeast Atlantic Areas*	*4 098 968*	*5,1 %*
67	Northeast Pacific	2 915 594	3,7 %
	World total	79 705 910	

*) Catch in 2010, according to Eurostat.

The dominating Arctic fishing areas are – as can be seen from table 1 – the Norwegian Sea, the Icelandic Grounds and the Barents Sea, from which about every 20th kilo of marine capture landings stemmed from in 2012. In this picture the waters east and west of Greenland (not to mention the Arctic Ocean) are marginal areas in comparison. That does not mean that fishing doesn't constitute an important activity for people operating in these areas, and support their livelihood to a high degree, only that volumes are modest when

[2] The most recent fishery statistics figures from NAFO (the Northwest Atlantic Fisheries Organization) show that 373 tonnes were taken in these areas in 2010 – however, nothing by Greenland. See: http://www.nafo.int/fisheries/frames/fishery.html. In previous Fishery Statistics publications by Statistics Greenland (see: http://www.stat.gl/dialog/topmain.asp?lang=da&subject=Fiskeri%20og%20fangst&sc=FI) – dating back to 1998 – it is reported that Greenland's catch of flatfish and shrimp – only in area 1A and 1B – amounted up to 43 000 tonnes. Needless to say – there is large uncertainties with these numbers.

compared to the large volume areas mentioned above. With the Northeaster Pacific fisheries taking place south of the Arctic Circle, its numbers is included just as a reference, an area where the productive Alaska Pollock fishery takes place. In the following we'll concentrate on, and narrow it to, the Northeast Atlantic fishery when describing Arctic fisheries.

In fact, volume of catch gives only one dimension of the importance of fishing activity. More important can be the value of the landings and the corresponding price for each kilogram landed from the different areas, and also to which degree the uptake of fish generates value adding activities in areas where they are landed. Furthermore, an important issue is the dependency that local communities, regions and nations have from their fish resources, and how this is developing over time. However, since volumes are the most available (and reliable) data at hand, this becomes the appropriate measure for notations and comparisons.

Fishery is one of the most important industries in the Arctic constituting relatively large shares of GDP in some countries (Greenland 15 %, Iceland 10 %). For local communities fishing, fish processing and/or fish farming can be even more important, and historically, fisheries have in many cases been the main reason for settlement in rural areas in the Arctic. Also Arctic aquaculture is important, where Norwegian salmon farming is the lead actor. However, Arctic aquaculture only constitutes a small share of total aquaculture production in the world, with about 2 percent of a total of 59 mill tonnes in 2011 (Hermansen & Troell, 2012). For Norway, fisheries and aquaculture industries share of national GDP only constitutes about 1 percent, the same as its share of employment. However, fish is the second most important export product in Norway (after oil) with nearly mNOK 70 billion in 2014 – where more than half the value stems from farmed salmon. Arctic aquaculture will however not be discussed to greater detail here, but interested readers might address Hermansen & Troell (2012).

In table 2 below the most important national actors and species in Arctic fisheries in the Northeast Atlantic is provided for 2012. Bear in mind that there can be huge differences over years depending on the state of the important biomasses in these ecosystem and, hence, the corresponding quotas (TACs; total allowable catch) advised by ICES (International Council for Exploration of the Seas, in this case) and set by governments – often in bi- and multilateral agreements. For instance, the TAC advice for Norwegian spring spawning herring (in areas I, II, V, IVa and XIVa) in 2015 was 283 000 tonnes. Six years earlier the advice was seven times higher, with 1 687 tonnes. For the Northeast Atlantic mackerel, which has a larger (and increasing) distribution area, and where coastal states haven't reached a final agreement on the allocation of quotas between them since 2007, the development has been opposite to the herring: the advice went from 349 000–456 000 tonnes in 2008 to 927 000–1 011 000 tonnes in 2014. ICES estimate of the catch in 2014 is however higher, with 1 396 000 tonnes.

Table 2 Main economic actors and species in (Northeast Atlantic) Arctic fisheries in 2012. Source: ICES

Country:	**Volume**	**Share**
Norway	1 602 805	39.1 %
Iceland	1 364 630	33.3 %
Russia	807 219	19.7 %
Faroe Islands	157 491	3.8 %
United Kingdom (incl. Scotland)	39 227	1.0 %
Greenland	38 661	0.9 %
Germany	24 025	0.5 %
Denmark	21 845	0.4 %
Other nations	43 065	1.1 %
Total	4 098 968	100 %
Species:	**Volume**	**Share**
Capelin	974 987	23.8 %
Cod	953 095	23.3 %
Herring	877 301	21.4 %
Mackerel	412 881	10.1 %
Haddock	358 758	8.8 %
Saithe	212 816	5.2 %
Redfish	48 574	1.2 %
Prawn	35 247	0.9 %
Greenland halibut	28 672	0.7 %
Blue whiting	25 178	0.6 %
Other	171 459	4.2 %
Total	4 098 968	100 %

Table 2 shows that Norway, Iceland and Russia are the nation that sets the tone in Arctic fisheries in the Northeast Atlantic, with as much as 92 percent of total uptake. The species targeted and landed in 2012 was principally capelin, cod, herring and mackerel, who together contributed with 78 per cent of total catch.

The information above gives only a portion of the total picture for current Arctic (Northeast Atlantic) fisheries. The fleet from the different national states operate for common resources in many instances but with different fleet structures – often a result of the fishery traditionally committed in those countries. Below the structure and activity of the main countries conducting Arctic fisheries is briefly visited, emphasising recent developments. In addition to the above mentioned, it should however first be mentioned that in 2013 a new fishery developed for Greenland off-shore fleet – namely for mackerel; a species which in later years have turned up continually further north in this area with a much broader distribution than earlier. Also, quotas for Northeast Atlantic cod peaked in 2013 (and subsequent years) to highest catch levels in 40 years (estimated to 966 000 tonnes in 2013). At the same time – as mentioned – the Atlantic herring biomass is on a downward trend, and the mackerel landings from theses area have been increasing since 2005. Furthermore, the spatial distribution of mackerel has changes substantially later years, with observations in the Spitzbergen fjords and an targeting fishery for mackerel along the Easter Greenland coast probably for the first time ever. At the same time, interyear climate varies, and, as an effect, the joint Norwegian Russian Ecosystem survey in the Barents Sea in August to October 2014 was unable to survey the whole area in the Spitzbergen region due to increased ice coverage compared to 2013 (Eriksen, 2014).

2.1. Norwegian fisheries

The Norwegian fisheries sector is one of large diversity, and has – as other countries – been subject to considerable changes in recent years. From 2000 to 2014 the number of registered fishing vessels was more than halved, from 13 000 to 6 000. A vast majority of vessels are small, below 11 meters, about 80 percent of the in 2014. However, the reduction in vessels has been the greatest in this vessel group (-56 percent). The group of larger off shore vessels (cod trawlers, purse seiners etc.), vessels above 28 meters, consisted of about 250 vessels in 2014 – a 30 percent reduction from 380 in 2000. The larger vessels also are responsible for the largest share of the total catch, 80 per cent in 2014, while the share of the large group of smaller vessels was 6 per cent. However, since smaller vessels to a larger degree target higher priced species (mainly cod) than larger vessels targeting pelagic species, their share of catch value is higher with 11 percent in 2014. The share of catch value for the larger vessels was 70 per cent. With more than 6 100 registered vessels in 2013, only 5 200 had landings registered, of which 4 100 with a catch value above NOK 50 000 (about € 6 400), while the 1 451 vessels that entered the profitability study of the Norwegian Directorate of Fisheries were responsible for landings constituting to 90.2 per cent of total catch value that year (mNOK 12 673).

Cod is the most important single species in Norwegian fisheries, constituting 20 and 32 percent of catch and catch value, respectively, in 2014, ahead of mackerel (14 %), herring (13 %), saithe (9 %), and haddock (8 %, when value of catch is considered). In the period 2000–2014, the number of registered fishermen in Norway have decreased from 20 000 to 11 300 (- 44 %).

2.2. Icelandic fisheries

The Icelandic fishing fleet is heterogeneous, with a large number of open vessels and smaller decked vessels, in addition to trawlers and larger decked vessels. Today the fleet is composed of about 1 700 fishing vessels (2013), a number that has decreased with roughly 300 since 2000 (15 percent). While the number of open vessels have decreased considerably in the period (- 22 %, from 1 100 to 860) the number of smaller decked vessels (less than 100 GT) have increased a little (7 %, from 600 to 650). And while the groups of medium sized decked vessels (trawlers incl., 100-499 GT, 500-999 GT and 1 000-1 499 GT) is reduced in the range 40-50 per cent (from a total of 270 to 160 vessels) the number of largest vessels (above 1 500 GT) has increased from 12 to 26 in the period. Trawlers and the large decked vessels target both demersal and pelagic species, but a trend in the period is the price increase for pelagic fish since catches to a much larger degree goes to human consumption markets rather than reduction fisheries for fish meal and -oil.

Pelagic catches dominate the volume (64 %) and constitute about 30 percent of catch value, while demersal species amount to one third of the volume and 61 per cent of value. The dominating species in Icelandic fisheries are (with share of landings in brackets) capelin (32 %), cod (17 %), herring (12 %) and blue whiting (8 %). Cod alone represents 10 per cent of the value of landings. The 1 500 (open and decked below 100 GT) has a 4 percent share of total volume in Icelandic fisheries in 2013 (1.4 mill tonnes) and an 8 percent share of the value (153 bill ISK). At the same time the 75 largest vessels' (above 1 000 GT) share of volume was 68 percent and, correspondingly, 50 percent of the catch value. In the period (2000-2013) the reduction in fishers has been from 6 100 to 3 600 (- 40 %).

2.3. Northwest Russian fisheries

Obtaining data on Northwest Russian fisheries is difficult. Not only due to language barriers but also due to the fact that conventional statistical reporting is normally done per nation – not necessarily for districts, regions or counties. This part therefore lean upon the work done by others (e.g.: Stammler-Gossmann 2014; Vilhjálmsson & Hoel, 2004; Boboedova, 2014; Moran, 2013; 2014; MRG 2015) in addition to international fisheries statistics.

The Northwest Russian fishing fleet is to a much larger degree homogeneous than in the other Arctic fishery nations. Under the Soviet era, industrialisation led to large units at sea supplying large seafood processing units on land. Also, with limited fish resources near the coast, a coastal fleet – like in Norway, Iceland and Greenland – did never develop in Northwest Russia, in the same way as in other nation around the Northeast Atlantic sea basin. The industrial fleet in this region is today located in the Murmansk and Arkhangelsk Oblast – and mainly the former. According to Moran (2013:11) and Stammler-Gossman (2014) there are 214 vessels registered in Murmansk; "*…of which 12 are large, 122 are medium-sized, and 68 are small.*" Stammler-Gossmann (2014:17) makes the distinction between vessel sizes as: large vessels are up to 120 meters length and medium-sized vessels are up to 60 meters length; a modern big trawler has around 100-120 people on board, while a medium-sized one has around 40. MRG (2015) report the Murmansk industrial fishing fleet to have 207 vessels; 11 extra-large vessels, 11 large vessels, 117 medium-size vessels and 68 small vessels (which adds up as contrary to the previous mentioned)[3]. Anon. (2013: 5-6) refer to a total of 214 vessels in 2012, and an additional 12 transport vessels. In addition there are about 100 vessels of different types active in coastal fisheries[4] responsible for landing about 22 000 tonnes of seafood – about 3 per cent of total landings in Murmansk

[3] Boboedova (2014) argues that in 2011 there were 219 vessels in the Murmansk region; 12 of the largest vessels (108 meters or more), 14 large vessels (72–108 meters), 125 medium sized vessels (50–70 meters) and 68 small vessels (less than 50 meters). In 2006 the total was 270 vessels, where most of the 'exit vessels' were among the large (-12) and medium sized (-44) vessels.

[4] Coastal vessels have a different meaning in Northwest Russian than for instance in Norway. As put forward in Vilhjálmsson & Hoel (2004: 702): "*The Russian perception of "coastal fishing" differs from that in neighboring countries While a Norwegian "coastal" fishing vessel normally has a small crew and goes to port for daily delivery of catches, a northwest Russian "coastal" fishing vessel has a crew of more than a dozen and stays at sea for weeks before landing the catch. The reasons for this are two-fold. The fishing industry that was developed during the Soviet period was based on large-scale fishing and processing. Traditions, skills, and infrastructure for small-scale coastal fisheries are therefore non-existent in the main fishing regions of the Russian Federation. In addition, fish stocks for developing a viable coastal fishery are not available.*"

region in 2013 (i.e. 700 000 tonnes according to MRG (2015). 10 years ago there were approximately 450 vessels according to Vilhjálmsson & Hoel (2004: 702).

According to Moran (2014) 12.5 per cent of Russian landings – adding up to 4.15 mill tonnes in 2013 – are caught in the Northeast Atlantic (520 000 tonnes). Russian official catch statistics[5] report a total Russian marine capture of 4 mill tonnes in 2013, of which 25 % (1 mill tonnes) was caught in the Northeast Atlantic while 69 % was caught in the Northwest Pacific. Of the catch in the Northeast Atlantic, about 834 000 tonnes was caught in Arctic areas (82 %). MRG (2015), however report landings in Murmansk region to add up to 700 000 tonnes in 2013, an increase of 23 per cent from 2012 (571 000 tonnes). Catch statistics from ICES show that Russian vessels' catch amounted to 950 000 tonnes in 2012 – or 807 000 tonnes caught in the Arctic parts (area I, II, Va or XIVa). Cod was the most important species (41 % of landings from Arctic areas), with haddock (18 %), herring (14 %), mackerel (9 %) and capelin (8 %). According to FAO (2012) Russian landings to Russian ports peaked after 2009 when a management decision to remove excessive formalities on documentation of landing operations, as up until early 2010 landings by vessels of the Russian Federation in national ports were treated as imports and vessel investments made abroad would be immensely taxed. Still today, large shares of Russian Northeast Atlantic catches are landed abroad even though the Murmansk region seafood processing industry processes roughly 550 000 tonnes of fish on an annual basis (Moran, 2013).

According to MRG (2015) the Murmansk fishery sector's share of regional GDP is 7 per cent, and the sector employs roughly 7 800 persons. In 2013 Murmansk was the port in Russia with the largest catch value (shipped fish production) with a total of RUB 31 billion (approx. mill € 732). According to Boboedova (2014) the number of fisheries employees was 6 200 in 2012 – 4 300 less than in 2005 (- 41 %). In Russia as a whole, the employment in the fishery sector in 2013 was 59 200[6].

2.4. Greenland fisheries[7]

Fisheries are Greenland's primary industry, with shrimps being the most important species. Fisheries' share of Greenland's economic activity (GDP) and total export was 13.6 and 90 percent[8,9], respectively, in 2013. The fishing fleet consisted in 2013 of 384 vessels; of which

[5] http://fish.gov.ru/activities/Documents/f407-0.pdf (in Russian).
[6] (www.gks.ru/bgd/regl/b14_12/IssWWW.exe/Stg/d01/16-01.htm
[7] Primary Source is the «Fishery and catch statistics" of Statistics Iceland: http://www.stat.gl/publ/da/FI/201402/pdf/Fiskeri%20og%20fangst%202013.pdf
[8] Statistics Greenland: http://www.stat.gl/publ/da/NR/201402/pdf/Produktionsbaseret nationalregnskab 2003-2013.pdf

193 below 10 meters length, 149 between 10-20 metres, 19 between 20-30 meters and 23 vessels larger than 30 meters. In addition to these vessels, Greenland fisheries sector also have a large number of snowmobiles (185), dog sledges (602) and jolly boats (1 442) – all active with permit to fish and land fish in 2013, mainly located in Northwest Greenland (Quaasuitsup). These "vessels" has as remarkable high share of the Greenland landings value (landings to Greenland) with as much as 29 percent of the total (mDKK 869) in 2013. Greenland vessels catch in 2013 amounted to 170 000 tonnes, of which 70 per cent in their own EEZ. The most important species (volume) was mackerel (31 % – caught in East Greenland waters, ICES areas XIVa,b), shrimp (25 %), capelin (16 % – in Icelandic waters) and Greenland halibut (6 %). In value terms, shrimp is by far the most important (63 % of a DKK 1.2 bill in total), then Greenland Halibut (12 %) and cod (7 %). Shrimp trawlers, as an important branch, can be two-partitioned: The larger off-shore trawlers, operating outside 3 nautical miles from the baseline and in open waters, have an obligation to land 25 percent of its catch to land-based production (leaving 75 percent to be on board processed and exported). The in-shore trawlers have an obligation to land 100 % for land-based production. In addition to fish and crustacean, Greenlandic vessels also landed 51 000 sealskin and 25 tons of whales. Greenlandic shrimp quotas are divided between off-shore and in-shore trawlers in a 57/43 percent distribution.

Unfortunately Statistics Greenland does not publish detailed figures relating to which (ICES/NAFO) area fish is caught. However, in their Statistical yearbook[10] for 2013, Figure 3.4 (p.8) shows that of the most important species (cod, crab, shrimp and halibut) – summing up to about 169 thousand tonnes in 2012 (of a total Greenland catch of 231 thousand tonnes – 73 %) – approximately 116 thousand tonnes are caught in NAFO areas 1a (Baffin Bay) and 1b (Davies' Strait), while 8 thousand tonnes are caught in ICES area XIV(a and b) and Other ICES areas, respectively. One can deduct that at least 125 thousand tonnes of Greenland's catch are caught in Arctic waters (55 %).

ICES catch statistics for 2012 show that Greenlandic vessels caught altogether 39 000 tonnes in the Arctic Northeast Atlantic waters, while EuroStat has no records of Greenland catches in the Arctic Northwest Atlantic. Total employment in the Greenland fisheries sector (fishing, catch and agriculture; fish processing industry excl.) is roughly 3 550 out of a total of 25 500 Greenland residents employed in 2013 – approximately 14 percent.

[9] Statistics Greenland: http://www.stat.gl/publ/da/IE/201401/pdf/Udenrigshandel 2013.pdf
[10] http://www.stat.gl/publ/da/SA/201307/pdf/2013%20statistisk%20%C3%A5rbog.pdf

2.5. Major Arctic fisheries – a summary

Arctic fisheries, when defined as fishing north of the Arctic Circle, is an activity mainly carried out in the Northeast Atlantic, but with some fishing, whaling and sealing taking place also in the Northwest Atlantic. In the Arctic Ocean – the basin around the North Pole – fisheries is hardly a noticeable activity, and prospects for increased fisheries in these areas, under the assumption that the ice cap will retract substantially, are small. As put forward by IPCC (2014b: 1704)[11]:

> "*The changes in distribution and migration of pelagic fish show considerable spatial and temporal variability, which can increase tensions among fishing nations. In this regard, tension over the Atlantic mackerel fisheries has led to what many consider the first climate change-related conflict between fishing nations, and which has emphasized the importance of developing international collaboration and frameworks for decision making. The Atlantic mackerel has over the recent decades been a shared stock between the EU and Norway. However, the recent advancement of the Atlantic mackerel into the Icelandic EEZ during summer has resulted in Icelandic fishers operating outside the agreement between the EU and Norway. Earlier records of mackerel from the first half of the 20th and second half of the 19th century show, however, that mackerel was present in Icelandic waters during the earlier warm periods. In the Barents Sea, the northeast Arctic cod, Gadus morhua, reached record-high abundance in 2012 and also reached its northernmost-recorded distribution (82°N). A further northward migration is impossible as this would be into the Deep Sea Polar Basin, beyond the habitat of shelf species. A further advancement eastwards to the Siberian shelf is, however, possible. The northeast Arctic cod stock is shared exclusively by Norway and Russia, and to date there has been a good agreement between those two nations on the management of the stock. These examples highlight the importance of international agreements and cooperation.*"

Even though distributional changes in fish biomasses can be expected in the areas under scrutiny here, they are expected only to a limited degree to continue into the Polar Basin, and if so, only for some fish stocks. Furthermore, the management regimes in effect in the areas where fisheries take place seem relatively robust, despite some tensions in the wake of re-distributed fish stocks. These tensions can, however, put great pressure on existing regulatory regimes. Especially when quota distribution depends on historical rights and the

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[11] See also feature articles by IMR-researchers in Norwegian press; "No fisheries expected in the Arctic Ocean" (02.12.2013):
www.imr.no/nyhetsarkiv/2013/februar/ikke_noe_fiskerieventyr_i_polhavet/nb-no;
and "Fish, fisheries and fisheries management in the Arctic Ocean" (02.13.2014)
www.imr.no/publikasjoner/andre_publikasjoner/kronikker/2014_1/fisk_fiske_og_fiskeriforvaltning_i_polhavet/nb-no

fish distribution turns out differently in the appurtenant zones of the coastal nations. As underlined by the IPCC (2014b: 456):

> "*Food production from the sea is facing diverse stressors, such as overfishing and habitat degradation, which interact with climate change phenomena, including warming, ocean acidification, and hypoxia. Projections of impacts on capture fisheries are constrained by uncertainties in marine primary production. Negative effects are projected to be most significant in developing nations in tropical regions. Nations at higher latitudes may even benefit from climate change effects on ocean ecosystems, at least initially.*"

The main actors in Arctic fisheries can be identified by Table 2, where Norway, Iceland and Russia are responsible for 92 per cent of the catches in Arctic Northwest Atlantic areas. Above, these nations' Arctic fishing activity, in addition to Greenland, has been accounted for to some detail. A vast difference exists in the nations' fisheries sector, often dependent of historical, political, demographic and biological factors as well.

In the next section the factor markets for the capture fishing industry will be scrutinised in order to highlight to what degree climate change might alter the adaptations made by fishers in their day-to-day and year-to-year business decisions. To some degree, such effects can coincide with similarities in the aquaculture industry/value chain, when the two share the same inputs. However, the nature of business and, hence, cost structure of the two different industries have more differences than similarities, which makes comparisons between the two difficult – at the best. Therefore, we address only the fisheries value chain, and the cost structure of the fishing industry, leaving the aquaculture "sailing its own sea". To some extent the fishing industry and the costs accrued there, serves as a supplier of one of the most important cost items for aquaculture – namely fish feed – for which smaller pelagic species are a major ingredient, in the form of fish meal and -oil.

3. Factor markets

The impacts of climate change on marine fish stocks are expected to affect the economics of fisheries and livelihoods in fishing nations through changes in the price and value of catches, fishing costs, income to fishers and fishing companies, national labor markets, and industry re-organization.
IPCC (2014b: 1702)

Arctic fisheries are today a modern industry in which effective intermediate markets exist for all inputs. Globalization of the seafood market has also lead to a situation where different nations' vessels land their catch within the borders of other nations. This is the case for the larger northwest Russian demersal trawlers which lands their catch at neutral freezing storage plants in Norwegian harbours, often sold on commission, or to some degree land their catch to transport vessels in open sea for direct transfer to (EU-)markets (Stammler-Gossman, 2014; FAO, 2014). The reasons for such action are different. To some degree Russian vessels can obtain higher prices by landing their catch abroad, while other incentives can be to avoid specific vessel-, catch- or bribery "taxes", or to take advantage of services supplied in foreign ports (Boboedova, 2014; Kisselova, 2006; Bendiksen & Nilssen, 2001; Nilssen *et al.*, 2005).

In order to achieve the goal of limiting the global temperature increase to 2 ºC, large-scale reduction of carbon emissions is demanded (Neuhoff, 2011). Further, "the abatement costs are minimized when the carbon price is equalized across sectors" (Stern, 2007: 384) since then it *"…creates incentives for companies and consumers to make carbon-efficient choices across a diverse set of activities [and give them] the flexibility to find the response that is the most suitable for their specific circumstances*" (Neuhoff, 2011: 238).

Of course, CO2-emissions are but one of the harmful gases for the atmosphere released when combusting fossil fuels. To quote Hodas (2004: 607-9):

> "*Some of the pollutants created by burning fossil fuels are inherently harmful and impose external costs on society*[12]*. Other emissions from fossil fuel combustion, such*

[12] Sulfur in fossil fuels, when burned, is emitted as SO2 (sulfur dioxide), which causes adverse respiratory effects and can be converted into acidic compounds that fall to the earth as acid precipitation. High temperature combustion results in the creation of nitrogen oxides (NOx), which can be noxious in their own right, and when combined with volatile organic compounds, humidity, and sunlight can result in ground level (tropospheric) ozone (O3), the major component of smog, with its adverse health effects. Burning fossil fuels can also release soot and fine particulates, which pose a health risk to people with asthma, and which can carry heavy metals, SO2, mercury, and carcinogens into human lungs. These pollutants also have adverse effects on the health and viability of ecosystems worldwide. Each of these pollutants has a different mechanism, range, and scale of action. For instance, some pollutants, such as mercury and other heavy metals, are directly toxic and long lasting. Other

as carbon dioxide (CO_2), are themselves benign[13]. However, in the atmosphere, CO_2, together with water vapour[14], methane[15], nitrous oxide[16], and other trace gases, have the ability to trap heat in the atmosphere. The greater the concentration of greenhouse gases in the atmosphere, the more heat is trapped, and the warmer the earth becomes. "

As noted above, fisheries are important industries in the nations/regions bordering the productive waters of the Northeast Atlantic. For all these countries fishing contributes significantly to their emissions of greenhouse gases. Unfortunately, we've been unable to find figures for the Northwest Russian fishing emissions (or even the Russian ones). For the other major Arctic fishery nations the following describe their emissions (in CO_2-equivalents):

- Norway[17]: Total CO_2-emissions from Norwegian firms and households added up to 65.3 million tonnes in 2013, of which fisheries contributed with about 2.1 % (1.4 mill tonnes). Since 1990 fisheries CO_2 emissions have been relatively stable (in the range of 1.2 to 1.6 mill tonnes) despite a 65 % reduction in the number of fishing vessels.
- Iceland[18]: Total man-made green-house gas emission in Iceland in 2010 was 4.5 mill tonnes of which fishing vessels were responsible for 12 % (540 thousand tonnes).
- Greenland[19]: Total domestic greenhouse gas emissions (in CO_2-equivalents) to air from Greenland households and industries in 2013 was 555 thousand tonnes, of which fisheries was responsible for 24.2 % (134.8 thousand tonnes).

pollutants, such a tropospheric ozone and acid precipitation, result from the interaction of fossil fuel emissions with other atmospheric influences and chemicals to produce adverse regional effects, which may last only hours, days or months until the emissions or atmospheric conditions abate, but many may be transported in the air for long distances causing damage far from their source of burning.

[13] The carbon cycle and CO_2 are central components in the web of life. In very simplistic terms, CO_2 is released when we metabolize our food to obtain the energy to live. Green plants use CO_2 in photosynthesis to create carbohydrates, cellulose, and other woody or fibrous structures and release oxygen, which animals and plants use to convert food into energy. Some of the carbon is absorbed by the oceans, and some is stored in soil. The remainder, about half of the original emissions, remains in the atmosphere for up to 200 years. The carbon cycle, in its rich complexity, is described in I.C. Prentice et al., *The Carbon Cycle and Atmospheric Carbon Dioxide*, *in* IPCC, CLIMATE CHANGE 2001

[14] Water vapor is the largest natural contributor to the greenhouse effect, but the amount of water vapor in the atmosphere is not directly affected by anthropogenic emissions of water vapor. However, human activity can increase atmospheric water vapor concentration indirectly by the emission of other greenhouse gases, such as carbon dioxide that warm the atmosphere, thereby increasing the rate of evaporation; this increased evaporation increases water vapor, which further accelerates global warming.

[15] Methane (CH_4), the major component of natural gas, is anthropogenically released into the atmosphere from coal mining, leaking natural gas pipelines, ruminant live-stock such as cows, rice paddies, and solid waste facilities.

[16] Nitrous oxide, N_2O, is produced both naturally in soil and water, and by human activity in agriculture, energy, industrial, and waste management activities. According to the U.S. EPA, "agricultural soil management accounted for 70 percent of U.S. N_2O emissions" in 2000 and "[f]rom 1990 to 2000, emissions from this source increased by 11 percent as fertilizer consumption, manure production, and crop production rose." N_2O is also produced when fuels are burned at high temperatures, in the manufacture of adipic and nitric acid, and in the context of management of human and animal wastes. N_2O accounts for 6.1% of US greenhouse gas emissions. Globally, "the atmospheric concentration of nitrous oxide has increased by 16 percent since 1750, from a pre-industrial value of about 270 ppb to 314 ppb in 1998, a concentration that has not been exceeded during the last thousand years."

[17] Source: Statistics Norway; www.ssb.no.

[18] Source: Statistics Iceland: http://www.statice.is/Statistics/Geography-and-environment/Gas-emission

If we assume that the Northwest Russian fishing fleet emits greenhouse gas at the same level as the Icelandic fishing fleet, the total Arctic (North Atlantic) fishing fleet emits in the range of 2.6 mill tonnes of CO2-equivalents. That is nearly 60 per cent of total emissions from Iceland in 2010, or approximately the same as the greenhouse gas emissions from Norwegian farm animal's flatulence in 2013.

In the next sub-chapter we go further into the data availability matter regarding the most important input factors for Arctic fisheries, and the methodology employed here.

3.1. Data and methodology

Having established that Norway, Iceland and Russia by far are the largest actors operating within fisheries in Arctic waters, the best way to get a hold of the input structure of fishing vessels in the Arctic – and the main cost components – could be established by viewing the respective nations' profitability studies for the fishing fleet. However, to our knowledge, such studies only exist for Norwegian and Icelandic fisheries. For Russia, and the northwest Russian fishing fleet, no uniform grouping and comparison exists. Earlier years' account figures for single companies (i.e. Murmansk Trawl fleet, owning 11 vessels; today a subsidiary of the Karat Fisheries Holding – an association of nine Russian fishing groups supplying Hong Kong based Ocean Trawlers[20]) has shown that the comparison of Western and Russian account figures is farfetched and not straight forward[21]. However, it could be argued, that the northwest Russian fleet composition, consisting primarily of large vessels, the average cost composition should be comparable to that of Icelandic vessels, whose structure is relatively equal. Furthermore, the renewal of the northwest Russian large off-shore fleet has to a considerable degree been accomplished by buying 'scrapped' Norwegian and Icelandic vessels with a long residue lifetime. In fact, used vessel transaction between nations operating in the Northeast Atlantic takes place in an ever greater extent. On the other hand, Russian legislation, tax regime and account practices still differ substantially from those in 'the western societies' which should perhaps motivate for reservations regarding drawing conclusions from comparisons between these nations' vessel accounts.

For the Norwegian fishing fleet, a profitability study have been conducted since the 1960's, with some changes made regarding vessel groups and the objective of the study. Also for Icelandic vessels there's a profitability study at hand, covering seven vessel groups over the

[19] Source: Greenland Statistics: http://bank.stat.gl/ENE2CO2e
[20] Source: http://www.undercurrentnews.com/2013/03/22/murmansk-trawl-fleet-in-talks-for-samherji-assets/#.UW-UU8qOBkQ
[21] Pers. Comm., Bjørn Inge Bendiksen, 16. April 2013.

period 1997–2011[22]. In Figure 3 below, the average composition of costs (and profit) in the Icelandic and Norwegian profitability studies respectively, are depicted in main cost components for the year 2011. The cost structure in fishing differs from vessel to vessel, depending on various factors like geography (distance to fishing grounds and landing ports), vessel/engine size, target species and fishing rights. The figure below exhibits the most important cost components (and operating profit) in 2011, for the Icelandic and Norwegian fishing fleet respectively. The percentages show the share of revenues.

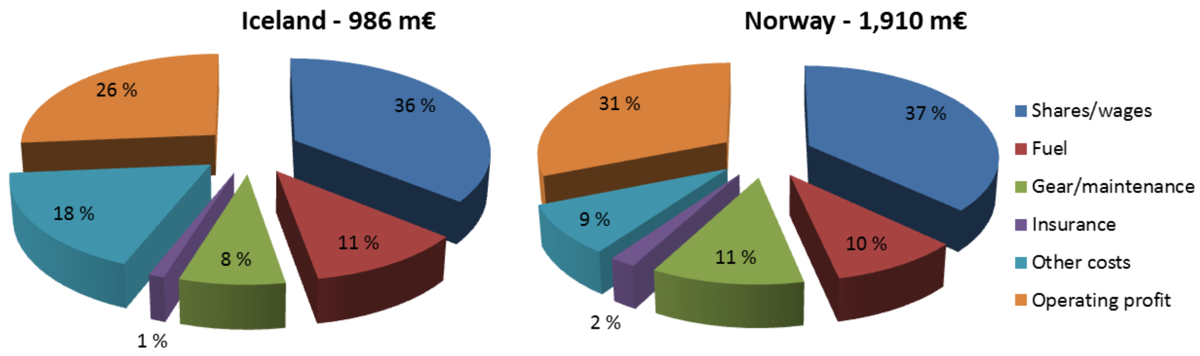

Figure 3 Main cost components and profit in the Icelandic and Norwegian fishing fleet in 2011. Revenues (heading) in mill EUR. Source: Statistics Iceland and Directorate of Fisheries, Norway

Figure 3 show that revenues[23] in Norwegian fisheries in 2011 were nearly twice as high as in Iceland. All over, in 2011, Norwegian catches were nearly the double of the Icelandic catch volume that year, while the Norwegian fishing fleet consisted of nearly four times as many vessels as the Icelandic fleet (6 250 vs. 1 655). However, the fishing vessel population that enter the Norwegian profitability study counted no more than 1 525 vessels, responsible for the uptake of 88 % of the Norwegian catch, and 91 % of the catch value in 2011. Hence the two fleets that are compared in the profitability studies are not as diverse as vessel numbers alone might give the impression of. That can be seen from comparing the pie diagrams above.

Figure 3 show that the main items on which the Icelandic and Norwegian fleet differ substantially are on other costs and gear and maintenance. Also, profits are different, but

[22] http://www.statice.is/?PageID=1222&src=/temp_en/Dialog/varval.asp?ma=SJA08101%26ti=Operating+accounts+of+fishing+1997-2011+++%26path=../Database/sjavarutvegur/afkoma/%26lang=1%26units=Million%20ISK

[23] For calculating ISK and NOK into EUR, exchange rates of 161.419 ISK/€ and 7.793 NOK/€ have been utilised.

these vary substantially between years and nations depending on biologic factors as well as market prices. Below the cost items are partly described in greater detail:

Shares/wages: Both countries, and to our knowledge most countries around the Northeast Atlantic basin, make use of sharecropping contracts when fishers are hired and remunerated for their work on fishing vessels (see for instance Mathiasson, 1999, for a literature review). Typically, the payment for their labour contribution in a fishery in a given timeframe is dependent – as a given percentage – from the value of landings, or net or gross revenues on that trip/during that period – either alone or in combination with some fixed benefits (mostly offered to officers or leading crew on larger vessels). Often provisions (food and drink) while at sea are supplemented. This remuneration is dependent on type of vessel, fishery, number of crew members and often settled in agreements mandatory for all vessels.

Fuel: Fuel costs are one of the main input costs for fisheries, and has been since oars and sails was went in to the history of professional fishing somewhere in the first half of the 20th century. The price for fuel is highly varying and prices paid dependent on the size of the vessel, where large vessels can obtain large rebates on high volumes. They pay a small margin on the prevailing PLATTS-quotation, while the price paid by smaller vessels include larger margins for the supplier, often to cover longer distance of transport to remote areas. In Norway, fuel costs are deducted from revenues before landing value is shared between vessel owner and crew in the coastal fleet, while in the off shore fleet, vessel owner is solely liable for the fuel cost and the crew share is independent of fuel use.

Gear/maintenance: Here the maintenance cost for vessel (hull, technical equipment, engine, etc.) and maintenance and investment cost for fishing gears are accounted for.

Insurance: These are the costs accruing for insuring the vessels and crew against unforeseen events. A relatively high cost component compared to other industries, reflecting the value of the real capital employed in the fishing fleet (and the replacement value) as well as the high risk occurring during Arctic fisheries.

Other costs: In this omnibus item costs occurring in connection with renting labour (other than crew), phone, harbour fees, disembarking costs, administration costs, packaging and freezing costs, bait costs, transportation and other costs are included.

Profit: This category is comprised not only of profits, but also net financial costs and depreciation of vessel and fishing permits and licences.

The main motive of this task was to "…*elucidate knowledge on how climate changes will spur governmentally or consumer induced price changes in factor or product markets. How these* *may alter the activity at sea, and the catch composition of the fishing fleet*.” Here, attacking the fishing fleets’ cost structure and factor markets the most obvious influence will come from governments – rather than consumers (revenues assumed exogenous given – and the most obvious cost item being the fuel cost. Of course, governments have the opportunity through regulation and taxation to affect all cost items. They can dictate (minimum- or maximum) wages, tax gear, vessel and other investment or operation items, dictate depreciation rates or divest firms’ and persons’ ability to take dividends and profits from the firm. That is at least in theory. But in a climate policy frame the most appurtenant measure above the fishing industry can be found by ways of carbon pricing. Moreover, carbon pricing in agreement with the goal of reducing fossil fuel combustion to a level that would imply an attainment of the “2-degree-warming” goal.

3.2. Fuel as a major input factor in fishing

From Figure 3 we see that fuel costs constitute about 10 per cent of revenues in both Iceland and Norway, and – if operating profit is excluded – about 15 percent of costs. With a value creation focus, adding wages to the operating profit which shows the remuneration of labour and capital, Norway is slightly ahead of Iceland with 68 versus 62 per cent. That is on an overarching level – for the total fleets in the two nations. The percentages in Figure 1 show only the greater picture for the aggregate fleet, from which specific fleet groups can deviate substantially. Different fleet segments have different cost shares. In the figures below the different fleet segments’ fuel cost share of revenues is given for Norway and Iceland, respectively, and as an average for the years 2008-2011.

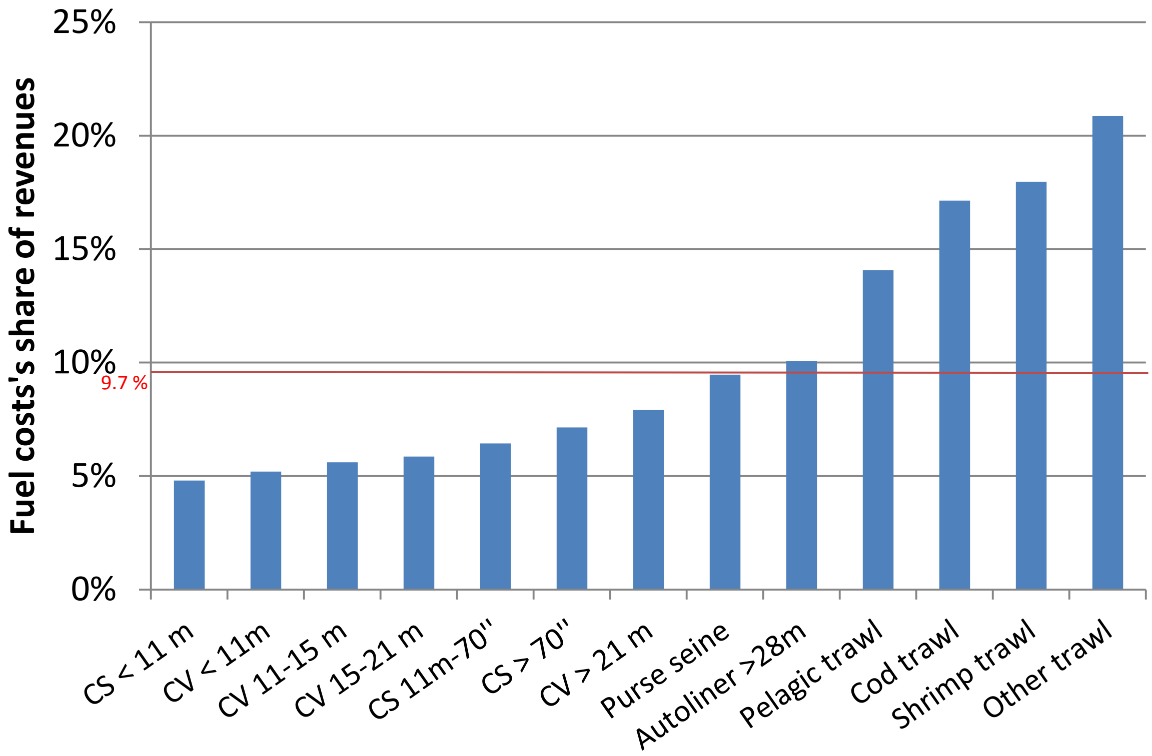

Figure 4 Average fuel cost as a percentage of average revenue for different Norwegian vessel groups, 2008-2011. Abbreviations: CS = coastal seiners, CV = coastal vessels. Sources: Norwegian Directorate of fisheries.

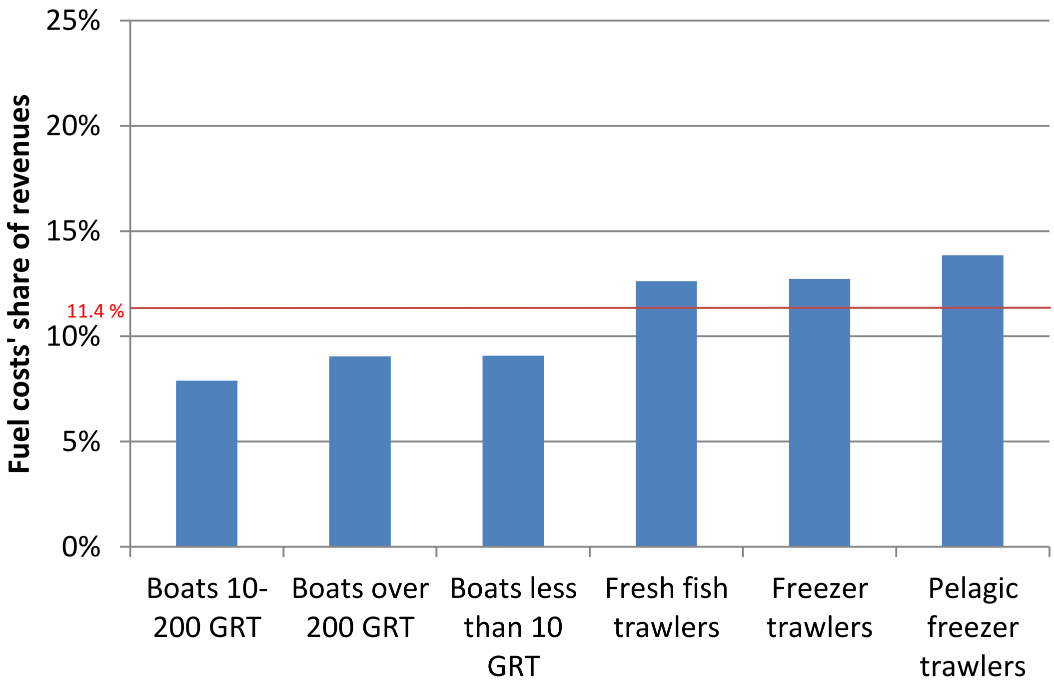

Figure 5 Average fuel cost as a percentage of average revenue for different Icelandic vessel groups, 2008-2011. Source: Statistics Iceland

The percentages in Figure 3 show only the greater picture for the aggregate fleet, from which specific fleet groups can deviate substantially. That is what can be discovered from Figure 4 and 5 regarding the fuel cost's share of revenues as an average for the years 2008-2011. Average fuel cost shares have been computed to smooth fuel price variations between years. As a momentum in the discussion regarding the fleet of the third most important Arctic fishing nation – Russia – the Nortwest Russian fleet consists mainly of large vessels utilising trawl both when targeting demersal and pelagic species. Moreover, this fleet consists of older vessels and are confronted with world market fuel price without any fuel subsidy schemes (deviating from other nations, as will be outlined later). Hence, it is reasonable to assume that the fuel cost shares experienced by the Northwest Russian fleet can be depicted in the range somewhere between the Icelandic freezer trawlers (13 %) and the Norwegian cod trawlers (17 %) – as a conservative estimation.

From Figure 5 we see the different vessel groups in Norwegian fisheries – in different sizes, gear technologies and fisheries – as they appear in the profitability survey for the Norwegian fishing fleet (Fiskeridirektoratet, 2012). In Figure 6, we find the corresponding groups for the Icelandic fishing fleet. From Figure 3 we saw that the total fleet in Iceland and Norway spent relatively the same share of fishing revenues on fuel in 2011 – approximately 11.4 and 9.7 % respectively. The lesson learnt from Figures 4 and 5 is that the two profitability surveys operate with quite different coarseness, with the Norwegian fleet is constituted of relatively many (13) vessel groups – more than the double of what we find in the Icelandic survey (6); that huge differences exist regarding the share of revenues spent on fuel (from 1/5 to 1/20); and that there is less variation among the vessel groups the Iceland survey operates with.

When operating with a relative measure for fuel consumption, like here, fuel costs' share of revenues, we also are in peril of concealing some sides of the reality. That is because differences among fleet segments can just as well come about due to more valuable catch landed, greater fuel prices demanded from different fleet segments or merely that some vessels combust more fuel for each kilogram of fish they catch. There are numerous descriptions in literature of differences in fuel volumes used per kilogram of catch. In Figure 6, findings from Schau *et al.*'s (2009) study are reproduced.

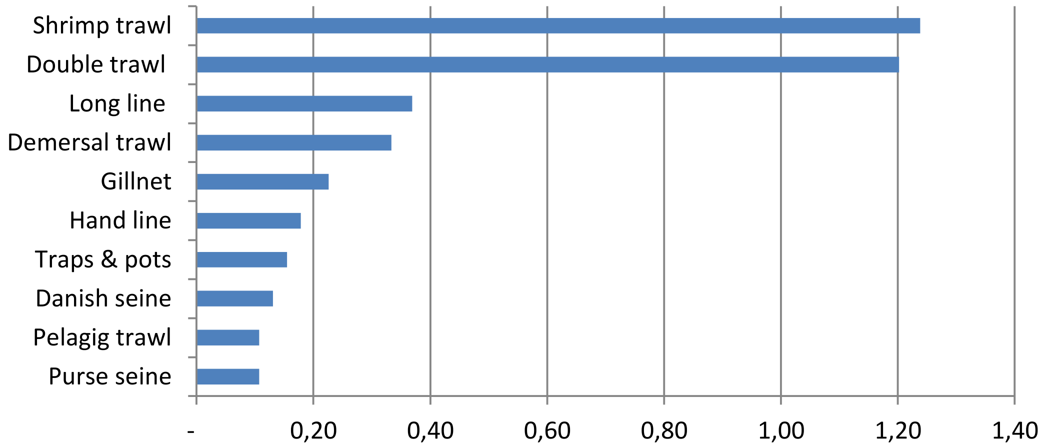

Figure 6 Average fuel consumption (in liters) per kilogram of catch for different gear usages, in the years 2001–2004. Source: Revised from Schau et al. (2009)

As can be seen from Figure 6, there are high variations between different gear types. While a purse seiner on average utilised about a deciliter fuel per kilogram catch, a shrimp trawler spends more than 10 times as much per kilogram caught. However, a kilogram of shrimp at this point in time (2001–2004) was worth nearly 4 times a kilogram of herring.

As shown in Figure 7 fuel prices – as recommended price for Marine Gas Oil supplied by the main oil retail companies in Norway (Statoil Fuel & Retail) – tend to fluctuate both within and between years, with 2008 as an example.

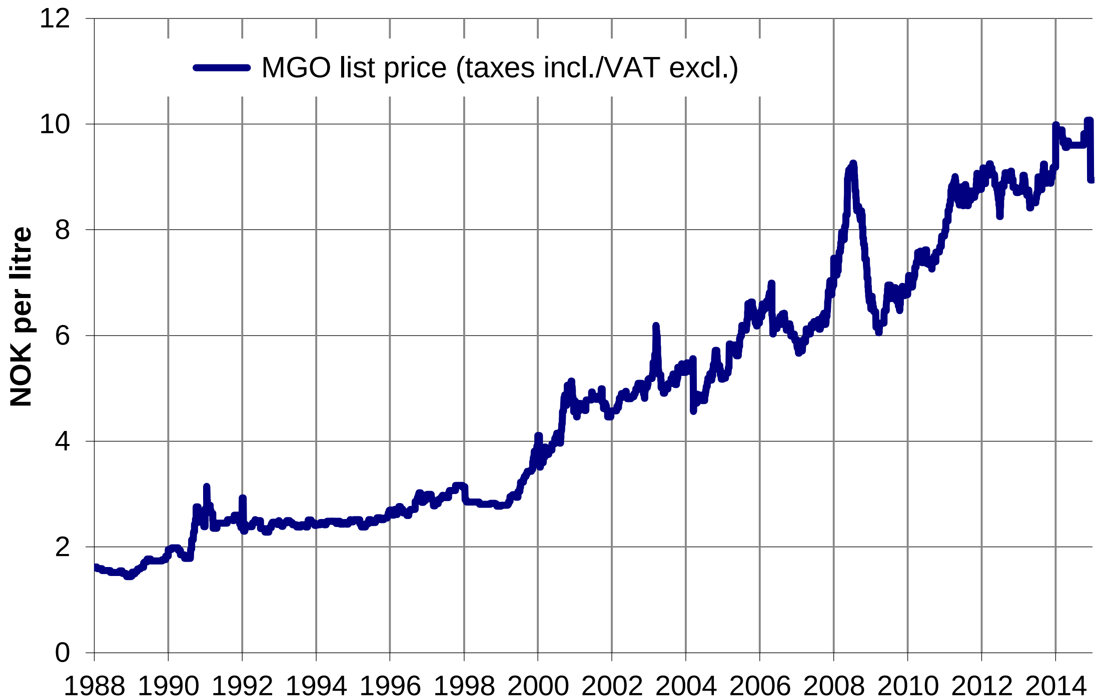

Figure 7 Mineral gas oil (MGO) list price (nominal) in Norway 1988–2014. Source: Statoil Fuel and retail

Figure 7 shows the nominal prices demanded by one of the main fuel suppliers to the Norwegian fishing fleet in the period 1988 to 2014 – Statoil (Fuel & Retail). As stated above, large customers (off shore vessels in special) pay fuel prices that deviate substantially from the recommended price (i.e. Platts-notation with a margin) – often more than 30 % below these. For the smaller more immobile coastal fleet, who buy only modest volumes of fuel when bunkering, this recommended price is more likely to appear on the receipt from the fuel company. From Figure 8 we see that the prices was the most volatile in 2007-2009, but has risen steadily with nearly two thirds from 2009 to 2014.

Having established that fuel not only is a major input factor for fishing industries in the Arctic, but also the most appropriate item for governments to address to cut carbon dioxide emission, the next section will address how fuel consumption in the fishing fleet is treated in the main Arctic fishing nations.

3.3. Fuel taxation in Arctic fisheries

Fuel subsidies are a main issue when fishing subsidies are under scrutiny, and an extensive literature exists on this matter. For instance in Tyedmers *et al.* (2005) global fuel consumption for fishing is estimated to 42.2 million tonnes in 2000, representing 1.2 % of total global oil consumption, responsible for 1.7 kg CO2-emissions for every kilogram of fish caught. On a regional level, concerning also the Northeast Atlantic Arctic fishery, Martini (2012) give insights in more detail how OECD-countries practice fuel taxes in the fishing fleet. He estimated the total fuel consumption in OECD-countries' fishing fleet in 2008 to 9.3 billion litres (7.9 mill tonnes), and fuel tax concessions to amount to USD 2 billion. For the Northeast Atlantic he notes that Norway (and Denmark; Greenland, together with 20 other OECD-nations) operates with fuel tax concessions, Iceland have no fuel tax concession or other support (as do 5 other nations), while the Russian Federation is the only nation that supports fuel for fishing by budgetary support. Moreover, Waldo *et al.* (2014) give a more detailed description on how the Nordic countries practices fuel tax concessions and the size of prospective carbon taxes on fossil fuels in the fishing industries, while Isaksen et al. (2015) give thorough analysis of the tax concession scheme in Norway and its historical levels.

In short, the different national fleets – Norwegian, Greenlandic, Icelandic and Northwest Russian – operate under different schemes. Hence, the three nations visited here, all have different legislation and regimes regarding the taxation of the respective fishing fleets' fuel consumption:

In Norway, marine gasoil – as with other mineral oils – is (in 2015) taxed with NOK 2.49 per litre upon bunkering. Of this, 0.9 NOK is a carbon dioxide (CO2) tax, whereas NOK 1.59 is the basic tax. In addition, a sulphur tax of NOK 0.081 is levied if the oil contains more than a 0.05 per cent weight share of sulphure – for each commenced 0.25 per cent weight share. Fishing vessels operating outside Norwegian waters (250 nautical miles outside the sea baseline) can bunker tax free fuel upon declaration. Fishing vessels operating in Norwegian waters are reimbursed the full basic tax and NOK 0.63 of the CO2 tax. In addition, vessels with engines larger than 750 kW are levied a 4 NOK/kg NOx-tax, which is earmarked a fund that financially supports investments in emission reducing measures aboard vessels[24]. This is an agreement between the Ministry of Environment and industry organizations, where the latter, by committing to reduce the NOx-emissions from the industry, pay a reduced tax (4 NOK/kg to a fund supporting emission reducing measures instead of NOK 17/kg to the State[25]). Hence, the conventional carbon tax on fuel is NOK 2.49 per litre, while fishing vessels get a reimbursement of NOK 2.22 per litre. Hence, the effective carbon tax is NOK 0.27 per litre for fishing vessels. In addition a sulphur tax of NOK 0.81 is levied. For vessels operating in foreign waters (250 nm outside the Norwegian baseling) no carbon taxes accrue.

According to the information we've been able to achieve on Iceland – from LIÚ (the federation of Icelandic fishing vessel owners) – Iceland has a low carbon tax rate compared to the Norwegian regime. A flat rate, differentiated between different fuels, is, however, applied to all fuel consumers, and, to our knowledge, no exemptions or refund schemes exist for industries or vessels operating either in Icelandic waters or outside. For marine gasoil and diesel ("*gas- og dísilolíu*") the tax is ISK 5.75 per litre[26], which – at the current conversion rate against NOK (1. Quarter 2013: ISK/NOK=22.62) – corresponds with a tax of about NOK 0.254 per litre.

For the Russian system we still haven't been able to find the tax level on mineral gas oil, despite our steady requests to different informants: D. Klochkov (pers. comm.), Marine Informatics Company, Murmansk Russia (Subcontractor ACCESS under UoL): In his opinion, Russian fishing vessels preferred to bunker fuel in Norway since Norwegian regulations towards fishing vessels represented a heavy subsidization of fuels. Hence Russian fuel taxes were considerably higher than Norwegian ones. A representative (pers.

[24] http://www.nho.no/naeringslivets-nox-fond/uendrede-satser-for-innbetaling-article25153-457.html
[25] http://www.lovdata.no/for/sf/sv/td-20121127-1217-019.html
[26] See Act on Environment and Resource tax (Lög um umhverfis- og auðlindaskatta) from 23. Dec. 2009, no. 129: http://www.althingi.is/lagas/141a/2009129.html.

comm. Jo Jørstad) for a Norwegian bunker firm in Kirkenes (a natural harbor for Russian fishing vessels) claimed that much of the reason that Russians fuelled vessel in Norway was that they avoided home ports since corruption and various kinds of "stamp fees" was still a natural part of business across the border. Another motive, he claims, is the fact that the structuration of the North-West Russian trawl fleet – from about 250 to 70-80 active vessels – has led to a greater element of former Western trawlers (from Norway and Iceland), for which it is easier to find spare parts and functional shipyards in Norway – in addition easier to perform a shift of crew (due to communication/transport infrastructure). An inquiry to the "Northern Fishing Industry Union", by the help of forwarding and translation from the Norwegian Fisherman Association, the leader of the fleet director – Nikolai Demianenko – asserts that the fishing fleet pays, similar to the suppliers of agricultural products, a somewhat lower fuel price than others (like transporters and merchant vessels) due to governmental decrees/statutory instruments. The size of the "rebate" ha cannot give, since fuel suppliers are not willing to reveal detailed information regarding the fuel price. However, the price of fuel is the same irrespective of whether vessels operate in the Russian EEZ or elsewhere. Martini (2012) denotes that Russian fuel tax concessions were RUB 18.46 per litre in 2008 (equals NOK 4.16 per litre). Moreover, he refers to a rough situation in the Russian fishing fleet in 2008, where high and increased fuel costs was overwhelmed domestic consumers, leading to budgetary payments to individuals and fisheries organizations (p. 38). Hence, information regarding Russian fuel tax concessions seems inappropriate to conclude. However, for 2008 they seem substantially larger than the other nations, without certainty regarding the duration time of these concessions.

In Waldo *et al.* (2014: 27) the level of fuel taxes in the different Nordic nations in 2010 are stated in the following for the here defined Arctic fishing nations (as EUR per liter marine gas oil/diesel). The second column gives the carbon prices for national citizens when fuelling – the second is what is levied the fishing fleet (added personally):

- Iceland: EUR 0.362 EUR 0.0355
- Norway: EUR 0.311 EUR 0
- Greenland: EUR 0.013 EUR 0.013

According to Stern (2006) the optimal CO2 quota price for the year 2100 should be EUR 0.159 per litre[27]. As seen, fuel taxes for domestic use by consumers in Norway and Iceland

[27] See Stern (2006: 322) where "…*the model […] point to a number around \$85/tCO_2 (year 2000 prices) for the central 'business-as-usual' case".* €159 per m^3 is referred to in Waldo *et al.* (2014: 27),

are already more than the double of this level. As can be seen, all nations noted above levy only minor taxes on the fuel consumption by the fishing fleet. After 2013, a minor share of the CO2 tax has not been reimbursed for Norwegian vessels operating in Norwegian waters (NOK 0.26 in 2014, approximately EUR 0.03), while vessels operating outside 250 nm from the baseline are levied no taxes on fuel. Hence all Arctic nations have the potential to tax the combustion of fossil fuel in the fishing fleet if their goal is to reduce national GHG-emissions.

Having established that fuel consumption is one of the obvious fishing vessel cost components that could be subject to authorities taxation policies in their pursuit of reaching the goal of reduced GHG-emissions, one question remain however: How would increased taxation of fuels used by fishing vessels alter the behaviour of the fishing fleet? That is the quest to answer in the next sub-chapter.

3.4. If fishing vessels in the Arctic were to meet more heavily taxed fuel

As shown above, the main fishing fleets in the Northeast Arctic are only to a modest degree levied environmental taxes on their fuel consumption. In most cases the fishing fleets emissions of CO2 are taxed below the levels met by consumers in the respective countries. Hence, by lower tax rates or tax concession schemes, the fishing fleet can be said to be taking advantages of a subsidy scheme that other industries and individuals are detached from. According to the principle of "polluters pay" there are obvious potentials for increased taxation on this product. Moreover, when analysing how the fleet would react to such a change in the taxation policy, the analytics are symmetric to one where a price increase occur.

However, the argument above, that different vessels – of different size, using different kind of gears, and with different radiuses of action – are sensitive to fuel price increases at a different range, makes a comparison between national fleets too shallow. For two reasons, we will in the following pursue differences between Norwegian vessel groups when fuel price increases are under scrutiny. First, since the Norwegian profitability survey is more fine-grained when it comes to different vessel sizes and gear use. Second, since other national vessel groups can be compared with counterparts in Norway. For instance in the Northwest Russian fishing fleet the larger trawlers can be compared with Norwegian pelagic or demersal trawlers (as a conservative proxy) – which is also the case for Icelandic vessels of this type. For Greenlandic shrimp trawlers we have no direct comparison object any longer in

by utilising conventional currency rates ($/€) and a assuming 2.6 tonnes CO2 per m3 combustion of diesel. Nordhaus (2007) strongly opposes this level cost for the optimal carbon price - taking social costs into account.

the Norwegian survey sample, since the reduction in the Norwegian shrimp trawler fleet was so big that this group of vessels was omitted from the 2007-survey and onwards, and the remainders were put into the cod trawler group – since they often have a licence for, and use shrimp trawl to some degree.

Having established that increased taxation (or annulment of tax concessions) is synonymous with increased prices and that the Norwegian vessel groups can to some degree represent vessels in other nation, a sensitivity test can be conducted on how a fuel prices increase will affect profitability in the Norwegian fishing fleet. The basis of this was the profitability survey's cost and earnings data (Fiskeridirektoratet, 2012; and former years), and the aim was to calculate the percentage change in fuel costs (adjusting the labour cost accordingly[28]) to generate a "break even" result (EBIT = 0), assuming that there are no effects on harvest and stock dependent costs from operational and capital adjustments.

One indicator of the fuel dependency of vessels is the percentage fuel cost increase that renders the average vessel break even (EBIT = 0). This is shown in Figure 8 for twelve vessel groups, using averages for the four years 2008–2011 to smooth out annual shocks.

[28] Labour costs in the Norwegian fisheries are normally calculated as a share of revenues minus some vessel costs. In the coastal fleet (vessel permissions less than 28 meters) crew shares are calculated from revenues *minus* fuel costs, as opposed to the larger offshore vessels where owners carry all fuel costs. Coastal vessel owners can therefore "shift" some of the fuel cost increase over to the crew. Hence, the effect of fuel price increases on profitability is smaller in the coastal fleet than in the offshore fleet.

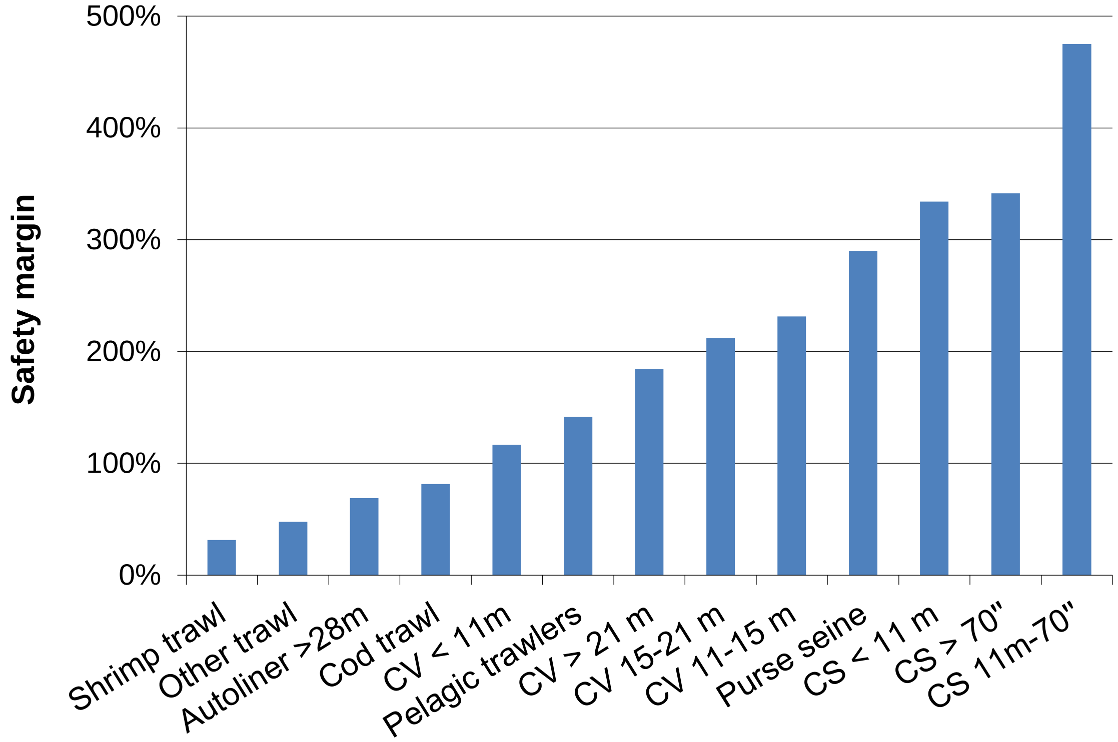

Figure 8 Fuel price increase "safety margin" for vessel groups with respect to fuel price (the increase allowed for a "break-even" result); mean for 2008–2011. Abbreviations: CS = coastal seiners, CV = coastal vessels (using hand line, long line, gill nets or Danish seine)

There is a huge variation in the results. As can be seen from Figure 8, shrimp trawlers can endure a 30 % fuel price increase before net results become red, while seiners can endure a four times as high fuel price or more before deficits will show. Trawlers, in general, are most sensitive to fuel cost increases, whereas coastal vessels and purse seiners could endure a doubling or even tripling of the fuel price. Note that these are vessel group means and that each individual vessel's performance can deviate substantially from the mean values. One should also bear in mind that the fuel prices born by different vessel groups of different lengths (or rather total fuel consumption) are facing very different prices for fuel in the basis). Hence a 300 percent fuel price increase for a coastal vessel below 11 meters has quite a different nominal value in the end than the same increase for a purse seiner. The actual price paid for fuel differs considerably with the size of the vessels, and rather large rebates are conceded to larger vessels and higher consumption. According to the 2011 figures, larger vessels (> 28 m) on average paid an oil price that was 18 per cent lower than the smallest vessels (< 8 m). On the other hand, most of the reimbursed mineral oil tax goes to the largest vessels, as demonstrated in Figure 9, for some vessel length groups. In 2011, the average fuel price (excl. taxes) paid by vessels less than 21 metres was 16 per cent higher than the price paid by vessels above 21 metres (NOK 5.33 vs. NOK 4.60 per liter). In fact, if the Norwegian fishing vessels were denied their fuel tax concession in 2011, prices would increase by NOK 1.573, which is analoguous with a price increase in the range of 27–34 %, just rendering the shrimp trawlers in the analysis above to a "break-even" result.

The reimbursements in Figure 9 cover the bunkering of the fleet operating within the limit of 250 nautical miles from the Norwegian baseline (225 mill litres). In addition the Norwegian fleet consumes fuel when operating outside this limit, for which no good data exist, but estimations add them to about half of the total reimbursed volume (Isaksen & Hermansen, 2009).

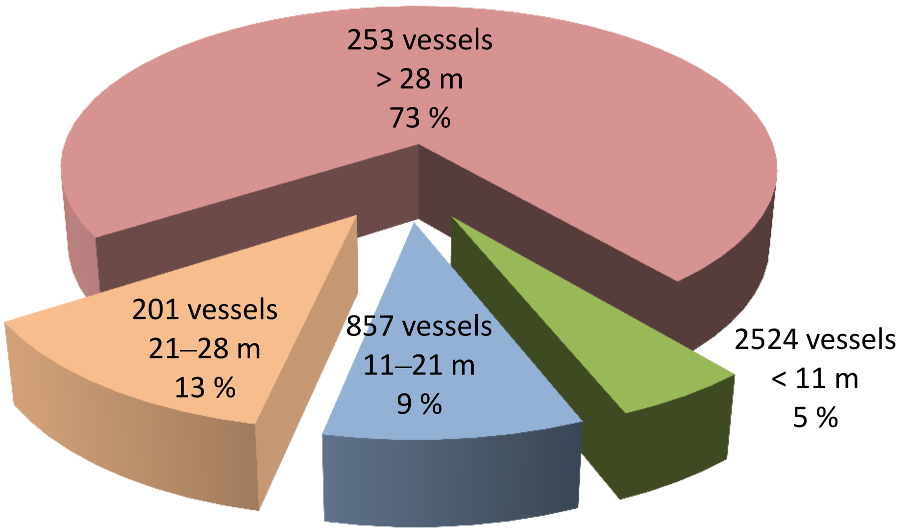

Figure 9 Distribution of Norwegian fuel tax reimbursements in 2011, on vessel groups (lengthwise). In total the reimbursement added up to NOK 354 mill. Source: Guarantee Fund for Fishermen

Thus, this is a short run economic analysis, for which the following discrepancies should be mentioned. Being a static, short run analysis, it has been implicitly assumed that the vessel groups will, on average, generate the same revenues and costs in the same manner under a fuel price increase as was the case for the 2008–2011 average. This is a relatively strong assumption since vessel owners, under the influence or even expectation of fuel price increases, will act to mitigate such cost increases. In short term, the adaptations to a higher fuel price is limited by the technology at hand, the fixed assets and current regulations. On a longer term, often discussed in climate change models, all input factors are variable which give a further enlarged frame of adaptations. In the long term, more fuel effective vessels, gears, engines, propellers etc. can be developed and adopted in the wake of higher fuel prices. Also, a shift in the fishery, where more profitable species are targeted (or with less cost under harvesting) or exploitation of spare capacity can increase the profitability if fuel prices increase.

3.5. Concluding remarks – fuel taxation

From the above we have seen that the Norwegian fishing fleet, and the Northeast Atlantic if the assumed similarity is valid, could and should be taxed for their consumption of fossil fuel for combustion. “Should”, since polluters should pay for their emissions, and “could”, since profitability in this industry is sufficient to bear the effects of a price increase in the range of an optimal carbon tax (Stern, 2006). That a fishery produces a profit is no surprising finding, since a properly managed fishery often produces a resource rent, where the landing value of fish exceeds the costs of fishing (evaluated at their alternative cost). As seen, the Northeast Atlantic fishery is one of the most productive on a global scale and management of fish stocks between nations seems fairly good compared to other areas of the world, where overfishing and IUUU-fishing is much more pronounced.

However, implementing carbon pricing for fuel consumption is not as straightforward and unproblematic as it seems. Nordic countries have long been first movers when it comes to environmental taxes on fuel. For instance in Norway, the first petrol tax was implemented in 1931 (though more for fiscal than environmental reasons), and in 1971 the first SO2-tax came into effect. The reason for the reluctance to introduce full carbon pricing is at least twofold. An obvious one is that industry actors will oppose to additional costs of operation, using the channels available. In Norway[29], as an almost parliament-wide compromise measure to promote more climate-friendly conduct, it was agreed to consider phasing out the fishing industry’s fuel tax exemptions in 2007. As a result the arrangement was evaluated in Isaksen and Hermansen (2009), but with the coinciding oil-price rice from 2008 and financial crisis hitting the seafood industry hard, the recommended actions were not easy politically. This was therefore first implemented for 2013 when the coastal fishing vessels paid the reduced rate of NOK 0.130 per litre (about one fifth of the full CO_2 rate), whereas distant water fishing is still fully exempted from the CO_2 tax.

As second reason is that the national fishing industries do not operate in an isolated sea. Even if nations do not compete directly for fish (since there are rules how to distribute quotas

[29] In the EU quota market for CO_2 emissions, the price per ton varied between NOK 124 and 235 (EUR 13.55–29.40) in 2008 [20] and was down to EUR 6.62 per ton in 2012 at a UK auction [23]. The taxes in Norway in 2008 (NOK 1.395 per litre of oil) and 2012 (NOK 1.599 per litre of oil) correspond to a rate of NOK 528 and 605 per ton of CO_2 emissions, respectively. These tax rates were approximately two to four times higher than the 2008 EU quota market price for CO_2, and in 2012 they were about twelve times as high. Thus, the CO_2 taxes in Norway are much higher than the EU Emissions Trading Scheme (EU ETS) prices. (Isaksen *et al.*, 2015).

per nation) all fishing nations compete in the same markets for seafood products. And since they produce from shared fish stocks they compete to a large degree with substitutes in the end markets, struggling for the consumers' preferences. In that respect, nations imposing unilaterally carbon pricing on their fishing fleet's fuel consumption will levy a competitive disadvantage on domestic vessels, if competing nations do not impose the same taxes. That is feasible to some degree, since – at least in some countries – fleet segments are less mobile and conduct their fishing operations merely in domestic, coastal areas. But for the larger fleet, operating in high seas, a bunkering leakage to foreign countries or in open sea will be probable – and with that also the risk for fish to accrue to foreign ports – if tax-free fuelling can be made abroad. The Northwest Russian experience, where hardly any landings from the modernized cod trawler fleet accrued to the Murmansk region as foreign fleet investments would be heavily taxed if vessels visited Russian ports, can stand as an example. Schütt *et al.* (2014: 132) describe this situation for Greenland in the following manner:

> *"Outside a three nautical mile line, fuel is supplied from international companies. The vessels bunker at sea, beyond the regulation of the Government of Greenland. This implies that fuel used for these vessels cannot be taxed efficiently. In 2011 the Government of Greenland introduced a minor environmental taxation on fuel, of 13.4 euro pr. m3 fuel (1,000 litre). In the comments to the legislation, it is noted that offshore trawlers use bunkering at sea, and that the Greenlandic Company is in competition with other international companies supplying these vessels. An environment tax, if hypothetically introduced for vessels above 200 GRT, would have to develop a method to enforce and control beyond the three nautical miles and in harbours in foreign countries."*

As Stern (2006) denotes, fishing is one of the most carbon intensive industries in UK, and at a carbon price of £19 per tonne CO_2, fossil fuel costs would increase so much in fisheries that product prices would have to increase by 5 % for profits in the industry to remain unchanged. Moreover, it is likely that a cost increase in the fishing industry could be transferred downstream the value chain and, at the final destination, end up as a price increase for the consumers. That depends on the market conditions in the (intermediate) markets and the power constellations between buyer and sellers (or merely the price elasticities of the products) and to some degree the price transmission signals (Bendiksen, 2008; Vavra & Goodwin, 2005).

The input markets for the fishing industry have been scrutinised here with respect to how climate change, and governmental abatement of such, can spur behavioural alterations in the fishing fleet. Not surprisingly, if the objection function of the society was to foster a more climate friendly fishery, then the most promising point of departure would be to tax the fuel consumption in order for the fishing fleet to take fully into account the societal cost of emitting harmful gases to the atmosphere. Even if not easily or effectively implemented on a pan-Arctic basis, such regulatory steps would have the potential to alter the fleets' catch composition, operational behaviour, gear use and mobility decision. Moreover, its effect on profitability in this business sector would isolated be negative, but only incrementally so. These effects would be visible in short to medium term, since on longer term, all inputs are variable, and actors could adapt to more fuel efficient hulls, engines and gear through technological development. However, since fuel taxation for the fishing fleet is facing the same challenges as international aviation and shipping, unilateral introductions of taxation schemes will be "crowded out" for the benefit of bunkering in open sea (beyond national jurisdiction) or “tax-free” fuelling abroad – with the threat of also reducing the level of domestic landings. Taxing the fuel consumption in the primary production could also lead to shifts in fish prices for consumers.

In the next chapter, the product markets or Arctic seafood would be scrutinised with respect to how climate change might alter consumers’ preferences.

4. Seafood product markets

Economics is about how scarce resources are allocated between individuals, households and firms in a society. A main assumption is that – in the absence of market imperfections – prices in the market will reflect the scarcity of the product. However, in addressing climate change two imperfections occur: Man created climate change is a 'negative externality', while the climate is a 'public good'. An externality is a cost (gain) from consumption or production that is not given a market value (credited or charged) through a market. When taking a car ride we don't pay for the climate change resulting from the accumulation of gases in the atmosphere. A public good is a good in for which no-one can be effectively excluded from using, and that the use by one person of that good does not reduce its availability to others. Fresh air is the best example of a pure public good. Hence, the markets fail to reveal the 'true' costs of production to the consumers, inasmuch as the price of a good does not reflect how the production contribute to unforeseeable effects on climate change. Moreover, the public good nature of harmful emissions to the atmosphere in the generation of consumer products calls for authorities' interventions to avoid or reduce what Hardin (1968) denoted as the "Tragedy of the commons".

If climate change and its consequences was better penetrated throughout the population, and humans were rational in the sense that they in their everyday choices took into consideration all the consequences their actions today had for an unforeseeable future, it might alter the preferences of consumers in a more environmental friendly or conscious way. In that respect, in the choice between different products, consumers would prefer products with less impact on climate change (i.e. products in which the producing process have had a less emissions of gases to the atmosphere than others) as long as the cost of buying it does not outweigh the monetary gains adhered to the future reduced climate change effects. Hence, in an isolated analysis, a product from sustainable fishing with low carbon footprints should receive a market benefit, by the way of achieving a price premium over less environmental friendly food products in end markets. If markets for seafood prices function correctly, giving economic actors the right incentives, this should contribute to making Arctic fishers more environmental friendly in their behaviour at sea. However, as we know from inter-temporal economic analysis, a person's valuation of a future outcome, anticipated to occur with an uncertain probability, is often outweighed by the lesser expected value of a certain outcome today, even if the expected utility of the former is greater than the last.

In the preceding chapter it was shown that Arctic fisheries only to a limited degree were charged for their emission of waste gases to the atmosphere from their combustion of fossil fuels. Moreover, when looking at industry profits, carbon pricing on fuel will only to a limited degree dampen industry profits. The main obstacle for implementing carbon pricing is the effect it can have on competitiveness of different nations' fleets. A regional/global agreement would therefore be the most suitable solution.

In this chapter, seafood end markets, or rather, consumers' attitudes and preferences towards environmental friendly captured seafood are under scrutiny. The object is to examine how Arctic fisheries and fishers' behaviour can be affected by consumer trends and preferences in the wake of climate change or climate change perception and consciousness. First, a brief outlook for global seafood markets and seafood trends are rendered. Then consumer's attitudes towards seafood are reviewed, together with some developments regarding seafood certifications and standards. Some preliminary findings regarding consumers' attitudes and preferences regarding seafood and purchasing situations are also presented, before some conclusions are made regarding the impact of climate change on consumers' behaviour and how this can effect fishing behaviour and industry development in the Arctic.

4.1. Global seafood markets and GHG-emissions

Fish have become an ever more important ingredient in the diet of an expanding global population and seafood production growth has outpaced that of the global population. Moreover, fish is among the most traded food commodities worldwide (FAO, 2014), and – a fact often overlooked – the value of fish and shellfish export from developing countries exceeds that of coffee, rubber, cocoa, tobacco, tea, meat and rice combined (Smith *et al.*, 2010). A main reason is that aquaculture production now accounts for 50% of total fish consumption by humans. In terms of average protein intake of people around the world, fish accounted for 6.5% in 2010. With production outpacing population growth, increased trade and urbanisation, fish have potential to become an even more important protein food component for the global population. Foreseeable demographic changes, together with consumer trends, might spur and increase this effect. A global population – increasing from 7.3 billion today (2015), to 8.1 billion in 2025 and 9.6 billion in 2050 – populating urban and coastal areas will increase the demand for seafood products, and – most probable – the prices achieved in the market place. However, the largest increase will take place in developing regions. Fisheries and aquaculture can play a prominent role in world food security, making a valuable nutritious contribution to diversified and healthy diets (FAO, 2014).

The globalisation of the seafood trade has also lead to a remarkable effect on the distribution channels, or value chains. It is no longer unusual to see fish caught by one nation's vessels, processed in another nation, and consumed by yet another nation's consumers. An ever increasing degree of Arctic catches are undergoing such changes, especially for Norway, where the seafood trade is taking advantages of decreased transportations costs, processing outsourcing to low-wage countries (with comparative advantages in labour- and production costs in highly labour intensive production technologies) and liberalisation of trade policies. Between 2007 and 2013, the share of the Norwegian cod catch that was exported unprocessed – either chilled or frozen round cod (headed and gutted) – increased from 22 % to 42 %, at the same time as total cod catches increased with 115 % – from 220 000 tonnes to 470 000 tonnes (Isaksen, 2014).

In 2012 the global sum of imports and exports of seafood added up to a total of nearly US$ 130 bill, 120 % above the level a decade ago (FAO 2014). The 10 largest exporting and importing countries are responsible for 53 % and 60 % of total exports/imports respectively, and some nations figure among the top 10 on both lists, i.e. China, USA and Spain. While China figure alone on the top exporter list (exporting for US$ 18 bill.), Japan and USA are the biggest importing countries (both importing seafood for more than US$ 17 bill) in front of China. Among the top exporters we also find Norway, Thailand, Chile and Viet Nam – countries with long coasts, not a too big population and pioneers within aquaculture. The largest single market for seafood is the EU, from which we find five of the top 10 seafood importers (Spain, France, Italy, Germany and UK) and imports in total constituted 36 % of world imports in 2012. For both Iceland and Norway, the share of export accruing to the EU is 62 % (for 2013 and 2014, respectively).

Despite the liberalisation and globalisation in seafood trade over recent decades, there are anecdotal evidence pointing to geopolitical disturbances or shocking incidents in trade affairs that can be of shorter or longer durability. From the view of Norway, the world's second biggest seafood exporter, Russia was our single largest export market in 2012 and 2013 with almost 11 % of the total export value the latter year. As of August 7th 2014, Russia introduced an import ban for seafood from Norway (as a consequence of the Norwegian follow up of EU sanctions in connection with the Ukraine-conflict), and Norwegian exports to Russia therefore was reduced with 48 % from 2013 to 2014. However, it seems that Norwegian seafood finds its way to Russian consumers by way of direct import to other Eastern European countries and re-exports into Russia. Other EU nation's food industries were of course also hit by the Russian import ban. There are also other examples of such incidents. One is the Chinese “cold shoulder” in the wake of the Nobel Peace Prize award to a Chinese dissident in 2010. Despite a small growth in salmon export to China from 2010 to 2013, the Norwegian market share fell from 91% to 31% – market shares that was taken over by the Faroese and Scottish salmon producers. Also, the anti-dumping cases from US (1991) for fresh whole salmon, and from EU, where a minimum price for salmon was introduced in 2006, only to be set aside in 2008, can serve as such examples.

Another form of demand shocks for food products are the ones which can be exemplified with the BSE food scandal in 1996 or the more recent horse-meat scandal, which makes consumers avoid some types of food items. For seafood, no such scandals have reached levels of public attention as the ones mentioned, but the Science article (Hites *et al.*, 2004) and the effects of it can serve as one example. Again an example from aquaculture and with effects for Norwegian seafood export. In short, Hites *et al.* (2004) claimed that farmed salmon contained higher levels of PCBs than wild salmon and that an intake of more than can 200 grams per month of farmed salmon could be dangerous to the health (cancer risk). Moreover, northern European salmon had according to the study more contamination (stemming from the fish feed) than its South American counterpart. The study was highly controversial and challenged by food scientists as well as the medical community, maintaining that the benefits of eating fish rich in fatty acids are better proven than the potential cancer risk of PCB exposure. The study was published in January and the Norwegian Council of Seafood had days of “firefighting” to refute the arguments. Knapp *et al.* (2007: 143f) show convincingly that US import of farmed salmon in January–March after the publication fell with 15–30 % in relation to the year before, but that the effect thereafter is without a clear pattern. This, they conclude, indicates that the negative effect from the Science-study on fresh farmed salmon demand in the US, if any, was short-lived. A Norwegian study on the same relationship (Wiesener, 2006) concluded that the negative health information spread by the Science article, had no effect on the demand for Norwegian farmed salmon to the EU, on neither volume nor price (value). Hence it seems as if consumers are aware of the attributes of seafood items that deal with health aspects, which can imply detrimental shocks in the demand for seafood items whose reputation is on trial. However, the effect seems to pass over during short time – if not too severe. But even though there are few examples of seafood scandals with high degree of seriousness, there are many examples of fraud within the seafood trade. Buck (2010) indicate that between 25% and 37% of all seafood products are mislabelled, which makes it the most mislabelled foodstuff of any food sector. In some cases where substantial profits are involved, seafood misdescription has been shown to be as high as 60-80% (Jaquet & Pauly, 2008).

Fraud and seafood scandals can – in the end – represent a big problem for seafood items that in general are esteemed by the public as healthy and nutritious. With an increase in global population the demand for animal proteins, and fish, will also increase. Capture fisheries today appear as exploited to such a degree that further supply of mentionable quantities seems not probable to contribute significantly to the increased demand seafood at affordable prices. A notable exception would be if large quantities of smaller pelagic species, today entering fish oil and meal production for feed, were to be used for human consumption. However, with aquaculture being the most prominent candidate in helping provide nutritious and healthy food to an increasing world population, the competition for these feed resources will be great, even though technological advances have made aquaculture species less and less dependent on fish based feed ingredients in the latter decade (FAO, 2014).

Not only is seafood a healthy and nutritious protein rich input in the diet of human being, it is normally also an animal protein which to a limited degree seize great resources in its production and therefor contribute relatively modest to emissions of green-house-gases to the atmosphere. This is of course a truth with varying validity since some fisheries are more carbon intensive than others (large hulls and engines for fishing vessels and great distances covered between landing ports and fishing grounds) but undoubtfully small scale artisanal fisheries and aquaculture ponds are avaricious in their use of inputs. Moreover, the full carbon footprint, from the making of the steel for the vessels to the seafood's mileage on its way to consumer, should be incorporated when comparing the environmental strain from different food products.

The environmental impact from any product production is often measured by use of life cycle analysis (LCA), where all the resources used over the entire lifecycle and assigning related emissions and impacts to the appropriate environmental impact categories of a product ends up with a measure comparable between products. A specific EU-project "Whitefish[30]" is concerned with the use of LCA methodology to determine the environmental impact of the cod and haddock fisheries of the Northeast Atlantic (de Boen *et al.*, 2012), where the goal of a so-called Batch Based Calculation of Sustainability Impact (BCSI) is also to measure the impact on social and economic sustainability, not merely the environmental impact.

[30] See http://www.whitefishproject.org/

One thorough analysis of carbon footprint comparisons among seafood products is Winther *et al.* (2009) who attach GHG-emissions (kg CO2-equivalents) per kilogram edible fish products at the wholesaler link for 22 different seafood products from Norwegian fisheries and aquaculture to different markets. Their findings show that for capture fishery products the most emissions stem from the use of mineral oil combustion and cooling agents on board the vessels. The exception is the use of purse seine in pelagic fisheries (herring and mackerel) who catch large volumes with limited use of fuel. These products omit less than 2 kg CO2-equivalents per kilogram, even when exported to Tokyo or Moscow. For whitefish species like saithe, haddock and cod the amount is in the range of 2–4 kg CO2 per kg product, where the higher values are attributed to fresh products to remote markets (Paris or London, long distance trucking) or if frozen, processed in China and re-transported to Europe. For aquaculture, most products – with one exception – have emissions in the level of 2.5 – 4 kg CO2 per kilogram, with most of the emissions stemming from the feed production. The exception case is when fresh fish is freighted air borne to Tokyo. Then the scale is blown (14 kg CO2 per kg). A recent Icelandic study on the carbon footprints from fresh cod loins to different markets are in the range of the Norwegian results (1-4 kg CO2-equivalents per kg) even when transported by air (Smárason *et al.*, 2014), while others again reach slightly different – and slightly higher – results when seafood products' GHG-emissions are under scrutiny (Buchspies *et al.*, 2011). Hence, there seem to be a discrepancy when reporting the carbon footprint levels from seafood products, dependent on the source. This can of course depend on different timing (stock size, abundance, etc.) and geographical variances in the samples, but there seem to be unanimously consensus on the fact that seafood products have emissions well below what we find for agricultural products like veal, beef and lamb (22, 16 and 12 kg CO2-equivalents per kg, respectively, all responsible for methane gas emissions), but not far from what is found for pork and poultry (4-5 kg CO2 equivalents per kilogram).

When turning to advices in order to reduce carbon footprints Winther *et al.* (2009) draw the attention to replacing refrigerants that are not climate and ozone neutral and to improve energy efficiency further in capture fisheries. For salmon, feed optimisation – including the replacement of animalistic to vegetal inputs in feed (Buchspies *et al.*, 2011) – is the most obvious in addition to reducing the feed conversion rate (the amount of feed needed for 1 kg farmed fish). Processing is only responsible for minor contributions to environment, mostly stemming from the production of packaging materials (Smárason *et al.*, 2014) but reductions can be made if processing is done ahead of exports so that smaller quantities are transported. Fresh products, demanding and unbroken cooling supply chain, are more energy intensive in transport than frozen goods.

Above some characteristics of the global seafood market have been accounted for, chosen due to its potential implication for the development of Arctic fisheries under the danger of potential climate change effect. To cover all relevant aspects of the international seafood markets is beyond the scope of this report. Arctic fisheries are diverse in many dimensions but in some respect similarities can be found. On a global level, fleets are high-tech and make use of the best available gear and technological equipment for catch, search and monitoring. Moreover, main markets are found in western developed societies, or aimed at middle and higher classes in developing countries. Hence, the majority of seafood offered is aimed at customers with high payment capability – not as cheap protein to consumers in poorer countries. In that respect an important issue brought forward by Smith *et al.* (2010) is that in the globalised seafood trade, developing countries depending on common property resource management may experience failing institutions during rapid change if they are not shielded from external forces represented by export oriented seafood production. Certification and eco-labelling of might relieve such a development if enabling a potential to differentiate between seafood suppliers. However, the success of such initiatives requires that consumers award a price premium to sustainable sourced seafood products (op. cit., p. 786) ensuring environmental, economic as well as societal sustainability.

In the next section a short selected dive into consumer science is undertaken, mustering issues enabling the visibility of a link between human perception of, and attitudes towards, seafood products on one hand, and its potential influence it can have on fishermen's day to day behaviour at sea.

4.2. Consumer attitudes towards seafood

According to standard economic analysis and welfare theory consumers are sovereign in a market economy, and the main reason for production being undertaken is the demand created as the sum of consumers' preferences toward some good. In a free competitive market in which individuals act self interestingly and market failures are absent, the price system will allocate resources efficiently between producers, consumers, employees and investors, in a way where consumers preferences (demand) are decisive for the supply of goods and services – not the other way around (namely Say's Law: "Supply creates demand").

As noted above, under the assumption that humans activities lead to climate change we have a situation where the free market solution is ineffective, since prices do not reflect the real scarcity of resources, due to the presence of both externalities and public goods (differences between social and private assessments of marginal costs and marginal benefits). Hence, the distortion created by this artefact implies that consumer sovereignty, from a pure economic standpoint is at odds, and that some kind of government market intervention is called for (usually by use of taxes) to balance the social and private assessment of marginal costs and benefits.

Still, in their transformation of inputs into final goods (and services), producers seek to satisfy consumer demands with their input-throughput-output paradigm. This can be done in various ways, innovations in efficiency, differentiation or organisation being the main pathways, under the objective to create the greatest possible surplus in production. While innovations in organisation – either horizontally or vertically – and/or efficiency seeks to create the most effective and lowest cost possible in transforming raw material to end products, differentiation innovations are adaptations where the profit maximising firm seeks to offer products with attributes that meet the consumers' preferences better than his competitors, for which the consumer is willing to pay for, either through a higher price or product loyalty (re-purchase). Hence consumers, in their self-interest seeking to maximise their utility, choose to buy the products that best meet their satisfaction of needs and the price is below or equal to their willingness to pay (within a given budget restriction).

The free market assumption is one seldom found in real world. Not only does it presuppose the absence of externalities and public goods, it also assume that actors are atomistic (neither buyers nor sellers are big enough to influence the market prices); all actors have full information (no information asymmetry); competition progresses over homogeneous goods and services (no product differentiation); free entry and exit of firms (no start-up or sunk costs) and perfectly divisible and mobile resources; no transaction costs (Gould and Ferguson, 1980). In real world commerce we know that these assumptions are not fulfilled. The supposition that differentiation does not occur can be rejected by a trip to the supermarket to buy, say, mineral water: Loads of alternatives exist for the consumer to choose between. For seafood a look into the refrigerator department would probably tell the same story.

When doing our day-to-day shopping round for groceries we stand above numerous choices. For a start, at least in the urbanised western world, we need to decide which location we should shop at. And if seafood is on the list: Should we go to the local (or central) dedicated fish monger, or can we find what we want at the local store or the nearby supermarket? And that is only the start of the process.

Under some purchasing situations one can assume that the buyers have full information or at least the ability obtain the information needed to cover all aspects of his or her purchase – or not to purchase – decision. Today's technological infrastructure enables individuals to monitor products' and services' attributes to a much greater detail than one or two decades ago. But rather than taking advantage of all the information available on packages or on internet, most of us – at least when groceries and not household capital items are under evaluation – lean on taking only a few attributes into consideration, not the total overall depiction of the item at hand. A typical purchasing process hanging over the shop refrigerator or fresh fish counter, when the upcoming next or second next seafood dinner meal is evaluated, we might ask ourselves the following questions: What species will go well to that or that recipe (or what fish was designated for that special recipe in mind)? Does the packaging, the look of the fish or my experience with this particular vendor/brand satisfy my fish quality expectations? And – perhaps finally – is the price right, according to my budget or expectations? Additional question could be: Is it fresh? Is it captured wild or farmed? Where/which ocean/country does it origin from? Could or should I buy fresh or frozen seafood (or do I even have an option)? Based on these typical questions[31] – and or others – on different seafood product attributes the consumer makes his choice between different seafood products (if alternatives are available or even under consideration) or even between seafood and another source of proteins.

Even if there's a jungle of information about seafood products that could be gathered to make an informed choice of seafood products, consumers typically only utilizes a few or some. In some cases, like in EU, there are regulations stating the minimum of information which consumers should have access to (on a label) when buying fish. That is, labels should specify the commercial name of the fish, the catch or farming area (of FAO catch statistic detail level), how it was obtained (captured or farmed) and type of processing/presentation (gutted, filleted, with/without head/skin/bones, thawed, breaded, etc.), and – of course – price. In addition, the producer is free to add the information on packaging that they sees fit,

[31] Claret *et al.* (2012: 260) lists up the following attributes influencing the households seafood purchases (while crediting a long list of scholars): "*…the sea fish attributes that may influence the households fish and seafood purchase are sensory properties, nutritional value, health related aspects, price/value for money, convenience, availability and seasonability, country of origin, obtaining method (wild or farmed) and product forms (fresh, frozen and others). They also pointed out the importance of other factors such as gender, age, ethnicity, education level, occupation, family size, presence of children in the household, previous experience with fish, and total income in fish selection and consumption.*"

and fish mongers can add advice on how to store or prepare the fish. In that respect, consumers can make their choices over a whole list of variables, which they in turn do or do not: Some consumers merely emphasise the price and assumed quality ("value for money") while others again make more thought-through choices and can put weight on the capturing method (gear) which the assume stresses the fish less under capture, or how it is processed. Even if at odds with the "economic man" in economics, assuming that humans appear rationally and enabled to choose between a long range of attributes with different weight in each' individual utility function, the typical consumer are unable – or at least unwilling – to gather all information and process it before making his or her choice.

Probably every individual facing a seafood purchasing situation have to narrow his or hers approach to the valuation problem to a limited number of factors, since decision makers in their meeting with numerous attributes have cognitive limits (March & Simon, 1958) and will concentrate on – and substantiate their choices from – the factors that most directly address their decision. As pointed out by Garicano (2000: 874): "*…each individual is able to acquire knowledge about a narrow range of problems*", and have limited ability to process information (Jones & Hill, 1988). Hence, the consumer is intendedly rational, but only limited so (Simon, 1978) since processing all information available would – to put it to the extreme – take the consumer to a mental hospital, rather than back home with seafood in his basket.

Having established that there is a jungle of information about seafood out in the open, free to evaluate for consumers (to a varying degree of course, depending on product, market and point of sale), there is also evidence that consumers only to a limited – but still varying – degree take advantage of such information. In Claret *et al*.'s (2012) study on Spanish seafood consumers (N=914), domestic fish was preferred for foreign fish, fresh before frozen, cheaper before expensive and wild fish before farmed – all attributes emphasised and determined in advance of the focus groups. Also, the attributes relative weight in evaluation followed that order (origin, storage, price and production). In fact those were the only attributes mentioned by the focus group participants, except for product quality and safety issues.

In general, consumers want to know that products are safe and sound, healthy and to some degree also want them to be ethically sourced. Whether we are out to buy a fish or a t-shirt, these are all attributes that we want our product to fulfil, but for food items especially the confidence we have in the goods are much obliged to our anticipation that these expectations are fulfilled *ex ante.* In developed societies the expectancy is that food is safe to eat, and constitutes no danger to our health – at least not in short term upon eating.

Moreover we want certainty for, and in some cases also take for granted, that the animals or fish offered on our plate has not been exposed suffering uncalled for (they do have to be killed, though, in an as "human" way as possible), and that workers (God forbid – no child labour) have been treated in a proper manner and get prospered payment for their input. To a large degree, producers do not put forward this kind of information on their products, even though it is a highly relevant issue for the purchasing decision (Grünert, 2005). Rather, we take it for granted that the producer has fulfilled his "obligation" on these matters, and, simultaneously, that producers have to fulfil some minor requirements set by authorities. To some degree, we put the same anticipation to the merchant from which we buy our groceries, to such a degree that shops and supermarket chains differentiate themselves from competitors to some degree by the standards they put on their sourcing efforts on products. Businesses who advertise by "locally grown" or "short mileage" food, or "not tested on animals" belong to this group. Hence, already at the time we decide on which shop we are going to do our purchases in we might already have set our standards regarding which attributes we individually weigh the heaviest, and also, to some degree what we can afford.

Sustainability and sustainable development has become a buzz-word in academics since the UN report on Environment and Development in 1987. Different academic communities put different meaning in the concept, but from its origin it should incorporate environmental, societal and economic sustainability. These three have been served as basis for sustainability standards and certification systems world-wide, especially within the food sector (Manning *et al.*, 2012). A large number of public and private standards for seafood exist, which can be further distinctly categories as codes, guidelines, labels or certification schemes (see Washington and Ababouch, 2011[32]; FAO, 2009; UNEP, 2009 for more details and typology). A few of the brands are portrayed in Figure 10, the best known in Europe being perhaps Marine Stewardship Council (MSC) and Friends of the Sea (FoS), which are both certification programs and also the two largest schemes (in coverage). Guides are typically green-, yellow- and red-listing different fish species from different fisheries, advising consumers what are safe to eat, and what are not, from an environmental perspective (Roheim, 2009).

[32] As the latest assessment of fisheries certification scheme, much on the following on certification schemes, practices and outreach is based on the work of Washington and Ababouch (2012).

Figure 10 Different eco-labels/seafood certification schemes

The purpose of eco-label certification schemes is to: "*…influence the purchasing decisions of consumers and the procurement policies of retailers and food services selling fish and seafood products, as well as to reward fisheries engaging in responsible fishing practices"* while the underlying rationale is: "*…based on provenance* (…) *to promote the quality of those products over similar products form other geographical areas*" (Washington and Ababouch, 2011: xiii, xiv). But, as illustrated in Figure 10, a vast range of schemes exist for captured seafood (approximately 400 according to FAO, 2009), each with different criteria for the fish/fishery to obtain the brand, and also with differing assessment processes and sponsors (private firms, NGOs or even governments).

MSC and FoS claims to cover 7 and 10 %, respectively, of world capture fisheries. However, only a small percentage of certified fisheries are expected to reach consumers in the form of labelled products. Moreover, the labels seem to be concentrated on species (salmon and demersal whitefish) and specific markets (Germany, Netherlands, UK and USA). While MSC seems to recognize producers using responsible fisheries, by "*…independent scientific verification of the sustainability of the stock; the ecosystem impact of the fishery; and the effective management of the fishery"*, (Washington and Ababouch, 2011: 24) while FoS' demands cover both carbon footprints and "social accountability". The latter views the sustainability of the stock, rather than fishery in the first, while fisheries affecting the seabed and generating more than 8 % bycatch will not be certified.

UNEP (2009: xvii) denotes that the MSC is certainly: *"…seen as something as the 'gold standard' of eco-labels".* However, FAO (2009: 96) ascertains: *"...it is legitimate to question whether the work of private certification bodies is complementing or adding value to the work of governments or simply adding another level of compliance cost. These costs appear to fall disproportionately on producers".* For certain, label users expect that this kind of differentiation can obtain a price premium over competing products in the marketplace. The cost and benefits from certification accrue different in the value chains. Retailers who potentially reap the benefits are also the drivers of eco-labelling taking place. Fishermen, or governments, take the actual costs of certification which depending on scheme and fishery can add up to more than US$ 250 000.

The two most utilised eco-labels above focus both on sustainable fishing, however a bit differently. But the weight in the certification process given to the environmental impact from different fisheries can at best be said only to a minor degree being taking into account – at least if carbon footprint is scrutinised as in the previous chapter. Both MSC has certified the Norwegian shrimp fishery taking place in the Barents Sea and conducted by off shore shrimp trawlers – the vessel group in Isaksen and Hermansen (2009) who had the highest fuel cost share of revenues in the period 2005–2006. Moreover in certification of the Norwegian and Russian Barents Sea cod, haddock and saithe fishery (trawlers) and Norwegian Northeast Atlantic cod, haddock and saithe fishery (trawlers and coastal vessels) MSC make no discrepancy between gear or vessel type, which can be seen from Figure 6 has quite different fuel consumption per kilogram of fish, and presumably also quite different seabed impact. Not too say that the fisheries are not sustainable. Point being that environmental impact, in this case carbon footprint, is – if not neglected, then – at least weighed easily. Icelandic fisheries are only to a minor degree certificated[33] in MSC or FoS. As can be found in Figure 10, Iceland has its own eco-label: "Iceland Responsible Fisheries" (IRF), based on the FAO Code of Conduct for responsible fisheries (see Nøstvold *et al*. (2012) for a review of – and comparison against MSC, for the IRF-label). Today Icelandic cod, haddock, saithe and golden redfish is certifies within IRF.

What seems to be the case from the literature review above is that consumers want to choose their seafood products in accordance with own preferences – in which sustainable sourcing seems far down on the list after quality, appearance, price and appearance. However, consumers in developed countries implicitly assume that food items bought in the

[33] Exception being Icelandic longline fishery for haddock and cod in Icelandic areas and the Northeast Atlantic (FoS), and Icelandic cod, haddock, saithe, golden redfish and lumpfish (the latter taken with gill nets) in the North East Atlantic (MSC).

market fulfill a minimum standard of requirements concerning food safety, sustainability and ethically correct food. From a wide range of information available when purchasing seafood, consumers choose their preferred product from only a few of them. Adding to the jungle of information, a proliferation of eco-labels – of different types and different responsible – has emerged since the late 1980's, trying to convince consumers to buy products in accordance with responsible fisheries. Most of them promote sustainable fisheries, attaching the greatest weight to fish stocks conditions. Only in modest levels do these address how fishing activity contributes to environmental stress other than its impact on fish stock conditions. Benefits from eco-labelling, and, hence, also the momentum to strive it forward, are mainly reaped by retail, who consolidates their market position, eases procurement and can harvest potential price premiums if becoming apparent.

In the next section findings from own consumer surveys in seafood markets are reported. This, however, represents only a "scratch in the surface" of the extensive literature on this field, but it expresses some important issues regarding how eco-labelling, and different other seafood product attributes, receives attention and is interpreted and understood by consumers. Finally, we highlight how and whether it contributes to obtaining a price premium in the market place, and if this "consumer training" is in accordance with the fostering of environmental friendly purchasing behavior.

4.3. Findings from consumer surveys and seafood markets

Over years Nofima – and especially the department of consumer and marketing research – has carried out research on consumer and buying behaviour, marketing strategies and sustainability and environmental labelling. Here, a bundle is presented, relevant for the question whether climate change awareness in the public can spur consumer collective purchasing power driving seafood sourcing (and especially fishing) in a way that induces and develop a more climate friendly way of production – especially less GHG emissions.

As an overarching angle of attack, a way of looking into the future has been by the way of foresight – or scenario – methodology. In three parallel projects Nofima has undertaken three different scenarios for the development of – among other things – the seafood industry in Norway: One projection of the trajectory path for the north of Norway towards 2040 (Olsen and Iversen, 2009), one for the whitefish and one for the pelagic seafood industry in Norway towards 2020 (Iversen, 2008a,b). Not only do they point to different future states (in regions or industries) but also how such a state can be obtained and the main drivers for such a development[34].

In the most detailed described scenario (Iversen, 2009) the main drivers – of relevance here – which are pointed to, are *consumer preferences*, *environmental awareness.* Within these we find the following relevant consumer preferences: organic food, ecological food, short mileage, ethical, functional food, low-fat, sustainable food, emotional consumption, convenience, food with a history, geographical origin, meal solutions, cult-items, identity building. In the category of environmental awareness, the following drivers are denoted: organic/ecological food, local food and sustainable food. These can again be categorised into four mega-trends of which one is *moral considerations*, the others being *health, convenience* and *taste.* Local food is coupled with the energy consumption aspect and carbon emission quotas, for which some trends can be reached through legislations, others by the conscious choice of consumers.

One of the pelagic scenarios is called the "green track", pointing to a nearby future (2020) for the pelagic industry described by: a) A market demanding pure and environmental friendly food. b) Consumers who are hyper sensitive regarding food safety issues. c) Effective and environmental friendly technology made pelagic fish the winner regarding CO2-emissions per meal. d) Fat fish is healthy and sound food, for which the willingness to pay is high. Among the wild-cards in this scenario is the geographical distribution of "Norwegian" pelagic species in the future, and the danger of too high concentrations of toxins in fish, or lower safety levels in the future (Iversen, 2009b).

Also the whitefish forecasting result (Iversen, 2008a) have a parallel green scenario called "Green and trendy", where consumers are oriented towards environment and sustainability, and historical, geographical and cultural food aspects. An extreme focus on energy consumption and CO2-emissions exist in 2020 (resulting in a ban on demersal trawling), seafood consumption has turned from "greybeard"-food to trendy food. To quote:

[34] From a more general point of view Arbo *et al.* (2013) in their review of scenarios for the Arctic, ascertain that fisheries is not at all well covered in the literature on Arctic scenarios – one exception being an own chapter in the Arctic Climate Impact Assessment (Vilhjálmsson and Hoel, 2005). Moreover they claim (p. 168): "*Opportunities for new fisheries are also briefly touched upon in, for instance, Emmerson (2011). There is a biological and bioeconomic literature on Arctic fisheries that we have not surveyed, which focuses on the consequences for fisheries of a warming Arctic (see, for instance, Eide 2008; Hunt and Drinkwater 2007). There is also a literature on legal and policy issues regarding the management of Arctic fisheries (cf. Jeffers 2010; Molenaar 2012; Molenaar and Corell 2009), but as far as we know, no newer or more in-depth assessments of Arctic fisheries have been undertaken after the Arctic Climate Impact Assessment."*

> *"Consumers want their consumption to a least as possible strain on the environment.(...) Consumers and environmental organisations has turned much of their attention to different environmental aspects with the catch, where gears, bycatch, high-grading and overfishing is accurately surveillance during catch operations. Better certification schemes made it realistic to demand certification of all wild stocks. Tax on emissions, in addition to bonus quota or quota deduction in relationship to energy consumption per kilogram of catch, turns the catch pattern towards more environmental friendly capturing. The use of passive gears and coastal fisheries increases."*

In the future vision covering the whole of northern Norway in 2040 (Olsen and Iversen, 2009) two scenarios are presented: The positive "Barents Blue" and negative "Blue Monday". In the first, global warming has created problems, but many fish stocks have grown, even though their distribution is more northern skewed. Fish is caught in a gentle way, often landed live and fed until quality is optimal. Some fish is even transported live to markets, and quality, sustainability and authenticity is in consumers' main focus. Fishing is connected with high profits, and the resource rent is ploughed back into the community, for research, infrastructure, environment and international co-operation. Traceability and electronic environment monitoring has brought illegal and unreported fishing to an end. Consumers can obtain product history, nutritive value and CO2-emissions from scanning the bar/QR code with their electronic device.

In utilising foresight techniques involving representatives from the industry, government, and industry organizations, the participation of stakeholders also see the potential for a climate neutral or improved society to arise, with bearings also into this sector. However, scenarios and foresighting is not the conventional apparatus when scrutinising consumer attitudes and preferences. Below, two studies looking into eco-labelling and consumer awareness is reported, before two studies addressing whether (eco-)labelling on seafood is able to obtain a price premium in the market place is presented.

The focus on sustainability in seafood marketing has since it's onset in the 1990's appeared to be a long-lived global trend, as obvious from the more than 400 labels found in today's seafood markets. However, different markets place emphasis on different types of sustainability. Honkanen (2011) and Honkanen and Nilssen (2013) refer to consumer surveys in France and UK, and interviews with supermarket purchasing agents, processors and food service representatives in Germany, UK and France, before concluding with the following: Social sustainability is an important factor for both consumers and professional purchasers in France, while in UK the emphasis is greater on environmental sustainability – as it is also among purchasers in Germany. In Germany, requirements on certification schemes appear to be put stronger emphasis on than in other markets. In focus groups, where participant are asked to give weight to buying criteria, sustainability do not come up at all, and when brought up by the moderator limited weight is given to this particular item[35]. In fact one conclusion is that consumer does not care much about sustainability in their buying process, since only 22 % of British, and 6 % of French consumers could recall to have seen a sustainability label during often or always during the ten last purchases of seafood. When confronted with the MSC-label, UK consumers recognised it and had great confidence in it, while the use of it in shops was more confined and label-loyalty was low. In France both recognition and use of the MSC-label was low.

Other findings were that in general, consumers care a great deal for the environment but this is not found in expression with their buying behaviour in relation to seafood products; the MSC-label is used consequently relatively seldom by consumers when buying seafood; French consumers are looking for quality and country of origin labels; consumers are concerned with sustainability as a general term, while becoming more uncertain when going down on product level. Moreover, the consumer trend towards sustainability is not consumer driven in France and UK, but rather by environmental organisations, retail chains and media. Hence, seafood producers and exporters must be ready to an increasing degree of meeting demands on sustainability documentation for their products – and in some cases it is a prerequisite in order to pass the gates of big supermarket chains. Another important finding is that sustainability labelling is not a good candidate for product differentiation; it is more a claim and a requirement to enter important markets, and as such, an unsufficient ground for a price premium.

Yet another line of research down a similar strain carried out at our institute is the comparison of sustainability labels, made by Nøstvold *et al.* (2012), holding the independent international sustainability schemes (like the MSC-alternative) up against either a) no sustainability certification scheme, or b) national initiatives (like the IRF). The main argument for national labels seems to be the coupling between Code of Conduct fisheries and the origin. Another one being national control over the label and keeping costs connected with certification down. Both advantages found with the Icelandic Responsible Fisheries label, and its Alaskan cousin. The disadvantage seems to be that the certification process takes

[35] In fact sustainability falls behind the following buying criteria (ranked order – most important first): Freshness, visual appearance, shelf life, fresh/frozen, species, variety, price, farmed/wild, country of origin, local product, responsibly sourced, convenience and package size. But just ahead of organic.

too long, and the reluctant acceptance in additional markets – dominated by MSC[36]. From a Norwegian perspective, where proponents have spoken out for following the Icelandic way or even abandon the eco-labelling all together, investigations show that it is unrealistic to expect to succeed without certification in many important markets, and that the industry must stand unified behind a Norwegian certification and labelling system, if it is to work.

Also, Nøstvold *et al.* (2013) undertook a case study in the UK, in addition to the Swedish market, by the way of in-depth interviews with supermarkets, producers, traders, hotels, restaurants and key informants in the markets. There, they conclude, that sustainability certification is today an established practices in the seafood trade and a significant factor within B2B-transactions. Certifications and consumer facing eco-labelling (MSC) is even more wide-spread and outreached in Sweden than in the UK, despite the fact that Swedish seafood actors believe it to be the other way around. In the UK, a price premium can be observed on consumer facing MSC-logoed products. Despite the widespread of sustainability logos in both counties, consumers are more often faced with labels stating that fish is "responsibly sourced". Moreover, Swedish respondents had a higher confidence in MSC than their British colleagues, but were just as confident in KRAV's (another Swedish eco-label) use of the WWF traffic lights (red, yellow and green listed seafood). Finally, they find that even though large quantities of sourced seafood is MSC-certified, when products are displayed in the seafood counter, the MSC-label seldom goes with – and the more luxurious the counter is, the less likely it is to find the label. Hence, professional purchasers are in general showing acceptance for that the consumer need not see the logo at the point of purchase, rather that the supermarket takes responsibility for the sustainability.

A last strain of research to be pursued here is one where investigations are undertaken in order to establish whether eco-labelled seafood, and utilisation of other labelling schemes, is able to obtain a price premium in important markets. As ascertained by Roheim and Sutinen (2006) the choice to enter a sustainability certification program can be based on a rationale economic supply side profitability consideration (gains outweighing costs), or a moral

[36] When differences between the two labels are highlighted, under the heading "The story of David and Goliath?", the authors reach this conclusion: "*[MSC] have support from some of the largest NGOs in the world and cooperate with large international retail chains like Carrefour. But being large is not always a benefit, and MSC are facing more criticism as they grow. In the marketplace they are considered by many as being too large and too commercial. In addition, they are increasing the price of seafood in as stressed European economic marketplace, some even claim without adding any concrete value. And even though their intentions are good, they are being criticised for being too compromising in their conditional approach to sustainability. In light of this, being small, limited to one country, having a B"B-program and relatively low cost, the IRF and other national programs might be seen as a good alternative or supplement to the MSC."*

consideration on the demand and/or the supply side. Under the assumption that eco-labelling then should bring extra profit to the firm(-s) exploiting such, a price premium should be expected for eco-labelled products (over non-labelled) covering, in theory at least, more than the costs of undertaking the certification scheme. For certain, distributional discrepancies in the value chain can lead to a situation where, under a price premium, profits are reaped by the retail link, while the costs for the certification scheme is (usually) borne by the upstream links in the value chain – typically the fishing industry, government or industry organisations.

From a large data material collected on 91 white fish products' attributes on a weekly basis over half a year in seven UK supermarket chains in Glasgow, Sogn-Grundvåg *et al.* (2013a) examined the price differences between private labels regarding price premiums on (eco-) labelled seafood products – including labels on "responsibly sourced". The authors find that the "line-caught" attribute (haddock and cod) enjoys a price-premium of 25 % over other, not stated gear-use, mainly trawl. The MSC eco-label exhibits a 13 % premium. However, they do raise the puzzle that large fish quantities entering the supermarkets with a MSC-label are displayed without it, perhaps due to "*…the 0.5% fee on retail sales charged by the MSC as well as a non-recurrent fee of €180–1,400 depending on sales volume."* (p. 372). Moreover, products that were labelled Icelandic (not necessarily IRF) were 6 % more expensive than not origin labelled products, while Scottish labelled products experienced a price premium of "only" 4 %, which is interesting since – as mentioned – consumers prefer local or home-country products (ethnicity).

Sogn-Grundvåg *et al.* (2013a) argues that their finding on the MSC price premium is on line with the findings of Roheim *et al.* (2011), who detected a 14 % MSC-label price premium on frozen Alaska Pollock products in the London-area. Moreover, the largest price premium, found for line caught cod and haddock products compared to fish captured with other methods (mostly trawl), speak for a situation where consumers prefer products caught with an environmentally friendly fishing method. The quality and sensory properties of line caught cod and haddock, evaluated as above other gears, strengthens this conclusion, and give hope regarding repeated purchases to uphold and maintain sufficient price premiums, since also the cost of long line fishing (bait, etc.) is presumed higher than for many other gears.

In Sogn-Grundvåg *et al.* (2013a) the same methodology and data source as above is utilised, but data is collected over a longer period – 68 weeks. Again, price premiums for 22 cod products and 47 haddock products were identified over the following attributes: "*catch method (line-caught or not), product form (loins, single fillets, or block/butterfly fillets), processing (skinless or skin-on, smoked or natural), promotion (on offer or not), origin*

(Icelandic, Norwegian, Scottish, or other), eco-label (MSC-labelled or not)" (p. 42). The largest price differences are found between different supermarkets due to different pricing strategies. Further, supporting the before mentioned study, line-caught haddock enjoy a 10 % price premium over haddock caught with other gears, and the MSC-labelled haddock also received a 10 % extra on price. In this study, at odds with the previous findings, Scottish origin labels on haddock were 10 % more expensive than other haddock products. Again, the other bring the attention to the premiums for the MSC-label and line-caught label, where the latter seems challenging since we do not know whether the customer appreciates the environmental friendliness or the extra quality entailed in line caught products[37].

Finally, as an integrated task of the ACCESS-project, López Zurita (2014) duplicated the methodology utilised in Sogn-Grundvåg (2013a,b) in a different geographical area, but with the same purpose: to identify potential premiums on eco- labelled responsibly sourced fish. In his research, 23 and 30 supermarkets in Madrid and Granada, respectively, was visited within the timeframe of one week in January 2014, collecting attributes from roughly 180 products from hake (119), salmon (12) and cod (51), in a total of 750 observations, of which 42 products carried an eco-label (of either MSC (10), Pescanova (29), Findus (10) or Andaluz (3)) – some with more than one. The results from the study were partly ambiguous, also due to product availability differences in the two cities. In short, some products seemed to enjoy a price premium in one city for some supermarkets but not for the other city or supermarkets (eco-labelled hake in El Corto Ingles in Grenada and in Carrefour in Madrid was the only found to have a significant price premium of about 30 %). When turning to explanations for the unidirectional findings Lopez-Zurita (op. cit.) turn to the fact that no distinction in his study is made between third party certification (like the MSC) and the private labels of big international companies.

Summing up the research on sustainability certification and consumer behaviour referred to above, the main findings can be summarised in the following manner: A development in course of a "greener" future have the potential of presenting the Norwegian (and even the Norheast Atlantic) fisheries. Taking into account that the first warnings regarding a self-made warmer globe are a quarter of a century old[38], and the pace of adaption hithereto undertaken,

[37] This puzzle is further elaborated for the effects upstream the value chain in Norway in another paper (Sogn-Grundvåg and Henriksen, 2014) where the first hand market for fish is under scrutiny and the social dilemma arising from market imperfections is pointed out due to power and dependency relationships between fish sellers and buyers in this market. This has led to a situation where fish of poor quality is traded at a too high price, and the presumable best quality fish – in small quantities from coastal vessels using hand and long line – is diminishing in volume.

[38] Dating from the First Assessment Report of the IPCC (1990).

it seems improbable that a carbon neutral society should occur within a generation or two. However, steps in order to make Northeast Atlantic fisheries more climate neutral could be implemented without big sacrifices or abruption in today's practises.

European consumers are in general concerned about environmental issues in purchasing situations (in some markets more so than in others) but not directly translated into action when purchasing seafood. Moreover, they neither seem familiar with what the eco-labels stand for. In current businesses, the eco-labels are rather a pre-requisite or a signal in the "business-to-business" (B2B) landscape, than a direct communication with customers, even though that also occurs in certain markets and with some customer segments. As a claim from professional purchasers in important markets, large seafood nations surrounding the Northeast Atlantic basin are under a mild pressure to undertake some third party certification of their stocks in order to fulfil the requirements for market entry in important markets.

Finally, research have shown that the MSC eco-label have reaped a price premium in some markets and for some products (as shown above). However, as accentuated by Washington and Ababouch (2011: 40), these represent spotty evidence, and the different distribution of costs and benefits in the value chain from the certification makes it at least improbable of being a Pareto improvement. Moreover, whether there is a net benefit for the chain is also unclear.

If there was a direct link between eco-labels and consumer choices under seafood purchases, in order for this to have a direct transmittable effect to fisher's behaviour at sea – in a more environmental friendly direction like less CO2-emissions, and gears gentle to the seabed – then eco-labels should take such considerations more into account than today's practices. Currently, the sustainability certification schemes operating on this scene are to a much greater degree evaluating the management practices for specific fisheries rather than the practical management in fishing operations. Moreover, sustainability also cover more than merely the environmental state of the stock, as it also should incorporate the state of societies dependent of specific fish stocks and the economic sustainability in the fishery.

4.4. Concluding remarks – seafood markets and climate change

The later decades has shown a considerable change in consumer habits, emphasising convenience, health and safety issues, variety, value for money and also introducing an ethical dimension to our meals. Food sector changes have come about as a response to these and other driving forces (income growth, globalisation and trade liberalisation among other thing). Moreover, growing urbanization on global scale will influence also seafood consumption patterns and the demand for fishery products (FAO 2014). For the Northeast Atlantic fishing fleet, competing with other protein sources in developed countries, further welfare increases on a global scale and increased urbanisation might very likely lead to a positive demand shift as more customers can be reached (with an unbroken cooling or freezing chain) and willingness to pay. Also, the probability of climate change hitting harder in other areas of the world were today large catches are landed, can dampen the world seafood supply and impose a price increase for Northeast Atlantic seaood from which output is anticipated to be stable or possibly increase.

Sustainability certification of seafood is for certain here to stay. Today there is a jungle of labels to choose between for the environment-conscious consumer. But despite the proliferation and wide-spread of eco-labels in developed societies the later decades, none of the certification scheme can be said to have had any significant effect on the fleet behaviour. Karlsen and Dreyer (2009) scrutinised the four most relevant eco-labels for Norwegian seafood, that is MSC, FoS and KRAV (Swedish), and found that none of the claims towerds fisheries put forward in those certifications schemes had little or any effect on the parameters decisive for the capture pattern of the fleet (i.e. fishing area, bycatch, fishing seasons, vessel size, vessel type, gear use, species, landing sites or fuel/energy consumption).

As stated above, the eco-labels practices today function as a signal in B2B-business, if not irrelevant for fishers or consumers, then at least not on top of their head when at sea or purchasing seafood. Hence, today's certification schemes and practices have little or no effect on the operational level in fisheries. If consumers to a greater degree demands environmental friendly seafood products, then an eco-label approach when purchasing seafood will have no effect on for instance the seabed pressure from trawling in the Northeast Atlantic. It will, however, imply that the species (or stocks rather) purchased have been managed well in current years.

Consumer power can be fierce, as the examples of food scandals and farmed salmons bad publicity in Science showed. However, it is a well-known fact that consumers' collective power is hard to organise. Hence, waiting for consumers to announce their environment-consciousness for the oceans individually by their sales slip in their choice of seafood, can be expected to be time consuming if not abrupt changes take place. Given these circumstances consumers are perhaps best guided by the actions of governments or NGO's setting standards for the maximum climate impact fishing operations should have – preferably through the market mechanism balancing the market incentives with social desirability. In that respect carbon pricing can be one way of reaching a common goal.

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