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Resource Rent in Norwegian Fisheries - Trends and policies

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Abstract in Norwegian:

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Ressursrenten i norske fiskerier -- utvikling og politikk

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Vi kan estimere den faktiske verdien av en naturressurs slik som fisk, skog og mineraler ved å bruke nasjonalregnskapet. Da benytter vi gjeldende kostnader, priser og tall for fangst/høstning/utvinning. Ressursrenten tilsvarer det som er igjen etter at alle kostnader er trukket fra fortjenesten, også kostnader ved å ha investert i fast kapital. Verdien av ressursrenten som fremkommer er gitt dagens forvaltningsregime og vil blant annet avhenge av markedsstruktur, teknologi og politiske føringer. Økonomisk teori tilsier at denne skulle være positiv dersom forvaltingen hadde optimal verdiskaping som målsetting.

I dette arbeidet studerer vi ressursrenten i norske fiskerier. Ved å bruke tall fra nasjonalregnskapet finner vi at den faktiske ressursrenten i norske fiskerier var negativ i perioden fra 1984 til 201 med unntak av 2010-2011. Samtidig finner vi at ressursrenten gradvis har økt i samme periode. Ved å dekomponere den faktiske ressursrenten for denne perioden finner vi at økningen i all hovedsak skyldes reduserte kostnader som følge av færre fiskere og færre fartøy.

For å få et anslag på hva verdiskapningen i sektoren kunne ha vært, beregner vi den optimale ressursrenten for norske fiskerier ved hjelp av en numerisk modell. For 2011 finner vi at den optimale ressursrenten er oppimot 8,7 milliarder NOK. Dette er om lag 6,7 milliarder mer enn den faktiske renten samme år enten vi måler den utfra tall fra nasjonalregnskapet eller ut fra Fiskeridirektoratets lønnsomhetsanalyser. Forskjellen på 6,7 milliarder er et mål på kostnadene ved dagens forvaltningsregime. Fordi ressursrenten kan økes med lavere antall fiskere og færre fartøy i sektoren, er vi per definisjon i en situasjon med ressurssløsing gitt at både humankapitalen og realkapitalen har en alternativ verdi i andre sektorer. Ved å gjøre en enkel justering av forskjellen mellom optimale og faktiske inntekter og kostnader lik det vi fant for 2011, viser resultatene at den optimale ressursrenten for 2010 og 2012 henholdsvis ligger 6,4 og 6,9 milliarder NOK over den faktiske renten. Selv om dette er en veldig enkel tilnærming er ikke beløpene langt fra de 6,7 milliardene vi fant var kostnadene ved å opprettholde forvaltningsregimet i 2011.

Vi utfører en rekke følsomhetsberegninger og finner at den optimale ressursrenten i 2011 er relativ stabil under ulike forutsetninger. Siden vi ikke har data for de mest effektive fartøyene i en fartøygruppe, kan vi ikke simulere en situasjon der alle fartøyene i en gruppe er like den mest effektive. Således får vi en lavere optimal ressursrente enn man kunne fått i en situasjon der fiskerne tok i bruk den mest effektive teknologien.

Vi har ikke funnet tall for hvor mye tid et spesielt fartøy i en fartøygruppe bruker på å fange et spesielt fiskeslag. Dette kan påvirke de variable kostnadene for ulike fartøygrupper og først og fremst gjøre våre resultater om optimal fordeling av fangsten på de ulike gruppene mer usikker.

Til slutt vil vi også understreke at noen fartøygrupper opp igjennom årene har hatt større mulighet til å effektivisere innenfor det til enhver tid gjeldende regelverket enn andre. Disse far-tøygruppene vil dermed komme ut med relativt lavere kostnader enn de som har hatt mindre mulighet til å velge teknologi og kapasitet.

Resource Rent in Norwegian Fisheries - Trends and policies

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Abstract:

The national wealth of a nation can be estimated via the System of National Accounts (SNA). Using the SNA, we find that the Norwegian fisheries contributed negatively to Norwegian national wealth in the period 1984-2014 with the exception of 2010-2011. However, because the values of all parameters entering the calculation are conditional on the existing management regime, the potential value of the natural resources may be concealed. According to our analysis this is the case for the Norwegian fishery sector. Using a numerical optimization model we find the contra factual resource rent if 2011's quotas where harvested efficiently with the available technology to be close to 8.7 billion NOK, which is 6.7 billion NOK more than the observed resource rent in 2011. Hence, national wealth calculations based on official statistics may trivialize the role of natural resources.

Keywords: fishery economics, resource rent, fish quotas

JEL classification: Q22, Q28

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1. Introduction

The World Bank (2005) calculated the national wealth of nations, and found that natural resource wealth in industrialized countries made up an insignificant share of their total wealth. In high-income OECD countries natural resource wealth made up about 2 per cent of their total wealth on average, and for some countries it was zero e.g. Japan (World Bank, 2005). This finding suggests that the natural resources are unimportant for developed countries. On the other hand, developed country governments may use the natural resource management regime in order to reach other goals than maximizing the rents from the resource. That is, instead of collecting the resource rents and redistributing them to provide public goods, the management regime may be geared towards providing public goods directly without redistributing resource rents. As we will see this might be the case for the current Norwegian fishery regime, which seeks to balance the different goals and requirements of the Marine Resources Act (see Section 2). In this paper we ask to what extent fulfilling these partly conflicting goals has a cost. In particular we inquire into the following question: What would the profits from the Norwegian fisheries have been if regulation only focused on profitability?

Profitability from a natural resource is often framed in terms of resource rents. The resource rent is the extra income an entity obtains from having the right to utilize a natural resource. With extra income we imply returns above the normal return to investments. In natural resource economics the net present value of the sum of all extra future income will be equal to value of the resource. Preserving the value of the natural resources is closely connected to the notion of sustainable development. In order to preserve the value of a natural resource, the yearly harvest from the resource must be restricted in some way. If not, one risks over-utilizing the resource such that future generations are forced to harvest at lower levels. Controlling the harvest level does not by itself ensure that the value is preserved, at least not maximized. In addition access to the resource must be regulated in ways that brings about an efficient way of harvesting.[1]

Statistics Norway has calculated the value of Norwegian natural resources for several years based on data from the System of National Accounts (SNA) (see e.g. Statistics Norway, 2014). The resources included in the Norwegian SNA are the renewable natural resource sectors; agriculture, forestry, aquaculture, fisheries and hydropower, and the nonrenewable natural resources; oil, gas and minerals. The calculations show that except from energy related natural resources (petroleum and hydropower), natural resources only make up a tiny part of Norwegian national wealth. For instance, in the calculations for 2013, Statistics Norway (2014) found that human capital comprised 72 per cent of national wealth, while energy related natural resources and physical capital comprised approximately 9 and 13 per cent, respectively. Financial wealth was around 6 per cent of national wealth, while the contribution of the renewable natural resources; agriculture, forestry, aquaculture and fisheries, taken together was close to zero. Our hypothesis is that the current management regimes for these renewable natural resources conceal their true value. In order to investigate our hypothesis we start with the Norwegian fisheries.

First we show the development of the components of resource rent over time from 1984 to 2014 based on SNA in order to explain why the realized resource rent has been low. The resource rent was negative in all years except for 2010 and 2011. On the other hand, the realized resource rent has gradually become less negative since 1984. Compensation of employees is the largest cost component affecting the rent of Norwegian fisheries, and this cost is much larger than the return on fixed capital and capital consumption. Total revenues in the sector have remained fairly constant, and the increase in resource rents seems to be mainly due to lower total costs of primarily labor and to a certain extent

[1] In Section 5 we elaborate further on management systems that ensure maximization of the resource rent from a fishery.

capital. Thus, the realized resource rent has increased mainly as a result of consolidation indicating that more of the fisheries income is distributed on fewer vessels and fishers.

In order to estimate the value of the Norwegian natural resources, this paper continues by calculating a contra factual value of the fishery resources given a cost efficient management practice. This has previously been done for Norwegian fisheries (see for example Hanneson, 1996; Steinshamn 2005), but as far as we know, all studies have used data that was collected before the Norwegian Structural Quota System was introduced. The Structural Quota System introduced trading in fishing rights to more vessel classes, and we would expect the system to lead to further improvements in the efficiency of the fleet. Using a numerical optimization model we maximize the value of the Norwegian fisheries applying catch quotas, prices, costs and technology in 2011 as found in Directorate of Fisheries (2012). We chose 2011 because this was the year (together with 2007) with total allowable catch closest to the average catch over the period 2006-2013. Our results indicate that the resource rent in 2011 could have been 6.7 billion NOK higher than the realized rent. This suggests that there still is a large potential for efficiency improvements in the Norwegian fishing fleet.

If the resource rent in the fishery sector can be increased by e.g. there being fewer fishers and vessels than with the present management, we have per definition a situation with resource waste in the fishery sector as well as less value creation elsewhere as both human and fixed capital have an alternative value in other sectors (see Section 3). Hence, 6.7 billion NOK is the cost *only* in the fishery sector in 2011 of having the present management system. Under-rating the value of a natural resource may also have more serious consequences. For instance, a low apparent value of a renewable natural resource over time could induce the Government to reduce their efforts into the management regime for the resource such that the resource is utilized in an unsustainable way, and the Government may sooner or later have to reallocate other resources in order to reach its policy goals. As far as we know, our paper is the first paper to compare resource rents calculations based on official statistics with the results from a numerical model. Our results confirm those of earlier studies in that there is a considerable potential to increase the resource rent from the fisheries. Thus, it points to what might be a general problem with calculations of national wealth in developed countries: the value of the natural resources may be underrated.

The issue of rent in fisheries has been discussed in general terms since the seminal studies of Gordon (1954) and Scott (1955). However, apart from Hanneson (1996) and Steinshamn (2005) there are a few other studies of fisheries resource rents in specific countries. Nielsen, Flaaten and Waldo (2012) compare 5 different fisheries from Iceland, the Faroe Islands, Denmark, Sweden and Norway with respect to realized and potential resource rents. The Norwegian small-scale coastal fishery and the Swedish pelagic fishery stood out as the fisheries with the highest potential for efficiency improvements; 65 and 71 per cent respectively. Andersen, Andersen and Frost (2010) is another example from Denmark that studied the whole Danish fishery sector. They also base their estimation of resource rents on a numerical model, and find that a reform of the Danish fishery policy could potentially increase resource rents by approximately 50 per cent in the short run, and more than 100 per cent in the long run. Yet another example is Matthiasson (2012), which calculates resource rents based on the official Icelandic Fishery Statistics. His calculation shows a resource rent of approximately 4 billion NOK for Iceland. Finally, the World Bank (2009) estimates the potential resource rent from all fisheries in the world taken together. They also use a numerical model, and include both gains from having a larger fish stock (as a result of more optimal stock management) which allows for higher yearly harvests, and from a more efficient fleet. Their mean estimate of the global loss in resource rent is $50 billion. Maintaining an inefficient fishing fleet is one of the major causes for the loss. For instance, the current global marine catch could be achieved with around half of the current global fishing capacity.

The rest of the paper is organized as follows: Section 2 describes the Norwegian policy regime. Section 3 gives an overview of how the resource rent is calculated using the SNA and Section 4 presents the realized resource rent in the fisheries over the last three decades. In Section 5 we take a closer look at the realized and potential resource rent in 2011, and in Section 6 we describe the data. Section 7 shows the optimization results and in Section 8 we perform various sensitivity analyses. Section 9 is a discussion of the results and Section 10 concludes.

2. The Norwegian Policy Regime

The Marine Resources Act of June 6, 2008 states that "the wild living marine resources belong to the Norwegian society as a whole". The act further states the following aims and requirements for Norwegian fishery policy:

i. a precautionary approach, in accordance with international agreements and guidelines,
ii. an ecosystem approach that takes into account habitats and biodiversity,
iii. effective control of harvesting and other forms of utilization of resources,
iv. appropriate allocation of resources, which among other things can help to ensure employment and maintain settlement in coastal communities,
v. optimal utilization of resources, adapted to marine value creation, markets and industries,
vi. ensure that harvesting methods and the way gear is used take into account the need to reduce possible negative impacts on living marine resources,
vii. ensure that management measures help to maintain the material basis for Sami culture.

Some of these requirements are conflicting. For, instance with point of departure in v) one may argue for individually transferable fishing quotas in order to ensure an efficient fishing fleet. On the other hand, an efficient fishing fleet may come into conflict with both iv) and vii) above.

In 2011 Norwegian fisheries had 10220 full-time fishers, 2548 part-time fishers and 6250 vessels (Directorate of Fisheries, 2015). Together, they landed approximately around 2 million tons of fish (excl. crustaceans, shells, seaweed and sea tangle). These numbers can be compared to the situation in 1984 – the first year of our resource rent calculations. In 1984 Norwegian fisheries had 22861 full-time fishers, 6767 part-time fishers and 24078 vessels. However, their landings in tons were approximately the same as in 2011. The downward trend in the number of fishers and vessels is partly due to official Norwegian policy. The Norwegian fishery management underwent a large transformation during the last part of the 20th century. Spurred by the collapse in the Atlanto-Scandian herring stock in the late 1960s the Norwegian Government started to restrict entry into an increasing number of fisheries. At the same time they introduced measures such as scrapping subsidies in order to reduce the overcapacity in the fleet. The excess capacity was a result of technological progress, for instance the introduction of fish finding equipment and mechanical purse seines (Hanneson, 2005).

The fishery management regime in Norway is complex, and we do not include a comprenhensive account of the regime in this paper. For as much as about 90 per cent of fisheries, Norway's annual total allowable catch (TAC) is determined in bilateral and multilateral negotiations with other nations. For the remaining part of the fisheries national authorities set TACs independently based on expert advice. For each stock, the TAC is first allocated between the vessel groups belonging to the costal fleet and vessels belonging to the ocean-going fleet. Then the TAC is broken down into different vessel groups, and further distributed within the vessel group among the vessels holding the necessary licenses to participate. All fishing vessels need to have a commercial license, and only Norwegian citizens and active fishers (that participated in at least three of the last five years) may apply for a commercial license. The rationale for this regulation can be found in the Marine Resources Act which seeks to ensure that the returns from the fisheries go to the active fishers in the coastal communities.

Quotas in both the costal fleet and the ocean-going fleet are tradable within certain restrictions set out by the Structural Quota System. The Structural Quota System was first introduced in 2004 in order to reduce overcapacity in the fishing fleet (The Norwegian Ministry of Trade, Industry and Fisheries, 2007). The main principle of the Structural Quota System is that a vessel owner can buy another vessel and transfer 80 per cent of the quota of the other vessel (a structural quota) to his/her own vessel. The vessel that hands over the structural quota must then be scrapped. In this way the system facilitates increased vessel profitability. However, other considerations are also taken into account, including regional policies. It follows from the Marine Resources Act that Norwegian fishery policy should aim for a geographically dispersed fishing fleet in order to support coastal communities and their cultural heritage. Several restrictions are therefore implemented, including maximum quota per vessel, geographically limited markets, transactions only within vessel groups and mandatory scrapping. These restrictions clearly imply that the TAC has been and still is not harvested in a cost minimizing way. A major shift took place during the period 2004-2006 when some trade across vessel types in the ocean-going fleet became permitted. In particular, this reduced the fleet of the trawlers, a type of ocean-going vessel.

Fishing quotas can be divided into ordinary quotas and structural quotas e.g. quotas that have been acquired through buying vessels. Below we present a table with the development in the share of structural quotas within vessel groups:

Table 1. Structural quotas in different vessel groups[2]

Vessel group	Percentage traded structural quotas		
	2008	**2011**	**2015**
Coastal vessels conventional (1-4)[3]	19.6	25.6	33.2
Ocean-going vessels conventional (5)	52.2	57.3	66.7
Cod trawlers (6)	50.1	59.6	61.9
Other trawlers (8)	38.9	58.5	72.1
Coastal seine (9-11)	32.4	43.4	51.5
Purse seiners (12)	17.9	18.3	20.2
Pelagic trawlers (13)	52.3	60.4	72.5

As we can see all vessel groups have undergone structural change. Note that the category "coastal vessel conventional" also includes vessels shorter than 11 meters for which there is no structural quota system. From Table 1, we conjecture that the amount of trading has been most extensive among the trawlers and ocean-going conventional vessels. This suggests that the ocean-going part of the fishing fleet has undergone larger structural changes than the coastal fleet. The reason could of course be that the coastal fleet was more efficient to begin with; however, anecdotal evidence also suggests that the incentives for reducing the number of vessels have been and still are much weaker within this fleet segment.

3. Calculation of the Realized Resource Rent of Fisheries from SNA

Statistics Norway has periodically calculated time series of resource rents for all Norwegian natural resource sectors to be used as sustainable development indicators (see e.g. Alfsen and Greaker, 2007). The calculation of resource rents in marine fisheries is comprehensive in that it includes full and part-

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[2] Source: The Norwegian Fishery Directorate (2015).
[3] The numbers refer to vessel groups used in our numerical model.

time fishers, and the net revenue from the capture of all wild marine organisms[4], by both commercial and non-commercial vessels. Table 2 presents the calculation method for the realized resource rent (Eurostat 2001).

Table 2. Calculation of the realized resource rent

Sign	Term
+	Basic value of production
-	Intermediate uses
+	Taxes on products
-	Subsidies on products
=	Gross product
-	Non-Industry specific taxes
+	Non-Industry specific subsidies
-	Compensation of employees
-	Return on fixed capital
-	Capital consumption
=	Resource rent of the sector

The basic value of production is equivalent to total revenues. The intermediate uses are the values goods and services consumed or used up as inputs in production, for instance fuel costs. Taxes on products, can be regarded as a part of the value that is created by the industry when the resource is extracted, while a product specific subsidy can be seen as part of the costs of extracting the resource. A product specific tax paid by the specific resource industry must therefore be added to the resource rent, while a product specific subsidy must be subtracted. This also goes for price support, which has

[4] Including crustaceans, shells and seaweed. Aquaculture is not included, and is treated as a separate sector.

been used in the Norwegian fisheries. The Norwegian SNA has neither registered product specific taxes nor product specific subsidies in the time period considered in this paper. The reason appears to be that the price support was administered by the sector interest groups. Thus, the SNA has only registered this as an industry specific net subsidy.

According to Eurostat (2001) industry specific taxes and subsidies are not to be included in the calculation of the resource rent because they are simply a transfer of the resource rent between the government and the industry, and do not affect the bottom-line value of the resource rent. Industry specific taxes and subsidies may, however, affect the structure of the industry. For instance, lowered financing costs to fishers taking up loans to purchase a fishing vessel will over time result in overcapitalization and "too many vessels chasing too few fish", and thus, contribute to reduced resource rents. Currently, Norwegian fishers are exempt from fuel taxes, which contribute to inefficient use of fossil fuels in the industry and increased CO_2 emissions. The cost, not including the tax administration costs, to the Norwegian Government of the fuel-tax exemption was estimated to NOK 999 million in 2011 (Isaksen, Hermansen and Flaaten, 2015).

Finally, according to Eurostat (2001), non-industry specific taxes must be subtracted and non-industry specific subsidies must be added because these transfers, being independent of industry, can be considered standard costs/income from doing business. An example of non-industry specific tax is social security contributions made by firms. Since industry specific taxes and subsidies should not be included in the resource rent calculations, and because, the distinction between what is industry specific and what is not is sometimes vague, we have chosen to leave all taxes and subsidies out of our resource rent calculations. Total taxes and subsidies generally lie between 3 and 7 per cent of the gross product as from 1993 to 2014, and more or less cancel each other out.[5] Thus, the net effect on our results would likely have been small.

When calculating compensation of employees, it is a goal to use wage rates that reflect the alternative value of the fishers. Here we apply a long term perspective, meaning that we ask what the likely wage of a fisher would be, if she had to find a job elsewhere at the start of her working career. With this perspective it seems correct to use the average wage rate in mainland Norway. Thus, we calculate the compensation of employees as the number of hours worked times this wage rate. We find that total wages calculated this way are only around three per cent higher than the actual remuneration of fishers as estimated by the profitability survey. We also include income to the vessel owners by using the number of hour worked for this group multiplied with the same wage rate as for employees.

When calculating the return to fixed capital, we need a measure of the value of the capital employed in the fishery sector. Again we base our calculations on the SNA. The SNA applies the perpetual inventory method, that is, every year capital is added based on the cost of new investments, and capital is subtracted based on an estimate of the lifetime and depreciation profile. For fishery capital the lifetime is set to 20 years, and the depreciation profile is geometric with 10 percent yearly rate. This should reflect the natural wear of this kind of capital. Clearly, the value of the capital in the SNA may be different from the actual market value of the capital, in particular, in periods with excess capacity in the fishing fleets worldwide. We, however, take a long term perspective, and essentially ask what the the return on the capital would have been if it had not been invested in the fishery sector in the first place. With this perspective, it seems correct to apply a rate of return of 4 percent and the capital value reported in the SNA.

[5] From 1993 to 2014 net subsidies (taxes) were around zero. However, in the period from 1984 to 1992 the industry and non industry specific net subsidies were considerable, up to 2 billion NOK (inflated to 2014 values) in 1984.

4. The Realized Resource Rent in Norwegian Fisheries over the Last Decades

Figure 1 shows the components of the resource rents in Norway for the period 1984-2014 as calculated using the SNA. The gross product is total revenue less the value of intermediate uses as explained above. The realized resource rent is negative for all years except for 2010 and 2011. For theses two years the gross product spiked due to high prices for fish products.

The reason for the negative rent is primarily the high level of compensation of employees compared to the gross product. Note that our compensation of employees includes time spent by the owners as well, and that we use the average mainland wage as the cost of labor. Thus, compensation of employees does not correspond to wages paid by the fishing firms.

Figure 1. The components of resource rent in Norwegian fisheries 1984-2014

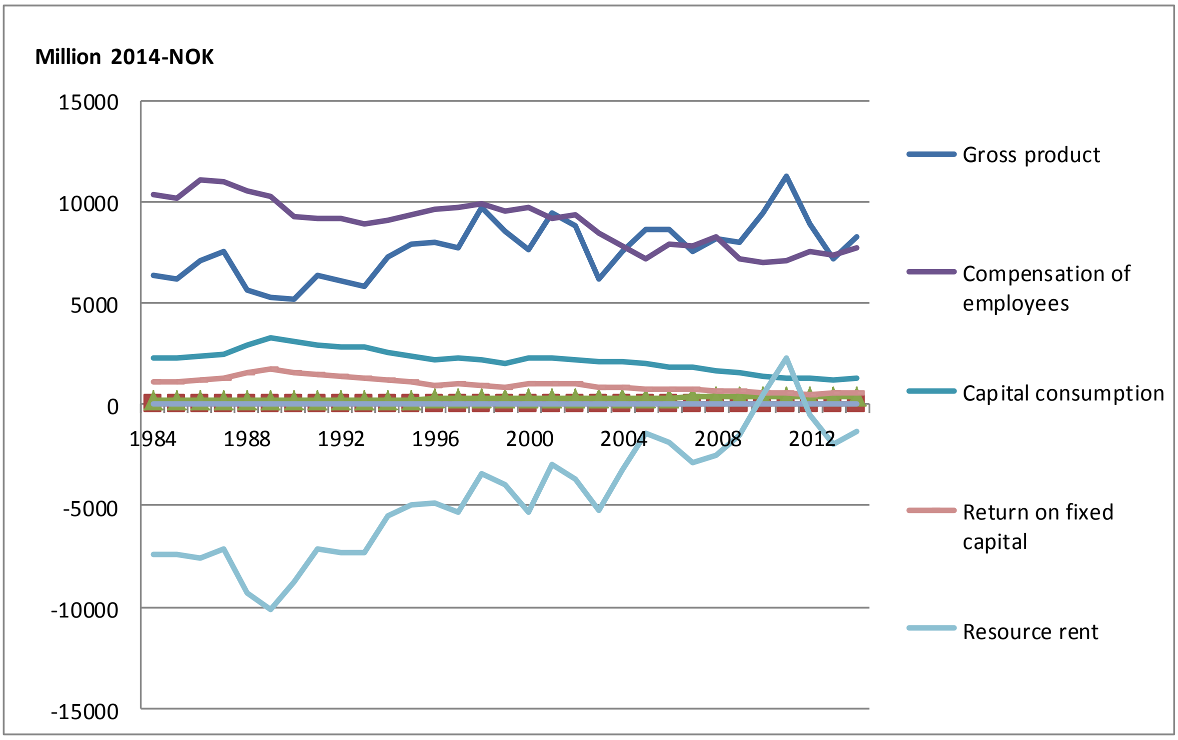
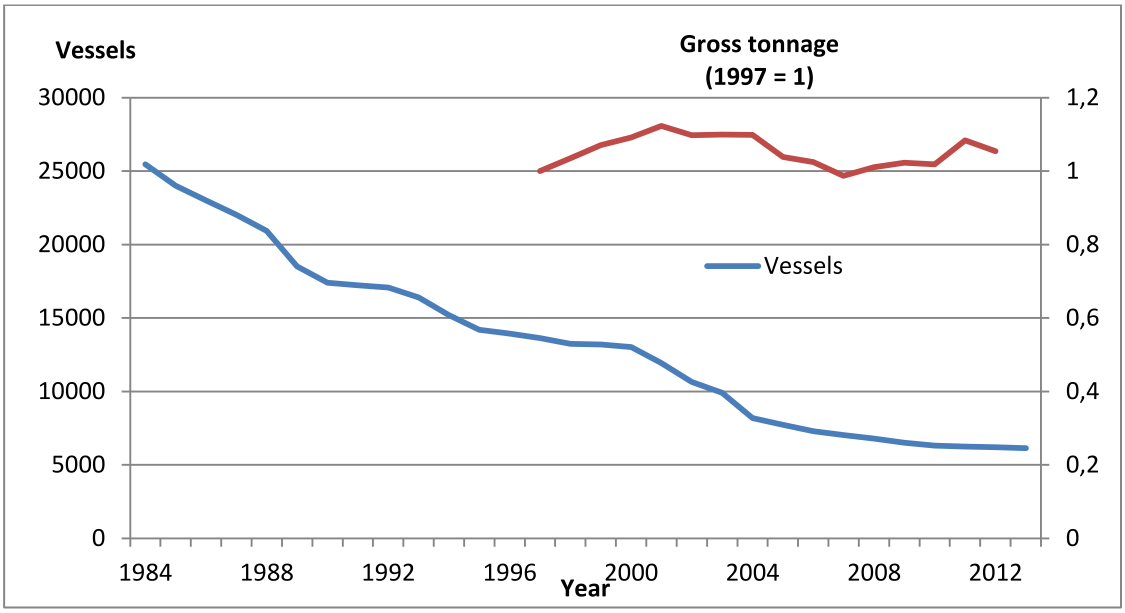


Figure 1 shows that the resource rent has been on an increasing trend from the late 1980s, although there are yearly variations due to changes in the gross product (i.e. price and/or catch). In the period 1984 to 1998 the gross product was on an increasing trend, but stabilized more or less from 1998 and onwards. Thus, after 1998 increases in realized rent mainly due to lower compensation of employees, but also due to reduced capital consumption and return on fixed capital. It is difficult to see any structural break in Figure 1 in year 2004 when the Structural Quota System was introduced. One reason could be that from 1998 to 2004, the government had a Unit Quota System in place for larger boats that also allowed some trading of individual fishing rights. In addition, there was a scrapping subsidy for smaller boats (Hanneson, 2004). This buy-back program was originally introduced in 1979, but mainly larger boats took advantage of the program until the mid-1990s when the program was ended. Then in 1998 the buy-back program was reintroduced, and smaller boats took part to a much larger extent. Figure 2 shows that capital consumption and return on fixed capital has declined in line with a lower number of vessels, although the gross tonnage[6] is more or less the same since 1996. This suggests a trend towards larger vessels.

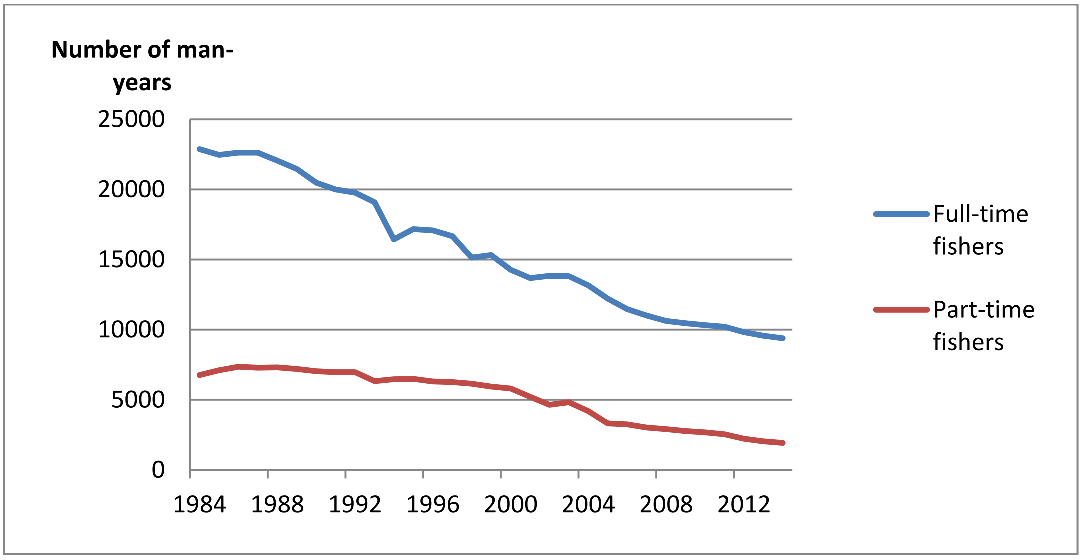
[6] Gross tonnage is a measure of the "total volume of all enclosed spaces of the ship". The measure for gross tonnage is defined by *The International Convention on Tonnage Measurement of Ships* and was adopted by the International Maritime Organization in 1969. We were not able to find older gross tonnage numbers for Norwegian vessels than 1997.

Figure 2. The number of vessels 1984-2013 and gross tonnage 1997-2012 in Norwegian fisheries



Even if the number of man-years for the full-time and part-time fishers has declined by around 60 and 72 per cent since 1984, respectively, as shown in see Figure 3, total compensation of employees is only 30 per cent lower in 2014 compared to the early 1980s due to increases in real wages.

Figure 3. The number of man-years in Norwegian fisheries 1984-2014



Apart from 2010 and 2011, the resource rent in the Norwegian fisheries has been negative over the period 1984 to 2014. This is the case despite all efforts taken by the fishery authorities to reduce the overcapacity in the fleet. On the other hand, there are still many restrictions in place governing the trading in fishing rights: maximum quota per vessel, geographically limited markets, transactions to a large extent only within vessel groups etc. By using the year 2011, which had a close to average allowable catches for the last decade as our point of departure, we now proceed to estimate the potential resource rent if all restrictions were removed.

5. A Closer Look at the Realized and Potential Resource Rent in 2011

The resource rent obtained depends on the management regime including (1) the total allowable catch (TAC) and (2) the technology used to harvest the TAC, that is, the types and numbers of vessels. In pure open access regimes, fish stocks become overharvested and may become extinct (Clark, 1990). Setting and enforcing catch quotas is one way of securing viable fish populations. In a sustainable fishery, the catch quota, i.e. the TAC, should be low enough so that fish stocks can regenerate between harvests and therefore can be harvested in perpetuity. Moreover, different sizes of the fish stocks allow for different levels of sustainable harvests. The TAC level typically denoted the Maxium Sustainable Yield (MSY) (Clark, 1990) is associated with the size of the stocks allowing for the highest level of perpetual harvests. While MSY is purely based on biological parameters, the optimal harvest level also takes economic parameters into account, and is called the bioeconomically optimal harvest level. We do not attempt to estimate the bioeconomically optimal harvest level in this paper. Instead we assume that the TACs in 2011 were close to MSY-levels for the fish stocks, and that the MSY-levels are not far away from the bioeconomically optimal harvest levels.

For a given TAC the number of vessels may be too large or the vessels used may be too inefficient to maximize the resource rent. In addition, the allocation of the TAC geographically and among vessels groups may lead to further loss of resource rent. As shown in Figure 1 and Table 3, Statistics Norway estimate the realized resource rent in Norwegian capture fisheries to 2011-NOK 2.153 billion. If we instead calculate the resource rent applying data from the profitability survey by the Directorate of Fisheries, the realized resource rent was 2011-NOK 2.050 billion.

Table 3. Estimates of the realized resource rent.

Resource-rent estimate	Resource rent (billion NOK)
SNA: Professional full-time fishers that earn a certain minimum annually	2.153 billion NOK
Profitability Survey: Professional full-time fishers[7] that earn a certain minimum annually	2.050 billion NOK
Profitability Survey: Ten most valuable fish species	1.453 billion NOK

The reason for the divergence in resource rent estimates is different ways of calculating fixed capital and the number of man-years applying the national accounts compared to the accounts in the profitability survey. To be included in the 2011 profitability survey vessels had to earn a certain level of income from their fishing operation[8]. If limiting ourselves to the ten[9,10] economically most important species the realized resource rent was 2011-NOK 1.453 billion.

[7] Statistics Norway calculates a factor, which is used to scale-up the basic value from the commercial vessels participating in the profitability analysis in Directorate of Fisheries (2012) to encompass the whole vessel fleet. We use the same factor to get comparable numbers between the SNA and the Directorate of Fisheries.

[8] To be included in the activity survey, earnings must be at least NOK 471,000 for vessels 0-9.9m, NOK 784,000 for vessels 10-10.9m, NOK 1,177,000 for vessels 11-14.9m and NOK 2,353,000 for vessels 15m and above.

[9] These species are cod, herring, haddock, saithe, mackerel, cusk, ling, blue whiting, capelin and shrimp. In Norwegian: torsk, sild, hyse, sei, makrell, brosme, lange, kolmule, lodde og reke.

[10] We focus on these ten species because they on average contributed to 90 per cent of the basic value in the years 2006-2013. 2006: 89 per cent, 2007: 91 per cent, 2008: 91 per cent, 2009: 89 per cent, 2010: 89 per cent, 2011: 91 per cent, 2012: 91 per cent and 2013: 90 per cent (Directorate of Fisheries, 2015).

Given today's TACs, number and types of vessels, and labor force we now move on to find an estimate of the potential resource rent if the catch could be redistributed among vessels according to the groups that receive the best price for the catch, have the lowest cost and where vessels operate at their maximum biologically and technically possible length of season. To do this we use a linear programming model based on Steinshamn (2005). The model maximizes net revenues, that is it maximizes resource rent, given the total allowable catch for each fish species i, TAC_i, which we assume is set to a sustainable level and the fixed catch capacity per vessel in vessel group *j* given by technology, KAP_j, by choosing the optimal number of vessels in each vessel group N_j and the total catch of fish species *i* for vessel group *j*, $Y_{i,j}$. The model is specified as:

(1) $$RR = \max_{N_j, Y_{i,j} \geq 0} \sum_{i=1}^{N} \sum_{j=1}^{M} (p_{i,j} - f_{i,j} VC_j) Y_{i,j} - \sum_{j=1}^{M} N_j FC_j$$

Subject to:

(2) $$\sum_j Y_{i,j} \leq TAC_i \qquad i = 1, ..., N$$

(3) $$\sum_i Y_{i,j} \leq KAP_j N_j \qquad j = 1, ..., M$$

(4) $$N_j \geq 0 \ , \ Y_{i,j} \geq 0$$

Here $p_{i,j}$ is the price received, VC_j is the variable cost, $f_{i,j}$ is the part of variable cost that should be allocated to fish species i, and FC_j is the fixed cost. Notice that the price depends both on species and vessel group, in other words, all vessels do not receive the same price for the same fish. The model in equations (1)-(4) is calibrated for the ten economically most important species with 2011 data for prices, costs, quotas and vessel groups as described below.

6. Data and calibration

In parameterizing our model we consider the thirteen vessels groups (see Table 4) that were included in the 2011 profitability survey of the fisheries (Directorate of Fisheries, 2012). These vessel groups harvested a total of 2 million metric tons in 2011, and the first-hand value was estimated to NOK 14.6 billion. This corresponds to about 91 per cent of the total first-hand value in Norwegian fisheries in 2011[11]. For TAC we use the actual total Norwegian catch in 2011 for the ten economically most important species. The TAC for these ten species was 1.83 million tons in 2011 (see table A1 in Appendix A), and constitute 71 per cent of the actual total resource rent when we apply total catches in the profitability survey (see Table 3).

Fish prices, $p_{i,j}$, for each vessel group and species, which are provided in Table A2, were also found in the 2011 profitability survey (Directorate of Fisheries, 2012). We measure the present capacity, KAP_j, of a single vessel in each vessel group as follows: Actual catch is first divided by number of days in operation listed in the profitability survey. This capacity is secondly multiplied with the potential number of days in operation (see Table A3). This potential capacity is further downscaled due to biological and/or technical reasons when calculating the adjusted potential variable costs for the various species/vessel groups (see below).

Actual variable costs, VC_j, for each vessel group is defined as operating expenses minus depreciation on the vessel, minus depreciation on the fishing licenses and permits, and minus insurance on vessel; all numbers used are as reported in the profitability survey. This value is divided by total catch to obtain average variable costs per kg for each vessel group (see Table A4 and A5). Clearly, vessels within a vessel category may be of different vintages, and the later vintages are likely more effective

[11] The reason is that the vessels included in the population have an income above a specific minimum level. This means that the number of vessels in the profitability survey are 1525, even if the Register of Norwegian Fishing vessels registers a total of 6250 in 2011 of which 5417 are active. Total catch in tons in the profitability survey is around 90 per cent of total Norwegian catch.

than the earlier vintages. Thus, the potential resource rent we calculate is probably lower than what one would find if all vessels were replaced by the vessels with the lowest variable costs within the vessel group.

In the base case the variable cost allocation parameter $f_{i,j}$ is set equal to 1 if vessel group *j* catches species *i* (according to the profitability survey), and set equal to 25 if vessel group *j* does not catch species *i*. This is a large enough upscaling of the variable cost to prevent the vessel group from harvesting those particular species in the model simulations. Setting $f_{i,j}$ equal to 1 implies that we set the share of time spent on harvesting a certain species equal to that species' share of the harvest measured in tons. Some vessel groups may, however, be relatively more effective in catching certain species than other. Examining the catches made by vessel group, a pattern emerges: each vessel group appears to specialize in one or two species that make up a lion's share of their catch. In order to look at the sensitivity of our resource rent calculation to specialization, we make the following assumption about the $f_{i,j}$-values. For the species in which a vessel group specializes, the vessel group spends up to 20 per cent less time, than the catch share measured in tons suggests. The rest of the time is allocated evenly to the other minor fish species within the total catch of a vessel group. One example of possible $f_{i,j}$-values is presented in Table A8.[12]

Finally, to estimate the fixed costs FC_j we use data for total fixed assets for each vessel group from Directorate of Fisheries (2012). We deduct the book value of fishing licenses and permits from this value to get the value of fixed capital, and we add insurance on vessel (see Table A5).

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[12] Steinshamn (2005) also included $f_{i,j}$-values different from unity. These were based on surveys conducted in 1994 and 1996 among the fishers, but the Directorate of Fisheries later formed new and consolidated vessel groups making it impossible to use the $f_{i,j}$-values from Steinshamn (2005) in this study.

Table 4. Vessel groups and number of fishers employed in each vessel group.

Vessel group number	Vessel description	Geographic regions of operation in Norway	No. vessels	No. employed
1	Coastal vessels using conventional gear. Vessels below 11 meters quota length	Mainly in the north, some south.	611	1039
2	Coastal vessels using conventional gear. Vessels 11-14.9 meters quota length	Mainly in the north, some south.	293	791
3	Coastal vessels using conventional gear. Vessels 15-20.9 meters quota length	Mainly in the north, some south	121	799
4	Coastal vessels using conventional gear. Vessels 21 meters quota length and above	All	37	392
5	Ocean-going vessels using conventional gear	All	35	1061
6	Trawlers. Vessels with cod trawling and/or shrimp trawling license	All	39	1556
7	Coastal shrimp trawlers	All	80	224
8	Other trawlers (fishing for saithe, lesser and greater argentines and more)	All	4	82
9	Coastal vessels using seine. Vessels below 11 meters quota length	All	43	77
10	Coastal vessels using seine. Vessels 11-21.35 meters quota length	All	93	409
11	Coastal vessels using seine. Vessels 21.36 meters quota length and above	All	62	552
12	Purse seines	All	80	1192
13	Pelagic trawlers	South	27	215
			1525	8389

The model also includes by-catch constraints showing the relationship for units of haddock caught per unit cod (see Table A6). The model includes restrictions on the permissible length of the season due to weather conditions; climate, resource availability etc. (see Table A7). Finally the model includes restrictions on the shrimp fisheries; it is unreasonable that coastal vessels with conventional gear 15-21 m' and 'coastal shrimp trawlers' would be able to increase their shrimp catches over what we have seen in the last three years by capturing market shares from ocean trawling vessels with cold storage plants (which are part of the trawlers on vessel group 6). Later in the sensitivity analysis we introduce further restrictions on other vessel groups. Steinshamn (2005) included a number of politically determined constraints on the distribution of fish catches among vessel groups; particularly coastal vessels versus ocean-going vessels. Our base case does not include any political constraints but the effect of political constraints is explored in the sensitivity analysis.

7. Optimization Results

Base case

In the base case, we limit the number of vessels in the fishery to the actual number of vessels in each vessel group in 2011. Moreover, the compensation to the owner of the vessel is set to the average mainland annual wage for the non-natural resource industries. Since the objective function is linear, the optimal solution will use the most profitable technology for each species up to the maximum capacity of that vessel group before employing another vessel group to harvest that particular species. Since our main goal is to estimate the potential resource rent given the current fleet, and we do not aim to predict the composition of the fleet exactly after a deregulation, we find the linearity assumption acceptable.

We find the maximum resource rent for the base case in 2011 for the ten economically most important species using the CONOPT optimization procedure in GAMS[13]. The profit maximizing resource rent from the ten economically most important species was found to increase by a factor of 4.24 from 2011-NOK 1.453 billion to 2011- NOK 6.156 billion. Add to this the resource rent of the species not

[13] The GAMS code is available from the corresponding author upon request.

included in this optimization (but included in the 2011 Profitability Survey), we get a total resource rent of NOK-2011 6.753 billion for commercial fishers and a resource rent of 2011-NOK 8.692 billion if the resource rent for these remaining species also could increase by a factor of 4.24 through efficiency improvements. Using these numbers and a discount rate of four per cent, the Norwegian fish resource is worth an estimated 2011-NOK 217 billion or 2015-NOK 233 billion (adjusted using the consumer price index).

The potential resource rent in 2011 is around 6.7 billion NOK more than the observed one. When decomposing the change in potential resource rent compared to the actual rent into changes in total revenue and total costs, we find that total revenue falls by about 10 per cent, which means that the catches are actually redistributed to vessels that receive a lower price in the optimum. Simultaneously, total costs falls by around 80 per cent, this means that maximization of resource rent is almost synonymous with allocating the catch to the most cost-effective vessel groups. In 2010 and 2012 the average fish prices were lower. However, if we adjust total revenue and total costs for the national accounts numbers in 2010 and 2012 correspondingly (see Figure 1), we find that the potential resource rent is 6.4 and 6.9 billion current NOK higher than the one observed in 2010 and 2012, respectively. Even if this is a very simple adjustment, these numbers are not far from the rent dissipation of 6.7 billion NOK in 2011.

Steinshamn (2005) calibrated a similar model with 2002 data that included ten species and also added some institutional constraints (i.e. the TAC distribution between coastal and ocean-going vessels). Steinshamn (2005) found that the resource rent could be increased from literally zero to 2002-NOK 7.365 billion that is 2011-NOK 9.2 billion[14]) with a five per cent discount rate[15]. Steinshamn's and our resource rent estimates necessarily differ because of model calibration, different species included

[14] Adjusted by the weighted average of the consumer price indices for public and private consumption.

[15] If running Steinshamns model with a four per cent discount rate the resource rent is 2002-NOK 7.921 billion.

in the optimization model, different structuring of vessel groups, and because Steinshamn (2005) includes some additional institutional constrains.

Figure 4 shows the model results in terms of participating vessel groups and their catch (in 1000 tons). Since the marginal profit is positive for at least one vessel group for all species, the entire TAC is caught. The only exception is the capelin and cusk fisheries, where the marginal income is negative for all vessel groups.[16] We emphasize that, over the years, some vessel groups have had greater possibilities for efficiency improvements within the prevailing regulations than others. These vessel groups will therefore come out with relatively lower costs than those who have had less opportunity to choose the technology and capacity that best suits the fisheries they participate in.

The most efficient vessel groups are 'other trawlers' (gr. 8) and 'pelagic trawlers' (gr. 13). All existing vessels in these vessel groups are utilized in the solution. In addition, gr. 3 'coastal conventional vessels 15-21m', gr. 4 'coastal conventional > 21 m', gr. 6 'trawlers', gr. 7 'coastal shrimp trawlers', gr. 10 'coastal seine 11-21m', gr. 11 'coastal seine > 21m' and gr. 12 'purse seines' are used in the solution. Vessel groups 1, 2, 5 and 9 are not fishing in the base case solution of the model. These groups either receive too low prices for their fish or have too high costs.

'Coastal shrimp trawlers' catch shrimp up to capacity (4,950 ton), 'coastal conventional vessels 15-21m' catch 150 ton and 'trawlers' catch the remaining (18,032). 'Pelagic trawlers' catch all saithe up to capacity (176,031 ton). Haddock is caught by 'other trawlers' (18,120 ton) and 'coastal seine vessels > 21m'(131,042 ton). 'Coastal seine vessels > 21m' also catch most of the cod (252,490 ton), while 'coastal seine 11-21m' catch 23,458 ton. 'Coastal conventional > 21 m' catch all the ling (14,431 ton). 'Purse seines' catch almost the whole herring quota (606,264 ton), while 'pelagic

[16] The landed value of capelin and cusk was around 6 per cent of the total value of our ten species in 2011.

trawlers' catch 9,378. Purse seines' catch the whole mackerel quota (199,501 ton) and all the blue whiting (18,323 ton). The purse seines are responsible for most of the catch; as much as 824,088 ton.

Figure 4. Model results, in terms of catch in 1000 tons for each vessel group and species.

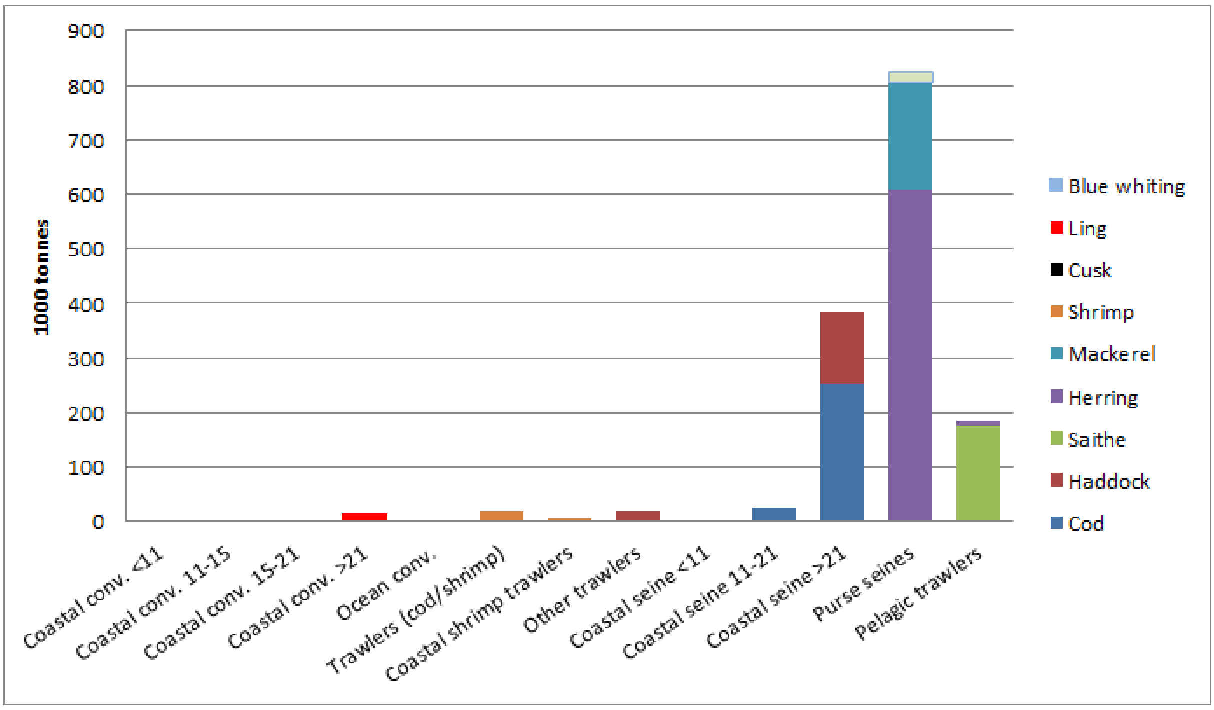
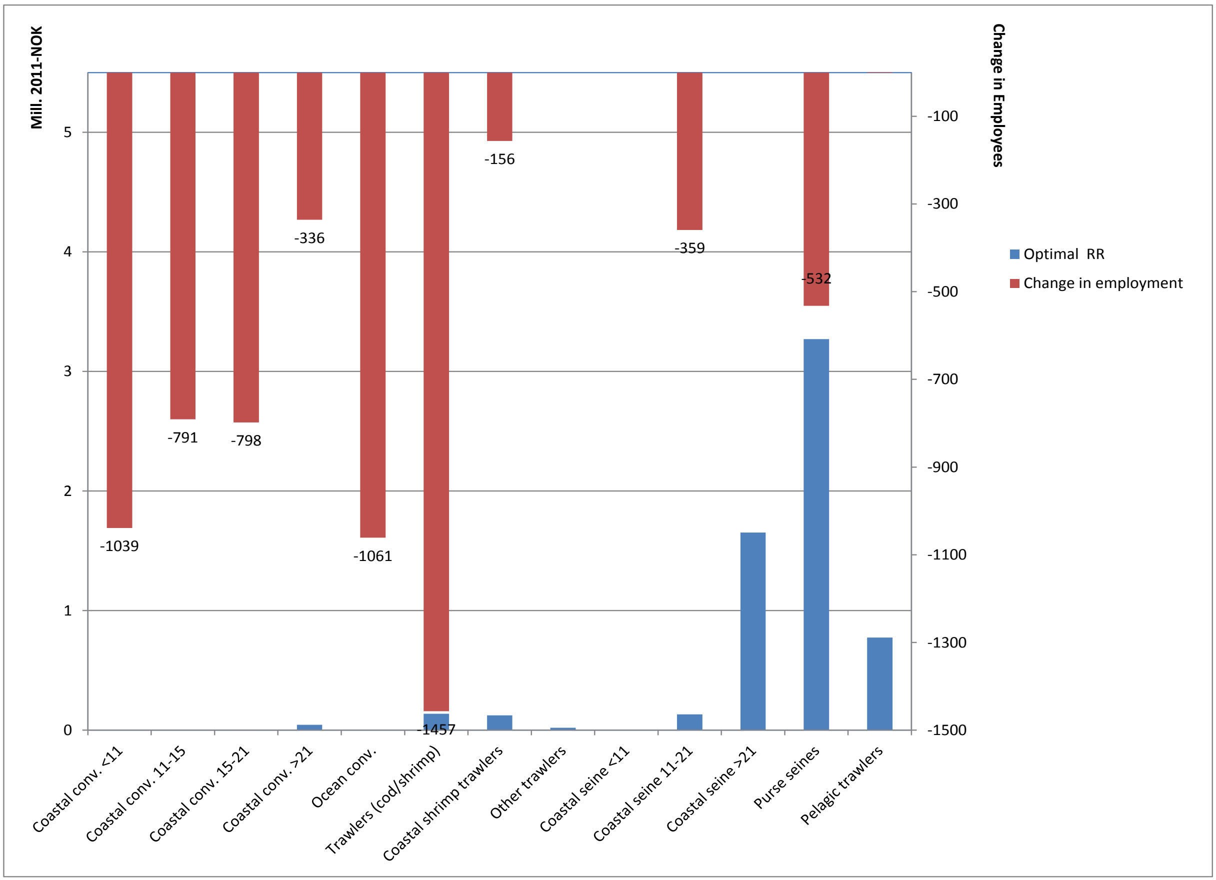


Figure 5 shows the distribution of the potential resource rent among vessel groups in the base case. As measured in 2011-NOK, 'purse seines' have the largest resource rent of 3.27 billion, 'pelagic trawlers' have a resource rent of 724 mill, 'trawlers' earn a surplus of 136 mill. and 'other trawlers' 20 mill. The resource rent among coastal vessel groups is distributed as follows: 'coastal shrimp trawlers': 123 mill., 'coastal seine vessels 11-21m': 131 mill., 'coastal seine vessels > 21m': 1.653 billion, 'coastal conventional vessels 15-21m': 5 mill., and 'coastal conventional vessels >21 m' 44 mill. Employment in fisheries is reduced from 8,389 positions to 1,784 positions.

Figure 5. Potential resource rent and change in number of employees by vessel group.



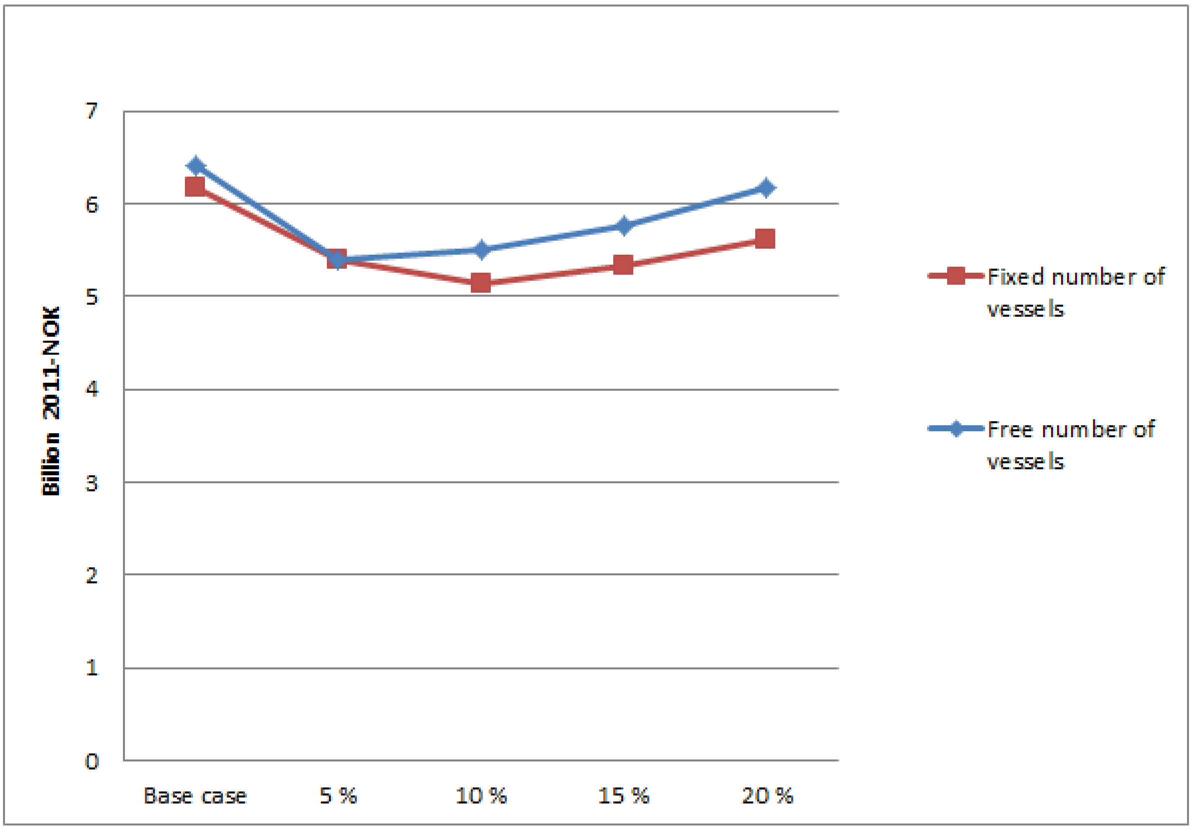
8. Sensitivity analysis

We also *emphasize* that the distribution of catch among vessel groups may be sensitive to the assumption that the same variable cost applies to all fish species being caught within a vessel group. It is possible that some of the vessels may be specially suited to catch certain species. In order to look at the sensitivity of our resource rent calculation to specialization, we make the following assumptions as described in Section 6: For the species in which a vessel group specializes, it spends up to 5, 10, 15 or 20 per cent less time than the catch share measured in tons suggests. The rest of the time is allocated evenly to the other minor fish species within the total catch of a vessel group. One example of possible $f_{i,j}$ -values with 20 per cent less time is presented in Table A8.[17]

Figure 6 shows the effects on the resource rent if less time is spent on catching the species in which a vessel group specializes. (We first consider the number of available vessels fixed at the 2011-level). Gradually the resource rent is reduced and with 10 per cent less time spent the resource rent is around one billion lower than in the base case. However, with further reduction in time spent, the resource rent starts to increase and in the 20 per cent scenario the resource rent is only around 9 per cent lower. The main reason for this development is that 'coastal seine vessels > 21m', 'ocean-going vessels with conventional gear' and 'trawlers ' are gradually catching more cod and haddock until they catch the whole quotas, while 'other trawlers' catch all of the saithe. While this happens they become more cost efficient and the resource rent increases. The catch of 'purse seines' is stable over the scenarios.

[17] Steinshamn (2005) also included $f_{i,j}$ -values different from unity. These were based on surveys conducted in 1994 and among the fishers, but the Directorate of Fisheries later formed new and consolidated vessel categories making it impossible for us to use the $f_{i,j}$ -values from Steinshamn (2005).

Figure 6. Resource rent in various scenarios. Base case and less time spent on catching the species in which a vessel group specializes. Different assumptions on number of vessels.



The base case finds the potential resource rent when using the existing vessel fleet more efficiently. The structure and efficiency of the current vessel fleet reflect past decisions and policies. What could the resource rent have been if we had a modernized fleet of vessels? Recognizing that a new vessel fleet will not appear overnight, Steinshamn (2005) strategy to answer this question was to keep the existing fleet of vessels while making each vessel as efficient as the most efficient vessel in the respective vessel group. We instead calculate the potential resource rent if one freely could add new vessels to the most efficient vessel *groups* (types). Figure 6 shows that the resource rent for the ten economically most important species in the base case increases by 2011-NOK 246 mill to 2011-NOK 6.402 billion if one had unlimited access to vessels in the most efficient vessel groups. Hence it appears that building additional vessels of the most efficient types would only make a relatively modest contribution to increasing the resource rent. However, with 20 per cent less time spent on catching the species in which a vessel group specializes, unlimited access to vessels leads to an increase in the resource rent increases of almost 10 per cent, due to the shift a shift in vessel structure.

The rest of the sensitivity analysis is based on f- values equal to one (we set the share of time spent on harvesting a certain specie equal to that species's share of the harvest measured in tons), and in addition we assume no new vessels. We first ran a case where we included politically determined constraints that divide the catch between coastal and ocean-going vessels. That is, certain coastal vessel groups were not allowed to harvest more pelagic fish (herring and mackerel) than they did in 2011 and certain ocean-going vessel groups were not allowed to harvest more cod than they did in 2011. Adding these constraints reduced the resource rent by an estimated 2011-NOK 731 mill.

In the base case we applied the actual wage for fishers in each vessel group as calculated by the profitability survey and the average mainland wage rate for the non-natural resource industries for owners and, and it may be questioned whether this alternative wage rate is reasonable. The educational level is relatively low in the fishery sector, meaning that the base case may apply a too high alternative wage rate. Applying the annual average wage rate for the primary sectors for both fishers and owners[18] leads to a resource rent of NOK 6.895 billions, a 12 per cent increase from the base case. Following Steinshamn (2005), we set the alternative wage rate for the owners to zero, but this only increases the resource rent with 3 per cent compared to the base case. The reason is that the number of owners compared to the number of fishers is relatively low in the vessel groups that have the highest profitability.

Further, we perform a sensitivity analysis with 10 per cent lower prices. This price decrease leads to a 19 per cent reduction in the resource rent. The reason is that the price changes to a large degree alter

[18] Applying the national accounts, the yearly wage rate in the primary sectors in 2011 was NOK 453,000 compared to a mainland wage rate of NOK 619,000. The latter was only one per cent lower than the average wage rate in the fishery sector.

the combined resource rent for 'purse seines' and 'pelagic trawlers', and these groups constituted the lion's share of resource rent in the base case.

It may be unreasonable to assume that 'pelagic trawlers' can catch all saithe up to capacity (176,031 ton), as saithe is a groundfish. We run a sensitivity analysis where the pelagic trawlers were allowed to catch only half of the quota. This reduces the resource rent by only 4 per cent. The reason is that the other half of the quota now is caught by 'purse seines' , a group being relatively cost-effective in the saithe fisheries, preventing a larger reduction in the resource rent.

We also study the effect on the results of the by-catch constraints between cod and haddock. Omitting the by-catch constrains has no effects on the results since they are not binding in the base case.

We also explore the effect of simply using the actual number of days in operation for each vessel group and not the potential number of days in estimating the resource rent. In other words, the fishing season for each vessel group is not increased and this means that vessels have constant capacity. We still take seasonal catch-limits into consideration if they are binding (see Table A7 in the appendix). The result is a reduction in the resource rent of 31 per cent from the base case.[19] The main explanation for this is a reduction in the value of the fisheries in vessel groups 'coastal conventional > 21 m', 'purse seines' and 'pelagic trawlers'. If we only extend the season to 250 days instead of 330 days for all vessel groups the result is a minor reduction in resource rent of 9 per cent. However, it is not reasonable to assume that these vessel groups cannot extend the season beyond 250 days. Generally, larger vessels can exploit the fish stocks a larger part of the year than smaller vessels, i.e. they can increase their fishing season and capacity. Finally, the interest rate has been set to four per cent in all

[19] Even with the present seasonal length (as well as with the present vessel and gear types) this means that resource rent increases from NOK 1.453 billion in the base case to 4.249 billion, an increase by a factor of 3.

previous resource rent calculations at Statistics Norway, thus we will not run any sensitivity analysis on this parameter value.

9. Discussion of Results

The actual resource rent has generally been on an increasing trend from 1984 to 2014. Norwegian fisheries have in some of the later years had positive resource rent. However, in 2012-2014 the present resource rent were again negative. Factors contributing to the increasing resource rent over time are:

- A year by year reduction in the number of hours worked in the sector reducing total compensation of employees
- A reduction in the number of vessels thus reducing fixed costs and capital consumption, although the gross tonnage has remain fairly constant

Thus the actual resource rent in Norwegian fisheries has in large part been increased by reducing harvesting costs through fleet consolidation, which has led to less employment and lowered capital costs. Furthermore, the optimization results suggest that the resource rent in Norwegian fisheries could be greater than today. In principle, the resource rent could be increased through further reductions in the number of vessels and employment, by increasing the season length, and by redistributing the catch to the vessels that receive the highest prices and have the lowest costs. Our results show that the single most important change in our estimate of the potential resource rent is allocating the catch to the most cost-effective vessel groups. We indicate that the resource rent could be increased by a factor of 4.24 from today’s level. For the ten economically most important species the resource rent in 2011 could be, according to our results, increased from about 1.5 billion NOK to about 6.2 billion NOK. This order of magnitude increase in the resource rent of Norwegian fisheries is consistent with the results of previous studies. We also show that our results are not dependent on the fact that some of the vessels may be especially suited to catch certain species.

10. Conclusions and Further Work

We find that the actual resource rent of Norwegian fisheries has increased through fleet consolidation resulting in fewer employed and less capital costs. We also find that there is potential for increasing the resource rent further through fleet consolidation, reducing employment, by allowing the most profitable vessels to catch more, and by extending the catch season. As the present resource rent can be increased by applying fewer fishers and fewer vessels, we are per definition in a situation of resource waste in the fishery sector as well as less value creation elsewhere in the economy as both human and fixed capital have an alternative value in other sectors. Furthermore, our results show that the dominating structural change needed is allocating the catch of the various species to the most cost-efficient vessels. We also show that our results are not dependent on the fact that some of the vessels may be specially suited to catch certain species. For our model calibration, we found that that the maximized resource rent in 2011 for the 10 most profitable species was about 6.2 billion NOK. If the same increase in the resource rent could be realized for all other species, the resource rent in 2011 for Norwegian fisheries could have been NOK 8.7 billion. Assuming that TACs were bioeconomically optimal, and for the prices and technology in 2011 this means that the Norwegian fish resource is worth 2011-NOK 217 billion.

Our sensitivity analyses show that it is highly probable that the potential resource rent could increase further if we had applied lower alternative wages than in the base case, as this might better reflect the fishers and owners true alternative value. In addition, we show that our results of a potentially high resource rent are neither dependent on assumptions of by-catch constraints nor capacity in 2011 for the various vessel groups. The potential resource rent is to some extent dependent on the extension of the actual fishing season, but not within reasonable assumption on seasonal length. However, the resource rent is of course highly dependent on the prices, especially on those species caught by the most efficient vessel groups. We find that the potential resource rent in 2011 is around 6.7 billion NOK more than the observed one. When decomposing the change in potential resource rent compared to the actual rent into changes in total revenue and total costs, we find that total revenue falls by about 10 per cent. Simultaneously, total costs falls by around 80 per cent. In 2010 and 2012 the average fish prices were lower. However, if we adjust total revenue and total costs for the national accounts numbers in 2010 and 2012 correspondingly, we find that the potential resource rent is 6.4 and 6.9 billion higher than the one observed in 2010 and 2012, respectively. Even if this is a very simple adjustment, these numbers are not far from the rent dissipation of 6.7 billion NOK in 2011.

The goal of this paper is not to suggest policy recommendations, but to make visible the cost of the present management system in the Norwegian fisheries. The Marine Resources Act emphasizes both settlement in coastal communities and efficient management of the resource. Some have argued that the ongoing rent dissipation simply is a way to redistribute income in the fishery sector. However, as the resource rent can be increased by applying fewer fishers and fewer vessels, we are per definition in a situation with resource waste in the fishery sector as well as lower value creation in other sectors, as both the fishers and vessels have an alternative value in other industries. However, only in the unrealistic situation where the fishers and vessels that are removed from the fisheries have zero alterative value in other sectors, the present management system could be described only as a way of financing employment in the fisheries through rent dissipation without leading to lower value creation in other industries as well.

The Marine Resources Act states that fish resources belong to Norway as a whole. The profitability of Norwegian fisheries has improved but is unequally distributed among vessel groups. The structural quota system has caused a consolidation in the fishing industry. In conjunction with the structural quota system the introduction of a tax on the resource rent was discussed in a government white paper (The Norwegian Ministry of Trade, Industry and Fisheries, 2007). If such a tax is to be introduced much more would have to be known about the distribution of the resource rent in fisheries among vessel groups and owners.

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Appendix

Table A1. Catch of each species by vessel group (tons)

Vessel group	Cod	Capelin	Herring	Blue whiting	Haddock	Saithe
1	28878	0	0	0	6552	5331
2	35861	0	5120	0	10916	10701
3	34667	0	7125	0	15209	7598
4	17996	4142	17303	0	12546	8355
5	29948	0	0	0	27671	9549
6	103617	0	0	0	72496	67629
7	878	0	1769	0	0	3247
8	794	0	0	0	492	15188
9	630	0	5366	0	29	514
10	9483	8120	64298	0	1217	10942
11	12812	20117	118759	0	2034	34091
12	384	282731	338798	11119	0	1788
13	0	29518	57104	7204	0	1098

Vessel group	Cusk	Mackerel	Ling	Shrimp
1	0	0	0	0
2	0	3262	2174	0
3	1199	0	1233	150
4	812	0	1523	0
5	10311	0	8760	0
6	0	0	483	18870
7	0	535	0	4112
8	0	0	0	0
9	0	2428	0	0
10	0	10693	258	0
11	0	23722	0	0
12	0	145909	0	0
13	0	12952	0	0

Table A2 Average price of each species by vessel group 2011-NOK per kg

Vessel group	Cod	Capelin	Herring	Blue whiting	Haddock	Saithe
1	10.49	0	0	0	7.47	7.1
2	10.85	0	3.25	0	7.03	7.22
3	11.22	0	4.39	0	6.66	7.52
4	11.85	1.64	4.21	0	6.76	7.57
5	14.74	0	0	0	11.15	10.38
6	12.29	0	0	0	8.51	9.55
7	13.27	0	4.25	0	0	9.65
8	14.5	0	0	0	9.11	8.69
9	10.47	0	3.82	0	6.2	5.59
10	10.51	1.57	4.2	0	4.79	4.8
11	10.61	1.95	4.76	0	5.07	4.91
12	8.55	2.21	5.84	4.08	0	4.67
13	0	2.14	5.23	2.27	0	7.13

Vessel group	Cusk	Mackerel	Ling	Shrimp
1	0	0	0	0
2	0	8.95	7.6	0
3	7.77	0	9.78	38.15
4	6.99	0	10.22	0
5	8.86	0	13.49	0
6	0	0	9.73	16.7
7	0	9.64	0	51.78
8	0	0	0	0
9	0	9.33	0	0
10	0	10.39	6.61	0
11	0	12.09	0	0
12	0	12.98	0	0
13	0	10.57	0	0

Table A3. Capacity per vessel by vessel group

Vessel group	Number of vessels, all	Total catch per year in tons	Present capacity per year per vessel in tons	Days in operation per year	Potential number of days in operation	Potential capacity per year per vessel in tons
1	611	40761	67	173	330	127
2	293	68034	232	197	330	389
3	121	67181	555	200	330	916
4	37	62677	1694	207	330	2701
5	35	86239	2464	332	330	2449
6	39	263095	6746	305	330	7299
7	80	10541	132	214	330	203
8	4	16474	4119	300	330	4530
9	43	8967	209	111	330	620
10	93	105011	1129	182	330	2047
11	62	211535	3412	182	330	6186
12	80	780729	9759	173	330	18616
13	27	107876	3995	192	330	6867

Table A4. Variable costs per kg

Vessel group	VC_j
1	18.16
2	11.03
3	8.67
4	6.35
5	10.44
6	7.93
7	25.08
8	7.08
9	8.32
10	4.61
11	3.91
12	3.23
13	2.36

Table A5. Insurance, fixed capital value and depreciation 2011-NOK

Vessel group	Insurance	Fixed capital value	Depreciation
1	24472	793740	67218
2	69796	1993793	175133
3	114469	4976681	378198
4	289408	17787350	1141719
5	467612	39170840	2308457
6	562586	64736886	5871420
7	75728	2301731	192430
8	328193	27377328	2817484
9	13980	774542	57965
10	142344	4127990	336927
11	348571	28331910	1595951
12	609190	66140942	4219244
13	323451	28136452	1994364

Table A6. By-catch of haddock per unit catch of cod in 2011

Vessel group	Lower limit (per cent)	Upper limit (per cent)
1	20	30
2	15	40
3	20	50
4	15	80
5	60	100
6	60	90

Table A7. Catch constraints

Vessel group	Catch constraint				
	Cod	Herring	Mackerel	Capelin	Blue whiting
1	2/3[20]				
2	2/3	1/2			
3	2/3	1/2			
4	2/3	1/2		1/3	
5	2/3				
6	2/3				
7					
8	2/3				
9	2/3	1/2	3/7		
10	2/3	1/2	3/7	1/3	
11	2/3	1/2	3/7	1/3	
12	2/3	1/2	3/7	1/3	2/3
13		1/2	3/7	1/3	2/3

[20] The season for cod is 330 days x 2/3 = 220 days. The potential capacity for vessel group 1 is 184 ton per vessel. This means that the adjusted potential capacity in the cod fisheries is scaled down with 2/3, i.e. 122.7 tons per vessel.

Table A8. f-values with minus 20 per cent on time spent[21]

Vessel group	Cod	Capelin	Herring	Blue whiting	Haddock	Saithe
1	0.72	25.00	25.00	25.00	1.62	1.76
2	0.62	25.00	1.53	25.00	1.25	1.26
3	0.61	25.00	1.31	25.00	1.15	1.29
4	0.65	1.61	0.64	25.00	1.20	1.30
5	0.71	25.00	25.00	25.00	0.69	1.60
6	0.49	25.00	25.00	25.00	1.18	1.19
7	1.60	25.00	1.30	25.00	25.00	1.16
8	3.07	25.00	25.00	25.00	4.35	0.78
9	1.71	25.00	0.67	25.00	16.46	1.87
10	1.37	1.43	0.67	25.00	3.88	1.32
11	1.66	1.42	0.64	25.00	5.16	1.25
12	102.66	0.72	0.77	4.51	25.00	22.83
13	25.00	1.18	0.62	1.75	25.00	5.91

Vessel group	Cusk	Mackerel	Ling	Shrimp
1	25.00	25.00	25.00	25.00
2	25.00	1.75	2.26	25.00
3	2.87	25.00	2.82	15.93
4	4.09	25.00	2.65	25.00
5	1.56	25.00	1.66	25.00
6	25.00	25.00	28.24	1.70
7	25.00	1.99	25.00	0.49
8	25.00	25.00	25.00	25.00
9	25.00	1.18	25.00	25.00
10	25.00	1.33	14.57	25.00
11	25.00	1.36	25.00	25.00
12	25.00	1.27	25.00	25.00
13	25.00	1.42	25.00	25.00

[21] Costs are set to 25 to prevent a vessel group from harvesting that particular species.