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Resource Rent in Norwegian Fisheries
Trends and policies

Abstract:

When we calculate national wealth, we derive the value of the natural resources belonging to the nation from numbers taken from the System of National Accounts (SNA). In many instances this approach may mask the true value of these resources because among other factors the method only takes the present management into consideration. A prominent case is the Norwegian fishery sector, which by Norwegians is considered to be of great importance for the country. All the same, its contribution to Norwegian national wealth was negative in the period from 1984 to 2009. This improved in 2010-12, but in 2013 and 2014, it was again negative.
This paper performs an in-depth investigation of resource rents (RR) from Norwegian fisheries. First, we show the development of the components of RR over time from 1984 to 2014 based on the SNA in order to explain the low resource rents. Compensation of employees is the largest cost component affecting the RR of Norwegian fisheries, and this cost is much larger than the return on fixed capital and capital consumption. We find that RR has for the most part increased since 1984 above all because employment has fallen and to some extent because the amount of capital has declined, while output has been more or less constant. Second, we use a linear programming model to estimate the contra factual RR under the most efficient harvesting of today's quotas using numbers from the Directorate of Fisheries. Although we do not consider whether today's quotas are optimal from a bioeconomic perspective, we find that the efficient RR in 2011 was around 9.3 billion NOK, more than 7 billion NOK greater than the actual RR in 2011.

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Introduction

The UN Report "Our common future" (1987) defines *"sustainable development"* as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*. One possible interpretation of *"sustainable development"* from an inter-generational perspective is that the level of *consumption* in any particular year should not exceed the level making it possible to maintain the same level of *consumption* in future years. Given this interpretation of sustainable development, the question becomes how to know whether we are consuming too much today. Different sets of indicators have been proposed in order to answer this question. One approach is the so-called *capital approach to sustainable development*; see e.g. Alfsen and Greaker (2007). Since "consumption" must be "produced" every year from the use of inputs of which we have certain stocks, we need to monitor the current state of the stocks of inputs, henceforth, the capital stocks. The capital stocks together are denoted *national wealth*, and the task becomes to ensure that *national wealth* is kept intact.

Statistics Norway has been involved in calculating Norwegian national wealth for several years based on national accounts data. Our figures show that national wealth per capita has been on an increasing trend throughout the period 1984 to 2014[1], which is an indication of sustainability. There are flaws in the methods used that may mask unsustainable practices. One obvious drawback is that the national wealth concept employed by Statistics Norway is not comprehensive, that is, national wealth should encompass all types of capital that contribute to human well-being. However, the national wealth calculations only encompass those assets that can be given an economic value from available economic statistics.

Today Statistics Norway relies heavily on the system of national accounts (SNA), that is, national wealth only includes the inputs used to produce net national income (NNI) as measured and defined in the SNA. These comprise inputs from natural resource stocks, human capital stocks, physical capital stocks and financial assets. While both the value of physical capital and foreign financial holdings is given directly in the SNA, the values of the natural resource stocks must be computed. Income, extraction costs, and expected lifetime is assessed and computed for each type of resource. The contribution of each resource stock to national wealth is then given as the present value of the future

[1] There were temporary setbacks in wealth per capita in 1989, 2003, 2008 and 2009.

stream of net incomes which are also coined *resource rents*. The resource rent is the additional income a nation/region obtains from having the exclusive right to exploit a natural resource. The resources included are the renewable natural resource sectors; agriculture, forestry, aquaculture, fisheries and hydropower, and the nonrenewable natural resources; oil, gas and minerals.

Despite everyone's perception of Norway being very rich in natural resources, the calculations show that apart from oil and gas, the natural resources only make up a tiny part of Norwegian national wealth. For instance, in the calculations from 2013, Statistics Norway found that human capital comprised 72 percent of national wealth, while oil and gas and physical capital comprised approximately 9 and 13 percent, respectively. Financial wealth was around 6 percent of national wealth, while the contribution of the renewable natural resources taken together was less than one percent.

Clearly, the method of calculating the resource rents is chosen mainly because it is simple, but if the method leads to a misconception of the importance of a natural resource, it should be reconsidered. For instance, if the resource is managed in a way which redistributes potential income from the resource to less well-off groups in the Norwegian society, the measured resource rents may be close to zero. Alternatively, the government could have maximized resource rents, taxed most of the resource rents and transferred the income to the same less well-off groups. In the latter case, the resource would have looked much more important to the economy, however, it may be politically preferable to transfer resource rents directly to the less well-off.

In order to disclose the true value of the Norwegian natural resources, we propose to calculate a contra factual value of the resources given an optimal management practice. This has previously been calculated for Norwegian fisheries (see for example Hanneson, 1996; Steinshamn 2005), but the last time was several years ago. In this paper we first compare the actual resource rent applying the annual profitability analysis of the Directorate of Fisheries with the value obtained from the Norwegian SNA in 2011. Second, we present an updated contra factual value of the Norwegian fisheries for the same year. Finally, we discuss whether the ongoing rent dissipation is an efficient way to redistribute income or whether there exists obvious ways to improve the resource management.

The Norwegian policy regime

The Marine Resources Act of June 6., 2008 no. 37 states that “the wild living marine resources belong to the Norwegian society as a whole” and the act requires that one uses a precautionary approach, an ecosystem approach, and that there is a safe use of gear. The Act also mandates that resources should be allocated to help ensure employment and settlement in coastal communities and that there should be an optimal utilization of resources that is adapted to marine value creation, markets and industries. 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 fishermen and vessels is partly due to official Norwegian policy. The Norwegian fishery management underwent a large transformation during the last part of the 19 century. Spurred by the collapse in the Atlanto-Scandian herring stock in the late 1960s the Norwegian Government started to restrict entry into more and more fisheries. At the same time they introduced measures such as scrapping subsidies in order to reduce the over-capacity in the fleet. The over-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 it is beyond the purpose of this paper to provide a full review of the whole regime. For as much as about 90 percent 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 overall TACs are allocated by the Norwegian government and politicians to 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 (participated at least three of the last five years) may apply for a commercial license. The rationale for this regulation is to ensure that the returns on the fisheries activities go to the active fishers in the coastal communities.

There is a distinction between vessel groups that belong to the costal fleet and those that belong to the ocean-going fleet when allocating TACs. For instance for cod, the ocean fleet is allocated a larger proportion of the national TAC should there be an increase in the national TAC. While, vessels in the costal fleet receive an annual permit based on the TAC, the boats in the ocean fleet have individual vessel quotas, which may last for several years. The individual vessel quotas only imply a right to fish a certain proportion of the overall TAC allocated to the ocean-going vessels. Moreover, the authorities can withdraw permits and licenses if conditions are not met, and can also allocate new licenses and permits. Licenses and annual permits are not tradable across fleets and vessel categories, as they are issued to and associated with a given vessel type. However, when vessels are traded within a vessel type, the license and annual permit follow the vessel when permission has been granted - with certain restrictions - by the authorities.

In order to reduce overcapacity in the fishing fleet, a system for quota consolidation in the fishing fleet called the Structural Quota System was introduced in 2004. The main principle of the Structural Quota System is that a vessel owner can buy another vessel and transfer the other vessel's quota (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. A geographically dispersed fishing fleet must be maintained in order to support coastal communities and their cultural heritage. Some restrictions are therefore implemented, including maximum quota per vessel, geographically limited markets, transactions only within vessel groups and mandatory scrapping. A major shift took place during the period 2004 to 2006 when some trade across vessel types became permitted. In particular, this reduced the fleet of the trawlers, a type of ocean going vessel. According to the Norwegian fishery authorities, the Structural Quota System resulted in the following degree of traded quotas in selected vessel groups: (check: for what year—all years?)

Table 1. Structural quotas in different vessel group)

Vessel group	**Percentage traded? structural quotas**
Purse seiners herring	18.6 per cent
Pelagic trawlers	54.7 per cent
Coastal vessels herring	39.6 per cent
Cod trawlers	57.0 per cent
Ocean-going line fishing vessels for cod	57.1 per cent
Coastal vessels cod	22.2 per cent

We see that the amount of trading is larger among the trawlers and ocean going line fishing vessels. As far as we can understand, only the ocean going part of the fishing fleet has undergone large structural changes. The coastal fishing fleet still receives a large share of the TAC for many fish stocks, and the incentives for reducing the number of boats are much weaker within this segment.

Calculation of Resource Rent of Fisheries in National Accounts

The calculation of resource rent in Norwegian natural resource sectors is presented in Table 2. Statistics Norway's calculation of resource rent (see e.g. Greaker, Løkkevik and Aasgaard Walle, 2005) in marine fisheries is comprehensive in that it includes full and part-time fishers, and the net revenue from the capture of all wild marine organisms[2], by both commercial and non-commercial vessels. The basic value of production is equivalent to total revenues. The intermediate uses are goods and services consumed or used up as inputs in production. There were no product specific taxes or subsidies in the time period considered in this paper. While there has been and still is in place a fuel tax exemption for fishing vessels, this subsidy is not product specific and is therefore not included in our RR calculations.

When calculating compensation of employees and return to fixed capital, it is a goal to use wage rates and rates of return that reflect the alternative value of both the fishers and the capital employed in the sector. Statistics Norway calculates the compensation of employees as the number of hours worked times the average mainland wage rate for the non-natural resource industries, and the return on fixed capital is four per cent of the value of the stock of fixed capital. We have to include income for the vessel owners, as their income is not part of the wages in the profitability analysis, but part of the operating profit.

Table 2. Calculation of resource rent

Sign	Term
+	Basic value of production
-	Intermediate uses
+	Taxes on products
-	Subsidies on products

[2] Including seal, whale, ocean salmon, sea trout, crustaceans, shells, seaweed and other income as e.g. freight traffic and own investment work. Aquaculture is not included.

=	Gross product
-	Non-Industry specific taxes
+	Non-Industry specific subsidies
-	Compensation of employees
-	Return on fixed capital
-	Capital consumption
=	Resource rent of the sector

Special care must be taken when deciding which subsidies and taxes to include in the calculation of the resource rent and how to include them. 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. There are no product specific taxes or subsidies in Norwegian fisheries. Industry specific taxes and subsidies are not 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 value of the bottom line value of the resource rent. However, industry specific taxes and subsidies may 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 over-capitalization and “too many boats 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 to the Norwegian Government of the fuel-tax exemption was estimated to NOK 999 million in 2011 (Isaksen, Hermansen and Flaaten, 2015). Non-industry specific taxes are subtracted and non-industry specific subsidies are 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 firms’ social security contributions.

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 National Account numbers. Gross product is total revenue fewer subsidies on products plus taxes on products, before we deduct the value of intermediate uses as explained in Table

2. The resource rent is negative for all years except for the period 2010-12[3]. The reason is primarily the high level of compensation of employees compared to the gross product. The resource rent is generally 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). The increase in rent is above all due to lower compensation of employees and to some extent reduced capital consumption and return on fixed capital. 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[4] is more or less the same. Even if the number of man-years for the full-time and part-time fishers has declined by around 60 and 72 per cent, respectively, as shown in see Figure 3, compensation of employees is only 30 per cent lower in 2014 compared to the early 1980s due to increases in real wages.

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

[3] The resource rent according to Statistics Norway and the national accounts was 3.364 billion NOK in 2011. However, applying the numbers in Directorate of Fisheries (2012) the rent is around 2 billion NOK. Part of the reson is that Statistics Norway includes part-time fishers. See also footnote 2.

[4] 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.

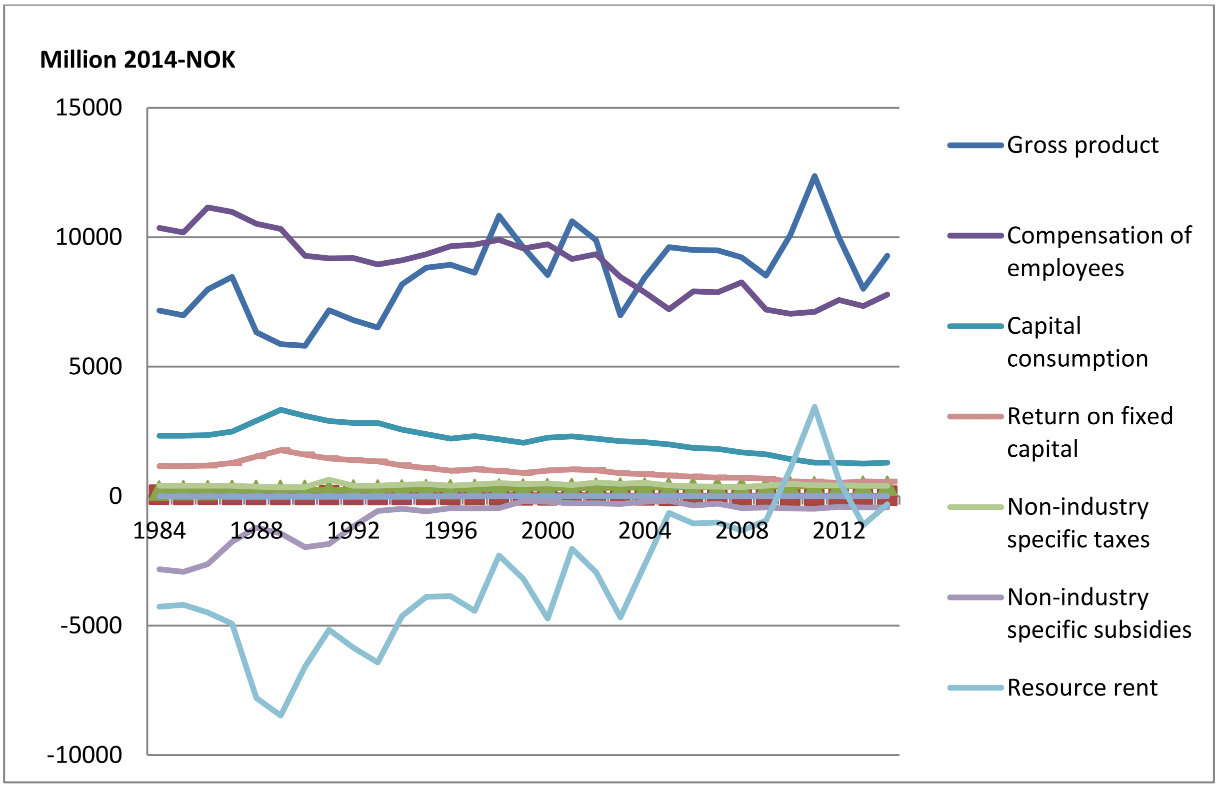


Figure 2. The number of vessels 1984-2013 and gross tonnage 1997-2012 in Norwegian fisheries

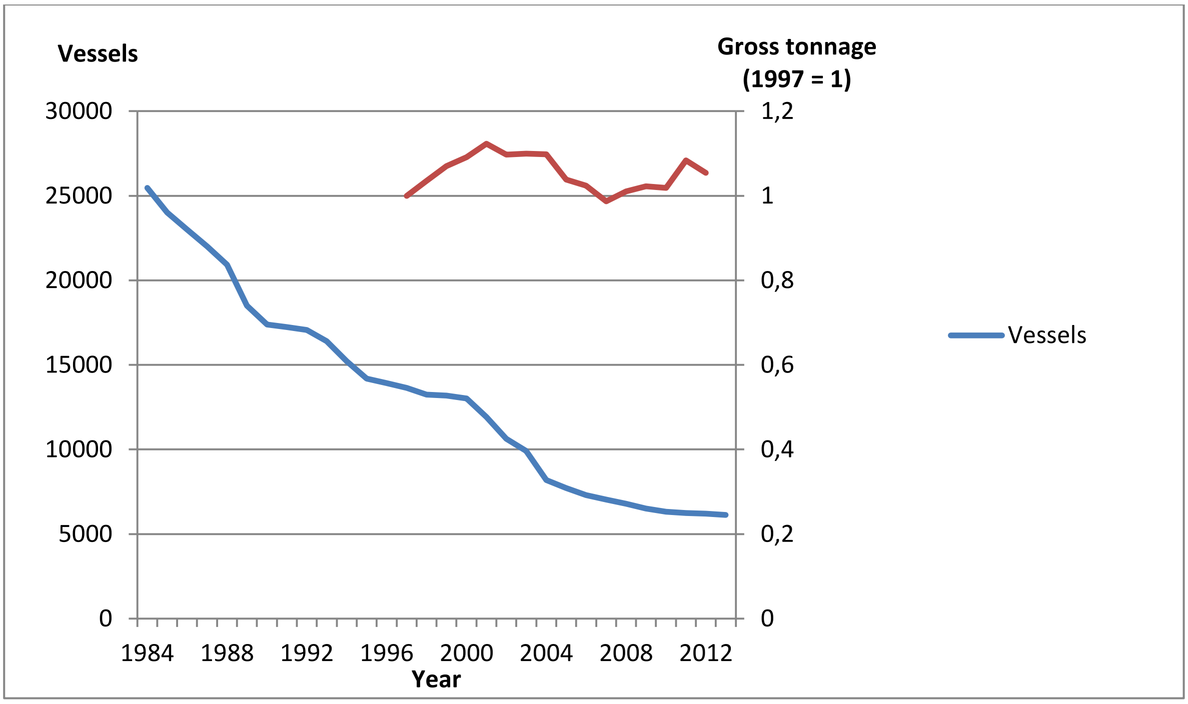
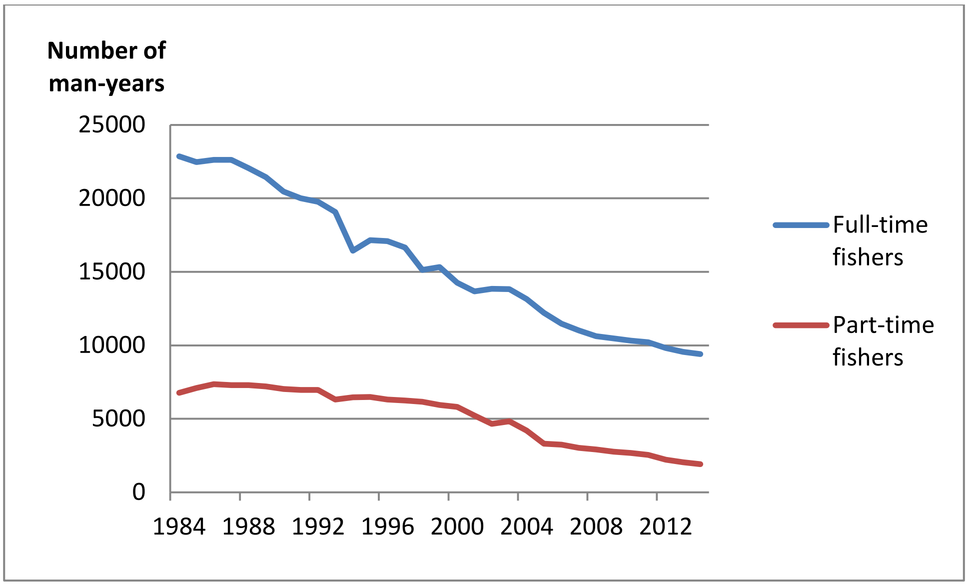


Figure 3. The number of man-years in Norwegian fisheries 1984-2014



A closer look at the resource rent in 2011, actual and potential

The resource rent obtained is highly dependent on the management regime such as (1) amount harvested (TACs) and (2) how this is harvested such as number of and composition of the vessel types, geographical distribution of quotas, and technology. Ideally, TACs could be set such that stocks could be harvested sustainably for perpetuity while maximizing profits for the entire fishery, a so-called bioeconomically optimal harvest level. There is some evidence that TACs have not been set to the bioeconomic optimal level and that some stocks have been overharvested in periods. For example, based on biological advice, the 2011's TACs were zero for coastal cod north of 62 latitude, Norway pout, and golden redfish. Even if the TACs are set to the bioeconomic optimal levels the number of vessels may be too large, the distribution of quotas may be inefficient and for some vessels, the technology may be inefficient in order to maximize the RR.

As shown in Figure 1 and Table 3 , Statistics Norway's estimate the resource rent in Norwegian capture fisheries to 2011-NOK 3.364 billion. This is, as already mentioned, a comprehensive measure of RR including part-time fishers, non-commercial fishers and harvest of salmon and sea trout, harvest of species other than fish and shrimp, as well as other income as e.g. freight traffic and own investment work. If we instead consider the RR for fishers included in the profitability survey by the Directorate of Fisheries, the calculated resource rent was 2011-NOK 2.050 billion. To be included in the 2011 profitability survey vessels had to earn a certain level of income from their fishing operation[5]. If further narrowing it down to the ten[6],[7] economically most important species the RR was 2011-NOK 1.453 billion.

Table 3. Estimates of the resource rent.

Source	Resource rent (billion NOK)
Statistics Norway RR. Full-time and part-time fishers, commercial and non-commercial harvest.	3.364 billion NOK
Profitability survey RR. Includes fishers that earn a certain minimum annually.	2.050 billion NOK
RR calculated for the ten most valuable species	1.453 billion NOK

Given today's TACs, number of vessels, and labor force we now move on to find an estimate of the maximum potential RR 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 season length. To do this we use a linear programming model based on Steinshamn (2005). The model maximizes net revenues, that is 'RR', given the total allowable catch for each fish species *i*, TAC_i, and the fixed catch capacity per vessel in vessel group *j*, 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) $$\sum_j Y_{i,j} \leq TAC_i \qquad i = 1, \ldots, N$$

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

[5] 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.

[6] 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.

[7] We focus on these six 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).

(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 time/effort coefficient, 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. We add to this model by-catch relationships and seasonal catch-limits (Steinshamn, 2005) which we discuss in the data section. Politically determined constraints, such as the distribution of catch between coastal and ocean going vessels are omitted from this model. 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.

Data

We consider the thirteen vessels groups (see Table 4) that are included in the Norwegian Government's 2011 profitability survey of the fisheries (Directorate of Fisheries, 2012).

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 of Norway, 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 of Norway	27	215
			1525	8389

These vessel groups harvested a total of 2 million metric tons in 2011 when the first-hand value was estimated to NOK 14.6 billion. This corresponds to about 91 percent of the total first-hand value in Norwegian fisheries in 2011[8]. For *TAC* we use the actual total Norwegian catch in 2011. However, we include only ten species in our optimization model. The *TAC* for these ten species was 1.83 million tons in 2011 (see table A1 in Appendix A), and constitute 71 percent of the total resource rent when we apply total catches in the profitability survey.

[8] 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 tonnes in the profitability survey is around 90 per cent of total Norwegian catch.

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 less depreciation on vessel and less depreciation on fishing licenses and permits and less insurance on vessel. This value is divided by total catch to get variable costs per kg (see Table A4 and A5).

The variable cost may be adjusted by a *time/catch relation* $f_{i,j}$ to take into account that the time used to catch fish of a certain species varies among species and vessel types. The f_{ij}-values applied in Steinshamn (2005) were based on estimates from the 1996 and 1994 Survey of Activities[9]. Steinshamn's (2005) numbers cannot be applied directly in our study as the Directorate of Fisheries has formed new and consolidated vessel categories since then. While Steinshamn (2005) operates with 25 vessel groups, we now have 13 groups (see Table 4). Furthermore, the only existing f-values are based on 17-18 year old data when stocks and technologies were different. Thus in lack of better knowledge, we chose to set all $f_{i,j}=1$.

To estimate 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).

We include bycatch constraints that show the relationship of haddock caught per unit cod (see Table A6). We also include restrictions on the length of the season due to weather conditions; climate, resource availability etc. (see Table A7). These are included in the model through an upward adjustment of the variable costs to get adjusted potential variable costs. Further, we introduce restrictions on the shrimp fisheries because it 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

[9] Aktivitetsundersøkelsen i 1996.

have seen in the last three years by capturing market shares from ocean trawling vessels with cold storage plant (which are part of the trawlers on vessel group 6).

Steinshamn (2005) also included a number of politically determined constraints on the distribution of fish catches among vessel groups; particularly coastal vessels versus ocean vessels. We do not want to implement political constraints in our base case as we are interested in the potential resource rent that is technical and biological possible, but we do include political constraints in a special case.

Optimization results

Base case

In the base case, we add by-catch constraints but limit ourselves the number of vessels in 2011 for each vessel group. We do not add politically determined catch distribution constraints among coastal and ocean going vessels. 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 species. 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[10]. The profit maximizing resource rent from only the ten economically most important species was found to increase by a factor of 4.55 from 2011-NOK 1.453 billion to 2011-NOK 6.614 billion. Add to this the resource rent of the species not included in this optimization (but included in the 2011 Profitability Survey), we get a total RR of NOK-2011 7.211 billion for commercial fishers if there is no efficiency improvement in the harvesting of these species and an RR of 2011-NOK 9.330 billion if these species also permit an increase in the RR by a factor of 4.55 through efficiency improvements. Using these numbers and a discount rate of four per cent, the Norwegian fish resource is worth 2011-NOK 233 billion or 2014-NOK 245 billion (adjusted using the consumer price index). When decomposing the change in RR compared to the base case into the changes in total revenue and total costs, we find that total revenue falls by about 10 per cent, which means that the catches are redistributed to vessels that receive a lower price in the optimum. Simultaneously, total costs falls by 80 per cent, this means that maximization of resource rent is almost synonymous with allocating the catch to the most cost-effective vessel groups.

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

Steinshamn (2005) calibrated a similar model with 2002 data that included 10 species and also added some institutional constraints (i.e. the TAC distribution between coast and ocean vessels). Steinshamn (2005) found that RR could be increased from literally zero to 2002-NOK 7.365 billion that is 2011-NOK 9.2 billion[11]) with a five percent discount rate[12]. Steinshamn's and our RR estimates necessarily differ because of model calibration, different species in the optimization model, differences in vessel groups, and because Steinshamn (2005) includes some additional institutional constrains. Our base case also includes a specific compensation to the owner of the vessel owner. In the base case, this compensation is set to the average mainland annual wages for non-resource sectors.

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 capelin fisheries, where the marginal income is negative for all vessel groups.[13] We would like to *strongly emphasize* that the distribution of catch among vessel groups is sensitive to e.g. how vessel groups have been defined by the Directorate of Fisheries. The most efficient vessel groups are coastal seine vessels < 11m' (gr. 9) and 'coastal seine vessels >21m' (gr. 11). All existing vessels in these vessel groups are utilized in the solution. In addition, 3 'coastal conventional vessels 15-21m', 4 'coastal conventional > 21 m', 6 'trawlers', 7 'coastal shrimp trawlers', 9 'coastal seine < 11m', 10 'coastal seine 11-21m', 12 'purse seines' and 13 'pelagic trawlers' are used in the solution. Vessel groups 1, 2, 5 and 8 are not fishing in the optimal solution given our calibration of the data. 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 (4,950).

'Pelagic trawlers' catch all saithe up to capacity (176,031 ton). Haddock is caught by 'coastal seine vessels < 11m' (26,660 ton), 'coastal seine vessels 11-21 m' (14,918) and 'coastal seine vessels > 21m'(107,584). 'coastal seine vessels > 21m' also catches all the cod (275,948 ton). 'coastal conventional > 21 m' catches all the cusk (12,322 ton) and all the ling (14,431 ton). 'purse seines' catches the whole herring quota (615,642 ton), the whole mackerel quota (199,501 ton) and all the

[11] Adjusted by the weighted average of the consumer price indeces for public andprivate consumption.

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

[13] Even if we double the length of the season and hence vessel capacity, which means a halving of the variable costs for all vessel groups, the capelin fisheries is still not profitable. The landed value of capelin was around 5 per cent of the total value of our ten species in 2011.

blue whiting (18,323 ton). The purse seines are responsible for most of the catch; as much as 833,436 ton.

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

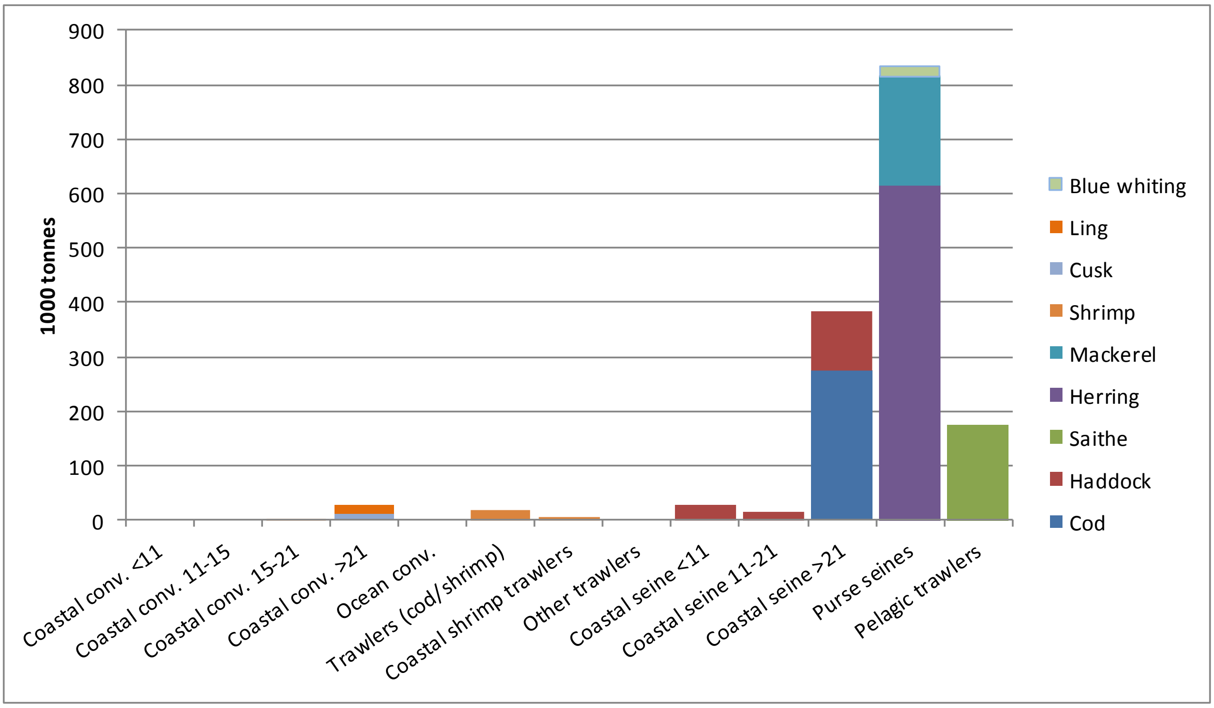
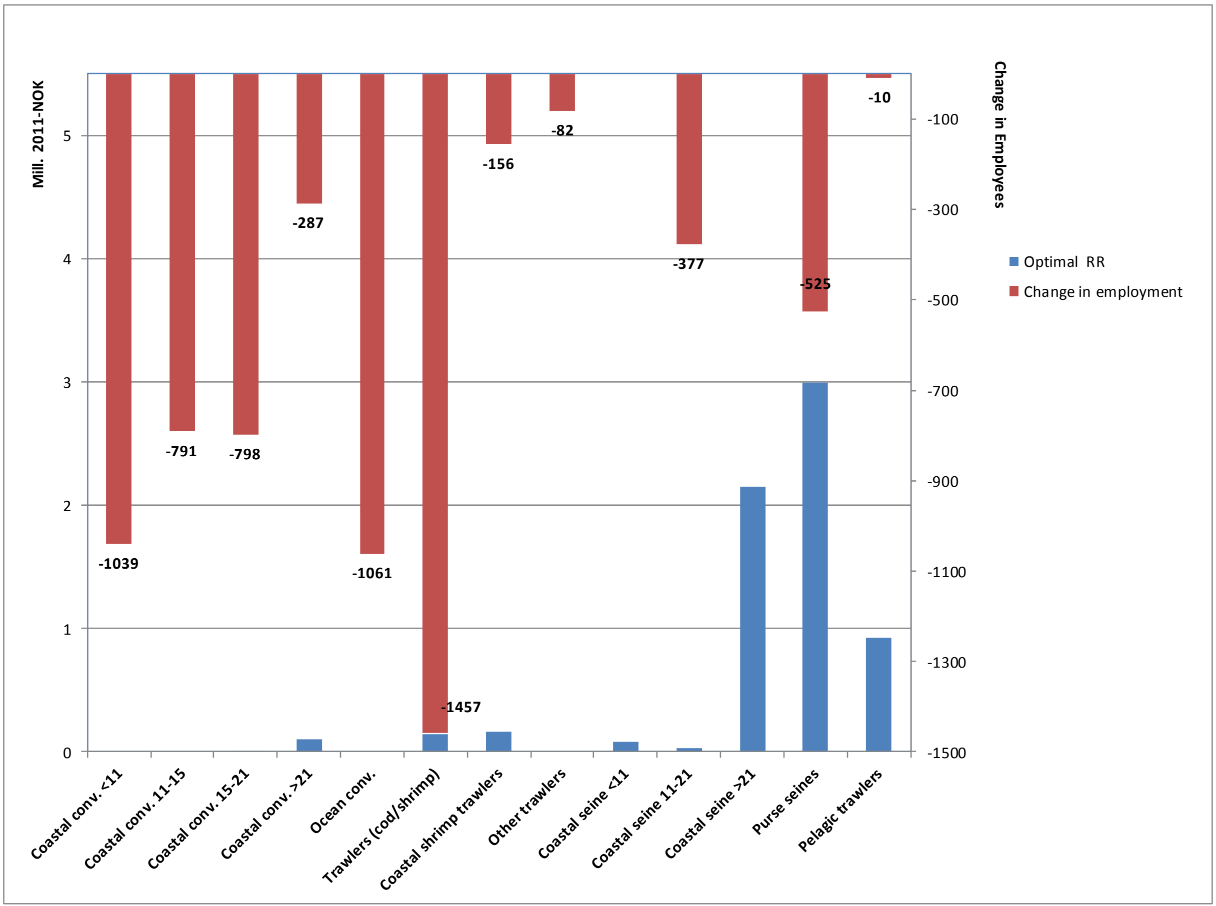


Figure 5 shows the distribution of the resource rent among vessel groups in the base case. As measured in 2011-NOK, 'purse seines' have the largest RR of 2.99 billion, 'pelagic trawlers' have RR of 926 mill, and 'trawlers' earn a surplus of 147 mill. The resource rent among coastal vessel groups is distributed as follows:

- 'coastal shrimp trawlers': 167 mill.,
- 'coastal seine vessels < 11m': 86 mill.,
- 'coastal seine vessels 11-21m': 29 mill.,
- 'coastal seine vessels > 21m': 2.156 billion.,
- 'coastal conventional vessels 15-21m': 5 mill.,
- 'coastal conventional vessels >21 m' 106 mill.

Employment in fisheries is reduced from 8389 positions to 1,806 positions.

Figure 5. Optimal resource rent by vessel group and change in employees by vessel group.



Maximum Potential Resource Rent for the most Efficient Vessel Groups

The resource rent is clearly dependent on the harvesting technology. Since the resource rent is not maximized under today's conditions and policy regime, the maximum potential resource rent is a hypothetical concept. The maximum potential resource rent critically depends on the assumptions we make for the use of labor and capital. The base case finds the maximum potential resource rent when using the existing vessel fleet more efficiently. The structure and efficiency of today's vessel fleet reflect past decisions and policies. What could the maximum potential resource rent be if we had a more optimal (modernized) fleet of vessels? Recognizing a new vessel fleet will not appear overnight, Steinshamn (2005) strategy to answer this question was to keep the existing fleet of vessels making each vessel as efficient as the most efficient vessel in the respective vessel group. To perform the analysis Steinshamn (2005) used data on costs from the Directorate of Fisheries. Because these cost data are not publicly available we were unable to repeat Steinshamn's analysis for 2011 in the available time frame for this study. Instead we calculate maximum potential RR if one freely could add new vessels to the most efficient vessel *groups* (types). We find that the resource rent from the ten economically most important species increases by 2011-NOK 287 mill to 2011-NOK 7.38 billion if one had unlimited access to vessels in the most efficient vessel groups.

The cost distributing quotas among coast and ocean going vessels.

We also ran a case where certain coastal vessels were not allowed to harvest more pelagic fish (herring and mackerel) than they did in 2011 and where certain ocean vessels were not allowed to harvest more cod than they did in 2011. These constraints reduced the resource rent by an estimated 2011-NOK 900 mill.

Sensitivity analysis

Probably the most uncertain parameter in our analysis is the time/catch relationship for species *i* and vessel group *j*, which is based on Steinshamn (2005) who as mentioned based his f_{ij}-values on data from the 1997 activity analysis. Unfortunately, no new data on the time/catch relationship has been gathered since 1997. The accuracy of the f_{ij}-values is limited because they reflect the fish stocks, technology that was present in 1997. The accuracy of the f_{ij}-values is further diminished by the fact that the official vessel groups in 1997 had been consolidated by 2002, and there were further consolidations by 2011. We attempted to generate new f_{ij}-values but concluded that too many inaccuracies arose. In the base case all $f_{ij} = 1$ meaning that all species are caught just as easily. This may be justified with newer technology for finding fish.

We therefore run a number of additional sensitivity analyses. First, we study how RR changes with other estimates of the alternative wage rate of the fishers and the owners. In the base case we applied the average mainland wage rate for the non-natural resource industries for both fishers and owners, 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 rates. Applying the annual average wage rate for the primary sectors[14] leads to a RR of NOK 7.282, a ten per cent increase from the base case. Following Steinshamn (2005), we set the alternative wage rate for the owners to zero. However, this only increases RR with 2.5 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.

[14] 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.

Further, we run a sensitivity analysis on prices (+ / -) 20 per cent. Actually this price increase and decline leads to a 36 per cent increase and a 37 per cent reduction in RR, respectively. The reason is that the price changes alter the combined resource rent for 'purse seines' and 'pelagic trawlers' with as much as 80 per cent, and these groups constituted the lion's share of RR in the base case.

We also study the effect on the results of the bycatch constraints between cod and haddock. Omitting the bycatch constrains has negligible effects on the results; the constraint is only binding for vessel group 4 'coastal conventional > 21 m' (see Table A6 in the appendix). RR only increases with NOK 1 million, with a decline in RR of vessel group 9 'coastal seine vessels >21m' of NOK 29 million, which is now not participating in the fisheries, and a corresponding increase in RR of vessel group 4 'coastal conventional > 21 m' of NOK 30 million.

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 RR. In other words, the fising season for each vessel group is not increased and 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 RR of 11 per cent from the base case.[15] The main explanation for this is a reduction in the value of the cod fisheries in 'coastal seine vessels >21m' (gr. 11) of almost NOK 700 million, although 'other trawlers' (gr. 8) increases its cod fishery somewhat. However, as 'coastal seine vessels >21m' is a group of large vessels, this result does not seem reasonable. 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. However, all in all, the latter two sensitivity analysis show that the bycatch constraints and the assumption of increased seasonal length in the base case, is not important for our result; RR can at least be increased by a factor of 4 from the present RR in 2011.
The interest rate has been set to four per cent in all previous RR calculations at Statistics Norway, thus we will not run any sensitivity analysis on this parameter value.

[15] Even with the present seasonal length (as well as with the present vessel and gear types) this means that RR increases from NOK 1.453 billion in the base case to 5.874 billion, an increase by a factor of 4.

Discussion of results

RR has generally been on an increasing trend from 1984 to 2014. Norwegian fisheries have in some of the later years has had positive RR. However, tin 2013 and 2014 RR were again negative. Factors contributing to the increasing RR:

- A year by year reduction in the number of hrs. worked in the sector reducing total compensation to 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 RR 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. Our optimization results suggest that the RR in Norwegian fisheries could be greater than today. In principle, RR could be increased through further decreasing number of vessels and employment, by increasing the season length and by redistributing the catch to the vessels that receive the highest prices and the lowest costs. Our results show that the single most important change in our optimization is allocating the catch to the most cost-effective vessel groups. We indicate that RR could be increased by a factor of 4.5 from today’s level. For the ten economically most important species the RR in 2011 could be, according to our results, increased from about 1.5 billion NOK to about 6.6 billion NOK. This order of magnitude increase in the RR of Norwegian fisheries is consistent with the results of previous studies. The optimal redistribution of catch among vessels depends on the calibration of the optimization model. The variable costs of each vessel group may be affected by time/catch relationships, for which we have no usable data. The last data on time/catch relationships were collected in a survey of fishers in 1996, when stock-levels and technology were quite different from today. Thus, while the RR could be increased considerably, we need better data on time/catch relationships to infer which vessel groups are the most efficient. With our calibration of the model, vessel groups that catch pelagic fish such as herring and mackerel are quite profitable, while coastal vessel groups appear less profitable, except for ‘coastal seine vessels > 21m’ which rank as the second most important vessel group after ‘purse seines’. Finally, RR could hypothetically be even greater if TACs were set at the bioeconomic optimal level. If TACs are interpreted as maximum sustained yield (MSY), then with improved technology for finding the fish and reduced search costs, MSY and bioeconomic optimal catch levels may not be all that different.

Conclusions and further work

We find that the RR of Norwegian fisheries has increased through fleet consolidation resulting in fewer employed and less capital costs. We also find that there is further potential for increasing the RR through further fleet consolidation, less employment, by allowing the most profitable vessels catch more and by extending the catch season. The dominating structural change needed is allocating the catch of the various species to the most cost-efficient vessels. For our model calibration, we found that that the maximized RR in 2011 for the 10 most profitable species was about 6.6 billion NOK. If the same increase in RR could be realized for all other species, the RR rent in 2011 for Norwegian fisheries could have been NOK 9.3 billion. Assuming that TACs were bioeconomically optimal, and for the prices and technology in 2011 this means that the Norwegian fish resource is worth NOK 230 billion.

Our sensitivity analyses show that it is highly probable that the optimal RR could increase further if we had applied lower alternative wages than in the base case, to better reflect the fishers and owners true alternative value. In addition, we show that our results of a potentially high optimal RR are neither dependent on assumptions of bycatch constraints nor on the extension of the actual fishing season and capacity in 2011 for the various vessel groups. However, RR is of course highly dependent on the prices, especially on those species caught by the most efficient vessel groups. Future work could see if we get the same relative increase in optimal RR in 2010 and 2012, when the average prices and actual RR were lower.

The Marine Resources Act emphasizes both settlement in coastal communities and efficient management of the resource. One way to finance employment and settlement in coastal communities is through RR dissipation. However, the employment in the fisheries sector has fallen by 75 per cent since 1984 thus less RR is dissipating into securing settlement in coastal communities.

The fish resources belong to Norway as a whole as is clearly stated in the Marine Resources Act. The profitability of Norwegian fisheries has improved but the profits are on fewer hands than earlier. This raises the question: at what point are Norwegian fisheries sufficiently efficient that a sector specific tax is necessary to be in compliance with the Marine Resources Act. In addition, while the RR has increased, RR is likely distributed unequally among vessel groups. If a sector specific tax was to be introduced, more would have to be known about the rent distribution among vessel groups.

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Appendix

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

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 tonnes	Present capacity per year per vessel in tonnes	Days in operation per year	Potential number of days in operation	Potential capacity per year per vessel in tonnes
1	611	40761	67	173	330	127
2	293	65860	225	197	330	377
3	121	64749	535	200	330	883
4	37	56200	1519	207	330	2421
5	35	67168	1919	332	330	1908
6	39	262612	6734	305	330	7286
7	80	10541	132	214	330	203
8	4	16474	4119	300	330	4530
9	43	8967	209	111	330	620
10	93	96633	1039	182	330	1884
11	62	191418	3087	182	330	5598
12	80	486879	6086	173	330	11609
13	27	71154	2635	192	330	4529

Table A4. Variable costs (not adjusting for seasonal length) 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. Bycatch 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[16]				
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

[16] The season for cod is 12 months x 2/3 = 8 months. The potential capacity for vessel group 1 is 184 tonne per vessel.This means that the adjusted potential capacity in the cod fisheriesis is scaled down with 2/3, i.e. 122.7 tonne per vessel.

Table A8. Adjusted potential variable costs per kg

Vessel group	Cod	Capelin	Herring	Blue whiting	Haddock	Saithe
1	14.28	25	25	25	9.52	9.52
2	9.89	25	13.18	25	6.59	6.59
3	7.89	25	10.52	25	5.26	5.26
4	6.14	11.94	7.96	25	3.98	3.98
5	16.02	25	25	25	10.68	10.68
6	11.10	25	25	25	7.33	7.33
7	16.58	25	16.26	25	16.26	16.26
8	9.66	25	25	25	6.44	6.44
9	4.20	25	5.6	25	2.8	2.8
10	3.81	7.62	5.08	25	2.54	2.54
11	3.24	6.48	4.32	25	2.16	2.16
12	2.55	5.10	3.40	2.55	1.70	1.70
13	25	4.11	2.74	2.06	25	1.37

Vessel group	Cusk	Mackerel	Ling	Shrimp
1	25	25	25	25
2	25	6.59	6.59	25
3	5.26	25	5.26	5.26
4	3.98	25	3.98	25
5	10.68	25	10.68	25
6	25	25	7.33	7.33
7	25	16.58	25	16.26
8	25	25	25	25
9	25	6.53	25	25
10	25	5.93	2.54	25
11	25	5.04	25	25
12	25	3.97	25	25
13	25	3.20	25	25