# The resource rent in Norwegian aquaculture from 1984 to 2020 – is the rent ripe for taxation?

**Mads Greaker and Lars Lindholt**

***Abstract:***

This study uses the National Accounts and the definitions of the UN System of Environmental-Economic Accounting to calculate the resource rents in Norwegian aquaculture in the period 1984-2020. If we know the remuneration of all input factors such as capital, labour, and intermediates except the remuneration of the ecosystem services used in aquaculture, the resource rent will appear as the difference between the value of output and the remuneration of all other input factors. This resource rent is a combination of a Ricardian rent and regulation rent. To assess the size of the rent, we perform various sensitivity analysis as introducing higher rates of return, applying alternative wage costs and by treating the stock of growing fish as real capital. A robust conclusion is that there has been a significant resource rent in aquaculture since 2000 and that it has risen markedly since 2012. In the period 2016-2020 it has averaged 18-20 billion NOK per year. Hence, both from an allocative justice and economic efficiency perspective, the Norwegian aquaculture industry seems ripe for resource rent taxation.

**Keywords:** Resource rent; Aquaculture; National Accounts; System of Environmental-Economic Accounting

**JEL classification:** Q22; L11; E22

**Acknowledgements:** Thanks to Erling Holmøy and Oddbjørn Grønvik for valuable remarks. Thanks to Brita Bye for comments to an earlier version of the paper. The project is financed by the Research Council of Norway.

**Address:** Mads Greaker, Oslo Metropolitan University and Statistics Norway, madsg@oslomet.no
Lars Lindholt, Statistics Norway, Research Department. E-mail: lli@ssb.no

# 1. Introduction

Economic profits obtained from utilizing natural resources is related to the term resource rent (RR). According to the UN System of Environmental-Economic Accounting, the RR is the income from the harvest operations that remains after all necessary input factors registered in the National Accounts (NA) have received their remuneration (SEEA, 2014). RR is thus the additional income from having access to a natural resource, or in other words; what you earn beyond the income you would normally earn by investing in real capital and human capital in competitive industries.

Calculating RRs is interesting from a taxation perspective. First, there is an allocative justice argument for taxing the extra income from utilizing a natural resource. To the extent that the natural resources of a country belong to the people, either by law or by common practice, it is by many seen as unfair that a few prospectors get away with a major share of the extra-normal profit. Second, it is generally acknowledged that a RR tax is close to neutral (see, e.g., Garnaut, 2010). A RR tax can thus provide the government with revenues without incurring significant dead weight losses. In Norway both the petroleum and the hydropower sector are subject to RR taxation.

In this paper we look at Norwegian aquaculture from the early beginning in the 1980s until today. Our research question is whether there is RR in this industry. The starting point for calculating the rent is that aquaculture production can be expressed by a production function, where one or more ecosystem services enter as input factors (Ministry of Climate and Environment, 2013). The relevant ecosystem services are, e.g., salinity in the water, tides, currents, seawater temperature, oxygen levels, carrying capacity of the seabed and the surroundings in general. Aquaculture firms use these ecosystem services together with other input factors such as juvenile fish, feed, labor and capital. The remuneration of the latter factors is readily available in the NA. By using the NA, we can thus calculate the RR, which then appears as the difference between the value of output and the remuneration of the factors with a market price.

We find that there has been a significant RR in aquaculture since 2000 and that it has risen markedly since 2012. In the period 2016-2020 it has averaged 18-20 billion NOK. Adjusting for corporate tax, about 80 per cent of these extra-normal profits accrue to the licensees, e.g., the aquaculture firms. As most of the licences once were given out for free by the Norwegian state, there are many voices in Norway arguing for resource taxation of the industry. The industry, however, succeeded in convincing the largest political parties to abandon RR taxation for aquaculture.

According to Åm (2021), this can partly be explained by the industry's success in convincing the politicians that their extra-normal profit was due to the hard work of entrepreneurs and not due to the use of scarce natural resources. In this paper we contest this view; of course, aquaculture entrepreneurs have likely worked hard (as most other entrepreneurs), however, in our opinion their extra-normal profit stems from their unique and free access to scarce natural resources.

Our finding about the high RR in aquaculture finds support in other studies. Flåten and Pham (2019) also estimate the RR in aquaculture. They base their estimates on the companies which is included in The Directorate of Fisheries' profitability survey (2021) to about 19 billion NOK in 2016. If this estimate is scaled up to include all aquaculture companies, the RR can be estimated to approximately 27 billion. Ministry of Finance (2019) applies tax data and show that the RR has varied from about 10 to about 23 billion NOK (2019-NOK) in the period 2013 to 2017. However, neither Flåten and Pham (2019) nor the Ministry of Finance (2019) provide a time series of RRs as we do. Lastly, the RR in aquaculture can also be interpolated from prices obtained in the two aquaculture license auctions that were held in Norway in the years 2018 and 2020.[1] This was done in the commission report which found a good match between auction prices and the RR estimates, see Ministry of Finance (2019).

There are several reasons why natural resources can give positive RR. The starting point for all the explanations is that natural resources are scarce and/or with limited access (see e.g. Brekke and Lurås in Brekke et al. 1997). This means that one can achieve extra-normal profits on utilizing a natural resource over a long period of time, without entry of new suppliers. Or, to put it another way, the limited access prevents free entry that would otherwise have pushed the profits down to the normal return on capital. Some authors coin this rent "regulation rent", see the discussion in Section 2. In addition, sites with more favourable environmental conditions can give rise to higher profits compared to lower quality sites. This is often referred to as "Ricardian rent" after David Ricardo, who at the start of the 19th century studied rent from different plots of land.

Not all natural resources will lead to positive RR. In some cases, it may simply be too costly to extract the resource compared to the market's willingness to pay for the resource. In other cases, the way the extraction is organized can entail too high costs and an inappropriate level of extraction so that RR becomes zero. The so-called tragedy of the commons is an example of the latter (Hardin, 1968). *A priori* it is thus not obvious that aquaculture will generate extra-normal profits. However, the limited

[1] This was the first occasion in which aquaculture licenses were auctioned. Before 2018 they were either provided free of charge, or to a low fixed price.

number of good localities worldwide suggest that there are extra-normal profits to be earned. Good localities depend, among other things, on climatic conditions, qualities of seawater and protection from weather and wind. Moreover, free entry at the good localities would lead to environmental degradation and high farmed salmon mortality. Thus, to ensure a healthy industry and to avoid environmental damages, governments in all salmon aquaculture countries regulate entry.

Statistics Norway has calculated the value of Norwegian natural resources for several years based on data from the NA (see e.g. Greaker et al., 2005; 2016; 2017). The resources included in the Norwegian NA are the renewable natural resource sectors; agriculture, forestry, aquaculture, fisheries and power production (and occasionally also agriculture and fishing for own use and hunting, and the nonrenewable natural resources; oil, gas and minerals.[2] The starting point for our estimations of RR in aquaculture is a Norwegian report (Greaker and Lindholt, 2019), which was used by the Aquaculture Tax Commission appointed by the Ministry of Finance in 2019. Compared to the Norwegian report, we extend the time series and add more robustness calculations.

We also include a discussion of the method used by Statistics Norway for the RR estimations, which again is based on the System of Environmental-Economic Accounting 's (SEEA) definition of the components of RR (SEEA, 2014). This method has received criticism in the literature. With point of departure in wild catch fisheries, Arnason et al. (2018) argue that the SEEA definition of RR mixes RR with intramarginal profits. Furthermore, Asche et al. (2020) argue that a significant part of the extra-normal profit in the Norwegian aquaculture industry is due to company specific technology and knowledge and not due to the use of scarce resources. We discuss the definition of RRs in Section 2 and Section 5 and conclude that the SEEA measure in the case of aquaculture is a robust measure of RR. The discussion is a novelty compared to similar studies of RR, see, e.g., the study of Norwegian fisheries in Greaker et al. (2017).

In the Norwegian debate following the report of the commission advocating RR taxation of aquaculture other arguments against the SEEA method of calculating RRs were also floated. Some argued that the stock of standing salmon in the sea should be included together with other forms of capital in the RR calculations. This is not the case for the NA as salmon is not considered to be livestock. In this paper we anyhow deal with the issue in a new manner and show that this would not significantly have changed the results for the RR calculations. Others argued that the specific risk in

---

[2] See Lindholt (2021) for an updated time series estimation of RR in oil and gas, forestry, fisheries and hydropower.

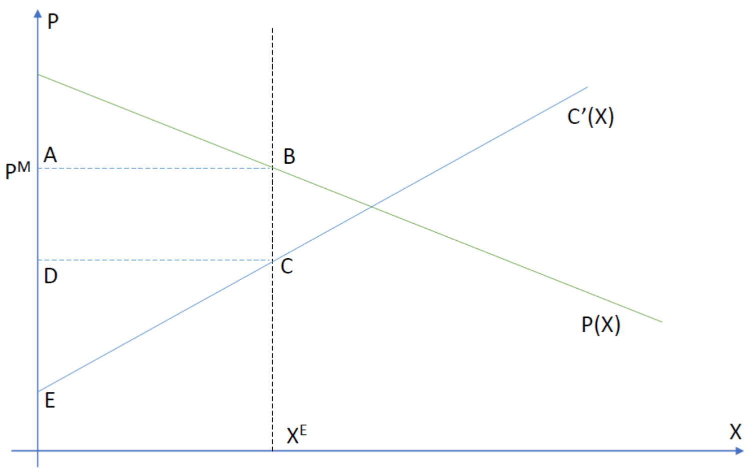
an aquaculture project should inform the choice of interest rate for the capital cost calculations. We provide an elaborate discussion of the choice of interest rate. In line with the capital asset prising model (CAPM), we argue that it is not the specific project risk that should be determining the cost of capital, but the systematic risk in aquaculture.  Finally, some argued that the value of a company's aquaculture licenses should be included among the capital assets in the RR calculations. This argument is obviously flawed; the value of a license should be equal to the current value of a stream of RRs from the operation. Hence by including the value of a license in the capital base, we would eliminate the RR we seek to uncover.

The rest of the paper is laid out as follows; Section 2 discusses the concept of RR, while Section 3 introduces the method for calculation of resource rent using NA. Section 4 presents the resource rent from 1984 to 2020, while Section 5 discusses the results. Section 6 concludes.

# 2. The concept of resource rent

RR is most often associated with non-renewable resources. Since they will ultimately run out, there is a scarcity rent reflecting the willingness to pay for having more of the resource. SEEA (2014) also uses the term RR for renewable resources, while other authors introduce terms like Ricardian rent and regulation rent. Below, with point of departure in Figure 1, we discuss how these terms relate to our RR concept.

**Figure 1 "Decomposition of our RR measure"**




On the x-axis we measure aquaculture production X, while on the y-axis we measure the price on the aquaculture product P. The upward sloping curve C'(X) is the Norwegian aquaculture industry supply curve. It is upward sloping because different sites along the Norwegian coast have different productivity, see Flåten and Pham (2019).[3] Note that the industry supply curve includes all cost paid by the firms for operating, also the alternative return on their invested capital. Finally, the downward sloping curve P'(X) is the residual world demand meeting the Norwegian industry. Within the market segment for salmon and trout, Norway is a major producer likely influencing world prices by their supply.

Aquaculture production involves both negative producer-to-producer externalities and environmental externalities. The denser the farming of salmon in an area, the more likely is an outbreak of diseases and parasites like the sea lice, both hampering production in the whole area. Outbreaks of sea lice also hurt wild salmon and trout stocks constituting a negative environmental effect. There are also other negative environmental effects like local pollution, occupation of areas that can no longer be used for recreation and escapes that also influence wild salmon stocks negatively. The Norwegian government has chosen to regulate the negative externalities by strictly controlling the number of licenses to operate.[4] Consequently, Norwegian aquaculture supply is limited to $X^E$ in the figure. The result is that the world market price $P^M$ exceeds marginal costs $C'(X^E)$.

The total profit of the industry is equal to the trapezoid ABCE. This is the profit we measure and denote RR. Some authors, see e.g., Arnason et al. (2018) and Flåten and Pham (2019), prefer to classify profits into different categories. They would call the triangle DCE *Ricardian rent* if the upward sloping industry supply curve were caused by differences in land productivity or *intramarginal profit* if the upward sloping supply curve were caused by differences in firm technology and knowledge. Moreover, the rectangle ABCD would be called *regulation rent* since the rent is caused by the government restricting access to the industry (Anderson, 1989).

We do not disagree with this classification, however, as long as we do not know the exact location of C'(X), we can do no better than measuring the whole trapezoid ABCE. Note that the regulation rent emerges because the government seeks to control the negative externalities from salmon farming. If

---

[3] According to Asche et al. (2020) productivity differences could also derive from intrafirm differences in technology and knowledge. We discuss this possibility in Section 5 and argue that site conditions likely are more important than specific firm technology and knowledge for the variability in profits between sites. One possible reason is that research and development in the industry has to a large extent been driven by the government ensuring that all firms get the latest technology and knowledge (Greaker et al. 2020). This view is substantiated by the results from the Norwegian auctions of aquaculture licenses in which prices varied significantly between areas and in which the same firms purchased several new licenses at different prices across regions.

[4] Norwegian production of salmon and trout is dived into 13 areas. The number of licenses is set for each area separately. To simplify, we have merged all areas here.

the government knew the marginal external cost of salmon farming, e.g., the length of the line segment BC, the government could have decided to put an environmental tax on the production of X instead of restricting access. Then the firms would have to pay for their use of the ecosystem services and the loss in productivity they inflicted on other farmers. Furthermore, this would have led to the same equilibrium output, but the government would have appropriated the whole rectangle ABCD as tax income.

Since firms with the best locations still earn an extra normal profit, RR taxation could then have been applied to the triangle DCE. We do not venture further into the choice of tax instruments here, just note that since the Norwegian government has chosen *not* to levy any environmental tax on aquaculture, the whole area ABCE seems appropriate for the discussion of RR taxation. To be correct, a RR tax is then a combination of paying for the use of ecosystem services and for the benefit of having access to the best sites. We return to the discussion of the various elements of RR in Section 5.

# 3. Method for calculation of resource rent using National Accounts

## 3.1. Introduction

In the NA «aquaculture» includes «stock changes, fish farming», «salmon and trout farming», «cod farming», «other fish farming», «fish fry, young fish and aquarium fish», «investment work fishing and machinery» and «income from freight traffic». It would have been desirable to separate "salmon and trout farming", "cod farming" and "other fish farming". However, it is not possible to obtain separate numbers from NA for work effort, capital stock, etc. for these groups. However, the RR for total aquaculture should be a highly valid estimate for the RR in fish farming, as "salmon and trout farming" over the last 10 years has contributed to between 80 and 90 per cent of the output in "aquaculture".

## 3.2. Output and resource rent

We will now turn to the calculation of RR. Since we apply figures from the NA, we use the definition according to SEEA (SEEA, 2014). The value added earned through domestic production activity in an industry is defined as output minus intermediate uses. Intermediate uses are goods and services consumed or used up as inputs in production. In aquaculture these are e, g. the purchase of juvenile fish as well as feed for the fish in the pens. When calculating output in aquaculture, both actual sales of fish and changes in inventories are included (i.e. the change in the stock of fish in pens/containers). To get the gross operating surplus (SNA basis), we deduct other taxes on production and add other subsidies on production and in addition we deduct compensation of employees. Since output includes all subsidies on products and excludes taxes on products, we must adjust for this by adding product taxes (specific taxes on extraction) and deduct product subsidies (specific subsidies to extraction) to get the gross operating surplus (for the derivation of resource rent). Finally, we deduct return on fixed capital and capital consumption from the gross operating surplus to get the RR. The general calculation method of RR in Norwegian natural resource sectors is presented in Table 1.

**Table 1. The composition of resource rent according to the System of Environmental Economic Accounting (SEEA).**

| |
|---|
| Output |
| - Intermediate uses |
| = Value Added |
| - Other taxes on production |
| + Other subsidies on production |
| - Compensation of employees (input costs for labour) |
| = Gross operating surplus (NA basis) |
| - Specific subsidies on extraction |
| + Specific taxes on extraction |
| = Gross operating surplus (for the derivation of resource rent) |
| - Consumption of fixed capital (depreciation) |
| - Return to produced assets |
| = Resource rent (RR) |

## 3.3. Taxes and subsidies

Product taxes and subsidies, called specific taxes/subsidies on extraction in Table 1, are taxes/subsidies levied directly on the product. A product tax is paid by the specific resource industry and must therefore be added to the RR, while a product subsidy must be subtracted. This is because 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 subsidy can be seen as part of the costs of extracting the resource (e.g. price support). Among the natural resource sectors only agriculture has product subsidies. Basically, there are no industries that have product specific taxes, i.e. taxes which vary proportionally with production.

In addition to the products taxes/subsidies there are taxes/subsidies that are more industry specific, as they follow the industry and not products, i.e. they are imposed independently of the production volume. The SEEA give no guidance to whether these should be included or not. However, we follow Greaker et al. (2005) who conclude that industry specific taxes/subsidies should not be considered when calculating the RR. These industry specific taxes/subsidies can influence the cost structure in the industry, e.g. investment subsidies may have led to overcapitalization and disproportionately high labour use. Even though the industry specific subsidies in this manner indirectly may have reduced the RR as we measure it, we do not include them in the calculations. Our calculations only reveal the size of the RR given the institutional framework conditions, and do not say anything about how large or small the RR could potentially have been.

The other production taxes should be deducted and vice versa for the other production subsidies. The reason is that these taxes/subsidies must in any case be paid regardless of industry. They can therefore be considered as normal operating costs/income by doing business. We have not found any examples of these non-industry-specific taxes/subsidies in the NA other than employer's social security and pension contributions and taxes on vehicles. However, we have not deducted this annual tax on motor vehicles as it accounted for less than 0.1 per cent of output in aquaculture production in 2016. We also do not interpret deductions of expenditure on *R&D* (SkatteFUNN) in aquaculture as a non-industry-specific subsidy. The amount is not a general support from running a business and it is not given to everyone. Further, the support amounted to less than 1 per cent of the value added in 2016.

## 3.4. Wage compensation

Compensation of employees are wages and employer's social security and pension contributions. Both components are subtracted from the value added in the RR calculations. The deduction of employer's social security and pension contributions is consistent with the deduction of other production taxes (as described in Section 3.3). The reason is that these taxes must be paid regardless of industry and can therefore be regarded as normal operating costs in doing business.

Wage compensation must reflect the alternative use value of the labour force. To calculate the wage compensation, we have first calculated an average hourly wage rate. This rate is obtained by taking the wage costs for mainland Norway divided by the number of hours worked for employees in mainland Norway. The reason why we use wages for mainland Norway and not the whole of Norway is that wage rates are particularly high for the oil and gas industry, probably because the high operating results have allowed for local wage increases. To find the wage compensation in the individual industry, the hourly wage rate is multiplied by the total hours worked for wage earners and self-employed. Thus, the wage cost per man hour of aquaculture farmers is assumed to equal the average wage rate in the mainland economy.

One can discuss whether the wage calculations described above give a correct picture of the alternative value of the labour force. The level of education in the aquaculture (and other primary industries) is relatively low, i.e. the average wage rate per year for mainland Norway is probably too high to apply to this industry and this reduces the RR. An alternative calculation method is to use the actual wage costs for aquaculture as they appear in the NA. This is done in the sensitivity analyses in Section 4.2.2.

### 3.5. Capital costs

In the same way as wages reflect the alternative value of labour, the cost of capital should reflect the alternative value of capital. The capital cost consists of two components: capital consumption and the return on existing real capital stock. From NA we can collect the value of capital in aquaculture. The capital concept includes i.e. machinery and equipment, buildings and means of transport. NA have for aquaculture registered "ships and vessels", "vans", "commercial buildings", "machinery" and "other facilities". All these objects make up the value of real capital. In addition, the capital concept includes *R&D* and other intangible capital (goodwill is not included in NA) registered as "own *R&D*".

The value of the fish in the sea is not included in the capital stock in NA. The reason is that fish in net pens are not defined as "livestock" in the NA in line with cows and sheep. The stock of cows and sheep yields a return in the form of, e.g., milk, offspring, and wool without being slaughtered, while fish in the sea must be slaughtered to give a yield. Thus, according to the SEEA fish in the sea shall not be included in the capital stock. Purchases of juvenile fish and feed are intermediate input factors in the production that are "built into" the product being sold. Therefore, the costs of these are deducted in full when we calculate the value added and, hence, the RR. Thus, these input factors cannot be considered in the same way as purchased equipment that is used repeatedly to "assemble" the finished product.

In addition, aquaculture companies are not obliged to capitalize investment costs in fish in the sea, but can charge expenses for juvenile fish and feed the same year. Skatteetaten (2021) states in the section on aquaculture that «… the purchase price for live fish and other aquatic organisms acquired during the year can be deducted directly…». A fish farming company will have incentives to choose direct deductions since it will be financially advantageous. We therefore assume that this is the practice followed for tax related purposes. However, we perform a sensitivity analysis in Section 4.2.1 to show the effect of including the value of fish in the sea as capital cost. The value of fish farming licenses is also excluded from the concept of capital. For our objective, it is correct, as it is these licences that give rise to RR as already discussed in the introductory section.

The values of the capital objects in NA are based on the original acquisition values. These acquisition values are then adjusted year by year with a sector-specific, geometric depreciation rate that should reflect the actual loss of value of capital. Below we have reported the most important depreciation rates for aquaculture production:

**Table 2. Depreciation rates. Per cent.**

| Capital object | Before 2003 | After 2003 |
|---|---|---|
| Commercial buildings | 3.3 | 4 |
| Ships and vessels | 9.7 | 10 |
| Vans | 20.5 | 13 |
| Machinery | 14,5 | 20 |
| R&D | 20 | 20 |

Source: Statistics Norway

Every year t, the capital stock *K* (now including *R&D*) in an industry is defined as follows:

$$(1) \qquad K_t = \sum_k S_{k,t-1}(1 - \delta_k) + \sum_k I_{k,t},$$

where $S_{k,t\text{-}1}$ is the holding of capital type *k* at the beginning of the period, $\delta_k$ is the depreciation rate for capital type *k*, and $I_{k,\,t}$ is the investments in period *t* in capital type *k*. The expression $\sum_k S_{k,t-1}\delta_k$ corresponds to the item «capital consumptions» in our calculations.

To be able to calculate the cost of capital, we must have a measure of what the return on capital ($K_t$) in the industry would have been applied in an alternative way. The required return on capital is discussed in detail in Ministry of Finance (2012), which deals with socio-economic analyses of public measures. The discussion is based on the capital asset pricing model (CAPM), see e.g. Bøhren et al. (2017). The starting point is that an investor in aquaculture will consider both the profitability of the project and the extent to which the project contributes to the investor's overall risk exposure. CAPM then gives the following formula for the required return ρ:

$$(2) \qquad \rho = r^f + \beta(r^m - r^f)$$

where $r^f$ is the risk-free interest rate, $r^m$ is the return on the market portfolio and $\beta$ is an expression of the project's systematic risk. The systematic risk is the part of the risk that an investor cannot diversify away from.

The recommendation in Ministry of Finance (2012) for public projects with normal risk and a horizon of less than 40 years is to use $\rho$ equal to 4 per cent as the real alternative interest rate. They assume a risk-free interest rate of 2.5 per cent and a risk adjustment of 1.5 per cent. It is not recommended to calculate $\rho$ from project to project. The reason is that both $\beta$, i.e. the systematic risk and the return on the market portfolio vary over time. They will therefore be sensitive to the period used as a starting point. On the other hand, the Ministry of Finance (2012) also states that for projects with a high systematic risk, it will be appropriate to use a discount rate that is higher. We will return to that in the sensitivity analysis in Section 4.2.3.

How does this relate to aquaculture? We illustrate the use of the formula for the required rate of return. According to our calculations, the main index on the Oslo Stock Exchange in the period 2000 to 2018 gave an average nominal return of 7.9 per cent. With a 2 per cent inflation and a 2.5 per cent risk-free interest rate, this implies $\beta$ approximately equal to 0.4 for us to have $\rho = 0.04$. Bøhren et al. (2017) find for 2015 based on weekly data betas of 0.19 for Marine Harvest and -0.33 for Bakkafrost, both of which are aquaculture companies. For the period from 2011 to 2015 based on monthly data, they find betas of 0.67 for Marine Harvest and -0.15 for Bakkafrost. This indicates that the systematic risk in aquaculture is not particularly high. In our basic estimates of the RR, we therefore use ρ = 0.04. However, in our sensitivity analysis in Section 4.2.3 we apply higher rates of return.

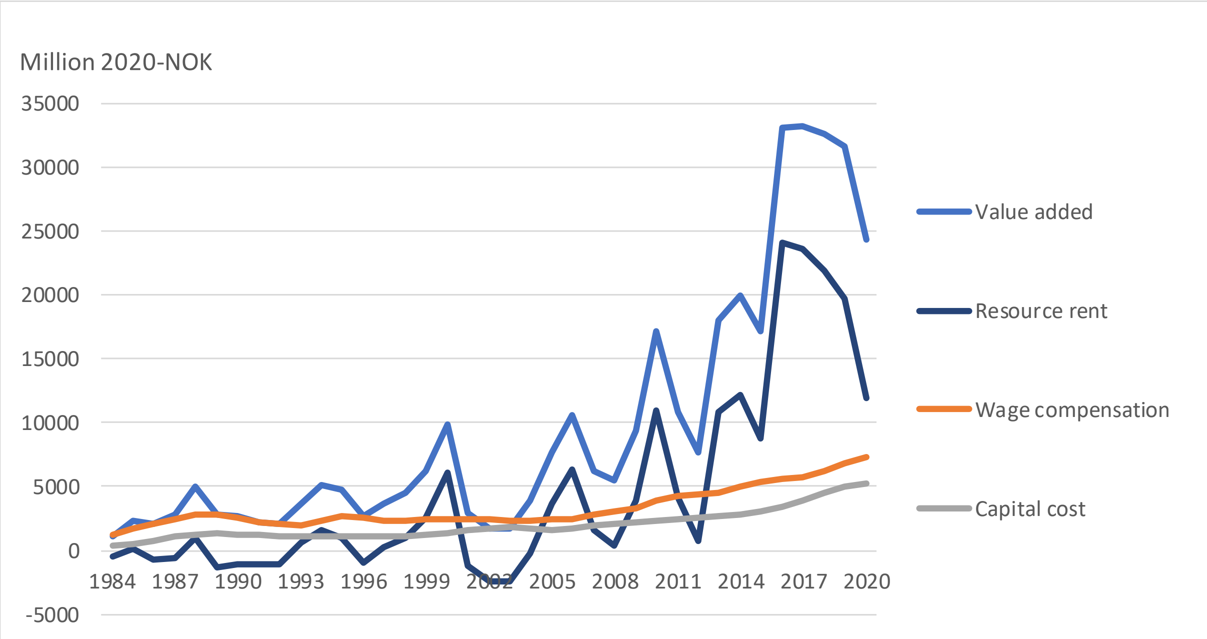
# 4. Resource rent from 1984 to 2020

## 4.1. Resource rent

All figures have been converted to 2020 prices to measure the purchasing power of the RR over time. The deflator is a weighted average of the ordinary consumer price index and the price index for public consumption. Figure 2 shows a decomposition of the RR in aquaculture for the period 1984 to 2020 based on a required rate of return of 4 per cent.

At its highest, the RR has been almost 25 billion 2020-NOK. In 2020, when the corona pandemic hit the economy, the RR fell to around 12 billion from 20 billion the preceding year. The RR was not particularly high until the 2000s. For some years in the period 1984-2004 it was even negative. Between 2000 and 2012 it fluctuated sharply. After 2012, the RR has risen markedly, and in the last five years it has been over 20 billion 2020-NOK.[5] We further see that aquaculture is not very capital intensive. Capital costs are less than wage compensation in all years.

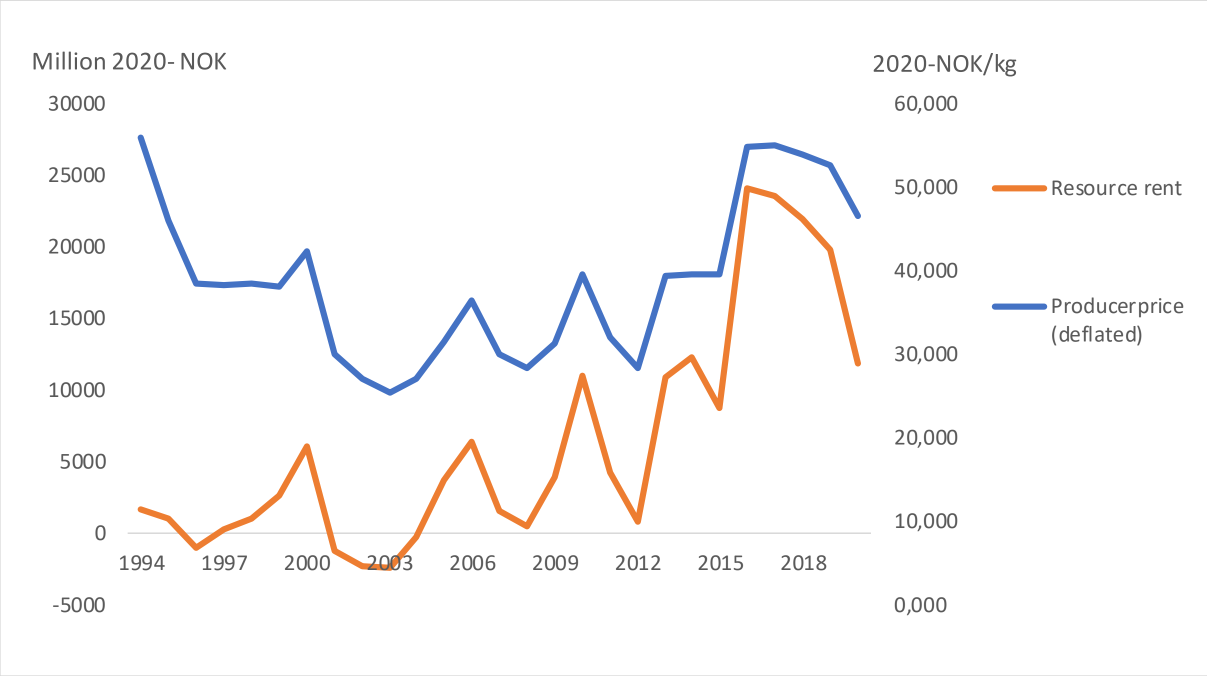
**Figure 2. Resource rent in aquaculture 1984-2020.**




Why is the RR rising so sharply from around 2012? The main explanation seems to be increased prices for salmon (and trout). In Figure 3, we compare inflation-adjusted salmon prices from The Directorate of Fisheries (2021) with the RR in aquaculture over the period 1994-2020.

[5] On average from 2000 to 2020, the RR is almost 8 billion 2020-NOK, and then the weak years from 2001 to 2004 are included. Over the last 10 years, the RR has averaged nearly 14 billion 2020-NOK.

**Figure 3. Prices on salmon (right axis), resource rent (left axis) 1984-2020.**




We see that the RR fluctuates with the salmon price in the period 2000-2020. Furthermore, we see that the increase in the RR from 2012 is related to increased salmon prices. Salmon prices were also high in the 1990s, but then it does not appear that the industry was able to take advantage of this to the same extent. It is reasonable to imagine that this is related to high costs. Production costs (at constant prices per kg of salmon) fell by around 80 per cent from 1991 to 2000 (Eikaas, 2011). The relation between the RR and the price of salmon seems to be stronger as the years go by; the correlation coefficient for the entire period is 0.73, while for the period 2000-2020 it is 0.98.

## 4.2. Sensitivity analysis

### *4.2.1. Fish in the sea included in the capital base*

As mentioned, the SEEA does not include fish standing in the sea in the capital base of the industry. However, the average rotation period for a salmon farm is 18 months. This implies that during the first year the farm must procure juvenile fish from a hatchery and breed the juveniles without getting any income from selling the fish. Admittingly, this constitutes an investment from which the farmer could have obtained an alternative return. In the following we discuss the effect of including standing fish in the sea in the capital base of the industry.

Our point of departure is a single farmer that starts her activity in Period 0. Assume a production cycle that lasts over two periods and let $c_1 + c_2$ be the variable cost per kg harvested fish incurred in Period 1 and Period 2, respectively. Further, let $x_t$ be the kg of harvested fish sold in year *t*, and $p_t$ the price per kg in year *t*. Finally, let $k_t$ be the investments in all other forms of capital in year *t*, and let $\rho$ be the cost of capital. For the sake of simplicity, apart from the standing fish in the sea, we assume away depreciation on the capital stock here. The table below then illustrates the effect of including the investments in juvenile fish in the capital base when calculating resource rents:

**Table 3. Accounting principles.**

| Period | 0 | 1 | 2 |
|---|---|---|---|
| Revenue | | $p_1x_1$ | $p_2x_2$ |
| Variable cost | $c_1x_1$ | $c_2x_1 + c_1x_2$ | $c_1x_3 + c_2x_2$ |
| Investment cost | $\rho k_0$ | $\rho k_1$ | $\rho k_2$ |
| SEEA resource rent | $-c_1x_1 - \rho k_0$ | $p_1x_1 - c_2x_1 - c_1x_2 - \rho k_1$ | $p_2x_2 - c_1x_3 - c_2x_2 - \rho k_2$ |
| Adjusted resource rent | $-\rho(c_1x_1 + k_0)$ | $p_1x_1 - (c_1 + c_2)x_1 - \rho(c_1x_2 + k_1)$ | $p_2x_2 - (c_1 + c_2)x_2 - \rho(c_1x_3 + k_2)$ |
| Difference | $-(1-\rho)c_1x_1$ | $-(1-\rho)c_1x_2 + c_1x_1$ | $-(1-\rho)c_1x_3 + c_1x_2$ |

First, note that we measure the capital value of fish in the sea by the payments the farmer makes in acquiring and breeding the juvenile fish, not their market value. The market value of the fish in the sea will in general be larger since there is a RR to be earned. Subtracting the capital cost of this RR when calculating the RR would distort our estimate of the actual RR. Second, note that if the investment in juvenile fish is included in the capital base, the investment is subtracted as a cost the moment the fish is sold. In other words, the "fish capital" is fully depreciated when the fish is harvested.

At the bottom row we calculate the difference in RR for the two measures. If this is negative, the SEEA measure of RR yields a lower estimate than the measure which include fish in the sea as capital. This will always be the case for the period 0. Then for later periods, the difference depends on whether production is growing or not. We have that the difference is negative if:

$$(3) \quad (1-\rho)c_1x_t > c_1x_{t-1}$$

Hence, if the growth rate of fish sold, $g = (x_t - x_{t-1})/x_{t-1}$, is larger than $\rho/(1-\rho)$, the SEEA estimate of the RR will yield a lower estimate than an estimate in which we had included the fish in the sea in the capital base. We have used $\rho = 4$ per cent in our base case. This implies that if the growth rate of in the production of salmon is greater than 4.2 per cent, our estimates are on the conservative side. According to Asche et al. (2020), the actual average growth rate of fish sold has been 4 per cent since 2010, and around 18 per cent in the period from the early 1970s until 2010. To shed more light on this issue, we will look at the years from 2015 to 2018 (The Directorate of Fisheries, 2021). In this period, the growth in production stagnated due to among other large problems with sea lice.

**Table 4. Salmon production volumes 2013 to 2020.**

| Year | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|
| Tons | 1.239.876 | 1.327.342 | 1.376.353 | 1.321.471 | 1.303.352 | 1.350.348 | 1.447.531 |
| Change | | 7% | 4% | -4% | -1% | 4% | 7% |

According to The Norwegian Directorate of Fisheries (2021) the average variable cost per kg produced fish in the period 2015-2018 was 27.3 NOK/kg. This figure includes labor, feed, miscellaneous running costs and outlay on juvenile fish. If 50 per cent of the variable cost is spent in year 1 and the rest in year 2 when the fish is sold[6], we can adjust our RR estimate for the period 2015 to 2018 by the formula derived above (with $c_1$ = 13.7 NOK/kg).

**Table 5. Adjusted resource rents 2015 to 2018 (Million NOK)**

| Year | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|
| SEEA estimate | 8140 | 22462 | 21660 | 21452 |
| Adjustment | -1476 | -962 | -96 | +538 |
| New RR estimate | 6664 | 21500 | 21564 | 21990 |

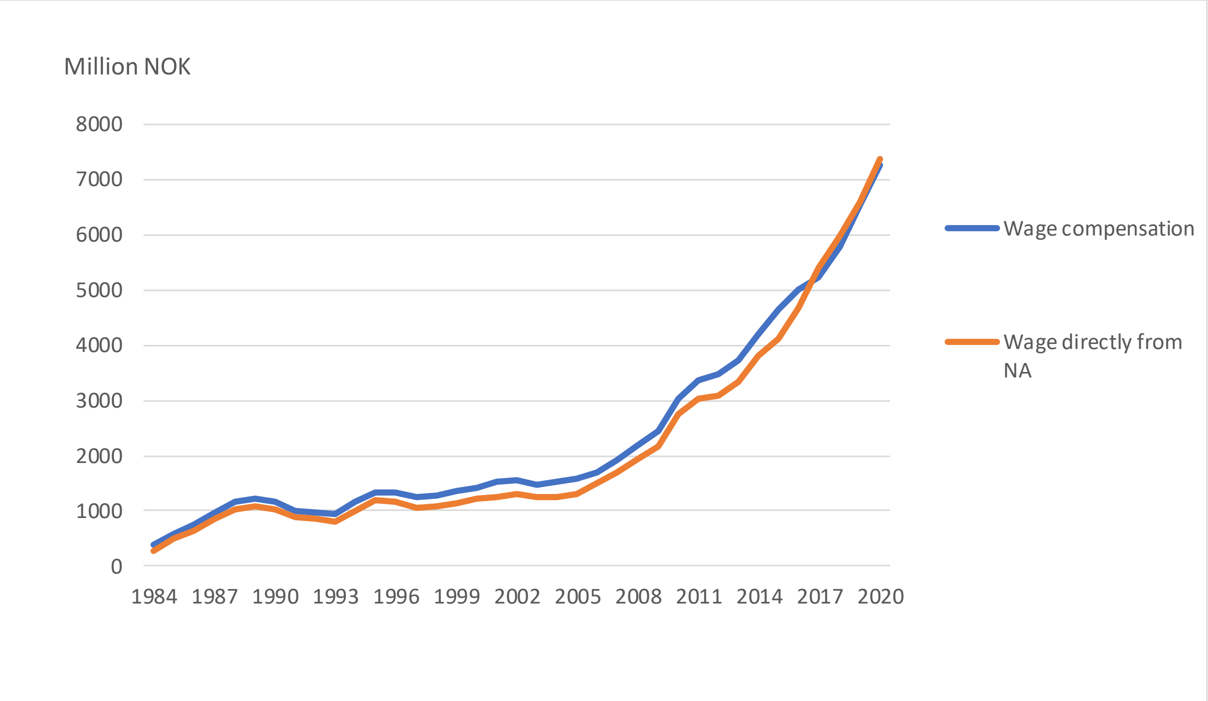
For all years, except from 2015, we see that the difference is small and for 2018 it goes in the opposite direction of common intuition. Hence, over all we feel confident that our time series has not provided a too large estimate of the RR.

[6] This seems reasonable as the cost of the juvenile fish is only about 10 per cent of the total variable cost.

#### *4.2.2. Wage compensation*

Figures 4 shows the development in wage costs in aquaculture, calculated in two different ways: 1) The hourly wage rate for mainland Norway multiplied by the total hourly wage for both employees and the self-employed in the industry, as done above; 2) use actual wage costs as they appear in aquaculture in NA, but only for the employees and not the self-employed. We see from Figure 4 that for aquaculture, actual wage costs are generally 10-20 per cent below the estimated wage compensation (but the last four years they have been marginally higher). This may reflect that the level of education of those who work in aquaculture is (or has been) relatively low, so that the average wage per. hours for mainland Norway is too high for this industry.[7] As the figures show, there are relatively small differences between the two ways of calculating wage costs and in addition wage consumption is only a small part of the RR as Figure 2 shows. Hence, we do not perform new calculations of the RR.

**Figure 4. Wages in aquaculture 1984-2020.**




#### *4.2.3. Capital cost*

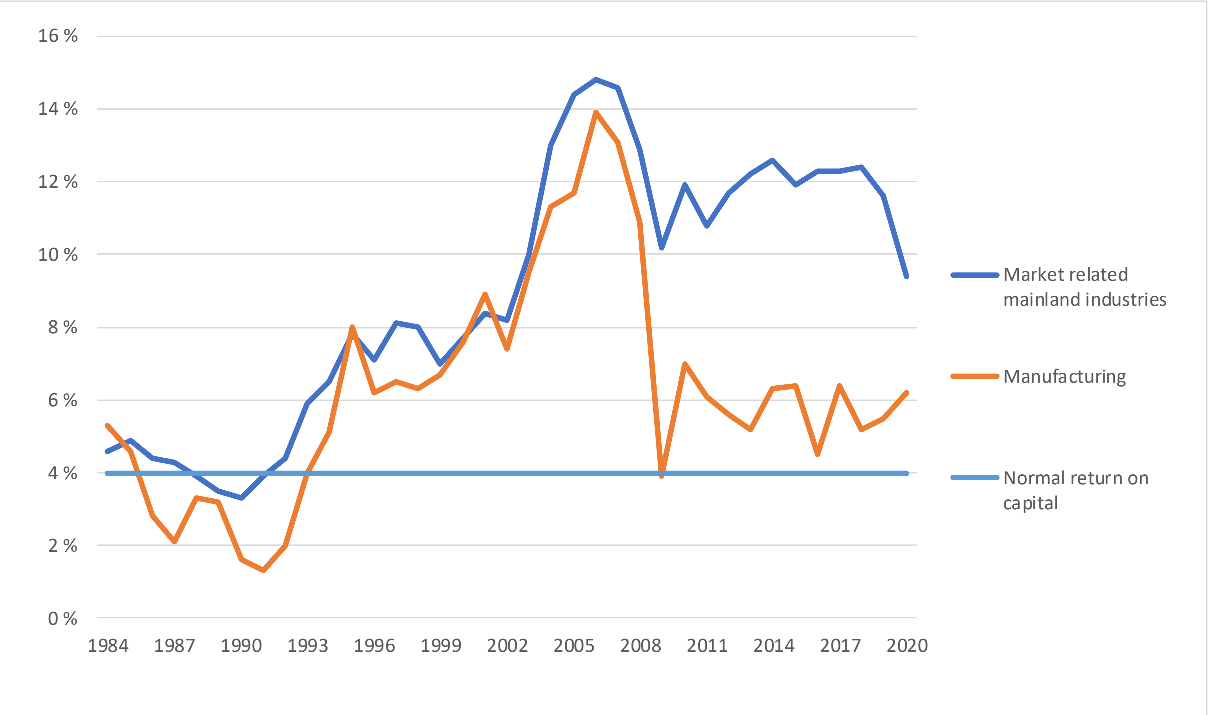
To check the robustness of our RR estimates, we apply alternative rates of return. We use the real rates of return to capital in market-oriented mainland industries as reported in Statistics Norway (2021).

[7] According to SINTEF (2018), there is a lot of foreign labor in aquaculture and they earn around 20 per cent less than Norwegian workers.

These current rates are calculated by dividing the operating profit for the sectors by the capital stock in the sectors. The operating profit is calculated as the profit after both capital depreciation and a hypothetical remuneration to the self-employed are included.

In Figure 5, the category «market-oriented mainland industries» includes all private enterprises except oil and gas extraction and housing services. Manufacturing is thus a subcategory of this category. As we see from Figure 5, the actual return on capital has exceeded the estimate we use for the normal return in most of the years we have included in our analysis. This may be due to problems in determining the value of the capital stock in service industries such as the financial sector and the consulting sector (these are part of market-oriented mainland industries). Furthermore, bankruptcies will not be properly represented as the operating profit is set at zero in the event of a bankruptcy, and the losses suffered by investors are not considered. In any case, we present alternative figures for the RR, where we use actual returns for manufacturing and mainland industries. We emphasize that applying higher discount rates than in our base case are appropriate for projects with e.g. a high systematic risk.

**Figure 5. Actual return on capital in the Norwegian economy 1984-2020.**

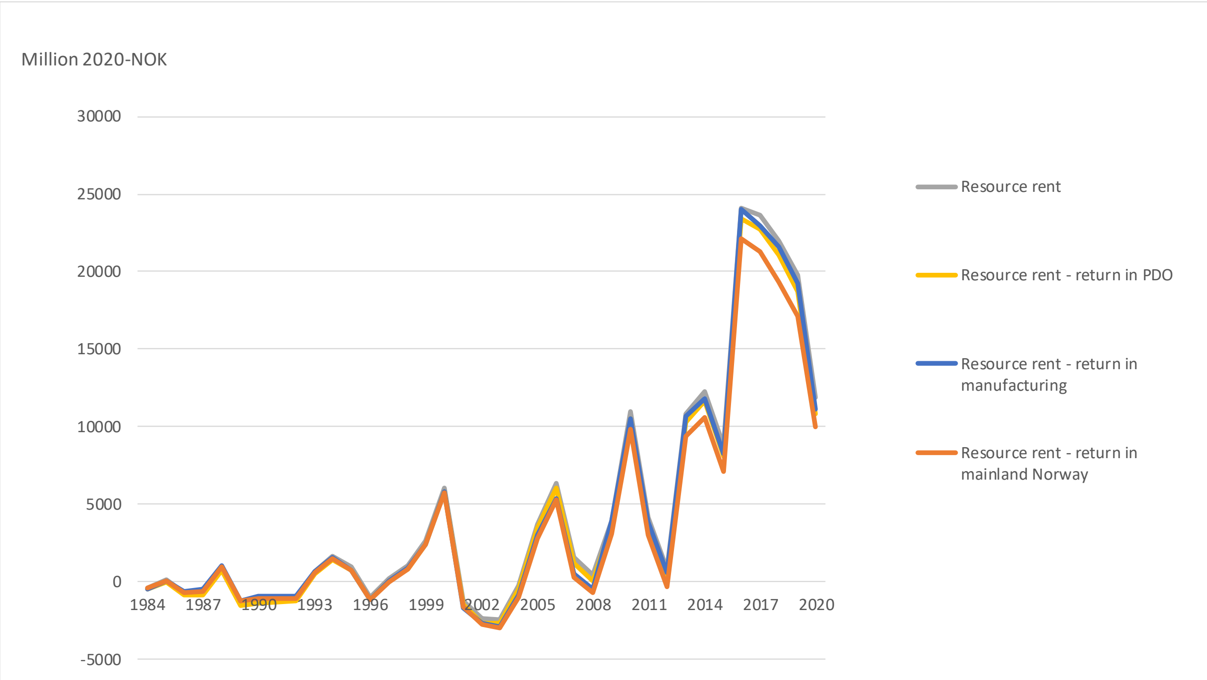



Source: Statistics Norway (2021)

The Ministry of Petroleum and Energy uses a 7 per cent real interest rate in the assessment of the so-called "Plan for development and operation (PDO)" for new oil fields.[8] We have therefore also made calculations of the RR with a 7 per cent return on capital for aquaculture.

Figure 6 shows that our RR estimate is relatively robust to the choice between the three rates of return. As aquaculture is not very capital intensive, it seems reasonable to use the return on capital in mainland Norway as an alternative cost for capital in the industry compared to our base case scenario. The RR declines from around 20 billion NOK to 18 billion in the last five years with an average rate of return of mainland Norway. The average RR is 6.5 billion NOK for the years 2000 to 2020 with the mainland return, down from 7.8 billion in the base case.[9] The rate of return in mainland Norway was around 12 per cent on average over the period 2000-2020. Hence, this rate of return for a fish farming company is significantly higher than our base case rate of return of 4 per cent.

**Figure 6. The resource rent with different required rates of return 1984-2020.**




[8] See e.g. Ministry of Petroleum and Energy (2018).

[9] On average from 2000 to 2020, the RR in the various sensitivity scenarios is around 6.5-7.3 billion, and then the weak years from 2001 to 2004 are included. If we look at the last 10 years, the RR has averaged around 12-13 billion with the various alternative required rates of return.

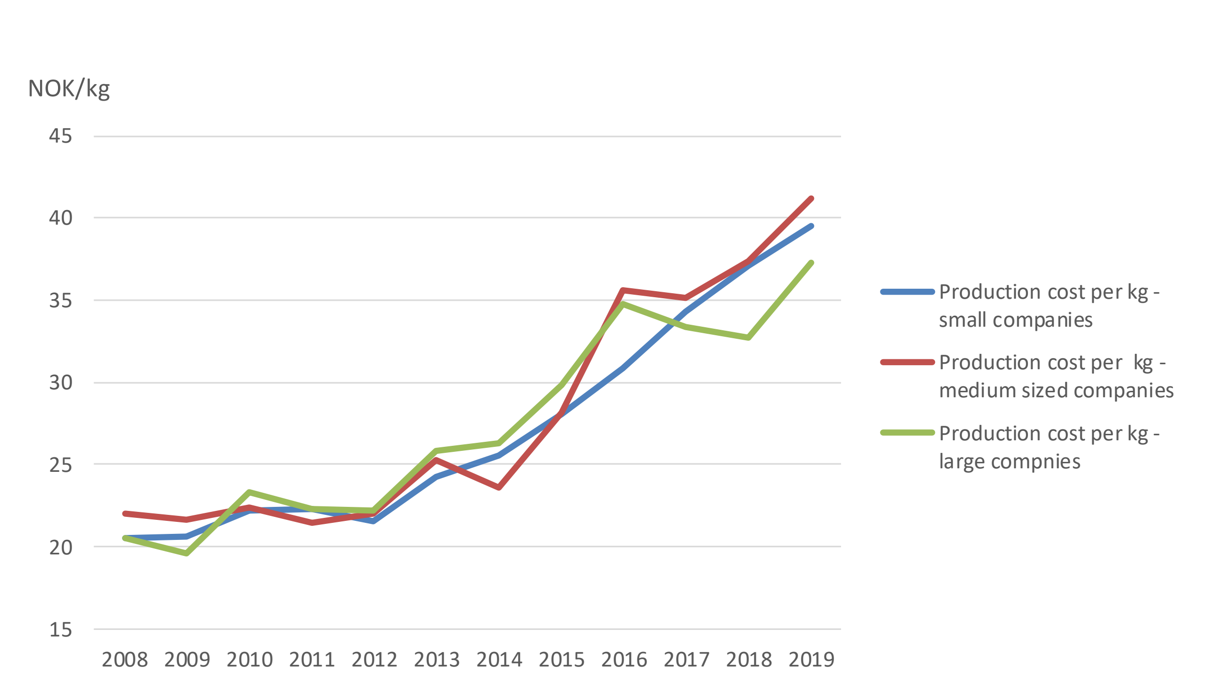
## 5. Discussion

There is a discussion in the literature, see e.g., Asche et al. (2020) and Misund and Tveterås (2020), to what extent there are intramarginal profits in the aquaculture industry. Intramarginal profits stem form differences in technology and knowledge. Some firms could for instance be better at marketing obtaining higher prices for their products. However, price differences tend to be limited between aquaculture firms (The Directorate of Fisheries, 2021). Consequently, eventual differences in profits between firms are likely to result from differences in the cost of production.

Difference in costs could be the result of variations in the quality of sites between companies and/or company efficiency. It is the latter component Asche et al. (2020) and Misund and Tveterås (2020) seek to separate from the RR as they argue that such rent should not be subject of RR taxation. In our opinion, none of these contributions succeeds in identifying an eventual intramarginal rent which is different from a land rent. Misund and Tveterås (2020) look at the variability of aquaculture firm profit. They find large variability, but this is not systematic across firms suggesting that firms are equal but are randomly hit by environmental hazards such as algae, disease and sea lice outbreaks that they cannot control. Asche et al. (2020) perform an empirical analysis in which aquaculture license prices are regressed on firm data. They find that the least efficient firms are willing to bid the most for a new license. This result is counter-intuitive; however, the location of the license is left out of the regression equation, and we thus worry that the regression is plagued with missing variable bias.

The Directorate of Fisheries (2021) presents variable costs for small (1-9 licenses), medium (10-19 licenses) and large (over 20 licenses) salmon and trout companies for the period 2008-2019. One could assume that larger companies have acquired the most efficient technology and that this should lead to lower costs. However, Figure 7 show that there are no systematic differences in production costs of salmon and trout between aquaculture companies of different size groups.

**Figure 7. Production costs for different company size groups 2008-2019.**




Moreover, we cannot reject the null-hypothesis that the costs are equal through an unpaired t-test between the three possible pairs of company size groups. Hence, small or no differences in economic profits between size classes could be an *indication* of high RR and low intramarginal rent since no size groups are more technically efficient than others. Further, research and development in the industry has to a large extent been driven by the government ensuring that all firms get the latest technology and knowledge, see Greaker et al. (2020).

The capital equipment of salmon farms includes open cages in seawater, a floating barge for production surveillance room and feed storage, anchoring systems, and automated feeding systems. The production technology includes digital sensor technologies for monitoring the environment and live salmon. The role of the farm manager and labor is primarily monitoring of the farm, making feeding decisions, maintenance and assisting release and harvesting of live salmon in and out of the cages (Misund and Tveterås, 2020). In our estimations we include real capital. The value of real capital encompasses the quality of the production equipment described above. Investment in fixed capital also includes own *R&D* activity. *R&D* may represent company-specific knowledge and technology. There are various studies that apply *R&D* as a proxy for technological change, see e.g. Lindholt (2015). Hence, the return on real capital which includes total *R&D* activity in aquaculture represents at least part of the intramarginal rent (if it exists). We cannot take into consideration that *R&D* activities in other sectors might affect the technology and return in aquaculture. Furthermore, according to Asche et al. (2020) various studies that try to measure RR, miss the role of intangible inputs such as the entrepreneurship, network and management, which may affect the profits of companies. Our estimations also include input costs for labour, which could also encompass the operational skills of aquacultural workers. Employees will normally receive remuneration through wages in line with his/her productivity. In addition, entrepreneurship may be linked to higher *R&D* activity. Hence, from the discussion above we argue that we to a large extent are able to separate between the contribution to the value of output from the remuneration of aquacultural services and other input factors.

Lastly, some have argued that the value of the firms' aquaculture licenses should be included in the capital base of the industry, and hence that the alternative return on the investment in licenses should be deducted from the RR. Theoretically, the value of an indefinite stream of RR can be considered as the highest license price a producer would be willing to pay to get access to the aquacultural resource. As the value of the licenses represents the origin of the RR itself, it should not be included in the calculation of RR. RR is precisely the accrued value of the permits and in a well-functioning market, the turnover value of such permits reflects the present value of owning and using the permits in the future. This thus reflects not just future RR based on the current management regime, but also expectations of any changes in regulations and the aquaculture otherwise (Ministry of Finance, 2019). The revenue from a well-designed auction of licenses without time limit would in principle be the total present value of the expected future RR.

# 6. Conclusions

Revenue from natural resources is related to the term resource rent. The resource rent is the income that can be attributed to a natural resource. It is measured as the residual profits when all necessary input factors have received their remuneration. There are only a limited number of locations in Norway (and worldwide) which are suitable for aquaculture activities and this give rise to resource rent. Good localities depend, among other things, on climatic conditions, qualities of seawater and protection from weather and wind. As with other natural resources, limited access in aquaculture prevents free entry that would otherwise have pushed the profits down to the normal return on capital. Some authors coin this rent "regulation rent". In addition, sites with more favourable environmental conditions can give rise to higher profits compared to lower quality sites. This is often referred to as "Ricardian rent".

The starting point for calculating the resource rent is that production of a natural resource can be expressed by a production function, where one or more ecosystem services are included as input factors. If we know the remuneration of all input factors such as capital, labour, technology and intermediates as juvenile fish and feed except the remuneration of the aquacultural services, the resource rent will appear as the difference between the value of output and the remuneration of all other input factors. Introducing the return on real capital including *R&D* expenses as well as labour costs, we are to a large extent able to separate between the contribution to output from aquacultural services and other input factors. We argue against the claim that a significant part of the extra-normal profit in the Norwegian aquaculture industry is due to company specific technology and knowledge and not due to the use of scarce resources. We also argue that the value of fish farming licenses should be excluded from the concept of capital, because for our objective it is these licences that give rise to resource rent.

Based on data and definitions in the NA and the SEEA we calculate the resource rent in aquaculture in Norway in the period 1984-2020. On average from 2000 to 2020, the resource rent is almost 8 billion NOK, and then the weak years from 2001 to 2004 are included. After 2012, the resource rent has risen markedly. If we look at the last 10 years, the resource rent has averaged around almost 14 billion. In the last five years it has been over 20 billion NOK and then we include 2020, when the corona pandemic hit the economy and the resource rent fell to around 12 billion from 20 billion.

We perform various sensitivity analysis as introducing higher rates of return, applying alternative wage costs and treating the stock of fish as real capital. This does not change the conclusion that there has been a significant resource rent in aquaculture since 2000 and that it has risen markedly since 2012.

## References:

Anderson, L.G. (1989): Conceptual constructs for practical ITQ management policies, in Neher, P.A., Arnason, R. and N. Mallett (eds.), *Rights based fishing*. The Netherlands: Kluwer Academic Publishers, 191–209.

Arnason, R., Bjørndal, T., Gordon, D.V. and M. Bezabih (2018): Measuring potential rents in the North Sea herring fishery, *American Journal of Agricultural Economics* 100 (3), 889–905.

Asche, P., Misund, B. and R. Tveterås (2020): Determinants of variation in aquaculture profits, SSRN paper, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3703168

Brekke, K. A., Lone, Ø. and T. Rødseth (1997): Economy and ecology, ad Notam Forlag (in Norwegian).

Bøhren, Ø., Michaelsen, T. and Ø. Norli (2017): Finance: Theory and practice, Fagbokforlaget (in Norwegian).

Eikaas, B. (2011): What has driven the consolidation in the aquaculture industry, and are there synergy effects for the purchasing company?, Master's thesis, NHH Bergen (in Norwegian).

Flåten, O. and T.T. Pham (2019): Resource rent in aquaculture, in J. O. Olaussen (ed.), *Contributions in natural resource economics – Festschrift to Anders Skonhoft*, 103–136. Bergen: Fagbokforlaget.

Garnaut, R. (2010): Principles and Practice of Resource Rent Taxation, *The Australian Economic Review* 43 (4), 347-356.

Greaker, M., Grimsrud, K.M. and L. Lindholt (2016): Resource rent in Norwegian fisheries - development and policy, Økonomiske Analyser 5, Statistic Norway (in Norwegian).

Greaker, M., Grimsrud, K.M. and L. Lindholt (2017): The potential resource rent from Norwegian fisheries, *Marine Policy* 84, 156–166.

Greaker, M. and L. Lindholt (2019): The economic rent in Norwegian aquaculture and power production from 1984 to 2018, Rapporter 2019/34, Statistics Norway (in Norwegian).

Greaker, M., Løkkevik, P. and M. A. Walle (2005): Development in Norwegian national wealth from 1985 to 2004: An example of sustainable development? Rapport 2005:13, Statistics Norway (in Norwegian).

Greaker M., Vormedal, L. and K. Rosendahl (2020): Environmental policy and innovation in Norwegian fish farming: Resolving the sea lice problem?, *Marine Policy* 117, 1-10.

Hardin, G. (1968): The tragedy of the commons, *Science* 162, 1243–1248. https://doi.org/10.1126%2Fscience.162.3859.1243.

Lindholt, L. (2015): The tug-of-war between resource depletion and technological change in the global oil industry, *Energy* 93, 1607-1616.

Lindholt, L. (2021): The value of having the exclusive right to exploit a natural resource, in Glomsrød, S., Duhaime, G. and I. Aslaksen (eds): *The economy of the North 2020*, Statistical Analysis 167, Statistics Norway, 93-94.

Ministry of Climate and Environment (2013): The benefits of nature - about the values of ecosystem services, NOU 2013:10 (in Norwegian).

Ministry of Finance (2012): Socio-economic analyses, NOU 2012: 16 (in Norwegian).

Ministry of Finance (2019): Taxation of aquaculture (in Norwegian), NOU 2019:18, (Introduction and summary in English), https://www.regjeringen.no/en/dokumenter/nou-2019-18/id2676239/

Ministry of Petroleum and Energy (2018): Prop 80 S 2017-2018 to the Parliament on the development and operation of the Johan Casterberg field (in Norwegian).

Misund, B. and R. Tveteras (2020): Sustainable growth, resource rent and taxes in aquaculture, available at SSRN: https://ssrn.com/abstract=3703158 or http://dx.doi.org/10.2139/ssrn.3703158

SEEA (2014): System of environmental-economic accounting 2012, SEEA Central Framework, Chapter V Asset accounts, United Nations, https://seea.un.org/sites/seea.un.org/files/seea_cf_final_en.pdf

SINTEF (2018): Narvik's development potential in aquaculture, Havbrukskonferanse Narvik 7. September (in Norwegian).

Skatteetaten (2021): Taxation-ABC 2020/2021 (in Norwegian), https://www.skatteetaten.no/rettskilder/type/handboker/skatte-abc/gjeldende/akvakultur-fiskeoppdrett-mv/A-11.014/A-11.016/

Statistics Norway (2021): Economic trends with economic outlook for the year 2020, (in Norwegian) https://www.ssb.no/nasjonalregnskap-og-konjunkturer/artikler-og-publikasjoner/_attachment/380156?_ts=16958558ee0

The Directorate of Fisheries (2021): Aquacultural data (in Norwegian), https://www.fiskeridir.no/Akvakultur

Åm, H. (2021): A critical policy study on why introducing resource rent taxation in Norwegian salmon aquaculture failed, *Marine Policy* 131, 104692.