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ORIGINAL ARTICLE

Cost–benefit analysis of the Greenland offshore shrimp fishery

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Abstract

This paper examines the social economic value of the Greenland offshore shrimp fishery. The contribution of fishery to the economy is examined using a cost–benefit analysis in which the objective of the report is to examine the current state of fishery rather than possible changes. The analysis is undertaken by assessing the economic state and development of fishery, as well as the changes in profits, sales and production in the years 2006 and 2007. Financial accounts and costs data provided by the companies fishing in Greenland have contributed to estimating the net economic value of the industry. As management cost is part of the social cost of fishery, this is included in the analysis as well. The paper concludes that there is a positive economic net benefit from the shrimp fishery in Greenland, which is believed to be caused by the efficient management system of fishery (based on an individual transferable quota system). It is further shown that the companies and the crew retain nearly the whole net benefit from fishery, while the public finance is not gaining much.

Keywords: Cost-benefit, shrimp, Greenland, bio-economics, fisheries.

1. Introduction

Shrimp fishery is an important industry for Greenland as most of its exports are fish and shrimp products.1 Various developments in the industry have been observed in the last two decades. These include the introduction of individual transferable quotas (ITQs), the reduction in the fishing fleet and the emergence of a few major companies that deal with shrimp fishing. Decreasing shrimp prices internationally has also influenced the industry.

The purpose of this paper was to analyze and assess the economic contribution of the offshore Greenlandic shrimp fishery to the economic welfare of Greenland. In order to determine the economic value of the industry, a cost–benefit approach was applied. The aim was not to assess the economic impacts, i.e. the economic activity generated by the fishery. Rather, the purpose was to estimate the economic net-benefit or rent of fishery. The surplus of output over input value is a measure of the net benefit (economic rent) generated by using inputs or resources (labour, capital, biomass, oil, etc.) to produce shrimp products. Positive net benefit2 is a gain to the economy as a whole: Production generates outputs that are more valuable than the resources used in creating them. Another objective of the paper was to show the distribution of the total added value between the different economic agents in Greenland.

This analysis is based on information from the accounts of offshore shrimp-fishing companies about their activities in Greenland, which has been acquired with a questionnaire sent to the companies. This questionnaire can be acquired by contacting the authors. The companies that have been included in this analysis are Ice Trawl A/S, Niisa Trawl A/S, Polar Seafood Trawl A/S, Qajaq Trawl A/S and Royal Greenland A/S. From Greenland Statistics, we have received yearly accounts, allocated quotas and catches of each firm.

Arnason (1990) find that a well-designed ITQ system will allow all resource rent to be generated and reflected in the quota value. Therefore, one empirical approach to determine the resource rent is to use the trading price of quotas. This requires well-functioning quota markets (Newell et al., 2005). Another empirical approach is to assess the economic value of fishery in Greenland.
annual resource rent using cost and earnings data. This approach is not very common, because it is relatively data demanding. However, in our case the quota-market is not very well functioning, because it is dominated by two large companies and hence we cannot use the quota price as the basis for determining the resource rent. Asche et al. (2009) has, based on cost and earning data, assessed the potential rent in an ITQ fishery, but not the realised rent. Unlike the above-mentioned studies, we include in our analysis the management cost. For a general overview of the pros and cons of ITQs, see Squires et al. (1995).

This paper includes three main parts – a methodology part discussing the cost–benefit approach used (Section 2), an introduction to fishery and the management system presenting the main characteristics of the Greenlandic shrimp fishery (Section 3) and a result and discussion part (Sections 4 and 5). The paper ends with the conclusion, which summarizes the main findings of this analysis.

2. Methodology

The purpose of the following section is to explain the necessary methodology for performing this analysis.

The first step is to define the overall constraints of the final analysis, i.e. which steps of the product life cycle should be included. Because of the aim of this report, the authors have set the constraints from “sea to sales” of the shrimp product out of Greenland. “Sea” in this context includes all the necessary activities for fishing shrimp, limited to Greenland as the fishing area, whereas “sales” refers to the delivery of the product to the sales companies, which can also be situated in other countries. Subsequent steps are ignored.

The second necessary step is to acquire information concerning the production and cost and earnings of each vessel. This was obtained by asking the companies to complete a spreadsheet about all costs, operating profit and investments for each vessel in each target year, as well as the type of product specified in shrimp size category, unit size of shrimp packs, quantity of catch and, finally, the price. All data focus on shrimp fishing and production for the target years 2006 and 2007. This information is supplemented with the annual accounts and data on yearly quotas and catches from Greenland Statistics. All these data are consistent and reliable.³ In fact, the documentation of the data and the extent of data sources used in this study are much better than in similar analyses.

Subsequently, a cost–benefit analysis (CBA) approach is used in order to analyze each vessel separately together with the total costs and benefits generated by the industry.

Because fishery is regulated by ITQs, we expect to find significant resource rents in fishery. Asche et al. (2009) refer to a “rule of thumb”: Resource rents up to 50% of the revenue, but it is not clear whether the authors mean potential or realized rents. Our expectations are however lower resource rents than 50% of the revenue, because fishery is dominated by two large companies, management cost is included in our analysis and higher cost is expected.⁴ Furthermore, our analysis is ex post. In ex ante analysis, most often first-best results are found based on a model exercise. Such results can be difficult to realize in practice. In open-access fisheries or fisheries under open-access, the resource rent is dissipated. Under limited entry regulation, the current fisher will upgrade the fishing vessels and other input use, leading to economic break even. Under individual quota, not transferable, some rents might be generated, but the full potential is not realized, because the low-cost fishermen cannot buy quotas from high-cost fishermen.

2.1. A short introduction to CBA

CBA is the most comprehensive policy evaluation tool from a welfare economic point of view.⁵ There are several reasons why CBA is considered so useful amongst researchers (see Arrow et al., 1996). Economic evaluation tries to assess the social desirability of a regulation compared with a given baseline situation or some other alternative, but can also be used as an approach to determine the actual state of a given situation. This is how we will apply CBA in our analysis. Therefore, economic evaluation can help public policy in focusing on the need for regulation and to find the scope and design of the regulation, e.g. by showing that a current regulation is not least-cost efficient. In CBA, the impacts in terms of benefits and costs is systematically determined and compared by transforming the impacts to monetary units.⁶ CBA has also been applied to evaluate fishery policy by Freese et al. (1995), Herrick et al. (1994) and Schwindt et al. (2000). Brown and Macfadyen (2007) apply a CBA to evaluate management responses to “ghost fishing”.

The basic foundation of CBA is a financial statement of the (changes in) the flow of income and cost that the (new) regulation generates for consumers and producers, i.e. the consumer and producer surpluses are determined. As part of the CBA, the single producer's income and cost can be determined, making it possible to set up an individual profit balance.⁷ The focus on incurred costs
and gained benefits by a society from a certain resource use makes CBA an economic rather than a financial analysis. Therefore, the financial statement has to be corrected, so that the statement is seen from a social point of view. Certain payments that occur in a financial analysis do not reflect a transfer of resources from one member of the society to another and are irrelevant from the perspective of society as a whole and are therefore not considered in CBA. Neglected transfer payments include direct taxes, interest payments as well as depreciation. Subsidies, on the other hand, need to be included since they represent a real resource cost to the society. Furthermore, it is important for a CBA to consider the following:

- whether market prices can be applied directly or a shadow price has to be calculated (more about this aspect latter),
- the extent of externalities (in fisheries there are normally significant negative externalities) and
- the mentioned flow of transfers which in a private analysis count, but not in social analysis.

Finally, costs incurred by changes in management could also be included. Since these costs normally are not included, the implicit assumption is that the changes in management cost are zero. This might be a reasonable assumption, when small changes in management are analysed. Since we are assessing the actual economic state of fishery, the current management cost is determined and included.

The time perspective is a crucial issue in CBA, because often the cost will be high in the short term due to initial investment cost, while the benefits tend to be higher in the medium to longer term. Therefore, in order to be able to compare the changes in benefits and costs, these are discounted back to the present period. The weighting of these flows at different time periods is possible by using a discount rate. The choice of discount rate is important and has to reflect the weight that the society puts on the future. The choice of the appropriate interest rate to use for the discounting is a widely discussed topic (see Weitzman, 2001). We will not consider this further in the paper. Nevertheless, the applied discount rate will be stated and briefly discussed in the analysis Section 4.

The goal of economic organization is to maximize the net benefit emanating from the production of goods and services over time. The overall economic net benefits to the society of fishery are therefore determined as follows:

\[
\text{Net benefits to society} = \text{NPV (benefits} - \text{costs)},
\]

where NPV is the net present value of the elements in parentheses since timing of costs and benefits matters.

If the net benefits (or NPV) to society are positive, then the regulation or the actual state of a situation contributes to the economic welfare, which means that the overall possibilities for consumption are increased. However, the analysis concerning distributional issues, such as who will experience a gain and who will experience a loss, is in this perspective not relevant. It is only of importance that potential gainers could compensate the potential losers, resulting in both parties being better off (Pareto efficient). It is not the case that the compensation actually happens; merely that it is possible (potential Pareto improvement). However, in practice, distributional issues and consequences are important and normally are included in the CBA. In this part, the financial flows become important.

3. State and development of Greenlandic shrimp fishery

The North Atlantic Ocean is abundant in northern shrimp (Pandalus Borealis), which are the primary shellfish there. In Greenland, shrimp have been harvested for more than 100 years, while since the 1960s the greatest increase in commercial shrimp fishing has been observed (Hvindel, 2006). Greenlandic shrimp are considered of high quality and have high retail value. Nowadays, approximately 85% of the Greenlandic exports are fish products, from which 55% are shrimp (Statistics Greenland, 2007).

3.1. The shrimp fishing regulations: Individual transferable quotas and total allowable catch

Shrimp fishing is regulated by quotas and licence regulations, where the total allowable catch (TAC) is based on the biological advice by the North Atlantic Fishing Organization (NAFO) in order to ensure sustainable use of the resource. The TAC for shrimp has increased from 50,000 tons in 1990 to over 130,000 tons in 2007, and it is assessed that currently the amount of harvested shrimp is at the maximum sustainable Yield (Hvindel, 2006; Sermitsiaq, 2007).

3.1.1. Individual transferable quotas. In general, fisheries can be organized by many different property rights arrangements, whereas sole ownerships, territorial use rights, individual non-transferable quotas and individual transferable quotas are some of the most used arrangements today. Individual quotas basically define property rights in harvesting volume as a fixed share of the TAC. Referring to the
literature, these property rights are of high quality, when being permanent, exclusive, secure and transferable. Therefore, it is argued that if other market imperfections are disregarded, harvesting with the usage of individual quotas will be conducted in an economically efficient way. This, in turn, implies that the TAC will be taken at minimum cost (Arnason, 1990). Greenland’s ITQ system for offshore and coastal shrimp fisheries was introduced by the Ministry of Fisheries and Hunting in 1990 (see Christensen & Vestergaard, 1993, for a description) and 1997, respectively. The Home Rule government may renew the allocation of the individual shrimp quotas within a five-year notice. The ITQs are therefore not a permanent property right, but can be viewed as right to harvest a certain share of the TAC for the next five years.

It is stated that this system sufficiently regulates fishing capacity according to the available resources and ensures that quota owners do not have any economic incentives to invest more than their respective quota share can support (OECD, 2005). This capacity adjustment process can take some time, if there is fleet overcapacity when the ITQs are introduced (Vestergaard et al., 2005). The Greenland Home Rule (2005) determines the TAC each year. The TAC is usually determined in accordance with advice from international research institutions such as International Council for the Exploration of the Sea (ICES) and NAFO.

The Greenland Fisheries License Control (GFLK) is in charge of the control and compliance with quota and license regulations and is also responsible for monitoring Greenlandic vessels fishing outside Greenlandic waters. In average, about 50 fisheries license controllers are employed at the GFLK. Furthermore, two inspectors are deployed onboard all high sea vessels in Greenlandic waters and a satellite system has been installed in order to control the operations and monitor all trawler movements and activities in Greenlandic waters, respectively.

### 3.1.2. TACs and Greenland quotas

Table I depicts the Greenlandic fishing quotas for the year 2000 till 2007. The most important result analysing the data is that the shrimp fishing quota has increased considerably during the last decade. In 2000, the total quota was 104,000 tons, while in 2003 it increased to 129,000 tons and in 2007 – to about 135,000 tons (OECD, 2005; Departement for Fiskeri, Fangst og Landbrug?, 2007). In comparison, the shrimp quota was only 47,900 ton in 1997 (Anon., 1998). Being more specific for the years 2006 and 2007, it can be stated that about 41% of the quotas have been issued for inshore shrimp fishing, whereas the other 59% – for offshore fishing – are allocated in the following way: 5% to the East coast and 54% to the West coast of Greenland in 2006 and 4% and 55% in 2007. Furthermore, it is important to mention that most shrimp fishing is undertaken by Greenlandic companies where the European Union has an agreement to fish up to 11,000 tons per year for the period 2007–2012 (European Commission, 2007).

### 3.2. The offshore shrimp industry

The shrimp-fishing industry is highly specialized as it involves long-term investments in large shrimp-harvesting vessels that can process the shrimp onboard. These trawlers are usually allowed to process up to 75% of their catch onboard (FAO, 2008). The last 25% of the catch has to be landed to onshore production facilities where the shrimp are processed to an unpeeled product. Smaller vessels have reduced in number because of the restructuring of shrimp fishing industry and the introduction of ITQs. Today, small vessels harvest only inshore (Hvindel, 2006). Currently, there are five to six main companies who harvest shrimp offshore with – in total – approximately 10–11 vessels, see Table II. Since it has been 16–17 years since the ITQ system was introduced, the capacity of fleet is adjusted to the fishing opportunities.

#### 3.2.1. Production and price development

The offshore shrimp catch in 2007 was 71,800 tons, which meant an increase of 1.7% from the year before (Department for Fiskeri, Fangst og Landbrug, 2007).
Landings to onshore shrimp processing facilities have increased from approximately 24,000 tons in 1987 to 60,000 tons in 2006 (see Figure 1), whereas about 45,000 tons is from the inshore fishery.11

Shrimp production is divided into two main categories: frozen, peeled shrimp and frozen, unpeeled shrimp. The variations in production and export of each type can be seen in Figure 2. Furthermore, shrimp-price changes for each production type are shown in Figure 3. Shrimp prices have changed in a non-uniform way. Especially, the frozen, unpeeled shrimp have reduced in value by a factor of 5 in the period 1996–2006. This decrease has been triggered most likely by the increased world market supply of warm-water shrimp, mostly from Asian countries (Departementet for Fiskeri, Fangst og Landbrug, 2008). 12

3.2.2. Employment. Fishing (including processing) is the primary industry in Greenland and employs 25% of the workforce. The processing industry accounts for 40% of this share, whereas fishing accounts for the remaining 60% (OECD, 2005). It has not been possible to get exact information about the employment numbers. However, in the official company accounts, the average crew number is disclosed to be around 31 per vessel. In Anon. (2006a), the crew number per vessel is assumed to be 40–50, while in Anon. (2006b), the crew number per vessel is assumed to be around 40. The employment rate has an impact on the assessment of the net benefit from fishery and the distribution of the net benefit between vessel owners, crew and the public sector. We will therefore apply sensitivity analysis to the employment figure, assuming an employment of either 30 or 40 persons per vessel.

4. Assessment of the benefits and cost

One has to realize that the assessment of benefits and cost by estimating the value of the shrimp and the cost to harvest them has the limitation that it does not address the potential net benefit of the harvest if the fishery was better managed, i.e. the benefits and costs are specific to the current regulatory system. However, the ITQ management of fishery is assessed to be highly efficient (Anon., 2006a) and consequently, using the actual benefits and costs is assumed not to be a serious limitation.

Equation 1 can be formulated as follows:

$$\text{NPV} = \sum_{t=0}^{20} \frac{B_t - C_t}{(1 + d)^t}$$
$$= \sum_{t=0}^{20} \frac{HV_t - (PC_t + HRC_t + EEC_t)}{(1 + d)^t}, \quad (2)$$

where benefit ($B$) is equal to the value of harvest (HV). Cost ($C$) is equal to private cost (PC), Home Rule cost (HRC) and external ecological cost (EEC). All the benefits and cost are evaluated by their willingness to pay and opportunity cost; i.e. market or observed prices are adjusted to reflect people’s willingness to pay or what they have to give up when using the factors in the shrimp fishery. We will assume that the EEC of fishery is equal to zero. We hereby ignore the value of other species that prey on shrimp (e.g. cod),13 and the impact that fishery might have on other fish stocks through the catch of juveniles. Since 2001, the use of sorting grid has been mandatory and the magnitude of by-catch of juvenile cod, redfish and Greenland halibut has since been observed to be insignificant (OECD, 2005). Another ecosystem externality is habitat change (Tschirhart, 2009). Since the cold water shrimp does not live at the bottom, but close to the bottom,

Table II. Number of vessels in the offshore shrimp fishery in the period 1990–2007.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>46</td>
</tr>
<tr>
<td>2003</td>
<td>12</td>
</tr>
<tr>
<td>2006</td>
<td>11</td>
</tr>
<tr>
<td>2007</td>
<td>11</td>
</tr>
</tbody>
</table>

Source: Anon. (2006a) and catch reports from GFLK.

![Figure 1. Landings to production facilities in the period 1996–2006.](source: Statistics Greenland.)
the often-mentioned negative impact of the trawl
gear on habitat areas is in this case minor. All in all,
the shrimp fishery does not currently create negative
ecosystem externalities, as it is assumed that the flow
of ecosystem services is not altered by fishery.

In the following subsections, we determine the
harvest value, the private cost and the management
cost.

4.1. Total harvest and value of the harvest
We assume that the gross benefits of the shrimp
harvest in any given year are reflected in the landed
value of the catch. This ignores potential consumer
surpluses. This, however, is not a significant pro-
blem, because most production is exported, and we
assume, following the usual convention, that only
those costs and benefits that accrue to Greenland
count. Under these circumstances, consumer sur-
plices accruing to people residing in Greenland are
very small and can therefore be safely omitted from
the calculations.

The answers from the five companies include
seven vessels in 2006 and nine vessels in 2007,
which explains why the reported catches in Table III
are lower than those in Table I. The whole offshore
shrimp fishery in 2006 is therefore not covered. Also,
the information about production from the compa-
nies in Table III does not match the catch exactly,
which might be due to the different timing of
registration of catches and production and differ-
ces in the methods of determining catches and
production (Director Henrik Leth, personal com-
munication, 2009).

4.2. Private cost
We are interested in both the private harvest cost and
public sector costs. The primary source of informa-
tion on the costs of operating the shrimp fleet is the
data provided by the companies in their yearly
accounts. It is reasonable to assume that expendi-
tures on inputs approximate the opportunity costs of
the inputs. There is no reason to assume that
industry purchases have a significant impact on
input prices or that the markets for most inputs are
distorted. Many of the inputs are imported and
hence the price is determined by the world market
prices. However, crew costs may be an exception.
This issue will be investigated in more detail in the
next section.

Operating expenses (fuel, other), crew wages and
fixed annual costs (e.g. repairs and gear) are
included under “running costs”, see Table IV. To
assess the capital cost, an estimate of the opportu-
nity cost of the annual capital investments is
required in the used framework, which is not
straightforward. The costs of investments should
be converted into a value of the stream of consump-
tion that would have resulted if the investments had
not taken place. The opportunity cost or shadow
price is the return that the capital could have earned
in its best alternative use. Estimating this shadow
price includes an assessment of the gross rate of
return applicable to this capital and the economic
depreciation rate (Hulten, 1990). The capital cost included in the annual accounts cannot be applied directly. Firstly, the figures do not include the opportunity cost of the equity capital. Secondly, they use depreciation claimed for accounting purposes, not based on an economic rate. Thirdly, they include cost of all capital employed in the industry. The first two issues do not need more clarification as they are common in CBA; the third issue is however not common and deserves some elaboration.

A significant portion of the capital employed represents the value of ITQ fishing licenses, which from the perspective of the fishermen is an asset. Needless to say, an ITQ license is a requirement for participation in fishery. For those who purchased their licenses, the cost of the ITQ license is a significant part of their capital investment. From a social point of view, the value of the ITQ license should not be included in the capital stock used to harvest shrimp, as it is not a real resource that is used up in the process of catching shrimp.14

Therefore, to estimate annual capital costs, we have ignored the value of ITQs licenses and used only vessel values. Using the answers from the questionnaire, we assume that the useful operating lifetime of a fishing vessel amounts to 20 years. To determine the rate of return applicable to this capital, we use annual rates of return to capital employed at 7%. The annuity, i.e. the annual capital cost, is then calculated using the following well-known formula:

\[
I = \text{capital cost} \times \frac{1 - [1/(1+r)^n]}{r},
\]

where \(I\) is the investment, \(r\) is the discount rate and \(n\) is the time horizon of the investment.

### 4.3. The management cost: Greenland home rule15

In addition to the private costs incurred by fishermen, the Greenland Home Rule, who has the responsibility for the shrimp fishery, spends resources to manage the shrimp fishery. The government expenditures on the fishery will approximate the social cost. However, it is difficult to quantify the costs of managing the shrimp resource for a number of reasons. Several public agencies and hence budgets are involved, and it is difficult to accurately assign a share of these various budgets and expenditures to the shrimp fishery. And while some costs

---

### Table III. Harvest volume and harvest value.

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total license/quotas (tons)(^a)</td>
<td>55,305</td>
<td>70,675</td>
</tr>
<tr>
<td>Total catch (tons)(^a)</td>
<td>55,305</td>
<td>64,432</td>
</tr>
<tr>
<td>Total harvest value (DKK 1000)(^b)</td>
<td>562,970</td>
<td>679,470</td>
</tr>
<tr>
<td>Total production (tons)(^b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooked at sea</td>
<td>23,666</td>
<td>31,286</td>
</tr>
<tr>
<td>Raw (“Italy” and “Japan”)</td>
<td>7,803</td>
<td>7,208</td>
</tr>
<tr>
<td>Industrial (landed)</td>
<td>14,049</td>
<td>18,028</td>
</tr>
<tr>
<td>Total harvest value (DKK 1000)(^b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooked at sea</td>
<td>283,556</td>
<td>402,692</td>
</tr>
<tr>
<td>Raw (“Italy” and “Japan”)</td>
<td>132,837</td>
<td>111,509</td>
</tr>
<tr>
<td>Industrial (landed)</td>
<td>77,167</td>
<td>96,542</td>
</tr>
</tbody>
</table>

\(^a\)Catch reports from GFLK.
\(^b\)Information from the fishing firms in the questionnaire.

---

### Table IV. Cost in the shrimp industry, DKK 1000.

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation expenses</td>
<td>202,240</td>
<td>243,739</td>
</tr>
<tr>
<td>Fuel</td>
<td>118,448</td>
<td>138,595</td>
</tr>
<tr>
<td>Landing, packages</td>
<td>57,925</td>
<td>70,349</td>
</tr>
<tr>
<td>Admin. and crew</td>
<td>25,827</td>
<td>34,796</td>
</tr>
<tr>
<td>Wages</td>
<td>139,954</td>
<td>177,649</td>
</tr>
<tr>
<td>Fixed costs</td>
<td>59,333</td>
<td>68,274</td>
</tr>
<tr>
<td>Capital costs</td>
<td>85,755</td>
<td>106,307</td>
</tr>
<tr>
<td>Total private cost</td>
<td>487,283</td>
<td>595,970</td>
</tr>
</tbody>
</table>
are directly derivable from budgets, other costs are indirect and extremely difficult to estimate accurately. There are no species-specific management budgets of Greenland Home Rule. However, it is possible to estimate an order of magnitude with respect to expenditures by the Home Rule government. The expenditures in the fiscal years 2006 and 2007 are set out in Table V. We include expenditures on scientific research and advice, control of the fishery and fees for membership of international organizations. The Science Research and Advice program at the Greenland Institute of Natural Resources involves expenditures on the biological sciences (e.g. stock assessment is required to set the total allowable catch).

These calculations yield an estimate of fisheries-related expenditures in Greenland. However, these expenditures relate to all fisheries, not just shrimp. In 2006, the export value of frozen, unpeeled shrimp accounted for 26.2% of the total value of fish exports (see Table VI for further details). This share has to be adjusted upwards, because the offshore shrimp fleet is landing shrimp for further processing onshore as cooked and peeled shrimp (8.1%). Consequently, the share of the offshore shrimp fishery of total fish exports is 34.3%. Using the assumption that 34.3% of the Greenland Home Rule fisheries-related budget can be allocated to the shrimp fishery gives an estimate of Greenland Home Rule expenditures on the shrimp fishery in 2006.16 Other ways of allocating the public expenditures could be used, such as number of vessels or number of landings. Using revenue shares reflect that public expenses on fisheries management are used in accordance with the economic importance of the fisheries. This estimation procedure is also applied to the budget for year 2007. The results are set out in Table V. The management cost is around 3% of the revenue.

Needless to say, the estimates of government costs attributable to the shrimp fishery are not precise and they may understate public expenditures on this fishery. Firstly, the estimates ignore the Greenland Home Rule expenses in the Directorate of Fishery, Hunting and Agriculture. Secondly, both the fishermen and other sectors use harbors. Parts of the harbour expenditures can be allocated to the fishery. There is no harbour fee in Greenland and hence the fishing fleets do not pay for using the harbours. Finally, the calculations ignore the marginal excess tax burden, i.e. the costs of taxation to fund these government expenditures. However, some revenues are captured by the shrimp tax. Our results are in accordance with the results from Arnason et al. (2000). They estimated the management cost in Iceland and Norway to be around 3% and 10% of the revenue, respectively.

5. Results of the CBA

As said before, we focus on analysing the current economic value and hence economic contribution of Greenland’s offshore shrimp fishery without comparing this situation to possible changes in the net benefits to society by applying, for example, a

Table V. Public management cost, DKK 1000.

<table>
<thead>
<tr>
<th>Expenditure</th>
<th>2003</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenland Institute of Natural Resources</td>
<td>20,000</td>
<td>21,224</td>
<td>21,649</td>
</tr>
<tr>
<td>fisheries-related activities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishery and license control</td>
<td>26,000</td>
<td>27,591</td>
<td>28,143</td>
</tr>
<tr>
<td>Fees for membership of organizations</td>
<td>1,000</td>
<td>1,061</td>
<td>1,082</td>
</tr>
<tr>
<td>Total</td>
<td>47,000</td>
<td>49,876</td>
<td>50,874</td>
</tr>
<tr>
<td>Offshore shrimp fishery</td>
<td>17,089</td>
<td>17,431</td>
<td></td>
</tr>
</tbody>
</table>

Source: Information is from Anon. (2006a), where the figures from 2003 are found. Assuming an increase at 2% per year gives the figures for 2006 and 2007.

Table VI. Calculation of the offshore shrimp fishery’s share of the total fish export, DKK m.

<table>
<thead>
<tr>
<th>Exports</th>
<th>2006</th>
<th>Share of fish export</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fish and fish products</td>
<td>2,038</td>
<td></td>
</tr>
<tr>
<td>Total exports of shrimp</td>
<td>1,197</td>
<td></td>
</tr>
<tr>
<td>Exports of frozen, unpeeled shrimp</td>
<td>533</td>
<td>0.2615</td>
</tr>
<tr>
<td>Exports of cooked, peeled shrimp</td>
<td>664</td>
<td></td>
</tr>
<tr>
<td>Offshore shrimp fisheries export of cooked, peeled shrimp*</td>
<td>165</td>
<td>0.0811</td>
</tr>
</tbody>
</table>

\*It is assumed that 25% of the offshore catches are produced as cooked, peeled shrimp and the basis of distribution of total catches between the offshore and inshore fleet is 57%/43%. All the catches from the inshore fleet are produced as cooked, peeled shrimp.
different fishery policy or a modified resource allocation of ITQs. This means in detail that all benefits and costs including public management cost are assessed annually and discounted to derive the net present value. Furthermore, market prices have been replaced with calculated shadow prices if necessary. This has been the case for the crew cost. Finally, the distribution of the net benefits is estimated because it is an important policy issue in Greenland.

5.1. Results: Annual net benefits and net present value

The following section presents the numerical results of the analysis, which includes on the one hand side the private and Home Rule costs and on the other hand the production, including the products with the shrimp size categories, quantities and price per kilo resulting in estimates of the gross output (harvest value).

One missing issue is an evaluation of whether the applied prices reflect opportunity cost. In Section 4.2, it was indicated that crew cost might be a problem in that respect. Using the employment figures from the yearly accounts (around 31 persons per vessel), the average yearly salary is estimated to be around DKK 700,000. This figure is very high. Assessing the opportunity cost is however a difficult task. Some of the crew is probably very essential for the fishery and can’t be replaced. Therefore, just assuming that the opportunity cost is the average income in Greenland will not be correct. It was decided to use the average yearly income of people outside the municipalities, around DKK 460,000, as opportunity cost, because many of these people are highly specialized. This leads to a downward reduction of the labour cost by one third or in other words the crew is receiving some of the net benefit, i.e. a salary beyond what is needed to keep them employed. This is called crew rent. We have in Table VII kept the paid wages as part of the private cost and therefore crew rents are added to reflect opportunity cost and economic rent. We will, however, also calculate the rent with employment at 40 persons per vessel.

The estimates in Table VII show that the yearly net benefit or economic rent from fishery and hence contribution to the Greenland economy is considerable, around 19% of the total harvest value. It is important to understand that this economic rent is due to an efficient fishery management system. The same kind of management system is also in function in, for example, Iceland and New Zealand where it had revealed the same positive economic results. Needless to say, the size of the economic rent will vary from year to year depending on the price and cost development and the amount of quota (TAC). The yearly benefits and cost can be extrapolated forward over 20 years using a proper discount rate and the NPV can be calculated using Equation 2. Using different assumptions about the social discount rate (3%, 5% and 7%), the NPV of the average annual net benefits using a time horizon at 20 years varies between DKK 1221 m and DKK 1715 m.

5.2. Distribution of net benefits

In this section, the net benefits are distributed between fishing firms, the crew and the public section, i.e. the Home Rule Government and the municipalities.

In order to be able to do this, the tax revenue has to be calculated. We use the information provided by the firms in the questionnaire and the flat tax rate (42%) for Nuuk, the capital of Greenland. The tax

### Table VII. Annual benefits, cost and net benefits generated by the offshore shrimp fishery, DKK 1000.

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest value</td>
<td>562,970</td>
<td>679,470</td>
<td>621,220</td>
</tr>
<tr>
<td>(-) Private cost</td>
<td>487,283</td>
<td>595,970</td>
<td>541,626</td>
</tr>
<tr>
<td>(=) Private net benefits</td>
<td>75,688</td>
<td>83,500</td>
<td>79,594</td>
</tr>
<tr>
<td>(-) Home Rule cost</td>
<td>17,089</td>
<td>17,431</td>
<td>17,260</td>
</tr>
<tr>
<td>(=) Fishery net benefits</td>
<td>58,598</td>
<td>66,069</td>
<td>62,334</td>
</tr>
<tr>
<td>(+) Crew renta</td>
<td>46,651</td>
<td>59,216</td>
<td>52,934</td>
</tr>
<tr>
<td>(=) Social net benefits</td>
<td>105,249</td>
<td>125,285</td>
<td>115,268</td>
</tr>
</tbody>
</table>

*aCrew rent = The difference between the actual salary and the opportunity cost of labour.*

### Table VIII. Calculations of the tax revenue, DKK 1000.

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrimp tax</td>
<td>289</td>
<td>379</td>
<td>334</td>
</tr>
<tr>
<td>Corporate tax</td>
<td>1,310</td>
<td>5,055</td>
<td>3,183</td>
</tr>
<tr>
<td>Tax of crew rents</td>
<td>19,594</td>
<td>24,871</td>
<td>22,232</td>
</tr>
<tr>
<td>Total tax revenue of net benefits</td>
<td>21,193</td>
<td>30,306</td>
<td>25,749</td>
</tr>
</tbody>
</table>

Source: Questionnaire and own calculations.
revenue related to the net benefit is the shrimp tax, the corporate tax and the tax of the crew rent (see Table VIII). Given the tax revenue and the benefits and cost calculated in the last section, it is possible to calculate the distribution of the net benefit or the resource rent between the firms, the crew and the public sector (see Table IX).

The payments of corporate taxes are low compared with a calculated payment. The main explanation of this difference is the depreciation rules according to the law, where the vessels are depreciated over 10 years and where depreciation on licenses is also allowed. A calculation applying the depreciation rules confirms that the level of corporate taxes shown in Table IX can be expected when the average life of the vessels is > 10 years. If the average life is higher than 10 years, i.e. the vessels are fully amortized, then the corporate tax payment increases to a level of around DKK 35-40 m. Another explanation for the low corporate taxes may be that some companies have activities beside shrimp fishery that contribute much less to the earnings than the shrimp fishery (Director Henrik Leth, personal communication, 2009).

The analysis of the distribution of the economic rent shows that the private companies and the crew are capturing the main part, up to 90% (see Table IX). If the company taxes are calculated using the tax rules, the annual tax revenue increases with DKK 16 m. The total net benefit does not change, but the public sector receives in this calculation a higher share of the rent, around 20%. Such levels of tax payments are however not currently realized, and we will not use this calculation further.

If the number of crew members is 40 instead of 30, then the average payment falls and hence the crew rent will fall (Table VII). The salary payment to the crew is now adjusted only by 16%. The overall annual net benefit falls (Table VII), and this will also change the distribution of net benefits shown in Table IX. The annual net benefit will decrease to DKK 87.7 m. The private companies will have the same surplus, while the net benefits to the crew and to the public sector will fall (due to less tax revenue from crew rent). The annual surplus to the crew is DKK 14.7 m, while the public sector in this case has an annual deficit of DKK 3.1 m.

5.3. Discussion of results

The economic rent or resource rent of the offshore shrimp fishery is substantial and as discussed related to the management system of ITQs. The sensitivity analysis on the employment per vessel and the discount rate does not change this conclusion. The annual economic rent in 2006 and 2007 on average varies between DKK 87.7 m and DKK 115.3 m, around 20% of the revenue. Asche et al. (2008) found in ex ante analysis of fisheries in Sweden, Denmark and UK potential resource rents to be between 20% and 30%. For fisheries in Norway and Iceland, the potential rent was higher, up to 50%. More interesting realized resource rents in a part of Icelandic fleet regulated by ITQs were estimated to be around 7%. However, management cost is not included as part of the social cost and therefore in total the rents will be lower. Overall, in our case the realized rent is as expected, but could probably be higher if costs were lower and/or more companies were involved in the quota trading.

Since the economic rent is showing the surplus when all the inputs have been paid, it is in principle a political decision how to share the surplus. The Greenland Home Rule already has a shrimp tax, which due to low prices does not provide significant revenue. The question is, therefore, whether the revenue to the public sector can be increased and under which circumstances it is a good idea? In Anon. (2006a), there is a discussion about letting the industry pay for the management cost.

There are, however, limitations for the taxation. The economic rent can be divided into scarcity and intra-marginal rent. The scarcity rent arises from the realization of a natural resource, here shrimp, while...
the intra-marginal rent is due to differences in the producer's cost; i.e. the fishermen have heterogeneous skills. The "high liners" in a fishery may have lower unit production costs than on average and therefore earn intra-marginal rent. It is difficult to capture this part of the economic rent. And it is a very difficult task to separate the intra-marginal rent from the scarcity rent, because it will require a detailed study and estimation of the individual company's production and cost relationships. The offshore shrimp fleet is relatively homogenous and the products the same, so the intra-marginal rent can be assumed to be relatively low. A second limitation is how the scarcity rent is spent. It is possible to design a system where the public sector collects a substantial part of the rent without impacting the incentives of the companies (see van Kooten & Bulte, 2000). If the public sector is spending the money wisely, then it might be as good as having the private companies collecting the rent (assuming of course that the private companies are the best to find profitable investments).

6. Conclusion

The economic benefit of the Greenland offshore shrimp fishery has been estimated for 2006 and 2007. The annual economic rent or surplus of the fishery is around DKK 100 m (19% of the harvest value), which is a result of the current ITQ management system of fishery. Thus, fishery contributes not only positively to the Greenland economy but also significantly, considering that the Greenland Gross Domestic Product was DKK 10.5 bn in 2007. The analysis has been limited to benefits (and cost) from an economic point of view – e.g. in education, or to replace other taxes, are arguments for having both of them collecting the rent.

These economic arguments may overlook the political economic argument that the Greenland public opinion might not be willing to tolerate the distribution of income resulting from the way the quotas have been allocated, even if they understand the efficiency of the system. So, to maintain a wider acceptance of the system, it may probably be necessary to let the public sector collect a higher share of the economic rent. This acceptance is important, because an abandonment of the fishery management system to a more inefficient one will have a negative impact on the economic growth in Greenland. There are other ways to regulate fishery efficiently and to collect the rent. One option is auctions where the quotas to the fishery are sold to the highest bidder. In this way, the rent is collected “up-front”. Whether such a system would generate higher rents is an open question and requires further research.

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Notes

2. Another concept is value added, which is calculated as the value of outputs minus the cost to materials. Value added does not reflect that the use of capital and labour has an (opportunity) cost, and hence it can be considered as a measure of the economic impacts of the production.
3. One check of the data is to compare the production figures with the export data. This is done by the Home Rule Government.
4. This is due to several issues; operating in Greenland is difficult from a climate point of view and there is a general lack of competition; see Paldam (1997).
5. Another method is cost-effectiveness where the ratio between impacts measured in physical terms and the monetary cost of different alternatives are compared. In this case, the benefits are not assessed in monetary terms.
6. It is not possible to “put money on all impacts”. However, a complete cost–benefit report will contain a description of the non-monetary impacts.
7. This can be useful information, because any changes in profit would influence the producer’s incentives and hence cause a reaction to policy changes.
8. In 2009, the form of government changed from Home Rule to Self-Government. We keep Home Rule, because our study is for 2007 and 2008.
9. However, the figures can’t be compared directly. The figure for 1997 has to be adjusted by a conversion factor, and so the adjusted TAC is close to 70,000 ton.
10. During 2006 and 2007, there have been some mergers between companies, which makes it difficult to state the exact amount of firms and vessels.
11. As the vessels are smaller in the inshore fishery, most of them are landing all their catches to the onshore production facilities.
12. The jump in prices for peeled shrimp in 1998 is due to change in the principle of transfer prices (Director Henrik Leth, personal communication, 2009).
13. Since the 1970s, the cod stock in Greenland waters has been low and therefore this effect of the shrimp fishery is insignificant. This might change in the future due to climate changes; see Vihljálmsson et al. (2005).
14. This will be an example of the well-known “double-counting” problem in CBA; see Schwindt et al. (2000).
15. In 2009, Greenland became more independent and the government is now called the Greenland Self-Government.
16. Alternatively, the expenditures can be assessed in a detailed analysis of the government budget. The result could be other management cost, because the regulation scheme of other living marine resources differs from the management system of shrimp fishery.
17. The crew salary is negotiated between the labour union SIK and the Confederation of Greenland Employers as a share of the revenue minus some of the variable cost. In other words, the surplus from the fishery is shared between the crew and the owners of the fishing trawlers. Such a system will generate higher wages, because some rents will be captured by the crew when the economic surplus is divided (Anon., 2006a).
18. If the average sales price is lower than or equal to DKK 13.00 per kilo, the shrimp tax is zero. The shrimp tax rate increases by 1% per DKK 1 increase in sales price. The basis of the shrimp tax is the sales prices.

References


