THE RESOURCE RENT IN SWEDEN'S FISHERY

Anton Paulrud
Swedish Board of Fisheries
Anton.Paulrud@fiskeriverket.se

ABSTRACT

The report is an analysis of the resource rent in the Swedish fishery, produced as a contribution to the new strategic plan for the Swedish fishery in the years 2007-2013 according to the draft EU regulation for the EFF (European Fishery Fund). A model has been produced based on linear programming. The study originates from the situation in 2004 and with this basis different scenarios are calculated for the coming years. Special emphasis has been put on the optimal resource rent and the maximum number of employed persons within the sector.

The actual current situation points to great deficits, and also to a fishery overcapacity. This is due to too many vessels sharing a resource too small. The fixed costs of the overdimensioned fishing fleet turn potential profits into great losses. The effects of restructuring the fishing fleet could be large. An optimal economic scenario suggests that more that 50% of the fleet should be restructured, and that more than 40% of these should even be scrapped, i.e. removed from the fleet altogether. The optimal scenario further suggests that only one-fifth of the total quotas should be landed; catching the remaining four-fifths is not profitable.

The goal of utilizing the fish resource is not only to maximize profits, but also for example to spread the use regionally or to maximize employment. The resource rent is expected to be zero at a maximized level of employment. The results show that a restructuring can increase employment as well, even with half of the current utilization of the resource, i.e. with half of the current total catch. The net- and hook segment and the small pelagic vessels are winners from an employment perspective. This is not only due to low incomes per fisherman (which is absolutely not true for the small pelagic vessels), but also to that the profits in these segments can be used to increase total capacity, i.e. the number of vessels.

The future is uncertain. Technological development and increasing prices and costs are some of the potential changes that can be expected to take place, but the calibers of these changes are unpredictable. The Baltic Sea seal population is another threat worth considering. A likely future scenario does nevertheless look bright from an economic perspective. The results indicate that restructuring can make the fishing fleet generate a relatively large profit without overexploiting the resource.

Keywords:

Resorce Rent, Bio-economic modeling, Fishery,

Introduction

The Swedish fishing industry is in a state of crisis. The mismanagement of the national natural resource of fish is obvious. The devastation is apparent both in terms of the biological resource and in terms of return on labor, return on capital, and resource rent. An improved management of the natural resource of fish - as well as other resources such as labor - may contribute to an increased welfare and to an economically and ecologically sustainable development. The fish resource is defined as a renewable natural resource, where present use in excess of the natural yield leads to a reduced future use. That is to say that if the harvest exceeds the reproduction, then the population will be affected and therefore also future reproduction. The usage of the fish resource is a typical example of how unregulated markets do not always bring about efficient solutions. The market failures that hence arise in the fishing industry usually result in inefficient production, consumption, and investments (DS 1997:81).

The first problem related to production inefficiency is due to the lack of individual owner rights. Fishing will continue until the costs equal the revenues implying a break-even result, which may eventually occur since the revenues can be assumed to decrease with increasing inputs (i.e. catching the first fish is easier than catching the last fish), assuming that cost per input does not change. In a situation with only one owner, he or she would choose the level of inputs with the largest difference between costs and revenues, i.e. where the resource rent (profit) is maximized. Unregulated fishing often leads to inefficiency in consumption as well. This may be because it results in fish being caught in the wrong place at the wrong time, making it impossible to sell the fish in its most profitable form (e.g. fresh), but instead in a less valuable form. Finally, unregulated fishing also leads to inefficiencies in terms of investments. For example, it encourages the maximization of catching capacity without any concern for the effects on the catching period, resulting in overcapitalization.

As pointed out earlier, solving the market failures of fishing requires better defined owner rights. Another seldom mentioned problem is the effects of the market interest rate on the usage of the natural resource. A high interest rate may require a complete harvest of a resource to make the harvest worthwhile, especially when it comes to resources with a low natural return (i.e., money used to own a resource can sometimes generate a higher return in, for example, a bank savings account). The government taking on and declaring the owner rights by means of for example a landing fee could be a possible solution to the owner right dilemma. This landing fee corresponds to the resource rent (profit) missing in unregulated fishing. The suggested system would be optimal, given a correctly determined fee, and the resource rent would by means of the collected fees go to the citizens (DS 1997:81).

Another alternative would be for the state to distribute transferable quotas to the individual fishermen corresponding to the optimal total catch, i.e. the catch generating the highest profit. The resource rent could go to the fishermen in the form of free-of-charge quotas or alternatively go to the state through a state sale of the quotas, depending on how the individual quotas are distributed. This method would allow fishing to function under the same institutional conditions as agriculture or forestry (DS 1997:81).

Other than these two main methods (landing fees and individual quotas), there is a multitude of systems aimed at regulating fishing, none or few of which bring about efficient solutions. The point of the most commonly used methods is to limit the fishermen's production inputs, rather than the size of their catches. These methods, often referred to as effort regulations, bias the composition of inputs and create less cost effective solutions. For example, a limitation of the number of fishing days per year results in an escalated equipping of the vessels, and therefore in increased costs and decreased employment. Increased costs may indeed help achieve the goal of a decreased total catch, but will do so in an inefficient manner with fishing taking place with unnecessarily high costs.

The present fishing politics are characterized by inefficient systems regardless of whether the goal is resource rent or employment maximization, or regional considerations. Resource rent refers to the national level economic surplus after covering all firm level costs (including capital costs). The term corresponds to the traditionally used ”ground rent”, which has historically been used in agriculture, referring to the compensation for allowing somebody to use one's land. It is important to point out that resource rent is not synonymous with net value to the economy. Estimating net value to the economy should include transfer payments such as EU structural support, unemployment benefits, etc. plus the costs of fishing control.

The following paper is brought about in response to the Swedish government's request that the Swedish Board of Fishery produce a draft of a strategic plan for the years 2007-2013, according to a coming EU regulation. The paper is intended to provide a basis containing an analysis of resource rent (profit), or value, in the Swedish fishing industry. First, the paper declares the current status of Swedish fishing. Then it describes possible outlooks related to various goals of action and scenarios that may arise. The basic model that the analyses are built upon is presented briefly before the possible future scenarios are described. Maximization of resource rent and maximization of employment within the fishing industry are focused on in particular.

Background to the analysis

The model

The model used in this paper to study fishing under various future scenarios is a so-called linear programming model. Linear programming is a common method when optimizing a goal function when there is a large number of variables and restrictions.

The goal function used in the model is the profit that arises when using the Swedish fishing resource - the so-called resource rent. A bit simplified, resource rent can be said to equal total revenues minus total costs, and must not be confused with the return to the fishermen, or salary, which when calculating the resource rent should be considered as costs included under total costs. The goal function, or the resource rent function, is maximized under given restrictions. The model restrictions can be changed, and the outcome of various scenarios (such as price increases, a change in the ban on fishing cod, or changes in the fishing quotas) can therefore be revealed. The goal function itself can be altered as well; the model can for example maximize employment instead of resource rent (given that the resource rent is zero or some other stated value). Other variables such as number of vessels of a certain kind or days at sea can be maximized as well. Furthermore, the model is able to calculate the current actual resource rent, which is presented in this paper.

Species, catches, and quotas

Swedish fishing is mainly based on around 40 different species, which in this report have been divided into 42 different groups (Table 1) in order to make the analysis manageable. In this report, catch refers to landed catch. Please note that some species have been divided into different groups depending on how or in which geographical locations they are caught. Also, a single group may contain more than one species. Most segments and types of fish within the segments include unidentified catch, or catches that were never specified by the fishermen. This report will disregard these unknown catches, despite their total size being relatively large (about 114 metric tons). One reason for this is the great difficulty in optimizing something that is entirely unknown. Neither does the estimation of the current situation include the unknown catches.

Table 1. Catches of the fishing fleet divided into 42 groups (2004 catches).

Species	Metric ton	Species	Metric ton	Species	Metric ton
Perch	53	Pollack	50	Sprat B. Sea for C.	44 671
Witch/Lemon sole	585	Ling	34	Sprat B. Sea for I.	36 396
Blue whiting	19 084	Mackerel	4 410	Flounder/Dab	163
Saithe	2 242	Monkfish	60	Brill/Turbot	45
Pike	20	Northern pink shrimp	2 308	Horse Mackerel	672
Zander	24	Spurdog	234	Sandeels	33 372
Catfish	64	Plaice	389	Cod W (W. Sea)	1 158
Norway lobster	894	Whitefish	194	Cod WP (B. Sea W.pop.)	2 198
European lobster	22	Vendace	1 814	Cod EP (B. Sea E.pop)	11 887
Halibut	4	Herring W. Sea	45 096	Whiting	126
Haddock	345	Herring B. Sea for C.	22 268	European eel (B. Sea)	170
Edible crab	146	Herring B. Sea for I.	21 073	European eel (W. Sea)	150
Hake	67	Lumpfish	196	Sole	16
Salmon	586	Sprat W. Sea	6 536	Trout	21

Short words: W (Western), B (Baltic), I (Industrial purpose), C (Consumption), W.pop (Western population), E.pop (Eastern population).

There are reasons to limit the model's possible total catch of each species. The possible total catch has therefore been limited to the 2004 levels of total catches of each species (unless otherwise noted).

Vessels, segments, and their different types of fishing
The Swedish fishing fleet consists of 1,597 licensed vessels (2004 data). Only 796 of these are considered active commercial vessels, i.e. each with a gross catch valued at more than SEK 80,000 (=2 Swedish "basbelopp" - a common threshold value in the Swedish tax system). Of the remaining vessels, 415 have a gross catch worth less than SEK 80,000, and 384 show no catch at all. These latter two groups of vessels (799 in total) are excluded due to their marginal importance in the model and therefore also in the coming report. The 796 active licensed vessels can be divided into 13 segments based on size, type of catch, and method of fishing (Table 2). This classification adheres to the EU data gathering program "Economic Assessment of European Fisheries" (EAEF) from 2005.

Table 2. Segments of the active Swedish licensed fishing fleet in 2004.

Segment	No. of vessels	Segment	No. of vessels
Demersal trawlers < 24 meters	74	Shrimp trawlers	53
Demersal trawlers > 24 meters	13	Net and Hook vessels in the Baltic Sea	168
Norway lobster trawlers <12 meters	22	Eel fishing in the Western Sea	42
Norway lobster trawlers >12 meters	45	Eel fishing in the Baltic Sea	47
Vessels >12 meters with passive gear	37	Other passive gear in the Western Sea	101
Pelagic fishing vessels <24 meters	55	Other passive gear in the Baltic Sea	84
Pelagic fishing vessels >24 meters	55	**Total**	**796**

The number of species that each segment is able to catch is limited in the model, due to natural limitations of the equipment, the geographic dispersion of the species, available catch statistics, and spatial distribution (demersal, pelagic, etc.). In the model, the possible catch by each segment is divided into target species and by-catch species according to the previous section. Observe that the by-catch also are landed and sold. The by-catch of the different species has (with only a few exceptions) been limited to a range of 75%-125% of the proportion of the certain specie divided by the target specie (or –s) within each fishery (based on 2004 catches). The relations that are created between the by-catch species and the target species are therefore mutual. The size of the by-catch is related to the size of the target species and no fishing if target species and by-catch quotas are missing.

Actual catches (but with catch limits in accordance with the model) are used when estimating the current situation, meaning that the species that the model considers to be impossible to catch by a segment are not included in the estimations. At any rate, these catches of "impossible" species make up for only an insignificant share (<1 %) of the total catch. The division into segments is therefore not perfectly realistic, although it does come very close. Below is a account of the different methods of fishing and types of catch made by the different segments.

The first two segments are the demersal ones (demersal trawlers <24 meters and demersal trawlers >24 meters), operating in three different locations. This means that they have three different catch distributions, i.e. one distribution for each species. First there is fishing for witch/lemon sole, catfish, haddock and cod W (Western Sea) off the Swedish west coast, with a by-catch of saithe, Norway lobster, halibut, hake, pollack, ling, monkfish, plaice, flounder/dab, brill/turbot, whiting and sole. The two other categories include fishing for cod from the Western Population (WP) and from the Eastern Population (EP) in the Baltic Sea. Both include by-catches of plaice, flounder/dab, and brill/turbot.

The fishing for Norway lobster with trawl gear is divided into two segments as well, according to the size of the vessels, i.e. smaller or larger than 12 meters. The by-catches in these two segments are the same: saithe, Norway lobster, halibut, hake, pollack, ling, monkfish, plaice, flounder/dab, brill/turbot, whiting, and sole.

Vessels larger than 12 meters with passive gear pursue two kinds of fishing in the Baltic Sea, fishing for cod WP and for cod EP, producing the same by-catches of plaice, flounder/dab, and brill/turbot.

There are two segments of pelagic fishing: vessels <24 meters and vessels >24 meters. These perform species- and area specific fishing, relatively speaking, although in great variety. The pelagic fishing with vessels smaller than 24 meters can be separated into six different types: (1) fishing in the Baltic Sea for Vendace with a by-catch of herring for industrial and consumption purposes, (2) clean fishing in the Baltic Sea for herring for consumption, (3) clean fishing in the Western Sea for herring for consumption, (4) clean fishing for sprat in the Western Sea and (5) in the Baltic Sea, and (6) clean fishing for herring in the Baltic Sea for industrial purposes only.

There are nine different types of fishing for the large pelagic vessels: (1) four-month seasonal fishing for blue whiting, (2) clean fishing for mackerel, which is also four-month seasonal, (3) fishing in the Western Sea for herring for consumption with a by-catch of blue whiting, and horse mackerel, (4) clean fishing in the Baltic Sea for herring for consumption, (5) clean fishing for herring in the Baltic Sea for industrial purposes, (6) clean fishing for sprat for consumption in the Western Sea, (7) Baltic Sea sprat fishing for consumption, with a by-catch-of herring for both consumption and industrial purposes, (8) Baltic Sea sprat fishing for industrial purposes, with a by-catch of herring for industrial purposes, and finally (9) three-month seasonal fishing for sandeels.

The shrimp trawlers operate in only one manner, but have a relatively large proportion of by-catch of a relatively large number of species: witch/lemon sole, blue whiting, saithe, catfish, halibut, haddock, hake, pollack, ling, monkfish, plaice, flounder/dab, brill/turbot, cod W, whiting, and sole. Net- and hook vessels in the Baltic Sea fish mainly for cod WP and cod EP, although seasonal fishing for lumpfish (maximum three months) can be seen as well. The by-catches of these three types of fishing are plaice, flounder/dab, and brill/turbot. The fishing for European eel in the Western Sea is relatively clean with a by-catch of only edible crab. In the Baltic Sea, on the other hand, the fishing for European eel results in a by-catch of plaice, flounder/dab, and brill/turbot.

The last two segments consist of fishing with other passive gear in the Western Sea and the Baltic Sea respectively, and are multi-faceted. The segment concerning the Western Sea shows six different types of fishing: (1) net fishing for various target species such as witch/lemon sole,
saithe, catfish, haddock, hake, pollack, plaice, flounder/dab, brill/turbot, and cod, with a by-catch of halibut, ling, monkfish, whiting, and sole; (2) cage fishing for lobster with a by-catch of edible crab; (3), (4) and (5) clean fishing for mackerel, spurdog, and lumpfish, respectively, with hardly any by-catch; and finally (6) cage fishing for Norway lobster , with a by-catch of only edible crab.

The Baltic Sea passive gear segment shows six types of fishing as well: (1) net fishing for various target species such as perch, zander, plaice, flounder/dab, brill/turbot, and cod WP, (2) same as (1) but with cod EP, (3) fishing for salmon and trout, (4) fishing for whitefish, (5) fishing for herring for consumption, and (6) three-month seasonal fishing for lumpfish.

Vessels, number of employed, days at sea, capacities, and costs
The model is based on homogenous (average) characteristics of all vessels within each segment, although of course in reality not all vessels in a segment are identical. An account of the vessel data used for each segment is presented below. The information is mainly gathered from the EU data gathering program "Economic Assessment of European Fisheries" in 2005 (EAEF).

The number of vessels is the actual number of vessels in the estimations concerning the current scenario, but when it comes to the optimization of the different scenarios there are no limitations on the number of vessels other than that the numbers must be whole numbers. This restriction is made in order to create correct fixed costs. The number of crew members is then estimated based on the number of vessels that the model determines is optimal depending on costs, revenues, capacity, etc.

The actual number of days at sea is used when calculating the actual current situation, while the number is set to 200 days per year in the process of optimization. Any effects of the current rationing in some segments are therefore not present in the optimizations of the model. The catch per vessel may not exceed the total capacity per vessel. The model uses catch per day as the capacity limit, based on total catch, number of days at sea, and type of vessel.

Fixed costs consists of capital costs, depreciation costs, and a desired profit. The capital cost and the depreciation cost are each estimated to 3% of the acquisition value. The desired profit is estimated to 5% of the capital value. Variable costs include fuel costs, vessel costs, personnel costs, and other flexible costs. The costs vary only among the different segments and not among the different species. There is therefore no possibility of differentiating the costs among the different types of fishing in the segments with more than one type of fishing. At any rate, the differences are deemed to be small. Table 3 presents the physical data for each segment.

Table 3. Physical data of vessels, by segment.

SEGMENT:	Dem. traw. < 24 m	Dem. traw. > 24 m	N. lob. traw.<12m	N. lob. traw.>12m	V. >12 m pass. gear	Pel.v. <24 m	Pel.v. >24 m
Variable cost (1000 SEK/metric ton catch)	11.52	9.00	32.13	34.25	13.23	1.90	1.63
Fixed cost/vessel (1000 SEK)	396	660	77	193	120	245	2 898
Capital/vessel (1000 SEK)	3 600	6 000	702	1 753	1 087	2 228	26 347
Capacity/vessel[1] (metric ton/day)	0.842	1.906	0.078	0.173	0.367	6.012	20.343
Employee/vessel (no.)	2.4	3.5	1.3	2.0	2.3	1.7	6.2
Fishingdays/vessel (no.)	138	169	118	142	135	55	193
Yearly income/employee (1000 SEK)	169	197	52	101	115	86	277
Est. yearly income/employee (1000 SEK)[2]	246	233	80	142	171	314	287

SEGMENT:	Shrimp traw.	N. and H. v. in the B. Sea	Eel in the W. Sea	Eel in the B. Sea	Other pass. in the W. Sea	Other pass. in the B. Sea
Variable cost (1000 SEK/metric ton catch)	26.11	8.84	32.07	30.70	24.26	12.26
Fixed cost/vessel (1000 SEK)	276	53	45	19	77	53
Capital/vessel (1000 SEK)	2 509	484	409	169	702	484
Capacity/vessel[1] (metric ton/day)	0.394	0.169	0.021	0.034	0.048	0.169
Employee/vessel (no.)	2.9	1.4	1.3	1.5	1.3	1.4
Fishingdays/vessel (no.)	155	140	200	151	212	155
Yearly income/employee (1000 SEK)	118	69	51	52	52	78
Est. yearly income/employee (1000 SEK)[2]	153	99	51	69	49	85

1) Catch per day; 2) Estimated for the model. Based on 200 days at sea and use of full capacity. Note that an increased number of days changes the yearly income. *Source: Based on Economic Assessment of European Fisheries (2005).*

Prices

The prices used in the model are 2004 mean prices per species and segment, gathered from the fishermen's transaction notes. The price of vendace has been adjusted and is estimated to SEK 27.36/kg. The prices of cod, herring, and sprat have been adjusted as well, since the transaction notes provide only average prices and lack the model distribution among regions as well as the division of herring and sprat between catch for consumption and for industrial purposes. New prices have been estimated based on 2004 statistics from the Swedish Board of Fishery and Statistics Sweden.

The prices of herring for the pelagic segments, the Baltic Sea European eel fishing segment, and the other passive gear segment in the Baltic Sea, are estimated to SEK 2.07/kg, SEK 2.60/kg, and SEK 4.53/kg, respectively. There is a difference in the price of pelagic sprat not only between the Western and the Baltic Sea, but also to some degree between small and large vessels. The sprat in the Western Sea, sprat W, has an estimated price of SEK 5.30 for both pelagic segments. The price of Baltic Sea sprat for consumption and for industrial purposes caught by small pelagic vessels is estimated to SEK 1.21/kg, while the price of the same fish caught by large pelagic vessels is SEK 1.31/kg. The price of cod caught in the Western Sea, Cod W, is estimated to SEK 18.00-20.50/kg depending on the segment, while the price of Baltic Sea Cod is estimated to an average of SEK 13.40/kg, with the exception of the other passive gear segment in the Baltic Sea segment, which shows a price of cod of SEK 14.69/kg.

Other restrictions

The Swedish fishery is currently restricted by factors other than the quotas as well. An example of natural restrictions is the limited spawning period of vendace - a period that is absolutely necessary for the fishing of the spawn. The model limits the fishing period for vendace by small pelagic vessels to two months. This affects the capacity since the other ten months of the year demands other types of fishing or alternatively a ship at shore. Another restriction that also affects the small pelagic vessels is the market-imposed restriction on Baltic Sea herring for consumption that states that the total catch may not exceed 130% of the 2004 level.

The large pelagic vessels are seasonally restricted to a maximum of four months per year of fishing for blue whiting and mackerel, and three months per year for sandeels. The market-imposed restriction on Baltic Sea herring for consumption, stating that the total catch may not exceed 130% of the 2004 level, includes the large pelagic vessels as well. The net- and hook segment in the Baltic Sea and the segment of other passive gear in the Baltic Sea both have 3-month seasonal restrictions on lumpfish fishing.

The model further takes the ban on cod fishing into account, which affects the segment of passive gear vessels larger than 12 meters and the two segments of demersal trawlers. The model bans cod fishing for 25 out of the 200 “baseline” fishing days per year. There is nevertheless a possibility of catching 200 kg of cod per day during the ban.

Results

The account of the model estimations is based on ten different scenarios, with the actual current situation (2004) being the first. Each scenario is discussed separately. If not otherwise noted, all scenarios are based on 2004 data, as described in the Background section. The included scenarios are: (1) the actual current situation; (2) optimal economic situation; (3) optimal economic situation with a 50% increase in fuel costs; (4) optimal economic situation with a 50% increase in catch prices; (5) optimal economic situation with a 50% increase in capacity (daily catch); (6) optimal economic situation with a 25% increase of the number of days at sea; (7) a situation with optimal employment; (8) a future probable optimal economic scenario with a seal problem; (9) a future probable optimal economic scenario without a seal problem

The selection of the nine scenarios is based on probable future changes. In order to make the changes easier to consider, each scenario presents only one change compared to the actual current situation. However, the last two scenarios do contain a combination of changes (details presented below).

Scenario 1: Actual current situation (2004)
This section provides a plain illustration of the current economic situation for the fishing fleet that has not been optimized in any way. The estimations called for certain assumptions (described earlier in the report) to be made. There are for example an assumed expected profit of 5%, capital costs of 3%, and depreciation costs of 3%. As mentioned earlier, actual landed catch is used in the estimations.

The current situation shows a resource rent deficit of SEK 47 million. The total actual catch is a little more than 250,000 metric tons, which is about 80% of capacity (based the catch from 200 days at sea). As mentioned earlier, the numbers of vessels and crew members are 796 and 1,625 respectively.

The large pelagic vessels show the largest resource rent deficit - SEK 115 million. Their Baltic Sea sprat fishing and their Western Sea fishing for blue whiting, sandeels, and horse mackerel do not even cover their average variable costs. The same goes for the small pelagic vessels fishing for sprat in the Baltic Sea. Also the large shrimp trawlers and the segment of other passive gear vessels in the Baltic Sea operate at a deficit of SEK 3 million each.

Scenario 2: Optimal economic situation
Optimization here refers to a maximization of resource rent. The optimization does call for certain assumptions (described earlier in the report) to be made. In contrast to the actual current situation with a restriction on the number of days at sea, in this optimized scenario the vessels can spend a full 200 days at sea. The model optimizes size of catch, number of vessels, etc.

The optimal situation shows a total surplus of SEK 216 million. The total catch is only a little more than 50,000 metric tons, or one-fifth of the actual current catch. With only very few exceptions, the quotas that are not landed consist of pelagic species (blue whiting, herring, Baltic Sea sprat, sandeels, and horse mackerel). The catch corresponds to nearly 100% of capacity. The number of vessels and crew members are 618 and 959 respectively, which corresponds to 75% of the actual current number of vessels and to almost 60% of the number of currently employed. The difference in proportional change between vessels and employed points towards the possibility of increasing profitability by using vessels with fewer employees, i.e. by using vessels with low labor costs. In the previous Table 3, yearly incomes for the different segments are shown.

The large resource rent surplus is mainly due the pelagic vessels, the small demersal vessels, and the Baltic Sea net- and hook fishery. The latter segment (Baltic Sea net and hook) shows the largest optimizing change: an increase in the number of vessels by 230. The number of small shrimp trawlers also increases by 6 vessels, while all other segments decrease their number of boats. The optimal situation removes the large shrimp trawlers and the large passive gear ships completely.

Scenario 3: Optimal economic situation with a 50% increase in fuel costs
In this situation everything remains the same as in the actual current situation with the exception of the fuel costs which increase by 50% (making them similar to the 2005 actual fuel cost). Fuel costs are considered variable costs, and their proportion of total costs varies among the segments. Fuel costs generally make up smaller proportions of total costs among the passive gear segments, which results in this scenario affecting these segments less than it does other segments.

The total numbers of vessels and employed are affected only marginally in this scenario. Four fewer vessels and 19 fewer crew members compared to the optimal economic scenario with no changes (Scenario 2) gives a total of 614 vessels and 937 crew members. The scenario shows a total surplus of SEK 190 million, but the total catch is only a little more than 35,000 metric tons. With only very few exceptions, the quotas that are not landed consist of pelagic species (blue whiting, herring, Baltic Sea sprat, sandeels, and horse mackerel). The catch corresponds to only a little more than 75% of capacity. This is due to the lack of available profitable fishing during certain periods of the year.

The effect of the high fuel costs is most pronounced among the large demersal and the small pelagic vessels, although it does take on different forms in the different segments. In this scenario, the large demersal segment decreases its total number of ships by 3. The small pelagic boats remain the same in number, but land significantly less fish; their remaining fishery consists of only Vendace and Baltic Sea herring for consumption and industrial purposes, producing a profitable overcapacity of 66%. This is a result of the very profitable seasonal fishing for vendace and the lack of other profitable fisheries to cover the rest of the year. Market restrictions prevent expanded fishing for herring in the Baltic Sea for consumption (maximum 130% of the total 2004 catch).

Net- and hook vessels is the only segment that increases its number of vessels under a scenario with increased fuel costs. This is due to the possibility of these vessels to increase their landings of cod that the other segments used to fish but do not anymore as a result of the expensive fuel.

Scenario 4: Optimal economic situation with a 50% increase in catch prices.
This scenario assumes the economically optimized scenario (Scenario 2) with the exception of a 50% increase in catch prices, showing a SEK 384 million surplus. The resource rent increases by significantly more than 75% compared to the optimal economic scenario with no changes (Scenario 2). The large increase is not only due directly to the increase in prices, but also indirectly to an increase in fishing activity - more species can be caught with a profit.

The total catch is only a little over 96,000 tons, or a little more than one-third of the current total catch. With only very few exceptions, the quotas that are not landed consist of pelagic species (blue whiting, Baltic Sea herring, Baltic Sea sprat, sandeels, and horse mackerel). Fishing these species is not profitable, despite the large increases in price. The catch corresponds to nearly 100% of capacity. The numbers of vessels and crew members are 659 and 1,024 respectively. However, these are fairly small increases compared to the numbers in the optimal economic scenario (Scenario 2): a smaller than 10% increase in vessels and a little larger than 5% increase in crew members.

The two pelagic segments are affected the most by the suggested price increase. The small pelagic vessels are able to catch the entire herring quota in the Western Sea. Sprat in the Western Sea is caught in smaller amounts in order to reach capacity. The small pelagic vessels actually decrease their resource rent compared to the optimal scenario (Scenario 2), but maintain total catch and the number of vessels. This is a result of these boats' fishery for herring and sprat in the Western Sea now being more profitable, compared to before the price increase when it was done merely to reach capacity. In order to complement the seasonal fishing for mackerel, the large ships operate in the Baltic Sea catching herring and sprat for consumption and herring for industrial purposes.

The profits increase drastically in the other segments, but the changes in their number of vessels are small since quotas to catch more fish are lacking. As mentioned before, the quotas that are not landed consist of mainly pelagic species.

Scenario 5: Optimal economic situation with a 50% increase in capacity (daily catch).
This scenario assumes the same optimization as in Scenario 2, with the exception of a 50% increase in capacity, producing a total surplus of SEK 234 million. The resource rent increases by almost SEK 29 million compared to an optimized scenario without a capacity increase (Scenario 2). This increase in resource rent is not only a direct effect of increased catches, but is also indirectly due to decreased fixed costs per kilogram of fish caught (i.e. a larger daily catch means a larger yearly catch, which means more fish to absorb the fixed costs.

The total catch is almost 90,000 metric tons, corresponding to almost 100% of capacity. Under this scenario, the numbers of ships and crew members are only 431 and 672, respectively. Quite intuitively, the demand for vessels and crew members decreases steeply, since each ship is able to catch more fish in the same amount of time.

The increased capacity affects the sizes of the fleets in all segments; they all decrease with the exception of the Baltic Sea net- and hook segment. The total catch of each segment remains the same as in Scenario 2, mainly due to the limited quotas. The only exception to this is the pelagic fishery, and the small vessels especially. These increase significantly in number and also increase their catch fourfold, due to increased Western Sea fishing for herring as a result of increased profitability.

Scenario 6: Optimal economic situation with a 25% increase in the number of days at sea.
This scenario is identical to Scenario 2 with the exception of a 25% increase in the number of days at sea. In other words, it assumes 250 days at sea in contrast to the previous 200. Please note that yearly income changes indirectly (i.e. it increases with the number of days at sea), while the quotas remain the same.

This scenario shows a total surplus of SEK 288 million. The resource rent increases by almost SEK 10 million compared to the optimal situation with no changes (Scenario 2). Similar to Scenario 6 (increased capacity), the increased resource rent is a result of an increased total catch and therefore of a decreased fixed cost per kilogram of catch. This also becomes apparent in the results where the fleet increases in size by more than 25%, which corresponds to the increase in the number of days at sea.

The total catch is 85,000 metric tons, which corresponds to almost 100% of capacity. The numbers of ships and crew members are only 520 and 806, respectively. The demand for vessels and crew members decreases significantly under this scenario since it allows each vessel to catch more fish.

The increase in the number of days at sea causes the sizes of the fleets in all segments to decrease significantly, but their catches do not change in size compared to the optimal scenario with no changes (Scenario 2). The only exception is the catch of small pelagic vessels, which increases to a large degree. This increase in catch consists of Western Sea herring, which becomes much more profitable due to the increased number of days at sea (compare this to Scenario 6 - increased capacity).

Scenario 7: Optimizing employment within the fishing fleet.
This scenario is optimized with regards to employment and not resource rent as in the previous scenarios. The resource rent is therefore assumed to be zero SEK. All other assumptions remain the same as before.

Here we point to the possibilities of not only maintaining employment but also increasing employment through a restructuring of the fishery. The results indicate that the number of vessels could be 2,873 and that the number of crew members could be 4,396. However, the total catch is only about 140,000 metric tons or a little more than half of the actual current catch (although still significantly greater than under most of the other scenarios). The overcapacity is, needless to say, large. The potential catch in this scenario is more than four times the landed catch, and more than double the allowed quota.

Even from an employment optimizing perspective, some segments will shrink. The segments of large shrimp trawlers and the large vessels with passive gear disappear completely, and the fleet of large pelagic ships diminishes greatly. However, compared to Scenario 2 there are still plenty of large pelagian ships and only somewhat fewer large demersal ships. The greatest changes in employment are found in the net- and hook segment with a little more than 1,300 crew members. One reason for this is of course the low yearly income within this segment, making labor relatively cheap capital (see Table 3). A further discussion on the effects of low yearly incomes is included in the last chapter of this report (Conclusions and Discussion).

The pelagic segments are responsible for the main changes in the sizes of catch. The profits generated from the vendace fishery by small pelagic vessels can to a large degree be used to increase employment by increasing the Western Sea herring fishery. The profits from the mackerel fishery by large pelagic vessels can be used to increase employment by increasing the Baltic Sea fishing for herring for consumption and for industrial purposes, and by increasing the fishing for sprat also in the Baltic Sea.

Scenario 8: A likely future optimal economic scenario with a seal problem.
This scenario is optimized with regards to several changes that are probable in the future. Here the prices of all species rise 25% compared to Scenario 2, with the exception of Northern pink shrimp. Fuel costs increase by 50% compared to the 2004 price. The Baltic Sea cod quotas increase by 20% for both the western and eastern population. The Baltic Sea sprat quotas for both consumption and industrial purposes go down by 40%, and the salmon and trout fisheries come to a complete halt. The number of days at sea for the large pelagic vessels increases to 275 (other segments remain at 200 days). Capacity, or daily catch, rises by 25%, and an improved selectivity decreases by-catch to 15% of the catch of target species. The ban on cod fishing is removed. The Baltic Sea seal population is forecasted to grow significantly in the future, which will affect the passive fishery greatly. The costs for the passive fishery segments (vessels over 12 meters with passive gear, Baltic Sea net and hook, and other boats with passive gear in the Baltic Sea) are therefore expected to double. Further, the seals affect capacity (daily catch) negatively in these segments, and a 25% increase in capacity is therefore not realistic among them.

This illustration of the future shows a total surplus of SEK 327 million. The total catch is almost 90,000 metric tons, or one-third of the current catch. The increased catches (compared to Scenario 2) are a result of increased prices and improved capacity, although the increased cod quotas contribute as well. With only very few exceptions, the quotas that are not landed consist of pelagic species (blue whiting, herring, Baltic Sea sprat, sandeels, and horse mackerel). The catch corresponds to almost 100% of capacity. The number of ships and crew members is 247 and 489 respectively, corresponding to half of the number of ships and one-third of the labor force in Scenario 2.

The large resource rent surpluses are produced mainly by trawlers and pelagic vessels. If this scenario becomes a reality, then the passive gear segments in the Baltic Sea will be eliminated entirely due to the changes in costs and capacity that the seals will bring on. An increased number of small pelagic vessels will increase their catches significantly, due to a greatly intensified Western Sea herring fishery. However, the number of large pelagic ships will be reduced to half of the number under Scenario 2 (the optimal scenario with no changes), while their catch will decrease only marginally.

Scenario 9: A likely future optimal economic scenario without a seal problem
Here the model is optimized in consideration of all conditions listed above in Scenario 8, but without the seal problem. The seal population does therefore not affect the fishery. This scenario shows a total surplus of SEK 346 million. The profit is SEK 20 million larger than in Scenario 8 (with a seal problem), while the total catch is the same at almost 90,000 metric tons. The increased catches (compared to Scenario 2) are a result of increased prices and improved capacity, although the increased cod quotas also contribute. With only very few exceptions, the quotas that are not landed consist of pelagic species (blue whiting, herring, Baltic Sea sprat, sandeels, and horse mackerel). The catch corresponds to almost 100% of capacity. The number of ships and crew members is 561 and 864 respectively, corresponding to more than twice the number of vessels and almost twice as many crew members as in the future scenario with a seal problem (Scenario 8).

The large resource rent surpluses are mainly due to the net- and hook segment and the pelagic segments, but the small demersal trawlers produce relatively large surpluses as well. If this scenario becomes reality, the fishery fleet will be completely dominated by the passive gear segments both in terms of number of ships and number of employed. The biggest difference compared to the future scenario with a seal problem will be that the small net- and hook vessels will increase in number at the expense of the large demersal ships. The large shrimp trawlers and the large passive gear vessels will disappear completely, similar to what would be expected in several of the other scenarios.

The number of large pelagian ships remains the same as in the scenario with a seal problem (Scenario 8). An increased number of small pelagic vessels will increase their catches significantly, due to a greatly intensified Western Sea herring fishery.

Conclusions

The presented results are coarse in nature and should be interpreted with care, as mere generalizations, i.e. they are estimated and presented by segment although reality shows significant variation within the segments. There is furthermore an innate uncertainty in the used data. However, the model has been tested (sensitivity analyses) and the results are deemed robust and stable. The model used will be developed further and our hope is that it will prove useful in many areas of economic analysis both in and outside the work of the Swedish Board of Fisheries.

The actual current situation points to great deficits, and also to a fishery overcapacity. This is due to too many vessels sharing a resource too small. The fixed costs of the overdimensioned fishing fleet turn potential profits into great losses. The effects of the large fixed costs show in fishing continuing conditional on the variable costs being covered. In some cases, especially in the pelagic segment with large ships, this limit has been surpassed, and the fishery seems to continue only in order to generate a flow of volume and money rather than profit. The fisheries that are profitable are mainly the fishing for vendace, the fishing with passive gear, and trawling for Cod with small boats (to better follow the conclusions see Table 4 bellow).

The effects of restructuring the fishing fleet could be large. An optimal economic scenario suggests that more that 50% of the fleet should be restructured, and that more than 40% of these should even be scrapped, i.e. removed from the fleet altogether. The optimal scenario further suggests that only one-fifth of the total quotas should be landed; catching the remaining four-fifths is not profitable. The unprofitable quotas are made up of mainly pelagic species such as blue whiting, sandeels, horse mackerel, sprat, and herring.

The effects of possible fuel price increases indicate an even lower profitability in trawling and in pelagic fisheries. These types derive a higher proportion of their costs from fuel expenses. The total catch would decrease due to a smaller pelagic catch. However, the demersal catches would remain the same but would transfer from cod trawlers to "passive" ships.

A future with increased prices would increase profitability greatly, although the size of the fleet would be affected only marginally, since the amounts of landed fish are limited by quotas. However, increased prices would increase the pelagian fishery since previously unprofitable species would then become profitable.

Future technological development may help increase capacity, i.e. daily catch, which would result in increased profits. The number of ships and crew members could be decreased significantly, and previously unprofitable species could become profitable. The effects would be the most noticeable in the pelagic sector, since it shows the highest proportions of not landed quotas. The number of pelagic vessels and their catches would increase greatly. Technological development (i.e. improved capacity) would result in profit growth for the other sectors that already take full advantage of the quotas as well, but this profit would be divided among a smaller number of vessels.

An increased number of days at sea would produce effects similar to improvements in capacity. The profits would grow due to the fixed costs being carried by larger volumes. The pelagic segments in particular would notice the effects, with their unused unprofitable quotas now becoming profitable. The number of pelagian vessels and the size of their catches would grow dramatically. An increased number of days at sea would however result in fewer ships in the other segments, despite improved profitability.

A growing population of seals would not cause any significant effects from an economic perspective. However, the passive equipment fishery would experience increased costs and a lowered capacity, leading to a shrinking in size.

Trawling, on the other hand, would grow correspondingly. This would indirectly result in fewer individuals employed in the fishing industry.

The goal of utilizing the fish resource is not only to maximize profits, but also for example to spread the use regionally or to maximize employment. The resource rent is expected to be zero at a maximized level of employment. The results show that a restructuring can increase employment as well, even with half of the current utilization of the resource, i.e. with half of the current total catch. The net- and hook segment and the small pelagic vessels are winners from an employment perspective. This is not only due to low incomes per fisherman (which is absolutely not true for the small pelagic vessels), but also to that the profits in these segments can be used to increase total capacity, i.e. the number of vessels.

The future is uncertain. Technological development and increasing prices and costs are some of the potential changes that can be expected to take place, but the calibers of these changes are unpredictable. The Baltic Sea seal population is another threat worth considering. A likely future scenario does nevertheless look bright from an economic perspective. The results indicate that restructuring can make the fishing fleet generate a relatively large profit without overexploiting the resource.

Table 4. Summary of evaluated scenarios.

SCENARIO:	**Actual current situation**	**Optimal economic situation**	**O. e. s. with a 50% increase in fuel costs**	**O. e. s. with a 50% increase in catch prices**	**O. e. s. with a 50% increase in capacity**
Resource rent (1000 SEK)	-47 139	215 686	190 024	384 055	234 425
Total catch (metric tons)	256 543	50 416	35 397	96 132	87 327
Total available catch (metric tons)	256 543	256 561	256 561	256 561	256 561
Total capacity (metric tons)	326 098	50 486	45 258	96 181	87 507
Total no. of vessels	796	618	614	659	431
Total no. of fishermen	1625	956	937	1024	672

SCENARIO:	**O. e. s. with a 25% increase in the no. of days at sea**	**Situation with optimized employment**	**A likely future o. e. s. with seal problem**	**A likely future o.e.s. without seal problem**
Resource rent (1000 SEK)	227 656	0	326 820	345 813
Total catch (metric tons)	85 437	139 978	89 542	89 525
Total available catch (metric tons)	256 561	256 561	226 776	226 776
Total capacity (metric tons)	85 551	571 330	89 716	89 820
Total no. of vessels	520	2873	247	561
Total no. of fishermen	806	4396	489	864

Acknowledgement

My work has benefited by information and comments from Tore Gustavsson at the Swedish Board of Fisheries.

References

DS 1997:81. Fisk och Fusk – Mål, medel och makt i fiskeripolitiken. Rapport till ESO (in Swedish). Fritzes. Stockholm 1997.