NATUR VÅRDS VERKET

FishSTERN

A first attempt at an ecological-economic evaluation of fishery management scenarios in the Baltic Sea region

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BalticSTERN

Systems Tools and Ecological-economic evaluation - a Research Network

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Contents

Preface

Inspired by “The Economics of Climate Change – the Stern Review” (2007), in September 2008 the Nordic Ministers of Environment jointly called for Stern-like reviews of the Nordic Seas, to get a broad perspective of the socio-economic consequences of human pressures on the marine environment.

Following this call, the Swedish Government instructed the Swedish Environmental Protection Agency (SEPA) to compile information on the economic implications of human impacts on the Baltic Sea and Skagerrak. The information was gathered in seven background reports in the Economic Marine Information project. In a final synthesis report “What´s in the sea for me?” (2009) SEPA concluded that the knowledge needed for a comprehensive analysis was lacking and further research needed. The Swedish Government decided to continue with in-depth analyses regarding the socioeconomic impacts of environmental developments in the Baltic Sea and Skagerrak and instructed SEPA to finance such studies.

In parallel, an international research network, BalticSTERN - with partners from all countries surrounding the Baltic Sea - was established with the purpose of conducting cost-benefit analysis regarding the environmental problems of the Baltic Sea. BalticSTERN also aims to give guidance on cost-effective measures and policy instruments needed to secure the ability of the Baltic Sea ecosystem to provide ecosystem services. The acronym STERN stands for Systems Tools and Ecological-economic evaluation - a Research Network. The network is coordinated by the BalticSTERN Secretariat, established at the Stockholm Resilience Centre. Based on the research carried out by the network, the Secretariat will prepare a synthesis report directed at decision-makers, to be published in 2012.

The FishSTERN is a sub-project within BalticSTERN financed by SEPA. The project delivered calculations on the values and costs of commercial fisheries in the Baltic Sea. The project was coordinated by Thorsten Blenckner, Baltic Nest Institute, Stockholm and Ralf Döring, Johann Heinrich von Thünen Bundesforschungsinstitut, Germany in partnership with the Institute of Food and Resource Economics, University of Copenhagen (Denmark), the Swedish Board of Fisheries (Sweden), Finnish Game and Fisheries Institute (Finland), Estonian Marine Institute (Estonia), Lithuanian Institute for Agrarian Economics (Lithuania), Sea Fisheries Institute (Poland), National Institute of Aquatic Resources, Technical University of Denmark (Denmark), UCC consultancy (Sweden).

Further information about the BalticSTERN partners, projects and publications can be found at: http://www.stockholmresilience.org/balticstern.

Summary

An ecosystem approach to management requires a holistic view by integrating different system components, and is now beginning to be more strongly included into marine policy decisions. The EU Marine Strategy Framework Directive (MSFD) addresses such an ecosystem approach, together with an economic assessment of the ecosystem. In the Baltic Sea, the overfishing of cod (*Gadus morhua*) has, along with eutrophication, been a major environmental concern. Overfishing has not only decreased the productivity of this stock, and thereby affected both commercial and recreational use, but has also altered the entire food-web dynamics.

The aim of this pilot study was to collect economic fisheries-related data, forming the basic input for a bio-economic model to simulate management scenarios for fisheries. To this end, economic fisheries-related data from seven countries around the Baltic Sea were collected. The collected data show that the Baltic Sea fishing fleets employ more than 9400 persons. In 2007, the industry generated around 160 million Euros of value added.

An overview of the current fisheries management was also undertaken, showing that the EU Common Fisheries Policy is the basic regulatory framework for nearly all countries. The distribution of fishing rights is however a national responsibility. Many countries are moving in the direction of more flexible quota management, where fishermen receive a certain share of the overall quota with the possibility to trade this share.

Bio-economic model tools have been used to simulate different management scenarios and their potential economic and ecological impacts. This model was constructed using the collected economic data and analyses how fishing effort changes would affect profits from fisheries and the state of the ecosystem. Based on this model approach, four management scenarios were calculated optimizing economic, social and ecological conditions.

The modelling results indicate that fisheries in the Central Baltic Sea are only profitable if the fishing effort is low, given current stocks size and fishing fleets structure. However, this result needs to be interpreted cautiously due to data-related problems. For example, some of the cost indicators were lacking for some countries due to different book-keeping rules, and when aggregated, the total landing data for the fleets did not correspond to the official ICES landings data in the Central Baltic Sea.

This first pilot study shows that the ecological-economic modelling tool functioned reasonably well but that the uncertainties in the economic input data caused unrealistic management scenarios. To improve such a fisheries-related ecosystem assessment, either the type of economic data needs to be improved to run more realistic scenarios or another economic approach needs to be applied.

Sammanfattning

EU's havsmiljödirektiv (Marine Strategy Framework Directive (MSFD)) utgår från den så kallade ekosystemansatsen. Ekosystemansatsen förutsätter ett holistiskt perspektiv, genom att integrera olika systemkomponenter. Denna studie är ett första försök att använda en kombinerad ekologisk och ekonomisk modell för att simulera och bedöma konsekvenserna av olika förvaltningsstrategier för fisket i Östersjön.

I Östersjön har överfisket av torsk (*Gadus morhua*), jämte övergödning, varit betydande miljömässiga bekymmer. Överfisket har inte bara reducerat produktiviteten hos torskbeståndet, och därmed påverkat såväl kommersiellt fiske som fiske i rekreationssyfte, utan även förändrat hela dynamiken i näringsväven.

Som grund för denna pilotstudie samlades ekonomiska fiske-relaterade data in från sju länder kring Östersjön. Den insamlade informationen visar att Östersjöns fiskeflotta sysselsätter mer än 9400 personer. År 2007 genererade flottan omkring 160 millioner Euro i förädlingsvärde.

Inom studien genomfördes även en översikt av den nuvarande fiskeförvaltningen. Den visade att EU's Common Fisheries Policy (den gemensamma fiskeripolitiken) är det grundläggande administrativa regelverket för samtliga EU-länder. Fördelningen av fiskerättigheter är dock ett nationellt ansvar. Många av länderna kring Östersjön rör sig mot ett mer flexibelt kvotsystem, där fiskarna erhåller en andel av den totala fiskekvoten med möjlighet att överföra kvoten inbördes.

Den kombinerade ekologiska och ekonomiska modellen har använts för att simulera olika förvaltningsscenarier i syfte att analysera hur förändringar i fisketryck påverkar vinsterna från fisket, samt tillståndet i ekosystemet. Med hjälp av modellen beräknades effekterna av fyra olika förvaltningsscenarier, med optimering för det ekonomiska, sociala respektive ekologiska utfallet.

Modelleringsresultaten indikerar att fisket i centrala Östersjön enbart är lönsamt om fisketrycket är lågt, givet nuvarande fiskbestånd och fiskeflottans struktur. Resultaten bör tolkas med försiktighet, bland annat beroende på osäkerheter i insamlade ekonomiska indata. Exempelvis saknades en del kostnadsindikatorer för vissa länder på grund av olika regler kring datainsamling. När informationen om det totala landningsvärdet aggregerades stämde den inte heller med ICES (International Council for the Exploration of the Sea) officiella landningsvärden för centrala Östersjön.

Denna första pilotstudie visar att den ekologisk-ekonomiska modellen är ett verktyg som fungerar rimligt väl. För att få fram mer tillförlitliga scenarier krävs att den ekonomiska informationen som driver modellen kan förbättras. Om detta inte är möjligt bör alternativa ekonomiska angreppssätt övervägas.

1. Introduction

An ecosystem approach to management requires a holistic view by integrating different system components and it is now being increasingly included in marine policy decisions. The ecosystem approach is knowledge-intensive and requires a thorough understanding of ecosystem structure and function, the dynamics of ecosystem services and their driving forces in relation to the ability of ecosystems to absorb external shocks and disturbances (resilience). The literature on ecosystem-based management, e.g., Browman et al. (2004, 2005) has only recently (Levin et al 2009, Tallis et al. 2010) started to include empirically-based insights into strategies that make transitions to such management possible.

The EU Marine Strategy Framework Directive (MSFD, adopted in June 2008) addresses such an ecosystem approach. The aim of the MSFD is to more effectively protect the marine environment across Europe by achieving good environmental status of the EU's marine waters by 2020, and to protect the resource base upon which marine-related economic and social activities depend. The MSFD constitutes the vital environmental component of the Union's future maritime policy, designed to achieve the full economic potential of oceans and seas in harmony with the marine environment.

As the MSFD addresses the importance of the economic state, it is relevant to advance knowledge and understanding of the feedbacks between good environmental status, or any other ecosystem target, in relation to the economic potential and its consequences for the ecosystem state.

In the Baltic Sea, besides problems associated with eutrophication, the overfishing of cod (*Gadus morhua*) has been a major environmental issue. This overfishing has not only decreased the productivity of this stock (Köster et al 2005), thereby affecting both commercial and recreational use, but has also altered overall fish productivity and food-web dynamics (Möllmann et al. 2009, Casini et al. 2008).

1.1 Short description of project

The aim of this pilot study is to develop a specific database for the economic fishing fleet data of the countries around the Baltic Sea, with the exception of Russia. Following from the data collection, the economic consequences of different management scenarios for the Central Baltic Sea will be analysed in order to discuss the trade-offs between fisheries and ecosystem health.

A. Economic data assimilation (Chapter 2)

The economic group of the project collected economic fisheries-related data from seven countries around the Baltic Sea (all countries surrounding the Baltic Sea except Russia and Latvia), which formed the basis for the modelling and management scenarios (see Table 1 and 2). Further, an overview on the available economic data and a first description of some economic indicators are given. This provides input to the economic analysis of the national fishing fleets around the Baltic Sea (see 2.1). In addition, a preliminary analysis of the subsidies to the fishing sector is provided (see 2.2).

B. Evaluation of current management (Chapter 3)

Before several management scenarios will be run/simulated, a description of today's fisheries management in the Baltic Sea is presented, including a description of the current fish quota allocations in the different countries around the Baltic Sea.

C. Food-web and economic modelling with management scenarios (Chapter 4)

Model tools are useful to simulate different management scenarios and their potential ecological/economic impacts. An existing but more advanced version of the Baltic Nest Institute food-web model has been applied to explore possible impacts of different management scenarios. The model is built within the Ecopath with Ecosim (EwE) software (www.ecopath.org), one of the most used software applications in ecological modelling connected to fish and fisheries. Thereafter, four management scenarios were calculated using an economic module which already exists in the EwE software. This module was calibrated with all the economic data, which were collected from the Baltic Sea countries. The module analyses fishing effort/capacity changes in the model, and it also performs optimization scenarios for fisheries policies based on certain economic, social and ecological assumptions.

D. Conclusions (Chapter 5)

In this chapter the main conclusions of the study are presented.

E. Ways forward (Chapter 6)

A reflection of the project and potential future improvements are presented.

2. Overview of the economic situation of the fishing fleets in the Baltic Sea

In the following chapter, a short overview on the available economic data within the project and some first results from the data delivered on certain indicators is given. In the national chapters, the specific economic characteristics for some of the Baltic Sea countries are shown (see Appendix 1). This section tries to give a first overview on the Baltic Sea fishing fleet. As this is a first attempt, some caution in the interpretation of the data has to been taken into consideration. Not even the annual economic report of the European Union provides a regional analysis of the Baltic Sea regularly, as the available data lacks in quality and comparability. For this report, we tried to gather this more specific data on a regional basis, i.e., Central Baltic Sea, to be able to run the Central Baltic Sea food-web and economic model with economic data. This is needed to manage fisheries in a cost-efficient and ecosystem-related context. Further, a short introduction to the problem of financial support to the fishing sector, and an overview on the subsidies paid to the fishing sector in the Baltic Sea is given.

2.1 General overview

In the cases of Germany, Sweden and Denmark some vessels operate both in the North Sea and the Baltic Sea. The allocation of for example the number of vessels, their capacity and the economic data in general has to be based on subjective assumption to have an idea of the activity of the vessels. This is especially the case in the Baltic Sea.[1] In this report, the allocation of the economic data has been made by using value of landings in the Baltic Sea in comparison to total landings as splitting factor. In this case, we split the cost data in the ratio of the value of landings in the Baltic Sea vs. the total value of landings of this fleet segment. Some parameters, such as effort days, are not collected in the same manner. Some countries (e.g., Germany) collect and report days at sea, while others use fishing days. Some countries do not publish data for certain fleet segment due to confidentiality (Germany), while others simply do not collect data for certain fleet segments (Lithuania).

This report covers the years 2005–2007, as data are currently not available for all countries for 2008. In the case of Latvia, data have been taken from the annual economic report on the European fishing fleet (European Communities 2009). Also for Finland we used data from 2005, for some parameters data is from 2006 and 2007.

[1] There are vessels fishing for cod in the Baltic Sea and in the North Sea. From the cost statements we have no information on how much of the costs are generated by fishing in the Baltic Sea compared to the North Sea.

Information Box 1:

Fishing capacity, defined in terms of tonnage, engine power and sometimes number of vessels, is one of the key factors that determine the fishing mortality caused by the fleet. The size and power of the fishing fleets are considered as the main measure of fleet capacity and thus a reflection of the pressure on the various fish stocks. Excess size and power of the fishing fleets is considered to be one of the major factors that leads to over-fishing. Power, tonnage and number of vessels are, however, not a direct measure of the effort of the fleet. For instance, the activity of the fleet is often very variable, which is not captured by these numbers. Furthermore, the size distribution of the vessels is an important factor in relation to the size of the pressure from the fishing fleets. Larger vessels are likely to exert a larger fishing pressure than the equivalent number of smaller vessels. This is due to the fact that larger vessels usually use active fishing gears like trawls and seine nets, whereas smaller vessels most often use passive gears like gill nets and long lines. In general, the catch per unit of fleet tonnage of the active fishing gear is larger than that of the passive gear. For example, the fleets of Greece and Portugal, which consist mainly of small vessels, are likely to have a lower fishing pressure than an equivalent tonnage in the Norwegian fleet. To improve the indicator ability to address fishing effort, both the type of fishing gear and associated efficiency and information of days at sea should be incorporated into the indicator, but this information is currently unavailable at the Pan-European scale.

(see:http://www.eea.europa.eu/data-and-maps/indicators/fishing-fleet-capacity/fishing-fleet-capacity-assessment-published-1#toc-0, see also Clark et al. 2003)

The parameters presented here are capacity (measured in gross tonnage), engine power (in kilowatt and numbers of vessels), effort measures (in terms of days at sea) and profitability indicators. Losses or poor profitability is normally assumed to be an indicator of overcapacity in the fleet (for a general overview on fisheries management consult Smith/Sissenwine 2010). As it is the aim of the European Common Fisheries Policy to reduce capacity in order to reach equilibrium of fishing capacity and fishing opportunities, a decline in numbers of vessels could be expected. This could be counteracted by an increasing number of fishing trips or technological improvements, like more effective gears or vessels with more engine power. The number of effort days will be analyzed as well as the parameters kilowatt and gross tonnage to check for counteraction. A possible scenario is that the overall number of vessels decreases, thus indicating a decrease in capacity, at the same time as new vessels (with more engine power and tonnage) are introduced to the fleets. As this might result in overall increases in fishing capacity, a control of this potential counteraction is needed.

Given our data, it was not possible to analyze whether the effectiveness of the gears has been improved. An increase in the average age of the vessels may indicate a lack of willingness to invest in new vessels, perhaps because of uncertainty over future prospects or a lack of financial resources restricting investment options.

In total, the number of vessels assigned to operate in the Baltic Sea, either by splitting the number according to the value of landings in the Baltic Sea in relation to total landing value, or because they operate only there, differs from year to year. In 2005, 4809 vessels were part of the Baltic Sea fishing fleet, while in 2006 and 2007, 6005 and 5905 vessels, respectively, were assigned to the Baltic Sea according to our approach. Table 1 shows the main parameters for the Baltic Fleet by Vessel/Gear Type.

Table 1. Economic overview of the Baltic Sea fishing fleet (all countries except Russia). For the modeling a different classification is used, see Appendix: modeling section.

Vessels Total	**2005** 4809	**2006** 6005	**2007** 5905
Passive gear			
Number	4016	5301	5251
Gross tonnage	25,257	23,970	22,185
Kilowatt	139,095	180,333	200,394
Average vessel age	23.75	23.2871	23.54
Employment	6220	7122	6706
Main Species (landing value)	Cod 44%	Cod >40%	Cod >40%
Net Profit/vessel (mill Euro)	-0,002	-0,007	-0,0001
GVA (mill Euro)	28,30	37,43	81,73
Demersal trawlers < 24 m			
Number	349	293	285
Gross tonnage	14,959	12,839	13,178
Kilowatt	64,824	57,380	59,034
Average vessel age	33.76	33,23	32,70
Employment	978	827	764
Main Species (landing value)	Cod 51%	Cod 30%	Cod 40%
Net Profit/vessel (mill Euro)	0,000	0,01	0,02
GVA (mill Euro)	26,59	73,15	29,76
Demersal trawlers > 24 m			
Number	92	79	69
Gross tonnage	12,900	12,405	11,305
Kilowatt	30,544	30,280	27,486
Average vessel age	31.04	26.70	32,02
Employment	550	493	431
Main Species (landing value)	Cod >40%	Cod >40%	Cod >40%
Net Profit/vessel (mill Euro)	0,181	0,030	0,053
GVA (mill Euro)	12,63	7,80	8,44
Pelagic trawlers < 24m			
Number	100	98	94
Gross tonnage	4,109	3,945	3,610
Kilowatt	20,903	20,025	18,335
Average vessel age	22	25	27
Employment	276	237	218

Main Species (landing value)	N.A.	N.A.	Sprat >59%, Herring>40%
Net Profit/vessel (mill Euro)	-0,001	0,009	0,007
GVA (mill Euro)	2,59	1,33	1,67
Pelagic trawlers > 24m			
Number	246	205	191
Gross tonnage	40,385	34,063	33,023
Kilowatt	106,988	87,054	85,308
Average vessel age	24	26	25
Employment	1547	1446	1197
Main Species (landing value)	Sprat > 59%, Herring >25%	Herring > 36%, Sprat >32%	Sprat >56%, Herring> 30%
Net Profit/vessel (mill Euro)	0,010	0,07	0,04
GVA (mill Euro)	25,18	48,43	42,3

Note: Beam trawlers and vessels using active and passive gears have not been analysed separately, drift and fixed nets, passive gears and polyvalent passive gears are all analyzed as passive gears, "N.A." stands for non-available. Starting with 2006 data, Finland integrated around 1200 additional vessels to the passive gear segment. Since 2006, all vessels have been assigned to the passive gear segment, independently of landing values. Finland did not report data on profit for 2007. For Latvia, data on profit and GVA are not included as they were not available.

GVA (Gross Value Added), Pelagic trawlers (fishing vessel that used fishing nets in the water column), Demersal trawlers (fishing vessel that used fishing nets along the sea floor).

Depending on the fleet segment, different dominant harvested fish species can be identified. Cod is, in terms of value, the most important species for the passive gear segment as well as for the demersal segments.

2.1.1 Economic situation of Baltic Sea fishing fleet

The Baltic Sea fishing fleet employs more than 9400 persons. In 2007, it generated more than 160 million Euros of value added. Obviously, the profitability depends on the different fishing fleet segments. The passive gear segment generated losses, while the pelagic segment seems to balance on the edge, changing from profits one year to losses another. The demersal gear segment with vessels of 24 m and more, shows stable profits, while in the length class below 24 m, the situation resembles the pelagic segment.

In general, one needs to keep in mind the restricted quality and availability of the data. However, some conclusions can still be drawn.

- The fleet segments are of different profitability, indicating some overcapacity in some segments.
- Some fleet segments (e.g. passive gear segment) seem to produce only losses and are candidates for insolvency.
- Fisheries (especially coastal and small-scale fisheries) have positive external effects on other sectors, e.g. tourism (some tourists only visit small coastal towns because of the fishing fleets in the harbours).
- The Baltic Sea fishing fleet employs more than 9400 people.

- The Baltic Fleet generated valuable value added for society. For example, in 2007, the total gross value added to more than 160 million Euros.
- Secondary impacts have to be taken into consideration. These impacts are e.g. employment and sales in the local fisheries retail sector, jobs and income at the dockyards, as well as work and income for local craftsmen.
- The different fleet segments are highly vulnerable to the condition of their main target species.

One problem during the project was the change in data collection on the European level resulting in different parameter definitions. We could therefore not compare data from 2007 onwards unrestrictedly (with the years before), i.e., some variables collected prior to 2007 do not match data collected from 2007 onwards. For example, the income from selling rights is now collected explicitly, while it remains unclear whether it has been included in the variable income for the years before. The segmentation of the fleet has also changed slightly.

Looking at the period since 2007, the condition of the cod stock has improved and overcapacity is no longer a main task in the cod fishery since the long-term management plan works (see chapter 3.2.1). There are several reasons for that. The most important is that during recent years the fleets in the Baltic States and Poland were significantly reduced. Additionally, the management plan includes both quota and effort limitations. Vessels are only allowed to fish a certain amount during a fixed number of days. It is clear that this means that capacity is under-utilized and a further reduction in the number of vessels would allow the remaining fleet to fish more on more days. The problem from a management perspective before and during the introduction of the management plan, was to reduce the fleet, especially in the western Baltic countries who had already reduced their fleets using drastic measures such as allowing fishermen to go bankrupt, or by paying a certain number of fishermen to leave the fishery. With catch and effort limitation, the managers tried to avoid the loss of many jobs.[2] In many countries around the Baltic Sea, fishermen are operating in remote areas with long fishing traditions and with few job alternatives.

Following the developments in many countries, many small-scale fishermen left fisheries in crisis. These fishermen often used more environmentally-friendly fishing methods than larger trawlers.[3] The real situation in the Baltic Sea at the moment is that increasing quotas and higher catch possibilities for the fleet meet very low prices. However, the low prices for cod causes the fishery to balance on the edge of profitability, which is perhaps not due to overcapacity but to lack of consumer demand. One explanation could be that

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[2] It is also debated who shall decide which fishermen will have to leave the fishery if governments decide to cut the fleet drastically.

[3] Despite taking bycatches of birds and harbor purpoise in the gill net fishery into account.

consumers may have shifted their demand to other species or food products due to the different public campaigning against the “overfishing” of cod. It seems in this context not “politically correct” to eat cod and this demand does not shift back to cod again. In simple economic reasoning: a constant demand in combination with increasing fish supplies leads to a decrease in prices. In this case, the overcapacity in terms of fishing opportunities might not be the only reason for non-profitability in a fishery, but perhaps also the demand side of the market.

The other important reason for a fishery becoming unprofitable may be due to environmental changes affecting the condition of a fish stock. For example, the cod recruitment success depends largely on the deep-water salinity and its oxygen concentration. Further, the increase in the sprat stock, -being a consumer of cod eggs and zooplankton important for cod larvae – is suggested as being a factor hindering the recovery of the cod stock. However, the quantitative importance of such a mechanism is still unclear.

2.2 Subsidies in the fishing sector

2.2.1 General remarks

In the public debate of fisheries, one of the overall perceptions is that fishermen receive a lot of subsidies to stay in business. As a consequence, the fishing fleets are too large compared to available resources. The EU introduced fisheries subsidies in the 1970s, basically as an instrument to improve the economic situation of fishing companies and to keep prices of fish on the markets at an affordable level for European consumers.

In 2006, the OECD (Organisation for Economic Co-operation and Development) published a report on the financial support to fisheries. “The fisheries sector in OECD countries receives around USD 6.4 billion a year in transfers from government” (OECD 2006: 9). However, 38% of this sum is for management, research and enforcement. Another 35% are directed to fisheries infrastructure (OECD 2006: 9). Only the remaining part, approximately 27%, is directed to the fishing sector. This sum also includes payments for, e.g. the development of fish processing facilities and marketing initiatives. Direct income subsidies for fishing vessels in the EU are only paid for some effort limitation regulations (e.g. fisherman stay at home instead of fishing). There are a few further payments for investments, e.g. the introduction of more selective fishing gear or improvement of safety on board. A detailed overview from the different countries around the Baltic Sea is unavailable and it would demand a substantial amount of effort to analyse every national European Fisheries Fund (EFF) operational program (see below) in detail. How much money is really allocated to the fishing sector is unclear as the operational program is only a plan to distribute the money, and the reality could be very different from the program.

The OECD uses a wide definition for fisheries subsidies. Many countries rarely count management or research as subsidies for the fishing sector. In addition, most of the harbour infrastructure is not solely used by fishing fleets.

Concerning the surrounding countries of the Baltic Sea, Germany was a founding member of the EU, while Denmark, Sweden and Finland joined later. Other countries were in the 'eastern bloc' and their fishing fleets were basically developed before 1990. After joining the EU, those countries received, and still receive, subsidies for restructuring the fishing sector and the scrapping of many vessels shows that capacity reduction is high on the agenda (and the increase in the eastern Baltic cod stock is a sign of reduced fishing pressure).

2.2.2 Overview of direct subsidies in the Baltic Sea

The main source for direct financial support in the EU is the EFF. Each country receives a certain share of the overall budget and then decides how to allocate it. In addition, each country has to provide additional funding from own sources as national contribution. The co-financing rate depends on the overall economic situation of the country (accession countries or regions with a comparably low value usually 25% (e.g. Poland), others 50% (e.g. Germany)). An Operational program for each country is developed and approved by the EU-Commission. The funding is organised in five priority axes (Fig. 2):

1) Adaption of the EU fishing fleet (e.g. putting vessels out of business (scrapping or decommissioning), use of more selective gear or improvement of safety on board),
2) Aquaculture, inland (lake, river) fishing, processing and marketing of fishery and aquaculture products,
3) Measures of common interests (e.g. improving the services offered by fishing ports, strengthening markets in fishery products or promoting partnerships between scientists and operators in the fisheries sector),
4) Sustainable development of fisheries areas (basically diversification measures in fishing dependent regions so that fishermen are able to get a different job), and
5) Technical assistance (e.g. covering costs for implementing regulations).

Figure 1 illustrates that countries have different aims with their part of the EFF, e.g. Germany allocated a relatively large share to marketing issues (Axis 3), while Poland distributed it more evenly.

The following table 2 illustrates that over 50% of the overall spending was transferred to Poland while the new member states (Estonia, Latvia, Lithuania, and Poland) received nearly 80% of the total funding. Included are the national co-financing contributions.

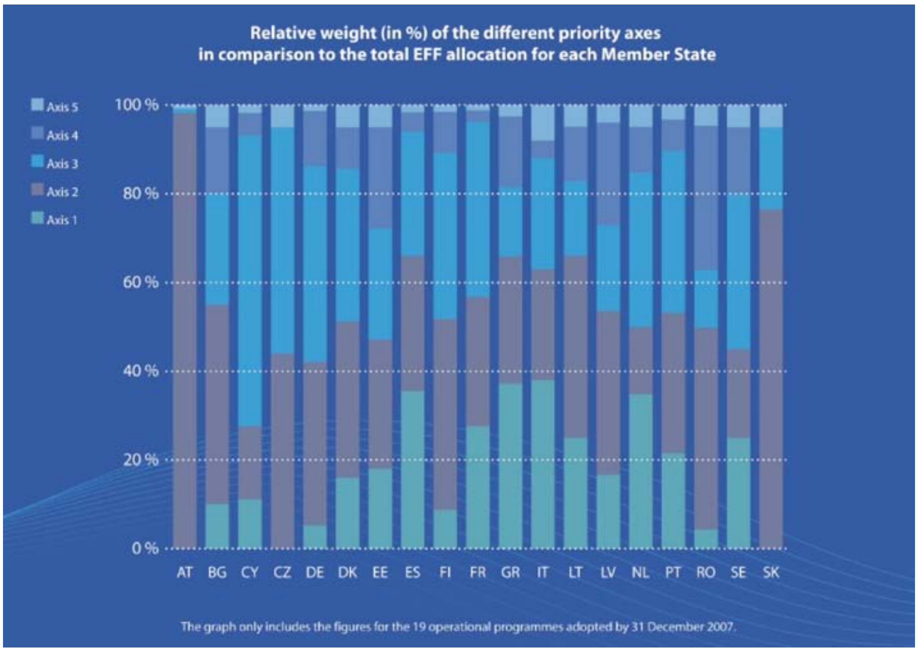

Fig. 1: The direct financial support of the EU via the European Fisheries Fund (EFF (2007-2013)). The figure shows the relative weight of the axis in the countries of the EU.

Table 2: Overview of the amounts of EFF (2007–2013) funding (including national co-financing) in the EU member states, including Baltic Sea and North Sea.[4]

Country	Priority Axis 1	Priority Axis 2	Priority Axis 3	Priority Axis 4	Priority Axis 5	Total
Denmark*	53.730.684,00 €	75.299.048,00 €	70.330.532,00 €	24.922.558,00 €	13.367.516,00 €	237.650.338,00 €
Estonia	20.352.708,00 €	32.778.572,00 €	28.279.552,00 €	25.708.684,00 €	5.637.870,00 €	112.757.386,00 €
Finland*	7.985.000,00 €	39.520.000,00 €	34.473.827,00 €	8.412.000,00 €	1.458.000,00 €	91.848.827,00 €
Germany**	6.013.334,00 €	44.489.634,00 €	66.533.197,00 €	10.594.000,00 €	1.528.161,00 €	129.158.326,00 €
Latvia	27.814.590,00 €	61.505.000,00 €	32.204.000,00 €	38.548.635,00 €	6.615.194,00 €	166.687.419,00 €
Lithuania	13.667.647,00 €	22.431.005,00 €	9.249.241,00 €	6.693.770,00 €	2.671.745,00 €	54.713.408,00 €
Poland	225.121.723,00 €	195.758.020,00 €	195.758.020,00 €	313.212.832,00 €	48.939.504,00 €	978.790.099,00 €
Sweden*	22.777.001,00 €	21.865.922,00 €	38.265.362,00 €	16.399.440,00 €	5.466.480,00 €	104.774.205,00 €
Total	377.462.687,00 €	493.647.201,00 €	475.093.731,00 €	444.491.919,00 €	85.684.470,00 €	1.876.380.008,00 €
*Cofinancing rate by 50%, others 25% (Denmark and Sweden in total with North and Baltic Sea region)						
**Cofinancing rate of 25% in Mecklenburg-Vorpommern (funding for western part of Schleswig-Holstein not included)						

As already mentioned, most of these payments are not directly paid to the vessel owners. Improved infrastructure or marketing conditions with higher prices as the goal may improve the economic performance of fishing companies. However, income subsidies or subsidies for investments are very limited from the EFF. The main sources of subsidies are the exemptions from fuel taxes. Fishermen, especially with larger vessels, are able to buy their fuel in other countries and may avoid national taxes as no fuel taxes are paid in Europe by fishermen.[5] Furthermore, as small-scale fishermen are unable to buy fuel in other countries, these fuel taxes would lead to distortion of

[4] The table is in German notation. Read 53.730.684,00 € as 53 Million 730 Thousand and 684 Euro.
[5] In Germany this is the only exemption mentioned in the national law on the taxation of fuel.

competition because small-scale fishermen would then have higher costs. It was not possible to give an overview on the fuel subsidies in the Baltic Sea as the amount of fuel the vessels used are not included in the national statistics, and even if those numbers would be available, it would be unclear if fishermen bought their fuel in the home country or not. Even for Sweden, where a calculation of the tax exemptions is available, this would be unclear.

2.2.3 Fuel Subsidies for Swedish Fisheries

Registered fishing vessels in Sweden are excluded from fuel tax, as is most other commercial waterborne traffic. Some vessels have the possibility to bunker fuel at a subsidised price without taxes, and other vessels have the possibility to have the fuel tax refunded.

In 2007, a total of 46,985 cubic meters of fuel were consumed in the Swedish commercial saltwater fisheries. This amount decreased to 41,377 cubic meters in 2008 because fishermen adapted their behaviour to save fuel because of the fast increasing fuel prices, as the price for fuel exempted from taxes increased from 3.38 SEK/litre to 5.32 SEK/litre. An increase in oil prices directly affects the fishing sector. The doubling of prices from 2006 to 2008 indicates a doubling in costs. As fishermen are exempted from the fuel tax, the increase in the prices for crude oil has different consequences. At the pump with all the taxes on the fuel, a doubling of prices for crude oil does not lead to a doubling in price because the fuel tax is always the same amount per litre. For fishermen without the taxes, a doubling in crude oil prices however means a doubling of the price.

The Swedish Board of Fisheries calculated the amount of tax exemption by calculating the energy tax and the carbon dioxide tax for the two basic fuel varieties: Oil EC 1 and Colour marked diesel. The results for 2005 to 2008 are summarized in table 3*.

Table 3.

Year	**Fuel consumption (m3)**	**Fuel subsidy, national average (SEK/litre)**	**Total value of fuel subsidies (Million SEK)(M€)**		**Profit (M€)**
2005	57,980	3.49	202.4	20.8	18.98
2006	58,817	3.51	206.4	21.2	7.38
2007	46,985	3.57	167.7	17.3	36.93
2008	41,377	3.90	161.4	16.6	~18

*Source: Swedish Board of Fisheries, Annual Economic Report

A comparison of the profit of the Swedish fleet with the amount of fuel subsidies shows the relative importance of the fuel tax exemption for the profitability of the fleet. On the other hand it is unclear if the fishermen could pass on the fuel tax to e.g., the customers, which would mean that the profitability of the fleet would be the same with or without fuel tax exemption.

3. Fisheries management in the Baltic Sea

3.1 Overview

The countries around the Baltic Sea are now, with the exception of Russia, members of the European Union. The Common Fisheries Policy (CFP) of the EU is therefore the basic regulatory framework for nearly all countries. The CFP regulates the general aspects of fisheries management in the Baltic Sea, in particular Total Allowable Catch (TAC). It does not regulate the distribution of fishing rights, which is still the responsibility of the individual member states and, therefore, each country has slightly different rules.

The EU Commission published a green paper on the reform of the CFP in 2009 showing that many stocks are not fished at a sustainable level. In the Baltic Sea, some stocks (see chapter 3.2) are below a level at which there is full reproductive capacity (Bpa, the precautionary biomass estimated from the fish stock assessment is often used as a reference point, www.ices.dk). At the Johannesburg summit, the EU committed itself to the Maximum Sustainable Yield (MSY) target, i.e., the largest average catch or yield that can continuously be taken from a stock under existing environmental conditions. All stocks shall be fished at a level that allows MSY by 2015. For many stocks in the Baltic Sea, this level is unknown or undefined. Only the two cod stocks and one herring stock (28.1, see Table 4) are classified as above the MSY stock level and, therefore, fulfilling the Johannesburg target (ICES 2010).

As eutrophication and salinity inflow into the Baltic Sea influences the development of fish stocks, these conditions needs to be included in the food-web model (chapter 4). There seems to be a perception that a reduction in nutrient inflow will reduce fishing opportunities in the future because of lower food availability. However, as some stocks (see chapter 3.2) are at a comparably low level, due to overfishing and other reasons, an implementation of a sustainable management may allow for higher catches even if there is a change in food abundance.

The green paper also reported that the fisheries management was unsuccessful from an economic standpoint and this is also the case for the Baltic Sea. Overuse of stocks leads to a loss of profits and gross value added, which means that better management may improve the fleet's economic performance and may in the long run lead to improved economic returns.[6] The main reason for this is that with a higher stock level the catch per unit of effort increases and costs are probably lower (higher catches with the same amount of effort).

[6] This can be part of the Ecopath modeling exercise.

Overcapacities in the fleets are seen as one of the main reasons[7] for overfishing.[8] There are several reasons for this overcapacity, e.g., the payment of subsidies for investments in the past management system where fishermen had incentives to invest in more efficient vessels to get a greater share of the overall quota. The payment of subsidies for investment is, according to economists, the main reason for the overcapacity, because the subsidies give fishermen a lower risk for investments and allow investment in situations where the fishermen may otherwise decide not to invest.

3.2 Stock status of the main species

In the Baltic Sea, three species dominate from a biomass perspective: cod, herring and sprat. Also in our model simulations these three species are considered (see chapter 4). This does not imply that other species have no or minimal importance for the fishermen. On the contrary, other species may have major importance for small-scale coastal fisheries operating within a certain range from the coast.

It is, however, not possible for us to take into account all the specifics for each country. In the food-web model used for this project, 'other species' are left out.

3.2.1 Cod

In September 2007, the Council of Ministers decided to implement a long-term management plan for the two cod stocks in the Baltic Sea. The main objective of the plan is to reach fishing mortalities (F)[9] of 0.6 for the western and 0.3 for the eastern stock. Basically two instruments are set: Total allowable catch (TAC) with a maximum fluctuation of 15%, and the limitation of fishing effort with a 10% reduction in days at sea, as long as F is above the above-mentioned fishing mortality target. A strong year class in 2005 and a substantial reduction in fishing effort since the implementation of the plan has led to a substantial increase in spawning stock biomass of the eastern stock. However, the western stock is still classified as overfished. ICES (International Council for the Exploration of the Sea,) estimated the average fishing mortality of the western stock during the period 2007–2009 to be 0.73, i.e.

[7] Other reasons are: unclear property rights leading to a race to fish, unclear stock status or the adoption of TACs which were too large for a long time sustainable fishing.
[8] As Grafton et al. note: "Many of the world's fisheries are challenged by a combination of overcapacity, overharvesting, habitat damage and poor economic returns. For the first time ever it appears the world's total harvest of fish from wild stocks is in decline because of over-fishing" (Grafton et al. 2006: 1).
[9] Fishing mortality (F) can be estimated by dividing the catch by the mean stock size. The catch includes annual commercial and recreational landings, along with dead discards (the total removal of the species by 'fishermen'). Fisheries biologists estimate next year's stock size by assuming the total mortality (natural and fishing) and the recruitment to the stock from collection of biological data. The aim is not to remove more fish from the stock but to keep the stock size constant (that translates to the 0.6 or 0.3 target in the cod management plans as long term targets) or in the case of the cod management plan to rebuild the stock over a certain period of time.

still higher than the target of 0.6. However, a strong year class 2008 allows for a slight increase in the TAC in 2011. The fishing mortality of the eastern stock is below 0.3 since 2009 and, therefore, the objective of the management plan is fulfilled. The maximum allowed TAC fluctuation of 15%, however, still limits the increase of the TAC for the eastern stock. The year classes 2005 and 2006 are strong and ICES predicts (ICES 2010) increasing discards and a threat of highgrading, i.e., changing smaller fish to larger specimens because of a higher value. The fishermen have smaller cod under the minimum landing size in their nets, and as they are not allowed to land it, this cod will be discarded. However, the introduction of the BACOMA net (special exit window to allow small cod to escape) improved the selectivity of the nets and discard rates have decreased over the last years.

The questions remains as to which development (really) led to the increase in the eastern cod stock: the better recruitment conditions, i.e., higher deep-water salinity and oxygen concentrations, or the decreasing fishing effort? Very likely both factors played a key role. Especially, the reduction of fishing effort in the eastern part of the Baltic Sea was substantial in recent years (see Motova & Kuzebski 2009).

3.2.2 Herring

In the Baltic Sea, five herring stocks are managed separately. Four of them are in the main basin, and the fifth is migrating between the North Sea and has its spawning grounds around Rügen island, Germany.

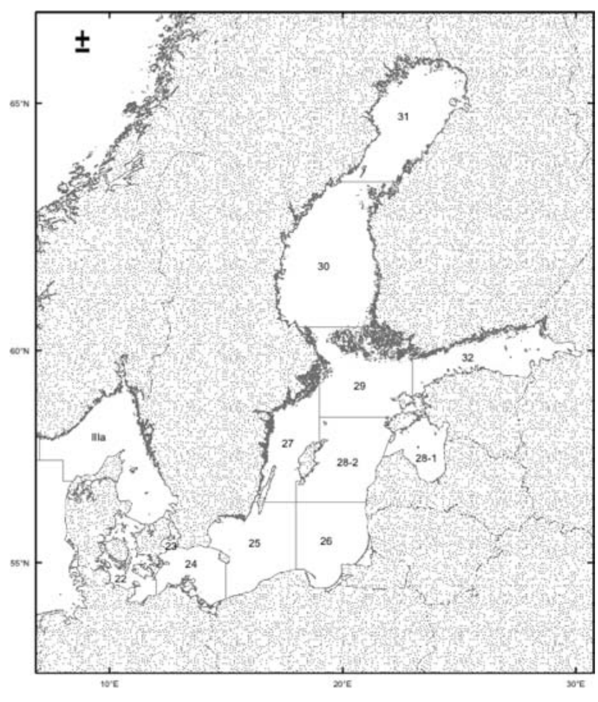

Figure 2: Showing the grids of the Baltic Sea areas, which the International Council for the Exploration of the Sea (ICES) is using for fish stock assessments (see also Table 4). Source: www.ices.dk

The western Baltic herring stock is part of a mixed fishery with the North Sea autumn spawning stock and spring spawning stocks in the Skagerrak-Kattegat area and, therefore, an assessment is rather complicated. For fisheries biologists it is hard to assess from the herring landings which stock the fish belongs to. The status of the stocks is as follows (Table 4):

Table 4: Herring stock status of the herring spawning stock biomass (SSB) in the Baltic Sea given for the different ICES subdivisions (ICES 2010), Bpa (level of full reproductive capacity), F (fishing mortality).

Stock	SSB	SSB to Bpa	F	F to FMSY	Overall status (ICES)
Western stock (3a/22)	Unknown	No Bpa defined[10]	0.43	+ 0.18[11]	Overfished
Subdivision 25–29 and 32 (excluding Gulf of Riga)	502,000 t	No Bpa defined	0.258	+ 0.038	Overexploited
Subdivision 30	502,000 t	No Bpa defined	0.16	0	Harvested sustainably
Subdivision 31	Unknown	No Bpa defined	Unknown	-	Unknown
Gulf of Riga	Unknown	No Bpa defined	0.42	+ 0.07	Overexploited (compared to high long term yields) Fished sustainably (precautionary approach)

Overall, the herring stocks are overexploited compared to the objective of high long-term yields. A long-term management plan is currently under consideration and may be adopted by the Council of Ministers in 2011.

3.2.3 Sprat

There is one sprat stock in the Baltic Sea. In the ICES advice 2011 (ICES 2010) the spawning stock biomass is calculated at around 825.000 t, which is approximately 20% above long term average of the stock size of sprat. The fishing mortality is 0.5, which is higher than the long-term yield (Fmsy), i.e., 0.4. There is a risk that this stock is being harvested unsustainable. Cod and sprat stock are related to each other in a predator-prey relationship as cod feeds on sprat and sprat partly feeds on cod eggs and larvae. Management decisions in the future have to take this into account. An objective of high cod landings in the future may contradict the possibility of high landings of sprat and vice versa. Sprat will also be part of the Long Term Management Plan (LTMP) for pelagic stocks.

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[10] Fisheries biologists are not able to calculate the stock size at which the stock has full productive capacity or they are unable to assess the stock size (SSB) at all because of insufficient biological data.

[11] The Johannesburg agreement to fish stock at maximum sustainable yield is translated into a fishing mortality to allow that (Fmsy). If the fishing mortality is higher (here +0.18) the stock will not reach the MSY level.

3.3 Property rights allocation in the countries around the Baltic Sea

The main issue in fisheries management is the allocation of fishing rights to the fishermen. In the EU, the Council of Ministers only decides on the overall total allowable catch (TAC), technical measures and management plans. The overall principle of TAC allocation is based on a fixed percentage for each country founded on the relative stability concept, i.e., the defined share between the fish stocks. This percentage was calculated from the country-specific catches before the introduction of the Economic Exclusive Zone (EEZ). At this stage countries gave up their rights to the EU in exchange for a part of the overall EU quota. In the Baltic Sea, many countries were not members of the EU but of the International Baltic Sea Fisheries Commission, which regulated fisheries until 2005. In the meantime, with nearly all countries being members of the EU, the relative stability concept is also the basic allocation principle for all EU member states. The member states then decide how to allocate the fishing rights to their fishermen. All fishermen harvesting EU-regulated species need a special permit and to be registered in the EU fleet register. This means there are general rules for everyone, independent of the country.

For example, the long-term management plan for cod includes the following general regulations:

- Special permit for every fishermen fishing on cod
- Days at sea effort regulation for each vessel
- Closed seasons (West of Bornholm 1–30th of April, East of Bornholm 1 July – 31st of August)
- Closed areas (mainly Bornholm deep)

The following table 5 includes the special rights allocation systems in the countries around the Baltic Sea.

Table 5: Overview on catch allocation mechanisms in countries around the Baltic Sea for fisheries on the main species.

Countries		IQ	ITQ	Capacity/ entry lim.	Add. Regulations/Comments
Denmark	2000–2009	X	(X)	X	ITQ stepwise since 2003, Special regulations for small-scale fishermen (< 17m, normally one day trips, etc.)
	2010		X		
	after 2010		X		
Germany	2000–2009	X		X	Better transferability of IQs may be possible in the future. At present fishermen may lose their IQs if they are not used; IQs are then given to another fisherman[12]
	2010	X			
	after 2010	X			

[12] This means that the fishermen may have to go out sometimes when it would be better to stay in port to fish out their quota.

Countries		IQ	ITQ	Capacity/ entry lim.	Add. Regulations/Comments
Sweden	2000–2009			X	ITQ for pelagic fisheries (2010), Effort limits in western waters/ Baltic Sea, Two week cod quota (vessel length/gear type), kwdays tradable
	2010	X	X		
	after 2010				
Poland	2000–2009	X			Open cod quota for coastal vessels and for pelagic species in general, limited ITQ (can be swapped but not sold) in cod fishery, Heavy reduction in no. of vessels in 2009
	2010	X	X		
	after 2010		X		
Lithuania	2000–2009			(X)	5% of cod quota to coastal vessels, herring and sprat open quota because of under-utilization
	2010	X		X	
	after 2010		X	X	
Estonia	2000–2009		X		Generally ITQ now
	2010		X		
	after 2010		X		
Finland	2000–2009				No IQ or ITQ in the fisheries in the open Baltic Sea
	2010				
	after 2010				

The main discussion in fisheries management from an economic standpoint is the question of incentives induced by the management measures. For fishermen, it is rational to invest in the improvement of their vessels if there is an open quota (no limit to individual catches). This leads to a race to fish until the quota is fished out. In the Baltic Sea, only Finland still relies on such a system. The basic measure is now an IQ system, meaning that the fishermen receive an individual quota but are not allowed to transfer it to other fishermen. Fishermen have an individual (personal) quota but are not allowed to sell or lease it. Further, fishermen who want to have higher quotas, have to buy not only the quota but the whole vessels the quota is attached to (like in Germany and Sweden)[13]. With a transferability of a quota, a more efficient system may be possible. Fishing quota moves to vessels with lower costs and this improves the overall economic returns. However, this may lead to fewer vessels remaining in a fleet and the possibility that quotas move out of regions.[14] If countries have different objectives with their fishing sector, e.g., regional distribution and maintaining a small-scale fishing sector, they may decide on certain rules for the transferability of rights, as for example in the case of Denmark.

The overall aim of fisheries management will be a sustainable and efficient use of the resources in the future. In the present context, we have therefore used the Ecopath with Ecosim food-web model to simulate certain management options that includes the sustainability of the ecosystem and the fishery.

[13] As many countries have introduced or are introducing ITQ/flexible IQ systems, this will not be the case in the future anymore.

[14] In Denmark, the fishing fleet is increasingly concentrated in fewer harbours with the necessary infrastructure. Some smaller harbours/cities bought quotas to keep the fishing fleet there (e.g. as a tourist attraction). In the event that the EU introduces ITQ on the community level, it is possible that fishermen from countries outside of the Baltic Sea buy quotas and then afterwards fish in the Baltic Sea.

3.4 Special case, an interview with a Swedish coastal fisherman

Rune Wikström at Möja Island in the Stockholm archipelago, Sweden, is a well-known person in both the fishing industry as well as in the Swedish Parliament. He agreed to let us interview him for a dialogue regarding the change of fishing over time.

Rune runs a normal-size, 12-meter boat, which is about 40 years old but in a well-kept condition and sufficient for Rune's fishing needs. He has been fishing for around 50 years. Rune concluded that he still spends roughly 100+ days every year on the boat despite being active in politics and a member of parliament.

He reported that fish species composition have changed over the last 50+ years. Herring, cod, sprat, eel and whitefish are the most common species that Rune fishes and all of them have different long-term cycles. Herring was the main target fish from the late 1950s to mid-1970s. Such large volumes of herring were fished that the Möja Island alone had almost 60 working fishermen. From the early 1980s to the peak in the mid-1980s, cod was the main species for fishing until its abrupt decline mid to late 1980s. Both herring and cod were overexploited according to Rune, because the volatility in regulations caused unsustainable fishing that prevented regeneration of the fish stock. Today, Rune is the only fisherman left on the island of Möja.

Today, the quotas in Sweden are divided between industry fishing, i.e. 65% of the total fisheries, and small fisheries, i.e. the remaining 35%. However, if the small fisheries cannot fulfil their quotas, these automatically divert to the industrial fishing.

Rune realized early that fishing alone would not support his livelihood. Today, Rune's business consists of a family business niche restaurant on the Möja Island. The restaurant is a branded restaurant and quite famous in the Stockholm area. Rune's fishing supports the business with fish in season and caters to the Swedish tradition of Christmas lunches and dinner. Today, Rune's business includes the restaurant which has a turnover of about 3 million Swedish kroner supporting 5,5 FTE. The cost of the boat and materials for fishing is approximately 55 000 SEK annually and includes service, fuel, materials and fishing gear and since the boat is old, there are no residual or interest payments to calculate.

The future of fishing as a business is far from positive. The regeneration of small fishing businesses is impossible due to harsh regulations on passing on fishing rights. If Rune, for example, was to let his grandson take over the boat he could not equally pass the fishing right. The fishing right would be forfeited and it is possible that the quota would be passed on to large industrial type fleets/boats. In short, the rules and regulations will starve the small-size fishing business.

4. Ecological and Economic Modelling

4.1 Central Baltic Sea food-web NEST model

The current version of the food-web NEST model is based on the Ecopath with Ecosim (EwE, see appendix chapter 3) software and covers the area of the Central Baltic Sea (ICES subdivisions 25–29 excluding Gulf of Riga, see Fig. 3), containing 28 functional groups (Fig. 4). The model has been developed using different databases and literature sources within the Baltic Nest Institute (www.balticnest.org). Fish groups are split into multi-stanza (like an age-structure) groups to represent the main temporal changes and shifts in diet composition along the age-structure. Fisheries are largely based on the three main fish species in the Central Baltic Sea, i.e., cod, sprat and herring. This mass-balanced model represents the state of the ecosystem in the middle of 1970s and the year 1974 has been chosen as a baseline for the temporal Ecosim simulation. To fit and run the Ecosim model, time series of biomasses, fishing mortalities and environmental drivers have been used (see table in the Appendix, chapter 3). Biomasses, catches and fishing mortalities are derived from the ICES WGBFAS 2008 report (ICES 2008), based on single fish species assessment. Calibration time series represent 33 years (1974–2006).

The food-web model is forced by fishing mortality and environmental variables (salinity and temperature, see Fig. 4).

Fig 3: The Baltic Sea area of the modelling focus in Ecopath with Ecosim.

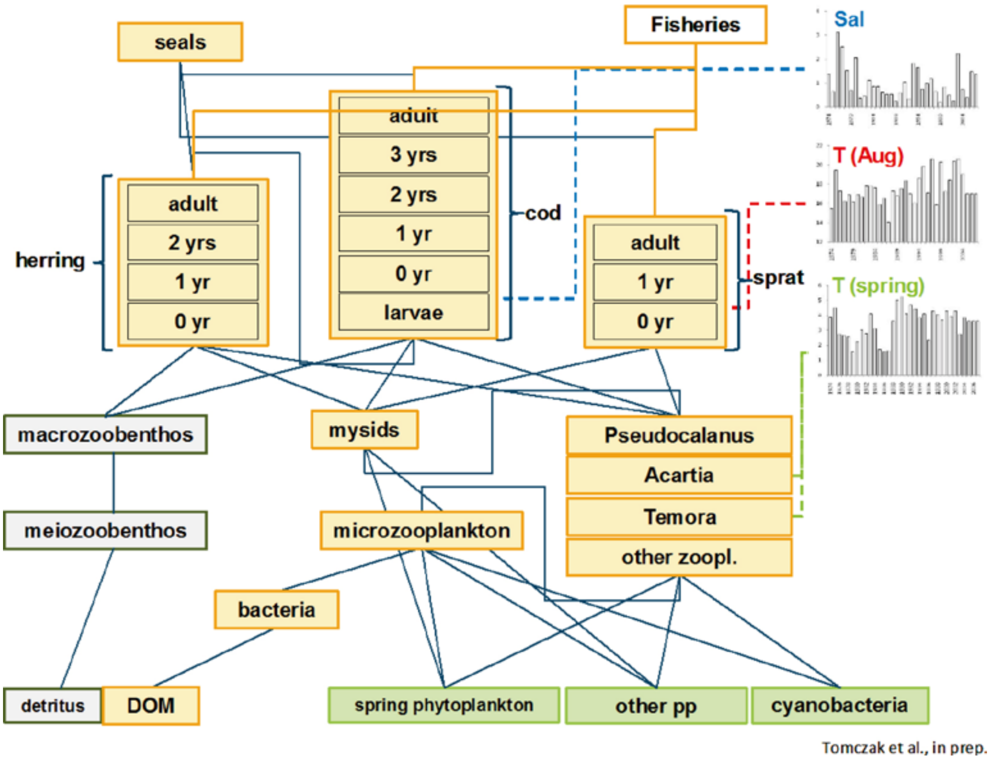

Fig. 4: The conceptual design of the BNI food-web model showing the 28 different functional groups and their forcing, i.e., salinity (Sal), temperature in spring and summer (T) as well as fisheries.

4.2 Economic modelling and Management scenarios

In this project we have used two approaches to perform an economic assessment of the foodweb scenarios:

1. Evaluation of dynamic fishing capacity per effort change (called fleet size dynamics), which is based on previous years' profits and catches.
2. Evaluation of the fleet efforts leading to an optimisation of one or more fishing policy aims, including optimal ecosystem status (maximum ecosystem maturity), rebuilding of specific stocks, maximum profit and/or maximum employment of the fishery.

Approach 1 is based on simulations, calculating the development of the ecosystem over time. This takes the interaction between the ecosystem and the fleet effort/capacity (fleet size) into account as a dynamic feedback process between fleet size and fish available. The second approach is an optimisation routine, determining the fleet efforts/capacities that adjust the ecosystem dynamics closest with certain fishing policy aims.

In the project, the features of the Fleet Size Dynamics module (approach 1) and the Policy optimisation module (approach 2) have been investigated and tested on fleet data collected for countries fishing in the central Baltic Sea (see chapter 2).

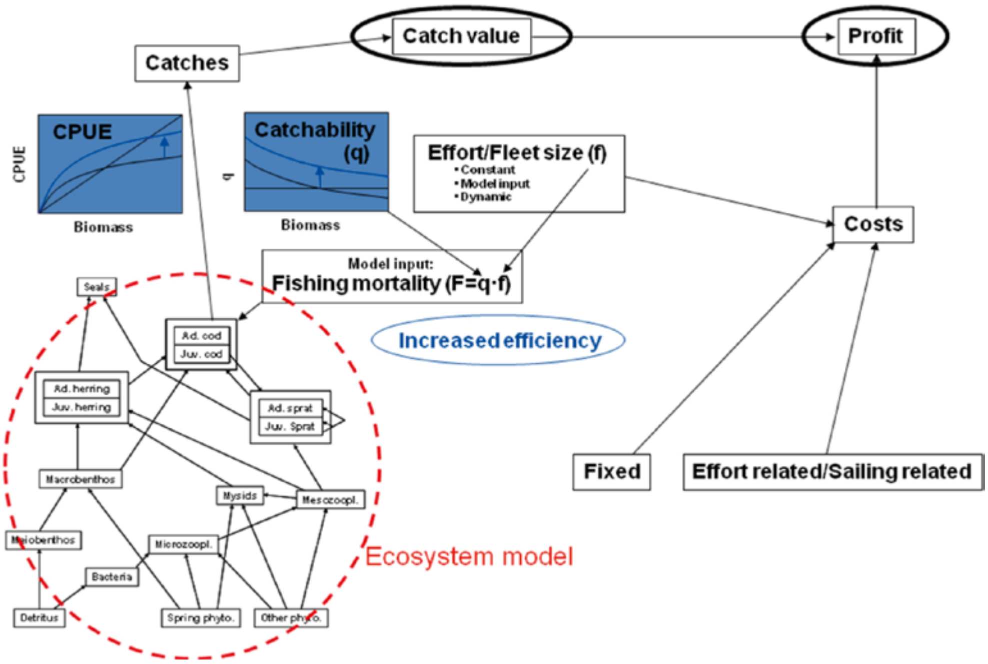

Figure 5: The schematic design of the interactions of the ecological and economic components in the Ecopath with Ecosim model used in this project.

4.3 Model results

In the following section, we focus only on the management optimisation results, as these are most relevant for the project. However, the economic modelling results from the fleet-size dynamics module can be found in Appendix 3.

4.3.1 Management optimisation

The management optimisation module searches for fishing effort patterns that optimises specific management and policy goals. The following management scenarios were considered:

- Maximization of fisheries profit (net present value, NPV).
- Maximization of social benefits, expressed as number of jobs per catch value.
- Maximization of ecosystem health.
- Combination of all three previous scenarios equally weighted.

The aim is to maximize the fleet efforts over the whole simulation period, i.e. 2006–2026, for the four above-mentioned conditions. The resulting fleet efforts are translated to fishing mortalities in Ecosim, which are then used to evaluate yield and fish biomasses.

The two first management scenarios reflect policy settings from a strictly socio-economic point of view, where the main objective is to optimise the cash flow and the employment of the fishery. The third scenario reflects the policy setting from a biological point of view, where the main objective is to (re)generate healthy fish stocks with long lifespans. The fourth, combined scenario reflects that optimal management should be based on a biological as well as an economic point of view, and that an optimal fishing policy must thus take into account viability of fishing fleets, reflected through earnings and employment, as well as ecosystem health.

The management scenarios yielded the following results:

1. The profit scenario resulted in a higher total fleet net present value than the other management scenarios.
2. The employment scenario resulted in the highest total fleet landings value of the four management scenarios.
3. The ecosystem health scenario resulted in the lowest total fleet landings value of the four management scenarios.
4. The fishing effort of all fleet segments except of one (OTH2440) was approximately set to zero in the management scenarios. The effort on OTH2440 was on the other hand increased relative to the start year in all scenarios cases.
5. The biomass changes of all functional groups, and especially for the target species, over the optimisation period were approximately the same for the four management scenarios.

Results 1–4 are generally as expected; the total fleet NPV is expected to be highest in the profit scenario, and the total fleet landings value is expected to be highest in the employment scenario, while the ecosystem health scenario should decrease the fishery, and thus the earnings of this, as much as possible. The reason why this is not much further reduced is that even at the profit and employment scenarios, the fishing intensity needed to be reduced drastically as otherwise the effort cost would be too high in order to make profits (see Fig 6 for the fishing pressure). This can also be seen in point 4, in which all the fishing efforts except of one were reduced to 0. So only the fishing fleet "other vessels between 24–40 meters" (OTH2440) was profitable because it has a low effort cost and fished only on cod, the fish with the highest value.

This low fishing pressure means that the ecosystem already has a relatively good status compared to the ecosystem health scenario. This explains why the total biomass of the species does not differ much between the scenarios. Figure 7 illustrates the cod biomass and Figure 8 the cod catches.

These simulation results illustrate the interaction between the effort cost and the number of fish available. In the long run, it is only profitable to have a low fishing at a relatively low fish biomass, as otherwise the effort cost would be too high to make profits. Figure 9 illustrates the potential profit for the four different management scenarios. As these model scenarios illustrate, this low fishing pressure will lead to an increase in the fish stock, in particular for cod, which will then in the long-run lead to a higher profit.

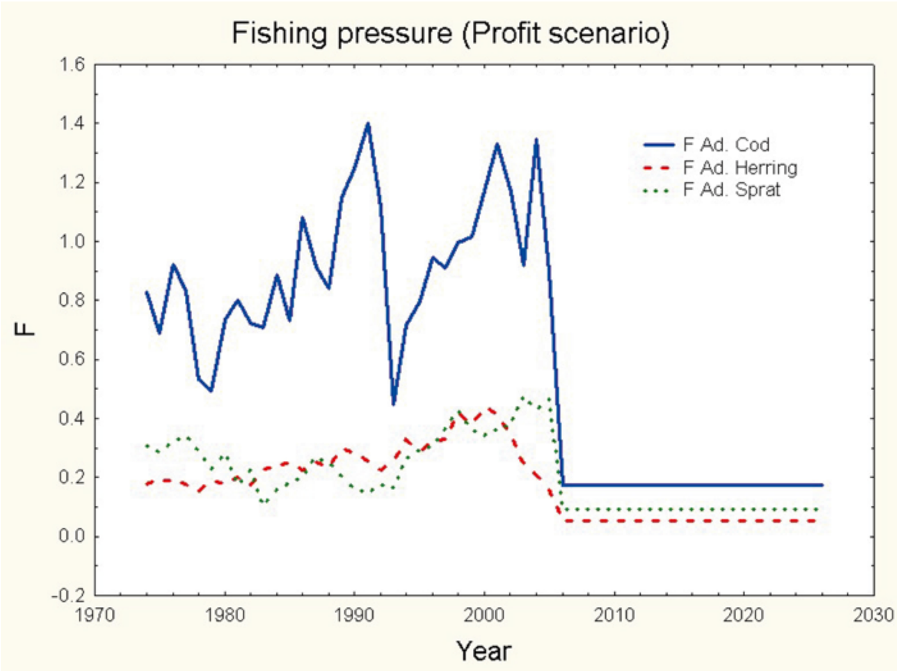

Figure 6: The fishing pressure (F) on the three main fish species in the Central Baltic Sea, cod, sprat, herring in the past and the profit management scenario (2006–2026).

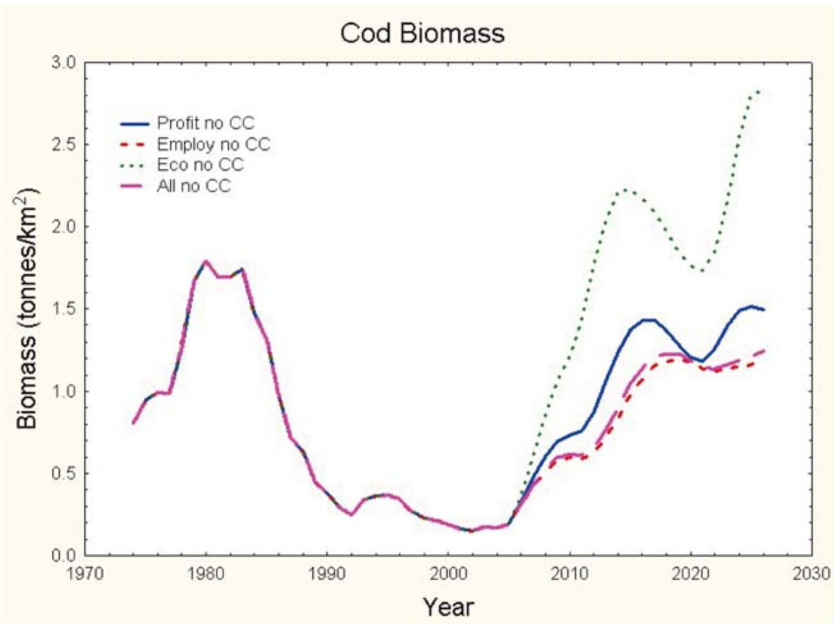

Figure 7: The cod biomass in tonnes km^2 in the historical period and for the four management scenarios, i.e., profit, employment, ecosystem health (Eco) and the combination of all three (all).

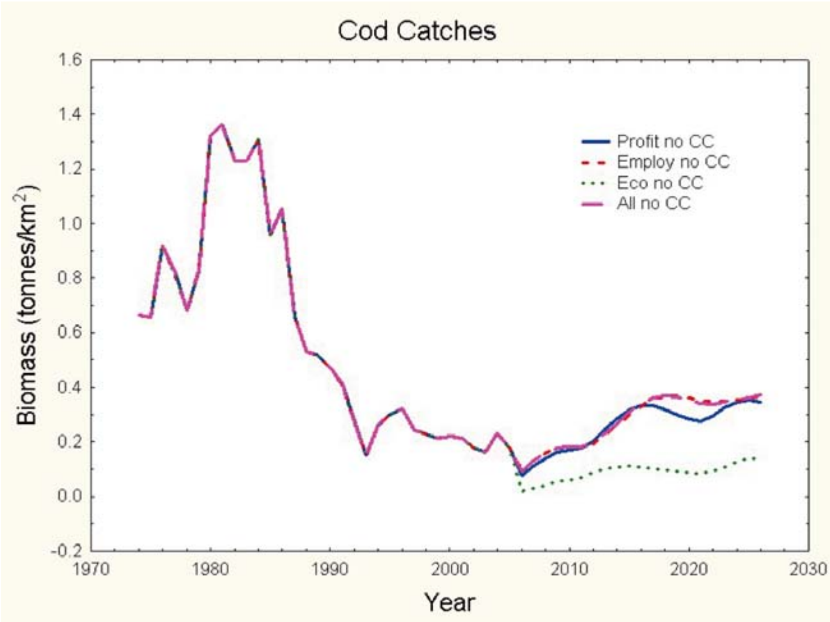

Figure 8: The cod catches in tonnes km^2 in the historical period and for the 4 management scenarios, i.e., profit, employment, ecosystem health (Eco) and the combination of all three (all).

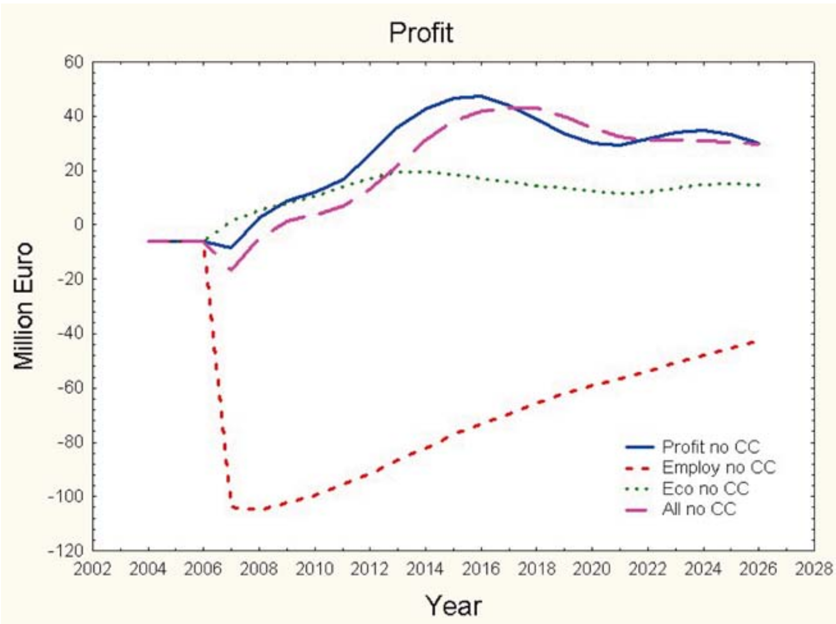

Figure 9: The simulated profit in million Euros of the four management scenarios, i.e., profit, employment, ecosystem health (Eco) and the combination of all three (all).

4.3.2 Limitations of the economic modules and data

During the project, it appeared that it is an enormous task to obtain a detailed understanding of how the two economic modules in EwE work. Thus, more time than initially planned was used for this, leaving less time for policy simulations. However, the detailed analyses of the dynamics of the two modules paid off in the sense that many aspects could not be included into this project but would be interesting to work with in the future:

- The Fleet Size Dynamics module (see appendix) has great potential: It was shown that the module can reproduce historical effort time-series, thus making it possible to use this module in future simulations. It would in this respect be interesting to investigate the capacity investment function closer, and maybe implement other investment functions and compare the results.
- The management scenarios clearly have potential to be a valuable tool in evaluating the economic effects of various policy objectives. However, the module, at present, has a number of limitations:
    - It is not possible to limit the fleet effort in the optimisations. As it is unrealistic that any fleet is forced to stop fishing completely, this limitation will often make the results of the policy search optimisations unrealistic.
    - It is not possible to limit catches, while performing the optimisations. This could be interesting from a policy point of view, e.g., how much can maximally be earned by the fleets while still complying with the quotas.
    - The module is both time and computer power consuming and needs powerful computers to run optimally. Even though the possibility is there, it is not at present possible to vary the effort independently for each year in the optimisation period.

Finally, it must be noted that the data collected for the study was in some respects inadequate. Data on some of the cost indicators were lacking for certain countries, and when aggregated the total landing data for the fleets did not correspond to the ICES landings data in the Central Baltic Sea. It is suspected that these data problems may be a reason for, e.g. seeing that all fleets but one are forced to stop fishing in the management optimisations, a clearly unrealistic result. It is recommended to repeat the data-collection and perform a more detailed quality-check on the new data for future work.

5. Conclusions

This report provides the results from a first attempt at an ecological-economic evaluation of the effects of different strategies for fisheries management in the Baltic Sea. The study included the following components i) collection of economic data from the fisheries sector in seven countries around Baltic Sea, ii) an overview of the current fisheries management (instruments and policies), iii) simulations of different management scenarios using an ecological-economical model for the Central Baltic Sea. This leads to the following conclusions:

1) The condition of the cod stock has recently been improved, indicating that the new EU implemented Eastern Baltic cod management plan is a step in the right direction. It seems that the low price of cod causes the fisheries to still be profitable which might not only be caused by overcapacity but also by a lack of consumer demand. This still needs to be tested.
2) The management overview shows that the EU Common Fisheries Policy is the basic regulatory framework for nearly all countries. It regulates the general aspects of management in the Baltic Sea, in particular Total Allowable Catch (TAC). However, the distribution of fishing rights is not included and is still the responsibility of the member states. The overview indicates that many countries move in the direction of a more flexible quota management with ITQs (individual transferable quota where fishermen receive a certain share of the overall quota with the possibility to trade it).
3) The ecological-economical modelling work indicates that fisheries in the Central Baltic Sea are only profitable if the fishing effort is low, given current stocks size and fishing fleets structure. This result needs to be interpreted with precaution due to data- related problems (see below).
4) This first attempt of ecological-economic modelling was successful and showed that such an approach can be used to guide future ecosystem-based management. The ecological model includes, besides fish, the dominant food-web dynamics, which would make it possible in the future to link fisheries scenarios to eutrophication scenarios. Two economic modules (fleet size dynamics and policy optimisation module) have been tested on fleet data collected for countries fishing in the Central Baltic Sea.
5) However, it must be noted that the data collected for the study were in some respects inadequate. Data on some of the cost indicators were lacking for some countries due to different book-keeping rules, and when aggregated, the total landing data for the fleets did not

correspond to the official ICES landings data in the Central Baltic Sea. The economic reported landings data consist only of the profit gained from the fish sold directly. That is the main reason why the results from the management simulations have to be interpreted with caution.

6) The economic data analysis also reveals other weaknesses. For example, parameters such as effort days are not collected in the same way, as some countries collect and report days at sea, while others use fishing days. Further, some countries do not publish data for certain fleet segments due to confidentiality. Until today, the economic data are based on specific countries around the Baltic Sea and no regional assessment has been performed due to the lacking quality and comparability of the data. Another problem was that the change in the data collection on the European level led to different parameter definitions, which does not allow comparison of data from 2007 onwards unrestrictedly with the years before. However, a regional assessment is probably needed for the Marine Strategy Framework Directive. For such an assessment either the type of data needs to be improved to run more realistic scenarios or another economic approach needs to be applied.

6. Way forward

Based on experience from the current project, we have identified gaps and indicated future model development and research directions. The next steps in the ecological-economic modelling of the Baltic Sea fisheries are the improvement of model parameterisation and stability as well as adding sensitivity analysis (e.g. 50% higher or lower cod biomass) to allow for more robust results and uncertainty descriptions. The food-web model has already been improved within the Baltic Nest Institute to reflect the food-web dynamics, however the economic modules need further development and parameterisation to reflect the full feedback loop between fisheries and food-web dynamics. To analyse not only the economic effect but also the overall ecosystem response, the economic model needs to be tested for different time perspectives – short-term from economic point of view (in time span 10–20 years) and long-term from the ecosystem point of view (50+ years). One of the most important factors, the eutrophication impact, could due to time limits not be tested. However, this should be included in future projects as part of scenario tests, taking into account the effect of the Baltic Sea Action Plan and the MSFD.

To reflect and increase importance of small-scale coastal fisheries, the flat fish functional group needs to be added to the model structure, since this stock supports coastal fisheries.

For the first time, a special overview on the economic data on the fishing fleets of the countries around the Baltic Sea was given. The data collection basically followed the same framework as for the EU data collection. However, more detailed data delivery in specific areas is necessary for the model calculations. For that, cost data must be specified for different areas to be able to link costs and earnings to very specific fish stocks included in the food-web model. At the moment, the basic problem is to divide the costs between the North Sea and Baltic Sea, as several vessels in Denmark, Germany and Sweden are fishing in both.

An improvement in the economic data will also allow more realistic results for the combined ecological and economic management simulations.

The main development for the fleet in the future might not be related to the decrease or increase in fish stock size, as more and more areas might be closed for fishing vessels due to the construction of windparks, sand and gravel removal and/or regulations of Natura 2000 areas, where some areas may be open only for certain types of fishing equipment to preserve birds and marine mammals. This component needs to be addressed further in a trans-sectorial spatial planning approach, providing a more complete picture of ecosystem-based management.

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Glossary

Bpa: The precautionary biomass estimated from the fish stock assessment, often used as a reference point for reproductive capacity.

Capacity: Fishing capacity is difficult to measure. At the moment Gross Tonnage (GT) and Kilowatt (kw) are used as proxies.

Capacity/entry limitation: Additional measures to limit fleet capacity if the fleet is only regulated by limiting the number of fishermen allowed to fish that stock without handing out a specific quota.

CFP: The Common Fisheries Policy is the European Commission's common structural policy for the fishing industry, currently under reform.

Days at sea: The number of days the fleet/individual vessels can fish per year.

Demersal trawls: Mobile gear fishing at the bottom.

Discards: Fishermen are not allowed to land fish for which they have no quota, or which is under the minimum size. They have to throw it over board (discard).

EEZ: Exclusive Economic Zone, a sea zone under the law of the sea over which a state has special rights over the exploration and use of marine resources.

EFF: The European Fisheries Fund provides financial support aimed at enhancing the sustainable European fishing and aquaculture industry.

Effort days: see Days at sea.

Fishing days: Larger vessels with longer distances to fishing grounds only count days when they really fish.

FTE: Full-time equivalent. This is a way to measure a worker's involvement in a project. An FTE of 1.0 means that the person is equivalent to a full-time worker, while an FTE of 0.5 signals that the worker only works half-time.

GVA: Gross Value Added

Highgrading: Throwing overboard smaller fish and keeping larger specimens because of a higher value, as smaller fish under the minimum size may not be landed.

ICES: The International Council for the Exploration of the Seas, a network of more than 1600 scientist from 200 institutes linked by an intergovernmental agreement to add value to national research effort on fisheries and marine ecosystems. (www.ices.dk)

IQ: Individual quota when fishermen receive a certain share of the overall quota without being able to trade or lease it.

ITQ: Individual quota when fishermen receive a certain share of the overall quota with the possibility to trade it.

Kilowatt: Power of the engine. Used to measure fleet capacity and to limit fishing effort (kwdays)

Kilowatt/days: There are regulations of effort via so-called kwdays. One measurement of fleet capacity is the amount of kilowatts (kw, the power of the engine). Days at sea are then allocated to the fleet by kw and not only by number of vessels, to reduce the incentive of fishermen to increase engine power on their vessels.

MSFD: The Marine Strategy Framework Directive, under EU's maritime policy, aims to more effectively protect the marine environments across Europe. It aims to achieve good environmental status of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend.

MSY: Maximum Sustainable Yield

NPV: Net Present Value. This is defined as the sum of the present values of the individual cash flows.

OECD: Organisation for Economic Co-operation and Development gathers governments of some 30 countries to address the economic, social and governance challenges of globalisation (www.oecd.org/about)

Overcapacity: More vessels or vessel capacity in a fleet than necessary to fish a stock. It does not mean the supply of caught fish exceeds the demand. In the Baltic Sea, many vessels in Poland and the Baltic States were scrapped and lowered the capacity (GT and kw) of the total fleet.

Overharvesting: Another word for overfishing. Overfishing occurs when the fishing mortality is higher than the stable long-term yields or leads to an increased risk for lower reproductive fish capacity.

Passive gear: Class of fishing gears not moving through the water: traps, gill nets and longlines.

Pelagic trawls: Mobile gear fishing in the water column.

SSB: Spawning Stock Biomass – part of the stock, which is able to spawn in that year (cod at an age of around three years, herring at around two, etc.).

TAC: Total Allowable Catch

Appendix 1. Economic situation of national fleets in the Baltic

All data presented in the appendix was collected according to a common key, decided upon at the first project meeting in October 2009. It was decided to collect data for all national fleet segments fishing totally or partly in the Central Baltic Sea. It was agreed to collect the following annual aggregated variables for each fleet, for the years 2005, 2006 and 2007:

- Number of vessels
- Capacity measured as gross tonnage (GT)
- Capacity measured as engine power (KW)
- Average age of vessels in the fleet segment
- Total income
- Crew costs
- Fuel costs
- Other variable costs
- Depreciation
- Capital costs
- Total fixed costs
- Employment – total number
- Employment – FTE
- Net profit
- Gross value added
- Total days at sea
- Days at sea in Central Baltic
- Total landings weight and landings value for all species
- Total landings weight and landings value for cod
- Total landings weight and landings value for herring
- Total landings weight and landings value for sprat
- Total landings weight and landings value for other species than cod, herring and sprat
- Landings weight and landings value for all species in the Central Baltic
- Landings weight and landings value for cod in the Central Baltic
- Landings weight and landings value for herring in the Central Baltic
- Landings weight and landings value for sprat in the Central Baltic
- Landings weight and landings value for other species than cod, herring and sprat in the Central Baltic

Not all countries were able to collect data for all variables. Below is given a summary of the data collected for each country, together with an overall discussion of the economic status of the fishery in the Central Baltic for each country.

1.1. Denmark

The following description of the economic situation for the Danish fishing fleet operating in the Baltic Sea is based on the period 2001-2008. Only vessels with yearly earnings above a minimum level, which was 252 725 DKK (approximately 34000 EUR) in 2007 are included in the outline. This level is used to sort out part-time fishing vessels from the annual collection of Danish Fishery Statistics, produced by the Institute of Food and Research Economics until 2008, and presently produced by Statistics Denmark.

In the following text, only fleet segments whose catch value in the Baltic Sea aggregated over the period 2001-2008 constitutes more than 25% of their total catch value in all fishing grounds during the period are considered. This reduces the Danish fleet fishing in the Baltic to 8 fleet segments: Netters below 12 m (GKu12m), Dinghies below 12 m (JOLRUSu12m), Polyvalent vessels below 12 m (SGTu12m), Polyvalent vessels 12-18 m (SGT1215m), Polyvalent vessels 15-18 m (SGT1518m), Trawlers below 12m (TRAu12m), Trawlers 12-15 m (TRA1215m) and Trawlers 15-18 m (TRA1518m). The total catch values for these segments, aggregated over the period 2001-2008, and distributed on fishing grounds are shown in table 1.

Table 1: Total catch values (mill EUR) over the period 2001-2008 for Danish fleet segments whose catch value in the Baltic constitute more than 25% of their total catch value

	Baltic	Other Areas	Total	Baltic/Total
GKu12m	74.55	66.88	141.44	0.53
JOLRUSu12m	24.92	13.50	38.42	0.65
SGTu12m	15.79	15.04	30.83	0.51
SGT1215m	13.77	24.62	38.39	0.36
SGT1518m	9.00	13.56	22.56	0.40
TRAu12m	5.67	8.62	14.29	0.40
TRA1215m	61.43	98.24	159.67	0.38
TRA1518m	66.03	126.2	192.23	0.34

Figure 1 shows the development in the number of vessels in each of the eight fleet segments. It is seen that fleet size decreases during the period for Netters below 12 meters, and for the three trawl segments, while the fleet size stays approximately constant over the period for the remaining segments.

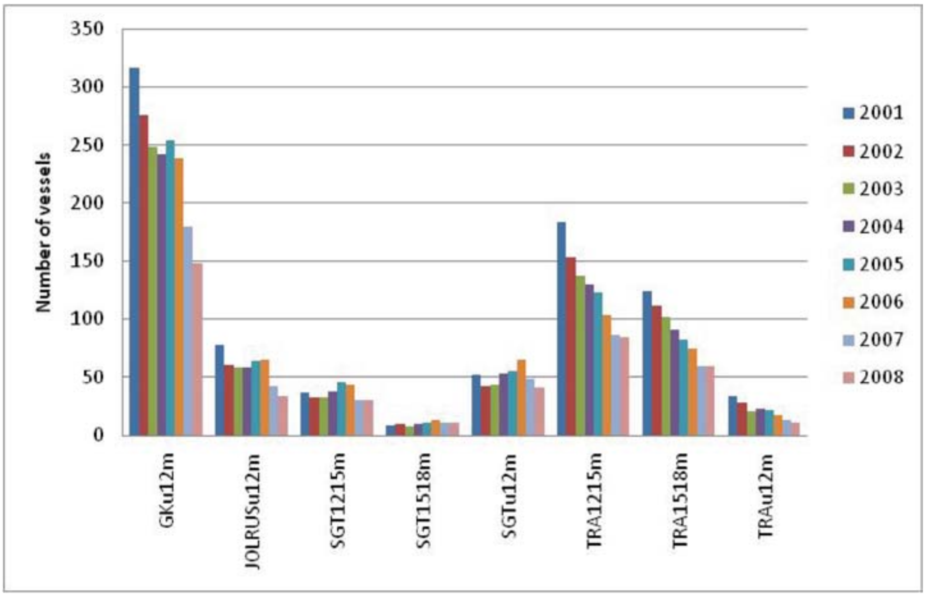

Figure 1: Development in the number of vessels 2001-2008 for the Danish fleet segments fishing in the Baltic Sea.

Figure 2 shows the development in the total catch value per vessel (1000 EUR) over the period in all fishing areas for the eight fleet segments. It is seen that the total catch value per vessel stays approximately constant over the period for vessels less than 12 meters. For vessels 12-15 meters there is a slight increase in catch value per vessel, while a more pronounced increase is observed for vessels 15-18 meters.

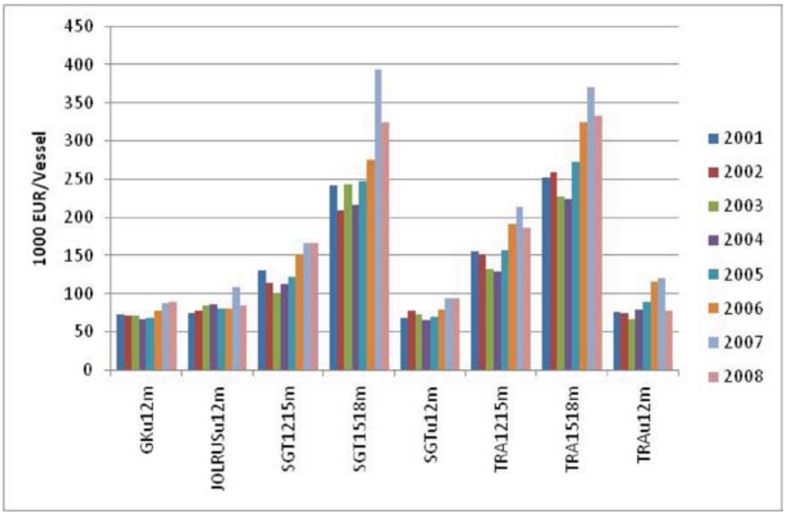

Figure 2: Total catch value (1000 Euro) per vessel aggregated over all fishing areas for each fleet segment taking more than 25% of their catch value in the Baltic Sea.

Figure 3 shows the percentage that the catch values in the sub areas 3B (the Sound), 3C (the Belt Sea and Western Baltic), and 3D (the Eastern Baltic) of the Baltic constitute of the total catch value during the period 2001-2008 for each fleet segment. It shows that especially small vessels below 12 meters fish in the Sound (3B), but that the fraction of the catch value taken here is generally below 15-20% of the total catch value during the period. In 3C (the Belt Sea and Eastern Baltic) the catch value is around 15% of the total catch value for all segments, except Polyvalent and Trawlers below 12 meters, that have higher relative catch values in this area. In 3D (eastern Baltic) especially the dinghies below 12 meters take a high fraction of their catch value, while Polyvalent below 12 meters are least active in this area. The remaining segments take around 20% of their total catch value in this area.

3D (Eastern Baltic) is especially interesting for the present project. In this area the Danish fleet segments have catches in the ICES sub areas 24, 25, 26 and 28, of which 25-28 are included in the Central Baltic which is the subject of the present study. The last part of figure 3 indicates that the catch value of the eight fleet segments in this area constitute between 10 and 30% of the total catch value in all Danish fishing grounds for these fleet segments.

Table 2 shows the distribution of species of catch value in the Baltic (see also Table 1) aggregated over the period 2001-2008 for the 8 fleet segments. It is seen that all segments, except dinghies below 12 meters, target Cod as their main species in the Baltic. Herring is only important for Trawlers 15-18 meters, while sprat is important for Polyvalent 15-18 meters, and trawlers 12-15 meters, and 15-18 meters. The Dinghies below 12 meters are atypical in that sense that 77% of their catch value in the Baltic comprises other species than Cod, Herring and Sprat. For these ~61% of their catch value in the Baltic is composed of European Eel.

Table 2: Total catch value in the Baltic (3B+3C+3D) aggregated over the period 2001-2008 distributed on Cod, Herring, Sprat and other species.

	Cod	Herring	Sprat	Other species
GKu12m	76.11%	0.36%	0.00%	23.53%
JOLRUSu12m	22.18%	0.81%	0.00%	77.01%
SGTu12m	77.63%	0.00%	0.02%	22.35%
SGT1215m	73.55%	1.04%	3.36%	22.05%
SGT1518m	62.69%	1.86%	19.73%	15.72%
TRAu12m	61.44%	0.01%	1.69%	36.86%
TRA1215m	69.25%	2.46%	9.33%	18.96%
TRA1518m	60.05%	12.21%	13.54%	14.20%

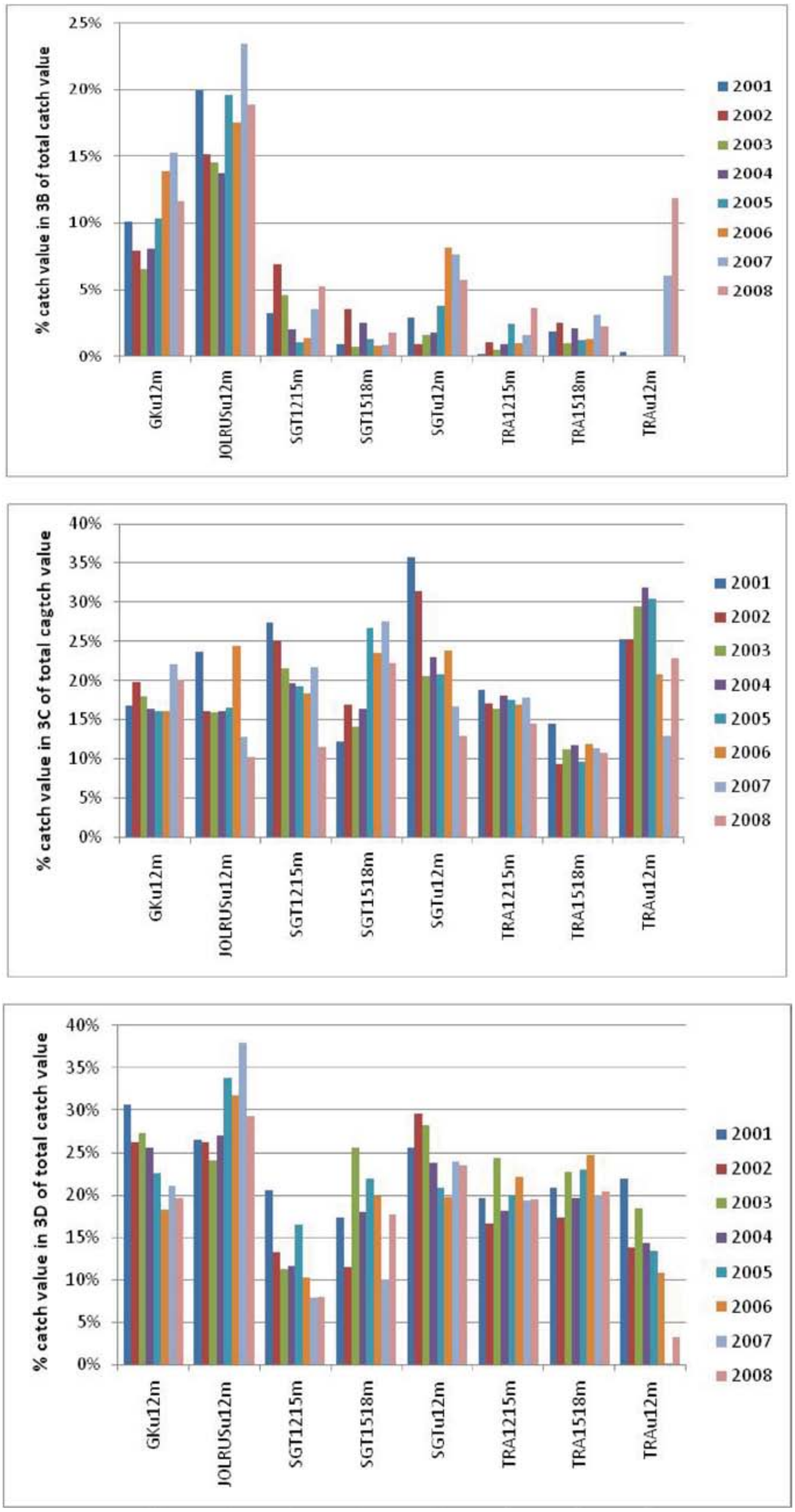

Figure 3: Percentage catch value in 3B, 3C and 3D of total catch value in the period 2001-2008 for the Danish fleet segments operating in the Baltic Sea.

Table 3 shows the total variable cost (1000 EUR) per vessel during the period 2001-2008 for the eight segments operating in the Baltic. The costs are based on vessels operating in all Danish fishing grounds. The variable costs are defined as the sum of fuel costs, running costs (ice, provisions etc.), maintenance costs, sales costs, and various service costs. The table firstly shows that the variable cost per vessel stays approximately constant during the period for the small vessels below 12 meters, while it increases steadily for Trawlers above 12 meters and for Polyvalent 12-15 meters. For the Polyvalent vessels 15-18 meters the variable costs first decreases but then increases again towards the end of the period.

Table 3: Total variable costs (1000 EUR/vessel) less depreciation and payment to capital and wages, for the Danish fleet segments operating in the Baltic Sea.

	2001	2002	2003	2004	2005	2006	2007	2008
GKu12m	28.79	30.75	28.31	30.49	32.52	35.99	36.93	42.60
JOLRUSu12m	21.77	24.96	33.31	25.25	28.39	23.44	38.40	39.96
SGTu12m	28.63	32.47	38.22	32.07	38.05	35.60	51.80	57.12
SGT1215m	47.98	34.42	36.33	46.73	50.44	60.82	84.17	96.65
SGT1518m	131.79	90.60	111.19	112.57	81.18	83.30	102.00	136.91
TRAu12m	50.28	28.82	35.70	28.18	38.56	33.88	46.85	38.74
TRA1215m	72.71	66.69	64.14	66.59	80.36	85.13	95.32	95.77
TRA1518m	104.89	108.53	100.34	109.36	116.03	130.81	153.33	149.27

Table 4 shows the total fuel costs (1000 EUR) per vessel for the eight fleet segments operating in the Baltic Sea during the period 2001-2008. The fuel costs are for operating in all Danish fishing grounds. As expected, the average the fuel costs per vessel increased for all segments during the period, although they decreased somewhat for Polyvalent 15-18 meters before increasing again.

Table 4: Fuel costs (1000 EUR/vessel) for the Danish fleet segments operating in the Baltic Sea.

	2001	2002	2003	2004	2005	2006	2007	2008
GKu12m	3.39	3.79	3.90	4.21	4.72	5.14	4.34	6.00
JOLRUSu12m	2.17	2.36	2.03	1.80	3.00	2.11	3.62	4.32
SGTu12m	5.98	5.52	6.37	7.24	7.54	9.34	9.60	13.85
SGT1215m	14.44	7.53	6.99	9.31	8.35	11.45	13.05	28.53
SGT1518m	37.91	24.58	35.09	40.22	29.01	14.62	12.27	46.94
TRAu12m	11.29	6.54	9.91	7.75	10.11	11.00	14.32	11.47
TRA1215m	19.65	16.65	19.50	20.39	25.83	27.46	25.74	30.50
TRA1518m	28.63	26.62	26.66	31.96	41.16	40.82	38.19	50.07

Table 5 shows the total wages (1000 EUR) per vessel for the eight Danish fleet segments operating in the Baltic Sea during the period 2001-2008. The wages are based on vessels operating in all Danish fishing grounds. Wages stay approximately constant during the period for all fleet segments, the only exception being the Polyvalent vessels 15-18 meters that have quite high wage costs in 2001 compared with the rest of the period.

Table 5: Wages (1000 EUR/vessel) for the Danish fleet segments operating in the Baltic Sea.

	2001	2002	2003	2004	2005	2006	2007	2008
GKu12m	54.73	53.68	55.23	48.19	46.49	53.46	48.69	54.22
JOLRUSu12m	57.16	50.36	54.11	54.22	54.55	51.25	59.48	65.01
SGTu12m	49.86	47.14	51.03	38.43	34.05	44.10	57.96	53.95
SGT1215m	77.25	60.09	49.58	48.66	64.88	59.69	56.32	98.77
SGT1518m	172.62	107.05	122.38	117.53	81.19	112.63	121.61	117.63
TRAu12m	57.43	41.56	71.36	62.44	54.92	48.58	82.12	50.34
TRA1215m	85.34	80.14	88.82	81.72	89.07	91.90	88.21	80.52
TRA1518m	124.99	126.96	111.03	121.18	130.86	148.76	151.30	136.74

Table 6 shows the net earnings (1000 EUR) per vessel for the eight Danish segments operating in the Baltic Sea during the period 2001-2008. The net earnings are based on vessels operating in all Danish fishing grounds. The net earnings are defined as total catch value (see figure 1) minus variable costs (table 3) and wages (table 5) and thus represents what is left for remuneration of capital in terms of interest payments and depreciation. It is firstly seen that especially the small vessels operate at negative net earnings or net earnings close to zero. However, the small vessels are often operated only by the owner, maybe with one hired help in short periods of the year. As such the net earnings less wages (see table 7) is a better indicator of the actual economic situation for these vessels. Table 7 shows that all the small vessels (less than 12 meters) operate at positive net earnings less wages.

Table 6 furthermore shows that some of the larger fleet segments (greater than 12 meters) also operated at negative net earnings for some of the years during the period. The segments with the best overall economy during the period are the Polyvalent vessels 12-15 meters (although they end with negative net earnings in 2008), the Polyvalent vessels 15-18 meters and the trawlers 15-18 meters.

Table 6: Net earnings (1000 EUR/vessel) for the Danish fleet segments operating in the Baltic Sea.

	2001	2002	2003	2004	2005	2006	2007	2008
GKu12m	-10.21	-13.24	-12.83	-11.75	-10.14	-11.86	1.30	-7.38
JOLRUSu12m	-4.60	2.55	-3.02	6.97	-2.05	6.00	10.85	-18.43
SGTu12m	-11.93	-5.57	-19.60	-6.78	-1.67	-0.31	-16.66	-19.02
SGT1215m	6.56	21.66	16.91	17.97	5.20	30.84	25.78	-30.13
SGT1518m	-62.35	10.68	8.99	-13.76	84.51	79.54	170.00	69.98
TRAu12m	-33.89	0.26	-44.19	-13.26	-6.22	32.55	-9.39	-12.11
TRA1215m	-3.11	4.19	-21.45	-19.45	-13.25	14.30	29.20	9.73
TRA1518m	20.61	22.74	14.52	-7.62	25.74	44.36	65.10	47.00

Table 7: Net earnings less wages (1000 EUR/vessel) for the Danish fleet segments operating in the Baltic Sea.

	2001	2002	2003	2004	2005	2006	2007	2008
GKu12m	44.52	40.44	42.40	36.45	36.36	41.61	49.99	46.84
JOLRUSu12m	52.56	52.91	51.09	61.19	52.51	57.25	70.33	46.57
SGTu12m	37.92	41.58	31.42	31.64	32.37	43.80	41.30	34.92
SGT1215m	83.81	81.75	66.48	66.64	70.09	90.53	82.10	68.64
SGT1518m	110.27	117.73	131.37	103.77	165.70	192.17	291.61	187.62
TRAu12m	23.54	41.82	27.17	49.19	48.70	81.13	72.73	38.23
TRA1215m	82.23	84.33	67.37	62.27	75.82	106.20	117.41	90.24
TRA1518m	145.60	149.70	125.55	113.56	156.60	193.12	216.40	183.74

Figure 4 and 5 show graphical representations of the numbers presented in table 6 and 7, in order to give an overview of the economic situation for the Danish fleet segments operating in the Baltic sea during the period 2001-2008. The figures firstly show that the economic situation for the large vessels (15-18 meters) generally improve over the period. Trawlers 12-15 meters are also seen to have increasing earnings during the period, while Polyvalent 12-15 meters seem to have improving economics during 2001-2006, but then increasing net earnings. The economic situation for the small vessels (less than 12 meters) stays more or less constant during the period.

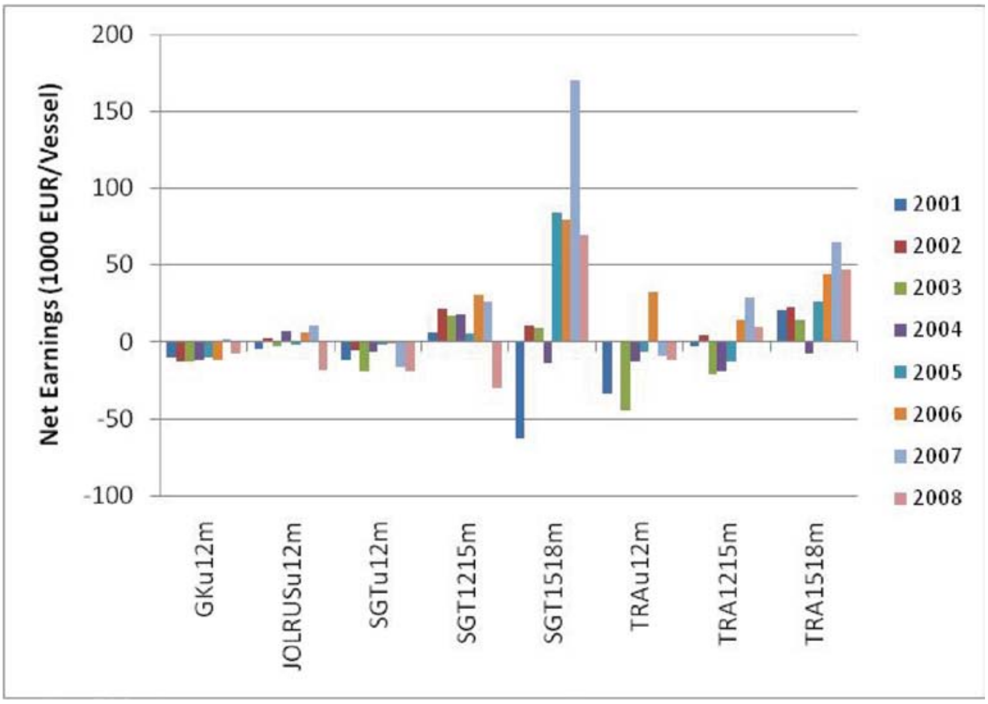

Figure 4: Graphical representation of net earnings (1000 EUR per vessel) for the Danish fleet segments operating in the Baltic Sea during the period 2001-2008.

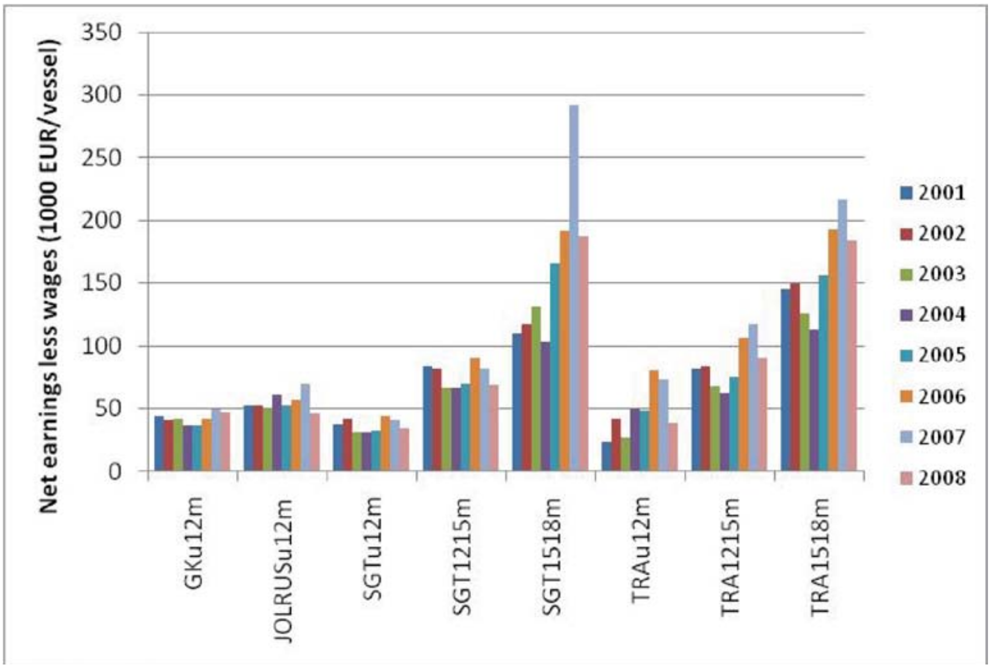

Figure 5: Graphical representation of net earnings less wages (1000 EUR per vessel) for the Danish fleet segments operating in the Baltic Sea during the period 2001-2008.

1.2 Estonia

1.2.1 Historical and actual fleet structure

The Estonian fishing sector in the Baltic could be divided into the two main segments: Baltic open-sea fishery (trawling) and Baltic coastal small-scale fishery (employing passive gears).

Baltic trawlers, targeting mainly herring and sprat, are the most important segment in the Estonian fishing fleet by the total revenue generated. Trawling in the Baltic Sea was started already in the early decades of the Soviet period (1950s-1960s). While the first trawlers were wooden and engines small, at the end of the Soviet period (1980s) Estonia had also a large and powerful steel trawler fleet. During the Soviet period two main types of vessels prevailed: steel trawlers type of "MRTK" (around 25 m, 220 kW, 120 BRT) and wooden vessels (around 13 m, 55 kW, 12 BRT). These vessels have been in use until today. However, some of them have been replaced by big and powerful vessels of western origin, typically bought as second-hand vessels with years of service. Since the 1990s, the number of open-sea vessels has decreased continuously. In 1998 the number of vessels was 216, but 10 years later it was only 64. There are two main reasons for changes in the structure of this fleet segment. Initially, after restoration of independence in Estonia the products of the trawling sector (canned herring and sprat) were still competitive only in the eastern market (mainly Russia and Ukraine). As the price level on these markets was low this activity did not produce enough profitability for enterprises and the number of vessels decreased year by year. Today the reason for decrease in the number of vessels is due to a decommissioning program aimed at achieving balance between the fishing fleet and fishing opportunities.

By the total number of vessels and fishermen, the largest segment of Estonian fleet is the coastal fishery employing mainly passive gears like gill nets and trap nets. The fleet is huge (around 900 boats), but consists mainly of very small boats (typical is 5-6 m long boat with outboard engine). The development of this fishery has been different from the trawlers segment. At the beginning of the 1990s, the opportunity to export fish to the European market emerged. The opening of this new market resulted in rapidly increasing pressure on fish stocks. While during the Soviet period this segment was moderate in size, partly due to the strict border regime enforced at sea, in beginning of the 1990s this fleet grew rapidly. After the increase in fleet and fishing effort, stocks started to decline. Also, fishing costs grew. These developments resulted in a decline in the importance of the coastal fishery during recent years. Even if the size of the fleet and the number of fishermen in this segment stays continuously high, the bulk of fishermen are today employed only part-time and receive most of their income from other sources.

1.2.2 Fishing grounds in the Baltic

The European Commission is taking into account the historic fishing opportunities and is setting the national shares of TACs for EU member countries.

Estonia has a national share of TACs (quotas) for following sea fish stocks in the Baltic:

1) Salmon in the Sub-divisions 22-31
2) Salmon in the Sub-division 32
3) Cod in Sub-divisions 22-24
4) Cod in Sub-divisions 25-32
5) Herring in the Subdivisions 25-27, 28.2, 29 and 32
6) Herring in the Sub-division 28.1 (Gulf of Riga)
7) Sprat in the Sub-divisions 22-32

1.2.3 Main species [coastal vs. open Baltic Sea]

Baltic open-sea fishery (trawling) targets mainly herring and sprat. Few vessels target also cod in the southern Baltic, employing both trawls and gill nets.

Baltic coastal small-scale fishery targets mostly freshwater species such as perch, pikeperch and pike, but also marine species such as flounder and spawning stocks of herring and garfish, as well as migratory species such as sea trout, salmon and whitefish.

1.2.4 Description of the economic situation from the data

The economic situation has been rather good for all fleet segments in recent years. Profit from fishing activity has increased. Also wages for crew members have followed a similar trend.

There are two main reasons for improvement of economic situation in fisheries:

1) The achievement of better balance between the size of the fleet and the available fishing opportunities;
2) The rise of the average price for key species like sprat and herring.

1.2.5 Changes from 2005-2007 until now

The total amount of income generated by the Estonian Baltic Sea fisheries in 2008 was 15.6 million euros, which is 36% higher than in 2005. The increase of income was not continuous during 2005-2008, but depended on the amount of subsidies. However, the total value of landings increased continuously. The increase was around 40% between 2005 and 2008. The total volume of landings increased only 2% at the same time. Changes in the value of landings foremost were caused by rise of the average price for key species like sprat and herring. Compared to 2005 in 2008 the average price of sprat and herring increased 68% and 44%, respectively.

The total amount of expenditure in 2008 was 11.3 million euros. In 2005 this number was 9.7 million euros. An increase in the amount of expenditure almost took place in each cost article, although the number of vessels and crew members decreased. All this is explained by continuous increasing of prices for goods and services in Estonia which in turn has caused pressure for rise of wages.

1.3 Germany

1.3.1. Introduction

Since a lot of German vessels operate in the North Sea and the Baltic Sea as well, it is a complicated task to separate the fleet. For this interim report the description of the fleet structure is covering the whole German fishing fleet when appropriate.

1.3.2. Fleet structure

On 1 January 2008 the German fishing fleet consisted of 1870 registered vessels with a total gross tonnage of 69.000 t and total power of 166.000 kW, see Figure 1. The overall average age of vessels was 27 years in 2008, see Figure 2. The graph shows a trend of an increasing average age, which has been as such for several years. Most newly-built vessels are smaller than 10m. The high uncertainty concerning expected future revenues is the key issue why only a small part of the German fleet is being renewed. Moreover, any subsidies for reconstruction, which have been granted several years ago, are no longer available.

The number of vessels has been decreasing constantly over the years, while the total kW and GT figures remained quite stable, which is basically due to constraints as provided by the Commission Regulation (EC) No 1438/2003. The trend has gone towards larger vessels. The increase in GT and kW is due to one single large pelagic trawler which had entered the German fleet during 2007 and is thus reflected only in 2008 capacity data.

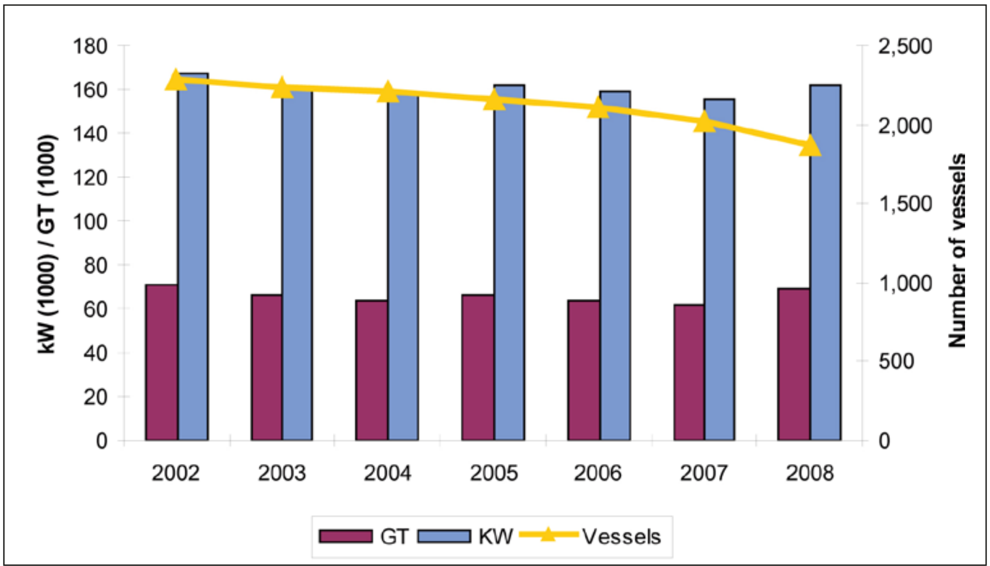

Figure 1: German national fleet capacity trends 2002-2008.

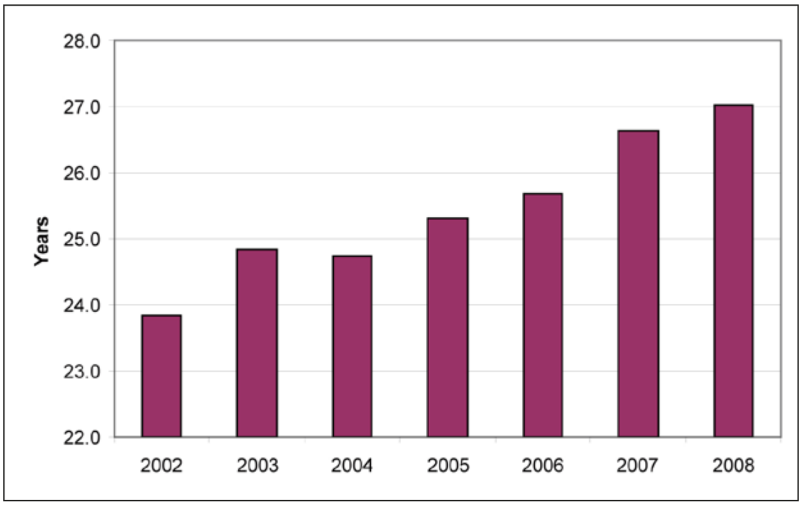

Figure 2: German national fleet age trend of 2002-2008

The structure of the fleet in the Baltic Sea is still a consequence of the division of Germany before 1990. In the GDR the government supported the fishing sector very heavily by a price guarantee. Therefore, looking at the structure of the fleet in the western part of Germany, smaller vessels stayed in business. As a consequence while in the western part the fleet consisted of larger vessels above 24 meters, in the eastern part vessels below 12 meters dominated the fleet. This structure is still more or less intact but a trend to larger vessels and decrease of the number of enterprises is now visible everywhere.

The total number of fishing enterprises in Germany was 1567 in 2008. The vast majority of fishing enterprises owned a single vessel, see Figure 3.

Enterprises with more than one vessel in most cases operate with passive gear, and usually only one if any of these multiple vessels is larger than 10 meters. These numbers illustrate that the vast majority of the vessels are still operated by the owner. The segment of large pelagic trawlers is owned by one company (based partly in the Baltic Sea (Rostock) but fishing in the Atlantic and Pacific). Here a concentration has taken place over the years, as this company has also entered the demersal segment.

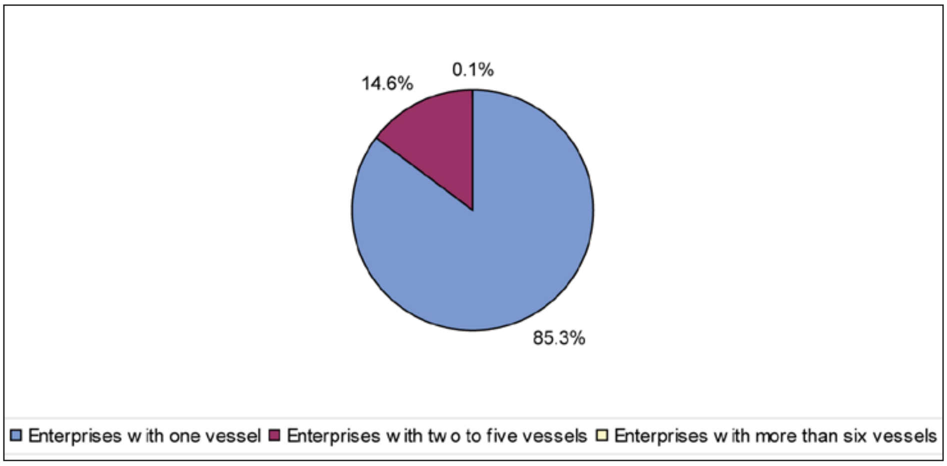

Figure 3: German fishing enterprise categories in 2008.

The total number of persons employed on vessels was 1,665 in 2008, which translates to 1,537 FTEs, see Figure 4. The big drop in the total number of employees results from a change in the determination procedure. Up to 2007, the total number was available from a social security system, which was mandatory for fishermen. This obligation is no longer in place, so the total number has to be estimated from crew size and effort data per vessel. Crew members of vessels with less than 50 days at sea have not been counted as this activity is not regarded as professional activity. This approach proves to be justifiable, as it has almost no effect on FTE numbers.

Even though the numbers from the time series are not directly comparable, a general trend can be seen towards a decreasing number of employed persons, which is in line with the decrease in vessel numbers.

Altogether, the German fishing sector is not an important sector regarding overall employment, even though these jobs are located in economically less-favoured areas. However, fishing activities have a beneficial effect on tourism and the related businesses, and it has some importance for fish processing. It has to be pointed out that the employment numbers do not include the items of the pelagic fleet, which are not published for confidentiality reasons.

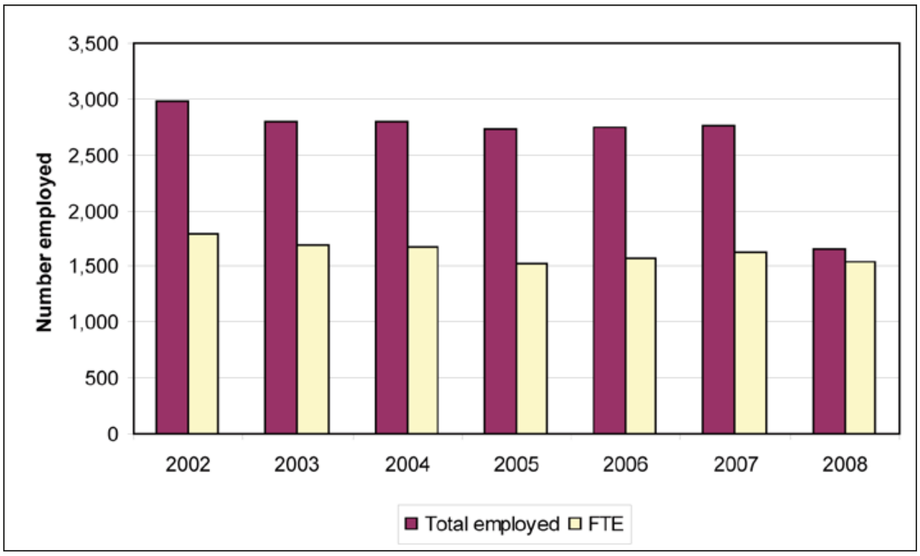

Figure 4: German national fleet employment trends 2002-2008.

1.3.3 Fishing activity

This section provides an overview of the fishing activity carried out by the German fishing fleet and describes some key trends in recent years.
In 2008 the German fishing fleet (excl. pelagic fleet) spent a total of 135 thousand days at sea. The number of fishing days is actually slightly higher, which is an artefact from the calculation following the official definition. The total volume of landings achieved during those fishing days was 117 thousand tons of seafood. The total amount of fuel consumed while catching this seafood amounted to a total of 54 million litres, see Figure 5.

Both the increase in the numbers of days at sea and fuel consumption are due to changes in the survey procedures. The number of days at sea is for the first time based upon an additional survey covering the vessels under 8m, which have no logbook obligation. This change accounts for about 48,000 additional days at sea especially in the Baltic Sea were most of these vessels are based. For vessels over 8m the number of days at sea has actually decreased by about 8% from 2007 to 2008.

Fuel consumption data for 2008 are based upon a considerably broadened set of survey data, resulting in much higher and more realistic data. By far the largest part (17 million litres) of the increase relates to the segment of demersal trawlers > 24m (having for the first time achieved a 100% coverage for over 40m). Moreover, data have become available for the segment of beam trawlers over 24m, which had not been estimated before.

A comparison between 2007 and 2008 within segments for which the sampling had not changed (not displayed) indicates no clear trend. A potential decrease in fuel consumption due to an increase in fuel prices, as expected, is not reflected in the data.

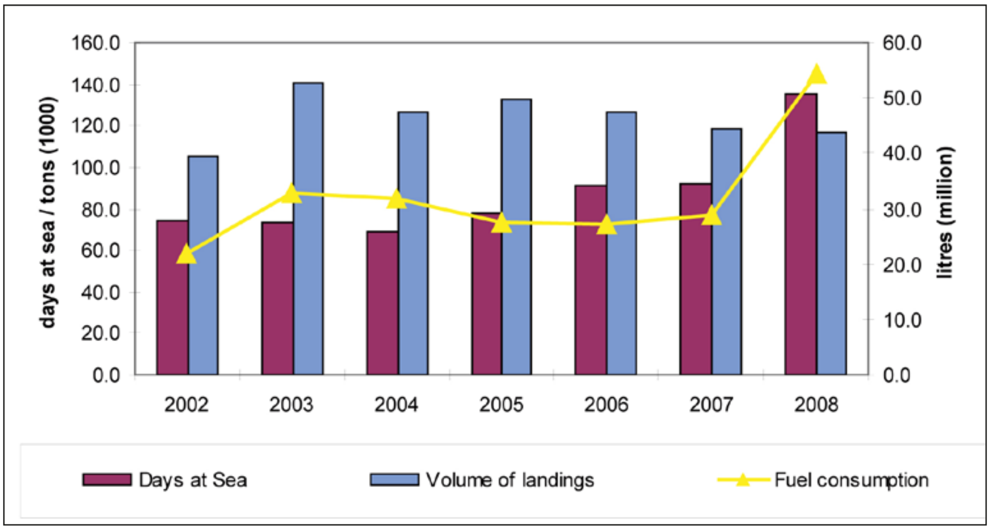

Figure 5: German national fleet days at sea, fuel use volume landed 2002-2008.

In terms of landings composition, in 2008 herring was the most common species landed in terms of tonnage (19.9 thousand tons), followed by sprat (19.3 thousand tons) and brown shrimp (17.9 thousand tons), see Figure 6.

Brown shrimp is the only species amongst these top 5 which is not regulated by quota or effort limitations. The increase in total catches in 2008 is therefore most likely due to a higher abundance of this species. In all other cases the landings quite closely reflect the German quota share, as the quota is in most cases fully exploited (quota exchange with other countries usually does not refer to the top landing species).

Overall, the volume of landings of the top species has remained surprisingly similar over the last years. Herring catches have dropped since 2006 due to low recruitment and subsequent cuts in quota (North Sea and Western Baltic Sea).

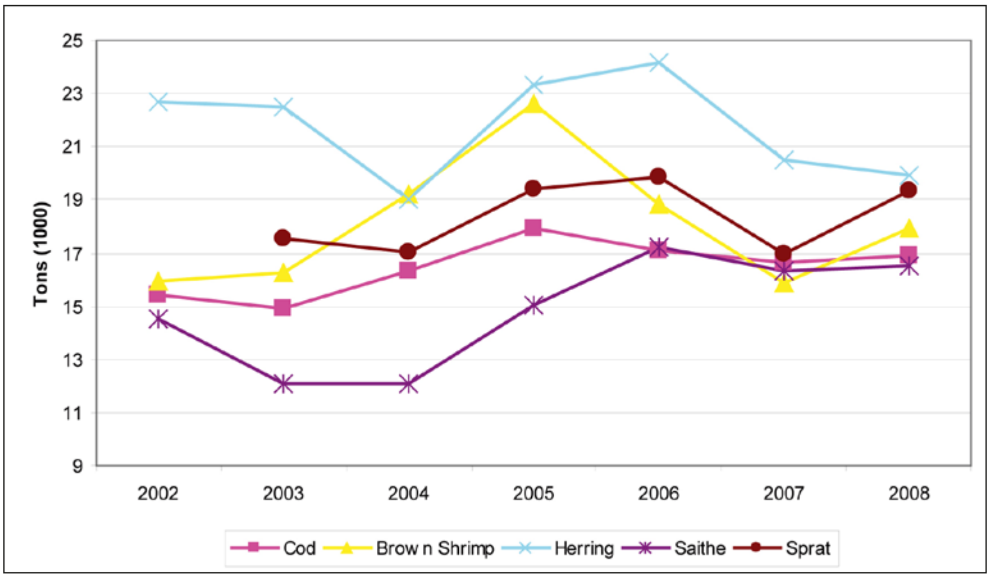

Figure 6: German national fleet top 5 species landed by volume 2002-2008.

1.3.4 Fishing grounds in the Baltic

The main German fishing grounds in the Baltic Sea are in German territorial waters or not far away from them. This is due to the high number of small vessels in the eastern part. Their main target species is Western Baltic Sea herring during the spawning season in the spring. For the fishermen being able to fish the herring when the stock concentrates in shallow waters this results in a comparably efficient static gear fishery in coastal areas. The larger vessels fish basically cod in deeper parts of the Western Baltic Sea and there is also a quite substantial gillnet fishery on cod in the Belt Sea. Only a few vessels fishing in the eastern Baltic Sea and Germany exchange eastern cod quotas for western ones to avoid longer trips for the German fishermen.

1.3.5 Main species (coastal vs open Baltic Sea)

In addition to the three main species in the Baltic Sea (cod, herring and sprat) German fishermen also targeting flatfish (especially flounder and plaice) and freshwater species in coastal areas (see also activity section above).[1]

1.3.6 Economic performance

This section provides an overview of the economic performance of the German fishing fleet (excluding the pelagic segments) and describes some key trends in recent years.

1.3.6.1 LANDING VALUES AND PRICES

In terms of landings composition, in 2008 brown shrimp achieved the highest value of landings (54.4 million euros), followed by cod (31.9 million euros) and Greenland halibut (16.3 million euros), see figure 7.

The figure for values of landings differs considerably from the figure for volumes of landings. Therefore sprat and herring, though important in terms of volume, are overall less important for the value of landings, as the price per kg is very low compared with most other species. Brown shrimp has remained the most valuable product for several years, and the advantage over cod, which had remained rather stable in terms of both catch and price, has increased also due to increased prices.

All prices per kg amongst the top 5 species have tended to increase during recent years. Though the total landings of the most important species remained stable, it has been stated by fishing businesses that effort limitations from management plans are getting to overrule limitations provided by quota.[2] In other words, it becomes more and more difficult to fish the assigned quota within the days at sea limitation. This applies in particular to cod and saithe.

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[1] A more comprehensive analysis will follow in the final report.

[2] The management plans include effort and catch limitations. In the past the catch limitations (TACs) were the limiting factor, now more and more the effort limitation is binding. Effort here means the days at sea which have been allocated to the individual fishermen.

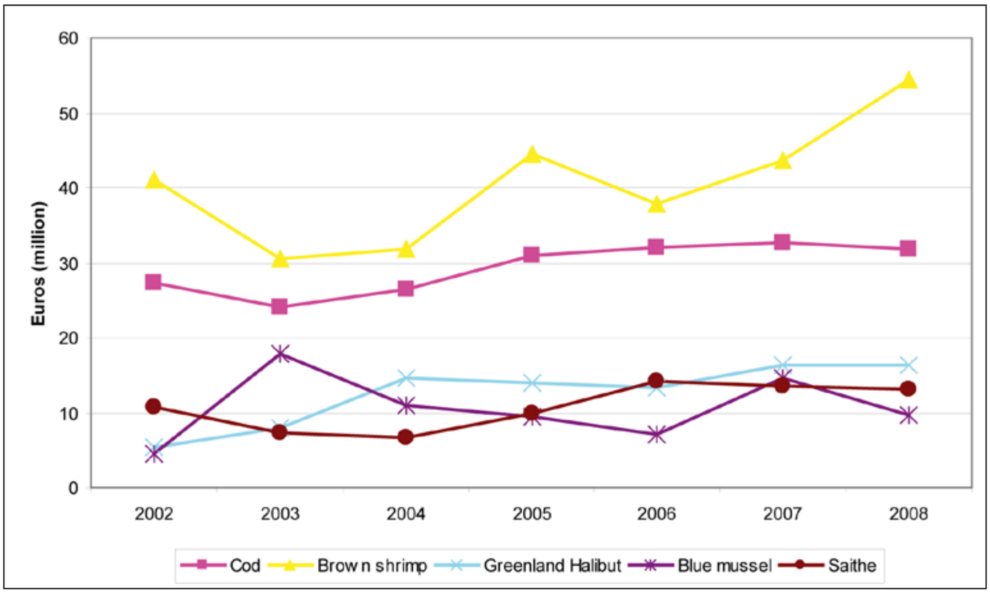


Figure 7: German national fleet top 5 species landed by value 2002-2008.

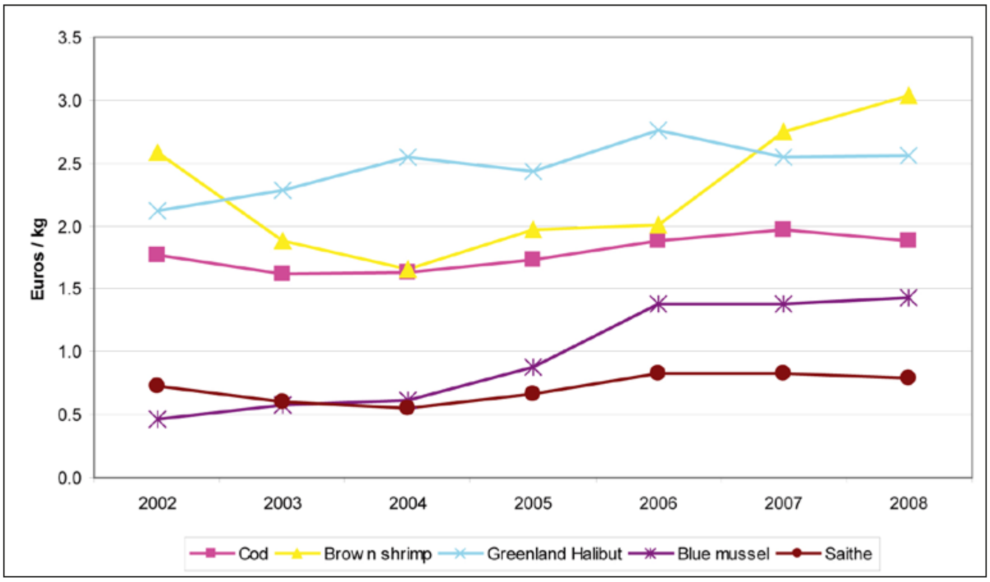


Figure 8: German national fleet price trends of top 5 species landed by value 2002-2008.

1.3.6.2 INCOME

The total amount of income generated by the German fishing fleet in 2008 was 167 million euros (excl. pelagic fleet). This consists of 163 million euros in landings values, 3 million euros in non fishing income, and approximately 1 million euros in direct subsidies. See table 1 and figure 9. German fishing rights are not tradable and therefore generate no income from trading. Sources of income other than landings are overall negligible.

As a general trend, the total income of the German fleet has increased between 2002 and 2008. Any sources of income other than landings are negligible for the German fleet.

Table 1: German national fleet costs and earnings statement 2006-2008.

	2006		2007		2008	
	Total (million euros)	% of total income	Total (million euros)	% of total income	Total (million euros)	% of total income
Income						
Value of Landings	151,291,880	100.0%	163,013,108	100.0%	162,950,135	97.6%
Income from fishing rights						0.0%
Direct Subsidies					861,334	0.5%
Other Income					3,162,867	1.9%
Total Income	151,291,880	100.0%	163,013,108	100.0%	166,974,336	100.0%
Expenditure						
Energy (fuel) cost	14,238,682	9.4%	16,825,749	10.3%	29,417,592	17.6%
Repair cost	9,493,650	6.3%	12,377,090	7.6%	21,789,566	13.0%
Variable cost	6,764,274	4.5%	7,521,714	4.6%	25,806,566	15.5%
Non variable cost	17,322,760	11.4%	20,906,674	12.8%	20,193,761	12.1%
Fishing rights	0	0.0%	0	0.0%	0	0.0%
Crew wages	52,621,907	34.8%	55,742,507	34.2%	31,824,794	19.1%
Unpaid value of labour					11,284,770	6.8%
Operating cash flow (OCF)	50,850,607	34%	49,639,374	30.5%	27,932,820	16.0%
Capital Cost	7,379,646	4.9%	8,420,879	5.2%		
Depreciation					25,129,514	15.1%
Interest					1,908,844	1.1%
Profit / Loss	43,470,961	28.7%	41,218,495	25.3%	-381,071	-0.2%
Gross Value Added (GVA)	103,472,514	68.4%	105,381,881	64.6%	68,905,517	41.3%
Total Capital Value	35,458,713		37,307,916		161,766,443	96.9%
Return on Investment (ROI)	143%		133%		1%	0

1.3.6.3 EXPENDITURE

In 2008, several changes have been applied to the collection and processing of economic data for the German fleet. Overall, the database has been broadened considerably, resulting in more precise data in many cases as compared to previous years. Moreover, estimation procedures have been adjusted to amended regulations and to additional experience gained. Therefore, most data are comparable for trends only between 2002 and 2007, while the leaps in data between 2008 and previous years do not reflect changes in real quantities. Nonetheless, 2008 data are to be regarded as the more precise ones.

As reflected in table 1, considerably higher values have been determined for the 2008 energy cost, repair cost and variable cost, while the determined crew cost were lower. The substantial increase in capital cost (depreciation, interest) is due to the replacement values of the vessels which have been estimated using a different approach, following the amended legal provisions (see table1 for changes in total capital value). Capital cost (depreciation, interest) are imputed, that means, in most cases the figures do not reflect actual monetary flows.

The total amount of expenditure by the German fishing fleet (excl. pelagic) in 2008 added up to 129 million euros. Due to the reasons mentioned, no meaningful trend analysis can be performed.

Leaving aside concrete numbers, according to independent statements from the fisheries business, expenditures increased especially due to increased raw material prices (oil and steel), while other costs could be kept more or less constant.

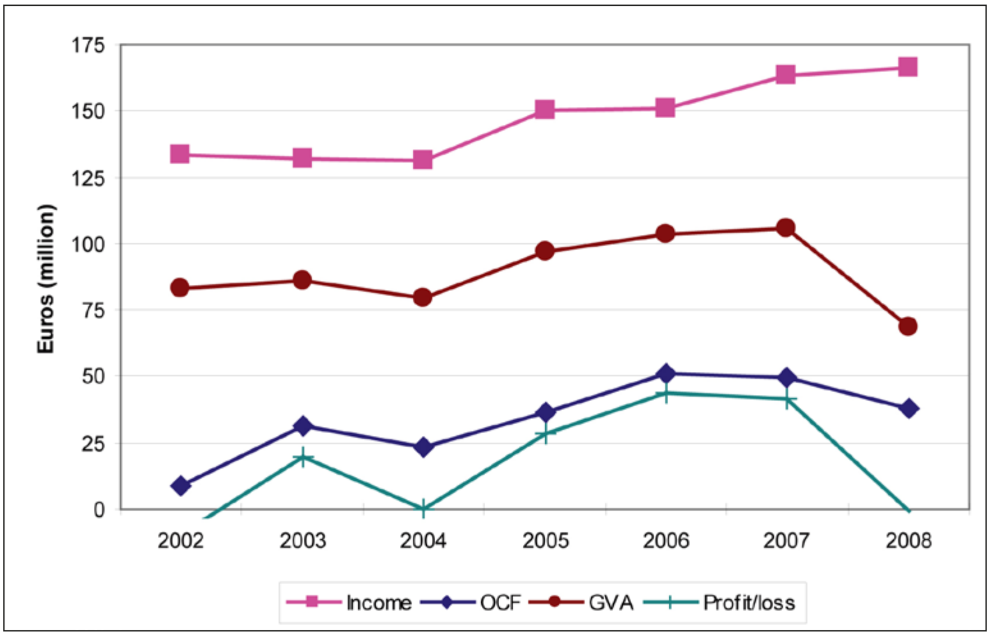


Figure 9: German national fleet economic performance indicators 2002-2008.

1.3.6.4 PROFITABILITY

The total amount of operating cash flow, gross value added and profit/loss generated by the German fishing fleet (excluding the pelagic fleet) in 2008 was 28 million euros, 69 million euros and -0.4 million euros respectively, see figure 9.

Income has increased constantly over the years, as well as OCF, GVA and profit. As outlined in the previous chapter, the determination of costs has changed for 2008 data, and so have the figures. Due to this change almost all cost items have been significantly higher than in previous years, meaning a trend analysis would not provide realistic results.

Taking into account imputed values for interest and depreciation, the overall profit became about zero in 2008. The capital value has a strong leverage effect on the ROI. As the capital value increased significantly with the amended calculation approach, the ROI decreased to about zero.

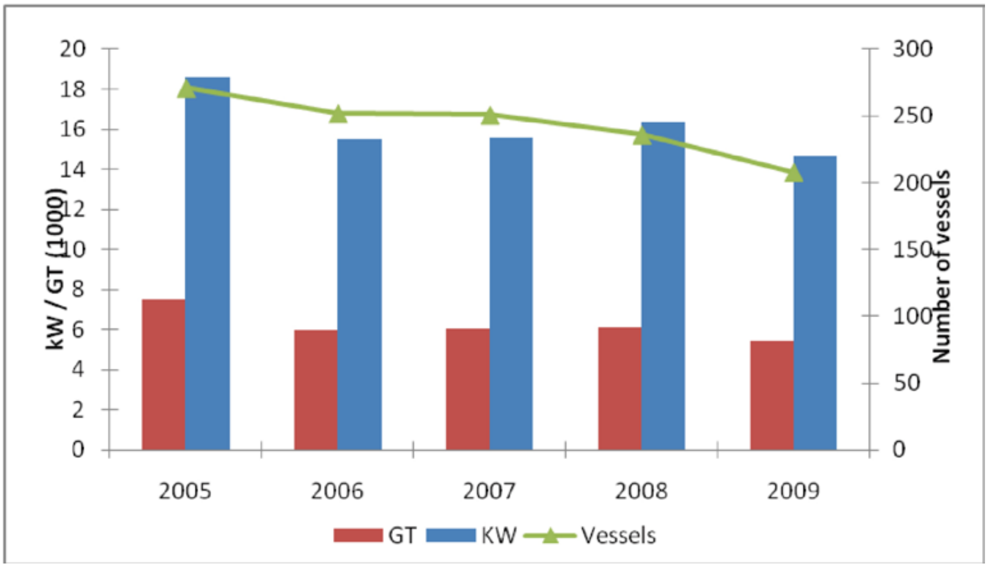
According to publications from the fishing business, most fisheries could perform in a profitable manner also in 2008. Any change for the worse in 2008 had been related to constraints due to quota and effort days.

1.4 Lithuania

1.4.1 Fleet structure (Vessels, Fishing Enterprises, Employment)

The Lithuanian fishing fleet consisted of 251 registered vessels in 2008 combined with registered tonnage of 60 965 GT and a total power of 68 953 kW. The Baltic Sea fleet of Lithuania consisted of 236 vessels with a total capacity of 6122 GT (see Figure 1) and 16345 kW, accounting for 11% and 24% of the total fleet respectively. The average age of vessels was 24 years in 2008,

In Lithuania the total registered tonnage of the Baltic Sea vessels decreased by 28% in 2005-2009, with a reduction of engine power by 21%. The capacity of the Lithuanian Baltic fishing fleet is decreasing due to fleet reduction schemes, implemented since 2004. Considerable decreases in the number of vessels in 2008-2009 can partly be explained by scrapping schemes, introduced in 2007 for the coastal fleet.



Data source: European fleet register.

Figure 1: Lithuanian Baltic fleet capacity trends 2005-2009.

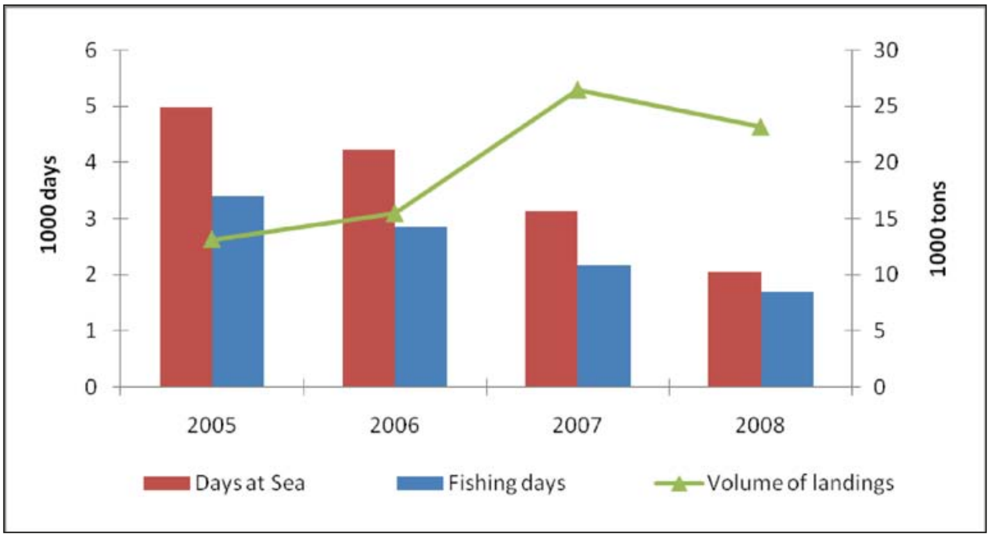
The total number of people working in the Baltic Sea fishery was about 500 in 2008, of which 294 were FTEs. However, a decrease in the total number of employed people was observed in 2004-2008 due to the implementation of capacity reduction schemes in Baltic.

1.4.2 Fishing activity

In 2008, the Lithuanian open Baltic Sea fishing fleet spent a total of 2055 days at sea, including 1704 fishing days. The total volume of landings achieved during those fishing days was almost 23 thousand tons. The fishing fleet mostly target sprat and cod, with by-catches of herring and plaice. Coastal fisheries are more diverse, but mostly targeted on cod and smelt fishery.

The volume of Lithuanian landings in the Baltic Sea increased by 71% in 2007 (see figure 2), due to the increase of sprat landings and quota usage. The effort in the open Baltic Sea has decreased gradually since 2005 (16-24% per year) mostly due to capacity reduction and decrease of cod fishing days in Baltic Sea.

Productivity of Baltic fleet increased from 3.9 tonnes per fishing day in 2005, to 13.6 tones in 2008 due to increase of small pelagic fishery.

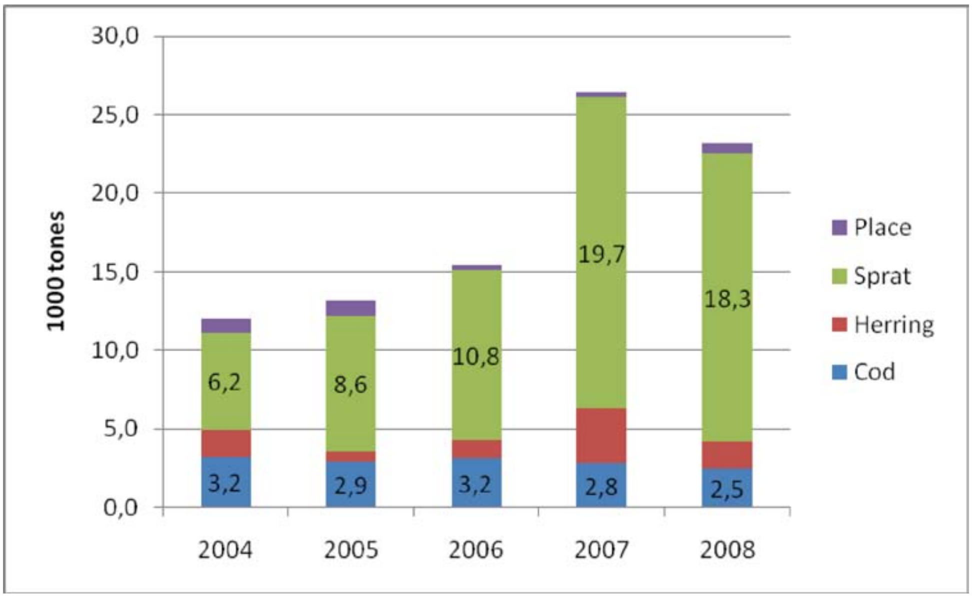


** total Baltic fleet, excluding coastal fishery*

Data source: Fishery Department under the Ministry of Agriculture.

Figure 2: Lithuanian effort and catches in the Baltic Sea 2005-2008.*

In terms of landings composition, in 2008 sprat was the most common species in volume (18.3 thousand tons, or 79%), followed by cod (2.5 thousand tons, 11%) and herring (1.7 thousand tons), see figure 3.



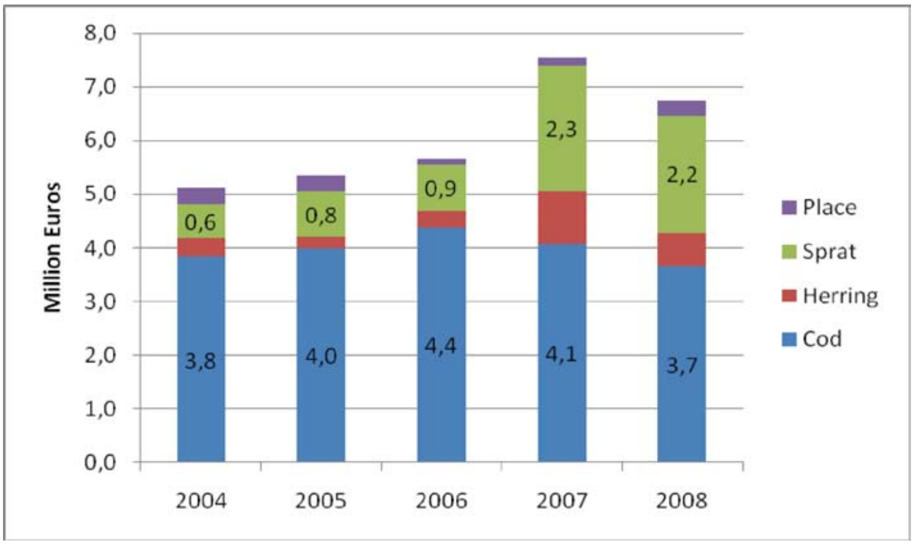
Source: Statistics Lithuania, Fishery Department under the Ministry of Agriculture.

Figure 3: Composition of Lithuanian Baltic fleet landings 2004-2008.

1.4.3 Economic Performance

1.4.3.1 LANDING VALUES AND PRICES

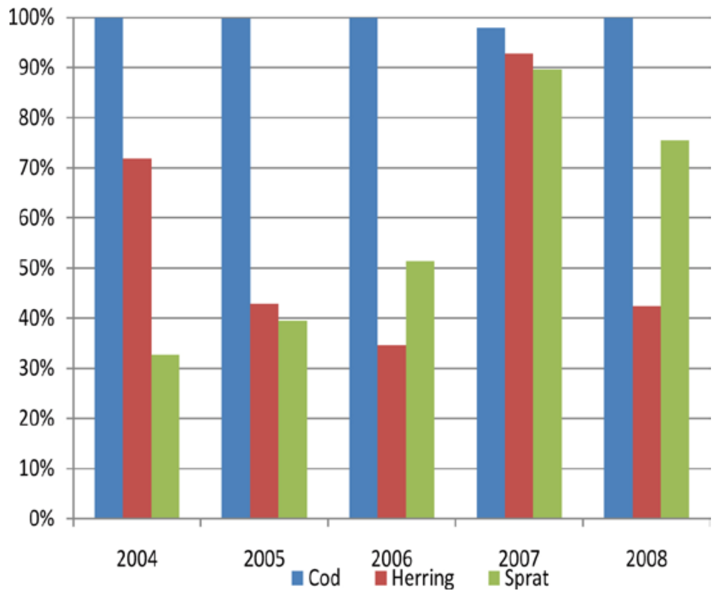
Cod is the most important fish species for the Lithuanian Baltic Sea fleet, as the value of cod landings compose more than 50% of total value of caught fish in the Baltic Sea. The value of cod landings in 2008 was 3.7 million Euros. The second very important fish species was sprat, with a landings value of 2.2 million Euros (33% of total value of landings).



Source: Statistics Lithuania, Fishery Department under the Ministry of Agriculture.

Figure 4: Total value of landings of species caught in the Baltic Sea by Lithuanian fleet.

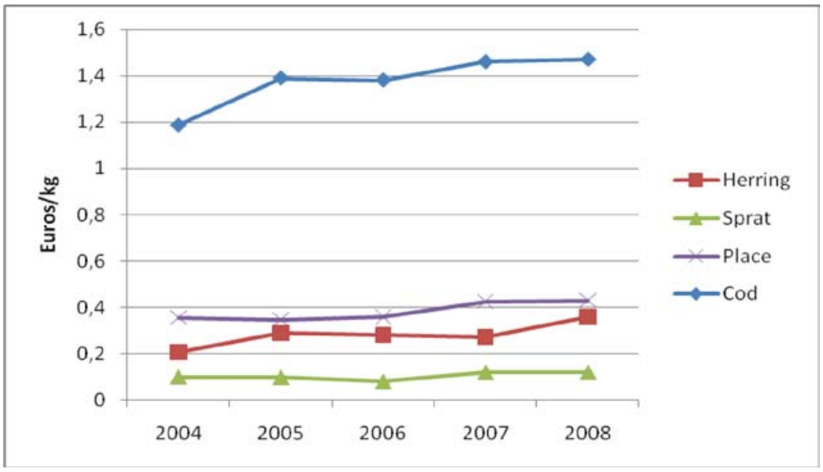
The total value of landings of Baltic Sea species – cod and sprat decreased by 10% and 7% respectively due to decrease of catches by 11% and 7%. The TAC of cod also decreased in 2008 by 5%. However the sprat quota was not utilized fully in 2008 (See Figure 5).



Source: Statistics Lithuania, calculated by author.

Figure 5: Lithuanian quotas utilization in the Baltic Sea, 2004-2008.

The average price of cod and herring increased rapidly in 2005 due to Lithuanian accession to the EU, expectations and increased possibilities to sell fish in other Baltic countries. Minor decrease of cod and sprat prices were observed in 2006, however prices continuously increased in 2007-2008.



Source: Lithuanian data collection program.

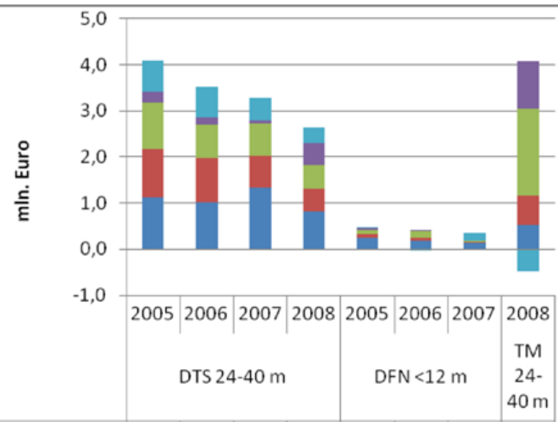
Figure 6: Average price species landed in Baltic Sea, 2004-2008.

1.4.3.2 INCOME

The Lithuanian Baltic Sea fleet in 2008 produced about 8% of the total Lithuanian income, while 11 vessels fishing in the Atlantic and Pacific Oceans produced the rest.

There were 3 main segments fishing in the Baltic Sea in 2008:

1. Demersal trawls and seiners 24-40 m, targeting cod;
2. Pelagic trawls 24-40 m, targeting sprat and herring;
3. Drift and fixed netters, mostly fishing in the coastal area;



	DTS 24-40 m 2005	DTS 24-40 m 2006	DTS 24-40 m 2007	DTS 24-40 m 2008	DFN <12 m 2005	DFN <12 m 2006	DFN <12 m 2007	TM 24-40 m 2008
Net Profit/Loss	0,7	0,6	0,5	0,3	0,0	0,0	0,2	-0,5
Total Fixed Costs per Segment	0,2	0,2	0,1	0,5	0,0	0,0	0,0	1,0
Other variable cost per segment	1,0	0,7	0,7	0,5	0,1	0,2	0,0	1,9
Fuel Cost per segment	1,1	1,0	0,7	0,5	0,1	0,1	0,0	0,7
Crew Cost per segment	1,1	1,0	1,3	0,8	0,2	0,2	0,1	0,5

Figure 7: Economic performance of Baltic Sea fleets, 2005-2008.

Demersal trawls and seiners 24-40 m

The demersal trawlers and/or demersal seiners 24-40 m segment consisted of 16 vessels in 2008 accounting for a total of about 1,876 GT and 3,530 kW. It is the most important Lithuanian fleet segment fishing in the open Baltic Sea in terms of value of landings and number of vessels. Since 2004 the capacity of this segment decreased by 58% in terms of number of vessels and by 62% of GT. The implementation of capacity reduction schemes affected this segment a lot.

In 2008, vessels of this fleet segment landed a total of 3,000 tonnes of fish and generated income of 2.6 million Euros (26% less than in 2007). Vessels of the segment mostly target cod with some by-catch of plaice. The cod represents 57% of the volume and 88% of the value of landings of this segment. Due to rapid reduction of the fleet capacity and the recent increase of cod quota for Eastern cod stocks, the average volume and value of landings of this segment increased in 2006-2008 and the increase is also expected in 2009.

Pelagic trawls 24-40 m

The pelagic trawl segment is relatively new for Lithuanian fisheries, as it appeared as a separate segment for the first time in 2008. Prior to this, there were vessels targeting pelagic species, but they were too few to be accounted as separate segment.

This fleet segment is the only segment which had no profit in 2008.

Drift and fixed netters < 12 m

The drift and fixed netters < 12 m segment is socially important for people living in the coastal areas as it provides employment, some income and fish for private consumption.

The drift and fixed netters < 12 m segment consisted of 85 vessels in 2008, 78 of them were < 10 m, the rest between 10 and 12 meters. The capacity of the fleet was 207 GT and 1913 kW in 2008. The capacity reduced drastically in 2008 in comparison with 2007 due to changes in the methodology of data collection and an increase in the availability of data the activity of vessels < 10 m. Thus, all vessels < 12 m were separated into categories of active and inactive vessels in 2008.

Vessels of the fleet segment landed a total of 321 tons of fish and generated average income about 3,066 Euros per vessel. Due to the reasons mentioned above, an increase of about 75% is observed comparing with 2008. According to the national rules, 5% of annual Lithuanian cod quota is reserved for this fleet segment. The income from cod catches composed about 42% of volume of landings, while smelt represented about 29%. The other fish species are herring, pikeperch, turbot and others.

1.5 Sweden

1.5.1 Introduction

Since the Swedish west-coast fleet has access to the Baltic on nearly the same terms as vessels based on in Baltic Sea ports, the description of the fleet structure covers the whole Swedish fishing fleet where appropriate.

Traditionally, small-scale fishing for herring has taken place along the Swedish coast, mainly with passive gears and also with small trawlers. The catches were used for direct human consumption as fresh herring. In the most southern provinces (Skåne and Blekinge) the dominant fleet was small trawlers and a part of the catches were processed.

When fishing for herring in the North Sea was banned in 1976, vessels from the Swedish west-coast began a more intensive fishery for herring in the Baltic. Many of these west-coast vessels, as well as many of the Baltic trawlers, switched to cod fishery in the 1980s due to the low price of herring and high abundance of cod in the Baltic, which also coincided with a high price as well.

Due to the gradual collapse of the fresh herring market in Sweden, the traditional small-scale fishery for herring has more or less ceased. The main catches are now taken by larger trawlers with outlet to the processing industry and fish meal plants. In 2009, 70% of the Swedish herring catch was taken by trawlers from the west-coast, which mainly are rather large vessels (length>30 meters). The rest was taken by less than 10 trawlers based in the Baltic basin. Concerning sprat, 80% was taken by west-coast trawlers and used for fodder purposes. However, there are about 10 small-scale trawlers with home ports on the island of Gotland and on the east coast that have specialised in fishing sprat for the freezing plants in Slite (Gotland) and Västervik (mainland east coast).

In the cod fisheries there is a mixture of trawlers and netters/hookers. The trawlers vary in size from about 12 meters up to 40 meters in length. The netter/hookers are mainly vessels less than 15 meters in length. Approximately 50% of the catches were taken by trawlers from the west-coast.
In the far north (Gulf of Bothnia) a rather profitable fishery has been developed based on vendace roe. The fishery is seasonal (September-October) and technically it is a mid-water trawl fishery within the archipelago.

1.5.2 Fleet structure

In 2008, the Swedish fishing fleet consisted of 1 509 registered vessels, with a combined registered tonnage of 43 072 GT and total power of 212 138 kW (see figure 1). The overall average age of vessels was 29.6 years in 2008, see figure 2.

The number of vessels, tonnage and power has all been decreasing since 2002. In 2002, the number of registered vessels was 1,818 with a combined tonnage of 44.850 GT and a combined power of 224 600 kW.

The decrease in the number of registered vessels stems from a combination of different factors. One factor is decreasing profitability. The total quota for Swedish fisheries has decreased over time, which has had an effect on the number of vessels involved in fisheries. Increases in costs make it harder to make any profit out of fishing, e.g. the increases in fuel costs where the price of fuel has practically doubled during the period 2002 to 2008. Some fishers have left the industry because it is not profitable for them to fish anymore. The average age among Swedish fishers is increasing and a part of the decrease in the number of vessels is attributed to fishers leaving the trade for retirement. The Swedish fisheries administration has also put efforts into decreasing the fleet in order to make the remaining vessels more profitable. An example of such measures are scrapping campaigns where fishers are paid to scrap their vessels.

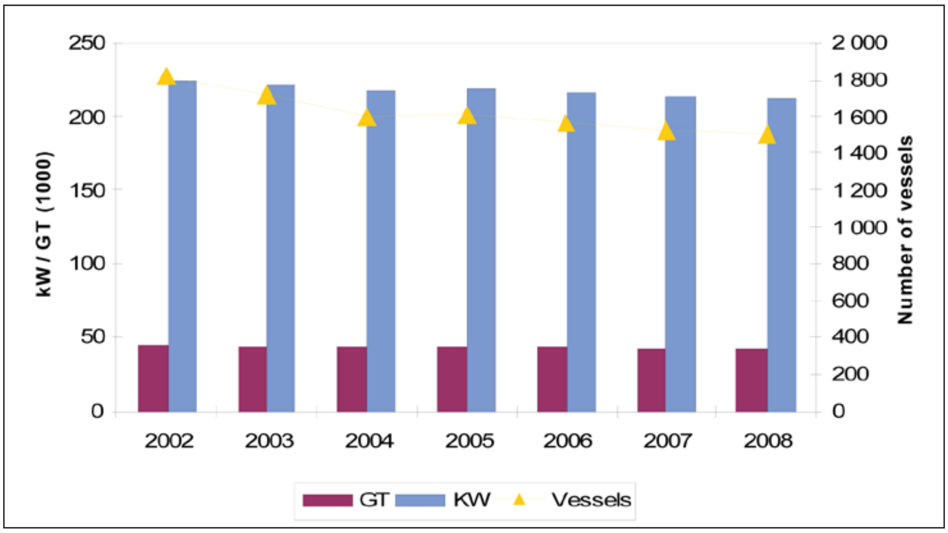


Figure 1: Swedish national fleet capacity trends 2002-2008.

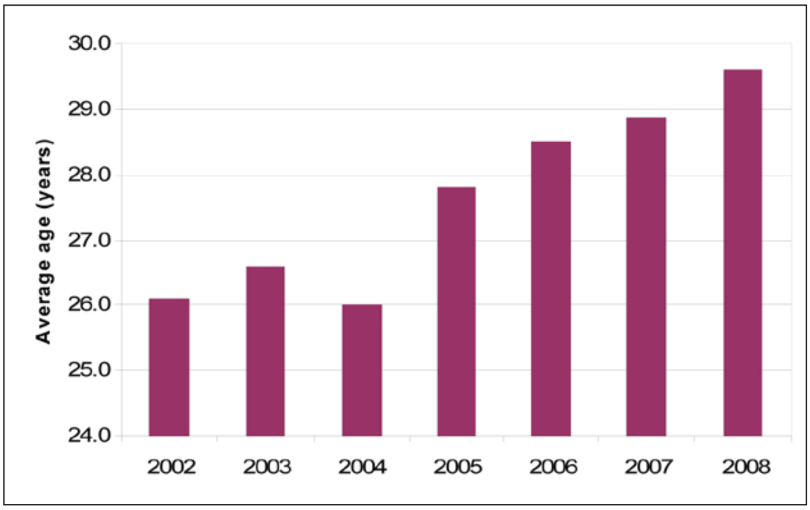


Figure 2: Swedish national fleet age trend 2002-2008.

1.5.3 Fishing grounds in the Baltic

Herring is fished all over the Baltic, including coastal waters and in the Swedish archipelago. Sprat is taken south of latitude 59 30 (Stockholm area) and mostly in the open sea. Cod is fished mainly south of the island of Gotland and both in the open sea and in coastal waters. Vendace is a freshwater species fished in the northern part of the Golf of Bothnia where the salinity is very low. Salmon is fished both in the open sea and along the coast from the Stockholm area and northwards. Fishing for eel is exclusively a fishery for silver eel and the catches are taken from the Stockholm area and southwards. Freshwater species like perch, pike, pike-perch and trout are caught in the archipelagos and north of the Stockholm area.

1.5.4 Main species (coastal vs. open Baltic Sea)

In terms of landing volume, sprat was the most important species with 81 000 tons in 2008 followed by herring with 57 000 tons and cod with 11 000 tons. All other species had landings less than 1 000 tons. However in terms of value, cod ranked highest with 170 MSEK (M€ 17.5) followed by herring with 142 MSEK (M€ 14.6) and sprat with 114 MSEK (M€ 11.8). These three species are normally taken in the open sea but for both cod and herring, a rather large fishery also takes place in coastal waters, inside the zone of four nautical miles. In addition to these three main species, the fishery for vendace is important in the north with a value of 24 MSEK (M€ 2.5) and eel is fished all along the southern part of the Swedish coast and the value is 13 MSEK (M€ 1.3). Catches of salmon have dropped but in 2008 were still worth MSEK 8 (M€ 0.8). Due to the ban of drifting salmon nets, most of the catches were fished in the coastal area with fixed gears, but the fishery with drift hooks in the open sea has increased.

Landings of cod in volume are relatively stable but dropped in 2005 before recovering in 2006 and 2007. The landings of cod decreased slightly in 2008 compared to 2007. The price per kilo of cod started to rise in 2005. It rose until 2007 but dropped in 2008, which explains the decrease in the total value of the landings of cod. The value of landings for herring initially decreased but has displayed a positive trend since 2005, although the volume has decreased. This is explained by the fact that the price per kilo has risen since 2005.

Demand and supply affects the price fishers receive for individual species and changes in landed quantities as an effect of changes in quotas will have an effect on the development in prices. Changes in consumer preferences also affect the prices fishers receive. For instance, domestic consumers may choose to boycott a certain species from a certain area due to alarming reports about the state of a certain stock. Fish that cannot be sold domestically has to be exported or be used in another way, for instance as input in the processing industry instead of human consumption or vice versa. The prices may change for this reason. Another example is increasing demand for aquaculture products. Increasing production volumes leads to lower prices and makes aquaculture products more attractive for consumers relative to wild captured seafood, thus affecting landing prices.

Changes in preferences may also stem from changes in income or phenomenons such as health trends where seafood is an alternative to meat products.

A lot of factors have an effect on the landings volumes and it is hard to distinguish and separate the effect of each and every one of them. A few of the most important factors are the development in quotas, price levels and number of vessels. The number of active vessels is of course linked to fishing permits and profitability.

1.5.5 Data table on economic indicators

1.5.5.1 EMPLOYMENT

Total employment and FTEs was 1 980 and 1 046 in the Swedish national fleet in 2008, see figure 3.

Estimates of the total number of people employed are available from 2002 and estimates of FTEs are available from 2006. The total number of people employed in the Swedish fleet has varied slightly since 2002 but decreased from 2006 to 2008. The overall effect was reinforced by a decrease in the number of FTEs. The decrease in employment is an effect of the decreasing number of vessels as well as a decrease in the total number of days at sea for the Swedish fleet.

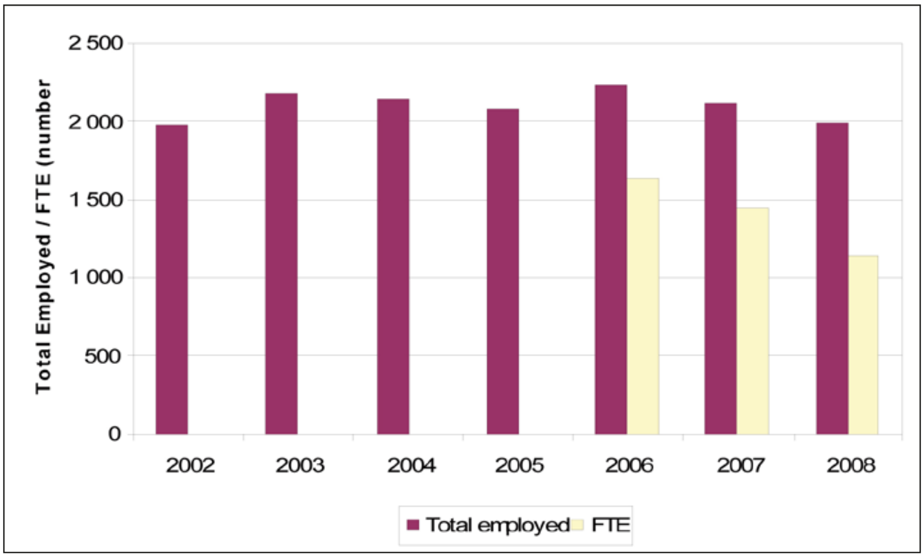


Figure 3: Swedish national fleet employment trends 2002-2008.

1.5.5.2 ECONOMY

The total amount of OCF, GVA and profit/loss generated by the Swedish fishing fleet in 2008 was 70 million euros, 81 million euros and 18 million euros respectively, see table 4.

The total amount of income generated by the Swedish fishing fleet in 2008 was 149 million Euros. This consists of 120 million in landings values, 0 million in fishing rights sales, 27 million in non fishing income, and 2 million in direct subsidies. The total amount of expenditure by the Swedish fishing fleet in 2008 was 97 million euros, see table 4. The value of the capital stock was 257 million in 2006 which decreased to 218 million in 2007 and 165 million in 2008. A part of this decrease is attributed to an extremely low level of new investment in the Swedish fleet.

Table 4: Swedish national fleet costs and earnings statement 2006-2008.

	2006		2007		2008	
	Total (million euros)	% of total income	Total (million euros)	% of total income	Total (million euros)	% of total income
INCOME						
value of landings	117	82.4%	121	85.1%	120	80.5%
income from fishing rights					0	0.0%
direct subsidies					2	1.1%
other income					27	18.3%
== TOTAL INCOME	142	100.0%	142	100.0%	149	100.0%
EXPENDITURE					0	
energy (fuel) cost	26	18.6%	21	15.0%	29	19.4%

	2006		2007		2008	
	Total (million euros)	**% of total income**	**Total (million euros)**	**% of total income**	**Total (million euros)**	**% of total income**
repair cost	21	14.8%	21	14.7%	22	15.1%
variable cost	18	12.4%	28	19.7%	6	4.1%
non-variable cost	4	2.5%	6	3.9%	9	5.8%
fishing rights					0	0.0%
crew wages	13	9.3%	14	10.0%	12	8.1%
=== OCF	60	42%	52	36.7%	70	47.5%
unpaid value of labour					19	12.7%
capital cost	53	37.6%	44	30.6%		
depreciation					32	21.8%
Interest					1	0.7%
=== PROFIT/LOSS	7	4.8%	9	6.1%	18	12.3%
=== GVA	74	51.7%	66	46.7%	81	54.4%
=== CAPVAL	257		218		165	
=== ROI	23%		24%		12%	

1.5.6 Description of the economic situation from the data

The main trend in income is positive, but this is largely due to the fact that income for Swedish fleet increased drastically in 2006. Fuel costs for the Swedish fleet have been steadily increasing, with the exception of a drop in 2007, which is explained by the fact that fuel prices and energy consumption decreased slightly during 2007. In 2008, the total energy consumption decreased but a large increase in fuel prices increased the total fuel costs. Crew costs were initially higher from 2002 to 2004 but decreased and displayed lower values in 2005 to 2007. The increase in crew costs for 2008 occurred because the value of unpaid labour is included, in addition to wages. Operating cash flow fluctuated during the period 2002 to 2008 and reached its highest value in 2008. Gross value added initially displayed a negative trend in 2002 to 2005 but the main trend since 2006 was positive. The main trend of profit in the Swedish fleet is negative, but there were positive indications of a potential return to profit in 2007 and 2008. Return on investment fluctuated a lot during the period, but it is hard to say if this stemmed from real changes in, e.g. profit or changes in the capital value calculation methodology.

A lot of factors affect the profitability of the Swedish fleet. The most important factors that influence the profitability of the Swedish fleet are the development of fish prices, fuel prices, quotas and the number of active vessels.

Technological development affects the efficiency and productivity of fisheries. Technological development in itself is not enough to improve efficiency but capital is needed, in order to invest in new technology. Currently the levels of investment in Swedish fisheries are low, due to a number of factors such as low profitability and general pessimism about the future of the industry. To improve efficiency and profitability, investments in new technology are needed; this requires improved access to finance, which in turn requires increasing profits. Swedish fisheries are thus caught in a “catch 22” situation.

1.5.7 Changes from 2005-2007 until now

As an effect of the management plan for cod in the Baltic Sea, a special permit for cod fishing gears was introduced in 2008 for vessels of a length of more than 8 meters, in accordance with article 10 in Council Regulation 1098/2007. When Sweden implemented this regulation, more restrictions were applied compared to demands in the regulation. Six large trawlers were scrapped in order to increase profitability for the remaining vessels.

Appendix 2. Subsidies

2.1 Estonia

EFF

Tables from Operationals programmes, mln. Euro

Year	EFF support
2007	9,1
2008	10
2009	10,9
2010	11,9
2011	13
2012	14,2
2013	15,5
Total	84,6

Total OP 2007-2013, mln Euro

Priority axes	Total public	EFF Contribution	National contribution	EFF co – financing rate
Priority axis 1. Measures for the adaptation of the fishing fleet.	20,3	15,3	5,1	75
Priority axis 2. Aquaculture, inland fishing, fish processing and marketing.	32,8	24,6	8,2	75
Priority axis 3. Measures of common interest.	28,3	21,2	7,1	75
Priority axis 4. Sustainable development of fisheries areas.	25,7	19,3	6,4	75
Priority axis 5. Technical assistance.	5,6	4,2	1,4	75
IN TOTAL	112,7	84,6	28,2	75

Additional government financial transfers to fisheries sector

There are several classifications for financial transfers to the fisheries sector. In aim to highlight which categories exist in Estonia, the following system will be used: direct payments, cost-reducing transfers and general services.

1) Direct payments

In this category, the most important measures are support schemes to modernize the assets of fishing enterprises (vessels, gears, harbours etc.). Also, there are vessel decommissioning payments in use.

2) Cost-reducing transfers

There is only one measure in use in Estonian fisheries that reduces costs for producers: fuel tax exemption. In Estonia, there are different taxes associated with the price of fuel for the end users. One of them is so-called excise duty. Fishing vessels had the right for reimbursement of this tax in 2005 and 2006. The system was then changed and now the fishermen have the possibility to apply for exemption from fuel tax.

3) General services

There is multitude of general service support in the Estonian fisheries. Such measures include: research, management and enforcement expenditure, regional development grants, support to build port facilities, payments to producer organisations, expenditure for restocking of fish resources and for fisheries information collection and analysis.

There are no mechanisms to increase revenues or for market intervention in Estonia.

2.2 Germany

Financing plan by priority axis for the period 2007-2013 (in EUR).

Convergence Objective regions(1)				
Priority	**Total Public a=(b+c)**	**EFF Contribution (b)**	**National Contribution (c)**	**EFF co-financing rate (2) (d)=(b)/(a)*100**
Priority axis 1	6.013.334	4.510.000	1.503.334	75,00
Priority axis 2	44.489.634	33.367.225	11.122.409	75,00
Priority axis 3	66.533.197	49.899.897	16.633.300	75,00
Priority axis 4	10.584.000	7.938.000	2.646.000	75,00
Priority axis 5 (3)	1.528.161	1.146.118	382.043	75,00
Total	129.148.326	96.861.240	32.287.086	75,00

Non Convergence Objective regions(1)				
Priority	**Total Public a=(b+c)**	**EFF Contribution (b)**	**National Contribution (c)**	**EFF co-financing rate (2) (d)=(b)/(a)*100**
Priority axis 1	7.270.000	3.635.000	3.635.000	50,00
Priority axis 2	48.386.000	24.193.000	24.193.000	50,00
Priority axis 3	37.575.894	18.787.947	18.787.947	50,00
Priority axis 4	23.000.000	11.500.000	11.500.000	50,00
Priority axis 5 (3)	1.776.460	888.230	888.230	50,00
Total	118.008.354	59.004.177	59.004.177	50,00

(1) Convergence: Brandenburg, Mecklenburg-Vorpommern (Baltic Sea coastal state), Lower Saxony (Lüneburg region only), Saxony, Saxony-Anhalt, Thuringia.
Non-convergence: Baden-Württemberg, Bavaria, Berlin, Bremen, Hamburg, Hessen, Lower Saxony (excluding Lüneburg), North-Rhine Westphalia, Rhineland-Palatinate, Schleswig-Holstein (Baltic Sea coastal state).

(2) The EFF co-financing rate may be rounded in the table. The precise rate used to reimburse payments is the percentage (d).

(3) In the case of operational programmes covering a mix of regions eligible under the Convergence Objective and the non-Convergence Objective, the total public contribution for priority axis 5 may be allocated to the predominant type of regions which have the highest total amount of public contribution in the operational programme.

2.3 Lithuania

The total eligible public expenditure of the programme is € 71,256,575 (own contribution 23.2%).

Financing plan by priority axis for the period 2007-2013 (in EUR).

EFF amounts	Convergence	% of total EFF allocations
Priority axis 1	13.667.647	25
Priority axis 2	22.431.005	41
Priority axis 3	9.249.241	17
Priority axis 4	6.693.770	12.2
Priority axis 5	2.671.745	4.8
Total	54.713.408	100

2.4 Sweden

Fuel subsidies

Registered fishing vessels in Sweden are excluded from fuel tax, as is most other commercial waterborne traffic. Some vessels have the possibility to purchase bunker fuel at a subsidised price without taxes and other vessels have the possibility to have the fuel tax refunded.

Table 1: Total amount of fuel consumed and price per litre for commercial saltwater fisheries. Source: Swedish Board of Fisheries.

Year	Fuel consumption (m^3)	Fuel Price excl. tax (SEK/litre)
2005	57 980	3.38
2006	58 817	3.99
2007	46 985	3.86
2008	41 377	5.32

In 2005, a total of 57 980 cubic meters of fuel were consumed in the Swedish commercial saltwater fisheries (freshwater fisheries not included). By 2008, this had decreased to 41 377 cubic meters. The average price of fuel the fishers pay (as estimated by the Swedish Board of Fisheries' research vessels' bunkering of diesel fuel) has increased from 3,38 SEK/litre (excluding tax) in 2005 to 5,32 SEK/litre (excluding tax) in 2008. It is worth noting that the average fuel price decreased slightly from 2006 to 2007.

The Swedish fuel tax on diesel consists of two parts. One part is a carbon dioxide tax and is the same independent of the environmental class of the diesel. The other part is an energy tax and differs depending on the environmental class. Primarily two types of diesel are used in the Swedish salt-water fisheries: fuel oil environmental class 1 (EC 1) and green colour-marked diesel.

Table 2: Swedish fuel taxes. Source: Swedish Tax Agency.

	2005		2006		2007		2008	
	Energy Tax	Carbon dioxide tax	Energy tax	Carbon dioxide tax	Energy tax	Carbon dioxide tax	Energy tax	Carbon dioxide tax
Fuel oil EC 1	1 036	2 609	1 042	2 623	1 057	2 663	1 277	2 883
Colour-marked diesel	735	2 609	739	2 623	750	2663	7 64	2 883
Average national fuel tax per litre of diesel	3.49		3.51		3.57		3.90	

The average national fuel tax per litre is calculated as the average of tax on fuel oil EC 1 and coloured-marked diesel, since the absolute shares of usage of the two fuel types are unknown.

Based on these averages and the total amount of fuel consumed in commercial saltwater fisheries, the total value of fuel subsidies was 202.4 million SEK in 2005. These decreased to 161.4 million SEK in 2008.

Table 3: Total value of fuel subsidies as calculated by the Swedish Board of Fisheries.

Year	Fuel consumption (m^3)	Fuel subsidy, national average (SEK/litre)	Total value of fuel subsidies (Million SEK) M€
2005	57 980	3.49	202.4 20.8
2006	58 817	3.51	206.4 21.2
2007	46 985	3.57	167.7 17.3
2008	41 377	3.90	161.4 16.6

Financing plan by priority axis for the period 2007-2013 (in EUR).

Priority axes	Total Public a=(b+c)	EFF Contribution (b)	National Contribution (c)	EFF co-financing rate(d)=(b)/(a)*100
Priority axis 1	22,777,001	13,666,201	9,110,800	60 %
Priority axis 2	21,865,922	10,932,961	10,932,961	50 %
Priority axis 3	38,265,362	19,132,681	19,132,681	50 %
Priority axis 4	16,399,440	8,199,720	8,199,720	50 %
Priority axis 5	5,466,480	2,733,240	2,733,240	50 %
Total	104,774,205	54,664,803	50,109,402	52 %

Appendix 3. Modelling

Ecopath with Ecosim (Christensen et al 2004) is a software for building food web models (www.ecopath.org), originally proposed by Polovina (1984) and later modified by adding the network analysis (Ulanowicz 1986). Trophic interactions among the functional groups (i) of an ecosystem can be described by a set of linear equations:

$P_i = Y_i + B_i + M2_i + Ei + P_i * (1\text{-}EE_i)$

Where Pi denotes total production; Y total catch; Bi total biomass; M2i predation mortality; Ei net migration; and EEi is the ecotrophic efficiency of functional group I (the fraction of production of i that is consumed within the system, exported or harvested).

EEi could be also expressed as:

$Bi*(P/B)_i * EE_i - \sum B_j * (Q/B)_j * DC_{ji} - Y_i - E_i = 0$

where (P/B)i denotes production/biomass ratio of prey (i); (Q/B)j the consumption/biomass ratio of predator (j); DCji the fraction of the prey in the average diet of a predator (Christensen and Pauly, 1992). The dynamic part of the food-web model is called Ecosim, which allows a temporal dynamic analysis of the food-web dynamics. The temporal model part is then fitted to long-term monitoring data. Ecosim is based on set of differential equations:

$$\frac{dB_i}{dt} = g_i \sum_j Q_{ji} - \sum_j Q_{ij} + I_i - (M_i + F_i + e_i)B_i$$

where dBi/dt represents the growth rate during the time interval dt of group (i) in terms of its biomass, Bi, gi the net growth efficiency (production/consumption ratio), Mi the non-predation ('other') natural mortality rate, Fi fishing mortality rate, ei emigration rate, Ii immigration rate, (and ei·Bi-Ii is the net migration rate). The two summations estimate consumption rates, the first expressing the total consumption by group (i), and the second the predation by all predators of the same group (i). The consumption rates, Qji, are calculated based on the 'foraging arena' concept, where Bis are divided into available and non-available components (Walters et al., 1997). The set of differential equations is solved in Ecosim using a Runge-Kutta 4th order routine.

Table 1: Forcing factors for the BNI NEST model. Y/B (stands for yield per biomass ratio).

Forcing Factor	Season	Forced Group	Type of forcing
Temp. 0-10m	Summer	Sprat	eggs production
Temp 0-50m	Spring	Acartia sp; T Temora sp	impact on the biomass
Salinity 80-100m Gotland Basin	Annual	Pseudocalanus sp	impact on the biomass
Salinity 80-100m Gotland Basin	Annual	Cod	eggs production and youngest stanza
Primary production	Seasonal	Phytoplankton biomass	Productivity of the phytoplankton
Macrozoobenthos biomass	Annual	macrozoobenthos	to fit relative biomass time series
Acartia biomas	Annual	Acartia sp	
Temora biomass	Annual	Temora sp	
Pseudocalanus biomass	Annual	Pseudocalanus sp	
Chlorophyll a	Spring	spring phytoplankton	
Chlorophyll a	Summer	other phytoplankton	
Sprat 1 biomass	Annual	Sprat Age 1	
Ad. Sprat biomass	Annual	Sprat Age 2+	
Herring 1 biomass	Annual	Herring Age 1	
Herring 2 biomass	Annual	Herring Age 2	
Ad. Herring biomass	Annual	Herring Age 3+	
Cod 2 Biomass	Annual	Cod Age 2	
Cod 3 Biomass	Annual	Cod Age 3	
Ad. Cod Biomass	Annual	Cod Age 3+	
Y/B_Sprat 1	Annual	Sprat Age 1	
Y/B_Ad. Sprat	Annual	Sprat Age 2+	Fishing pressure on given group
Y/B_Herring 1	Annual	Herring Age 1	
Y/B_herring 2	Annual	Herring Age 2	
Y/B_Ad. Herring	Annual	Herring Age 3+	
Y/B_Cod 2	Annual	Cod Age 2	
Y/B_Cod3	Annual	Cod Age 3	
Y/B_Ad. Cod	Annual	Cod Age 3+	

Fleet/Effort Dynamics Module:
In Ecosim there are two possibilities for setting fishing effort:

- Time-series set manually by the user, either in time-series files or directly in the Ecosim module.
- Dynamic fleet-effort change, described below.

The latter module, the so-called fleet/effort dynamics module, calculates the effort for each fleet in a given year as a function of the total profit of the fleet in the previous year. This effort is then used to calculate the fleet catches in the given year, and as such the fleet/effort dynamics module invokes bio-economic feedback between catches and fleet effort.
The fleet effort in year *t* is given by:

$$E_{f,t} = \frac{\widetilde{K}_{f,t-1} \cdot CI^{P}_{f,t-1}}{ES_{f,t-1} + CI^{P}_{f,t-1}} \tag{1}$$

Where:

- $\widetilde{K}_{f,t-1}$ is the fleet capacity of fleet *f* in time period *t-1* measured in units of the effort $E_{f,0}$ in time period *0* .
- $CI_{f,t-1}$ is the current income of fleet *f* in time period *t-1*.
- *P* is the 'effort response power parameter' (default value equals *3* in Ecopath).
- $ES_{f,t-1}$ is an effort scaling factor of fleet *f* in time period *t-1*.

$\widetilde{K}_{f,t-1}$ is evaluated using the so-called 'slow time response model', given by:

$$\widetilde{K}_{f,t-1} = \widetilde{K}_{f,t-2} \cdot (1 - \frac{\rho_f}{12}) + \frac{1}{12} \cdot \widetilde{K}_{f,0} \cdot \left(\lambda_f + \rho_f\right) \cdot \frac{CP_{f,t-2}}{CP_{f,0}} \tag{3}$$

Where ρ_f is the (yearly) capacity depreciation rate (default value equals 0.06 in Ecopath), λ_f is the initial capital growth rate, which is by default set to 0.2 by Ecopath, and $CP_{f,t-2}$ is the current profit for fleet *f* in time period *t-2*.

As such it is seen that the effort change in year *t* is based on an 'investment rule' for overall fleet capacity, determined by (i) capacity depreciation, and (ii) capacity increase/decrease given fleet profits in the previous years.

The fleet/effort dynamics module will be used to assess the following management scenario:

- Status Quo: No changes from today's situation with respect to quota allocation between countries and allocation regimes in the different countries. Long-term management plan(s) will not work. Using the fleet/effort dynamics module will ensure production of zero rents in the fishery, corresponding to the status quo situation.

Fishing Policy Search

The fishing policy search module searches for fishing policies that maximize specific policy goals. This is done by maximizing, by varying fleet efforts, an objective function. The latter is based on four weighted policy objectives, recognizing that fishing policies may aim to satisfy more than one objective, e.g. that fishing policies are based on biological as well as economic objectives. As such the objective function is based on four weighted aims:

- To maximize fisheries' rent
- To maximize social benefits, expressed as number of jobs per catch value.
- To maximize mandated rebuilding of certain species, by setting threshold biomasses for these.
- To maximize 'biomass diversity', or ecosystem 'maturity', meaning ecosystems which are dominated by large, long-lived organisms.

The variables used to maximize the objective function, the fleet efforts (or fleet 'sizes') can be set over the whole Ecosim simulation period, or part of this. The final fleet efforts can be set to be constant over the whole optimization period, or can be allowed to vary from year to year, or from one pre-set period to the next. The resulting fleet efforts are translated to fishing mortalities in Ecosim, assuming a linear relationship between effort and fishing mortality, and that the catch composition for each fleet remains constant, and equal to the composition in the start year, during the simulation period.

As such the Fishing Policy Search modules assume effort rather than quota regulation. The module will in the project be used to assess the following management scenarios:

- Status Quo: No changes from today's situation with respect to quota allocation between countries and allocation regimes in the different countries. Long-term management plan(s) will work. The Policy Search Module will optimise mandated rebuilding of stocks using Bpa as limits.
- Optimal fisheries management with flexible management regimes.

Construction of Economic input to the model

Landings data and economic fleet data have been collected for fleets fishing in the Central Baltic Sea for Denmark, Sweden, Germany, Lithuania, Estonia and Poland. Data was collected for the period 2005-2007. Collected economic data included total income, crew costs, fuel costs, other variable costs, depreciation and capital costs, and total fixed costs per fleet segment. Not all countries were able to collect data for all the economic indicators. However, collected landings weight and value are complete for all countries.
28 national fleet segments operating in the Central Baltic Sea were identified. These were aggregated into 6 fleet segments used in the model:

1. Trawlers less than 12 meters (TR0012)
2. Other vessels less than 12 meters (OTH0012)

3. Trawlers 12-24 meters (TR1224)
4. Other vessels 12-24 meters (OTH1224)
5. Trawlers 24-40 meters (TR2440)
6. Other vessels 24-40 meters (OTH2440)

The aggregation is based on equal gear and length group. First, the 28 segments were divided into the length groups less than 12 meters, 12-24 meters and 24-40 meters. Secondly, fleets using trawls were collected in one group and the remaining gears (mostly passive and polyvalent passive gears) were collected in 'Other vessels'.

The aggregation of vessels into the 6 groups was considered necessary as the management optimization scenario in Ecosim is not able to handle an optimization for 28 segments. As the fleets included in each aggregated segment are of approximately equal size and use similar gears, it is believed that the aggregation will not bias the results of the optimizations compared to if each fleet segment were included separately.

Table 2: This table showing the gear and target species of the landed fish of the different fleet segments, aggregated for the Ecopath with Ecosim modeling, fish in tonnes /km²

	OTH0012	OTH1224	OTH2440	TR0012	TR1224	TR2440
Size	0-12m	12-24m	24-40m	0-12m	12-24m	24-40m
Location	Coastal	Open Sea	Open Sea	Coastal	Open Sea	Open Sea
Gear	Gillnets trapnets	Gillnets Longline	Gillnets Longline	Bottom Trawl	Bottom & Pelagic Trawl	Pelagic Trawl
Landings						
Cod	14599	7354	966	176	24007	23074
Herring	2029	32	0	0	10778	97534
Sprat	14	835	0	25	28389	322736

As complete cost data were lacking for some countries, it was decided to use a proxy for fixed and variable cost of the six segments in the model, based on the average of the collected Danish cost data for the period 2005-2007. Denmark has a long tradition for collecting reliable economic data.

The food-web model is calibrated for the period 1974-2005. Thus it is initialised in 1974 with regard to biological and economic input data to Ecopath. Therefore, it has been necessary to produce landings and cost data for 1974 for each of the aggregated fleet segments used in the model. Landings data have been produced by ICES Baltic Fisheries Assessment Working Group. However, price and cost data for the national fleets are first available for ~2000 and onwards. Thus proxies for prices and fleet costs have been estimated using the average Danish cost structure over the period 2005-2007 (shown in table 3), and on the reported landings data for 1974.

Table 3. Average cost data over the period 2005-2007 for the Danish fleet segments used to calculate cost proxy values for the data collection of the fleet segments.

Danish fleet segments	Total variable cost/ landings value	Capital Costs/ vessel (mEUR)	Fixed Costs/vessel (mEUR)	Landings Value/ vessel (mEUR)
PGP0012	0,8167	0,0123	0,0193	0,0801
PMP0012	0,7225	0,0135	0,0232	0,0888
PMP1224	0,6925	0,0559	0,0608	0,3428
DTS0012	0,7225	0,0135	0,0232	0,0888
DTS1224	0,6925	0,0559	0,0608	0,3428
PT2440	0,6383	0,2261	0,1885	1,0122
PGP1224	0,6726	0,0563	0,0604	0,2911

The Fleet Size Dynamics module

The Fleet Size Dynamics module (approach 2) calculates dynamic fleet effort changes over time in the Ecosim model. Thus the effort of each fleet is evaluated in each monthly timestep as a function of the landings values and profits in the previous month. The fleet efforts are subsequently used to calculate fleet catches of each target species in each monthly timestep. These fleet catches are aggregated into overall catches of the target species, and as such fishing mortalities are evaluated as a function of dynamic fleet efforts when the Fleet Size Dynamics Module is invoked. This module invokes dynamic bio-economic feedback between fleet capacity and stock status in the Ecosim simulations.

The central elements of the Fleet Size Dynamics module are an effort change function and a capacity investment function; the former determines the effort change from timestep to timestep as a function of the capacity change, which is determined in each timestep as a function of the capacity, landings value and profit of the fleet in previous timestep. The two functions are calibrated with four basic fleet dynamics parameters, comprising initial fleet capacity, depreciation over time of fleet capacity, capacity growth over time of the fleet, and a factor describing how fast income changes produces effort changes. Default values of these fleet dynamics parameters are provided by Ecosim but optimally they should be estimated for each fleet prior to simulation runs.

The fleet dynamics parameters have been estimated for each of the six aggregated fleet segments using recorded time series for effort, landings values and profit for the fleets over the calibration period (1974-2006). To our knowledge this is the first attempt to estimate the parameters for the investment function used in Ecosim. The parameters have been estimated by fitting the effort change function to the effort time series recorded for the calibration period. This has been done using the software Mathematica, i.e. outside Ecosim.

Subsequently, the reliability of the estimated parameters have been tested by running Ecosim over the calibration period (1974-2006) with the Fleet Size Dynamics module turned on and then comparing the yield and biomass time-series resulting from this run with the original calibration biomass and yield time-series. When the Fleet Size Dynamics module is turned on the fish biomasses are related to the fleet efforts, i.e., linked to the fishing mortality. If the Fleet Size Dynamics module predicts the original calibration efforts well, the biomasses and yields resulting from the Fleet Size Dynamics run should be close to the original calibration results.

Figure 1 shows, as an example, the original yield time series of adult cod, herring and sprat ("fitted" line in Fig. 1), together with the time series resulting from the Fleet Size Dynamics module over the calibration period. The results are presented for the scenario including climate change, but are not very different from the results for the scenario with no climate change. It is seen that the fit between the true calibration yield values and the estimated yields are not perfect, but still relatively good, and that the estimations predict the trends (increases/decrease) in yield.

Figure 2 shows the ratio between the biomasses in 2006 and 1974 for all functional groups included in the model. Again the results are presented for the scenario including climate change. The ratios are shown for the original calibration data and for the biomasses resulting from the Fleet Size dynamics simulation. The simulation model to a high degree predicts the true biomass fractions.

Overall, it is concluded from the comparisons that the Fleet Size Dynamics module reproduces the calibration period results to a satisfactory degree. It can thus be concluded that the Fleet Size Dynamics module has potential for future use, especially in future simulations.

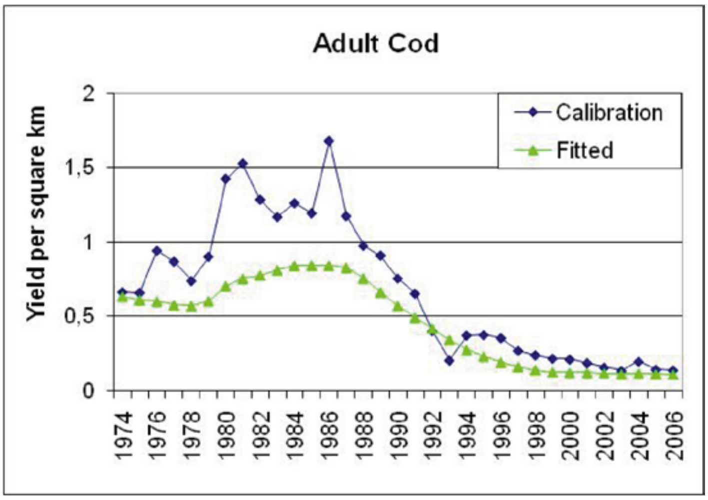


Figure 1: Yield time series for adult cod, herring and sprat. Blue data points denote original calibration time series, while green data points denote yield evaluated with the Fleet Dynamics Module turned on.

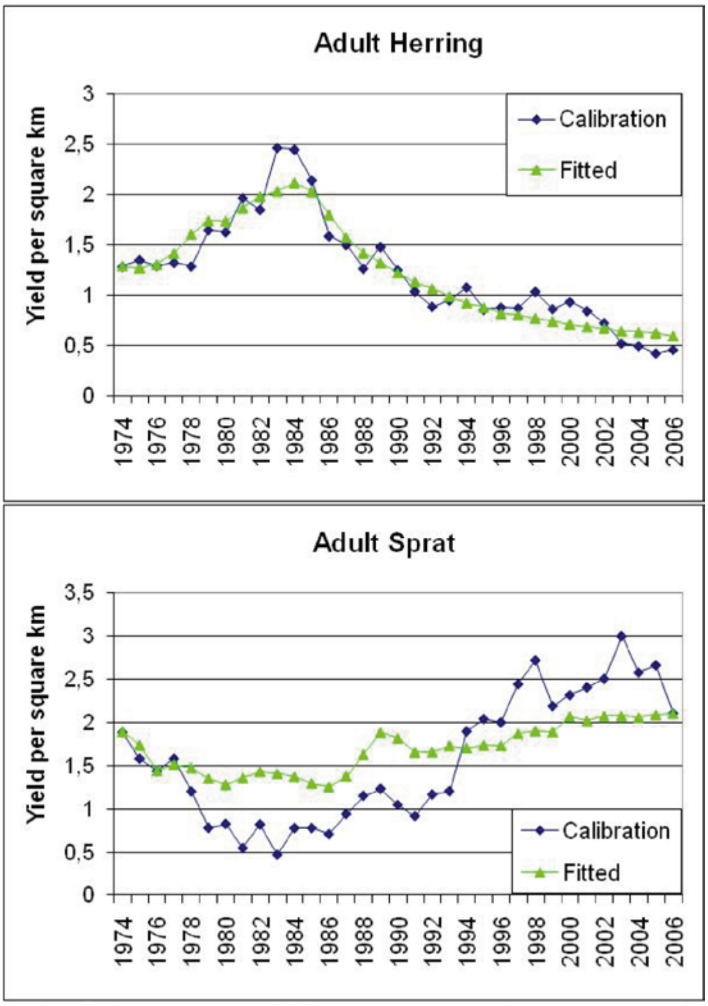


Figure 1, *continued*: Yield time series for adult cod, herring and sprat. Blue data points denote original calibration time series, while green data points denote yield evaluated with the Fleet Dynamics Module turned on.

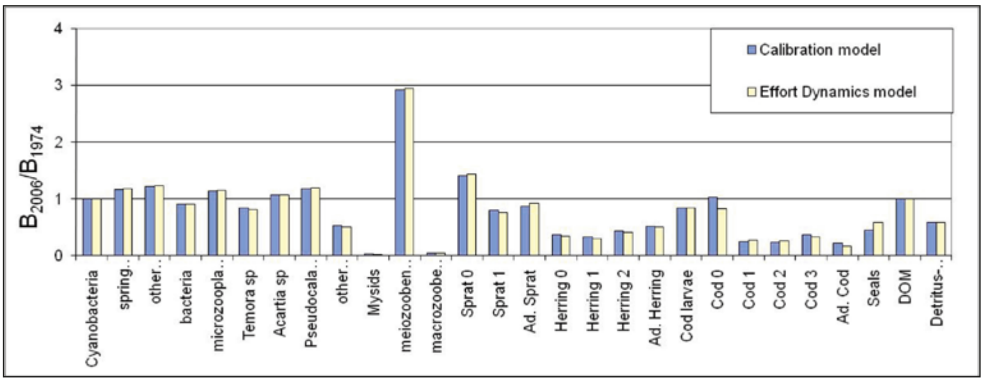


Figure 2: Ratio between 2006 and 1974 biomasses of the 28 functional groups evaluated in the basic calibration model and in the effort dynamics module.

Appendix 4. Current fishing management

4.1 Rights allocation main species

All fishermen fishing EU-regulated species need a special permit and must be registered in the EU fleet register. This means there are general rules for everyone, independent of his/her origin. There are basically two fisheries to separate: demersal (fishes feeding on the ground) and pelagic (open water species).

General regulations demersal and pelagic fleets

For the demersal and pelagic fleet segments all countries around the Baltic Sea are subject to the regulations of the long-term management plan for cod or specific measures in the Council regulations on catch possibilities for herring and sprat in the Baltic Sea.

The long term management plan for cod includes the following general regulations:

- Special permit for every fishermen fishing on cod
- Days at sea effort regulation for each vessel
- Closed seasons (West of Bornholm 1-30th of April, East of Bornholm 1 July – 31st of August)
- Closed areas (mainly Bornholm deep)

For the pelagic species, common regulations for 2010 would be included in Council regulation 1226/2009 on fishing opportunities in the Baltic Sea. However, there are no specifics in the regulations but member states may decide on measures for their vessels (see below).

Specifics for EU-MS

The following table 3.2 includes the special rights allocation systems in the countries around the Baltic Sea for fisheries on the main species.

[3] This means that the fishermen may have to go out sometimes when it would be better to stay in port to fish out their quota.

Table 3: Overview on catch allocation mechanisms in countries around the Baltic Sea for fisheries on the main species

Country		IQ	ITQ	Capacity/ entry reg.	Add. Regulations/Comments
Denmark	2000-2009	X	(X)	X	ITQ stepwise since 2003, Special regulations for small scale fishermen (< 17m, normally one day trips, etc.)
	2010		X		
	after 2010		X		
Germany	2000-2009	X		X	Better transferability of IQs possible in the future, IQ can be redistributed when quota not fished out[3]
	2010	X			
	after 2010		(X)		
Sweden	2000-2009			X	ITQ for pelagic fisheries (2010), Effort limits in western waters/Baltic Sea, Two week cod quota (vessel length/gear type), kwdays tradable
	2010	X	X		
	after 2010				
Poland	2000-2009	X			Open cod quota for coastal vessels and for pelagic species in general, ITQ in cod fishery, Heavy reduction in no. of vessels in 2009
	2010	X	X		
	after 2010		X		
Lithuania	2000-2009				Buy rights via auctions, special rights for stocks outside TAC regulation, 5% of cod quota to coastal vessels, herring and sprat open quota because of underutilization
	2010	X			
	after 2010	X			
Estonia	2000-2009		X		Generally ITQ now
	2010		X		
	after 2010		X		
Finland	2000-2009				No IQ or ITQ in the fisheries in the open Baltic Sea
	2010				
	after 2010				
Latvia	2000-2009				
	2010				
	after 2010				

4.2 Rights allocation coastal waters

Some of the general regulations for fishermen fishing on the main species are also valid for the coastal fleets (basically within 12 sm – zone).

General regulations

The vessels with a cod quota are also subject to the regulations of the long term management plan for cod. This includes the requirement of a special permit, the days at sea regulation and the closed seasons (with exemptions).

Specifics for EU-MS

Coastal fisheries are very diverse in the Baltic Sea. In general we may define coastal fisheries via vessel length (below 12 m), area (inside 12 sm) or character as mixed fishery (coastal stocks (often fresh water species) and main species). In the table 4 below we summarize the specifics for coastal fisheries.

Table 4: Overview on catch allocation mechanisms in countries around the Baltic Sea for coastal fisheries

Country		IQ	ITQ	Effort limitation	Area rights	Add. Regulations/Comments*
Denmark	2000-2009	X	(X)			Vessels below 17 m are allowed to buy quota from vessels above 17 m but not vice versa
	2010		X			
	after 2010		X			
Germany	2000-2009	X		X		Effort limitations in coastal waters (maximum length in gill nets, number of trap nets and hooks)
	2010	X		X		
	after 2010		(X)	X		
Sweden	2000-2009			X		Closed areas for certain fishing methods in coastal waters
	2010	X	X	X		
	after 2010			X		
Poland	2000-2009					No quotas for coastal vessels
	2010					
	after 2010					
Lithuania	2000-2009					Quota allocation from records of catches in a three year period, 5% of cod quota to coastal vessels, possible to buy quota via auctions, permit esp. for coastal waters
	2010	X				
	after 2010	X				
Estonia	2000-2009		X			Some specifics in coastal waters
	2010		X		(X)	
	after 2010		X		(X)	
Finland	2000-2009				(X)	Permits for certain areas (private property rights on this area)
	2010				(X)	
	after 2010				(X)	
Latvia	2000-2009					
	2010					
	after 2010					

*Only additions to list in Table 3.2.

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FishSTERN

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A first attempt at an ecological-economic evaluation of fishery management scenarios in the Baltic Sea region

The aim of this subproject was to collect economic fisheries-related data, forming the basic input for a bio-economic model to simulate management scenarios for fisheries. Data from seven countries around the Baltic Sea were collected and put into the model. The modelling results indicate that fisheries in the Central Baltic Sea are only profitable if the fishing effort is low, given current stocks size and fishing fleet structure. However this result needs to be interpreted cautiously due to data-related problems. To improve such a fisheries-related ecosystem assessment, either the type of economic data needs to be improved or another economic approach needs to be applied. FishSTERN is a subproject within the BalticSTERN research network.

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