Final report

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Study on the remuneration of spawning stock biomass

(Call for tenders MARE/2008/11 – Lot 3)

by

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This report does not necessarily reflect the view of the European Commission and in no way anticipates the Commission's future policy in this area.

With the exception of the baseline statistics on 2005-7, all other figures in this report are results of the simulation model FISHRENT. The only correct interpretation is in relative comparisons between scenarios and indicators, but NOT in their absolute values. The model does not forecast the future, and certainly not for a period of 15 or 25 years. The model is a mathematical expression of generally accepted theoretical concepts. The model is a tool for consistent exploration and comparison of consequences of specific policy decisions. Therefore it may not be concluded, for example, that the nominal net profit of the various case study fisheries could reach the indicated values within the indicated period of time.

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LIST OF ACCRONYMS

AER	Annual Economic Report
Atl	Atlantic area
BER	Break-even revenue
Blim	Biomass - limit
Bpa	Biomass – precautionary approach
BS	Baltic Sea
GSA	Geographical sub-area
GVA	Gross value added
H	Current harvest ratio (catch / catchable biomass)
HCR	Harvest control rules
Hmsy	Harvest ratio at MSY level
Ht	Target harvest ratio
ITQ	Individual transferable quota
MAGP	Multi-annual Guidance Programme
Med	Mediterranean Sea
MEY	Maximum economic yield
MPA	Marine protected area
MSY	Maximum sustainable yield
NPV	Net present value
NPV GVA_{15}	Net present value of gross value added of the years 1-15 of the simulation
NPV Prf_{15}	Net present value of net profit of the years 1-15 of the simulation
NS	North Sea
Prf	Net profit
SSB	Spawning stock biomass
TURF	Territorial Use Right in Fisheries
VTQ	Vessel transferable quota

Fishing gears

DFN	Drift and fixed nets
DTS	Demersal trawl and seine
HOK	Gears using hooks
PG	Passive gears
PGP	Polyvalent passive gears
PTS	Pelagic trawl and seine
TBB	Beam trawl

EXECUTIVE SUMMARY

Main conclusions

The present study simulates recovery of stocks and elimination of overcapacity) of seven EU fisheries, which represented in 2005-7 about 20% of the EU fisheries production. The main results are presented in terms of net profit which is interpreted as an indicator of the level and trend of the resource rent.

The seven fisheries generated in 2005-7 annually a net profit of 212 mln euro with about 7,400 vessels. In the baseline scenario the total nominal net profit of these fisheries increases to 1 bln euro by year 15, while the fleet would be reduced to 5,700 vessels. Consequently, the net profit/vessel would increase by 520%. Despite the significant costs of such adaptation, the total annual average net present value of the net profit over the 15 years would be almost 500 mln euro, 130% more than the average profits of 2005-7. The average discounted net profit per vessel would be over the 15 years 200% higher than in 2005-7

The scenarios indicate that the structure of the fleets involved in the various fisheries would change, in some case even very significantly, towards the relatively more efficient segments. This implies that significantly higher earnings would be shared among a smaller group of beneficiaries.

It must be stressed that the calculation of net profit is based on data which is far from satisfactory and consequently far reaching assumptions were unavoidable. However, the scenarios confirm that significantly better economic performance can be achieved in the EU fisheries sector in general. The potential for improvements is very different in different fisheries. The study demonstrates that management policies must be tailored to the nature of the fisheries and that one panacea does not exist.
It cannot be concluded that more restrictive policies would in general lead to better economic results. The scenarios show that structural changes in the fleet composition are one of the drivers of higher profits. This implies that promotion of economic efficiency and optimization of the fisheries contribution to the EU economy calls for creation of conditions within which the vessel operators will be able to adapt flexibly to the existing fishing opportunities within the long term sustainability constraint.

Terms of reference

The objective of this study is to establish an analytical approach to estimate the potential resource rent and apply it to a number of case study fisheries, which are representative for the total EU fisheries sector. In this way the study demonstrates to which extent it is desirable and feasible to pursue policies aiming at exploitation of fish stocks at the levels of maximum sustainable yield (MSY) or maximum economic yield (MEY).

The terms of reference of the study are:
1. To examine possible alternatives (e.g. MSY, MEY) for estimating the resource rent in EU fisheries;
2. To identify and use bio-economic model(s) suitable for estimation of resource rents;
3. To apply the analysis to a range of fisheries, representing the EU diversity;
4. To explore the impact of a range of interest rates for net present value;
5. To estimate potential resource rents for the current fleets and for a fleets without overcapacity.
6. To assess costs of management and the feasibility of their recovery.

Theoretical background

Apart from the Introduction, the report is composed of 9 chapters. Chapter 2 presents the theoretical background to the study in two respects – the theory of the resource rent and the state-of-art in bio-economic modelling of the resource rent. The resource rent is reviewed in a broader scope, beyond the simplified static single species approach. It is demonstrated that in a multi-species situation a unique MSY or MEY may not exist and 'political' choices are required, affecting fishermen as well as fish stocks. Benefits of fish production are interpreted also in relation to welfare economics and producer and consumer surplus. Making a direct link of these two concepts to the resource rent is not possible, which shows that resource rent may be a too narrow concept in relation to welfare. Finally, the role of the fisheries sector is interpreted within input-output analysis. This brief review leads to the conclusion that benefits of fish production to the society need to be evaluated in a broader context. However, not all of these considerations could be applied empirically. The study takes fully into account the multi-species multi-fleet character of most EU fisheries, but considerations of welfare economics and input-output analysis are not included.

Resource rent is usually related to 'above normal profits', which can be extracted by the society as remuneration of a natural resource. These above normal profits are at present divided between capital and labour, as a result of historically established agreements, i.e. the remuneration of crews on share basis. In chapter 2 this study argues that it is the total 'benefits to the society' obtained from the natural resource which matter. How these benefits should be divided between labour, capital and resources (or royalties paid to society) is a political question, to which economics cannot give an answer. Following the request of the European Commission the study uses the net profit as the main benchmark of the resource rent.

Second part of chapter 2 is related to bio-economic modelling. Five potentially relevant bio-economic models were reviewed and compared on a large number of criteria. It was concluded that these models fell short of the terms of reference of the present study. On the basis of experiences with these models a new bio-economic model was developed which integrates a number of specific features:

- Ability and flexibility to deal with multi-species / multi-fleet situations;
- Simulation and optimization;
- Input and output driven fisheries management policies;
- Independency and full feedback between biology (stock-growth function), economics (production function) and behaviour (investment function);
- Tailored to the available data from DCF and ICES.

The model (called FISHRENT) simulates values of biological and economic variables and shows explicitly the consequences of different policy decisions. The calculations are based on a 3-year average of 2005-7 and the simulation runs for a period of 25 years, although only the first 15 years are used for the analysis. The main result of the model is the net present value of net profit and gross value added calculated for the first 15 years of the simulation. The model generates also a variety of other indicators, e.g. size of stocks and fleets, production costs, catches and landings.

To deal fully with the points 3-6 of the terms of reference 14 scenarios were designed for model simulations:

- Six scenarios (1-6) deal with different management approaches, based on TACs, effort and open access. The scenario which is closest to the present management regime is selected as the 'baseline' scenario and is used as benchmark and basis for the scenarios 7-14;
- Two scenarios (7-8) deal with application of different discount rates;
- One scenario (9) addresses the consequences of the recovery of management costs;
- Five scenarios (10-14) evaluate the net profit generated by fleets without overcapacity under different adaptation paths. Two of these scenarios are based on maximization of the net present value of net profit and of gross value added.

EU overview

The analysis has been implemented in seven case study fisheries:

1. North Sea flatfish
2. North Sea cod
3. Baltic Sea cod
4. Atlantic hake
5. Atlantic anchovy
6. Mediterranean anchovy (GSA 16)
7. Mediterranean hake (GSA 9)

These case studies reflect the varieties of policies (input and output management), gears (passive and active), vessel sizes (<12m as well as >40m) and species (demersal, pelagic, benthic).

Chapter 3 summarizes the results of the seven case studies, presenting an overview at EU level. It shows the role of the case study fisheries within the total EU fisheries sector and integrates the results of the 14 scenarios.

The case studies represent approximately 20% of the value and volume of EU fisheries production in the period 2005-7, 10% of the number of vessels, 20% of gross tonnage (GT) and 26% of net profit. They cover fisheries of 10 Member States, representing 11% in Italy, 80% in Belgium and between 34% and 62% in the other eight MS. The multi-species character of these fisheries follows clearly from the role which the identified target species play in the total revenues, which range from about 20% to 50%.

Most of the quantitative analysis is based on data for 2005-7 collected under the Data Collection Regulation (Reg. 1639/2001).

Information on management costs has been drawn from several sources and estimates have been made accordingly. OECD data 2004-2006 was used as a primary source. This data was compared to the budgets of EFF priority axis 1, data collection and research and costs of management, enforcement and control, obtained from various sources. The relevant EU costs were estimated at a total of almost 1.4 billion euro per year. They were allocated to the individual fleet segments in the different fisheries, using their share in production value of the national fisheries.

At EU level the case study results of the different scenarios were compared using three indicators: nominal 15-year average net profit, nominal net profit in year 15 and discounted 15-year average net profit. Furthermore, dynamic comparison is presented in trends of nominal net profit, fleet and profit/vessel.

The results are consistent with the theoretical expectations. They illustrate that different fisheries need to be managed differently in order to achieve an improvement from the current situation. Restrictive policies may be expected to produce positive results in the North Sea and Baltic Sea fisheries, but much less in the Atlantic and the Mediterranean, because restrictions on target species significantly affect the revenues from 'other' (non-target) species. The analysis illustrates that there is not one single measure of rent. Even considering only one indicator, namely net profit, produces analytical nuances. In most fisheries, restrictive measures will in the end lead to recovery of the economic performance, reduction of the size of the sector and concentration of benefits among a smaller number of vessel owners and fishermen. However, optimum benefits (maximum net profit or gross value added) can be only achieved if the fleet is able to react flexibly to the new fishing opportunities and allowed to grow along with the stocks. Some segments are more efficient than others and generate relatively higher profits. This means that redistribution of the fishing opportunities among the segments towards the more efficient ones will increase the profits further.

Discount rates can be used either to compare different streams of benefits (profits) or to compare the profits of year 15 with the year 1 (situation in 2005-7). The simulations use a basic discount rate of 3.5%. Sensitivity analysis shows that application of a discount rate of 5% reduces the net present value of net profits (NPV Prf_{15}) by 10-14%. On the other hand a lower discount rate of 2% increases the NPV Prf15 by 11-18%. Comparing the Prf in 2005-7 to the discounted Prf in year 15 appears to be rather sensitive to the value of the discount rate. This sensitivity is illustrated by the calculation of a 'break-even' discount rate, which ranges approximately between -1% and +10%.

Simulations of imposition of recovery of management costs conclude that impact on fleet behaviour (investments) is rather limited and consequently the net profit before cost recovery is not affected. Evidently, this result is determined by the selected level of cost recovery, and should this level be increased, the impact may change.

Five scenarios of different adaptation paths towards fleet without overcapacity were tested. Three of these scenarios deal with elimination of technical capacity, distinguishing between instantaneous adaptation and gradual adaptation. The instantaneous adaptation of effort takes place either through the number of vessels or through the number of days at sea per vessel. The last two scenarios optimize NPV GVA_{15} and NPV Prf_{15}. Result of scenario 14 can be interpreted as MEY. Results of the scenario 13 reflect the contribution to GNP.

The results of the scenarios 10-12 eliminating technical capacity are very similar. Five out of seven fisheries do not produce significantly higher NPV Prf_{15} than the baseline scenario, exceptions being NS flatfish and Mediterranean anchovy. This means that approaches like a 'one-off scrapping scheme' may not produce a significantly better result than a continuation and full implementation of the present management.

The level of flexibility assumed under the two optimization scenarios is far from realistic. The optimization scenarios mostly lead to the highest aggregate profits, but not necessarily highest profits per vessel. This illustrates that private and public interests are not served with the same policy approach. In general, elimination of overcapacity leads to higher profits and smaller fleets, i.e. greater benefits are reaped by a smaller group of producers. Overcapacity may be eliminated by scrapping or by an autonomous process of strict imposition of TAC or effort restrictions. The public costs of scrapping schemes have not been included in the analysis. This would certainly reduce the attractiveness of scenarios 10 and 12 compared to other options.

Case study results

Chapters 4-10 present the individual case studies. Each case study describes first the present situation in terms of definitions of fleet segments, their dependence on specific species and their economic indicators. Management of each fishery is analysed by reviewing the existing input and output measures, including property rights. The main part of each case study is devoted to the elaboration of the 14 scenarios to determine the potential net profit. The scenarios are based on different runs of the FISHRENT model.

It is important to stress that the FISHRENT model generates scenarios under an explicit set of assumptions (e.g. the selected form of the mathematical relations) and does not forecast the future. The value of the scenarios lies in their mutual comparisons and in precise identification of the required political choices and their relative consequences.

The core question of this study is whether well managed fisheries and recovered stocks will generate a higher resource rent, using net profit as a proxy. For this purpose a detailed analysis of various management approaches and fleet adaptations paths has been carried out in the case studies. The main results are summarized below as follows:

- Static comparison of net profit of 2005-7 and nominal (i.e. not discounted) net profit realized in year 15 of the simulation. This comparison shows the potential improvement of the performance of the sector, but it disregards the costs which must be born in the initial period as fishing effort has to be reduced to allow the stocks to recover.
- Dynamic comparison of net profit 2005-7 with an average net present value of net profit over a period of 15 years (average NPV Prf_{15}). This simplified comparison accounts for the costs and benefits of the entire simulation period.
- Apart from net profit, also comparisons of the size of the fleet and the performance per vessel in the different situations are presented. Size of the fleet is also a proxy for employment. Net profit / vessel indicates how much the efficiency of the fleet would increase and consequently the potential for imposition of payment for access, i.e. recovery of resource rent.

It must be repeated that all results presented below are based on the simulation runs of the FISHRENT model and should be interpreted in the light of the detailed discussion presented in the main part of the report. All relevant figures are presented in table 0.1.

North Sea and Baltic Sea fisheries

The baseline scenarios for the North Sea and Baltic Sea fisheries indicate that TAC min policy would lead to a significant increase of the net profits. In 15 years the net profit of these 3 fisheries could increase from about 140 mln euro in 2005-7 to about 840 mln euro. At the same time the size of the fleet would be reduced from 4,600 vessels to 3,600 vessels.

The static comparison conceals the importance of the costs which have to be born in order to achieve the indicated improvement. The average NPV Prf_{15} is estimated at 370 mln euro, i.e. an average increase of annual net profit by 160% from 2005-7. The average NPV Prf_{15} per vessel would increase by 240%.

In these fisheries, comparison of the baseline and the optimisation scenario shows that part of the potential resource rent may remain unexploited if too strict fleet policies are followed.

Atlantic fisheries

In the two Atlantic fisheries net profit generated in year 15 in the baseline scenario would be over 100 mln euro, i.e. 320%, higher than the net profit of 2005-7, while the fleet would be reduced by 26%. Net profit per vessel would be in the year 15 about 470% higher than in 2005-7.

The dynamic comparison shows that, when adaptation costs are accounted for, the average NPV Prf_{15} would be about 160% above the level of 2005-7. The average NPV Prf_{15}/vessel would be about 260% higher than in 2005-7.

Mediterranean fisheries

The two Mediterranean fisheries which have been analysed show a much more mixed picture than the five fisheries discussed above. Profits of anchovy fishery remain overall at a constant level, in terms of nominal and net present value. The average NPV Prf_{15} of the hake fishery would deteriorate.

In total in year 15 the net profit in Mediterranean fisheries would be approximately equal to 2005-7As the number of vessels would fall by little over 20%, the average net profit/vessel would be about 45% above the 2005-7 level.

The dynamic comparison shows that the average NPV Prf_{15} would be 17% lower than in 2005-7. The productivity per vessel would remain constant.

Final comments

The simulations indicate clearly that different fisheries need to be managed with different means, due to the differences in their structure in terms of composition of fleets and catches.

Significant improvements of performance can be achieved in the long term, although the short term costs (in terms of reduction of fishing effort, catches and revenues) are in some cases significant.

Analysis of the report is based on net profit as a proxy of the resource rent, assuming that the capital value and costs provided under DCR are representative. An estimation of the resource rent in its original meaning, accounting for 'normal profit' with adapted capital costs is presented in Annex 3.

Figure 0.1 Comparison of net profit, fleet and net profit/vessel in the baseline and optimisation scenarios 13 and 14 in relation to 2005-7

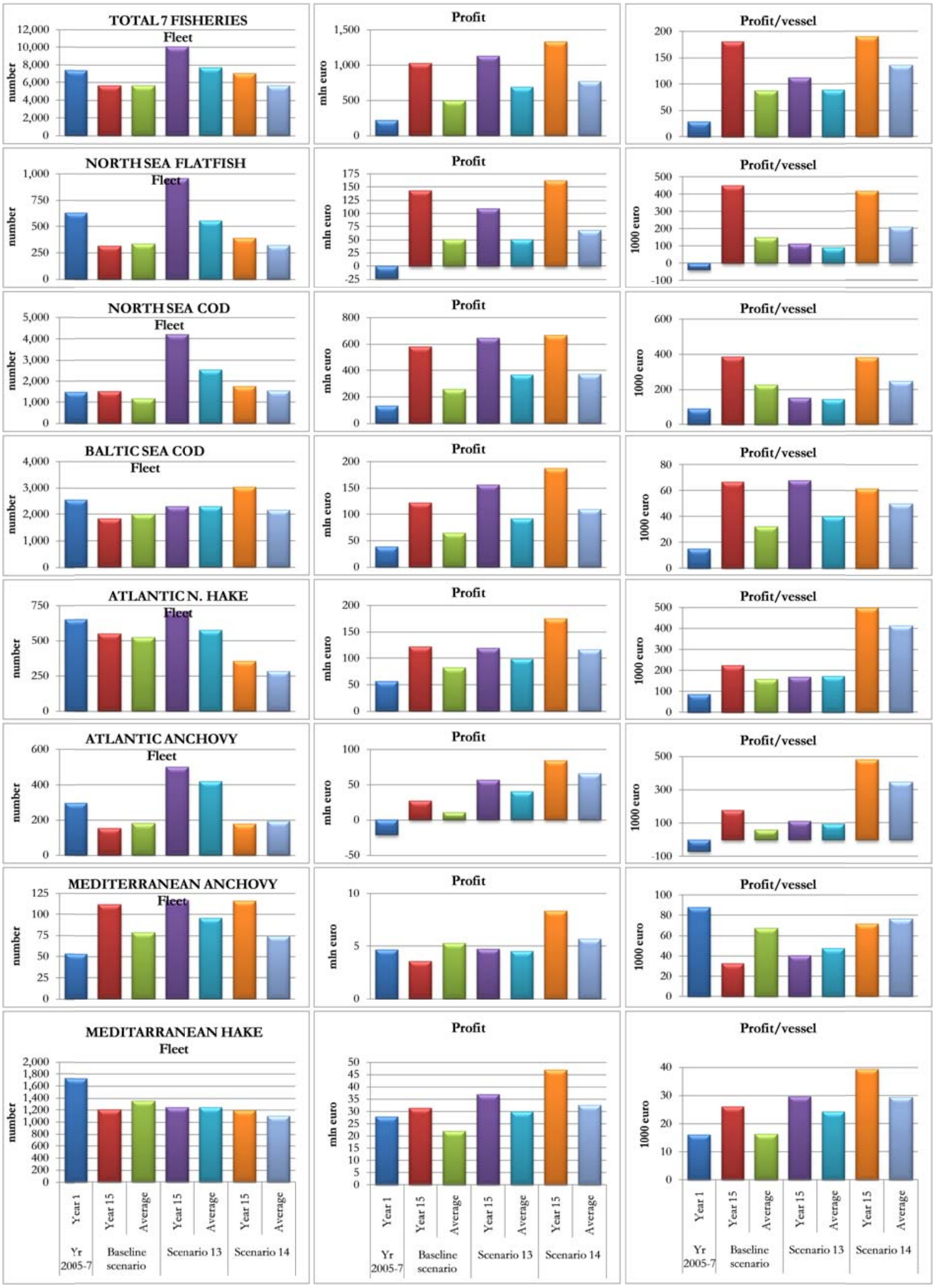

Table 0.1 Comparison of net profit, fleet and net profit/vessel in year 2005-7, baseline scenario and optimisation scenario 14.

	Year 2005-7	Baseline scenario		Optimisation scenario 14		Baseline scenario		Optimisation scenario 14	
Net profit	Million euro					Index (Year 2005-7=100)			
		Nominal year 15	Average NPV Yr 1-15	Nominal year 15	Average NPV Yr 1-15	Nominal year 15	Average NPV Yr 1-15	Nominal year 15	Average NPV Yr 1-15
NS flatfish	-24	143	50	162	67				
NS cod	130	577	259	667	373	443	199	512	286
BS cod	38	122	65	187	109	319	169	491	285
- Sub-total NS + BS	*144*	*842*	*374*	*1,016*	*549*	*583*	*259*	*704*	*380*
Atl. hake	56	121	81	175	116	217	146	314	208
Atl. anchovy	-21	27	11	84	66				
- Sub-total Atlantic	*35*	*148*	*92*	*260*	*182*	*424*	*264*	*743*	*520*
Med. anchovy	5	4	5	8	6	77	114	180	122
Med. hake	28	31	22	47	32	112	78	167	116
- Sub-total Mediter.	*33*	*35*	*27*	*55*	*38*	*107*	*83*	*169*	*117*
Total 7 fisheries	212	990	462	1,331	769	467	218	628	363
Fleet	Number of vessels					Index (Year 2005-7=100)			
		Year 15	Average Yr 1-15	Year 15	Average Yr 1-15	Year 15	Average Yr 1-15	Year 15	Average Yr 1-15
NS flatfish	626	317	338	958	552	51	54	153	88
NS cod	1,475	1,506	1,148	4,214	2,536	102	78	286	172
BS cod	2,533	1,828	2,001	2,304	2,295	72	79	91	91
- Sub-total NS + BS	*4,634*	*3,651*	*3,487*	*7,476*	*5,383*	*79*	*75*	*161*	*116*
Atl. hake	650	547	522	705	573	84	80	108	88
Atl. anchovy	295	153	179	498	419	52	61	169	142
- Sub-total Atlantic	*945*	*700*	*701*	*1,203*	*992*	*74*	*74*	*127*	*105*
Med. anchovy	53	112	157	116	191	211	296	219	360
Med. hake	1,729	1,204	1,354	1,244	1,243	70	78	72	72
- Sub-total Mediter.	*1,782*	*1,316*	*1,511*	*1,360*	*1,434*	*74*	*85*	*76*	*80*
Total 7 fisheries	**7,361**	**5,667**	**5,699**	**10,039**	**7,809**	**77**	**77**	**136**	**106**
Net profit/vessel	1000 euro					Index (Year 2005-7=100)			
		Nominal year 15	Average NPV Yr 1-15	Nominal year 15	Average NPV Yr 1-15	Nominal year 15	Average NPV Yr 1-15	Nominal year 15	Average NPV Yr 1-15
NS flatfish	-39	450	149	169	122				
NS cod	88	383	226	158	147	434	255	179	167
BS cod	15	67	32	81	47	442	214	539	314
- Sub-total NS + BS	*31*	*231*	*107*	*136*	*102*	740	344	436	328
Atl. hake	86	221	156	249	203	258	182	290	236
Atl. anchovy	-71	177	60	170	157				
- Sub-total Atlantic	*37*	*212*	*132*	*216*	*183*	572	356	584	495
Med. anchovy	87	32	34	72	30	37	38	82	34
Med. hake	16	26	16	38	26	161	100	233	162
- Sub-total Mediter.	*18*	*26*	*18*	*40*	*27*	145	98	222	146
Total 7 fisheries	29	175	81	133	98	607	282	461	342

Note: it is not possible to calculate indexes of series with changing signs.

Table 0.2 Comparison of the effect of different policies on average NPV Prf_{15} and the average net profit in 2005-7in the 7 fisheries (mln euro)

Scenarios	North S. flatfish	North S. cod	Baltic S. cod	Atlantic hake	Atlantic anchovy	Medit. anchovy	Medit. hake
Average 2005-7	-24	130	38	56	-21	5	28
Average NPV Prf 15							
1. TAC min	50	259	65	81	7		
2. Effort min	48	251	79	74	11	5	22
3. TAC max	0			60	21		
4. Effort max	-1			40	23	6	-2
5. Open access	-2	177	34	22	23	6	-2
6. Min min	62	258	64	81	7		
7. Discount rate 2% 2%	50			81	11	5	22
8. Discount rate 5%	50			81	11	5	22
9. Recovery mgt. costs	53	259	65	79	11	6	22
10. Static present fleet	13	242	56	62	0	5	18
11. Static minimum fleet	37	239	66	85	4	5	18
12. Dynamic minim. fleet	61	264	68	97	16	5	26
13. Optimum fleet (GVA)	51	367	91	99	40	4	30
14. Optimum fleet (profit)	67	373	109	116	66	6	32

SUMMARY FOR NON-SPECIALISTS

Fish stocks are a renewable natural resource. Exploitation of fish stocks generates benefits to the society, either in the physical form of food or in monetary form of income. A rational fisheries management should maintain the fish stocks at a relatively high sustainable level and it should promote an economically efficient exploitation, avoiding excessive investments and its undesirable consequences.

The objective of the present study is to determine what benefits could be generated from the EU fish stocks and how. It is expected that higher catches could be realized in the long run if the stocks would be able to recover. Such recovery is only possible if fishing pressure (catches) would be reduced in the short run. Lower catches mean evidently lower earnings for the fishing fleets. The decrease in earnings can be considered as investment, which will be earned back by higher production in the future.

The study presents a quantitative analysis of these processes – interactions between fishing fleets, fish stocks and management measures. A mathematical model (FISHRENT) was developed for this purpose. The model is based on real statistical data for the period 2005-7 and generates simulations of 15-25 years. The model is a tool for exploration of scenarios, evidently it does not forecast the future.

In total 14 scenarios were designed to deal with the terms of reference of this study. Six scenarios reflect different management regimes, based on restrictions of catches, fishing effort or leaving the fishery free. Two scenarios evaluate the consequences of different discount rates, i.e. different ways to account for benefits obtained only in the (distant) future. One scenario assumes that the costs of fisheries management would be charged to the catching sector and evaluates the consequences of a cost recovery regime. Finally, four scenarios consider how much the benefits would increase if fleet overcapacity would be completely eliminated.

The model and the 14 scenarios are applied to seven EU fisheries, whose variety reflects the realities of the EU catching sector. These fisheries differ in terms of size of vessels, types of gears, regions, exploited species and management regimes.

Main conclusions

The main conclusions of the study can be summarized as follows:

- There is not one single way to measure the benefits of fish stocks to the society. Higher production of food may not lead to the highest creation of income. And income (i.e. access to fish stock) allocated to one part of the fishing industry may be at the expense of another part.
- In a multi-species fishery, where a group of fleets exploit several fish stock concurrently, it is unlikely that all stocks can be exploited at their maximum potential level. Allowing one stock to grow implies that other stocks may be constrained, or even depleted.
- Instantaneous elimination of overcapacity does not lead to significantly higher benefits than its gradual elimination and continuation of the existing management regime, assuming it is fully implemented.
- The simulations confirm that unmanaged open access fisheries are not sustainable and produce low benefits to the society.
- In order to pursue optimum benefits from the fishery resources to the society, explicit political objectives need to be formulated allowing for a definition of a proper benchmark against which the benefits should be measured.

The present study simulates recovery of stocks and elimination of overcapacity) of seven EU fisheries, which represented in 2005-7 about 20% of the EU fisheries production. The main results are presented in terms of net profit which is interpreted as an indicator of the level and trend of the resource rent.

The seven fisheries generated in 2005-7 annually a net profit of 212 mln euro with about 7,400 vessels. In the baseline scenario the total nominal net profit of these fisheries increases to 1 bln euro by year 15, while the fleet would be reduced to 5,700 vessels. Consequently, the net profit/vessel would increase by 520%. Despite the significant costs of such adaptation the total annual average net present value of the net profit over the 15 years would be almost 500 mln euro, 130% more than the average profits of 2005-7. The average discounted net profit per vessel over the 15 years would be 200% higher than in 2005-7

Taking into account the assumptions made, the scenarios show that overall major improvements of the economic performance in EU fisheries could be achieved. Evidently, significant differences between the different fisheries exist, which leads to different conclusions on potential for improvement as well as appropriateness of various management approaches. It cannot be concluded that more restrictive policies would in general lead to better economic results. The scenarios show structural changes in the fleet composition. This implies that promotion of economic efficiency and optimization of the fisheries contribution to the EU economy calls for creation of conditions within which the vessel operators will be able to adapt flexibly to the existing fishing opportunities within the long term sustainability constraint.

1. INTRODUCTION

1.1. Objective and terms of reference

The objective of the study is to establish an analytical approach to estimate the potential resource rent and apply it to a number of case study fisheries, which are representative for the total EU fisheries sector. In this way the study demonstrates to which extent it is desirable and feasible to pursue policies aiming at exploitation of fish stocks at the levels of maximum sustainable yield (MSY) or maximum economic yield (MEY).

The terms of reference of the study were specified as follows:

1. To examine possible alternatives for estimating the resource rent in EU fisheries, using different targets of sustainability (e.g. MSY, MEY);
2. To identify and use bio-economic model(s) suitable to estimate resource rents in EU fisheries, by appropriately allocating resource rents between fish stocks and fleet segments that exploit those stocks;
3. To give practical case studies for a range of EU fishery and fleet types, using different management regimes (e.g. effort regulation, TAC regulation, individual transferable quotas).
   There shall be 2 cases per each of the following geographical areas: Baltic/North Sea, Atlantic, and Mediterranean/Black Sea and shall represent the diversity of EU fisheries and fishing fleets, and cover a mix of:
   - Active and passive gears
   - Demersal, pelagic and benthic fisheries (single species, multi-species)
4. To explore the impact of a range of interest rates for net present value, applied to the practical cases above.
5. An estimation of potential resource rents for each case should be assessed for the current fleet and for a fleet size without overcapacity.
6. Assess costs of management of each case (e.g. fisheries administration, control and enforcement, research, subsidies) and assess to what extent successfully generated and extracted resource rents can cover these costs. Also, to what extent could additional rents be captured by society (e.g. as a payment for resource use?

The report is structured as follows. After the Introduction, chapter 2 presents the theoretical background along with a variety of considerations and assumptions, required to develop an empirical application of the concepts of resource rent, MSY and MEY. The chapter presents a brief review of the main bio-economic models and compares them to the model FISHRENT which was developed for the purpose of this study. The chapter 2 also discusses topics related to valuation (shadow pricing), uncertainty and discount rates. Finally, chapter 2 describes the logic of the 14 scenarios which were elaborated for each case study in order to highlight various aspects of the determination of the resource rent. Chapter 2 shows that in a multi-species multi-fleet situation, which is characteristic for most EU fisheries, one single optimum (maximum) resource rent cannot be determined without subjective value judgements (e.g. political preferences). The last part of chapter demonstrates that political choices must be made in terms of species to be protected, fishing fleets to be restricted and time within which specific conservation goals should be achieved. The bio-economic model which was developed for the purpose of this study shows explicitly the quantitative consequences of such choices.

Chapter 3 summarizes the results of the seven case studies and puts them in EU-wide context. It shows the role of the case study fisheries within the total EU fisheries sector and integrates the results of the 14 scenarios runs in terms of which they are analysed.

Chapters 4-10 present the individual case studies. Each case study describes first the present situation in terms of definitions of fleet segments, their dependence on specific species and selected economic indicators. Management of each fishery is analysed by reviewing the existing input and output measures, including property rights, as far as relevant. The main part of each case study is devoted to the elaboration of 14 scenarios to determine the potential resource rent. The scenarios are based on different runs of the

FISHRENT model. The model generates the net present value of net profit, used as the main proxy for resource rent. The model also shows the adaptation paths of stocks, fleets and their various indicators of economic performance.

The first six scenarios reflect the different types of policy – i.e. input or output driven and the level of restrictions imposed (high or low). One scenario simulates an open access fishery. The policy scenario which is closest to the present practice is selected as a 'baseline scenario', to which the results of other scenarios are compared. Scenarios 7 and 8 analyse the consequences of different time preferences, expressed in different discount rates compared to the baseline. Scenario 9 compares the resource rent of the baseline scenario to the estimated management costs and evaluates consequences of costs recovery. Finally, scenarios 10-13 simulate different approaches to achieving an optimum result, in terms rapid (instantaneous) or gradual adaptation of fishing effort and consequently faster or slower recovery of stocks. Not all scenarios are relevant for each case study, but consistent numbering has been maintained throughout for easier comparisons.

It is important to stress that the FISHRENT model generates scenarios under an explicit set of assumption (i.e. the selected form of the mathematical relations) and does not forecast the future. The value of the scenarios lies in their mutual comparisons and in precise identification of the required political choices and their relative consequences.

The report is completed with two annexes. Annex 1 presents a detailed description of the FISHRENT model, how it can be used and the procedures for its adaptation to the different 'sizes', in terms of number of fleet segments and species. Annex 2 contains details of management costs by MS.

2. METHODOLOGY

2.1. Theory of resource rent

In theoretical textbooks, determination of the resource rent is usually based on simple examples of single species, single fleet situations, which produce one neat optimum. However, the reality is a little more complex and attempting to determine one simple optimum proves rather elusive. This section discusses therefore several issues which are relevant in general, although not all have been applied for the purposes of this study:

- Single species / single fleet situation is presented to show the basic concept.
- Multi-species situation shows that an optimum may not be socially or environmentally acceptable. This example highlights the limits of scientific contribution to policy preparation and the need for political decisions.

Static single species case

The general concept of resource rent and the relation between MSY and MEY is illustrated in Figure 2.1. In many EU fisheries the level of fishing effort lies to the right of MSY. Theoretically, production volume and value could be increased while production costs could be reduced by reducing fishing effort. This concept has been formulated by Warming[1] already in 1911, Gordon (1954)[2] and many other authors since then. MEY is the level of production at which maximum resource rent could be collected by the society in a well-managed fishery.

Fishing effort at MEY level lies below the MSY-level. Although physical production is lower, it is conventionally assumed that the accompanying lower fishing effort and consequently lower costs and higher productivity more than off-set the loss in physical production and lead to a higher resource rent (bold line at MEY). However, the static approach assumes implicitly a low discount rate, i.e. a weak time preference. If a high discount rate would be assumed, than the MEY fishing effort would be higher than the effort at MSY level because the fishing fleet would not only take the yield of the stock, but also part of the stock itself.

Although the Figure 2.1 clearly represents the concepts of MSY and MEY, the far reaching simplification does not do justice to the complex reality. Figure 2.1 reflects a single species, static situation. In reality, several species, with different economic and biological characteristics are caught at the same time. The stock abundance as well as prices of fish and inputs change from year to year. Adjustment of the fleet and fishing effort takes place gradually and is not costless. If the duration of adjustment and time preferences are taken into account it may not be beneficial to reduce effort in the short run. It will take a number of years for the stocks to recover and to produce a higher yield. In a dynamic evaluation, the costs of recovery, in terms of income foregone in the short run must be compared to the benefits in the long run. (See Conrad and Clark (1994, p. 75)[3] for "the golden rule" of capital accumulation, and Clark, Clarke and Munro (1979)[4] for irreversible investments.)

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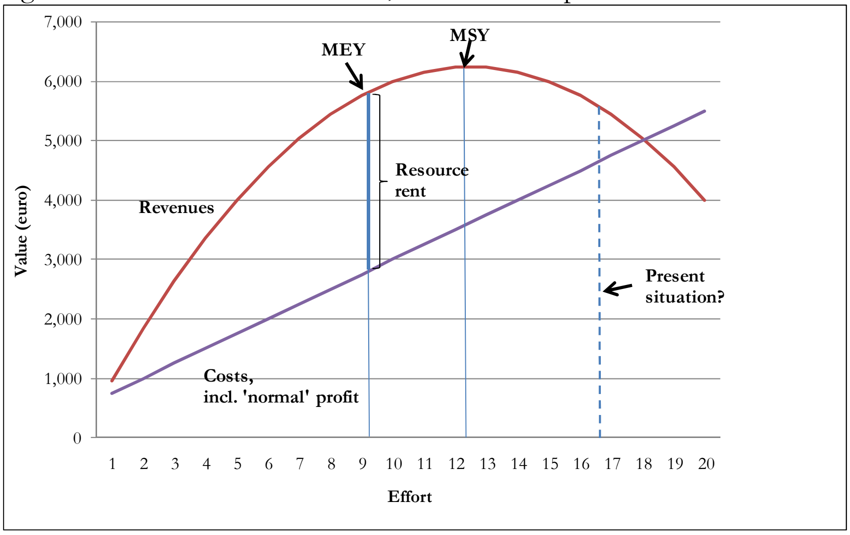
[1] Warming, J. (1911), Om grundrente af fiskegrunde, Nationaløkonomisk Tidsskrift, 49, 499-505.

[2] Gordon, H. Scott (1954): The economic theory of a common property resource: the fishery. *Journal of Political Economy* 62: 124-142.

[3] Conrad, J. M. and C. W. Clark (1994) *Natural resource Economics*. First printed 1987, Cambridge University Press.

[4] Clark, C. W., F. H. Clarke and G. R. Munro (1979) The Optimal Exploitation of Renewable Resource Stocks: Problems of Irreversible Investment. *Econometrica* 47: 1, pp. 25-47.

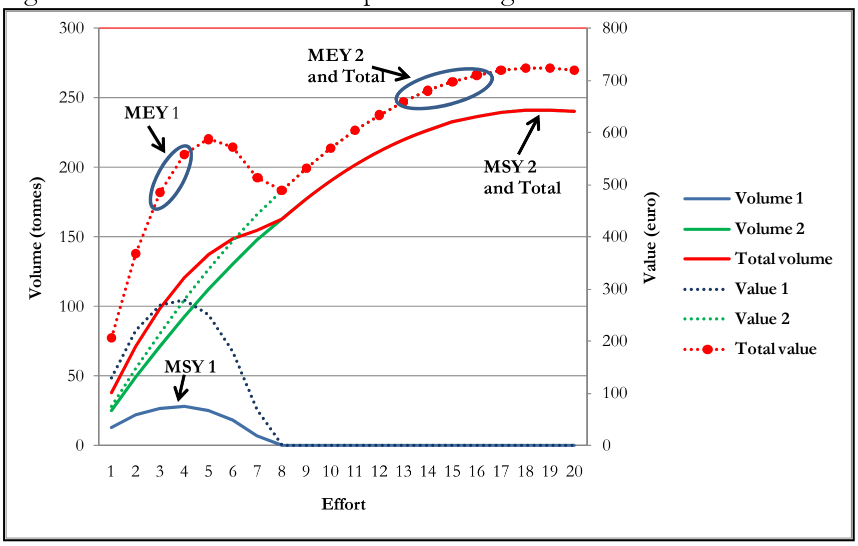
Figure 2.1. Relation between MSY, MEY and the present situation



Static multi-species case

Management of two species with very different biological characteristics may offer a single best solution to MSY and MEY, but as illustrated in Figure 2.2 solution may not be socially or environmentally acceptable. The situation in Figure 2.2 assumes that the management area contains two species. Species 1 is a small stock of highly priced fish, but very vulnerable to overfishing and even extinction. Species 2 fetches a much lower price, but the stock is large and if fully exploited can deliver higher contribution to the economy (MEY2), greater production of food (MSY2) and as the fishing takes place at a much higher level of effort, it may also offer more employment. Price for this increase in 'welfare' is that species 1 is (almost) completely fished out.

Figure 2.2. Dilemmas of multi-species management



The multi-species situation in Figure 2.2 illustrates the scope of political decisions required to determine an optimum – food production, employment and income versus maintenance of environmental integrity.

Dynamic case

The above presented single- and multi-species cases are static. They do not account for different adaptation paths which follow from the policy measures taken, biological characteristics of species and behaviour of fleets.

Figure 2.3 is based on scenarios 1 and 3 of the NS flatfish fishery. It shows that one fishery may develop quite differently depending on the management policy. Which approach produces the highest resource rent over a given period can be estimated using the net present value method, which 'reduces' the streams of resource rent of each case to one single value. The net present value depends on the selected discount rate and on the time horizon. Table 2.1 shows that scenario 1 produces the highest net present value with a 15 year time horizon under both discount rates, but at 10% its advantage is lower. Setting the time horizon at 8 years and discount rate at 0%, scenario 3 would produce higher resource rent.

Table 2.1 Effect of discount rates and time horizon on the net present value of the two scenarios

	Time horizon 15 years		Time horizon 8 years	
Discount rate	0%	10%	0%	10%
Scenario 1	3,045	1,380	1,204	866
Scenario 3	2,268	1,161	1,275	844

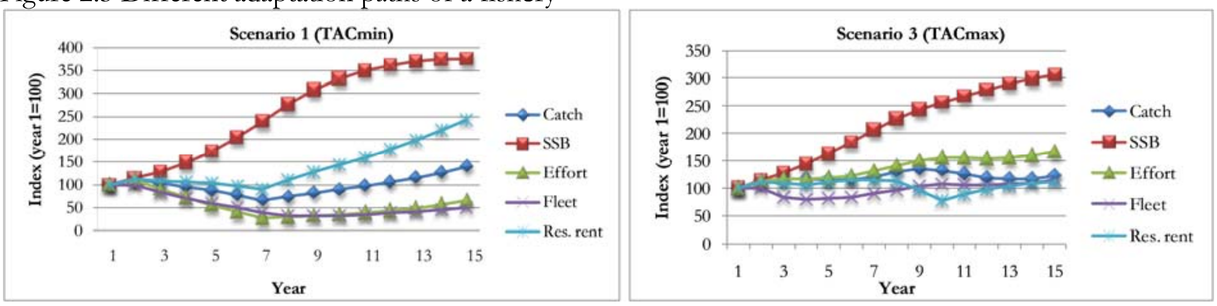
Figure 2.3 illustrates that several other considerations may be taken into account when deciding which policy should be followed:

- Income distribution: scenario 3 maintains a larger size of the fleet throughout the entire period. This implies that a larger number of fishermen can share in the benefits of the resource.
- Final outcome: at the end of the 15 years scenario 1 leads to larger SSB and higher resource rent but lower employment.

To account for such considerations quantitatively requires the use of shadow prices. The problems related to them are discussed in section 2.4.

Consequently, the level of effort which produces the highest MEY, compared to the present situation, is not a-priori uniquely determined, contrary to the impression created by the single species case. It may change according to the assumptions made (e.g. expectations of stock recovery and fleet behaviour) and it will fluctuate in time.

Figure 2.3 Different adaptation paths of a fishery



Choice of resource rent indicator

Resource rent is defined as the remuneration of the production factor 'fish stock'. In theory this is the amount of 'excessive profit', over and above the normal profit level which would be valid for the specific activity. This excessive profit is realized by the producers as they have exclusive access to the production factor fish.

Application of the theoretical concepts in an empirical analysis should take into account several considerations:

1. Relevance of theoretical assumptions.
2. Availability of data.
3. Feasibility of estimation of 'normal profit'.

4. Implications for policy advice.
These aspects are briefly discussed below.

Annex 3 presents an estimation of the resource rent of the seven fisheries making all required assumptions.

Ad. 1 Relevance of theoretical assumptions

The theory uses a production function in which the catch is a function of effort, i.e. homogeneous production factors (labour, capital and other inputs), and fish stocks. It is assumed that capital is owned by firms which pursue profit maximization. Labour availability is driven by utility functions, inter alia by choices between income and free time. This strengthens the clarity of the concept.

In empirical analysis the theoretical assumptions have to be tested and adaptations must be introduced if the assumptions do not hold sufficiently. The main issues to address are in general the lack of homogeneity.

Ad. 2 Availability of data

Calculation of profit requires reliable data on depreciation costs and capital value. Under DCR (2002-7) capital costs included depreciation and interest costs. However, various MS followed different approaches to estimate these two values. The same argument applies to the valuation of capital (called 'investment'). This problem has been addressed under the new DCF programme. However, DCF data was not yet available for the purposes and the present study and it would offer only one observation (namely 2008), while the present study uses a 3-year multi-annual average as baseline data to eliminate influences of short term fluctuations.

Apart from valuation of vessels and their equipment, there are two other assets which present specific statistical or empirical problems:

- Fishing rights: Value of fishing rights is included under DCF, but for 2008 not many MS have managed to provide it. In some MS the value of fishing rights is at least equal to the value of the vessels. At present a common approach to valuation of fishing rights has not yet been developed. It presents also specific problems.
  - When fishing rights (ITQs, effort allocations or licenses) are tradable then part of the 'rent' is included in the market prices, which makes them unsuitable for valuation purposes when resource rent is to be determined.
  - A market price does not exist for non-tradable fishing rights, although the value may be hidden in prices of vessels to which these rights are attached[5].
  - An approach to valuation of fishing rights will have to deal with the question whether all fishing rights should be valued or only those which have been actually acquired and not only obtained free of charge from the government. It can be argued that opportunity costs exist in both cases.
- Investments on shore: Particularly multi-vessels firm and firm operating larger vessels have assets (and personnel) on shore. Information on the value of these assets is not collected under DCF at all.

Ad. Estimation of normal profit

Obtaining an indicator of 'normal profit' depends on perceptions of risk, time preference, etc. Normal profit level (or opportunity costs of capital) is different in different economic sectors. Normal profit may be even different in different fleet segments. Finally, required profitability would have to be applied as a percentage of capital value, for which reliable data does not exist. Therefore estimation of 'normal profit' would have to be based on two figures, both being highly uncertain. Result of such calculation, making all necessary assumptions, is presented in annex 3.

[5] Guyader, O. et al. (2003). A hedonic analysis of capital stock in fisheries: the case of second hand market of the French fishing vessels. XVth EAFE Conference Proceedings. Ifremer, Brest.

The concept of profit, while simple in theory, is elusive in practice, i.e. in statistics. This is also the reason why Eurostat does not publish any data on profits realized in various economic sectors. The Structural Business Statistics do not contain an explicit definition of profit. The closest indicator in SBS is the 'Gross operating surplus', which is the difference between revenues and operational costs.

2.2. Bio-economic modelling

Relevance of existing models

An in-depth review of existing bio-economic models (developed in the EU) has been prepared under the project '*Survey of existing bio-economic models*'[6]. Of the 13 models which are discussed in the report, only few are concerned with the calculation of the resource rent. Detailed comparison of these models and FISHRENT is presented in Table 2.2.

The EIAA model (Economic Interpretation of the ACFM Advice) has been widely used to assess the economic consequences of the TAC/quota management of the EU[7]. The model is output driven. Extended version of the EIAA model developed in 2004 / 2005 contains a biological yield function (Ricker) and an economic production function (Cobb-Douglas) and allows estimation of maximum profit[8]. EIAA model is convenient as it is written in Excel. However, during the years of development of the model, it had become rather complex and difficult to understand and retrace how the various variables are linked. For this reason EIAA was not considered suitable to develop further for the purpose of this project.

BEMMFISH (Bio-economic Model for the Mediterranean Fisheries) is an input driven model developed for Mediterranean fisheries[9].

The World Bank/FAO study (WBF-model) is an output driven model. It generates the yield from the fish stocks as a function of the stock size. Based on the yield, the minimum effort to catch the yield at any stock size is calculated. By use of fish prices and effort costs the yield and effort that provides the largest profit is selected and the maximum resource rent (profit) is found. The WBF-model uses only "one stock" and "one fleet", all aggregated at the global level. It makes a point estimate of the 'rent' but it does not consider how and when this point could be reached and at which cost.

The EMMFIDD, the Swedish Resource Rent Model for the Commercial Fishery (SRRMCF model) and the Norwegian model are linear programming models that maximize profit (resource rent) subject to quota and catch constraints. These models are static but very detailed and flexible in terms of use of harvest control rules that can contain input as well as of output constraints. These models generate the fleet composition in terms of the number of vessels in each fleet segment that would maximize the resource rent.

Model requirements

On the basis of the review of models and the objective of the project, it became evident that a new model had to be constructed which would meet the following requirements:

- Integrate simulation (application of different management strategies) and optimization (determination of optimum value of resource rent and other variables). This is implemented by having a simulation model in which optimization can be achieved by using the Excel Solver.
- Integrate output- and input-driven policies, so that one model could be consistently applied to different situations in the EU, particularly in the Atlantic and the Mediterranean / Black Sea areas.
- Multi-species / multi-fleet, with flexible number of species and segments to be accommodated.

[6] AZTI et.al., *Survey of existing bio-economic models*, FISH, 2007/07, Final report April 2009
[7] Frost et al., 2009
[8] Frost et al. 2009, p.10-11.
[9] Guillen et al. 2004

- Close link to available economic and biological data, to allow empirical applications.
- Balanced construction between various components: biology-economics-policy.
- Dynamic behaviour, including investment and effort functions, to allow simulation of adjustment paths to an optimum.
- Flexibility for applications of various types of relations which play an important role in any bio-economic model (e.g. different stock-growth functions, approaches to payment for access, etc.).
- Use of a well-known platform (Excel) to allow easy use by the members of the project team, a broad introduction and accessibility to new users.

A new model, named FISHRENT, was developed on the basis of earlier experiences. FISHRENT contains six modules as presented in the project proposal:
1. Biological module
2. Economic module
3. Interface module
4. Market module
5. Behaviour module
6. Policy module

The main characteristics of the basic model are:
- The model accounts for eight species and eight fleet segments, but can be extended to a larger number if required[10]. Procedure for such extension is described in Annex 1.
- The model is a dynamic simulation model, running for a period of 25 years. Extension to a longer period is possible.
- By using the Excel Solver tool, the model can be used as an optimization model, which is particularly relevant in relation to the estimation of the resource rent.
- The model combines input and output based management, as well as their combinations. This has been achieved by a two stage calculation, in which first relevant combination of effort and catch is determined (starting either from catch or from effort constraints) and subsequently applied in the actual simulation.
- The model contains various options for the collection of rent (payment for access), including fixed payment per unit of capacity (vessel), payment per unit of effort (days-at-sea) and tax on revenues or profits.

Figure 2.4 shows some of the features of the FISHRENT model. Once the data of the baseline period is inserted and the parameters of the equations have been estimated, changing the policy type adapts instantaneously the graphics and the estimations of the rent so that the results of the various policy scenarios can be easily viewed. In addition, the model produces output of all variables, which can be transferred to a separate database for further analysis.

The FISHRENT model is as closely tailored to the real world as possible[11]. It contains three distinct dynamic processes:
1. The fish stocks develop using a 2nd degree polynomial stock-growth function. The catchable biomass is determined by its growth and the realized catch, which may exceed the sustainable catch when too much fishing effort is allowed.
2. The changes of the fleet size are determined with an investment function, which in its turn is related to profit level of the previous year, using the ratio between realized revenue and break-even revenue.
3. The production of the fleet is based on a Cobb-Douglas production function, where catch depends on effort and the biomass.
4. Changes in fleets and stocks are related only indirectly, through the consequences of the choices of the management regimes and several simultaneous interactions.

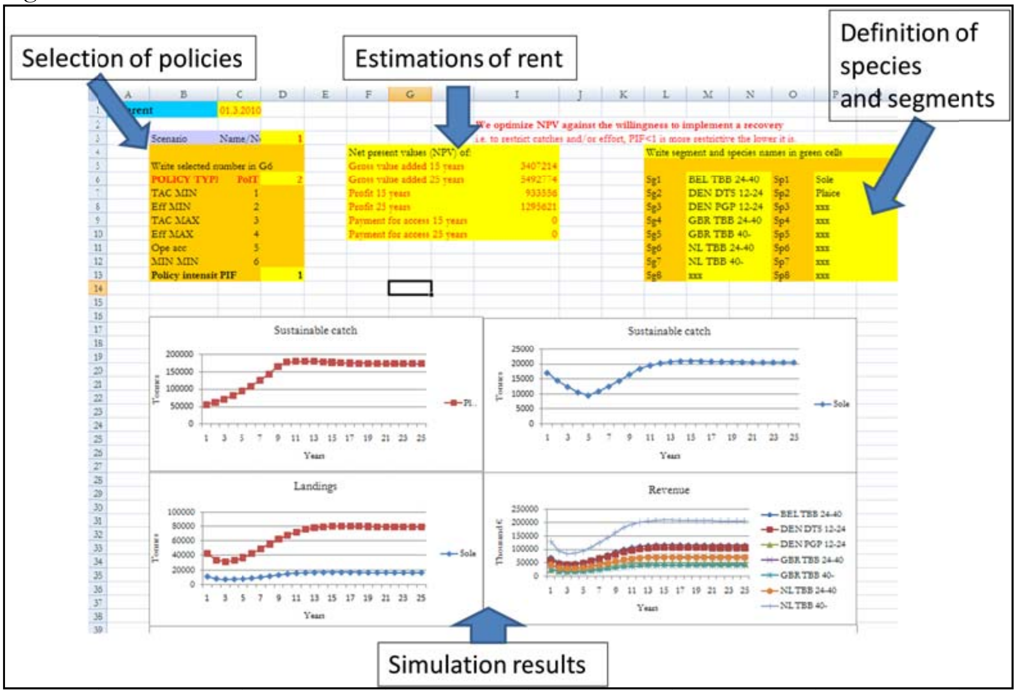
Consequently, the model allows stock to be over- or underexploited and fleets to grow and to contract. The model is described in detail in annex 1.

[10] Various other sizes have been implemented for the case studies.
[11] Full description is presented in Annex 1.

Table 2.2 Comparison of FISHRENT with selected bio-economic models

Criteria	**FISHRENT**	**EIAA**	**BEMMFISH**	**World Bank**	**EMMFID**	**Norwegian model**
Model objective	Estimation of net profit and GVA for specific EU fisheries	Economic evaluation of biologic advice	Modelling of Mediterranean fisheries	Estimation of resource rent on global level	Estimation of resource rent for the whole Danish fishery	Estimation of resource rent for the major part of the Norwegian fishery
Estimates resource rent	Annual and NPV - profits	Annual profit	Annual and NPV of profits	Point estimate of maximum profit	Point estimate of maximum profit	Point estimate of maximum net profit
Simulation / optimization	Simulation and optimization using Excel solver	Simulation	Simulation	Optimization by solving the profit equation	Optimization using linear programming	Optimization using linear programming
Input / output driven	Input and output	Output	Input	Output	Input and output	Input and output
Policy options	Open access, TAC, effort restriction, access fees, taxes	TAC	Fishing time (effort), vessels, taxes	None	Open access, TAC and effort restriction	Open access, TAC and effort restriction
Fish prices elasticity	Yes	Yes	Yes	No	No	No
Accounting for exogenous fuel price changes	Yes	No	No	No	No	No
Investment function	Yes	No	Yes	No	No	No
Biological input	Biomass, Stock-growth function in a flexible format. Source: ICES and Italian institutes	Average recruitment and yield per recruit Source: ICES	Stock-growth function	Single species Logistic (2nd deg. polynomial) and Fox function. Sources: FAO and other	TAC/catch restrictions	TAC/catch restrictions
Economic input	Multi fleet. DCF data, distinguishing 5 cost components	Multi fleet. DCF data, distinguishing 5 cost components	DCF with minor assumptions	Variable and fixed costs, Source: large variety of data	Detailed cost structure	Detailed cost structure
Dynamic/static Number of years	Dynamic: 25 years, expandable	Static: 3 point estimates current year, next year, long term.	Dynamic: 40 years	Static	Static	Static
HCR / management plans	Multi-species – multi-fleet mgt. by TACs, effort, access fees and taxes	Single species and managements plans in terms of TAC/quota	Effort and taxes	No	Single species and management plans in terms of TAC/quota and effort	No
Discards	Undersized and over-quota disc.	No	No	No	No	No
Software	Excel	Excel	Java	Excel	GAMS/Excel	Matlab
Dynamic / Static	Dynamic	Static	Dynamic	Static	Static	Static
Dimensions:						
– Fleets	Up to eight, expandable	Unlimited	Multi-fleet	Single fleet	26	25 aggregated to 11
– Species	8 species, expandable	25 species; all EU stock management areas (> 130)	Unlimited	Single species	118 stocks	10
– Area unit	Fishery areas, defined on basis of target stocks	Based on stock management definition	None	Single area (earth)	34 stock management areas; 14 regions	None
– Time unit	Year	Year	Year	NA	Month	Year

Figure 2.4. Drivers sheet of the FISHRENT model



References to chapter 2.2:
Prellezo Raúl, Alyson Little, Rasmus Nielsen, Jesper Levring Andersen, Christine Rockmann, Paolo Accadia and Jeff Powell (2009). *Bioeconomic models review*. Final report. April 2009.
Report of the joint SGECA - SGRST sub-group meeting on bio-economic modelling. Commission staff working paper. Ispra 4-6 October 2005 and 7-9 March 2006.
Holt S. (2009) *Sunken Billions – But how many?* Fisheries Research 97: 3–10
World Bank (The) and FAO (2009) *The Sunken Billions, The economic Justification for Fisheries Reform.*
Frost H., J.L. Andersen, A. Hoff, Th. Thøgersen (2009) *The EIAA Model* FOI report 200
Hoff A. and H. Frost (2008) *Modelling combined harvest and effort regulations: the case of Dutch beam trawl fishery for plaice and sole in the North Sea.* ICES Journal of Marine Science 65, 6: 822-831.
Nielsen M., B. L. Cozzari, G. Eriksen, O. Flaaten, E. Gudmundsson, J. Løkkegaard, K. Petersen and S. Waldo (2007) *Focus on the economy of the Nordic fisheries.* FOI report 186

2.3. Description of the scenarios

The terms of reference of this study require including the following options in the analysis of the resource rent:

1. Application of different management regimes (point 3);
2. Exploration of different discount rates (point 4);
3. Recovery of management costs and payment for access (point 6);
4. Estimation of the resource rent under current fleet and a fleet without overcapacity (point 5).

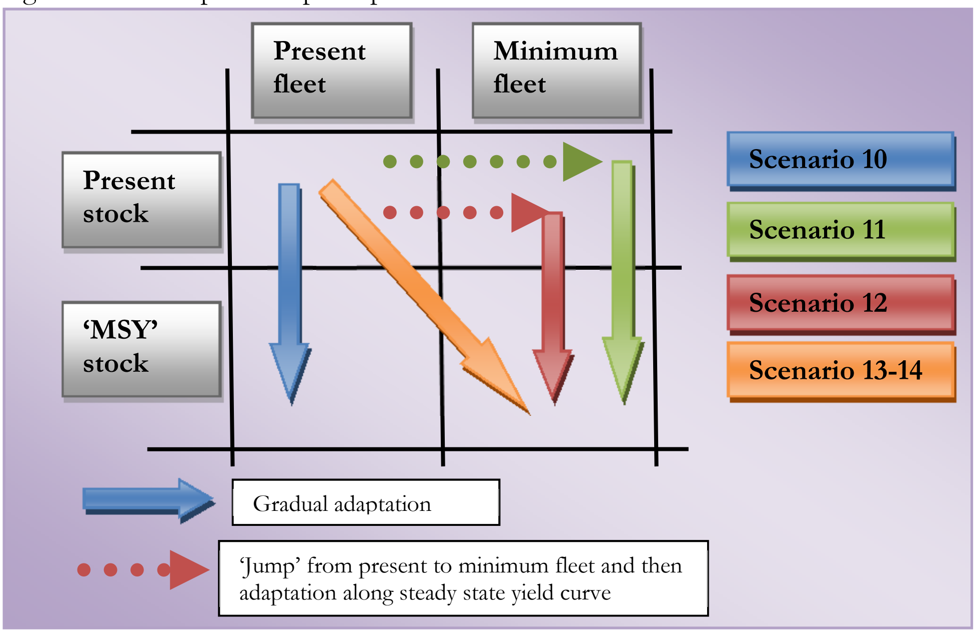
In order to meet these requirements, 14 scenarios have been formulated and applied to the case studies, as far as relevant[12]. The first six scenarios deal with different management regimes: output driven (TACs), input driven (effort) and open access. In case of input and output driven scenarios, in a multispecies fishery, it is necessary to decide whether the most or the least restrictive species should be used as the guiding principle. Therefore, for output and input driven regimes both these options have been tested. In this way it is possible to estimate the 'boundaries of the system'. In case that input and output measures would be in place, also a scenario applying the most restrictive of these two is presented.

[12] Output policy is not relevant for the Mediterranean case studies.

One of the management scenarios (1-6) which reflects the closest the present situation is selected as baseline and all other scenarios (7-13) are adaptations of the baseline scenario.

The scenarios 10-13 are based on the baseline scenario and reflect various options of moving from the present situation to a situation without overcapacity. In these scenarios the stock recovers always gradually, but it is assumed that the adaptation of the fleet can take place gradually as well as instantaneously. This is presented in Figure 2.5 and described further under scenarios 10-13.

Figure 2.5. Conceptual adaption paths



Scenario 1. TAC minimum

The stock-growth function of each species determines the sustainable harvest level, i.e. in practice the TAC for a given year. Effort of each fleet segment is set at a level consistent with the most restrictive TAC. Which species is most restrictive for a specific segment depends on its catch per unit of effort of that species and its allocation of TAC. Therefore different species may be most restrictive to different fleet segments in any given year. The dynamics of the model allow also changes of the most restrictive species for a specific segment in the course of the years.

Scenario 2. Effort minimum

Harvest ratio on a specific species in a given year is compared to the sustainable harvest ratio. Effort is adapted proportionately to the ratio of the two mortalities. Comparison of these mortalities for each species allows to select a ratio which is most restrictive and accordingly the lowest allowable level of effort is than applied to each segment.

Scenario 3. TAC maximum

The stock-growth function of each species determines the sustainable harvest level, i.e. in practice the TAC for a given year. Effort of each fleet segment is set at a level consistent with the least restrictive TAC. Which species is least restrictive for a specific segment depends on its catch per unit of effort of that species and its allocation of TAC. Therefore different species may be least restrictive to different fleet segments in any given year. The dynamics of the model may also lead to changes of the least restrictive species for a specific segment in the course of the years.

Scenario 4. Effort maximum

Harvest ratio on a specific species in a given year is compared to the sustainable harvest ratio. Effort is adapted proportionately to the ratio of the two mortalities. Comparison of these mortalities for each species allows to select a ratio which is least restrictive and accordingly the highest allowable level of effort is than applied to each segment.

Scenario 5. Open access

In this scenario there are no constraints on output or input. The size of the fleet segments varies with the investments, which depend on profits. Production and productivity of each segment depend on the size of the stock and on the level of effort.

Scenario 6 TAC minimum / Effort minimum

The most restrictive management measure, input or output, determines the level of effort which each segment may apply in any given year. This scenario may be more constraining than the scenarios 1 and 2 as the constraint may be based on TAC in one year and on effort in another one.

Scenario 7. Discount rate 2%

All management scenarios apply a discount rate of 3.5% to calculate the net present values. Scenario 7 is identical with the selected baseline scenario, but applies a discount rate of 2%. Lower discount rate implies a lower time preference, i.e. net profit in the future is valued almost as much as net profit at present. Specifically, net profit of 100 euro in year 15 is valued as much as net profit of 74 euro in year 0.

Scenario 8. Discount rate 5%

All management scenarios apply a discount rate of 3.5%. Scenario 8 is identical with the selected baseline scenario, but applies a discount rate of 5%. Higher discount rate implies a higher time preference, i.e. net profit in the future is valued less than net profit at present. Specifically, net profit of 100 euro in year 15 is valued as much as net profit of 48 euro in year 0.

Scenario 9. Recovery of management costs

The annual management costs are determined on the basis of OECD data and cross-checked with several other sources. The costs are allocated to each fleet segment proportionately to its share in value of the national fishery production. The scenario assumes that a lump sum payment equal to the allocated annual management costs is charged to each segment.

Scenario 10. Static present fleet

Scenario 10 is based on the baseline scenario and it assumes further that the size of the present fleet cannot be reduced and adaptation of effort can only take place by adjusting the number of days-at-sea per vessel. There are no investments or disinvestments. The number of vessels remains constant. The maximum level of effort is determined by the maximum number of days-at-sea per vessel times the umber of vessels.

Scenario 11. Static minimum fleet

In this scenario the present fleet is reduced instantaneously to the minimum required to exploit the present fishing opportunities (either in terms of TAC or in terms of effort). This means a 'one-off scrapping scheme'. After that reduction, the effort is adapted by changing the number of days-at-sea per vessel, as long as it remains below a specified maximum. The number of vessels is maintained constant at the original minimum level.

Scenario 12. Dynamic minimum fleet

The number of vessels is reduced instantaneously to the minimum, each fishing the maximum number of days-at-sea. After the first year the size of the fleet changes according to the allowed level of effort, i.e. number of vessels is equal to the allowed effort divided by the maximum number of days-at-sea per vessel. The investment function is disabled.

Scenario 13. Optimum fleet (GVA)

The scenario uses the Excel Solver to calculate the optimum number of vessels which would generate the maximum net present value of gross value added in 15 years. Vessels of each segment use the maximum possible number of days-at-sea per year. This scenario produces the optimum solution for each individual year. The annual investments in each segment are constrained to maximum change of -20% and +10% of the number of the vessels per year. This means that further improvement of the optimum could be achieved if this constraint would be eliminated.

Results of the scenario 13 can be interpreted as maximum contribution to GNP.

Scenario 14. Optimum fleet (profit)

This scenario is identical to scenario 13, but it maximizes net present value of net profit instead of gross value added. The results of the scenario 14 can be interpreted as the MEY situation.

Scenarios 13 and 14 reflect ranges of the theoretical solution under an ITQ system. ITQs are expected to lead to a high level of efficiency, as each individual producer is expected maximize his income (profit and labour remuneration) through acquisition of an optimum amount of fishing rights to operate at a maximum level of days-sea[13] (i.e. optimum utilisation of the production capacity).

Optimization in scenarios 13 and 14 implies that the policy constraints described under scenarios 1-4 are not active.

2.4. Other topics

Baseline period

The model is based on average economic data of the period 2005-7, as collected under the Date Collection Regulation.

Discount rate

Low discount rates will produce higher net present value and lead to preference of higher benefits in the future. This means that policies imposing major restrictions in the short term, which are expected to generate higher benefits in the future, would be evaluated favourably.

On the other hand, high discount rate favours more gradual policies, where the stock recovery lasts relatively longer, while income for the fishing sector is maintained at a higher level in the short run.

The baseline discount rate is set in this study at 3.5%. This value is proposed by the UK Treasury[14] for the purposes of 'green accounting'. Alternative values have been set at 2% and 5%.

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[13] See P. Andersen, J.L. Andersen and H. Frost, *ITQs in Denmark and resource rent gains*, Marine Resource Economics, Volume 25, p.11-22, 2010

[14] HM Treasury, *The Green Book, Appraisal and Evaluation in Central Government*,

Uncertainty and stochasticity

The FISHRENT model is dynamic, but deterministic. It must be stressed that the results must not be interpreted as forecasts of the future. The model is suitable to generate sets of scenarios, which can be mutually compared. Comparison of the scenarios generates information in the following areas:

- consequences of different types of policies;
- differences in levels of achieved benefits;
- ranges of possible outcomes.

More than 60 scenarios were elaborated for the seven case studies. Review of the results shows that they are consistent with developments which can be expected on the basis of qualitative, theoretical or expert analysis. This may be considered as an important validation of the operation of the model.

The model version used does not contain stochastic elements. However, it is in principle possible to introduce stochasticity by replacing the stock-growth function by a RANDBETWEEN function, available in Excel.

Prices

The analysis is based on constant average market prices, observed in the baseline period 2005-7. The choice for constant prices was agreed with the Commission, based on the following arguments:

- Results of the model reflect more clearly the consequences of changing size of stocks and fleets, while with variable prices, part of the calculated resource rent would have to be ascribed to price effects.
- Application of price elasticity for the purpose of this study is questionable for at least two reasons:
- The landings of a specific species by the segments in the case study fisheries represent an unknown share of the total landings of that species. However, the price of the species depends on the total landings. It would have to be assumed that the relative change in the landings of each species in the case study fishery is equal to the relative change in total landings.
- One value of price elasticity is valid only for relatively small changes of total supply. However, recovery of stocks from overexploited to sustainable level may imply that the changes in landings are substantial. In that case application of one value for price elasticity may not be correct.

Nominal, real and discounted values

All calculations are based on constant prices, so that effects of inflation are eliminated. It is assumed that the change of prices of inputs and fish would be identical, not having any net effect on net profit or profits. The term 'real' value is usually related to deflated prices, after accounting for inflation. As inflation is not considered, the term 'real' is not used.

Future net profit and profit is discounted with a rate specified above. This rate reflects time preference. Comparing discounted values is particularly relevant when a choice has to be made between several options where costs and benefits occur at different points of time.

Within one scenario it may be relevant to compare nominal net profit in time (e.g. year 1 and year 15). The comparison reflects the net effects of underlying variables - i.e. changes of composition of the fleet and its production costs, catches, state of stocks, etc. – before time preference is taken into account[15].

[15] This may be illustrated with the following example: Assume that a fishery is in a stable MSY or MEY situation in year 1 and remains there for the entire period. Comparing nominal values shows that performance remains unchanged. However, comparing Prf of year 1 to a discounted Prf of year 15, could lead to a wrong conclusion that the performance deteriorates as with a discount rate of 3.5%, Prf of year 15 would be about 60% of the year 1, even if the nominal values are equal.

Management costs

The estimated resource rents should be compared to the management costs (i.e. administration, control and enforcement, research and subsidies) of each case fishery. This task faced a number of problems, which were addressed as follows:

1. Management costs are incurred at the level of the MS or EU, but not at the level of fishery or segment. Therefore, national management costs were allocated to the individual segments on the basis of the share of the production value of that segment in the national total.
2. National management costs are not directly available from any source.
3. Administration, control and enforcement are in different MS carried out by different organizations, which also deal with other areas than fisheries alone. The budget allocations are not necessarily related to one activity, but may be shifted according to need. Costs of administration, control and enforcement used in this study are therefore based on two recent sources – OECD[16] and MRAG[17]. These two independent sources were used to check consistency of the results, which proved to be satisfactory.
4. In many MS fisheries research is carried out by several research institutes. However, these institutes are not only involved in fisheries research, but also in other areas related to aquaculture, environment, oceanography, etc. Costs of research were therefore estimated using the 2009 budget for the Data Collection Framework, with an add-on of 30% for data analysis.
5. The main lines of subsidies in EU fisheries are:
   a. European Fisheries Fund, in particular priority axis 1 and partly axis 3 and 4. As priority axis 3 and 4 are partly dedicated to other activities, they were accounted for by taking 50% of their value, but only for the EU totals not for the individual case studies.
   b. Access to the waters of third countries. This subsidy is not relevant to any of the case studies.
   c. *De minimis* support – the allowed expenditure is highlighted in the text but not accounted for in the case studies as most countries have made little or no use of it, with the exception of Spain and France[18].

The costs accounted for under 'management costs' are costs directly related to management measures taken within CFP (e.g. EFF) and costs incurred to prepare and implement those measures (research, control and enforcement), Certain subsidies, not directly related to management, e.g. support to social security, exoneration from excise taxes, *de minimis* and third country agreements have not been taken into account. These subsidies would reduce the resource rent by the same nominal amount.

Details of management costs are presented in Annex 2.

Shadow prices

The market prices reflect at best short term scarcity in imperfect markets. The market prices of fish do not reflect well the stock sustainability, the utility[19] of the fish stocks to the society nor the needs and interests of future generations. The societal utility may contain many widely varying aspects ranging from existence value to production of food and creation of employment in remote areas. To account for these considerations requires the use of shadow (or economic) prices.

The theory of resource rent proposes to apply a required profitability (shadow interest rate or opportunity costs) to the capital value of the catching sector and to calculate the resource rent as the difference between the realized and required profitability. The section on 'Resource rent' points out that focussing on profit alone is a too narrow interpretation of the concepts proposed in the theory and that part of the rent may be also contained in the remuneration of labour. The theory assumes that shadow value of both production factors can be estimated, i.e. shadow price as well as the volume of capital and labour, to

[16] OECD, Financial support to fisheries: Implications for sustainable development, Paris 2006, p.30

[17] MRAG Ltd., Oceanic Développement, Poseidon Aquatic Resource Management Ltd, Lamans s.a., Institute of European studies and IFM, 'Impact Assessment of a Proposal to Reform and Modernise the Control System applicable to the Common Fisheries Policy', May 2008

[18] Framian bv, Economic analysis of raising de minimis aid for fisheries, project MARE/2008/12, January 2009, 63p.

[19] Utility may contain user as well as existence value.

which shadow prices should be applied, (i.e. value=price*volume). However, that is not the case at the moment.

From the above it follows that estimation of shadow values for capital and labour requires four components, each of them bringing with it specific problems:

1. Determination of a shadow profitability (interest) rate requires taking into account the risk profile of the economic activity. This means that a unique shadow profitability rate does not exist and that it may be even different between different parts of the catching sector. Furthermore, if shadow profitability is interpreted as 'opportunity costs', it must be clearly defined to whom these opportunity costs apply. Opportunity costs to the society may be relatively low, because constraints of shifting from one capital good to another are limited or absent. On the other hand, opportunity costs to the fishing firms may be relatively high because their flexibility is limited and investing in alternative activities implies also high transfer costs. There has been no empirical research in this area. Within this study the value would be therefore highly speculative.
2. The shadow profitability has to be applied to the value of capital invested in the sector. Valuation of capital is complex. Some values have been estimated under DCR, but these are not based on a common set of definitions. First steps for homogenization were taken under DCF for 2008 data[20]. However, this data was not available in time for application in this study. Furthermore, ad hoc review of the 2008 data points still to a number of inconsistencies, which need to be addressed first before the data can be used.
3. Determination of shadow price of labour requires taking into account different wage levels in the various MS, but also by professional profile, including risk, educational level and sex. Eurostat data appears to be highly incomplete[21], so that ad hoc estimations would be unavoidable. Furthermore, the Eurostat data are based on earnings of employees, which would have to be adapted to self-employed status of fishermen and possibly significant difference in working hours. Application of average opportunity costs of labour assumes that shifting from one occupation to another is costless and not constrained, assumptions which barely hold in practice.
4. Shadow price of labour has to be applied to the employment, expressed in full-time equivalents. A similar argument applies in this case as in relation to capital. DCR does not provide FTE standardized data and DCF 2008 data was not available in time for the project. Ad hoc review of the new FTE[22] values raises questions about the reliability[23].

Sensitivity analysis

Sensitivity analysis is presented by comparing the results of the 14 scenarios. This comparison shows how much the resource rent changes under different conditions of management, discount rate, costs recovery and fleet adaptations.

Sensitivity has not been carried out in relation to changes of the parameters of the equations. However, as stated earlier, the model is a tool to generate scenarios and the value of the scenarios is in their mutual comparison. Consequently, comparing results of the model using different function parameters would be conceptually inconsistent. Rather, for each set of parameters, all 14 scenarios would have to be run and mutually compared. This would require resources beyond those available for this study and it is not likely that this would lead to a higher quality of the overall analysis.

[20] Standardisation is based on: IREPA Onlus et.al., 2006. Evaluation of the capital value, investments and capital costs in the fisheries sector Study No FISH/2005/03.

[21] This applies in particular to wages by economic activity and educational level (series: earn-gr-nace2, earn-ses06-49 and earn-gr-isco) and to lesser extent to minimum wages (series: earn-mw-avgr1).

[22] Standardisation is based on: 'LEI et.al., 2006, Calculation of labour including full-time equivalent (FTE) in fisheries Study No FISH/2005/14, 142 p.' and amended by the SGECA 07-01 report (15-19 January 2007, Salerno, 21 p. + annexes

[23] All statistical systems have to be improved in time to solve arising problems. Therefore it is not surprising that this also applies to DCF 2008 data.

Resource rent by species

The calculation of the resource rent is based on the segments participating in the seven selected fisheries.

Annex 4 presents an estimation of the resource rent (average NPV Prf15) by species. The resource rent has been allocated to individual species on the basis of their relative role in the total revenues of the fishery. This approach implies that a proportionate share of the resource rent has been allocated to 'other' species, which are not explicitly specified in the calculation.

Interpretation of the scenarios

With the exception of the baseline statistics on 2005-7, all other figures are results of the simulation model FISHRENT. The only correct interpretation is in relative comparisons between scenarios and indicators, but NOT in their absolute values. The model does not forecast the future, and certainly not for a period of 15 or 25 years. The model is a mathematical expression of generally accepted theoretical concepts. The model is a tool for consistent exploration and comparison of consequences of specific policy decisions. Therefore it may not be concluded, for example, that the nominal net profit of the various case study fisheries could reach the indicated values within the indicated period of time.

3. EU OVERVIEW

3.1. Role of case studies within EU fisheries

Fleet and landings

The seven case studies analysed in the report represent overall around 20% of the total EU fisheries, varying from about 9% in terms of the number of vessels to almost 24% in terms of value of production and in line with these numbers also 26% of the net profit[24]. This can be considered as a significant share. The comparison of the number of vessels and the value and volume of landings implies, that the case studies reflect the operation of the relatively more commercially orientated fleet segments. The profitability of the various fisheries differs widely. While some make losses others make significant profits of up to about one third of the value of landings.

Table 3.1 Selected indicators of case studies and EU total (average 2005-7)

	Fleet		Landings		Net profit (mln euro)	Employ-ment
	No. vessels	1000 GT	Value (mln euro)	Volume (1000 t)		
1. North Sea flatfish	626	100	392	240	-24	1,883
2. North Sea cod	1,475	87	390	224	130	4,244
3. Baltic Sea cod	2,533	37	151	116	38	4,499
4. Atlantic hake	650	87	517	124	56	1,018
5. Atlantic anchovy	295	35	225	73	-21	2,934
6. Mediterranean anchovy	53	3	21	8	5	1,276
7. Mediterranean hake	1,729	17	133	13	28	7,980
Total case studies	7,361	366	1,829	798	212	19,339
EU total	77,097	1,903	7,718	4,060	806	129,569
Case studies as % of EU total	9.5%	19.2%	23.7%	19.7%	26.3%	14.9%

Source: DCR 2009 (data 2002-2007)

The case studies cover fisheries of 10 Member States, representing 11% of the average value of landings in 2005-7 in Italy, 80% in Belgium and between 34% and 62% in the other eight MS.

Most case study fisheries are multi-species, so that fleets depend only partially on the species and stocks defined as ‘target’. In terms of value, the dependence varies between 17% for North Sea cod and 49% for North Sea flatfish. In case of Atlantic anchovy, the figures for 2005-7 do not reflect current dependence well due to the restrictions under the present recovery plan.

The multi-species character of these fisheries has significant consequences for the analysis of their functioning under various management regimes and estimation of the ‘resource rent’, which is discussed in section 2.1

[24] See comments on the reliability of the data on net profit in chapter 2.

Table 3.2 Overview of case studies in relation to national and EU-27 fisheries[25]
(value of landings - average 2005-7, mln euro)

Member State	National total (DCF)	Case study							Total case studies	Case studies as % of MS total
		North Sea flatfish	North Sea cod	Baltic Sea cod	Atlantic hake	Atlantic anchovy	Mediterranean anchovy	Mediterranean hake		
AZO	31								0	0%
BEL	86	69							69	80%
CYP	11								0	0%
DEU	155		45	40					85	55%
DNK	393	86	72	32					190	48%
ESP	1,735				188	128			316	18%
EST	14								0	0%
FIN	25								0	0%
FRA	1,248				329	97			426	34%
GBR	822	66	273						339	41%
GRC	776								0	0%
IRL	224								0	0%
ITA	1,426						21	133	154	11%
LTU	4								0	0%
LVA	21								0	0%
MLT	11								0	0%
NLD	383	171							171	45%
POL	42			26					26	62%
PRT	343								0	0%
SVN	1								0	0%
SWE	114			53					53	46%
Total	7,718	392	390	151	517	225	21	133	1,829	24%

Source: DCR 2009 (data 2002-2007)

Table 3.3 Share of target species in the total value and volume of the case study fisheries
(average 2005-7)

Case study	Value	Volume
1. North Sea flatfish	49%	26%
2. North Sea cod	17%	12%
3. Baltic Sea cod	36%	22%
4. Atlantic hake	29%	26%
5. Atlantic anchovy	40%	82%
6. Mediterranean anchovy	34%	53%
7. Mediterranean hake	31%	40%

Source: Calculation on the basis of DCR 2009 (data 2002-2007)

Table 3.4 shows that there are significant differences between the average performance of the different fisheries. In particular, the Mediterranean hake fishery 'enjoys' an average price, which is many times higher than the price in the other fisheries. Consequently, this fishery achieves a relatively high net profit per tonne of landings. All other fisheries achieve a Prf/tonne between -300 and 600 euro.

The North Sea flatfish fishery has the highest fuel intensity, with 33% of total revenues being spent on fuel costs. This fishery is relatively homogenous, being composed largely of beam trawlers. The average fuel efficiency in other fisheries is substantially lower, although the fleets involved are often more diverse, so that the average hides a spread of fuel intensity among the fleet segments involved.

[25] Note: The national totals are the sums of segments included in DCF data. The actual values may be for some countries higher. However, countries included in the case studies have a high or full coverage in DCF.

Table 3.5 Economic indicators (average 2005-7)

Case study	Average price (euro/tonne)	Fuel costs as % of income	Net profit / tonne landings (euro/tonne)	CPUE total (tonnes/day at sea)	CPUE target species (tonnes/day at sea)
1. North Sea flatfish	1,631	33%	-101	2.4	0.6
2. North Sea cod	1,746	10%	581	1.4	0.2
3. Baltic Sea cod	1,307	11%	329	0.6	0.1
4. Atlantic hake	4,187	19%	450	0.9	0.2
5. Atlantic anchovy	3,069	13%	-285	1.5	na
6. Mediterranean anchovy	2,666	14%	580	1.2	0.6
7. Mediterranean hake	10,258	22%	2,144	0.1	0.0

Source: Calculation on the basis of DCR 2009 (data 2002-2007)

Management costs

For the purpose of this study management costs compiled by OECD (data for 2004-6) have been used in the scenario simulation. They were cross checked against three types of management costs obtained from various sources: capacity adjustment; management, enforcement and control and research. The OECD allocation to the case study fisheries amounts to 117 mln euro, while on the basis of other sources an amount of 138 mln euro was found. Comparison of the various sources implies that the data used is reliable. The overall EU management costs are presented in Annex 2.

Table 3.6 Management costs (mln euro/year)

	EFF – axis 1 (a)	Management, enforcement and control (b)	Research (c)	Total (a+b+c)	Total used in FISHRENT (OECD)
1. North Sea flatfish	5.4	14.2	6.6	26.2	24.2
2. North Sea cod	4.3	23.2	6.6	34.1	23.1
3. Baltic Sea cod	14.9	16.8	1.8	33.5	16.9
4. Atlantic hake	15.1	7.4	6.0	28.5	28.5*
5. Atlantic anchovy	4.8	1.8	1.5	8.1	11.0
6. Mediterranean anchovy	0.7	0.2	0.1	1.0	1.6
7. Mediterranean hake	4.7	1.5	0.8	7.0	11.8
Total case studies	49.9	65.1	23.4	138.4	117.1
EU total	262.4	354.8	107.5	642.9	

Sources: Annex 2 and OECD; * based on Annex 2.

3.2. Comparison of policy options (scenarios 1-6)

The terms of reference of the study call for comparison of the performance of the case study fisheries under different management regimes. This comparison was carried out with a new bio-economic model FISHRENT, distinguishing 6 policy options:

1. TAC min: policy decisions are driven by the most restrictive TAC advice.
2. Effort min: policy is driven by the stock with the most restrictive fishing effort.
3. TAC max: policy decisions are driven by the least restrictive TAC advice.
4. Effort max: policy is driven by the stock with the least restrictive fishing effort.
5. Open access: no active policy. Changes in the fishery are driven by fishermen behaviour only.
6. Min min: the most restrictive of the two policies TAC min or Effort min determines the constraints imposed on the fishery each year

Detailed description of the scenarios and the model is presented in section 2.3 and annex 1.

The main benchmark for the comparison of the policy options is the net profit (Prf), which is considered as a proxy for the resource rent. The six policy options can be compared in three different static ways among themselves and to the situation in the baseline (average 2005-7, year 1 of the simulation).

1. Prf of the baseline (year 1) and the average nominal Prf of the 15 years of each scenario run. This comparison allows conclusions on attractiveness of the policies from the perspective of the total period of 15 years. Time preference is not included.
2. Prf of the baseline (year 1) and the nominal Prf of the year 15 of each scenario run. This approach shows how the fishery is expected to perform in the year 15 in relation to the baseline and it compares the performance of the scenarios in the year 15 mutually. Time preference is not included.
3. Prf of the baseline (year 1) and the average discounted Prf of the 15 years of each scenario run. This approach accounts for the time preference, using the main discount rate of 3.5%.

These comparisons can be considered static, as they take one single number to represent the whole period of 15 years.

Although static comparisons have their analytical value, they disregard the details of the 'adjustment process'. A more dynamic comparison is therefore presented to reflect also the short and long term consequences of restrictions.

In the following comparisons, scenarios 1, 2 and 6 are restrictive, while scenarios 3, 4 and 5 impose little or no restrictions. Not all scenarios are relevant for all case studies. Therefore in some case studies, some scenarios have not been elaborated. Detailed evaluation of the impact of the various policies in the case study fisheries is presented in the respective chapters. These evaluations show that in some situations positive resource rents can be generated while some stocks would be completely depleted.

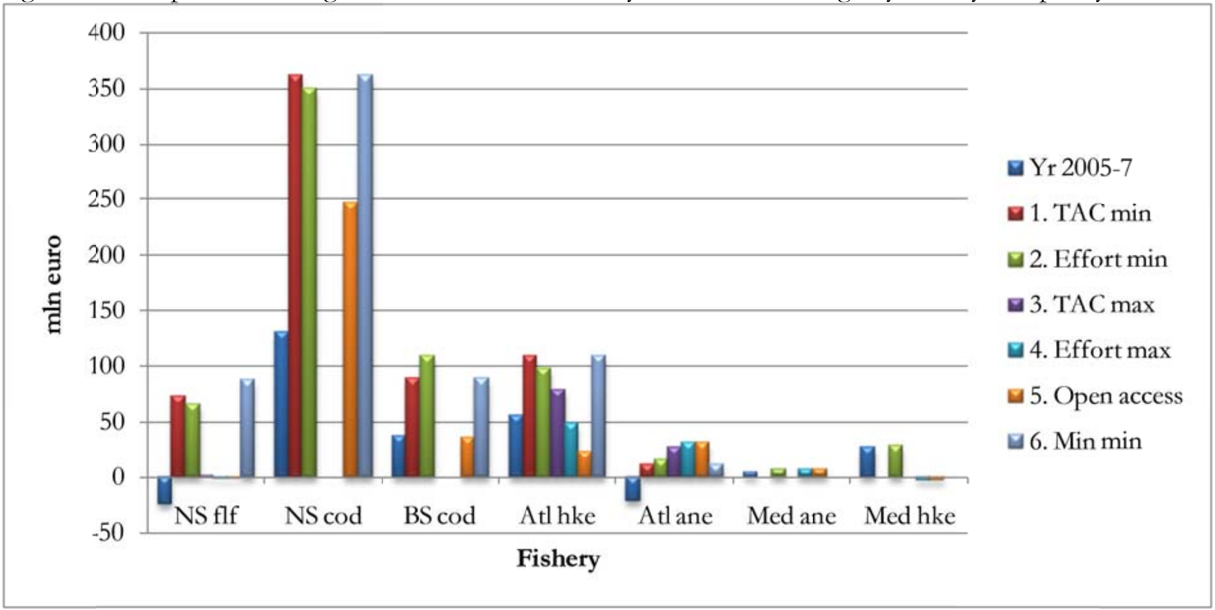
Comparison of average nominal net profit

Figure 3.1 shows that the consequences of various policies lead to very different outcomes in the different fisheries:

1. North Sea flatfish faced losses in 2005-7. It would significantly benefit from restrictive policies, while the non-restrictive policies would reduce the average nominal profits to zero (break-even level). There is not a significant difference between effort or TAC management.
2. Restrictive TAC and effort policies would be very beneficial in case of North Sea cod, increasing the level of average nominal profits about three times. However, non-restrictive policies could not be tested[26], except for the Open access. This policy could also lead to doubling of average nominal net profit, because the restrictions to exploit other species than cod would be lifted. This illustrates that from the perspective of rent creation, it would be rational to manage the 'NS cod fishery' with focus on other species than cod, because cod plays only a minor role in the performance of most fleet segments involved.
3. Restrictive policies would increase the rent created in the Baltic Sea cod fishery. Open access would be clearly detrimental.
4. In the case of Atlantic hake, TAC min policy would about double the profits. Also Effort min and TAC max would produce an improvement from the situation of 2005-7. Open access would lead to a deterioration.
5. The Atlantic anchovy fishery made on average loss in 2005-7. The non-restrictive policies would raise the net profit most,, primarily because the fleet would be able to exploit other species than anchovy more intensively.
6. The nature of the Mediterranean anchovy fishery (in GSA 9)is such that none of the policy scenarios would significantly improve its profitability.
7. In the Mediterranean hake fishery (in GSA 16) the Effort min policy would maintain the profits at the level of 2005-7. Open access policy would reduce the present profits to zero.

[26] The scenario has only one target species, namely cod. Consequently there is no distinction between minimum and maximum effort.

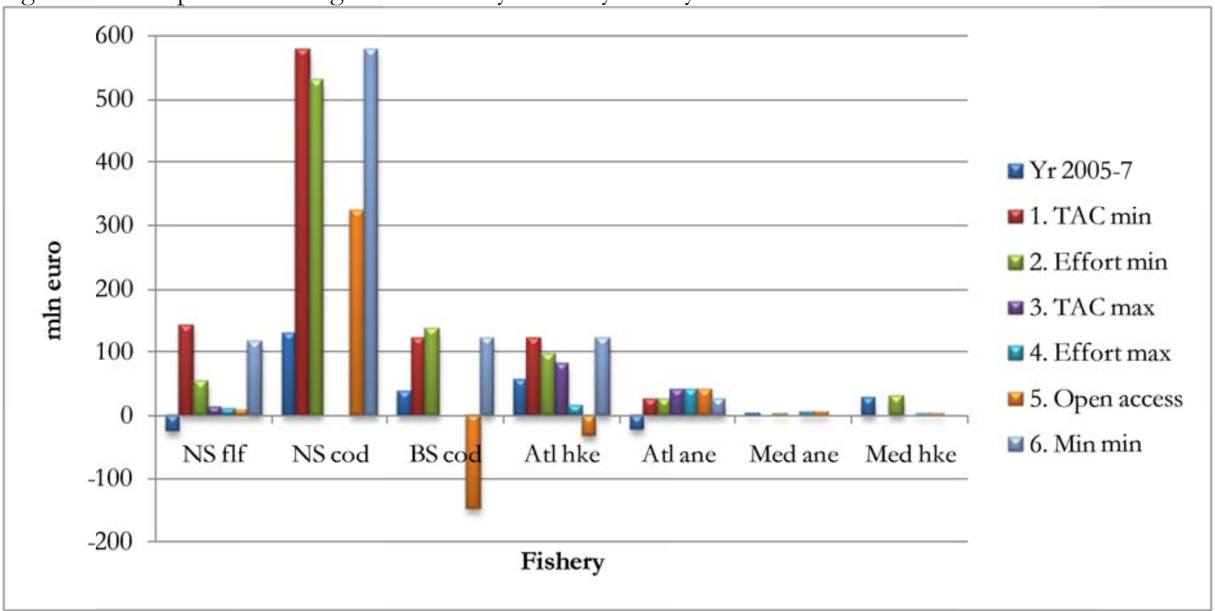
Figure 3.1 Net profit – average 2005-7 and nominal 15 year nominal average by fishery and policy scenario



Comparison of nominal net profit in year 15

The results presented above regarding the 15 year average nominal net profit are rather similar to the comparisons of the nominal net profit in year 15, as presented in Figure 3.2. The only exception is Baltic Sea cod and Atlantic hake, where Open access would lead to a significant deterioration and turn present profits into losses.

Figure 3.2. Net profit – average 2005-7 and year 15 by fishery and scenario



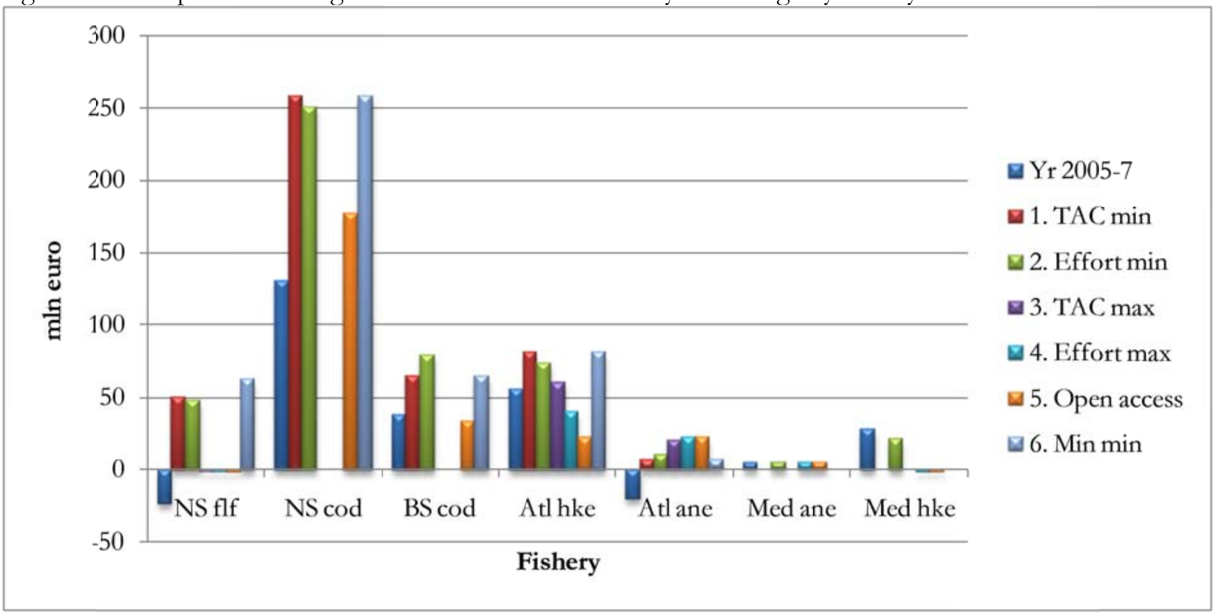
Comparison of average discounted net profit

Analysis of discounted net profit takes time preference into account. Comparing average discounted net profit to the situation in 2005-7 assumes implicitly that this performance would be maintained also in the future, which is not certain. The comparison highlights the dilemma between short term and long term choices.

The seven analysed fisheries show rather different results of the various scenarios compared with the baseline situation 2005-7 (see Figure 3.3):

1. In the NS flatfish fishery all restrictive policies can be expected turn losses in 2005-7 to average discounted profits.
2. Restrictive policies could produce significant improvements in case of North Sea cod. Open access seems to have some merits as well, compared to the present situation. Non-restrictive policies could not be tested.
3. In case of Baltic Sea cod, improvements can be achieved, in particular by the Effort min policy.
4. The average discounted net profit in the Atlantic hake increases somewhat in the restrictive policy scenarios.
5. In the Atlantic anchovy the non-restrictive scenarios produce an improvement compared to the present losses. The restrictive scenarios would lead to performance slightly above the break-even level.
6. The average discounted net profit is not very sensitive to the policy choice in the Mediterranean anchovy fishery.
7. In the Mediterranean hake fishery the average discounted net profit is slightly lower in the Effort min scenario than in the baseline 2005-7. Other scenarios lead to complete dissipation of profits.

Figure 3.3. Net profit – average 2005-7 and discounted 15 year average by fishery and scenario



Dynamic evaluation

Figure 3.4 highlights the dilemmas of restrictive measures in fisheries. The basic scenarios in all fisheries were either TAC min or Effort min. In most fisheries the nominal net profit decreases for 1-2 years and rises substantially in the subsequent period. Between the years 10-15 it reaches its maximum. For the total of the seven fisheries, the nominal net profit increases by 400%, or 800 mln euro. This is particularly the result of the very substantial gains in the NS cod fishery, which accounts for 53% of this increase, followed by NS flatfish which contributes 21% to the total increase.

The social 'price' of this improvement is the reduction in the size of the sector, expressed in terms of number of vessels. The reduction of the fleet lasts overall for about 7 years, although there are differences between the individual fisheries. In that period the number of vessels falls from little over 5,000 to about 3,800, i.e. by 24%. In some fisheries the fleet is reduced by 30-50%, the extreme being in NS flatfish where 70% of the vessels would have to stop operating by year 9. While in some fisheries the fleet recovers even beyond the level of the baseline, overall it remains about 10% below it.

The following further comments can be made:

1. It can be safely assumed that employment is affected more or less proportionately with the size of the fleet.
2. The consolidation process allows a smaller group of fishermen to collect the larger benefits. As outlined in the section 2.2 part of the created resource rent will be collected by the labour.

Conclusion on policy comparisons

The model results illustrate that different fisheries need to be managed differently in order to achieve an improvement from the current situation. Restrictive policies may be expected to produce positive results in the North Sea and Baltic Sea fisheries, but much less in the Atlantic and the Mediterranean. Restrictive measures will in the end lead to recovery of the economic performance, reduction of the size of the sector and concentration of benefits among a smaller number of vessel owners and fishermen.

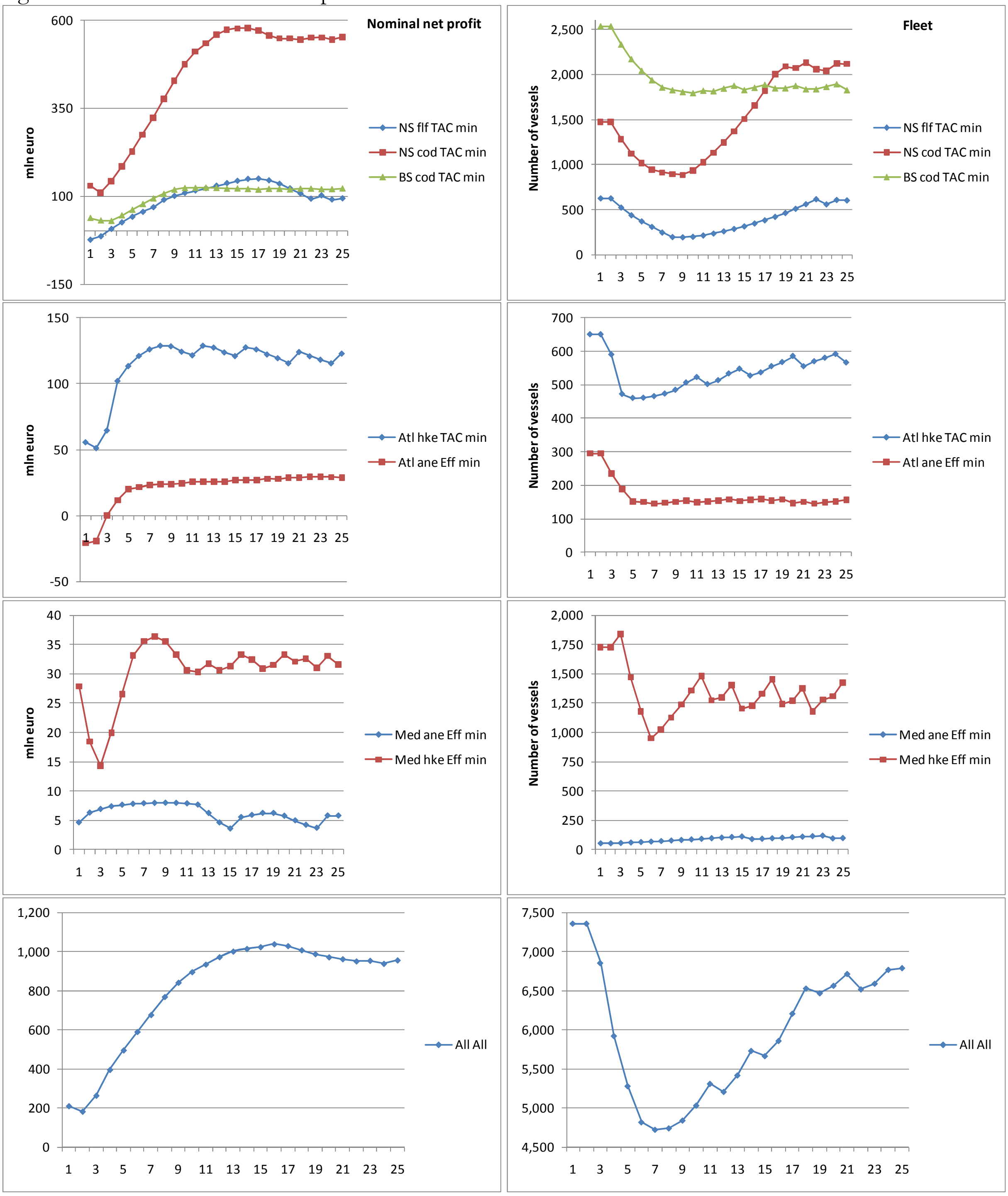
The analysis illustrates that there is not one single measure of rent. Even considering only one indicator, namely net profit, produces analytical nuances, as illustrated in Table 3.7:

- .Nominal net profit would increase from 200 mln in 2005-7 to 1,000 mln in 15 years.
- Total average NPV Prf_{15} would be 132% higher than then in 2005-7.
- Total average nominal net profit would be 175% higher than then in 2005-7.
- About 46-55% of the increase of the net profit indicator can be attributed to NS cod, 21-26% to NS flatfish, 10% to BS cod and 16-20% to the two Atlantic fisheries. The net profit in the Mediterranean fisheries would barely change.

Table 3.7 Comparison of three profit indicators in the baseline scenario with 2005-7 (mln euro)

	2005-7 (nominal)	15 year average (nominal)	Average NPV Prf_{15} (discounted)	Year 15 (nominal)
NS flatfish	-24	73	50	143
NS cod	130	362	259	577
BS cod	38	89	65	122
Atlantic hake	56	109	81	121
Atlantic anchovy	-21	16	11	27
Mediterranean anchovy	5	7	5	4
Mediterranean hake	28	29	22	31
Total	212	686	493	1,025

Figure 3.4. Trends in nominal net profit and fleet in baseline scenario



3.3. Role of discount rate (scenarios 7-8)

The influence of the discount rate on the net present value of a 'stream of benefits' depends on the composition of those 'benefits' over time. Lower discount rate favours situations where large incomes are generated further in the future. In that case the time preference is low, i.e. it is less relevant when the benefits are realized. Higher discount rate favours flows of income realized in the short term.

Table 3.8 presents the effect of different discount rates. Baseline results have been discounted against 3.5% and two alternatives of 2% and 5% have been subsequently applied to the baseline scenario. Despite the differences in the various models used, a lower discount rate leads to a NPV Prf_{15} which is 11-18% higher than the baseline. On the other hand, the higher discount rate reduces the NPV Prf_{15} by 10-14%.

Table 3.8 Impact of different interest rates on NPV Prf_{15}

Scenario	1. NS flatfish	2. NS cod	3. BS cod	4. Atl. hake	5. Atl. anchovy	6. Med. anchovy	7. Med. hake
Mln euro							
01. TAC min, 3.5%	754	3,885	969	1,222			
02. Effort min, 3.5%					161	79	328
07. Discount rate 2%	884	4,468	1,109	1,381	190	88	369
08. Discount rate 5%	645	3,395	850	1,087	136	71	293
Index (baseline scenario = 100)							
01. TAC min	100	100	100	100			
02. Effort min					100	100	100
07. Discount rate 2%	117	115	114	113	118	111	113
08. Discount rate 5%	86	87	88	89	85	90	89

Considering only the discounted value in the year 15, at a discount rate of 3.5% value of 1000 euro now, would be equal to 1,675 euro in year 15. At 2% and 5% respectively, the values in year 15 would be 1,345 euro and 2,079 euro. These values reflect only the effect of the time preference. They have nothing to do with deflating to account for inflation.

As presented in Table 3.7 the baseline scenarios for most fisheries lead to substantially higher nominal net profit in year 15, except for the two Mediterranean fisheries. After application of baseline discount rate of 3.5%, the discounted net profit in year 15 is significantly higher than in year 1 in the North Sea and Baltic Sea fisheries, but much less in the Atlantic fisheries. This value is even lower in the Mediterranean fisheries. Using a lower discount rate of 2% increases the discounted net profit of year 15 above year 1 for the fisheries 1-5, but not for Mediterranean fisheries 6 and 7.

The 'break-even' discount rate shows the value at which net profit in year 15 would be equal to the net profit in year 1[27]. For the NS flatfish and Atlantic anchovy fishery, these values are extremely negative as these fisheries make a loss in 2005-7. For Baltic fisheries NS and the Atlantic hake the break-even discount rate is 5-10%. Substantially lower values of -2% to 1% result in the Mediterranean fisheries.

The time preference depends on specific conditions of the fishery and the (local) economy in general. Relatively high discount rate may be applicable in regions with a dynamic economy, where it is likely that losses due to contraction of the fishing sector would be compensated by other activities. On the other hand, in a stagnating economy, a low discount rate may be justified as even low income in the future is given a relatively high importance. The choice of discount rate depends also on 'political' preferences regarding the inter-generational division of welfare (income). Consequently, different discount rates may be appropriate in different fisheries and at different times. It is not possible to identify one single 'best' discount rate.

[27] This value is calculated as $[(Prf_{15}/Prf_1)^{\wedge(1/15)} - 1]$

Table 3.9.Impact of different interest rates on discounted net profit in year 15

Indicator	1. NS flatfish	2. NS cod	3. BS cod	4. Atl. hake	5. Atl. anchovy	6. Med. anchovy	7. Med. hake
Mln euro							
Prf, 2005-7	-24	130	38	56	-21	5	28
Nominal Prf, year 15	143	577	122	121	27	4	31
Discounted Prf, yr 15, 3.5%	85	344	73	72	16	2	19
Discounted Prf, yr 15, 2%	106	429	91	90	20	3	23
Discounted Prf, yr 15, 5%	69	278	59	58	13	2	15
'Break-even' discount rate	-212.6%	10.4%	8.1%	5.3%	-201.8%	-1.7%	0.8%
Index (baseline scenario = 100)							
Prf, year 1		100	100	100		100	100
Nominal Prf, year 15		443	320	217		77	112
Discounted Prf, yr 15, 3.5%		265	191	130		46	67
Discounted Prf, yr 15, 2%		329	238	161		57	83
Discounted Prf, yr 15, 5%		213	154	104		37	54

Conclusion on impact of discount rate

Discount rates can be used either to compare different streams of benefits (Prf) or to compare the Prf of year 15 with the present one. Sensitivity analysis shows that changing the baseline discount rate of 3.5% to 5% reduces the NPV Prf_{15} by 10-14%. On the other hand a lower discount rate of 2% increases the NPV Prf_{15} by 11-18%. Comparing the Prf in the baseline (year 1) to the discounted Prf in year 15 appears to be rather sensitive to the value of the discount rate. This sensitivity is illustrated by the calculation of a 'break-even' discount rate, which ranges approximately between -2% and +10%, excepting the fisheries with losses in 2005-7. One unique 'best' discount rate does not exist, as it depends on a broad variety of conditions and considerations.

3.4. Recovery of management costs (scenario 9)

Management costs have been estimated for the seven case study fisheries on the basis of the shares of the involved fleet segments in the value of the national fisheries production, related to the total national costs of management (national totals are presented in annex 2). The management costs attributed to each segment were than subtracted from the profits of each fleet as a lump sum amount. In this approach, in principle payment of management costs reduces profitability, raises the level of the break-even revenues and consequently reduces the level of investments. The extent to which this leads to significant differences with the baseline scenario depends on various relations within the overall dynamics of the fishery, e.g. relation of management costs to revenues and their impact on change in break-even revenues.

Table 3.10 shows that payment of management costs would reduce the profits in scenario 9 by 65% in case of Atlantic anchovy, but only by 6% in case of the North Sea cod. In most other fisheries the reduction would amount to 20-30%. Due to the above mentioned process, costs recovery leads to a further increase in efficiency and consequently to slight improvement of profits before payment of management costs, which can be seen by comparing scenario 9 to the baseline scenario (Table 3.10).

Table 3.10 Average annual profits in baseline and in scenario 9 and management costs (mln euro)

Fishery	Baseline	Scenario 9		
	Profit	Profit before payment of management costs	Management costs	Management costs as % of profit
1. North Sea flatfish	73.4	76.3	24.2	32%
2. North Sea cod	361.9	361.9	23.1	6%
3. Baltic Sea cod	89.3	89.3	16.9	19%
4. Atlantic hake	109.3	106.7	28.5	27%
5. Atlantic anchovy	15.9	16.8	11.0	65%
6. Mediterranean anchovy	6.8	7.2	1.6	22%
7. Mediterranean hake	29.0	29.8	11.8	40%

In the year 15 of the scenario 9 most fleets are slightly smaller compared to the baseline scenario. However, there are almost no changes in the net profit.

Table 3.11 Comparison of the baseline (1 or 2) and scenario 9 in year 15

Scenario	1. NS flatfish	2. NS cod	3. BS cod	4. Atl. hake	5. Atl. anchovy	6. Med. anchovy	7. Med. hake
Fleet (number of vessels)							
Baseline	317	1,506	1,828	547	153	112	1,204
9	314	1,506	1,828	531	146	101	1,328
Net profit before payment of management costs (mln euro)							
Baseline	143	577	122	121	27	4	31
9	146	577	122	125	29	6	32

3.5. Adaptation paths (scenarios 10-14)

This section deals with the question of potential resource rents which could be achieved if overcapacity would be eliminated. Five distinct adaptation paths to fleets without overcapacity are explained in section 2.3 (scenarios 10-14). Scenario 10 maintains the fleet at the present level, but eliminates overcapacity by reducing the number of days at sea. Scenario 11 reduces the number of the vessels to the technical minimum, while the number of days at sea per vessel is set at the maximum level. Scenario 12 reduces the number of vessels to the technical minimum in the first year, but allows adjustment in the course of time if stocks and profits allow it. Scenarios 10-12 eliminate the technical overcapacity and consequently also solve implicitly the 'control problem'. The fleet does not have the capacity to exceed sustainable level of exploitation. However, in these scenarios it is possible that the production remains below the sustainable level, as the fleet may be too small to make full use of the available fishing opportunities. Scenario 13 maximizes the net present value of gross value added. This scenario shows the net profit when the fisheries contribution to the EU GNP would be maximized. Scenario 14 is similar to scenario 13, but maximizes the NPV Prf_{15}. Scenario 13 represent the interests of the society at large, while scenario 14 stresses primarily the interests of the vessel owners. Scenarios 13 and 14 optimize the economic capacity and achieves catches at a sustainable level in the long run, although not necessarily in each year, because investments in the fleet are constrained to a maximum of 10% up and 20% down.

Consequences for the net profit

Table 3.12 shows that recovery paths in scenarios 10-12 have relatively little impact on the NPV Prf_{15} in the two Mediterranean fisheries, the two cod fisheries and the Atlantic hake, the indexes remaining between 75 and 120. Considering that net profit is the bottom line, and consequently may fluctuate strongly, and stochasticity of the data, this may be considered as a very stable result. This implies that taking measures in addition to the TAC min or Effort min is unlikely to produce noticeable results. However, the structure of the fleets which produce the similar values of NPV Prf_{15} may significantly differ. This is illustrated in the development paths of the fleets presented in Figure 3.6 and Figure 3.7. The most important conclusion for these five fisheries is that different approaches to effort adaptation do not lead to significantly different NPV Prf_{15}. It is not relevant whether fleet or effort are constrained and how, but rather that the imposed constraints need to be effectively implemented.

The NS flatfish and Atlantic anchovy, the two fisheries making loss in 2005-7, the type of adaptation path makes a significant difference. The highest net profit would be achieved in scenario 12, when the fleet is instantaneously reduced in the beginning and subsequently allowed to grow again with the recovered stocks. Scenarios 11 and 12 contain explicitly a 'one off scraping scheme' but the public costs of scrapping schemes have not been taken into account in the simulations. Doing so may (significantly) reduce the benefits of these scenarios.

The two optimization scenarios 13 and 14 would lead in the cod and hake fisheries to an increase in NPV Prf_{15} by 20-70% over the 2005-7 situation, in most case approximately 40%. In the NS flatfish fishery, scenario 14 does not lead to significantly better results than scenario 12. This applies also to Mediterranean anchovy fishery. The Atlantic anchovy fishery would very significantly benefit from further optimization.

It must be stressed that optimization scenario are highly hypothetical as it is not clear which additional policies could achieve such results. In principle, optimization requires reduction of the fleet which is already profitable and there are no policy instruments which could oblige fishing firms, which operate according to the management rules, to stop fishing.

Table 3.12 Impact of the recovery paths on NPV Prf_{15}

Scenario	1. NS flatfish	2. NS cod	3. BS cod	4. Atl. hake	5. Atl. anchovy	6. Med. anchovy	7. Med. hake
Mln euro							
01. TAC min	754	3,885	969	1,222			
02. Effort min					161	79	328
10. Static present fleet	202	3,628	834	923	-5	79	264
11. Static minimum fleet	555	3,586	994	1,279	57	75	273
12. Dynamic minimum fleet	921	3,965	1,024	1,461	235	80	392
13. Optimum fleet (GVA)	760	5,509	1,370	1,481	594	67	449
14. Optimum fleet (profit)	1,010	5,599	1,630	1,742	985	85	486
Index (baseline scenario = 100)							
01. TAC min	100	100	100	100			
02. Effort min					100	100	100
10. Static present fleet	27	93	86	76	-3	100	80
11. Static minimum fleet	74	92	103	105	36	95	83
12. Dynamic minimum fleet	122	102	106	120	146	102	119
13. Optimum fleet (GVA)	101	142	141	121	369	85	137
14. Optimum fleet (profit)	134	144	168	143	612	108	148

Resource rent is often related to the 'excessive profits' realized by private producers over and above normal profit level (section 2.1). Figure 3.5 shows how total profits in year 15 and average profits per vessel would be affected by the different adaptation paths in the seven case study fisheries

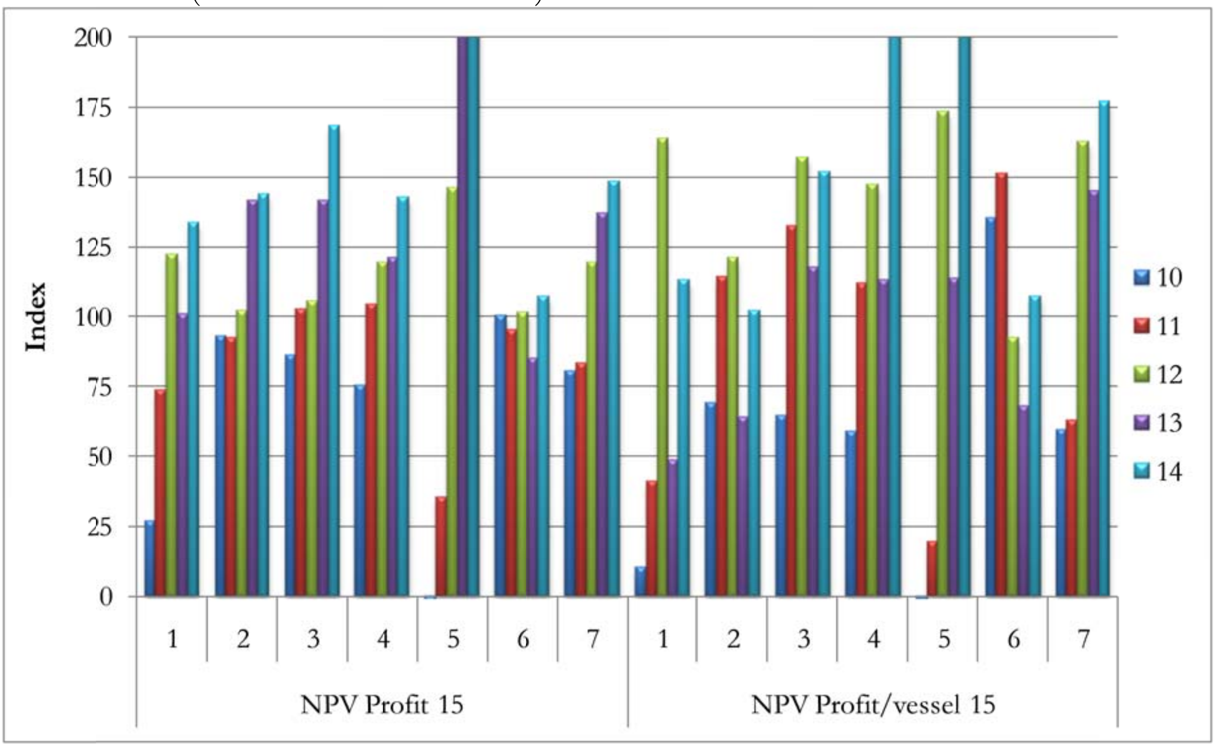
In relation to the net present value of profits, the following conclusions can be drawn:

1. The NPV of total profits over 15 years in scenario 10 is lower than in the baseline, while in scenario 11 it is either lower or about equal to the baseline. The constraints imposed on the fishing capacity in these two scenarios do not allow to exploit fully the sustainable fishing opportunities.
2. Scenario 13 leads to higher aggregate profits than in the baseline in most fisheries, except NS flatfish (1) and Mediterranean anchovy (6).
3. By definition, scenario 14 produces highest NPV $Profit_{15}$, although in some fisheries the differences from the results of some other scenarios are not significant.
4. Due to the reduction of the number of vessels, the NPV of profit per vessel is highest in scenario 12 or 14 for all fisheries. From the perspective of individual firms, these are the most attractive scenarios. They combines the benefits of reduction of the fleet in the beginning, with fleet adaptations during the entire period. However, it is interesting to notice that optimization of aggregate profits does not

necessarily lead to highest level of profits per vessel. This is particularly the case in the North Sea fisheries.

5. Scenario 13 leads to (in some cases significantly) lower NPV of profit/vessel as its focus is on maximization of NPV GVA_{15}. This scenario will increase the size of the fleet to exploit fully the available resources, although this may lead to a lower profitability of individual vessels. Consequently, this scenario leads also to highest employment.
6. The comparison between scenarios 13 and 14 illustrates that maximization of 'resource rent' depends on the choice of indicator to be maximized and that trade off exists between private and public interests. Choices can be made between highest benefits to the society (GVA), to the sector as whole (profit), to individuals working in the sector (GVA/vessel) or to the individual entrepreneurs (profit/vessel[28]).

Figure 3.5 NPV of total profits and average profits / vessel over 15 years by fishery and scenario (index baseline scenario = 100)*



*Several indexes exceed the 200-value, but were not fully included to keep the other values legible. This applies to NPV $Profit_{15}$ in fishery 5 (Atl. anchovy) scenario 13 (index=369) and scenario 14 (index=612) and NPV $Profit/vessel_{15}$ fishery 4 (Atl. hake) scenario 14 (index=287) and fishery 5, scenario 14 (index=465).

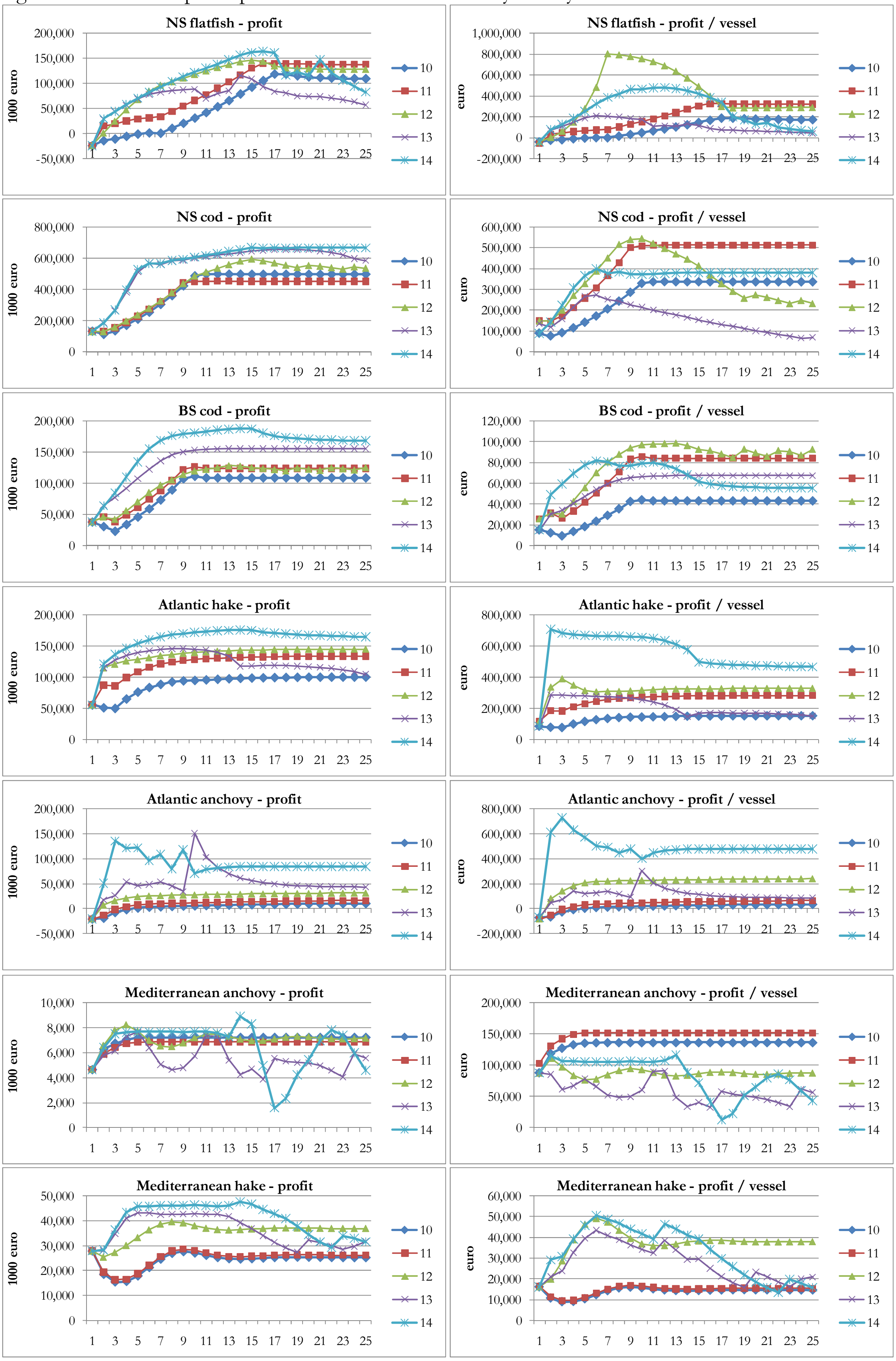
Achieving a steady state

Figure 3.6 and Figure 3.7 show the simulation results over the 25 years of each case study for the four indicators – GVA, fleet, aggregate profits and profit/vessel. These figures show whether the fisheries reach a steady state, i.e. a relatively constant levels of each of those indicators. Scenarios 10-12 reach a steady state, mostly within 10 years. The optimization scenario 13 shows a more volatile development. In that scenario GVA stabilizes after about 15 years for most fisheries, except NS cod. The size of the fleet stabilizes only in three out of seven fisheries and the same applies to the level of profits.

[28] It would be preferable to use profitability (profit per unit of capital), but this value cannot be determined with the present data.

Figure 3.6 GVA and fleet in scenarios 10-14 by fishery

Figure 3.7 Profit and profit per vessel in scenarios 10-14 by fishery



4. NORTH SEA FLATFISH FISHERIES

4.1. Summary and conclusions

Main conclusion

The seven segments analysed in this fishery realized in 2005-7 on average a total net loss of 24 mln euro. Average annual discounted net profit ranges under most scenarios between 50 and 70 mln euro. Elimination of overcapacity and recovery of stocks would produce a discounted net profit of 55-97 mln euro by the year 15. (see Figure 4.1)

Brief description of the case study

The target species of the North Sea flatfish sector are European plaice and Common sole. The first part of this case study report (section 1-6) provides information about the seven fleet segments that contribute the most to the North Sea flatfish sector, including the fleets of Belgium, Denmark, The UK and the Netherlands. Fleet economic indicators are estimated and compared, after a more general presentation of the various segments. Most values applied in this case study are based on an average of the years 2005-7.

Section 7 describes the results of 14 scenario runs with the FISHRENT model. The model was run for 6 policy simulation scenarios and four optimization scenarios with different fleet adaptation paths. Furthermore, the possibilities for recovery of management costs were investigated using this model and effects of different discount rates were tested.

Divergence / convergence of the results

Results of the different scenarios are compared in terms of the net present value of net profit over 15 years (NPV profit_{15}). Comparison of the policy scenarios to the Open access scenario shows that the most restrictive policy scenarios (TAC min, Effort min and Min min) score much better than no policy at all. The TAC min scenario, which resembles the present policy in the North Sea flatfish fishery most, has a NPV profit_{15} of 750 million euro while the Open Access scenario shows a negative NPV of profit. The optimum fleet scenario 14, where NPV profit_{15} is maximized, scores 34% higher than the TAC min scenario.

Choice of baseline policy

The TAC min scenario was chosen as baseline policy scenario as this resembles the present policy for the NS flatfish fishery. In this scenario, effort is determined by the most restrictive TAC and TACs cannot vary more than 15% from year to year. In reality the fishery is also managed by both TACs and effort restrictions. TACs, however, may be considered the primary management tool.

Achieving MSY

On basis of the stock growth function of the FISHRENT model, MSY of sole was estimated at 28,000 tonnes, with Hmsy of 0.3. This MSY is only reached in the Effort min scenario. This is an effort management scenario where allowable effort in each year is determined by the most restrictive target harvest ratio. Hmsy of plaice was estimated at 0.26. None of the scenarios reaches Hmsy for plaice. In the TAC max, Effort max and Open access scenarios, where in the first simulated years effort is higher than sustainable from the perspective of the sole stock. In these scenarios, the sole stock is depleted and profitability of the fishery is very poor. The fleet does not have the possibility to invest and expand to the size required to fish the complete plaice TAC.

Achieving MEY

MEY is here defined as the maximum net present value of net profit over 15 years. The maximum discounted profit was found in the Optimum fleet scenario 14. This is not surprising because this is the only scenario where NPV $profit_{15}$ is explicitly maximized. The policy scenarios with highest NPV $profit_{15}$ were the Min min, the TAC min and Effort min scenario, the three most restrictive policy scenarios.

Role of discount rate

The basic discount rate, used in all scenarios, is 3.5%. A higher discount rate implies lower discounted profit and a lower discount rate implies higher discounted profit. Using a discount rate of 2% instead of 3.5%, results in a 15% higher NPV $profit_{15}$. Using a discount rate of 5% instead of 3.5% results in a 13% lower NPV $profit_{15}$.

Impact of eliminating overcapacity

Four optimization scenarios with different adaptation paths of the fleet have been run with the FISHRENT model. In the static present fleet scenario, overcapacity is not removed but a capacity ceiling is imposed which keeps the fleet at the size of the base year. Disadvantage of this scenario is that there is also no downward adjustment of the fleet when this would be required. This scenario has a much lower score on the NPV $profit_{15}$ years than the main TAC min scenario.

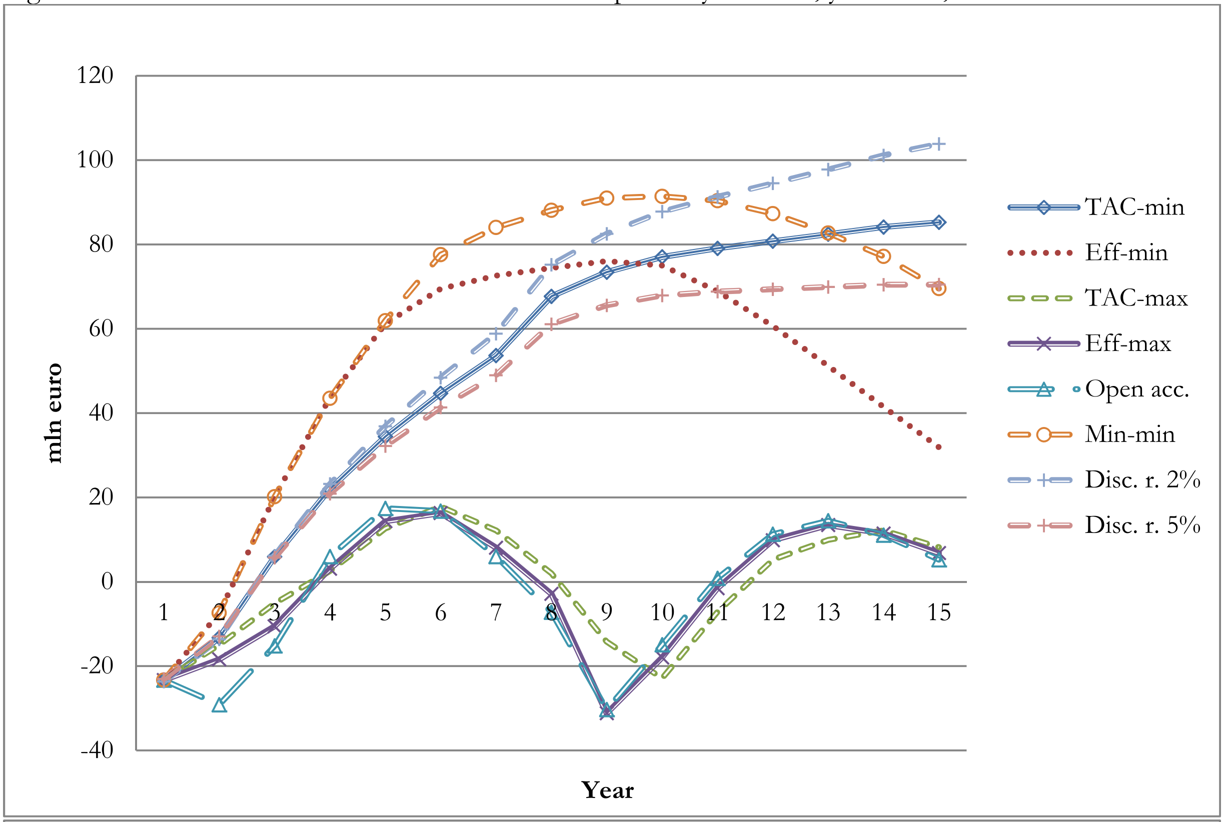
In the static minimum fleet scenario, overcapacity is completely removed in year one and the fleet is kept at that size throughout the simulation. The NPV $profi_{15}$ of this scenario is higher than in the static present fleet scenario. In the dynamic minimum fleet scenario the fleet is maintained at minimum level throughout the simulation period. In other words the fleet is operating at full capacity level, using the maximum number of days at sea per vessel. This scenario scores much better than the static present fleet scenario and the static minimum fleet scenario. In the optimum fleet scenario, where NPV $profit_{15}$ is maximized, all segments are also operating at full capacity throughout the simulation period but on top of that, the relative size of each of the segments is optimized. Not surprisingly, this scenario has by far the best results in terms of NPV $profit_{15}$.

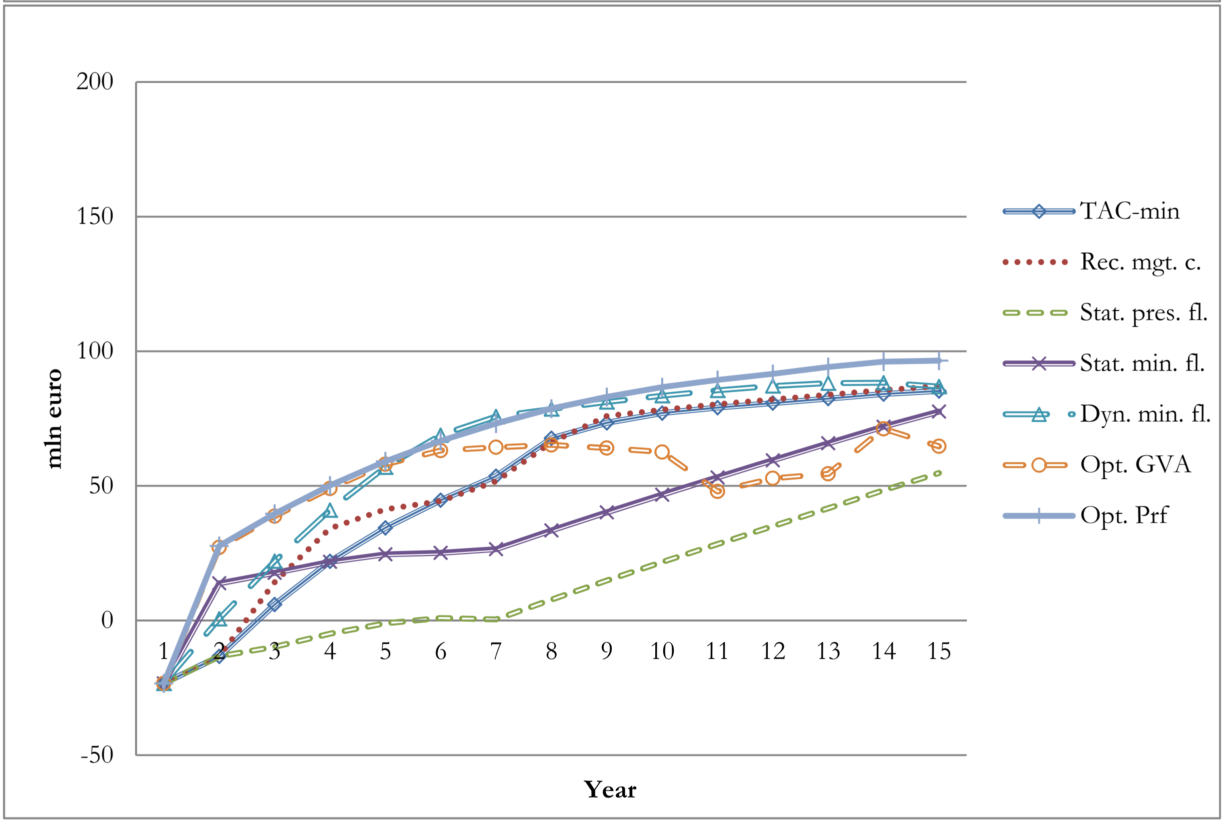
Management costs and rent recovery

Payment of an annual access fee equal to the management costs directly affects the profit of the segments. All segments had negative profits in the base year and the extra costs of payment for access cause profits in the first years to be even more negative and it takes longer than in the main scenario before the profits turn positive. Nevertheless, after 5 years all segments are making a profit. NPV $profit_{15}$ after payment for access is about 10% lower than in the main scenario. The difference is app. equal to the total discounted payment for access over these 15 years. The discounted value of profits over these 15 years is 33% lower than in the main scenario.

If the government would try to capture more resource rent from the fishery, by for instance doubling the payment for access to twice the management costs the NPV of profit would decrease to 266 million euro, a further deterioration by 33%.

Figure 4.1 North Sea flatfish – discounted annual net profit by scenario, years 1-15, mln euro





4.2. Case study definition

4.2.1. Fleet and landings

In this section the largest contributors to the North Sea flatfish fishery are presented. They include a total of seven segments, with 619 vessels, in the four countries Belgium, Denmark, the UK and the Netherlands. The Danish demersal trawl/seiner category (DTS) and the polyvalent passive gears (PGP) – both of 12-24 meters are involved, and also beam trawlers (TBB) in Belgium, the UK and the Netherlands are included. The beam trawlers consist of two vessel categories; one with vessels between 24-40 meters and one with vessels >40 meters. The role of the fleet segments within their national fishery sectors is presented in

Table 4.1 Role of case study fisheries within national fishery sectors

Member State	Total fishery sector		Case study fleets	
	Total revenues (mln euro)	Total fleet (number of vessels)	Revenues (mln euro)	Fleet (number of vessels)
BEL	86	110	69	55
DNK	794	2,114	86	365
GBR	822	4,129	65	69
NLD	383	612	172	137

Of the 619 vessels, more than half (365) belongs to the Danish fleet and about one third (173) to the Dutch fleet. Only 48 vessels belong to the Belgian fleet, and 69 to the British fleet. However, in terms of GT, the largest fleet segment is the Dutch beam trawlers of more than 40 meters (42,190 GT), followed by the Belgian beam trawlers of 24-40 meters (16,200 GT). Whereas the British and the Dutch beam trawlers of 24-40 meters are almost equal in terms of tonnage (11,040 GT and 10,670 GT respectively), the three smallest categories are the UK beam trawlers of >40 meters and the two Danish fleet segments Table 4.2.

The target species, Common sole and European plaice, constitute a large share of total value of landings but a much smaller share of the volume of landings. Whereas the target species are 56% of the total value, they are only 30% of total volume of landings. Table 4.2 presents all harvest by the selected segments that operate in the North Sea, implying that also the Belgian and the UK catches in the Atlantic area are included.

Table 4.2 Role of target species

MS	Gear	Size	No. vessels	GT (1000)	Value (mln euro)		Landings (1000 t)	
					Target species	Total	Target species	Total
BEL	TBB	24-40	55	16.2	12.4	69.1	3.4	16.2
DNK	DTS	12-24	258	8.6	12.6	59.7	5.7	132.9
DNK	PGP	12-24	107	3.9	11.2	26.2	3.5	20.4
GBR	TBB	24-40	54	11.0	8.4	41.1	3.8	12.9
GBR	TBB	>40	15	7.4	16.7	23.6	6.6	8.6
NLD	TBB	24-40	48	10.7	26.0	43.7	5.9	10.3
NLD	TBB	>40	89	42.2	109.2	128.1	24.4	39.0
Other					33.4		33.4	
Total			626	100	230	391.4	63	240.3

Averages 2005-7. Source: DCR

* Sole and plaice are also caught by other fleet segments. Volume and value of these landings by other segments can be found in Table 4.3 and Table 4.4.

The largest volume of target species is landed by the Dutch beam trawlers >40meters (35% of total landings of European plaice and Common sole), followed by the Danish trawl/seiner (21%). All the other fleet segments land from 7-10% each of the total landings of target species. Looking at the share of total value of landings, the Dutch beam trawl fleet over 40 meters is also here contributing the most (42%), followed by the Belgian beam trawlers (15%) and the Dutch beam trawlers of 24-40 meters as well as the Danish trawl/seiner (both 11%). The remaining categories contribute 6-8% each to the total value of landings of the target species.

Further 11 segments are fishing European plaice and common sole in the North Sea than the seven already mentioned. They include a Belgian segment (beam trawl between 12-24 meters), three more Danish segments (beam trawl between 12-24 meters, pelagic trawlers of 12-24 meters and combined mobile and passive gears of 12-24 meters), four German segments (demersal trawl/seiner, drift nets/fixed nets and three beam trawl segments of 12-24 meters, 24-40 meters and >40 meters), one more British segment (beam trawl between 12-24 meters) and two more Dutch segments (demersal trawl/seiner and beam trawl between 12-24 meters). Note that these 11 other segments are contributing with 14% and 16% of volume and value of landed European plaice and Common sole, respectively, considering only harvests made in the North Sea (harvests in the Atlantic Sea excluded). These seven segments represent 79% of the total landings of plaice and sole from the North Sea.

4.2.2. Composition of landings

In the Table 4.3 and Table 4.4, not only European plaice and Common sole are included, but also the volume and value of other important fish species harvested by the different segments, such as the Atlantic cod, turbot and the lemon sole. Whereas turbot is important to most segments, the Atlantic cod is particularly important to the two Danish segments. Lemon sole is harvested by the Belgian and the UK beam trawlers.

The total volume of Atlantic cod is 11,200 tonnes (5% of total) and the value is 25 mln euro (6% of total). The shares of turbot and lemon sole are very small. A large share of the harvests of the two Danish segments as well as the largest vessel segment of the UK are species not mentioned here included under 'others'. They compose 74%, 60% and 67% of total value of these three segments, respectively. This share is almost 30% for the Belgian beam trawl segment and around 20% for both Dutch vessel segments. The shares are even higher when looking at the total values, as, for example, the Danish demersal trawl/seiner category harvests almost 90% in tonnes of other not mentioned species.

The last two columns of the Table 4.3 and Table 4.4 provide information about landings of target species from the North Sea. As mentioned above, only the beam trawlers of 24-40 meters in the UK and in Belgium have catches of target species outside the North Sea, namely in the Atlantic area. Table 4.3 and Table 4.4 also show the contribution of 'other fleets' that harvest Common sole and European plaice in the North Sea. Their shares are rather small.

Table 4.3. Composition of landings by segment (1000 tonnes)

MS	Gear	Size	Comm. sole	Europ. plaice	Atlantic cod	Turbot	Lemon sole	Other	Total	Comm. sole	Europ. plaice
										North S.	North S.
BEL	TBB	24-40	2.9	4.2	0.0	0.3	0.8	8.1	16.2	0.6	2.8
DNK	DTS	12-24	0.2	5.5	9.3	0.0	0.0	117.8	132.9	0.2	5.5
DNK	PGP	12-24	0.6	3.0	2.5	0.1	0.0	14.3	20.4	0.6	3.0
GBR	TBB	24-40	0.8	4.1	0.0	0.2	0.0	7.9	12.9	0.2	3.6
GBR	TBB	>40	0.5	6.1	0.0	0.2	0.2	1.7	8.6	0.5	6.1
NLD	TBB	24-40	1.7	4.2	0.0	0.4	0.0	4.0	10.3	1.7	4.2
NLD	TBB	>40	7.2	17.2	0.0	1.4	0.0	13.2	39.0	7.2	17.2
Other										1.8	7.9
Total			13.8	44.2	11.8	2.6	1.0	166.8	240.3	12.7	50.3

Averages 2005-7. Source: DCR 2007

Table 4.4. Composition of landings by segment (mln euro)

MS	Gear	Size	Comm. sole	Europ. plaice	Atlantic cod	Turbot	Lemon sole	Other	Total	Comm. sole North S.	Europ. plaice North S.
BEL	TBB	24-40	32.3	8.2		3.3	3.7	20.3	69.1	6.6	5.8
DNK	DTS	12-24	2.3	10.3	17.6			87.0	59.7	2.3	10.3
DNK	PGP	12-24	6.0	5.2	7.5	1.4		29.6	26.2	6.0	5.2
GBR	TBB	24-40	9.5	7.5		2.3		23.6	41.1	2.2	6.2
GBR	TBB	>40	5.2	11.5		2.6	0.7	2.9	23.6	5.2	11.5
NLD	TBB	24-40	17.8	8.2		3.5		11.3	43.7	17.8	8.2
NLD	TBB	>40	76.2	33.0		4.1		31.8	128.1	76.2	33.0
Other										18.3	15.0
Total			149.4	83.8	25.0	17.2	4.4	206.5	391.4	134.7	95.1

Averages 2005-7. Source: DCR 2007

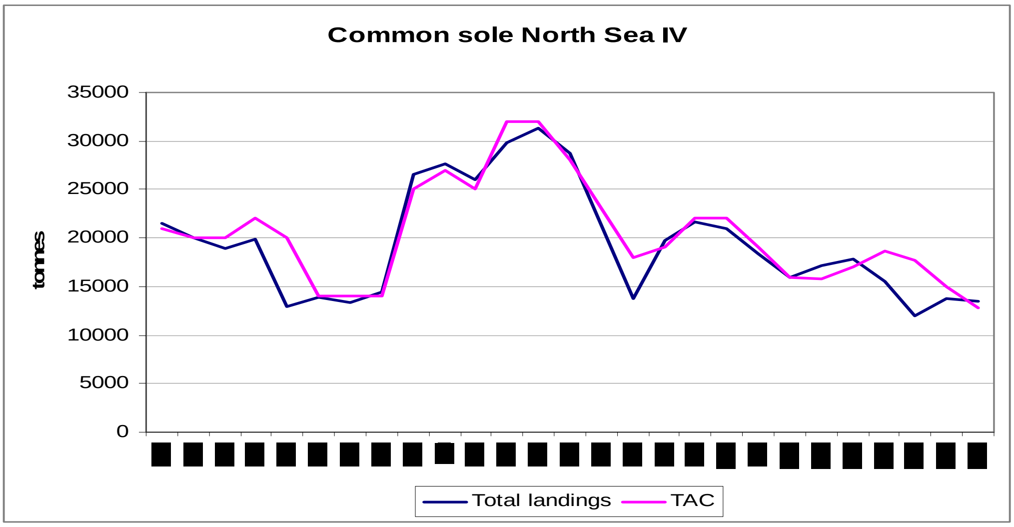
4.3. Historical indicators

In Figure 4.2 and 4.3, the total landings and TACs in the North Sea over the years 1982 to 2008 are shown. Whereas the total landings and TACs have been rather close over the years for Common sole, the TAC has been a lot higher than the landings for European plaice before 1996.

Figure 4.2 shows that for common sole, there was a decrease in landings and TAC in the mid-80s followed by a rather stringent increase until a peak was reached in 1994. After 1994, the TACs and landings decreased significantly. Presently landings and TAC are less than half the weights landed in 1994. During the very last years, the TAC has been higher than the landings for Common sole.

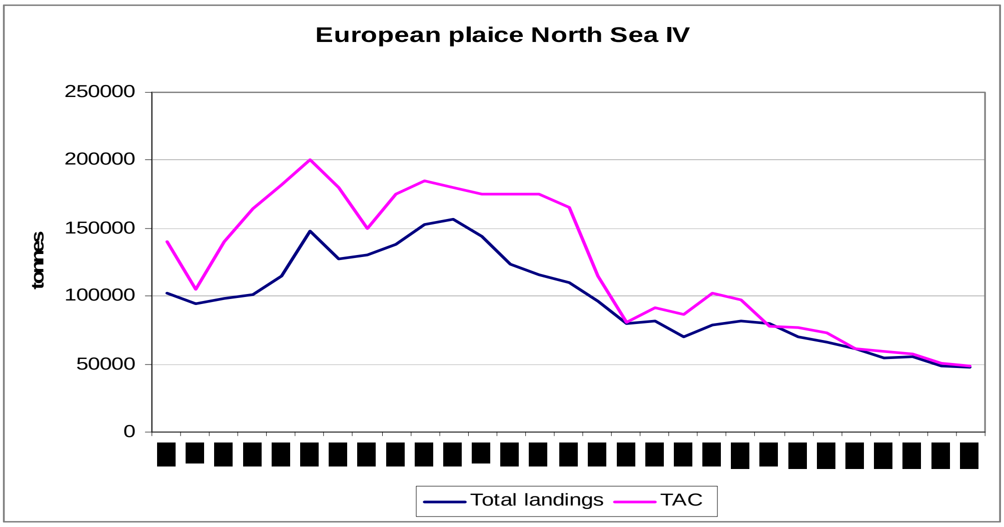
Figure 4.3 shows a slightly different trend of landings and TAC for European plaice. In the second half of the eighties there was a peak in landings and TAC. Thereafter, both landings and TAC for European plaice have decreased until present with less than one third of the observed peak in landings and one fourth of the peak of the TAC.

Figure 4.2 Total landings and TAC of Common sole in the North Sea, 1982-2008.



(Source ICES, 2009).

Figure 4.3 Total landings and TAC of European plaice in the North Sea, 1982-2008.



(Source ICES, 2009)

The largest landings of the two target species took place for Common sole in 1994 (31,291 tonnes) and for European plaice in 1990 (156,261 tonnes). In comparison, the landings and TACs for European plaice and Common sole were 13,435 tonnes and 147,687 tonnes, respectively.

According to ICES (2009), the mortality rate for maximum sustainable yield (Hmsy) is 0.3 for European plaice and 0.2 for Common sole in the North Sea (See Annex 1, Table A1). However, it is not straightforward to judge on the exact maximum sustainable yield (MSY), although it is possible to assume that this value would be close to the largest landings in the past years, which were 31,000 tonnes for Common sole and 156,000 tonnes for European plaice[29]. Note that this would imply that the sustainable spawning biomasses (SSB) should be larger than they are at present (See Annex 1, Table A1).

For two successive years, the stocks of plaice and sole have been classified within safe precautionary boundaries. An increase is observed for the SSB the two last years for both species. The main reason for this increase is the reduction of fishing mortality under the present management plan (ICES, 2009). Also a reduction of capacity of the fleets, limitation of fishing effort and high fuel prices have contributed to the decrease in fishing mortality.

The North Sea flatfish fisheries are currently preparing to meet future challenges, such as expected high future oil prices, increased fishing restrictions by regulations on target species as well as lower price on fish products because of cheap fish substitutes imported from Asia. As a consequence, the vessels in the North Sea flatfish sector are now more diverse than before.

4.4. Fleet efficiency

In this section, several economic indicators are estimated to compare the different segments. The profits of all fleet segments are negative, and most negative for the beam trawl segments of 24-40 meters in the UK and Belgium.

Employment is measured in FTE, except for the Belgian segment where employment is presented in terms of number of people. Employment is highest for the Dutch beam trawlers longer than 40 meters and the Danish demersal trawl/ seiner, and lowest for the British segment of Beam trawl longer than 40

[29] The biomass growth function used in the FISHRENT model implies MSY of 28,000 tonnes for sole and 140,000 for plaice

meter. Looking at the average price efficiency indicator, they all have a value between 2400-3700 (euro/t), but the Danish demersal trawl/seiner has a much lower value (<1000). The fuel costs as a share of income is the lowest for the two Danish segments. The profit/ landings is least negative for the Danish demersal trawlers and seiners. The catch per unit effort (CPUE) is high for largest vessel sizes in the UK and the Netherlands, but small for the polyvalent passive gear of Denmark. The value per unit effort (VPUE) is high for the beam trawl segments and low for the Danish segments.

Table 4.5 Economic indicators (average 2005-7)

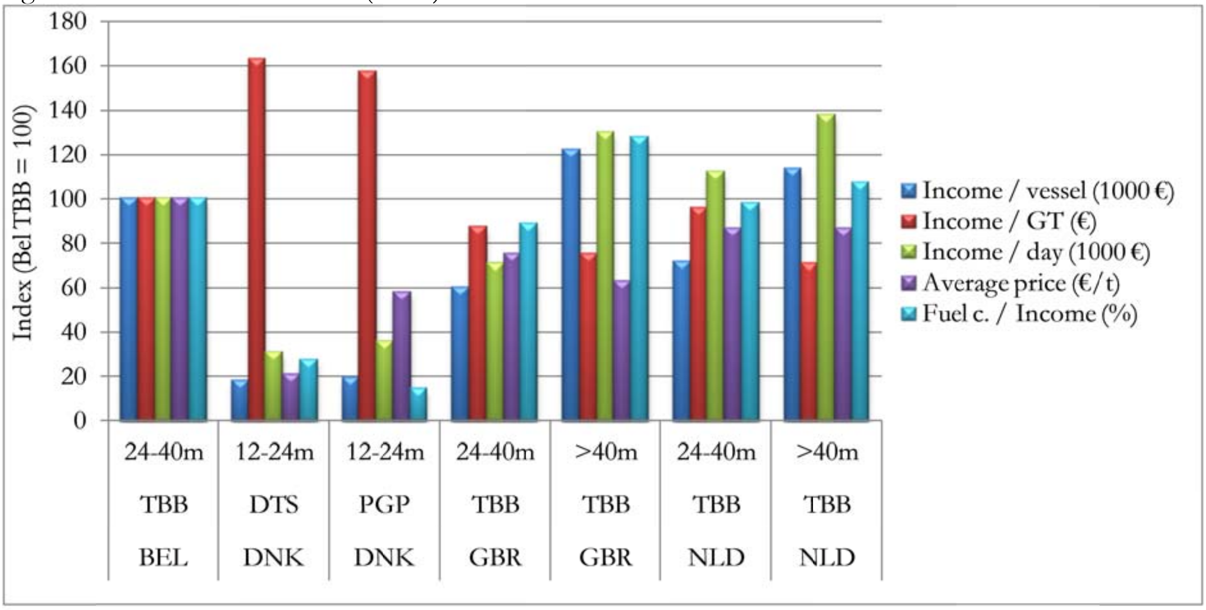
MS	Gear	Size	Gross value added (mln euro)	Profit (mln euro)	Empl. (FTE)	Average price (euro/t)	Fuel costs % of income	Profit / tonne landings	CPUE total (t/day)	VPUE target species (1000 euro/day)
BEL	TBB	24-40	7.1	-2.1	338.3*	3472.1	39%	-328.7	1291.7	5.4
DNK	DTS	12-24	35.0	-1.6	518.4	882.3	11%	-24.1	1877.7	1.7
DNK	PGP	12-24	16.7	-0.7	254.1	2431.1	6%	-68.4	778.7	1.9
GBR	TBB	24-40	11.1	-2.5	268.3	3136.0	34%	-193.6	1225.6	3.8
GBR	TBB	>40	2.6	-7.5	77.9	2641.4	50%	-877.2	2604.5	6.9
NLD	TBB	24-40	15.5	-1.9	211.0	3637.5	38%	-185.6	1445.0	6.2
NLD	TBB	>40	42.2	-3.5	552.9	3651.0	42%	-89.8	2307.4	7.6

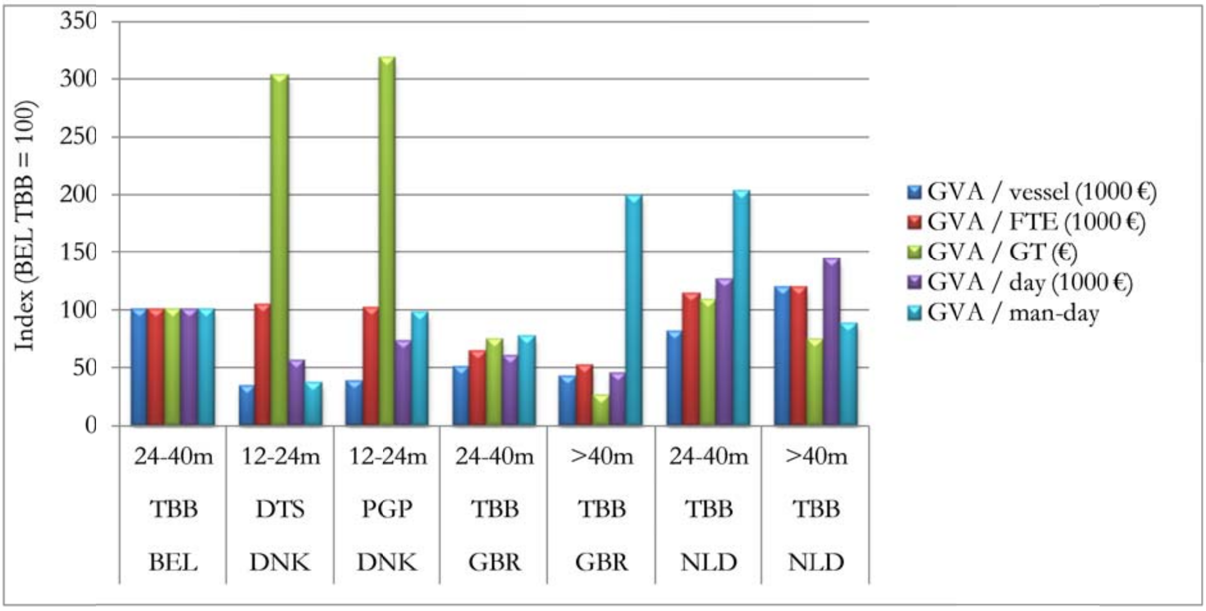
*Total employment is provided, FTE is not available

In Table 4.5, efficiency measures of the different fleet segments are compared with respect to income per vessel, income per GT, income per day, average price and fuel consumption per income. Compared with the Belgian fleet, both the Danish fleet segments are more efficient when it comes to income per GT and fuel consumption per income, and less efficient for the others. The British beam trawlers of 24-40 meters are more efficient in terms of fuel consumption per income, and less efficient with the other efficiency measures. The British beam trawlers of more than 40 meters are more efficient in terms of income per vessel and income per day, but less efficient with fuel consumption per income. This is also the case for the largest Dutch beam trawl category. The segment of Dutch beam trawlers of 24-40 meters is rather close to the Belgian efficiency measures, although lower income per vessel and lower average prices are observed.

In Figure 4.4, the different fleets are compared with the Belgian fleet segment with respect to several efficiency measures. The Belgian beam trawl segment is standardised to 100 to find relative differences with the other segments..

Figure 4.4 Economic indicators (index)





4.5. Management of the fishery

4.5.1. General description

The flatfish sector in the North Sea is managed by restrictions of Total Allowable Catch (TAC), effort restrictions and technical measures. Fishing effort has been substantially reduced since 1995. This reduction in fishing effort is reflected in recent estimates of fishing mortality.

In 2007, the EC has adopted a management plan for flatfish in the North Sea (Council Regulation (EC) No. 676/2007). This plan has two stages. The first stage aims at an annual 10% reduction of fishing mortality in relation to the fishing mortality estimated for the preceding year, with a maximum change in TAC of 15% until the precautionary reference points are reached for both plaice and sole for two successive years. In the second stage, the management plan aims for exploitation of plaice at and F=0.3 and sole at H = 0.2[30].

4.5.2. Output management

Main output management measures in the flatfish fishery are the TACs for sole and plaice. The four countries Denmark, Belgium, the UK and the Netherlands, contributing with the largest landings of plaice and sole in the North Sea, have implemented the management of their national share of these TACs in different ways. In the UK, the Netherlands and Denmark, quota are allocated individually to fishermen or fishing companies. In these countries, individual quota can be traded.

1.5.2.1 Catch restrictions

Catch restrictions in the Netherlands

An official system of ITQ trade was implemented in 1985, after a period when extensive 'unofficial' transfers took place. This system is managed by a co-management framework with fishers being responsible for the industry, organized by groups of fishing firms since 1992. Fishermen in each group are in charge of controlling ITQ transfers, and controlling accessory maximum days-at-sea that has been introduced, between members on a permanent basis (buying/selling), or on a yearly basis (leasing), using agreed transfer prices (Smit, 2001). In 1993, the transfer of quotas became restricted by limited periods at the end of the year when quotas were nearly exhausted to prevent doubtful transfers.

Catch restrictions in the UK

In the UK, the national share of the TACs is distributed over vessels on basis of landings in a fixed reference period, namely the years 1994-96 (MRAG, 2007). This is referred to as the fixed quota allocation system (FQA). The FQAs are grouped within their Producers' organisation (POs) and the government manages quotas for non-members of the POs. (Van Hoof et al, 2002). Hence, UK quota is allocated to POs, non-sector, and < 10m vessels proportionally to the aggregate number of FQA units held by vessels in each group at the beginning of each year (MRAG, 2007). Since 2002, the FQA units can be traded separately from vessel licences.

Catch restrictions in Belgium

In Belgium the main management aim is to fish the EU TAC quota share as efficiently as possible – implying as high incomes and as low costs as possible (Task Force Visserij, 2006). The quotas in Belgium are divided by means of area and species by a national quota commission that meets every month to give advice on quota allocation. Their advice is further implemented at Ministry level (Adriansen, 2009).
Catches are spread over the whole fishing season mainly by setting maximum catches of a given stock per day. Since 2006 it was made more flexible by setting the upper limit of harvest per day to the sum of the day limits (Adriansen, 2009).

Catch restrictions in Denmark

Until 2006, the Danish fishery was based on common pool quotas (CPQ) (Raakjær Nielsen and Christensen, 2006). Fisheries management in Denmark is primary about dividing the national quotas over time and space. Catch rations are allocated in accordance with vessel length irrespective of gear used and only take limited geographical considerations (Christensen and Raakjær, 2006).

[30] ICES interprets the F for the preceding year as the estimate of F for the year in which the assessment is carried out. The basis for this F estimate in the preceding year will be a constant application of the procedure used by ICES in 2007.

Vessel Transferable Quotas (VTQs) were implemented in the Danish demersal fisheries 1 January 2007 (MRAG, 2007). The main difference between the ITQ and VTQ systems is that in the former the fish quota can be transferred by the owner independently of the fishing vessel to which it was initially allocated. In the case of the VTQ system the fish quotas (allocated on a 3 year historic record) and the vessel to which they are allocated are inseparable and thus only transferable together

1.5.2.2 Property rights

Property rights in the Netherlands

As mentioned above, an official system of ITQ trade was implemented in 1985. Co-management groups have pooled the quota (ITQs) since 1993, whereby the board of each group is responsible for the compliance with the group quota. The ownership of the rights remains with the individual holders. These groups facilitate trade, hiring and renting of the ITQs between their members, which make the system flexible. The ITQs also serve as security for banks if a loan is required to finance, for example, a vessel. The values of harvesting rights have increased 30 times per vessel over the years 1983-1998. (Smit, 2001).

The transfers since 1985 are subject to some main rules (MRAC, 2009). For instance, quotas can only be bought by owners of a fishing vessel that is registered on an EU list and who is in the possession of a license. Moreover, the transfers have to be approved and registered by the Fisheries Department.
It is very difficult for newcomers to access fishing rights in the existing quota transfer market (MRAG, 2009). Also is it difficult for nationals of other Member States to access fishing rights, although in principle this is possible.

Property rights in the UK

The stated purpose of the POs management responsibilities is to enable planning of the use of particular quotas in order to optimise the returns to their members. The POs administer and manage a total of 95% of the quotas for their member vessels. They manage the quota as a collective transferable quota, as there is a lively trade in fishing licences and quotas in the UK. The pooling of quotas allows fishermen to have some flexibility for their actual catch in a multispecies fishery. In the UK the trading in quotas is not explicitly allowed, but not illegal either. Consequently there are no restrictions on the trade in quotas in the UK.

FQAs can now be leased, traded permanently, or 'swapped' in the UK independently of vessel licences (MRAG, 2007). These processes are managed by POs and Fisheries Administrations. Quota trading among POs increased nearly seven-fold between 1995 and 2000. Quite a number of UK vessels are owned and used by Dutch fishermen as a result of quota hopping in the past. (Van Hoof et al, 2002; MRAG, 2007).

Property rights in Belgium

Belgium is against transferable rights and works with a collective utilisation system (MRAG, 2007). Quota for sole and plaice are distributed over vessels on basis of engine power. These vessel quota are in principle not tradable. The only way to acquire more quotas within the collective system is to buy a withdrawn vessel without the use of public aid. When a vessel leaves the fleet without public aid, its registered engine power can be used for addition to the registered engine power of an existing fishing vessel. In doing so, the vessel owner receives extra catch possibilities for those stocks that are allocated in function of kW.

The difficulty for newcomers to access the sole and plaice fishery is principally related to the availability of vessels, as the value of the right to fish is included in the vessel price. The fishing licence follows the vessel and is in principle not tradable.

The access of nationals of other Member States to fishing rights is theoretically possible, but limited in practice because of the need to prove a genuine economic link with the coastal area. Criteria for this are that at least 50% of the crew members live in the Belgian coastal area, or at least 50% of the landings of the vessel on a yearly basis occur in Belgium.

Property rights in Denmark

VTQs have been allocated free of charge according to the historical 3-year record of the fishing vessels applying for quotas (MRAG, 2007). The quotas are not divisible from the vessel to which they have been allocated, meaning that vessel and quotas can only be traded together. There is a high demand for vessels with quotas.

Fishers can establish groups where VTQs are pooled on a yearly (13-months) basis. Members of a pool group are free to swap, lease or lend their quotas within the group. Pool groups must have by-laws and a chairperson, who must approve swaps and keep track of, and report on group quota utilisation. In 2008 there were 11 pool groups in Denmark comprising 670 fishing vessels.

There is a holdback/reserve scheme through which new entrants can make a multi-annual quota loan. Every year a small proportion of the national quota is set aside for loan to new entrants below the age of 40 (young fishers). The loan period is a maximum of 8 years. After 4 years the loan is reduced each year. In addition, new entrants are allowed (within some limitations) to buy VTQ from existing vessels without necessarily taking ownership of the vessel. The intention is that during the 8 year loan period (especially after year 4) the newcomer becomes well established and financially able to buy the VTQ he wants on normal conditions. At present there are 20 young fishers who have taken out VTQ loan.

The Danish fisheries law is very strict on who can own a fishing vessel. The requirement that 60% of the vessel capital shall be owned by active fishermen excludes company ownership. The owners shall be Danish or EU citizens and hold Danish A-licence. To fulfil the license requirements the rights holder must be a resident of Denmark.

4.5.3. Input management

In all EU Member States licences in kW and GT are obligatory on the basis of the EU Fleet Register regulation. Whereas in Denmark and in the UK the licence management is a major component, limitation on days at sea seems to be the most important in Belgium and the Netherlands. Only in the Netherlands several input restrictions are tradable, including the days at sea.

Effort restrictions in the Netherlands

The right to fish is established by possession of a fishing licence. The engine power of a vessel is registered on the licence. Fishing licences can be freely transferred. It is also possible to aggregate more than one licence on one vessel. The licensing scheme is coupled to the EU fleet register.

Fishing vessels are restricted by a maximum number of days at sea. The allocation of days at sea is dependent on the type of fishery. For example, the North Sea beam trawl fleet was limited to a maximum of 143 days per vessel in 2007. Days at sea are transferable between vessels within the same fishery. The system of transferable effort quota (days at sea) is managed by the co-management groups. Days at sea can be transferred between members on a permanent basis (buying/selling), or on a yearly basis (leasing).

Effort restrictions in the UK

All UK-registered vessels must hold a licence issued by the UK Fisheries Department. Detailed administrative rules specify how fishermen can transfer or aggregate licences. (Van Hoof et al, 2002). No new fishing vessel licences are issued in UK because of the need to control the size of the fleet. People wishing to license a vessel for the first time must obtain an existing licence 'entitlement'. This arises when an existing licensed vessel is sold, scrapped, or is otherwise de-registered.

UK vessels holding quota must also comply with numerous restrictions on fishing methods, closed areas, etc (MRAG, 2007). Notable are the limitations on days-at-sea during 2007 for vessels >10 m, designed to protect hard-pressed stocks of cod and sole around the UK. Days-at-sea are transferable from one vessel to another in the same fishery.

Effort restrictions in Belgium

Anyone fishing for species subject to the quota system is required to hold a government licence for the vessel. The licensing system is an additional measure to control fishing capacity and is directly connected to the EU Fleet Register. The licence determines the power, tonnage and length of the vessel. Licences are granted within a given segment on the basis of the engine power: The fishing capacity licences are not transferable. Access to rights (quotas, licence) is determined by the purchase of a withdrawn vessel (without public aid).

Specific rules apply to the kW and tonnage of a new vessel. Increasing the engine power on a fishing licence is possible, through the principle of combining the engine power of fishing vessels which are definitively withdrawn from the fleet without receiving aid. Maximum allowed engine power per vessel has risen from 957 to 1,200 kW in 2006. A new vessel (either newly built without State aid or second-hand) may be placed on an existing fishing licence at any time, but for the large-vessel fleet and the coastal fishing fleet, the tonnage of the new vessel is limited to 0.3 times the withdrawn engine power in KW. For the small-vessel fleet, this factor is increased to 0.445. (MRAG, 2009).

In addition to these arrangements, individual non-transferable effort quotas have been introduced in the sole and plaice fishery. A days-at-sea system was introduced to control activity in an attempt to ensure an optimal time repartition of catches. In 2009 the total Belgian number of days at sea in the flatfish sector decreased by 9.5% for the flatfish sector, compared to the previous years (Adriansen, 2009 p 38).

Effort restrictions in Denmark

Within the framework of CFP, the Ministry of Food, Agriculture and Fisheries (MFAF) has the right to define access to and exclusion from fisheries through the distribution of licences. The Danish management of fishery builds on access regulation in combination with regulation of the total fleet capacity measured by tonnage and engine power. Access regulation implies that in order to fish, a person must be an authorised full time/part time fisher and the vessel must be registered as a fishing vessel and granted a license. This license specifies tonnage and engine power of the vessel. Hence, fleet capacity constitutes an integrated part of the access regulation. (OECD, 2003).

Effort regulation is used to directly regulate the activity of fishing vessels. The regulation specifies the maximum number of days at sea for each vessel based on fishing gear and mesh size used by the vessel. The days at sea are transferable.

Input property rights

As mentioned above, the Netherlands has a rights based fisheries management regime consisting of a number of transferable individual rights, including licenses expressed in quantities of engine power per vessel, and transferable days at sea. Trade in days at sea is managed by the co-management groups. In Denmark days at sea are also transferable while licences are not. Input rights are not transferable in the UK and Belgium.

4.6. Management costs

4.6.1.Summary of OECD data

Table 4.6 presents the management costs by fleet segment based on OECD data. The national management costs have been attributed to individual fleet segments assuming that their share in management costs is equal to their share in total revenues of the national fishing sectors. Management costs of the fleet segments are in general between 4 and 7% of total revenues except for the Belgian fleet segment where management costs are 21% of total revenues.

Table 4.6 Management costs according to OECD, average 2004-2006* , (mln euro)

	BEL TBB 24-40	DEN DTS 12-24	DEN PGP 12-24	GBR TBB 24-40	GBR TBB 40-	NL TBB 24-40	NL TBB 40-
Direct Payments	3.1	1.0	0.4	0.2	0.1	0.8	2.2
- Decommissioning		0.9	0.4			0.8	2.2
- Fleet renewal and modernization		0.1	0.0	0.1	0.0		
- Other		0.1	0.0	0.1	0.1		0.0
General Services	1.5	3.5	1.5	1.4	0.8	1.9	5.6
- Management and enforcement		1.0	0.4	1.2	0.7	0.1	0.4
- Research		0.5	0.2	0.8	0.5	0.0	0.0
- Other		1.9	0.8	0.0	0.0	0.4	1.2
Total	4.5	4.5	2.0	1.7	0.9	2.7	7.9

*sum of national and EU contributions regarding marine capture fisheries.

4.6.2.Support to fishing sector (FIFG and EFF)

Table 4.7 presents the average annual support to marine fisheries by fleet segment from FIFG and EFF. The share of national costs allocated to individual segments has been assumed proportionate to the share of the segment in the total revenues of the national marine fisheries sector. For most segments, the FIFG support is higher than the costs according to the OECD. For reasons of consistency across the case studies, OECD data is used in the FISHRENT model when simulating the effects of recovery of management costs.

Table 4.7 Average annual support to the marine fisheries from FIFG and EFF, (mln euro)*

	BEL TBB 24-40	DEN DTS 12-24	DEN PGP 12-24	GBR TBB 24-40	GBR TBB 40-	NL TBB 24-40	NL TBB 40-	Total
FIFG - Axis 1 and 2	5.4	3.5	1.5	0.6	0.3	5.1	15.0	31.6
EFF - Axis 1	1.7	0.1	0.1	0.4	0.2	0.7	2.1	5.4

4.6.3.Costs of research and management

shows an estimation of management and enforcement costs by segment based on data from the MRAG report (MRAG, 2008, p. 160) Research costs by segments have been estimated on basis of National DCF budget plus 30%. Again, the management and research costs have been allocated to the fleet segments on basis of their share in total revenues of the national fishery sectors. This estimation of management and research costs gives somewhat lower results than the OECD data.

Table 4.8 Estimated management and research costs, (mln euro)

	BEL TBB 24-40	DEN DTS 12-24	DEN PGP 12-24	GBR TBB 24-40	GBR TBB 40-	NL TBB 24-40	NL TBB 40-	Total
Management, control, enforcement	1.1	2.4	1.1	1.5	0.9	1.9	5.4	14.2
Research (DCF+30%)	1.5	0.6	0.3	0.6	0.4	0.6	1.7	5.5

Sources: MRAG (2008) and Com. Decision 811/2009

4.7. Estimation of the resource rent

4.7.1. Comparison of scenarios

The model FISHRENT has been run for 14 scenarios with different options for development of effort, fleet and catches. Table 4.9 presents the basic results from these model runs in terms of NPV $profit_{15}$ and profit, catch, fleet and effort in year 15.

Table 4.9 Comparison of the scenarios

Scenario	Effort (1000 DAS)	Fleet (no. vessels)	Catch (1000 t)	Discounted Profit year 15 (mln euro)	NPV $profit_{15}$ (mln euro)
Average values 2005-7					
2005-7	95,542	626	53,382	-24,1	
Values in year 15 of the scenario					
1. TAC min	62,755	317	75,072	85.2	753.9
2. Effort min	115,982	646	99,558	31.9	716.0
3. TAC max	161,154	715	65,354	8.2	-4.8
4. Effort max	161,647	716	66,791	6.8	-22.4
5. Open access	162,114	718	67,593	5.2	-31.0
6. Min min	98,857	494	94,587	69.5	934.1
7. Discount rate 2%	62,755	317	75,072	106.1	870.3
8. Discount rate 5%	62,755	317	75,072	68.7	656.8
9. Recovery mgt. costs	62,857	314	75,180	87.0	788.6
10. Static present fleet	62,755	626	75,072	54.8	201.8
11. Static minimum fleet	75,486	430	83,113	77.6	555.0
12. Dynamic min. fleet	65,867	297	76,563	86.9	921.3
13. Optimum fleet (GVA)	217,374	958	106,002	64.7	760.4
14. Optimum fleet (profit)	88,199	388	65,071	96.5	1009.5

The first 6 scenarios are simulations of different policy options. These policy options concern different strategies for limiting catches by TACs or effort restrictions. In scenario 1 and 3, catches are restricted by TACs, that are calculated on basis of target harvest ratio. In the TAC min scenario effort is determined by the most restrictive TAC (the TAC that requires lowest effort) while in the TAC max scenario effort is determined by the least restrictive TAC. This implies that in the TAC max scenario one of the stocks will be overfished. In Scenarios 2 and 4 the fishery is managed by effort restrictions. These effort restrictions are directly calculated from target harvest ratio. In the Effort min scenario, the effort is determined by the stock with most restrictive harvest ratio and in the Effort max scenario by the stock with least restrictive harvest ratio. Scenario 6 is the most precautionary scenario where effort is chosen as the minimum of the effort determined by the most restrictive TAC and by the most restrictive target harvest ratio. Scenario 5 is the Open Access scenario where landings and effort are not restricted at all.

The TAC min scenario has been selected as the main scenario because this is regarded as the scenario that comes closest to the present policies with respect to North Sea flatfish. In this scenario, effort is each year determined by the most restrictive TAC, in other words, the TAC that requires lowest fishing effort. This would guarantee that none of the target species will ever be overfished. However, in line with the present policy, the TAC is not allowed to vary by more than 15% from year to year. This means that in some cases it is still possible that catches and landings are higher than the sustainable catch.

The TAC min and Min min scenarios and the Effort min scenario score best in terms of NPV $profit_{15}$. These are also the most restrictive scenarios where catches are restricted most in the first years of the scenario and where biomass grows quickest. This results in much higher catches and biomass in year 15 compared to the base year. Catches in Effort min scenario are almost twice as high as in the base year. In these restrictive scenarios effort is cut in the first period, but in the last year it is slightly higher than in the base year. The Effort min scenario scores third of the 6 policy scenarios in terms of NPV $profit_{15}$, but substantially lower than the TAC min and Min min scenario. This is largely due to differences in the size of the fleet, which is much larger in the Effort min scenario than in the other two scenarios.

The less restrictive scenarios Effort max and TAC max have considerably lower – even negative - scores on NPV $profit_{15}$, which indicates that it is essential to invest in biomass growth in the first years in order to have a profitable fishery in the second half of the scenario period. The results of these scenarios are quite similar in terms of fleet, effort, catch and NPV $profit_{15}$. They are only slightly better than the results in the open access scenario.

In scenario 7 and 8 the effects of different discount rates are investigated. Scenario 7 demonstrates that using a discount rate of 2% instead of 3.5% results in a 15.4% higher NPV $profit_{15}$. In scenario 8 the discount rate is 5% instead of 3.5%. This results in an 12.9% lower NPV $profit_{15.}$

Scenario 9 (recovery of management costs) shows that NPV $profit_{15}$ is slightly (5%) higher than in the basic TAC min scenario when the fishery has to compensate the government for the management costs. Thus it is possible for the government to introduce a payment for access to the fishery that compensates for the management costs. There is even room for a higher payment for access, so that society is able to capture a larger part of the resource rent without seriously disturbing the profitability of the fishery.

Scenarios 10 to 14 are different types of optimization scenarios. Of these scenarios, the optimum fleet scenario 14 has by far the best results in terms of NPV $profit_{15}$, as could be expected because this is the only scenario where NPV $profit_{15}$ is explicitly maximized . Discounted profit in year 15 in this scenario is also higher than in the other scenarios. Details of the optimization scenarios will be discussed in section 4.7.5.

Total resource rent from target stocks

The segments included explicitly in the case studies catch only a part of the sustainable catches of sole and plaice. The rest is caught by other segments, possibly within other fisheries. It was decided that this distinction must be made explicitly by calculating the ratio between the total value of target species caught by the included segments and the total value of sustainable total catch. In this case study this ratio is 0.79, which means that the segments explicitly considered in the model are assumed to capture 79% of resource rent. Total resource rent from the sole and plaice rent, can thus be found by multiplying the NPV $profit_{15}$ reported in Table 4.9 with 1/0.79. Discounted resource rent over 15 years in the MEY situation (scenario 14) can thus be estimated at 1.3 billion euro, while in the TAC min scenario (scenario 1), total resource rent from the sole and plaice stocks is 0.95 billion euro.

4.7.2.Policy options (selection from scenarios 1-6)

Summary

Six policy scenarios have been simulated using the FISHRENT model. Results of these 6 policy scenarios are summarized in Table 1.10.

Table 4.10 Effect of different policies on net profit, harvest ratio, catches, effort and fleet

Indicator / segment	2005-7	Scenarios**					
		1. TAC min	2. Effort min	3. TAC max	4. Effort max	5. Open access	6. Min min
NPV $profit_{15}$		753.9	716.0	-4.8	-22.4	-31.0	934.1
Harvest ratio (year 15)*							
Sole	0.5231	0.1929	0.3028	1	1	1	0.2511
Plaice	0.2166	0.0812	0.1222	0.0985	0.1004	0.1014	0.1107
Catch in (1000 t, year 15)							
Sole	10,907	15,470	20,130	0	0	0	20,027
Plaice	42,475	59,602	79,428	65,354	66,791	67,593	74,560
Effort (1000 DAS, year 15)							
BEL TBB 24-40	12,650	8,084	13,904	8,311	7,916	8,048	13,923
DEN DTS 12-24	35,346	25,777	44,491	106,395	106,133	105,432	39,088
DEN PGP 12-24	13,161	4,159	14,307	23,748	23,569	23,544	7,789
GBR TBB 24-40	10,550	7,688	13,280	13,500	13,738	13,756	11,658
GBR TBB 40-	3,317	2,417	3,876	3,197	3,130	3,121	3,665
NL TBB 24-40	7,008	4,739	8,821	3,171	3,236	4,263	7,735
NL TBB 40-	16,827	12,308	21,180	6,030	7,054	7,072	18,664
Fleet (no vessels, year 15)							
BEL TBB 24-40	55	35	65	36	34	35	69
DEN DTS 12-24	258	132	249	463	461	458	181
DEN PGP 12-24	107	21	75	103	102	102	40
GBR TBB 24-40	54	34	72	59	60	60	52
GBR TBB 40-	15	11	20	14	14	14	20
NL TBB 24-40	48	21	46	14	14	19	46
NL TBB 40-	89	64	118	26	31	31	86

*F=1 implies that the stock is almost extinct.

On basis of the stock growth functions in FISHRENT, MSY harvest ratio has been estimated at 0.3 for sole and 0.26 for plaice. This has been used as target harvest ratio in all policy scenarios. In the base year harvest ratio for sole is 0.52, much higher than Hmsy. Base year harvest ratio for plaice was 0.21, lower than target mortality. In the main scenario for this case study, the TAC min scenario, catches of sole and plaice at the end of the simulation period are almost 50% higher than in the base year. However, harvest ratio of sole and plaice is still below MSY level.

At the end of the 15 year simulation period, target harvest ratio for sole is only reached in the Effort min scenario. Catches of sole in this scenario are app. 20,000 tonnes. This corresponds to MSY (28,000 tonnes) when catches of other segments and undersized discards, that have been estimated at 10% of the total catch weight, are included. In the Min min scenario harvest ratio for sole is slightly lower , but at a higher level of biomass. The resulting sole catch is almost equal to that in the Effort min scenario.

None of the scenarios reaches Hmsy for plaice. Highest H for plaice is found in the Effort min scenario (0.12) and in the Min min scenario (0.11), which is far below Hmsy (0.26). The results of the TAC max scenario and the Effort max scenario tells us why. If effort is determined by the least restrictive stock (plaice), the sole stock will be completely fished out. In these scenarios, there is no sole stock left at the end of the simulation period and hence sole catches in year 15 are zero. NPV in these scenarios is much lower than in the more restrictive scenarios because also the catch of plaice is lower than in the Effort min and Min min scenario. The plaice TAC is not fully fished, because, when only catching plaice, profitability of the fishery is not good enough to invest in new vessels up to the point where the plaice TAC can be fished.

The results of the six policy scenarios show that policy does matter for achieving good economic results. Comparison of the policy scenarios to the Open access scenario shows that the most restrictive policy scenarios (TAC min, Effort min and Min min) score much better in terms of NPV $profit_{15}$ than no policy at all. Results of the TAC max and Effort max scenario are quite similar to those of the Open access scenario, which indicates that in these scenarios the fishery is hardly restricted.

Scenario 1. TAC min

The TAC Min scenario is considered the main scenario for the NS flatfish case study because it resembles the actual policy for this fishery more than the other scenarios. In this scenario the effort is determined by the most restrictive TAC. This means that in principle none of the target species would ever be overfished. However, there is an extra condition that prevents the TAC from varying by more than 15% from year to year. This way the TAC and the catch in some years can be higher or lower than what is considered sustainable catch.

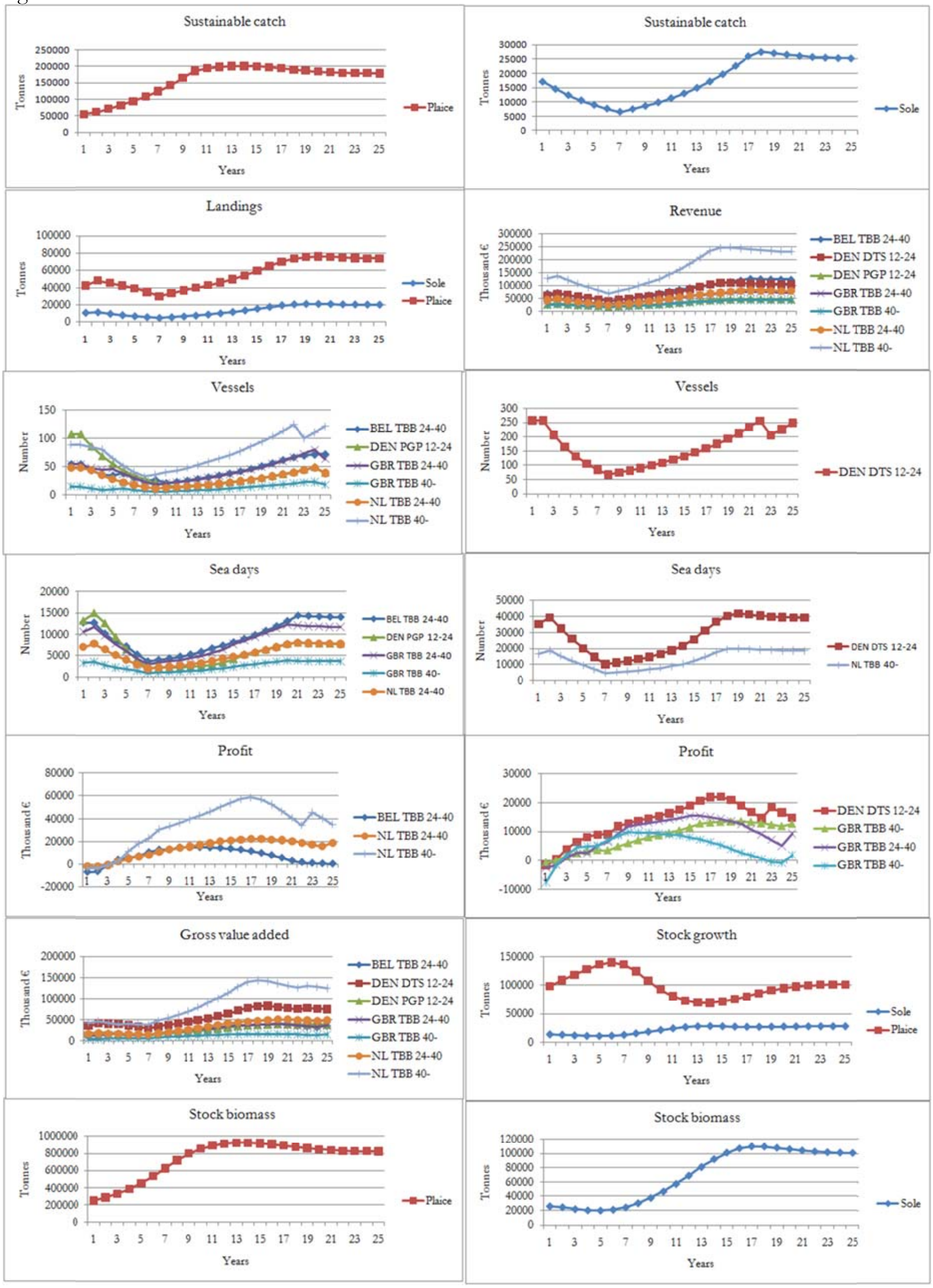
In the base year harvest ratio of sole is 0.52 while Hmsy has been estimated at 0.3. Harvest ratio of plaice was below Hmsy. All fleet segments considered in the model were suffering losses, partly due to the historically high fuel prices and partly due to the fact that the fish stocks were below MSY level.

After the base year, in which harvest ratio of sole was far above Hmsy, effort in terms of both number of vessels and days at sea starts to decrease as a consequence of the decreasing TAC for sole. Biomass of sole and plaice are increasing from the start of the simulation period because of the decreasing fishing activity. The minimum level of effort and landings is reached after 7 years. From that year, effort and landings, revenues and net profit are increasing again until they stabilize around year 15. At that time harvest ratio of sole has moved up to 0.25, which is close to Hmsy (0.3).

Catches of sole in year 15 are app. 40% higher than in the base year. Catches of sole are equal to the TAC, while catches of plaice are much smaller than the TAC. This is the consequence of the assumption that effort is tuned to the most restrictive TAC, in this case the TAC of sole. Profit of all segments increases from the start of the period because of the lower effort and costs and because of the growing stocks that cause CPUE to increase. In year 15, total profit of the segments is 143 million Euro compared to a loss of 24 million in the base year. The number of vessels of each of the fleet segments is lower than in the base year. Biomass of plaice and sole is about four times the level of the base year.

The NPV $profit_{15}$ of this scenario is 753.9 million Euro, 5% higher than the Effort Min and 24% lower than the Min min scenario.

Figure 4.5 Results of scenario 1. TAC min



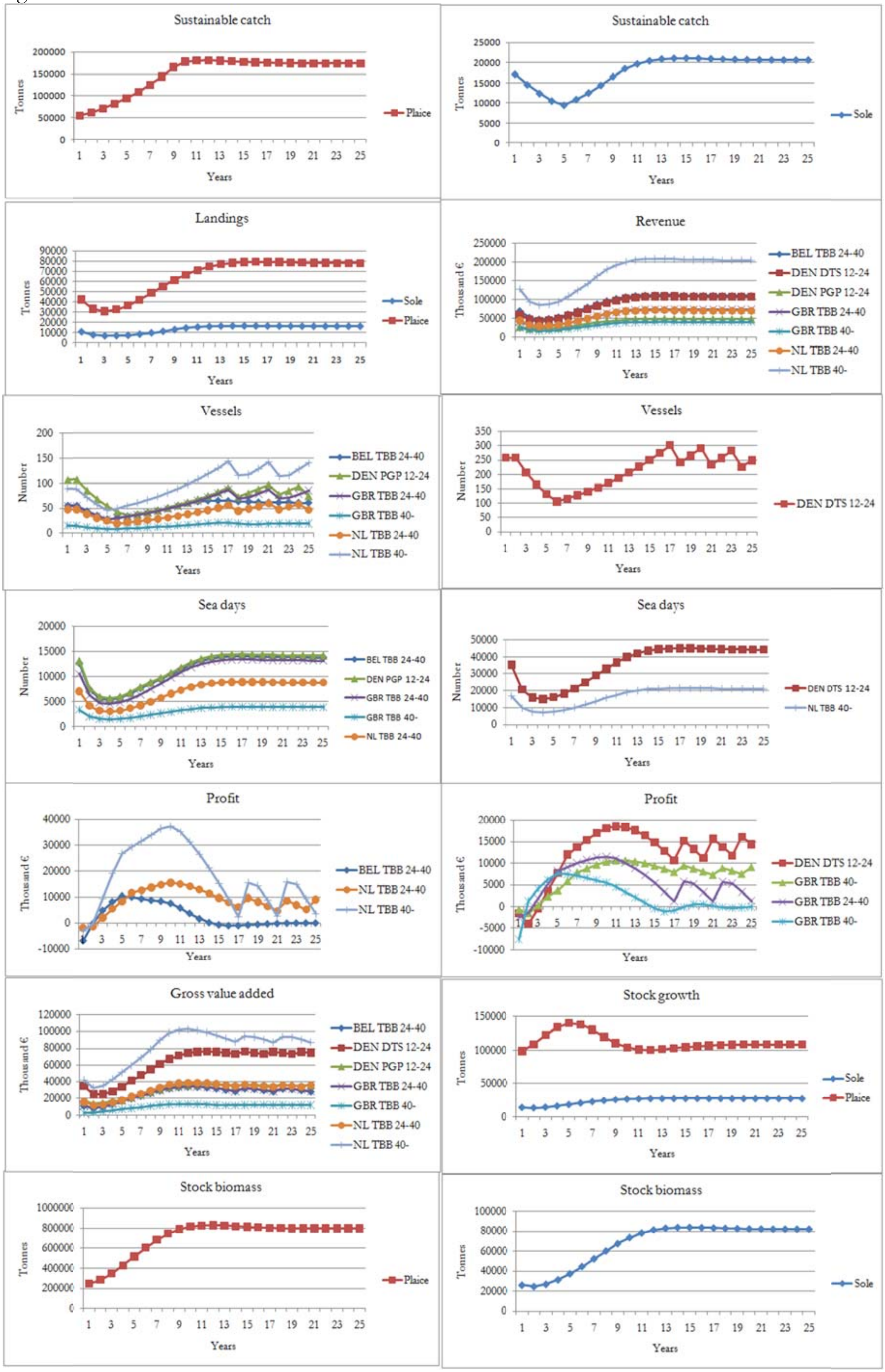
Scenario 2. Effort min

In the Effort min scenario, effort is cut severely immediately after the base year. As a result of that also landings and revenues are decreasing in the first few years. The sole and plaice stocks are recovering from the start of the simulation, also causing profitability of the fleet to increase because of lower costs and higher CPUE. In year 4 landings and revenues reach a minimum and after that they are increasing again. Fleet size and days at sea are increasing from year 6.

In year 15, stocks have recovered and both the sole and plaice stock have quadrupled. Net profit in the last year of the simulation period has increased from -24 million euro in the base year to more than 50 million Euros in year 15. Harvest ratio of sole in year 15 equals Hmsy (0.3) and sole catch by the 7 segments is around 20,000 tonnes which corresponds to MSY of 28,000 tonnes when catches by other segments and discards of undersized fish are included. Sole catch is about 33% higher than in the TAC min scenario. Harvest ratio of plaice in year 15 is 0.12, much lower than Hmsy, like in all scenarios. Due to the recovered plaice stock, plaice catch is considerably higher (+87%) than in the base year while effort is 33% higher. Catch of plaice is 33% higher than in the TAC min scenario.

The NPV $profit_{15}$ of this scenario is 716 million Euro, 5% lower than in the TAC Min scenario and 23% lower than in the Min min scenario but much higher than the TAC max and Effort max scenarios, where NPV $profit_{15}$ is negative.

Figure 4.6 Results of scenario 2. Effort min



Scenario 3. TAC max

In the TAC max scenario, effort is determined by the least restrictive TAC. This can be TACs for different stocks in different years, but in North Sea flatfish case study it is usually the TAC for plaice. As a result of that, the sole stock is structurally overfished in this scenario.

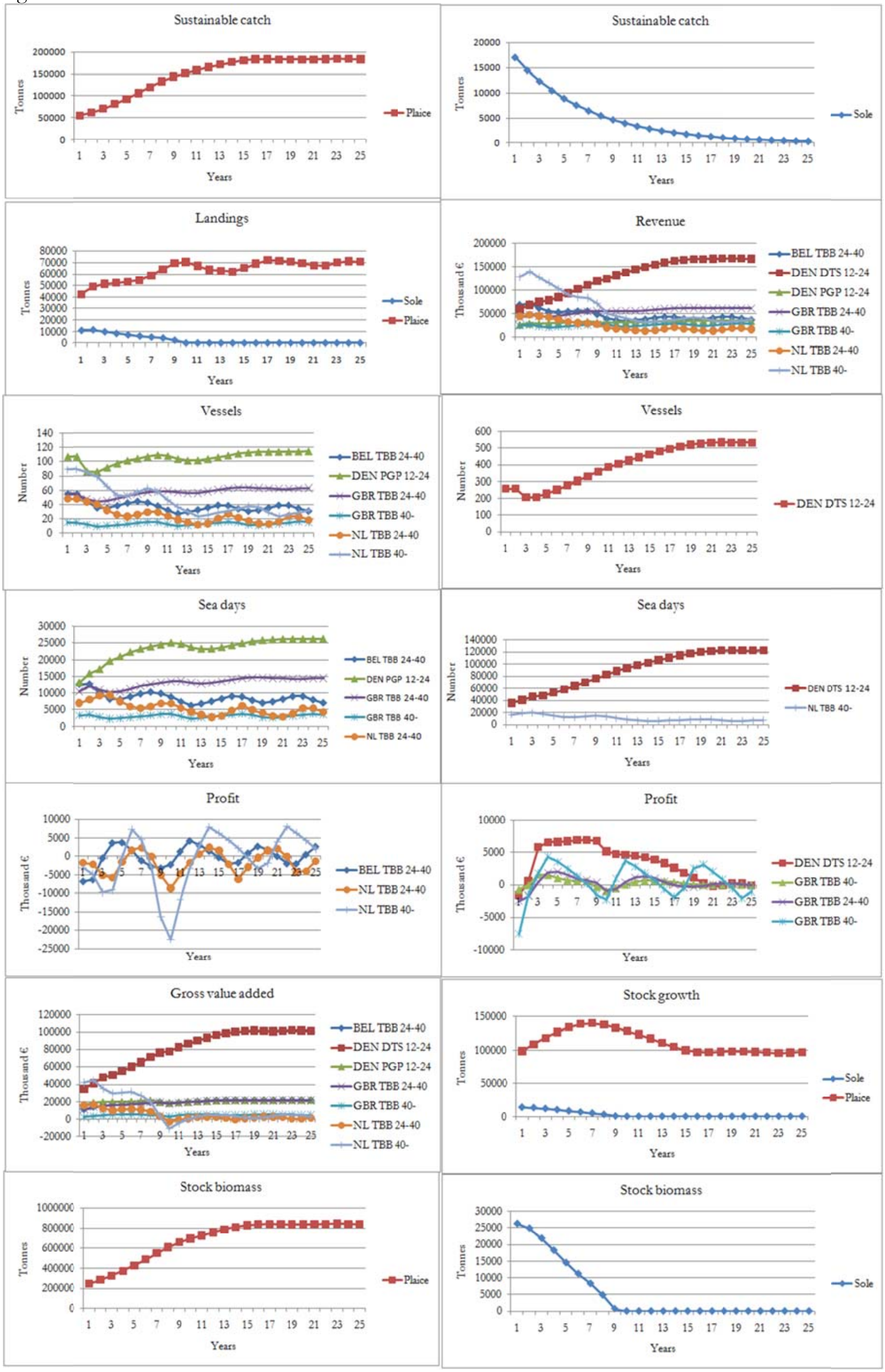
In first years of the simulation period there is no decrease of effort like in scenario 1 and 2. Total effort is even increasing compared to the base year. Catches of sole are higher than the sole TAC and hence part of the sole catch is discarded and the sole stock is gradually decreasing in size until it is depleted in year 10. Catches of plaice are within the TAC and the plaice stock is recovering. The TAC for plaice is gradually increasing but landings increase much slower as the fleet doesn't have the capacity to catch the whole plaice TAC.

During the first years, profitability of the fishery is improving and turning from negative to positive, but as the sole stock is getting depleted the profits are going down and turning negative again. The declining profitability does not allow for investments that would be needed to increase capacity to the point where the plaice TAC can be fished completely. During the simulation period, there are periods with slightly positive profits and small investments and periods with negative profits and disinvestments.

In year 15, net profit of the whole fishery is app 8 million euro but turning negative again two years later. The NPV $profit_{15}$ in the 15 years simulation period is -4.8 mln euro, less negative than in the Effort max and Open access scenario. However, it's clear that the TAC max scenario performs much worse than the more restrictive scenarios TAC min, Effort min and Min min.

Economic results of the fleet segments differ widely in this scenario, depending on their relative efficiency for catching sole or plaice. After an initial decrease in size, the profitability of the Danish segment of demersal trawlers is improving substantially, causing investments in new vessels. As these investments continue, the fixed costs of the fleet are rising and profits are going down again. The segments of Dutch and, to a lesser extent, Belgian beam trawlers are decreasing in size significantly during the simulation period, because of their high dependence on sole in combination with high fuel costs. These fleets cannot be profitable when fishing only for plaice, at least not at the 2005-7 level of fuel prices.

Figure 4.7 Results of scenario 3. TAC max



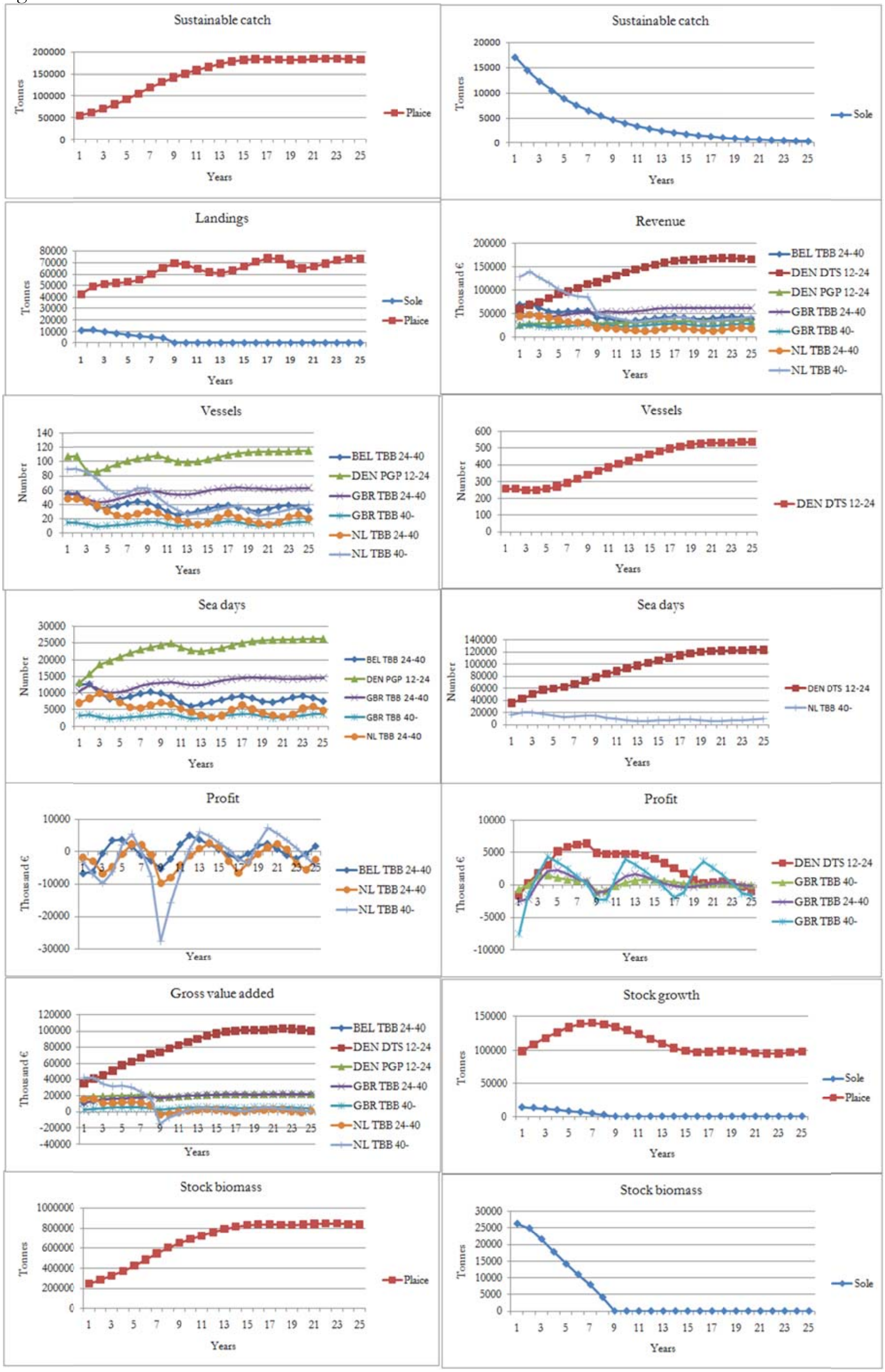
Scenario 4. Effort max

In the Effort max scenario, effort of each fleet is determined by the target harvest ratio that is least restrictive in terms of effort which is usually the target harvest ratio for plaice.

Developments in this scenario are very similar to those in the TAC max scenario. The sole stock gets depleted and at the same time the plaice stock is growing, causing effort to increase too. Profitability of the fishery as a whole is low and most of the segments are either decreasing in size or roughly staying at the same level. The only exception is the Danish segment of demersal trawlers that almost doubles in size.

NPV $profit_{15}$ is -22 million euro, only slightly less negative than in the Open access scenario. The similarity of economic results to the Open access scenario indicates that the fishery is hardly restricted in the Effort max scenario.

Figure 4.8 Results of scenario 4. Effort max



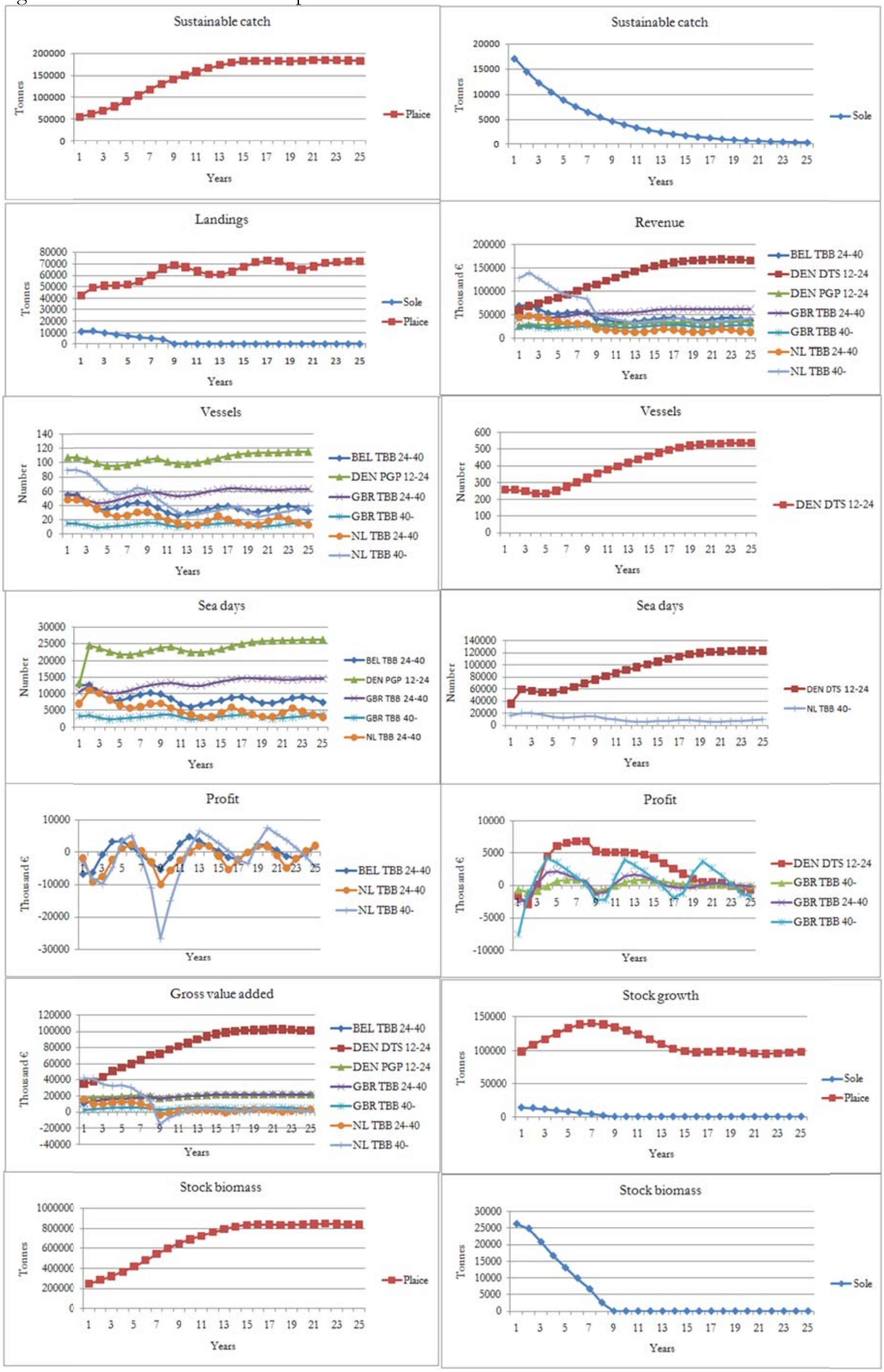
Scenario 5. Open access

In the Open access scenario, the fishery is not restricted by any policy measures. Effort is determined by the number of vessels in each fleet segment. These vessels assumingly are operating at a full capacity, as they are not restricted by any policy. Development of the fleet size is determined by the same investment function as in the other scenarios with investment depending on profit.

As profits of all segments are negative in the base year, all segments are initially decreasing in size. Total effort, however, shows an increase from the beginning of the simulation period because the remaining vessels are operating at full capacity. Landings of plaice and sole are gradually increasing. Landings of sole are higher than sustainable and the sole stock is structurally overfished until it is depleted after year 8.

In year 15, net profit of the total fishery is 8.8 million euro, about 37% lower than in the TAC max scenario and 24% lower than in the Effort max scenario. Profits in the more restrictive scenarios are much higher, which shows that a restrictive fisheries management is essential for extracting the potential resource rent. NPV of total profit is negative at app. -31 million Euro, which is slightly more negative than in the Effort max and the TAC max scenario.
Developments in this scenario are similar and parallel to the Effort max and TAC max scenario. This indicates that these two scenarios are hardly restricting the fishery.

Figure 4.9 Results of scenario 5. Open access



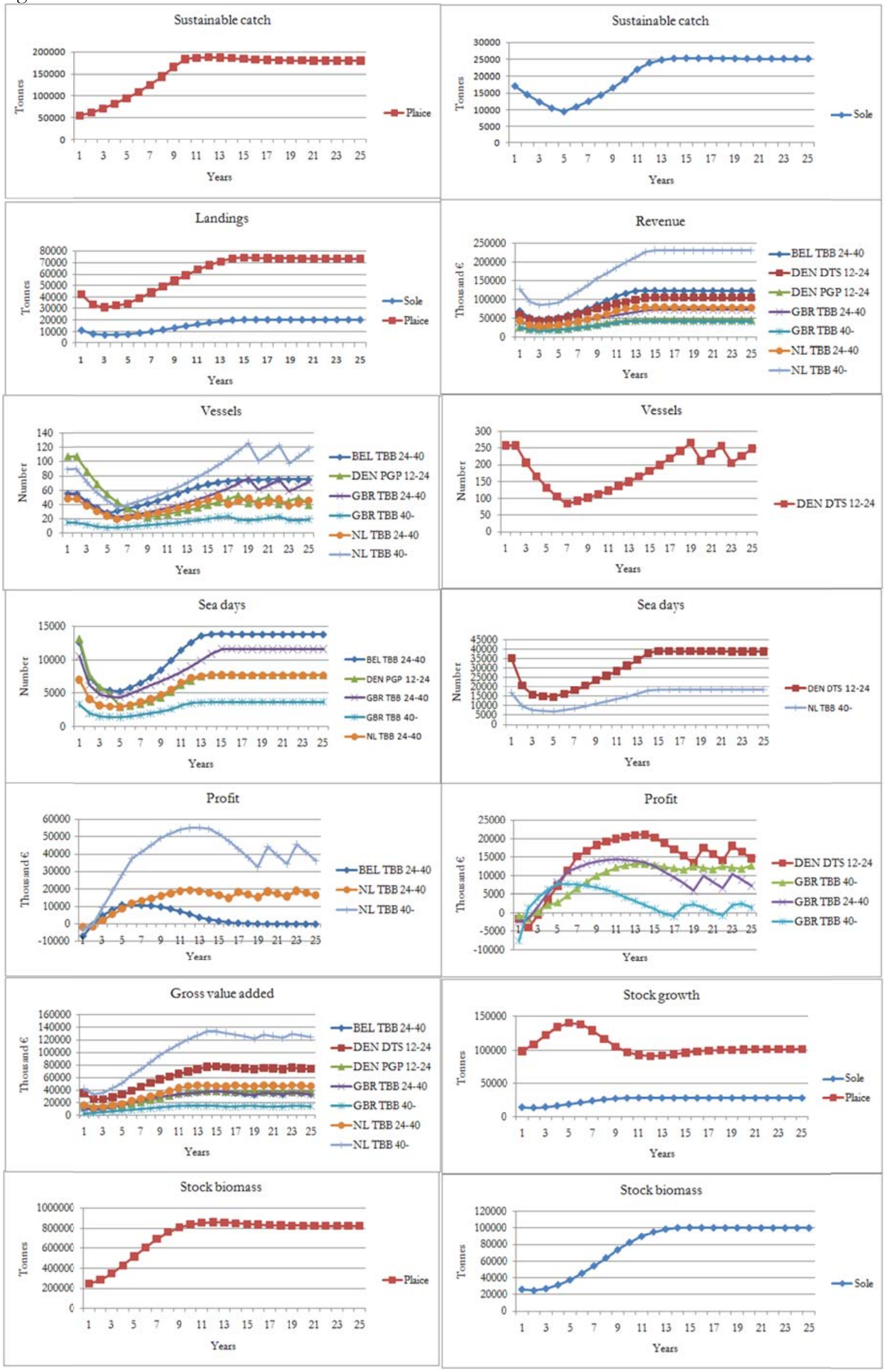
Scenario 6. Min min

In the Min min scenario, effort of the flatfish fleet is determined by either the most restrictive TAC or the most restrictive target harvest ratio in terms of effort, whatever is the most restrictive of these two. If the TAC is always more restrictive this scenario would be similar to the TAC min scenario and if the effort restriction would be always most restrictive this would be similar to the Effort min scenario. However, it appears that in this case study sometimes the TAC restriction is most restrictive and sometimes the effort restriction, so the Min min scenario, has its own dynamics and economic results. Nevertheless, these dynamics are very much similar to those of the Effort min scenario and to a lesser extend the TAC min scenario.

Just like in the TAC Min and Effort min scenario, effort decreases during the first years of the simulation period. As a result of that, the sole and plaice stock increase in size and profitability of the fleet improves. The higher profits cause new investments and fleet size increases again and in year 15 most of the segments are back at their original size. After a few years of decline, landings and revenues increase again and in year 15 both landings and revenues are about twice the level of the base year. Harvest ratio of sole is 0.25, slightly under Hmsy, and harvest ratio of plaice is 0.11, about 50% of Hmsy.

NPV $profit_{15}$ is app 934 million euro, 24% higher than in the TAC min scenario and 30% higher than in the Effort min scenario.

Figure 4.10 Results of scenario 6. Min min



4.7.3. Role of discount rate (scenarios 7-8)

Table 4.11 Effect of discount rate on net profit

Indicator	2005-7	Scenario		
		Main scenario Discount rate 3.5%	7. Discount rate 2%	8. Discount rate 5%
NPV profit$_{15}$ (mln euro)		753.9	870.3	656.8
Nominal profit$_{15}$* (mln euro)	-24.1	142.8	142.8	142.8
Discounted profit$_{15}$* (mln euro)		85.2	106.1	68.7

*year 15

The appropriate discount rate depends on time preference of the relevant economic subjects. A higher discount rate is appropriate when the relevant economic subjects attach relative high value to present costs and benefits and low value to future costs and benefits. Table 4.1 shows the effect of different discount rates on the discounted economic results. The basic discount rate, used in all scenarios, is 3.5%. A higher discount rate implies lower discounted profit and a lower discount rate implies higher discounted profit.

Scenario 7. Discount rate 2%

Using a discount rate of 2% instead of 3.5% results in a 15% higher NPV profit$_{15}$. The discounted value of Profit$_{15}$ is 24% higher than in the main scenario.

Scenario 8. Discount rate 5%

Using a discount rate of 5% instead of 3.5% results in a 13% lower NPV profit$_{15}$. The discounted value of Profit$_{15}$ is 19% lower than in the main scenario.

4.7.4. Resource rent and recovery of management costs (scenario 9)

Table 4.11 Effect of recovery of management costs on net profit

Indicator	2005-7	Scenarios	
		Main scenario: No recovery of management costs	9. Recovery of management costs
NPV profit$_{15}$ before pfa*		753.9	788.6
NPV profit$_{15}$ after pfa		753.9	510.5
Nominal Profit$_{15}$ (mln euro) before pfa	-24.1	142.8	145.7
Nominal Profit$_{15}$ (mln euro) after pfa	-24.1	142.8	121.6
Fixed payment for access (mln euro)		0.0	24.2
NPV Payment for access$_{15}$		0.0	278.1

Pfa = payment for access

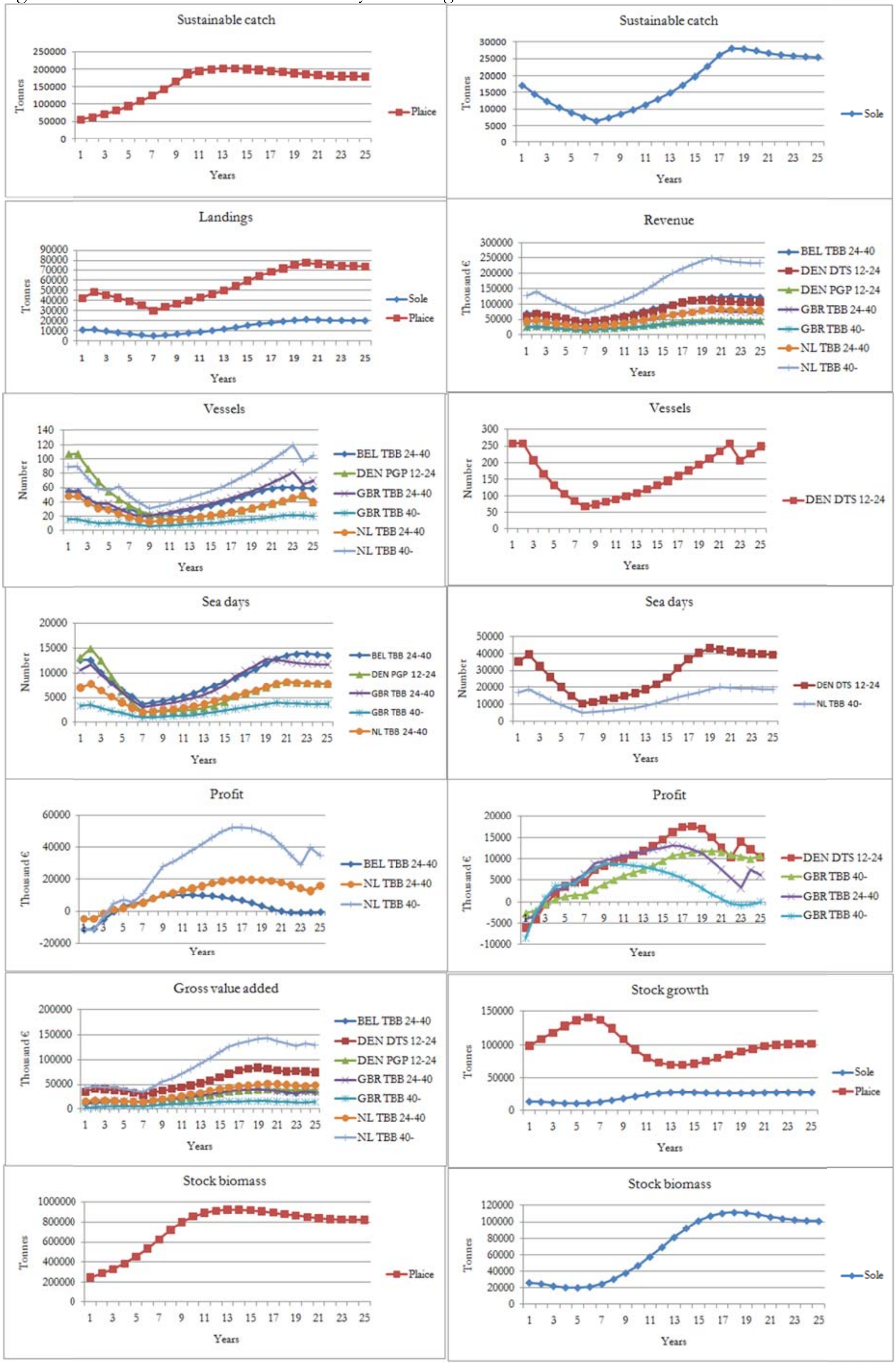
This scenario investigates whether recovery of management costs is possible without affecting profitability of the fishery in unacceptable ways. The scenario is based on the management costs data from the OECD as presented in section 4.6 . The share of national costs allocated to individual segments has been assumed proportionate to the share of the segment in the total revenues of the national marine fisheries sector (see Table 4.6).

In this scenario, each fleet segment has to pay an annual access fee equal to the management cost allocated to the segment. This directly affects the profit of the segment and consequently investments. All segments had negative profits in the base year and the extra costs of payment for access cause profits in the first years to be even more negative and it takes longer than in the main scenario before the profits turn to positive. Nevertheless, after 5 years all segments are making a profit.

The discounted value of profits after payment for access over these 15 years is 32% lower than in the main scenario. NPV $profit_{15}$ before payment of access is 5% higher than in the main scenario . This is due to the lower profits that limit investment and hence the capacity of the fleet. Effort is also slightly lower in the first few years of the scenario and the fish stocks are growing quicker. However, this is a minor effect. Nominal profit in year 15 after payment for access is 15% lower than in the main scenario.

If the government would try to capture more resource rent from the fishery, by for instance doubling the payment for access to twice the management costs the NPV of profit would decrease to 266 million euro, a further deterioration by 33%. Nominal profit after payment for access would decrease by 16% to 102 million euro.

Figure 4.11 Results of scenario 9. Recovery of management costs



4.7.5. Optimization of capacity (scenarios 10-14)

Table 4.12 Impact of optimization of the fleet size

Indicator	2005-7	Scenarios*					
		Main scenario TAC min	10. Static present fleet	11. Static minimum fleet	12. Dynamic minimum fleet	13. Optimum fleet (GVA)	14. Optimum fleet (profit)
NPV $profit_{15}$ (mln euro)		753.9	201.8	555.0	921.3	760.4	1009.5
Nominal $profit_{15}$ (mln euro)	-24.1	142.8	91.8	130.0	145.6	108.4	161.7
Discounted $profit_{15}$ (mln euro)		85.2	54.8	77.6	86.9	64.7	96.5
$Fleet_{15}$ (no vessels)	626	317	626	430	297	958	388
$Effort_{15}$ (1000 DAS)	95,542	62,755	65,292	75,486	65,867	217,374	88,199
$Catch_{15}$ (1000 t)	53,382	75,072	76,322	83,113	76,563	106,002	65,071

*NPV row refers to the sum, other rows refer to values in year 15

The five optimization scenarios deal with different adaptation paths of the fleet. Scenarios 10-12 simulate different adaptation paths within the TAC min scenario. Scenario 13 and 14 are "policy free" scenarios where NPV GVA_{15} is and NPV $profit_{15}$, respectively, are maximized with just one condition that annual investment and disinvestment cannot exceed the maximum as defined by the investment function.

In the static present fleet scenario the number of vessels is kept constant after the base year. This scenario has 73% lower NPV $profit_{15}$ than the main scenario. Effort and catch in this scenario are comparable to the main TAC min scenario, but fixed costs are much higher because the fleet is not reduced.

In the static minimum fleet scenario, the number of vessels is reduced to the minimum number required for the effort exerted in the first year (430 vessels) and maintained at that level throughout the whole simulation period. NPV $profit_{15}$ is 26% lower than in the main scenario) and the underlying developments in fleet size, effort and catch are quite different. In year 15, effort and catches in scenario 11 are significantly higher than in scenario 10 and 12 and in the main scenario while the number of vessels is 36% higher than in the main scenario. This causes relatively high fixed costs and, consequently, lower NPV $profit_{15}$

The dynamic minimum fleet scenario has the highest NPV $profit_{15}$ of the three "policy optimization scenarios" and also higher than the main scenario. The dynamic fleet scenario ends up with a smaller fleet in year 15 than the main scenario.

The optimum fleet scenario 13, where NPV GVA_{15} is maximized, shows a quite different development. The resulting NPV GVA_{15} is much higher than in the main scenario and the "policy optimization" scenarios 10-12, but NPV $profit_{15}$ is only slightly higher than in the main scenario and substantially lower than in scenario 12. By year 15 the fleet has expanded to 958 vessels, three times as much as in the main scenario and 50% more than in base year. This is mainly due to expansion of the two Danish segments with relatively small vessels and low fixed costs. Effort in terms of days at sea is almost four times as high as in the main scenario, but these are days at sea of relatively small vessels. Catches in year 15 are more than 50% higher than in the basic TAC min scenario.

In scenario 14, where net profit is maximized, NPV $profit_{15}$ is - of course - higher than in all other scenarios, including scenario 13. NPV GVA_{15} is significantly higher than in the main scenario and in the policy optimization scenarios 10-12, but much lower than in scenario 13. Obviously, maximization of net profit requires a different strategy than optimization of GVA. The most striking difference is in the development of the fleet. In year 15 the fleet is app. 60% smaller than in scenario 13 (but still larger than in the main scenario and in the dynamic minimum fleet scenario). Catches in year 15 are lower than in the main scenario and all other optimization scenarios. Effort in year 15 is much lower than in scenario 13 but higher than in the main scenario and in the other optimization scenarios. However, it must be noted that this concerns effort in terms of days at sea of relatively small vessels. Just like in scenario 13, there is a relative shift of effort from the Dutch, Belgian and UK segments to the two Danish segments with relatively small vessels. The effort of all other segments is reduced compared to the base year.

Scenario 10. Static present fleet

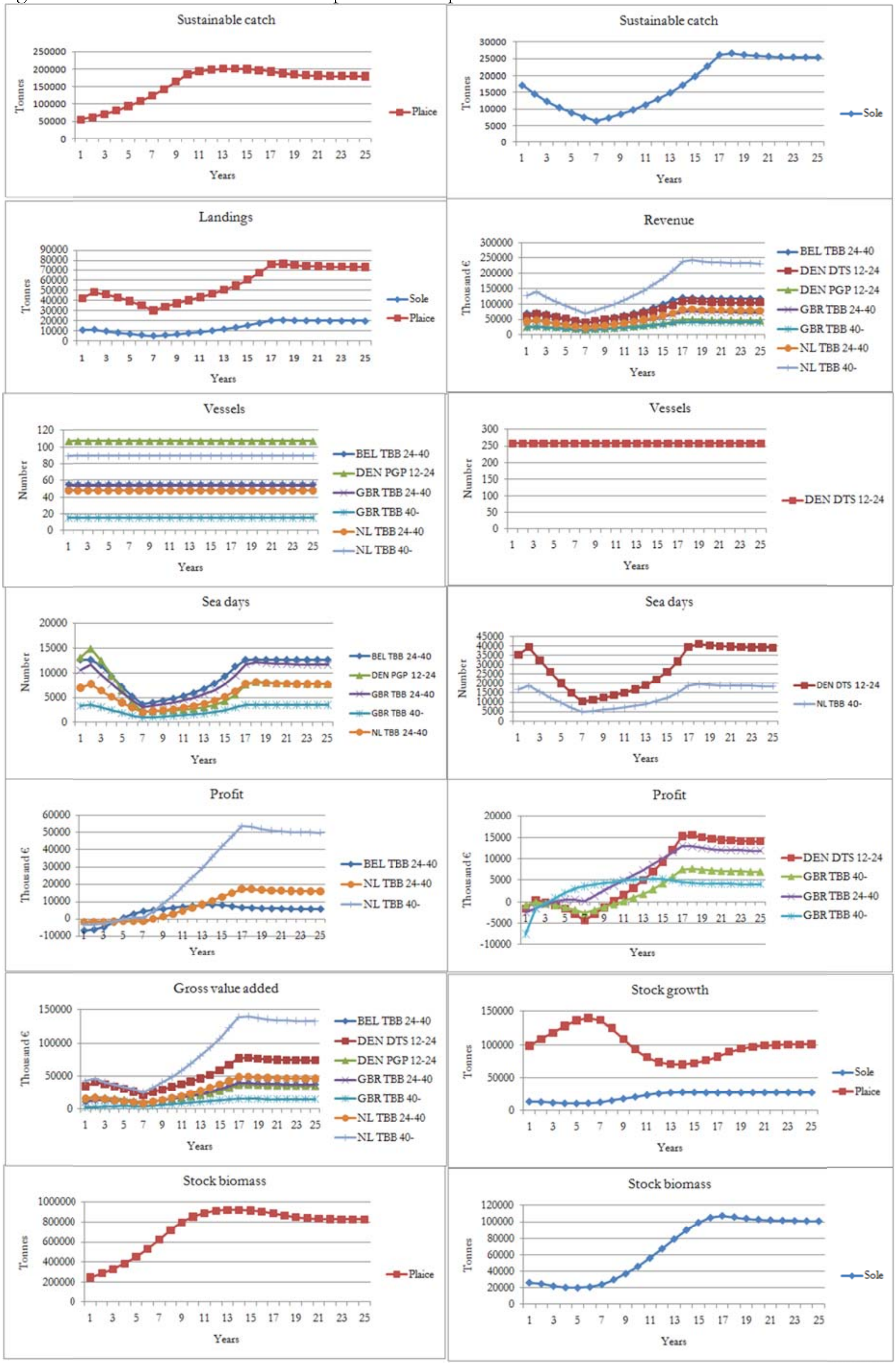
In the static present fleet scenario, the number of vessels in each segment is frozen at the level of the base year, 626 vessels for the total of the seven segments considered. This means that effort can only vary by changes in the number of days at sea per vessel.

This scenario has a 73% lower NPV $profit_{15}$ than the main scenario. Main difference is that throughout the simulation period, the main scenario has a much smaller fleet (app 50%) and, consequently, lower fixed costs. Development of effort in this scenario is similar to the developments in the main scenario. Catches, harvest ratio and revenues also develop similarly.

In year 15, the (constant) number of vessels in the fleet is almost twice as high as in the main scenario. Effort in year 15 is almost equal in both scenarios and hence the number of days per vessel is about 50% lower in the static present fleet scenario. Catches and harvest ratio of sole and plaice in year 15 are practically equal in both scenarios. In year 15, nominal and discounted net profit of the fishery are about 36% lower in the static present fleet scenario than in the main scenario, mainly because of higher fixed costs and capital costs due to the larger number of vessels. In general, development in the fishery is similar in both scenarios. The main difference is that effort varies both by changes in the number of vessels and by number of days at sea per vessel in the main scenario and only by number of days at sea per vessel in the static fleet scenario. As a consequence, the fleet is operating far below full capacity in the static present fleet scenario during the period of adaptation with relatively low effort.

The conclusion is that keeping the fleet at the present size may become a burden to the fleet when effort has to be decreased in order to let the stocks recover and also afterwards when stocks have recovered and less effort is needed for sustainable catches.

Figure 4.12 Results of scenario 10. Adaptation with ‘present’ fleet



Scenario 11. Static minimum fleet

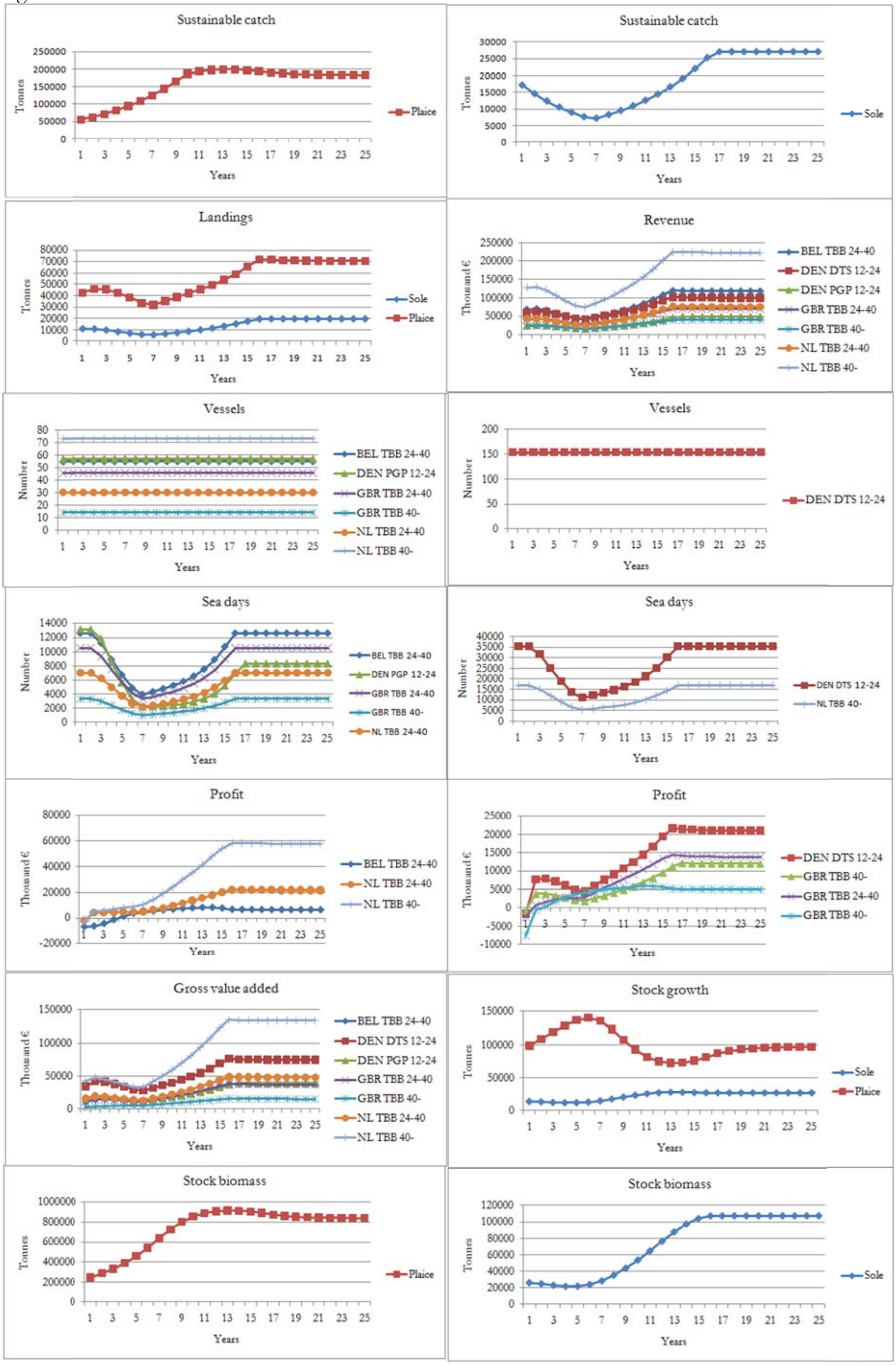
In this scenario the fleet of all segments is reduced to the minimum level required for the effort exerted in the first year (430 vessels) and maintained at that level throughout the whole simulation period. As a consequence, effort can never be higher than in year 1. Just like in the static present fleet scenario, effort can only vary by changes in the number of days at sea per vessel.

From year 3 to 7 this scenario shows a decreasing number of days at sea per vessel and hence decreasing effort caused by the decreasing TACs for sole and plaice. After year 7, effort, landings and revenues are increasing again, reaching a stable level after year 15.

In year 15, catches and harvest ratio of sole and plaice are higher than in the main TAC min scenario and the static present fleet scenario. Harvest ratio of both sole and plaice is, however, still below Hmsy. Nominal profit is lower than in the main scenario and the other policy optimization scenarios 10-12.

NPV $profit_{15}$ is 130 million euro, 9% lower in the main scenario and also lower than in the dynamic minimum fleet scenario (scenario 12) but higher than in the static present fleet scenario.

Figure 4.13 Results of scenario 11. Static minimum fleet



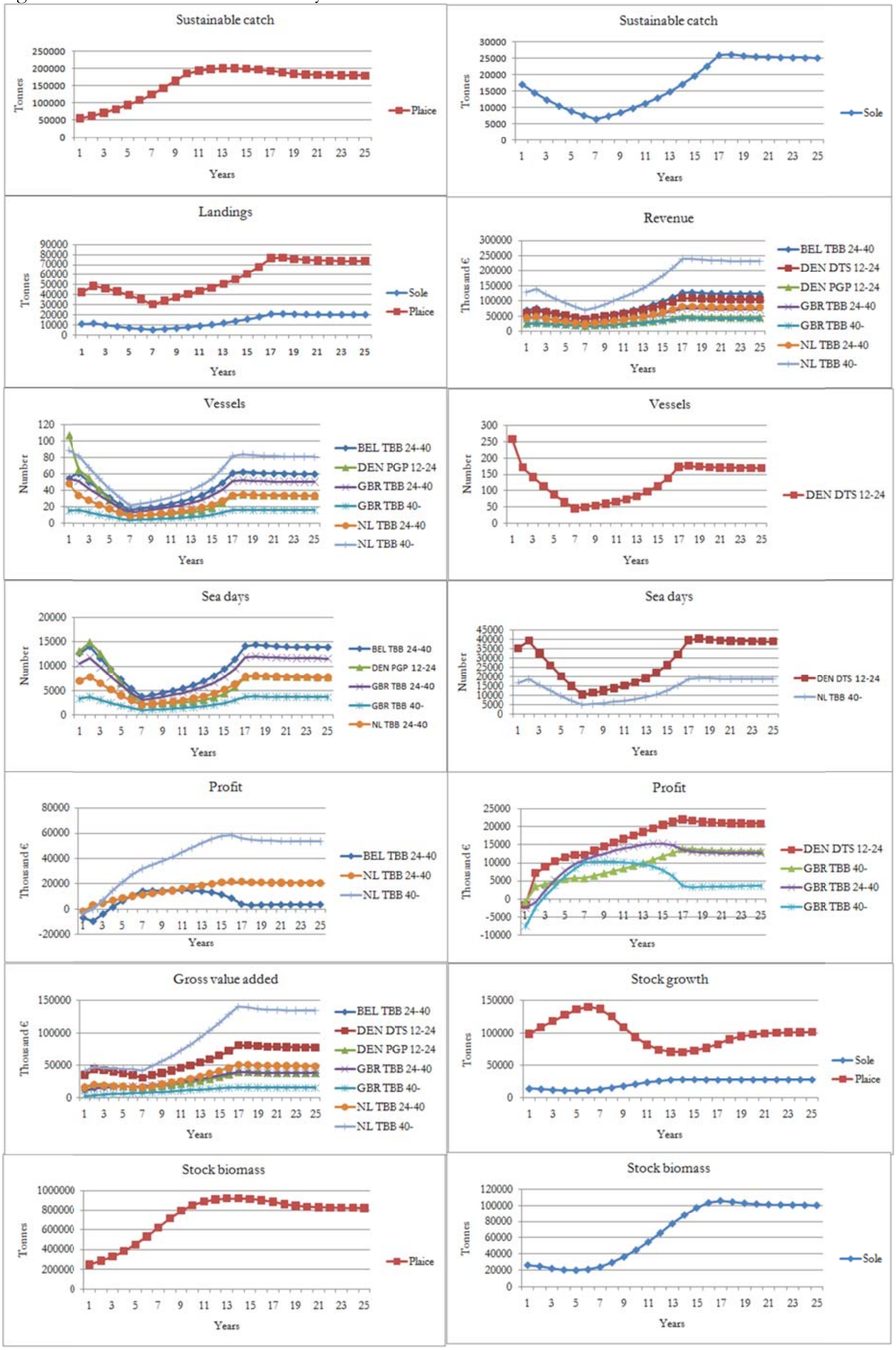
Scenario 12. Dynamic minimum fleet

In this scenario the fleet is maintained at minimum level throughout the simulation period. In other words the fleet is operating at full capacity level, using the maximum number of days at sea per vessel. The investment function is passive, meaning that fleet size each year adjusts to the minimum level required for the effort of that year and there are no limits to investment or disinvestment. Contrary to scenario 10 and 11, in this scenario the number of days at sea per vessel is constant at the maximum level and effort can only vary by changes in the number of vessels.

In year 15, catches and harvest ratio of both sole and plaice are slightly higher than those in the main (TAC min) scenario while effort is 5% higher with a 6% smaller fleet. Harvest ratio of both sole and plaice, however, is still below Hmsy.

NPV $profit_{15}$ is only 22% higher than in the TAC min scenario. This difference is caused by lower capital costs in the dynamic minimum fleet scenario during the adaptation process between year 1 and 15. In the dynamic fleet scenario, the fleet can adjust immediately to the changing effort levels while investment is limited in the TAC min scenario.

Figure 4.14 Results of scenario 12. Dynamic minimum fleet



Scenario 13. Optimum fleet (GVA)

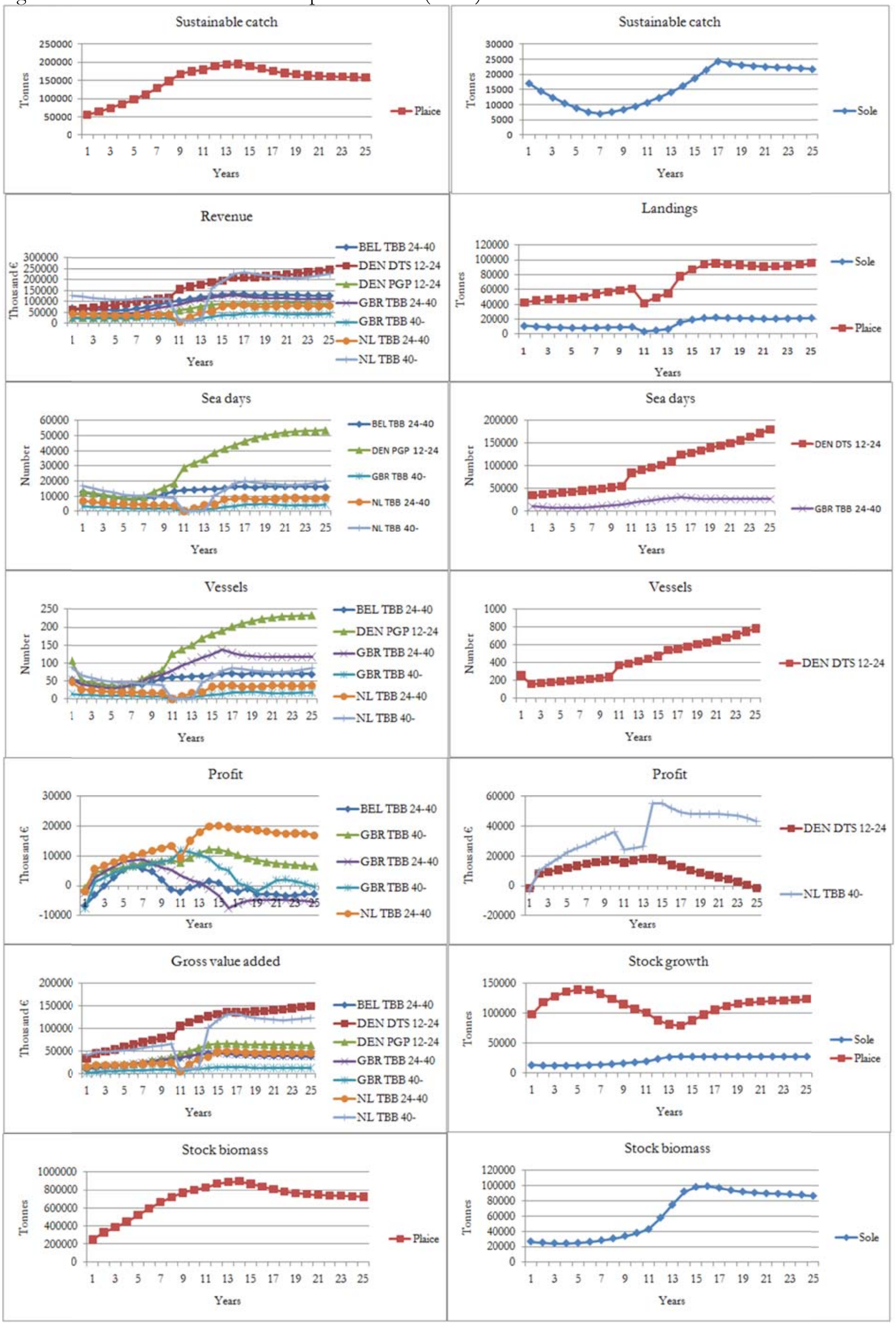
This scenario has a different character than the other optimization scenarios 10-12, which are all based on the TAC min scenario, simulating different adaptation paths for the fleet. In the optimum fleet scenario, the number of vessels of each segment in each year is optimized, maximizing NPV GVA_{15}. The only condition is that investment and disinvestment in any year do not exceed the limits specified in the investment function. However, in this case the investment function is disabled and investment does not depend on profit or BER. There is no restriction of the fishery by TACs, allowable effort or any other policy in this scenario. How this optimum solution is reached could be achieved not relevant. The optimum fleet scenario is not simulating any reality, but merely exploring what is in principle possible in terms of maximizing NPV GVA_{15}.

Developments in this scenario are quite different from all other scenarios. During the first years of the simulating period, there is a decrease in effort (days at sea) but the decrease is much smaller than in the policy based scenarios. After year 5, the total number of days at sea starts increasing until in year 15 it is more than two times the base year effort. Similarly, after an initial decrease, the total number of vessels starts increasing from year 6. In year 15 the fleet consists of 958 vessels, 53% more than in the base year. From year 2, all fleet segments are operating at full capacity, using the maximum number of days at sea. The development differs widely per fleet segment. In year 15, the two Dutch segments are app. 30% smaller than in the base year. The British segment of beam trawlers of 24-40m has more than doubled in size while the UK segment of large beam trawlers has been reduced by 18%. The two Danish segments of 12-24m have increased in size by 68% and 85%. This indicates that for optimizing GVA it is optimal to use relatively small vessels with low fuel costs although it should also be noticed that in the long run there is a place for all segments; none of the segments goes to zero.

In year 15, total effort in terms of number of days at sea is almost 3.5 times as high as in the main (TAC min) scenario, but the average size of the vessels has decreased. Catches of sole are 25% higher and catches of plaice are 60% higher than in the main scenario. Harvest ratio of sole is 0.38, substantially higher than Hmsy (0.3) and harvest ratio of plaice is 0.15, higher than in the main scenario but lower than Hmsy (0.2). Maximizing GVA in the flatfish fishery clearly means finding a compromise between the optimal exploitation of the two target species.

NPV $profit_{15}$ is 760 billion euro, only 1% higher than in the TAC min scenario and substantially lower than in scenario 12 and 14. Apparently, maximization of profits takes a different strategy than maximization of gross value added.

Figure 4.15 Results of scenario 13. Optimum fleet (GVA)



Scenario 14. Optimum fleet (profit)

In this scenario, the number of vessels of each segment in each year is optimized, maximizing NPV $profit_{15}$. Just like in scenario 13, the only condition is that investment and disinvestment in any year do not exceed the limits specified in the investment function. The optimization of net profit scenario is not simulating any reality, but merely exploring what is in principle possible in terms of maximizing NPV $profit_{15}$.

In the beginning of the simulation period, fleet and effort are reduced significantly, but less than in the main (TAC min) scenario. After year 7, effort starts increasing again until in year 15 it is only 8% lower than in the base year. The fleet shows a similar development, but is reduced much more than effort. In year 15 the number of vessels is 38% lower than in the base year. All fleet segments are smaller than in the base year, but the two Danish segments and the British segment of small beam trawlers are reduced less that the others. All other segments are reduced by more than 50%.

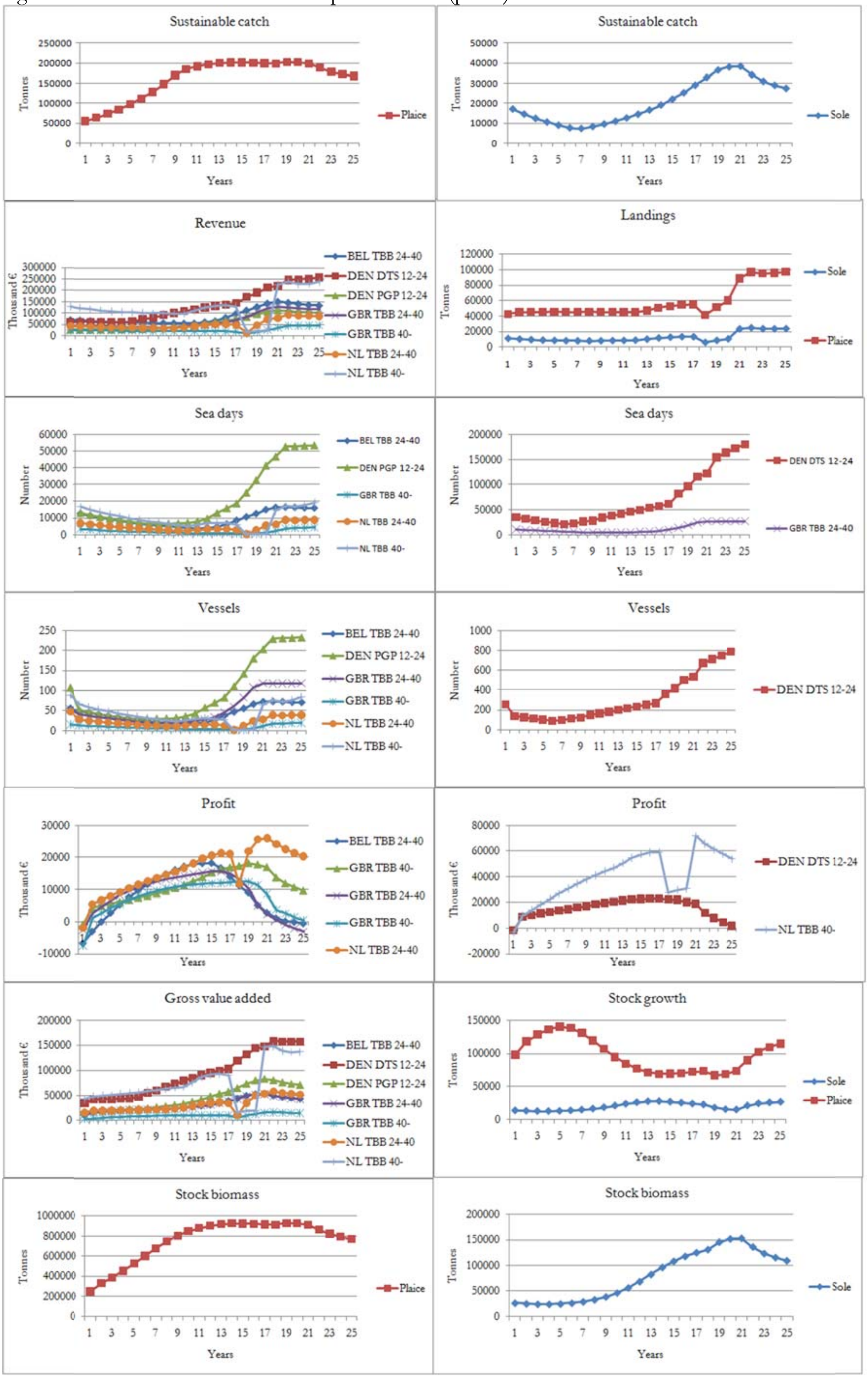
From year two, all segments are using the maximum number of days at sea per vessel. Catches of sole and plaice are 14% and 24%, respectively, higher than in the base year. Harvest ratio of sole and plaice are 0.15 and 0.07 respectively, much lower than in the base year and also lower than Hmsy of both species.

In year 15, the total fleet consists of 388 vessels, 22% more than in the main scenario. All fleet segments are operating at full capacity, using the maximum number of days at sea per vessel. Total effort in year 15 is 41% higher than in the main scenario. Catches of plaice are 12% lower than in the TAC min scenario and catches of sole are 19% lower. Harvest ratio of sole is 0.15, 25% lower than in the main TAC min scenario and only 50% of Hmsy (0.3). Harvest ratio of plaice is 0.07, 12% lower than in the main scenario and only 27% of Hmsy (0.26). This indicates that in year 15 the fleet has not been able to expand to an optimal size after its initial reduction.

The development of the individual fleet segments differs substantially between the profit optimization scenario and the main scenario. At the end of the simulation period, the Danish segments DTS 12-24 and PGP 12-24 are 78% and 169%, respectively, larger in scenario 14 than in the main scenario. All other segments are smaller than in the main scenario. Apparently, profit maximization is enhanced by investments in smaller vessels, saving fuel costs and capital costs. The higher effort in scenario 14 compared to the main scenario concerns days at sea of – on average – smaller vessels. This also may explain why profit is maximized with higher effort in terms of days at sea and lower catches of plaice and sole than in the main scenario.

NPV $profit_{15}$ is 34% higher than in the main scenario. This is mainly due to higher revenues and lower capital costs throughout the simulation period. Net profit in year15 is 13% higher than in the main scenario, although revenues are slightly lower. This is more than compensated by lower crew costs and capital costs.

Figure 4.16 Results of scenario 14 – Optimum fleet (profit)



Comparison of scenarios 13 and 14

Scenario 14 can be regarded as representing the private sector perspective. Resource rent is viewed as net profit as this is the excess remuneration of capital. Scenario 13 takes a society perspective, maximizing the sum of capital and labour remuneration. In other words, this scenario maximizes the contribution of the fisheries sector to the GDP.

In scenario 14, NPV $profit_{15}$ is 34% higher than in scenario 13 and 33% higher than in the main (TAC min) scenario. However, NPV GVA_{15} is 12% lower than in scenario 13 and only 16% higher than in the main scenario. This is caused by lower NPV Crew $costs_{15}$ (28%) and NPV capital $costs_{15}$ (27%). (Table 4.14). The same pattern can be seen when comparing GVA, net profit, labour costs and capital costs in both scenarios in year 15 of the simulation. In scenario 14, net profit is 49% higher than in scenario 13, but GVA is 28% lower, mainly due to a lower remuneration of labour (48%).

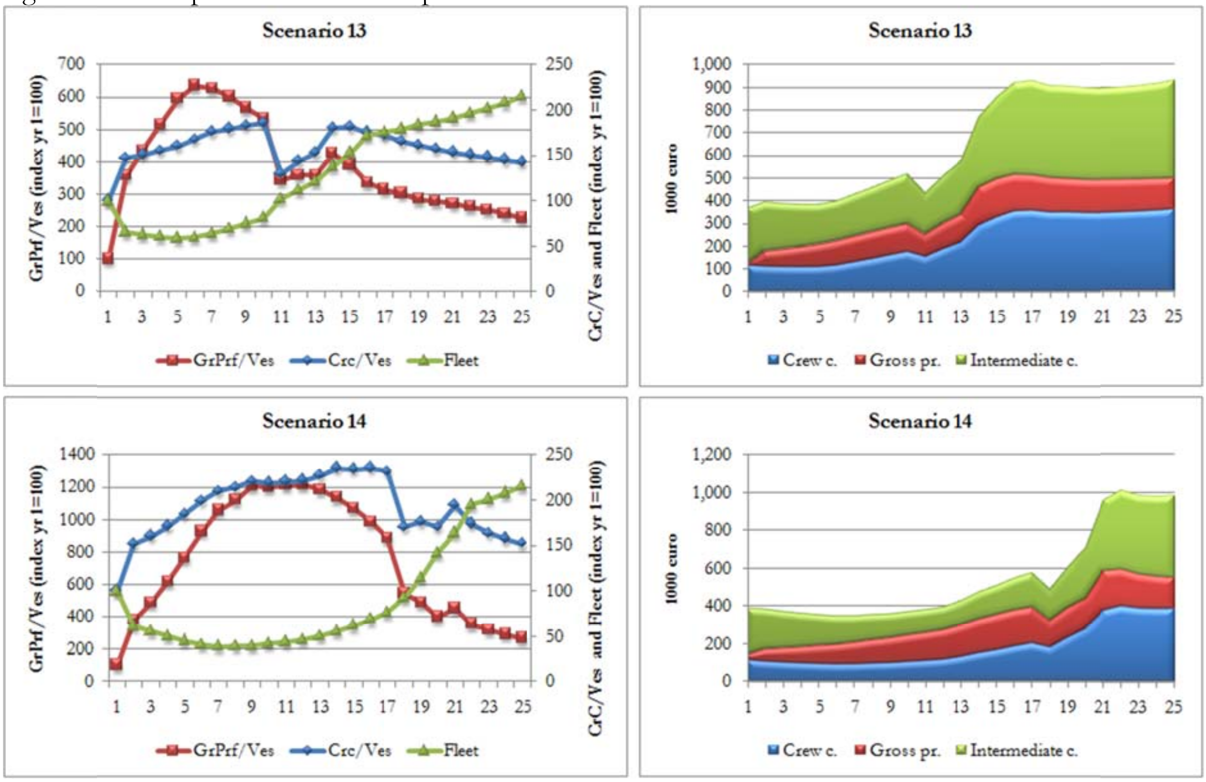
Apparently, strict maximization of net profit does not (necessarily) lead to maximization of total remuneration of all production factors. The most striking difference between the two scenarios concerns the development of the fleet. In year 15 the total fleet is 60% smaller in scenario 14 than in scenario 13, 38% smaller than in the base years 2005-7 but still 22% larger than in the main scenario.

Comparing year 15 in scenario 14 to the base years 2005/2007, shows that maximization of net profit in this case leads to significant increase in GVA (145%) and crew costs (44%) but also to a decrease of capital costs (54%) because of the smaller fleet in scenario 14. Net profit in year 15 is 161 mln euro compared to a 24 mln euro loss in 2005-7.

Table 4.13 Comparison of scenarios 13 and 14 (values in mln euro, fleet number of vessels)

	Scenario 13	Scenario 14
NPV GVA_{15}	2,966.2	2,601.5
NPV $profit_{15}$	760.4	1,009.5
NPV Crew $costs_{15}$	1,792.7	1,288.4
NPV capital $costs_{15}$	413.1	303.6
GVA year 15	491.1	354.2
Profit year 15	108.4	161.7
Crew costs year 15	323.5	168.8
Capital costs year 15	59.2	23.8
Fleet – average 1-15	552	321
Fleet – year 15	958	388

Figure 4.17 Comparison of the two optimization scenarios



4.7.6. Assumptions and technical background

Assumptions:

- For each of the seven fleet segments and for each of the two target species, it has been assumed that 10% of the catch is discarded as undersized fish
- Revenues from other species have been assumed to be a constant percentage of the revenues from target species for each of the fleet segments.
- With respect to other fleet segments catching the same target species from the same stocks it has been assumed that their share in the catch is equal to their share in the TAC.
- The other segments' share in the resource rent has been assumed to be equal to their average share in the TACs for sole and plaice weighted with the prices of sole and plaice.
- Fish prices and fuel prices are considered constant throughout the simulation period

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ANNEX 1.

Table A1. Basic economic data of the flatfish sector in the North Sea, including a total of seven segment classifications of four EU member countries.

	Seg. 1	Seg. 2	Seg. 3	Seg. 4	Seg. 5	Seg. 6	Seg. 7
SEGMENT CLASSIFICATION							
Member State	**Belgium**	**Denmark**	**Denmark**	**UK**	**UK**	**Netherlands**	**Netherlands**
Gear	**TBB**	**DTS**	**PGP**	**TBB**	**TBB**	**TBB**	**TBB**
Length group	**24-40**	**12-24**	**12-24**	**24-40**	**>40**	**24-40**	**>40**
EFFORT DATA							
No vessels	55	258	107	54	15	48	89.3
DAS/vessel	110	137	123	204	196	146	190
Max DAS (estimate)		270	270	270	270	270	270
CPUE (calculated) (t/day)	1292	1877.73	778.65	1225.55	2604.50	1444.99	2307.40
Effort (DAS)	12563	35373	13113	11000	3000	7000	17000
Technol. Progr. (% p.y. if available)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
COSTS DATA							
Fuel	26.8	6.46	1.50	14.17	11.77	16.6	53.35
Labour	24.6	27.63	13.04	10.09	4.77	10.1	26.55
Variable c.	10.6	7.27	3.16	5.10	5.61	3.2	10.04
Fixed costs	5.3	4.62	1.95	5.15	1.74	4.7	12.37
Capital costs (depr+inter.)	3.7	8.90	4.32	3.48	5.37	7.3	19.14
REVENUES AND CATCH							
Total revenue	69.00	59.83	26.20	41.00	24.00	44.00	128.00
Catch composition (4-8 species per segment + rest) (tonnes)							
Common sole	2.86	0.21	0.57	0.79	0.48	1.68	7.19
European plaice	4.17	5.52	2.95	4.06	6.10	4.22	17.23
Atlantic cod	0.00	9.30	2.52	0.00	0.00	0.00	0.00
Turbot	0.28	0.00	0.14	0.19	0.22	0.39	1.41
Lemon sole	0.83	0.00	0.00	0.00	0.17	0.00	0.00
OTHERS	8.08	117.82	14.25	7.90	1.67	3.95	13.15
-incl	Monkfishes	Norw.lobst	Europ.hake	Anglerfish	Com.dab	Com.shrimp	Brill
-incl.				Cuttlefish		Brill	Com.dab
Prices							
Common sole	11.28	10.94	10.82	10.98	10.98	10.89	10.73
European plaice	1.97	1.86	1.78	1.72	1.88	1.93	1.91
Atlantic cod	0.00	1.90	3.03	0.00	0.00	0.00	0.00
Turbot	11.69	0.00	9.77	12.55	11.94	9.06	9.05
Lemon sole	4.42	0.00	0.00	0.00	4.22	0.00	0.00
Biological parameters	SSB	MSY	Hmsy				
European plaice	245823.3	156261	0.3				
Common sol	26294.3	31291	0.2				

5. NORTH SEA COD FISHERIES

Cod in the North Sea and cod in the Baltic Sea are exploited by the same type of vessels and to some extent by the same fleet segments. The characteristics of the fisheries are also to a large extent the same. Therefore it could be argued that these fisheries should be analysed together in the same model, but as these are two distinct cod stocks which are exploited independently of each other the two fisheries are analysed separately. However, the statistics are produced on fleet segment basis irrespective of the fishing areas. Therefore, it was necessary to allocate the fleet segments' landings, costs and earnings between these two areas in an arbitrary way. Because of the similarities there is a great overlap of the text for the North Sea and the Baltic Sea cases.

5.1. Summary and conclusions

Main conclusion

The six segments analysed in this fishery realized in 2005-7 on average a total net profit of 130 mln euro. Average annual discounted net profit ranges under different scenarios between 180 and 370 mln euro. Elimination of overcapacity and recovery of stocks would produce a discounted net profit of 240-370 mln euro by the year 15. (see Figure 5.1)

Brief description of the case study

The cod stock in the North Sea is assessed together with the Skagerrak and the Eastern Channel (all for short named the North Sea) although three different quotas are set for these three waters. In the Kattegat there is also a small stock which is not assessed due to its currently low size. Further a cod fishery takes place is around the British Isles outside of the North Sea, which impact the catch statistics of the UK fleet segments. United Kingdom (40% of landings), Denmark (25%) and Germany (10%) are the main actors from the EU. Belgium and the Netherlands take another 12-15% and Norway the rest.

Fleet segments from UK, Denmark and Germany particularly dependent on cod are selected for the case. The total TAC for cod in the North Sea, the Skagerrak and the Kattegat has constituted around 20,000 tonnes per year over the last years. The quota around the British Isles constitutes a little less than 6,000 tonnes of which around 4,500 tonnes came from the Channel. Cod is caught in almost all fisheries in the North Sea which impacts the cod fishery seen in isolation strongly as any change in the cod landings affects other species and *vice versa.*

Two approaches could be pursued in analyses of the cod fishery in the North Sea. One is to consider cod an unavoidable by-catch in other fisheries. Cod catches are therefore dependant on these fisheries' species compositions. The other approach is to consider cod the main target species and treat other species as by-catches in the cod fishery i.e. dependant on the cod fishery. It is the latter approach that is pursued here.

There are three characteristics of the cod fishery in the North Sea, which make it very difficult to analyse. The first one is that cod is hardly the most important target species for any of the fleet segments at the moment. That means that the profitability of these segments is strongly influenced by a number of other species for some of which the biological information is poor. Secondly, presently the spawning stock biomass is lower than 40,000 tonnes, which is 25% of the precautionary spawning stock biomass of 150,000 tonnes. If a conventional approach to estimating a stock recruitment function based on historical data is used this would lead to a rather rapid growth of the stock if the present quotas are low enough to secure the growth. In practice this growth may be obstructed as the cod is an un-avoidable by-catch for many fleet segments. Discards are taken into account in the case. Thirdly, the recruitment to the stock is very variable with a number of "outliers", which influences the estimate of the stock-growth function. Therefore a modified stock-growth data set is used for the estimation in which outliers, 10% of the observations, are removed before estimation. This procedure produces a lower growth but a more robust result.

Divergence / convergence of the results

Comparing the scenarios that have been tested by use of the developed model some divergence is observed but it could be argued that for practical reasons the divergence is not big. Model calculations show that it is important that the management plan is fine-tuned with respect to the path to the optimal harvest ratio which seems not to be the case for the North Sea cod if the resource rent over time is going to be maximized.

It has been decided to include only cod as target species although the fishery is a multi-species fishery. For the North Sea, species such as cod, haddock, saithe, whiting, plaice, sole, herring and sprat are subject to the kind of assessment that is required for estimation of yield functions. In cod fisheries the first four species are relevant. The importance of these four species varies substantially among the cod-dependant fleet segments. Further data is not published in AER on the level of detail that makes a full species specification by segment possible. Therefore, these species are put together with the non-assessed stocks, in particular nephrops.

The inclusion of other species except cod in the model is important for the results. Three options have been used: a) the value of other species is a function of the landings value of cod, b) the value of other species is fixed per sea day and c) the value of other species is constant. Option a) forms basis for the presented results. The consequence is that landings of other species increase when the cod landings increase and the implicit assumption is that other species are "overexploited" to a similar extent as cod. In option b) the number of days at sea increases in the long run when the cod stock recovers and the landings of other species increase too. In option c) the change is associated only with cod. The development of the various indicators is similar for option a) and b) although there are differences among the fleet segments. The results for option c) show lower values for catches of other species, effort and profit.

Choice of baseline policy

Since 1983 and even before the cod fishery in the North Sea has been subject to comprehensive management in terms of TACs, gear and landings restrictions. Since 2004 a management plan for cod has been in place in terms of a target minimum spawning stock biomass (SSB) at 150,000 tonnes. The SSB-target is pursued by reducing the harvest ratio, transformed into a TAC, by 10% each year until the target SSB will be reached. If the proposed TAC is lower than 85% of last year's TAC, 85% of last years TAC is the new TAC. A similar limit, 15% higher, upwards counts. This TAC policy is chosen as the baseline although it is not necessarily performing best among the options tested here.

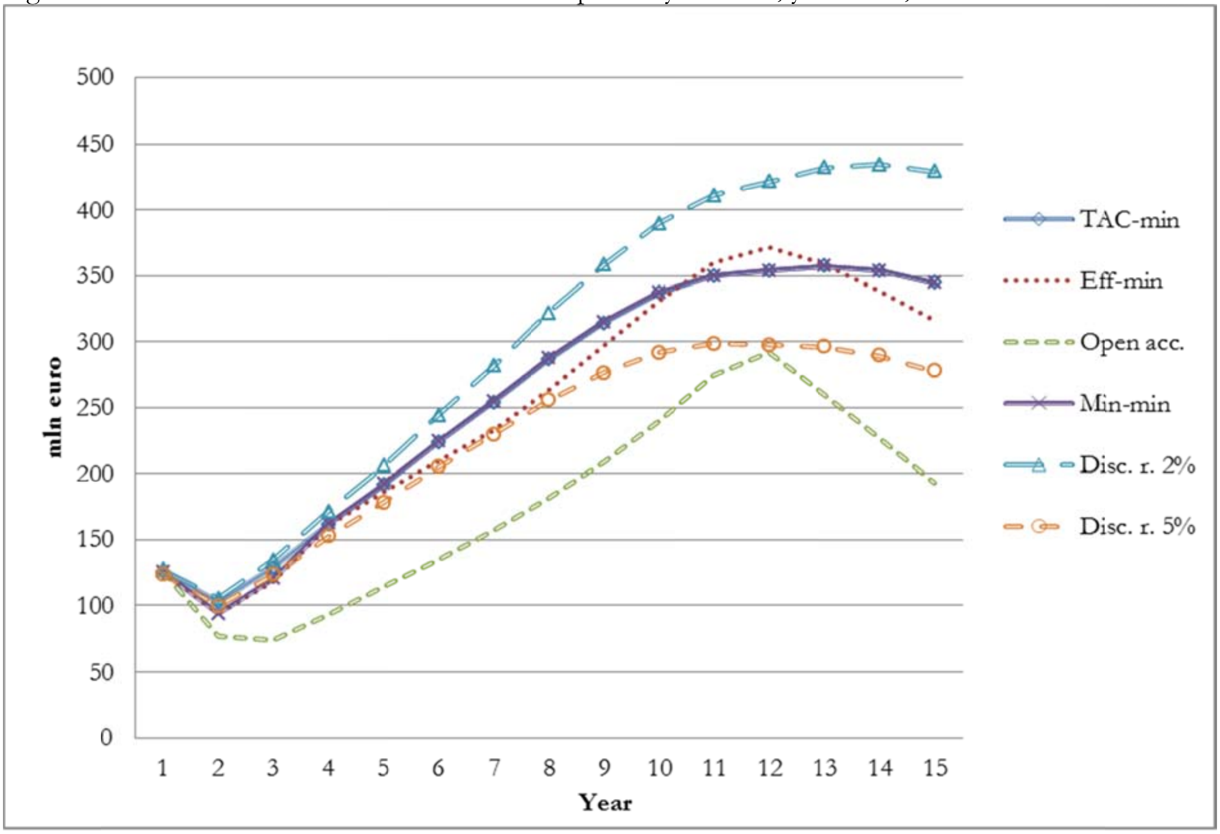
Achieving MSY

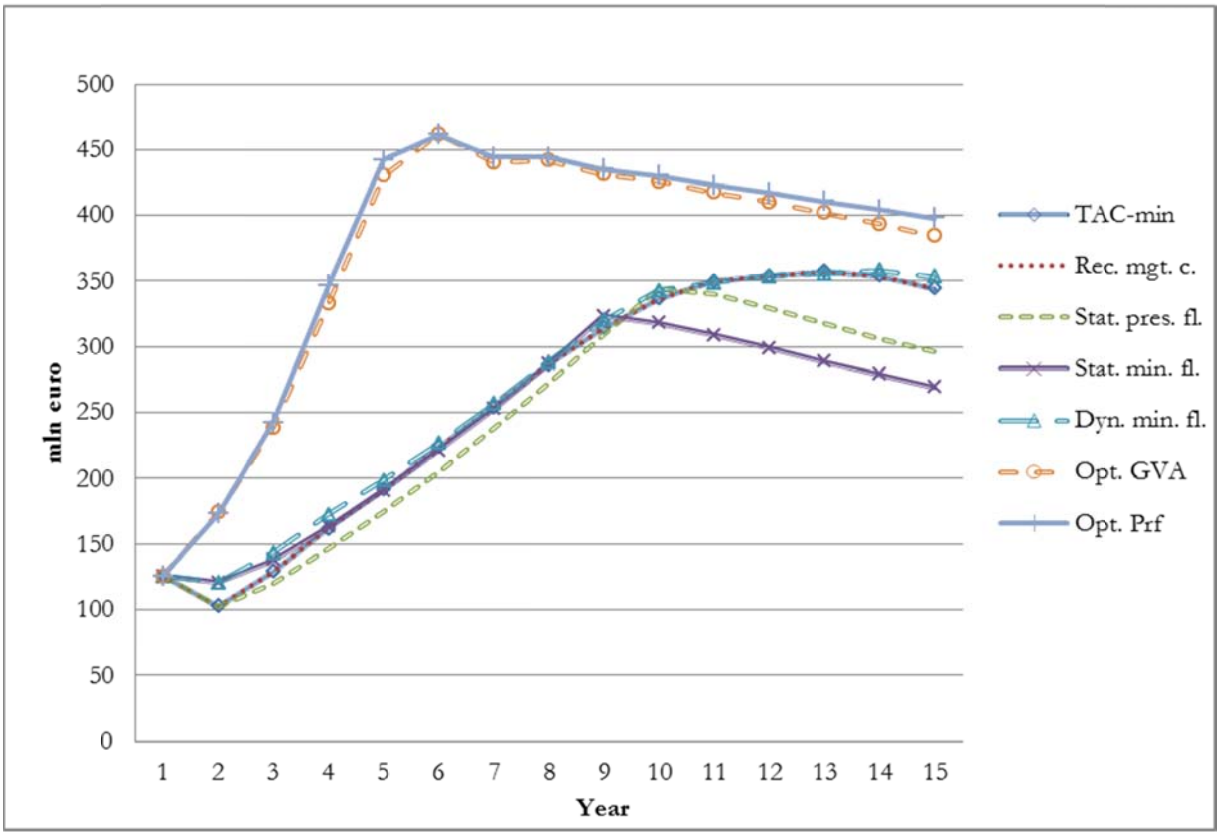
The maximum sustainable yield is derived from the estimated stock-growth function for the North Sea cod stock. Applying a 2nd degree polynomial relation produces statistically good results and this function can be solved for the optimal stock size with respect to MSY. The difficulties appear when different fleets with different species compositions and cost structures are introduced.

Achieving MEY (NPV Profit$_{15}$)

The maximum economic yield is by definition the combination of fish stock abundance and number of vessels times days at sea (effort) that maximizes the resource rent – defined as the discounted net profit (NPV Profit). The dominant technology in the cod fishery is trawl, although for Denmark the fishery is also executed by small gill netters 0-12m. These two types of vessels are chosen for the calculations for the North Sea cod case, with five segments of trawlers and one segment of gill netters. It is assumed that the gill netters are more impacted by stock abundance than the trawlers implying that catches per unit of effort increase more for gill netters than for trawlers when the stock abundance increases. A technological progress rate of 1% is used in the model.

Figure 5.1 North Sea cod – discounted annual net profit by scenario, years 1-15, mln euro[31]





[31] As only one species has been used, TAC-max and Eff-max scenarios were not calculated.

Role of discount rate

The choice of discount rate plays a role in particular in the assessment of the recovery of the cod stocks. Using a high discount rate makes recovery less attractive than a low discount rate. The reason is that the landings will have to decrease for some years to allow the stock to increase. By using a high discount rate less emphasis is placed on future gains compared to present losses. The net present value is dependent of the length of time considered. A short period tends to favour that no changes should be made as short term losses exceed the long term gains. A long period favours changes which can produce stock recovery.

Impact of eliminating overcapacity

Overcapacity reduces the economic performance of the fishery, but does not necessarily impact the stock recovery if the fishermen comply with restrictions in terms of TAC/quotas or fishing effort. In the TAC/quota case fishermen are allowed to land an amount of fish equal to the quotas and discard over-quota catches. In certain cases this leads to substantial discards in other cases no discards takes place.

In the first year of the model the number of days at sea per vessel is lower than the, physically, possible number per year. In the model no investments in vessels take place if the current number of days per vessel is lower than 70% of the maximum number. In this way some overcapacity is avoided over the years. It is important to observe, however, that the capacity in terms of number of vessels will increase compared to the initial capacity as the stock size and hence the catches increase.

Management costs and rent recovery

Recovery of management costs and other types of contemporary public costs affect the profit of the fishermen as they consider this type of payment a cost. In principle this impacts the investments. From a socio-economic viewpoint management costs recovered by a fee are considered a transfer payment and not as a cost to the society. Therefore, a fee does not affect the gross value added but is included in the gross value added alongside remuneration of labour and capital.

5.2. Case study definition

5.2.1. Fleet and landings

The annual TAC for cod for the North Sea, the Skagerrak and the Kattegat 2005-7 was around 22,000 tonnes per year of which the TACs for the North Sea were around 18,000 tonnes, for the Skagerrak around 3,000 tonnes and for the Kattegat around 800 tonnes. The TAC for the English Channel was around 4,500 tonnes, mainly exploited by France with 75% and the UK with less than 10%.

The Danish fleet segments fish in the North Sea, the Skagerrak and the Kattegat. The German and the UK fleet segments fish in the North Sea, with small catches of the UK segments in the Channel. The quotas for the North Sea, the Skagerrak and Kattegat are included in the model in the calculation of quota shares and the German, Danish and UK shares of the total TAC for these three areas were 11%, 30% and 39% respectively. The rest was taken by mainly Belgium, the Netherlands and France. Outside the EU, Norway takes an additional 15% on top of the EU quota. Table 5.1. shows the estimated size of the case study fleet segments of the total fleets.

Table 5.1 Role of case study fisheries within national fishery sectors. North Sea cod

Member State	Total fishery sector		Case study fleets	
	Total revenues (mln euro)	Total fleet (number of vessels)	Revenues (mln euro)	Fleet (number of vessels)
Germany	156	2,134	36	65
Denmark	384	3,120	60	805
United Kingdom	847	6,852	320	605

Source: AER

As it is not possible from the AER data to distinguish the cod landings between the fishing areas an estimated distribution of the landings has been made. The British fleet segments are fishing in the North Sea mainly. The total German landings are distributed based on the distribution of days at sea, according to the AER, between the North Sea and the Baltic Sea, which is 71% for DTS 12-24m and 39% for DTS 24-40m to the North Sea. Danish landings are divided (based on national statics) with 49% to the North Sea for PGP 0-12m and 73% to the North Sea for DTS 12-24m. The rest is allocated to the Baltic Sea. When this distribution is applied both for cod, for the total of species, for days at sea and for number of vessels Table 5.2 shows the role of cod for the North Sea compared to the total landings of the selected segments.

Table 5.2 Role of target species. Estimated for the North Sea, Skagerrak and Kattegat, average 2005-7

MS	Gear	Size	No. vessels	GT (1000)	Landings (1000 t)		Value (mln euro)	
					Cod	Total	Cod	Total
DEU	DTS	12-24	55	3.9	3.4	13.8	5.5	13.6
DEU	DTS	24-40	10	6.4	3.6	23.0	7.5	22.6
DNK	PGP	0-12	617	2.3	3.5	7.6	7.3	16.1
DNK	DTS	12-24	188	6.4	6.8	48.5	12.8	42.8
GBR	DTS	12-24	496	40.1	3.6	71.9	9.4	189.8
GBR	DTS	24-40	109	28.1	4.9	58.9	14.1	120.8
Other					-3.8			
Total 1)					22.0			

1) Average TAC for North Sea, Skagerrak, Kattegat
Source: AER

Table 5.2 also shows that the total landings of the selected fleets exceed the TAC with 3,800 tonnes. There are two explanations for this. One is that the landings of the UK fleet segments include landing from other waters around the British Isles, and another one is that the distribution for the German and the Danish segments is not correct. As the UK share of the cod quotas around the British Isles is less than 1,000 tonnes this alone cannot explain the difference, therefore the German and the Danish allocations seem too high. The German cod quota in the North Sea was 2,400 tonnes and the Danish was 6,600 tonnes. This problem is dealt with in the model using a scaling procedure and does not affect the parameter estimates of the model's equations.

5.2.2. *Composition of landings*

Only the total composition of landings is available for all fishing areas i.e. from the British Isles to the Baltic Sea. Gill netters and small trawler in the Baltic Sea have the highest share of cod in their landings. Table 5.3 shows the landings of seven species including cod for the selected segments. The group "Other" constitutes a relatively large share of the total landings and shows that a variety of other species constitutes important shares of the fleet segments' landings. For the North Sea fleet segments sprat and herring are included in "Other".

Table 5.3 Composition of landings by segment, all areas, average 2005-7 (1000 tonnes)

MS	Gear	Length (m)	Cod	Haddock	Saithe	Plaice	N. lobster	Other	Total
DEU	DTS	12-24	4.8			1.5	0.2	12.9	19.4
DEU	DTS	24-40	9.2	1.8	15.1			32.9	59.0
DNK	PGP	0-12	7.1			1.7		6.6	15.4
DNK	DTS	12-24	9.3			5.5	1.6	50.0	66.4
GBR	DTS	12-24	3.6	14.2			30.2	23.9	71.9
GBR	DTS	24-40	4.9	24.2			2.1	27.7	58.9

Source: AER

Norway lobster plays an important role in terms of value for many trawl fleet segments, see Table 5.4. Norway lobster is found in the waters outside the Baltic Sea. Further, haddock is important for the UK trawlers but not for other segments. Saithe is important for the large German trawlers.

Table 5.4 Composition of landings by segment all areas, average 2005-7 (mln euro)

MS	Gear	Length (m)	Cod	Haddock	Saithe	Plaice	N. lobster	Other	Total
DEU	DTS	12-24	7.8			2.7	1.4	7.2	19.1
DEU	DTS	24-40	19.2	2.8	11.6			24.5	58.1
DNK	PGP	0-12	14.9			3.3		14.6	32.8
DNK	DTS	12-24	17.6			10.3	14.1	16.6	58.6
GBR	DTS	12-24	9.4	20.0			110.5	49.9	189.8
GBR	DTS	24-40	14.1	38.8			9.7	58.2	120.8

Source: AER

For the UK segments cod measured in value plays a minor role with only 5% for DTS 12-24m and 12% for DTS 24-40m. These two segments are the most important "cod segments" of the UK fleet. Therefore they are included in the analysis, although it could be argued that they should have been excluded all together to avoid disturbance of the results. The calculations show that, in particular, these two segments' development is strongly impacted by other species than cod.

To include haddock in the model as a target species would have made this impact smaller and the required stock assessment for estimation of a stock-growth function for the model is available. Haddock is only important, relatively, for the UK DTS 24-40m, but for the DTS 12-24 Norway lobster is completely dominant, and as no stock assessment is available for nephrops the problem could not be alleviated.

5.3. Historical indicators

From the mid 60ies until the mid 80ies the catches from the North Sea cod stock have fluctuated between 200,000 and 400,000 tonnes (ICES 2008). The estimated MSY catches are around 200,000 tonnes. Since the beginning of the 90ies the catches have decreased from around 200,000 tonnes to around 50,000 tonnes. The discards are significant and the landings are only around half of the catches over the last ten years.

The spawning stock biomass (SSB) has over the last ten years declined from around 70,000 tonnes to around 30,000 tonnes and has been lower than the annual catches and at about the same size as the landings. From the mid 60ies to the mid 80ies the SSB exceeded 150,000 tonnes which is considered the general goal to which the stock should recover (equal to the precautionary B_{pa}). The minimum level for the North Sea SSB is estimated at 70,000 tonnes (which is equal to B_{lim}). The average harvest ratio for age groups 2-4 has been 0.9 for the period 1993-2007 with an increasing trend from the 60ies to the 90ies and then a decreasing trend.

5.4. Fleet efficiency

Looking at the profit (gross revenue minus all costs) the Danish segments perform worse, while the German trawlers DTS 24-40m perform very well. The UK fleet segments show positive profit as well. Whether this is caused by different methods of estimating the fixed costs, in particular, or it reflects real differences is difficult to say. The Danish data are considered reliable being collated on a regular basis since 1995, and there is no reason to expect that the Danish segments are performing significantly worse than the other fleet segments.

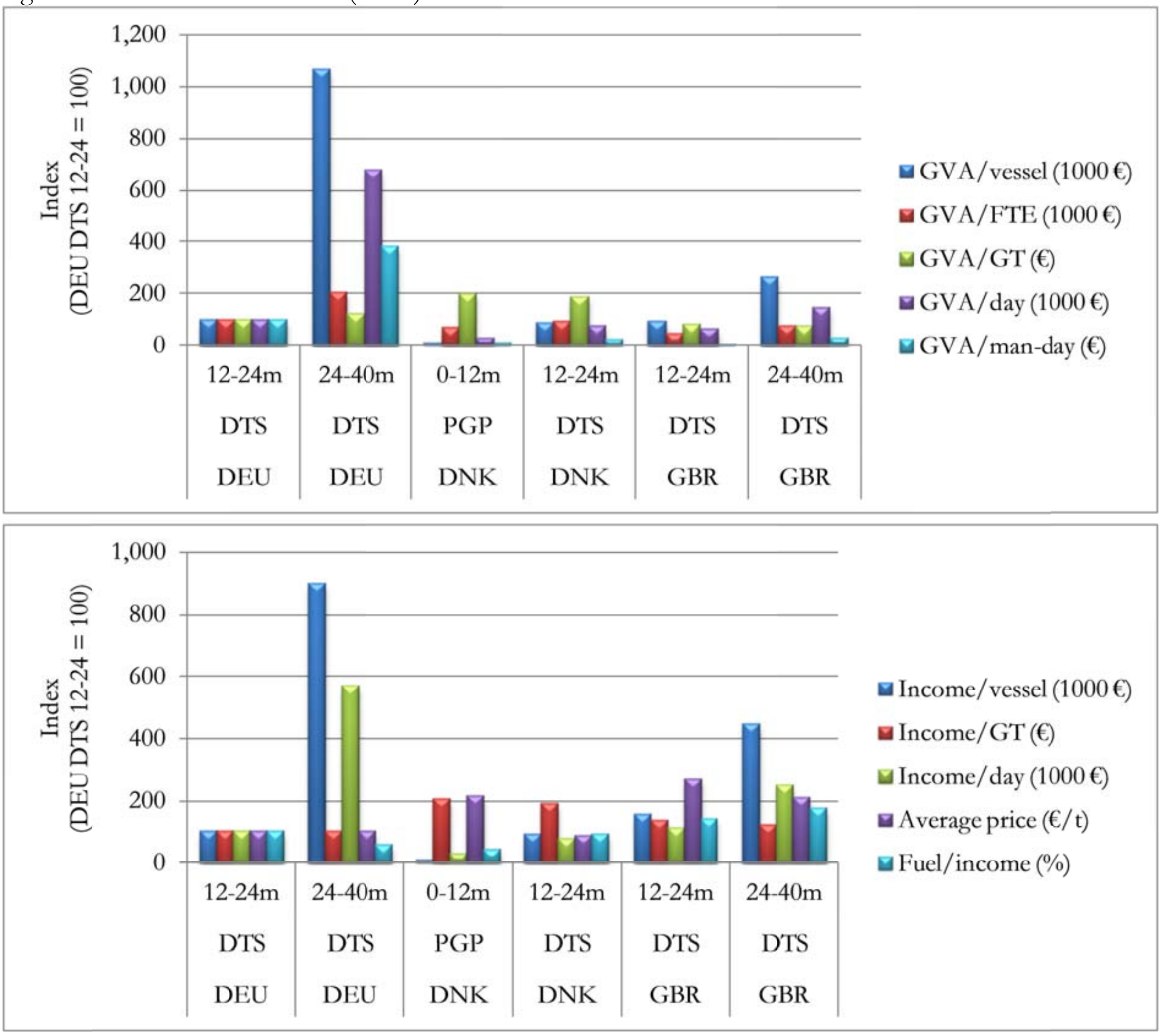
The total landings in volume and value of the selected segments and the share of cod of the total landings combined with the economic indicators show, in general, a very diverse picture, cf. Table 5.5.

Table 5.5 Economic indicators on fleet segment level. Average 2005-7

MS	Gear	Length (m)	Gross value added (mln €)	Profit (mln €)	Employ-ment (FTE or persons)	Average price (€/t)	Fuel costs of landings value	Profit/ tonne landings	CPUE total (t/day)	CPUE target species (t/day)
DEU	DTS	12-24	11.7	2.5	160	990	0.12	129	2.145	0.532
DEU	DTS	24-40	42.1	24.7	282	990	0.07	419	12.250	1.899
DNK	PGP	0-12	19.5	-5.5	387	2,130	0.05	-357	0.293	0.136
DNK	DTS	12-24	35.0	-1.6	519	880	0.11	-24	1.874	0.262
GBR	DTS	12-24	69.7	8.5	2,121	2,640	0.17	118	0.877	0.044
GBR	DTS	24-40	43.6	6.2	775	2,050	0.21	105	2.544	0.211

Economic indicators are shown in Figure 5.2. It is noticed that for the German trawlers (DEU DTS 24-40m) the indicators are different in structure from the other fleet segments. The reason for this is that the average size of the vessel in this segment is 2.5 times the average size of the UK vessels in the same segment. The German segment includes deep-sea trawlers which do not fish in the Baltic Sea and maybe even not in the North Sea, but it is not possible to distinguish these vessels in the statistics. The segment is included in the analysis to achieve a fleet structure that shows a large difference.

Figure 5.2 Economic indicators (index)



5.5. Management measures

5.5.1. General description

Recovery plans for cod in the North Sea have been in place since 2004. Furthermore, an effort (days at sea) limitation programme has been in place since 2003.

5.5.2. Output management

Catch restrictions

The general goal is to recover the North Sea cod stock to a level at 150,000 tonnes SSB (which is equal to B_{pa}). The minimum level for the North Sea SSB is estimated at 70,000 tonnes (which is equal to B_{lim}).

The means to achieve the goal is to gradually reduce the fishing mortality by 25% if the SSB is lower than B_{lim}. If the SSB is above B_{lim} but lower than B_{pa} the reduction should be 15%, and if SSB is above B_{pa} the reduction should be 10%. If the SSB is above B_{lim} the TAC must not be lower or higher than 15% of the previous year's TAC

Property rights [32]

Denmark has since 1993 applied a system with non-transferable individual quotas for demersal species. From 2007 the system was transformed into a system with individual transferable quotas. The United Kingdom has applied a system with restricted transferability of individual quotas management via the producer organizations. In Germany the national quotas are divided on fleet segments. Individual vessel quotas are used for the deep-sea fleet, which is not included in the analysis.

5.5.3. Input management

Effort restrictions

Days at sea limitations were introduced in 2003 as regard the maximum days per month present within the area and absent from port by fishing gear in Kattegat, North Sea and Skagerrak, Eastern Channel, West of Scotland and Irish Sea. Within each member state the days at sea can be transferred between vessels and segments by use of kW-days coefficients taking into account the differences in engine power.

From 2006, 2007 and 2008 the allowable number of days at sea was specified for a further detailed range of gear types and mesh sizes and became gradually more restrictive. From 2009 the days at sea management has been changed from a general provision laying down the maximum number of days at sea per gear type to an allocation of a maximum number of days at sea per vessels group per member state.

Input property rights

All the fleets have been subject to the fleet limitation programmes of the EU in terms of capacity and kW ceilings. These ceiling have increased the value of the vessels in the fleet.

[32] Info on property rights is drawn from the MRAG – RBM study

5.6. Management costs

The impact of an accession fee has been tested on the profit of the fleet segments and the consequences for the investments i.e. lower profit would lead to lower investments and hence lower fishing mortality. From the fishermen's point of view an accession fee is considered a cost, but for the society it is part of the resource rent.

Only incomplete information about financial transfers from the Government to the fisheries sector is available. One source is the OECD as shown in Table 5.6, while other sources are the allocation from the European Fisheries Fund (EFF), see Table 5.7, and estimates made by MRAG, see Table 5.8.

The financial transfers are made on a national basis and have been allocated to the fleet segments according to their landing value in proportion to the total national landings value.

The costs estimated by MRAG for management and control (Table 5.8) are used in the model to test the impact of cost recovery for these management items.

5.6.1. Summary of OECD data

The OECD data has been distributed among fleet segments according to the value of landings in the segment in proportion to the total number of vessels. The level of detail of the OECD data varies significantly between member states.

Table 5.6 Management costs according to OECD, average 2004-2006*, (mln euro), North Sea cod

	DEU DTS 12-24m	DEU DTS 24-40m	DNK PG 0-12m	DNK DTS 12-24m	GBR DTS 12-24m	GBR DTS 24-40m
Direct Payments	0.3	0.3	0.6	1.5		
- Decommissioning			0.5	1.3		
- Fleet renewal and modernization			0.1	0.2	0.4	0.3
- Other	0.2	0.2	0.0	0.1	1.0	0.6
General Services			1.9	5.2		
- Management and enforcement			1.1	3.0	9.7	6.1
- Research			0.3	0.8	6.0	3.8
- Other			0.5	1.4	0.1	0.1
Total	0.3	0.4	2.5	6.7	17.2	10.9

*sum of national and EU contributions regarding marine capture fisheries.

5.6.2. Support to fishing sector (EFF)

The data from the European Fisheries Fund (EFF) have been distributed among fleet segments in the same way as above.

Table 5.7 Average annual support to the marine fisheries from EFF, (mln euro). North Sea cod

	DEU DTS 12-24m	DEU DTS 24-40m	DNK PG 0-12m	DNK DTS 12-24m	GBR DTS 12-24m	GBR DTS 24-40m	Total
EFF - Axis 1	0.2	0.3	0.3	0.7	1.8	1.1	4.3

5.6.3. Costs of research and management

Table 5.8 shows the estimated management and research costs from the MRAG-RBM study and the DCF budgets raised by 30%, distributed among fleet segments in the same way as above. The MRAG data have been used in the model in the costs recovery scenario.

Table 5.8 Estimated management and research costs, (mln euro). North Sea cod

	DEU DTS 12-24m	DEU DTS 24-40m	DNK PG 0-12m	DNK DTS 12-24m	GBR DTS 12-24m	GBR DTS 24-40m
Management, control, enforcement (MRAG)	2.6	4.3	1.4	3.7	6.9	4.3
Research (DCF+30%)	0.7	1.1	0.1	0.2	2.8	1.7

Sources: MRAG (2008) and Com. Decision 811/2009

5.7. Estimation of the resource rent

5.7.1. Comparison of scenarios

The analysis is designed in such a way that the species of the fleet segment's catch compositions are caught in a mixed fishery. One scenario covers the case where the fishery stops as soon as the quota of the most restrictive species is taken (TAC min scenario) while another scenario considers the case where the fishery stops when the least restrictive quota is taken (TAC max scenario). Further the model evaluates in a similar manner two scenarios where the fishery stops when the most and the least restrictive number of days at sea are reached (Effort min and Effort max scenario). In the effort scenarios, the days at sea are estimated from the Htarget in proportion to the current H multiplied to the effort in the preceding year, starting with the baseline effort. In the TAC scenarios the TACs are estimated from the Htarget/H proportion applied to the stock in the baseline (start year). The most restrictive scenario is the Min min, in which the TAC and effort restrictions are compared and the most limiting is selected every year.

Finally, an Open access scenario has been tested in which there are no restrictions apart from the physical number of days at sea and the speed and magnitude of the (dis)investments. The latter is limited so that investments in new capacity can at most constitute 10% of the capacity in the year before, while disinvestments can at most constitute 20% of the previous year's capacity.

These six policy scenarios are used to test implications of different types of TAC and effort policies. Further, the impact of the magnitude of the discount rate is investigated in scenario 1 (TAC min), which is considered to be the baseline policy scenario. A discount rate at 2% is compared to the default at 3.5% (scenario 7) and a discount rate at 5% (scenario 8). In scenario 9 the impact of cost recovery of the management and control costs is estimated.

Finally, based on the policy option of TAC management scenarios 10-12 have been estimated where the present number of vessels have been kept constant for the whole simulation period (scenario 10), the minimum present number of vessels required if all vessels are using their maximum number of days at sea per year is kept constant (scenario 11), and eventually (scenario 12) the minimum number of vessels in scenario 11 is allowed to change by use of the investment function which is disregarded in scenario 10 and 11.

The analyses are closed by scenario 13 which is a dynamic optimization (non-linear programming) where optimal effort and cod stock are determined by maximising the gross value added (GVA) over 15 years, and by scenario 14 where profit is maximized. By this procedure an estimate of the maximum resource rent is obtained i.e. an estimate of the MEY.

The model can work with several species/stocks subject to quota restrictions. A meaningful inclusion requires that future quotas are known or could be estimated based on stock assessment. Further, some importance of each single species in the catch composition is also required to be used as a meaningful restriction. This is necessary to avoid that the species which in practice are disregarded by the fishermen and the managers play a role in the analysis. None of these assumptions are fulfilled, and there is a risk that "strange" results may occur if species/stocks for which the conditions are not fulfilled are included in the model and admitted to control the fishery. Therefore, only one target (quota) species, cod, is included in the model, and catch of other species is a function of the cod fishery. Including only one quota species entails that the TAC min and the TAC max as well as the Effort min and Effort max scenarios are the same. Hence, scenario 3 and 4 are left blank in Table 5.9.

In order to match the cod landings of the selected fleet segments with the total quota it is necessary to allocate share of the total quota to the fleet segments considered in the model and use a scaling procedure to secure that cod landings of segments not included in the model are taken into account. The landings of cod of these other segments have been set to a fixed share of the landing of the selected fleet segments.

The start values for days at sea per vessel per year are lower for all segments than the assumed maximum number, in particular, for gill netters for which many inactive vessels is included in the statistics. The maximum number of days at sea per vessel per year is set at 120 days for gill netter 0-12m, 200 days for trawlers 12-24m, and 240 days for trawlers 24-40m. These value have been assumed because of lack of information about the maximum number of days at sea.

The shape of the stock-growth function is extremely important for the results. For cod the estimated growth is strong as the present catches could potentially be increased 3-4 times to reach MSY. In the TAC scenarios the effort is determined by the cod TAC. Therefore, the fishery stops when the TAC is exhausted and there is no discard of over-sized fish. The discard of undersized fish is set at 20% (ICES 2008). In the effort scenarios it is assumed that all over-sized fish can be landed.

Table 5.9 shows that the effort and capacity will have to increase in almost all scenarios once the cod stock is recovered. Landings (catch) of cod will increase 3-4 times compared to the baseline and in the optimal case (scenario 13) six times. In this case effort must increase four times and the number of vessels three times.

Table 5.9 Comparison of the scenarios

Scenario no.	Effort (1000 DAS)	Fleet (no. vessels)	Catch of cod (1000 t)	Profit year 15 discounted	NPV $Profit_{15}$
	Average values 2005-7				
2005-7	164	1,475	25.6	130	
	Values in year 15 of the scenario				
1. TAC min	268	1,506	77.9	344	3,885
2. Effort min	399	2,300	89.8	392	4,529
3. TAC max	-	-	-	-	-
4. Effort max	-	-	-	-	-
5. Open access	797	4,507	141.1	490	5,838
6. Min min	268	1,506	77.9	344	3,885
7. Discount rate 2%	268	1,506	77.9	429	4,468
8. Discount rate 5%	268	1,506	77.9	278	3,395
9. Recovery mgt. costs	268	1,506	77.9	206	3,619
10. Static present fleet	202	1,479	69.9	296	3,628
11. Static minimum fleet	164	881	60.1	270	3,586
12. Dynamic min. fleet	268	1,434	78.2	353	3,981
13. Optimum fleet (GVA)	678	4,214	141.3	384	5,525
14. Optimum fleet (profit)	355	1,750	114.5	398	5,599

The effort scenarios are performing better than the TAC scenarios. The Open access (scenario 5) is apparently performing very well. This is happening because the effort and investments are restricted upwards and downwards in the Open access scenario, by incidence in an almost optimal way. Finally, the Min min is controlled both by TACs and effort restrictions. This scenario 6 is the same as scenario 1 because the TAC restrictions are binding.

5.7.2. Policy options

Summary

Table 5.10 shows specific indicators for selected policy options which is TAC management, effort management, open access (no TAC of effort management), and both TAC and effort management.

Effort management performs better than TAC management comparing the net present value of the profit over 15 years (NPV $Profit_{15}$), but this is partly because the TAC management is not fine-tuned in terms of the harvest ratio with respect to rate of increase in the fishery from present to year 12 where the stock is built up to a long term sustainable level. The built up rate of the stock is determined by the interaction of the stock growth, the investment behaviour and the management restrictions.

The harvest ratio is defined as the proportion between the catches and the catchable stock and cannot be compared directly with the "biological" fishing mortality rates that are determined for age groups 2-4. The present harvest ratio in the model is 0.14 e.g. 14% of the total catchable biomass. This rate is halved under the TAC and effort management programmes. In the Open access scenario the rate is 0.14. The Open access scenario performs best but it is actually controlled as the increase in investments per year is limited to 10%.

It is important to emphasize that the results strongly depend on the assumption made for other species. This assumption is that other species are basically as "overfished" as cod. Therefore when cod landings increase other species increase too and that assumption probably leads to an overestimation of profit and effort.

If the calculations are performed based on the assumption that the landing value of other species than cod is constant the effort and the capacity will build up according to the recovery of the cod stock. However, after 10-15 years the profit of the fleet segments goes significantly down because the fleet is built up too much. This will not lead to disinvestments because the profit is still positive. Instead it will lead to capital stuffing. This happens because the fishery is managed via the harvest ratio which is transformed either into a TAC or an effort in terms of days at sea. Capital stuffing can be avoided either by direct control of effort or the number of vessels or by an ITQ-scheme.

Table 5.10 Effects of different policies on profit, harvest ratio, catches, effort and fleet

Indicator	2005-7	Scenarios**					
		TAC min	Effort min	TAC max	Effort max	Open access	Min min
NPV $Profit_{15}$		3,885	4,529	-	-	5,838	3,885
Profit year 15 discounted	130	565	546	-	-	893	565
Harvest ratio (year 15)*							
Cod	0.14	0.06	0.07	-	-	0.13	0.06
Catch in (1000 t, for scenarios year 15)							
Cod	25.6	77.9	89.8	-	-	141.1	77.9
Effort (1000 DAS, for scenarios year 15)							
Cod	164	268	399	-	-	797	268
Fleet (no vessels, for scenarios year 15)							
Cod	1475	1,506	2,300	-	-	4,507	1,506

Further, it is assumed that the cod stock is able to increase if the present harvest ratio is reduced. It is difficult to judge whether this assumption is reasonable. If the cod is caught as by-catch in other fisheries and these fisheries are allowed to continue according to the present pattern, and as it is compulsory to discard the catches of cod over the quota the required growth may not happen.

In the following Figures 5.3-11 including six sub-figures the development of some indicators are shown. The sustainable catch shows the catch according to the management rules be it TAC or effort. Landings net of discard are shown in the next one. Effort and capacity is shown in terms of total days at sea for the segments and the number of vessels. These two panels are shown only for 15 years as in most case effort continues to increase overall 25 years and because of the scale blurs the development of the first years too much. The two lower panels show the profit (gross revenue minus all costs) and the gross value added (remuneration of labour, capital and fish stocks).

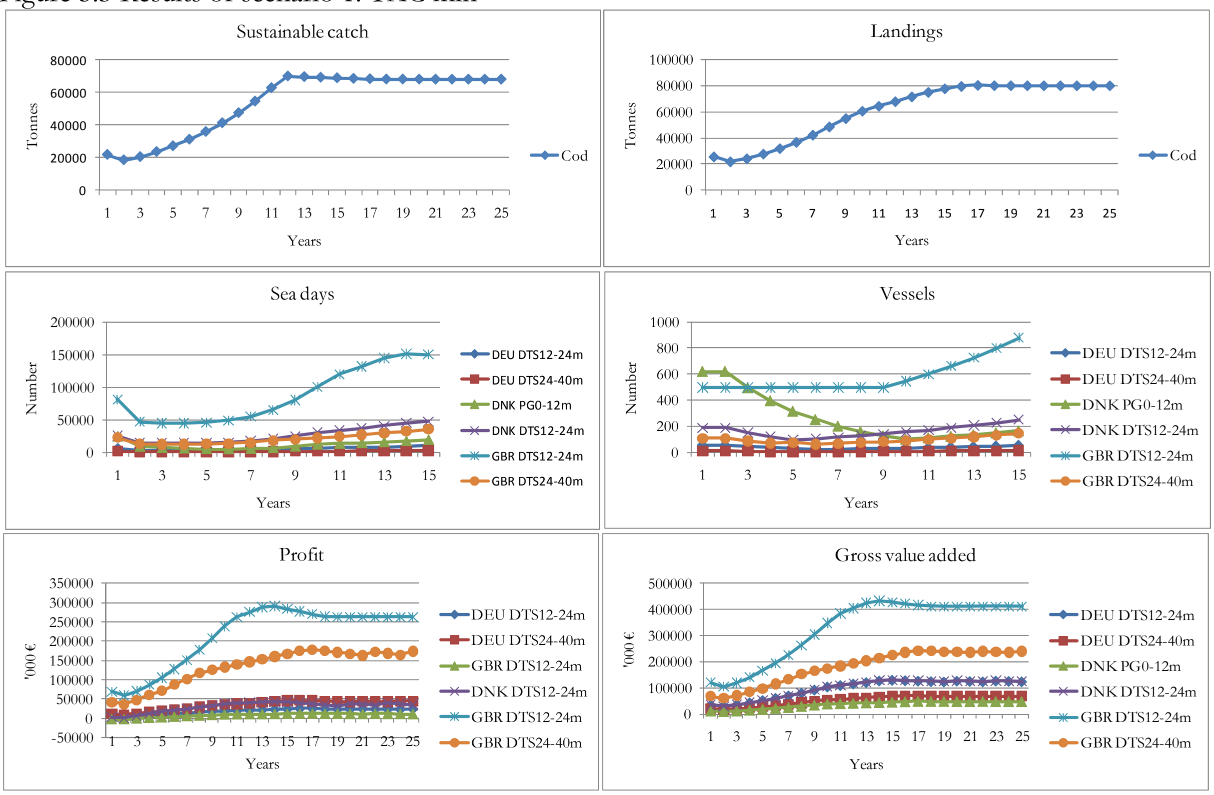
Scenario 1. TAC min

The fishery conducted by the six fleet segments is driven by the TAC for cod. For each segment the landing value of all other species is estimated in proportion to the value of cod. The species compositions of the fleet segments are very different, but it is assumed that the cod drives the fishery.

The fishery is carried out by small or medium sized trawlers and small gill netters. For the latter group information is uncertain as a large part of the registered vessels are inactive in practice.

The model calculations show that when the fishery is managed by TACs, based on the target H the landings will fall in year two and three (year one is the base) and then increase gradually to the MSY level. The number of days at sea will fall until year six and after that increase. The number of vessels will stay below the initial level almost throughout the period in particular for the gill netters which is a consequence of the very low level of days at sea per vessel in the base line. There is no discard of over-quota catches in scenario 1 as the fishery will stop when the TAC is taken.

Figure 5.3 Results of scenario 1. TAC min

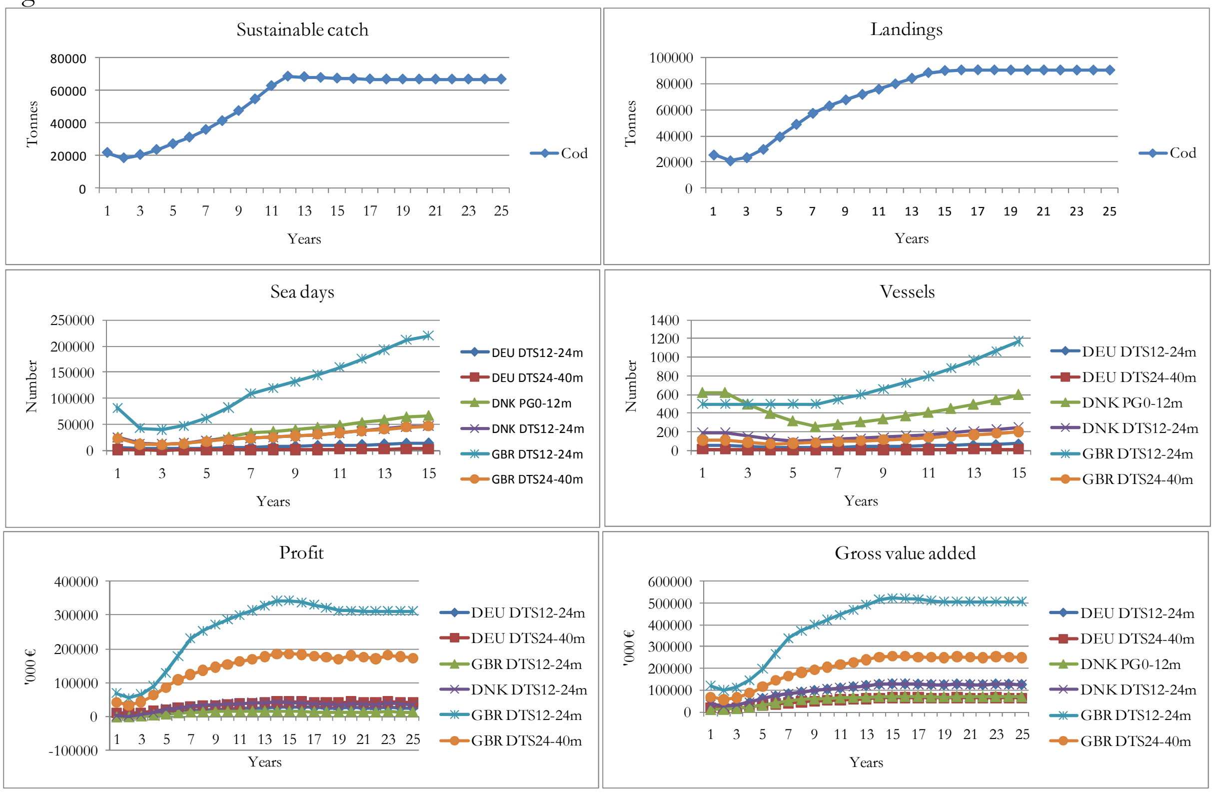


Scenario 2. Effort min

The target effort in a given year is chosen by adjusting the number of days at sea in the baseline with the proportion between Htarget and the current H calculated each year. This development is, however, restricted by the borders of the investment in vessels (10% up and 20% down as maximum each year). If the potential effort is less than the target effort then catches are based on the potential effort, leading to a lower harvest ratio than 'proposed'. In the effort managed fisheries there is no discard of over-quota catches as there are no quotas.

Given these assumptions scenario 2 performs better than scenario 1. The NPV $Profit_{15}$ is higher in scenario 2 and so is the number of days at sea and the number of vessels. The reason for this result is that in scenario 1 the fleet is reduced to a too low level and the stock reaches a too high level. Therefore potential landings are not fully exploited in scenario 1 compared to scenario 2.

Figure 5.4 Results of scenario 2. Effort min



Scenario 3. TAC max

As only one species, namely cod, determines the effort, TAC max is the same as TAC min. If other species than cod are chosen as "drivers" e.g. by assuming that the catch of other species determines the catch of cod the tendency is that the cod will by overexploited and in certain cases driven to extinction.

Scenario 4. Effort max

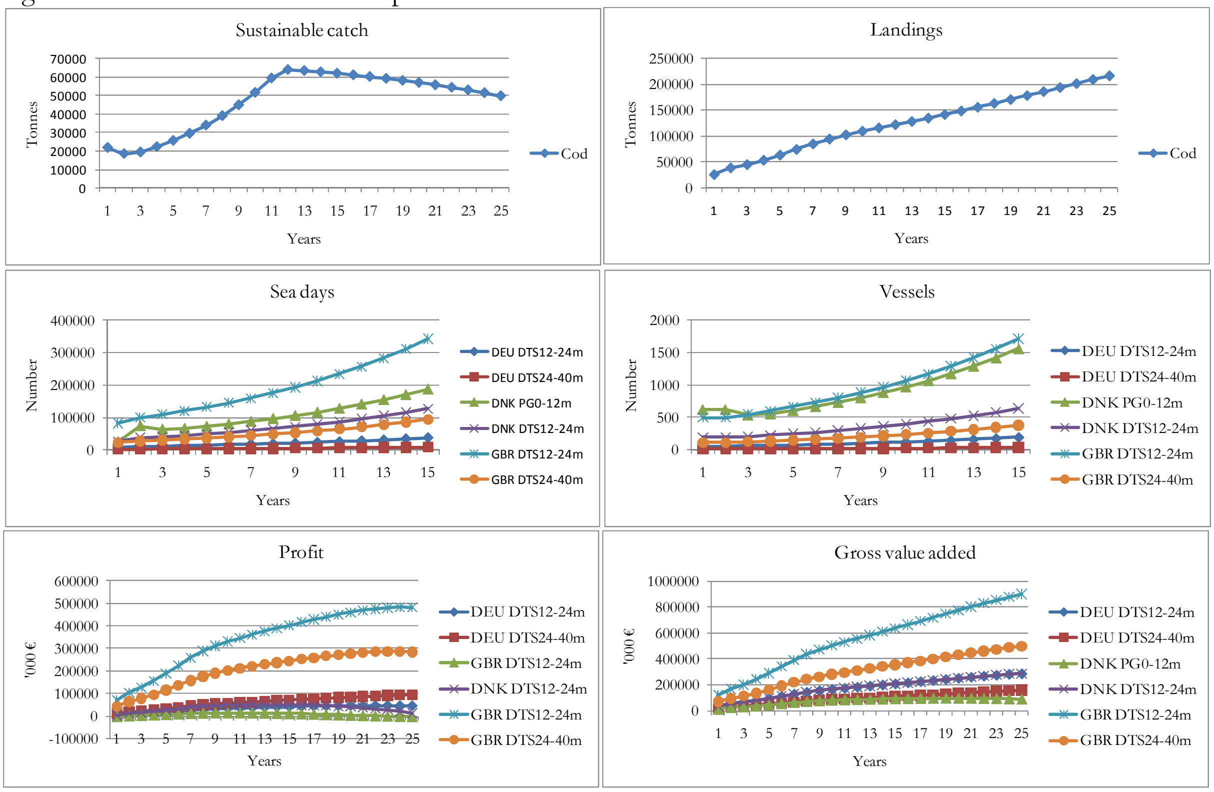
As for scenario 3.

Scenario 5. Open access

In the Open access scenario the catches are unrestricted by TAC/quota or days at sea limitations. It is, however, important to notice that the same upper and lower ceilings regarding investment in number of vessels applies as in scenario 1 and 2 to reflect that adjustments cannot be made instantly.

Because the fleet segments are profitable in the baseline, investments take place, which entails that the landings increase but the stock biomass and the sustainable catch go down in the very long run i.e. after year 15. There is no discard of oversized fish in this case because Open access is by definition not limited by quotas.

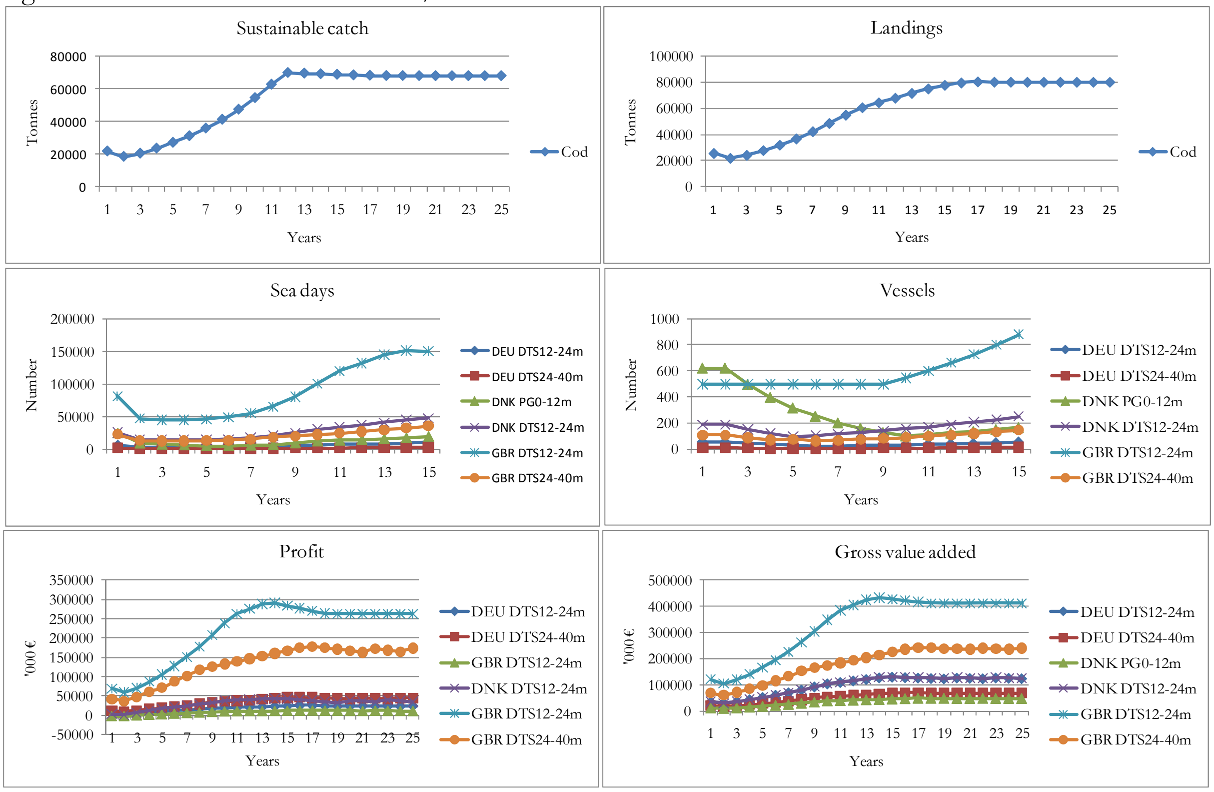
Figure 5.5 Results of scenario 5. Open access



Scenario 6. Min min

In this scenario the model chooses each year the lowest number of days at sea either because of quota or because of effort limitation. In all years the TAC/quotas determine this restriction and therefore the scenario is identical to TAC min.

Figure 5.6 Results of scenario 6. Min / min



5.7.3. Role of discount rate (scenarios 7-8)

Scenario 1 is chosen as the main scenario and the discount rate is 3.5%. If the discount rate is reduced to 2% (scenario 7) the NPV $Profit_{15}$ increases by 15%. In year 15 the profit is 25% higher. If the discount rate is increased to 5% the NPV $Profit_{15}$ is 13% lower, and the profit in year 15 is 19% lower. It is thus clear that the simulation results are sensitive to the choice of discount rate, which is also shown in Table 5.11.

Table 5.11 Effect of discount rate on profit (mln euro)

Indicator	2005-7	Scenario		
		Main scenario Discount rate 3.5%	7. Discount rate 2%	8. Discount rate 5%
NPV $Profit_{15}$		3,885	4,468	3,395
Nominal $Profit_{15}$*	130	577	577	577
Discounted $Profit_{15}$*		344	429	278

*this is the value in year 15, not the sum of profits

5.7.4. Resource rent and recovery of management costs (scenario 9)

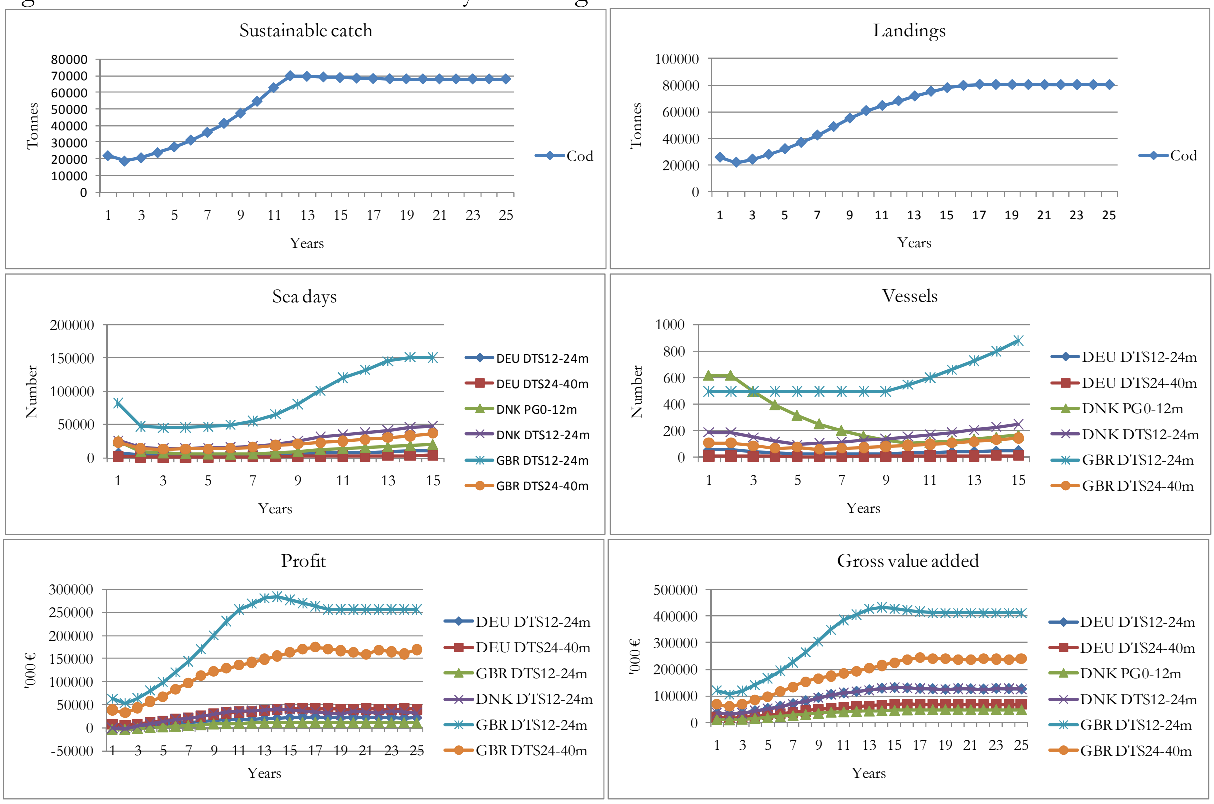
MRAG data is used in the calculation of cost recovery. The scenario does not differ from the TAC scenario. The reason is that investments are not affected, although higher costs lead to higher break-even revenues. However, the profit is lower in scenario 9 than in scenario 1. If recovery of management costs is considered as a tax it will not influence the gross value added.

Table 5.12 Effect of cost recovery of management costs (mln euro)

Indicator	2005-7	Scenarios*	
		Main scenario: No recovery of management costs	9. Recovery of management costs
NPV GVA_{15} (mln euro)		6,436	6,436
Nominal GVA_{15} (mln euro)	268	947	947
NPV $Profit_{15}$		3,885	3,619
Fixed payment for access (mln euro)		0	23
NPV Payment for $access_{15}$		0	266
Nom $Profit_{15}$ (mln euro)	130	577	554

The conclusion is that the profit to the fishermen will decrease and thereby influence the economic performance of the fleet, but from a management point of view there will be no changes. Changes will occur if the imposed 'access fees' would be further increased.

Figure 5.7 Results of scenario 9. Recovery of management costs



5.7.5. Optimization of capacity (scenarios 10-14)

The scenarios shown in Table 5.13 deal with the question of instantaneous or gradual adaptation of the fleet and parallel elimination of overcapacity. The baseline shows the present situation (2005-7), while the main scenario is scenario 1 with TAC and investment restrictions. In the static present fleet (scenario 10) the number of vessels is constant but the number of days at sea per vessel is allowed to vary subject to the management option which is TACs. In the minimum static fleet the number of vessels is reduced presently to number of vessels required if all vessels use the maximum number of days at sea per vessel. This number is then kept constant. The dynamic fleet is the fleet after the investment behaviour is re-introduced into the model. And finally the optimal case is shown.

Table 5.13 Impact of optimization of the fleet size

Indicator	2005-7	Scenarios*					
		Main scenario TAC min	10. Static present fleet	11. Static minimum fleet	12. Dynamic minimum fleet	13. Optimum fleet (GVA)	14. Optimum fleet (profit)
NPV $Profit_{15}$ (mln euro)		3,885	3,628	3,586	3,981	5,525	5,599
Nominal $Profit_{15}$ (mln euro)	130	577	496	450	591	644	667
Discounted $Profit_{15}$ (mln euro)	130	344	296	270	353	384	398
$Fleet_{15}$ (no vessels)	1,475	1,506	1,475	881	1434	4,214	1,750
$Effort_{15}$ (1000 DAS)	164.3	268.3	251.6	164.3	267.8	667.9	355.2
$Catch_{15}$ (1000 t)	25.7	77.9	76.7	66.4	78.2	141.3	114.5

*NPV row refers to the sum, other rows refer to values in year 15

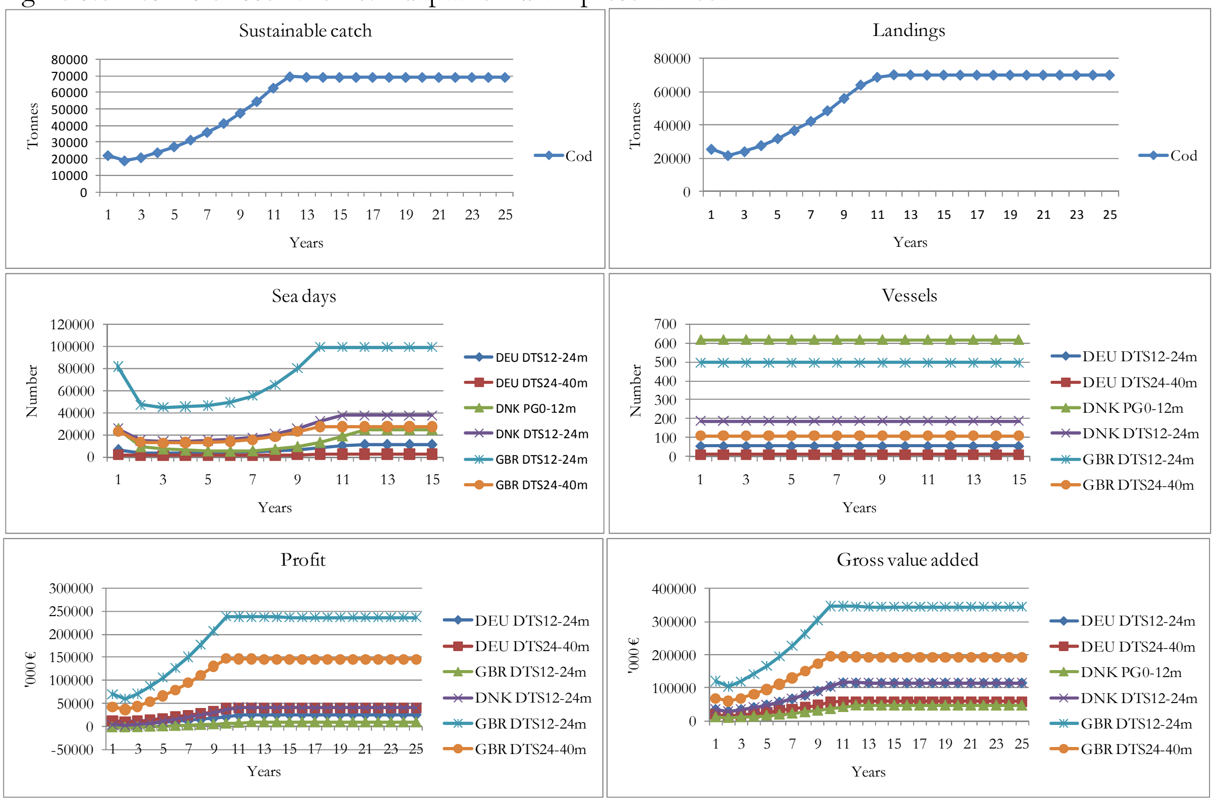
The scenarios for optimization of the size of the fleet show that the NPV Profit with a static fleet (scenario 10 and 11) is almost the same as for the TAC min scenario. But there are large differences in the underlying number of vessels, days at sea and catches in year 15 after adjustments have taken place. A more comprehensive adjustment will take place in scenario 12 and 13 where investments are allowed. In scenario 12 the fleet is allowed to adjust from a very low level i.e. the level of the minimum fleet, while the adjustment in scenario 13 takes place from the baseline with a higher number of vessels in year one. The best scenario is no. 13 where catches are estimated at around 140,000 tonnes. This Figure could be compared with the MSY for cod which is around 200,000 tonnes. However, in scenario 13 the stock biomass is higher than in the MSY. The effect of a high stock is a high catch per unit effort and hence lower cost per catch unit but on the other hand the growth of the stock is lower than in the MSY case. The result of scenario 13 is therefore in line with what should be expected from the MEY situation. The profit (revenue – all costs) is maximized in scenario 14. This scenario performs worse than scenario 13 and, in particular, the number of vessels and the number of days at sea are lower in scenario 14 compared to scenario 13. The reason is that the low profit recorded for vessels PG 0-12m (small gill netters) implies that the fleet is competed out.

Scenario 10. Static present fleet

The assumption in this scenario is that the number of vessels is kept constant at the initial level (2005-7). The TAC min scenario is chosen. The total number of days at sea for each segment is calculated, and this number of days is divided by the constant number of vessels. Therefore the number of days per vessel varies over time. If the number of days per vessel exceeds the maximum number of days at sea per vessel the maximum number of days is used. Such a situation does not occur for any of the fleet segments until year 10.

As the present fleet is controlling scenario 10 the total number of vessels is the same as in the baseline, but the number of days at sea in year 15 is almost 50% higher in scenario 10. The catches are 30% higher compared to scenario one and three times higher compared to the baseline in year 15.

Figure 5.8 Results of scenario 10. Adaptation with 'present' fleet

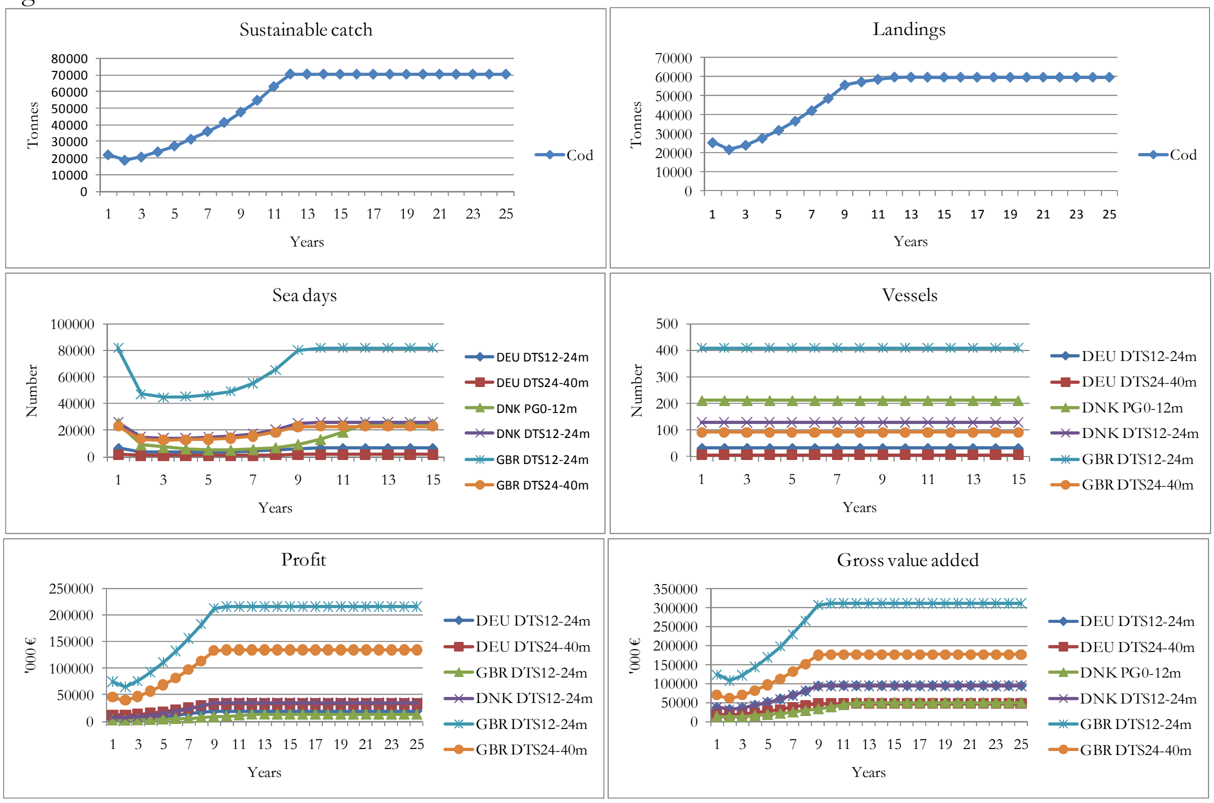


Scenario 11. Static minimum fleet

In scenario 11 the number of vessels is reduced according to the total number of allowed days at sea per fleet segment, so that each vessel in the segment uses the maximum allowed number of days at sea per vessel. This number is maintained throughout the 25 years for each fleet segment.

As the management is kept at the minimum fleet the number of days at sea is the same as the in the baseline. The economic performance in terms of profit is not improved significantly compared to scenario one and ten, but there are large underlying differences in catches number of vessels and days at sea.

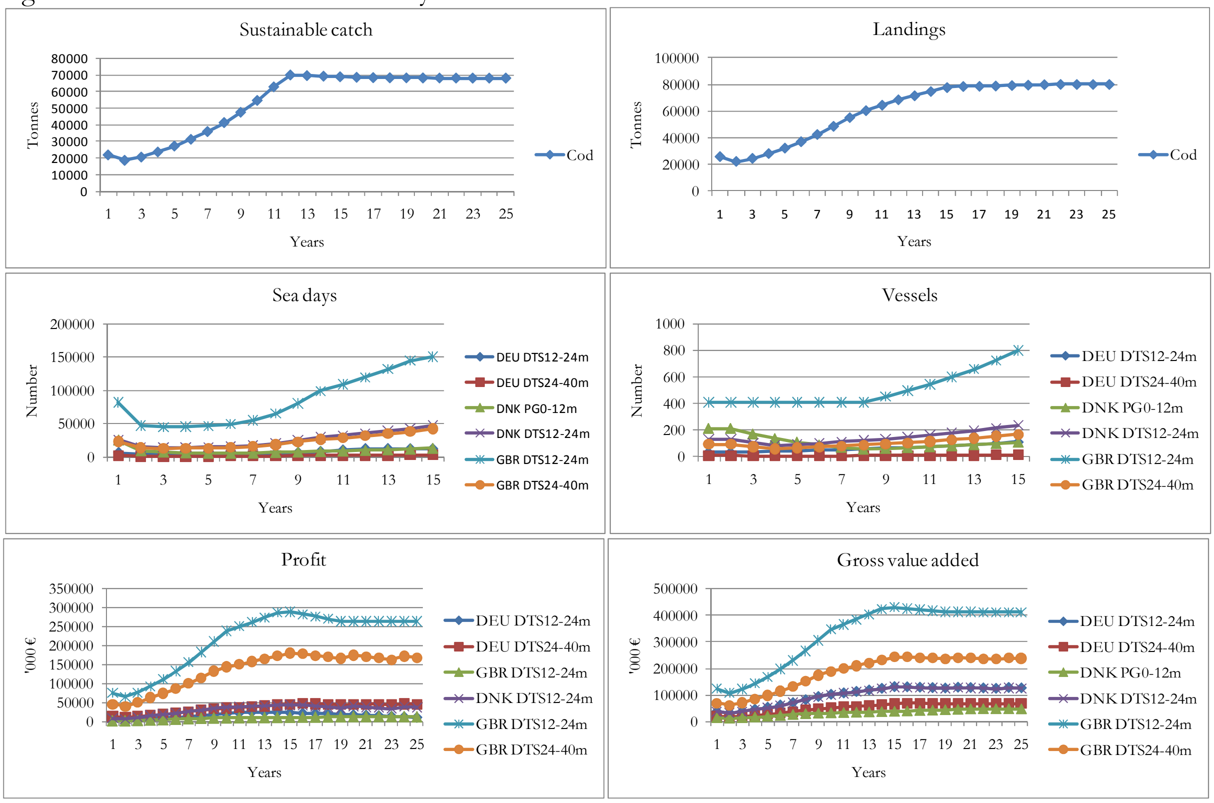
Figure 5.9 Results of scenario 11. Static minimum fleet



Scenario 12. Dynamic minimum fleet

Compared to scenario 11 it is now possible to invest in scenario 12 according to the same rules as in scenario one. The TAC min management is the same as for scenario one. The stock conditions are therefore the same and there are no differences from scenario one. The economic performance is further improved. The number of vessels in year 15 is almost the same as in scenario one. The difference between scenario 12 and 11 is bigger in terms of gross value added and profit over time, but in year 15 the number of vessels in scenario 12 is 1,434 compared to 881 in scenario 11 and around 1,500 in scenario one and the baseline..

Figure 5.10 Results of scenario 12. Dynamic minimum fleet



Scenario 13. Optimum fleet (GVA)

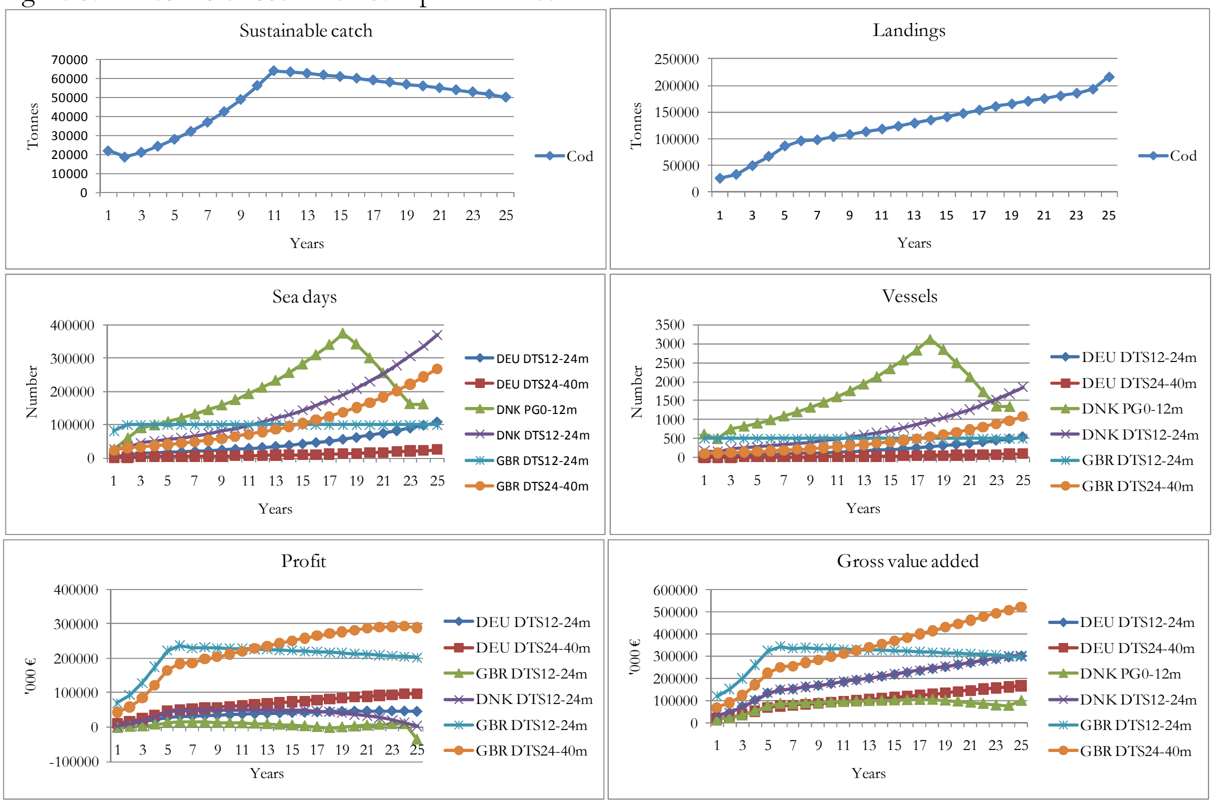
In the scenario for the optimal fleet the objective is to maximize gross value added over 15 years. The applied method is non-linear programming. There are no management restrictions in this version i.e. no TAC or effort limitations apart from the natural physical limitations such as the growth conditions for the stocks and that the number of days per vessels cannot exceed the maximum number of days. This means that the model chooses the number of vessels and hence the catches and the size of the fish stock that maximizes gross value added.

One restriction is kept, however, and that is the investments limits according to which the number of vessels cannot change upwards by more than 10% and downwards by more than 20% per year.

There are several combinations of vessels that will yield maximum resource rent, each equally good, and thus the model chooses one of them.

This scenario yields the highest GVA, number of days at sea, number of vessels and catches and landings.

Figure 5.11 Results of scenario 13. Optimum fleet



Scenario 14. Optimum fleet (profit)

This scenario is carried out under the same assumptions as for scenario 13. The difference is that in scenario 14 profit (revenue – all costs) is maximized contrary to the GVA in scenario 13. Scenario 14 is performing worse than scenario 13, in particular, because the number of vessels in segment PG 0-12m is driven down. In scenario 13 the number of vessels in this segment increases over time, see Figure 5.12 and Table 5.14.

Figure 5.12 Results of scenario 14. Optimum fleet (profit)

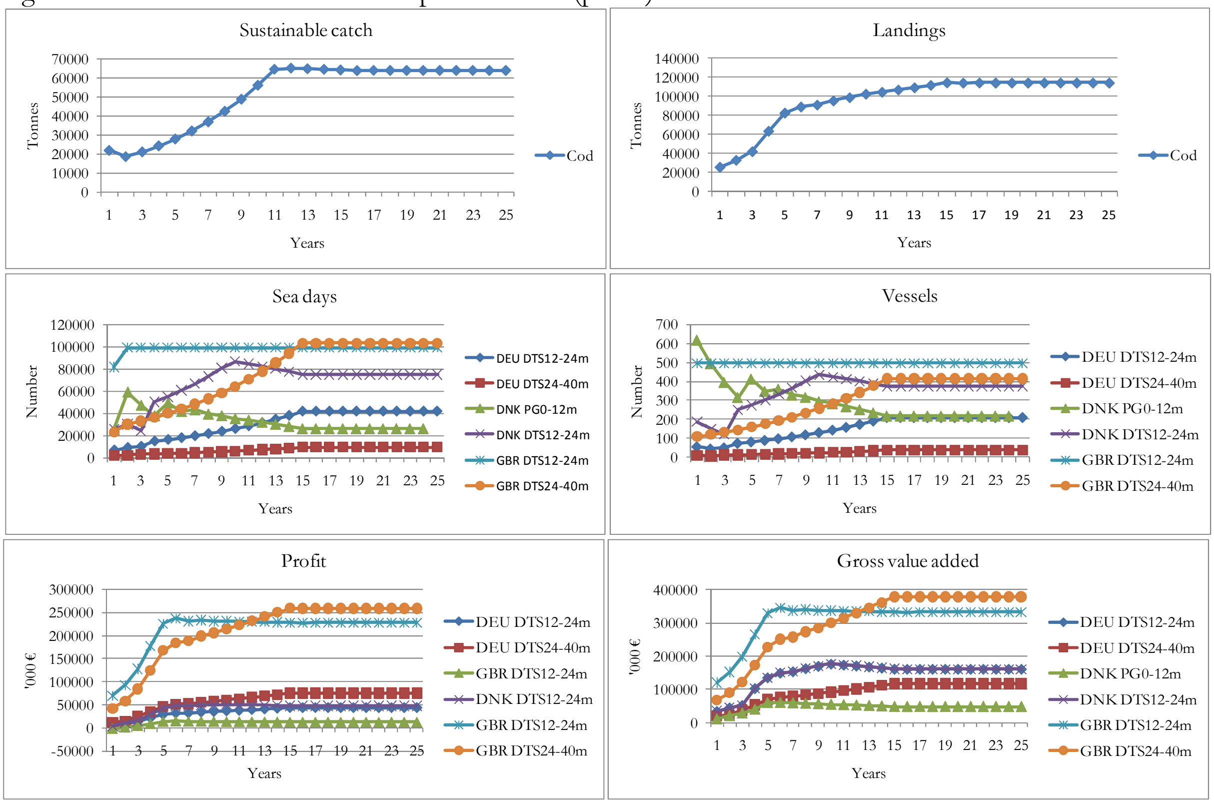
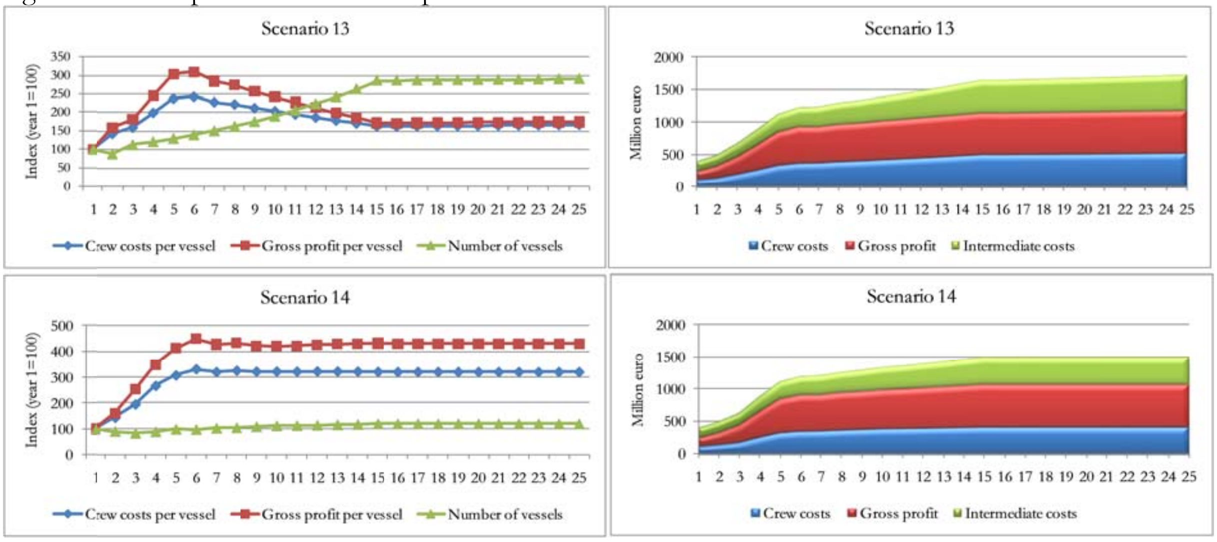


Table 5.14 Comparison of scenarios 13 and 14 (values in mln euro, fleet number of vessels)

	Scenario 13	Scenario 14
NPV GVA$_{15}$	9,950	9,607
NPV profit$_{15}$	5,525	5,599
NPV Crew costs$_{15}$	3,813	3,457
NPV capital costs$_{15}$	612	551
GVA year 15	1,228	1,140
Profit year 15	644	667
Crew costs year 15	493	401
Capital costs year 15	91	72
Fleet – average 1-15	2,552	1,526
Fleet – year 15	4,214	1,750

Figure 5.13 Comparison of the two optimization scenarios



5.7.6. Assumptions and technical background (by main model modules)

There is no deviation from the common approach (model) approved by the team for the study. It is important to emphasize, however, that as the model is very detailed it is also very data demanding with respect to amount and quality of data – a demand which has been difficult to meet. A main reason for the data problems is the terms of reference request for an analysis of a specific "fishery" in this case the cod fishery in the North Sea. In a fishery many species are exploited by many fleets. This characteristic requires a careful delineation of a fishery with respect to catch composition and fleet economics, which is not possible from the current statistics.

As for the Baltic Sea, the way the biological indicators i.e. harvest ratios and the stock-recruitment function are specified requires that adjustments are made before use in the model. A number of problems arise in the estimation of the yield functions (stock-growth) and the application in the model. For the North Sea cod stock ICES presents information not only for the spawning stock biomass (SSB) but also for the total stock biomass (CB) which is 4-6 times the size of the SSB.

The harvest ratio used in the model is defined as the catches in proportion to the catchable biomass (CB) and therefore ICES data for the total biomass is used instead of the SSB. Further the catchable biomass in the model is included in the production function and impacts the catch per unit effort. Therefore the stock-recruitment is estimated on basis of the total stock biomass (CB) rather than the SSB.

The estimated functional form for the North Sea cod stock is a 2nd degree polynomial relation:

$$\text{Recruits} = -111991 + 2.088571*CB - 0.0000017*CB^2$$

Recruit are measured in number of fish ('000) at age 1 and the CB is in weight (tonnes). The parameters to CB are significant at a 5% confidence level, while the constant term is not. The catchable biomass of the function equal to maximum sustainable yield (MSY) is 607,267 tonnes CB. The MSY yield (catches) is estimated at 208,868 tonnes at a weight per recruit at 0.4 kg. The weight per recruit is estimated taking the catches in weight in proportion to the total stock biomass in weight and is lower than ICES estimate at 0.6 kg (ICES 2008).

If the recruitment is made a function of the SSB the estimation produces significant parameters to both variables and the SSB that produces the MSY is 179,000 tonnes which is little higher than the 150,000 tonnes SSB consider the precautionary limit for the SSB (ICES 2008). At the MSY the yield in proportion to the CB is 0.42.

References to chapter 5

ICES. 2008. *Report of the ICES Advisory Committee 2008*. *ICES Advice*, 2008. Book 6, 326 pp.

6. BALTIC SEA COD FISHERIES

Cod in the Baltic Sea and cod in the North Sea are exploited by the same type of vessels and to some extent by the same fleet segments. The characteristics of the fisheries are also to a large extent the same. Therefore it could be argued that these fisheries should be analysed together in the same model, but as these are two distinct cod stocks, which are exploited independently of each other the two fisheries are analysed separately. However, the statistics is produced on fleet segment level irrespective of the fishing areas. Therefore, it has been necessary to divide the fleet segments' landings, costs and earnings between these two areas in an arbitrary way. Because of the similarities there is a great overlap of the text for the Baltic Sea and the North Sea cases.

6.1. Summary and conclusions

Main conclusion

The eight segments analysed in this fishery realized in 2005-7 on average a total net profit of 38 mln euro. Average annual discounted net profit ranges under most scenarios between 55 and 109 mln euro. Elimination of overcapacity and recovery of stocks would produce a discounted net profit of 65-112 mln euro by the year 15. (see Figure 6.1)

Brief description of the case study

The cod stock in the Baltic Sea is divided in an Eastern and a Western stock where the Eastern stock is the largest and probably also the most vulnerable with respect to environmental conditions and impact of fishing. Both stocks have sustained very high harvest ratios over the last 50 years, and the growth has declined significantly, in particular for the Eastern stock, since the 90ies (Bastardie et al. 2010; Lindegren et al. 2009).

Two approaches could be pursued in the analyses of the cod fishery in the Baltic Sea. One is to consider cod an unavoidable by-catch in other fisheries. Cod catches are therefore dependant on these fisheries' species compositions. The other approach is to consider cod the main target species and treat other species as by-catches in the cod fishery i.e. dependant on the cod fishery. It is the latter approach that is pursued here as cod is the most important species economically in the Baltic Sea.

There are two problems with the cod fishery in the Baltic Sea which makes it difficult to analyse. Firstly, presently the spawning stock biomass of the Eastern stock is around 100 000 tonnes which is around 20% of the highest spawning stock biomass recorded in the latter half of the 70ies and the beginning of the 80ies. The Western spawning stock biomass is presently around 30,000 tonnes. If a conventional approach to estimating a stock growth function based on historical data is used this would lead to a rather rapid growth of the stock if the present quotas are low enough to secure the growth could commence. In practice this growth may be obstructed as the cod is competing with other species and apparently a downwards shift in the level and the variability of the growth took place in the 80ies (Bastardie et al. 2010; Lindegren et al. 2009). Secondly, the Eastern and the Western stocks should be analysed separately, which would require a further division of the statistics of the fleet segments. Therefore a modified stock-growth data set is used for the estimation of the stock-growth function in which the very high growth and SSB in the 70ies and 80ies have been disregarded in the estimation. This procedure produces a lower growth but a more robust result. As the SSB of the Western stock is around 25% of the Eastern stock the study is delineated to the Eastern stock.

Divergence / convergence of the results

Comparing the scenarios that have been tested by use of the developed model some divergence between the scenarios is observed but it could be argued that for practical reasons the divergence is not big. It seems to be very important that the management plan is fine-tuned with respect to setting the TAC over time in an optimal way which seems not to be the case for the Baltic Sea cod.

Cod is the target species for the Baltic Sea and although the fishery is a multi-species fishery the other species are not assessed and less important. The two other important species in the Baltic Sea is herring and sprat but these species are not caught together with cod. As data for catch compositions is not published in AER on fishing area level it means for the Danish and German fleet segments that some overestimation of the catches of other species for the Baltic Sea occurs as the catch of species from the North Sea is allocated to Baltic Sea.

The inclusion of other species except cod in the model is important for the results. Three options have been used: a) the value of other species made a function of the landings value of cod, b) the value of other species is fixed per sea day and c) the value of other species is constant. Option a) forms basis for the presented results. The consequence is that landings of other species increase when the cod landings increase and the implicit assumption is that other species are "overexploited" such as cod. In option b) the number of days at sea increases in the long run when the cod stock recovers and the landings of other species increase too. In option c) the change is associated only with cod. The development of the various indicators is similar for option a) and b) although there are differences among the fleet segments. The results for option c) show lower values for catches of other species, effort and profit.

Choice of baseline policy

The cod fishery in the Baltic Sea has been subject to comprehensive management in terms of TACs, gear and landings restrictions. Since 2007 a management plan for cod has been in place in terms of target harvest ratios (Htarget). The harvest ratio has been transformed into TACs that are adjusted each year until the Htarget has been reached. As for the North Sea case if the TAC is lower than 85% of last year's TAC, 85% of last year's TAC will count as the TAC. A similar limit, 15% higher, upwards counts. This policy is chosen as the baseline scenario although it is not necessarily performing best among the options tested here.

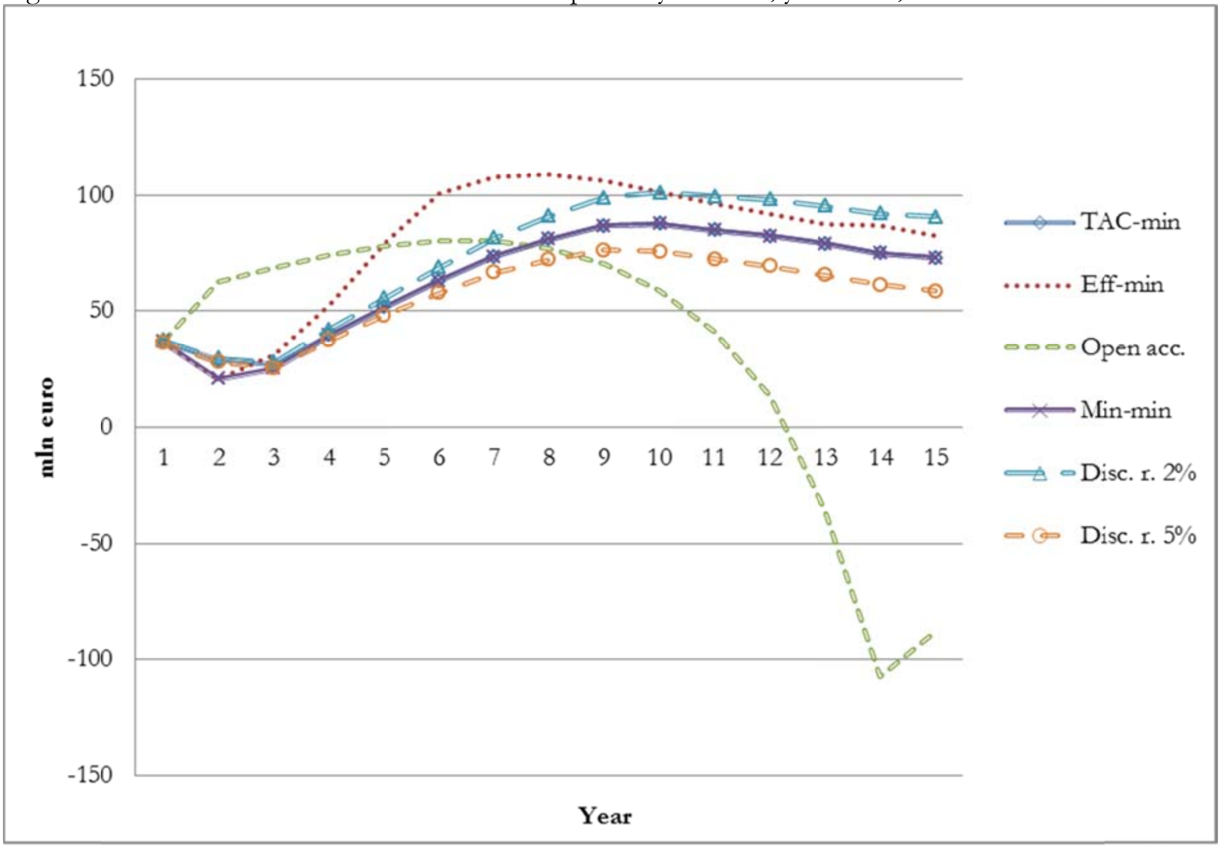
Achieving MSY

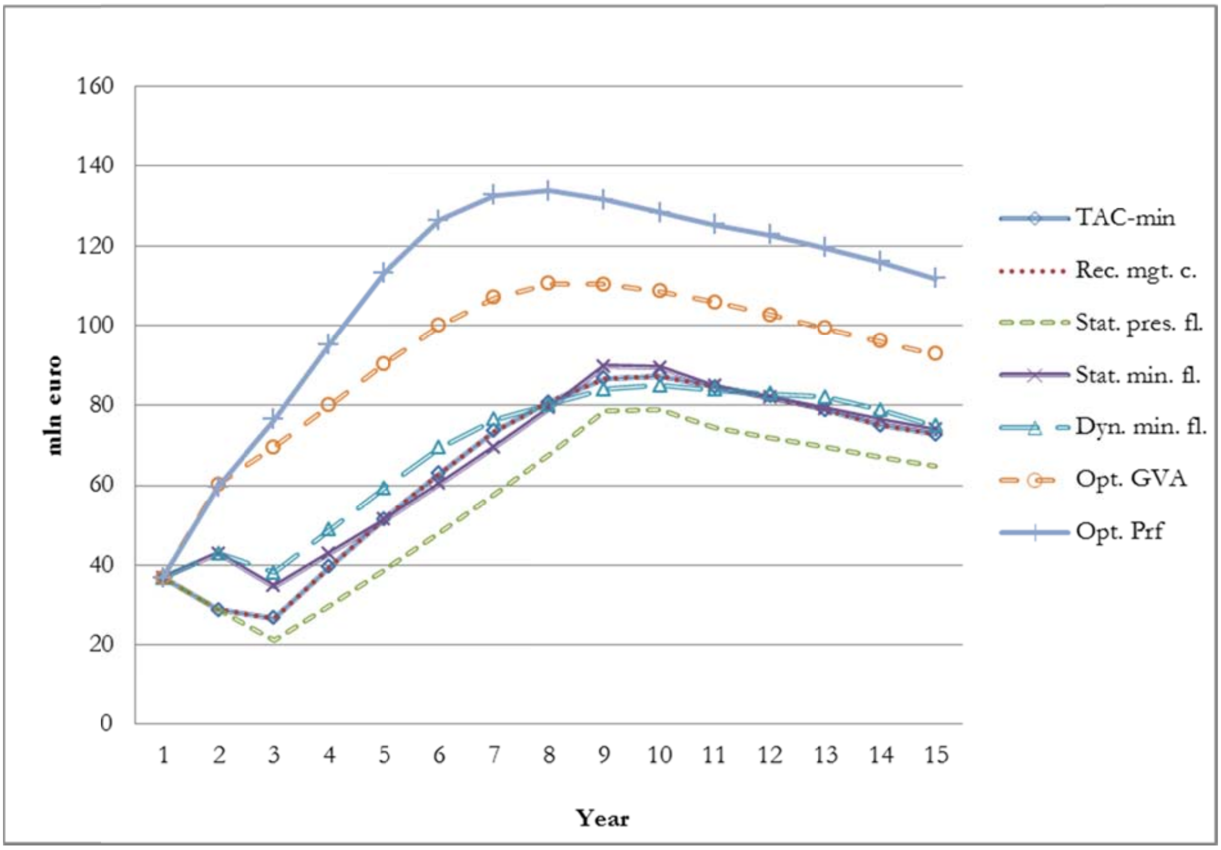
The maximum sustainable yield is derived from the estimated stock growth functions for the Eastern stock disregarding the smaller Western stock. Applying a 2^{nd} degree polynomial relation produces statistically good results and this function could be solved for the optimal stock size with respect to MSY.

Achieving MEY (NPV Profit$_{15}$)

The maximum economic yield is by definition the combination of fish stock abundance, catches and fleet sizes that maximizes the resource rent – defined as the maximum profit. In the Baltic Sea nine countries are exploiting the cod stock although Denmark, Germany, Poland and Germany are the main actors as the stock abundance is higher in the Southern part of the Baltic Sea than in the Northern part. The dominant technology is trawl and gill net. Gill net is used by small vessels many of which are active only part of the year. These types of vessels are chosen for the calculations in the Baltic Sea cod case in order to obtain variability in the fishery. It is assumed that the gill netters are more impacted by stock abundance than the trawlers implying that catches per unit effort increases more for gill netters than for trawlers when the stock abundance increases. A technological progress rate at 1% is used in the model.

Figure 6.1 Baltic Sea cod – discounted annual net profit by scenario, years 1-15, mln euro[33]





[33] As only one species has been used, TAC-max and Eff-max scenarios were not calculated.

Role of discount rate

The choice of discount rate plays a role in particular in the assessment of the recovery of the cod stocks. Using a high discount rate makes recovery less attractive than low discount rates. The reason for this is that the landings will have to decrease for some years to allow the stock to increase. By using a high discount rate less emphasis is placed on future gains compared to present losses. The net present value is dependent of the length of time considered. A short period tends to favour that no changes should be made as short term losses exceed the long term gains. A long period favours changes which can produce stock recovery.

Impact of eliminating overcapacity

Overcapacity reduces the economic performance of the fishery but does not necessarily impact the stock recovery if the fishermen comply with restrictions in terms of TAC/quotas or fishing effort. In the TAC/quota case fishermen are allowed to land an amount of fish equal to the quotas and discard over-quota catches.

In the first year of the model the number of days at sea per vessel is lower than the, physically, possible number per year. In the model no investments in vessels take place if the current number of days per vessel is lower than 70% of the maximum number. In this way some overcapacity is eliminated over the years. It is important to observe, however, that the capacity in terms of number of vessels will increase compared to the initial capacity as the stock size and hence the catches increase.

Management costs and rent recovery

Recovery of management costs and other types of contemporary public costs affect the profit of the fishermen as they consider this type of payment a cost. In principle this impacts the investments. From a socio-economic viewpoint management costs covered by a fee or a tax is often considered a transfer payment and not a cost. Therefore, a fee does not affect the gross value added but is covered by the gross value added alongside remuneration of labour and capital.

6.2. Case study definition

6.2.1. Fleet and landings

The statistics produced by JRC for the annual economic report (AER) that form basis for this description do not allow for a distinction between landings of cod from the Baltic and the North Sea. In the calculations of the resource rent of one particular fish stock it is necessary to allocate landings and costs to fishing fleets, whose catch compositions and exploitations patterns on fishing grounds are very diverse.

The Baltic Sea cod is divided into the Eastern and the Western stock separated by the island Bornholm. These stocks are exploited by all the countries around the Baltic Sea. The total landings 2005-7 were on average 65,000 tonnes. Denmark, Sweden, Germany and Poland account for more than 80% of the landings as the cod abundance is higher in the Southern part of the Baltic Sea than in the Northern part. Finland, Estonia, Latvia, Lithuania and Russia account for less than 20% of the total cod landings (ICES. 2008).

The most important fleet segments are trawlers 12-24m and 24-40m as well as gill netters 0-12m and 12-24m. Two fleet segments for each of the countries Denmark, Sweden, Germany and Poland are selected for the calculations carried out in this case, but it is not possible to distinguish landings by Danish and German vessels of cod from the Baltic Sea and the North Sea, the Skagerrak and the Kattegat. For Germany the statistics provided by JRC includes a disaggregation of days at sea on the Baltic and the North Sea. The cod landings of the two German segments are divided in the same proportion. For Denmark no disaggregation of days at sea is available. However, national Danish statistics from the Directorate of Fisheries include landings by fleet segments, species and fishing grounds. The statistics show that 51% of the total catch value of gill netters 0-12m and 27% of trawlers 12-24m originates from the Baltic Sea. Therefore, the number of days at sea and vessels for these segments is divided in the same way. For Poland and Sweden it is assumed that all landings and hence all fishing effort are placed in the Baltic Sea. For at least Sweden it is an overestimation as some of the Swedish landings originate from the Kattegat and the Skagerrak.

Table 6.1 shows the total number of vessels registered for fishery and the estimated number fishing in the Baltic Sea according to the assumptions mentioned above. Not all vessels are active. As an example only on third of the registered Danish vessels are active with an annual turnover above 30,000 euro. However, all vessels are included in the calculations, which entails that the number of days at sea per vessel for some segments is very low.

Table 6.1 Role of case study fisheries within national fishery sectors. Baltic Sea cod

Member State	Total fishery sector		Case study fleets	
	Total revenues (mln euro)	Total fleet (number of vessels)	Revenues (mln euro)	Fleet (number of vessels)
Germany (DEU)	156	2,134	41	38
Denmark (DNK)	384	3,120	20	713
Poland (POL)	41	965	16	733
Sweden (SWE)	108	1,565	43	1,050

The annual total allowable catch (TAC) for cod for the North Sea, the Skagerrak, the Kattegat, and the Baltic Sea was 90,000 tonnes in 2005-7. The TAC for the Baltic Sea was 66,000 tonnes, see Table 6.2. The total landings of the selected fleet segments constituted around two-third of the TAC in all waters. The Swedish gill netters are most extensively dependant on cod with a cod share of the total landing volume at almost 50%.

Table 6.2 Role of target species. Estimated for the Baltic Sea, average 2005-7

MS	Gear	Size	No. vessels	GT (1000)	Landings (1000 t)		Value (mln euro)	
					Cod	Total	Cod	Total
DEU	DTS	12-24	22	1.6	1.4	5.6	2.3	5.5
DEU	DTS	24-40	16	9.9	5.6	36.0	11.7	35.5
DNK	PGP	0-12	643	2.3	3.6	7.8	7.6	16.7
DNK	DTS	12-24	70	2.4	2.5	17.9	4.8	15.8
POL	PGP	0-12	630	2.7	3.4	12.6	4.3	10.4
POL	DTS	12-24	103	4.5	3.1	7.5	3.8	5.9
SWE	PGP	0-12	894	4.0	3.3	6.3	5.4	14.2
SWE	DTS	12-24	156	9.5	5.2	22.3	8.6	29.2
Other					39.4		39.4	
Total 1)					66.0		66.0	

1) TAC for the Baltic Sea
Source: AER and the Danish Fisheries Directorate

6.2.2. Composition of landings

The Baltic Sea is the most important in terms of cod catches with 60,000 tonnes in 2007 compared to 18,000 tonnes from the North Sea. The fleet segments with the highest share of cod are the small vessels mainly fishing in the Baltic Sea. Table 6.3 shows the landings of seven species including cod for the selected segments in all fishing areas, not only the Baltic Sea. The group "Other" constitutes a relatively large share of the total landings and shows that a variety of other species constitutes important shares of the fleet segments' landings.

Table 6.3 Composition of landings by segment, all areas, average 2005-7 (1000 tonnes)

MS	Gear	Length (m)	Cod	Haddock	Saithe	Plaice	N. lobster	Sprat	Herring	Other	Total
DEU	DTS	12-24	4.8			1.5	0.2			12.9	19.4
DEU	DTS	24-40	9.2	1.8	15.1					32.9	59.0

DNK	PGP	0-12	7.1			1.7				6.6	15.4
DNK	DTS	12-24	9.3			5.5	1.6			50.0	66.4
POL	PGP	0-12	3.4						2.7	6.6	12.6
POL	DTS	12-24	3.1						1.3	3.2	7.5
SWE	PGP	0-12	3.3				0.2			2.8	6.3
SWE	DTS	12-24	5.2				0.8	7.9		8.5	22.3

The landings in value show that Norway lobster plays an important role for many trawler fleet segments, see Table 6.4. However, Norway lobster is found only in the waters outside the Baltic Sea, while saithe is important for the large German trawlers. Saithe are not caught in the Baltic Sea. For the Baltic Sea sprat and herring is to some importance, generally, but for some segments these species are hidden in the "Other" group.

Table 6.4 Composition of landings by segment, average 2005-7 (mln euro)

MS	Gear	Length (m)	Cod	Haddock	Saithe	Plaice	N. lobster	Sprat	Herring	Other	Total
DEU	DTS	12-24	7.8			2.7	1.4			7.2	19.1
DEU	DTS	24-40	19.2	2.8	11.6					24.5	58.1
DNK	PGP	0-12	14.9			3.3				14.6	32.8
DNK	DTS	12-24	17.6			10.3	14.1			16.6	58.6
POL	PGP	0-12	4.3						0.7	5.4	10.4
POL	DTS	12-24	3.8						0.3	1.8	5.9
SWE	PGP	0-12	5.4				1.9			6.9	14.2
SWE	DTS	12-24	8.6				7.7	1.3		11.6	29.2

6.3. Historical indicators

In recent years the spawning stock biomasses of both the Eastern and the Western Baltic cod have been low and hence the catches and landings. The development in catches over the last 50 years shows large variations.

From the Eastern Baltic stock the average catches 1966-2007 were 165,000 tonnes with a level above 200,000 tonnes per year in 1979-1988. Catches peaked in the period 1980-1985 with more than 300,000 tonnes per year. Since 1992 the landings have stayed below 100,000 tonnes with a decreasing trend and are now close to 50,000 tonnes yearly. The estimated discard in proportion to the catches is 4% on average for 1966-2007 for the Baltic Sea (ICES 2008).

The spawning stock biomass, constituting fish at ~three years of age and older, is 50%-100% higher than the catches with the largest difference when the catches are highest. The average fishing mortality rate for the age groups 4-7 was on average 0.9, which implies that around 60% of the fish of these age groups are caught each year. The highest estimated fishing mortality rate is 1.4 implying that around 80% of the fish of the age groups 4-7 was caught

The Western Baltic Sea cod stock is smaller than the Eastern stock and is generic different from the Eastern Baltic stock although some interaction between the stocks occur. On average 1970-2007 the landings were 36,000 tonnes per year. The development in landings could be described for three periods: In 1970-1985 landing were around 45,000 tonnes per year, in 1986-1993 they were around 22,000 tonnes and from 1994-2007 they were around 32,000 with a decreasing trend towards around 25,000 tonnes.

For the Western stock the spawning stock biomass, constituting fish at ~three years of age and older, is about the same size as the annual landings. The cod is above the minimum size when it is 2-3 years old. The Western cod is subject to a very high fishing mortality rate at 1.1 on average (approximately 66% is removed) for the age groups 3-6.

6.4. Fleet efficiency

Looking at the profit (gross revenue minus all costs) the Danish segments perform worse than the Swedish, the German and the Polish segments. Whether this is caused by different method of estimating the fixed costs, in particular, or it reflects real differences is difficult to say. The Danish data are considered reliable being collated on a regular basis since 1995, and there is no reason to expect that the Danish segments are performing significantly worse than the other fleet segments.

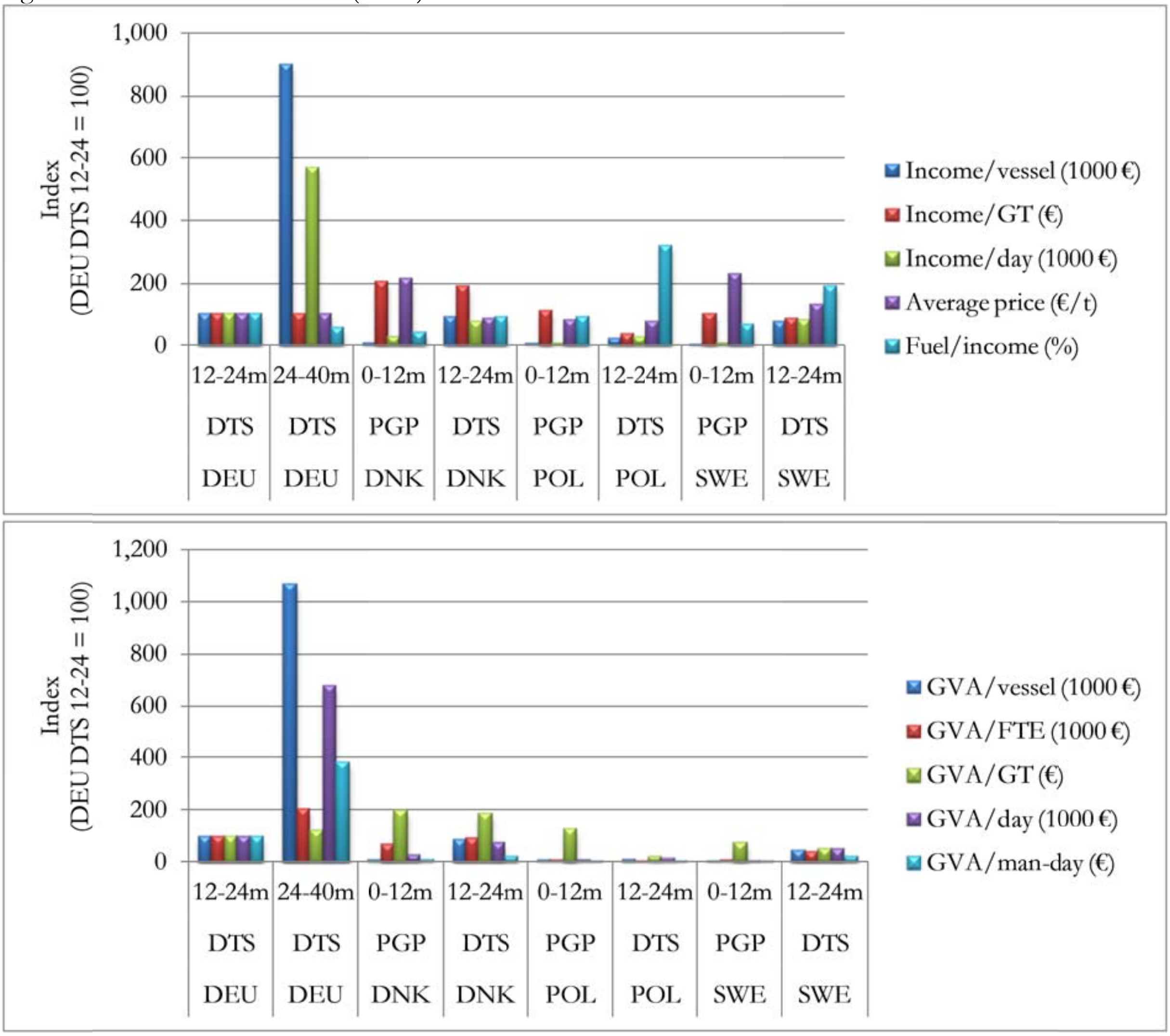
The total landings in volume and value of the selected segments and the share of cod of the total landings combined with the economic indicators are presented in Table 6.5 which, in general, shows a very diverse picture.

Table 6.5 Economic indicators on fleet segment level. Average 2005-7

MS	Gear	Length (m)	Gross value added (mln €)	Profit (mln €)	Employ-ment (FTE or persons)	Average price (€/t)	Fuel costs of landings value	Profit/ tonne landings	CPUE total (t/day)	CPUE target species (t/day)
DEU	DTS	12-24	11.7	2.5	160	990	0.12	129	2.145	0.532
DEU	DTS	24-40	42.1	24.7	282	990	0.07	419	12.250	1.899
DNK	PGP	0-12	19.5	-5.5	387	2,130	0.05	-357	0.293	0.136
DNK	DTS	12-24	35.0	-1.6	519	880	0.11	-24	1.874	0.262
POL	PGP	0-12	7.5	4.6	1,300	820	0.11	364	0.210	0.056
POL	DTS	12-24	2.0	0.1	401	790	0.38	13	0.724	0.295
SWE	PGP	0-12	6.4	4.1	1,099	2,260	0.08	655	0.095	0.050
SWE	DTS	12-24	11.0	5.2	351	1,310	0.23	233	1.330	0.310

Economic indicators are shown in Figure 6.2. It is noticed that for the German trawlers (DEU DTS 24-40m) the indicators are different in structure from the other fleet segments. These vessels are much larger than other vessels in the Baltic Sea. The German segment includes deep-sea trawlers which do not fish in the Baltic Sea but it is not possible to distinguish these vessels in the statistics. The segment is included in the analysis to achieve a fleet structure that shows a large difference.

Figure 6.2 Economic indicators (index)



6.5. Management measures

6.5.1. *General description*

Cod is the most important species in the Baltic Sea measured in value and it has shown large fluctuations in stock abundance over time although subjected to quotas management since the mid 70ies. Further technical measures such as minimum mesh size and minimum size of fish that it is allowed to land have been used even longer.

6.5.2. *Output management*

Catch restrictions

TAC and quota management for both the Eastern and the Western stocks have been used even before the agreement of the CFP in 1983. The TAC/quota management was the responsibility of the Baltic Sea Fisheries Commission (BSFC) until the new Baltic member states joined the European Union from May 2004. Since then the responsibility was transferred from BSFC to a bilateral agreement between the EU and Russia (Kaliningrad). The TAC/quota management system has later been supplemented by a recovery plan for cod in 2007.

For the Baltic Sea target fishing mortality rates (0.6 for age groups 3-6 for the Western stock and 0.3 for age groups 4-7 for the Eastern stock) are set and a 10% reduction from the current level is applied each year in pursuit of the target F. However, if the derived TAC is 15% lower or 15% higher than previous years TAC then this limit shall apply. Fishing area and period restrictions apply as well to the Baltic Sea cod fishery.

Output property rights [34]

For cod Denmark has since 1993 applied a system with non-transferable individual quotas. From 2007 the system was transformed into a system with individual transferable quotas. The other member states have applied quota management supplemented with technical restrictions as regard fishing gear and fishing areas.

6.5.3. Input management

Effort restrictions

No restrictions in number of days at sea have been used until 2009.

Input property rights

The Baltic Sea fleets have been subject to the fleet limitation programmes, set by the EU, in term of capacity ceilings. These ceiling have increased the value of the vessels in the fleet.

6.6. Management costs

The impact of an accession fee has been tested on the profit of the fleet segments and the consequences for the investments i.e. lower profit would lead to lower investments and hence lower fishing mortality. From fishermen point of view an accession fee is considered a cost, but from society it is considered part of the resource rent and should be subtracted to estimate the "real" resource rent.

Only incomplete information about financial transfers from the Government to the fisheries sector is available. One source is the OECD as shown in Table 6.6, while other sources are the allocation from the European Fisheries Fund (EEF), see Table 6.7, and estimated made by MRAG, see Table 6.8.

The financial transfers are made on a national basis and the transfers have been allocated to the fleet segments according to their landings value in proportion to the total landings value.

The costs estimated by MRAG for management and control (Table 6.8) are used in the model to test the impact of cost recovery for these management items.

6.6.1. Summary of OECD data

The OECD data has been distributed among fleet segments according to the value of landings in the segment in proportion to the total number of vessels. The level of detail of the OECD data varies significantly between member states.

[34] Info on property rights should be drawn from the MRAG – RBM study

Table 6.6 Management costs according to OECD, average 2004-2006* , (mln euro): Baltic Sea cod

	DEU 12-24 DTS	DEU 24-40 DTS	DNK 0-12 PG	DNK 12-24 DTS	POL 0-12 PG	POL 12-24 DTS	SWE 0-12 PG	SWE 12-24 DTS	Total
Direct Payments	0.1	0.9	0.6	0.5	na	na	0.3	0.5	
- Decommissioning			0.5	0.5	na	na			
- Fleet renewal and modernization			0.1	0.1	na	na			
- Other			0.0	0.0	na	na	0.4	0.7	
General Services			2.0	1.9	na	na	3.5	6.6	
- Management and enforcement			1.2	1.1	na	na			
- Research			0.3	0.3	na	na			
- Other			0.6	0.5	na	na			
Total	0.1	0.7	2.6	2.5	na	na	4.2	7.9	

*sum of national and EU contributions regarding marine capture fisheries.

6.6.2. *Support to fishing sector (EFF)*

The data from the European Fisheries Fund (EFF) have been distributed on fleet segments in the same way as above.

Table 6.7 Average annual support to the marine fisheries from EFF, (mln euro). Baltic Sea cod

	DEU 12-24 DTS	DEU 24-40 DTS	DNK 0-12 PG	DNK 12-24 DTS	POL 0-12 PG	POL 12-24 DTS	SWE 0-12 PG	SWE 12-24 DTS	Total
EFF - Axis 1	0.1	0.4	0.3	0.0	8.1	4.7	0.5	0.9	14.9

6.6.3. *Costs of research and management*

Table 6.8 shows the estimated management and research costs from the MRAG-RBM study and the DCF up-grade by 30% distributed on fleet segments in the same way as above. The MRAG data have been used in the model in the costs recovery scenario.

Table 6.8 Estimated management and research costs, (mln euro). Baltic Sea cod

	DEU 12-24 DTS	DEU 24-40 DTS	DNK 0-12 PG	DNK 12-24 DTS	POL 0-12 PG	POL 12-24 DTS	SWE 0-12 PG	SWE 12-24 DTS	Total
Management, control, enforcement	1.0	6.7	1.6	0.1	0.3	0.2	2.4	4.5	16.8
Research (DCF+30%)	0.3	1.7	0.4	0.0	0.3	0.2	0.9	1.8	5.6

Sources: MRAG (2008) and Com. Decision 811/2009

6.7. Estimation of the resource rent

6.7.1. *Comparison of scenarios*

The analyses are designed in such a way that the species of the fleet segment's catch compositions are caught in a mixed fishery. One scenario covers the case where the fishery stops as soon as the quota of the most restrictive species is taken (TAC min scenario) while another scenario considers the case where the fishery stops when the quota of the least restrictive quota is taken (TAC max scenario). Further the model evaluates in a similar manner two scenarios where the fishery stops when the most restrictive number of days at sea (Effort min scenario) or the least restrictive days at sea (Effort max scenario) are reached. In the effort scenarios the days at sea are estimated from the Htarget in proportion to the current H multiplied to the effort the year before starting with the baseline effort, while in the TAC scenarios the TACs are estimated from the Htarget/H proportion applied to the stock in the baseline (start year).

Further an Open access scenario has been tested in which there are no restrictions apart from the physical number of days at sea and the speed and magnitude of the invest- and disinvestments.. The latter is limited such that investments in new capacity can at most constitute 10% of the capacity in the year before, while disinvestments can at most constitute 20% of the previous year's capacity. Finally, a Min min scenario, in which the model currently chooses the most restrictive effort from either TAC or effort management, has been tested.

These six scenarios are used to test implications of different types of TAC and effort policies. Further, the impact of the magnitude of the discount rate is investigated in scenario 1 (TAC min), which is considered to be the baseline policy scenario. A discount rate of 2% is compared to the default of 3.5% in scenario 7 and a discount rate of 5% in scenario 8. In scenario 9 the impact of cost recovery of the management and control costs is estimated.

Finally, based on the policy option of TAC management scenarios 10-12 have been estimated where the present number of vessels have been kept constant for the whole simulation period (scenario 10), the minimum present number of vessels required if all vessels are using their maximum number of days at sea per year is kept constant (scenario 11), and eventually (scenario 12) the minimum number of vessels in scenario 11 is allowed to change by use of the investment function which is disregarded in scenario 10 and 11.

The analyses are closed by scenario 13 which is a dynamic optimization (non-linear programming) where optimal effort and cod stock are determined by maximising the gross value added (GVA) over 15 years. In scenario 14 the profit is maximized. By this procedure an estimate of the maximum resource rent is obtained i.e. an estimate of the MEY.

The model can work with several species/stocks subject to quota restrictions. A meaningful inclusion requires that future quotas are known or could be estimated based on stock assessment. Further, some importance of each single species in the catch composition is also required to be used as a meaningful restriction (see table 6.3). This is necessary to avoid that the species which in practice are disregarded by the fishermen and the managers play a role in the analysis. None of these assumptions are fulfilled, and there is a risk that "strange" results may occur if species/stocks for which the conditions are not fulfilled are included in the model and admitted to control the fishery. Therefore, only one target (quota) species, cod, is included in the model, and catch of other species is a function of the cod fishery. Including only one quota species entails that the TAC min and the TAC max as well as the Effort min and Effort max scenarios are the same. Therefore scenario 3 and 4 are left blank in Table 6.9.

In order to match the cod landings of the selected fleet segments with the total quota it is necessary to allocate shares of the total quota to the fleet segments and use a scaling procedure to secure that cod landings of other segments are taken into account. The landings of cod of other segments are a fixed share of the landing of the selected fleet segments.

The start values for days at sea per vessel per year are lower for all segments that the assumed maximum number, in particular, for gill netters for which many inactive vessels is included in the statistics. The maximum number of days per vessel per year is, arbitrarily as no precise information is available, set at 120 days for gill netters 0-12m, 200 days for trawler 12-24m and for trawlers 24-40m as the latter is expected to be similar to the 12-24m.

The shape of the stock growth function is extremely important for the results. For the Baltic Sea the SSB is used in the model as no information for the total stock is available. The SSB is estimated to be able to grow to 2-3 times the size of the present SSB. In the TAC scenarios the effort is determined by the cod TAC. Therefore, there is no discard of over-sized fish. The discard of undersized fish is 10% which is high compared to the estimates made by ICES suggesting 3-4% in weight (ICES 2008). In the effort and open access scenarios it is assumed that all over-quota fish is permitted to be landed.

Table 6.9 shows that the effort and capacity could be reduced in almost all scenarios if the cod stock is recovered. Landings (catch) of cod will increase 1.5-2 times compared to the baseline, which could be caught without an increase in effort. Note that the catches shown in Table 6.9 are the catches taken by the selected fleet segments, which is about 42% of the quota. The low share of the selected segments is caused by the problems with the distribution of the catches on the Baltic and the North Sea.

Table 6.9 Comparison of the scenarios (mln euro)

Scenario no.	Effort (1000 DAS)	Fleet (no. vessels)	Catch of cod (1000 t)	Profit year 15 discounted	NPV Profit$_{15}$
	Average values 2005-7				
2005-7	194	2,533	28.0	38[1)]	
	Values in year 15 of the scenario				
1. TAC min	86	1,828	47.5	73	969
2. Effort min	186	2,246	55.9	83	1,190
3. TAC max	-	-	-	-	-
4. Effort max	-	-	-	-	-
5. Open access	663	5,000	0	-88	510
6. Min min	86	1,828	47.5	73	969
7. Discount rate 2%	86	1,828	47.5	91	1,109
8. Discount rate 5%	86	1,828	47.5	59	850
9. Recovery mgt. costs	86	1,828	47.5	43	774
10. Static present fleet	86	2,533	47.5	65	834
11. Static minimum fleet	86	1,474	47.5	74	1,007
12. Dynamic minimum fleet	86	1,360	47.5	75	1,039
13. Optimum fleet (GVA)	300	2,304	66.0	93	1,370
14. Optimum fleet (profit)	407	3,041	76.1	112	1,630

1) year 1

The effort scenarios are performing better than the TAC scenarios. The open access (scenario 5) is apparently performing very well. But the fishery collapses after year 15 indicated by the negative profit in year 15. Finally, the Min min is controlled both by TACs and effort restrictions. This scenario 6 is the same as scenario 1 because the TAC restrictions are binding.

6.7.2.Policy options

Summary

Table 6.10 shows specific indicators for specific policy options which is TAC management, effort management, open access (no TAC of effort management), and both TAC and effort management.

Effort management performs better than TAC management comparing the net present value of the profit over 15 years (NPV profit$_{15}$), but this is partly because the TAC management is not fine-tuned in terms of the harvest ratio with respect to rate of increase in the fishery from present to year 12 where the stock is built up to a long term sustainable level. The built up rate of the stock is determined by the interaction of the stock growth, the investment behaviour and the management restrictions.

The harvest ratio is defined as the proportion between the catches and the catchable stock and cannot be compared directly with the "biological" harvest ratios that are determined for age groups 2-4. The present harvest ratio is 0.68 e.g. 68% is taken of the catchable biomass approximated by the spawning stock biomass in the model for the Baltic Sea. This rate is halved under the TAC and effort management programmes. The Open access scenario shows a rate at 1, this entails that the whole biomass is fished down.

It is important to emphasize that the results are strongly dependant on the assumption made for other species, which is that these are basically "overfished" as cod is. Therefore when cod landings increase other species increase too and this assumption probably overestimates the magnitude of profit and effort.

If the calculations are performed based on the assumption that the landing value of other species than cod is constant the effort and the capacity will built up alongside the recovery of the cod stock. However, after year 10-15 year the profit of the fleet segments goes significantly down because the fleet is built up too much. This will not lead to disinvestments because the profit is still positive. Instead it will lead to capital stuffing. It happens because the fishery is managed via the harvest ratio which is transformed either into a TAC or an effort in terms of days at sea. Capital stuffing can be avoided either by direct control of effort or the number of vessels or by an ITQ-scheme.

Table 6.10 Effects of different policies on profit, harvest ratio, catches, effort and fleet

Indicator	2005-7	Scenarios**					
		1. TAC min	2. Effort min	3. TAC max	4. Effort max	5. Open access	6. Min min
NPV $Profit_{15}$		969	1,190	-	-	510	969
Profit year 15 discounted	38[1)]	73	83	-	-	-88	73
Harvest ratio (year 15)*							
Cod	0.68	0.24	0.30	-	-	1	0.24
Catch in (1000 t, for scenarios year 15)							
Cod	28.0	47.5	55.9			0	47.5
Effort (1000 DAS, for scenarios year 15)							
Cod	194	86	186	-	-	663	86
Fleet (no vessels, for scenarios year 15)							
Cod	2,533	1,828	2,246	-	-	5,000	1,828

1) year 1

Further, it is assumed that the cod stock is able to increase if the present harvest ratio is reduced. It is difficult to judge whether this assumption is reasonable and to what extent the large pelagic stocks in the Baltic sea hinders recovery.

In the following figures 6.3 – 6.12 including six sub-figures the development of some indicators is shown. The sustainable catch shows the catch according to the management rules be it TAC or effort. Landings net of discard are shown in the next one. Effort and capacity are shown in terms of total days at sea for the segments and the number of vessels. The two lower panels show the profit (gross revenue minus all costs) and the gross value added (remuneration of labour, capital and fish stocks).

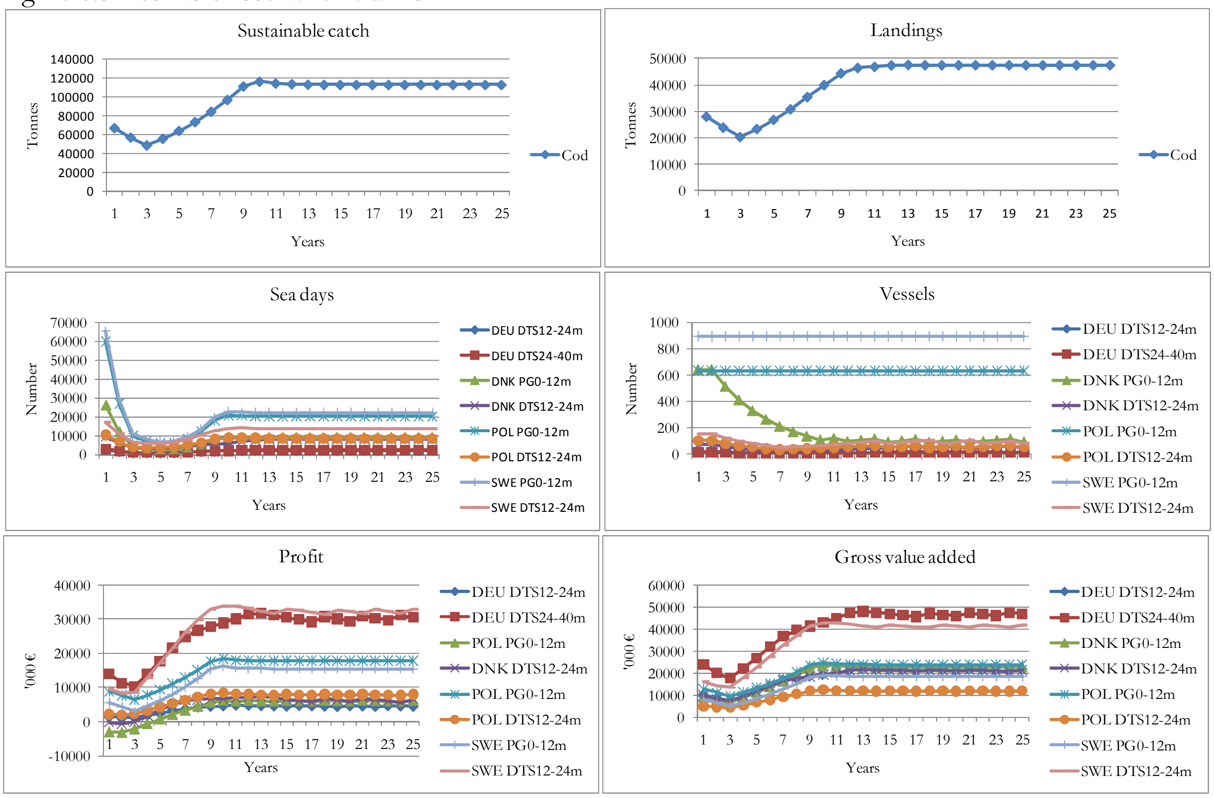
Scenario 1. TAC min

The fishery conducted by the eight fleet segments is driven by the TAC for cod. For each segment the landing value of all other species is estimated in proportion to the value of cod. It implies that the value of other species varies proportional to cod. The species compositions of the fleet segments are very different, but as cod constitutes the most important species it is assumed that the cod drives the fishery. There are no stock assessments for almost all the species except cod in the segments' catch composition in the Baltic Sea.

The fishery is carried out by small or medium sized trawler and small gill netter. For the latter group information is uncertain as a large part of the registered vessels are inactive in practice.

The model calculations show that when the fishery is managed by TACs in pursue of the target H at 0.3 applicable for the Eastern stock the landing will fall in year two and three (year 1 is the base) and then increase gradually to the MSY level. The number of days at sea will fall until year six and then increase. The number of vessels will decrease throughout the period compared to the current situation except for the gill netters from Poland and Sweden. There is no discard of over-quota catches in scenario 1.

Figure 6.3 Results of scenario 1. TAC min

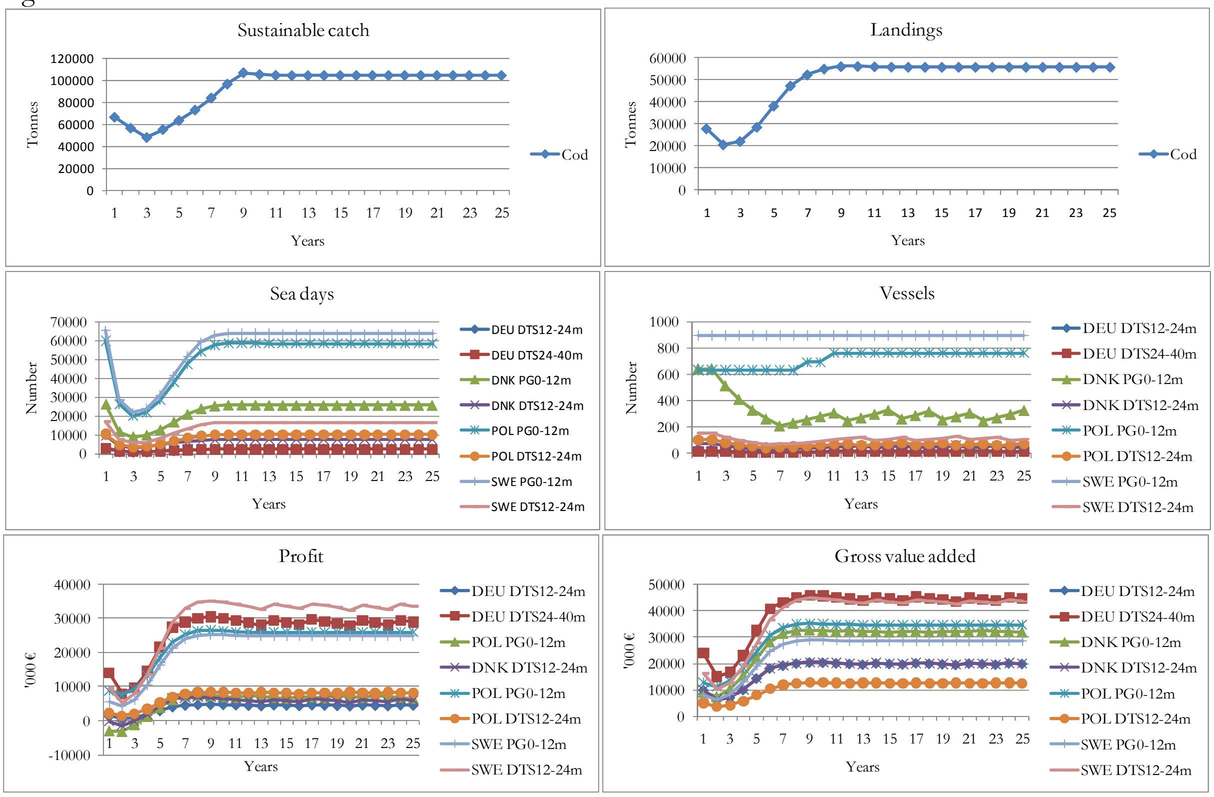


Scenario 2. Effort min

The effort is chosen by adjusting the number of days at sea in the baseline with the proportion between Htarget and the current H calculated each year. This development is restricted by the borders of the investment in vessels (10% up and 20% down as maximum each year). If the potential effort is less than the target effort then catches are based on the potential effort, leading to a lower harvest ratio than 'proposed'. In the effort managed fisheries there is no discard of over-quota catches as there are no quotas. In the effort managed fisheries there is no discard of over-quota catches as there are no quotas.

Given these assumptions scenario 2 performs better than scenario 1. The net present value of the profit is higher in scenario 2 and so is the number of days at sea and the number of vessels. The reason for this result is that in scenario 1 the fleet is built down to a too low level and the stock to a too high level. Therefore potential landings are lost in scenario 1 compared to scenario 2.

Figure 6.4 Results of scenario 2. Effort min



Scenario 3. TAC max

As only one species, namely cod, determines the effort, TAC max is the same as TAC min. If other species than cod are chosen as "drivers" e.g. by assuming that the catch of other species determines the catch of cod the tendency is that the cod will by overexploited and in certain cases driven to extinction.

Scenario 4. Effort max

As for scenario 3.

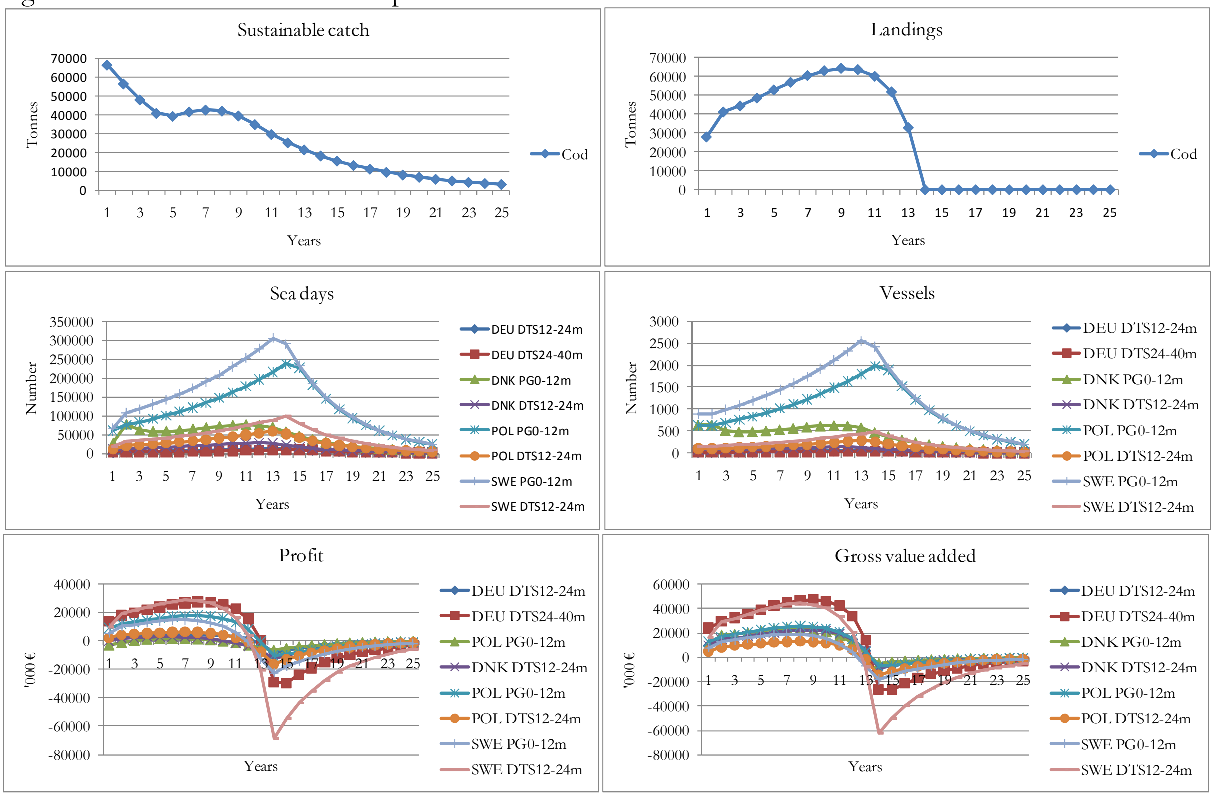
Scenario 5. Open access

In the Open access scenario the catches are restricted by TAC/quota or days at sea limitations. It is, however, important to notice that the same upper and lower ceilings regarding investment in number of vessels applies as in scenario 1 and 2 to reflect that adjustments cannot be made instantly.

Because the fleet segments are profitable in the baseline investments takes place, which entails that the landings increases but the stock biomass and the sustainable catch go down. There is no discard of oversized fish in this case because of the open access is by nature not limited by quotas.

The result is that over a number of years the cod stock will be reduced to zero, as the fleet will not adjusted quickly enough when the profit goes down and becomes negative. It should be observed that over a 15 year period the fishery is performing just as well as the other scenarios under the given circumstances. It is not until after 15 years that the fishery breaks down.

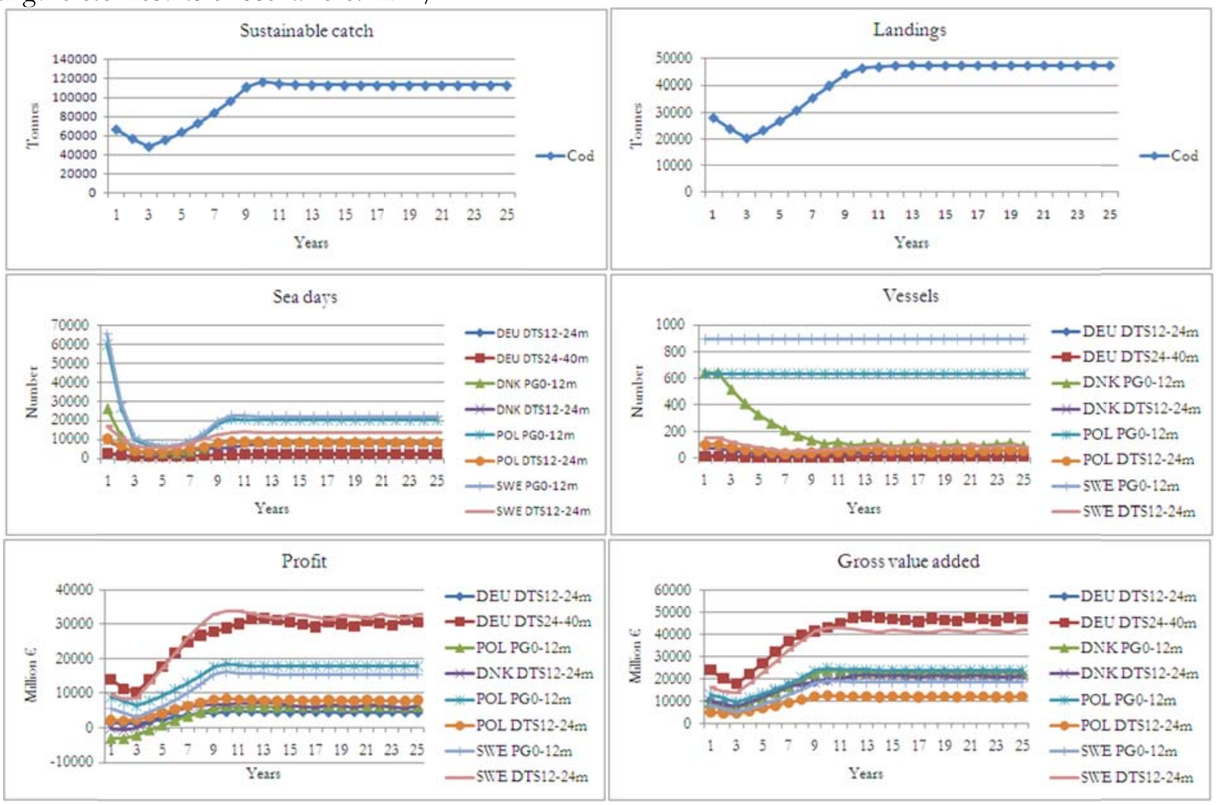
Figure 6.5 Results of scenario 5. Open access



Scenario 6. Min min

In this scenario the model chooses each year the lowest number of days at sea either because of quota or because of effort limitation. In all years the TAC/quotas determines this limit and therefore the scenario is similar to TAC min.

Figure 6.6 Results of scenario 6. Min / min



6.7.3. Role of discount rate (scenarios 7-8)

Scenario 1 is chosen as the main scenario and the discount rate is 3.5%. If the discount rate is reduced to 2% (scenario 7) the net present value increases with 14%. In year 15 the profit is 25% higher. If the discount rate is increased to 5% the net present value is 12% lower, and the gross value added is 19% lower. These scenarios indicate that the results are rather sensitive to the choice of discount rates as shown in Table 6.11.

Table 6.11 Effect of discount rate on profit (mln euro)

Indicator	Baseline	Scenario		
		Main scenario Discount rate 3.5%	7. Discount rate 2%	8. Discount rate 5%
NPV Profit$_{15}$		969	1,109	850
Nominal Profit$_{15}$*	38	122	122	122
Discounted Profit$_{15}$*		73	91	59

6.7.4. *Resource rent and recovery of management costs (scenario 9)*

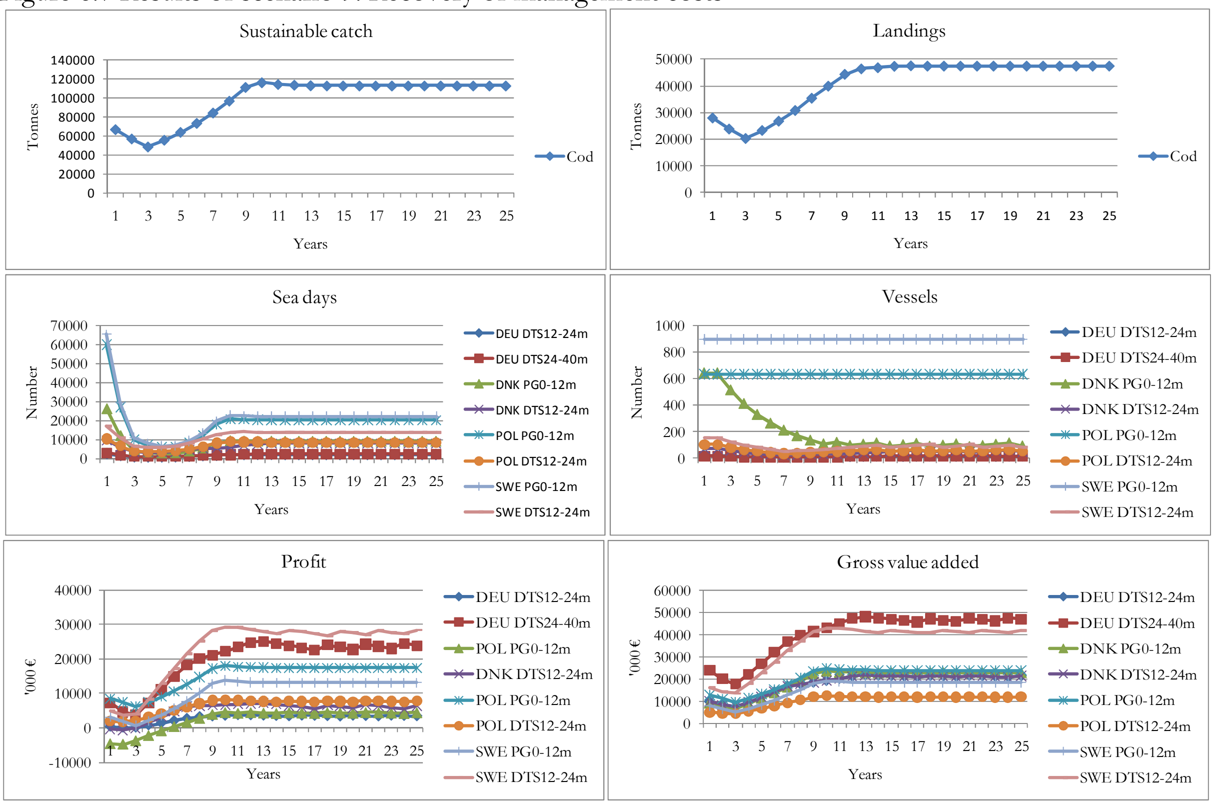
MRAG data is used in the calculation of cost recovery. The scenario does not differ from the TAC min scenario (Figure 6.3) in the case of the Baltic Sea. The reason is that the investments are not affected although higher costs lead to higher break-even revenue. However, the profit is lower in scenario 9 than in scenario 1. If recovery of management costs is considered a tax it will not influence the gross value added. From the fishermen's point of view cost recovery is considered a cost that affects the profit and eventually the investments.

The conclusion is that the profit of the fishermen will decrease and thereby influence the economic performance of the fleet, but from a management point of view there will be no changes. Changes will happen if the recovery costs are higher.

Table 6.12 The effect of recovery of management costs. Baltic Sea cod (mln euro)

Indicator	2005-7	Scenarios*	
		Main scenario: No recovery of management costs	9. Recovery of management costs
NPV GVA_{15} (mln euro)		1,642	1,642
Nominal GVA_{15} (mln euro)	89.6	197	197
NPV $Profit_{15}$		969	774
Fixed payment for access (mln euro)		0	17
NPV Payment for $access_{15}$		0	194
Nom $Profit_{15}$ (mln euro)	38.1	122	105

Figure 6.7 Results of scenario 9. Recovery of management costs



6.7.5. Optimization of capacity (scenarios 10-14)

The scenarios shown in Table 6.13 deal with the question of instantaneous or gradual adaptation of the fleet. The baseline shows the present situation, while the main scenario is scenario 1 with TAC and investment restrictions. In the static present fleet the number of vessels is constant but the number of days at sea per vessel is allowed to vary subject to the management option which is TACs. In the minimum static fleet the number of vessels is reduced in year one to the number of vessels required if all vessels use the maximum number of days at sea per vessel. This number is then kept constant. The dynamic fleet is the minimum fleet with the investment behaviour re-introduced into the model. And finally the optimal case is shown.

Table 6.13 Impact of optimization of the fleet size

Indicator	2005-7	Scenarios*					
		Main scenario TAC min	10. Static present fleet	11. Static minimum fleet	12. Dynamic minimum fleet	13. Optimum fleet (GVA)	14. Optimum fleet (profit)
NPV $Profit_{15}$ (mln euro)		969	834	1,007	1,039	1,370	1,630
Nominal $Profit_{15}$ (mln euro)	38	122	109	124	125	156	187
Discounted $Profit_{15}$ (mln euro)	38	73	65	74	75	93	112
$Fleet_{15}$ (no vessels)	2,533	1,828	2,533	1,474	1,359	2,304	3,041
$Effort_{15}$ (1000 DAS)	193.8	85.9	85.9	85.9	85.9	300.4	407.3
$Catch_{15}$ (1000 t)	28.0	47.5	47.5	47.5	47.5	68.2	76.1

*NPV row refers to the sum, other rows refer to values in year 15

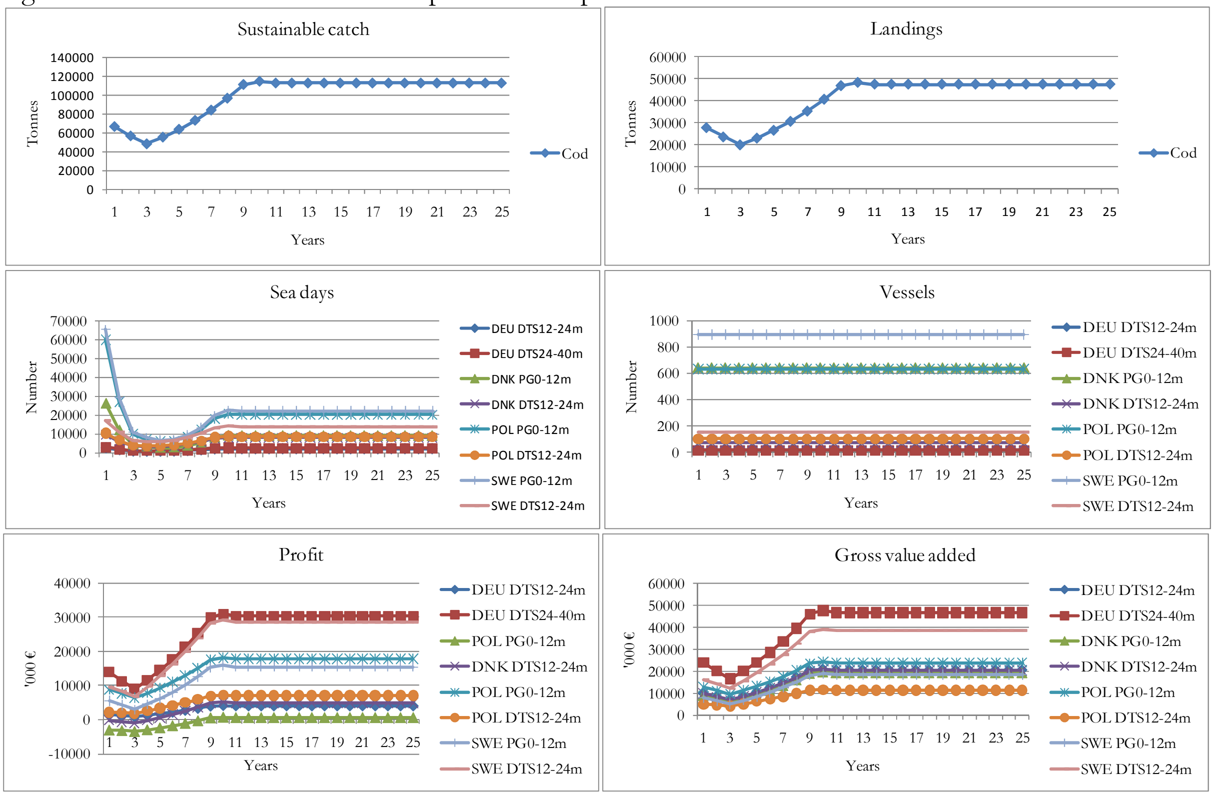
The scenarios for optimization of the size of the fleet show that the NPV Profit with a static fleet (scenario 10 and 11) is almost the same as for the TAC min scenario. But there are large differences in the underlying number of vessels, days at sea and catches in year 15 after adjustments have taken place. There is very little effect of introducing investments to the static minimum fleet. A more comprehensive adjustment will take place in scenario 13 where caches are estimated at around 68,000 tonnes. This figure could be compared with the MSY for cod at around 200,000 tonnes. However, in scenario 13 the stock biomass is higher than in the MSY situation. The effect of a high stock is a high catch per unit effort and hence lower cost per catch unit but on the other hand the growth of the stock is lower than in the MSY case. The profit (revenue – all costs) is maximized in scenario 14. This scenario performs marginally better than scenario 13 and, in particular, the number of vessels in the segments PG 0-12m for Denmark, Sweden and Poland causes this difference. An increase at around 2% in NPV GVA_{15} is achieved by a substantial increase in the number of days at sea and the number of vessels; see Table 6.13.

Scenario 10. Static present fleet

The assumption in this scenario is that the number of vessels is kept constant at the initial level (2005-7). The TAC min situation is chosen. The total number of days at sea for each segment is calculated, and this number of days is divided by the constant number of vessels. Therefore the number of days per vessel varies over time. If the number of days per vessel exceeds the maximum number of days at sea per vessel the maximum number of days is used. Such a situation does not occur for any of the fleet segments and indicates overcapacity with the current number of vessels even when the cod stock is recovered.

As the Htarget management (scenario 1) is controlling scenario 10 the total number of days at sea will be the same as in scenario 1, entailing that the stock condition will be exactly the same in the two scenarios but the number of vessels in year 15 is almost 40% higher in scenario 10 and hence the gross value added and the profit will be lower.

Figure 6.8 Results of scenario 10. Adaptation with ‘present’ fleet

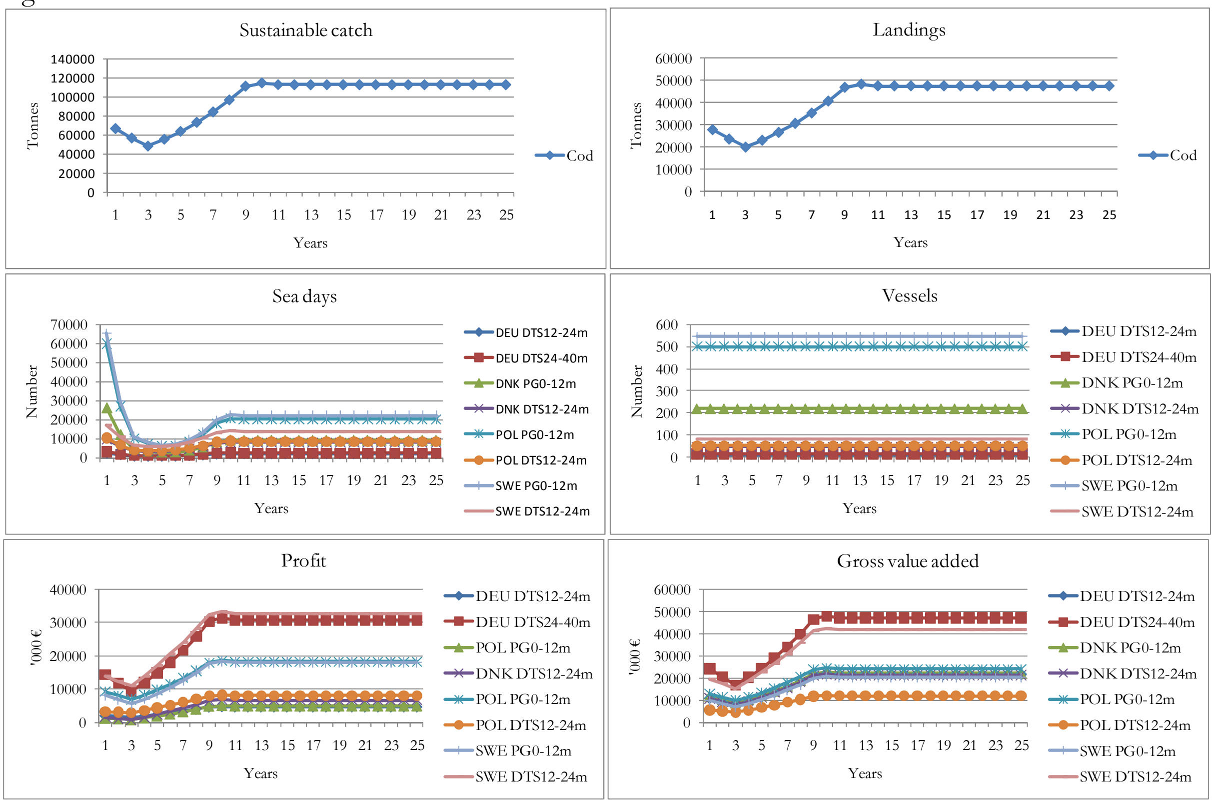


Scenario 11. Static minimum fleet

In scenario 11 the number of vessels is reduced to the minimum required level at the maximum days at sea per vessel year 1 and this number is maintained throughout the 25 years for each fleet segment.

As the management is kept at TAC min (scenario one) the fish stock conditions is the same and the total number of days at sea is the same. The economic performance is further improved, however, as the number of vessels is around 20% lower as in scenario one. The profit is only slightly higher in scenario 11 than in scenario one.

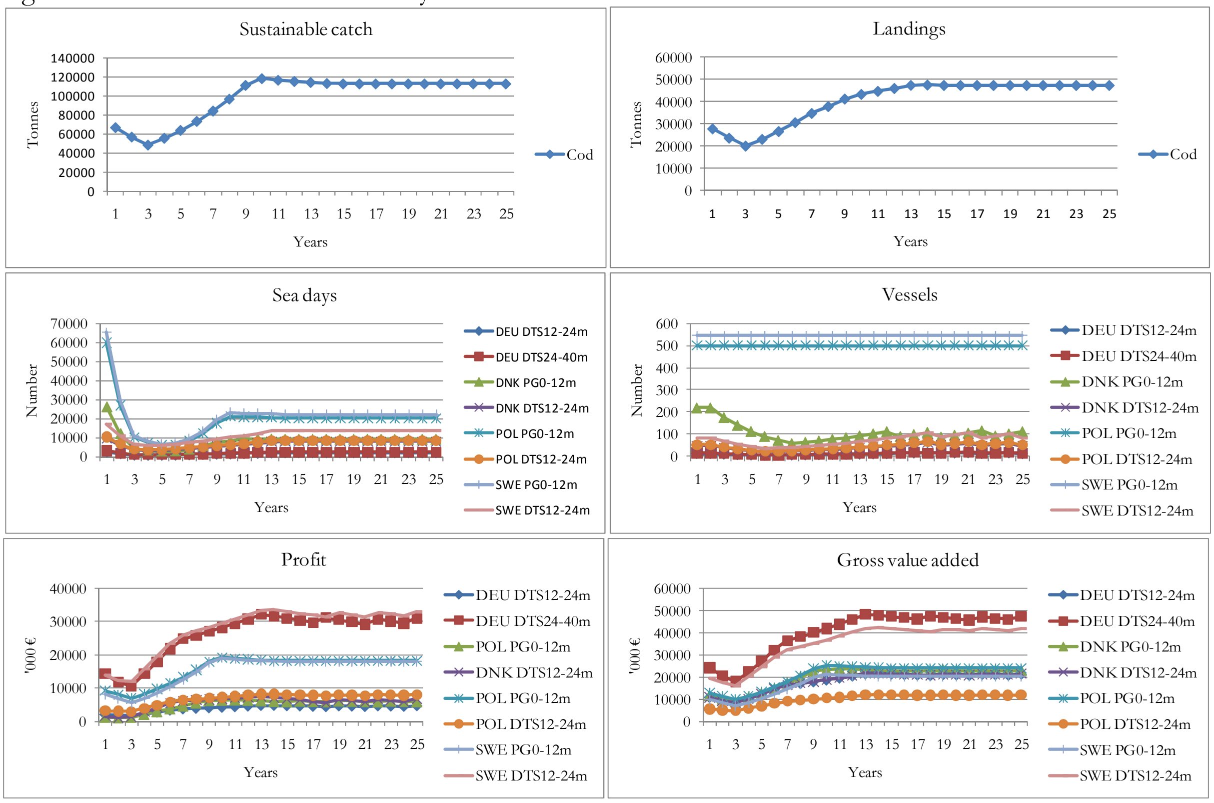
Figure 6.9 Results of scenario 11. Static minimum fleet



Scenario 12. Dynamic minimum fleet

Compared to scenario 11 it is now allowed to invest in scenario 12 according to the same rules as in scenario 1. The TAC min management is the same as for scenario 1. The stock conditions are therefore the same and there are no differences from scenario 1. The economic performance is further improved as the number of vessels in year 15 is 25% lower than in scenario 1. The difference between scenario 12 and 1 is the initial number of vessels being 2533 in scenario 1 and 1474 (around 40% lower) in scenario 12. The difference between scenario 12 and 11 is not big in terms of gross value added and profit over time, but in year 15 the number of vessels in scenario 12 is 1,360 compared to 1,474 in scenario 11.

Figure 6.10 Results of scenario 12. Dynamic minimum fleet

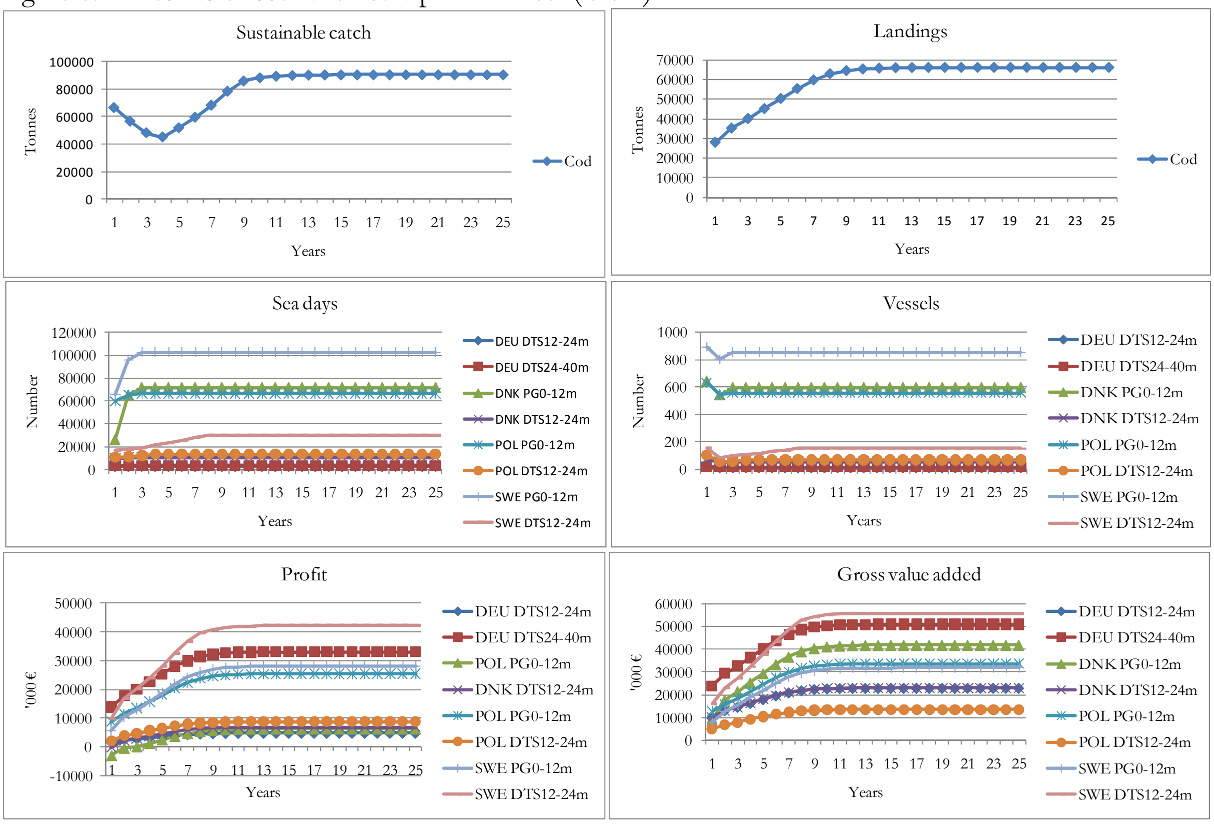


Scenario 13. Optimum fleet (GVA)

In the scenario for the optimal fleet the objective is to maximize gross value added over 15 years. The applied method is non-linear programming. There are no management restrictions in this version i.e. no TAC or effort limitations apart from the natural physical limitations such as the growth conditions for the stocks and that the number of days per vessels cannot exceed the maximum number of days. This means that the model chooses the number of vessels and hence the size of the fish stock that maximizes gross value added.

One restriction is kept, however, and this is the investment limits according to which the number of vessels cannot change upwards by more than 10% and downwards by more than 20% per year.

Figure 6.11 Results of scenario 13. Optimum fleet (GVA)



Compared with TAC min (scenario one) a number of interesting differences appear. In the optimum scenario 13 the net present value of gross value added is 45% higher than in scenario one. The landings in year 15 is 37% higher and the number of se days 300,400 vs 85,900) and the number of vessels (2,304 vs 1,878) is also higher in scenario 13 vs scenario one. The reason for this surprising result is that because of the investment behaviour the number of vessels in scenario one is driven to a too low level and the stock to a too high level compare to scenario 13. In scenario one this leads to a stock growth that is lower than it could have been and therefore catches are lower.

However to obtain the results in scenario 13 full transparency into the future and complete control over the effort is required which may not be possible in practice.

Scenario 14. Optimum fleet (profit)

This scenario is carried out under the same assumptions as for scenario 13. The difference is that in scenario 14 profit (revenue – all costs) is maximized contrary to the GVA in scenario 13. Scenario 14 is performing slightly better than scenario 13. The number of vessels in the segment PG 0-12m changes significantly. The Danish decrease while the Swedish and the Polish increases. Although the totals of GVA and profit do not differ much, there are differences in the composition on profit, crew share and capital remuneration, see Table 6.14.

Figure 6.12 Results of scenario 14. Optimum fleet (profit)

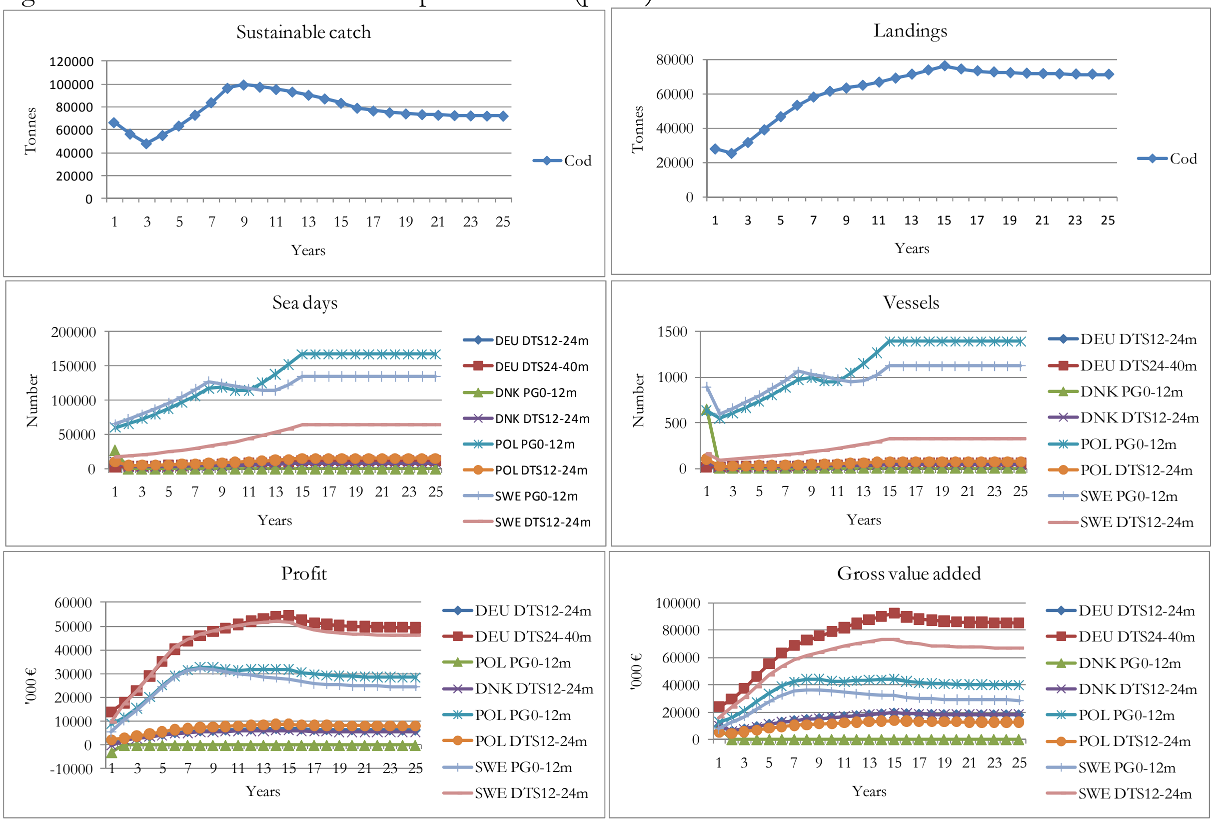
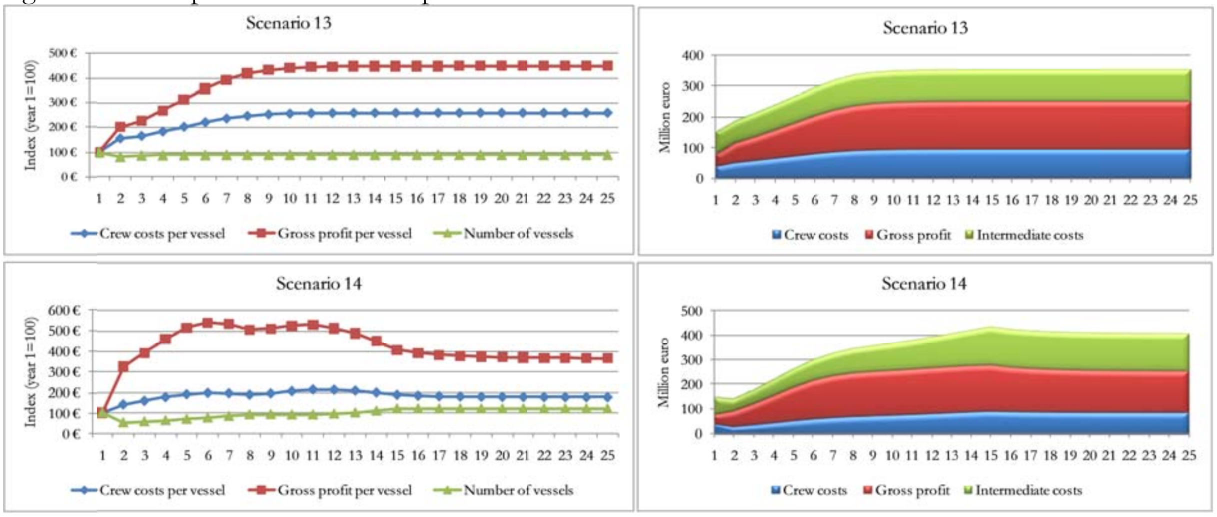


Table 6.14 Comparison of scenarios 13 and 14 (values in mln euro, fleet number of vessels)

	Scenario 13	Scenario 14
NPV GVA$_{15}$	2,384	2,435
NPV profit$_{15}$	1,370	1,630
NPV Crew costs$_{15}$	903	707
NPV capital costs$_{15}$	111	98
GVA year 15	261	292
Profit year 15	156	187
Crew costs year 15	95	91
Capital costs year 15	10	14
Fleet – average 1-15	2,295	2,166
Fleet – year 15	2,304	3,041

Figure 6.13 Comparison of the two optimization scenarios



6.7.6. Assumptions and technical background (by main model modules)

There is no deviation from the common approach (model) approved by the team for the study. It is important to emphasize, however, that as the model is very detailed it is also very data demanding with respect to amount and quality of data – a demand which has been difficult to meet. A main reason for the data problems is the request of the terms of references for an analysis of a specific "fishery" in this case the cod fishery in the Baltic Sea. In a fishery many species are exploited by many fleets. This characteristic requires a careful delineation of a fishery.

Computation of resource rent requires that fish stock yield functions are estimated. The yield from a fish stock is dependent on the growth, the natural mortality and the intrinsic growth of the stock. The growth as a function of the spawning stock size (SSB) shows a substantial variation. For the Eastern stock the growth was on average 1966-2007 287 million fish at age 2. But if the very high growth in the 80ies are disregarded the average is 114 million fish at age 2. For the Western stock the average growth at age 1 was 97 million fish in the period 1970-2007.

A number of problems arise in the estimation of the yield (stock-growth) functions and the application in the model used in this study. One problem is whether the very high growth of the Eastern stock in the 80ies is caused by favourable environmental factors or by a low harvest ratio. Evidence indicates that environmental factors played a very important role (Lindegren et al. 2009). Therefore this period is disregarded when estimating the growth function. Another problem is that there are two stocks which are exploited by the same fleets as single fishery. In principle the fisheries on these two stocks should be considered independent of one another but it is not possible to divide the fishing fleets in an Eastern and a Western component. As the Eastern stock is the largest approximately 3-4 times the Western stock and the Western stock is the more stable, only the Eastern stock has been used in the estimation of the yield function. Catches from the Western stock is then considered in the same way as other species and included in the model by a mark-up procedure which is a function of the revenue from the Eastern stock. The rationale behind this assumption is that if one stock is recovered by adjusting the harvest ratio downwards a proportional recovery will take place for the other stocks.

A problem as regard modelling is the way the harvest ratios are estimated and the target harvest ratios are set in the management plans. In ICES-reports (ICES 2008) and in the management plans the harvest ratios are expressed only for some age groups of the total stock. Therefore, the target fishing mortally rates set by the management plans cannot be used without modification. The bio-economic model does not use age structured fish stocks, but the total stock, and the harvest ratio is expressed as the total catches in proportion to the stock.

Information about the size of the total stock biomass is not always available in the ICES reports and therefore the spawning stock biomass is used for the estimation of the relationship between growth and stock biomass. The estimated functional form for the Eastern stock is a 2'nd degree polynomial relation:

$$\text{Recruits} = 1.8870*\text{SSB} - 0.00000312*\text{SSB}^2$$

The intersection is forced through zero although it could be argued that once the SSB goes below a certain level no growth is possible. Both parameters are significant at a 5% level. The recruits are in number of fish (1000) and the SSB (in tonnes). The peak point of the function equal to maximum sustainable yield (MSY) is SSB at 302 361 tonnes and 285 mln recruits at age two. The recruits are transformed to weight by use of 0.65 kg as a measure for the yield per recruit (ICES 2008).

References to chapter 6

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7. ATLANTIC NORTHERN HAKE FISHERIES

7.1. Summary and conclusions

Main conclusion

The five segments analysed in this fishery realized in 2005-7 on average a total net loss of 56 mln euro. Average annual discounted net profit ranges under most scenarios between 60 and 116 mln euro. Elimination of overcapacity and recovery of stocks would produce a discounted net profit of 59-105 mln euro by the year 15. (see Figure 7.1)

Summary of the case study

The Northern Hake fishery is part of a mixed fishery in which vessels from seven MS are included although vessels from Spain and France can be considered as the mayor contributors. Gears taking part in this fishery are nets, trawls and hooks with vessels of a length range that goes from 12 to 40 meters.

Northern hake is managed by means of TACs and quotas, among some other technical measures (restrictions in mesh sizes, area closures,…) and in some cases (Spain) by the means of transferable fishing rights, even if it can be considered that, currently, output measures are the most restrictive management tools. Furthermore, since, the beginning of 21st century northern hake has been involved in an emergency plan, a recovery plan (in both some input, output and control measures have been applied) and currently a long term management plan is to be implemented.

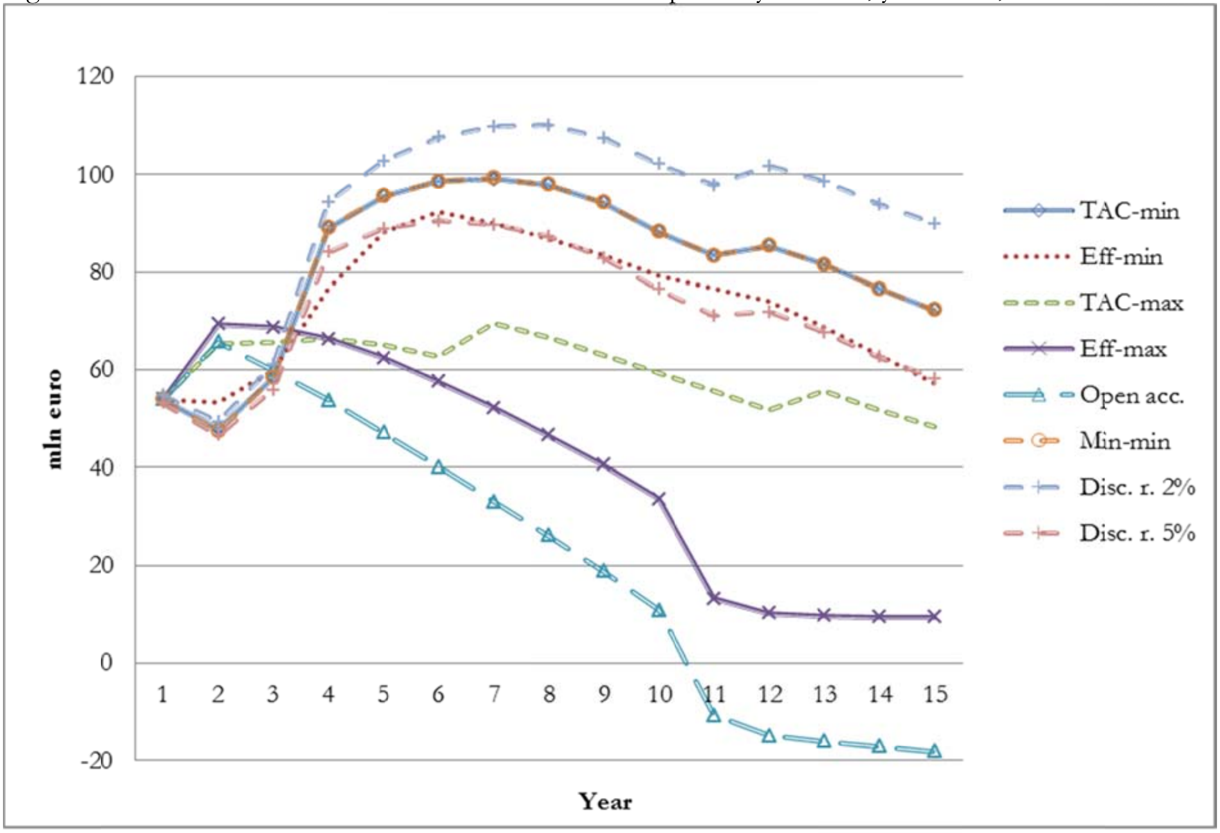
As a regulated multi-fleet, multi-species fishery, performance is principally driven by the policy option (PO) selected. In the simulations performed in this work there are two different general management strategies, i.e., safe or restrictive options (TAC min and Effort min) and extreme or non-restrictive options (TAC max and Effort max). Nevertheless, it is better to start with the Open access situation. Results from this policy option show that when using it a result compatible with the sustainability concept cannot be achieved. It implies that some kind of management is required. Looking at the more extreme options Effort max produces clearly unsustainable results and TAC max provides results which are not completely compatible with sustainability (even if the results are less extreme).

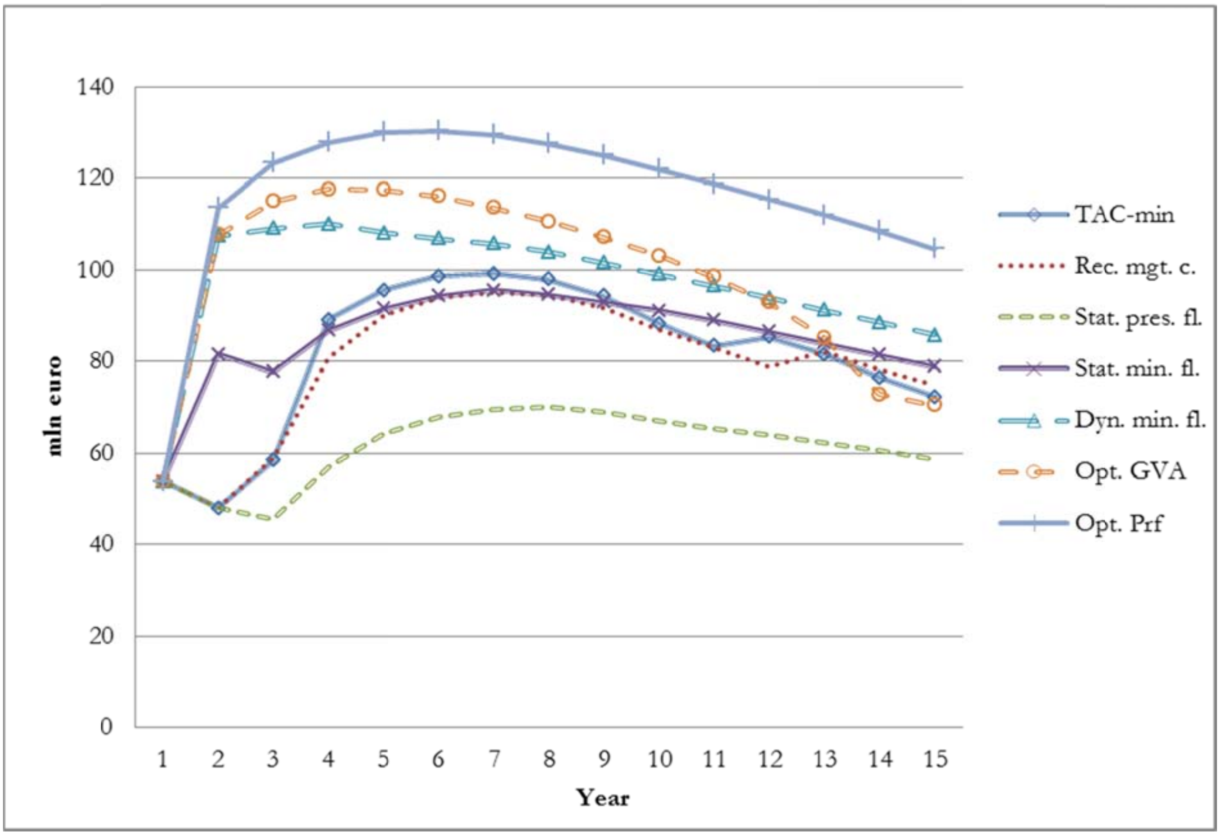
Following the discussion above there are two possible candidates compatible with the sustainability concept, TAC min and Effort min (three if one includes Min min, but this PO almost replicates the TAC min policy). Both POs produce results compatible with the biological sustainability. It implies that the selection of the baseline PO has to be done using other criteria. The concepts of MEY and MSY arise in this discussion. The highest yield (of all the species considered) is obtained using the Effort min PO. In that sense this policy option can be related to the MSY concept. TAC min shows the highest NPV Profit$_{15}$ therefore it can be related to the MEY.

As a baseline policy option TAC min has been selected. First of all this PO provides the highest NPV Profit$_{15}$ which given that the work deals with resource rent is an important indicator for the selection. Secondly, TAC is the main management tool in this fishery. Following these two indicators, selecting TAC min as the PO provides the highest sustainable NPV Profit$_{15}$ and does not imply any breakdown in the current management system.

When rent is considered as a target it has to be said that one single value cannot be determined. Apart from the conceptual definition, future benefits have to be discounted and in reality there is not a single discount rate. In that sense there have been made comparisons between different discount rates and the absolute values differ considerably. Furthermore, it has to be noted that the discount rate can determine not only the real value of the rent but also the PO required to maximize it, due to the different timings of the stream of benefits.

Figure 7.1 Atlantic northern hake – discounted annual net profit by scenario, years 1-15, mln euro





In the case study some scenarios on changes in the capacity have been tested. Results show how smaller fleets do not immediately create higher rents. Overcapacity has to be seen in terms of the number of vessels and characteristics of each particular segment, in terms of the total catching capacity and also in terms of the technology and the economic performance of each segment. Vessels operating at their maximum possible effort do not necessarily generate higher rents (even with a reduction in the total number of vessels) at least not if all the simulation period is considered. Furthermore, the maximum rent (optimization scenario) is obtained with a higher number of vessels than in the baseline (average 2005-7) and the selected baseline scenario (TAC min). In that sense it is very important not only to consider the total number of vessels but the allocation of them within the segments. That is, overcapacity has to be measured at the segment level.

Finally, in terms of the management costs, results are heavily dependent on how these costs are allocated to each segment. In the particular case in which income is used as the allocation criterion, it has been shown that a lump sum tax generates the right incentives to the fleet. The NPV $Profit_{15}$ plus the cost recovery is higher than the NPV $Profit_{15}$ when the same policy option without cost recovery is used.

To sum up, using a discount rate of 3.5% resource rent (NPV $Profit_{15}$) of this fishery ranges from 332 million euro (open access) to 1,742 mln euro (optimum), depending on the PO used and the scenario considered. It implies that there is an 80% difference between the lowest and the highest PO. Meeting the criteria of sustainability, the rank is shorter, starting from 1,104 mln euro (Effort min) to 1,742 million euro (Optimum fleet) which reduces the possible differences to 37%. The base PO (TAC min) generates a rent of 1,222 million euro, which is 30% lower than the maximum rent that can be obtained (by optimizing the number of vessels). Other capacity alternatives create higher rents (<5% in static minimum fleet and <20% in the dynamic minimum fleet) than the base policy option. If the fleet is set at the baseline level (scenario 10) the reduction will be of 24%. If a system of recovery of management costs is implemented, it creates an increase in the total rent (NPV $Profit_{15}$ and recovery of costs) of 25% comparing to the baseline PO. In other words, additional rents are created. Finally it should be noted that these values (and their relative differences) change with the discount rate. Reducing it from 3.5% to 2% increases the NPV $Profit_{15}$ of the same PO (base) by 13%, on the other hand a discount rate of 5% reduces the NPV $Profit_{15}$ of the same PO (base) by 11%.

7.2. Case study definition

7.2.1.Fleet and landings

The catches of the Northern stock of hake made by the Spanish fleet are concentrated on a single fleet named the "300 fleet". This fleet accounts for all the Spanish catches of Northern stock of hake. It is captured in a wide area covering the Western Atlantic Waters. The different segments existing in this fleet, catch hake as a single species fishery (longliners HOK 24-40) and pair trawlers DTS 24-40), as a target species in a mixed fishery netters (DFN 24-40) and part of the bottom trawlers (DTS 24-40), or as a fishery targeting some other species (mainly anglerfish and megrim) which is the case of the remaining bottom trawlers (DTS 24-40).

For France around 650 vessels could be considered as belonging to the hake fishery[35]. These vessels (catching at least 1 tonne of hake per year) are heterogeneous in terms of gears used and size of the hull. On this basis, 4 segments are explicitly considered: demersal trawlers (DTS 12-24m), demersal trawlers (24-40m), netters (DFN 12-24m) and netters (DFN 24-40m).

Netters are the major contributors to the French hake landings (71% in volume and value) with 78 vessels. Particularly, the large netters (24-40m) contribute almost 48% of the total landings of hake in France. The demersal trawler segment (DTS) contributes 26% to the total landings with 365 vessels. A brief analysis of the catch composition of each fleet segment shows the relative importance of nephrops and anglerfish for

[35] Not all of them have been considered in the modelling part.

the DTS 12-24m "targeting nephrops" (respectively 45% and 12% of the total earnings), anglerfish for the DTS 12-24m "targeting fish" and DTS 24-40m (27% of the total earnings for each) and sole for the netters 12-24m (46% of the total earnings).

The fleets of Spain and France account for around 90% of the catches of this stock of hake, and the contribution of the segments considered is around the 80%. It implies that the role of the remaining segments is limited. These remaining segments are gears using hooks in France, demersal trawlers (12-24m) in the UK and demersal trawlers in Ireland (12-24m and 24-40m). In Spain in the mid 90's of the past century a new gear was developed for fishing hake: the very high vertical opening net pair trawlers. These trawlers in contrast with the traditional otter trawlers catch almost exclusively hake (between 85% and 90 % of the landings).

Hake, nephrops, megrims, sole and anglerfishes have been considered as target species.

Table 7.1 Role of target species

MS	Gear	Size	No. vessels	GT (1000)	Landings (1000 t)		Value (mln euro)	
					Target species	Total	Target species	Total
ESP	DTS	24m-40m	112	24	21.1	35.0	90.9	111.3
ESP	HOK	24m-40m	79	19	11.1	16.2	49.5	77.4
FRA	DTS	12m-24m	313	26	10.5	45.8	70.4	186.5
FRA	DTS	24m-40m	56	10	5.3	18.9	22.4	55.7
FRA	DFN	12m-24m	60	3	4.6	5.3	37.5	66.2
FRA	DFN	24m-40m	19	5	3.7	5.2	16.5	21.3
Total			639	87	56.3	126.4	287.2	518.4

Source: DCR 2007. ICES 2009 and SEC 2007

Table 7.2 shows the role of the case study fleets within the national fishery sector. Spain has 13,725 registered vessels and the case study accounts for 2% of them. France, had 4,737 vessels and the case study accounts for 10%.

Table 7.2 Role of case study fisheries within national fishery sectors (average 2005-7)

Member State	Total fishery sector		Case study fleets	
	Total revenues (mln euro)	Total fleet (number of vessels)	Revenues (mln euro)	Fleet (number of vessels)
France	1,248	4,737	329	448
Spain	1,735	13,725	188	191

Source: DCR 2007

7.2.2. Composition of landings

Table 7.3. Composition of landings by segment (1000 tonnes)

MS	Gear	Size	Hake	Nephrops	Sole	Anglerfish	Megrim	Others	Total
ESP	DTS	24m-40m	14.2	0	0	3.0	3.9	13.9	35.0
ESP	HOK	24m-40m	11.1	0	0	0	0	5.1	16.2
FRA	DTS	12m-24m	1.1	3.0	0.9	5.5	0	35.3	45.8
FRA	DTS	24m-40m	1.1	0	0	2.3	1.9	13.6	18.9
FRA	DFN	12m-24m	1.9	0	2.1	0.6	0	0.7	5.3
FRA	DFN	24m-40m	3.7	0	0	0	0	1.5	5.2
Total			33.1	3.0	3.0	11.4	5.8	70.1	126.4

Source: DCR 2007. ICES 2009 and SEC 2007

Table 7.3 shows the composition of the volume of landings by segment. Spanish DTS 24-40 and HOK 24-40 account for a major part of the total landings of hake. Nevertheless depending on the segment there are some other important species such as anglerfishes for the French DTS 12-24 or sole for the French DFN 12-24.

Table 7.4. Composition of landings by segment (mln euro)

MS	Gear	Size	Hake	Nephrops	Sole	Anglerfish	Megrim	Others	Total
ESP	DTS	24m-40m	63.3	0.0	0.0	14.7	12.8	20.4	111.3
ESP	HOK	24m-40m	49.5	0.0	0.0	0.0	0.0	27.9	77.4
FRA	DTS	12m-24m	4.9	27.4	11.2	27.0	0.0	116.1	186.5
FRA	DTS	24m-40m	4.9	0.0	0.0	11.3	6.3	33.3	55.7
FRA	DFN	12m-24m	8.5	0.0	26.1	2.9	0.0	28.7	66.2
FRA	DFN	24m-40m	16.5	0.0	0.0	0.0	0.0	4.8	21.3
Total			147.6	27.4	37.3	55.9	19.1	231.2	518.4

Source: DCR 2007 and ICES 2009 and SEC 2007

Table 7.4 shows the composition of the value of landings by segment. Hake is an important species for all the fleets.

7.3. Historical indicators

According to ICES, landings of northern stock of hake reached their maximum in 1955 when 155,000 tonnes were landed. In recent years (only since 1978 ICES has a proper evaluation of this species been carried out –not as unique management unit yet) the maximum has been 66,500 tonnes in 1989. Nevertheless this cannot be considered a proxy of the sustainability maximum of the stock given that from this year, stock size has steadily decreased to reach its minimum in 1996. Landings have been at a level of around 42,000 tonnes from this period onwards.

Anglerfish is managed under a single TAC even if two different species exists (black and white anglerfish). In comparison with hake, these two species have evolved differently. In the past (before 1960) there was not a directed fishery targeting anglerfish. Maximum landings were reached in 1985. Since these management stocks exist (from the beginning of 1986 when the northern stock of anglerfishes was separated from the southern one due to the entry of Spain and Portugal to the former EEC) the maximum level of landing of both species has occurred in 2007 (around 36,000 tonnes), even if according to ICES it is not likely to be sustainable. MSY level of production of anglerfish can be set at 27,000 tonnes[36].

According to ICES, nephrops in the Bay of Biscay reached its maximum catches in 2006. However, it should be noted that more than 50% was discarded. There is not a full analytical assessment of this stock but according to recent catch trends, maintaining recent catches (2005-7) seems to be sustainable. Given that also in this period there has been the peak of the catches, MSY should be around 6000 tonnes[1].

Spain has had a large fleet targeting hake. In 1981 there were 416 vessels (trawlers, netters and longliners) involved in this fishery but by 2005-7 there were only 191 active vessels on average.

The number of French vessels catching hake is much more variable given that the behaviour of many of them can be considered as 'opportunistic', i.e. flexibly adapting fishing strategy to availability of stocks. The average number of vessels catching hake is above 400.

[36] ICES (2008) Report of the Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim (WGHMM). Copenhagen.

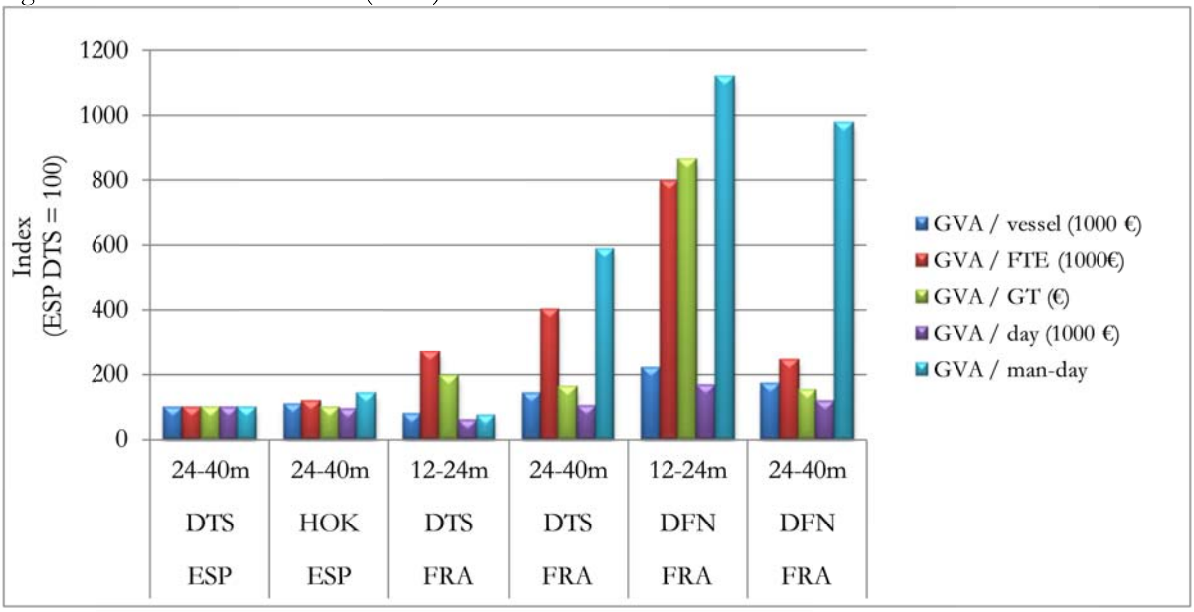
7.4. Fleet efficiency

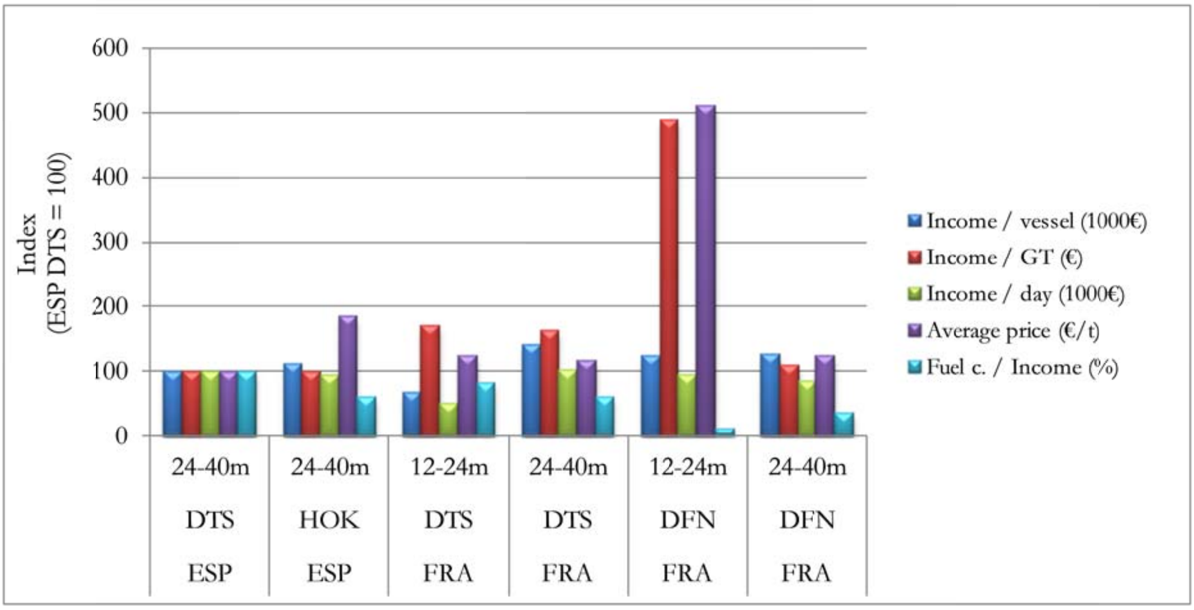
Table 7.5. Economic indicators

MS	Gear	Size	Gross value added (mln euro)	Profit (mln euro)	Employ-ment (FTE)	Average price (euro/t)	Fuel costs as % of income	Profit / tonne landings	CPUE total (t/day)	CPUE HKE (t/day)
ESP	DTS	24m-40m	41	-1	1,818	3,125	21%	-2,57	1.99	0.79
ESP	HOK	24m-40m	32	-3	1,379	4,183	18%	-0,40	1.00	0.69
FRA	DTS	12m-24m	89	-10	1,328	3,945	20%	0,03	0.80	0.03
FRA	DTS	24m-40m	29	-5	424	2,914	22%	-0,06	1.57	0.07
FRA	DFN	12m-24m	49	3	353	6,079	7%	0,47	0.59	0.18
FRA	DFN	24m-40m	12	1	237	3,906	9%	0,38	1.10	0.80
Total			252	-15	5,539	4.020	16%	-0.11	1.17	0.42

Source: DCR 2007 and ICES 2009 and SEC 2007

Figure 7.2 Economic indicators (index)





In terms of fleet efficiency an important conclusion can be drawn. Fixed nets seem to be more economically efficient. The reason for this is that, even technically, trawlers are able to produce a higher income using their capacity (GT) and effort (fishing days), higher fish prices and especially fuel lower consumption all of which make netters economically more efficient. Nevertheless it is important to mention that this does not necessarily imply that these are the vessels that would maximize resource rent, given the multi-species nature of the fishery.

7.5. Management measures

7.5.1.General description

The main target species of this fishery (hake, nephrops, megrims, sole and anglerfish) are managed by TACs and quotas. However, there are also some other measures in place.

Hake has always been the main driver in terms of additional management initiatives. In that sense following concerns in the late 1990s about the low level of the stock biomass and the possibility of recruitment failure a range of technical measures was introduced (Council Regulations N°1162/2001. 2602/2001 and 494/2002) aimed at improving the selection pattern and protecting juveniles. Subsequently a recovery plan was introduced (Council regulation EC Reg. No 811/2004).

The recovery plan consists of setting a TAC equivalent to a target H of 0.25 (Fpa) or a lower H to prevent decline in SSB and with the constraint that annual change in TAC should not exceed 15%.

7.5.2.Output management

Catch restrictions

Main target species of this fishery (hake, nephrops, megrims, sole and anglerfish) are managed by TACs and quotas. Given the multi-species composition of the catches of the fleets involved in this fishery, some other species (that could be important at a métier level) are not under the TAC system (sea bass, squids, pouts, among others).

Property rights

Currently the implementation of an ITQ system for the Spanish fleet is under consideration for this fishery but it has not entered into force yet. There is a clear overlap of this system with the effort limitation system and with the transferability of the fishing rights, which makes it difficult to make it operational.

In France, the State is responsible for ensuring it's sustainable exploitation and for the allocation of rights to fish (fishing licence, catch quotas, effort quotas, etc) to avoid privatisation of fishing rights

7.5.3.Input management

Effort restrictions

The Spanish fleet ("300 fleet") has also been under the constraints of effort limiting system (fishing rights), even if nowadays this system cannot be considered as limiting the activity given that there are more fishing rights than the potential fishing effort.

The system is based on a closed census created when Spain entered the EU in which there could be a replacement of capacity but not an increase of it. This census did not allow complete freedom to operate in this fishery. Only 145 of the initial 300 vessel could operate simultaneously. The system has been regulated through annual allowed number of days by ICES sub-area, which implies that not all vessels can access the whole spatial distribution of the stock of hake.

Both member state's fleets have a technical measure which imposes a minimum 100 mm mesh size for otter-trawlers when hake represents more than 20% of the total amount of marine organisms retained on board, with a dispensation for vessels less than 12 m and which return to port within 24 hours of their most recent departure. Furthermore, two areas are defined, one in Sub area VII and the other in Sub area VIII, where a 100 mm minimum mesh size is required for all otter-trawlers, irrespective of the proportion of hake caught.

Finally, since the end of 2005, the French vessels involved in the nephrops fishery in the Bay of Biscay are regulated by licenses. These licenses are given only to vessels using a square mesh panel allowing 20-30% escapement of undersized hake. This licence system will allow the fishermen's organisations to apply further restrictions such as technical measures (gear modifications), temporal closures or individual quotas.

Input property rights

Within the census, effort fishing rights (fishing days) are property of the vessel owner. These fishing rights are fully transferable, even if under some conditions on the accumulation of them. Furthermore, the conditions imposed for the transferability have been the main driver of the evolution of the fleet. At a first stage the transferability was not compatible with the scrapping scheme, as the number of active vessels was not reduced. When both became compatible, the fleet was reduced by more than 30%. Afterwards some limits on the accumulation of fishing rights were imposed, which created changes in the regional distribution of the fleets but not in the total size of it. Currently, a system in which transferability is allowed, but with a reduction of the operational fishing rights, is under consideration (it will probably come into force in 2011). This reduction is going to be implemented by a mandatory purchase by the public authorities of a percentage of the fishing rights that are transferred. These fishing rights would be made available once the level of TACs would allow higher fishing effort.

As commented above, the licence system allows individual quotas although they have not been implemented. In this particular topic it must be mentioned that French fishermen's organisations strongly reject the implementation of IQs or ITQs. Moreover, since 1997 French law[37] forbids the transferability of fishing rights.

7.6. Management costs

7.6.1.Summary of OECD data

The allocation of OECD management costs to each fleet segment (Table 7.6) has been made using the relative weight of the income obtained by each segment to the total income of the MS to which each segment belongs. In that sense more than the 40% of the total management costs have been allocated to the FRA+ESP DTS 24-40[38] segment even if the number of vessels of this segment is not the highest one (this is the case of the FRA DTS 12-24 segment).

Among these two MSs several differences arise:

- In the period 2004-06 management costs represented for France around 6.8% of the total income obtained by the fleets. This percentage is almost doubled for Spain (12%).
- In the period 2004-06 management costs for Spain have had a decreasing trend. The structure of costs has been stable except for modernization and construction of new vessels for which the trend has

[37] Act on Sea Fisheries and Aquaculture of 18 November 1997.

[38] DTS 24-40 segment of both member states have been merged into one to maintain the structure of a single gear by segment. Nevertheless, this segment is driven by the Spanish vessels which account for the 70% of the total vessels of this segment. For editing purposes in the figures it has been represented as ALL DTS 24-40).

been descending. For France a trend cannot be obtained. 2006 doubles the costs of 2005 which is again 30% higher than in 2004.

Table 7.6 Management costs according to OECD, average 2004-2006. (mln euro)

	FRA DTS 12-24	FRA+ESP DTS 24-40	FRA DFN 12-24	FRA DFN 24-40	ESP HOK 24-40	Total
Direct Payments	5.2	11.3	1.1	0.6	5.6	23.8
- Decommissioning	2.1	2.7	0.4	0.2	1.2	6.6
- Fleet renewal and modernization	2.4	6.4	0.5	0.3	3.4	13.0
- Other	0.8	2.1	0.2	0.1	1.1	4.2
General Services	6.3	6.0	1.3	0.7	2.1	16.5
- Management and enforcement	1.8	0.7	0.4	0.2	0.0	3.1
- Research	4.3	1.8	0.9	0.5	0.1	7.7
- Other	0.2	3.4	0.0	0.0	2.0	5.7
Total	11.5	17.3	2.4	1.3	7.7	40.3

7.6.2. Support to fishing sector (FIFG and EFF)

In terms of the support to the fishing sector, Spain spends 89.6 million euro on EFF Axis 1 and France 20.4 mln euro.

Table 7.7 Average annual support to the marine fisheries from FIFG and EFF. (mln euro)

	FRA DTS 12-24	FRA+ESP DTS 24-40	FRA DFN 12-24	FRA DFN 24-40	ESP HOK 24-40	Total
FIFG - Axis 1 and 2	5.6	13.5	2.0	0.6	8.2	30.0
EFF - Axis 1	3.0	6.7	1.1	0.3	4.0	15.1

The allocation by fleet segment has been made using the same weights as for the OECD data, and FRA+ESP DTS 24-40 and ESP HOK 24-40 segments are those with highest allocation (the two segments including Spanish vessels).

7.6.3. Costs of research and management

In terms of the costs of research and management, Spain expends 27.6 million euro if management is considered and 16.7 million euro considering only research. The values for France are 16.8 million euro and 15.8 million euro, respectively.

Table 7.8 Estimated management and research costs. (mln euro)

	FRA DTS 12-24	FRA+ESP DTS 24-40	FRA DFN 12-24	FRA DFN 24-40	ESP HOK 24-40	Total
Management	2.5	2.5	0.9	0.3	1.2	7.4
Research	2.4	1.8	0.8	0.3	0.7	6.0

Sources: MRAG (2008) and Com. Decision 811/2009

The allocation by fleet segment has been made using the same weights as for the OECD data, and FRA DTS 12-24 and FRA+ESP DTS 24-40 segments are those with the highest allocation and represent around 70% of the costs of management and research.

7.7. Estimation of the resource rent

7.7.1. Comparison of scenarios

The Northern stock of hake is being managed by TACs and quotas as well as effort. Both possibilities can be selected as the main scenario. Nevertheless, as it has been mentioned earlier, effort restrictions do not impose an important constrain given the low number of vessels in relation to the total effort allocation.

In Table 7.9 it can be seen that TAC min policy is providing the highest NPV $Profit_{15}$ (1,222 mln euro).of all the POs analysed (scenarios 1 to 6). It is followed by Effort min (1,104 mln euro) and TAC max (901 mln euro). In order to understand this result it is important to analyse the evolution of some indicators.

In terms of the discounted Profit of year 15, TAC min policy is the one providing the highest value. It implies that in comparison with the TAC max scenario, TAC min sacrifices the short term in favour of the last years of the simulation (after year 4 of the simulation the total Profit of the TAC min policy is higher than total Profit of the TAC max policy). Furthermore, the NPV $Profit_{15}$ is also higher than the Effort min policy option.

Neither TAC max nor Effort max (and obviously Open access) can be considered as sustainable in the long run as it is shown in Table 7.10.

Comparing TAC min and Effort min the differences come from the number of vessels and the total catches in year 15, for which Effort min has higher values for both. It will create higher total fixed costs which cannot be compensated with the higher revenues obtained from the higher catches. In general it can be said that the lower the total number of vessels the higher the resource rent.

Effort min is limiting the activity too strictly. Obviously this is the most conservative policy option, but with a lower NPV $Profit_{15}$ than the TAC min PO.

Catches in year 15 are maximized by TAC max policy but only TAC min, Effort min and Min min can be considered as sustainable policies. The remaining three policy options result on an H level in year 15 (at least for some species) beyond the MSY level. TAC min and Effort min policy options have similar values in terms of catches but the NPV $Profit_{15}$ of this last one is 10% lower.

All these characteristics imply that to follow the requirements of a sustainable policy in which rent is maximized, TAC min policy option has to be selected as the main scenario.

Table 7.9 Comparison of the scenarios

Scenario no.	Effort (1000 DAS)	Fleet (no. vessels)	Catch (1000 t)	$Profit_{15}$ (mln euro)	NPV $Profit_{15}$ (mln euro)
Average values 2005-7					
2005-7	132	650	110	56	
Values in year 15 of the scenario					
1. TAC min	123	547	63	72	1,222
2. Effort min	143	636	66	57	1,104
3. TAC max	192	723	66	48	901
4. Effort max	205	735	54	9	603
5. Open access	214	765	44	-18	332
6. Min min	123	547	63	72	1,222
7. Discount rate 2%	123	547	63	90	1,381
8. Discount rate 5%	123	547	63	58	1,086
9. Recovery mgt. costs	123	509	63	74	1,190
10. Static present fleet	123	650	63	58	923
11. Static minimum fleet	106	472	61	78	1,279
12. Dynamic minimum fleet	123	440	63	85	1,461
13. Optimum fleet (GVA)	198	705	68	70	1,481
14. Optimum fleet (profit)	99	353	66	104	1,742

After selecting the TAC min as the main policy option other scenarios based on this PO have been run. The first two have considered a lower (2%) or a higher (5%) discount rate (scenarios 7 and 8). Scenario 9 (Cost recovery) analyses the consequences of recovering the management costs allocated to each segment Last four scenarios explore possible adaptation paths of the fleets by fixing the number of vessels to the baseline level (scenario 10 – Static present fleet) and using the minimum number of vessels in a static sense (scenario 11 – Static minimum fleet) or in a dynamic sense (scenario 12 – Dynamic minimum fleet).

Two final scenarios have been also run where the PO is not playing any role. Scenario 13 maximizes the NPV GVA_{15} while Scenario 14 maximizes the resource rent (NPV $Profit_{15}$). In both cases the control variables are the number of vessels of each segment.

The H target selected for the species are, 0.29, 0.30, 0.8, 0.55 and 0.37 for hake, nephrops, sole, anglerfish and megrim, respectively. TAC min, Min min and Effort min are producing results below the target F, and also below the baseline H (except for anglerfish) while the rest of the policy options are above the baseline and target F. TAC min, Min min and Effort min can be considered clearly as sustainable and Open access and Effort max as unsustainable given that hake, megrim and hake are above the H target. Furthermore using these last two policy options megrim is driven almost to extinction (F=1). TAC max can also be considered to be above the sustainability levels, especially for megrim and nephrops.

TAC max gives the highest level of overall catches with 66.5 thousand tonnes. Effort min leads to the highest catches of hake and TAC max maximises the catches of the rest of the species, except anglerfish which are maximized under Effort max policy.

The number of vessels in year 15 is reduced in TAC min, Effort min and Min min policy options compared to the baseline situation. In particular the lowest number of vessels is obtained using TAC min and Min min policy options reducing them by 19% compared to the base case. The highest number of vessels is obtained by the least restrictive policy (Open access) increasing the fleet by 16% compared to the base case. Looking at the evolution of the number of vessels by segment, TAC min is substantially reducing the number of vessels of two segments (FRA DFN 12-24 and ESP HOK 24-40) compared to the base case which implies that in year 15 the overall number of vessels will be 16% lower compared to the TAC max scenario (which is the one with the highest NPV $Profit_{15}$).

Table 7.10 Effect of different policies on profit, harvest ratio, catches, effort and fleet

Indicator	2005-7	Scenarios					
		1. TAC min	2. Effort min	3. TAC max	4. Effort max	5. Open access	6. Min min
NPV $Profit_{15}$		1,222	1,104	901	603	332	1,222
Nominal $Profit_{15}$	56	121	96	81	16	-30	121
Discounted $Profit_{15}$		72	57	48	9	-18	72
Harvest ratio (year 15)							
Hake	0.36	0.24	0.30	0.29	0.42	0.86	0.24
Nephrops	0.24	0.23	0.19	0.31	0.31	0.31	0.23
Sole	0.33	0.30	0.33	0.40	0.39	0.39	0.30
Anglerfish	0.32	0.39	0.38	0.47	0.51	0.50	0.39
Megrim	0.27	0.32	0.34	0.47	1.00	1,00	0.32
Catch in (1000 t. for scenarios year 15)							
Hake	33.3	40.6	43.2	41.4	33.9	24.2	40.6
Nephrops	3.1	3.7	3.5	4.1	4.1	4.1	3.7
Sole	3.1	2.9	3.2	3.7	3.6	3.6	2.9
Anglerfish	9.8	9.8	9.7	11.4	12.1	11.8	9.8
Megrim	5.8	5.5	5.8	5.8	0.0	0.0	5.5
Effort (1000 DAS. for scenarios year 15)							
FRA DTS 12-24	67.6	84.7	73.4	109.4	108.3	107.8	84.7
FRA ESP DTS 24-40	30.6	29.8	33.2	37.4	56.9	50.9	29.8
FRA DFN 12-24	12.7	3.4	13.8	34.7	33.4	32.6	3.3
FRA DFN 24-40	4.8	1.4	5.2	7.2	6.0	5.1	1.4
ESP HOK 24-40	16.3	3.9	17.7	2.9	0.2	17.6	3.9
Fleet (no vessels. for scenarios year 15)							
FRA DTS 12-24	313	352	302	391	387	385	352
FRA ESP DTS 24 40	168	156	164	171	203	182	156
FRA DFN 12-24	60	16	66	124	119	117	16
FRA DFN 24-40	19	7	24	26	21	18	7
ESP HOK 24-40	79	16	79	12	5	63	16

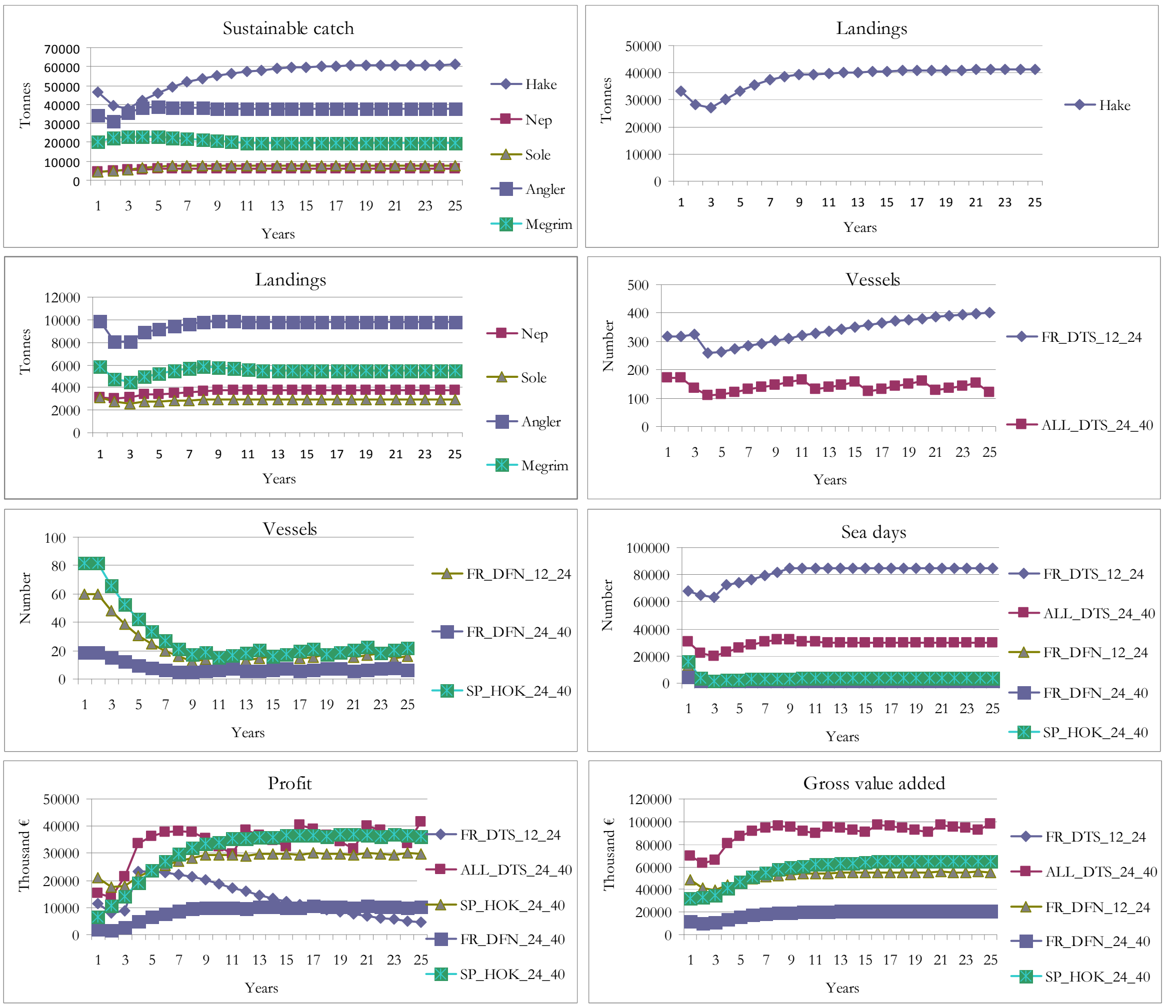
Scenario 1. TAC min

This scenario has been selected as the base scenario. Based on TAC limitations the logic of the dynamic of this scenario is to reduce the landings of the first years of the simulation by reducing the sustainable catch. It will also imply a reduction of the fishing effort. It also creates some adjustments in the number of vessels even if the trends are not the same for all segments.

As can be seen in the figure below between years 3 and 4 of the simulation the target catches tend to rise and the landings with them. By year 9, landings are stabilized for the rest of the simulation period. Following that, the number of vessels and days at sea also stabilize around the same value as in year 15. There is a clear exception to this behaviour for the segment FRA DTS 12-24. This segment from year 3 to the end of the simulation is able to increase the catches of all the species except hake (for this species 5 years are required). Consequently, profits and investment increase up to the 6th year of the simulation. The profits will start to decrease but their absolute positive level makes investments possible, and hence the number of vessels increases till the end of the simulation. Negative profits of FRA DFN 12-24, FRA DFN 24-40 and ESP HOK 24-40 lead to reduction of the fleet till year 7. After this year capacity of these three segments is stabilized.

Overall, in year 15 there is a reduction of the total number of vessels compared to the baseline. But this is not general for all the segments. Profits and GVA in this year are the highest of the six policy options and the landings of all the species are stabilized at a sustainable level (slightly higher levels for anglerfish and megrims and lower for the rest of the species than in the base line). NPV Profit$_{15}$ of the simulation is also the highest of the PO selected (Scenario 1 to 6).

Figure 7.3 Results of scenario 1. TAC min



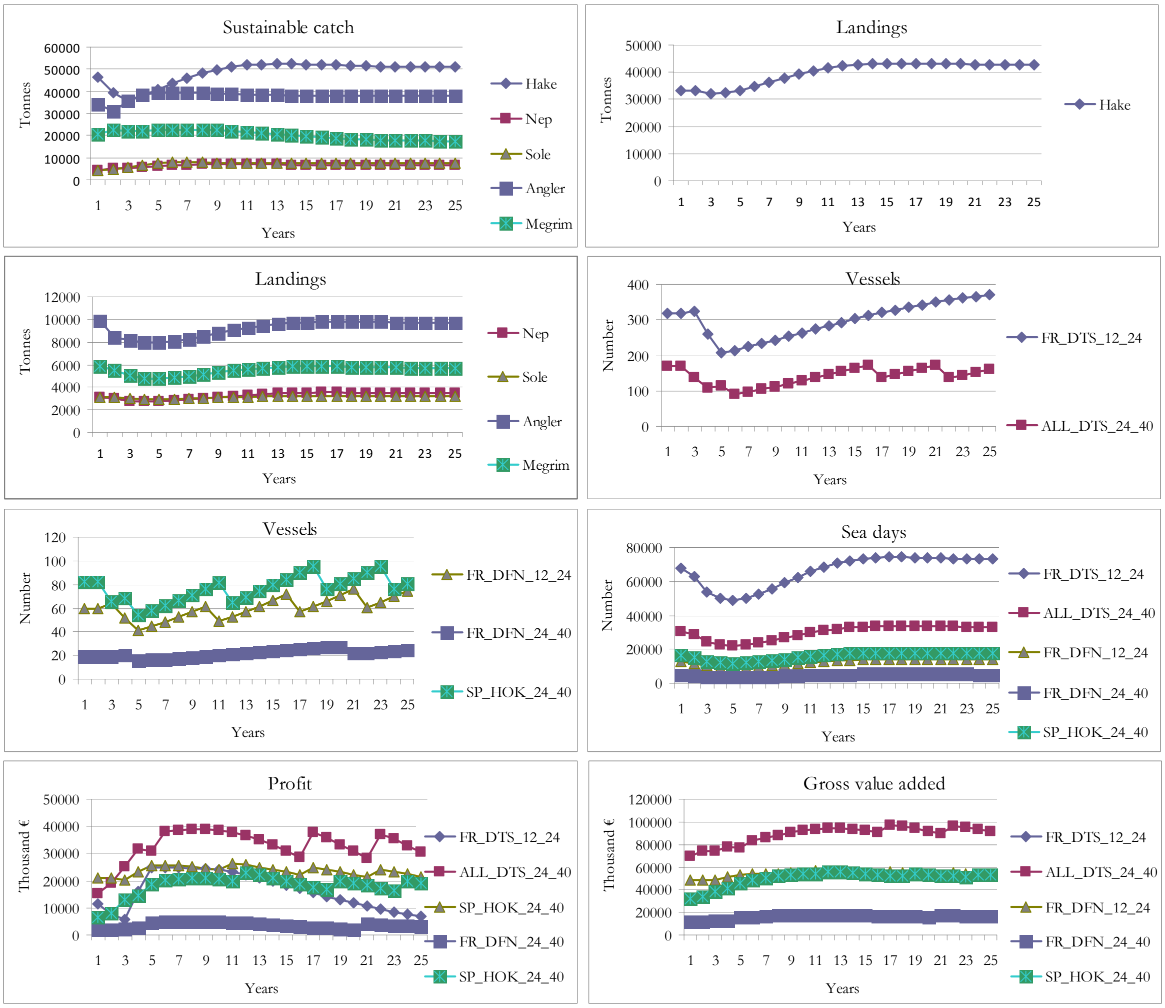
Scenario 2. Effort min

Effort min policy gives a lower value (10% lower) in terms of the NPV $Profit_{15}$ than the TAC min policy. Nevertheless this result is obtained in a different way. As in TAC min PO the initial years of the simulation present a reduction in the number of days at sea and landings of all the fleets, and this reduction is even higher than in TAC min. Landings are not stabilized until year 10 of the simulation.

The main difference, comparing with the TAC min PO, comes from the distribution by fleet of these changes. FRA DTS 12-24 is reducing its number of vessels by 30% until period 5 of the simulation. ESP HOK 24-40 and FRA DFN 12-24 reduce their fleet by a similar percentage, but afterwards their levels are stabilized. In conclusion, TAC min policy option is more restrictive than Effort min policy option for these two fleets.

Overall the number of vessels and the total days at sea in year 15 is lower than in the base case but higher than in the TAC min option. Considering also the redistribution of this effort among fleets, results show how Profit in year 15 and NPV $Profit_{15}$ are lower than in the TAC min PO even if the trend followed by profits can be considered as similar.

Figure 7.4 Results of scenario 2. Effort min



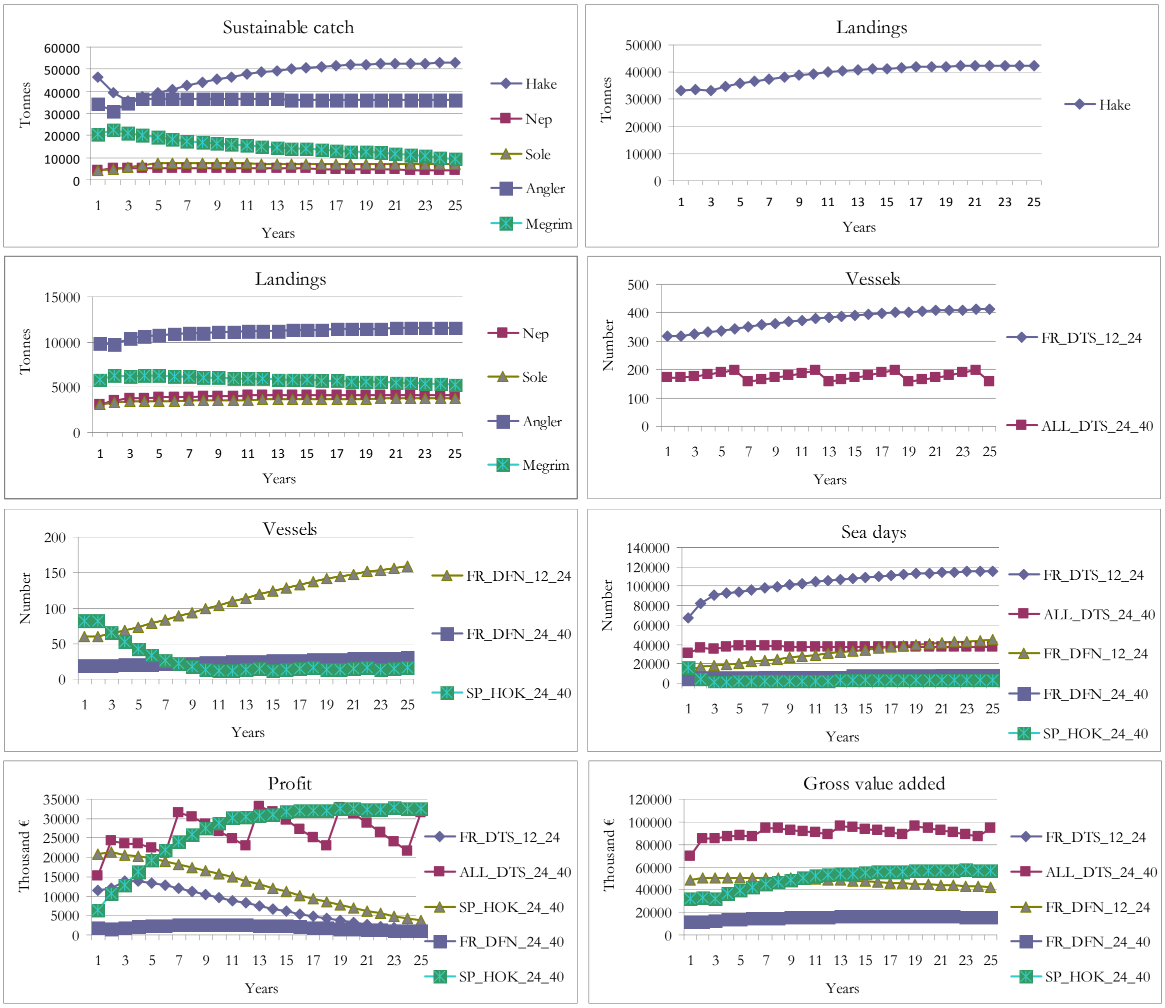
Scenario 3. TAC max

TAC max is the policy option with the third highest NPV $profit_{15}$ after the TAC min and Effort min POs. The problem with this PO is that it obtains these results in a non sustainable way. In this policy option landings of all the species are increased and in particular H in year 15 of nephrops and megrim are too high to be considered as sustainable. It is also possible to find differences in the trend of the landings, since the reduction of landings using Effort min or TAC min policy options in the first periods of the simulations is smaller than using TAC max.

Total numbers of vessels and total days at sea have increased comparing to the baseline (except for ESP HOK 24-40 segment), which is a completely opposite result comparing to the most restrictive POs (TAC min and Effort min). This is the main reason for obtaining lower profits than in the previous two (and more restrictive) POs.

This TAC max scenario is a clear example of a policy driven by the most abundant species (hake). This species is exploited up to the maximum sustainable catch, but in the meantime less abundant species such us megrim or nephrops suffer from this exploitation driving their respective fishing mortalities to non sustainable levels.

Figure 7.5 Results of scenario 3. TAC max



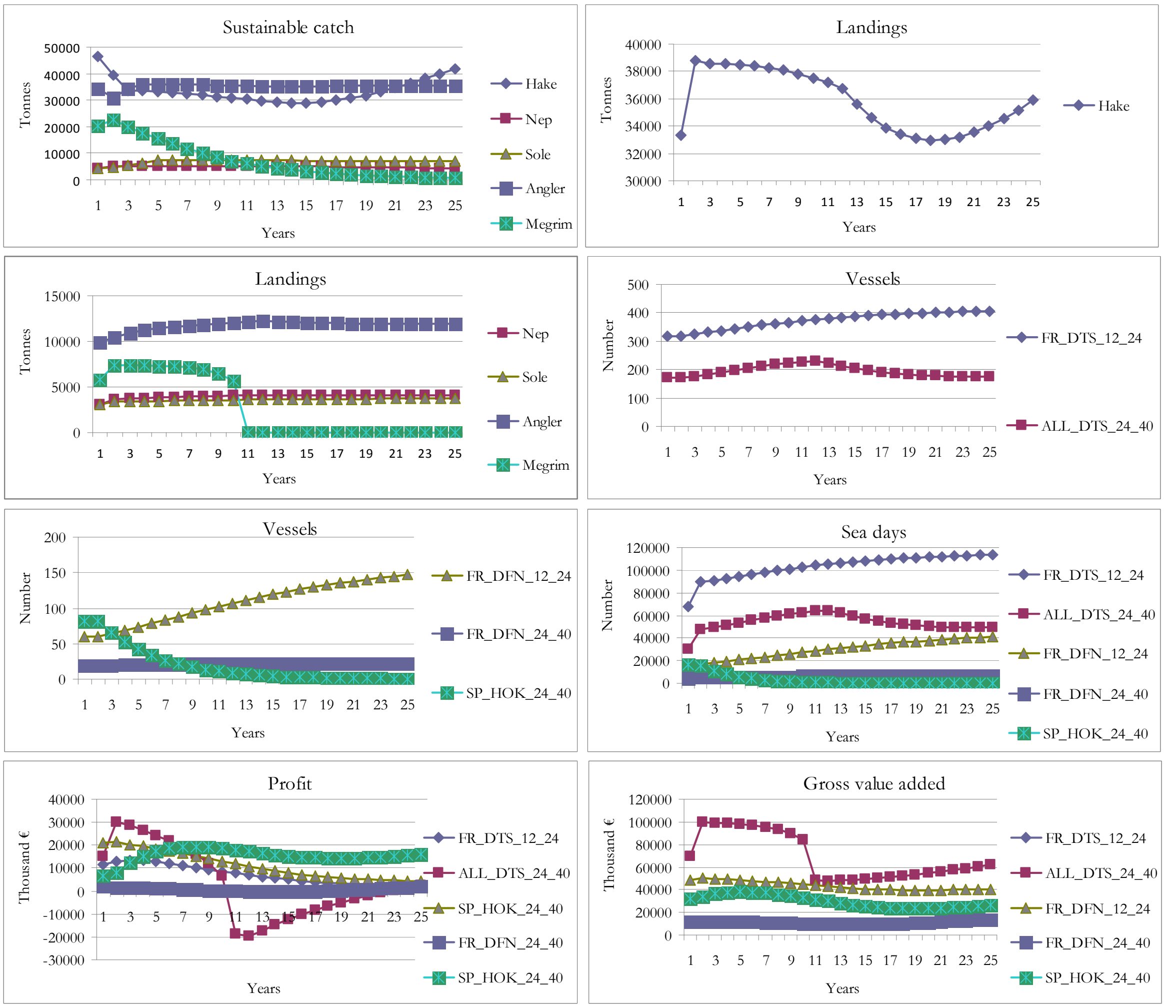
Scenario 4. Effort max

Effort max scenario can be interpreted in this case study as the one showing what happens when the policy option creates situations beyond the limits of the exploited system. Exploitation of the megrim is fully collapsed and the mortality of the rest of the species is above the H target. The only species that can be considered as sustainably exploited is sole.

In the first years of the simulation number of vessels starts to rise or remains constant (for some segments). The deteriorated biological situation (see the decreasing trend of the sustainable catch of hake and megrim in the figure below) leads to falling profits and some fleets (such as ESP HOK 24-40) will disappear.

Profits of all the segments analysed tend to zero and in fact big trawlers face negative profits in the last years of the simulation (years 10-15). The NPV $Profit_{15}$ is lower than in TAC min, Effort min and TAC max scenarios. As a conclusion it can be said that the situation in year 15 is clearly unsustainable in biological and economic terms.

Figure 7.6 Results of scenario 4. Effort max

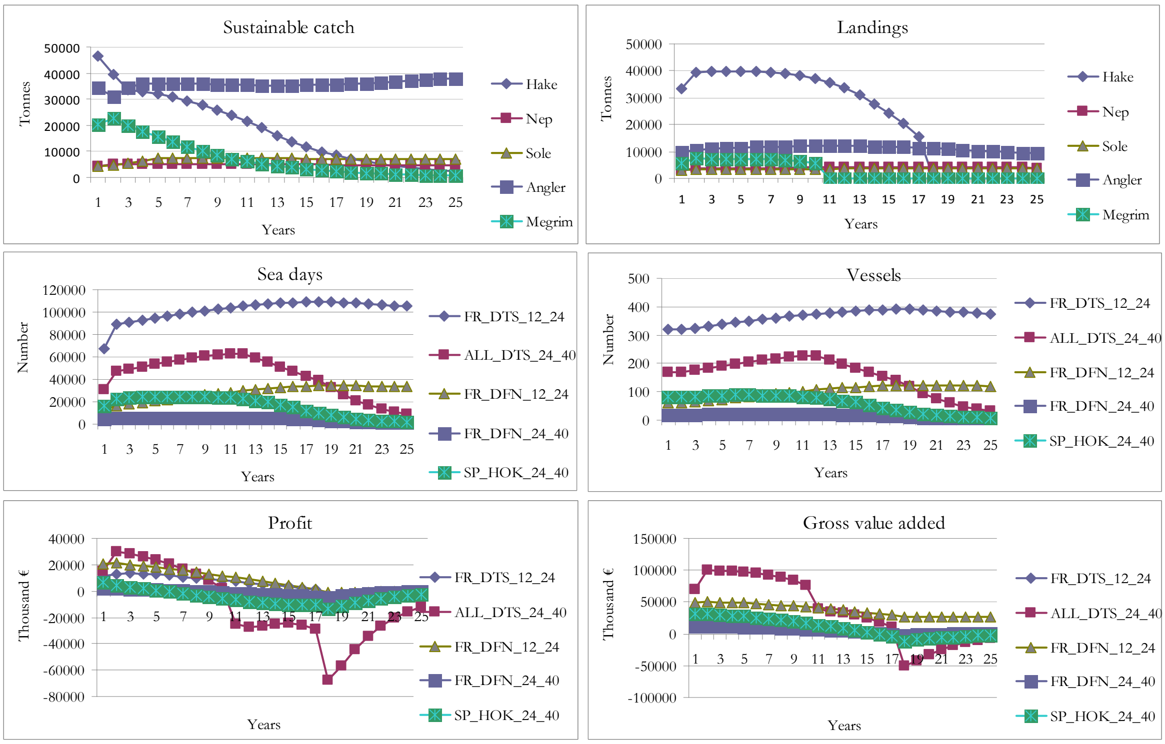


Scenario 5. Open access

The open access situation presents the results that can be seen in the vast literature describing the regime. The dynamics of the different indicators shown in the figure below are similar to the TAC max, but given that no limit is imposed in the effort, hake is also depleted.

The overall result of this policy option is that the stocks considered are overexploited, except sole, and that overcapacity rises with the highest number of vessels of all the policy options tested (increasing the fixed costs). The total catches reach lowest level in year 15, combined with the highest overall effort and the lowest NPV $Profit_{15}$. Again, it can be described as an unsustainable policy option in biological and economic terms.

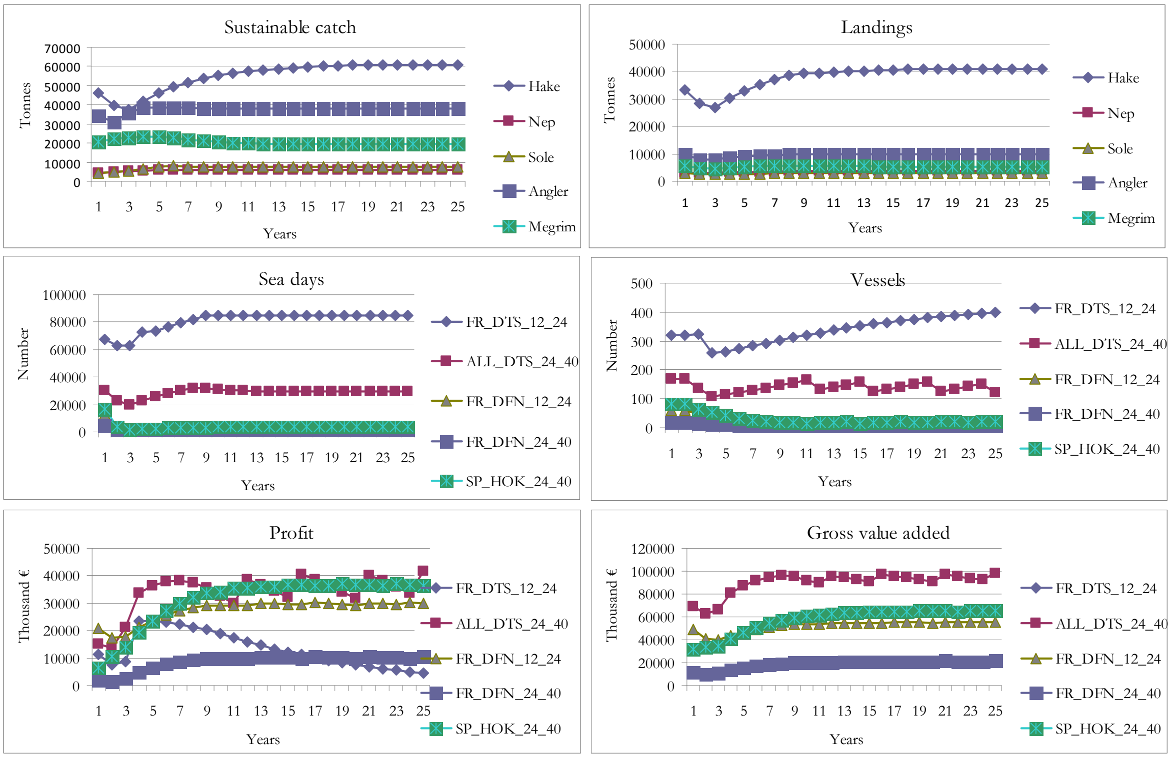
Figure 7.7 Results of scenario 5. Open access



Scenario 6. Min min

This policy is a mix between TAC min and Effort min in the first 4 years of the simulation. Afterwards it follows exactly the TAC min policy. In that sense the results obtained by this last policy can be extrapolated to the Min min policy option.

Figure 7.8 Results of scenario 6. Min / min



7.7.2. Role of discount rate (scenarios 7-8)

Table 7.11 Effect of discount rate on profit

Indicator	2005-7	Scenario		
		Main scenario Discount rate 3.5%	7. Discount rate 2%	8. Discount rate 5%
NPV $Profit_{15}$		1,222	1,381	1,087
Nominal $Profit_{15}$	56	121	121	121
Discounted $Profit_{15}$		72	90	58

The discount rate affects the NPV of a flow of values; in this case it affects the flow of the profits. The first result that can be obtained from Table 7.11 is straightforward, the lower the discount rate the higher will be the NPV $profit_{15}$ and the other way around. The same happens with the discounted value of the profit in year 15.

The relative changes (comparing them to main scenario) are not so straightforward. Scenarios 7 and 8 imply, respectively, a negative and a positive change of the discount rate (1.5 percentage points). The profit of year 15 is hence increased by a 25% and decreased by 20%, respectively. While the NPV $profit_{15}$ changes by a 13% and 11%, respectively. In other words the same change in absolute terms does not imply symmetric relative changes.

The discounted profit in year 15 is always higher than the baseline, for this policy option and for the three discount rates selected. The discount rate required to obtain a value lower than the baseline has to be higher than 5.40% (note that this result is only valid for this policy option).

Scenario 7. Discount rate 2%

The nature of this scenario is to give more weight to the future than to the present in comparison to the main scenario. Discounted profit is 90% higher than in the baseline and 25% higher than comparing it to the main scenario. In this case the NPV $profit_{15}$ is 13% higher than in the main scenario.

Scenario 8. Discount rate 5%

The nature of this scenario is to give less weight to the future than to the present in comparison to the main scenario. Discounted profit is 3% higher than in the baseline and 19% lower than the main scenario. In this case the NPV $profit_{15}$ is 11% lower than in the main scenario.

7.7.3. Resource rent and recovery of management costs (scenario 9)

This scenario has been selected in a way in which each segment has to make an annual payment equal to the management cost allocated to them. The exact allocations by segment, and hence the annual amount to recover by segment, is based on the cost of support (EFF Axis 1 in Table 7.7) and management and research costs (Table 7.8) are 7.9 mln euro for FRA DTS 12-24, 11 mln euro for FRA+ESP DTS 24-40, 2.8 mln euro for FRA-DFN 12-24, 0.9 million euro for FRA DFN 24-40 and 5.9 mln euro for ESP HOK 24-40. It implies approximately 28.5 mln euro per year or a NPV of 328 mln euro in the 15 years of the simulation (using a discount rate of 3.5%).

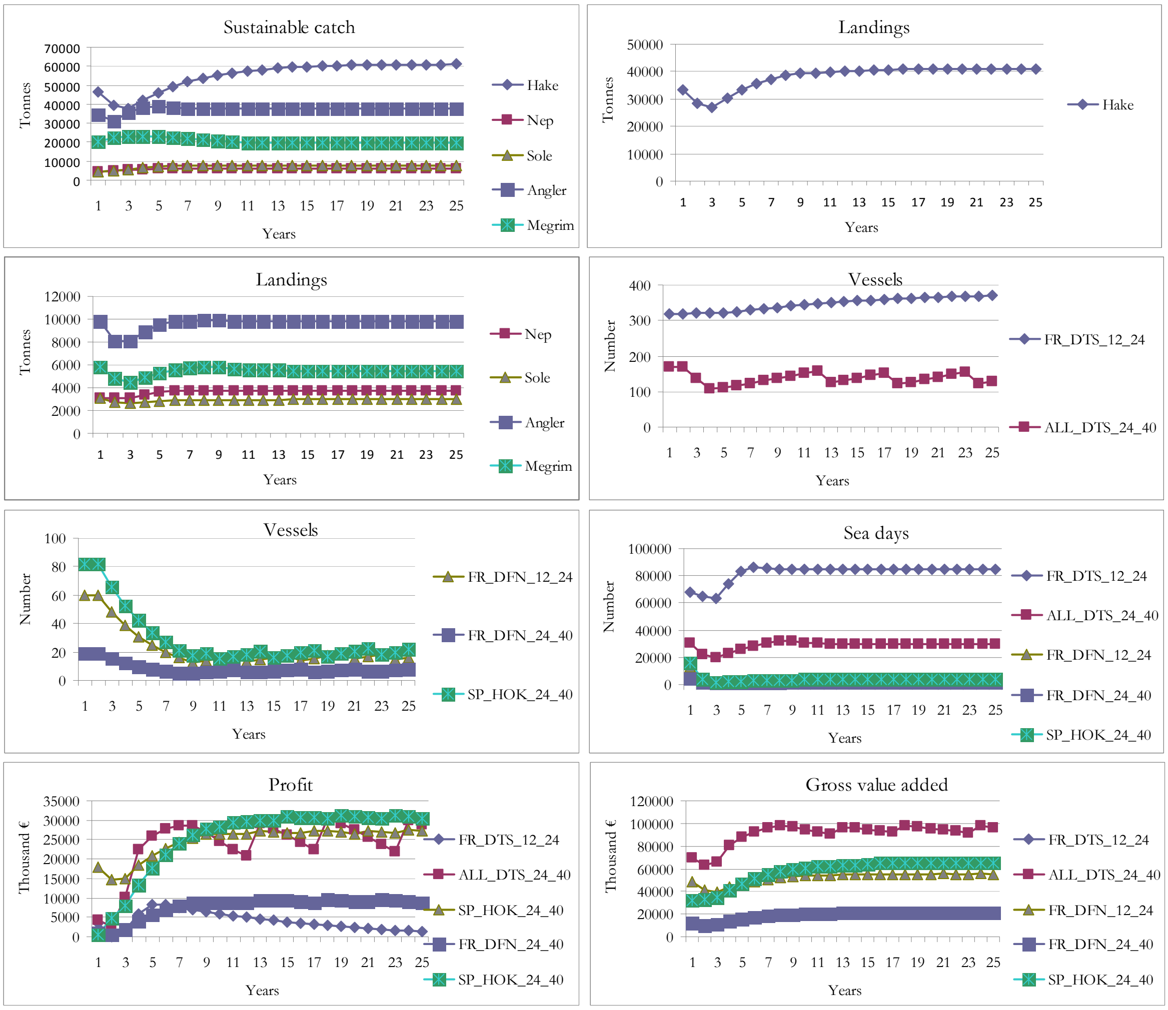
In this scenario the NPV $profit_{15}$ will be 1,190 mln euro and hence adding the NPV of the payments for access made (328 mln euro) the result is 1,518 million euro, that is, 296 mln euro above the main scenario (TAC min). It implies that additional rents are obtained given that the fixed payments are creating the right incentives.

In particular there are two fleets affected in the simulation period; FRA DTS 12-24 will increase the investment and the fleet will be bigger after the period 4 of the simulation while the FRA+SP DTS 24-40 segment will be reduced. The rest of the segments are not being affected until the period 7 of the simulation in which all the remaining segments face a small disinvestment. This re-distribution of the fleet induced by the cost recovery system is creating these higher NPV $profits_{15}$ through a reduction of the total number of vessels while total catches are similar.

Table 7.12 Resource rent and recovery of management cost

Indicator	2005-7	Scenarios	
		Main scenario: No recovery of management costs	9. Recovery of management costs
NPV GVA_{15} (mln euro)		3,477	3,137
Nominal GVA_{15} (mln euro)	56	333	336
NPV $Profit_{15}$		1,222	1,190
Fixed payment for access (mln euro)/year		0	28.5
NPV Payment for $access_{15}$		0	328
Nom Profit (mln euro)	55.7	121	125

Figure 7.9 Results of scenario 9. Recovery of management costs



7.7.4. Optimization of capacity (scenarios 10-14)

Table 7.13 Impact of optimization of the fleet size

Indicator	2005-7	Scenarios*					
		Main scenario TAC min	10. Static present fleet	11. Static minimum fleet	12. Dynamic minimum fleet	13. Optimum fleet (GVA)	14. Optimum fleet (profit)
NPV $Profit_{15}$ (mln euro)		1,222	922	1,279	1,461	1,481	1,742
Nominal $Profit_{15}$ (mln euro)	56	121	98	132	143	118	175
Discounted $Profit_{15}$ (mln euro)	56	72	59	79	86	70	105
$Fleet_{15}$ (no vessels)	639	547	650	472	440	705	353
$Effort_{15}$ (1000 DAS)	132	123	123	106	123	198	99
$Catch_{15}$ (1000 t)	110	63	63	61	63	68	66

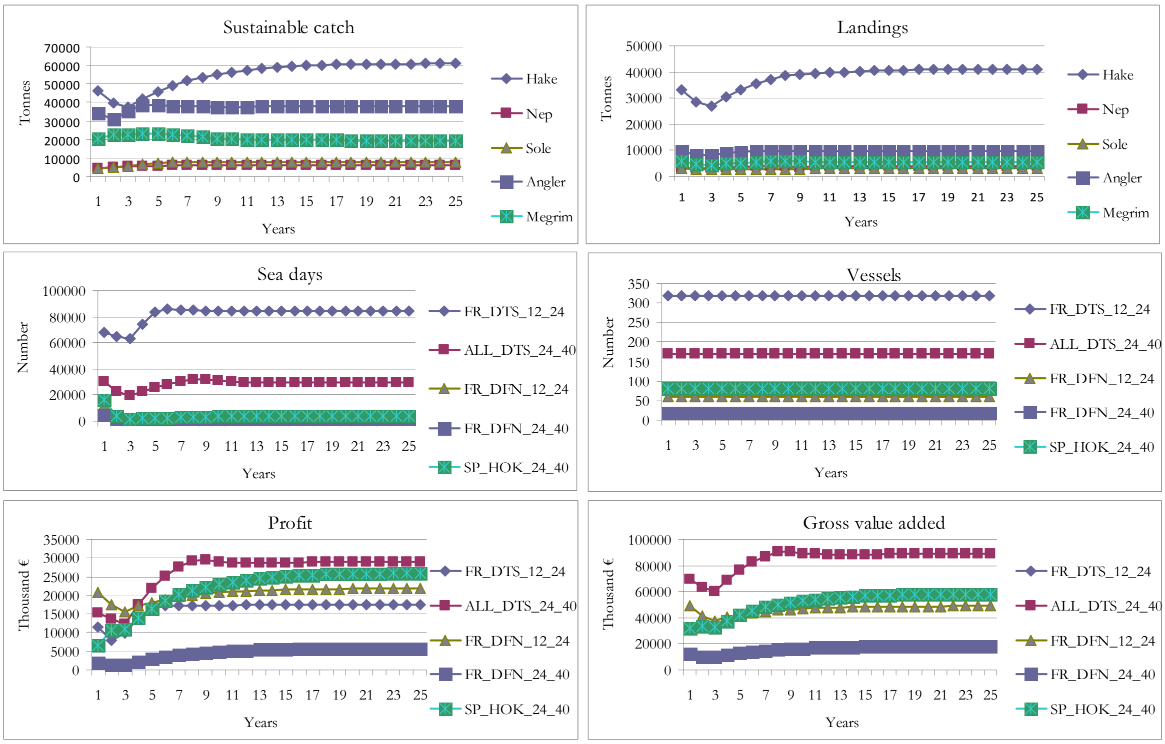
*NPV row refers to the sum, Other rows refer to the value in year 15.

Scenario 10. Static present fleet

This scenario is based on maintaining the number and composition of the present (baseline) fleet throughout the whole simulation period and simultaneously using the TAC min policy option. As it can be seen in Table 7.13 the NPV $Profit_{15}$ is lower than in the main scenario. The reason for this is that in the first years of the simulation the existing bigger fleet do not to follow the (dis)investment decisions reducing the total profits. This effect is maintained in all the years of the simulation.

As it can be seen in the figure below, levels of landings, as well as the sustainable catches are almost the same as in the main scenario. The reason for that is that independently to the dynamics of the fleet, the TAC min policy option is the main driver of the fishery.

Figure 7.10 Results of scenario 10. Adaptation with 'present' fleet



Scenario 11. Static minimum fleet

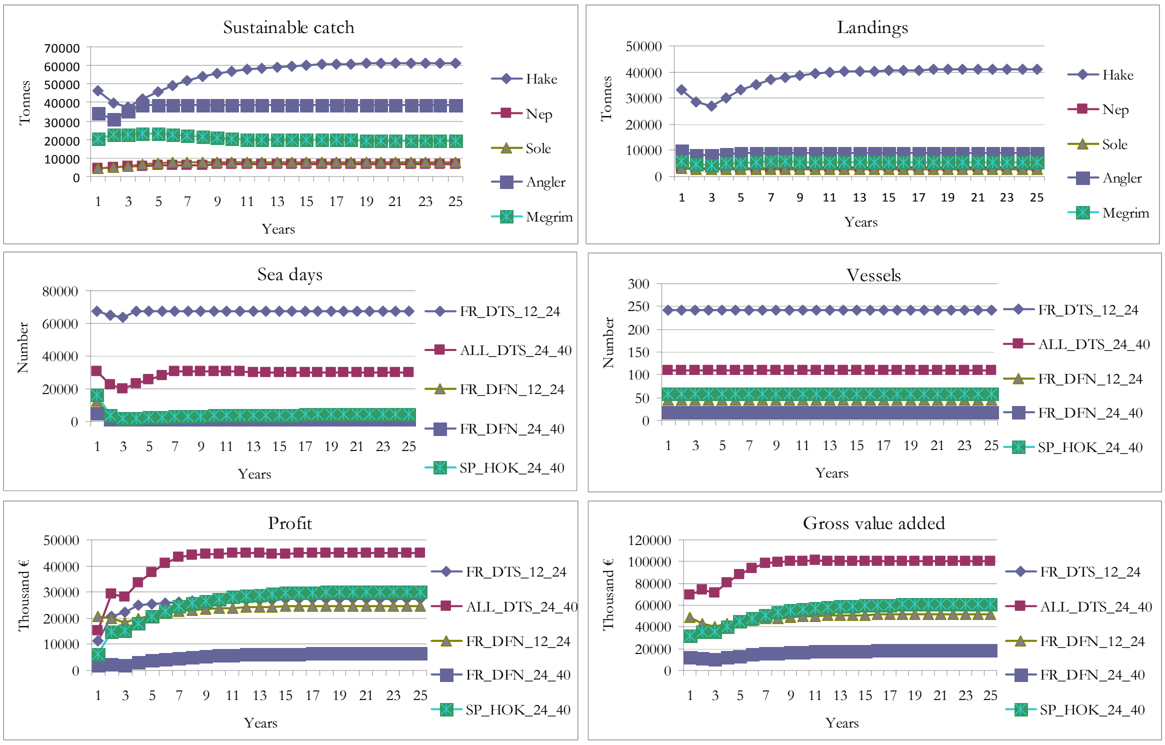
In this scenario it is assumed that each vessel uses the maximum possible effort of the first year. Given that the current effort is lower than the maximum possible, the number of vessels of each segment will be reduced in the first year of the simulation. This number of vessels is maintained constant at this minimum level.

The year 15 of the simulation shows a lower number of vessels than in the scenario 1. In this particular case study it reduces the number of vessels comparing to the main scenario obtaining a higher NPV $profit_{15}$ than in the TAC min PO in which investment decisions are considered (scenario 1). Profit in year 15 is a 9% higher than in the TAC min PO.

Overall the profit shows an increasing trend until year 5 of the simulation and then it remains stable. Number of vessels, effort and catches are also stable through the simulation period. These catches can be considered to be sustainable.

The policy can be considered as sustainable in biological and economic terms.

Figure 7.11 Results of scenario 11. Static minimum fleet



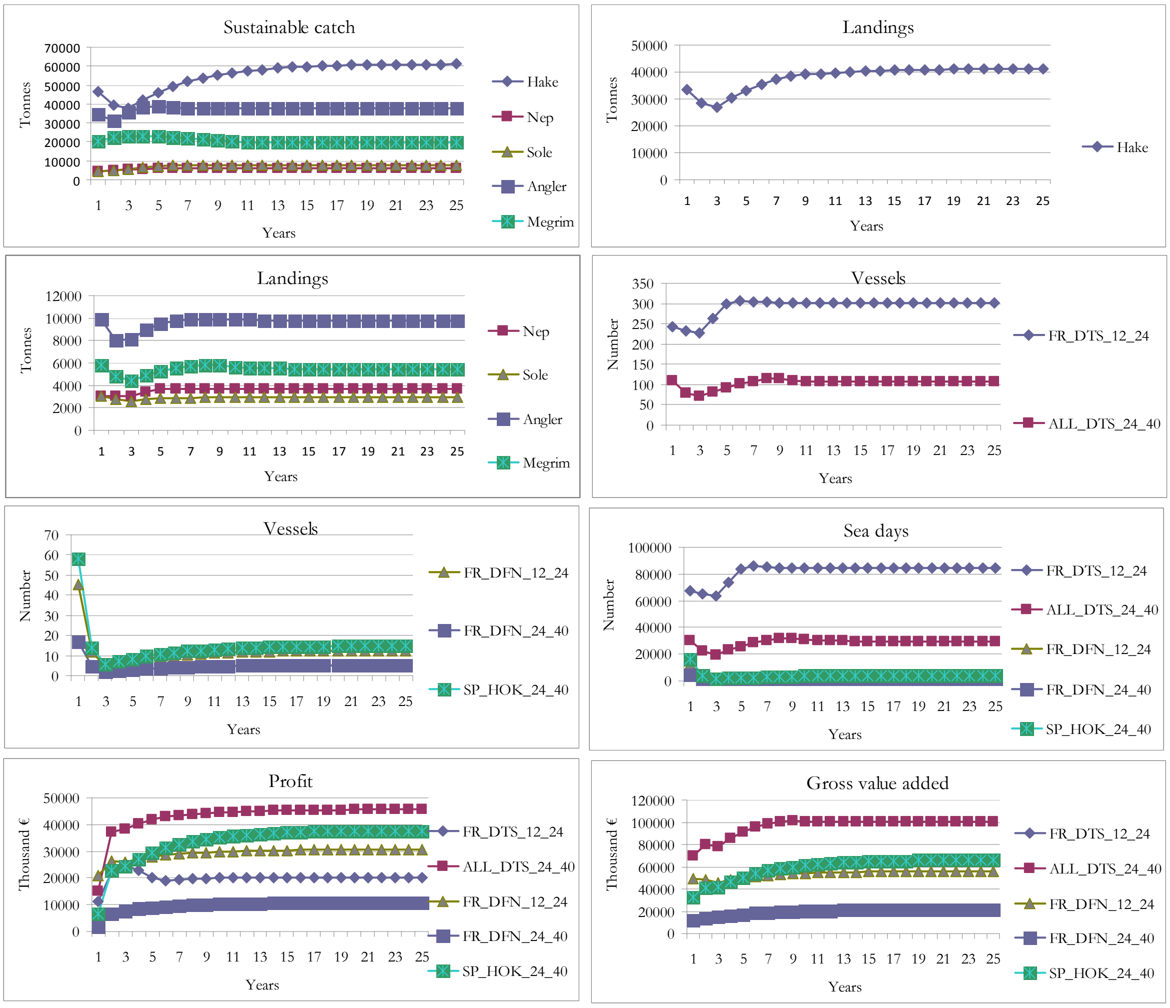
Scenario 12. Dynamic minimum fleet

In this scenario each vessel uses the maximum effort that they can in each year of the simulation. The total effort allowed follows from the policy option and this drives the evolution of the different segments.

The number of vessels is reduced at the beginning of the simulation, but after year 4 it starts to rise. At the end the results present higher NPV profit$_{15}$ and level of catches as in scenarios 10 and 11 (present fleet and minimum –static- fleet) and the lowest number of vessels of all the scenarios tested.

The policy can be considered as sustainable in biological and economic terms.

Figure 7.12 Results of scenario 12. Dynamic minimum fleet



Scenario 13. Optimum fleet (GVA)

This scenario maximizes NPV GVA_{15}. The optimization is free (no restrictions) under the following constraints:

- The fishing mortalities (F) of all the species have to be equal or lower to 1. This constraint is simply considering than an H higher than 1 is unrealistic[39].
- At least 1 vessel per segment is required in all the periods. Furthermore, the number of vessels in each segment changes at most by +/-20% from one year to next.

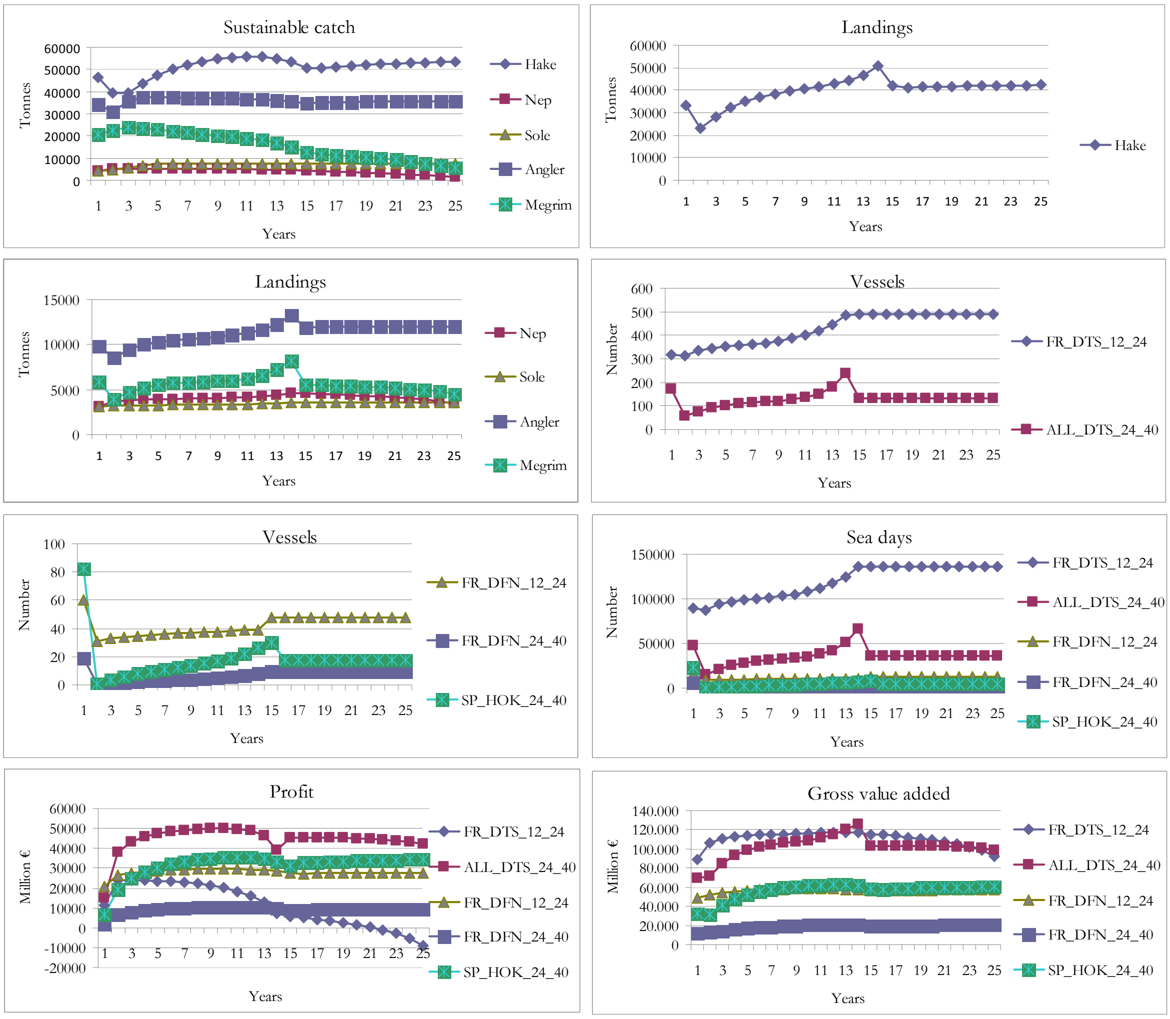
Results of the simulation show how the NPV GVA_{15} can be increased by 11% from 3,477 to 3,888 mln euro. This is not made by reducing the total number of vessels, at least in overall terms. Actually, the optimization procedure increases the number of vessels of the segments. In the first two periods of the simulation all the segments reduce their number of vessels. Afterwards there are small changes in the number of vessels of the segments but of minor magnitude except for the FRA DTS 12-24 and FRA+ESP DTS 24-40 segments. These two segments start to increase their number of vessels up to a level beyond (FRA DTS 12-24) or similar (FRA+ESP DTS 24-40) to the baseline situation.

It is also remarkable that the GVA in year 15 is slightly lower than in scenario 12 even if the NPV GVA_{15} is higher.

Nevertheless and even if the NPV $profit_{15}$ is higher than the rest of the fleet changes scenarios and also than the baseline scenario (1,481 mln euro) which implies that the maximization of the GVA goes in line with the maximization of the rent obtained, the maximum profit is not obtained, and obviously it will require a reduced number of vessels as it will be shown in scenario 14.

[39] It is straightforward that this constraint is implicit in the other scenarios tested. Nevertheless for this scenario it has to be made it explicit for computing (optimization) purposes.

Figure 7.13 Results of scenario 13. Optimum fleet



Scenario 14. Optimum fleet (profit)

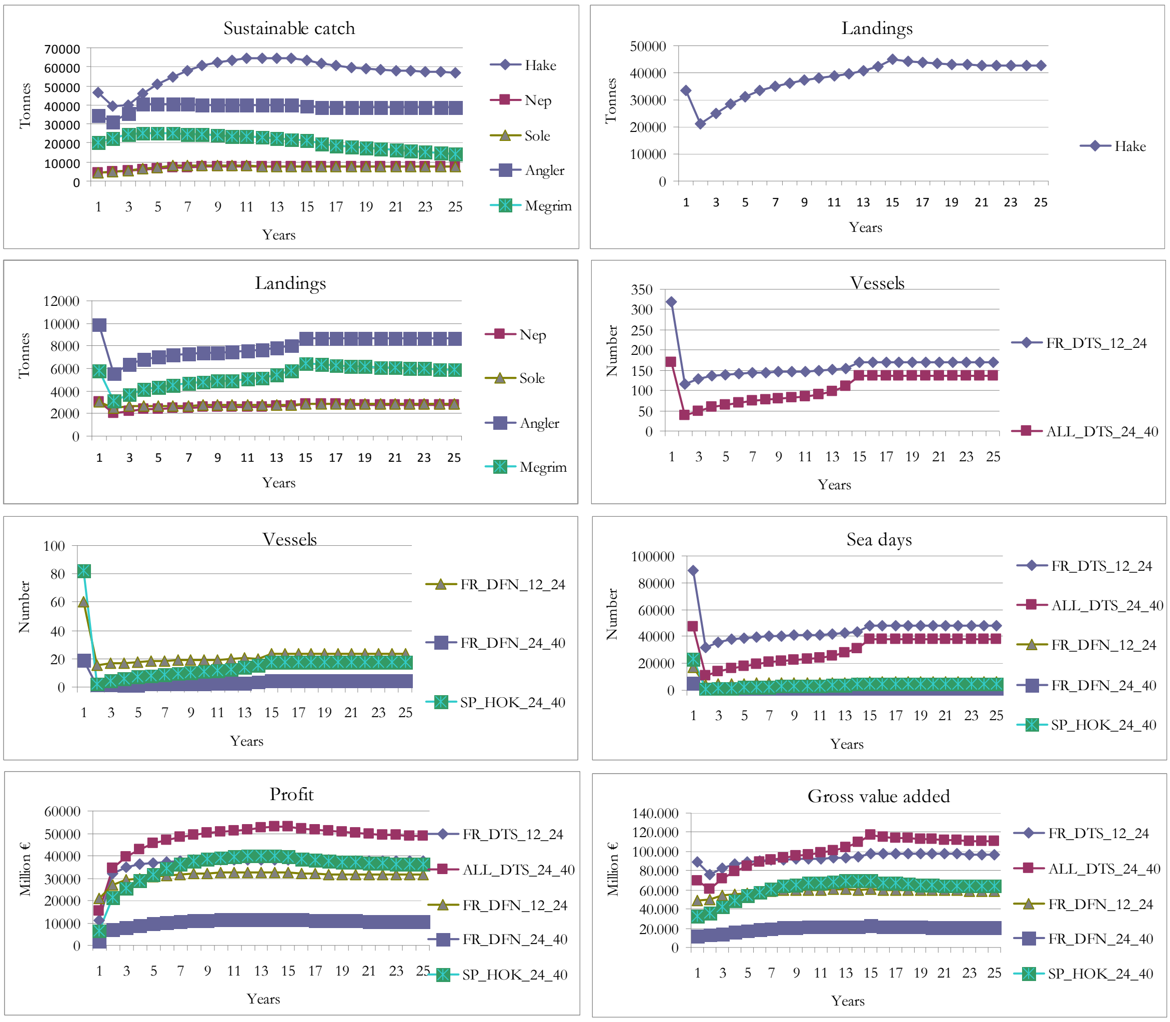
This second optimum fleet scenario has been designed determining the number of vessels of each segment from the period 2 to the period 15 of the simulation in a way in which the NPV of the net profit is maximized. The optimization is free (no restrictions) except for some constraints that have been used in order to obtain "real" and interior solutions. In particular the constraints used are:

- The fishing mortalities (F) of all the species have to be equal or lower to 1. This constraint is simply considering that an H higher than 1 is unrealistic[40].
- At least 1 vessel per segment is required in all the periods. Furthermore, the number of vessels in each segment changes at most by +/-20% from one year to next.

Results of the simulation show how the NPV of the net profit can be increased by 42% from 1,222 to 1,742 mln euro. This is made by reducing the total number of vessels in overall terms and by segment. NPV of the GVA will be slightly higher than in the base line scenario.

It can be seen how profits of all the segments will steadily increase till period 10 of the simulation. Afterwards they will remain stable, while catches will remain at approximately the same level as in the baseline scenario.

Figure 7.14 Results of scenario 14. Optimum fleet (profit)



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[40] It is straightforward that this constraint is implicit in the other scenarios tested. Nevertheless for this scenario it has to be made it explicit for computing (optimization) purposes.

These results can be better explained by comparing them with scenario 13.

Figure 7.15 Comparison between scenario 13 and scenario 14.

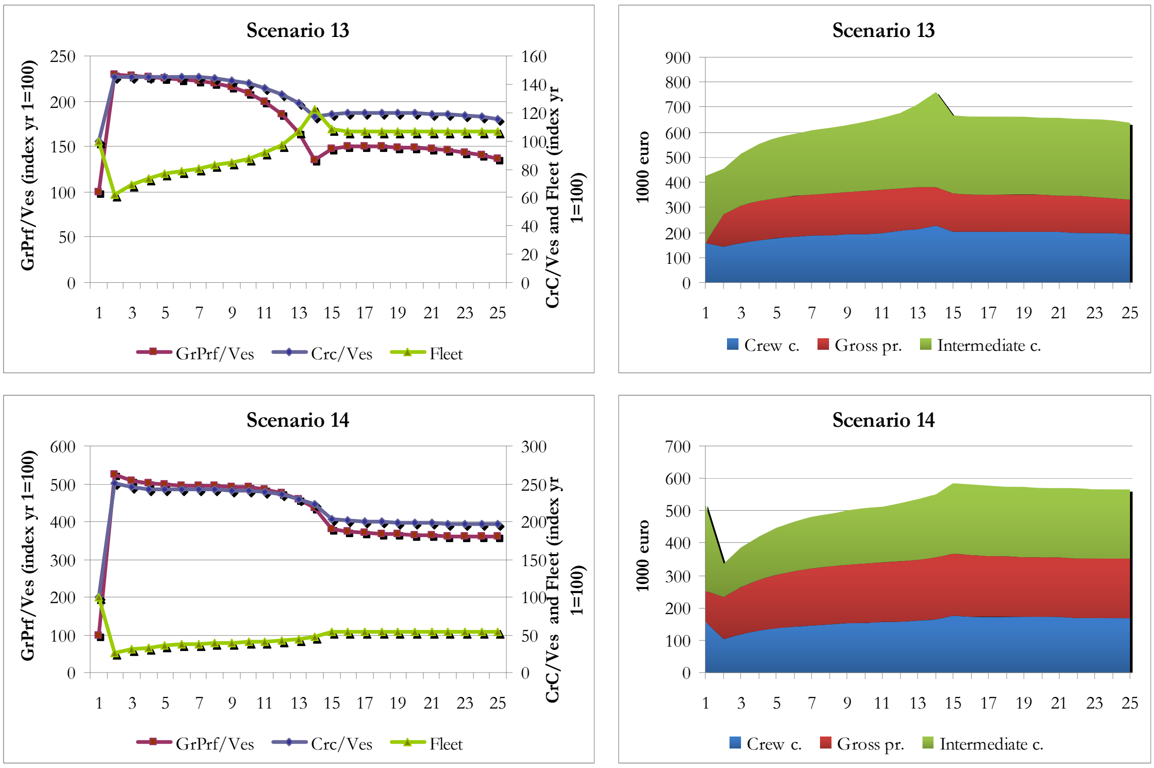


Table 7.14 Comparison of scenarios 13 and 14 (values in mln euro, fleet number of vessels)

	Scenario 13	Scenario 14
NPV GVA_{15}	3,888	3,569
NPV $profit_{15}$	1,481	1,742
NPV Crew $costs_{15}$	2,114	1,671
NPV capital $costs_{15}$	292	156
GVA year 15	354	367
Profit year 15	118	175
Crew costs year 15	205	175
Capital costs year 15	31	17
Fleet – average 1-15	573	281
Fleet – year 15	705	353

As it can be seen the main difference between scenarios comes from the fleet size. When GVA is maximized one fleet (FR DTS 12-24) increases their size compared to the baseline situation. When Profits are maximized all the fleets reduce their size at the beginning of the period. This can be easily seen in the figure above, where scenario 13 presents increasing trends for the fleet along the simulation while scenario 14 presents a flat trend.

In terms of the Gross profit and crew costs (per vessel) in both cases the trends are similar, but not the value of the index. It is clear how scenario 14 presents an index value for both indicators that double the one obtained in scenario 13.

Considering the absolute values, scenario 14 always gives higher gross profit (except for the first three periods of the simulation in which the possible increments of the fleet sizes are constrained) but lower crew costs. This is a consequence of the nature of scenario 13 in which the maximum of the sum of these variables (discounted) is the target and hence the labour remuneration is optimized by increasing the number of vessels (scenario 13).

Both objectives (max profit and max GVA) are quite different in the results that are provided. Max GVA (scenario 13) is based on increasing the fleet (at least one segment) and by increasing the remuneration of the labour the value added is increased. On the other hand, scenario 14 increases the performance by vessel of each vessel individually, but with a much lower number of vessels on hence with lower absolute values on the labour remuneration.

7.7.5.Assumptions and technical background (by main model modules)

The main assumption considered in this case study is how to allocate AER 2009 data.
AER 2009 provides data of the French and Spanish fleet segments targeting the northern stock of hake in a multispecies context. Nevertheless it has some limitations that have been solved, for the purpose of this study, combining the different sources of information. The main difficulties encountered are:

- The fleet segments considered for Spain are not split for the Mediterranean and Atlantic areas. Furthermore for the case of the Atlantic some vessels only operate in the ICES Division VIIIc, which corresponds to the southern stock of hake (same species but different management stock. which is being exploited only by Spain and Portugal).
- The fleet segments considered for France are not split for the Mediterranean and Atlantic areas.
- AER 2009 does not provide capital costs for the Spanish segments
- AER 2009 does not provide fixed costs for the French segments.

Considering these limitations several assumptions and modifications have been done in order to extract from the AER 2009 the corresponding number of vessels and their economic performance variables.

The data sources available and used, for doing so, are:

- The AER 2009
- SEC (2007). "Impact assessment of long-term management plans for northern hake"
- (SGBRE-05-07) and the ICES (several years). Report of the Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim (WGHMM). I. C. A. 09. Copenhagen.

The steps considered to convert the data of the segments of AER 2009 to data of the northern hake case study are:

- Select the segments to be considered from SEC (2007)
- Compare the data of both countries used in the SEC (2007) with the data of the AER and assume that the proportion of the vessels targeting northern hake by segment remains constant.
- Capital cost for Spain has been obtained from a subset of vessels from which data exists and extrapolated to the rest of the fleet. This subset is for the vessels with base ports Ondarroa and Pasaia and accounts for approximately the 30% of the total Spanish fleets targeting northern stock of hake.
- Fixed costs for France have been obtained from (SEC 2007).
- Missing prices have been obtained from the AER 2009 assuming the same price/segment structure for France and Spain.

Some other assumptions have been made through the estimation of the parameters:

- Elasticity for biomass and effort of the production function have been obtained from M. Dolores Garza-Gil, Manuel M. Varela-Lafuente, Juan C. Surís-Regueiro (2003). European hake fishery bioeconomic management (southern stock) applying an effort tax. Fisheries Research 60. PP199–206. For the rest of the segments similarities between gears have been used to fix these parameters.
- Finally some estimations of the growth function of some stocks (anglerfish and nephrops) have been made by fixing the carrying capacity at the maximum of a moving average. The reason for that is that given the available data it has been impossible to obtain a statistically significant estimation of intrinsic growth rate and carrying capacity simultaneously.

8. ATLANTIC ANCHOVY FISHERIES

8.1. Summary and conclusions

Main conclusion

The four segments analysed in this fishery realized in 2005-7 on average a total net loss of 21 mln euro. Average annual discounted net profit ranges under most scenarios between 7 and 66 mln euro. Elimination of overcapacity and recovery of stocks would produce a discounted net profit of 5-507 mln euro by the year 15. (see Figure 8.1)

Summary of the case study

Anchovy of the Bay of Biscay is a short-lived pelagic fish. The stock experiences large inter-annual fluctuations in abundance caused mainly by variations in recruitment mostly driven by environmental factors. Recruitment has been very low since 2001. In particular, recruitment of the year 2004 was classified as a failure. This has resulted in a decline of the stock and led to the closure of the fishery in the second half of 2005 until 2009. In year 2010 the fishery has been reopened with a low TAC of 7,000 tonnes. The anchovy has historically been one of the main resources of revenues for the Spanish purse seiner fleet and for French purse seiners and trawlers.

Anchovy fishery has traditionally been managed through annual TACs shared between France and Spain. Currently a Long Term Management Plan for this species is under development.

A variety of policy scenarios has been tested in this multi-species and multi-fleet fishery. Three of the policy options are restrictive (TAC min and Effort min and Min min) and the others are less restrictive (TAC max and Effort max). Restrictive policies options produce biologically sustainable results (F below the H target) while non-restrictive policies do not.

Among all the sustainable policies, the one with the highest sustainable NPV $Profit_{15}$ is the Effort min and it is also the one giving the highest sustainable catches, in that sense this policy option (PO) is the one closest to the MSY concept of the policy options analysed. Following these two characteristics this policy has been selected as the baseline scenario.

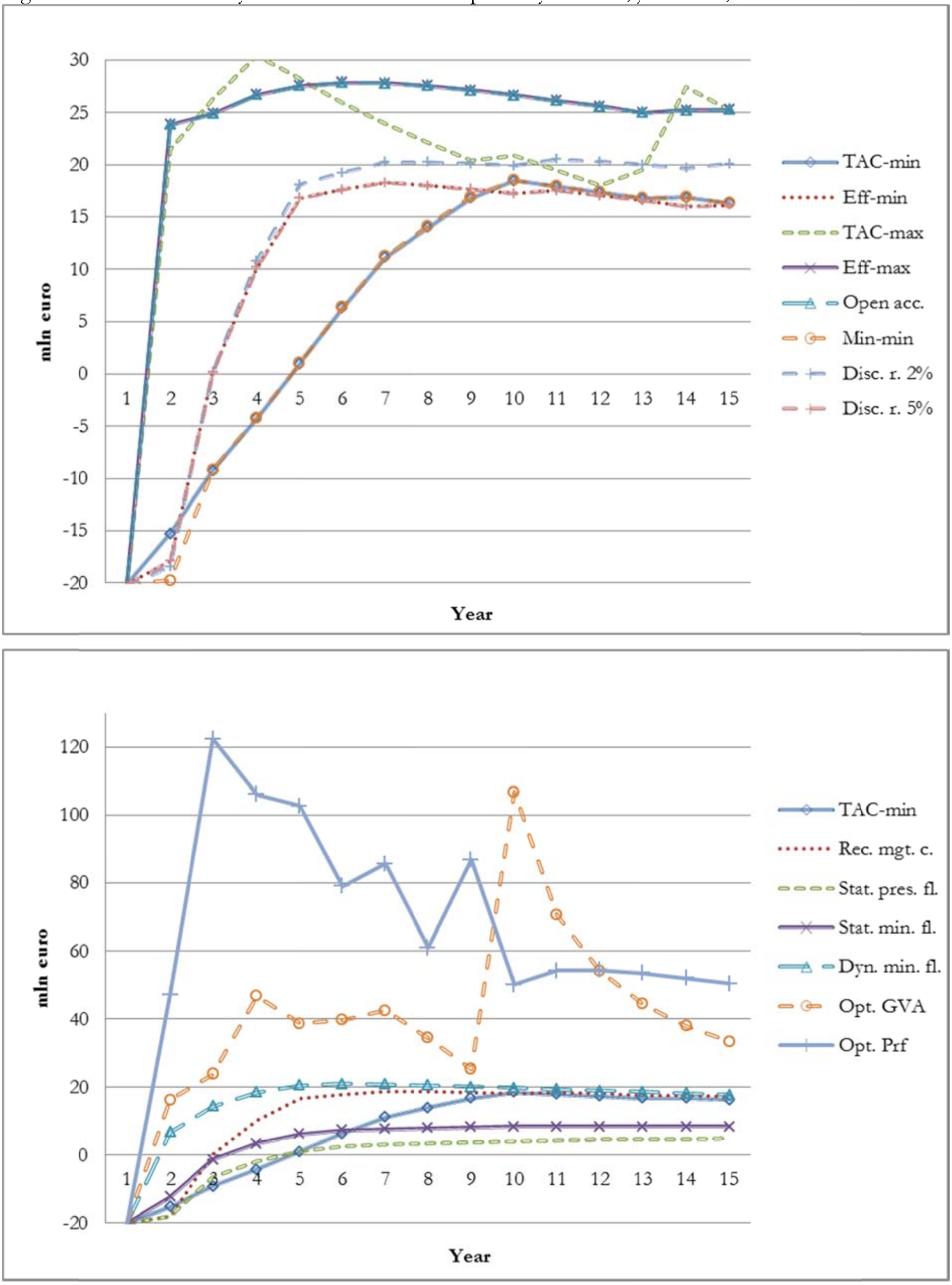
The discount rate is an important factor that has to be taken into account to calculate the net present value of the profit. It makes it necessary to test different discounts rates. As expected, depending on the discount rate selected the NPV $Profit_{15}$ differs considerably. For the baseline policy option the NPV $Profit_{15}$ is a 15% lower than when the discount rate used is 5% rather than 3.5% and 18% higher when the discount rate used is 2.5%.

Several scenarios deal with the question of instantaneous or gradual adaptation of the fleet. These scenarios show how when the fleets are set constant at the initial level and when the fleets are reduced to the minimum required level in year one and this level is maintained throughout the period, the NPV $Profit_{15}$ is lower than in the baseline PO. However, the dynamic minimum fleet scenario gives higher rents than the baseline scenario.

The optimum fleet size, calculated by maximizing the NPV $Profit_{15}$, is higher than in the baseline scenario, but this conclusion can vary if each segment is analysed separately. In that sense it can be concluded that the overcapacity has to be measured at the segment level and not at a fishery level.

The feasibility and consequences of the full recovery of management costs have been also analysed. The management costs allocated to each segment are assumed fixed. In this case, additional rents can be captured by society because they set the right incentives. In this particular case study the NPV $Profit_{15}$ are higher when the management costs are recovered than when they are recovered (without adding up the net present value of the payments).

Figure 8.1 Atlantic anchovy – discounted annual net profit by scenario, years 1-15, mln euro



To summarize, using a discount rate of 3.5% the maximum resource rent (NPV Profit15) is given by the optimum fleet scenario (985 mln euro) and the minimum is given by the static current fleet scenario, -4.9 mln euro. Therefore, the range between the lowest and the highest resource rent is high, showing how there is much room to improve the rent obtained from this fishery. Depending on how the adaptation of the fleet is, the rents are higher or lower than the rents given by the baseline PO. The implementation of the system of recovery of management costs creates additional total rents which including the payments are around the 84%.

8.2. Case study definition

8.2.1.Fleet and landings

Anchovy of the Bay of Biscay is exploited by the Spanish purse seiner fleet, French purse seiner fleet and French pair trawler fleet. Two different segments exploit anchovy in each country (SP PTS 12-24 and SP PTS 24-40 in Spain and in France the segments are FR PTS 12-24 and FR PTS 24-40).

The number of Spanish vessels operating in the fishery is around 150. 20 of them belong to the SP PTS 12-24 segment and 130 of them to the SP PTS 24-40 segment. For France, the segment FR PTS 12-24 has 96 vessels and the segment FR PTS 12-24 has 49. As Table 8.1 shows, the Spanish PTS 24-40 segment has the highest total gross tonnage (18,600 GT), followed by French PTS 24-40 (7,900 GT).

The specified fleets account for the 100% of the TAC of anchovy of the Bay of Biscay. Role of anchovy in total landings has been very low in the last few years as fishery has been closed since 2005. However, before the fishery closure the anchovy used to contribute between 25% and 40% of the total revenues for Spanish fleets and around 30% of the total of fishing value of the French fleet. The fishery has been reopened in 2010, with a TAC of 7,000 tonnes.

Volume of landings of anchovy in the Bay of Biscay decreased from 37,000 tonnes in 2000 to 16,000 tonnes in 2004. Apart from 2000 and 2001, the French pelagic trawlers and purse seines accounted for the biggest share of the landing value. In year 2010 80% of the TAC is going to be exploited by Spain and 20% by France.

The French anchovy fishery in ICES area VIII has been under license schemes since the end of 2007. The decommissioning schemes were implemented, especially in 2007, to reduce the size of the fleet. The Spanish fleet has been also reduced considerably in the last years (40% approximately).

Apart from anchovy, these fleets also exploit other species. Spanish fleet exploits mackerel, bluefin tuna and albacore, which currently is the main source of revenues of SP PTS 24-40. France exploits pilchard, bluefin tuna and European seabass. Species considered in this case study are mackerel, bluefin tuna, albacore and pilchard given that these species have the highest percentage of catches for the entire fleet as a whole.

Table 8.1 Role of target species (average 2005-7)

MS	Gear	Size	No. vessels	GT (1000)	Landings (1000 t)		Value (mln euro)	
					Target species	Total	Target species	Total
SP	PTS	12-24	20	0.6	0.3	0.5	0.2	1.9
SP	PTS	24-40	130	18.6	23.7	26.1	44.9	45.9
FR	PTS	12-24	96	7.4	22.6	32.3	17.0	36.5
FR	PTS	24-40	49	7.9	22.0	25.1	32.6	39.3
Total			295	34.4	68.6	83.9	94.7	235.0

Source: DCR 2007

As it can be seen in Table 8.1 target species in this case study accounts for 40% of the total revenues.

Table 8.2 Role of case study fisheries within national fishery sectors (average 2005-7)

Member State	Total fishery sector		Case study fleets	
	Total revenues (mln euro)	Total fleet (number of vessels)	Revenues (mln euro)	Fleet (number of vessels)
France	1,248	4,737	47.8	143
Spain	1,735	13,725	75.8	152

Table 8.2. shows how Spanish fleet of this case study accounts for 1% of the total fleet of the fishery sector. In France this fleet represents around the 3% of the total national fleet.

8.2.2.Composition of landings

Table 8.3 Composition of landings by segment (1000 tonnes) (average 2005-7)

MS	Gear	Size	Anchovy	Mackerel	Bluefin tuna	Albacore	Pilchard	Other	Total
SP	PTS	12-24	0.01	0.0	0.0	0.0	0.2	0.2	0.41
SP	PTS	24-40	0.24	4.1	3.2	10.9	5.5	2.4	26.3
FR	PTS	12-24	0.02	6.2	0.4	2.2	13.9	9.7	32.4
FR	PTS	24-40	0.02	5.1	5.5	0.1	11.3	3.1	25.1
Total			0.30	15.5	9.1	13.3	30.7	15.4	84.3

Source: DCR 2007

Table 8.4 shows the composition of the value of landings by segment. Pilchard is an important species for French fleets, and albacore for Spanish fleets. The amount of anchovy landings is very low in general terms due to the anchovy closure from 2005 to 2007. Mackerel has an important amount of landings for all the segments analysed. Segments with a longer size have higher landings of bluefin tuna, while the albacore landings are different between all segments but especially important for the biggest Spanish segment (SP_PTS 24_40).

Table 8.4 Composition of landings by segment (mln euro) (average 2005-7)

MS	Gear	Size	Anchovy	Mackerel	Bluefin tuna	Albacore	Pilchard	Other	Total
SP	PTS	12-24	0.07	0.0	0.0	0.1	0.1	1.7	1.9
SP	PTS	24-40	1.44	2.5	14.0	26.0	2.5	0.9	47.3
FR	PTS	12-24	0.17	3.7	1.9	5.2	6.2	19.5	36.7
FR	PTS	24-40	0.17	3.1	24.1	0.3	5.1	6.7	39.5
Total			1.85	9.3	40.1	31.5	13.8	28.9	125.45

Source: DCR 2007

As it can be seen in Table 8.4 anchovy contribution to these fleets is very low from 2005 to 2007 due to the closure of the fishery. Compared to other segments, SP PTS 12-24 catches relatively low quantities of bluefin tuna and albacore while other species play an important role in the total landings. On the contrary, the catch of the segment SP PTS 24-40 is mainly composed of target species and only 9% is related to other species. Pilchard is more important for the French fleet than for Spanish fleet.

8.3. Historical indicators

Highest catch records of anchovy in Subarea VIII (Bay of Biscay) was 83,615[41] tonnes in 1965. After this year catches of anchovy sharply decreased, and have never again risen above 48,400 tonnes.

Catches of mackerel were low in the 1960s, but increased up to more than 800,000 tonnes in 1993. The 1996 catch and TAC were reduced by 200,000 tonnes compared with 1995. The catches have been stable since 1998. The SSB of the Western stock declined in the 1970s from above 3.0 mln tonnes to 2.2 mln in 1994, and then it increased up to 2.7 million tonnes in 1999. The precautionary management plan for Northeast Atlantic mackerel implies catches between 527,000 t and 572,000 t in 2010. The SSB is expected to remain stable in 2011 for a catch in this range. Consequently, the catches at MSY level could be around 550,000 tonnes.

[41] Ices Advice 2009. Book 7.

Declared catches of bluefin tuna in the East Atlantic and Mediterranean reached a peak of over 50,000 tonnes in 1996, and then decreased substantially, stabilizing around TAC levels of 35,000 tonnes established by ICCAT for the most recent period. The 2007 and 2008 reported catches were at 34,514 tonnes and 23,868 tonnes respectively. Although the results of the projections are highly dependent on the estimated state of the stock in 2007 and future recruitment levels (both being uncertain), ICCAT considers it unlikely that the stock can be rebuilt in 15 years, at 50% probability. This implies short term yields at 15,000 tonnes or less, but the long-term gain could lead to catches of about 50,000 tonnes with substantial increases in spawning biomass.

Total reported landings of albacore for the North Atlantic began to decline after 1986, due to a reduction of fishing effort by the traditional surface (trolling and bait boats) and longline fisheries. Some stabilization was observed in the 1990s, mainly due to the increased effort and catch by new surface fisheries (driftnets and mid-water pelagic pair trawl) with a maximum catch in 2006 at 36,989 tonnes. Since 2006 a decreasing trend of catch is observed in the North Atlantic. According to ICCAT, the catch limit of 29,000 tonnes can be considered as an estimate of MSY.

The current fishing mortality of pilchard does not appear detrimental for the development of the stock, which is largely driven by the incoming recruitment. Therefore, ICES advises on the basis of exploitation boundaries in relation to precautionary considerations that the current level of fishing mortality (0.2) could be maintained as a guide for management. This corresponds to a catch of 75,000 tonnes in 2010. The average catches of the recent years have been around 96,000 tonnes.

Fleet size of this case study has been decreasing over time. Spanish fleet has decreased by 32% from 2000 to 2007, and the French fleet by about 17%.

8.4. Fleet efficiency

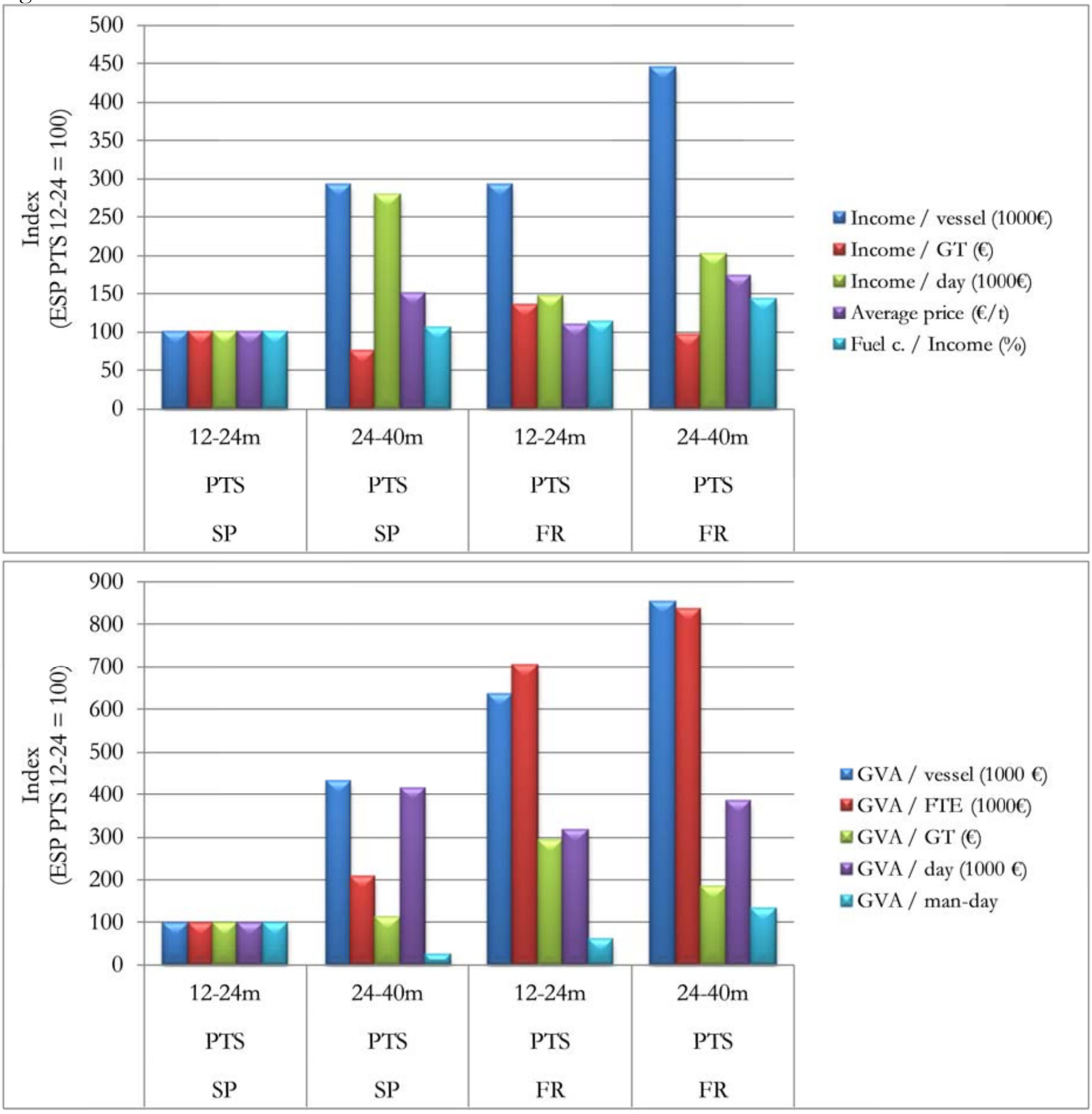
Table 8.5 Economic indicators (average 2005-7)

MS	Gear	Size	Gross value added (mln euro)	Profit (mln euro)	Employ-ment (FTE)	Average price (euro/t)	Fuel costs as % of income	Profit / tonnes landings	CPUE total (t/day)	CPUE target species (t/day)
SP	PTS	12-24	0.5	-0.9	107.0	1,1	13%	-2.9	0.5	0
SP	PTS	24-40	17.6	-12.9	1,9	1,6	14%	-0.6	12.5	0
FR	PTS	12-24	18.1	-1.8	551	1,2	15%	-0.06	16.8	0
FR	PTS	24-40	12.1	-1.3	312	1,9	19%	-0.06	9.3	0
Total			48.3	-16.9	2,9	5,8	15%	-3.6	39.1	0

Source: DCR 2007 and ICES 2009 and SEC 2007

Table 8.5 shows how segment FR PTS 24-40 has the highest income per vessel followed by FR PTS 12-24 and SP PTS 24-40. The segment FR PTS 24-40 has also the highest GVA per vessel and GVA per FTE. On the other hand, the segment SP PTS 12-24 has the lowest indicators, except for the income per GT and the GVA per man-day. With regard to the GVA per man-day the segment SP PTS 24-40 has the lowest value. In conclusion, French fleets are economically more efficient than Spanish purse seiner fleet. The larger the vessel the higher the efficiency (GVA/vessel and GVA/FTE) it achieves.
Nevertheless in terms of rent generated, all segments present negative profits which imply that an efficiency indicator such as the ratio of profit by landed tonne will also be negative, specially for the Spanish segments.

Figure 8.2 Economic indicators



8.5. Management measures

8.5.1. General description

Anchovy is managed by TACs and quotas. The advice of ICES is based on biological reference points. The limit reference point, Blim, identifies the minimum spawning biomass of the stock below which ICES considers there is a high risk of a serious decline of the stock and from where the probability of recovery would be low. Bpa is the biomass below which the stock would be regarded as potentially depleted or overfished.

According to ICES, in 2005 the biomass was calculated to be below the Blim. Following that advice Commission Regulation (EC) N°1037/2005 of 1st July 2005 established emergency measures for the protection and recovery of the anchovy stock in ICES Subarea VIII and for this reason the fishery was closed. In 2006 the fishery was reopened with a very low TAC of 5,000 tonnes (Fisheries Council of 22 December 2005). The Council Regulation (EC) No 51/2006 of 22 December 2005 in the article 5 established that "Commission shall immediately stop fishing activities concerning anchovy in subarea VIII if STECF advises that the spawning stock biomass at spawning time in 2006 is less than 28,000 tonnes". As the anchovy spawning stock biomass in 2006 was below the threshold of 28,000 tonnes[42], the fishery was banned on the 21st July of 2006 (Commission Regulation (EC) Nº 116/2006, 20th July 2006). Anchovy fishery has been closed for five years. In 2010 the fishery has been reopened with a TAC of 7,000 tonnes. Mackerel, bluefin tuna and albacore are also managed by TACs and quotas. Pilchard, on the contrary, does not have any explicit management objectives.

The European Commission has adopted a proposal for a long-term plan to manage the anchovy stock in the Bay of Biscay (Proposal for a Council Regulation establishing a long- term plan for the anchovy stock in the Bay of Biscay and the fisheries exploiting that stock (SEC (2009) 1076 final). This plan proposes a rule to determine the TAC based on the biological situation of the stock

8.5.2. Output management

Property rights [43]

In case of Spain, TURFs[44] are implemented in the anchovy fishery in the Bay of Biscay through Spain's fishing guilds. Fishing guilds have managed to survive by adapting to the changing political conditions in recent years and to the collapse of key resources such as anchovy. The rights to exploit the anchovy in the Bay of Biscay belong to the fishing guilds. Rights are allocated for an indefinite period of time. The civil society and law recognize the role of fishing guilds and their traditional rights to coastal areas and their exploitation. Territorial rights are not transferable.

In France, the licences are coupled with other rights-based arrangements such as geographical limits, community based catch quota and individual non-transferable quotas. Rights are transferable between POs (Community Catch Quota), not between individuals. Quotas may be divided into sub-quotas per PO if the level of quota usage exceeds 70% during at least one of the three previous years. The calculation of the sub-quotas is a function of three criteria: i) track record of each PO member vessel: ii) market orientation; iii) socioeconomic equilibrium.

8.5.3. Input management

Effort restrictions

In the case of Spain, the fishing guilds play a key role (non-profit bodies of public law, Fisheries Law Article 45). The fishing guilds have the right to regulate some aspects of the management of the anchovy fishery. They regulate the entry of vessels and fishermen in the fishery so that anybody aiming to fish must become a member of the fishing guilds. Entry of new fishing vessels is regulated by the DGPE[45]. Fishing guilds also play a constitutionally recognized role as providers of advice to the state and autonomous government with regards to technical measures. There is no direct access to fishing rights for newcomers. Rights are tradable only among vessels which are already permitted to participate in the fishery. Thus newcomers can only access rights by purchasing the triad vessel-license-right from the active boat owners.

In case of France, newcomers must acquire a licence for stocks under special fishing permit or national licence and submit a demand of transfer of quotas. A reserve of quotas has also been created to provide some track record for new entrants to the sector. The concentration of fishing rights was partly frozen

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[42] The threshold is used to prevent stock collapse along with the Minimum Biological Acceptable Level based (Blim) on spawning stock biomass, currently implemented for small pelagic fish and other species. The Article 5 of Council Regulation 51/2006 requires the Commission to prohibit fishing activities if STECF advises that the spawning stock size in 2006 is less than 28,000 tons. Nowadays the biomass precautionary reference (Bpa) point of 33,000 tonnes is established by the European Union, the limit which would allow the reopening of the anchovy fishing grounds.

[43] " An analysis of existing Rights – Based Management (RBM) instruments in Member States and on setting up best practices in the EU. Final Report: Part II. Catalogue of Rights-Based Management Instruments in coastal EU Member States". European Commission.

[44] TURF is Territorial Use Right in Fisheries.

[45] DGPE denotes Directorate General of State Property.

under control related to modification of quotas sharing rules in 2006: there is a fixed reference year for quota sharing and professional and administrative arrangements to control transfer of quota.

Input property rights

In Spain rights have been concentrated in Galician fleets because they seem to be more economically efficient. This has caused a restructuring of the fleet. The fleet of the Basque region has been reduced in terms of rights and number of vessels. The current regulation APA/3773/2006 does not specify any limits on concentration of fishing rights.

Regarding France, fishing enterprise/fishermen must first obtain an exploitation authorisation for its vessels and a Community fishing licence. Set up in 1988, the PME[46] is the main instrument of fishing capacity control set up in relation to the Multi-Annual Guidance Programmes (MAGP). It is the main instrument to control capacity and the geographical distribution of the different segments of the French fishing fleet. It is a general requirement and each fishing vessel must obtain a PME before being allowed to fish. The PME determines a number of the vessel's technical characteristics such as length (loa), power (kW), and tonnage (GT or UMS). Therefore it is directly related to the EU Fleet Register.

8.6. Management costs

8.6.1. Summary of OECD data

The allocation of OECD management costs to each fleet segment (Table 8.6) has been made using the relative weight of the income obtained by each segment to the total income of the MS to which each segment belongs. In that sense more than the 60% of the total management costs have been allocated to the SP PTS 24-40 followed by FR PTS 12-24 with 30%.

Table 8.6 Management costs according to OECD, average 2004-2006 (mln euro)

	FRA PTS 12-24	FRA PTS 24-40	ESP PTS 12-24	ESP PTS 24-40	Total
Direct Payments	1.1	1.1	0.2	3.8	6.2
- Decommissioning	0.4	0.5	0.0	0.8	1.7
- Fleet renewal and modernization	0.5	0.5	0.1	2.3	3.4
- Other	0.2	0.2	0.0	0.7	1.1
General Services	1.3	0.1	0.1	1.4	2.9
- Management and enforcement	0.4	0.4	0	0	0.8
- Research	0.9	0.9	0.0	0.1	1.9
- Other	0.5	0.5	0.1	1.4	1.5
Total	2.3	0.5	0.2	5.2	8.2

8.6.2. Support to fishing sector (FIFG and EFF)

In terms of the support to the fishing sector, Spain spends 89.6 million euro on EFF Axis 1 and France 20.4 mln euro.

Table 8.7 Average annual support to the marine fisheries from FIFG and EFF, (mln euro)

	FRA PTS 12-24	FRA PTS 24-40	ESP PTS 12-24	ESP PTS 24-40	Total
FIFG - Axis 1 and 2	1.2	1.2	0.2	5.1	7.7
EFF - Axis 1	0.3	0.4	0.2	3.8	4.8

[46] PME is the "Permis de mise en exploitation".

The allocation by fleet segment has been made using the same weights as for the OECD data. As Table 8.7 shows, the amount allocated in FIFG (Financial Instrument for Fisheries Guidance 2002 – 2006) is almost the double of EFF (European Fisheries Fund 2007 -2013). Again SP PTS 24-40 is accounting for more than the 65%.

8.6.3. Costs of research and management

In terms of the costs of research and management, Spain expends 27.6 million euro if management is considered and 16.72 million euro considering only research. The values for France are 16.8 million euro and 15.78 million euro, respectively.

Table 8.8 Estimated management and research costs, (mln euro)

	FRA PTS 12-24	FRA PTS 24-40	ESP PTS 12-24	ESP PTS 24-40	Total
Management, control, enforcement	0.5	0.5	0.0	0.8	1.8
Research (DCF+30%)	0.5	0.5	0.0	0.5	1.5

Sources: MRAG (2008) and Com. Decision 811/2009

The allocation by fleet segment has been made using the same weights as for the OECD data (see Table 8.8). In respect to management, control and enforcement costs, ESP PTS 24-40 has the highest allocation. On the contrary, in respect to research costs French fleets have the highest allocation.

8.7. Estimation of the resource rent

8.7.1. Comparison of scenarios

The first six scenarios in Table 8.9 can be divided in two types: more restrictive policies (TAC min, Effort min and Min min) and non-restrictive policies (TAC max, Effort Max and Open access). The non-restrictive scenarios give higher (almost two times) NPV $Profit_{15}$ than the more restrictive policies. The problem in non-restrictive scenarios is that they are unsustainable given that some target species become overexploited. Therefore, the only sustainable policies in the present case study are TAC min, Effort min and Min min. Among all these sustainable policies Effort min is the one with a highest NPV $Profit_{15}$.

The two following scenarios are related to the discount rate. Scenarios 7 and 8 have considered a lower (2%) and a higher (5%) discount rate and their impact on NPV $Profit_{15}$. There is an increase of 18% in the NPV $Profit_{15}$ when the discount rate is 2%, while when the discount rate increases to 5% NPV $Profit_{15}$ decreases by 15%.

Last four scenarios explore possible adaptation paths of the fleets by fixing the number of vessels to the baseline level (scenario 10), using the minimum number of vessels in a static sense (scenario 11) or in a dynamic sense (scenario 12). In scenario 13 the optimum fleet that maximizes the NPV GVA_{15} has been estimated. Finally a maximization of the rent has been estimated by changing the fleet size and composition (scenario 14). In this case the rent that can be obtained (NPV $Profit_{15}$) is the highest one and has been calculated to be 985 mln euro.

Table 8.9 Comparison of the scenarios

Scenario no.	Effort (1000 DAS)	Fleet (no. vessels)	Catch (1000 t)	Profit year 15 (mln euro)	NPV $Profit_{15}$ (mln euro)
Average values 2005-7					
2005-7	48.1	295.0	90.1	-20.8	
Values in year 15 of the scenario					
1. TAC min	16.8	94	53.5	16.28	103.84
2. Effort min	24.5	153	70.2	16.12	160.98
3. TAC max	64.4	330	133.2	25.24	308.99
4. Effort max	70.8	361	134.2	25.26	347.25
5. Open access	70.8	361	134.2	25.26	347.25
6. Min min	16.9	94	53.5	16.32	100.33
7. Discount rate 2%	24.5	152	70.2	20.07	190.37
8. Discount rate 5%	24.5	152	70.2	12.99	136.30
9. Recovery mgt. costs	24.1	146	68.7	17.30	169.89
10. Static present fleet	24.5	295	70.2	4.84	-4.98
11. Static minimum fleet	24.5	251	70.2	8.36	57.34
12. Dynamic min. fleet	24.5	127	70.2	17.74	235.39
13. Optimum fleet (GVA)	100	498	137	33.42	594.16
14. Optimum fleet (profit)	36	176	89	50.40	985.20

8.7.2. Policy options (scenarios 1-6)

Table 8.10 Effect of different policies on profit, harvest ratio, catches, effort and fleet

Indicator	2005-7	Scenarios**					
		1. TAC min	2. Effort min	3. TAC max	4. Effort max	5. Open access	6. Min min
NPV $Profit_{15}$		103.84	160.98	308.99	347.25	347.25	100.33
Nominal $Profit_{15}$	-20.8	27.28	27.01	42.29	42.33	42.33	27.35
Discounted $Profit_{15}$		16.28	16.12	25.24	25.26	25.26	16.32
Harvest ratio (year 15)*							
Anchovy	0.81	0.17	0.25	0.69	0.78	0.78	1.00
Mackerel	0.18	0.06	0.08	0.26	0.31	0.31	1.00
Bluefin tuna	0.24	0.09	0.11	1.00	1.00	1.00	1.00
Albacore	0.29	0.07	0.11	0.23	0.22	0.22	1.00
Pilchard	0.16	0.06	0.08	0.26	0.31	0.31	1.00
Catch in (1000 t, for scenarios year 15)							
Anchovy	22	16.3	21.9	35.6	33.0	33.0	16.3
Mackerel	15	8.6	11.4	25.7	25.9	25.9	8.6
Bluefin tuna	10	6.4	6.6	0.6	0.0	0.0	6.5
Albacore	15	8.0	11.4	21.7	21.4	21.4	8.0
Pilchard	28	14.2	19.1	49.7	53.9	53.9	14.2
Effort (1000 DAS, for scenarios year 15)							
ESP PS 12-24	3	1	1	3	3	3	1
ESP PS 24-40	20	7	10	19	18	18	7
FRA PS 12-24	18	5	9	23	22	22	5
FRA PS 24-40	8	4	4	20	27	27	4
Fleet (no vessels, for scenarios year 15)							
ESP PS 12-24	20	5	8	19	19	19	5
ESP PS 24-40	130	42	61	104	102	102	42
FRA PS 12-24	96	23	60	110	108	108	23
FRA PS 24-40	49	24	24	97	133	133	24

*F=1 implies that the stock is almost extinct.

The H target selected for the species are for anchovy 0.63, mackerel 0.27, bluefin tuna 0.11, albacore 0.41 and pilchard 0.41. In scenarios TAC max, Effort max and Open access the harvest ratio of bluefin tuna in year 15 is 1 (Table 8.10), consequently these scenarios were considered as unsustainable. If the analysis is focused on the NPV $Profit_{15}$, the highest values are obtained in those scenarios which are biologically unsustainable. Among the sustainable scenarios Effort min is the best one, where the NPV $Profit_{15}$ is half of those obtained in scenarios 3, 4 and 5. The most restrictive scenarios lead to a reduction of fleet size of around 68%.

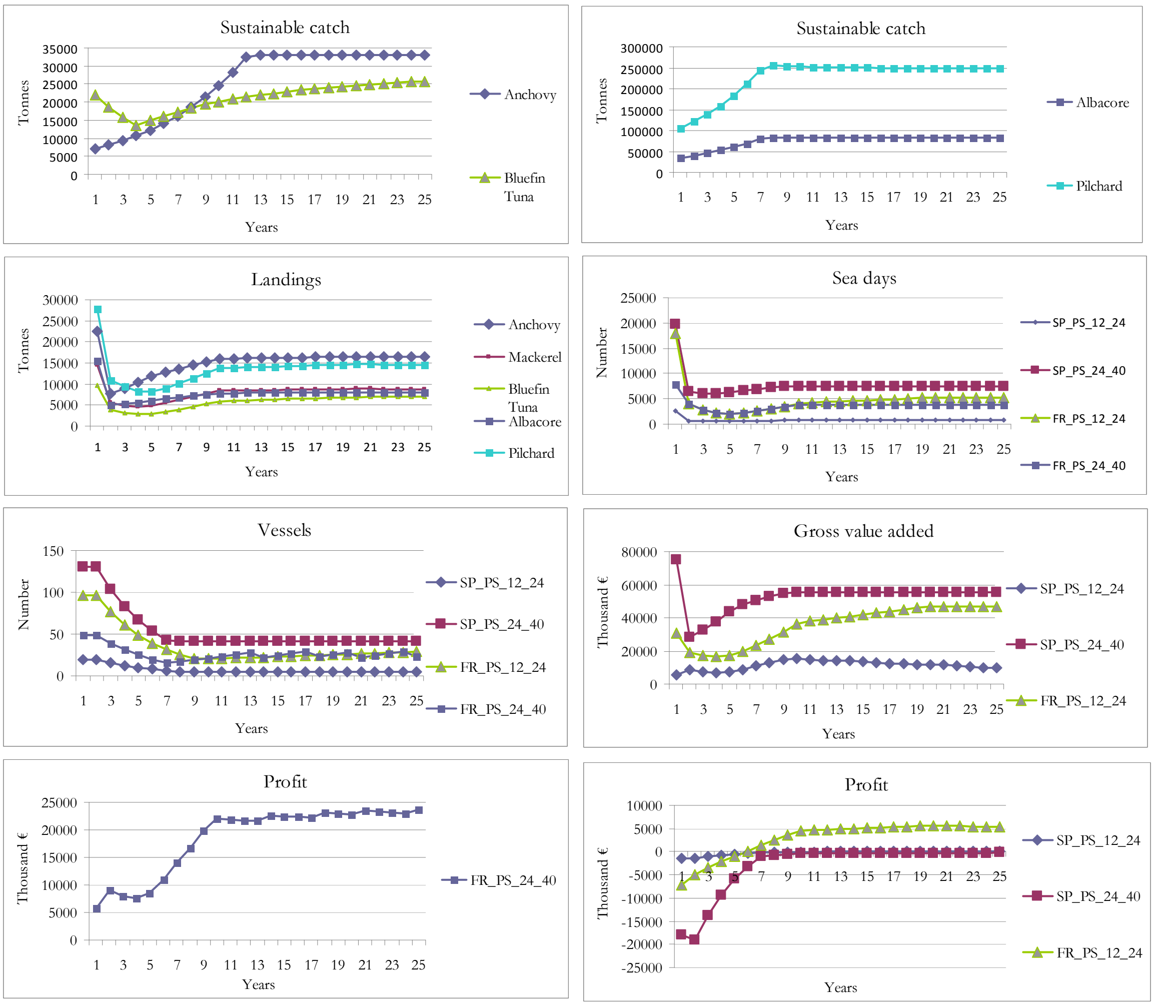
Catches by species vary according to the policies adopted. In the more restrictive policies catches of all species are lower than in the baseline scenario, but in the more expansive policies catches of all species are higher than in baseline scenario, except for bluefin tuna whose catches are near to zero.

Focusing on fleet segments, using expansive policy options the fleet size varies its trend between segments. French fleet size rises significantly in those scenarios, specially the segment FRA PTS 24-40, whose fleet increases around 400%. The reason for this increase is that the break-even revenues (BER) are lower than the realized revenues. This implies that they can assign a part of their revenues to investments in new vessels. For the Spanish fleets, on the contrary, the BER is below the revenues in all years predicted; consequently, they do no have any means to invest.

Scenario 1. TAC min

TAC min is sustainable scenario from the biological point of view as the H in year 15 is lower than the H target selected. Nevertheless this scenario is providing the second lowest NPV $Profit_{15}$ of all the POs tested (scenarios 1 to 6). The reason for that is that the fleet size of all segments decreases during the first 7 years of the simulation, after which it stabilizes. Effort and landings also decrease significantly, but the profit and the gross value added increase until year 9 and remain constant thereafter. Compared to the initial situation, in year 15 the fleet size has decreased in total by around 68%, the effort by 65% and catches by about 41%. Sustainable catches increases significantly for all the species considered but it can be said that this PO is too restrictive in this sense.

Figure 8.3 Results of scenario 1. TAC min



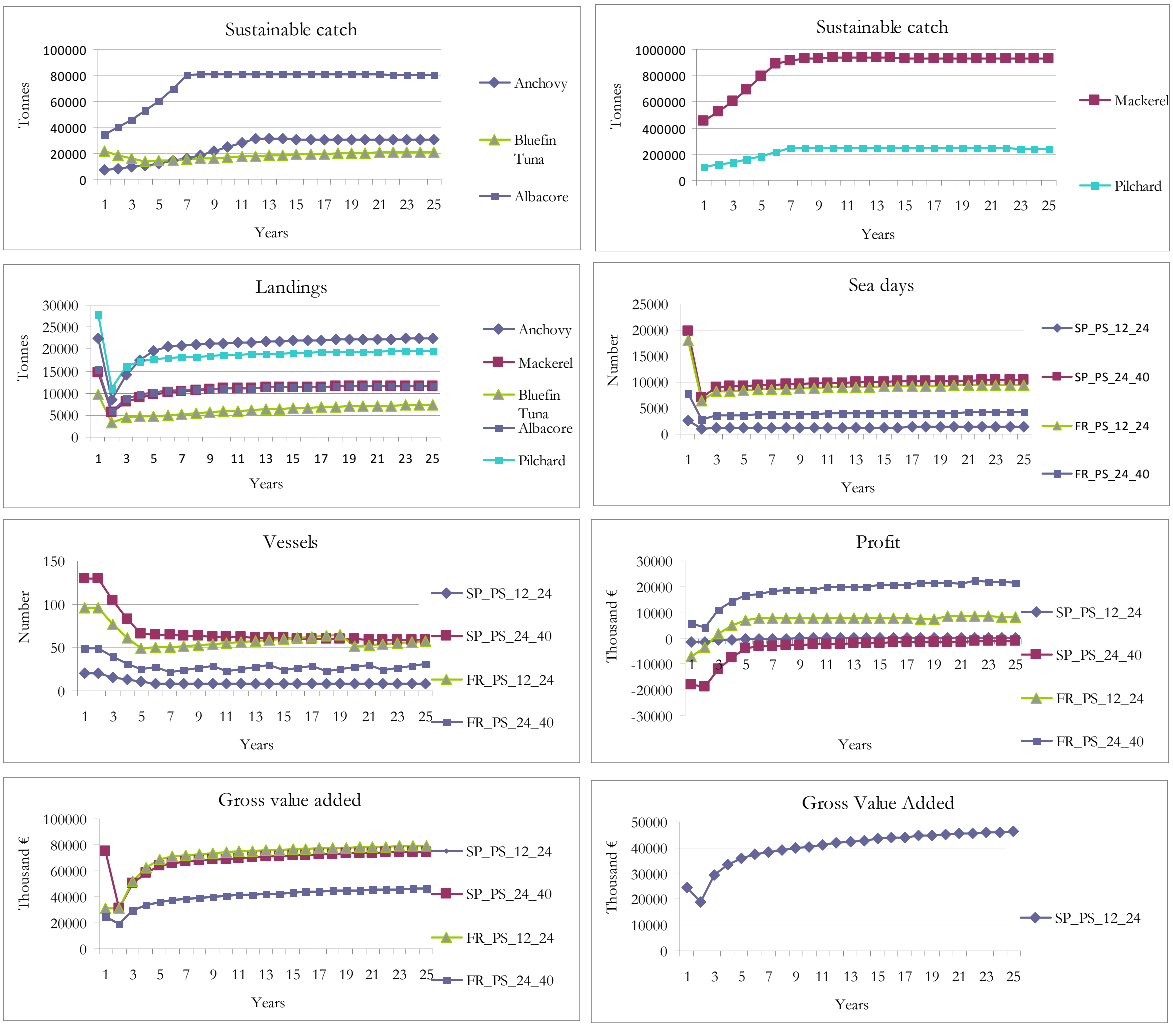
Scenario 2. Effort min

Effort min scenario produces a NPV Profit$_{15}$ of 161 mln euro, the highest rent of all the sustainable scenarios tested. The fleet size of all the segments decreases until year 7 and stabilises thereafter. The effort in year 15 is half of the baseline situation, and catches decrease by 22%.

This policy option reduces the effort of all the segments in the first years of the simulation, and then after the 3rd year it stabilizes. Profit has an increasing trend for all the segments after year two of the simulation and stabilizes after year five.

Numbers of vessels have also a decreasing trend at the beginning and the stabilization of the fleet size occurs in the 7th period of the simulation.

Figure 8.4 Results of scenario 2. Effort min

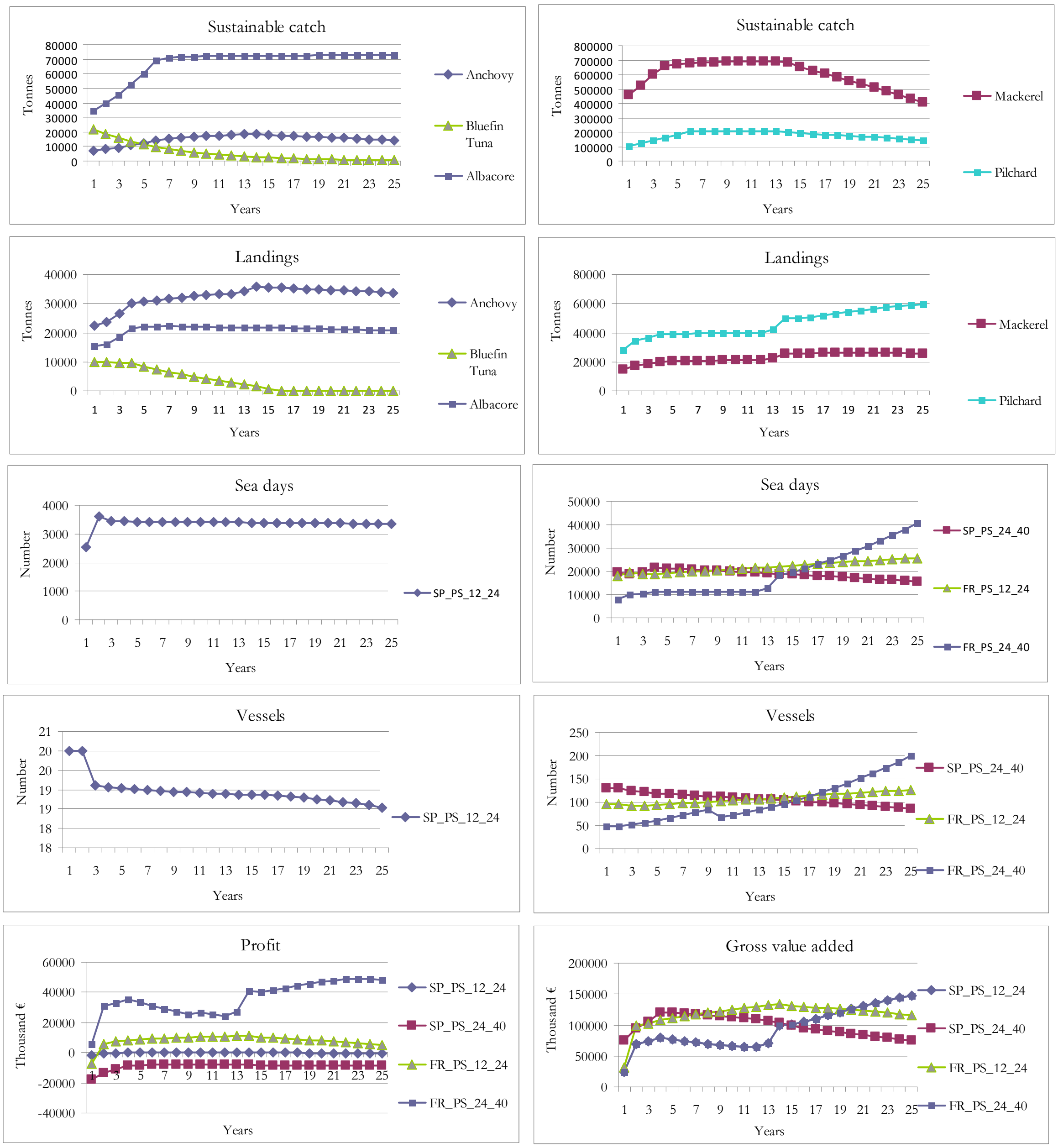


Scenario 3. TAC max

This scenario is completely different from the previous two scenarios. The NPV $Profit_{15}$ is 309 million euro, higher than in scenario 2, nevertheless it behaves in a clearly unsustainable way. Landings of bluefin tuna are reduced to levels close to zero in year 15. Landings of anchovy and albacore increase in the first 5 years and then they maintain their level. On the other hand mackerel and pilchard landings increase until year 15, even if sustainable catch of these two species is stable from the period 5 of the simulation.

Regarding the fleet, Spanish fleets are reduced, but the French fleets grow, especially in the FRA PTS 24-40 segment which goes from 50 vessels in the baseline period to 100 vessels after 15 years. Profit is increased for all the segments in the first two years of the simulation but afterwards it stabilizes or decreases.

Figure 8.5 Results of scenario 3. TAC max



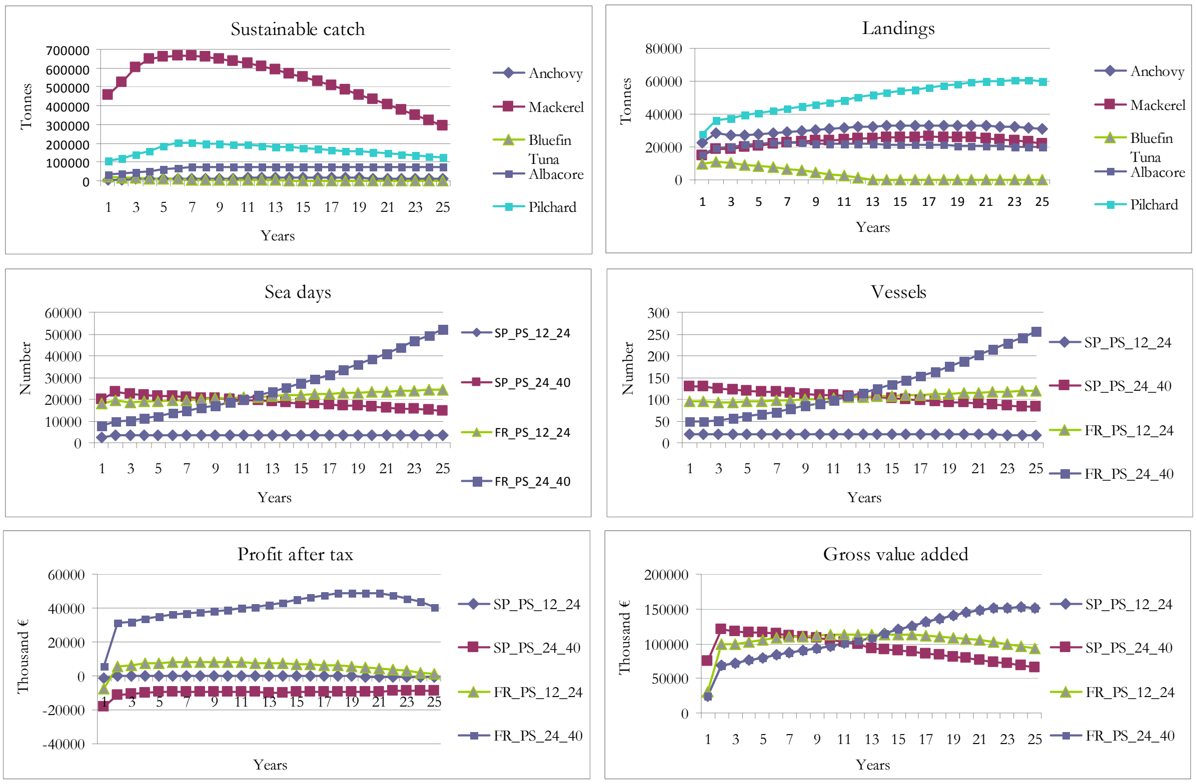
Scenario 4. Effort max

This policy option provides one of the highest NPV $Profit_{15}$ but as it will be shown it provides the same values as the open access scenario policy option. The reason for this is that this policy option is not limiting the effort of any segment and hence the effort selected by each segment will be the maximum that they can generate.

As a consequence bluefin tuna landings from year 13 are zero while the landings of the remaining species are increasing. By contrast sustainable catch shows a decreasing trend after year 7 (approximately) of the simulation for these species. As a consequence this PO can be considered as a biologically unsustainable policy.

In the meantime the size of the French fleet increases, especially the segment FRA PTS 24-40 (and their profits). The Spanish fleet decreases slightly and their profits are stable or slightly increasing after year two of the simulation.

Figure 8.6 Results of scenario 4. Effort max



Scenario 5. Open access

The Open access model provides exactly the same results as the Effort max policy.

Figure 8.7 Results of scenario 5. Open access

Scenario 6. Min min

In this scenario, either the minimum effort or the minimum TAC are combined, depending on which is most restrictive. The NPV $Profit_{15}$ is the lowest one of all the POs analysed (100 mln euro). This policy follows almost the same trends as the TAC min PO which shows that the results obtained for this PO can be extrapolated to the Min min PO.

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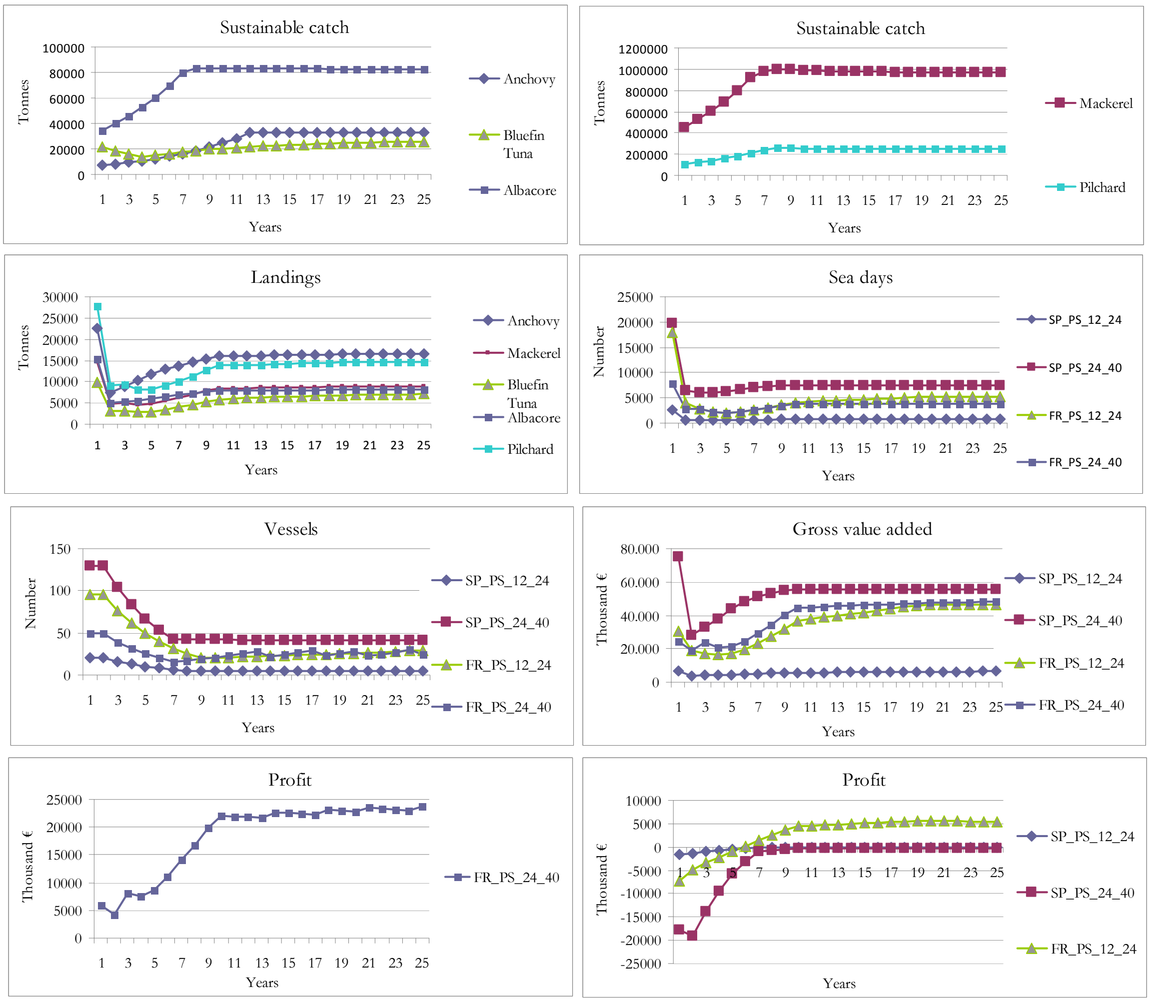
Figure 8.8 Results of scenario 6. Min / min



8.7.3. Role of discount rate (scenarios 7-8)

Table 8.11 Effect of discount rate on profits

Indicator	2005-7	Scenario		
		Main scenario Discount rate 3.5%	7. Discount rate 2%	8. Discount rate 5%
NPV $Profit_{15}$		160.98	190.37	136.30
Nominal $Profit_{15}$	-20.8	27.01	27.01	27.01
Discounted $Profit_{15}$		16.12	20.07	12.99

As Table 8.11 shows how the NPV $Profit_{15}$ varies with the change of the discount rate.

Scenario 7. Discount rate 2%

When the discount rate is 2% instead of 3.5% the discounted profit in year 15 increases by a 25% and the net present value by 18%.

Scenario 8. Discount rate 5%

The nature of this scenario is to give less weight to the future than to the present in comparison to the main scenario. In the scenario 8, where the discount rate is 5%, the discounted profit decreases around 19%, and the net present value of profit around 15%.

8.7.4. Resource rent and recovery of management costs (scenario 9)

This scenario has been selected in a way in which each segment has to make an annual payment equal to the management cost allocated to them. The exact allocations by segment, and hence the annual amount to recover by segment, is based on the cost of support (Axis 1 in Table 8.7) and management and research costs in Table 8.8 are: 252 thousand euro for SP PS 12-24, 6.3 mln euro for SP PS 24-40, 2.2 mln euro for FR PS 12-24 and 2.2 mln euro for FR PS 24-40. It implies 10.9 mln euro per year or a NPV of 127 mln euro in the 15 years of the simulation (using a discount rate of 3.5%).

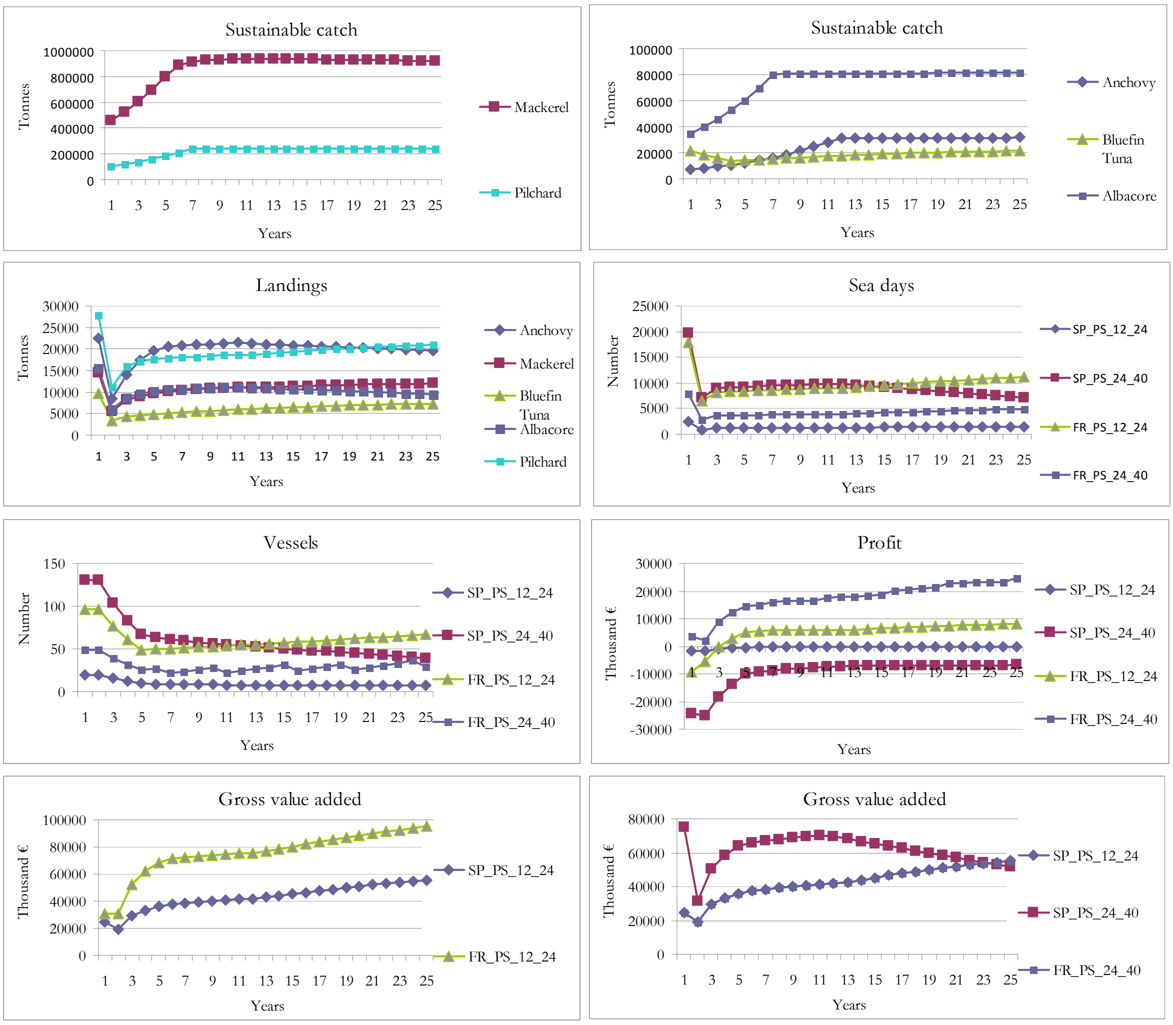
In this scenario the NPV $Profit_{15}$ is 170 mln euro. Adding to it the NPV of the payments for access made (127 mln euro) the result is 297 million euro, that is, 136 mln euro above the baseline scenario (Effort min). Consequently, there are additional rents that could be captured by society when this tax is imposed.

The reason for this is that when this system of a fixed payment is set the number of vessels of all the segments are decreased.

Table 8.12 Resource rent and recovery of management cost

Indicator	2005-7	Scenarios*	
		Main scenario: No recovery of management costs	9. Recovery of management costs
NPV GVA_{15} (mln euro)		1,983	1,855
Nominal GVA_{15} (mln euro)	137	202	201
NPV $Profit_{15}$		161	170
Fixed payment for access (mln euro)		0	11
NPV Payment for $access_{15}$		0	127
Nom $Profit_{15}$ (mln euro)	-21	27	29

Figure 8.9 Results of scenario 9. Recovery of management costs



8.7.5. Optimization of capacity (scenarios 10-14)

Table 8.13 Impact of optimization of the fleet size

Indicator	2005-7	Scenarios*					
		Main scenario Effort min	10. Static present fleet	11. Static minimum fleet	12. Dynamic minimum fleet	13. Optimum fleet (GVA)	14. Optimum fleet (profit)
NPV Profit$_{15}$ (mln euro)		161	-4.98	57	235	594	985
Nominal Profit$_{15}$ (mln euro)	-21	27	8.11	14	29	56	84
Discounted Profit$_{15}$ (mln euro)		16	4.81	8.36	17	33	50
Fleet$_{15}$ (no vessels)	295	153	295	251	127	498	176
Effort$_{15}$ (1000 DAS)	48	24	24	24	24	100	36
Catch$_{15}$ (1000 t)	90	70	71	71	71	137	89

*NPV row refers to the sum, other row refer to the value in year 15.

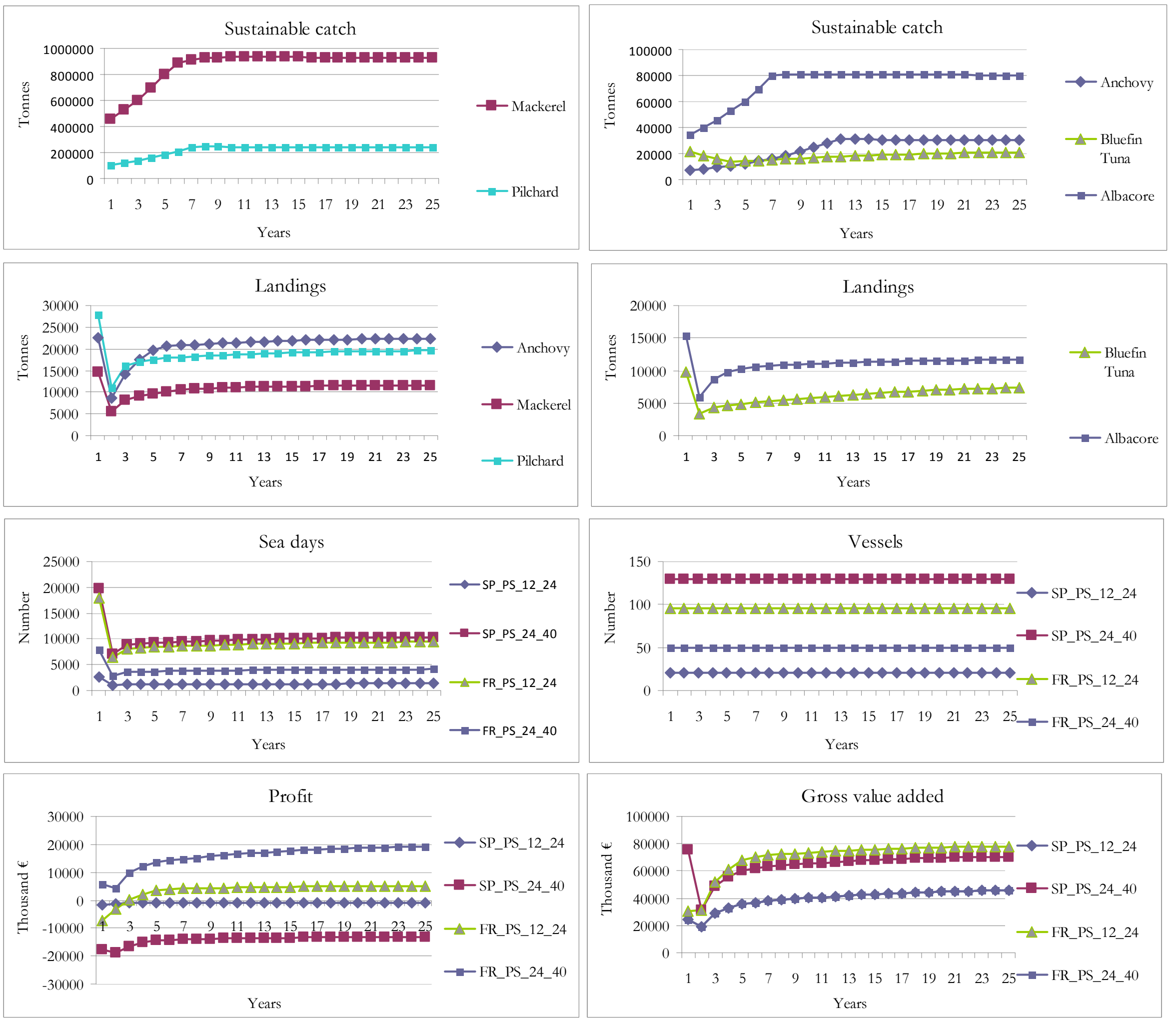
The fleet size varies between all these scenarios. Focusing in scenarios 10, 11 and 12, Table 8.13 shows that the lower the fleet size the higher the rents are, given that, the best way to adjust the fleet is forcing each vessel to use the maximum effort that they can in each step of the simulation.

Compared with the Effort min, in scenario 13 the number of vessels increases by 68%, and the rents that this scenario gives are the highest of all the scenarios tested.

Scenario 10. Static present fleet

Landings and DAS in scenario 2 are very similar to scenario 10 but the number of vessels has increased by 93% and therefore DAS/vessel decreases considerably in scenario 10: from 157 to 81. $Profit_{15}$, in scenario 2 is positive (161 million euro) but in scenario 10 it is negative (around minus 5 million euro).

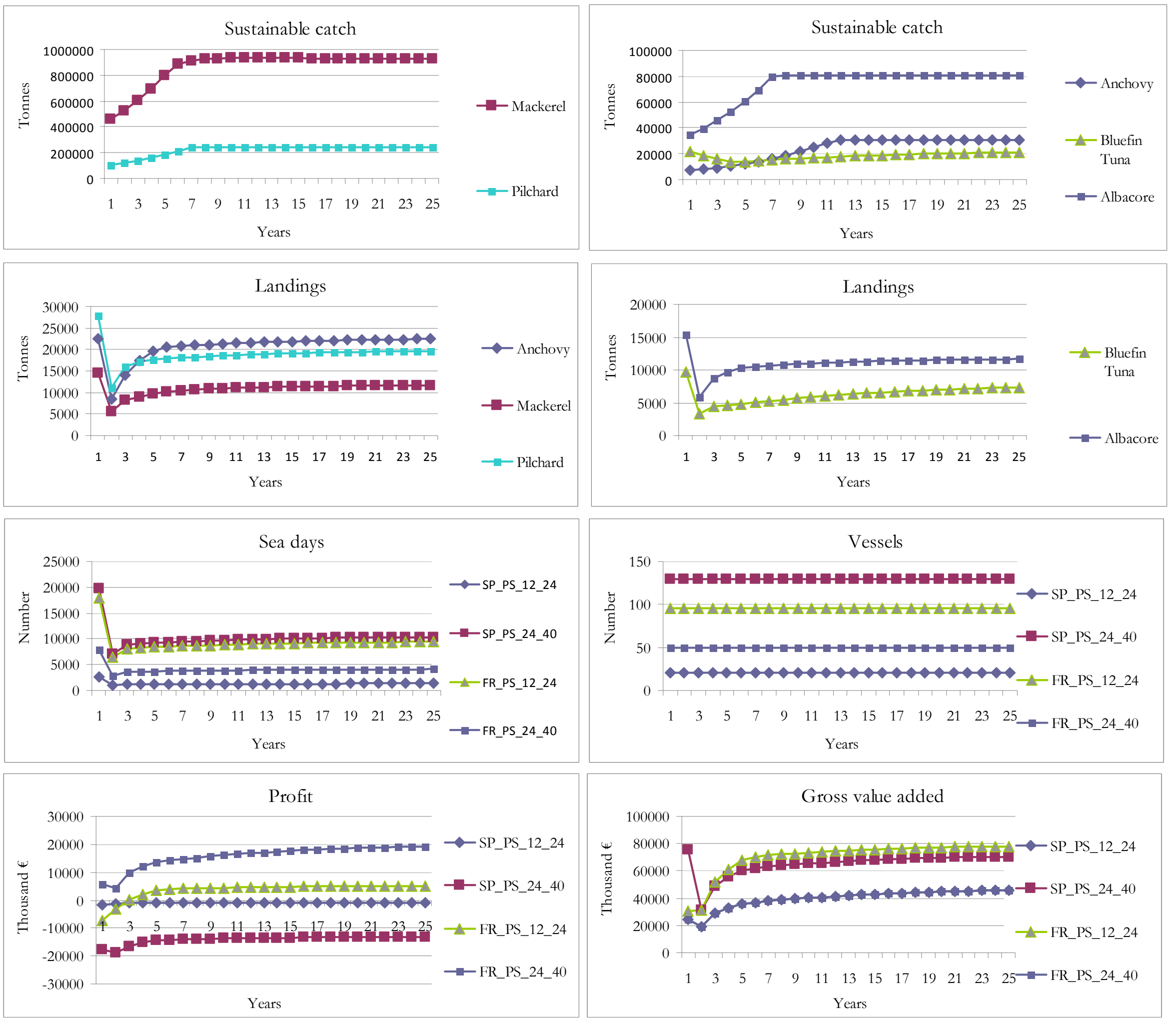
Figure 8.10 Results of scenario 10. Adaptation with 'present' fleet



Scenario 11. Static minimum fleet

The total catches and total effort (DAS) are identical to the selected baseline scenario, and the fleet size increases by 64% compared to Effort min scenario. Days per vessel in this scenario are around 96.

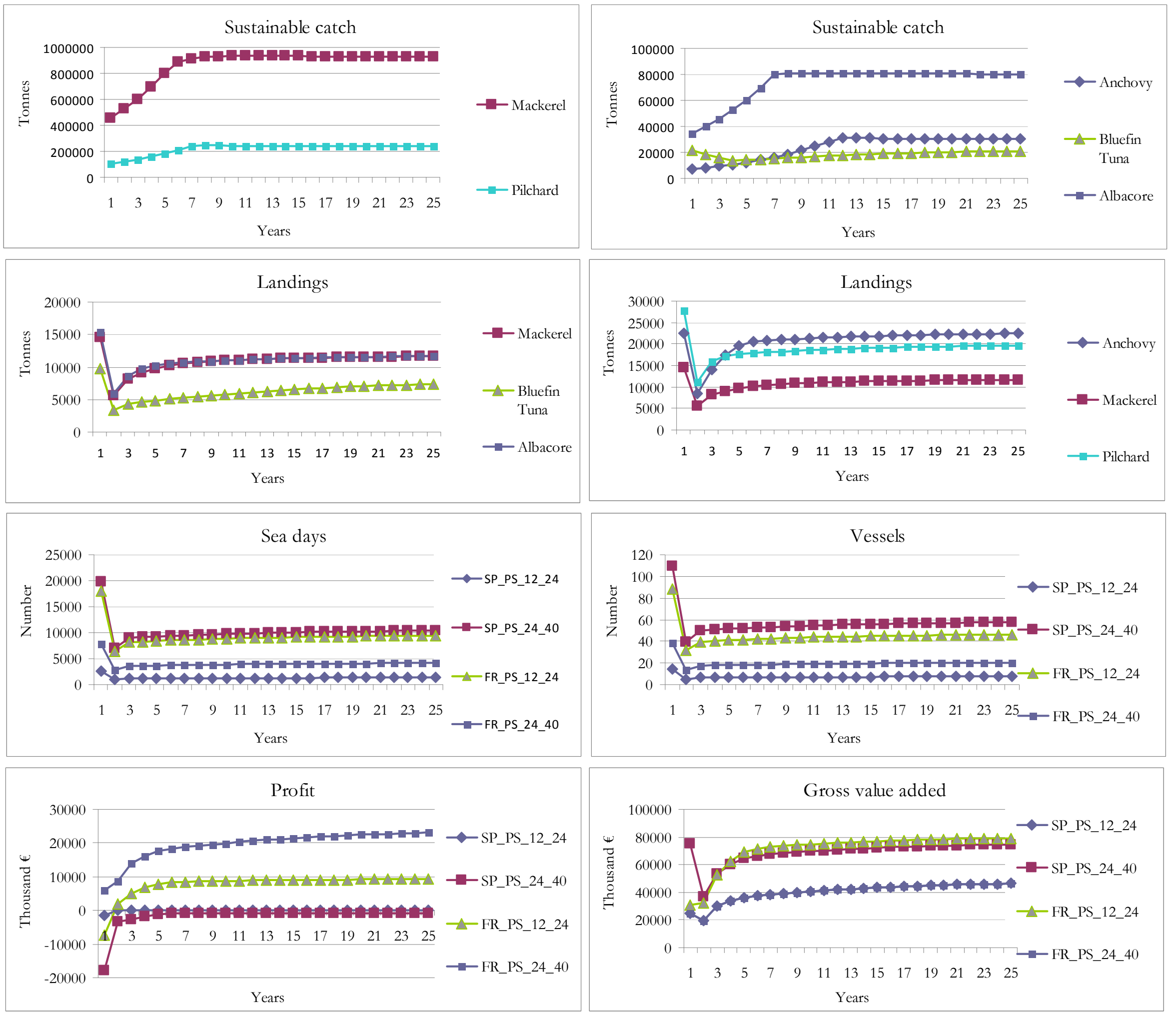
Figure 8.11 Results of scenario 11. Static minimum fleet



Scenario 12. Dynamic minimum fleet

In this scenario the fleet is maintained at the minimum level and there are no constraints to (dis)investments. The number of vessels of all segments decreases in the first year, and then it remains constant. Comparing these results with the main scenario, effort and catches do not change, but the fleet size decreases. Finally, the NPV $Profit_{15}$ is 46% higher than in the baseline scenario.

Figure 8.12 Results of scenario 12. Dynamic minimum fleet



Scenario 13. Optimum fleet (GVA)

In scenario 13 the number of vessels by segment is selected in such a way where NPV GVA_{15} is maximized. Nevertheless the result of this optimization is giving the result of maximizing the segment FP PTS 24-40 leaving the others segments with zero vessels.

In order to provide an interior solution, a constraint in which FRA PTS 24-40 cannot be increased more than 300%[47] in comparison with the baseline situation is introduced. With this constraint, the solution is again to maximize the number of vessels of the segment FRA PTS 24-40 and then to maximize the number of vessels of the segment FRA PTS 12-24 while the remaining segments disappear. Again imposing the 300% restriction to this last segment an interior solution is obtained where catches are the highest of all the scenarios analysed and by the nature of this scenario the highest NPV GVA_{15} of 5,442

[47] This constraint has been defined on an arbitrary basis.

million euro is obtained. In the meantime NPV $Profit_{15}$ is also well above the baseline policy option and around 594 mln euro. As it can be seen in the figures below there are jumps in almost all the variables analysed. It implies that this scenario is not sustainable. Furthermore some species such as bluefin tuna will be completely exploited by the year 15 of the simulation.

Figure 8.13 Results of scenario 13. Optimum fleet (GVA)

Scenario 14. Optimum fleet (profit)

This second optimum fleet scenario has been designed determining the number of vessels of each segment from the period 2 to the period 15 of the simulation in a way in which the NPV of the net profit is maximized. The optimization is free (no restrictions) except for some constraints that have used in order to obtain "real" and interior solutions. In particular the constraints used are:

- The harvest rates (H) of all the species have to be equal or lower to 1. This constraint is simply considering than an H higher than 1 is unrealistic[48].
- At least 1 vessel per segment is required in all the periods. Furthermore, the number of vessels in each segment changes at most by +/-20% from one year to next.

In order to provide an interior solution a constraint in which FR PTS 24-40 cannot be increased more than 300%[49] in comparison with the baseline situation. With this constraint, the solution is again to maximize the number of vessels of the segment FR PTS 24-40 and then to maximize the number of vessels of the segment FR PTS 12-24 while the remaining segments disappear. Again, imposing the 300% restriction to this last segment an interior solution is obtained.

With these restrictions (the same as in scenario 13) results of the simulation show how the NPV of the net profit can be increased by 66% from 594 to 985 mln euro. In the meantime there is a reduction of the NPV GVA of 54%. This result is obtained reducing the total number of vessels in overall terms. All segments will be eliminated from the fishery except the French PS 12-24. NPV of the GVA will be slightly lower than in the baseline scenario.

It can be seen how profits of all the segments are zero (or almost French PS 24-40) except for French PS 12-24. They will rapidly increase at the beginning of the simulation and steadily fall till period 10 of the simulation. Afterwards they will remain stable, while catches will remain at a lower level than in the baseline scenario.

[48] It is straightforward that this constraint is implicit in the other scenarios tested. Nevertheless for this scenario it has to be made it explicit for computing (optimization) purposes.

[49] This constraint has been defined on an arbitrary basis.

Figure 8.8.14 Results of scenario 14. Optimum fleet (profit)

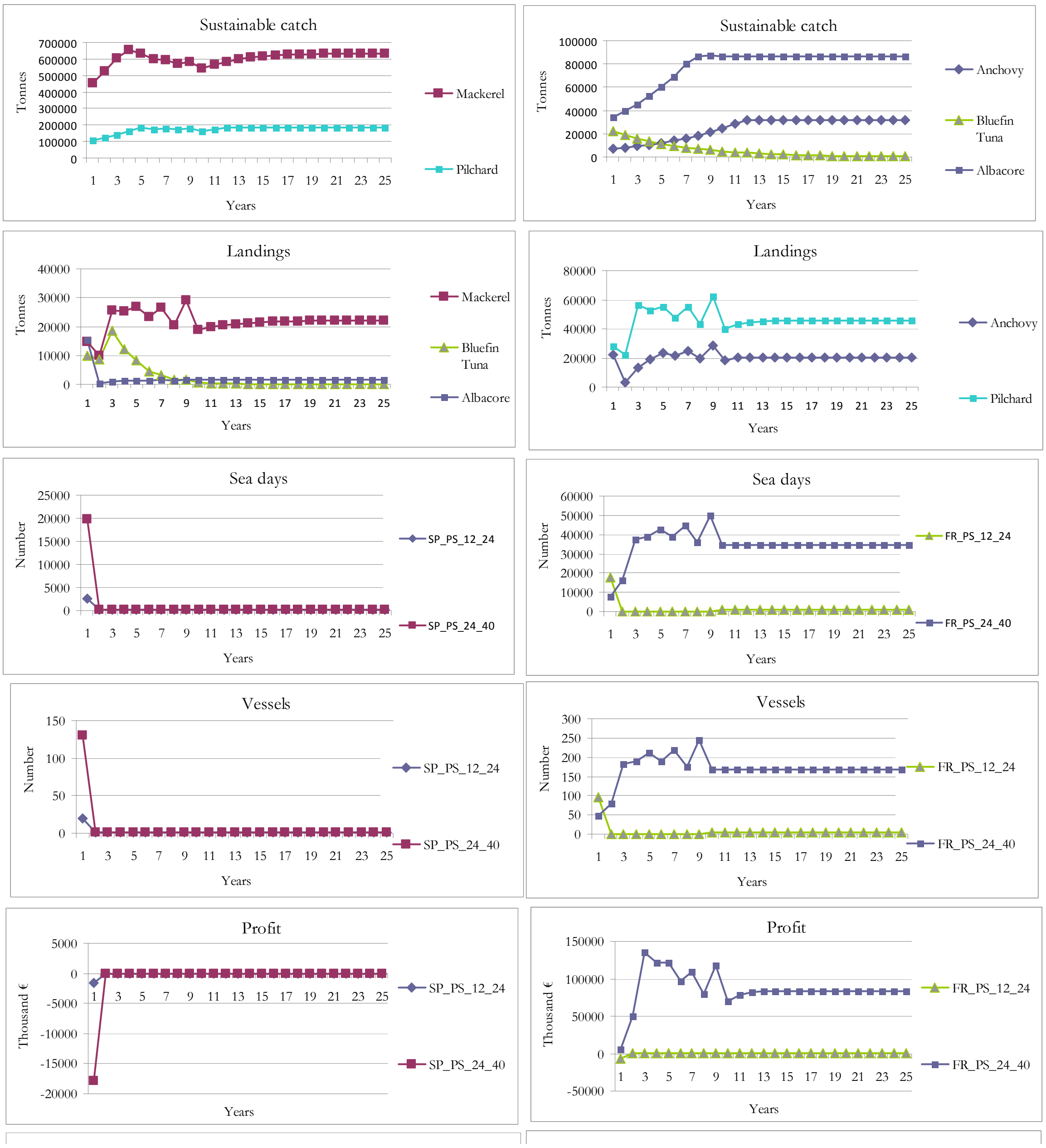
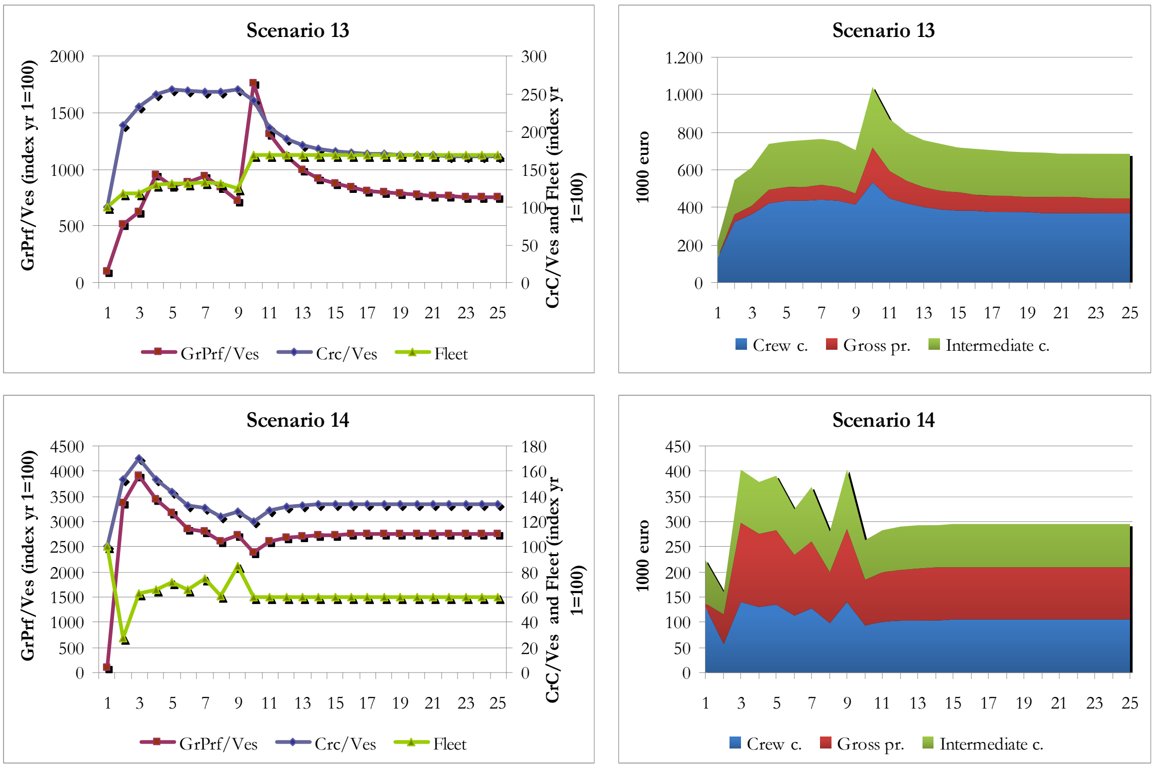


Table 8.14 Comparison of scenarios 13 and 14 (values in mln euro, fleet number of vessels)

	Scenario 13	Scenario 14
NPV GVA$_{15}$	5,442	2,529
NPV profit$_{15}$	594	985
NPV Crew costs$_{15}$	4,517	1,301
NPV capital costs$_{15}$	331	243
GVA year 15	479	209
Profit year 15	56	84
Crew costs year 15	385	105
Capital costs year 15	38	20
Fleet – average 1-15	419	191
Fleet – year 15	498	176

These results can be better explained by comparing them with scenario 13.

Figure 8.15 Comparison between scenario 13 and scenario 14.



As it can be seen the main difference between scenarios comes from the fleet size. When GVA is maximized one fleet (FR PS 12-24) increases their size compared to the baseline situation. When profits are maximized all the fleets reduce their size at the beginning of the period and in overall terms and then in this segment (FR PS 12-24) which is the one that is stable until the end of the simulation. This can be easily seen in the figure above, where scenario 13 presents increasing trends for the fleet along the simulation while scenario 14 presents first a decreasing trend and after period 3 a flat trend.

In terms of the gross profit and crew costs (per vessel) in both cases the trends are similar, but not the value of the index. It is clear how scenario 14 presents an index value for both indicators that doubles the one obtained in scenario 13.

In absolute values scenario 14 has always higher gross profit and lower crew costs. This is a consequence of the nature of scenario 13 in which the maximum of the sum of these variables (discounted) is the target and hence the labour remuneration has to be increased by increasing the number of vessels and hence the crew remuneration (scenario 13).

Both objectives (max profit and max GVA) are quite different in the results that are provided. Max GVA (scenario 13) is based on increasing the fleet (at least one segment) and by increasing the remuneration of the labour the value added is increased. On the other hand, scenario 14 increases the performance by vessel of each vessel individually, but with a much lower number of vessels and hence with lower absolute values on the labour remuneration.

8.7.6. Assumptions and technical background (by main model modules)

Due to the lack of data, some assumptions have been made to estimate the economic value of the segments which are involved in the Bay of Biscay anchovy fishery. AER provides the data of the Spanish and French segments in general, and values have been extracted for the anchovy of Bay of Biscay fishery. For this purpose, some other sources of information have been used with the aim to improve the estimations. These sources are: "Long-term Management of Bay of Biscay Anchovy (SGBRE-08-01)", the ICES and the ICCAT.

The steps considered to convert the data of the segments of AER 2009 to data of the Anchovy of the Bay of Biscay fishery case study are:

- Select the segments to be considered from "Long-term Management of Bay of Biscay (SGBRE-08-01)".
- Compare the data of both countries used in the SGBRE-08-01 with the data of the AER and assume that the proportion of the vessels targeting anchovy of the Bay of Biscay by segment remains constant.
- It has been assumed that the capital cost for the Spanish fleet is equal to the French fleet.
- Fixed costs for France are assumed equal to the Spanish fleet.

Another assumption that has been made through the estimation of the parameters:

- The estimation of the growth function of anchovy has been made by fixing the carrying capacity as the maximum of a moving average (5 years). The reason for that is that given the available data it has been impossible to obtain a statistically significant estimation of intrinsic growth rate and carrying capacity simultaneously.

9. MEDITERRANEAN ANCHOVY FISHERIES (GSA 16)

9.1. Summary and conclusions

Main conclusion

The main segment analysed in this fishery realized in 2005-7 on average a net profit of 5 mln euro. Average annual discounted net profit oscillates under most scenarios around 5 mln euro. Elimination of overcapacity and recovery of stocks would produce a discounted net profit of 3-5 mln euro by the year 15. (see Figure 9.1)

Brief description of the case study

The case study analyses the pelagic fishery in the southern coast of Sicily (GSA 16), which is the most important fishing area for the Sicilian fleets. In this area, pelagic fisheries are exclusively practiced by vessels authorized to mid-water pair trawl and purse seine with an overall length between 12 and 24 meters. In accordance with the fleet segmentation adopted in the DCR, these vessels are classified as pelagic trawls and seiners (PTS 1224). In 2007, this fleet segment consisted of 51 vessels with an average capacity of 63 GT per boat. The main target species include European anchovy and European pilchard. These species accounted for a 53% of all landings in terms of volume and 34% in value. European anchovy represents the most important species in terms of both landings and revenues with 29% of total landings in weight and 25% in value. European pilchard represents the second most important species in terms of landings amounting to 24% of total production. In terms of value, given the low average price (1.12 euro/kg), this species contributes for just a 9% to total revenues.

Divergence / convergence of the results

Comparing the different scenarios, the level of landings varies from 9,600 tonnes in scenario 11 to 19,200 tonnes in scenario 14. The level of landings is a function of the fishing effort applied on the biomass. Consequently, also the minimum level of fishing effort, equal to 7,000 days at sea, is achieved in scenario 11, and the maximum level of 18,000 in scenario 14. Fishing effort consists of two components, number of vessels and average fishing days per vessel. The minimum number of vessels are registered in scenario 11 (45 vessels), while the maximum number in scenario 14, where the fleet size is estimated in 116 vessels. Generally, scenarios applying higher levels of fishing effort are also those with higher profits. The highest value of profit is found in scenario 14 (5 million euro), while the maximum NPV $profit_{15}$ (88 million euro) is estimated in scenario 7. However, this is due to the use of a discount rate (2%) lower than that used in other scenarios (3.5%). The maximum values in NPV $profit_{15}$ at a discount rate of 3.5% is registered in scenario 14, with a value of 85 million euro. The lowest value is estimated at 71 million euro in scenario 8. Also this result is affected by the interest rate, which is set at 5%. Among scenarios with an interest rate at 3.5%, the lowest value, estimated in 75 million euro, is in scenario 11.

All scenarios, with the exception of scenario 11, lead to an increase in the fleet size. This is due to the under-exploitation status of the two stocks. The most significant increases are in scenario 14. In these scenarios, the fishermen behaviour leads to an increasing overexploitation of European anchovy and consequently its extinction. Based on this, scenarios 4 and 5 are unsustainable from an environmental point of view.

Choice of baseline policy

Scenario 2 (Effort min) has been selected as "main scenario" or the scenario reflecting better than others the actual management system. Scenario 2 simulates a policy option directed to achieve the MSY for the stock showing the maximum overexploitation rate (difference between current and target harvest ratio) or the minimum under-exploitation rate (when all stocks are underexploited). In the present case study, both European anchovy and pilchard are underexploited and the stock with the minimum under-exploitation rate is European anchovy. As for the other options, scenario 4 (Effort max) is directed to achieve the

MSY for the stock showing the minimum overexploitation rate (when all stocks are overexploited) or the maximum under-exploitation rate (when at least a stock is not overexploited), while scenario 5 simulates an Open access situation. As the actual management system is not open access, but consists of a number of management measures directed to safeguard all the stocks exploited by fishing activities, scenario 5 cannot be adopted as main scenario. Furthermore, as in the present case study all stocks are underexploited, both scenarios 2 and 4 suggest an increase in fishing effort. However, scenario 2 is more conservative than scenario 4. For this reason, scenario 2 has been selected as the main scenario.

Achieving MSY

Scenario 2 simulates a policy option directed to achieve the MSY for the stock showing the minimum under-exploitation rate. As this is selected as the “main scenario”, also the scenarios from 7 to 12, based on the main scenario, operate to achieve the same objective. The stock with the minimum difference between H target and H current is European anchovy. MSY cannot be achieved for both species at the same time. The level of fishing effort corresponding to the MSY for anchovy will maintain a status of under-exploitation for sardine (the harvest ratio will be lower than the target F). Among the scenarios directed to achieve MSY for European anchovy, scenario 9 is the most efficient showing the best economic performance (83 million euro in NPV profit_{15}).

Achieving MEY (NPV profit_{15})

Even though scenario 9 is the most efficient among the scenarios directed to achieve MSY, results do not match with the MEY solution. The scenario showing results closest to the MEY solution are scenarios 13 and 14. Both scenarios are directed to achieve the MEY by optimizing the number of vessels of all fleet segments over the simulation period, but MEY is expressed in terms of GVA in scenario 13 and profit in scenario 14. In terms of profits, scenario 14 shows the best economic performance among the simulated scenarios. The maximum resource rent over the first 15 years of the simulation period, equal to 85 million euro, has been estimated in this scenario as the NPV of profit. In year 15, a fleet of 116 vessels is active in scenario 14. This represents an increase of 120% compared with the baseline, and 4% with the fleet in the main scenario.

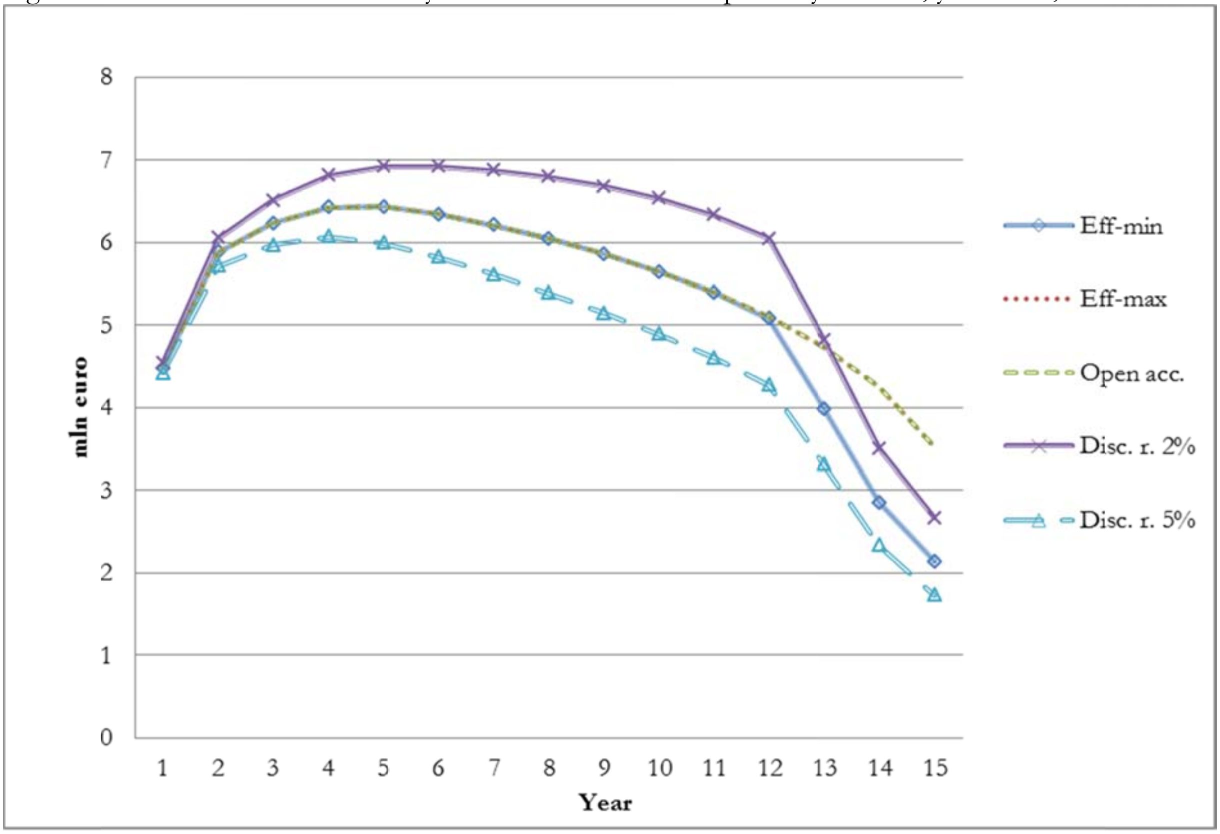
Role of discount rate

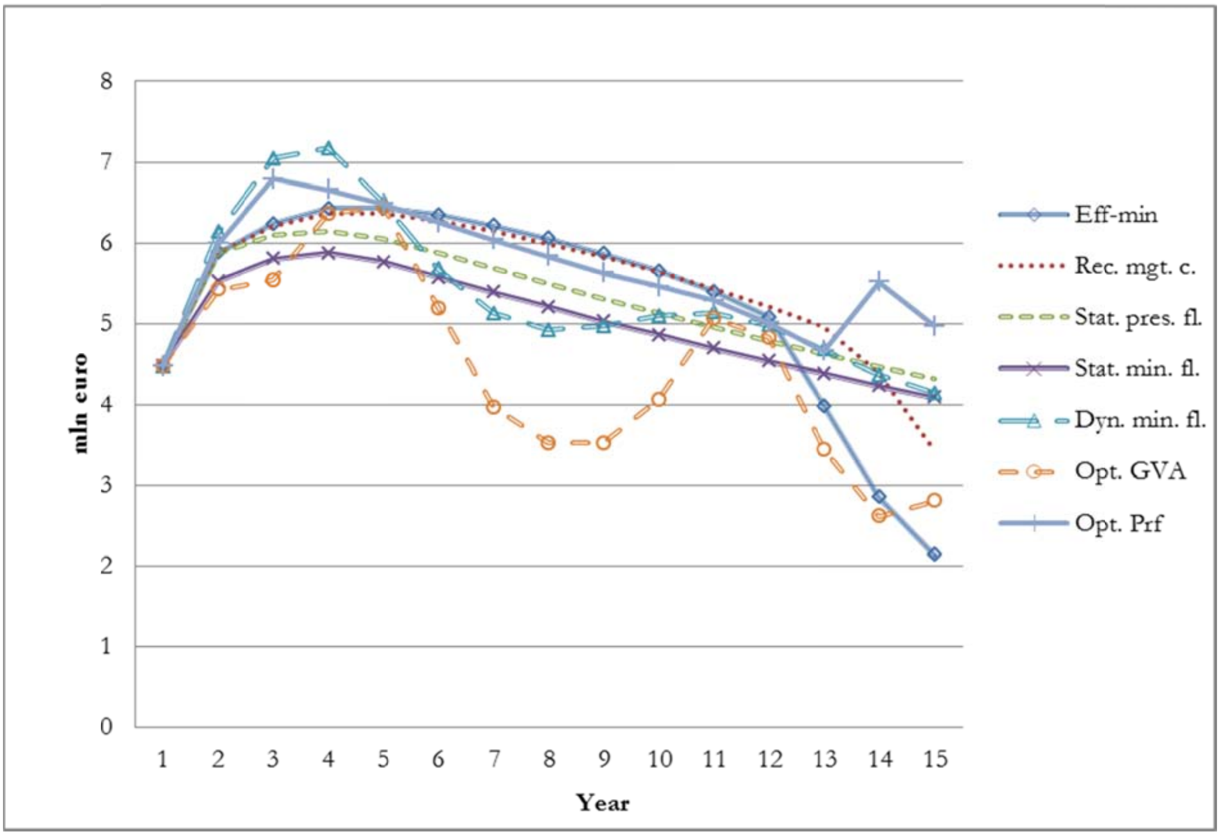
Scenarios 7 and 8 differ from each other scenario as discount rates of 2% and 5% respectively have been applied instead of 3.5%. However, compared with the main scenario, variations in the discount rate have not produced any effect on the dynamics of the system. The same nominal profit is registered in year 15 for the three scenarios. Regarding the NPV profit_{15} and the discounted profit of year 15, obviously the highest values are estimated at the lowest discount rate.

Impact of eliminating overcapacity

In this case study, the two stocks included in the model, European anchovy and European pilchard, show levels of harvest ratio lower than those matching with the MSY. As a consequence, these stocks cannot be considered overexploited and these fisheries do not require a reduction of fishing effort. Given the status of these stocks, overcapacity is not an issue in any of the scenarios and the number of vessels can be increased.

Figure 9.1 Mediterranean Sea anchovy – discounted annual net profit by scenario, years 1-15, mln euro[50]





50 TAC scenarios are not relevant for this fishery and therefore have not been calculated.

Management costs and rent recovery

The introduction of a fixed payment for access has reduced the profitability and made the sector less attractive. As a consequence, investments in new vessels are lower than those in the main scenario. A total of 87 vessels would operate in year 15 for this scenario compared to a number of 112 in the main scenario. However, the increase in the average days at sea per vessel produced a level of fishing effort higher than that in the main scenario. Even though fishing effort is higher in this scenario, landings are almost equal in the two scenarios. The different composition of fishing effort highlights a higher efficiency when a payment for access is introduced. Indeed, reducing the number of vessels and increasing the average number of fishing days allows the fleet to reduce fixed and capital costs (which depend on the number of vessels). Nominal profit in year 15 for this scenario amounts to 5.2 million euro, higher than the value of 3.6 million euro in the main scenario. The difference between these value is due to the fixed and capital costs. Even after deducting the 1.6 million euro, as the payment for access, estimated profits remain positive.

9.2. Case study definition

9.2.1. Fleet and landings

The case study deals with the pelagic fishery along the southern coast of Sicily (GSA 16), which is the most important fishing area for the Sicilian fleets. In this area, pelagic fisheries are exclusively practiced by vessels authorized to mid-water pair trawl and purse seine with an overall length between 12 and 24 metres, which are concentrated in the port of Sciacca. In accordance with the fleet segmentation adopted in the DCR, these vessels are classified as pelagic trawls and seiners (PTS 1224). In 2007, this fleet segment consisted of 51 vessels with an average capacity of 63 GT per boat. The main target species include European anchovy (Engraulis encrasicolus) and sardines (Sardina pilchardus). These species accounted for a 53% of all landings in volume and 34% in value.

Table 9.1 Role of case study fisheries within national fishery sectors

Member State	Total fishery sector		Case study fleets	
	Total revenues (mln euro)	Total fleet (number of vessels)	Revenues (mln euro)	Fleet (number of vessels)
Italy	1,426	14,428	21.6	51

Source: IREPA, 2007

Table 9.2 Role of target species

MS	Gear	Size	No. vessels	GT (1000)	Landings (1000 t)		Value (mln euro)	
					Target species	Total	Target species	Total
ITA GSA16	PTS	12-24	51	3,193	4.0	7.6	7.4	21.6
Total			51	3,193	4.0	7.6	7.4	21.6

Source: IREPA, 2007

9.2.2. Composition of landings

European anchovy represents the most important species in terms of both landings and revenues. This species accounts for 29% of total landings in weight and 25% in value. European pilchard represents the second most important species with 24% of total volume. In terms of value, given the low average price (1.12 euro/kg), this species contributes only 9% of total revenues. In 2007, the group of other species contributed around 47% of the total volume and 66% in value. Other important species are Northern bluefin tuna and greater amberjack. Northern bluefin tuna accounts for 19% of total revenues and 9% of catches, while greater amberjack for a 17% in value and 5% in weight.

Table 9.3 Composition of landings by segment (tonnes)

MS	Gear	Size	European anchovy	European pilchard	Other	Total
ITA GSA16	PTS	12-24	2.2	1.8	3.5	7.6
Total			2.2	1.8	3.5	7.6

Source: IREPA, 2007

Table 9.4 Composition of landings by segment (mln euro)

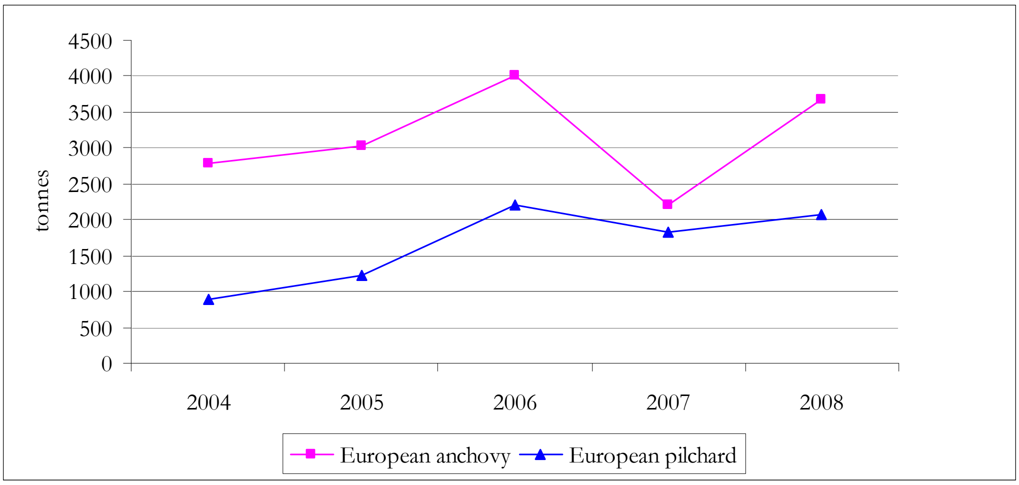
MS	Gear	Size	European anchovy	European pilchard	Other	Total
ITA GSA16	PTS	12-24	5.4	2.0	14.2	21.6
Total			5.4	2.0	14.2	21.6

Source: IREPA, 2007

9.3. Historical indicators

Trends in the levels of landings for anchovy and sardine in GSA 16 are reported in Figure 9.2 for the period 2004-2008. The highest levels of landings are registered in 2006 for both anchovy and sardine. In that year landings achieved 4,000 tonnes for European anchovy and 2,200 for European pilchard. Landings dynamics are similar between the two pelagic stocks showing an increase from 2004 to 2006, a reduction in 2007, particularly significant for anchovy, and a new increase in 2008 reporting the values close to the maximum of the period analysed.

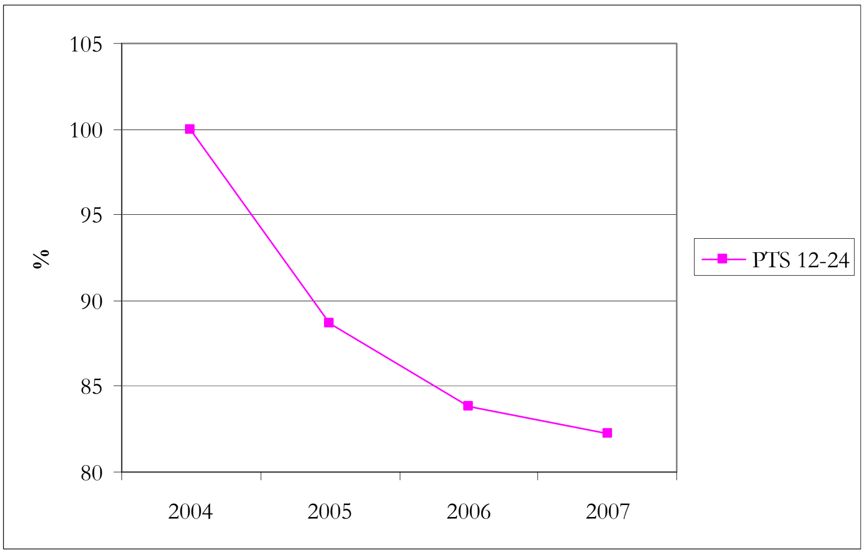
Figure 9.2. Landings by target species (2004-2008 data)



Source: IREPA

The fleet dynamic in the period 2004-2007 in terms of number of vessels is shown in Figure 9.3. The pelagic fleet in GSA 16 shows a strong reduction of almost 20% in the number of vessels, passing from 62 vessels in 2004 to 51 in 2007. The most significant reduction in the size of pelagic fleet took place in 2005, when the number of vessels was reduced by 7 units.

Figure 9.3 Change in vessels number (2004-2007 data)



Source: IREPA

9.4. Fleet efficiency

As pelagic fishery in GSA 16 is practiced by a single fleet segment, comparison of fleets in terms of efficiency is not applicable. Economic indicators for the fleet segment PTS 1224 are presented in Table 9.5.

Table 9.5 Economic indicators

MS	Gear	Size	Gross value added (mln euro)	Profit (mln euro)	Employ-ment	Average price (euro/t)	Fuel costs as % of income	Profit / tonne landings (euro/t)	CPUE total (t/day)	CPUE target species (t/day)
ITA GSA 16	PTS	12-24	41.36	13.5	1,276	2,540	14.3	580	1,133.1	708.4
Total			41.36	13.5	1,276	2,540	14.3	580	1,133.1	708.4

Source: IREPA, 2005-7

Figure 9.4 Economic indicators
Not applicable for the case study

9.5. Management measures

9.5.1. General description

The small pelagic fishery in GSA 16 is regulated by a series of technical measures limiting both the input and the output.

Pelagic fisheries can be exerted only by vessels authorized to mid-water pair trawl and purse seine. The fleet segment PTS 1224 includes both purse seiners and pelagic trawlers. All vessels are required to hold a licence, which is centrally managed by the General Direction of Fishery of the Ministry of Agriculture Food and Forestry Policy. Licences are issued by the Ministry to the ship-owner and they are not transferable. The licence specifies detailed terms and conditions for the operations, including limitations on fishing areas and gear used. The licence identifies the vessel through a European code and other information concerning the vessel characteristics (i.e. name, authorized gear, GT, kW, LOA etc.).

Consequently, one fishing licence corresponds exclusively to one fishing vessel. Licences are valid for eight years and are renewed on the request of the ship-owner.

9.5.2.Input management

Effort restrictions

In addition to the fishing licence, for the mid-water pair trawlers in the port of Sciacca, each year the national authority authorises a limited number of vessels to engage small pelagic fishery with mid-water trawls. This number varies from one year to another, according to the scientific advices and the market conditions. Fishing with mid-water trawl is also subject to annual, temporary suspensions, which is usually foreseen from August to September for a minimum of 30 days.

The minimum mesh size is 20 mm for mid water pair trawlers and 14 mm for purse seiners. With reference to the current legislation at European level (Council Regulation (EC) No 1967/2006) and national legislation (Law 963, 14 July 1965, as further amended, and Presidential Decree 1639 of 2 October 1968, as further amended), minimum size for anchovies is 9 cm overall length, while 11 cm is established for sardines. The measure relating to minimum landing sizes is linked to other technical measures, such as the ban to fish within the 3-miles from the coast to prevent fishing in the areas where juveniles are concentrated

Input property rights

As the licences are not transferable, there are no input property rights in this fishery.

9.6. Management costs

9.6.1.Summary of OECD data

Detailed data on management costs are not available at GSA level. For this reason the management costs of each case study have been assumed proportionate to the share of the fleet segment in the total national revenues. GSA 16 PTS 1224 on average represents 12% of the Italian management costs, i.e. 1.6 million euro.

On the basis of the OECD statistics on government financial transfers, management cost are primarily destined for direct payments (62%), while general services represent 38% of total management costs. 16% of direct payments consists of decommissioning costs (0.2 million euro) and 8% of renewal and modernization costs (0.1 million euro). 38% of direct payments are other costs, which include temporary withdrawal, joint venture, support to small scale fishery, support to freshwater fishery and to protection and development.

In relation to general services, enforcement and research costs represent 13% and 5% respectively of total management costs. Management and enforcement amount to 0.2 million euro, while research to 0.1 million euro.

Table 9.6 Management costs according to OECD, average 2004-2006* , (mln euro)

	PTS 12-24 GSA 16
Direct Payments	1.0
- Decommissioning	0.3
- Fleet renewal and modernization	0.1
- Other	0.6
General Services	0.6
- Management and enforcement	0.2
- Research	0.1
- Other	0.3
Total	1.6

*sum of national and EU contributions regarding marine capture fisheries.

** share of national costs allocated to individual segments have been assumed proportionate to the share of the segment in the total revenues of the national marine fisheries sector.

9.6.2. Support to fishing sector (FIFG and EFF)

In order to evaluate the FIFG and the EFF support to the caching sector, the measures under the FIFG axis 1 and 2 have been compared with the measures foreseen under the EFF priority axis 1. In both cases they have been estimated on the basis of the share in the total national revenues and they represent 1.6% of the EFF and FIFG funds allocated to Italy. Average annual FIFG allocation amounts to 4.8 million euro, while average annual EFF support amounts to 0.7 million euro.

Table 9.7 Average annual support to the marine fisheries from FIFG and EFF, (mln euro)*

	PTS 12-24 GSA 16
FIFG - Axis 1 and 2	4.8
EFF - Axis 1	0.7

9.6.3. Costs of research and management

In absence of detailed data, management, control and enforcement costs are those estimated from the OECD statistics. Research costs have been estimated as a quota of the national DCF budget augmented of a 30%. The quota related to the pelagic fishery in GSA 16 has been calculated according to its share in national landings value.

Table 9.8 Estimated management and research costs, (mln euro)

	PTS 12-24
Management, control, enforcement	0.2
Research (DCF+30%)	0.1

Sources: OECD and Com. Decision 811/2009

9.7. Estimation of the resource rent

9.7.1. Comparison of scenarios

Table 9.9 Comparison of the scenarios

Scenario no.	Effort (1000 DAS)	Fleet (no. vessels)	Catch (1000 t)	Profit year 15 discounted (mln euro)	NPV $Profit_{15}$ (mln euro)
Average values 2005-7					
2005-7	7	53	7.7	4.5	
Values in year 15 of the scenario					
1. TAC min					
2. Effort min	11	112	13.1	2.1	79.0
3. TAC max					
4. Effort max	17	112	17.1	3.5	82.6
5. Open access	17	112	17.1	3.5	82.6
6. Min min					
7. Discount rate 2%	11	112	13.1	2.7	88.1
8. Discount rate 5%	11	112	13.1	1.7	71.3
9. Recovery mgt. costs	13	87	13.1	3.4	82.6
10. Static present fleet	8	53	10.8	4.3	79.3
11. Static minimum fleet	7	45	9.6	4.1	75.4
12. Dynamic min. fleet	12	80	13.9	4.1	80.4
13. Optimum fleet (GVA)	15	98	16.1	4.3	83.2
14. Optimum fleet (profit)	18	116	19.2	5.0	85.0

Table 9.9 shows the main results by scenario. As the fisheries in this case study are multi-species and managed by an input control regime, scenarios 1, 3 and 6 (based on TAC policies) are not applicable. Among the applicable scenarios, scenario 2 (Effort min) has been selected as "main scenario" or the scenario reflecting better than others the actual management system. Scenario 2 simulates a policy option directed to achieve the MSY for the stock showing the maximum overexploitation rate (difference between current and target harvest ratio) or the minimum under-exploitation rate (when all stocks are underexploited). In the present case study, both European anchovy and pilchard are underexploited and the stock with the minimum under-exploitation rate is European anchovy. As for the other options, scenario 4 (Effort max) is directed to achieve the MSY for the stock showing the minimum overexploitation rate (when all stocks are overexploited) or the maximum under-exploitation rate (when at least a stock is not overexploited), while scenario 5 simulates an Open access. As described above, the actual management system is not open access, but consists of a number of management measures directed to safeguard all the stocks. As in the present case study all stocks are underexploited, both scenarios 2 and 4 suggest an increase in fishing effort. However, scenario 2 is more conservative than scenario 4. For this reason, scenario 2 has been selected as the main scenario.

Scenarios from 7 to 14 are based on the main scenario, but include specific assumptions described in the detail in the related sections. In particular, scenarios 13 and 14 are aimed to estimate the optimum fleet maximizing NPV GVA_{15} and NPV $profit_{15}$ respectively. A general overview of the simulated scenarios highlights that values of fishing effort and landings are generally higher than those realized in the baseline. Compared with the main scenario, the NPV $profit_{15}$ is lower in scenarios 8 and 11, and higher elsewhere.

Comparing the different scenarios, the level of landings varies from 9,600 tonnes in scenarios 11 to a 19,200 tonnes in scenario 14. The level of landings is a function of the fishing effort and the biomass. Consequently, also the minimum level of fishing effort, equal to 7,000 days at sea, is found in scenario 11, and the maximum level of 18,000 results from scenario 14. Fishing effort consists of two components, number of vessels and average fishing days per vessel. The different combinations of these components can be derived by comparing the columns of effort and fleet in Table 9.9. The minimum number of vessels is in scenario 11 (45 vessels), while the maximum number is in scenario 14, where the fleet size is estimated in 116 vessels. Generally, scenarios applying higher levels of fishing effort are also those with higher profits.

Table 9.9 shows the discounted profit of year 15 and the NPV $profit_{15}$ for each of the simulated scenarios. The highest values of profit is in scenario 14 (5 million euro), while the maximum NPV $profit_{15}$ (88 million euro) is estimated in scenario 7. However, this is due to the use of a discount rate (2%) lower than that used in other scenarios (3.5%). The maximum values at a discount rate of 3.5% is realized in scenario 14, with an NPV $profit_{15}$ of 85 million euro. The lowest value is estimated at 71 million euro in scenario 8. Also this result is affected by the interest rate, which is set at 5%. Among scenarios with an interest rate at 3.5%, the lowest value, estimated in 75 million euro, is in scenario 11.

Scenario 2 simulates a policy directed to achieve the MSY for the stock showing the minimum under-exploitation rate. As this is selected as the "main scenario", also the scenarios from 7 to 12, based on the main scenario, pursue same objective. The stock with the minimum difference between H target and H current is European anchovy. MSY cannot be achieved for both species at the same time. The level of fishing effort corresponding to the MSY for anchovy will maintain a status of under-exploitation for sardine (the harvest ratio will be lower than the target H).

Among the scenarios directed to achieve MSY for European anchovy, scenario 9 is the most efficient showing the best economic performance (NPV $profit_{15}$ of 83 million euro). However, this cannot be considered as a scenario directed to achieve the MEY. The scenario showing results closest to the MEY solution are scenarios 13 and 14. Both scenarios are directed to achieve the MEY by optimizing the number of vessels of all fleet segments over the simulation period, but MEY is expressed in terms of GVA in scenario 13 and profit in scenario 14. As profit is maximized in scenario 14, this scenario shows the highest NPV $profit_{15}$ among all scenarios.

All scenarios, with the exception of scenario 11, lead to an increase in fleet size. This is due to the under-exploitation status of the two stocks. The most significant increase is in scenario 14. In these scenarios, the fishermen behaviour leads to an increasing overexploitation of European anchovy and consequently its extinction. Based on this, scenarios 4 and 5 are unsustainable from an environmental point of view.

As reported above, the maximum NPV $profit_{15}$ is produced by scenario 14. This result is related to the pelagic fisheries in GSA 16 as a whole. In multi-species fisheries, the economic performance depends on the contribution of a number of stocks. The contribution of each stock can be estimated proportionately to the share of total revenues coming from that stock. In all scenarios, the target species contributing the most to the total revenues is European anchovy. In particular, in the main scenario this quota is estimated at around 32%.

9.7.2. Policy options (scenarios 1-6)

Summary

Table 9.10 Effect of different policies on profit, harvest ratio, catches, effort and fleet

Indicator	2005-7	Scenarios**					
		1. TAC min	2. Effort min	3. TAC max	4. Effort max	5. Open access	6. Min min
NPV $Profit_{15}$			79.0		82.6	82.6	
Profit year 15 discounted	4.5		2.1		3.5	3.5	
Harvest ratio (year 15)*							
European pilchard	0.2		0.3		0.4	0.4	
European anchovy	0.6		0.8		1.5	1.5	
Catch in (1000 t, for scenarios year 15)							
European pilchard	1.8		3.2		4.3	4.3	
European anchovy	3.1		5.0		6.4	6.4	
Effort (1000 DAS, for scenarios year 15)							
PTS 12-24	7		11		17	17	
Fleet (no vessels, for scenarios year 15)							
PTS 12-24	53		112		112	112	

*F=1 implies that the stock is almost extinct.

As reported above, scenario 2 (main scenario) and all the scenarios based on the "main scenario" (scenarios from 7 to 12) simulate a policy option directed to achieve the MSY for the stock showing the minimum under-exploitation rate. This stock is European anchovy, which H target is estimated in 0.79. Table 9.10 shows that a value close to this has been achieved in year 15 by scenario 2. In multi-species fisheries, MSY cannot be achieved for all species at the same time. The level of fishing effort determining MSY for European anchovy allows under-exploitation of the other stocks. Indeed, the harvest ratio in year 15 for European pilchard is lower than the related target F.

The other two scenarios reported in Table 9.10 show identical results. Even though scenario 4 pursues the MSY for the stock showing the maximum under-exploitation rate, for reasons explained in the scenario section, simulation results are driven by fishermen behaviour under an open access system. As a consequence, H target is not achieved for any of the stocks. On the contrary, these scenarios lead to the extinction of European anchovy after year 17.

In terms of economic performance, Table 9.10 shows a higher value for scenarios 4 and 5 compared with the result obtained in scenario 2. Profit in year 15 for scenarios 4 and 5 is 65% higher than that estimated in scenario 2, while the NPV $profit_{15}$ in scenarios 4 and 5 is 4% higher than that obtained in the main scenario. However, the economic performance in scenarios 4 and 5 is not sustainable and declines dramatically after year 17 with the extinction of European anchovy.

Comparing the results in year 15 of scenario 2 with the baseline, Table 9.10 shows a significant increase in harvest ratio for both stocks. The strongest increase occurs for European pilchard. Harvest ratio for this species rises by 40% compared with the baseline. This is also the species showing the strongest increase in landings (more than 80%). As for European anchovy, this stock shows an increase in harvest ratio and landings of 33% and 63% respectively.

Scenario 1. TAC min

Figure 9.5 Results of scenario 1. TAC min
Not applicable for the case study.

Scenario 2. Effort min

The policy option aims to achieve MSY for at least one stock in the long run. Given a number of species, the model calculates the ratio between the target and the current harvest ratio in each time period for each of the species considered and selects the minimum value of these ratios. Fishing effort is changed proportionately to this ratio. As the minimum value is associated to the stock showing the maximum overexploitation rate, this policy option is directed to safeguard the most depleted stock. However, when all stocks are underexploited (F current is lower than H target), the policy option increases fishing effort to achieve the MSY for the stock with the minimum under-exploitation rate.

As reported above, both stocks appear underexploited in the baseline and European anchovy is the species with the minimum under-exploitation rate. As a consequence, the change of fishing effort is driven by the status of this stock.

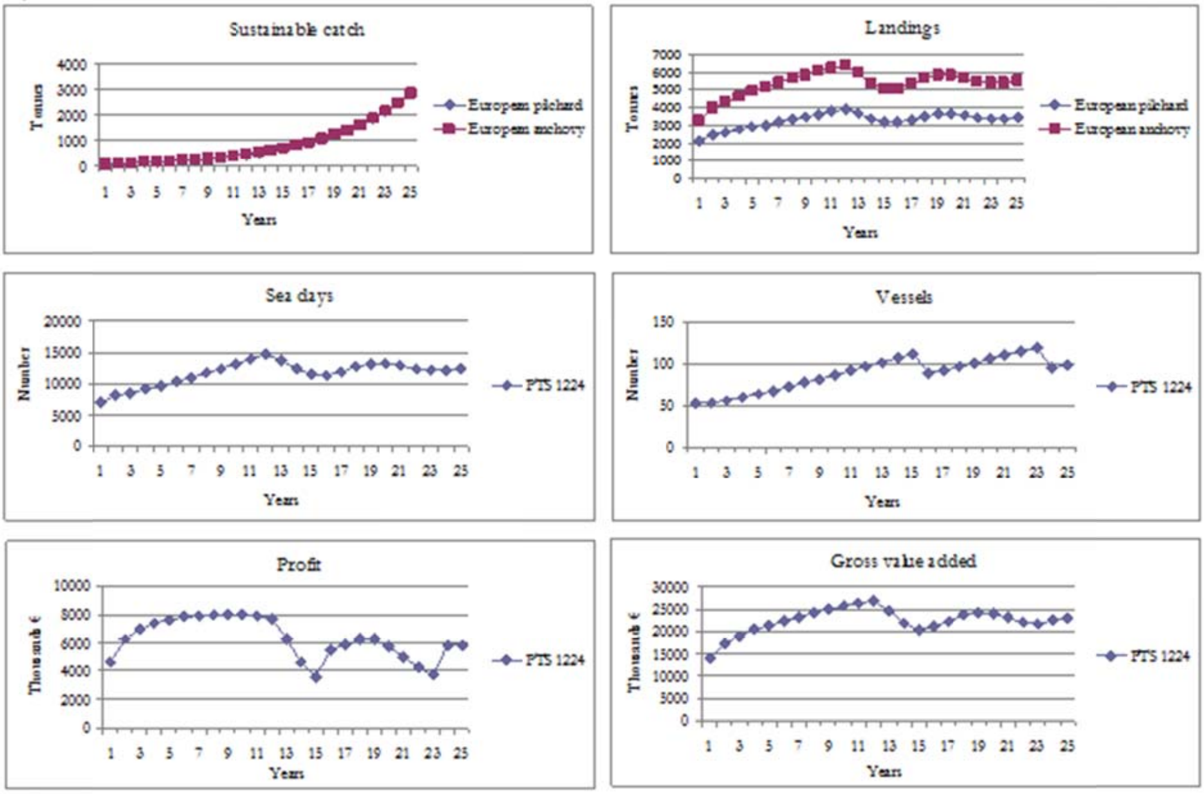
The two stocks are exploited to a different extent by the only one fleet, PTS 1224. At the baseline, the fishing effort is 7,000 days at sea. The total landings are in the baseline 7,730 tonnes.

Fishing effort shows an increasing trend in the first 12 years, as the stock was underexploited at the baseline, and a tendency to the long term equilibrium thereafter. The level of fishing effort corresponding to the MSY for European anchovy can be estimated in around 12,400 days at sea. However, this level is not achieved in the first 15 years of the simulation period. This is also due to the changes in the number of vessels due to the investment function. In the first 12 years of the simulation, the increase in fishing effort is due to the investment in new vessels, while after that year the policy option tends to reduce fishing effort or maintain it at a constant level. As European pilchard remains underexploited and the marginal productivity of effort is particularly high, the number of vessels tends to increase. The increase in the number of vessels is compensated by reducing the average days at sea (by the policy option). As the average number of days at sea per vessel falls, profitability turns negative and the number of vessels is reduced. These interactions between fishermen and policy behaviours explain the up-and-down fluctuations in the number of vessels in Figure 9.6. The link between the number of vessels and the levels of profitability appears also by comparing the related graphs in Figure 9.6. Variations in profit are opposite to variations in number of vessels.

The trend in profit shows an increase in the first 12 years and a reduction thereafter at lower levels. The level of profit in the long run seems to move around that estimated at the baseline.

In year 15, the system has not achieved its long term equilibrium. There is a peak in the number of vessels, and a lowest point in days at sea, landings and profit. The total fishing effort, equals to 11,000 days at sea, is almost 70% higher than the level estimated at the baseline. The fleet increases more than double compared to the baseline, from 53 to 112 vessels, while the number of days at sea per vessel per year decreases of 21%. The total catch shows an increase of 70% from 7,730 tonnes at the baseline to 13,130 tonnes in year 15. Landings of European pilchard and anchovy show increases of 80% and 63% respectively.

Figure 9.6 Results of scenario 2. Effort min



Scenario 3. TAC max

Figure 9.7 Results of scenario 3. TAC max

Not applicable for the case study

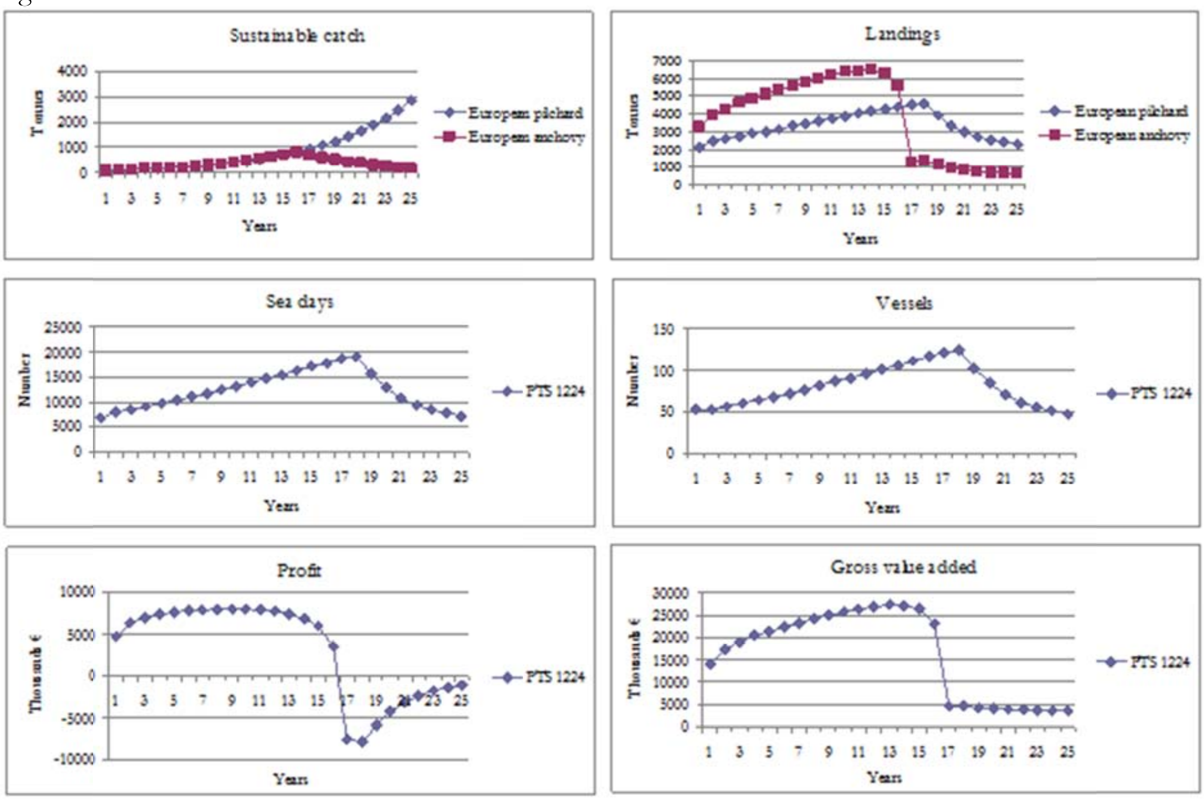
Scenario 4. Effort max

This scenario pursues MSY for at least one stock in the long run. The model calculates the ratio between the target and the current harvest ratio in each time period for each species and selects the maximum value of these ratios. Fishing effort is changed in accordance with this value. As the maximum value is associated to the stock showing the minimum overexploitation rate, this policy option is directed to safeguard the least depleted stock. However, when at least one stock is underexploited, the policy produces an increase in fishing effort to exploit the stock showing the maximum unde-rexploitation rate. However, as management authorities cannot impose an increase in the number of vessels or days at sea, the model selects the minimum level of effort between that suggested by the policy option and that resulting from the fishermen behaviour under an open access system, which is determined by the investment function.

Both stocks included in the model are underexploited at the baseline. The stock showing the maximum under-exploitation rate is European pilchard. Therefore, the selection of fishing effort is driven by the status of this stock. However, similarly to scenario 2, also in this scenario the increase in fishing effort identified by the policy option to achieve the MSY for European pilchard is higher than that potentially realized in an open access situation. Over the entire simulation period, changes in fishing effort are driven by fishermen behaviour, while policy decisions have no effect.

As a consequence, results obtained by this scenario are identical to those produced in the open access scenario. To avoid duplications, the main results for both cases are described under scenario 5.

Figure 9.8 Results of scenario 4. Effort max



Scenario 5. Open access

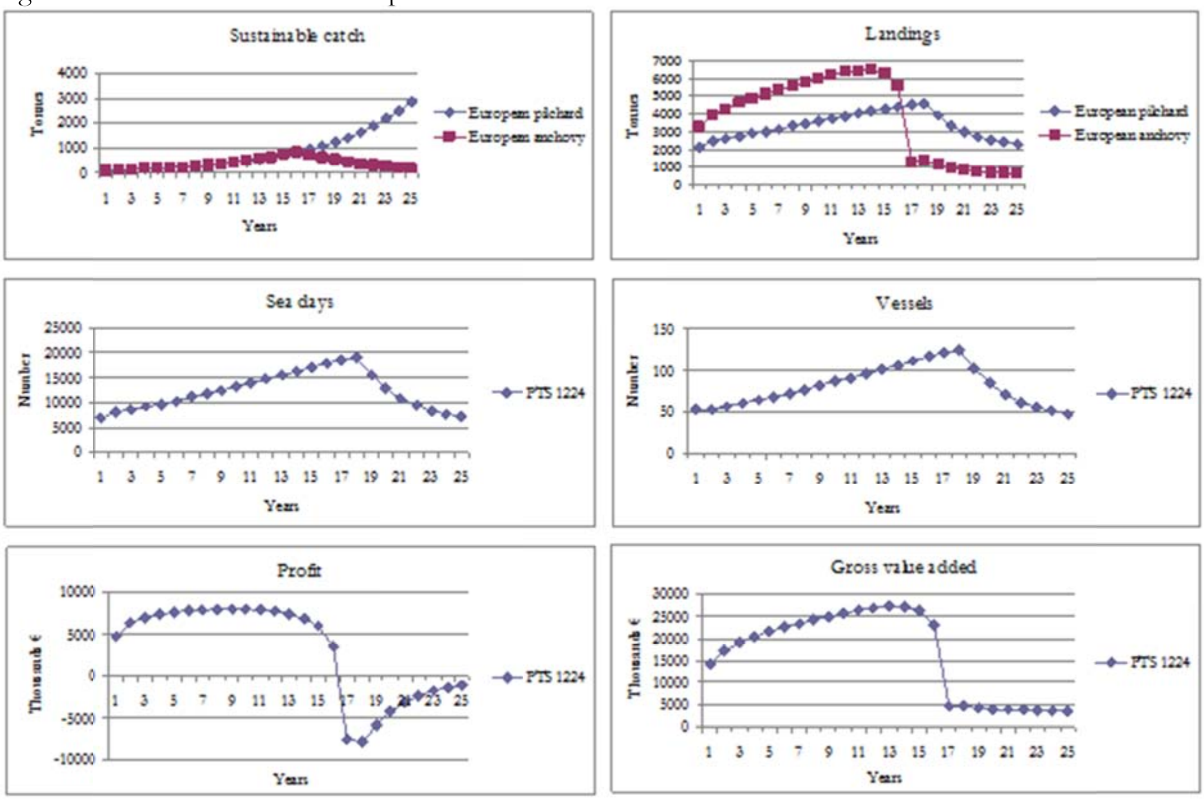
In this scenario there is no management policy. Variations in days at sea and number of vessels are defined by fishermen behaviour under the assumptions on the maximization of average days at sea per vessel and the investment function described in section 2.3 (FISHRENT model).

The maximum number of average days at sea for each of the fleet segments is reached in the second year of the simulation. As a consequence, the evolution of total days at sea (given by the maximum fishing days per vessel multiplied by the number of vessels) shows the same trend as the number of vessels. In the first 18 years, there is a significant investment in new vessels with an increase in the number of vessels of around 230%. The rising fishing effort and harvest ratio impacts negatively on the status of stocks. In particular, increasing the exploitation of European anchovy, the most vulnerable stock, leads to its "extinction" in year 17. As the stock of anchovy does not r recover, variations in the following period of simulation are based only on European pilchard.

The depletion of European anchovy makes the fishing activities unprofitable for the fleet. In year 17, profits are negative at 7.5 million euro. As a consequence, many vessels leave the activity in the following years. In the last year there are only 48 vessels active. The decrease in the number of vessels reduces losses after year 18, but does not eliminate them entirely.

In the year 15, the system has not achieved its long term equilibrium. The number of vessels is still increasing. The total fishing effort, 17,000 days at sea, is more than double the level of the baseline, due to an increase in the fleet from 53 to 112 vessels, and an increase in the number of days at sea per vessel to the maximum level. The total catch shows an increase of 220% from 7,730 tonnes in the baseline to 17,050 tonnes in year 15. Landings of European pilchard and anchovy show increases of 245% and 206% respectively.

Figure 9.9 Results of scenario 5. Open access



Scenario 6. Min / min
Figure 9.10 Results of scenario 6. Min / min
Not applicable for the case study

9.7.3. Role of discount rate (scenarios 7-8)

In the main scenario, a discount rate of 3.5% has been used to calculated the NPV $profit_{15}$. Scenarios 7 and 8 differ from the main scenario as discount rates of 2% and 5% respectively have been applied.

Variations in the discount rate have no effect on the dynamics of the system. The nominal profit in year 15 is same for the three scenarios. This value is lower than that estimated at the baseline. Regarding the NPV $profit_{15}$, obviously the highest values are obtained at the lowest discount rate.

Table 9.11 Effect of discount rate on profit

Indicator	2005-7	Scenario		
		Main scenario Discount rate 3.5%	7. Discount rate 2%	8. Discount rate 5%
NPV $Profit_{15}$		79.0	88.1	71.3
Nominal $Profit_{15}$*	4.5	3.6	3.6	3.6
Discounted $Profit_{15}$*		2.1	2.7	1.7

*this is the value in year 15, not the sum of profits

Scenario 7. Discount rate 2%

Comparing scenario 7 with the main scenario (scenario 2) shows that the changes in discount rate have no effect on nominal profit, while discounted profit is 24% higher when the discount rate is set at 2%. Regarding the net present value of profit, a discount rate of 2% leads to an increase of 11% in this indicator.

Scenario 8. Discount rate 5%

Comparing scenario 8 with the main scenario (scenario 2) shows that the changes in discount rate have no effect on nominal profit, while discounted profit is 20% lower when the discount rate is set at 2%. Regarding the net present value of profit, a discount rate of 5% leads to a decrease of 10% in this indicator.

9.7.4. Resource rent and recovery of management costs (scenario 9)

The full recovery of management costs is simulated in this scenario by adding a fixed payment for access to each fleet segment. These amounts are estimated as an average of OECD data in the period 2004-2006. This scenario is based on the "main scenario", (Effort min).

Results obtained in scenario 9 are similar to the scenario 2. Comparing Figure 9.11 with Figure 9.6 shows similar trends in the main variables. The main difference is related to the level in the number of vessels, which determines also differences in fishing effort, landings and economic indicators. The introduction of a fixed payment for access has reduced the profitability. As a consequence, investments in new vessels are lower than those in the main scenario. There are in total 87 vessels in year 15 in scenario 9 compared to 112 in scenario 2. However, the increase in the average days at sea per vessel produced a level of fishing effort (13,000 fishing days) higher than that in the main scenario (11,000 fishing days). Even though fishing effort is higher in this scenario, landings are almost equivalent in the two scenarios.

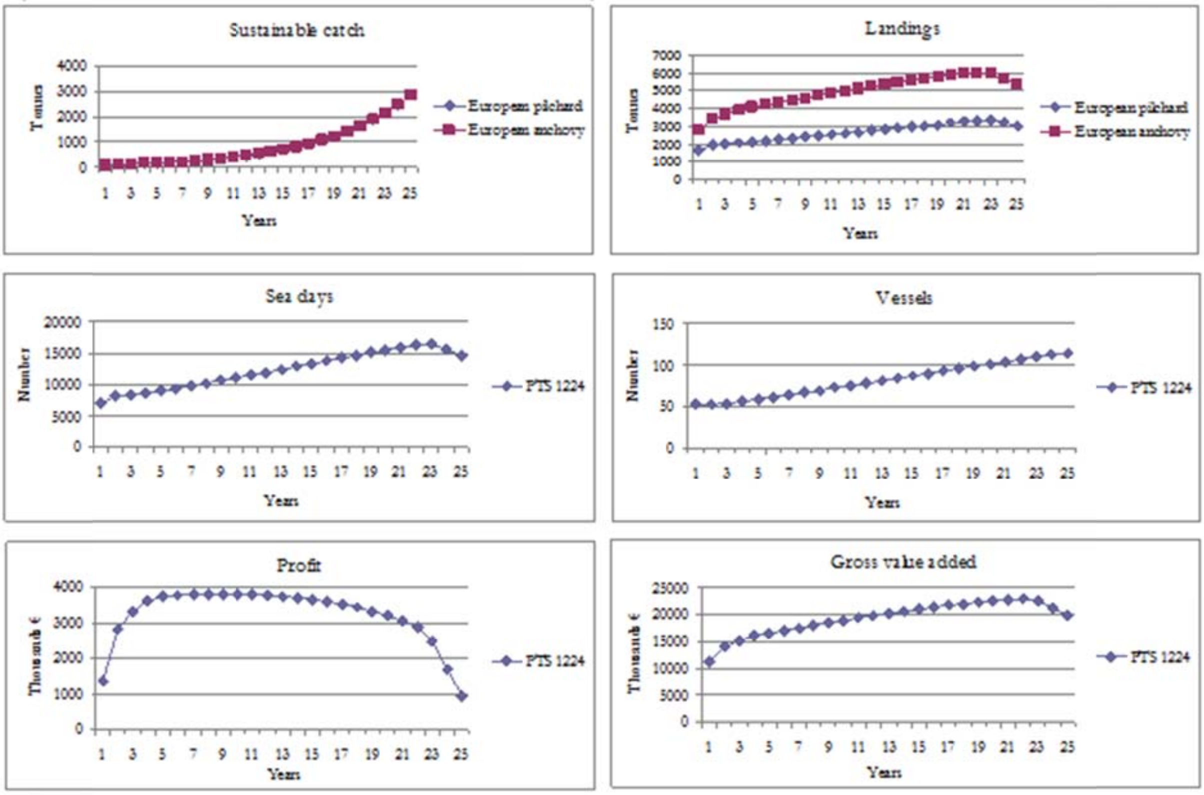
The different compositions of fishing effort highlights a higher efficiency in scenario 9. Indeed, reducing the number of vessels and increasing the average number of fishing days allows the fleet of scenario 9 to reduce fixed and capital costs (which depend on the number of vessels). In Table 9.12, nominal GVA in year 15 amounts to 21.1 million euro, slightly higher than the value of 20.4 million euro estimated in scenario 2. The difference between these values is due to the fixed costs. When comparing profits, the difference between scenario 9 and 2 is higher as this includes also the additional benefit deriving from the reduced capital costs.

Obviously, profits in Table 9.12 do not include the payment for access. This amounts to 1.6 million euro. When this cost is deducted from profit, the economic performance in scenario 9 will be lower than that in the main scenario. Figure 9.11 and Figure 9.6 show the profits after the deduction of payments for access. Payment for access is particularly relevant representing around 30% of total profits.

Table 9.12 Consequences of recovery of management costs

2005-7	Baseline	Scenarios*	
		Main scenario: No recovery of management costs	9. Recovery of management costs
NPV GVA_{15} (mln euro)		251.9	198.2
Nominal GVA_{15} (mln euro)	13.8	20.4	21.1
NPV $Profit_{15}$		79.0	82.6
Fixed payment for access (mln euro)		0.0	1.6
NPV Payment for $access_{15}$		0.0	0.9
Nom $Profit_{15}$ (mln euro)	4.5	3.6	5.2

Figure 9.11 Results of scenario 9. Recovery of management costs



9.7.5. Optimization of capacity (scenarios 10-14)

Scenarios 10 to 14 simulate the main optimum paths to achieve MSY or MEY. In particular, the level of fishing effort corresponding to MSY can be obtained at different combinations of its components, number of vessels and average days at sea per vessel. In the main scenario, MSY for European anchovy is achieved by one combination of fishing effort components given by the interactions between the management policy and the fishermen behaviour in terms of new investments. Scenarios 10 to 12 are directed to reach the MSY for European anchovy by using the same management option (Effort min), but imposing constraints on the system. The fleets in scenarios 10 and 11 are supposed to be stable, and equal respectively to the fleet operating at the baseline and the minimum fleet able to produce the same fishing effort at the baseline. In scenario 12, the average days at sea per vessel are supposed to be constant and equal to an assumed maximum level, while the fleet is modified each year by the policy option. Differently form the other scenarios, scenarios 13 and 14 are directed to achieve the maximum contribution to GNP and the MEY (i.e. maximum NPV GVA_{15} in scenario 13 and maximum NPV $profit_{15}$ in scenario 14 respectively) by optimizing the number of vessels of all fleet segments over the years from 2 to 15.

Table 9.13 Impact of optimization of the fleet size

Indicator	2005-7	Scenarios*					
		Main scenario TAC min	10. Static present fleet	11. Static minimum fleet	12. Dynamic minimum fleet	13. Optimum fleet (GVA)	14. Optimum fleet (profit)
NPV $Profit_{15}$ (mln euro)		79.0	79.3	75.4	80.4	83.2	85.0
Nominal $Profit_{15}$ (mln euro)	4.5	3.6	7.2	6.9	6.9	7.1	8.3
Discounted $Profit_{15}$ (mln euro)	4.5	2.1	4.3	4.1	4.1	4.3	5.0
$Fleet_{15}$ (no vessels)	53.0	112.0	53.0	45.0	80.0	98.0	116.0
$Effort_{15}$ (1000 DAS)	6.8	11.4	8.1	6.9	12.2	14.8	17.7
$Catch_{15}$ (1000 t)	7.7	13.1	10.8	9.6	13.9	16.1	19.2

*NPV row refers to the sum, other rows refer to values in year 15

Table 9.13 shows the values of the main variables in year 15 for each of the scenarios described above, and provides a comparison with the baseline. The main scenario and scenarios form 10 to 12 are directed to achieve the MSY of European anchovy. This should be obtained at a level of fishing effort estimated in around 12,400 days at sea. However, the only scenario able to achieve the MSY is the scenario 12, where this level is reached at the end of the simulation period. On the contrary, fleet in scenarios 10 and 11 cannot increase sufficiently to achieve this level of fishing effort given the constraints on the number of vessels and the maximum average days at sea per vessel. Therefore, no scenario achieves MSY for European anchovy in year 15. The closest value is in scenario 12, which shows also the highest level of landings (13,930 tonnes). This level of landings is only lower than those obtained in scenario 13 (16,150 tonnes) and scenario 14 (19,200 tonnes). Those represent the optimal levels from an economic point of view as scenario 13 is directed to maximize GVA and scenario 14 is aimed to maximize profit over the first 15 years of simulation. According with the theory, as stocks are not overexploited, the landings increase when fishing effort increases.

As scenario 14 is aimed to maximize profits, nominal and discounted profits in year 15 and NPV $profit_{15}$ in scenario 14 are higher than those estimated in other scenarios. As for the other scenarios in Table 9.13, NPV $profit_{15}$ raises with increases in the level of landings, and landings raise with increases in the level of fishing effort.

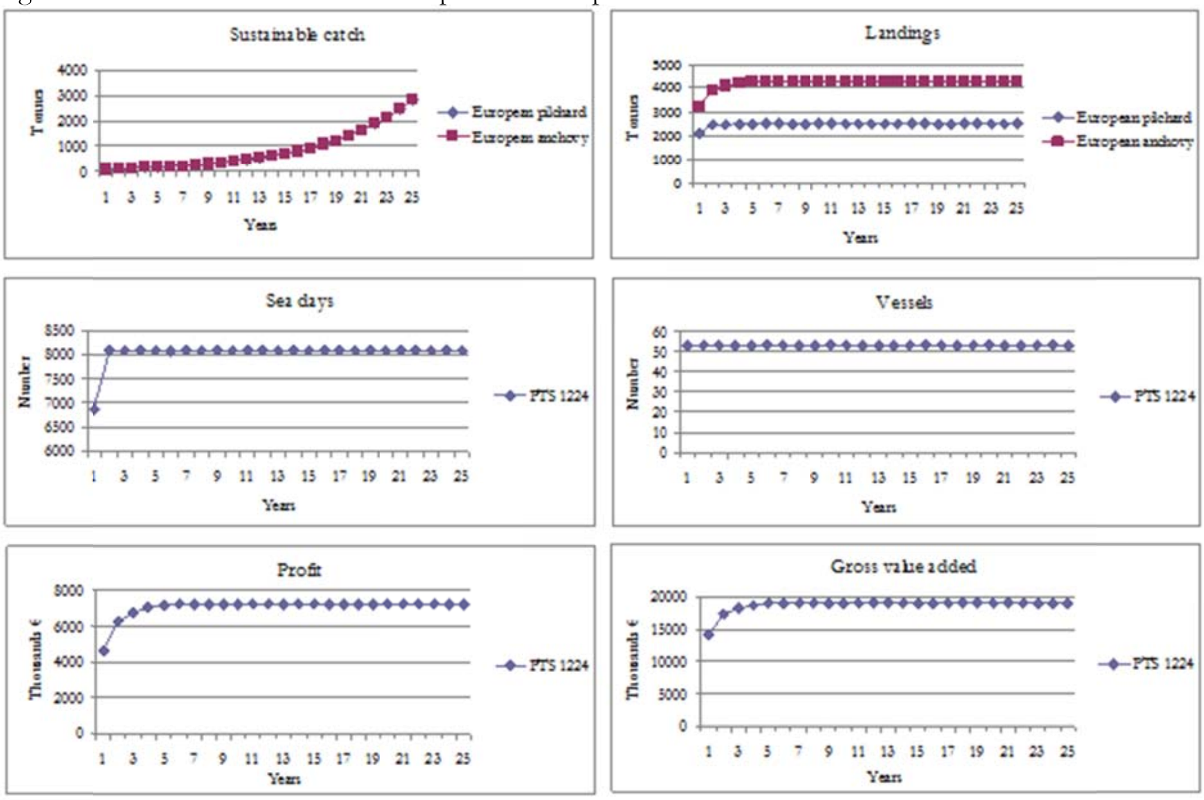
Scenario 10. Static present fleet

The fleet in scenario 10 is supposed to remain stable and equal to the fleet operating at the baseline. The average days at sea per vessel are changing according to the fishing effort selected by the policy option. However, even though the policy option tends to increase fishing effort by modifying the average fishing days, these cannot increase more than a an assumed maximum number of days per vessel. As a consequence, fishing days per vessel increase in year 2 and remain at the maximum level over the entire simulation period.

Results obtained by scenario 10 show changes only in the first years of the simulation. Fishing effort is constant and equal to 8,000 days after year 2. The levels of landings for European anchovy and pilchard show a slight increase in the first 6 years and remain at the corresponding long term equilibrium levels (2,485 tonnes for pilchard and 4,289 tonnes for anchovy) thereafter. The economic indicators follow a similar trend. Constant values of 19 million euro and 7.2 million euro are estimated for GVA and profit respectively after the year 6.

Given the lower number of vessels and days at sea, the economic performance in terms of GVA in scenario 10 is poorer than that in the main scenario. On the contrary, NPV profit[15] in scenario 10 is almost equivalent to that estimated in scenario 2. This is due to the reduced labour and capital costs in scenario 10.

Figure 9.12 Results of scenario 10. Adaptation with 'present' fleet



Scenario 11. Static minimum fleet

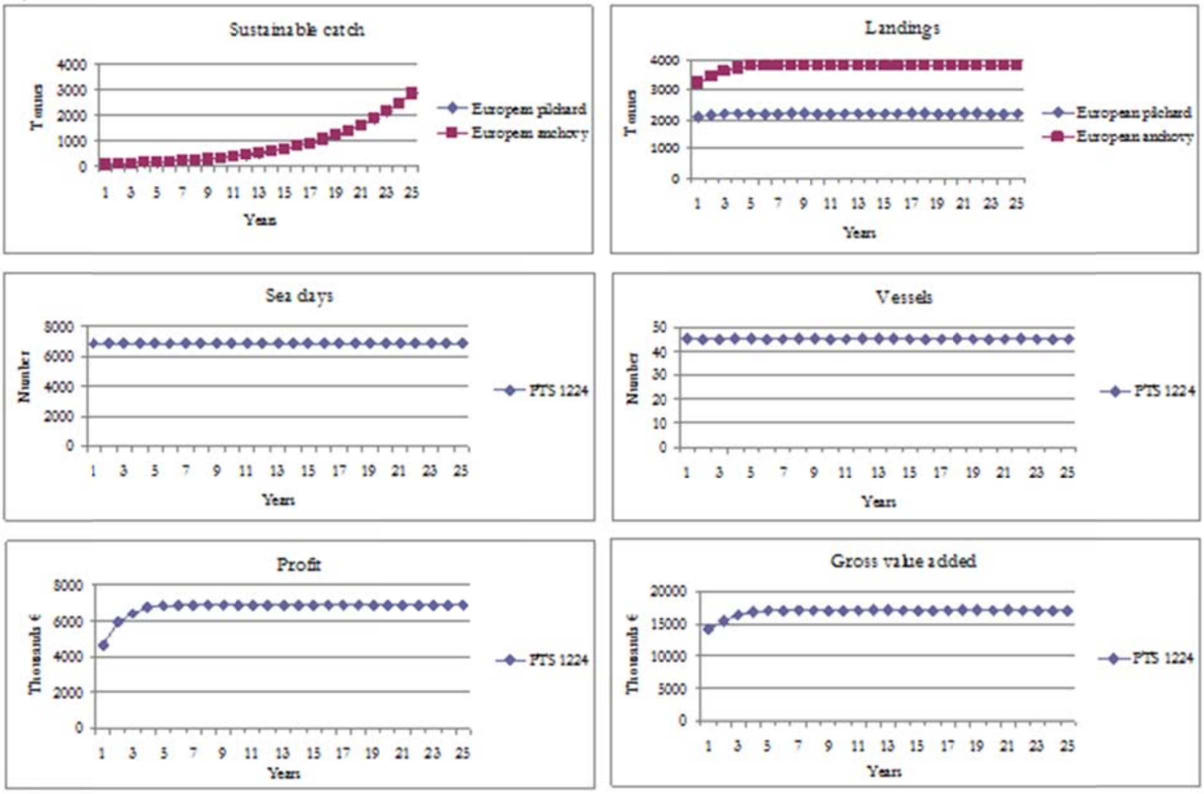
The fleet in scenario 11 is supposed to be stable and equal to the minimum fleet able to produce the same fishing effort as the baseline given a maximum days at sea per vessel. The average days at sea per vessel are changing according to the fishing effort selected by the policy option.

Scenario 11 is very similar to scenario 10. The only difference is related to the fleet size selected as starting value. This is equal to the baseline fleet in scenario 10 (53 vessels), while in scenario 11 this is set at a lower level (45 vessels). Also in this scenario the average days at sea per vessel are set to the maximum level after year 2 and maintained constant over the simulation period. As a consequence, fishing effort is lower than in scenario 10, and so are harvest ratio and levels of landings.

The gross value added reported in Figure 9.13 is lower then in Figure 9.12 (scenario 10). In Table 9.13, nominal profit in year 15 amounts to 6.9 million euro in scenario 11, lower than 7.2 million euro in scenario 10. In terms of NPV $profit_{15}$, scenario 11 shows a value over the first 15 years of simulation equal to 75.4 million euro, against 79.3 million euro in scenario 10.

Given the lower number of vessels and fishing effort, results in scenario 11 are poorer than those in the main scenario. In particular, NPV $profit_{15}$ is 5% lower than in the main scenario.

Figure 9.13 Results of scenario 11. Static minimum fleet



Scenario 12. Dynamic minimum fleet

In scenario 12, the average days at sea per vessel are supposed to be constant and equal to an assumed maximum level, while the fleet is changing each year in accordance with the fishing effort selected by the policy option.

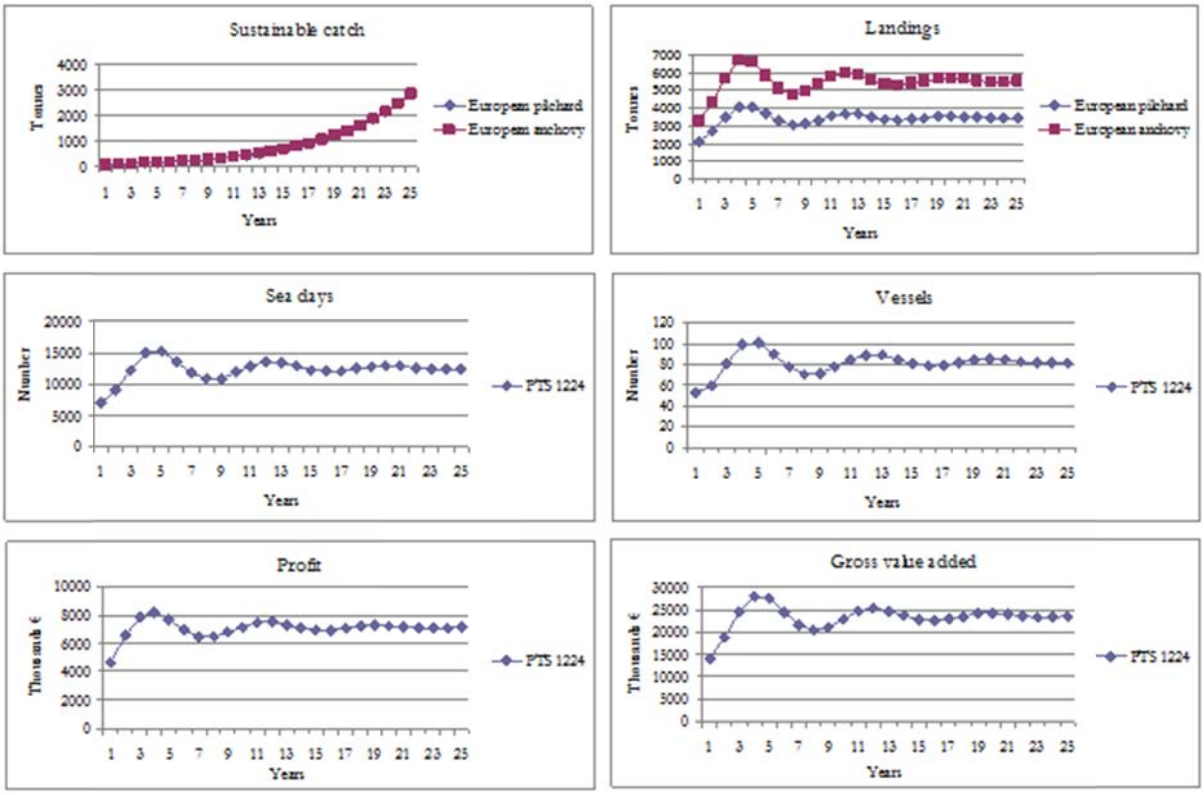
This is the only scenario where fishing effort is exclusively driven by the policy option. As a result, this is also the only scenario able to achieve the MSY for European anchovy. Fishing effort shows a clear trend to the level corresponding to the MSY. This level, estimated at 12,400 days at sea, is achieved at the end of the simulation period. Variations in fishing effort are determined by changes in the number of vessels as the average fishing days is set constant. In the year 15, there are 80 vessels, 52% more than those active in the baseline and 28% less than those in the main scenario.

Landings of both species show an increase in the first four years of the simulation period, and fluctuate around 5,500 tonnes for anchovy and 3,400 tonnes for pilchard thereafter. Total catches in year 15 are equal to 13,930 tonnes, a level higher than that registered in the previous scenarios, main scenario included, which shows a maximum level of 13,130 tonnes in the same year.

The gross value added reported in Figure 9.14 is higher than in Figure 9.6

Figure 9.6 (main scenario). Nominal profit in year 15 amounts to 6.9 million euro in scenario 12, almost twice the level of 3.6 million euro estimated in scenario 2. The difference between these values is due to the different fishing effort. Scenario 12 shows a NPV profit_{15} of 80 million euro, against 79 million euro in the main scenario.

Figure 9.14 Results of scenario 12. Dynamic minimum fleet



Scenario 13. Optimum fleet (GVA)

Differently from other scenarios, scenario 13 is directed to achieve the maximum contribution to GNP (maximum NPV GVA_{15}) by optimizing the number of vessels of all fleet segments over the simulation period.

Compared with other scenarios, very different results are produced by scenario 13. While fishing effort in previous scenarios was driven by management rules aimed at achieving the MSY for the most or the least depleted stock, scenario 13 is directed to find the optimum solution over the first 15 years in terms of GVA maximization. The optimum fleet is estimated by maximizing NPV GVA_{15}, while average days at sea per vessel are derived by the policy option selected in the main scenario (Effort min) with constraints given by the number of vessels and the maximum average level of fishing days registered in the period 2005-7 used as an upper bound. After year 15, fishing effort is driven by the same policy option adopted in the main scenario.

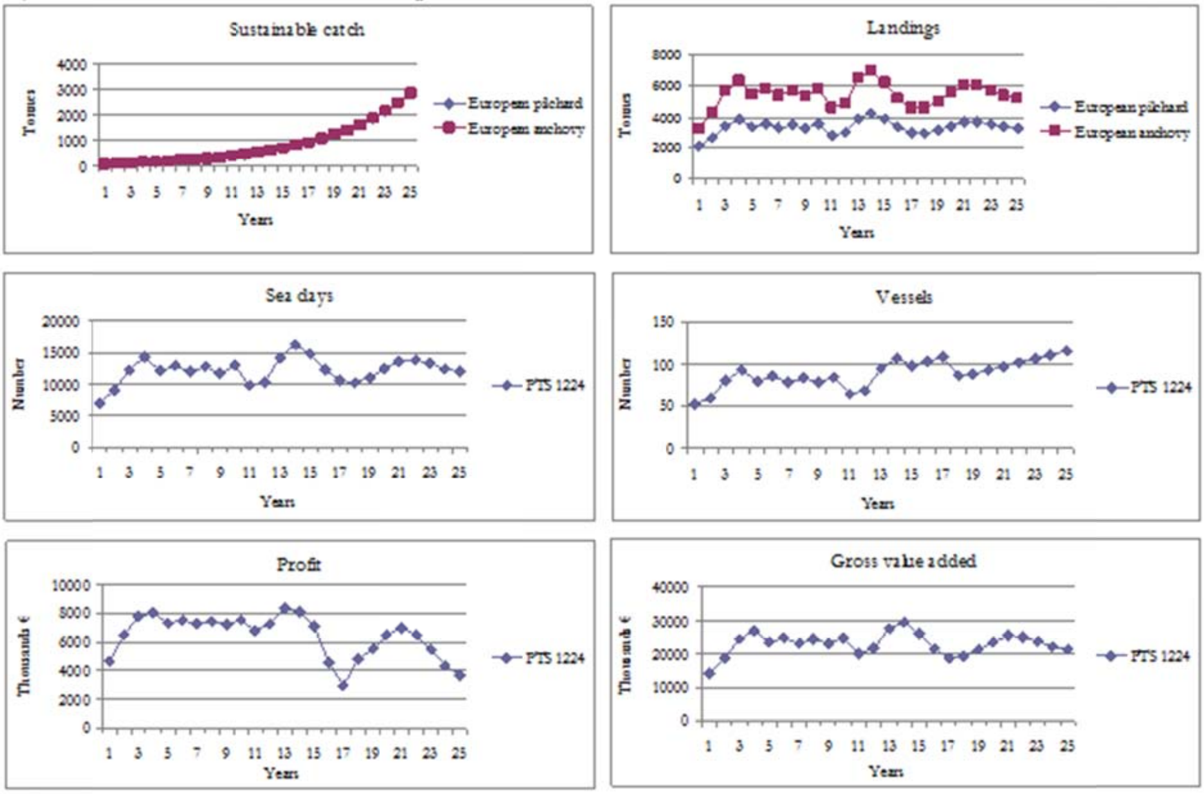
Trend in fishing effort does not show a tendency to equilibrium in the first 15 years. Corrections are related to the optimization process, while the policy option is not affecting fishing effort as increases in the average number of fishing days are not allowed over the maximum level. In the year 15, there are 98 vessels, 87% more than in the baseline and 12% less than in the main scenario.

During the 15 years when the GVA is maximized, fishing effort and harvest ratio are maintained at levels lower than those needed to achieve the MSY for European anchovy. Only in year 15 this level is exceeded.

Landings of both species increase in the first four years of the simulation period, and fluctuate around 5,500 tonnes for anchovy and 3,300 tonnes for pilchard thereafter. This is due to the increase in fishing effort. Total catches in year 15 are equal to 16,150 tonnes, a level higher than in the other scenarios based on the same policy option, main scenario included, which reach a maximum of 13,130.

Scenario 13 shows the best economic performance in terms of GVA among the scenarios based on the policy option “Effort min”. In the year 15, total nominal profit is estimated at more than 7 million euro, almost double than the value in the main scenario. Table 9.13 shows also a level of NPV $profit_{15}$ of 83 million euro, 5% higher than the value of 79 million euro in the main scenario. Profit shows an increase in the first three years, a stable level until year 15, and strong variations thereafter.

Figure 9.15 Results of scenario 13. Optimum fleet



Scenario 14. Optimum fleet (profit)

As well as scenario 13, also scenario 14 is directed to achieve the MEY by optimizing the number of vessels of all fleet segments over the simulation period, but MEY is here expressed in terms of profit instead of GVA.

Compared with the non-optimization scenarios, results are very different. In those scenarios, fishing effort was driven by management rules aimed at achieving the MSY for the most or the least depleted stock. On the contrary, this scenario is directed to find the optimum solution over the first 15 years in terms of profit maximization. The optimum fleet is estimated by maximizing the NPV profit[15], while average days at sea per vessel are derived by the policy option selected in the main scenario (Effort min) with constraints given by the number of vessels and the maximum average level of fishing days registered in the period 2005-2007 used as an upper bound. After year 15, fishing effort is driven by the same policy option adopted in the main scenario.

Trend in fishing effort does not show a tendency to equilibrium in the first 15 years. Corrections are related to the optimization process, while the policy option is not affecting fishing effort as increases in the average number of fishing days are not allowed over the maximum level. In the year 15, there are 116 vessels, 120% more than in the baseline and 4% more than in the main scenario.

During the 15 years when the profit is maximized, fishing effort and harvest ratio are maintained at levels lower than those needed to achieve the MSY for European anchovy. Only in the last two years of optimization (years 14 and 15) this level is exceeded.

Landings of both species increase in the first four years of the simulation period, is stable until year 13 and shows a peak in years 14 and 15. This is due to the increase in fishing effort in the same years. Total catches in year 15 are equal to 19,200 tonnes, the highest level among all scenarios, main scenario included, which reach a maximum of 13,130.

Scenario 14 shows the best economic performance in terms of profits among the simulated scenario. In the year 15, total nominal profit is estimated at more than 8 million euro, more than twice the value in the main scenario. Table 9.13 shows also a NPV $profit_{15}$ of 85 million euro, 8% higher than the value of 79 million euro in the main scenario. Profit shows an increase in the first three years, a stable level until year 13, a maximum in years 14 and 15, and strong variations thereafter.

Figure 9.16 Results of scenario 14. Optimum fleet - max profit

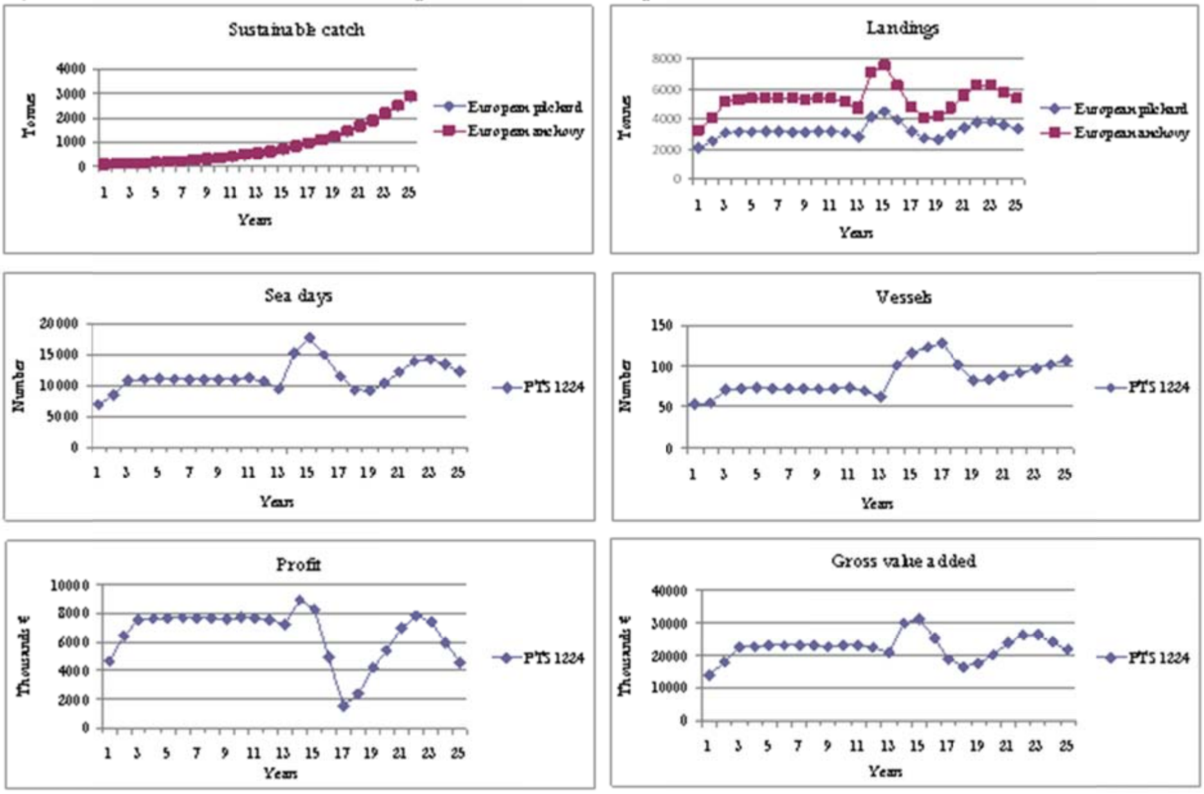


Figure 9.16 shows similar trends in the main variables for scenarios 13 and 14. However, some differences occur in the levels of these variables. Both scenarios are directed to optimize the number of vessels over the first 15 years of the simulation period, but scenario 13 is aimed to maximize GVA while scenario 14 is aimed to maximize profit. As a consequence, the NPV GVA_{15} in scenario 13 (268 million euro) is 4% higher than that in scenario 14 (258 million euro). For the same reason, the NPV $profit_{15}$ in scenario 14 (85 million euro) is 2% higher than in scenario 13 (83 million euro). As a consequence, the actualized values of crew costs and capital costs are higher under scenario 13 than scenario 14.

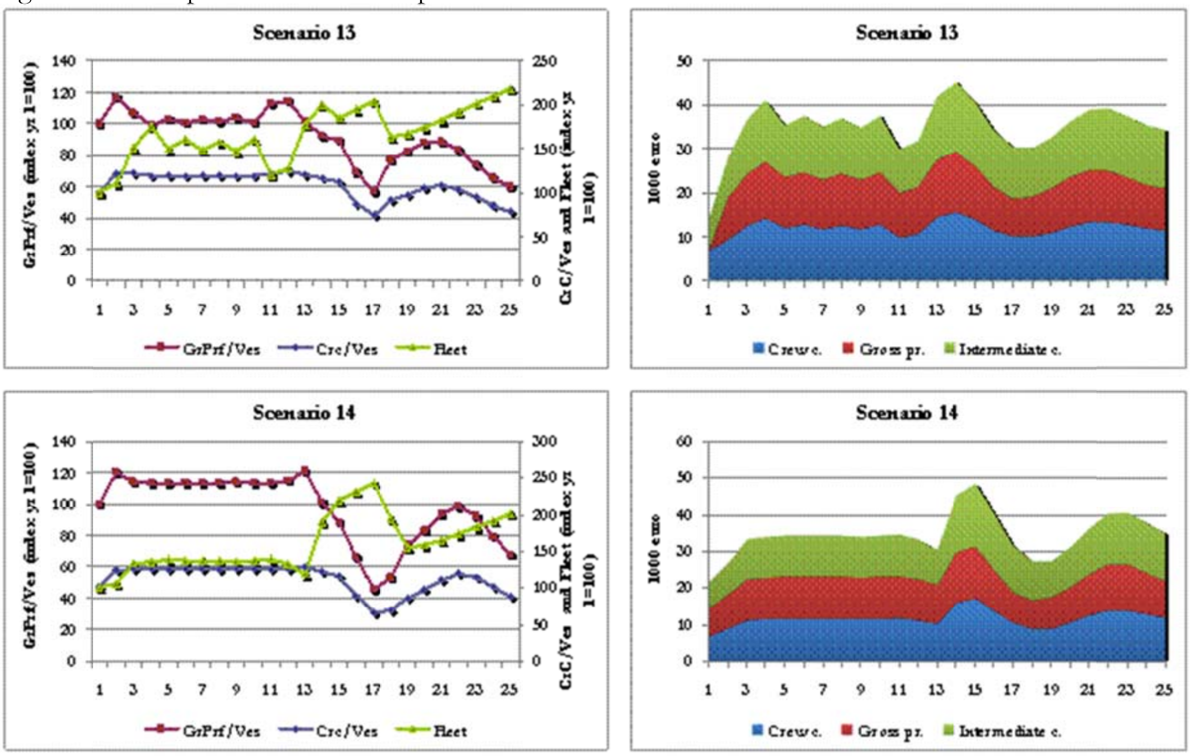
In year 15, both GVA and profit are higher in scenario 14 (31.26 and 8.33 million euro respectively) than in scenario 13 (26.17 and 7.13 million euro respectively), and so are crew and capital costs. The better performance in all indicators of scenario 14 in year 15 depends on the fleet size registered in that year. Indeed, 116 vessels are estimated under scenario 14 and only 98 under scenario 13. However, the number of vessels in that year is not representative of the real effects of these scenarios on the fleet. Comparing the average number of vessels over the simulation period (years 1-15), scenario 14 shows a number lower than that estimated under scenario 13. This means that the maximum profit is obtained at an average fleet size lower than that needed to maximize GVA.

Table 9.14 Comparison of scenarios 13 and 14 (values in mln euro, fleet number of vessels)

	Scenario 13	Scenario 14
NPV GVA_{15}	267.73	258.39
NPV $profit_{15}$	83.19	85.05
NPV Crew $costs_{15}$	137.96	130.71
NPV capital $costs_{15}$	46.58	42.64
GVA year 15	26.17	31.26
Profit year 15	7.13	8.33
Crew costs year 15	14.03	16.99
Capital costs year 15	5.01	5.93
Fleet – average 1-15	80	74
Fleet – year 15	98	116

(Note: sum of the 3 bullets gives the total – this is why they are all included)

Figure 9.17 Comparison of the two optimization scenarios



9.7.6. Assumptions and technical background (by main model modules)

The main assumption is related to the estimation of the current status of pelagic stocks. The status of stocks has been derived from time series data on biomass collected by ecosurvey. These data have been combined with landings data collected by IREPA to estimate a logistic function for each stock. As reported above, based on the methodological approach adopted, both European anchovy and European pilchard result underexploited in the baseline. This evaluation does not necessarily match with other scientific advice (see, for instance, STECF-SGMED-09-02 report).

10. MEDITERRANEAN HAKE FISHERIES (GSA 9)

10.1. Summary and conclusions

Main conclusion

The three segments analysed in this fishery realized in 2005-7 on average a total net profit of 28 mln euro. Average annual discounted net profit ranges under most scenarios between 17 and 32 mln euro. Elimination of overcapacity and recovery of stocks would produce a discounted net profit of 15-28 mln euro by the year 15. (see Figure 10.1)

Brief description of the case study

This case study analyses the fishing vessels registered in the maritime areas of Liguria, Tuscany and Lazio (GSA 9), authorized for trawling and passive gears such as drift nets, lines, pots and other traditional techniques in demersal fisheries. The main target species include European hake, Norway lobster, striped mullet and horned octopus. Three fleet segments are mainly involved in this fishery: demersal trawlers with an overall length between 12 and 24 meters (DTS 12-24), small fishing boats with an overall length of less than 12 meters using passive gear (PGP 0-12), and polyvalent and passive gears vessels (PGP 12-24) with an overall length between 12 and 24 meters. The "other" segment includes trawlers and passive gears vessels less than 12 metres. In 2007 the selected target species amounted to 31% of total demersal landings and revenues. European hake is the most important demersal species representing 13% of landings in weight and 14% of landings in value. Norway lobster is the second most important species in terms of value. Even though this species represents just a 2% of total landings, this contributes to total revenues for almost 7%. Other important species in terms of value are striped mullet and horned octopus, which contributions are 6% and 5% respectively.

Divergence / convergence of the results

Comparing the different scenarios, the level of landings varies from 3,410 tonnes in scenarios 4 and 5 to a level of 11,840 tonnes in scenario 13. The level of landings is a function of the fishing effort applied on the biomass. Consequently, also the minimum level of fishing effort, equal to 74,000 days at sea, is achieved in scenario 4 and 5, and the maximum level of 176,000 in scenario 13. Fishing effort consists of two components, number of vessels and average fishing days per vessel. The minimum number of vessels is registered in scenarios 4 and 5 (461 vessels), while the maximum number in scenario 10, where the fleet is assumed to be constant and equal to that estimated at the baseline (1,729 vessels). Among the scenarios with the same level of fishing effort, those using a lower number of vessels show also higher profits. The highest values for discounted profit of year 15 and NPV $profit_{15}$ are in scenario 14, while the lowest values are in scenarios 4 and 5.

Choice of baseline policy

Scenario 2 (Effort min) has been selected as "main scenario" or the scenario reflecting better than others the actual management system. Scenario 2 simulates a policy option directed to achieve the MSY for the stock showing the maximum overexploitation rate (difference between current and target harvest ratio). In the present case study, this stock is represented by European hake. As for the other options, scenario 4 (Effort max) is directed to achieve the MSY for the stock showing the minimum overexploitation rate (when all stocks are overexploited) or the maximum under-exploitation rate (when at least a stock is not overexploited), while scenario 5 simulates an Open access situation. As the actual management system is not open access, but consists of a number of management measures directed to safeguard all the stocks exploited by fishing activities, scenario 5 cannot de selected as main scenario. Furthermore, the main management measures are directed to reduce fishing effort. As in the present case study some stocks are underexploited, scenario 4 suggests an increase in fishing effort. Then, this cannot be considered as representative of the real system.

Achieving MSY

Scenario 2 simulates a policy option directed to achieve the MSY for the stock showing the maximum overexploitation rate. As this is selected as the "main scenario", also the scenarios from 7 to 12, based on the main scenario, operate to achieve the same objective. The stock with the maximum difference between H current and H target is European hake. All these scenarios determine the application of a level of fishing effort equal to 138,000 days at sea, which is equivalent to the target harvest ratio for European hake. However, MSY cannot be achieved for all species at the same time. The level of fishing effort resulting from these scenarios determines a status of under-exploitation for the other three stocks (the harvest ratio in year 15 is lower than target F). All the scenarios directed to achieve MSY for European hake apply the same level of fishing effort. However, the optimal combination of effort components (number of vessels and number of average fishing days per vessel) is different. The optimal combination of effort components producing the highest resource rents is obtained reducing the number of vessels at the minimum level. Comparing the scenarios directed to achieve MSY, scenario 12 shows the minimum number of vessels and the maximum resource rent, estimated in 392 million euro. This scenario is then the most efficient and shows the best economic performance in this group of scenarios.

Achieving MEY (NPV profit$_{15}$)

Even though scenario 12 is the most efficient compared with the other scenarios directed to achieve MSY, results do not match with the MEY solution. The scenarios showing results closest to the MEY solution are scenarios 13 and 14. Both scenarios are directed to achieve the MEY by optimizing the number of vessels of all fleet segments over the simulation period, but MEY is expressed in terms of GVA in scenario 13 and profit in scenario 14. Compared with the other scenarios, scenario 14 shows the best economic performance. The maximum resource rent over the first 15 years of the simulation period, equal to 486 million euro, has been estimated in this scenario as the NPV of profit. The optimization process suggests a strong reduction in all fleet segments. In the year 15, the total number of vessels in scenario 14 is 1192, 30% lower than those in the baseline. Compared with the baseline, PGP 0012 are reduced of 20%, DTS 1224 of two-thirds and PGP 1224 of more than 70%. Compared with the main scenario, the total fleet is just 1% lower in scenario 14, but significant differences are in the fleet composition. PGP 0012 increases by 20%, while DTS 1224 and PGP 1224 show reductions of almost 60%. The optimal fleet size and its composition indicate that PGP 0012 represents the most efficient fleet segment in terms of long term profitability. Indeed, this fleet segment shows the lowest weight of fixed and capital costs on total income (less than 18%).

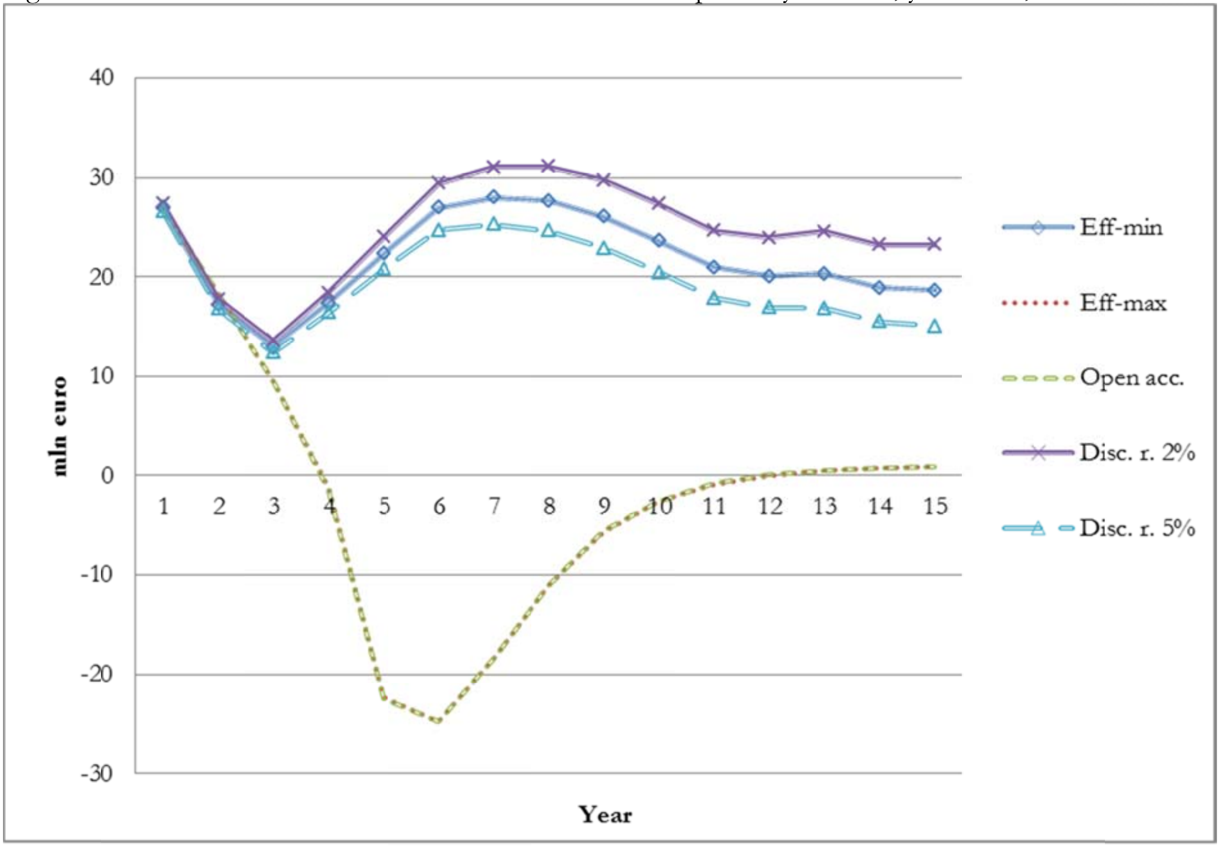
Role of discount rate

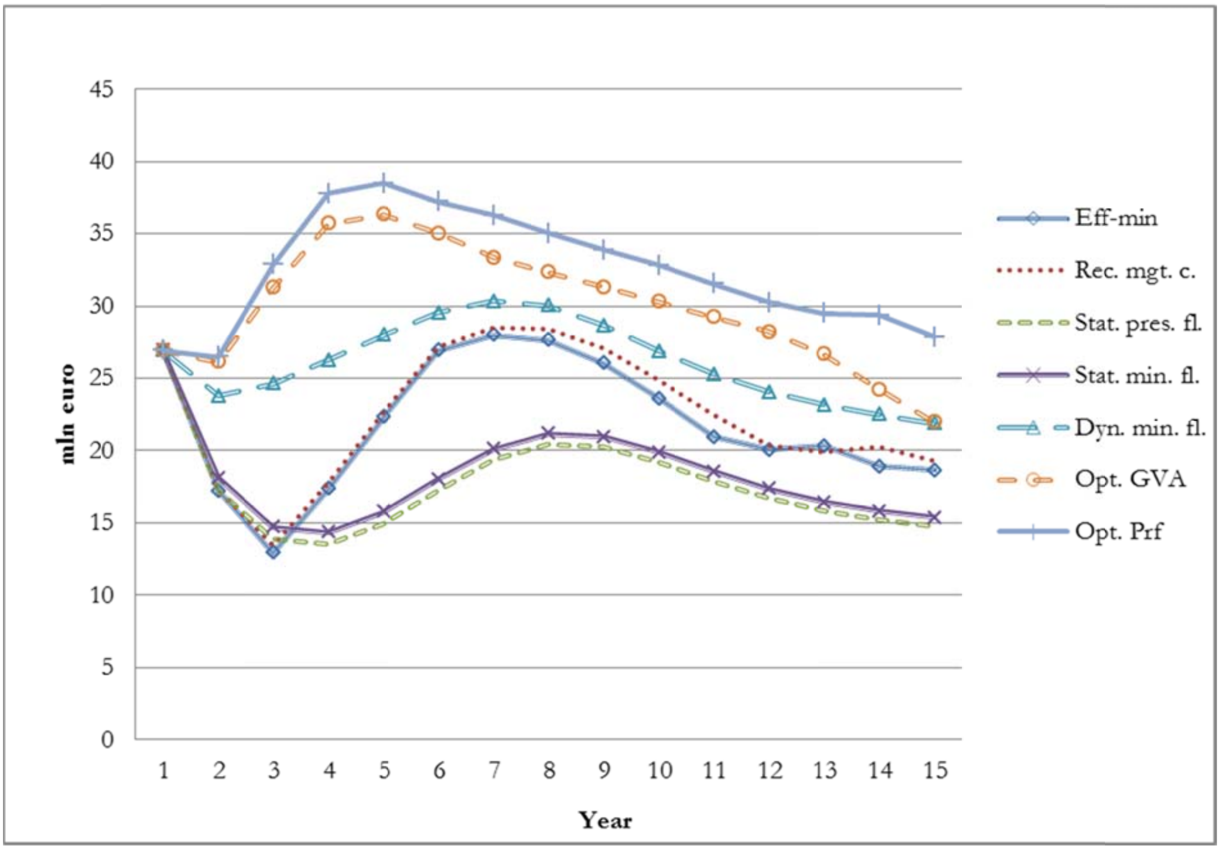
Scenarios 7 and 8 differ from each other scenario as discount rates of 2% and 5% respectively have been applied instead of 3.5%. However, compared with the main scenario, variations in the discount rate have not produced any effect on the dynamics of the system. The same nominal profit is registered in year 15 for the three scenarios. Regarding the NPV profit$_{15}$ and the discounted profit of year 15, obviously the highest values are estimated at the lowest discount rate.

Impact of eliminating overcapacity

In this case study, four of the main target species are included in the model. Based on the biological approach adopted to estimate stock-recruitment relationships, only European hake and horned octopus are overexploited at the baseline (average data over the period 2005-7). On the contrary, Norway lobster and striped mullet show levels of current H lower than target F. European hake is the species with the maximum overexploitation rate. All the scenarios directed to achieve MSY for this stock show a reduction in the number of vessels. This reduction is estimated in 30%, from 1,729 to 1,204 vessels, in the main scenario. The elimination of overcapacity in this scenario determines a NPV profit$_{15}$ over the first 15 years of the simulation period equal to 328 million euro. However, the path to achieve MSY can be different and so the composition of fishing effort both in terms of effort components (number of vessels and number of average fishing days per vessel) and fleet structure. Scenario 12 shows the best combination of fishing effort components reducing the number of vessels of 45%, from 1,729 to 957 vessels, and

Figure 10.1 Mediterranean Sea hake – discounted annual net profit by scenario, years 1-15, mln euro[51]





[51] TAC scenarios are not relevant for this fishery and therefore have not been calculated.

increasing the average days at sea per vessel. The economic performance for this solution is estimated in 392 million euro as NPV profit15. However, optimal solutions optimizing the efficiency of the fleet from an economic point of view are provided by scenario 13 and 14. Scenario 13 shows a higher number of vessels, 1244, but removes completely the fleet segment PGP 1224 and increases the number of small scale vessels. The NPV profit15 estimated in this scenario is equal to 449 million euro. Scenario 14 shows a number of 1192 vessels maintaining active the fleet segment PGP 1224, and a value of 486 million euro for NPV profit15.

Management costs and rent recovery

The introduction of a fixed payment for access has reduced the profitability and made the sector less attractive. As a consequence, investments in new vessels are lower than those in the main scenario for DTS 12-24 and PGP 12-24. On the contrary, the number of vessels of PGP 00-12 is higher in the present scenario. A total of 1,328 vessels would operate in year 15 for this scenario compared to a number of 1,204 in the main scenario. Notwithstanding, the level of fishing effort remains the same as this is defined by a policy option common to both scenarios. The same fishing effort determines also an equal harvest ratio, exploitation rate and level of landings. The different compositions of fishing effort in the two scenarios highlights a higher efficiency when a payment for access is introduced. Indeed, reducing the number of vessels for DTS 12-24 and PGP 12-24 and increasing the vessels of PGP 00-12 allows the entire fleet to reduce fixed and capital costs (which are higher for bigger size vessels) maintaining variable costs (which are dependent on fishing effort) at the same levels of the main scenario. Therefore, as largely expected, the introduction of a payment for access increases the efficiency of the fleet. Nominal profit for the entire fleet in year 15 amounts to 32.3 million euro, higher than the value of 31.3 million euro in the main scenario. The difference between these value is due to the fixed and capital costs. However, after deducting the amount of 11.8 million euro, as the payment for access for the entire fleet, the economic performance results significantly reduced. Indeed, payment for access is particularly relevant representing around 37% of total profits. However, among the three fleet segments considered, only PGP 12-24 will register negative profits as a consequence of the introduction of a fixed payment for access.

10.2. Case study definition

10.2.1. Fleet and landings

This case study deals with the fishing vessels registered in the maritime areas of Liguria, Tuscany and Lazio (GSA 9), authorized for trawling and passive gears such as drift nets, lines, pots and other traditional techniques in demersal fisheries. The main target species include European hake, Norway lobster, Striped mullet and Horned octopus.

Three fleet segments are mainly involved in this fishery: demersal trawlers with an overall length between 12 and 24 meters (DTS 12-24), small fishing boats with an overall length of less than 12 meters using passive gear (PGP 00-12), and Polyvalent and Passive Gears vessels (PGP 12-24) with an overall length between 12 and 24 meters. The "other" segment includes trawlers and passive gears vessels less than 12 meters.

In 2007 the trawling segment (DTS 12-24) amounted to 335 boats having an overall tonnage of almost 13,000 GT. This fleet segment represents 19% of the total number of vessels operating in the area and 78% of total GT. More than 1,300 vessels, 75% of the total number and 16% of total GT, are small fishing boats (PGP 00-12). The third group of vessels, PGP 12-24, consists of 71 units equivalent to 5% of the total GSA 9 demersal fleet, measured both in number and tonnage.

The main fleet segments contributed for around 97% to the total landings in GSA 9, both in quantity and in value. Trawlers account for above 78% of target landings, small scale fishery for 15% and Polyvalent and Passive Gears segment for another 4%.

Table 10.1 Role of case study fisheries within national fishery sectors (2005-7)

Member State	Total fishery sector		Case study fleets	
	Total revenues (mln euro)	Total fleet (number of vessels)	Revenues (mln euro)	Fleet (number of vessels)
Italy GSA 9	1,426	14,428	123.7	1,709

Source: IREPA, 2007

Table 10.2 Role of target species

MS	Gear	Size	No. vessels	GT (1000)	Landings (1000 t)		Value (mln euro)	
					Target species	Total	Target species	Total
ITA GSA9	DTS	12-24	335	13.0	3.1	7.5	31.0	66.9
ITA GSA9	PGP	0-12	1,303	2.6	0.6	4.4	6.7	50.7
ITA GSA9	PGP	12-24	71	0.9	0.2	0.7	1.3	6.2
Other			25	0.2	0.1	0.4	0.6	3.4
Total GSA9			1,734	16.7	4.0	13.0	39.8	127.2

Source: IREPA, 2007

10.2.2. Composition of landings

In 2007 the selected target species account for 31% of total demersal landings and revenues. European hake is the most important demersal species representing 13% of landings in weight and 14% in value. Norway lobster is the second most important species in terms of value. Even though this species represents just 2% of total landings, an average price of around 34 euro/kg determines a contribution to total revenues of almost 7%. Other important species are striped mullet and horned octopus which contributions to total landings value account for 6% and 5% respectively.

As for the composition of landings by fleet segment, the selected target species represent 41% of the total production and 46% of total revenues for demersal trawlers (DTS 12-24). The same species amount to 13% of the production in weight and in value for PGP 00-12, and to around 23% for PGP 12-24.

European hake results to be an important species for all fleets both in weight and in value. Striped mullet and horned octopus represent almost a quarter of total landings for demersal trawlers, while their incidence on the production of the other fleet segments is lower than 1%. Also Norway lobster is caught almost exclusively by DTS 12-24, representing 13% of their revenues.

Table 10.3 Composition of landings by segment, (fleet active in GSA 9, tonnes)

MS	Gear	Size	European hake	Horned octopus	Norway lobster	Striped mullet	Other	Total
ITA	DTS	12-24	1,007.7	836.3	260.0	1,013.3	4,423.1	7,540.5
ITA	PGP	00-12	571.2	18.2	0.2	20.2	3,813.5	4,423.3
ITA	PGP	12-24	156.0	0.3	0.0	1.3	526.2	683.8
ITA	Other		18.0	32.9	0.3	61.2	272.7	385.1
Total			1,752.8	887.7	1,752.8	887.7	260.6	1,096.0

Source: IREPA, 2007

Table 10.4 Composition of landings by segment ((fleet active in GSA 9, 1000 euro)

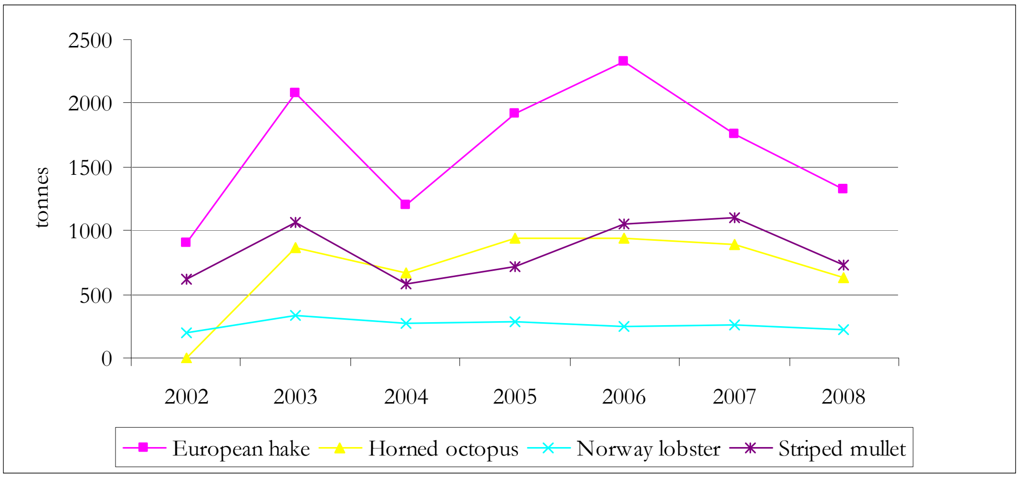
MS	Gear	Size	European hake	Horned octopus	Norway lobster	Striped mullet	Other	Total
ITA	DTS	12-24	9,129	5,959	8,850	7,068	35,891	66,897
ITA	PGP	00-12	6,587	60	5	98	43,948	50,698
ITA	PGP	12-24	1,343	2	0	6	4,808	6,158
ITA	Other		129	156	11	354	2,770	3,419
Total			17,187	6,176	8,866	7,526	87,417	127,172

Source: IREPA, 2007

10.3. Historical indicators

Trends in the levels of landings for the selected target species in the demersal fisheries in GSA 9 are reported in Figure 10.2 for the period 2002-2008. The highest levels of landings are concentrated in the years 2003 and 2006. The only exceptions are represented by striped mullet with a level of landings of 1,096 tonnes in 2007. In 2006 European hake and Horned octopus show their maximum levels of landings: almost 2,330 tonnes for European hake and 945 tonnes for Horned octopus. In 2003 the highest levels are registered for Norway lobster with 331 tonnes.

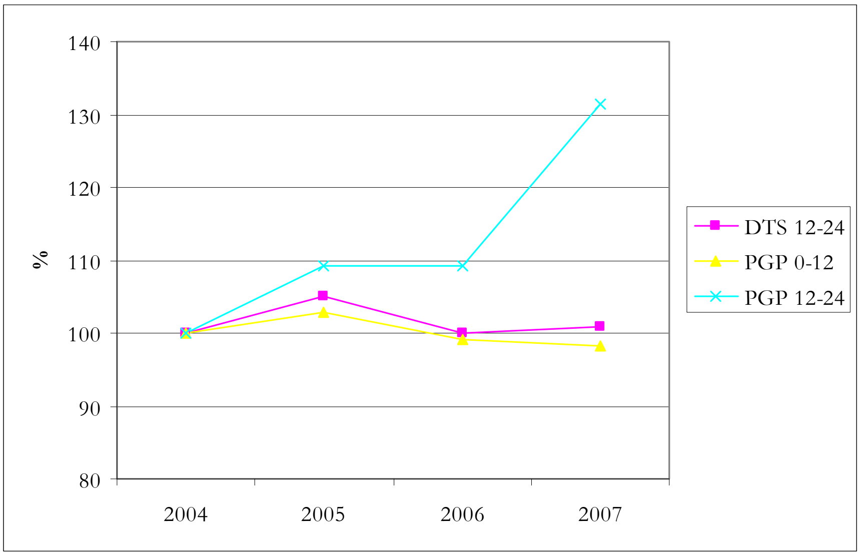
Figure 10.2 Landings by target species (2002-2008 data)



Source: IREPA

The evolution in the period 2004-2007 of the three fleet segments operating in demersal fisheries in GSA 9 in terms of changes in the number of vessels is reported in Figure 10.3. Fleet segments DTS 12-24 does not show significant variations in the number of vessels. PGP 00-12 shows a small reduction of almost 2% from 2004 to 2007. On the contrary, the number of vessels classified as PGP 12-24 has increased significantly during the period analysed. In 2007, an increase of more than 30% compared with 2004 has been registered for this fleet segment.

Figure 10.3 Change in vessels number by fleet segment (2004-2007 data)



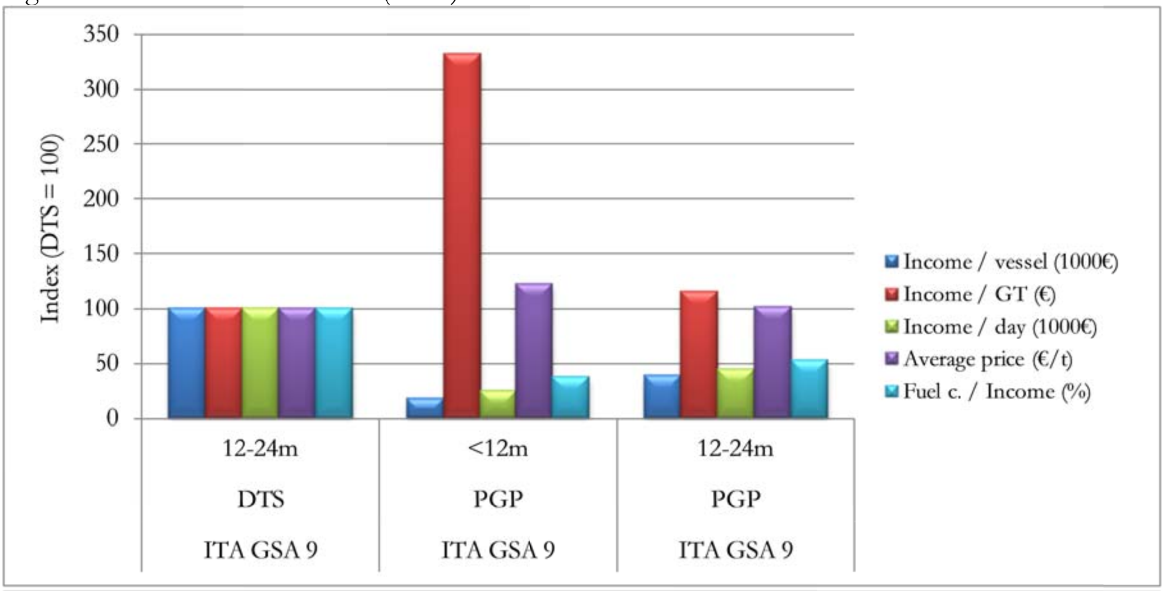
Source: IREPA

10.4. Fleet efficiency

In absolute terms, the gross value added produced by the small scale fishery segment (PGP 00-12) represents 47% of the total GVA in the period 2005-7. This fleet segment produces a third of the total profit and employs almost 60% of the total workforce. In the period considered, small fishing boats have also recorded the highest average price and the highest profit per tonne of landings. The CPUE of total production and CPUE of target species landings amount to 27.3 and 7.2 respectively. These represent the lowest levels if compared with the other fleet segments. In particular, total CPUE is 80% lower than the total CPUE estimated for trawlers (DTS 12-24) and 50% lower than total CPUE. As for the CPUE of target species, small scale fishery records 89% lower than the trawler segment and 68% lower than the total demersal fishery.

Demersal trawlers (DTS 12-24) is the major segment in terms of average income per vessel and average income per day (Figure 10.4). It also records the highest average GVA per vessel, per employee and per day. The fuel cost represents 30% of income: the highest incidence if compared with the other segments. Polyvalent and Passive Gears segment (PGP 12-24) contributes for around 5% to GVA and profit of demersal fisheries in GSA 9. The CPUE of total landings and target species are respectively 56% and 67% lower than those estimated for the trawlers.

Figure 10.4 Economic indicators (index)



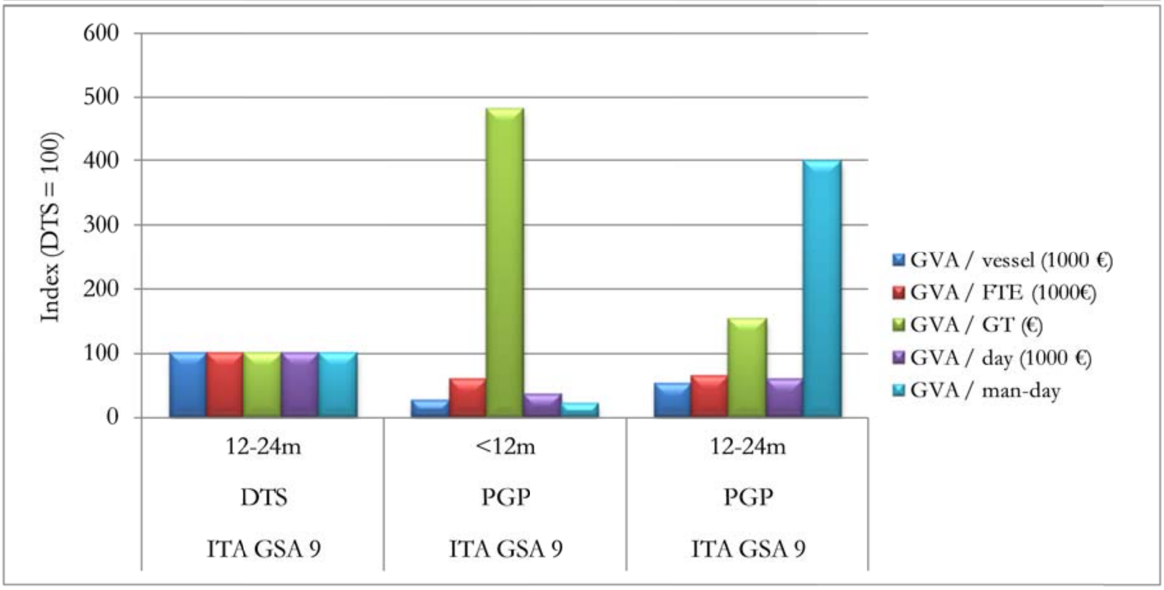


Table 10.5 Economic indicators (fleet active in GSA 9)

MS	Gear	Size	Gross value added (mln euro)	Profit (mln euro)	Employ-ment	Average price (euro/t)	Fuel costs as % of income	Profit / tonne landings (euro/t)	CPUE total (t/day)	CPUE target species (t/day)
ITA	DTS	12-24	112.9	28	2,724	9,040	0.3	4532	135.7	65.9
ITA	PGP	0-12	114.2	52	4,674	11,089	0.1	8059	27.3	7.2
ITA	PGP	12-24	10.8	3	402	9,229	0.2	6057	59.4	22.0
	Other		7.2	3	179	8,966	0.2	294	104.4	16.4
Total GSA9			245.2	86	7,980	9,725	0.2	3752	57.0	22.4

Source: IREPA

10.5. Management measures

10.5.1. General description

The Italian management system for demersal fisheries is mainly based on input control measures (limitation of licences, time and area closures, mesh size restrictions) and partly on output control measures (landings minimum size).

All vessels are required to hold a licence, which is centrally managed by the General Direction of Fishery of the Ministry of Agriculture Food and Forestry Policy. Licences are issued by the Ministry to the ship-owner. The licence specifies detailed terms and conditions for the operations, including limitations on fishing areas and gear used. The licence identifies the vessel through a European code and other information concerning the vessel characteristics used (i.e. name, authorized gear, GT, kW, LOA, etc.). Consequently, one fishing licence corresponds exclusively to one fishing vessel. Licences are valid for eight years and are renewed on the request of the ship-owner. In the last years a limit on the issue of new licences has been imposed by the administration. This limit has been set in order to comply with the capacity reduction planned first, under the European Multiannual Guidance Programs (MAGPs), in force in the period 1983-2002, and then under the EC Reg. 1438/2003, establishing the new entry-exit regime. To comply with the capacity objectives, the national Administration sets that for those segments where overcapacity has been assessed (as in case of bottom trawl fishery) no new licence can be issued and transferability of the existing licence on another vessel can only be authorized in case the other vessel has at least the same tonnage and power of the old one.

10.5.2. Input management

Effort restrictions

The main fishing effort control variables are technical measures, as mesh size, and area and time closures. As far as the time closure, the seasonal withdrawal is, perhaps, the most efficient effort control measure of the Italian fishery management system, both in terms of resources conservation and in terms of enforcement control. It has been applied continuatively since 1988 and applies both to trawlers and to mid-water pelagic nets as its main aim is the safeguard of the juveniles of demersal species. In particular, the seasonal withdrawal is intended to safeguard demersal species during their recruitment seasons. Considering the multispecificity of the Italian fishery, these periods vary from species to species and the period provided each year by the seasonal withdrawal represent a compromise, based on scientific advice, for the main species caught by trawlers and mid-water pelagic nets. It should be outlined that this measure is applied in different periods and, depending on the areas of the Italian coastline, it can be compulsory or facultative. In particular, for GSA 9 (as for the all Tyrrhenian fleets) the seasonal withdrawal has been compulsory until 1997, facultative in the years 1998-1999, compulsory again in 2000 and 2001 (only in some harbours), facultative in the period 2002-2007. In 2007 it has been applied again in a compulsory way. Beside the seasonal withdrawal the bottom trawlers fishing activity is regulated by forbidding the fishing activity during week end and other national days.

The trawling fishery is largely influenced by the implementation of a number of area closures, among which the most important are Marine Protected Areas (MPAs), fishing protected areas and some technical measures defining limits from the shore for the trawling activity. As far as MPAs, in the GSA9 area 4 MPAs already exist, for 5 areas the administrative process to become MPAs has started and 2 further areas have been individuated as possible future MPAs. Italian MPAs are generally divided into 3 different zones according to their different environmental features (A, B and C), where the fishing restrictions are gradually less restrictive. Generally, fishing activities are allowed partly in zone B and in zone C, but only by resident fishermen and by the use of traditional fishing technique (i.e., in the zone C of the Portofino MPA professional fishing is permitted only by resident fishermen and by the use of a fishing tool called "tonnarella", which is a traditional fixed trap - very similar to the tuna traps – used to capture white fish as greater amberjack and saddled seabream.

As far as the fishing protected areas, two zones have been established in GSA 9. They respond to the need to protect juveniles concentration of some species in specific areas. In these zones the fishing activity is completely banned. The two zones, one in the waters of the Tucsonan archipelago and the other in the waters opposite to the Gaeta promontory represent nursery area for European hake. The first one, especially in spring, is a nursery area also for blue whiting and horned octopus.

Beside the above measures, the trawling activity in Italy is regulated by a series of technical measures limiting both the input (mesh size and area restrictions) and the output side (size selectivity). Since the beginning of 2007, the main reference of the technical measures regulating the trawling fishery in GSA 9 is the EC Reg. no 1967/2006 which amends the EC Reg. no. 2847/93, abrogates the EC Reg. 1626/1994 and establishes new management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea.

As far as the net used by trawlers, the above regulation establishes a set of technical rules that can be summarized in:

1. Minimum mesh size:
   - until 31.12.2007: >40 mm;
   - since 1.7.2008 the mesh can be 40 mm squared or 50 mm rhomboidal.
2. Minimum size (and the way to measure it) for some landed species (Annex III of the above regulation). A number of species listed in the Annex III represent target species of the bottom trawling fishery in GSA 9. Some minimum sizes are the following:
   - European hake: 20 cm;
   - Mullet: 11 cm;
   - Lobster: 70 mm total length; 20 mm carapace length;
   - Shrimp: 20 mm carapace length.
3. Fishing at distance < 1.5 nautical miles from the coast (until 31.12.2007 trawling net can fish < 1.5 nautical miles but not < 50 m isobaths).

Input property rights

As the licences are not transferable, there are no input property rights in this fishery.

10.6. Management costs

10.6.1. Summary of OECD data

Detailed data on management costs are not available at GSA level. For this reason the management costs of each case study have been assumed proportionate to the share of the fleet segment in the total national revenues. GSA 9 DTS 12-24 on average represents 12% of the Italian management costs, equal to 6.7

million euro. PGP 00-12 and PGP 12-24, with 4.7 and 0.4 million euro, account for 3.7% and 0.3% of total management costs respectively.

On the basis of the OECD statistics on government financial transfers, management cost are primarily destined for direct payments (62%), while general services represent 38% of total management costs. 16% of direct payments consists of decommissioning costs and 8% of renewal and modernization costs. 38% of direct payments are other costs, which include costs for temporary withdrawal and joint venture, support to small scale fishery, support to freshwater fishery and to protection and development.

In relation to general services, enforcement and research costs represent 13% and 5% of total management costs respectively.

Table 10.6 Management costs according to OECD, average 2004-2006* , (1000 euro)

	GSA 9 DTS 12-24	GSA 9 PGP 00-12	GSA 9 PGP 12-24	Total GSA9
Direct Payments	4.2	2.9	0.2	8.3
- Decommissioning	1.1	0.8	0.1	2.2
- Fleet renewal and modernization	0.6	0.4	0.0	1.1
- Other	2.6	1.8	0.2	5.1
General Services	2.6	1.8	0.2	5.1
- Management and enforcement	0.8	0.6	0.1	1.7
- Research	0.3	0.2	0.0	0.6
- Other	1.4	1.0	0.1	2.8
Total	6.7	4.7	0.4	13.4

*sum of national and EU contributions regarding marine capture fisheries.
**share of national costs allocated to individual segments have been assumed proportionate to the share of the segment in the total revenues of the national marine fisheries sector.

10.6.2. Support to fishing sector (FIFG and EFF)

In order to evaluate the FIFG and the EFF support to the caching sector, the measures under the FIFG axis 1 and 2 have been compared with the measures foreseen under the EFF priority axis 1. In both cases they have been estimated on the basis of the share in the total national revenues.

Table 10.7 Average annual support to the marine fisheries from FIFG and EFF, (mln euro)*

	GSA 9 DTS 12-24	GSA 9 PGP 00-12	GSA 9 PGP 12-24	Total
FIFG - Axis 1 and 2	17.1	11.9	1.3	30.3
EFF - Axis 1	2.7	1.9	0.2	4.7

10.6.3. Costs of research and management

In absence of detailed data, management, control and enforcement costs are those estimated from the OECD statistics. Research costs have been estimated as a quota of the national DCF budget augmented of a 30%. The quota related to the demersal fishery in GSA 9 has been calculated according to its share in national landings value.

Table 10.8 Estimated management and research costs, (mln euro)

	GSA 9 DTS 12-24	GSA 9 PGP 00-12	GSA 9 PGP 12-24	GSA 9 Total
Management, control, enforcement	0.84	0.59	0.05	1.48
Research (DCF+30%)	0.47	0.33	0.03	0.83

Sources: MRAG (2008) and Com. Decision 811/2009

10.7. Estimation of the resource rent

10.7.1. Comparison of scenarios

Table 10.9 Comparison of the scenarios

Scenario no.	Effort (1000 DAS)	Fleet (no. vessels)	Catch (1000 t)	Profit year 15 discounted (mln euro)	NPV Profit$_{15}$ (mln euro)
Average values 2005-7					
2005-7	244	1,729	13.6	27.6	
Values in year 15 of the scenario					
1. TAC min					
2. Effort min	138	1204	10.7	18.7	327.9
3. TAC max					
4. Effort max	74	461	3.4	0.9	-29.9
5. Open access	74	461	3.4	0.9	-30.0
6. Min min					
7. Discount rate 2%	138	1204	10.7	23.2	369.0
8. Discount rate 5%	138	1204	10.7	15.0	292.9
9. Recovery mgt. costs	138	1328	10.7	19.3	336.4
10. Static present fleet	138	1729	10.7	14.8	263.7
11. Static minimum fleet	138	1697	10.7	15.3	273.5
12. Dynamic min. fleet	138	957	10.7	21.9	391.8
13. Optimum fleet (GVA)	176	1244	11.8	22.0	449.0
14. Optimum fleet (profit)	164	1192	11.1	27.9	486.3

Table 10.9 shows the main results by scenario. As the fisheries under analysis in this case study are multi-species and managed by an input control regime, scenarios 1, 3 and 6 (based on TAC policies) are not applicable. Among the applicable scenarios, scenario 2 (Effort min) has been selected as "main scenario" or the scenario reflecting better than others the actual management system. Scenario 2 simulates a policy option directed to achieve the MSY for the stock showing the maximum overexploitation rate (difference between current and target harvest ratio). In the present case study, this stock is represented by European hake. As for the other options, scenario 4 (Effort max) is directed to achieve the MSY for the stock showing the minimum overexploitation rate (when all stocks are overexploited) or the maximum under-exploitation rate (when at least a stock is not overexploited), while scenario 5 simulates an Open access. As described above, the actual management system is not open access, but consists of a number of management measures directed to safeguard all the stocks. Furthermore, the main management measures are directed to reduce fishing effort. As in the present case study some stocks are underexploited, scenario 4 suggests an increase in fishing effort. Then, this cannot be considered as representative of the real system.

Scenarios from 7 to 14 are based on the main scenario, but include specific assumptions described in the detail in the related sections. In particular, scenarios 13 and 14 are aimed to estimate the optimum fleet maximizing NPV GVA$_{15}$ and NPV profit$_{15}$ respectively. A general overview of the simulated scenarios highlights values generally lower than those registered at the baseline for all the variables reported in Table 10.9. However, as data simulated in year 15 are related to sustainable solutions, these are not comparable with data estimated in a non-equilibrium status at the baseline. In particular, the average catch in the period 2005-7, equal to 13,620 tonnes, is not sustainable in the long term given the status of overexploitation of the main target species, while the values estimated in year 15 are generally sustainable or very close to the sustainable level.

Comparing the different scenarios, the level of sustainable landings varies from 3,410 tonnes in scenarios 4 and 5 to a level of 11,840 tonnes in scenario 13. The level of landings is a function of the fishing effort and the biomass. Consequently, also the minimum level of fishing effort, equal to 74,000 days at sea, is found in scenario 4 and 5, and the maximum level of 176,000 results from scenario 13. Fishing effort consists of two components, number of vessels and average fishing days per vessel. The different combinations of these components can be derived by comparing the columns of effort and fleet in Table 10.9. The minimum number of vessels is in scenarios 4 and 5 (461 vessels), while the maximum number is in scenario 10, where the fleet is assumed to be constant and equal to that estimated at the baseline (1729 vessels). Among the scenarios with the same level of fishing effort, those using a lower number of vessels show also higher profits. Table 10.9 shows the discounted profit of year 15 and the NPV $profit_{15}$ of simulation for each of the simulated scenarios. The highest values for both indicators are in scenario 14, while the lowest values are in scenarios 4 and 5.

Scenario 2 simulates a policy directed to achieve the MSY for the stock showing the maximum overexploitation rate. As this is selected as the "main scenario", also the scenarios from 7 to 12, based on the main scenario, pursue same objective. The stock with the maximum difference between H current and H target is European hake. All these scenarios determine the application of a level of fishing effort equal to 138,000 days at sea, which is equivalent to the target harvest ratio for European hake. However, MSY cannot be achieved for all species at the same time. The level of fishing effort resulting from these scenarios determines a status of under-exploitation for the other stocks (the harvest ratio in year 15 is lower than the target F).

All the scenarios directed to achieve MSY for European hake apply the same level of fishing effort. However, the optimal combination of effort components (number of vessels and number of average fishing days per vessel) is different. The optimal combination from an economic viewpoint, given by the lower number of vessels, is realized in scenario 12. This scenario is then the most efficient and shows the best economic performance among this group of scenarios. However, this cannot be considered as a scenario directed to achieve the MEY. The scenarios showing results closest to the MEY solution are scenarios 13 and 14. Both scenarios are directed to achieve the MEY by optimizing the number of vessels of all fleet segments over the simulation period, but MEY is expressed in terms of GVA in scenario 13 and profit in scenario 14. However, these results are partially affected by the policy option defined in the main scenario, which represents the basis for scenarios 13 and 14 as well. Scenario 13 (proxy for MEY scenario) shows a NPV $profit_{15}$ higher than that estimated in scenario 12 (best economic performance in MSY scenarios). A difference of 57.2 million euro is registered, equivalent to a 15% more for scenario 13. Scenario 14, which is specifically directed to maximize profit, shows a NPV $profit_{15}$ higher than those estimated in scenarios 12 and 13.

All the scenarios have shown a reduction in the fleet size. The most significant reduction has been registered in scenarios 4 and 5 with more than 70% of the vessels removed. However, this reduction is not directly produced by the policy option, which is instead directed to increase fishing effort. The management policy determines an increasing overexploitation of some stocks and consequently their extinction. European hake and horned octopus result completely depleted in year 15. This determines the exit of a significant part of the fleet. Given these results, scenarios 4 and 5 can be defined as unsustainable from both an environmental and an economic point of view. Another scenario determining the exit of a relevant part of the fleet is scenario 13. In this case, the optimum fleet maximizing NPV GVA_{15} consists of only two of the existing fleet segments. To achieve the MEY (in terms of GVA) solution, PGP 12-24 should be removed. On the contrary, MEY expressed in terms of profit in scenario 14 can be achieved maintaining active all fleet segments, but reducing significantly their size.

As reported above, the maximum NPV $profit_{15}$ is produced by scenario 14. This result is related to the demersal fisheries in GSA 9 as a whole. In multi-species fisheries, the economic performance depends on the contribution of a number of stocks. The contribution of each stock can be estimated proportionately to the share of total revenues coming from that stock. In all the scenario based on the main scenario (Effort min), the target species contributing the most to the total revenues is European hake. In scenarios 4 and 5, as European hake does not produce landings as well as horned octopus, the target species contributing the most to the total revenues is striped mullet.

10.7.2. Policy options (scenarios 1-6)

Summary

Table 10.10 Effect of different policies on profit, harvest ratio, catches, effort and fleet

Indicator	2005-7	Scenarios					
		1. TAC min	2. Effort min	3. TAC max	4. Effort max	5. Open access	6. Min / min
NPV Profit15			327.9		-29.9	-30.0	
Profit year 15 discounted	27.6		18.7		0.9	0.9	
Harvest ratio (year 15)*							
European hake	1.0		0.8		47.7	47.7	
Norway lobster	0.5		0.3		0.3	0.3	
Striped mullet	0.7		0.3		0.4	0.4	
Horned octopus	0.9		0.6		46.3	46.3	
Catch in (1000 t, for scenarios year 15)							
European hake	2.0		1.5		0.1	0.1	
Norway lobster	0.3		0.2		0.2	0.2	
Striped mullet	1.0		0.9		1.0	1.0	
Horned octopus	0.9		0.7		0.1	0.1	
Effort (1000 DAS, for scenarios year 15)							
DTS 12-24	61		35		44	44	
PGP 00-12	173		97		28	28	
PGP 12-24	10		6		2	2	
Fleet (no vessels, for scenarios year 15)							
DTS 12-24	339		275		235	235	
PGP 00-12	1,327		887		216	215	
PGP 12-24	63		42		10	10	

*F=1 implies that the stock is almost extinct.

As reported above, scenario 2 (main scenario) and all the scenarios based on the "main scenario" (scenarios from 7 to 12) simulate a policy option directed to achieve the MSY for the stock showing the maximum overexploitation rate. This stock is European hake, which H target is estimated in 0.77. Table 10.10 shows that this level has been achieved in year 15 by scenario 2. In multi-species fisheries, MSY cannot be achieved for all species at the same time. The level of fishing effort determining MSY for European hake allows under-exploitation of the other stocks. Indeed, the harvest ratio in year 15 for Norway lobster, striped mullet and horned octopus is lower than the related target F. MSY for European hake is obtained in scenario 2 by applying a level of fishing effort equal to 138,000 days at sea. Fishing effort is distributed among fleet segments as reported in Table 10.10. However, this effort distribution represents just one of the infinite potential fleet structures able to achieve the MSY.

The other two scenarios reported in Table 10.10 show almost equivalent results. Even though scenario 4 pursues the MSY for the stock showing the minimum overexploitation rate, for reasons explained in the scenario section, simulation results are driven by fishermen behaviour under an open access system. As a consequence, H target is not achieved for any of the stocks. On the contrary, these scenarios lead to the extinction of European hake and horned octopus as shown in Table 10.10. The exclusion of these species from landings produces a dramatic decrease in fisheries profitability and the exit of a large part of the fleet. In terms of economic performance, Table 10.10 show values very low for scenarios 4 and 5 compared with the results obtained in scenario 2. Profit in year 15 for scenario 4 is just 5% of that estimated in scenario 2, while the NPV profit15 in scenario 4 is negative (-30 million euro).

Comparing the results in year 15 for scenario 2 with the baseline, Table 10.10 shows a significant reduction in harvest ratio for all stocks. The strongest reduction occurs for striped mullet. Harvest ratio for this species declines of around an half compared with the baseline. However, this is also the species showing the lower reduction in landings (just 10%). On the contrary, European hake, which shows the lowest reduction in harvest ratio (24%), registers an high decrease in landings of 26%. This is due to the different sensitivity of each stock to changes in fishing effort. A total reduction in fishing effort of 44% is equally distributed among fleet segments. This is due to the policy option which affects all fleet segments at the same extent. In terms of number of vessels, PGP segments show reductions higher than 30%, while the decrease in DTS 12-24 is limited to 20%.

Scenario 1. TAC min
Figure 10.5 Results of scenario 1. TAC min
Not applicable for the case study

Scenario 2. Effort min

The policy option simulated in this scenario aims to achieve MSY for at least one stock in the long run. Given a number of species, the model calculates the ratio between the target and the current harvest ratio in each time period for each of the species considered and select the minimum value of these ratios. Fishing effort is changed proportionately to this value. As the minimum value is associated to the stock showing the maximum overexploitation rate, this policy option is directed to safeguard the most depleted stock.

Based on the biological approach adopted to estimate stock-recruitment relationships, only European hake and horned octopus appear overexploited in the baseline (average data over the period 2005-7). On the contrary, Norway lobster and striped mullet show levels of current H lower than the target F. European hake is the species with the maximum overexploitation rate. As a consequence, the change in fishing effort levels is driven by the status of this stock.

The four stocks are exploited to different extent by each of the three fleet segments. At the baseline, the fishing effort is 244,000 days at sea. More than 70% is due to PGP 00-12, a quarter to DTS 12-24, and the remaining 5% to PGP 12-24. The total landings are in the baseline 13,600 tonnes. However, given the different levels of catchability, most of landings are produced by DTS 12-24 (more than 60%).

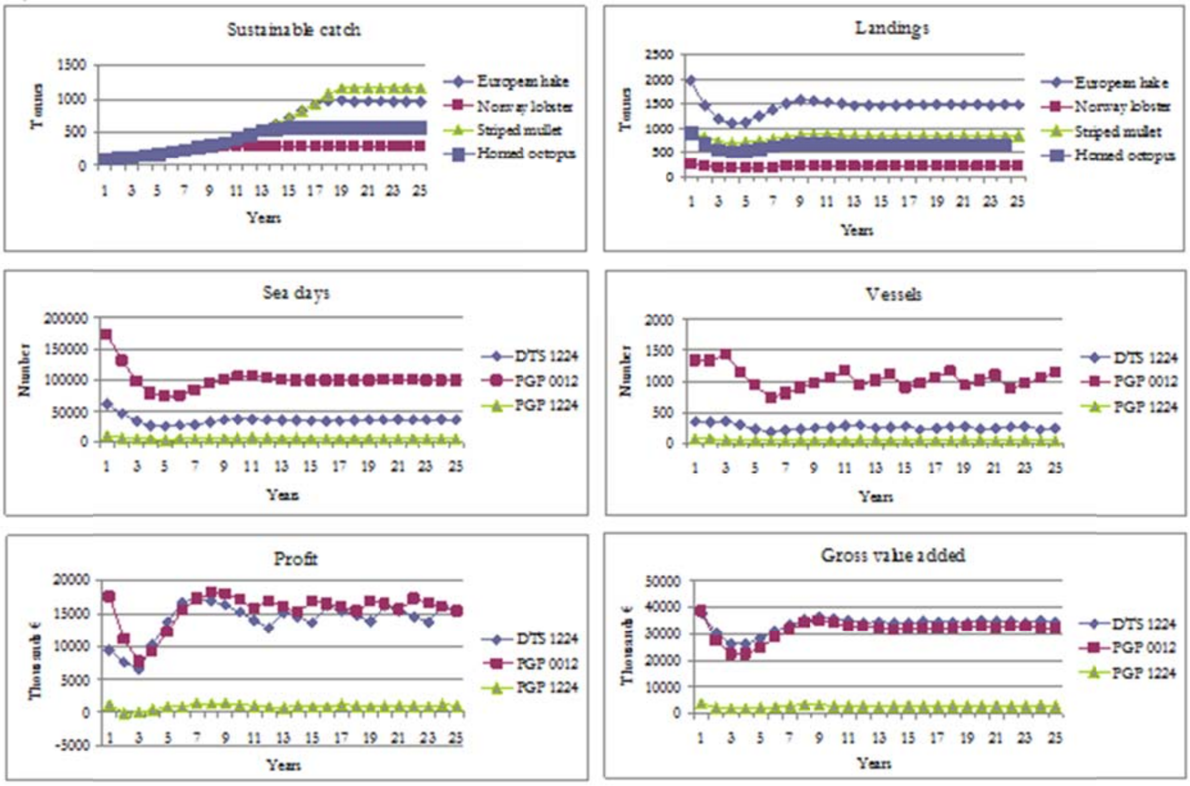
As all fleet segments catch European hake, the reduction in fishing effort produced by the policy option equally affects each of them. Indeed, the same percent variations are applied to all fleet segments. Days at sea in Figure 10.6 shows a similar trend for the three fleet segments. The only difference is related to the starting levels of fishing effort. Fishing effort is significantly reduced in the first 5 years of the simulation as the level in the baseline was unsustainable for European hake. In the following years, days at sea show a tendency to the level, estimated in 138,000 days for the entire fleet, corresponding to the MSY for this species. However, this level is not completely stable as small corrections are needed to compensate the changes in the number of vessels due to the investment function.

As some stocks are underexploited at the level of fishing effort corresponding to the MSY for European hake and the marginal productivity of effort is particularly high, the number of vessels tends to increase. The increase in the number of vessels is compensated by reducing the maximum average days at sea (by the policy option). As the average number of days at sea per vessel falls, profitability turns negative and the number of vessels is reduced. The interactions between fishermen and policy behaviours explain the fluctuations in the number of vessels in Figure 10.6. The link between the number of vessels and the levels of profitability appears also by comparing the two graphs in Figure 10.6. Variations in profit are opposite to variations in number of vessels.

The main trend in profit shows a strong decrease in the first years of the simulation, and a recover thereafter. The level of profit in the long run seems to be higher than that in the baseline for DTS 12-24, and very close to those levels for the other fleet segments.

In the year 15, the system seems to have already achieved its long term equilibrium. The total fishing effort, equals to 138,000 days at sea, represents 56% of the level estimated at the baseline. The fleet decreases of 30%, from 1729 to 1204 vessels, and the number of days at sea per vessel per year decreases of 19%. The decrease in the number of vessels is not homogeneous among fleet segments. PGP segments show reduction over 30%, while DTS 12-24 is reduced by less than 20%. The total catch shows a reduction of 22% from 13,620 tonnes in the baseline to 10,670 tonnes in year 15. Landings of European hake and horned octopus show decreases of almost a quarter compared with the baseline. As for Norway lobster and striped mullet, reductions of 20% and 10% respectively are registered.

Figure 10.6 Results of scenario 2. Effort min



Scenario 3. TAC max

Figure 10.7 Results of scenario 3. TAC max

Not applicable for the case study

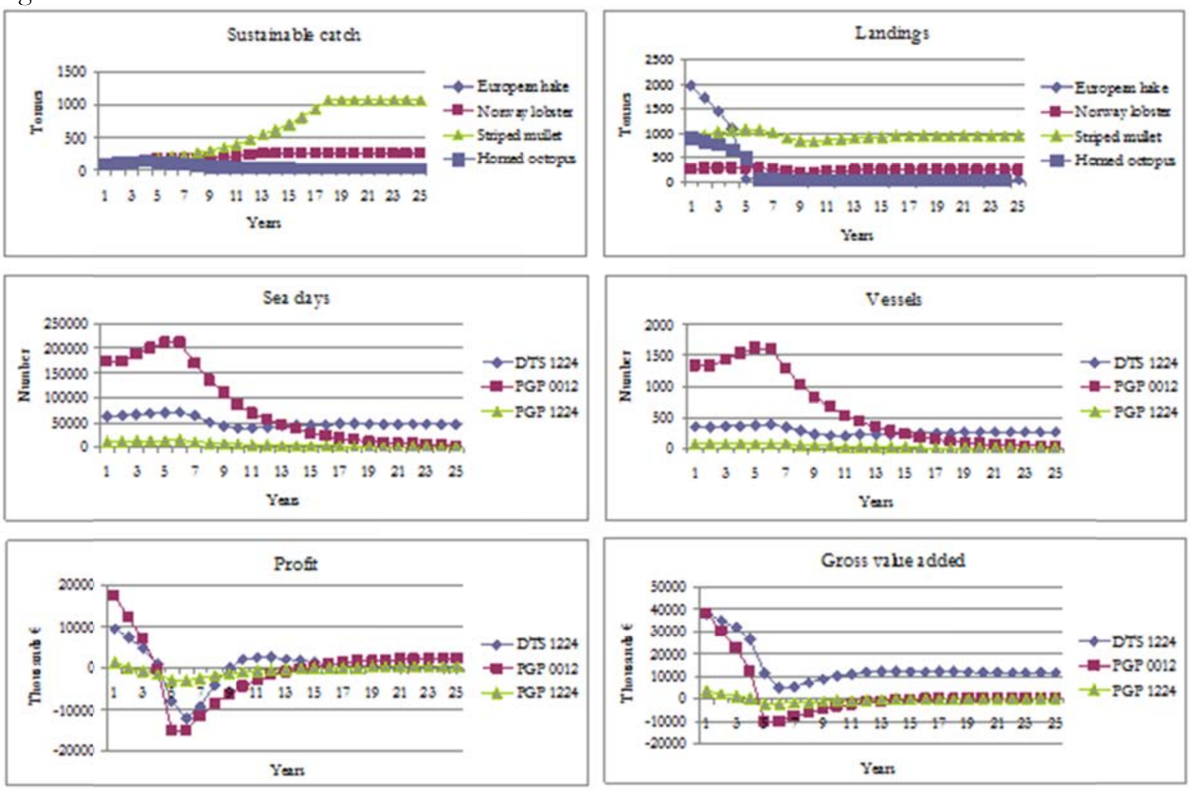
Scenario 4. Effort max

This scenario pursues MSY for at least one stock in the long run. The model calculates the ratio between the target and the current harvest ratio in each time period for each species and select the maximum value of these ratios. Fishing effort is changed in accordance with this value. As the maximum value is associated to the stock showing the minimum overexploitation rate, this policy option is directed to safeguard the least depleted stock. However, when at least one stock is underexploited, the policy produces an increase in fishing effort to exploit this stock at its MSY. However, as management authorities cannot impose an increase in the number of vessels or days at sea, the model selects the minimum level of effort between that suggested by the policy option and that resulting from the fishermen behaviour under an open access system, which is determined by the investment function.

European hake and horned octopus appear overexploited in the baseline, while Norway lobster and striped mullet show levels of current H lower than those of target F. At the baseline, Norway lobster is the species with the maximum under-exploitation rate (minimum overexploitation rate). Therefore, the selection of fishing effort is initially driven by the status of this stock. However, for DTS 12-24 and PGP 00-12, the increase in fishing effort identified by the policy option to achieve the MSY for Norway lobster is higher than that potentially realized in an open access situation. Then, in the first year of the simulation, the policy decision impacted only on PGP 12-24. In the following 4 years, changes in fishing effort by fleet segment are driven by the policy option or the fishermen behaviour depending on the fleet segment, while policy option has no effect in the remaining period.

As a consequence, results obtained by this scenario are very similar to those produced in the open access scenario. To avoid duplications, the main results for both cases are described under scenario 5.

Figure 10.8 Results of scenario 4. Effort max



Scenario 5. Open access

In this scenario there is no management policy. Variations in days at sea and number of vessels are defined by fishermen behaviour under the assumptions on the maximization of average days at sea per vessel and the investment function described in section 2.3 (FISHRENT model).

The maximum number of average days at sea for each of the fleet segments is reached by assumption in year 2. As a consequence, the evolution of total days at sea (given by maximum number of days per vessel multiplied by the number of vessels) shows the same trend as the number of vessels. In the first 5 years, there is a significant investment in new vessels with an increase in the fleet of around 20%. This increase is particularly relevant for PGP segments (+22%), while the number of DTS 12-24 raises of just over 10%. However, the augmented fishing effort and harvest ratio impact negatively on the status of stocks. In particular, increasing the exploitation of European hake and horned octopus, the most depleted stocks, leads to their "extinction" in year 5 and 6 respectively. As the model does not allow depleted stocks to recover, variations in the following period of simulation are based only on the remaining stocks, Norway lobster and striped mullet.

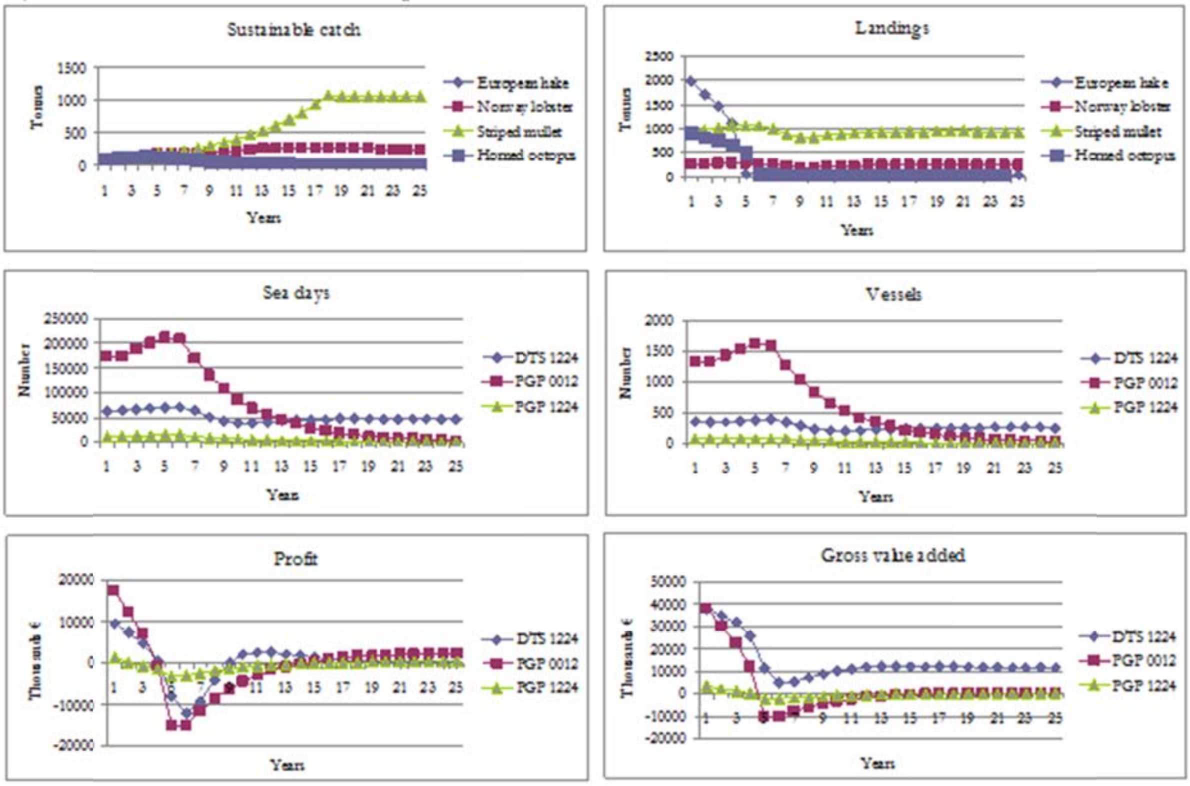
The exclusion of these species from landings makes the fishing activities unprofitable for all fleet segments. As a consequence, many vessels leave the activity in the following years. However, the effect on fleet segments are not homogeneous. As in the model total revenues of PGP segments depend almost exclusively on European hake, the exclusion of this species determines a very strong damage to the economic sustainability of these fleets. On the contrary, the more diversified landing composition in the model of DTS 12-24 allows these vessels to be less vulnerable to the "extinction" of a species. Indeed, vessels belonging to PGP segments show a reduction of more than 80% in year 15 compared with the baseline, while DTS 12-24 declines of less than 30% in the same period. It is important to highlight that this result depends on the inclusion of just four species in the model. The diversification of landing composition by fleet segment in the model could be not representative of the real system.

The decrease in the number of vessels allows the fleet to return in a situation of profitable fisheries but at levels very much lower than those registered in the baseline.

In the year 15, the system has not yet achieved its long term equilibrium. The number of vessels of PGP segments is still declining, while DTS 12-24 shows an increasing trend. The total fishing effort, 74,000 days at sea, is 30% of the level estimated in the baseline due to a reduction of 73% in the fleet, from 1729 to 461 vessels, and an increase in the number of days at sea per vessel to the maximum level. As described above, the decrease in the number of vessels is particularly strong for PGP segments.

The total catch shows a reduction of 75% from 13,620 tonnes in the baseline to 3,410 tonnes in year 15. Landings of European hake and horned octopus are null for the reasons described above (values reported in Table 10.10 are due to model numerical approximation), while Norway lobster shows a reduction of 10% and striped mullet an increase of 1% compared with the baseline.

Figure 10.9 Results of scenario 5. Open access



Scenario 6. Min / min

Figure 10.10 Results of scenario 6. Min / min

Not applicable for the case study

10.7.3. Role of discount rate (scenarios 7-8)

In the main scenario, a discount rate of 3.5% has been used to calculated the NPV $profit_{15}$. Scenarios 7 and 8 differ from the main scenario as discount rates of 2% and 5% respectively have been applied.

Variations in the discount rate have no effect on the dynamics of the system. The nominal profit in year 15 is the same for the three scenarios. This value is higher than that estimated at the baseline. Furthermore, the value simulated for the year 15 can be considered as sustainable, while the baseline situation does not assure a stable level for profit in the future. Regarding the NPV $profit_{15}$, obviously the highest values is obtained at the lowest discount rate.

Table 10.11 Effect of discount rate on profit

Indicator	2005-7	Scenario		
		Main scenario Discount rate 3.5%	7. Discount rate 2%	8. Discount rate 5%
NPV $Profit_{15}$		327.9	369.0	292.9
Nominal $Profit_{15}$*	27.6	31.3	31.3	31.3
Discounted $Profit_{15}$*		18.7	23.2	15.0

*this is the value in year 15, not the sum of profits

Scenario 7. Discount rate 2%

Comparing scenario 7 with the main scenario (scenario 2) shows that the changes in discount rate have no effect on nominal profit, while discounted profit is 24% higher when the discount rate is set at 2%. Regarding the NPV $profit_{15}$, a discount rate of 2% leads to an increase of 13% in this indicator.

Scenario 8. Discount rate 5%

Comparing scenario 8 with the main scenario (scenario 2) shows that the changes in discount rate have no effect on nominal profit, while discounted profit is 20% lower when the discount rate is set at 2%. Regarding the NPV $profit_{15}$, a discount rate of 5% leads to a decrease of 10% in this indicator.

10.7.4. Resource rent and recovery of management costs (scenario 9)

The full recovery of management costs is simulated in this scenario by adding a fixed payment for access to each fleet segment. These amounts are estimated as an average of OECD data in the period 2004-2006. This scenario is based on the main scenario (Effort min).

Results of scenario 9 are very similar to the scenario 2. Comparing Figure 10.11 with Figure 10.6 shows the same trends in the main variables. The only differences are related to the levels in the number of vessels and consequently in profit and gross value added. The introduction of a fixed payment for access has reduced the profitability and made less attractive the sector. As a consequence, investments in new vessels are lower than those in the main scenario for DTS 12-24 and PGP 12-24. On the contrary, the number of vessels of PGP 00-12 is higher in the present scenario. There are in total 1328 vessels in year 15 in scenario 9 compared to 1204 in scenario 2. Notwithstanding, the level of fishing effort remains the same as this is defined by the policy option common to both scenarios. The same fishing effort determines also an equivalent harvest ratio, the same exploitation rate and levels of landings.

The different composition of fishing effort in the two scenarios highlights a higher efficiency in scenario 9. Indeed, reducing the number of vessels for DTS 12-24 and PGP 12-24 and increasing the vessels of PGP 00-12 allows the entire fleet of scenario 9 to reduce fixed and capital costs (which are higher for bigger size vessels) maintaining variable costs (which depend on fishing effort) at the same levels of scenario 2. Therefore, as largely expected, the introduction of a payment for access increases the efficiency of the fleet. The GVA reported in Figure 10.11 shows levels higher than those reported in Figure 10.6 (main scenario) for each of the fleet segments considered. In Table 10.12, nominal GVA for the entire fleet in year 15 amounts to 68.9 million euro, higher than the value of 68.6 million euro estimated in scenario 2. The difference between these value is due to the fixed costs. When comparing profits, the difference between scenario 9 and 2 is higher as this includes also the additional benefit deriving from the reduced capital costs.

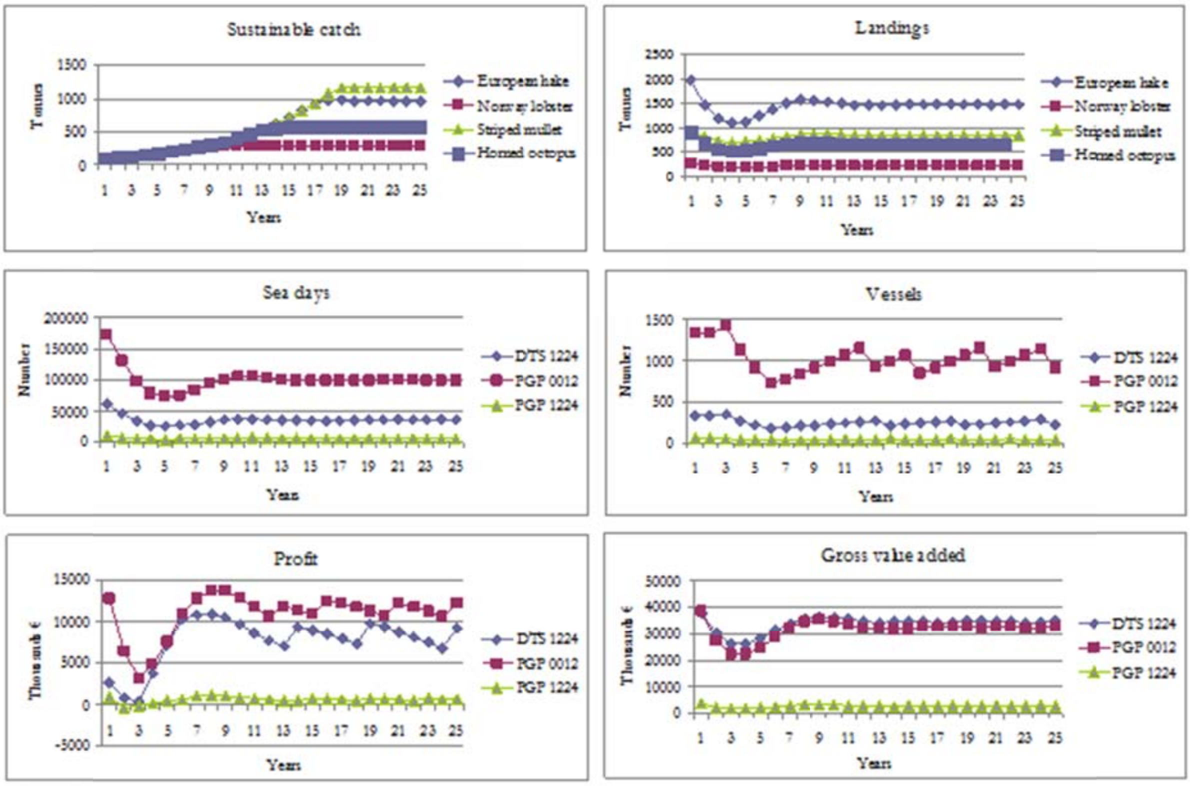
Obviously, profits in Table 10.12 do not include the payment for access. This amounts to 11.8 million euro. When this cost is deducted from profit, the economic performance in scenario 9 will be lower than that estimated in the main scenario. Figure 10.11 and Figure 10.6 show the profits after the deduction of payments for access. Payment for access is particularly relevant representing around 37% of total profits. However, among the three fleet segments considered, only PGP 12-24 shows a level of profits lower than the payment for access in years 2 and 3.

Table 10.12 Consequences of recovery of management costs

Indicator	005-7	Scenarios*	
		Main scenario: No recovery of management costs	9. Recovery of management costs
NPV GVA_{15} (mln euro)		754.7	757.7
Nominal GVA_{15} (mln euro)	79.3	68.6	68.9
NPV $Profit_{15}$		327.9	336.4

Fixed payment for access (mln euro)		0.0	11.8
NPV Payment for access$_{15}$		0.0	7.0
Nom Profit$_{15}$ (mln euro)	27.6	31.3	32.3

Figure 10.11 Results of scenario 9. Recovery of management costs



10.7.5. Optimization of capacity (scenarios 10-14)

Scenarios 10 to 14 simulate the main optimum paths to achieve MSY or MEY. In particular, the level of fishing effort corresponding to MSY can be obtained at different combinations of its components, number of vessels and average days at sea per vessel. In the main scenario, MSY for European hake is achieved by one combination of fishing effort components given by the interactions between the management policy and the fishermen behaviour in terms of new investments. Scenarios 10 to 12 are directed to reach the MSY for European hake by using the same management option (Effort min), but imposing constraints on the system. The fleets in scenarios 10 and 11 are supposed to be stable, and equal respectively to the fleet operating at the baseline and the minimum fleet able to produce the same fishing effort at the baseline. In scenario 12, the average days at sea per vessel are supposed to be constant and equal to an assumed maximum, while the fleet is modified each year by the policy option. Differently form the other scenarios, scenarios 13 and 14 are directed to achieve the MEY (i.e. maximum NPV GVA_{15} in scenario 13 and maximum NPV $profit_{15}$ in scenario 14) by optimizing the number of vessels of all fleet segments over the years from 2 to 15.

Table 10.13 Impact of optimization of the fleet size

Indicator	2005-7	Scenarios*					
		Main scenario TAC min	10. Static present fleet	11. Static minimum fleet	12. Dynamic minimum fleet	13. Optimum fleet (GVA)	14. Optimum fleet (profit)
NPV $Profit_{15}$ (mln euro)		327.9	263.7	273.5	391.8	449.0	486.3
Nominal $Profit_{15}$ (mln euro)	27.6	31.3	24.8	25.7	36.6	36.8	46.7
Discounted $Profit_{15}$ (mln euro)	27.6	18.7	14.8	15.3	21.9	22.0	27.9
$Fleet_{15}$ (no vessels)	1,729	1,204	1,729	1,697	957	1,244	1192
$Effort_{15}$ (1000 DAS)	244	138	138	138	138	176	164
$Catch_{15}$ (1000 t)	13.6	10.7	10.7	10.7	10.7	11.8	11.1

*NPV row refers to the sum, other rows refer to values in year 15

Table 10.13 shows the values of the main variable in year 15 for each of the scenarios described above and provides a comparison with the baseline. The main scenario and scenarios form 10 to 12 are directed to achieve MSY of European hake, and this is obtained at a level of fishing effort equal to 138,000 days at sea. This level of fishing effort produces a total amount of catches equal to 10,670 tonnes. As reported above, the main difference among these scenarios is related to the composition of fishing effort. Scenario 12 shows the minimum number of vessels, while scenario 10 the maximum number equal to the baseline. Very different results are reported in scenarios 13 and 14, with levels of fishing effort higher than those estimated for the other scenarios. In year 15, scenario 13 shows a level of fishing effort equal to 176,000 days at sea, corresponding to 11,840 tonnes of landings, while scenario 14 shows a level of effort equal to 164,000 days at sea, corresponding to 11,120 tonnes of landings. These are the optimal levels obtained by maximizing GVA and profit respectively over the first 15 years of simulation.

As scenario 14 is aimed to maximize profits, nominal and discounted profits in year 15 and NPV $profit_{15}$ in scenario 14 are higher than those estimated in other scenarios. The second best scenario from an economic perspective is represented by scenario 13, which is directed to maximize GVA. As for the other scenarios in Table 10.13, profit in year 15 and NPV $profit_{15}$ increase with reductions in the number of vessels. Scenario 12 shows the lowest number of vessels and the highest NPV $profit_{15}$, while scenario 10 shows the highest number of vessels and the lowest NPV $profit_{15}$.

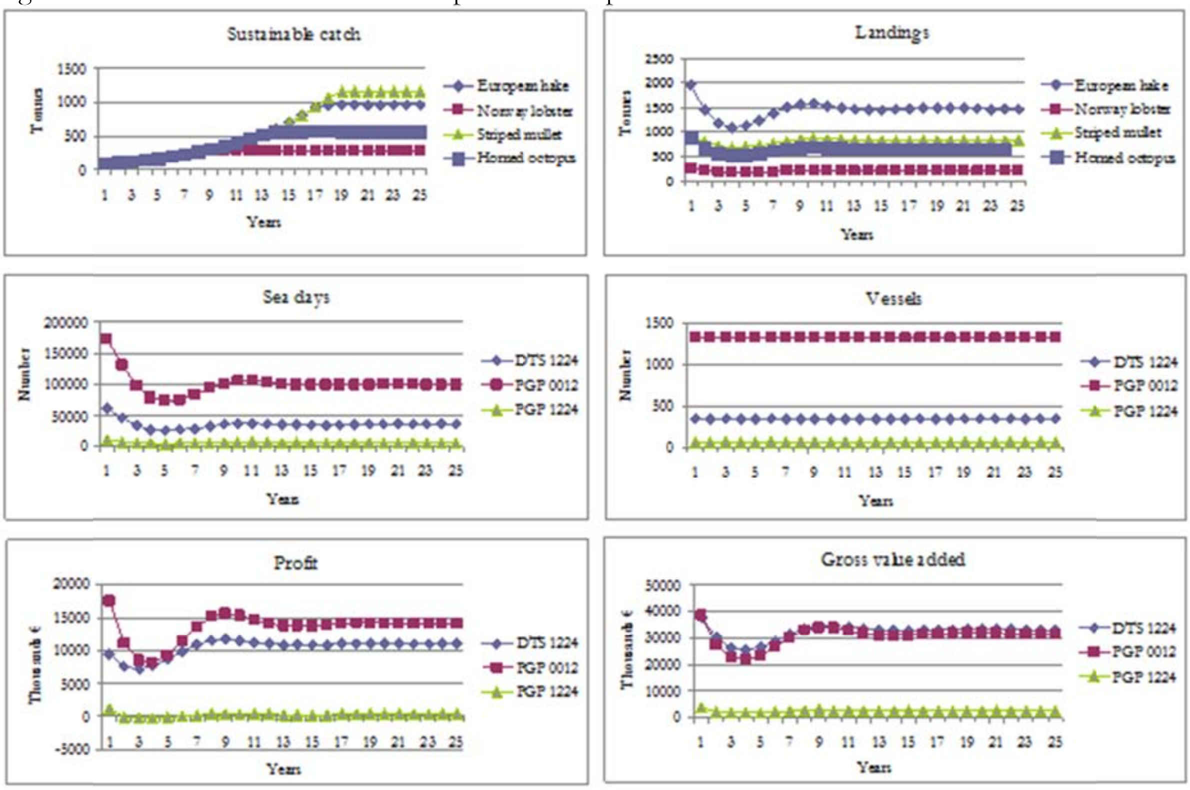
Scenario 10. Static present fleet

The fleet in scenario 10 is supposed to remain stable and equal to the fleet operating at the baseline. The average days at sea per vessel are changing according to the fishing effort selected by the policy option.

Results obtained in scenario 10 are very similar to scenario 2. Comparing Figure 10.12 with Figure 10.6, with the exception of number of vessels and profits, the same trends occur in the main variables. As fleet size is constant in scenario 10, profits are not affected by variations in the number of vessels and show a more stable tendency to the equilibrium. The higher number of vessels over the simulation period in scenario 10 determines also augmented fixed and capital costs. As a consequence, profits and GVA are lower than those estimated in the main scenario. A total of 1729 vessels have been estimated in year 15 in scenario 10 compared to 1204 vessels in scenario 2. Notwithstanding, the level of fishing effort remains the same as this is defined by the policy option common to both scenarios. To activate the same fishing effort at a higher number of vessels, the average days at sea per vessel are reduced in scenario 10. The same fishing effort determines also an equivalent harvest ratio, the same exploitation rate and levels of landings.

The different composition of fishing effort in the two scenarios highlights a higher efficiency in the main scenario. In scenario 10, maintaining the number of vessels at the baseline level and decreasing the average days at sea per vessel reduces the efficiency of the fleet increasing the costs needed to produce the same level of landings. The GVA reported in Figure 10.12 shows levels lower then those in Figure 10.6 (main scenario) for each of the fleet segments. When comparing profits, the difference between scenario 2 and 10 increases as profits in the latter scenario include a higher capital cost. In Table 10.13, nominal profit for the entire fleet in year 15 amounts to 24.8 million euro in scenario 10, lower than the value of 31.3 million euro estimated in scenario 2. The difference between these values is due to the fixed costs. Scenario 10 shows a NPV $profit_{15}$ equal to 264 million euro, against a level of around 328 million euro estimated in the main scenario.

Figure 10.12 Results of scenario 10. Adaptation with 'present' fleet



Scenario 11. Static minimum fleet

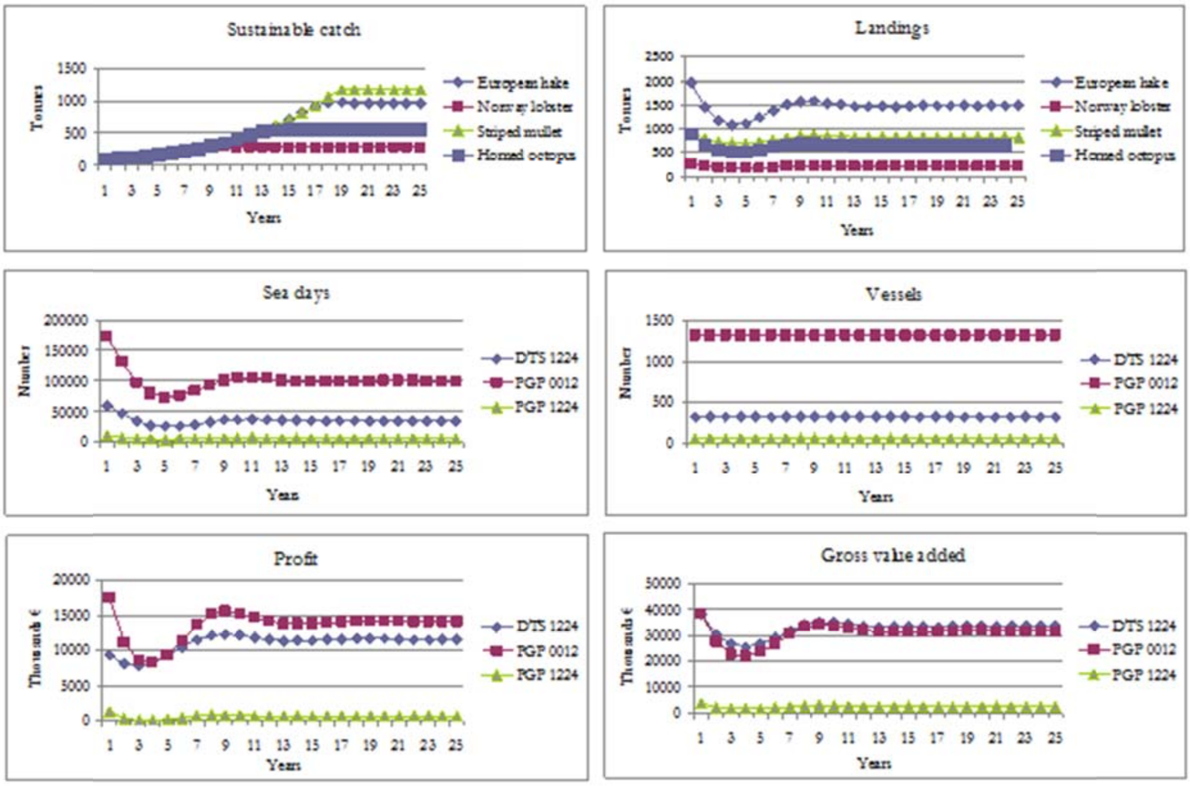
The fleet in scenario 11 is supposed to be stable and equal to the minimum fleet able to produce the same fishing effort as the baseline given a maximum days at sea per vessel. The average days at sea per vessel are changing according to the fishing effort selected by the policy option.

Scenario 11 is very similar to scenario 10. The number of vessels is constant in both scenarios and equal to the starting value in year 1. The only difference is related to the fleet size selected as starting value. This is equal to the baseline fleet in scenario 10 (1729 vessels), while in scenario 11 this is set at a lower level (1697 vessels). As the same level of fishing effort is employed in both scenarios, also harvest ratio, exploitation rates, and the levels of landings and revenues are equivalent. The use of a lower number of vessels in scenario 11 determines a higher efficiency and a better economic performance.

The gross value added reported in Figure 10.13 is higher than in Figure 10.12 (scenario 10) for each of the fleet segments. In Table 10.13, nominal profit for the entire fleet in year 15 amounts to 25.7 million euro in scenario 11, higher than the value of 24.8 million euro in scenario 10. In terms of NPV profits[15], scenario 11 shows a value of 273 million euro, against a level of around 264 million euro in scenario 10.

Given the similarities between scenarios 10 and 11, the same considerations reported in the previous section and regarding the comparison of scenario 10 with the main scenario hold also for the comparison of scenario 11 with the main scenario.

Figure 10.13 Results of scenario 11. Static minimum fleet



Scenario 12. Dynamic minimum fleet

In scenario 12, the average days at sea per vessel are constant and equal to an assumed maximum level, while the fleet is changing each year in accordance with the fishing effort selected by the policy option.

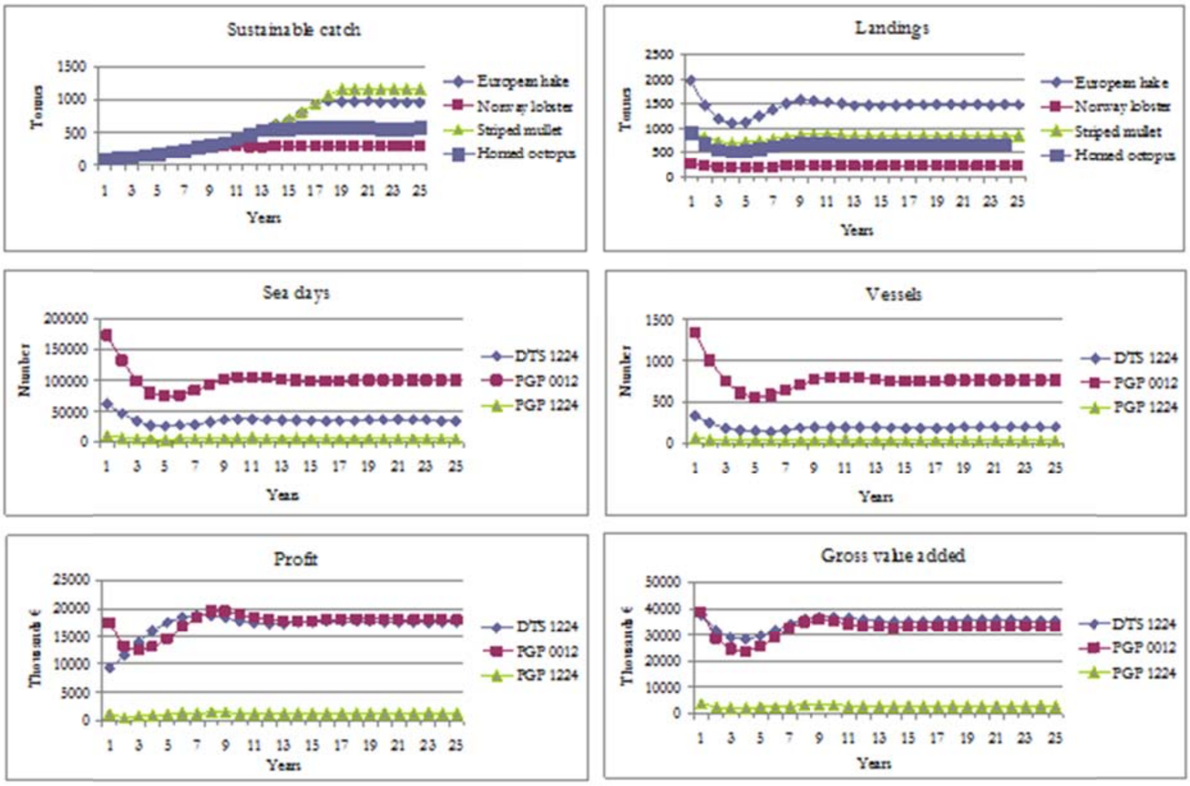
The graphs related to sustainable catch, landings and days at sea in Figure 10.14 show the same trends of the main scenario. This is due to the policy option, which is common to both scenarios. Indeed, the same levels of fishing effort, defined by the management policy and directed to achieve the MSY for European hake, are simulated for the two scenarios. As a consequence, these produce also the same harvest ratio and the same levels of landings and revenues.

As in scenarios 10 and 11, the difference with scenario 2 is given by the different composition of fishing effort. Scenarios 10 and 11 were characterised by the use of a higher number of vessels and a reduced number of average days at sea, which determined a lower fleet efficiency and then lower profit and NPV $profit_{15}$. On the contrary, scenario 12 uses the maximum number of average fishing days per vessel and the minimum number of vessels. As a consequence, scenario 12 results more efficient than scenario 2. The reduced number of vessels over the simulation period determines also a decrease in fixed and capital costs. As a consequence, profits and gross value added are higher than those in the main scenario. A total of 957 vessels have been registered in year 15 in scenario 12 compared to 1204 vessels in scenario 2.

The GVA reported in Figure 10.14 shows levels higher then those in Figure 10.6 (main scenario) for each of the fleet segments. In Table 10.13, nominal profit for the entire fleet in year 15 amounts to 36.6 million euro in scenario 12, higher than the value of 31.3 million euro in scenario 2. The difference between these values is due to the fixed and capital costs. Scenario 12 shows a NPV $profit_{15}$ equal to 392 million euro, against a level of around 328 million euro in the main scenario.

Scenario 12 shows the best economic performance among all the scenarios where fishing effort is driven by a management policy. Given a management system aimed to achieve the MSY for the most depleted stock (European hake), scenario 12 shows the optimal path to this end by an economic point of view.

Figure 10.14 Results of scenario 12. Dynamic minimum fleet



Scenario 13. Optimum fleet (GVA)

Differently from other scenarios, scenario 13 is directed to achieve the MEY (maximum NPV GVA_{15}) by optimizing the number of vessels of all fleet segments over the simulation period.

Compared with other scenarios, very different results are produced by scenario 13. While fishing effort in previous scenarios was driven by management rules aimed at achieving the MSY for the most or the least depleted stock, scenario 13 is directed to find the optimum solution over the first 15 years in terms of GVA maximization. The optimum fleet is estimated by maximizing the NPV GVA_{15}, while average days at sea per vessel are derived by the policy option selected in the main scenario (Effort min) with constraints given by the number of vessels and the maximum average level of fishing days registered in the period 2005-7 used as an upper bound. After year 15, fishing effort is driven by the same policy option adopted in the main scenario.

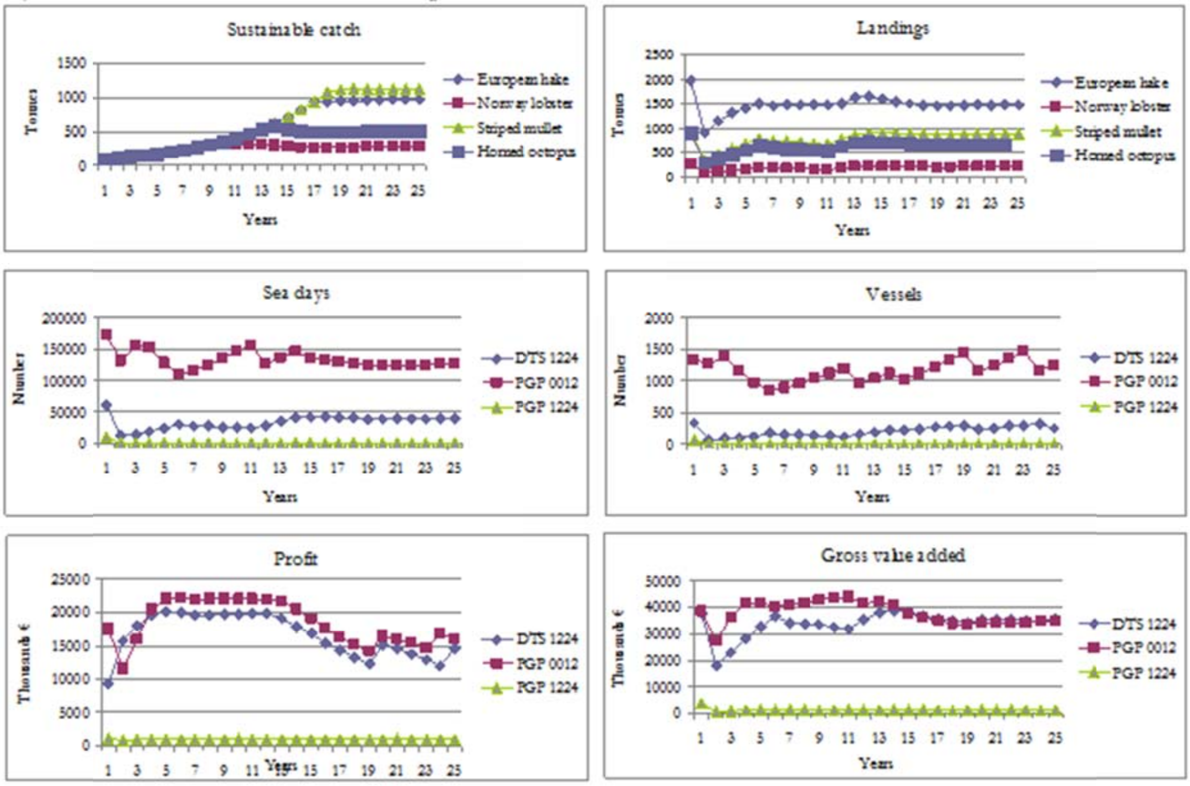
Trend in fishing effort does not show a tendency to equilibrium in the first 15 years. Corrections are probably due to the policy option, which affects the average number of fishing days per vessel for the fleet segment PGP 00-12 in some years. When the policy option determines a change in the average fishing days, the optimal fleet changes for all fleet segments. Even though a clear trend in fishing effort is not identified, the optimization process suggests the removal of the fleet segment PGP 12-24, a strong reduction of DTS 12-24 (at least in the first period) and the conservation of PGP 00-12 at a level close to that in the baseline. In year 15, there are 1244, 28% lower than in the baseline. PGP 00-12 are reduced of 23%, DTS 12-24 of 34% and PGP 12-24 completely removed. The differences in fleet segments are even more significant if compared with the main scenario. The total fleet is a 3% higher in scenario 13, but this difference is due to only PGP 00-12 (+15%), while DTS 12-24 are reduced of almost 20%. The optimal fleet size and its composition indicates that PGP 12-24 represents the lowest efficient fleet segment in terms of long term profitability. Indeed, fixed and capital costs represent almost a quarter of total income for this fleet segment, while this quota is under 20% for DTS 12-24 and PGP 00-12. In particular, PGP 00-12 shows the lowest weight of fixed and capital costs on total income (less than 18%).

During the 15 years when the profit is maximized, fishing effort and harvest ratio are maintained at levels lower than those needed to achieve the MSY for European hake. As this is the most overexploited stock, harvest ratio is also lower than the target H estimated for the other stocks at MSY. Therefore, in accordance with the theory, H at MEY is lower than H at MSY.

Landings of all species show a strong reduction in year 1, and an increasing trend thereafter. This is mainly due to the decrease in the fishing effort of DTS 12-24 and PGP 12-24. Total catches in year 15 are equal to 11,840 tonnes, a level higher than in the other scenarios, main scenario included, which shows a maximum level of 10,670 tonnes in the same year. GVA for DTS 12-24 and PGP 00-12 show similar trends, while the economic indicators (GVA and profit) for PGP 12-24 decline to zero given the elimination of this fleet segment.

Obviously, scenario 13 shows the best economic performance in terms of GVA among the simulated scenarios. Regarding the level of profits, total nominal profit in year 15 is estimated at almost 37 million euro, 18% more than in the main scenario. Table 10.13 shows also a value of NPV $profit_{15}$ equal to 449 million euro in scenario 13, 37% higher than the level of around 328 million euro in the main scenario. Profits of PGP 00-12 show a reduction in year 1, an increasing trend until year 13, and a return to the starting values in the following years. Profits of DTS 12-24 show a similar trend, but anticipated of a year. Profits increase since the beginning of the simulation, while the declining trend starts in year 13.

Figure 10.15 Results of scenario 13. Optimum fleet



Scenario 14. Optimum fleet (profit)

As well as scenario 13, also scenario 14 is directed to achieve the MEY by optimizing the number of vessels of all fleet segments over the simulation period, but MEY is here expressed in terms of profit instead of GVA.

Compared with the non-optimization scenarios, results are very different. In those scenarios, fishing effort was driven by management rules aimed at achieving the MSY for the most or the least depleted stock. On the contrary, this scenario is directed to find the optimum solution over the first 15 years in terms of profit maximization. The optimum fleet is estimated by maximizing the NPV $profit_{15}$, while average days at sea per vessel are derived by the policy option selected in the main scenario (Effort min) with constraints given by the number of vessels and the maximum average level of fishing days registered in the period 2005-2007 used as an upper bound. After year 15, fishing effort is driven by the same policy option adopted in the main scenario.

Trend in fishing effort does not show a tendency to equilibrium in the first 15 years. Corrections are mainly related to the optimization process, while the policy option does not significantly affect fishing effort as increases in the average number of fishing days are not allowed over the maximum level. Even though a clear trend in fishing effort is not identified, the optimization process suggests a strong reduction in all fleet segments. In particular, PGP 1224 is initially removed by the optimization process in the first simulation year, and increase slowly thereafter. In year 15, there are 1192 vessels, 30% less than in the baseline. PGP 0012 are reduced of 20%, DTS 1224 of two-thirds and PGP 1224 of more than 70%. Compared with the main scenario, the total fleet is just 1% lower in scenario 14, but significant differences are in the fleet composition. Indeed, PGP 0012 increases by 20%, while DTS 1224 and PGP 1224 show reductions of almost 60%. The optimal fleet size and its composition indicates that PGP 0012 represents the most efficient fleet segment in terms of long term profitability. Indeed, as reported above, this fleet segment shows the lowest weight of fixed and capital costs on total income (less than 18%).

As well as scenario 13, fishing effort and harvest ratio in scenario 14 are maintained at levels lower than those needed to achieve the MSY for European hake. As this is the most overexploited stock, harvest ratio is also lower than the target H estimated for the other stocks at MSY. Therefore, in accordance with the theory, H at MEY (both in terms of GVA and profit) is lower than H at MSY.

Landings of all species show a strong reduction in year 1, and an increasing trend thereafter. This is mainly due to the decrease in the fishing effort of DTS 1224 and PGP 1224. Total catches in year 15 are equal to 11,120 tonnes, a level higher than those estimated in the non-optimization scenarios, main scenario included, which shows a maximum level of 10,670 tonnes in the same year. GVA for all fleet segments show similar trends in the first 15 years with a decrease in the first simulation year, an increase in the following years, and a stable trend thereafter.

Obviously, scenario 14 shows the best economic performance in terms of profits among the simulated scenarios. In year 15, total nominal profit is estimated at almost 47 million euro, almost a 50% more than in the main scenario. Table 10.13 shows also a value of NPV $profit_{15}$ equal to 486 million euro in scenario 14, 48% higher than the level of around 328 million euro in the main scenario. Profits of PGP 0012 and PGP 1224 show a reduction in year 1, an increasing trend until year 15, and a decreasing trend thereafter. Profits of DTS 1224 show a similar trend with the exception of the reduction in the first year. Indeed, profits for trawlers increase since the beginning of the simulation period.

Figure 10.16 Results of scenario 14. Optimum fleet – max profit

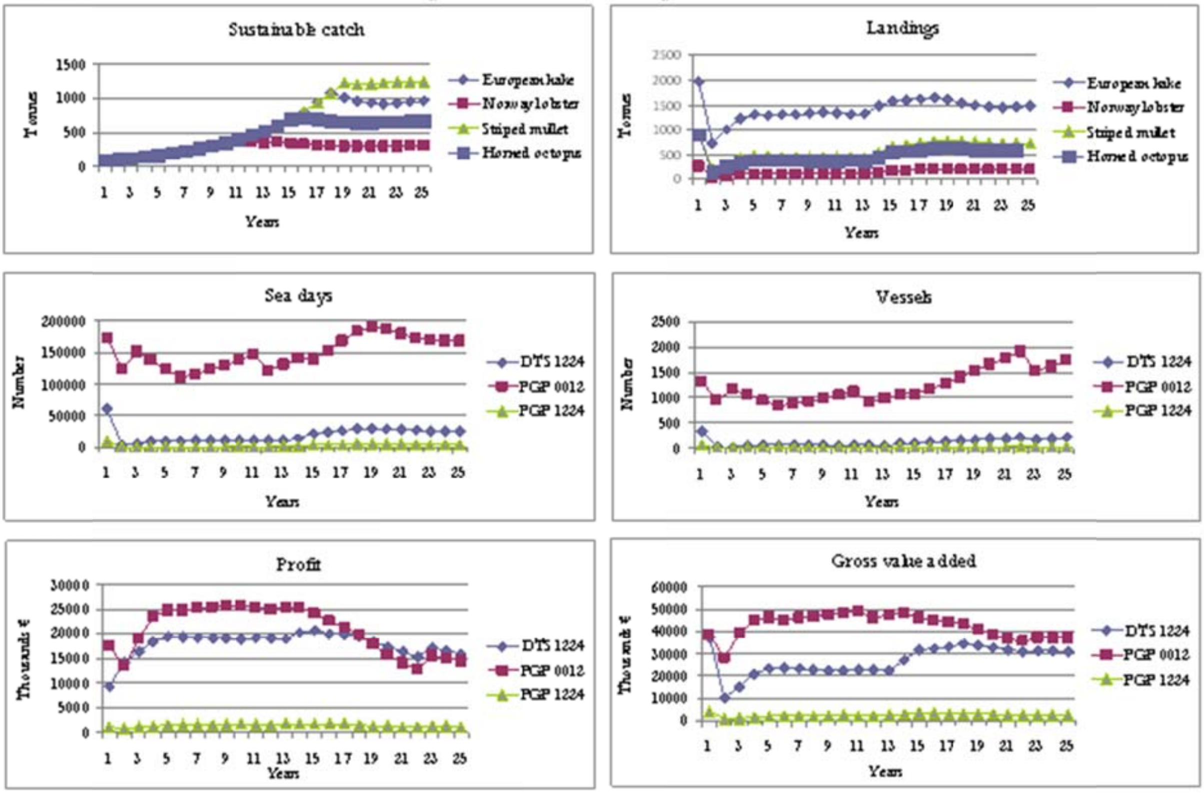


Figure 10.17 shows similar trends in the main variables for scenarios 13 and 14. However, some differences occur in the levels of these variables. Both scenarios are directed to optimize the number of vessels over the first 15 years of the simulation period, but scenario 13 is aimed to maximize GVA while scenario 14 is aimed to maximize profit. As a consequence, the NPV GVA_{15} in scenario 13 (844 million euro) is 6% higher than that in scenario 14 (796 million euro). For the same reason, the NPV $profit_{15}$ in scenario 14 (486 million euro) is 8% higher that that in scenario 13 (449 million euro). However, in year 15, both GVA and profit are higher in scenario 14 (48.73 and 27.87 million euro respectively) than in scenario 13 (45.92 and 21.98 million euro respectively). This is also related to the fleet size equal to 1192 vessels in scenario 14 and 1244 vessels in scenario 13. As a consequence, the actualized values of crew costs and capital costs are higher under scenario 13 than scenario 14.

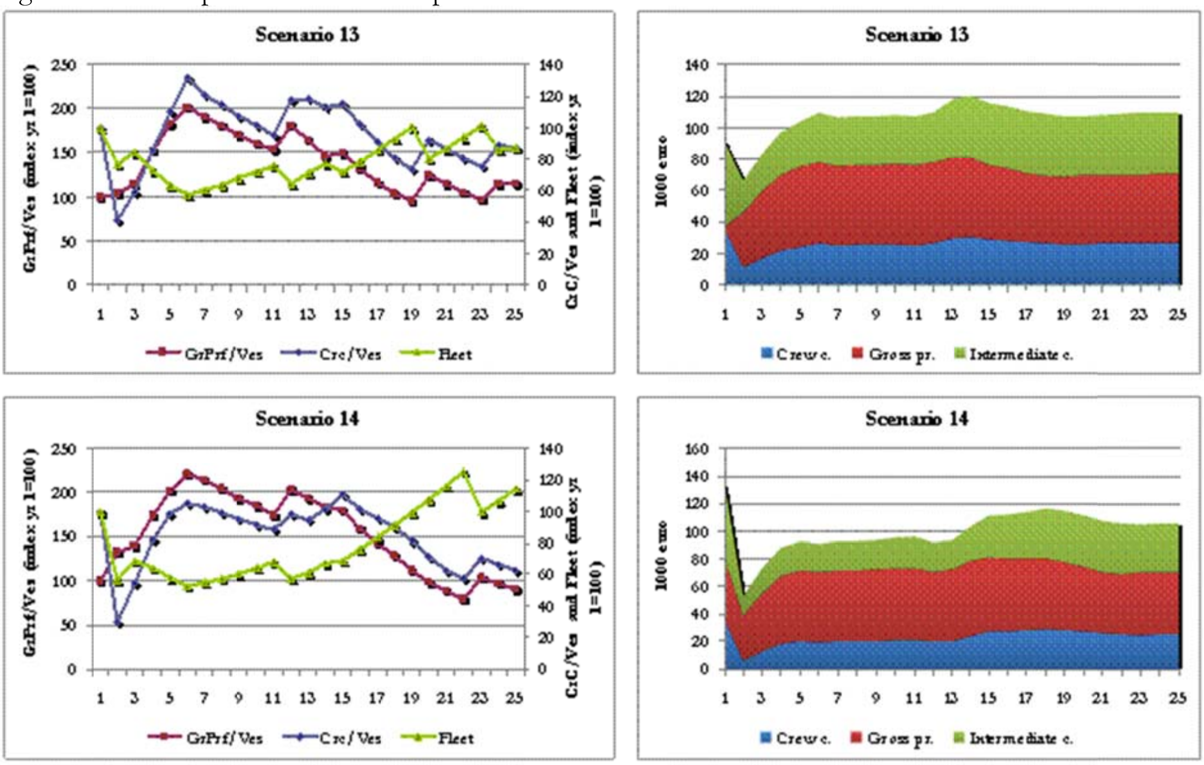
In year 15, both GVA and profit are higher in scenario 14 (81.64 and 46.49 million euro respectively) than in scenario 13 (76.93 and 36.82 million euro respectively), while crew and capital costs are higher in scenario 13. These results are depending on the fleet composition. Even though scenario 14 shows a number of vessels lower than that in scenario 13, the size of the fleet segments with the highest weight of profits on GVA, PGP 0012 and PGP 1224, increases from scenario 13 to scenario 14. On the contrary, the fleet segment DTS 1224, whose profits represent a lower share of GVA, shows a reduction of 50%.

Comparing the average number of vessels over the simulation period (years 1-15), scenario 14 shows a number lower than that estimated under scenario 13. This means that the maximum profit is obtained at an average fleet size lower than that needed to maximize GVA.

Table 10.14 Comparison of scenarios 13 and 14 (values in mln euro, fleet number of vessels)

	Scenario 13	Scenario 14
NPV GVA_{15}	844.42	796.30
NPV $profit_{15}$	449.00	486.27
NPV Crew $costs_{15}$	292.29	234.69
NPV capital $costs_{15}$	103.13	75.34
GVA year 15	76.93	81.64
Profit year 15	36.82	46.69
Crew costs year 15	29.51	27.13
Capital costs year 15	10.60	7.82
Fleet – average 1-15	1,243	1,104
Fleet – year 15	1,244	1,192

Figure 10.17 Comparison of the two optimization scenarios



10.7.6. Assumptions and technical background (by main model modules)

The main assumption is related to the estimation of the current status of demersal stocks. The status of stocks has been derived from time series data on biomass indexes and harvest ratio collected in the GRUND project. These data have been combined with landings data collected by IREPA to estimate a logistic function for each stock. However, stocks landed in Italian demersal fisheries are generally more than 50. Unfortunately, data are available only for few of them. Therefore, an additional assumption is related to the representativeness of the four target species included in the model. It is assumed that variations in the total landings and revenues are driven by variations in the landings of these species.

ANNEX 1. DESCRIPTION OF THE MODEL FISHRENT

INTRODUCTION

The FISHRENT model was developed on the basis of earlier experiences of the team in bio-economic modelling, inter alia EIAA, BEMMFISH, TEMAS, AHF and others which were evaluated within the project 'Survey of existing bio-economic models' (Prellezo et.al. 2009). However, none of these models was appropriate to estimate resource rents under different conditions and management regimes, as required in the present project.

On the basis of the review of models and the objective of the project, it became evident that a new model had to be constructed which would meet the following requirements:

- Integrate simulation (application of different management strategies) and optimization (to determine optimum value of resource rent and other variables). This is implemented by having a simulation model in which optimization can be achieved by using the Excel Solver.
- Integrate output- and input-driven approaches, so that one model could be consistently applied to different situations in the EU, particularly the Atlantic and the Mediterranean / Black Sea areas.
- Accommodate multi-species / multi-fleet fisheries, with flexible number of species and segments.
- Close link to available economic and biological data, to allow empirical applications.
- Balanced composition between various components: biology-economics-policy.
- Dynamic behaviour over a long period, including stock-growth, investment and effort functions, to allow simulation of adjustment paths to an optimum.
- Flexibility for applications of various types of relations (e.g. different stock-growth functions, approaches to payment for access, etc.).
- Use of a well-known language (Excel) to allow a broad introduction and accessibility to different users.

The FISHRENT model contains six modules:

1. Biological module
2. Economic module
3. Interface module
4. Market module
5. Behaviour module
6. Policy module

The main characteristics of the FISHRENT model are:

- The model accounts for eight species and eight fleet segments (4*4 version is also available), but can be extended to a larger number if required, or reduced to a smaller size. The procedures for adaptations are described in Annex 1.
- The model is a dynamic simulation model, running for a period of 25 years. Extension to a longer period is possible.
- By using the Excel Solver tool, the model can be used as an optimization model, which is particularly relevant in relation to the estimation of the resource rent.
- The model combines input and output based management, as well as their combinations. This has been achieved by a two stage calculation, in which first relevant combination of effort and catch is determined and subsequently applied in the actual simulation model.
- The model contains various options for the collection of rent (payment for access), including fixed payment per unit of capacity (vessel), payment per unit of effort (day-at sea) and tax on revenues or profits.

- The model contains a large number of features, including parameter for technological progress, discards of sized and undersized fish, various options for simulation of investments, etc. Details description is presented below.

In table A.1 The FISHRENT rent model is compared to several main models, which have been developed and applied recently. The comparison shows that the model integrates various features, which have not been integrated in a similar way before:

Table A.1 Comparison of FISHRENT with selected bio-economic models

Criteria	FISHRENT	EIAA	BEMMFISH	World Bank	EMMFID	Norwegian model
Model objective	Estimation of resource rent for specific fisheries	Economic evaluation of biologic advice	Modelling of Mediterranean fisheries	Estimation of resource rent on global level	Estimation of resource rent for the whole Danish fishery	Estimation of resource rent for the major part of the Norwegian fishery
Estimates resource rent	Per year, NPV of profits	Annual profit	Per year and NPV of profits	Point estimate of max. rent	Point estimate of max. rent	Point estimate of max. rent = net profit
Simulation / optimization	Simulation and optimization	Simulation	Simulation	Optimization by solving the profit equation	Optimization using linear programming	Optimization using linear programming
Input / output driven	Input and output	Output	Input	Output	Input and output	Input and output
Policy options	Free access, TAC and Effort restriction	TAC	Fishing time (effort), vessels, taxes	None	Free access, TAC and Effort restriction	Free access, TAC and Effort restriction
Fish prices elasticity	Yes	Yes	Yes	No	No	No
Accounting for exogenous fuel price changes	yes	No	No	No	No	No
Investment function	Yes	No	Yes	No	No	No
Biological input	Biomass. Stock-growth function in a flexible format. Source ICES and Italian institutes	Yield in terms of TACs and abundances of spawning stock biomasses. Source: ICES	Stock-growth function	Single species model Logistic (=2nd degree polynomial) Fox. Sources: FAO and other	TAC/catch restrictions	TAC/catch restrictions
Economic input	Multi fleet. DCF data, distinguishing 5 cost components	Multi fleet. DCF data, distinguishing 5 cost components	DCF with minor assumptions	Distinguishes between variable and fixed costs, Source: large variety of data	Detailed cost structure	Detailed cost structure
Number of years	25 years, expandable	3 point estimates Current year, next year, and long term.	40 years	Static	Static	Static
HCR / management plans	Multi-species, Six policy options: - TAC min - TAC max	Single species, management plans in terms of TAC/quotas	No	No	Single species, management plans in terms of TAC/quotas	-

	- Effort min - Effort max - Min-Min - Open access				and effort	
Discards	Two types: undersized and over-quota.	No	No	No	No	No
Software	Excel	Excel	Java	None	GAMS/Excel	Matlab
Dynamic / Static	Dynamic	Static	Dynamic	Static	Static	Static
Dimensions:						
• Fleets	Up to eight, expandable	Unlimited	Multi-fleet	Single fleet	26	25 aggregated to 11
• Species	Up to eight, expandable	25 species; 110 stocks	Unlimited	Single species	118	10
• Area unit	Fishery areas based on stock definitions	Based on stock management definition	None	Single area (earth)	34 fishing areas based on stock definitions; 14 regions	None
• Time unit	Year	Year	Year	NA	Month	Year

The FISHRENT is a full feed-back model, containing independent procedures for the development of the stock (stock-growth function), production and effort (production and investment function). Consequently the model can shift according to the most restrictive constraint, be it the total available effort of each fleet segment or the TAC/quotas of specific species. This approach allows to simulate the economic performance of individual fleet segments independently of each other over a long period of time.

The following description presents fully all features of the FISHRENT model. For the purpose of the 'Study on remuneration of spawning stock biomass' some of these features have been disabled, by setting specific parameters at a specific value(see table A.3).

CONCEPTS

Modelling in general

Mathematical model links a set of variables with mathematical equations in order to simulate a certain development. The solution is determined by these equations and various types of constraints to which they may be subject. In case of optimization, the model is extended with an 'objective function' or 'objective variable'.

There are two types of variables:

- Endogenous (or dependent) variables – the values are determined in the model.
- Exogenous (or independent) variables – the values come from other sources. Two types of exogenous variables can be distinguished:
- Equation parameters, which may have been estimated on the basis of available statistics; assumed or calibrated (i.e. determined by trial and error so that the model produces certain results – e.g. reproduces historical values);
- Baseline data, i.e. starting values of the endogenous variables - year 1 in a dynamic model, and various constants.

The model consists of two types of relations:

- Mathematical equations, linking the endogenous variables. Once set, the equations do not change.
- Constraints and decision rules, steering the calculations along a certain path or constraining the endogenous variables to remain with specified boundaries. Regarding constraints and decision rules, distinction can be made again between endogenous and exogenous:

Endogenous constraints and decision rules are based on specific algorithms in the model;
Exogenous constraints and decision rules are choices which can be made before running the model.

The model needs to be based on a set of sound theoretical and empirical concepts. These concepts allow to distinguish the main modules (components) of the model and their relations. Modular approach to model building allows at any time to develop specific modules further, without having to adapt the model as a whole. Such development does not necessarily affect the relations between the modules.

Each model is structured around three fundamental components:

- Input, i.e. the values of all exogenous variables;
- Calculation, i.e. all relations, constraints and some decision rules;
- Output, i.e. the way in which the result are presented.

These components can be further sub-divided into suitable steps.

FISHRENT modules

The FISHRENT model is a generalized multi-species multi-fleet simulation model, built in Excel. The basic version contains 8 segments and 8 species and runs for a period of 25 years. The dimensions of the model can be flexibly reduced or expanded. The model is structured in six modules: biology, economy, interface, prices, behaviour and policy. In addition, the Excel model contains a module with the totals. The general structure of the model and its modules is presented in Figures A.1 and A.2.

The biological module contains the stock-growth function. The economic module contains the economic performance of the fleets. The core section of the model is the interface which contains the bio-economic production functions for each combination of segment and species. This module reflects the interaction between the fishing fleet and the fish stocks. The price module contains fish price elasticities and the possibility to adapt the price fuel. The behaviour module determines the (dis)investment behaviour of the fleet, according to the realized economic performance. The policy module contains six policy options based on different approaches to management by TACs and effort including an option of open access fishery.

Figure A.1 Multi-species / multi-fleet relations in the FISHRENT model

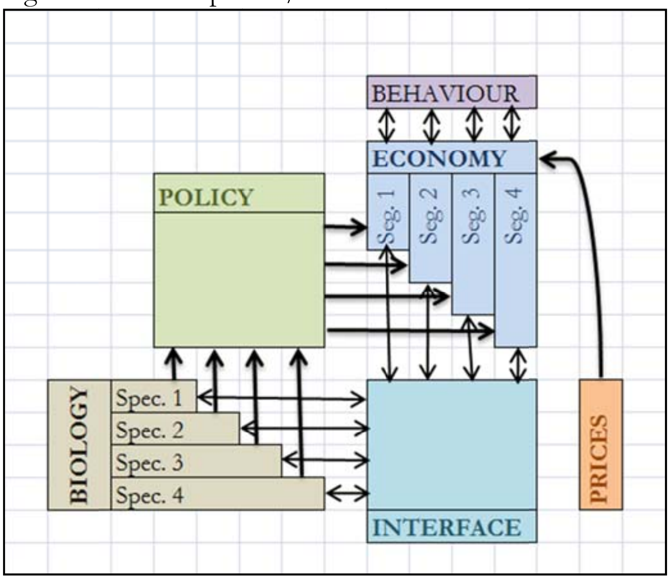


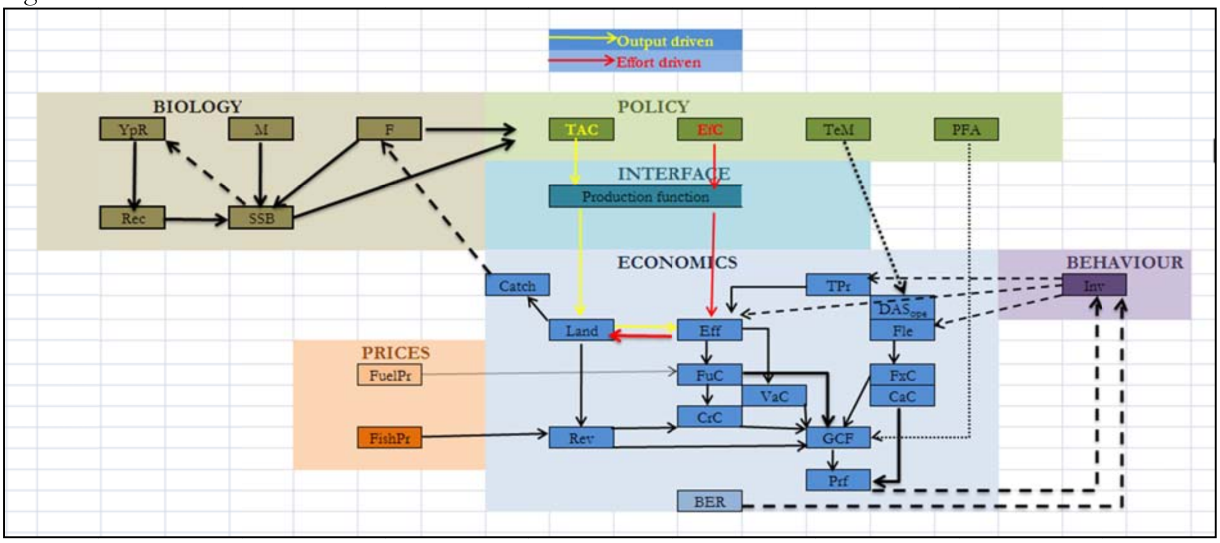
Figure A.1 shows that all variables specified in the modules are defined in any given year by segment, species or both, described further in table A.2.

Table A.2. Definition of module dimensions

Module	Segment	Species	Explanation
Biology	ALL	X	There is a separate stock-growth relation for each species, which is (assumed) equal to stock.
Interface	X	X	Catches are determined by a production function, independently for each relevant combination of segment and species.
Economy	X	ALL	Performance of each individual segment is modelled. Performance is determined by the total catch of all species, and thus revenues.
Behaviour	X	ALL	Changes of the size of each segment are driven by a segment-specific asymmetric investment function, i.e. different constraints can be imposed to investments and disinvestments.
Prices	X	X	Fish prices can change with landed volumes, based on price elasticity. Furthermore price differences attributed to individual segments (gears) can be accounted for.
Policy	X	X	Output measures (TACs) are specified by species. Input measures (effort) are specified by segment.
Totals	X	X	Included at the bottom of the sheet

*ALL means sum of all segments or species.

Figure A.2. FISHRENT modules and their contents



The relations within each module are in general terms described below. The mathematical description, including the required constraints and decision rules, is presented in the following section.

Biological module

The biological module contains two relations:

- Stock-growth relation (called recruitment) - a 3rd degree polynomial function, but only 2nd degree is used.
- Biomass function - the sum of biomass in the previous period pus recruitment minus catch. Furthermore assumed discards of undersized fish are subtracted.

Economic module

The economic module contains the following relations:

- Revenues – sum of catches times prices. Prices can be adapted to qualities attained by different segments / gears.
- Fuel costs – depending proportionately on fishing effort. Can be adapted by changing the fuel price, either once (instantaneously) or trend wise (annual trend).

- Variable costs – depend proportionately on fishing effort.
- Crew costs – based on a share of revenues and if appropriate taking account of fuel and/or variable costs.
- Fixed costs – are a fixed value per vessel. Change with the size of the fleet.
- Capital costs – as fixed costs, constant per vessel, changing with size of the fleet.
- Gross cash flow – according to definition.
- Profit – according to definition revenues minus all costs.
- Payment for access – allows for different kinds of payments:
- Lump-sum
- Share of profit
- Payment per unit of effort
- Share of revenues per species
- Profit after payment for access
- Gross value added – according to definition
- Fuel use – fuel costs divided by fuel price.
- Break-even revenues – according to definition, but crew costs are considered as fixed costs, on the basis of the expectation that fishing may not be an attractive profession at a level of income lower than the level realized in a given year.

The economic module also generates net present values of profit and gross value added over 15 and 25 years. This distinction was introduced in particular in relation to the optimization runs of the model. When a model is run for 15 years and profit or gross value added are maximized over that period, the model will tend to fish out all the stocks at the end of the period as it does not take into account what happens beyond that time horizon. This is evidently not desirable. This problem has been resolved by 'optimizing' over a period of 25 years, but using the net present value of the first 15 years only. In this way destruction of stocks is avoided within the first 15 years.

Interface module

The interface module contains three functions for each combination of fleet segments and species:
1. Catch – based on a standard Cobb-Douglas production function. Power of 'effort'-variable contains an additional parameter which represents the technological progress.
2. Discards – over-quota catch is discarded. Catch is confronted with 'Target landings' (segment share of TAC, see policy module) and if catch exceed Target landings, part of the excessive catch can be discarded. An assumed value of a discard parameter determines which percentage is discarded and consequently also how much is landed, albeit illegally. Discards of undersized fish are accounted for in the catchable biomass equation.
3. Landings – difference between catch and discards.

The selected production function in the interface is a Cobb Douglas production function in which fishing effort in terms of days at sea and catchable biomass determines the catches. Technical progress is included in the production function.

Price module

Price module contains two equations:
1. Prices of fish, which include a price elasticity for each species. Furthermore, price differentials for specific segment-species combinations can be accounted for using specific parameters.
2. Fuel price can be adapted for one-time rise or for annual trend.

Behaviour module

The behaviour module simulates the level of fishing effort trough changes of the number of vessels and/or the number of days-at-sea per vessel. It contains the following relations:

- Fleet (number of vessels) – the fleet of preceding year plus or minus investments (fleet change).
- Days at sea/vessel – operational – total effort (see policy module) divided by the number of vessels.
- Days at sea/vessel – maximum – constant value, which can be annual adapted by a assumed parameter.
- Effort (Fleet * days) – follows from the production function, in combination with the selected policy option.
- Investment (number of vessels) – it is assumed that the fleet changes, i.e. (dis)investments take place, proportionately to the relation between the break-even revenues and the realized revenues. However, maximum limits to annual increase or decrease of the fleet can be imposed in terms of the percentage change of the fleet. The two limits can be different, which creates an asymmetric (dis)investment behavior. Furthermore, there are no investments if the average number of days at sea per vessel falls below a specified level of the maximum number of days at sea. The maximum increase from one year to next has been set at 10% and the maximum decrease at -20% of the number of vessels. These percentages are based on the DCF data 2002-2008, which show that 75-85% of annual changes of the size of the fleet fall in this range. The precise percentage depends on the sample of selected segments.

Policy module

Finally, the policy module determines level of landings and/or effort. It contains harvest control rules in terms of TAC/quotas and effort. Although payment for access is also a policy decision, it is incorporated in the economic module, due to its different impact. The policy module contains a set of decision or selection rules the level of landing and/or effort is determined, starting either from the a decision on TAC or from a decision on total allowable effort. Through these selection procedures it is possible to integrate input and output driven policy into one model.

Furthermore, the policy module contains two other features:
1. Constraints on maximum change of TAC from one year to another, the +/-15% as applied in various fisheries.
2. The 'policy intensity factor', which is value between 0 and 1 reflecting the extent to which policy decisions follow the biologic advice. This factor allows to simulate the consequences of taking into account 'socio-economic dimensions' of taking restrictive management measures.

The policy choice is made within a multi-species context and therefore the policy must decide whether the most or the least restrictive biologic advice (in relation to harvest ratio of a given set of species) should be taken as a starting point. For example, species A may be relatively abundant, but effort (harvest ratio) which could be allowed on this species may lead to overfishing (too high ha
revest ratio)) of a species B. On the other hand, taking species B as a starting point of the policy will lead to underutilisation of species A. The policy module contains six policy choices, which precisely highlight this policy dilemma:
- TAC_{min} – The most restrictive TAC is used to determine the level effort which the fleet can exert. This may lead to underutilization of other species.
- $Effort_{min}$ – Most restrictive effort level is allowed, which leads to relatively low catches.
- TAC_{max} - The least restrictive TAC is used to determine the level effort which the fleet can exert. This may lead to overfishing of other species.
- $Effort_{max}$ - Least restrictive effort level is allowed, which leads to relatively high catches.
- Open access – Fishery is driven by economic incentives. Neither TAC nor effort constraints are imposed.
- Min min – Minimum level of TAC and effort is imposed. Depending on the definition of the TAC_{min} and $Effort_{min}$ options, this option will produce same results as one of those two.

Effort which follows from an 'Effort policy option' is inserted in the production function and generates catch. When a 'TAC police option' is selected, than a corresponding level of effort is calculated from an 'inverse production function', where effort is the endogenous variable (on the left side of the equation).

Both effort and TACs are derived from the present and target harvest ratio in combination with other variables in the model.

Structure of the workbook

The workbook distinguishes input, calculation and output worksheet, plus two intermediate sheets.

- Input sheets: Drivers and Model parameters
- Calculation: Multi-year model
- Output: Drivers and DB2 (DB = database)
- Intermediate: Model input and DB1

The model is run with several macros, so it must be run in macro enabled mode.

The workbook contains six sheets, which have the following functions. The different modules of the model are coloured differently for easier navigation in a worksheet with more than 800 rows.

1. Drivers sheet contains the following components:
    - Choice of the six policy options;
    - Policy intensity factor i.e. to which extent the manager will follow the biologic advice or enforce the policy restrictions (harvest control rules);
    - Input area for 'scenario number', to distinguish the results of each model run in subsequent analysis (see DB2)
    - Input areas for the names of the relevant species and segments;
    - Input area for setting the discount rate
    - Output area with the main results regarding net present value of gross value added, profit and payment for access over 15 and 25 years.
    - Output area with selected graphics showing the development of the main indicators over the simulated period of 25 years.

The Drivers sheet allow to run various policy scenario and see the results immediately.

2. Model parameters (MP) contains:
    - Full list of all parameters of the model, which have to be either estimated or assumed;
    - Full list of the initial values of all variables, which must be inserted there.
    - Other technical information: distinction between formulas, constraints and initial values (column C), dimensions of variables (column G), acronyms of variables (column H) definitions of the parameters (column Z), etc..

Areas where values have to or can be inserted are white, while all other areas are coloured.

3. Model input (MI) – contains all equations for one year. It is constructed parallel to the Multi-year model sheet. Contains general description of the variables, dimensions and relations. It serves as a guideline to the use of the model.

4. Multi-year model (MYM) – contains the calculation for a 25 years period. It also contains the calculation of the net present values of gross value added and profit over 15 and 25 years and infinity. Inclusion of these net present values is necessary on this sheet in order to allow the use of the Excel Solver. Namely, the Solver can be run on one sheet only and cannot refer to objectives or constraints on other sheets.

5. DB1 - copies the MYM sheet for database use. DB1 contains a macro 'Convert' which converts a 2-dimensional table to a 1-dimnesional table in DB2, generating a database format.

6. DB2 – contains the complete MYM sheet in a database format, which than can be analysed using Pivot table(s) or MS Access. The results of each scenario (model run) can be copied from DB2 into a new database or workbook and compared, as each run bears a different number.

Model definition

The MP sheet contains all input and the year 1 as the baseline for the MYM sheet. The following sections present the mathematical formulation and discuss their meaning.

All variables are composed as follows:

Name_xy,	x = segment index, y = species index; when index = a means, sum of *all* species and/or segments

Parameters are composed as:

Name_xyz,	x = segment index, y = species index and z = sequential number of the parameter in a relation;

This notation and the names of the variables and parameters are as in the model. Parameters are written in italics, variables in normal. In most equation, only variables of the same year are related, so that time denomination is not required. When referring to preceding year, time denomination (t-1) is stated.

The model makes a distinction between 'target' and 'non-target' species. Target species are species included explicitly in the model with their biological functions.. Non-target species are all other species caught / landed by the segment. Non-target species must be included to obtain the total revenues of the segment.

The model distinguishes segments and 'other segment'. Segments are those explicitly included in the model with their economic functions. Other segments are segments are segments catching target species. The other segments must be included to obtain the correct harvest ratio of each target species.

Catches of 'other species' by 'other segments' are not included in the model.

Biological module

Growth function

The biological module simulates the growth for each species using 3rd degree polynomial stock-growth function.

(1) $\text{Rec-ay} = \text{Rec-ay0} + \text{Rec-ay1}*\text{CB-a1}^{\text{Expo-ay1}} - \text{Rec-ay2}*\text{CB-a1}^{\text{Expo-ay2}} + \text{Rec-ay3}*\text{CB-a1}^{\text{Expo-ay3}}$

Where: CB = catchable biomass[52]
Rec = parameters
Expo = exponents / parameters

The advantage of the 3rd degree polynomial is that it is easy to estimate by use of Excel's standard functions.

It is well known that stock-growth and stock-recruitment functions are statistically weak. The function selected in the model is just one of many possibilities and may be replaced by functions like Ricker of hockey-stick. By using the RANDBETWEEN function in Excel, it is also possible to run the model stochastically, with random growth (only limited by the known minimum and maximum values). This

[52] SSB has been used as a proxy

would require to run the model many times and subsequently analyse the boundaries of such 'chaotic' system.

Biomass function

The biomass function contains the following elements:

- Biomass of the preceding year;
- Recruitment;
- Catch of the individual segments, upgraded for discards of undersized fish (not part of TAC).
- Upgrade of the catch of segments 1-8 for catch by other segments, expressed as (1- sum of TAC shares);
- Lower limit CB=1, not allowing the species to be fished out completely. In this case CB is set at a low value of 0.000001 as otherwise the catch may exceed the biomass and in this way this anomaly is reduced to a very low value. The problem that Catch may exceed CB could be resolved by introducing a CBproxy, which would first check whether Catch<CBproxy. However, this would further complicate the model and the numerical results would not be significantly improved.

(2) CB-ay = IF $\{(\text{CB-ay}_{t-1} + \text{Rec-ay}_{t-1} - [\Sigma_x \text{Catch-xy}_{t-1} * (1+\textit{Disc\_xy0})]) / (\Sigma_x \textit{TACsh\_xy0})\} < 1$, 0.000001, $\{(\text{CB-ay}_{t-1} + \text{Rec-ay}_{t-1} - [\Sigma_x \text{Catch-xy}_{t-1} * (1+\textit{Disc\_xy0})]) / (\Sigma_x \textit{TACsh\_xy0})\}$

Where	CB_{t-1}	= catchable biomass in year t-1
	Rec_{t-1}	= growth in year t-1
	Catch	= catch in year t-1
	Disc	= discards of undersized fish
	TAC	= TAC share of the segment

Economic module

Revenues

Gross revenue is estimated for each fleet segment taking the landings net of discards and multiplied with constant fish prices. Prices differ for the species but are constant for all segments. Revenues from target species are upgraded by revenues from other species, either by a lump sum or a percentage. Specific price differential of the segment from the average is also included.

(3) Rev-xa = (Σ_y Land-xy * FishPr-ay * *PrSeg_xy0*) * (1 + *OtSpR_xa0*) + *OtSpF_xa0* * Eff-xa

Where	Land	= landings
	FishPr	= fish price
	PrSeg	= price differential for the segment from the average price
	Eff	= effort
	OtSpR	= revenues from non-target species as a percentage of target species
	OtSpF	= revenues from non-target species per unit of effort

Fuel costs

The fuel costs depend on fuel use per unit of fishing effort, effort and fuel price. Fuel price may be differentiated between segments.

(4) FuC-xa = *FuC_xa0* * Eff-xa * *FuelPr_1a0*

Where	*FuC*	= fuel use per unit of fishing effort
	Eff	= effort
	FuelPr	= fuel price

Crew costs

Crew costs are often calculated as a share of the gross revenues after deduction of fuel costs and/or variable costs.

(5) CrC-xa = (Rev-xa - *CrC_xa1**FuC-xa - *CrC_1a2* * VaC-xa) * *CrC_xa0*

Where	Rev	= revenues
	FuC	= fuel costs
	VaC	= variable costs
	CrC_xa0	= crew share

CrC_xa1 and *CrC_xa2* are either 0 or 1 to take the fuel costs or variable costs into account.

Variable costs

Variable costs, being e.g. costs of landings, auction and harbour fees, depend on gross revenues.

(6) VaC-xa = Rev-xa * *VaC_xa0*

Where	Rev	= revenues
	VaC_xa0	= variable costs as percentage of gross revenues

Fixed costs

The fixed costs, also named vessel costs or semi-fixed costs are administration, insurance, maintenance etc. It is assumed that these costs are dependent on the value of the segment. The value of the segment is separated in a unit price per vessel and the number of vessels. In this way fixed costs will change with the changing size of the fleet in the segment.

(7) FxC-xa = *FxC_xa0* * Fle-xa * *InvPrice_xa*

Where	Fle	= number of vessels
	FxC_xa0	= fixed costs per vessel
	InvPrice_xa	= percentage change in the vessel price

The unit price (InvPrice-xa) is determined taking the total fixed costs for a segment in the base year divided by the number of vessels.

Capital costs

Capital costs are calculated in the same way as fixed costs,

(8) CaC-xa = *CaC_xa0* * Fle-xa * *InvPrice_xa*

Where	Fle	= number of vessels
	CaC_xa0	= capital costs per vessel
	InvPrice_xa	= percentage change in the vessel price

Gross cash flow

The gross cash flow is the difference between revenues and all operational costs.

(9) GCF-xa = Rev-xa - FuC-xa - CrC-xa - VaC-xa - FxC-xa

Where	Rev	= revenues
	FuC	= fuel costs
	CrC	= crew costs
	VaC	= variable costs
	FxC	= fixed costs

Profit

Profit is calculated before and after payment for access.

(10) Prf-xa = GCF-xa - CaC-xa

Where	GCF	= gross cash flow
	CaC	= capital costs

(11) PrfaTax-xa= Prf-xa – FpfAcc-xa

Where	Prf	= profit
	FpfAcc	= full payment for access

Payment for access is a policy (control) variable and the function form is included under the policy module.

Profit discounted, sum over 15 years and sum over infinity

The discounted profit has meaning only in the dynamic model working for a number of years. Different discount rates are allowed for the different segments to reflect different time preferences although it seems most meaningful to use the same discount rate for all segments as default. The net present value is computed for a 15 years period and for infinity using the profit before access and tax payments.

(12) $\text{Npv15-xa} = \Sigma_t \text{ Prf-xa}_t * [1 - (1+\mathit{Dis\_xa0})^{\wedge -(\text{DisPeriod-xa1}/\mathit{Dis\_xa0})}]$

Where	Prf	= profit
	Dis_xa0	= discount rate
	DisPeriod-xa1	= year t

The net present value for infinity may be also used to estimate the maximum resource rent from a fully adjusted fishery. In principle the maximum resource rent over 15 years will occur when the stocks become extinct.

$$\text{NPV-xa=Npv15-xa+Prf}_{t=15}/\mathit{Dis\_xa0}*(1+\mathit{Dis\_xa0})^{\wedge -(15+1)}$$

As a 15 years period normally is long enough to assure fully adjustment it is assumed that the profit in year 15 will continue infinitely. Therefore, this profit is discounted to period 16 in time and further discounted to period 0.

The model also calculates the net present value over 25 years, but this is done by the NPV-function of Excel.

Break-even revenues

The break-even revenue shows the gross revenue with given capital costs that yields a zero profit at. It is a useful indicator showing how far away a fishery is from making profit and thereby also provides information about overcapacity in term of excess capital costs.

The break-even revenues consider crew costs as fixed costs. This approach is justified on the basis of three related arguments:

- In the EU fisheries is skipper ownership commonplace. This implies that there is no clear distinction between remuneration of labour and capital.
- Crews are remunerated on share basis, which could lead in a break-even situation to unacceptably low crew share. It would be unrealistic to expect that operation at break-even level could be continued indefinitely, while that is precisely the principle of break-even.
- Inclusion of crew costs among 'fixed costs' reduces the fluctuations of investments throughout the simulated period.

Ratio of break-even revenues to realized revenues determines the level of investments in the following period.

(13) BER-xa = (CrC-xa + FxC-xa + CaC-xa) /
[(1 - FuC-xa/Rev-xa - VaC-xa/Rev-xa - FPfAcc-xa/Rev-xa)]

Where
CrC = crew costs
FxC = fixed costs
CaC = capital costs
FuC = fuel costs
Rev = revenues
VaC = variable costs
FPfAcc = full payment for access

Fuel use

Fuel use is for some fisheries an important indicator. Therefore a fuel use relation has been included in the model.

(14) FuU = Eff-xa * *FuU_xa0*

Where
Eff = Effort
FuU_xa0 = Fuel use per unit of effort

Interface

Catch

The core equation of the model is the Cobb-Douglas production function. The catch (excl. undersized discards) is a function of effort, stock abundance and technological progress.

(15) Catch-xy = Catch-xy0 * Eff-xa^$^{Catch\text{-}xy1}$ * CB-ay^$^{Catch\text{-}xy2}$ * (1+Catch-xy3)

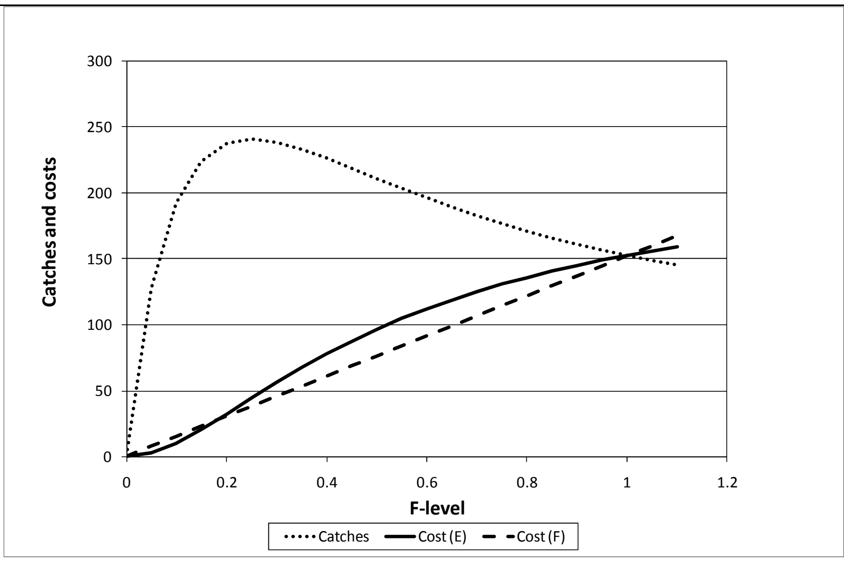
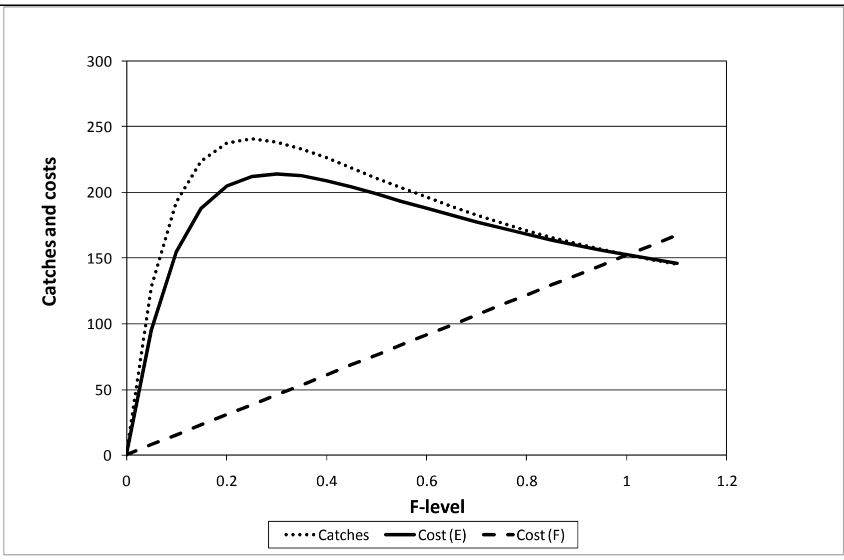
Where
Eff =Effort
CB = Catchable biomass
Catch_xy3 = Rate of technological progress
Catch_xy0, Catch_xy1, Catch_xy2 = estimated parameters
Catch_xy1 + *Catch_xy2* = 1

The total catch of a species must also account for catch by 'other segments', which has been accounted for in the biomass function (2).

The parameters of the function are estimated based on theory and few empirical studies. The technological progress is hardly above 1.5% per year (Frost et al, 2009). For trawlers that are less impacted by stock abundance than by vessels technology the exponent for effort is between 0.6-0.9 while the exponent for the stock is between 0.1-0.4. For gillnet the opposite is to be expected. For pelagic and demersal species with schooling behaviour the exponent for the stock is low while it is higher for demersal species. Setting these parameters makes it possible to estimate the Catch-xy0 parameter.

The importance of the exponents is significant as shown in Figure A.3 in which the catch and the fishing costs (being a function of the effort) is shown for different harvest ratios. For further explanation see Frost et al. (2009). It is seen that the optimal fishing mortality rate may not differ in the two examples but the size of the resource rent, and what could be gained by optimal adaptation differs significantly.

Figure A.3. Catches and costs under different assumptions about the relationship between harvest ratio and effort.

	2.1 Cobb-Douglas production function α= 0.4 β=0.6 Low catch-effort flexibility High stock-catch flexibility
	2.2 Cobb-Douglas production function α= 0.9 β=0.1 High catch-effort flexibility Low stock-catch flexibility

Source: Frost et al (2009) figure 7.
Costs (E) = assumes linear relation between costs, effort and mortality.
Costs (F) = assumes non-linear relation between costs, effort and mortality.

Over-quota discards

The landings are derived from the catches after subtraction of over-quota catches, which must be discarded.

(16) Disc-xy = IF(Catch-xy > LandT-xy, *Disc_xy1* * (Catch-xy - LandT-xy), 0)

Where	Catch	= catch
	LandT	= target catch, based on segment share in TAC (see policy module)
	Disc	= share of over-quota catch which is discarded

Behaviour

The behaviour module determines the (dis)investment and changes in effort level (days-at-sea per vessel).

Investment function

Theoretically the investments are determined by expectations of future profit, but there is no empirical data, which could be used to support such theorem in the model. Instead, perceived profitability in the preceding year, expressed as ratio between break-even revenues minus realized revenues divided by realized revenues is used to determine in the (dis)investments in each year. When break-even revenues exceed realized revenues than the fleet will expand and vice versa.

This leads in some years to quite substantial changes in the number of vessels in a fleet segment, which can be justified as vessels from other segments may enter the given fishery. At the same time, it was recognized that the inertia of the system does not allow such full flexibility. Consequently, parameters have been introduced as limits to maximum annual (dis)investments. As different parameters have been applied to investments and disinvestments, an asymmetric investment behaviour can be simulated.

Furthermore, it has been assumed that the active fleet will first achieve a certain minimum number of days-at-sea per vessel before the number of vessels will be expanded. This assumption was introduced to avoid continuous growth of the fleet, while at same time the number of days-at-sea per vessel would be proportionately falling[53].

(17) Inv-xa = IF(DASope-xa < *InvDays_xa3* * DASmax-xa, -(*InvLimd_xa2* * FLE-xa),
IF(BER-xa < 0, -(*InvLimd_xa2* * FLE- xa),
IF(*PrfShare_xa0* * $(\text{REV-xa - BER-xa})_{t-1}$ / REV-xa_{t-1} > *InvLimu_xa1*,
InvLimu_xa1 * FLE- xa,
IF(*PrfShare_xa0* * $(\text{REV-xa - BER-xa})_{t-1}$ / REV-xa_{t-1} < -*InvLimd_xa2*,
InvLimd_xa2 * -FLE- xa,
PrfShare_xa0 * $(\text{REV-xa-BER-xa})_{t-1}$ / REV-xa_{t-1} * FLE- xa))))

Where	Rev	= revenues
	BER	= break-even revenues
	Fle	= fleet, number of vessels
	DASope	= operational (actual) number of days-at-sea per vessel
	DASmax	= maximum number of days-at-sea per vessel
	PrfShare_xa0	= share of profit dedicated to investments,
	InvLimu_xa1	= upper limit for investments, as a relative change of the fleet
	InvLimd_xa2	= lower limit for investments, as a relative change of the fleet
	InvDays_xa3	= minimum level of capacity utilization, under which no investments take place

[53] Such situation has occurred in practice in the past, e.g. the king crab fishery in Alaska.

The behaviour module assumes that only segments which historically participated in the fishery will be able to do so also in the future. While the size of these segments may be reduced almost to zero, there is no provision to allow new types of vessels (technologies) to enter into the fishery.

Effort function

Effort is measured as the total number days-at-sea for each fleet segment. This is the product of the number of vessels and the operational number of days at sea per vessel per year. Total effort which a segment can exert depends on the selected policy option (see policy module). However, that effort level may be higher than the maximum effort which the segment can generate. Therefore, the appropriate effort level has to be selected.

(18) Eff-xa = IF(Eselect-xa>Fle-xa * DASmax-xa, Fle-xa * DASmax-xa, Eselect-xa)

Where	Eselect	= effort selected in the policy module
	Fle	= fleet
	DASmax	= maximum number of days-at-sea per vessel

The model also operates with the maximum number of days at sea per vessels per year.

Fleet (number of vessels)

Number of vessels in a segment is equal to the fleet of preceding year plus the (dis)investments in that year.

(19) Fle-xa = Fle-xa_{t-1} + Inv-xa_{t-1}

Where	Fle	= fleet
	Inv	= (dis)investments

The number of vessels is constant if the investment function is turned off e.g. by setting the profit investment share, PrfShare-xa0, at zero. Changes in the number of vessels affect the number of days-at-sea, fixed and capital costs and ultimately the profit.

Price module

Fish prices

Fish prices are based on the prices of the baseline year, possibly adapted by a price elasticity. However, this is only relevant if the fishery lands a significant share of the total supply of a species.

(20) FishPr-ay = *FishPr_ay0* * (Land-a1 / Land-a1_{t-1})$^{\wedge(\text{-}PrEl\_a11)}$

Where	FishPr	= fish price
	Land	= landings
	PrEl	= price elasticity

Fuel price

The fuel price level can be adjusted by an annual percentage change (FuelPr-xa0), which can be also differentiated between fleet segments.

(21) FuelPr-xa = FuelPr-xa_{t-1} * (1 + *FuelPr_xa0*)

Where	*FuelPr_1a0*	= is annual percentage change of fuel price

Policy module

Policy choice

The fisheries management pursues the achievement of long term sustainable exploitation of fish stocks at MSY level. There are in principle two approaches: output (TAC) driven approach and effort driven approach. Although in some fisheries constraints in both areas exist, one of them is always most binding. However, in a multi-species multi-fleet situation, it is fundamentally impossible to achieve the MSY level for all species concurrently. This gives rise to two situations:

- One species is fished at MSY level, while other species are overfished. Policy focusing on this species will be least restrictive, using the TAC or effort related to that species as benchmark for the overall activity of the fleet.
- One species is fished at MSY level, while other species remain underutilized. Policy focusing on this species will be most restrictive, using the TAC or effort related to that species as benchmark for the overall activity of the fleet.

These two options have been included in the model. A third option, which would take some 'average' value as a starting point has not been modelled, as it is not clear how such 'average' should be determined and because the two 'extreme' options provide information about the 'limits of the system' within which all other options fall.

The model requires determining a unique and consistent composition of three elements:

- catches, which affect biomass,
- landings, which determine revenues, and
- effort, which determines part of the costs.

This is achieved in the policy module in principle as follows:

1. The MSY level of biomass and growth (sustainable harvest) of each species is calculated from the 2nd degree polynomial stock-growth function, by setting the first derivative equal to zero.
2. The resulting ratio $(\text{Catch/Biomass})_{msy}$ is interpreted as Hmsy.
3. Current harvest ratio (H) realized in each year is compared to Hmsy and the ratio (Hmsy/H) determines the biologic advice - either effort or TAC is adjusted by that ratio. Evidently, the ratios are different for each species, which creates the need to select from the most or the least restrictive approach.
4. It is than a policy choice to determine whether output or input driven policy should be implemented and whether the most or the least restrictive approach should be followed. This leads to four possible choices, which have been supplemented by further two choices: open access (free fishing) and pursuit of most restrictive policy possible. Consequently six the model contains 6 policy choices:
   a. TAC min; choose the effort required to catch the most binding TAC/quota
   b. Eff min; choose the lowest effort determined by the target H in proportion to the current H for all the species
   c. TAC max; choose the effort required to catch the most binding TAC/quota
   d. Eff max; choose the highest effort determined by the target H in proportion to the current H for all the species
   e. Ope access; no restrictions imposed
   f. Min min; choose the effort required to catch the most binding TAC/quota or the lowest effort (combine 1 and 2).

Sustainable catch and selected TAC

Sustainable catch is calculated as the growth of the biomass, including natural mortality and adapted to the ratio harvest ratio divided by total harvest. In some fisheries it has been agreed that the TACs would change at most by X% from one year to another. Therefore, this constraint has been also incorporated. The constrained can be lifted by setting TAC-ay0=0.

(22) TAC-ay = IF(CB-ay * (1 - EXP$^{(-(Htarget_ay0+M_ay0))}$) * *Htarget_ay0* / (*Htarget_ay0* + *M_ay0*) <
(1 - *TAC_ay0*) * TAC-ay$_{t-1}$, (1 - *TAC_ay0*) * TAC-ay$_{t-1}$,
IF(CB-ay * (1 - EXP$^{(-(Htarget_ay0+M_ay0))}$) * *Htarget_ay0* / (*Htarget_ay0* + *M_ay0*) >
(1 + *TAC_ay0*) * TAC-ay$_{t-1}$, (1 + *TAC_ay0*) * TAC-ay$_{t-1}$,
CB-ay * (1-EXP$^{(-(Htarget_ay0+M_ay0))}$) * *Htarget_ay0* / (*Htarget_ay0* + *M_ay0*)))

Where	CB-ay	= catchable biomass
	Htarget-ay0	= target (msy) harvest ratio
	M-ay0	= natural fishing mortality
	TAC-ay0	= maximum change of TAC from one year to another
	TAC-ay$_{t-1}$	= TAC preceding year

Target landings

Target landings are equal to the historical segment share in the TAC. Target landings are required to compute the effort level required to exploit the set TACs and the over-quota catches.

(23) LandT-xy = TAC-ay * *TACsh_xy0*

Where	TAC	= total allowable catch
	TACsh	= segment share in the EU TAC

Landings

Landings of a segment are catches minus over-quota discards.

(24) Land-xy = Catch-xy - Disc-xy

Where	Catch	= catch
	Disc	= over-quota discards

Minimum and maximum effort computed from TAC

As elaborated above, when TAC policy is selected, the TAC resulting from equation (25) is inserted in the inverse production function to determine the effort required to catch each species. The effort levels are compared and the lowest or highest effort level is selected to be used in the model for the calculation of catch of other species and costs.

(25) MinEfTAC-xa = MIN{[(LandT-xy / (*Catch_xy0* * CB-ay ^ *(Catch_xy2*(1+Catch_xy3))*)]^*(1/Catch_xy1)*}
(26) MaxEfTAC-xa = MAX{[(LandT-xy / (*Catch_xy0* * CB-ay ^ *(Catch_xy2*(1+Catch_xy3))*)]^*(1/Catch_xy1)*}

Where	LandT-xy	= target landings
	CB-ay	= catchable biomass

Catch-xy0, Catch-xy1, Catch-xy2, Catch-xy3 = parameters of the production function

Minimum and maximum effort from target Ht

When effort policy is selected, allowable effort for each species is adjusted by the ratio between target harvest ratio and partial harvest ratio caused by the segment. The ratios regarding all species are compared and minimum or maximum is selected according to the policy choice. Adjustment from one year to the next is not constrained by an X% limit, as in case of TACs.

(27) MinEfC = MIN(Eff-xa$_{t-1}$ * Htarget-ay0 / (H-ay$_{t-1}$))
(28) MaxEfC = MAX(Eff-xa$_{t-1}$ * Htarget-ay0 / (H-ay$_{t-1}$)

Where	Eff-xa$_{t-1}$	= effort preceding year
	Htarget-ay0	= target harvest ratio
	H-ay$_{t-1}$	= harvest ratio in preceding year

Total and partial harvest ratio

The total harvest ratio is calculated as catch divided by biomass. However, as the segments in the model do not necessarily catch the whole TAC, their catch is extrapolated to total catch by dividing by their aggregate TAC share. Partial fishing mortalities of all segments are also calculated, but not used.

(29) H-ay = [Catch-ay / (Σ_x TACsh-xa)] / CB-ay
(30) Hpar-xy = Catch-xy / CB-ay

Where	Catch	= catch
	CB	= biomass

Effort in open access fishery

In case of free fishery it can be expected that the present fleet will exert the maximum number of days-at-sea per vessel.

(31) FreeE-xy = Fle-xy * DASmax-xy

Where	Fle	= fleet (number of vessels)
	DASmax	= maximum number of days-at-sea per vessel

Effort selection

Appropriate level of effort is selected on the basis of the policy choice. The last term "Policy type?" is included as a warning should an invalid number of policy type be inserted.

(32) Eselect =IF(PolT=1, MinEfTAC-xa, IF(PolT=2, MinEffC-xa,
IF(PolT=3, MaxEfTAC-xa, IF(PolT=4, MaxEfC-xa,
IF(PolT=5, FreeE-xa, IF(PolT=6, MIN(MinEfTAC-xa, MinEfC-xa),
"Policy type?"))))))

Payment for access

The formula for payment for access allows to account for four different types of payments, all being differentiated by segment specific fees:

- Lump sum
- Payment per unit of effort
- Profit tax
- Payment as percentage of value of landed fish

By setting the parameters at 0 or a non-0 value, various combinations of payments can be simulated.

(33) PfAcc-xa = *PfAcc_xa0* + *PfEff_xa0**Eff-xa + *ProTax_xa0**Prf-1a + Σ_x(*PfFish_ay0**Land-ay*FishPr-ay)

Where	*PfAcc_xa0*	= lump sum payment
	PfEff_xa0	= payment per unit of effort
	Eff	= effort
	ProTax_xa0	= profit tax
	Prf	= profit
	PfFish_ay0	= payment for landed value
	Land	= landings
	FishPr	= fish price

Totals

At the bottom of the worksheet, totals of all relevant variables are calculates as sums of segments and/or species.

(34) Catch	Catch-ay	= Σ_x Catch-xy
(35) Discards	Disc-ay	= Σ_x Catch-xy
(36) Landings	Land-ay	= Σ_x Land-xy
(37) Target landing	LandT-ay	= Σ_x LandT-xy
(38) Revenues	Rev-aa	= Σ_x Rev-xa
(39) Fuel costs	FuC-aa	= Σ_x FuC-xa
(40) Crew costs	CrC-aa	= Σ_x CrC-xy
(41) Variable costs	VaC-aa	= Σ_x VaC-xy
(42) Fixed costs	FxC-aa	= Σ_x FxC-xa
(43) Capital costs	CaC-aa	= Σ_x CaC-xa
(44) Gross cash flow	GCF-aa	= Σ_x GCF-xa
(45) Profit	Prf-aa	= Σ_x Prf-xa
(46) Full payment for access	FPfAcc-aa	= Σ_x FPfAcc-xa
(47) Profit after access payment	PrfaTax-aa	= Σ_x PrfaTax-xa
(48) Profit discounted	PrfDis-aa	= Σ_x PrfDis-xa
(49) NPV 25 years	Npv25-aa	= Σ_x Npv25-xa
(50) NPV infinity	Npv-aa	= Σ_x Npv-xa
(51) Break-even revenues	BER-aa	= Σ_x BER-xa
(52) Gross value added	GVA-aa	= Σ_x GVA-xa
(53) Fuel use	FuU-aa	= Σ_x FuU-xa
(54) Fleet (number of vessels)	Fle-aa	= Σ_x Fle-xa
(55) Days at sea/vessel – operational	DASop-aa	= Eff-aa / Fle-aa
(56) Effort – segment	Eff-aa	= Σ_x Eff-xa
(57) Total investment	TotInv-aa	= Σ_x TotInv-xa
(58) Investment (number of vessels)	Inv-aa	= Σ_x Inv-xa

Other indicators

Three other indicators are calculated as well, although they are not used in the model.

(59) Catchability	Catchability	= Fpar-xy / Eff-xy
(60) Catch per unit effort	CPUE-xy	= Catch-xy / Eff-xy

Adaptation of the model to fewer fleet segments and species

The model is constructed for eight fleets segments and eight species (8x8 version) but is available in smaller versions (4x4 and 2x2). These versions can be used for fewer fleet segments and species.
However, the model will produce errors on two occasions:

- Division by zero
- Choosing effort according to the policy choice of effort determined by the most restrictive TACs or effort.

Division by zero

Number of vessels set at zero for a segment implies zero revenue, but as revenue is used as denominator in the break-even and hence the investments calculations this leads to an error. Therefore, the number of vessels for segments that are not used must be set close to zero e.g. 0.0001.

Species in terms of fish stocks set at zero imply an error in the number of days at sea as stocks are used as denominator in some of the effort equations depending on H and Htarget. Therefore the stocks that are not used must close to zero e.g. 0.0001.

In the model the stocks are not allowed to go below 1 (could be substituted by a small number close to zero) to make sure that the model does not work with negative stocks and that a stock can grow again after having been depleted. Therefore the stocks will always be 1 even if set close to zero in the parameter sheet. This will cause a small error (over estimation) in the in the results for the fleet segments.

Choosing effort according to minimum TAC or effort.

This adjustment is related to the choice of policy and is only needed if fewer species are used than the models dimension for species. If species are omitted by setting the initial stocks at zero the model still takes these species into account in the choice of TAC or effort in the policy equations. As the model in the MIN case chooses effort according to the most restrictive quota of the species or the most restrictive effort, the effort will be determined by the species and hence the effort will be zero.

Therefore it is necessary to delete the species not used from the policy equations in the model. This is done in the Policy section of the model, which comprises four sub-sections: A choice of the most restrictive and the least restrictive TAC, and a choice of the most restricted or the least restrictive effort. There is one equation for each fleet segment i.e. 32 equations must be addresses. However, only the equations for the most restrictive TACs or effort constraints (the MIN cases) need to be adjusted and only for the equations including the active fleets segments. If, for example, the 8x8 version is used for six fleet segments and eight species no adjustment is necessary as all species are used. But if the model is used for 6 species 12 equations need adjustment in order to delete the two species “positions” not used in the equations for the six fleet segments.

Running the Excel Solver

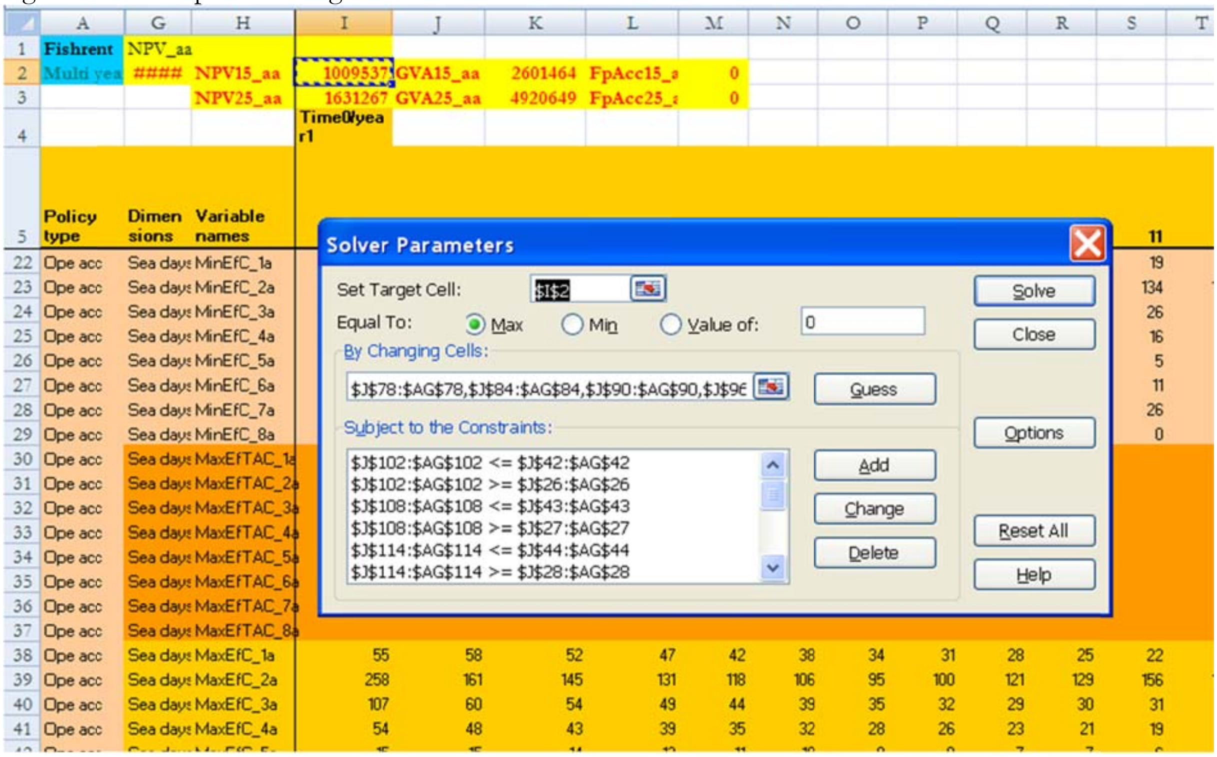
When using the FISHRENT model for optimization it must be born in mind that the Solver may not produce optimum results in its first run. The default settings of the Options are set at maximum time of 100 seconds and maximum 100 iterations, which may not be sufficient. Increasing the default settings does not provide a guarantee that the optimum values will be found. Therefore it is recommended to run the Solver in several consecutive steps until the results do not change any more. After each run the Excel file must be stored under a new name and the Solver must be run again in this new file.

The Solver must be set according to the desired values, on the sheet ‘Multi year model’, example being presented in the following figure:

- Target set points to required value in column I or K
- Changing cells are the cells containing the number of vessels

- Constraints reflect values which cannot be exceeded, i.e. minimum or maximum effort.

Figure A.3 Example of setting values to run the Excel Solver



Screen clipping taken: 14/07/2010, 13:47

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Pavel Salz (LEI) and Hans Frost (SJFI), *Model for economic interpretation of the ACFM advice (ELAA),* Presentation at the XI EAFE Annual Conference, Esbjerg, 2000

Frost Hans, Jesper Levring Andersen, Ayoe Hoff and Thomas Thøgersen, *The ELAA Model Methodology, Definitions and Model Outline*, FOI Report no. 200., Institute of Food and Resource Economics, Copenhagen, 2009.

Prellezo Raúl, Alyson Little, Rasmus Nielsen, Jesper Levring Andersen, Christine Rockmann, Paolo Accadia, and Jeff Powell, *Survey of existing bio-economic models*, Final report, 2009.

Table A.3 List of parameters and their settings

Name	Acronym	Units	Value	Comment
Target harvest ratio	Htarget-ay0	Coefficient	Calculated	From the relevant advisory body (ICES)
Mortality - natural	M-ay0	Coefficient	Species specific	From the relevant advisory body (ICES)
TAC constraint	Tac-ay0	Coefficient	Species specific	From the relevant advisory body (ICES)
Payment – lump sum	PfAcc-xa0	1000 euro	0	Is the payment for the license
Payment per unit of effort	PfEff-xa0	Coefficient	0	Related to the effort
Payment – profit tax	ProTax-xa0	Coefficient	0	Related to the effort
Payment – fish value	PfFish-ay0	Coefficient	0	Related to the landings
Fleet (no. of vessels)	Fle-xa	Number	Segment specific	Number of vessels of the segment
Days at sea/vessel - operational	DASope-xa	Number	Calculated	Operational days at sea per vessel
Days at sea/vessel - maximum	DASmax-xa	Number	Assumed	Maximum number of operational days at sea per vessel
Days at sea / vessel - maximum	DASmax-xa1	Percentage	0	Potential percentage increase of the maximum number of fishing days Not used
Investment price vessel	InvPrice-xa	1000 €	1	Total investment of the total segment divided by the number of vessels in 1000 €. Not used
Investment (no. of vessels)	InvPrice-xa0	Percentage	0	Not used
Investment (no. of vessels)	PrfShare-xa0	Coefficient	0.2	It is a Boundary coefficient. The share between the (Rev-BER)/Rev.
TAC share	TACsh-110	Coefficient	Calculated	It is the share of the landings made by the segment to the total landings of the stock.
Catchable biomass	CB-ay	Tonnes	Species specific	Spawning stock biomass used as a proxy.
Growth	Rec-ay	Tonnes	Species specific	Growth is estimated by recruitment (number of fish) multiplied by yield per recruit. The function include M and r.
Growth	Rec-ay0	Coefficient		Estimated (intercept)
Growth	Rec-ay1	Coefficient		Estimated (order 1)
Growth	Rec-ay2	Coefficient		Estimated (order 2)
Growth	Rec-ay3	Coefficient		Estimated (order 3)
Growth	Expo-ay1	Coefficient	1	
Growth	Expo-ay2	Coefficient	2	
Growth	Expo-ay3	Coefficient	3	
Catch	Catch-110	Coefficient	Estimated	Constant in the production function
Catch	Catch-111	Coefficient	0.2 or 0.6	Exponent of effort
Catch	Catch-112	Coefficient	0.8 or 0.4	Exponent of biomass
Catch	Catch-113	Percentage	0	The annual technical progress, (note that the function is not linear)
Discards – undersized fish	Disc-110	Percentage	0	Percentage of the discards
Discards – quota fish	Disc-111	0 to 1	0	1: can land all caches 0: cannot land over-quota catch.
Fuel price	FuelPr-xa	Coefficient	1	It is the nominal increased of the fuel cost relative to base case year: =1: Fuel cost as in the base case

				>1 Fuel cost higher than in the base case <1 Fuel cost lower than in the base case Not used
Fuel price	FuelPr-xa0	Percentage	0	Annual growth of the fuel cost relative to the previous year.
Fish prices	FishPr-ay	€/kg	Calculated	
Fish prices	PrEl-ay1	Coefficient	0	
Fish prices	PrSeg-110	Coefficient	1	If > 1 the price of this segment /species is increased
Revenues	OtSpR-xa0	Percentage	Calculated	Percentage of the revenue obtained by the other species.
Revenues	OtSpF-xa0	1000€	Calculated	Fixed amount of the other species by vessel
Revenues	Related to the effort	1000€/fishing day	Calculated	Not done yet Not used
Fuel costs	FuC-xa0	Coefficient	Calculated	Total fuel cost in 1000 € divided by total fishing days
Crew costs	CrC-xa0	Coefficient	Calculated	Depends on the drivers (CrC-1a1 and CrC-1a2)
Crew costs	CrC-xa1 and CrC-xa2	0 or 1	Calculated	If (0,0) total crew cost divided by total revenues (1,0) total crew cost divided by (total revenues – fuel cost) (0,1) total crew cost divided by (total revenues – variable costs) (1,1) total crew cost divided by (total revenues – variable costs –fuel costs)
Variable costs	VaC-xa0	Coefficient	Calculated	Total variable costs divided by total revenues
Fixed costs	FxC-xa0	1000€/vessel	Calculated	Fixed costs divided by number of vessels
Capital costs	CaC-xa0	1000€/vessel	Calculated	Capital costs divided by number of vessels
Discount rate	Dis-xa0	Coefficient	3.5% and 2% resp. 5%	At a first stage Common for all the fleets but with a sensitive analysis of it.
Fuel use	FuU-xa0	1000 liters /sea day	Calculated	Not a role in the model but the result is calculated. Not used
Policy intensity factor	PIF	0 to 1	1	=1: strictly follows biologic advice >1: less strict than biologic advice <1: more strict than biologic advice

LIST OF VARIABLES AND SYMBOLS

Biological module	
Catchable stock biomass	CB
Yield per recruit	YpR
Recruitment	Recr 3rd degree polynomial or Ricker
Parameters	Rec (4 coefficients) and Expo (3 exponents)
Policy module	
TAC constraint	TAC
Effort constraint	EfC
Payment for access	PfAcc
Payment for fish	PfFish
Target harvest ratio	Htarget,
Natural fishing mortality	M
Tac band	Tac
Economic module	
Revenues	Rev
Fuel costs	FuC
Crew costs	CrC
Variable costs	VaC
Fixed costs	FxC
Capital costs	CaC
Gross cash flow	GCF
Profit	Prf
Payment for access	FPfAcc
Profit after tax	PrfaTax
Profit discounted	PrfDiS
NPV 15 years	Npv15
NPV infinity	Npv
Break-even revenues	BER
Fuel use	FuU
Discount factor	Dis
Discount period	DisPeriod
Interface	
Target landings (quotas)	LandT
Catch including under- and oversized discard	CatchT
Catch excluding undersized discards	Catch
Discards oversized fish	Disc
Landings	Land
Catch-xy0	catch coefficient
Catch-xy1	exponent for effort (days at sea)
Catch-xy2	exponent for stock size
Catch-xy3	coefficient for technical progress (%)
Prices	
Fuel price	FuelPr
Fish prices	FishPr
Price elasticity	PrEl
Behaviour	
Effort (Fleet * days)	Eff
Investment (number of vessels)	Inv
Fleet (number of vessels)	Fle

Days at sea/vessel - operational	DASope
Days at sea/vessel - maximum	DASmax
Investment price vessel	InvPrice
Investment share of profit	PrfShare
Interest rate	Int
Time horizon for investment	Period
Price for vessel entry	OppIn
Price for vessels exit	OppOut

ANNEX 2. ESTIMATION OF EU MANAGEMENT COSTS

Table A2.1 Estimation of annual EU management budgets related to the catching sector by MS (mln euro)

MS	Landings value (average 2005-7)	DCF 2009		EFF Annual average budget[54]		Enforcement etc.[55] (2007)	Annual average budget *De minimis*
		Budget[56]	Budget +30%	Axis 1	50% Axis 3+4		
BE	**86**	1.42	1.84	2.16	1.77	1.35	3.9
BG		0.37	0.48	1.52	3.05		0.1
CY	**11**	0.46	0.60	0.63	1.99	*0.51*	0.5
DE	**155**	5.78	7.51	1.90	9.84	29.41	16.3
DK	**393**	5.98	7.77	6.10	8.35	32.15	19.2
EE	**14**	0.58	0.75	2.91	3.86	1.99	1.2
ES	**1,735**	12.86	16.72	89.57	50.60	27.60	42.6
FI	**25**	1.65	2.15	1.14	3.06	1.36	2.4
FR	**1,248**	12.14	15.78	20.36	12.03	16.80	46.2
GR	**776**	4.44	5.77	13.97	6.33	*35.65*	6.0
IE	**224**	6.10	7.93	6.62	1.43	52.43	2.8
IT	**1,426**	6.36	8.27	47.28	18.79	*65.50*	31.4
LT	**4**	0.38	0.49	2.36	1.52	0.26	1.7
LV	**21**	0.44	0.58	3.97	5.05	1.11	1.3
MT	**11**	0.60	0.78	0.41	0.39	*0.49*	0.1
NL	**383**	3.88	5.04	6.37	3.86	16.23	12.0
PL	**42**	1.03	1.34	32.16	36.36	1.25	7.0
PT	**343**	2.96	3.85	9.57	10.18	23.67	5.2
RO		0.57	0.74	1.90	10.00	*0.00*	0.2
SE	**114**	5.12	6.66	3.25	3.90	16.86	3.7
SV	**1**	0.19	0.25	0.41	0.93	*0.05*	0.4
UK	**822**	9.34	12.14	7.85	8.94	30.19	34.2
Total	**7,708**	**82.67**	**107.47**	**262.43**	**202.23**	**354.85**	**238.7**

Table A2.2 Summary of EU management budgets related to the catching sector (mln euro)

Item	Amount
EFF[57], axis 1 (average 2007-2013)	262.4
EFF, 50% axis 2	202.2
Administration, enforcement and control (2007)	354.8
Research (DCF+30%) (2009)	107.5
Third countries [58]	150.0
De minimis[59] (average 2007-2013)	238.7
EAGF[60] (expenses 2008)	52.0
Total	1,367.6

[54] Based on National Operational Programmes (prices 2007-8), EU and National contribution

[55] Values in italics are extrapolations on the basis of available average Enforcement costs / Value of landings, based on MRAG Ltd., Oceanic Développement, Poseidon Aquatic Resource Management Ltd, Lamans s.a., Institute of European studies and IFM (2008). 'Impact Assessment of a Proposal to Reform and Modernise the Control System applicable to the Common Fisheries Policy'

[56] Council Dec. 811/2009

[57] The total annual EFF budget amounts to almost 1 bln euro.

[58] http://ec.europa.eu/fisheries/cfp/external-relations/bilateral-agreements-en.htm, accounting for a 4-year average payment to Mauritania, annual averages for the period 2005/6-2010/12 depending on the duration of the agreements.

[59] http://ec.europa.eu/fisheries/cfp/external-relations/bilateral-agreements-en.htm, accounting for a 4-year average payment to Mauritania.

[60] SEC(2009)1368 PART II, Annexes to the Commission staff working document accompanying the 2nd financial report from the Commission to the European Parliament and the Council on the European Agricultural Guarantee Fund – 2008 financial year, Brussels, 21.10.2009

Budgets EU level (CFCA and DG MARE) have not been included, but will not significantly affect the total costs.

The indicated budgets are not necessarily identical to expenses.

ANNEX 3. ESTIMATION OF THE RESOURCE RENT

Introduction

The main text of the report presents the results of the scenarios in terms of net profit, which can be calculated from the available data. However, the data on capital costs has not been homogenized under DCR, so that it was not considered reliable enough to calculate Resource rent for all fisheries and scenarios individually and give this value such a pronounced place in the report.

The formula of net profit applied in the main text is:

Net profit = Revenues – operational costs – capital costs

It is not clear how the capital costs have been estimated in different MS because:

- There exist different approaches to valuation of capital, which is the basis for the calculation of depreciation and interest costs. In particular it is not clear whether historical or replacement values have been used and how they have been determined.
- There are different possible depreciation schemes.
- It is not clear whether interest costs have been included or not and if so, which interest rates have been used.
- Some MS did not report any capital costs or capital values at all under DCR (e.g. Spain) so that additional information had to be drawn from other sources.
- Normally it could be expected that depreciation costs amount to 8-12% of the historical price[61]. However, some MS report values which produce ratios of 25-35%, which raises questions of reliability.

Fisheries economics literature, based on the neoclassical economic theory, defines the resource rent as 'excessive profits', over what could be considered the normal profit. This can be summarized in a formula:

Resource rent = Revenues – operational costs – depreciation – normal profit

In this formula : *Net profit = Revenues – operational costs – depreciation;*
and normal profit includes opportunity costs of capital (interest costs) and profit as a reward for risk, etc.

Estimating capital value, depreciation and normal profit

To calculate depreciation and normal profit requires determination of the capital value, to which relevant percentages can be applied. Three options of capital value were tested:

1. DCR data 2005-7
2. Nominal values of observations of 50 historical prices of new vessels in France and the Netherlands.
3. Indexed observations of the 50 historical prices.

DCR 2005-7 contains information on capital value and capital costs for 75 fleet segments with a total of about 25,000 vessels. This excludes all segments for which data was incomplete for the considered period. On the basis of this data average capital value and capital costs were estimated for the four main size groups 0-12m, 12-24m, 24-40m and 40+m.

Under the Irepa study[1.], some information was compiled on costs of construction of fishing vessels – mainly beam trawlers of 24, and 40m in the Netherlands and trawlers (mostly 23-24m) and passive gear vessels (6-13m) in France. All these vessels were built in between 1983 and 2002.

[61] See Irepa onlus et.al., *Evaluation of the capital value, investments and capital costs in the fisheries sector*, Final report, November 2006.

Regression analysis of the nominal prices of these 50 observations, where prices is function of the length, gives the following result:

*Price1 = 108.6*m - 902.6*, with $R^2 = 0.92$ (price is in 1000 euro)

In order to account for the different construction years, the vessels prices were recalculated to the year 2005, under the assumption of 1% annual increase of the construction costs. This new price series generated a slight improvement in the regression coefficient:

*Price2 = 0.546 * m^2 + 98.7 * m - 789,* with $R^2 = 0.95$

Under the assumption of average length of the vessels in each length group of, 9m, 16m, 28m and 42m respectively, the three approaches generated the following average prices per vessel and total capital values in the year 2005-7 (Table A3.1).

Table A3.1 Prices per vessel by length group (1000 euro)

Length group	DCR value / vessel	Price 1	Price 2	Assumed price per vessel
0-12m	28	75	144	125
12-24m	196	835	930	900
24-40m	859	2,138	2,403	2,300
40+m	1,778	3,659	4,320	4,000

The above average prices give 'impression' that most MS report depreciated value of theirs, although it is not clear whether this value is based on historical or replacement price. For estimation of depreciation and net profit the total capital value is required. For this purpose, an assumed price, based on prices 1 and 2 was set.

In 2005-7 the total fleet operating in the 7 analysed fisheries was composed of 7,361 vessels. According to DCR the capital value of these vessels was 1.4 bln euro and capital costs 179 mln euro / year. The value of the fleet was recalculated on the basis of assumed prices and amounts than to 4.8 bln euro. Taking an average of 7% for depreciation costs implies annual depreciation costs of 336 mln euro in 2005-7, almost double the value of the DCR. The 7% linear depreciation costs is based on the following structure proposed by the Irepa study:

Table A3.2 Total value of the fleet in 2005-7 according to DCR and assumed price

Length group	Number of vessels	Value DCR (mln euro)	Value based on assumed price (mln euro)
0-12m	4,110	113	514
12-24m	2,405	471	2,164
24-40m	742	637	1,707
40+m	104	185	417
Total	7.361	1,407	4,802

Table A3.3 Derivation of average depreciation rate

	Linear depreciation rate	Renovation every X years	Share in total investment
Hull	2.5%	40	60%
Engine	10%	10	20%
Electronics	20%	5	10%
Other equipment	16%	7	10%
Average	**7%**		

Source: IREPA, 2006, p.31

Considering the significant difference between the capital costs reported under DCR (which also contain costs of interest) and the more realistic 'assumed price' per vessel, the depreciation costs in the present resource rent calculation is based on the above estimated value in combination with the 7% average depreciation rate.

Normal profit

While there is a vast literature discussing the theory of 'normal' and 'super' profits, the quantifications of these concepts are scarce. Normal profit is the remuneration of the capital and entrepreneurship. It depends inter alia on conditions for availability of capital, (perception of) risk, scarcity of required skills, intertemporal preferences, expectations, etc. An objective determination of normal profit is probably not possible. Therefore normal profit is assumed at the level 15% of the capital value[62].

Resource rent – baseline scenario

On the basis of the above re-evaluation of the capital value and costs and the results of the baseline scenarios, it is possible to make an approximation of the resource rent, in its original meaning.

Table A3.4 shows that the total landings value of the seven considered fisheries would increase by 65% in 15 years. The gross profit (before accounting for capital costs) would increase threefold in that period. The average annual discounted gross profit is about 50% higher than the gross profit in 2005-7.

On the basis of the above elaborated approach and assumptions, the resource rent of the seven fisheries amounted in 2005-7 to -425 mln euro. The baseline scenarios indicate that a significant improvement could be achieved. In 15 years the resource rent could increase to almost 500 mln euro. The average discounted resource rent over the 15-year period would reach about -15 mln euro.

Further comments on table A3.4:

- Total fuel costs decrease due to smaller fleet, which operates at a higher level of capacity utilization.
- Nominal crew costs increase very significantly, due to lower employment.
- Total landings increase by 35% in 15 years, although average landings are only marginally higher than in 2005-7.
- The number of vessels below 12m decreases and remains at a new lower level. The numbers of the larger vessels decrease as well in the beginning of the period, but increase when stock recovery allows it. This shows the changes in the structure of the fleet.

Resource rent – optimization scenario 14

Scenario 14 optimizes the size of the fleet in order to achieve maximum net profit (using DCR capital costs). The average NPV Prf_{15} amounts in the baseline scenario to -15 mln euro, and in scenario 14 to 258 mln euro..

Figure A3.1 shows that the potential for improvement is different in different fisheries. As stated in the main text, it is not clear which measures should be put in place to promote the optimum development of scenario 14.

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[62] Eurostat published non-harmonized retail bank interest rates to companies for loans over 1 year until 2002. Between 2000 and 2002 the rates ranged for the EU-15 MS between 5% and 7% (as far as available at all).

Table A3.4 Main results of the baseline and scenario 14 and estimation of resource rent, all 7 fisheries

		Baseline scenario		Scenario 14	
Economic indicators (mln euro)	Year 2005-7	Year 15 (nominal)	Average NPV / year	Year 15 (nominal)	Average NPV / year
Revenues	1,832	3,019	1,681	3,467	2,052
Fuel costs	344	300	191	345	212
Crew costs	594	948	524	985	586
Variable costs	245	385	223	419	255
Fixed costs	257	215	149	228	132
Capital costs	179	146	102	159	98
Net profit	*212*	*1,025*	*493*	*1,331*	*769*
Gross profit	391	1,171	595	1,490	867
Depreciation	336	280	194	332	194
Normal profit, 10%	720	600	416	711	416
Resource rent	**-665**	**291**	**-15**	**447**	**258**
Other indicators	**Year 1**	**Year 15**	**Average 1-15**	**Year 15**	**Average 1-15**
Landings (1000 t)	262	346	273	426	265
Fleet (number of vessels)	7,361	5,668	5,621	7,017	5,664
– 0-12m	4,110	2,669	3,100	3,793	3,219
– 12-24m	2,405	2,396	1,951	2,291	1,752
– 24-40m	742	527	501	898	643
– 40+m	104	75	68	35	50

Sensitivity analysis – baseline scenario

Resource rent, being the bottom line of the calculation, is very sensitive to minor changes in revenues, being result of price and/or volume fluctuations. It is much less sensitive to other production parameters, as indicated in Table A3.5.

Reduction of revenues by about 10% would reduce the resource rent in the year 15 of the baseline scenario to zero. The average NPF Prf15 is slightly negative, so that the average revenues would have to increase by about 1% to bring the resource rent to zero. To eliminate the negative average resource rent (average NPV Prf15), the fuel price would have to decrease by about 5% and the variable costs (excl. fuel) by 13%.

Table A3.5 Baseline scenario - sensitivity of resource rent to change in main economic parameters (change of resource rent, mln euro)

	Year 2005-7	Year 15	Average NPV
Resource rent (baseline value)	-665	291	-15
Revenues, -15%	-275	-453	-252
Normal profit, +1%	-48	-40	-28
Error in capital value, -10% 1)	82	68	47
Depreciation, 10% 2)	-144	-120	-83
Fuel price, +50%	-172	-150	-96
Variable costs, +20%	-61	-96	-56

1) Effect of valuation of the capital by 10% less than the present calculation.
2) Depreciation set at 10% instead of the assumed 7%.

In addition, it should be noted that the management costs have not been accounted for. These costs were estimated at 117 mln euro for the seven case study fisheries. If the management costs would remain constant, the average annual NPV of the management costswould amount to 90 mln euro, reducing the average NPV of the resource rent to about -132 mln euro.

Resource rent by fishery

Figure A3.1 and Table A3.6 present the results of the calculation of the resource rent per fishery. It must be stressed that, at lower level of disaggregation the reliability of the figures decreases even further. The results show that there are very significant differences between potential improvements in the various fisheries, which are evidently also related to their absolute size (value of landings).

Figure A3.1 Resource in the 7 fisheries in 2005-7, year 15 and average NPV, baseline and scenario 14

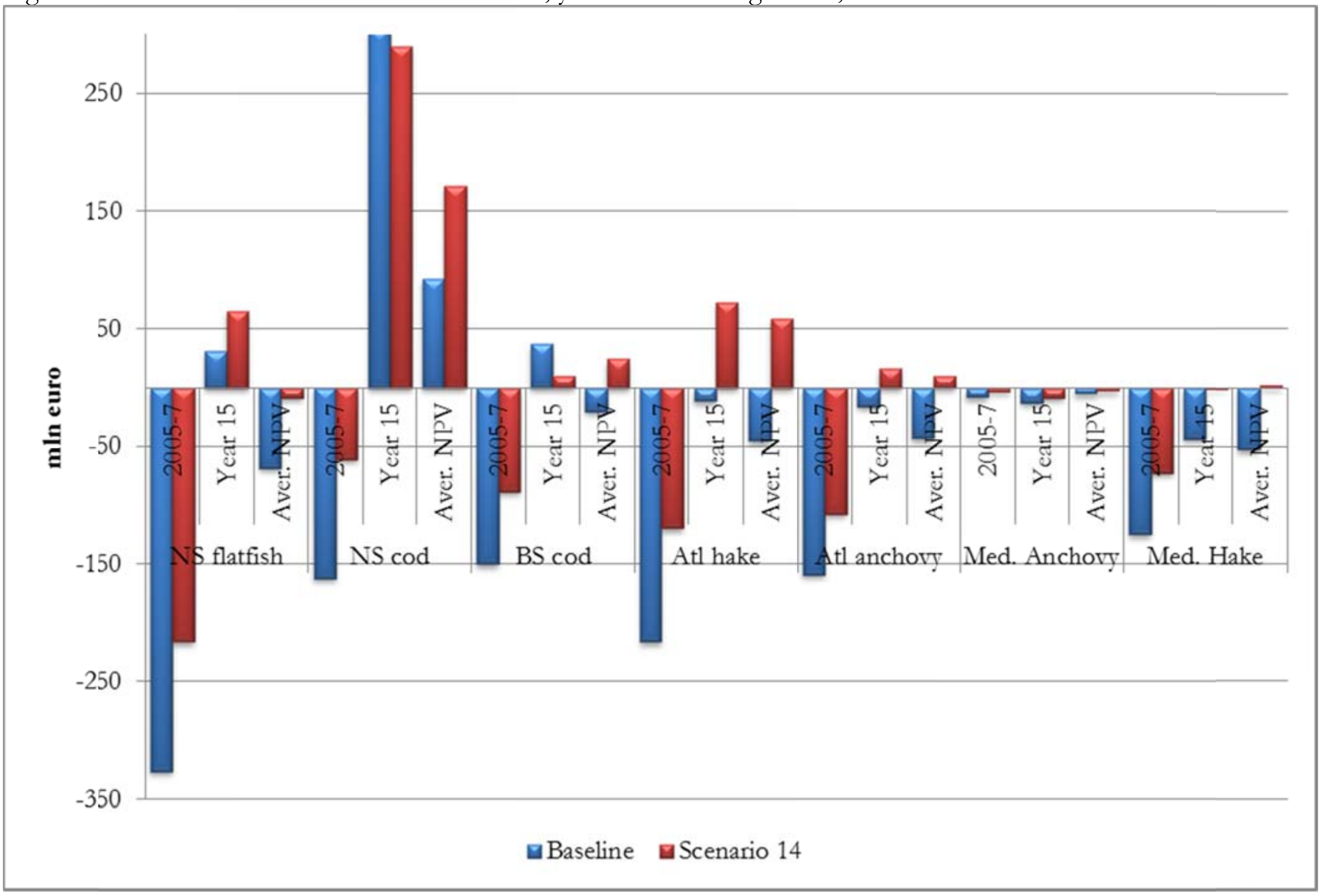

Table A3.6 Estimation of the resource rent per fishery, baseline scenario (mln euro)

	North Sea flatfish			North Sea cod			Baltic Sea cod			Atlantic hake			Atlantic anchovy			Mediterranean anchovy			Mediterranean hake		
	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV
Revenues	391	548	275	391	1,195	543	152	257	148	519	594	419	224	287	192	21	33	25	133	104	78
Fuel costs	130	91	60	38	66	28	17	13	8	97	94	67	29	15	11	3	5	4	30	17	13
Crew costs	117	178	75	105	324	147	40	68	39	159	180	127	131	161	109	7	11	9	36	25	19
Variable costs	45	63	32	39	120	54	17	28	16	79	93	65	47	66	44	2	4	3	15	12	9
Fixed costs	71	42	34	45	63	32	28	19	15	91	75	55	11	5	5	2	4	2	9	7	6
Capital costs	52	31	25	33	46	23	11	7	6	37	31	23	27	14	13	3	6	3	16	12	10
Profit	-24	143	50	130	577	259	38	122	65	56	121	81	-21	27	11	5	4	5	28	31	22
Gross profit	28	173	75	163	623	282	49	129	70	93	152	105	6	41	24	7	9	8	44	43	32
Depreciation	188	45	65	173	101	79	106	29	40	164	52	64	88	18	30	8	7	5	90	28	37
Normal profit	166	96	78	152	217	110	94	62	51	145	112	85	77	38	37	7	15	8	79	59	47
Resource rent	-326	32	-68	-162	304	93	-150	38	-20	-215	-11	-45	-159	-16	-43	-8	-13	-5	-125	-44	-52
Other indicators	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.
Landings (1000 t)	53.4	75.1	52.4	25.6	77.9	48.8	28.0	47.5	37.0	55.2	62.6	57.5	90.1	71.3	65.8	5.3	8.2	8.3	4.1	3.2	3.1
Fleet	626	317	338	1,475	1,506	1,148	2,533	1,828	2,001	650	547	522	295	153	179	53	112	79	1,729	1,204	1,354
– 0-12				617	167	266	2,166	1,616	1,787	0	0	0	0	0	0	0	0	0	1,327	887	1,048
– 12-24	365	153	176	739	1,181	779	351	197	203	379	368	335	116	68	73	53	112	79	402	317	307
– 24-40	157	90	94	119	158	104	16	15	11	271	179	186	179	85	106						
– 40+	104	75	68																		

Capital c. adapted include depreciation (7%) and normal profit (15%) of the estimated capital value.

Table A3.7 Estimation of the resource rent per fishery, scenario 14 (maximum net profit) (mln euro)

	North Sea flatfish			North Sea cod			Baltic Sea cod			Atlantic hake			Atlantic anchovy			Mediterranean anchovy			Mediterranean hake		
	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV	Yr 1	Yr 15	Aver. NPV
Revenues	391	508	297	391	1,486	826	152	432	229	519	587	366	224	294	238	21	48	26	133	111	71
Fuel costs	130	63	61	38	107	54	17	47	20	97	82	44	29	26	21	3	8	4	30	13	8
Crew costs	117	169	86	105	401	230	40	91	47	159	175	111	131	105	87	7	17	9	36	27	16
Variable costs	45	58	34	39	144	82	17	46	25	79	96	59	47	57	45	2	6	3	15	12	7
Fixed costs	71	33	28	45	95	49	28	47	21	91	41	25	11	3	3	2	4	2	9	5	3
Capital costs	52	24	20	33	72	37	11	14	7	37	17	10	27	20	16	3	6	3	16	8	5
Profit	-24	162	67	130	667	373	38	187	109	56	175	116	-21	84	66	5	8	6	28	47	32
Gross profit	28	185	88	163	739	410	49	201	115	93	192	127	6	104	82	7	14	9	44	55	37
Depreciation	77	38	31	71	143	76	44	61	29	68	38	21	36	28	23	3	7	4	37	17	11
Normal profit	166	82	66	152	306	162	94	130	62	145	81	46	77	59	49	7	16	8	79	37	24
Resource rent	-215	66	-9	-61	290	172	-88	10	25	-119	73	59	-107	17	10	-3	-9	-3	-72	0	3
Other indicators	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.	Yr 1	Yr 15	Aver.
Landings (1000 t)	53	65	42	26	115	62	28	76	41	55	66	40	90	89	72	5	12	6	4	3	2
Fleet	626	388	321	1,475	1,750	1,526	2,533	3,041	2,166	650	353	281	295	176	191	53	116	74	1,729	1,192	1,104
– 0-12				617	219	343	2,166	2,512	1,856										1,327	1,062	1,021
– 12-24	365	291	195	739	1,080	932	351	473	279	379	194	177	116	6	11	53	116	74	402	130	83
– 24-40	157	62	76	119	452	252	16	56	31	271	159	104	179	170	180						
– 40+	104	35	50																		

Capital c. adapted include depreciation (7%) and normal profit (15%), of the estimated capital value.

ANNEX 4. RESOURCE RENT BY SPECIES

Table A4.1 Average NPV Prf15 (mln euro)

Fishery / scenario	01	02	03	04	05	06	10	11	12	13	14
Atlantic anchovy											
Total	12.9	20.3	39.5	44.4	44.4	12.4	-0.9	7.1	30.0	75.7	126.6
Anglefish	3.7	5.3	9.0	9.5	9.5	3.6	-0.2	1.9	7.9	11.0	27.1
Mackerel	0.3	0.5	1.1	1.3	1.3	0.3	0.0	0.2	0.7	1.5	5.3
Bluefin tuna	1.7	2.0	2.4	2.6	2.6	1.6	-0.1	0.7	3.0	3.7	9.9
Albacore	1.4	2.0	4.2	4.8	4.8	1.3	-0.1	0.7	3.0	4.4	2.4
Pilchard	0.4	0.7	1.5	1.9	1.9	0.4	0.0	0.2	1.0	2.4	8.4
Atlantic hake											
Total	156.6	141.6	115.8	78.2	43.8	156.5	118.3	164.0	187.6	190.4	223.5
Hake	45.6	43.6	32.0	21.6	12.0	45.6	34.3	48.9	54.3	52.8	71.3
Nephrops	9.2	7.4	6.8	4.6	2.6	9.1	7.0	9.2	11.0	11.5	10.9
Sole	10.2	10.0	8.4	5.6	3.2	10.2	7.7	10.8	12.3	13.1	16.0
Anglerfish	13.2	11.4	10.2	7.3	4.1	13.2	10.0	13.6	15.9	16.5	17.1
Megrim	5.1	4.6	3.9	2.2	1.2	5.1	3.8	5.5	6.1	6.0	7.4
Baltic Sea cod											
Total	123.6	152.0			67.2	122.4	106.4	126.9	130.8	175.3	208.4
Cod	45.7	57.0			24.9	45.3	39.3	46.8	48.4	65.4	73.9
Mediterranean anchovy											
Total		10.2		10.6	10.6		10.2	9.7	10.3	8.7	10.9
Eur. pilchard		1.2		1.2	1.2		1.1	1.1	1.2	1.0	1.2
Eur. anchovy		3.3		3.4	3.4		3.3	3.2	3.3	2.8	3.5
Mediterranean hake											
Total		42.1		-3.7	-3.7		33.9	35.1	50.3	57.7	62.4
Hake		5.8		-0.3	-0.3		4.7	4.8	6.9	7.8	8.6
Nephrops		2.9		-0.5	-0.5		2.4	2.5	3.5	3.4	2.8
Striped mulliet		2.3		-0.4	-0.4		1.9	1.9	2.8	2.7	2.2
Horned octopus		1.9		-0.1	-0.1		1.5	1.5	2.2	2.2	1.9
North Sea cod											
Total	495.0	479.2			337.9	493.5	462.4	457.8	505.3	704.4	715.8
Cod	76.9	85.6			88.3	76.7	74.3	72.9	78.5	135.0	128.5
North Sea flatfish											
Total	95.4	91.3	-0.8	-3.1	-4.3	118.8	25.0	70.2	117.0	97.0	128.4
Sole	26.4	28.0	-0.1	-0.5	-0.7	35.1	6.9	19.7	32.2	21.0	33.1
Plaice	21.0	20.0	-0.2	-0.9	-1.2	24.4	5.5	15.2	25.9	20.3	28.2

Table A4.2 Nominal net profit in year 1 (all scenarios) and in year 15

Fishery / scenario	Baseline - Yr 1	01	02	03	04	05	06	10	11	12	13	14
Atlantic anchovy												
Total	-41.6	54.6	54.0	84.6	84.7	84.7	54.7	16.2	28.0	59.5	112.0	168.9
Anglefish	-14.2	14.4	14.0	19.7	18.5	18.5	14.5	4.2	7.3	15.4	18.3	39.8
Mackerel	-1.6	1.4	1.3	2.5	2.6	2.6	1.4	0.4	0.7	1.4	2.2	7.4
Bluefin tuna	-8.0	7.4	5.5	0.4	0.0	0.0	7.5	1.6	2.8	6.0	3.1	0.2
Albacore	-6.8	4.9	5.1	8.4	8.4	8.4	4.9	1.5	2.6	5.6	7.0	2.0
Pilchard	-2.3	1.7	1.6	3.6	4.0	4.0	1.7	0.5	0.8	1.8	3.9	11.8
Atlantic hake												
Total	111.5	242.2	192.2	161.8	31.4	-60.9	242.2	197.0	264.5	287.3	236.3	350.6
Hake	32.0	73.8	60.7	46.2	8.5	-13.5	73.8	60.0	83.7	87.6	66.2	119.5
Nephrops	6.1	13.9	10.1	9.5	2.1	-4.7	13.9	11.3	14.2	16.4	14.7	15.4
Sole	8.2	15.0	12.6	11.4	2.5	-5.6	15.0	12.2	16.3	17.8	15.6	21.2
Anglerfish	10.4	19.6	15.0	13.9	3.3	-7.2	19.6	16.0	20.7	23.3	20.6	25.5
Megrim	4.1	7.4	6.1	4.8	0.0	0.0	7.4	6.0	8.4	8.7	6.4	12.7
Baltic Sea cod												
Total	76.3	243.9	276.5			-294.5	243.9	217.4	247.7	251.0	311.2	374.6
Cod	28.2	90.0	103.8			-103.0	90.0	80.2	91.4	92.6	116.1	131.8
Mediterranean anchovy												
Total	9.3		7.2		11.8	11.8		14.5	13.7	13.9	9.4	16.7
Eur. pilchard	1.1		0.9		1.5	1.5		1.6	1.5	1.6	1.1	1.9
Eur. anchovy	2.9		2.3		3.7	3.7		4.7	4.5	4.4	3.0	5.4
Mediterranean hake												
Total	55.8		62.5		2.9	3.0		49.6	51.4	73.3	73.6	93.4
Hake	8.1		8.6		0.0	0.0		6.8	7.0	10.0	9.8	13.0
Nephrops	3.8		4.3		0.6	0.6		3.4	3.6	5.1	5.1	4.9
Striped mulliet	2.7		3.5		0.5	0.5		2.8	2.9	4.1	4.1	3.9
Horned octopus	2.6		2.7		0.0	0.0		2.1	2.2	3.2	3.2	3.2
North Sea cod												
Total	260.3	1,154.1	1,059.0			647.0	1,154.1	992.4	903.1	1,183.9	1,288.2	1,334.1
Cod	40.8	179.7	188.4			174.0	179.7	165.3	147.2	181.7	264.8	245.8
North Sea flatfish												
Total	-48.3	285.6	107.0	27.5	22.8	17.5	233.0	183.5	260.1	291.2	216.9	323.4
Sole	-14.6	87.8	35.4	0.0	0.0	0.0	72.2	55.8	80.0	88.2	53.3	86.3
Plaice	-9.7	57.5	23.8	9.3	7.8	6.0	45.7	36.8	51.5	58.6	40.9	61.9

This annex presents an estimation of the resource rent (average NPV Prf15) by species and the total for each fishery. The resource rent has been allocated ot individual species on the basis of their relative role in the total revenues of the fishery. It is noted that:

1. The difference between the sum of specified species and Total is the resource rent allocated to 'Other' species.
2. Scenarios 7-9 would present same relative distribution as the baseline scenarios 1 or 2 (according to fishery) and therefore are not presented.

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