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NECESSITY

Economic Impact Assessment of Changes in Fishing Gear

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Preface

The report is the result of the economic assessment of fishing gear trials carried out in the NECESSITY (NEphrops and CEtacean Species Selection Information and TechnologY) project under the 6th Framework Programme, Scientific Support to Policy (SSP), with specific focus on Species-Selective Fishing. The work has been carried out with the cooperation of researchers from five institutes working in fisheries economics.

The methodology applied is cost-benefit analysis used in such a way that economic, biological and technical information form composite parts. An integrated model is developed as a basis for the results presented. However, the success of the economic assessment has been dependent of the results of the gear trials and the available supplementary information.

NECESSITY comprises gear trials within nephrops fisheries with by-catches of demersal species, and in pelagic trawl fisheries with by-catches of sea mammals.

Hans Frost, FOI, (DK) has headed the nephrops part of the bio-economic analysis, and been mainly responsible for the assessment of the nephrops trials in the Skagerrak, Kattegat and the Fladen Ground. James Innes, CEMARE, (UK) has been mainly responsible for the assessment of trials around Aran, in the Clyde, and around the Farne Islands. Sebastien Metz, CEDEM, (F) has been mainly responsible for the cases in the Bay of Biscay.

Philip Rodgers, Erinshore Economics Limited, (UK) has headed the pelagic trawl part and been mainly responsible for the cases covering pelagic trawling for sea bass, while Erik Buisman, and Kees Taal, LEI, (NL) have been mainly responsible for the case of Dutch pelagic freezer trawlers. Finally, Jan-Tjeerd Boom, FOI, (DK) has been responsible for the Section concerning willingness to pay for the conservation of sea mammals.

Director General Søren E. Frandsen
Institute of Food and Resource Economics
Copenhagen, September 2007

Methodology

Economic Impact Assessment

Economic Impact Assessment has become an explicit part of studies carried out for the European Union with respect to implementing new policies, as outlined in the standards and requirements provided in the Commission Guidelines on Impact Assessment (SEC (2005)791 of 15 June20052).[1]

These guidelines specify the key analytical steps in impact assessment as:

1. Identify the problem.
2. Define the objectives.
3. Develop main policy options.
4. Analyse their impacts.
5. Compare the options.
6. Outline policy monitoring and evaluation.

The economic assessments may take several forms, of which cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA) are the most important; for an introduction to project appraisal see Perman, May, McGilvray and Common (2003, pp.- 351-473). CBA and CEA are the methods applied in the NECESSITY project. In general, one can distinguish between top down approaches and bottom up approaches as listed below in Table 1.1. Top down approaches address the problem from the manager's point of view and make use of extensive calculations, while the bottom up approach starts out from the population and searches for some sort of consensus. While the top down approaches listed in Table 1.1. are alternatives, partly depending on the type and amount of information that is available, the bottom up approach shows the elements that could be included, fully or partly, in this approach.

Of the top down approaches, CBA (see Table 1.1.) requires most information as it requires information on both benefits and costs. Cost Minimization Analysis (CMA) and CEA require information on either costs or benefits only, while Cost-Utility (CU) requires information about utility but not necessarily in economic terms. Finally, the optimisation approach offers the possibility of including several conflicting goals

[1] http://ec.europa.eu/governance/impact/docs/key_docs/sec_2005_0791_en.pdf

(benefits). Life Cycle Assessment (LCA) accounts for benefits and costs in "physical" terms i.e. no value assessment is included. This approach is more often used in natural science than in social science.

The general aim in NECESSITY is to apply the CBA method. However, the benefit side includes catch and hence fish stock projections that are associated with great uncertainty. Moreover, ideally a CBA is performed to make it possible to choose between alternatives. In NECESSITY, however, the technical trials have been specified beforehand, which means that the economic analyses are rather closer to impact assessments in the sense that these particular gear changes are assessed and light thrown on the net benefit from implementation.

Although none of the cases in NECESSITY can be subjected to a complete CBA, or any of the other approaches, the description of an ideal approach is carried out in order to present the framework with which the cases are confronted. The purpose is to make it more clear how projects (cases) should be designed to make it possible to accomplish proper economic impact assessments, and which assumptions and short cuts it has been necessary to undertake in the assessment of the cases within the NECESSITY project itself.

Table 1.1. Types of Economic Impact Assessment

Top-down approaches:	Bottom-up approach
Cost-Benefit Analysis (CBA)	Purpose/output sought – ranging from
Cost-Minimization (CMA)	- general feedback to
Cost-Effectiveness (CEA)	- binding agreement (regulation)
Cost-Utility (CU)	Membership selection – e.g.
Life Cycle Assessment (LCA)	- agency chooses members or
Optimization	- everyone can participate (selfselection)
- Multi Attribute Utility (MAU)	Decision rule –
- Multi Objective Programming (MOP)	- consensus or
	- majority voting
	Who provides charges
	Who provides information

Derived from Kjærsgaard, Jens (2003): Approaches to environmental project appraisal, an essay. Institute of Food and Resource Economics, Copenhagen

A complete execution of a CBA contains as a minimum the following elements:

1. Define project and alternatives
2. Identify economically relevant impacts
3. Determine relevant time horizon

4. Physically quantify impacts
5. Calculate a monetary evaluation
6. Discount costs and benefits
7. Calculate net present value

The CBA evaluates benefits and costs of a project over a time-period from society's point of view. In this respect, the behaviour of people affected by the project must be taken into consideration. Projects may be beneficial from society's point of view but not necessarily from the view of the people that are affected. Alignment between private and societal objectives may be achieved either by carrot (money transfer) or by stick (enforcement and control). Because of the market failure in fisheries, large discrepancies between the view of society and people affected may be foreseen. This is partly caused by differences in time horizons and partly by externalities. An example of the latter is that a reduction in discards that may be beneficial to society may not necessarily be to the benefit of the fisherman. Therefore the incentive to fishermen to comply with changes, for example in fishing gear, is very much dependent on the profit they can expect from such changes.

Item four in the execution of a CBA includes both biological and technical impacts. The biological impacts in particular are associated with uncertainty when projections are made for a long time into the future. Such projections are however only carried out in NECESSITY for cases where the requisite initial information is available, i.e. for *nephrops* in the Kattegat.

The monetary evaluation in item 5 must be carried out using real prices, which basically implies that prices must be set net of taxes and subsidies. Prices must, as such, reflect the real use of resources. From the fisherman's point of view taxes are costs but from society's point of view taxes are financial transfers as they do not entail the real use of factors of production and commodities. The economic evaluation must therefore include an analysis in real economic terms and also in financial terms where the latter take into account the payments the fishermen are confronted with i.e. interest payments on loans, depreciation of capital, etc. In practice, many of the costs and earnings items are generally the same from society's and individual's points of view, but in cases where there are differences, for example in the interest rate (costs), these differences will be dealt with explicitly.

Discounting benefits and costs rests on the assumption that present production and consumption will be valued higher than future production and consumption. The discount rate takes this into account but society and fishermen may have different discount rates and time horizons. Society's time horizon is longer than the fisherman's i.e. if the fisherman is not able to meet his economic obligations in the short-run, he does care about the long-run.

External costs and benefits, for example the change in the size and value of fish stocks and all management costs, are disregarded by fishermen, but not by society.

Verbally, this can be expressed from society's point of view as:

Economic profit = net present value (benefits – costs + external benefits – external costs – costs of information, management, control, and enforcement)

Finally, distributional aspects must be considered. The strong criteria for accepting a change is that the net present value is positive and that nobody is worse off when some are better off (the Pareto criterium). This criterium is, however, prohibitively strong, and a weak version is more commonly used such that if the benefit to those being made better off is sufficient to enable those being made worse off to be compensated and still produce a positive net present value then the project can be carried out.

The model

CBA and decision criteria

Formally, the problem is expressed as in (1). Execution of a CBA requires that different projects are compared with the aim of finding the best project economically. The limiting case is where one project (the baseline) continues as hitherto, and the alternative project comprises implemented changes. Formula (1) shows the model for the baseline:

$$(1) \qquad NPV_j^0 = \sum_{t=0}^{T} \frac{\sum_{i=1}^{I} H_{i,t}^0 * P_{i,t}^0 - C_t^0 - G_t^0 + V_t^0 - U_t^0}{(1+d)^t} - I_j^0$$

Where the index i is the species; j is the fleet segment; and t is time. NPV^0 is the net present value (profitability of investment) in the base case, H is landings (harvest), P

is fish price, *C* is variable costs, *G* is fixed costs, and *V* is external effects (net), for example, willingness to pay for the survival of whales, or if discarding is considered ecologically harmful. *U* is management costs (information gathering, administration, monitoring, control and enforcement). Finally, *I* is investment costs in gear, and *d* is the discount rate.

For a project with changes to the base case the formula appears as:

(2) $$NPV_j^1 = \sum_{t=0}^{T} \frac{\sum_{i=1}^{I} H_{i,t}^1 * P_{i,t}^1 - C_t^1 - G_t^1 + V_t^1 - U_t^1}{(1+d)^t} - I_j^1$$

The variables in (2) are the same as for (1) but different data inputs will be used for different projects. Therefore, the decision rule as to whether a new project should be accepted or rejected is based on the difference between NPV for the whole fleet, compared for projects of the same duration, as shown in (3) and (4):

(3) $$\sum_{j=1}^{J} NPV_j^1 > \sum_{j=1}^{J} NPV_j^0 \quad \text{; accept}$$

(4) $$\sum_{j=1}^{J} NPV_j^1 < \sum_{j=1}^{J} NPV_j^0 \quad \text{; reject}$$

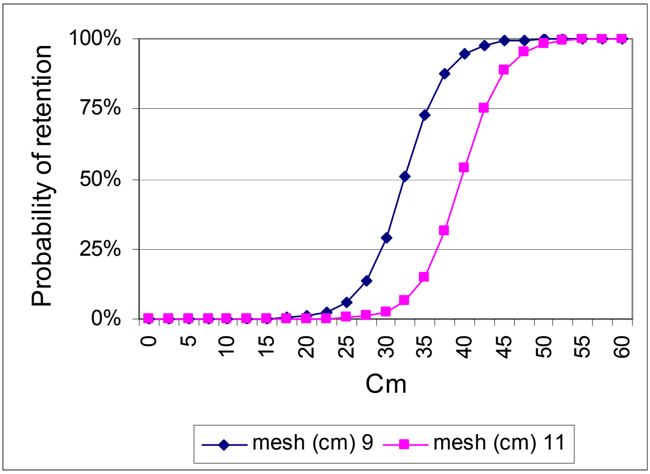
This decision rules means that if a change in gear yields a higher net present value for the whole fishery, i.e. all pertinent fleet segments, the project should be accepted, and vice versa. That means, on the other hand, that some fleet segments may be worse off following the gear change while others may become better off.

Selectivity, catches and landings

The calculation that is accomplished by using Equations (1) to (4) requires information about all the variables H, P, C, W, M, I, and d. Information about landings, H, is derived from biological models in which catches (landings and discards) are estimated. In age-structured models the number of fish, for example, at age 1 in year 1, is reduced to the number of fish at age 2 in year 2 and so forth. This decay is caused by natural mortality and by fishing mortality. The share that is caught is the portion of total mortality known as fishing mortality, the remainder being natural mortality. Further, only fish above a minimum size are allowed to be landed. The rest are either discarded or landed illegally and will, therefore, not appear in the recorded landings of a vessel.

A change in gear specification can be expected to lead to a change in selectivity. Selectivity is the proportion of fish in each age-group that is retained in the gear. If selectivity is high the probability of escape for small fish is high. An example of the selection of two different mesh sizes is shown in Figure 1.1. With the small mesh size the probability of being retained is 50% or more for fish at a length at 32.5cm or more. If the mesh size is increased to 110mm the probability of being retained is 50% or more for fish at a length of 40 cm or more. With the high mesh size the probability of a fish 32.5cm in length being retained is only 6% in this example. Hence selectivity increases with mesh size.

Figure 1.1. An example of gear selectivity



Formally, catches of each species as a function of age-group can be expressed as shown in Equation (5).

(5) $$C^0_{a,t} = N_{a,t}(1 - \exp(-(M_a + F^0_a))\frac{F^0_a}{M_a + F^0_a}$$

Where the indices are: *a,* age-group, *t* year. *C* is catch, *N* is the number of fish, *M* and *F* are natural and fishing mortality respectively. The baseline fishing mortality is denoted by 0, i.e. the fishing mortality for the baseline mesh size. It is assumed that recruitment to the stock N is constant over time, i.e. that $N_{0,t}=N_0$ for all t.

The selectivity of the gear is implicitly captured by F_a in Equation (5). The selection can be expressed in various forms; one is (ICES 1996):

(6)
$$S = \frac{1}{1 + exp(-r - l_{50} \cdot l)} \quad \text{or}$$

$$S = \frac{exp(r + l_{50} \cdot l)}{1 + exp(r + l_{50} \cdot l)}$$

where S is the probability of being retained. The length of the fish is denoted by l. The parameter, l_{50}, is the length of a fish that has a 50% probability of being retained, and r is the distance between l_{75} and l_{25}. The parameters l and r are species and gear specific. In other specifications of selectivity functions S is explicitly a function of the mesh size keeping the parameters l and r constant.

Given knowledge of the relationship between selectivity and length (Equation 6), the catch equation can be reconstructed for the new mesh size by scaling the baseline fishing mortality by varying the selectivity parameters. As the catch is specified as a function of fishing mortality by age-groups (cf. Equation 5), selectivity S must be transformed in such a way that S also matches fishing mortality F by age-groups.

Often weight and not length is recorded at age-group level e.g. in ICES reports. The weight information can however be used to calculate length-at-age by use of the relationship shown by Equation (7), see Coull et al. (1989):

(7)
$$w = \alpha \cdot l^{\beta} \quad \text{or} \quad l = \frac{1}{\alpha} \cdot w^{1/\beta}$$

where α and β are species-specific parameters taking into account whether the parameters are for gutted or un-gutted fish. If neither weight nor length information by age-group is available, one possible method is to use a growth function, for example that of von Bertalanffy (1938):

(8) $$l = L_\infty \cdot (1 - \exp(-K \cdot (a - a_0)))$$

where L_∞ is the maximum length of a fish, and K and a_0 are species-specific parameters.

Combining information by age groups of F, w, and l makes it possible to calculate S for age-groups and hence F_a. By using the ratio between selectivity in the base case (denoted 0) and in the case of gear change (denoted 1) to scale F for each age-group, the modified Equation (9) will appear as:

(9) $$C_{a,t}^1 = N_{a,t}(1 - \exp(-(M_a + \frac{S_a^1}{S_a^0} \cdot F_a^0))\frac{\frac{S_a^1}{S_a^0} \cdot F_a^0}{M_a + \frac{S_a^1}{S_a^0} \cdot F_a^0}$$

While catches occur for all age-groups, only fish from age-groups over a certain minimum length are allowed to be landed. Therefore, the landings (or harvest) inserted in Equation (2) are calculated as:

(10) $$H_{i,t}^1 = \sum_{a=min\,size}^{A} C_{a,t}^1$$

Discards are then calculated as $\sum_{a=0}^{a=min\,size} C_{a,t}^1$. However, they are omitted in the subsequent calculations.

In the present model, future catches are determined by the fishing mortality rate F, influenced only by the variations entailed in changes in selectivity. However, a more comprehensive approach as to how changes in selectivity may impact upon profitability, and hence future effort, could be included. An indication of how that could be done is found in Hoff and Frost (2006).

Finally, when the calculation is carried out at fleet segment level the fishing mortality rate F must be adjusted appropriately. This is done by using the recorded landings of the pertinent species of each fleet segment in proportion to the total landings of all segments J of the pertinent species:

(11) $$h_{i,0,j}^{0} = \frac{H_{i,0,j}^{0}}{\sum_{j=1}^{J} H_{i,0}^{0}}$$

Hence, at fleet segment level, the equation using partial fishing mortality rates looks like:

(12) $$C_{a,t,j}^{1} = N_{a,t}(1-exp(-(M_a + \frac{S_a^1}{S_a^0} \cdot F_a^0 \cdot h_{i,0,j}^0)) \frac{\frac{S_a^1}{S_a^0} \cdot F_a^0 \cdot h_{i,0,j}^0}{M_a + \frac{S_a^1}{S_a^0} \cdot F_a^0 \cdot h_{i,0,j}^0}$$

Prices

The definition of price effects in economics is of variations in demand caused by changes in price. The effects dealt with here are inverse effects; namely changes in aggregated prices for a species caused by alterations in the total supply of each species arising from adjustments in the composition of age groups. Thus there is a distinction between two price effects. The first is the effect of changes in catch composition with respect to the size of the fish. For most species larger fish receive a higher price when compared to small fish. The price for each size of fish is kept constant but as composition changes the aggregated price will change. The other effect is caused by general changes in supply and demand, and is brought about by market price elasticities. The latter effect is disregarded in the NECESSITY project mainly because most gear changes are local in nature compared to the fact that the supply of many species is of a global nature. That means that local supply changes have little impact on total supply.

The first effect, however, is included and it is necessary to produce information about prices as a function of age group. This type of information is not recorded. What is recorded, however, are the prices by size-group frequently defined by the minimum weight of a fish or the maximum number of fish per kg. When this information is combined with the average weight per fish in the age groups a price can be estimated for each age group. This approach means that in Equation (1) and (2) of the CBA, landings and prices are essentially estimated at age-group level.

Costs

Costs are divided into variable and fixed costs specified by fleet segment. In principle, all costs influenced by the gear change should be included. However, in the application of the NECESSITY model fixed costs are disregarded because the influence on them from a gear change is difficult to identify in the long-run. The change in fixed costs is linked to changes in the capacity of the fleet, i.e. the number of vessels and their size. These changes are of a long-run nature and are influenced by entry and exit considerations, see Hoff and Frost (2006).

External effects

External effects, either positive or negative, are economic consequences for other people who cannot avoid them. They are not subject to price determination in a market and are therefore difficult to quantify. Examples of external effects are the value (cost) of reducing the whale population or other non-marketable by-catch species. A chapter in this report is specifically devoted to that kind of externality. Another example is the value (cost) of discards from an ecological or an ethical point of view. Changes in discarding are partly included in the catch function because a reduction increases the stock size in the long-run.

Management costs

Management costs are generally disregarded. They comprise the costs of information gathering, administration, monitoring, and control and enforcement in the base case compared to the case with gear changes. Not least, information gathering in terms of research projects can be rather expensive. However, research is difficult to quantify in terms of benefit to society, and net research costs are often disregarded. It is reasonable to assume that monitoring and enforcement costs will increase but it is difficult to assess the magnitude of such an increase.

Investment in gear

A change in gear will entail higher investment costs in the short-run, in particular if a new regulation is implemented at short notice and without derogations. If the changes are introduced over a period of time making it possible to depreciate the original gear, extra costs will only occur if the new gear has a design that makes it permanently more expensive than the original. Certain types of gear, for example, with panels (windows with larger mesh sizes) may not be more expensive while gear with grids (steel or fibreglass devices) may be permanently more expensive. Makers of fishing trawls have indicated that the cost of gear changes intended to improve selectivity may be accomplished at costs less than €3,000 per trawl.

Discount rate

Discounting is a technique used to compare costs and benefits that occur in different time periods. It is a separate concept from inflation, and is based on the principle that, generally, people prefer to receive goods and services now rather than later. This is known as 'time preference', see HM Treasury (2003). For individuals, time preference can be measured by the real interest rate on money lent or borrowed. Amongst other investments, people invest at fixed, low risk rates, hoping to receive more in the future (net of tax) to compensate for the deferral of consumption now. These real rates of return give some indication of their individual pure time preference rate. Society as a whole also prefers to receive goods and services sooner rather than later, and to defer costs to future generations. This is known as 'social time preference'; the 'social time preference rate' (STPR) is the rate at which society values the present compared to the future.

In the United Kingdom, the HM Treasury advises researchers to use a STPR at 3.5% before tax, while the Danish Treasury recommends 6%, see Kjellingbro (2004)[2], who discusses the magnitude of this number and indicates that it may be too high.

As described in HM Treasury's definition of STPR above, a difference between individuals and society's discount rates could easily occur. Time preferences and risk perception will differ, and normally individuals will require a higher discount rate than society (which is able to spread risk and use time horizons that cross generations). For society, tax is not considered a cost while this is the case for the individual.

For the fisherman taking into account tax, the capital market rate of return on bonds and equities, and risk, which could be significant in fisheries, a much higher rate of return is demanded. A study carried out for Irish fishermen by Hillis and Whelan (1992) indicates discount rates above 20%. A "laboratory study" in which a number of individuals were given a small amount of money which could be spent freely either on commodities or placed in the "bank" also indicated very high interest rates (above

[2] Although this paper is in Danish many references in the paper are in English

20%) if people were able to defer from spending the money on commodities and put it in the bank (Harrison, Lau, and Williams, 2002).

The net present value (*NPV*) calculated from society's point of view and from the individuals' point of view would therefore differ, and projects accepted as giving a net benefit by society may be rejected as loss-makers by individuals. The discount rate used in the NECESSITY case studies varies but is generally set at 5%. Sensitivity calculations are carried out with higher interest rates to assess individuals' inclination to accept the project in terms of gear change.

Scope of the analysis

It is important to design the CBA in such a way that all costs and earnings arising from the changes in the fishing gear are included in the calculations. It is often difficult to delimit the analysis because the impact of gear changes declines the longer the distance from the direct changes to the persons affected. The present analysis is restricted to trawl fisheries that are directly involved. However, other fisheries targeting the same species may also be affected, for example, gill-netters and seiners fishing for demersal species in competition with the trawlers. The benefits and costs accruing to these fisheries are only included briefly in discussion about positive or negative net contribution. Downstream effects are also discussed only in general terms or omitted.

1.3 Data

The modelling approach developed is very demanding of data and it is not possible in any of the cases shown in Table 1.2 below to obtain all the required information. However, a classification is undertaken with the aim of assessing the extent to which the required data exists. There are four options to take into account as shown in Table 1.2 and discussed below.

Tabel 1.2. Model and data options

	Data-rich	Data-poor
Fleet approach	Model: Equations 1-10 All relevant fleet segments All relevant species All variables included	Model: Equations 1-4 Limited number of fleet segments Limited number of species Only landings value, variable costs
Fishery approach	Model: Equations 1-10 No breakdown on fleet segments All relevant species All variables included	Model: Equations 1-4 No breakdown on fleet segments Limited number of species Only landings value, variable costs

1.3.1. Fleet approach

The most comprehensive option is the data-rich fleet approach. A fleet is defined by characteristics describing the vessels e.g. length, engine power, type of gear, etc. All fleet segments affected by the proposed gear change must be identified. In this respect, it is necessary to choose impact criteria in terms of a relevant variable, and the magnitude of the variable that is used to assess the degree to which a fleet segment is affected. If, for example, landings value is chosen as the impact criteria, how large a share of the total landings value of the segment should the species affected by the gear change constitute to qualify the segment to be selected for the analysis? This is not a straightforward choice to make, but it is important in order to get a picture of the objective of the gear change. Is the purpose of the gear change, for example, aimed at increasing landings of *nephrops*, or is the aim to reduce by-catches and discards?

The data-rich fleet approach makes it possible to calculate distributional effects i.e. which segments may gain and which may lose.

The data-poor approach will often identify itself by a lack of fish stock assessment which makes it impossible to calculate the stock effects from gear changes. The approach is not entirely irrelevant, however, because indications of changes in landings prices and costs may be present for each of the pertinent fleet segments.

The borderline case is where information is available for only one segment and one species in terms of landings value and variable costs.

1.3.2. Fishery approach

In the fishery approach, fleet segments are disregarded and the platform is the species. A fishery could be defined as landings of a certain number of species from a certain area. Principally, costs will have to be disaggregated and assigned to those fisheries. If this is not possible, it means that only the contribution to the NPV of the value of landings from this fishery (several or single species) can be considered. Costs are thus disregarded, or assumed not to vary between the baseline case and the case with gear change. This is a less complicated approach which is pertinent if stock assessments are carried out, but no information is available about landings and costs at the fleet segment level.

The distinction between the data-rich and data-poor fishery approaches is mainly of a biological nature. The borderline case in the data-poor approach is where stock assessment is available for only one species. Changes in landings can be evaluated by use of Equations (2) and (5). If no such stock assessment is available, an assessment could still be carried out based on estimates of future landings after the gear change compared with estimated landings before the gear change.

1.3.3. Scaling

Execution of a CBA requires data to be collated from many different sources. Therefore preparing the data input is often time-consuming and in certain cases almost prohibitive for the execution of the CBA.

One particularly difficult problem is to link the data collated from the “catch model” (Equations 5-10) to the CBA formulas (Equation 1-2). Firstly, stock projections are carried out subject to a number of assumptions, such as constant recruitment, fixed distribution of fishing mortality by age-group, etc.; assumptions that will for certain not hold for more than a limited time period. However, the purpose of the CBA is to assess the effect of a specific measure and not the general effect taking all possible changes into account. The CBA is as such a projection rather than a prognosis. In prognoses, the effects of other changes can easily overshadow and obscure the effect of the change in question, but it is not the purpose of the CBA to evaluate the effect of these other changes.

Another difficult problem is related to the estimates of important parameters that form the basis for projections of the base case and the scenario with changes, i.e. the calibration of the baseline scenario. The selectivity parameters used to calculate S (Equation 6) are estimated based on surveys carried out with specific vessels fishing in specific periods and specific areas. The question is to which extent these estimates can be used in CBAs covering not only the annual activity of the particular survey vessels, but the entire pertinent fleets’ activities?

This scaling problem may in fact prevent a CBA and any economic impact assessment. The problem is, well known and the use of parameters with substantial uncertainty is thus circumvented by sensitivity analyses in which the economic results of their variability are investigated.

As the selectivity parameters are recorded at trip level, linking selectivity changes to fishing mortality rates should in principle occur at the same level and not to the aggregate fishing mortality rates and harvest used in the CBA formulas. The scaling would then be from the single vessel's landings in a specific period and area to the entire fleet's landings in the same period and area. Subsequently the scaling up would occur from that particular period and area to the whole year and all relevant areas. The level at which the former type of data are collated is indicated in Table 1.3.

Tabel 1.3.

	Data-rich	Data-poor
Fleet approach	*Vessel trip level:* Number of days at sea, landings by species composition, area, period, prices *Annual level:* Number of vessels, number of trips, variable costs, fixed costs	As for data-rich but less extensive
Fishery approach	*Trip level:* Number of days at sea, landings by species composition, area, period, prices	As for data-rich but less extensive

In the data-rich fleet approach much information is collected at vessel trip level. However, most of the economic information is collected at sampling level for the fleet on an annual basis. If costs are to be allocated at trip level it is necessary to construct an allocation procedure in which the cost-dependency on days-at-sea, landings etc. is specified.

As indicated, there are several ways to address the scaling problem. The aim is to minimize the uncertainty of the economic results in terms of net present value for each of the scenarios so that the decision rule (Equations 4-5) will lead to an unequivocal answer. It is clear that the scaling problem may be difficult to overcome, and that a solution is to assess the sensitivity of the net present values to changes in parameter values.

1.4. Conclusion

The conclusion is that a fully integrated bio-economic cost-benefit analysis is very data demanding and difficult to configure. By its nature, the CBA is looking at the future comparing a baseline situation and another where changes have taken place. Future stock projections are encumbered with great uncertainty, as are technological changes. Finally, the gear trials that form the bases for the CBA have, by nature, to be carried out in limited time and space.

Given these comments about uncertainty, the application of cost-benefit analysis provides a useful insight not only on the overall benefit to society and private enterprises of carrying through different changes but also to which elements are critical in the aim to ensure a successful outcome.

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2. Willingness to pay for saving sea mammals

2.1 Introduction

In general, the optimal economic utilization of a marine resource depends on the stream of benefits that can be derived from the fishery compared to the stream of costs of harvesting over time. In traditional analyses, benefits only include direct benefits in the form of the market price of the landed fish, while costs only include the direct harvesting costs such as capital, effort and fuel. However, to derive an optimal social stock-harvest combination, other costs and benefits have to be included in the analysis. Examples are the damage done by fishing activity to the ecosystem and unintended death of non-target species among which can be sea mammals. The value of these costs can be incorporated in fisheries analysis, but a major problem is how to estimate the costs to the eco-system and the value of non-target species.

Here, we will focus on the valuation of sea mammals as an unintended by-catch in fisheries. The value of sea mammals in this case flows mainly from the existence value that people attach to them, although there can be a recreational value (or option values) in that some persons will want to preserve the animals and the possibility of seeing them in their natural surroundings. The existence value can be assessed in two ways. People can be asked directly how much they are willing to pay (WTP) for a decrease in sea-mammal by-catch in fisheries. This is a stated preference method since respondents state a WTP without actually paying the amount. Another method is to see how demand for seafood products changes when they are labelled as sea-mammal safe. This is a revealed preference method in that the consumers through their actual choices in the market reveal their preferences.

Unfortunately, not many studies exist that address the stated problem directly. Only in the case of tuna is there some evidence on consumer behaviour with respect to by-catch of dolphins through the ’dolphin-safe’ labelling of canned tuna.

2.2 Economic Valuation

In economics, the value of a good stems from the utility people derive from the good. If the good is supplied through a market, people can express their WTP for the good by stating the maximum price they are prepared to offer for a certain quantity of the good. Doing this for several different quantities gives a demand function for the individual consumer. The total value of the good that the consumer actually buys is then given by the area under the demand function up to the quantity that he buys. The marginal WTP is given by the price since this is what the consumer would be willing to pay for an additional unit of the good. Hence, for market goods, A value can be established by estimating the total demand function.

The value of a good can be derived from several value categories. Direct use-value is what a consumer derives from using the good as an input to a process which transforms it. This can be the use of apples for food, or the use of a tree for timber. Indirect use-value is derived from recreation or services the good provides. Examples are a walk through a forest, spotting whales or the pollution-cleansing capacity of natural wetlands. Besides use-values, there also exist non-use values. Amongst these are existence value and bequest value. Existence value means that people value a good for its mere existence, without them ever using the good directly or indirectly. So, people value the existence of whales, even though they will never see one, let alone eat their meat. This holds for many wildlife resources. In general, people are willing to pay some amount to ensure the existence of certain biotopes and animals even though they will never visit them. Bequest value is related to this in that it gives the value to people for knowing that future generations will be able to enjoy the different goods.

A major problem now is that private markets can capture direct use-value, and to some extent indirect use-value, but not non-use value. The reason for this is that non-use value has the character of a public good. This means that if the good is provided to one person, the good is available in the same quantity to all people. So, if someone ensures that there is a viable population of gray whales, then others, who would like the gray whale to be in existence, derive value from this too, without having to pay for it. This is rather different from a private good, where utility only comes from direct consumption. Hence, the fact that I eat an apple does not give higher utility to (most) others. The result is that markets will not supply public goods, since they will not be able to capture the cost of providing the good through the market, but from a societal point of view, public goods do give value and, hence, should be provided. The major problem then is to find out how much of the good should be provided. That is, we have to estimate the value of the good to society and compare that with the cost of supplying the good, but since markets for the good do not exist, data on its value are not available.

Economists have developed several techniques to estimate the non-market value of goods. They can be divided in two main categories: stated preference methods and revealed preference methods. In the latter method, market goods can be used in the valuation of non-market goods. For example, people pay to travel to national parks. The expense used for travelling to the park (including the value of time) then gives an estimate for the value of the park. Another method is known as the hedonic pricing method (HPM). Here, the value of a market good depends on the supply of a non-market good. The method most used is the house price method. Houses are generally more expensive when they are located near a recreational site such as a forest. The main disadvantage of revealed preference methods is that they can only measure use-values. Stated preference methods can measure both use and non-use values. With these methods respondents are asked, through a survey, about their willingness to pay. The survey can be open-ended or several amounts can be given from which the respondents can choose. Another method is dichotomous choice, where one amount is mentioned, which the respondents can accept or reject. More advanced methods have been developed, such as choice experiments, where there are different surveys that state different attributes of the good and/or different prices.

Both stated and revealed preference methods are not without problems, so that in general, the estimates that are found in valuation studies are inexact measures of people's willingness to pay.

2.3 Environmental Valuation of Sea Mammals

One method of estimating the economic value of sea mammals is through questionnaires. This method is known as the Contingent Valuation Method (CVM). Basically, the respondent is asked to say how much he or she is willing to pay for the protection of a certain animal. This can be either stated as the WTP for an increase in the numbers of the species or as a WTP to avoid deterioration of the species. The question can be open ended, where respondents have to state the amount they are willing to pay, or dichotomous choice, where a value is stated in the survey and respondents can either accept to pay the amount or reject it. By varying the amount in the surveys, a demand function can be estimated. Another element is how the payment is to occur, either as a yearly amount or as a lump-sum amount.

Table 2.1. WTP per household (1993) for threatened and endangered species

Survey date	Species	Gain or loss	Size of change	Willingness to pay: Lump sum	Willingness to pay: 1993	Willingness to pay: Annual 2006	Survey Region
1984	Gray-blue whale	Avoid loss	100%		$33.33	$45.83	CA households
	Sea otter	Avoid loss	100%		$28.88	$39.71	
1991	Gray Whale	Gain	50%		$17.15	$23.58	CA households
	Gray Whale	Gain	100%		$19.23	$26.44	CA households
	Gray Whale	Gain	50%		$26.50	$36.44	CA visitors
	Gray Whale	Gain	100%		$31.51	$43.33	CA visitors
2000	Steller Sea Lion	Gain				$70.54	US households
1988	Monk Seal	Avoid loss	100%	$119.70		($11.52)	HI households
	Humpback Whale	Avoid loss	100%	$172.92		($16.64)	
1991	Sea Turtle	Avoid loss	100%	$ 12.99		($1.25)	NC households

Source: Loomis and White (1996), Giraud et al. (2002).
Notes: The 2006 amounts were calculated using the consumer price index. Lump sum amounts are converted to annual amounts using a 7% discount rate. CA=California, HI=Hawaii Islands, NC=North Carolina

Some results from CVM surveys are reported in Table 2.1. The amounts in the Table give the willingness to pay per household, either as a payment per year, or as a single lump-sum payment. The Table shows that there is a willingness to pay for the preservation or increase in size of threatened and endangered species, although the amounts vary between species. The WTP for the last three species mentioned in Table 2.1 are given as single payments. Converting these to annual payments gives a WTP of $8.38, $12.10 and $0.91 for the monk seal, the humpback whale and the sea turtle respectively when using a discount rate of 7% (at 5% the numbers are $5.99, $8.65 and $0.65). Compared to the amounts stated for the other species, these amounts seem rather low. However, the differences may stem from a difference in the questions asked. For example, in the study on the humpback whale, respondents were asked for their WTP to provide one-time emergency assistance to protect whales in Hawaii (Samples and Hollyer 1990). The WTP to pay for the gray whale is given for both a 50% and a 100% increase in the population and clearly shows a decreasing marginal WTP (Loomis and Larson 1994).

A major problem with the studies mentioned above is that they give the total willingness to pay for a certain level of sea mammal population or for the protection of the species. Hence, the amounts are only valid at that level and do not tell us anything about the WTP for other levels. Another problem arises when respondents are asked about their WTP for preservation of the species. In most cases, the respondent is not informed about the minimum viable population. The result is that the total WTP derived from the study does not give an indication about the optimal species population. As Bulte and Van Kooten (1999) show for the minke whale, the same total WTP estimates can be consistent not only with extinction, but also with strict conservation (i.e., no fishing) being optimal. To prevent such problems, one needs to elicit the marginal willingness to pay. The only case where it is possible to infer marginal WTP is in the study on gray whales by Loomis and Larson (1994).

2.4 Eco-labelling

Several forms of eco-labelling exist. Within Europe, several general eco-labels exist at the national level and one, the flower, at the EU level (see Pickering *et al*, 2001, App. 1, for an overview). These are aimed at products produced by environmentally friendly methods in general, and applied to seafood do not necessarily take by-catch of sea mammals into account. An eco-label especially targeting seafood is the Marine Stewardship Council (MSC) label. The MSC was created in 1996 by Unilever and the World Wide Fund for Nature (WWF) to encourage responsible fishing practices that lead to sustainable fisheries. The MSC scheme builds on three key principles of sustainability: 1) the target fish population should not be overexploited, 2) preservation of the ecosystem, and 3) operation of the fishery in accordance with local, national and international laws and standards.

Even though sustainability labels aim at increasing the stock of the target species, they may have the opposite effect, depending on how the premium people are willing to pay varies with stock size and how well the fishery is managed (Gudmundsson and Wessells 2000)

Other labels targeting seafood are the dolphin-safe label for canned tuna and the turtle-safe label for shrimps. These labels target the by-catch in tuna and shrimp fisheries directly in that the labels can only be used on products that only have a small by-catch of dolphins or turtles.

Pickering *et al.* (2001) give a stated preference analysis of eco-labeling of seafood. Respondents were asked for their willingness to pay for several seafood products that were given a sustainability label. The sustainability label refers to the Marine Stewardship Council (MSC) scheme. The study attempts to determine consumer WTP by two methods: an open-ended CVM and a choice experiment. In the latter, respondents are presented with different product choices, considering various product attributes (type of fish, quality, eco-labelled or not) and a price. The respondents can then state whether the price is acceptable for that bundle or not. Results of the study with respect to eco-labelling are given in Tables 2.2 and 2.3.

Table 2.2. WTP per household in the UK for products with a sustainability label

Product	Significant willingness to pay premiums % (CVM)	Significant willingness to pay premiums % (CE)	Existing prices at time of survey £ per kg
Fresh & chilled cod fillets	+34%		4.70
Fresh & chilled salmon steaks	+24%	+87%	6.00
Smoked haddock fillets	+20%	−14%	7.00
Fish fingers	+14%		4.20
Canned tuna	+15%		3.00
Prawns		−23%	9.30

Source: Pickering et al. (2001, p.3)

The Tables show that in general, there is a positive WTP for eco-labelled seafood, with most premiums lying in the 15%-30% range. However, there are negative WTPs and very high WTP too. Furthermore, the Tables show that WTP premium varies with the type of seafood and between countries. The report also shows that eco-labelling may lead to an increase in purchase frequency of seafood.

Table 2.3. WTP per household in Denmark for products with a sustainability label

Product	Significant willingness to pay premiums % (CVM)	Significant willingness to pay premiums % (CE)	Existing prices at time of survey DKK per kg
Fresh & chilled cod fillets	−4%	+28%	90.00
Fresh & chilled salmon steaks		+22%	84.00
Smoked salmon fillets		+31%	166.50
Frozen breaded plaice	+14%		50.00
Canned mackerel	+6%	+141%	37.20
Shrimp	−7%		159.70

In another study, Wessells *et al*. (1999) analyze several aspects that affect consumer preferences for eco-labelled seafood. These include which species is labelled, who is the certifier and several household attributes such as membership of an environmental organization and household income. They show that in general, consumers are willing to pay for eco-labelled seafood, but that their WTP is dependent on many variables. A conclusion that can be drawn is that eco-labelling must be accompanied by campaigns that inform the public about the fisheries and the eco-label.

A problem with WTP through eco-labelling is that only the WTP from individuals buying the products is measured. However, persons not buying seafood may have a

WTP for a sustainable fishery. Hence, in general, WTP measured through eco-labelling will give an under-estimation of the real WTP. However, eco-labelling can be used to capture some of the WTP for more sustainable fisheries.

2.5 Dolphin-Safe Tuna.

In the pacific, catches of yellowfin tuna have habitually been accompanied by a large by-catch of dolphins. The eco-label 'dolphin-safe tuna' was introduced in the US to designate canned tuna associated with a much lower by-catch of dolphins. Now, virtually all canned tuna in the US is dolphin-safe. Also, in other countries, the dolphin-safe label has been introduced, even in cases where all canned tuna on the market already was dolphin-safe. Teisl et al. (2002) find that the dolphin-safe label increases demand for canned tuna in the USA relative to where no label is used. This should be seen against a background of declining sales of tuna in general. It cannot easily be deduced from this study how much demand increases and it is therefore hard to determine the WTP for dolphin-safe fisheries.

2.6 Turtle-Safe Shrimp.

In several areas, shrimp fisheries are associated with a substantial by-catch of sea turtles. To counter this, the 'turtle-safe shrimp' label has been introduced. To our knowledge, no studies exist that assess the effect of this label on consumer behaviour.

2.7 Conclusions

It is clear that people attach a positive value to the existence of sea mammals. They are willing to pay substantial amounts to keep populations of several species at viable levels. This fact should be taken into account in fisheries policy. It implies that by-catch of sea mammals represents a cost to society that should be treated on a par with other costs and benefits flowing from fisheries. Doing so means that by-catch of sea mammals should be reduced from their current levels. Such a reduction can be attained through regulatory measures, especially gear specifications and perhaps fishing area restrictions.

Eco-labelling can assist regulation, but cannot replace it entirely. With eco-labelling, the consumer can make a choice between products with a high or low by-catch of sea mammals. If consumers switch to products with low sea mammal by-catch this will force fishers and the seafood industry to reduce by-catch. Since sea mammal-safe fish can fetch a higher price on the market, such eco-labels may then go some way to recovering the additional costs to the seafood industry. However, through eco-labelling, only consumers of seafood can express a WTP for sea mammal-safe fisheries. The preferences of people that do not consume seafood are thus not taken into account, and it is also likely that seafood consumers have a higher WTP than the additional price of seafood. Hence, the optimal level of by-catch of sea mammals for society could be lower than the level that will be reached when only eco-labelling is applied.

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3. Management regimes

The general principles of resource management of the Common Fisheries Policy (CFP) are laid down in Council Regulation 2371/2002 and the Road Map (European Commission 2002).

There are three main elements in the resource management policy:

1. Total Allowable Catches (TAC) and quotas
2. Effort controls
3. Technical measures
   a. Mesh size (panels, grids) (EU)
   b. Minimum landings sizes (EU)

3.1 Total Allowable Catches and Quotas

The International Council for the Exploration of the Sea (ICES) is the main supplier of fish stock assessments by the use of methods known as virtual population analyses (VPA and XSA). Based on various types of catch and landings information, catch per unit of effort (CPUE) information and surveys, it is possible to estimate the stock biomass by age (or length) groups by solving a large system of equations. For a number of fish species VPA is performed every year, and this forms the basis for the TAC recommendations put forward by ICES. The underlying information about stock size by age-groups is used in the CBA shown in Section 4. If this information were not available a full application of the model shown in Section 1 would not be possible.

ICES does not carry out stock assessments (WKNEPH Report 2006) of the *nephrops* stocks by use of VPA or XSA, as it is difficult to determine their age directly. Length compositions of the *Nephrops* stocks could be estimated from selectivity trials but this kind of information is not published by ICES. Stocks are assessed by use of CPUE indices and underwater surveys conducted by television. The proposed TACs are, therefore, generally determined by developments in historical landings. The general trend in the TAC has shown an increase for all the management areas, cf. Table 3.1. Compared with the CPUE information, *nephrops* do not seem to be overexploited.

Table 3.1.	EU TACs for Nephrops by management area, tonnes				
Area	2002	2003	2004	2005	2006
IIIa,IIIbcd	4500	4500	4600	4700	5170
IIa,IV (EU zone)	16623	16623	18987	21350	28147
Vb,VI	11340	11340	11300	12700	17675
VII	17790	17790	17450	18596	21498
VIIIabde	3200	3000	3150	3100	4030
VIIIc	360	180	180	162	-
IX,X,CECAF	800	600	600	540	486

Source: The EIAA model

The United Kingdom is by far the most important player with more than half of the total landings of *nephrops*, see Table 3.2. France, Ireland and Denmark come next.

Table 3.2. EU TACs for Nephrops by Member State, average 2003-2005, tonnes

Area	BEL	DNK	DEU	IRL	ESP	FRA	NLD	PRT	SWE	GBR	Total
IIIa,IIIbcd		3381	10						1210		4600
IIa,IV (EU zone)	993	993	12			31	512			16445	18987
Vb,VI				159	23	93				11504	11780
VII				6620	1077	4361				5887	17945
VIIIabde				0	185	2898					3083
VIIIc				0	167	7					174
IX,X,CECAF					145			435			580
Total	993	4374	22	6779	1597	7392	512	435	1210	33836	57149

Source: The EIAA model

There is a clear regional difference as to where the landings of each country originate as shown in the left column of Table 3.2. Area III is the Skagerrak, Kattegat and southern Baltic Sea, Areas II and IV comprise the North Sea. The area codes then move south through the English Channel, the seas around Ireland and down to the west coast of Spain and Portugal (Areas IX and X).

3.2 Effort management

Effort management has taken place on two levels; namely, by vessel capacity restrictions and by days-at-sea limitation. Since 2003, restrictions on vessels have been reinforced by the revision of the CFP. However, this type of restriction is not sufficiently directed towards protection of individual fish stocks. As a consequence, days-at-sea limitations were introduced on 1st February 2003, see Table 3.3, with the aim of allowing stocks, cod in particular, to recover.

Table 3.3. Maximum days per month present within an area and absent from port by fishing gear in the Skagerrak, Kattegat, North Sea, Eastern Channel, West of Scotland and Irish Sea

Gear	Mesh size	2003	2004	2005
Demersal trawls, seines or similar towed gears except beam trawl	≥ 100mm[1]	9	10 (+3[3])	9 (+3[3])
Beam trawl	≥ 80mm	15	14	13
Static demersal nets including gill-nets, trammel nets and tangle nets		16	14	13
Demersal longlines		19	17	16
Demersal trawls, seines or similar towed gears except beam trawl	70 – 99mm[2]	25	22	21
Demersal trawls, seines or similar towed gears except beam trawl	16 – 31mm	23	20	19

1. Kattegat and Skagerrak 90mm
2. Kattegat and Skagerrak 70 – 90mm with grid and square-mesh cod-end
3. Extra days to Denmark because of reduction in number of vessels

Source: Council Regulation (EC) No. 2341/2002 OJ L 356 of 31/12/2002; Council Regulation (EC) No. 2287/2003 OJ L 344 of 31/12/2003; Council Regulation (EC) No. 27/2005 OJ L 12 of 14/1/2005.

3.3 Technical restrictions

Restrictions on days at sea, however, influence the level of catches of *nephrops*. Since 1st March 2004, for example, a regulation has applied in the Skagerrak and Kattegat that fishing with towed gear with meshes of 70mm to 89mm is permitted only if square meshes are used in the cod-end and extension. This rule is directed towards the *nephrops* fishery, see Table 3.4. Directed fishing for most demersal species using these mesh sizes is prohibited. Since 1st January 2005, the rule has been reinforced so that these mesh sizes are allowed only if a sorting grid and square-mesh panel in the cod-end and extension are used.

The consequence has been that this mesh size has been abandoned by the fishermen. Now they almost all use 90mm mesh and above, which allows them to target all species in the Skagerrak and Kattegat freely. They are granted extra days at sea in these waters if they use a mesh of 120mm and above.

Table 3.4. Mesh sizes for trawl, target species
Specific gear (mesh size) is only allowed for targeting the species marked X, i.e. the smaller the mesh size the fewer the number of target species allowed.

	Region 1 and 2 except Kattegat and Skagerrak										Kattegat and Skagerrak(6)							
Mesh size in mm for trawl	<16	16-31			32-54	55-69	70-79	80-99		>= 100	<16	16-31		32-69		70-89		>= 90
Minimum percentage of target species	95	90/60 (3,5)	60	30	90/60 (4)	90	35	30	70	none	50	50	20	50	20	50	30	none
Sandeel (1,2)	X	X			X		X	X	X	X	X	X	X	X	X	X	X	X
Norway pout		X			X		X	X	X	X		X		X	X	X	X	X
Sprat		X			X		X	X	X	X		X		X	X	X	X	X
Blue whiting		X			X		X	X	X	X		X		X	X	X	X	X
Sardine		X			X		X	X	X	X		-		-	-	-	-	-
Brown shrimp			X	X	X		X	X	X	X			X	X	X	X	X	X
Mackerel		ø			X	X	X	X	X	X				X		X	X	X
Horse mackerel					X		X	X	X	X				X		X	X	X
Herring					X		X	X	X	X				X		X	X	X
Prawn		ø	X	X	X		X	X	X	X					X	X	X	X
Norway lobster		ø			æ		X	X	X	X							X	X
Sole		ø			æ				X	X								X
Plaice		ø			æ				X	X								X
Dab		ø			æ				X	X								X
Lemon sole		ø			æ				X	X								X
Witch		ø			æ				X	X								X
Flounder		ø			æ				X	X								X
Turbot		ø			æ				X	X								X
Megrim		ø			æ				X	X								X
Brill		ø			æ				X	X								X
Pollock		ø			æ				X	X								X
Whiting		ø			æ				X	X							X	X
Hake		ø			æ				X	X								X
Cod										X								X
Saithe										X								X
Haddock										X								X
Ling										X								X

1. <16mm mesh is allowed only part of the year (March till October incl) in the North Sea and Skagerrak; March till July (incl) in the Kattegat.
2. Outside the period indicated in 1. only using mesh at 16mm or above.
3. Catch on board at least 90% of two or more target species (marked X), or at least 60% of one target species and less than 5% of mixed cod, haddock, saithe and less than 15% of species marked ø.
4. Catch on board at least 90% of two or more target species (marked X), or at least 60% of one target species and less than 5% of mixed cod, haddock, saithe and less than 15% of species marked æ.
5. Specific rules for herring.
6. From 1st January 2005, in the Kattegat and Skagerrak trawl meshes between 70 and 89mm are allowed only with a square-mesh panel. Extra days at sea granted in 2005 if the trawl used has 120mm square-mesh sorting window.
Source: Council Regulation (EC) no. 850/98, OJ L. 125 of 27/4/1998, Annex I and IV.

The permitted minimum landing size of fish is shown in Table 3.5. All fish below the minimum must be put back into the sea. It is not prohibited to catch fish below these sizes but they must not be retained on board. Usually the discarded catch is dead when returned to the sea.

Tabel 3.5 Permitted Minimum Landing Sizes for fish

	------ North Sea -----		Skagerrak and Kattegat		Baltic Sea, Sound and Belt	
	DK	EU	DK	EU	DK	EU
	cm	cm	Cm	cm	cm	cm
Sandeel (1,2)						
Norway pout						
Sprat						
Blue whiting						
Sardine						
Brown shrimp						
Mackerel		30		20		
Horse mackerel		15				
Herring		20		18		
Prawn						
Norway lobster	13	8,5	13	13	13	13
Sole	24,5	24	24,5	24	24,5	
Plaice	27	22	27	27	27	25
Dab	25	23	25	23	25	
Lemon sole	26	25	26	25	26	
Witch		28		28		
Flounder	25,5	25	25,5	20	25,5	25
Turbot	30	30	30	30	30	30
Megrim		25		25		
Brill	30	30	30	30	30	30
Pollock		30				
Whiting		23		23		
Hake	40	30	40	30	40	
Cod	40	35	40/35	30	35	35
Saithe	40	35	40	30	40	
Haddock	32	30	32	27	35	
Ling		63				

Source: Council Regulation (EC) no. 850/98, OJ L. 125 of 27/4/1998, Annex XII

References:

European Commission (2002) *Communication from the Commission on the Reform of the Common Fisheries Policy, Roadmap,* Office for Official Publications of the European Communities, Luxembourg. http://europa.eu.int/comm/fisheries/reform/proposals_en.htm.

4. Case studies

The model developed in Section 1 has been applied to a number of selectivity trials. The trials planned at the commencement of the project are listed in Table 4.0. Some of the trials concern *nephrops* and by-catches of demersal fish species. Some cover pelagic trawling and the opportunities to avoid by-catches of cetaceans (dolphins and porpoises) by using various devices fitted to the trawl.

Cases have been selected within each ICES area. Three cases have been selected within the *nephrops* fisheries. Some of them are data-rich while others are more data-poor. Pelagic trawling is the more difficult to analyse because these fisheries are rather data-poor with respect to both biological and economic information. The selection of cases has also been affected by the outcome of the trials, which was impossible to predict in advance.

A number of species are subject to stock assessments. Officially published data from ICES are used. In general, no assessment is published for *nephrops* in terms of age or length composition. For cod, haddock, whiting, hake and plaice, information is published. Stock assessments in terms of age composition, fishing mortality rates, and natural mortality are used as inputs in the stock projections that form a basis for the estimates of future landings in the baseline case and those with gear changes. Table 4.1 indicates areas for which stock assessment is available for all or some of the species.

The case studies have been accomplished through a procedure generally along the following lines:

1. General presentation in terms of landings of the fishery covering the trial
2. Fleets costs and earnings
    a. Landings composition (to select segments if possible)
    b. Economic performance (to form the baseline and to calibrate the CBA model)
3. Calculations and results (model, assumptions, results) arising from full application of the model require:
    a. Projection of landings of various species per fleet segment over between 10 and 30 years based on fish stock assessments,
    b. Projection of the costs of fleet segments over a period of 10 to 30 years consistent with 3a.

The purpose of this procedure is to draw a picture of the fisheries that are subject to the differing technical gear changes. Irrespective of whether full information is available, for example, about stock developments, the presentation of economic performance of the relevant fleet segments provides valuable information about the ability to incorporate such changes with respect to economic performance.

Table 4.0. Summary of proposed experiments by area, species, modification and method

Task No.	ICES Area	Fishery	By-catch Species	Gear type	Modification	Method	Stock assess.
3.2	IVa	Fladens	Cod/Haddock/ Whiting	*Nephrops* trawl	Inclined separator panel	Twin Trawl	Yes
3.3	IIIa	Skagerrak	Cod	*Nephrops* trawl	Large mesh escape panels	Twin Trawl	Yes
3.4	IIIa	Skagerrak	Cod	*Nephrops* trawl	Grid	Twin Trawl	Yes
3.5	VIIb, VIa	Aran, Clyde	Cod/Haddock/ Whiting/Hake	*Nephrops* trawl	Large mesh escape panels with grid	Twin Trawl	Yes
3.6	IVb	Farne	Cod/Haddock/ Whiting	*Nephrops* trawl	Rigid grid/net grid/ cut-away trawl	Twin Trawl	Yes
3.7	IVb,c	Botney Gut	Cod/Haddock/ Whiting	*Nephrops* beam trawl	Lowered headline, square-mesh panel	Twin Beam	Yes
3.8	VIIg	Irish Sea (Smalls)	Hake/ Whiting/Haddock	*Nephrops* trawl	Cut-away upper panel/ inclined panel	Twin Trawl	Yes
3.10	VIII	Bay of Biscay	Hake	*Nephrops* trawl	Flexible grids	Twin Trawl	
3.11	VIII	Bay of Biscay	Hake	*Nephrops* trawl	Side escape panels	Twin Trawl	
3.12	Med.	Western Med	Hake/Blue Whiting	Bottom otter trawl**	Square-mesh panels and grids	Cover	
3.13	Med.	Adriatic	Hake	Bottom trawl**	Extension with square-mesh window	Separate covers	
3.14	Med.	Aegean	Hake	Crustacea trawl**	Square-mesh panels	Separate covers	
3.15	IXa	Algarve	Blue Whiting	Crustacea trawl**	Square-mesh panels	Small mesh covers	
3.16	IXa	Algarve	Blue Whiting/ Boarfish	Crustacea trawl**	Grids	Small mesh covers	

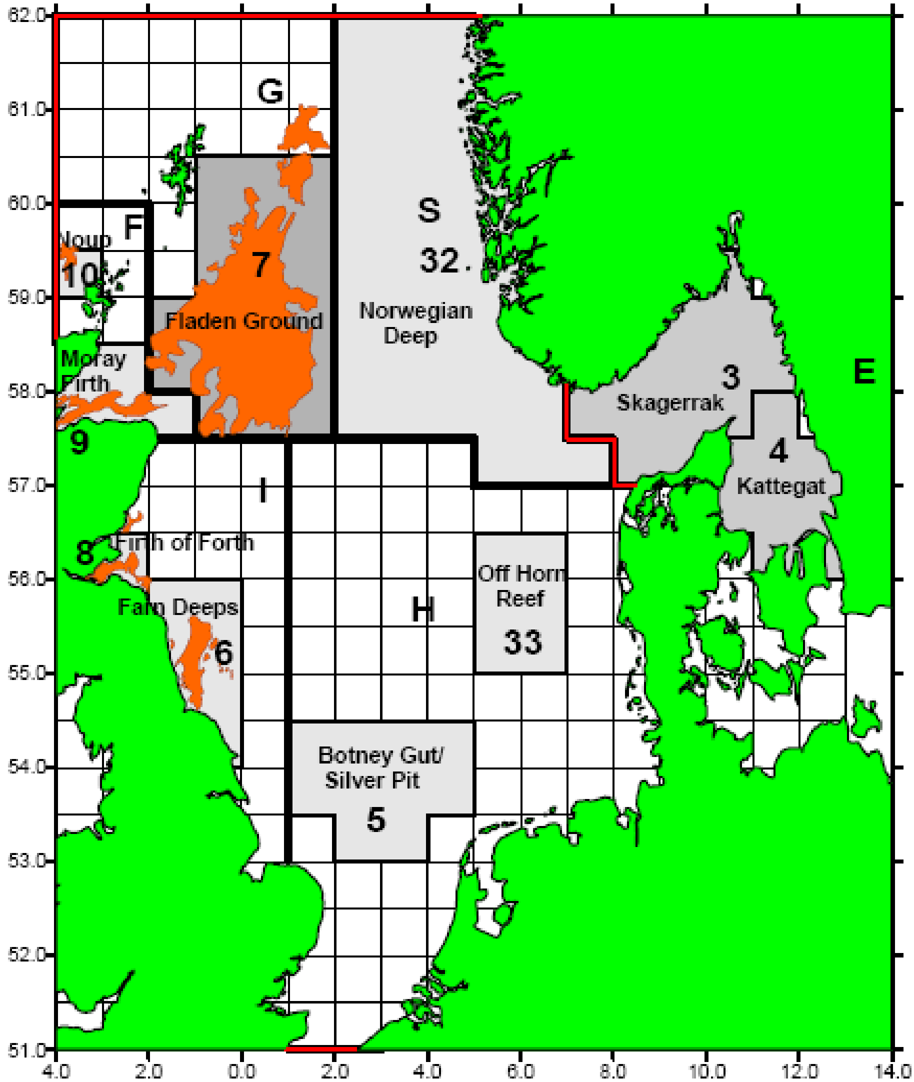
Table 4.0. cont. Pelagic trawl: Fishery and mitigation methods for cetaceans

Fishery	Proposed Tests
Bass VIIe,f + VIIIa,b	PTM, Testing plastic + metal grid PTM, Test rope devices PTM, Cod-end closure (IFREMER) PTM, Test grid
Albacore VII + VIII	PTM, Behaviour studies using pods and video footage + gear noise measurements (BIM+USTAN) PTM, Testing interactive deterrents (sub-contracted development by AquaTec Subsea) Test of excluder devices Test of codend closure (IFREMER+BIM)
Herring, Mackerel, Horse Mackerel VIIe,f,g + VIIIb,c	OTM, Tests with excluder section or square-mesh grid mackerel and horse mackerel + tests of interactive pingers in OTM + PTM fisheries (RIVO+BIM) OTM, Test interactive acoustic devices in the horse mackerel fishery in English Channel (DIFRES+BIM)
Hake, VIII	PTB, Testing excluder devices or noise deterrents
Gear type	Topics
OTM	Tests with excluder section or square-mesh grid, mackerel and horse mackerel OTM fisheries Test on alternative tactics (discard storage onboard)
OTM	Test acoustic devices in the horse mackerel fishery in Channel Testing excluder devices (plastic grid + rope devices (Xd) in bass fishery, and albacore fisheries) Behaviour of cetaceans around trawls using pods Testing interactive (or white noise) deterrents (sub-contracted development by AquaTec Subsea) Testing acoustics (+excluder devices) in mackerel fishery
PTM	Sea Bass PTM, cod-end closure + grid
PTM	Tuna PTM, cod-end closure + grid Testing excluder devices

OTM: Midwater Otter Trawl, or single boat pelagic trawl
PTM: Midwater Pair Trawl
PTB: Bottom Pair Trawl (high vertical opening)

The following map 4.0 of management areas for *nephrops* shows where the trials have taken place.

Map 4.0. Management areas for Nephrops



Source: ICES, WGNSSK Report 2006, Figure 3.1.1

4.1. The North Sea, Kattegat and Skagerrak

The trials concerning *nephrops* caught in the Skagerrak, Kattegat and the North Sea Fladen Ground are shown in Table 4.0.

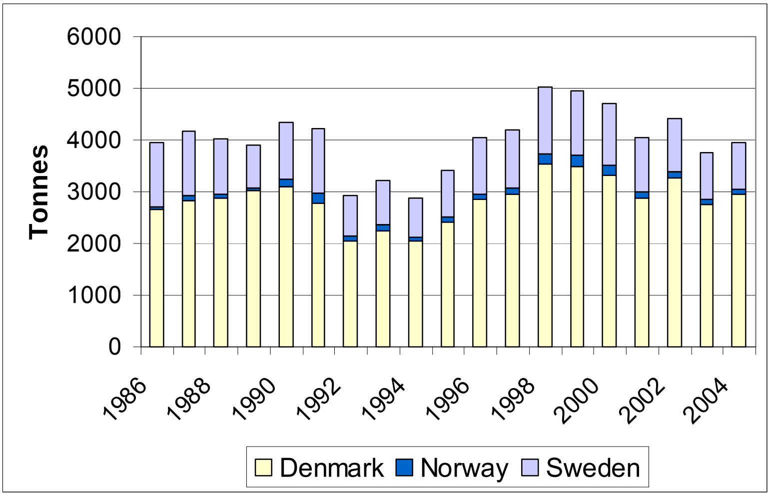
The case under consideration comprises the Kattegat and Skagerrak because the gear trials were carried out together. The North Sea case failed to produce applicable results for an economic analysis.

4.1.1. Landings

4.1.1.1. Skagerrak

Landings of *nephrops* from the Skagerrak have fluctuated around 4,000 tonnes over the last two decades with no clear trend, see Figure 4.1.1. The composition of landings by country has been stable over the years with Denmark landing, on average, 71%, Sweden 26% and Norway 3%. Germany and the Netherlands have recorded less than 1% of landings.

Figure 4.1.1. Nominal landings (tonnes) of Nephrops in the Kattegat and Skagerrak (Division IIIa), 1986-2004 as officially reported to ICES



Source: ICES, WGNSSK Report 2005, Table 14.3

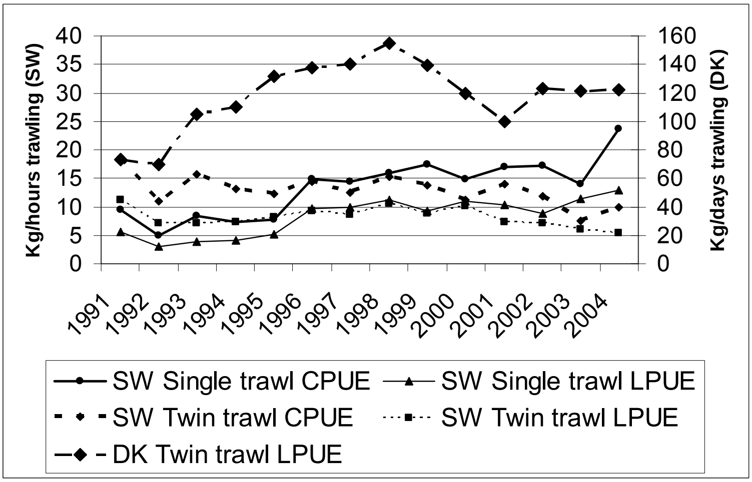
No stock assessment in terms of VPA is carried out for *nephrops* by ICES. Instead CPEU and landings per unit of effort (LPUE) in terms of catches and landings per hour trawling (Sweden) and per day trawling (Denmark) are extracted from logbooks, see Figure 4.1.2. The landings ratio of the catches for Swedish vessels varies between 50% and 70% with an average of 62% for the whole period. There is no significant difference between single trawl and twin trawl. Hence, the discard rate in terms of weight is estimated at an annual average of 38%.

While all the Norwegian landings are recorded as from the Skagerrak, only 59% of Danish landings and 64% of Swedish landings have come from that source. In this respect, Denmark and Sweden show a similar pattern.

The LPUEs indicate no problems of overexploitation. They have shown no clear downward trend; quite the contrary for Swedish trawlers. Single trawl shows a slight rising trend while twin trawl has been rather stable. The Danish figures show a strong upward trend until 1998, then a fall to around 120kg per day where landings seem to have stabilised over the last few years.

ICES considers the Swedish data more reliable than the Danish. However, LPUE and CPUE data cannot take technological improvement and changes in regulations fully into account. Despite that, the general picture is that the *nephrops* stock in the Kattegat and Skagerrak (Division IIIa) is not overexploited, although it suffers from substantial discarding problems.

Figure 4.1.2 Nephrops in the Skagerrak (Functional Unit 3); CPUE and LPUE of Swedish and Danish Nephrops trawlers (per hour trawling for Sweden and per day trawling for Denmark)



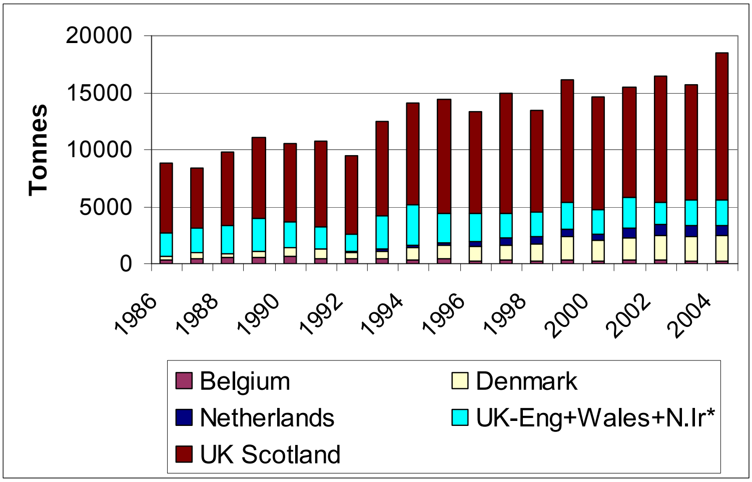
Source: ICES, WGNSSK Report 2005, Table 14.7 and 14.8

4.1.1.2. The North Sea

Scotland, part of the UK, is by far the most important player in the North Sea with landings in recent years at around 10,000 tonnes. This is, on average, two-thirds of the landings over the last decade. England and Denmark are of almost equal importance with around 2,000 tonnes each (around 25% combined), while the final 8% is taken by eight different countries with the Netherlands and Belgium as the most important in that group.

Scottish landings have doubled over the last twenty years, while the Danish have quadrupled and English landings have been stable, see Figure 4.1.3.

Figure 4.1.3. Nominal landings (tonnes) of Nephrops in Division IV, 1986-2004 as officially reported to ICES

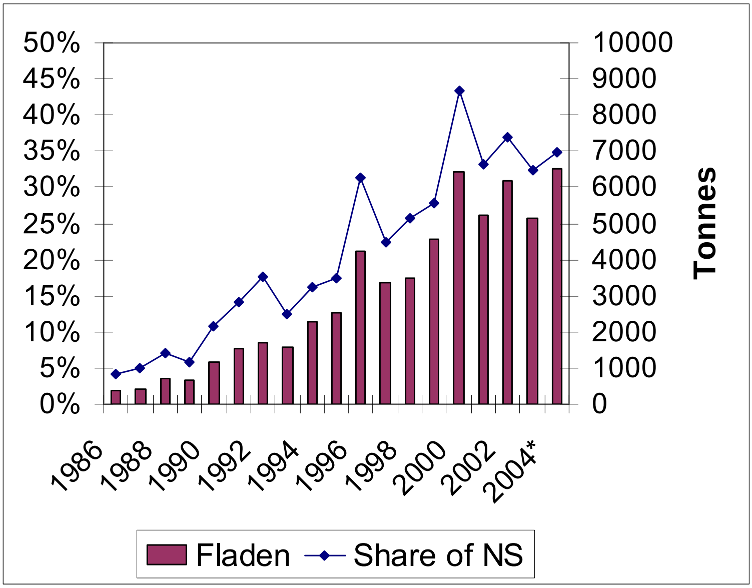


Source: ICES, WGNSSK Report 2005, Table 14.14

4.1.1.2.1. The Fladen Ground

Landings of *nephrops* from the Fladen Ground have increased substantially over the last two decades almost entirely due to increased Scottish landings from that area, see Figure 4.1.4. The Scottish landings increased from around 400 tonnes in the beginning of the 1980s to around 8,000 tonnes in recent years. This means that most of the recorded increase in Scottish landings of *nephrops* has taken place from the Fladen Ground.

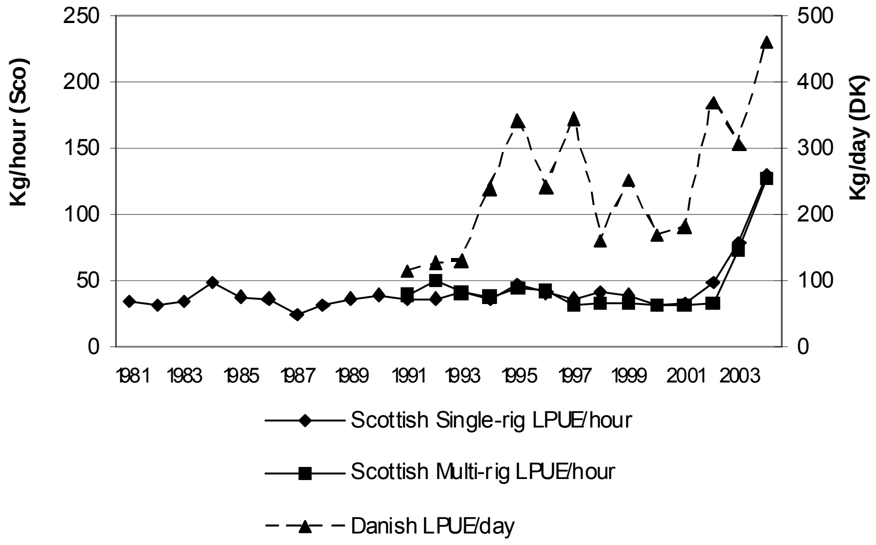
Figure 4.1.4. Landings from the Fladen Ground (right hand axis) and the share of the total landings from the North Sea (left hand axis)



Source: ICES, WGNSSK Report 2005, Table 14.14 and 14.26

Stock assessment relies on the LPUE for the Fladen Ground. Hence, the Scottish figures are particularly important because of the developments in that fishery, see Figure 4.1.5. Disregarding the final two years, landings per hour trawling average 37kg with a standard deviation at around 5kg. Single rig and multi-rig have shown similar tendencies. The Danish figures are based on much smaller landings and effort, and show substantial variation. The main conclusion, however, seems to be that the stock is not overexploited.

Figure 4.1.5. Nephrops from the Fladen Ground (Functional Unit 7): LPUE (kg/hours trawling of Scottish Nephrops trawlers and kg/days trawling of Danish trawlers)

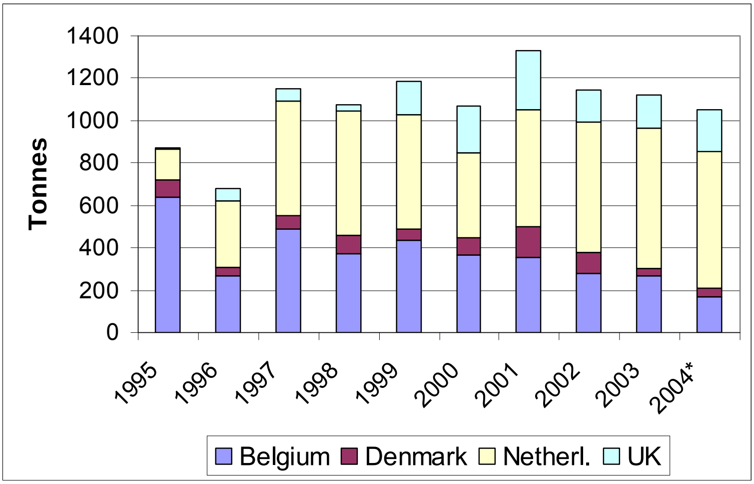


Source: ICES, WGNSSK Report 2005, Table 14.27 and 14.28

4.1.1.2.2. Botney Gut and Silver Pit

The landings recorded from Botney Gut and Silver Pit constitute around 1000 tonnes in total. The Netherlands accounts for around two-thirds of that, see Figure 4.1.6. Over the last decade, Dutch and British landings have expanded while Belgium has suffered a decline.

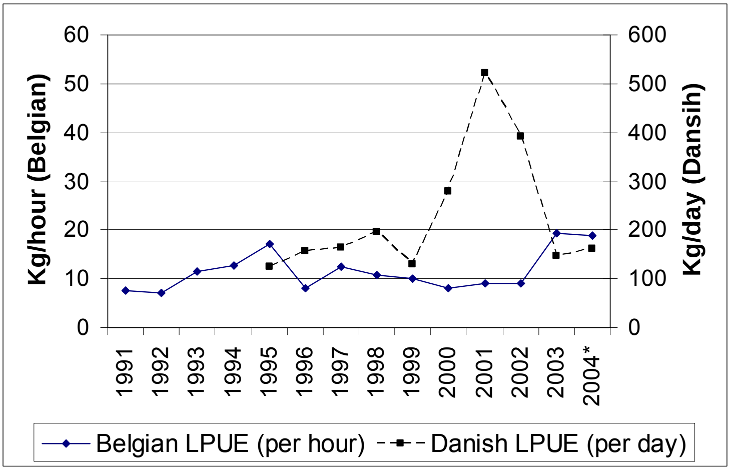
Figure 4.1.6. Nephrops Botney Gut and Silver Pit (Functional Unit 5): landings (tonnes) by country, 1991-2004



Source: ICES, WGNSSK Report 2005, Table 14.47

Landings per unit effort (LPUE) are reported by ICES for Belgian and Danish vessels for Botney Gut, see Figure 4.1.7.

Figure 4.1.7. Botney Gut - Silver Pit (Functional Unit 5): Landings (tonnes), effort (000hours trawling and LPUE (kg/hours trawling) of Belgian Nephrops trawlers, 1991-2004



Source: ICES, WGNSSK Report 2005, Table 14.48 and 14.49

4.1.2. Fleets, costs and earnings.

4.1.2.1 Landings composition

For the Cost-Benefit calculations, it is important to know the catch composition, preferably in each individual haul. Such information is not readily available. From aggregate information published in the Annual Economic Report (AER) some information can be derived. From an economic point of view, only landings count, while discards, to a lesser extent, only affect costs of fishing. Because of the regulations, *nephrops* were caught in directed fisheries using 70mm mesh size or above, together with a number of other species for which landings are allowed. In the baseline period for the calculation, 2002 to 2004, a directed fishery for *nephrops* using 70 to 100mm in the North Sea and 70 to 90mm in the Kattegat and Skagerrak has taken place at certain times while larger meshes have been used in other periods in fishing directed towards cod, haddock and saithe, etc.

Information available at the trip level shows a landing composition broadly dispersed across *nephrops*, members of the cod family, and flatfish. With the changes in the rules from 2005 fishermen have abandoned smaller mesh sizes and use 100mm (90mm) or above. This change removes restrictions on them in terms of target species.

The importance of *nephrops* for Denmark, Sweden and the United Kingdom is shown in table 4.1.1 extracted from the AER. *Nephrops* are important in all countries with 10%, 8% and 12% respectively, measured in value in the baseline period, 2002 to 2004.

In the Danish case, no single fleet segment is particularly dependent on *nephrops* as identified in the statistics in the AER. The 24 to 40m trawler segment targets *nephrops* mainly in the North Sea and Skagerrak.

Table 4.1.1 Share of Nephrops of total landings

	Value Average 2002 to 2004	Volume Average 2002 to 2004
Denmark: National fleet,	10.2%	0.4%
Denmark: Trawlers 24 - < 40 m	11.5%	0.3%
Denmark: Trawlers < 24 m	30.2%	2.5%
Sweden: National fleet,	7.9%	0.3%
Sweden: *Nephrops* trawlers	66.6%	37.7%
Sweden: Cod trawlers < 24 m	7.9%	1.8%
United Kingdom: National fleet	12.5%	4.5%
UK: Northern Irish *Nephrops* trawlers		74.5%
UK Scottish *Nephrops* trawlers		61.8%
UK: Scottish demersal trawlers < 24 m		25.0%

Source: AER

For the two Danish trawler segments, the industrial fishery (for fish-meal and -oil) is conducted in a way that does not affect *nephrops*. The inclusion of the industrial fishery in the data presented in Table 4.1.1 shows, however, the importance of the industrial fishery for the Danish trawlers. Other fish are herring and mackerel, and a large number of species for which no stock information exists. *nephrops* are targeted together with roundfish and flatfish.

A problem regarding the aggregate data available is that discards of over- and undersized fish and fish that have contact with the gear in the water but escape, are poorly covered if covered at all. The calculations which follow disregard these problems i.e. the calculations are based on information covering age-groups one and above. The gear impact on age-group zero is disregarded. Therefore, an implicit assumption is that no changes in the zero age-group occur as a consequence of the gear change.

4.1.2.2. Economic performance of fleets, dependent on *Nephrops*

From the AER, seven fleet segments particularly dependent on *nephrops* from Denmark, Sweden and the United Kingdom are identified and key economic indicators for these segments are presented in Table 4.1.2 for Denmark, the segments are chosen according to length, while for Sweden and the UK the length groups have been further subdivided according to the most important species in the landings composition.

Table 4.1.2. Main economic indicators for fleet segments particularly dependent on Nephrops

	Value of landings	Crew share	Gross cash flow	Net profit	Gross value-added
Denmark					
Trawlers 24 - < 40 m	74	27	4	-21	31
Trawlers < 24 m	81	42	-1	-17	41
Sweden					
Nephrops trawlers	6	2	0	0	2
Cod trawlers < 24 m	14	3	3	3	0
United Kingdom					
Scottish/N. Irish *Nephrops* trawlers	14	2	1	0	3
Scottish *Nephrops* trawlers	66	12	5	-4	17
Scottish demersal trawlers<24m	61	15	16	1	-10

Tabel 4.1.2.. Cont...

	Employment on board (FTE)	Invested capital (€m)	Effort (000 days at sea)	Volume of landings (000t)	Fleet - number of vessels	Fleet – total kW (000)
Denmark						
Trawlers 24 - < 40 m	633	147	26	368	118	70
Trawlers < 24 m	988	115	63	136	370	82
Sweden						
Nephrops trawlers	114	14	9	1	67	15
Cod trawlers < 24 m	178	40	10	9	74	23
United Kingdom						
Scottish/N. Irish *Nephrops* trawlers	312	12	15	7	89	20
Scottish *Nephrops* trawlers	961	83	43	14	289	44
Scottish demersal trawlers<24m	850	108	34	32	181	54

Source: AER

Nephrops constitutes around 10% of the total value of Danish landings, and the two selected fleet segments take around 95% of these. In Sweden, *nephrops* constitute a little less than 10% of the total value of landings with a declining trend. The two selected fleet segments take around 75% of the Swedish total. In the United Kingdom *nephrops* constitutes around 13% of the total value of landings, while the three selected fleet segments take around 75% of them.

Further incomplete information is available for two segments, one from France using pots and one from Ireland using trawl.

4.1.3. CBA projections and results

The cases investigated are one with a 90mm mesh size and one with a 90mm mesh including a 120mm window in the upper part of the cod-end of the trawl. The design of the trawl and the placing of the panel are intended to be neutral with respect to *nephrops* i.e. no changes in selectivity or catches are assumed for this species. Further, it is assumed that landings of all other species except cod and plaice (as well as *nephrops*) are constant. This latter assumption is made because of lack of data for other species, either with respect to published stock assessments from ICES or selectivity information from the trials.

The cost-benefit model applied to these cases is the most extensive version including the economics and stock dynamics. The base year is chosen to be 2003 to dovetail the economics and the biological assessments published in ICES reports, in a year in which gear changes in term of panels or windows had not yet been implemented.

The Danish fleet of trawlers below 24m in length has been subdivided into three to make a total of four segments. Danish vessels below 12m and above 40m in length do not target *nephrops*. For these segments, costs and earnings data are available and are shown in Table 4.1.3. The value of landings comprises all species caught. The variable costs comprise fuel, ice, provisions, landing and sales costs. The gross margin is calculated as the difference between landings and variable costs, and this measure forms the basis for the net present value calculated in the cost-benefit analysis.

Table 4.1.3. Costs and earnings for Danish vessels at vessel level, Base year 2003, €000

Length	Landings value	Variable costs*	Gross margin	Labour costs	Margin**
12-15m	144	65	79	89	-10
15-18m	213	100	113	111	2
18-24m	404	191	213	186	27
24-40m	691	374	317	253	64

* Before remuneration of labour and capital
** Before remuneration of capital
Source: Costs and earnings statistics, Institute of Food and Resource Economics

Total landings and the shares of *nephrops*, cod and plaice are shown in Table 4.1.4 for these segments. Note that *nephrops*, cod, and plaice are less important in terms of weight while they are very important in terms of value, not least for the smaller vessels. This picture is influenced by the fishery for industrial species that is prosecuted by the larger vessels as part of their yearly fishing pattern. Other important species in the catch composition are sole, anglerfish and haddock. There are no recorded selectivity measures for these species, however, from the trials. Therefore, they are omitted from Table 4.1.4 and included in the group “other species”.

The figures are averages covering all trawl types and different mesh sizes. The landings composition reached by use of 70 to 90mm meshes is different from the landings composition for mesh sizes above 90mm. Therefore, vessels using different mesh sizes for most of the year are affected differently. This path, however, is not pursued here.

The unit prices shown in Table 4.1.4 are further disaggregated (see Table 4.1.7) with the purpose of including the price effects emanating from changes in catch compositions as a result of gear changes.

Table 4.1.4. Landings composition for Danish vessels, Base year 2003

Weight Fleet segment Length	*Nephrops*	Plaice	Cod	Other species	Total (tonnes)
12-15m	13%	7%	20%	60%	6,478
15-18m	4%	3%	12%	81%	23,650
18-24m	3%	5%	7%	85%	44,996
24-40m	3%	5%	3%	89%	33,559
Value Fleet segment Length	***Nephrops***	**Plaice**	**Cod**	**Other species**	**Total (€000)**
12-15m Total	52%	8%	22%	17%	11,258
15-18m Total	38%	7%	25%	29%	19,615
18-24m Total	30%	12%	17%	41%	34,426
24-40m Total	25%	8%	9%	58%	38,181
Unit price in € Fleet segment Length	***Nephrops***	**Plaice**	**Cod**	**Other species**	
12-15m Total	7.17	1.94	1.96	0.50	
15-18m Total	7.29	2.06	1.77	0.30	
18-24m Total	7.08	1.84	1.87	0.37	
24-40m Total	10.65	1.98	3.10	0.74	

Source: The Danish Fisheries Directorate, The DFAD database, Vessels with landings of *nephrops* from the Kattegat or Skagerrak.

To apply the selectivity model, shown in Equations (5) to (10) above, as part of the CBA, a series of biological data are required of stock composition by age-groups in the base year, natural mortality, fishing mortality, length and weight of the fish. The data used are extracted from ICES reports (ICES WGBFAS 2006 for cod, and ICES WGNSSK 2005 for plaice), see table 4.1.5.

Recruitment for cod is taken as the average recruitment from 1980 to 2004 at age one, which is 9.864 million with a maximum at 20.984m and a minimum at 0.894m. Natural mortality for all age-groups is 0.2.

Recruitment for plaice is taken as the average recruitment from 1978 to 2004 at age two, which is 51.008m. Estimated maximum recruitment was 134.6m and the minimum 25.7m. Natural mortality for all age-groups is 0.1.

As noted earlier, this type of information does not allow us to account for what happens to the fish that have gear contact but are not brought on board. Nor is the impact of discarding under- and oversized fish included. These issues could be dealt with in sensitivity analyses and qualitative statements concerning in which direction the net present value will move.

Table 4.1.5 Starting parameters (2003) to the biological projection model for the Kattegat and Skagerrak

	Cod			Plaice		
Age-group	Fishing mortality at age	Stock numbers at age (thousands)	Weight at age (kg) in the catches	Fishing mortality at age	Stock numbers at age (thousands)	Weight at age (kg) in the catches
1	0	894	0.55			
2	0.361	3100	0.7	0.0276	134646	0.243
3	0.9817	991	1.37	0.1732	30982	0.252
4	1.0569	305	2.46	0.3534	32129	0.271
5	0.8941	120	3.75	1.1027	14602	0.29
6	0.5172	33	5.92	2.4976	4960	0.298
7	0.8094	8	7.84	2.0876	1163	0.4
8(+)	0.8094	0	10.89	2.0653	166	0.464
9				0.7004	40	0.605
10				1.4661	15	0.642
11(+)				1.4661	7	1.29

Note: 8(+) and 11(+) contains values for age 8 and 11 onwards for cod and plaice respectively

As the gear selectivity is a function of the length of the fish while the available information is on weight of the fish (cf. Table 4.1.5), a transformation from weight to length is accomplished by use of Equation (7). Table 4.1.6 contains information about parameters to Equation (7), and

$$w = c * a * l^b,$$

where w is round (live) weight and c is the adjustment parameter from gutted to round weight. The parameters are estimated for the North Sea and are used for the Kattegat and Skagerrak because of lack of information from those areas.

Table 4.1.6 Estimated weight to length parameters for North Sea cod and plaice

	Cod	Plaice
a	0.0175	0.0215
b	2.8571	2.7901
c	1.17	1.07

Source: Coull, K.A., A.S. Jermyn, A.W. Newton, G.I. Henderson, and W.B. Hall (1989)

Prices recorded in Table 4.1.4 are average prices for all size (and age) groups. The average price will, however, change once the size composition in the landings changes. To capture this effect the model applied is an age-structured model. Recorded prices are published according to grade and quality. Here, quality differences are disregarded. The average weight of the fish in each grade is known, and, based on the average weight in each age-group, prices are transformed to price by age-group. Prices according to size grade are shown in Table 4.1.7.

Table 4.1.7 Prices of cod and plaice according to grade, 2003

	------------------------ Cod	--------------------------		------------------------ Plaice	--------------------	
Grade	Kg per fish	€ per kg	Relative Price	Kg per fish	€ per kg	Relative Price
1	>=7	4.60	2.33	>= 0.6	2.28	1.19
2	4-7	3.48	1.76	0.4-0.6	2.15	1.12
3	2-4	2.85	1.44	0.3-0.4	2.08	1.08
4	1-2	1.97	1.00	0.15-0.3	1.92	1.00
5	0.3-1	1.51	0.76			

Source: Danish Fisheries Directorate and Council Regulation (EC) No 2406/96 of 26 November 1996 laying down common marketing standards for certain fishery products.

The majority of landings, around 70%, are recorded as Size Grades 4 and 5 for cod, and as Grade 4 for plaice, representing around 50% of landings by weight. The price differences between grades are quite substantial as shown in Table 4.1.7. For cod, Grade 1 received 2.33 times the price per tonne of Grade 4. For plaice, the difference is smaller. It also varies over time. It is therefore to be expected that lowering the fishing mortality on the younger age-groups will result in substantial price effects.

In Table 4.1.8 the prices applied are shown according to age-group, weight and length. It should be noted that the minimum landing size in Demark for cod from the North Sea and the Skagerrak is 40cm and 35cm from the Kattegat, while the EU minimum size is 35cm and 30cm respectively, see Table 3.5. For plaice the minimum landings size in Denmark is 27cm in the North Sea, Kattegat and Skagerrak, while the EU minimum is set at 22cm for the North Sea.

Table 4.1.8 Prices transformed from size grade to age-group, weight and length, 2003

	Cod			Plaice		
Age-group	Weight (kg)	€ per kg	Length (cm)	Weight (kg)	€ per kg	Length (cm)
1	0.55	1.50	35			
2	0.7	1.50	39	0.243	1.6	28
3	1.37	1.97	49	0.252	1.6	28
4	2.46	2.84	60	0.271	1.6	29
5	3.75	2.84	70	0.29	1.6	29
6	5.92	3.47	82	0.298	1.9	30
7	7.84	4.59	90	0.4	2.3	33
8 (+)	10.89	4.59	101	0.464	2.3	35
9				0.605	2.4	38
10				0.642	2.4	39
11(+)				1.29	2.4	50

With reference to Table 4.1.8 under the Danish national regulations no cod in age-groups 1 and above must be discarded, and none of the plaice must be discarded.

The 40 cm Danish minimum mesh size for cod in the North Sea and Skagerrak is disregarded in the CBA. The reason is that the calculations are performed for a base case and a case with gear changes. Both cases include all the age-groups listed in Table 4.1.8 The effect of that is, however, that the positive impact of a gear change will be underestimated because the largest fall in landings in the first years after a gear change will relate to age-group one.

Cod, plaice and other species are caught by using a variety of gear types, in particular gill-nets and trawls. It is assumed the fishing mortality induced by gill-nets is unchanged, and the impact on fishing mortality caused by changes in the trawl fishery is partitioned according to the trawlers' share of the total landings of these species in the

Kattegat and Skagerrak. The trawlers' share appears in Table 4.1.9, and the figures for the Kattegat have been chosen for use in the CBA calculations.

Table 4.1.9 Trawlers' shares of cod and plaice in the Kattegat and Skagerrak, 2003

	Cod		Plaice	
	Total (tonnes)	Trawlers as a % of Total	Total (tonnes)	Trawlers as a % of Total
Skagerrak	3066	43.9%	4846	38.8%
Kattegat	1444	58.9%	2036	34.2%
Total	4510	48.7%	6882	37.4%

Finally, it is assumed that the gear changes are introduced for all countries at the same time. If that were not the case, the fishing mortality rates would have to be adjusted according to the Danish share of the total landings. In the Kattegat and Skagerrak, Danish landings constitute around two-thirds of the cod and 85% of the plaice.

The selectivity data are taken from the trials executed for Tasks 3.2 and 3.3 (see Table 4.0). Estimates are obtained for *nephrops*, cod, plaice, whiting, and witch. The trial period was autumn 2005. The estimates are preliminary and are used for cod and plaice but disregarded for *nephrops*, whiting, and witch. For *nephrops*, no stock estimates based on age-structures are available, and the same is true of whiting and witch, though they are of less importance. Therefore, landings of these species are assumed unaltered after a gear change. The selectivity parameters for cod and plaice are shown in Table 4.1.10.

Table 4.1.10. Input data from the selectivity trials for cod and plaice in the Kattegat and Skagerrak (Area IIIa)

	Cod		Plaice	
Range *r* (cm)	6.97	10.93	2.49	11.34
Selection l_{50} (cm)	23.02	27.05	21.91	18.5
Mesh size (cm)	9	9(12)	9	9(12)

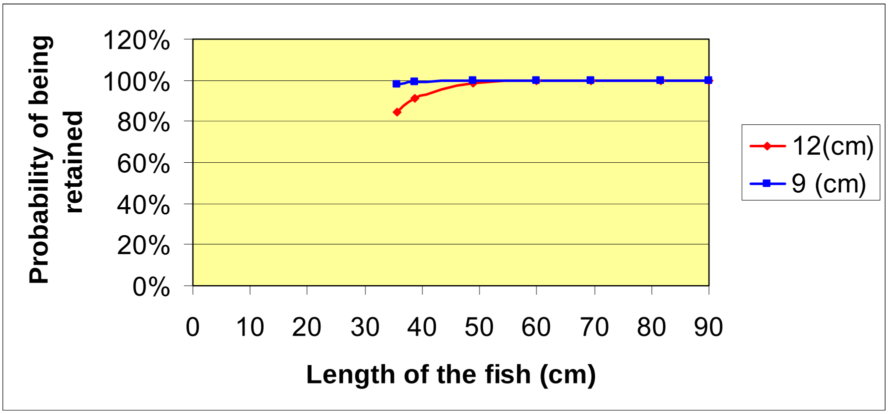
Source: The Danish NECESSITY trial team

A LOGIT function has been used to calculate the probability of retention (Equation (6)). The following shortcomings of the procedure should be noted. The selectivity estimates refer to a short period of time, a specific fishing ground and a certain vessel. The estimates form the basis for scaling up to the entirety of the fish stocks and fleet operations in the area. Therefore, the results from the CBA are vested with considerable uncertainty. The consequences of this are investigated by applying sensitivity analysis.

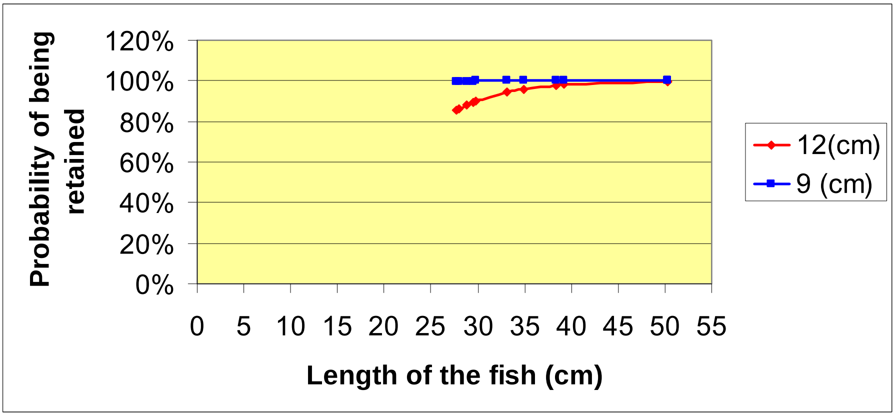
Selectivity ogives are calculated and presented in Figure 4.1.8. The ogives are shown for age-groups 1 and upwards for cod and age 2 and upwards for plaice. This implies that the effect of the gear change on the 0-group for cod and 0- and 1-groups for plaice is disregarded. As no information is recorded for younger age-groups, their inclusion would require the use of estimates, for example, from a von Bertalanffy function, see Equation (8) in Section 1.

Figure 4.1.8. Selectivity curves for the Kattegat and Skagerrak trials

Cod



Plaice



Source: the Danish NECESSITY trial team

Applying the change in selectivity to the biological projection model, see Table 4.1.10, the changes between the baseline and the case with a 120mm square-mesh panel are shown in Figure 4.1.9 for cod and plaice in value and in weight. For example, after 2011 when landings stabilise, the value of landings of cod is nearly 2% higher than the baseline figure.

Figure 4.1.9 Projected changes in landings of cod and plaice with a 120mm square-mesh panel

It is noted that the change in value is stronger than the change in weight for both species reflecting that the unit price increases in the long-run owing to a change in the composition of landings towards older and larger fish that fetch a higher price. There is a small fluctuating decrease in cod landings in the beginning of the period, and a large decrease in plaice landings. The calculations are based on ICES stock assessments, which entails the uneven age composition witnessed in 2003. This is reflected in the beginning of the projection period. After seven years, the system approaches an equilibrium, where there will be little tendency to change.

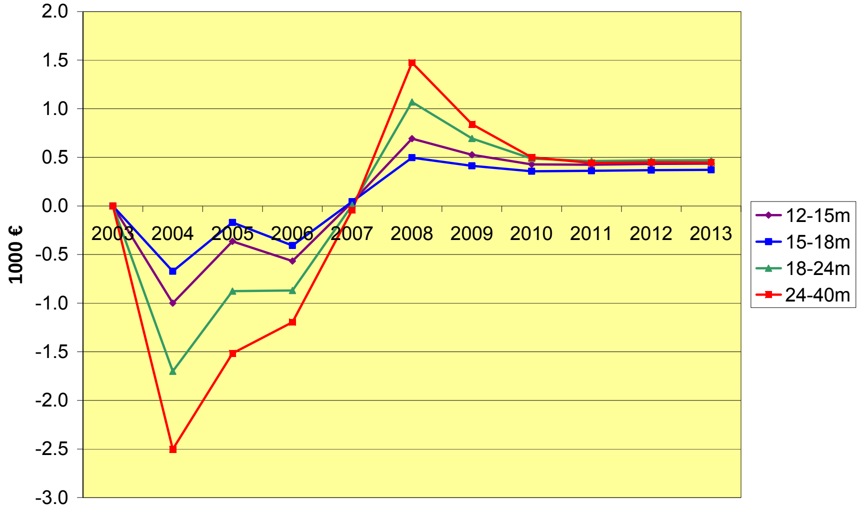
4.1.4. Results for Danish *Nephrops* trawlers fishing in ICES Sub-Area IIIA

The comparison of the base case, i.e. without gear change, with the case of a gear change has been performed using Equations (1) to (4). A number of simplifying assumptions have been made which are summarized below:

H: landings are constant for all species except cod and plaice
P: fish prices are constant for all species except cod and plaice, where price is a function of size grade
C: variable costs are kept constant
G: fixed costs are kept constant
V: external effects (net) are disregarded i.e. for example, discards are not con sidered ecologically or ethically harmful.
U: management costs (information gathering, administration, monitoring, con trol and enforcement) are kept constant
I: investments costs in gear are assumed to be the same with and without gear change
D: the discount rate is fixed at 5%
T: the time horizon is fixed at 10, 20, and 30 years

Results from this run are shown in Figure 4.1.10 for the difference in gross revenue between the gear change case and the base case. As it is assumed that only one gear type is used, the impact of the gear change on the larger trawlers is the strongest. This is caused by the relatively higher share of cod and plaice in these trawlers' landings. The projection is shown for 10 years. This period is long enough to enable the stock to reach biological equilibrium, as constant recruitment and mortality rates are assumed.

Figure 4.1.10. Changes in gross revenue at the vessel level



As a consequence of the cost assumptions, the indicator used to calculate net present value is the gross margin, defined as gross revenue minus variable costs exclusive of crew share. In fact, the decision rule would make the same choice of case even if the NPV of gross revenue was used. The results are presented in Table 4.1.11.

Fishermen will emphasise the importance of the short period, 10 years, and probably less, while society will place greater stress on the 20- to 30-year periods. The results show that not all fishermen might accept society's view. At the fleet segment level, smaller vessels will benefit over 10 years while the larger ones would not. Over a long time horizon of 20 to 30 years all segments will benefit.

Table 4.1.11. Net present value (NPV) over 10, 20 and 30 years

	Vessel level			Segment level				
Length	10	20	30	Length	No. of vessels	10	20	30
		€000					€000	
12-15m	0.5	2.5	3.8	12-15m	86	39	217	326
15-18m	0.7	2.4	3.5	15-18m	84	55	203	294
18-24m	-0.4	1.8	3.2	18-24m	96	-42	172	304
24-40m	-1.7	0.4	1.7	24-40m	61	-106	24	104

NPV=gross revenue minus variable costs (before remuneration of labour and capital)

The direction in which the NPV would move as a result of changes in the assumptions is shown in Table 4.1.12. It is to be expected that the fishermen will minimise their costs but a gear change would lead to cost increases.

Table 4.1.12 Impact of assumptions

	NPV increase	NPV decrease
C: variable costs increase		X
G: fixed costs increase		X
V: external effects (net) positive	X	
U: management costs increase		X
I: investments costs in gear increase		X
D: the discount rate increase		X
Broader design of analysis to include gill-net and seine	X	

As all costs are kept constant throughout the period over which the NPV is calculated, cost increases will lead to lower net present values and therefore to less incentive to accept gear changes. External effects are of little interest to the fishermen, but are of concern to society. If a higher value is placed on them, the NPV will increase from society's point of view.

A discount rate of 5% is applied, which is a level used in many public projects, but it is considered high, for example, compared to HM Treasury's (United Kingdom) recommendation at 3.5%. On the other hand, surveys indicate that the private discount rate could be as high as 20%.

The general conclusion is that, from society's point of view, the appositive effect of introducing a 120mm square-mesh panel in *nephrops* trawls cannot be rejected. There is a positive net present value for periods longer than 10 years, and below ten years positive effects arise for small vessels, while negative effects emerge for larger vessels. It has to be noted, however, that it is assumed that landings of *nephrops* will remain unchanged, while for cod and plaice together, a positive effect will occur. Other demersal species are assumed to remain unchanged between the baseline and the case with gear changes.

The effects are small and most sensitivity analyses regarding the trawl fishery tend to influence the net present value negatively. An instant positive effect for gill-netters and seiners, that are very dependent on cod and plaice, will occur. This effect is not evaluated in the project.

References

AER, Concerted Action, *Economic performance of selected fishing fleets.* Annual report from the Concerted Action (Q5CA-2001-01502) Economic Assessment of European Fisheries, 2004, ISBN 90-5242-958-8. http://www3.lei.wur.nl/ca/

4.2. Aran, Clyde, Farn, and Irish Sea

The trials concerning *nephrops* caught in Aran, Clyde, Farn Deeps and Irish Sea (Smalls) grounds are shown in Table 4.0. The location of *nephrops* grounds in the North Sea is illustrated in Map 4.0.

4.2.1. Landings

It is suggested that, for the North Sea as a whole, the abundance of *nephrops* has generally been increasing in recent years (ICES 2006). A general overview of the North Sea *nephrops* fisheries has already been provided in Section 4.1.1.2 and covers, in particular, the important Fladen Ground (Functional Unit 7) situated in Area IVa. Below we present an overview focusing primarily on the Farn Deeps, the most significant *nephrops* ground in ICES Area IVb.

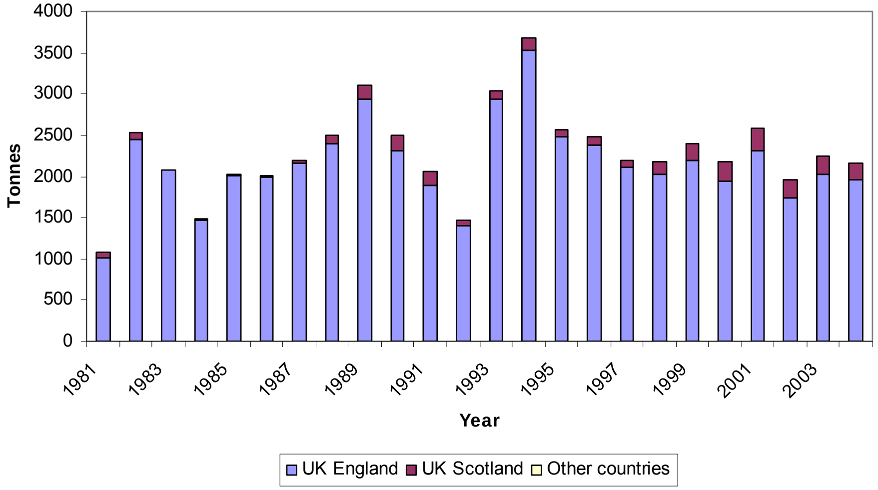
4.2.1.1. Farn Deeps

Nephrops from the Farn deeps appear to be exploited at a sustainable level (ICES 2006) and in the decade leading up to 2004 landings have tended to fluctuate between 2,000 and 2,500 tonnes (Figure 4.2.1.). Analytical stock assessments are not undertaken, so TV surveys, CPUE and LPUE are used in their place. All signs currently indicate the stocks are healthy (ICES 2006). Landings from the other significant ground in Area IVb, the Firth of Forth (Functional Unit 6), tended to fluctuate between 1,500 and 2,000 tonnes over the same period and it is believed this ground is also currently fished at a sustainable level (ICES 2006).

Landings from the Farn Deeps have historically been dominated by English vessels. These have taken an average 92% of the area's total annual landings over the last decade, the remaining 8% being taken almost entirely by Scottish vessels. Farn Deeps *nephrops* landings accounted for 54% of all such landings by UK vessels from the four Functional Units[3] in Area IVb in 2004 (ICES 2006). The Firth of Forth accounted for a further 41% in the same period, almost 100% of which were taken by Scottish vessels (Figure 4.2.2).

[3] The Functional units (FUs) in Area IVb consist of; FU 5, Boney Gut/Silver Pit; FU 6, Farn Deeps; FU 8, Firth of Forth; and FU 33, Off Horne Reef.

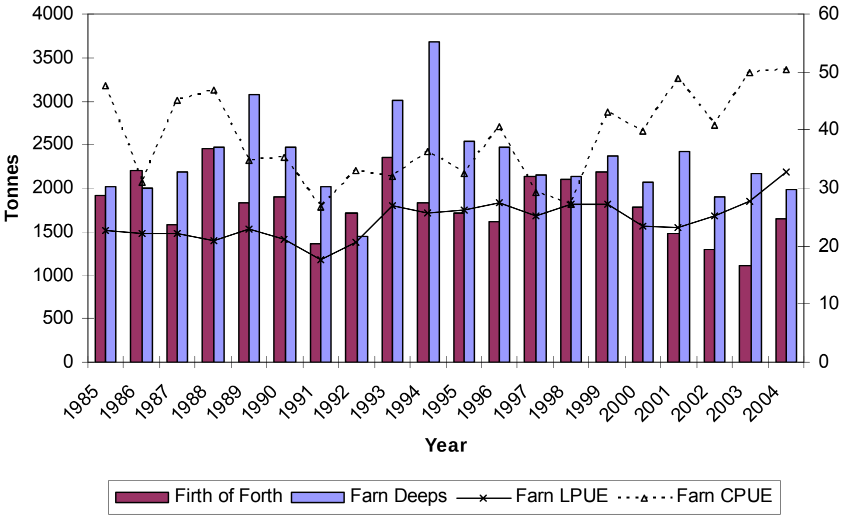
Figure 4.2.1. Nominal landings of *Nephrops* (tonnes) from the Farn Deeps (Functional Unit 6) by country, 1981 to 2004



Source: ICES, WGNSSK Report 2006, Table 3.4.4.2

ICES calculates CPUE and LPUE for the Farn Deeps in terms of catches and landings per hour of trawling (kg/hr^{-1}) (UK vessels) using logbook data (Figure 4.2.2.). Neither of the measures indicates overexploitation, both tending to show an upward trend. CPUE and LPUE in 2004 were the highest on record at 50.3 and 32.7 kg/hr^{-1} of trawling, respectively. Provisional figures for 2005 were even higher at 56.7 and 38.7 kg/hr^{-1}.

Figure 4.2.2 *Nephrops* landings and LPUE from the Farn Deeps (UK *Nephrops* trawlers) and the Firth of Forth (Scottish vessels) 1985 to 2004.



Source: ICES, WGNSSK Report 2006, Tables 3.4.4.8 and 3.4.4.4

4.2.2. Fleets, costs and earnings

The 2005 economic survey of the UK fishing fleet (Anderson et al 2007) provides average and total figures for *nephrops* vessels operating in the North Sea, West of Scotland and Irish Sea (see Tables 4.2.1 and 4.2.2, respectively). These indicate that UK *nephrops* vessels operating in the North Sea earned more on average than those operating off the West of Scotland, with those in the Irish Sea earning least. The UK North Sea *nephrops* segments have also seen large increases in the level of profit they have made since 2001. The survey reports that in 2005 single- and twin-rig vessels made average profits of approximately £43,000 (€63,000) and £87,000 (€128,000) (before depreciation and interest), respectively. More-detailed information relating to area of capture and composition of landings is unknown for these vessels and as such cannot be directly employed in the analysis. However, assuming these vessels are representative of nephrops vessels for the areas to which they pertain they provide some insight into the differing cost structures.

Table 4.2.1 Average costs, earnings and vessel characteristics, UK vessels in 2005

Segment		Fishing income[a]	Non-fishing income[a]	Crew share[a]	Gross cash flow[a]	Net profit (after depreciation & interest) [a]	Gross value-added[a]	Days fished in 2005	Volume of landings (tonnes)	Vessel power (kW)	Average length (m)
North Sea	*Nephrops* trawl	234	12	68	59	19	126	165	98	253	16
	Nephrops twin rig trawl	385	19	102	114	47	216	176	152	371	20
West of Scotland	*Nephrops* trawl	103	2	33	19	13	52	156	35	166	15
	Nephrops twin rig trawl	196	18	54	61	21	115	186	66	261	17
Irish Sea	*Nephrops* trawl	93	11	27	16	16	44	148	61	187	16
	Nephrops twin rig trawl	154	16	53	29	6	81	179	97	316	19

[a] £000 s

Source: Anderson et al, 2007

Table 4.2.2 Total costs, earnings and segment characteristics, UK vessels in 2005

Segment		Total vessel population	Active vessel population	Fishing income[a]	Crew share[a]	Gross cash flow[a]	Net profit (after depreciation & landings[a]	Gross value-added[a]	Days at sea[b]	Volume of landings (000 tonnes)	Power kW s[b]
North Sea	*Nephrops* trawl	133	130	30.40	8.70	7.60	2.40	16.30	21.4	12.7	32.9
	Nephrops twin rig trawl	55	55	21.10	5.60	6.20	2.60	11.30	9.6	8.3	20.4
West of Scotland	*Nephrops* trawl	133	130	13.30	4.20	2.40	1.60	6.70	20.3	4.5	21.6
	Nephrops twin rig trawl	26	26	4.90	1.30	1.50	0.50	2.80	4.6	1.6	6.5
Irish Sea	*Nephrops* trawl	62	61	5.60	1.60	0.90	0.90	2.60	8.9	3.7	11.4
	Nephrops twin rig trawl	34	31	4.70	1.60	0.80	0.10	2.50	5.5	3	10.1

[a] £m, [b] 000 s

Source: Anderson *et al*, 2007

4.2.3. CBA projections and results

The purpose of this study has been to undertake a CBA that considered the effects of vessels currently targeting *nephrops* taking up modified fishing gear in an effort to reduce the associated whitefish by-catch. This is considered against a baseline of 'business as usual' where vessels continue to operate employing their current gears with catches fixed at the level observed in the base year (i.e. positive or negative increments to revenues and costs as a direct result of the adoption of the novel gear). This negates the need for full costs and earnings data relating to the *nephrops* fleet (as all other costs are assumed constant).

Cases 3.5 (large-mesh escape panel) and 3.6 (cutaway trawl) have been considered; 3.8 was not undertaken. Sea trials for Case 3.5 were originally conducted west of Scotland, as outlined in Table 4.0. However, more-comprehensive data was later obtained from additional trials in the North Sea. Case 3.6 was also conducted in the North Sea (Farn Deeps). Each trial applied a different combination of gear modifications. Case 3.5, the CEFAS/SFIA trial, compared a 'standard' commercial trawl (85mm cod-end mesh) and a 'cutaway trawl' that used a cod-end mesh of 80mm, a 90mm square-mesh panel and a section of 200mm diamond mesh fitted to the upper panels behind the headline (see Revill *et al,* (2006) for full gear specification). Case 3.6, the FRS/BIM trial, compared; a 'EU standard' commercial *nephrops* trawl (80mm cod-end mesh); and trawl with 95mm cod-end with 100 open meshes and a 5m long 120mm knotless square-mesh panel (SMP) inserted 4m to 9m from the cod-line (see Kynoch *et al* (2006) for full gear specification).

Catch-comparison data obtained from the sea trials for Cases 3.5 and 3.6 were applied to observed landings by UK *nephrops* trawl vessels from Area IVb. Landings figures for *nephrops*, cod, haddock and whiting were obtained from the UK Marine and Fisheries Agency (MFA) for the years 2003 and 2005 and are used as base years in the analysis. *Nephrops* vessels were defined as those vessels using a minimum mesh size of 80mm where *nephrops* constitute over 30% of landings, following Annex I of EC Regulation 850/1998. This UK fleet was subdivided into four segments over 10m registered length, and one under 10m. A 24m to 36m category was initially considered, however, as the number of vessels exceeding 24m was very low an 18m to 36m category was used instead.

The initial cost of uptake relating to the new gears (i.e. the cost of adapting existing gears) is considered low and expected to be relatively inconsequential. The total cost of labour and materials for the gear tested in Case 3.6 was estimated at around £500 (€735) per vessel (Pers. comm. Ferro R.S.T, 2007). The frequency and cost of replacing the gear was also assumed to be in line with existing costs. Reductions in revenue were derived by estimating the value of whitefish 'by-catch' expected to be lost as a direct result of the trial gears' altered efficiency.

Landings, share and price of *nephrops*, cod, haddock and whiting for the base year of 2003 are shown in Table 4.2.3. From this, we can see *nephrops* are most significant in terms of both weight and value for all segments, especially the smaller vessels. It is, however, possible that in the case of <10m vessels this is more an artefact of logbooks not being mandatory for vessels of this size. In all but one case (10m to 12m) haddock is the next most valuable species landed, followed by cod and then whiting. Information on changes in selectivity relating to 'other' species such as sole or anglerfish was not available and therefore considered to remain constant. Highest average unit prices for *nephrops* are attained, first, by the largest vessels (18m to 36m) and secondly, the smallest (<10m). The price *nephrops* attain is strongly influenced by their quality at sale.

Table 4.2.3 Landings composition for UK Nephrops trawl vessels operating in Area IVb, base year 2003

Weight Vessel	Cod	Haddock	Nephrops	Whiting	Total (tonnes)
Length					
<10m	0.50%	4.22%	94.09%	1.20%	569
10-12m	4.71%	6.25%	86.49%	2.56%	722
12-15m	4.25%	9.34%	80.90%	5.51%	884
15-18m	7.13%	16.44%	67.56%	8.87%	1468
18-36m	5.66%	21.68%	61.43%	11.22%	2084
Value Vessel	**Cod**	**Haddock**	**Nephrops**	**Whiting**	**Total(€000)**
Length					
<10m	0.22%	1.22%	93.39%	0.18%	1907.03
10-12m	2.67%	2.20%	94.75%	0.38%	1853.71
12-15m	2.81%	4.07%	91.89%	1.22%	1994.70
15-18m	4.40%	6.12%	87.52%	1.96%	3497.62
18-36m	3.22%	4.63%	89.65%	2.49%	5511.09
Unit price in € Vessel	**Cod**	**Haddock**	**Nephrops**	**Whiting**	
Length					
<10m	1.48	0.97	3.50	0.50	
10-12m	1.46	0.91	2.81	0.38	
12-15m	1.50	0.98	2.56	0.50	
15-18m	1.47	0.89	3.09	0.53	
18-36m	1.51	0.56	3.86	0.59	

Source: UK Marine and Fisheries Agency (MFA)

The effect of uptake was estimated for each trial gear (Cases 3.5 and 3.6) against the base case of 'business as usual' in 2003 or 2005. Estimating the net present value (NPV) in each case required a number of assumptions to be made. Case 3.5 undertook trials on vessels of differing size and determined that the trawls' selectivity parameters were not significantly altered by vessel size (Revill et al 2006). It was therefore assumed the gear effects would be uniformly felt by all sizes of vessel within the fleet.

No significant difference in the landings of *nephrops* was observed in either set of trials. It is therefore assumed the trial gears are neutral with respect to the selectivity of this species (Revill et al 2006, Kynoch et al 2006). Furthermore, catch comparison data pertaining to each case resulted in the assumption that landings of all species except cod, haddock and whiting in Case 3.5 and whiting in Case 3.6 remain constant. Additionally we assume; the gear is adopted at the same point in time by all vessels; fixed costs are constant; unit prices remain constant; management costs are constant; the net external effects are constant; and a discount rate of 5% over a time horizon of 10, 20 and 30 years, with all benefits and costs assumed constant after the first 10 years. We also assume that all social benefits and costs are fully reflected in the private (i.e. economic) benefits and costs to the *nephrops* trawlers. Other social uses of the resource are angling or other non-use values associated with healthier whitefish stocks. This extends to not accounting for any subsequent changes in consumer surplus that may occur from increased whitefish landings.

Under the above assumptions, Scenario 1 considers the effects of expected reductions in whitefish by-catch on UK vessel revenue from nephrops in Area IVb, as indicated by the two sets of sea trials. A 5% discount rate is applied and no subsequent increase in whitefish landings, as a result of stock levels recovering, is allowed for (Table 4.2.4.). Sensitivity analysis is then performed by considering Scenario 1 under discount rates of 3.5, 7.5 and 10% (Table 4.2.6).

Scenario 2 develops 1 by allowing for a 0.5% year-on-year increase in the landings of whitefish to nephrops vessels for the first 10 years and no further change (above the 5% increase) thereafter (Table 4.2.5). Applying a uniform percentage value to expected landings after accounting for the new gear is somewhat simplistic but allows us to postulate on the potential compensatory effect to nephrops vessels from any whitefish stock recovery. The 0.5% increase is hypothetical but loosely based around estimates from studies relating to the cases. A range of year-on-year increases was then applied (1%, 2% and 5%) (Table 4.2.7).

The analysis was then repeated using a base year of 2005 and the same scenarios considered (see appendix for tables). Additionally, the trial gear NPV as a proportion of the business as usual NPV (assuming catch quantities, values and composition of the base year) was calculated and is reported in the results tables.

4.2.4. Results for UK vessels fishing in Area IVb

Table 4.2.4. Scenario 1: Net Present Value (NPV) over 10, 20 and 30 years, base year 2003

Case	Length	Vessel level (€000)			No. vessels	Segment level (€000)			Trial NPV as proportion of business as usual NPV		
		10	20	30		10	20	30	10	20	30
3.5 – large mesh escape panel	<10m	-1.71	-2.64	-3.20	88	-150.41	-231.89	-281.91	-0.90%	-0.90%	-0.90%
	10-12m	-7.62	-11.75	-14.29	40	-304.66	-469.98	-571.48	-1.88%	-1.88%	-1.88%
	12-15m	-21.88	-33.77	-41.06	29	-634.58	-979.21	-1,190.79	-3.65%	-3.65%	-3.65%
	15-18m	-46.04	-71.05	-86.41	37	-1,703.40	-2,628.97	-3,197.19	-5.58%	-5.58%	-5.58%
	18-36m	-32.84	-50.68	-61.64	72	-2,364.29	-3,649.07	-4,437.82	-4.92%	-4.92%	-4.92%
3.6 – cutaway trawl	<10m	-0.17	-0.26	-0.32	88	-15.02	-23.19	-28.20	-0.09%	-0.09%	-0.09%
	10-12m	-0.78	-1.20	-1.46	40	-31.11	-48.01	-58.39	-0.19%	-0.19%	-0.19%
	12-15m	-3.70	-5.70	-6.94	29	-107.18	-165.44	-201.20	-0.62%	-0.62%	-0.62%
	15-18m	-8.18	-12.63	-15.36	37	-302.69	-467.20	-568.20	-0.99%	-0.99%	-0.99%
	18-36m	-8.40	-12.97	-15.78	72	-605.05	-933.91	-1,135.80	-1.26%	-1.26%	-1.26%

5% Discount rate

Table 4.2.5. Scenario 2: Net Present Value (NPV) over 10, 20 and 30 years, base year 2003, allowing for a 0.5% year on year increase in whitefish landings over the first 10 years (constant thereafter)

Case	Length	Vessel level (€000)			No. vessels	Segment level (€000)			Trial NPV as proportion of business as usual NPV		
		10	20	30		10	20	30	10	20	30
3.5 – large mesh escape panel	<10m	-1.68	-2.57	-3.11	88	-147.73	-225.99	-274.03	-0.89%	-0.88%	-0.88%
	10-12m	-7.31	-11.07	-13.38	40	-292.36	-442.87	-535.26	-1.81%	-1.77%	-1.76%
	12-15m	-21.28	-32.43	-39.28	29	-617.05	-940.58	-1,139.20	-3.55%	-3.50%	-3.49%
	15-18m	-44.20	-67.00	-81.00	37	-1,635.34	-2,478.96	-2,996.87	-5.36%	-5.26%	-5.23%
	18-36m	-32.02	-48.88	-59.23	72	-2,305.39	-3,519.25	-4,264.46	-4.80%	-4.74%	-4.73%
3.6 – cutaway trawl	<10m	-0.17	-0.26	-0.31	88	-14.69	-22.45	-27.22	-0.09%	-0.09%	-0.09%
	10-12m	-0.76	-1.16	-1.41	40	-30.42	-46.50	-56.37	-0.19%	-0.19%	-0.19%
	12-15m	-3.61	-5.52	-6.70	29	-104.82	-160.22	-194.24	-0.60%	-0.60%	-0.59%
	15-18m	-8.00	-12.23	-14.83	37	-296.00	-452.47	-548.53	-0.97%	-0.96%	-0.96%
	18-36m	-8.22	-12.56	-15.23	72	-591.69	-904.46	-1,096.47	-1.23%	-1.22%	-1.22%

5% Discount rate

Table 4.2.6. Scenario 1: NPV over 10, 20 and 30 years, base year 2003, allowing for discount rates of 3.5, 7.5 and 10%

Dis-count-rate	Case	Length	Vessel level (€000) 10	20	30	No. vessels	Segment level (€000) 10	20	30	Trial NPV as proportion of business as usual NPV [a] 10	20	30
3.5	3.5 – large mesh escape panel	<10m	-1.83	-2.98	-3.79	88	-160.64	-261.97	-333.82	-0.90%	-0.90%	-0.90%
		10-12m	-8.14	-13.28	-16.92	40	-325.41	-531.02	-676.78	-1.88%	-1.88%	-1.88%
		12-15m	-23.37	-38.15	-48.63	29	-677.82	-1,106.45	-1,410.31	-3.65%	-3.65%	-3.65%
		15-18m	-49.18	-80.29	-102.34	37	-1,819.55	-2,970.69	-3,786.76	-5.58%	-5.58%	-5.58%
		18-36m	-35.08	-57.27	-73.00	72	-2,525.52	-4,123.42	-5,256.20	-4.92%	-4.92%	-4.92%
	3.6 – cu-taway trawl	<10m	-0.18	-0.30	-0.38	88	-16.05	-26.20	-33.40	-0.09%	-0.09%	-0.09%
		10-12m	-0.83	-1.36	-1.73	40	-33.23	-54.25	-69.16	-0.19%	-0.19%	-0.19%
		12-15m	-3.95	-6.45	-8.22	29	-114.49	-186.95	-238.31	-0.62%	-0.62%	-0.62%
		15-18m	-8.74	-14.27	-18.19	37	-323.33	-527.94	-673.00	-0.99%	-0.99%	-0.99%
		18-36m	-8.98	-14.66	-18.68	72	-646.32	-1,055.33	-1,345.28	-1.26%	-1.26%	-1.26%
7.5	3.5 – large mesh escape panel	<10m	-1.54	-2.19	-2.51	88	-135.67	-192.91	-220.69	-0.90%	-0.90%	-0.90%
		10-12m	-6.87	-9.77	-11.18	40	-274.75	-390.90	-447.25	-1.88%	-1.88%	-1.88%
		12-15m	-19.73	-28.08	-32.13	29	-572.22	-814.35	-931.82	-3.65%	-3.65%	-3.65%
		15-18m	-41.51	-59.09	-67.61	37	-1,535.95	-2,186.20	-2,501.70	-5.58%	-5.58%	-5.58%
		18-36m	-29.61	-42.15	-48.23	72	-2,131.85	-3,034.47	-3,472.41	-4.92%	-4.92%	-4.92%
	3.6 – cu-taway trawl	<10m	-0.15	-0.22	-0.25	88	-13.54	-19.28	-22.06	-0.09%	-0.09%	-0.09%
		10-12m	-0.70	-1.00	-1.14	40	-28.05	-39.92	-45.69	-0.19%	-0.19%	-0.19%
		12-15m	-3.33	-4.74	-5.43	29	-96.64	-137.57	-157.43	-0.62%	-0.62%	-0.62%
		15-18m	-7.38	-10.50	-12.02	37	-272.92	-388.50	-444.58	-0.99%	-0.99%	-0.99%
		18-36m	-7.58	-10.79	-12.34	72	-545.55	-776.59	-888.69	-1.26%	-1.26%	-1.26%
10	3.5 – large mesh escape panel	<10m	-1.40	-1.86	-2.04	88	-123.30	-164.02	-179.72	-0.90%	-0.90%	-0.90%
		10-12m	-6.24	-8.31	-9.10	40	-249.66	-332.28	-364.13	-1.88%	-1.88%	-1.88%
		12-15m	-17.93	-23.87	-26.16	29	-519.91	-692.14	-758.54	-3.65%	-3.65%	-3.65%
		15-18m	-37.72	-50.22	-55.04	37	-1,395.46	-1,858.00	-2,036.33	-5.58%	-5.58%	-5.58%
		18-36m	-26.90	-35.82	-39.26	72	-1,936.84	-2,578.90	-2,826.44	-4.92%	-4.92%	-4.92%
	3.6 – cu-taway trawl	<10m	-0.14	-0.19	-0.20	88	-0.14	-0.19	-0.20	-0.09%	-0.09%	-0.09%
		10-12m	-0.64	-0.85	-0.93	40	-0.64	-0.85	-0.93	-0.19%	-0.19%	-0.19%
		12-15m	-3.03	-4.03	-4.42	29	-3.03	-4.03	-4.42	-0.62%	-0.62%	-0.62%
		15-18m	-6.70	-8.92	-9.78	37	-6.70	-8.92	-9.78	-0.99%	-0.99%	-0.99%
		18-36m	-6.88	-9.17	-10.05	72	-6.88	-9.17	-10.05	-1.26%	-1.26%	-1.26%

[a] These values are the same for every rate of discount as both the 'trial' gear NPV and 'business as usual' NPV have the same discount rate applied

Table 4.2.7. NPV over 10, 20 and 30 years, base year 2003, allowing for a 1, 2 and 5% year on year increase in whitefish landings over the first 10 years (constant at 10, 20 and 50, respectively, thereafter)

% increase in whitefish landings	Case	Length	Vessel level 10 (€000)	Vessel level 20 (€000)	Vessel level 30 (€000)	No. vessels	Segment level 10 (€000)	Segment level 20 (€000)	Segment level 30 (€000)	Trial NPV as proportion of business as usual NPV [a] 10	20	30
1	3.5 –	<10m	-1.65	-2.50	-3.02	88	-150.41	-231.89	-281.91	-0.87%	-0.86%	-0.85%
	large	10-12m	-7.00	-10.39	-12.48	40	-304.66	-469.98	-571.48	-1.73%	-1.67%	-1.64%
	mesh	12-15m	-20.67	-31.10	-37.50	29	-634.58	-979.21	-1190.79	-3.45%	-3.36%	-3.33%
	escape	15-18m	-42.36	-62.94	-75.58	37	-1703.40	-2628.97	-3197.19	-5.14%	-4.95%	-4.88%
	panel	18-36m	-31.20	-47.08	-56.82	72	-2364.29	-3649.07	-4437.82	-4.67%	-4.57%	-4.53%
	3.6 –	<10m	-0.16	-0.25	-0.30	88	-14.36	-21.72	-26.24	-0.09%	-0.08%	-0.08%
	cuta-	10-12m	-0.74	-1.12	-1.36	40	-29.73	-44.98	-54.35	-0.18%	-0.18%	-0.18%
	way	12-15m	-3.53	-5.34	-6.46	29	-102.45	-155.00	-187.27	-0.59%	-0.58%	-0.57%
	trawl	15-18m	-7.82	-11.83	-14.29	37	-289.32	-437.74	-528.85	-0.95%	-0.93%	-0.92%
		18-36m	-8.03	-12.15	-14.68	72	-578.32	-875.01	-1,057.14	-1.20%	-1.18%	-1.17%
2	3.5 –	<10m	-1.59	-2.37	-2.85	88	-139.70	-208.29	-250.40	-0.84%	-0.81%	-0.80%
	large	10-12m	-6.39	-9.04	-10.67	40	-255.45	-361.52	-426.63	-1.58%	-1.45%	-1.41%
	mesh	12-15m	-19.46	-28.44	-33.95	29	-564.47	-824.70	-984.45	-3.24%	-3.07%	-3.01%
	escape	15-18m	-38.68	-54.84	-64.75	37	-1,431.14	-2,028.92	-2,395.91	-4.69%	-4.31%	-4.18%
	panel	18-36m	-29.56	-43.47	-52.01	72	-2,128.68	-3,129.78	-3,744.37	-4.43%	-4.22%	-4.15%
	3.6 –	<10m	-0.16	-0.23	-0.28	88	-13.69	-20.26	-24.29	-0.08%	-0.08%	-0.08%
	cuta-	10-12m	-0.71	-1.05	-1.26	40	-28.36	-41.96	-50.30	-0.18%	-0.17%	-0.17%
	way	12-15m	-3.37	-4.99	-5.98	29	-97.71	-144.57	-173.33	-0.56%	-0.54%	-0.53%
	trawl	15-18m	-7.46	-11.03	-13.23	37	-275.94	-408.27	-489.50	-0.90%	-0.87%	-0.85%
		18-36m	-7.66	-11.33	-13.59	72	-551.60	-816.10	-978.48	-1.15%	-1.10%	-1.08%
5	3.5 –	<10m	-1.41	-1.96	-2.31	88	-123.64	-172.89	-203.13	-0.74%	-0.67%	-0.65%
	large	10-12m	-4.54	-4.97	-5.23	40	-181.63	-198.82	-209.37	-1.12%	-0.80%	-0.69%
	mesh	12-15m	-15.84	-20.45	-23.27	29	-459.31	-592.92	-674.95	-2.64%	-2.21%	-2.07%
	escape	15-18m	-27.64	-30.51	-32.27	37	-1,022.76	-1,128.86	-1,193.99	-3.35%	-2.40%	-2.09%
	pane	18-36m	-24.66	-32.65	-37.56	72	-1,775.25	-2,350.84	-2,704.21	-3.69%	-3.17%	-3.00%
	3.6 –	<10m	-0.13	-0.18	-0.21	88	-11.70	-15.87	-18.43	-0.07%	-0.06%	-0.06%
	cuta-	10-12m	-0.61	-0.82	-0.95	40	-24.24	-32.87	-38.17	-0.15%	-0.13%	-0.13%
	way	12-15m	-2.88	-3.91	-4.54	29	-83.51	-113.26	-131.53	-0.48%	-0.42%	-0.40%
	trawl	15-18m	-6.37	-8.64	-10.04	37	-235.83	-319.86	-371.44	-0.77%	-0.68%	-0.65%
		18-36m	-6.55	-8.88	-10.31	72	-471.41	-639.38	-742.49	-0.98%	-0.86%	-0.82%

5% Discount rate

The NPV, for UK *nephrops* vessels, of undertaking any of the cases, under all the scenarios considered, is consistently negative. However, even in the worst-case scenario (Scenario 1), in which the *nephrops* vessels fail to feel any compensatory effect from whitefish stocks recovering, the projected reductions in revenue are marginal. The greatest impact will be felt by the 15m to 18m sector under Case 3.5 (an approximately 5.6% loss) and the 18m to 36m sector under Case 3.6 (an approximately 1.3% loss) (Table 4.2.4.). In both cases, the smaller vessels feel less of an impact as whitefish had a less significant effect on revenue in the first instance. Again, however, the effect on the <10m fleet may not be fully accounted for. A very similar pattern was also observed when using a base year of 2005 but in this instance, the greatest impact was felt by the 15m to 18m fleet in both cases (see; Table 4.2.9). In addition, the relative magnitude of all vessel losses would further diminish if the landings of 'other' species were included in the analysis. Lastly, it is thought unlikely that the potential losses *nephrops* vessels are expected to incur in adopting either of the gears will be significantly offset by whitefish stocks increasing (and therefore increasing their contribution to landings).

From the policy perspective, any perceived reduction in revenue (that is often observed to result in larger than proportional reductions in profits) is likely to make *nephrops* vessels unwilling voluntarily to adopt the gears, however marginal the losses may be. As such, mandatory uptake with some form of compensatory (perhaps transfer) payment may be required.

References

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Appendix to Section 4.2.3

Table 4.2.8. Landings composition for UK Nephrops trawl vessels operating in Area IVb, base year 2005

Weight Vessel	Cod	Haddock	Nephrops	Whiting	Total (tonnes)
Length					
<10m	0.65%	0.72%	94.10%	4.53%	1,132
10-12m	1.31%	0.98%	92.53%	5.17%	909
12-15m	2.04%	2.56%	82.00%	13.40%	1,298
15-18m	3.65%	6.95%	64.72%	24.69%	1,598
18-36m	4.60%	12.59%	65.74%	17.06%	2,022

Value Vessel	Cod	Haddock	Nephrops	Whiting	Total (€000)
Length					
<10m	0.22%	0.19%	99.05%	0.54%	4,670,003
10-12m	0.69%	0.38%	98.08%	0.85%	2,820,398
12-15m	1.27%	1.16%	94.84%	2.73%	3,332,121
15-18m	2.58%	3.23%	88.32%	5.86%	3,633,965
18-36m	2.94%	4.66%	88.03%	4.38%	5,158,643

Unit price in € Vessel	Cod	Haddock	Nephrops	Whiting
Length				
<10m	1.39	1.06	4.34	0.49
10-12m	1.62	1.21	3.29	0.51
12-15m	1.60	1.16	2.97	0.52
15-18m	1.61	1.06	3.10	0.54
18-36m	1.63	0.94	3.42	0.65

Source: UK Marine and Fisheries Agency (MFA)

Table 4.2.9. Scenario 1: NPV over 10, 20 and 30 years, base year 2005

Case	Length	Vessel level (€000) 10	20	30	No. vessels	Segment level (€000) 10	20	30	Trial NPV as proportion of business as usual NPV 10	20	30
3.5 – large mesh escape panel	<10m	-2.45	-3.77	-4.59	88	-210.36	-324.43	-394.45	-0.52%	-0.52%	-0.52%
	10-12m	-6.69	-10.32	-12.54	40	-220.76	-340.48	-413.98	-0.90%	-0.90%	-0.90%
	12-15m	-22.80	-35.18	-42.78	29	-797.88	-1,231.27	-1,497.33	-2.75%	-2.74%	-2.74%
	15-18m	-69.38	-107.07	-130.22	37	-2,011.88	-3,105.11	-3,776.26	-6.35%	-6.35%	-6.35%
	18-36m	-49.18	-75.90	-92.31	72	-2,803.16	-4,326.47	-5,261.65	-6.23%	-6.23%	-6.23%
3.6 – cutaway trawl	<10m	-1.30	-2.01	-2.44	88	-111.88	-172.69	-210.02	-0.27%	-0.27%	-0.27%
	10-12m	-3.20	-4.94	-6.01	40	-105.59	-162.98	-198.21	-0.43%	-0.43%	-0.43%
	12-15m	-11.45	-17.67	-21.49	29	-400.70	-618.49	-752.20	-1.38%	-1.38%	-1.38%
	15-18m	-32.39	-49.99	-60.80	37	-939.20	-1,449.67	-1,763.06	-2.96%	-2.96%	-2.96%
	18-36m	-17.46	-26.96	-32.78	72	-995.43	-1,536.47	-1,868.63	-2.21%	-2.21%	-2.21%

5% Discount rate

Table 4.2.10. Scenario 2: NPV over 10, 20 and 30 years, base year 2005, allowing for a 0.5% year on year increase in whitefish landings over the first 10 years (constant thereafter)

Case	Length	Vessel level (€000) 10	20	30	No. vessels	Segment level (€000) 10	20	30	Trial NPV as proportion of business as usual NPV 10	20	30
3.5 – large mesh escape panel	<10m	-2.40	-3.67	-4.45	88	-206.38	-315.65	-382.73	-0.51%	-0.50%	-0.50%
	10-12m	-6.52	-9.94	-12.04	40	-215.08	-327.95	-397.24	-0.87%	-0.86%	-0.86%
	12-15m	-22.34	-34.18	-41.45	29	-782.04	-1,196.37	-1,450.73	-2.69%	-2.67%	-2.66%
	15-18m	-67.42	-102.76	-124.45	37	-1,955.09	-2,979.96	-3,609.14	-6.17%	-6.09%	-6.07%
	18-36m	-48.15	-73.65	-89.30	72	-2,744.80	-4,197.86	-5,089.91	-6.10%	-6.04%	-6.03%
3.6 – cutaway trawl	<10m	-1.27	-1.94	-2.36	88	-109.41	-167.25	-202.75	-0.27%	-0.27%	-0.27%
	10-12m	-3.13	-4.78	-5.80	40	-103.26	-157.84	-191.35	-0.42%	-0.42%	-0.41%
	12-15m	-11.20	-17.11	-20.75	29	-391.85	-598.99	-726.15	-1.35%	-1.34%	-1.33%
	15-18m	-31.67	-48.41	-58.69	37	-918.45	-1,403.95	-1,702.01	-2.90%	-2.87%	-2.86%
	18-36m	-17.08	-26.11	-31.65	72	-973.45	-1,488.02	-1,803.92	-2.16%	-2.14%	-2.14%

5% Discount rate

Table 4.2.11. Scenario 1: NPV over 10, 20 and 30 years, base year 2005, allowing for discount rates of 3.5, 7.5 and 10%

Discount rate	Case	Length	Vessel level 10 (€000)	Vessel level 20 (€000)	Vessel level 30 (€000)	No. vessels	Segment level 10 (€000)	Segment level 20 (€000)	Segment level 30 (€000)	Trial NPV as proportion of business as usual NPV [a] 10	20	30
	3.5 –	<10m	-2.61	-4.26	-5.43	86	-224.68	-366.54	-467.11	-0.52%	-0.52%	-0.52%
	large	10-12m	-7.15	-11.66	-14.86	33	-235.79	-384.68	-490.24	-0.90%	-0.90%	-0.90%
	mesh	12-15m	-24.35	-39.75	-50.67	35	-852.26	-1,391.28	-1,773.40	-2.75%	-2.74%	-2.74%
	escape	15-18m	-74.11	-120.99	-154.23	29	-2,149.06	-3,508.73	-4,472.63	-6.35%	-6.35%	-6.35%
	panel	18-36m	-52.53	-85.77	-109.33	57	-2,994.31	-4,888.88	-6,231.97	-6.23%	-6.23%	-6.23%
3.5	3.6 – cu-	<10m	-1.39	-2.27	-2.89	86	-119.51	-195.14	-248.76	-0.27%	-0.27%	-0.27%
	taway	10-12m	-3.42	-5.58	-7.11	33	-112.79	-184.17	-234.77	-0.43%	-0.43%	-0.43%
	trawl	12-15m	-12.23	-19.97	-25.46	35	-428.03	-698.90	-890.93	-1.38%	-1.38%	-1.38%
		15-18m	-34.60	-56.49	-72.01	29	-1,003.26	-1,638.14	-2,088.23	-2.96%	-2.96%	-2.96%
		18-36m	-18.65	-30.46	-38.83	57	-1,063.33	-1,736.23	-2,213.26	-2.21%	-2.21%	-2.21%
	3.5 –	<10m	-2.21	-3.14	-3.59	86	-189.72	-269.86	-308.74	-0.52%	-0.52%	-0.52%
	large	10-12m	-6.03	-8.58	-9.82	33	-199.10	-283.21	-324.02	-0.90%	-0.90%	-0.90%
	mesh	12-15m	-20.56	-29.26	-33.48	35	-719.47	-1,023.94	-1,171.68	-2.75%	-2.74%	-2.74%
	escape	15-18m	-62.55	-89.04	-101.89	29	-1,814.09	-2,582.13	-2,954.79	-6.35%	-6.35%	-6.35%
	panel	18-36m	-44.34	-63.12	-72.23	57	-2,527.56	-3,597.75	-4,117.01	-6.23%	-6.23%	-6.23%
7.5	3.6 – cu-	<10m	-1.17	-1.67	-1.91	86	-100.88	-143.60	-164.33	-0.27%	-0.27%	-0.27%
	taway	10-12m	-2.89	-4.11	-4.70	33	-95.21	-135.53	-155.09	-0.43%	-0.43%	-0.43%
	trawl	12-15m	-10.32	-14.69	-16.82	35	-361.30	-514.31	-588.55	-1.38%	-1.38%	-1.38%
		15-18m	-29.20	-41.57	-47.57	29	-846.84	-1,205.47	-1,379.48	-2.96%	-2.96%	-2.96%
		18-36m	-15.75	-22.41	-25.65	57	-897.55	-1,277.65	-1,462.08	-2.21%	-2.21%	-2.21%
	3.5 –	<10m	-2.00	-2.67	-2.92	86	-172.41	-229.41	-251.39	-0.52%	-0.52%	-0.52%
	large	10-12m	-5.48	-7.30	-7.99	33	-180.93	-240.76	-263.83	-0.90%	-0.90%	-0.90%
	mesh	12-15m	-18.68	-24.86	-27.25	35	-653.68	-870.27	-953.77	-2.75%	-2.74%	-2.74%
	escape	15-18m	-56.83	-75.67	-82.94	29	-1,648.16	-2,194.48	-2,405.12	-6.35%	-6.35%	-6.35%
	panel	18-36m	-40.29	-53.64	-58.79	57	-2,296.35	-3,057.60	-3,351.10	-6.23%	-6.23%	-6.23%
10	3.6 – cu-	<10m	-1.07	-1.42	-1.56	86	-1.07	-1.42	-1.56	-0.27%	-0.27%	-0.27%
	taway	10-12m	-2.62	-3.49	-3.83	33	-2.62	-3.49	-3.83	-0.43%	-0.43%	-0.43%
	trawl	12-15m	-9.38	-12.49	-13.69	35	-9.38	-12.49	-13.69	-1.38%	-1.38%	-1.38%
		15-18m	-26.53	-35.33	-38.72	29	-26.53	-35.33	-38.72	-2.96%	-2.96%	-2.96%
		18-36m	-14.31	-19.05	-20.88	57	-14.31	-19.05	-20.88	-2.21%	-2.21%	-2.21%

[a] These values are the same for every rate of discount as both the 'trial' gear NPV and 'business as usual' NPV have the same discount rate applied

Table 4.2.12. Scenario 2: NPV over 10, 20 and 30 years, base year 2005, allowing for a 1, 2 and 5% year on year increase in whitefish landings over the first 10 years (constant at 10, 20 and 50, respectively, thereafter)

Discount rate	Case	Length	Vessel level €000: 10	Vessel level €000: 20	Vessel level €000: 30	No. vessels	Segment level €000: 10	Segment level €000: 20	Segment level €000: 30	Trial NPV as proportion of business as usual NPV [a]: 10	Trial NPV as proportion of business as usual NPV [a]: 20	Trial NPV as proportion of business as usual NPV [a]: 30
1	3.5 – large mesh escape panel	<10m	-2.35	-3.57	-4.31	86	-202.40	-306.88	-371.02	-0.50%	-0.49%	-0.49%
		10-12m	-6.35	-9.56	-11.53	33	-209.39	-315.41	-380.50	-0.85%	-0.83%	-0.82%
		12-15m	-21.89	-33.18	-40.12	35	-766.21	-1,161.47	-1,404.13	-2.64%	-2.59%	-2.57%
		15-18m	-65.46	-98.44	-118.69	29	-1,898.31	-2,854.81	-3,442.02	-5.99%	-5.84%	-5.79%
		18-36m	-47.13	-71.39	-86.28	57	-2,686.45	-4,069.26	-4,918.18	-5.97%	-5.86%	-5.82%
	3.6 – cu-taway trawl	<10m	-1.24	-1.88	-2.27	86	-106.94	-161.80	-195.48	-0.26%	-0.26%	-0.26%
		10-12m	-3.06	-4.63	-5.59	33	-100.93	-152.70	-184.49	-0.41%	-0.40%	-0.40%
		12-15m	-10.94	-16.56	-20.00	35	-383.00	-579.48	-700.10	-1.32%	-1.29%	-1.28%
		15-18m	-30.96	-46.84	-56.58	29	-897.71	-1,358.23	-1,640.96	-2.83%	-2.78%	-2.76%
		18-36m	-16.69	-25.26	-30.51	57	-951.46	-1,439.56	-1,739.21	-2.11%	-2.07%	-2.06%
2	3.5 – large mesh escape panel	<10m	-2.26	-3.36	-4.04	86	-194.44	-289.33	-347.58	-0.48%	-0.46%	-0.45%
		10-12m	-6.00	-8.80	-10.52	33	-198.01	-290.34	-347.02	-0.80%	-0.76%	-0.75%
		12-15m	-20.99	-31.19	-37.45	35	-734.54	-1,091.67	-1,310.92	-2.53%	-2.43%	-2.40%
		15-18m	-61.54	-89.81	-107.16	29	-1,784.74	-2,604.51	-3,107.78	-5.63%	-5.32%	-5.22%
		18-36m	-45.08	-66.88	-80.26	57	-2,569.75	-3,812.04	-4,574.71	-5.71%	-5.49%	-5.42%
	3.6 – cu-taway trawl	<10m	-1.19	-1.75	-2.10	86	-102.00	-150.91	-180.93	-0.25%	-0.24%	-0.24%
		10-12m	-2.92	-4.32	-5.17	33	-96.26	-142.42	-170.76	-0.39%	-0.38%	-0.37%
		12-15m	-10.44	-15.44	-18.51	35	-365.30	-540.47	-648.01	-1.26%	-1.20%	-1.19%
		15-18m	-29.52	-43.68	-52.37	29	-856.22	-1,266.80	-1,518.85	-2.70%	-2.59%	-2.55%
		18-36m	-15.92	-23.56	-28.24	57	-907.49	-1,342.65	-1,609.80	-2.02%	-1.93%	-1.91%
5	3.5 – large mesh escape panel	<10m	-1.98	-2.75	-3.22	86	-170.55	-236.68	-277.28	-0.42%	-0.38%	-0.36%
		10-12m	-4.97	-6.52	-7.47	33	-163.88	-215.12	-246.58	-0.67%	-0.57%	-0.53%
		12-15m	-18.27	-25.21	-29.47	35	-639.53	-882.27	-1,031.30	-2.20%	-1.97%	-1.89%
		15-18m	-49.79	-63.92	-72.59	29	-1,444.04	-1,853.62	-2,105.07	-4.56%	-3.79%	-3.54%
		18-36m	-38.94	-53.34	-62.18	57	-2,219.64	-3,040.41	-3,544.30	-4.93%	-4.38%	-4.20%
	3.6 – cu-taway trawl	<10m	-1.01	-1.37	-1.60	86	-87.17	-118.23	-137.30	-0.21%	-0.19%	-0.18%
		10-12m	-2.49	-3.38	-3.93	33	-82.27	-111.58	-129.57	-0.33%	-0.29%	-0.28%
		12-15m	-8.92	-12.10	-14.05	35	-312.20	-423.44	-491.72	-1.07%	-0.94%	-0.90%
		15-18m	-25.23	-34.22	-39.74	29	-731.76	-992.48	-1,152.54	-2.31%	-2.03%	-1.94%
		18-36m	-13.61	-18.45	-21.43	57	-775.57	-1,051.91	-1,221.55	-1.72%	-1.51%	-1.45%

5% Discount ra

4.3. The Bay of Biscay

Among the fourteen different *nephrops* case studies defined in the project, see Table 4.0, two concern experiments based in the Bay of Biscay. They are described in the project proposal:

> "The French fleets operate in the Celtic Sea and the Bay of Biscay in ICES Area VIII. […] The Bay of Biscay fishery is much larger with approximately 230 trawlers (12 to 16 m) fishing *nephrops* and species such as monkfish, megrim, sole and hake. Annual French landings of *nephrops* are generally around 6,000 tonnes. The incidental capture and discard of small hake is prevalent in the French *nephrops* fisheries."

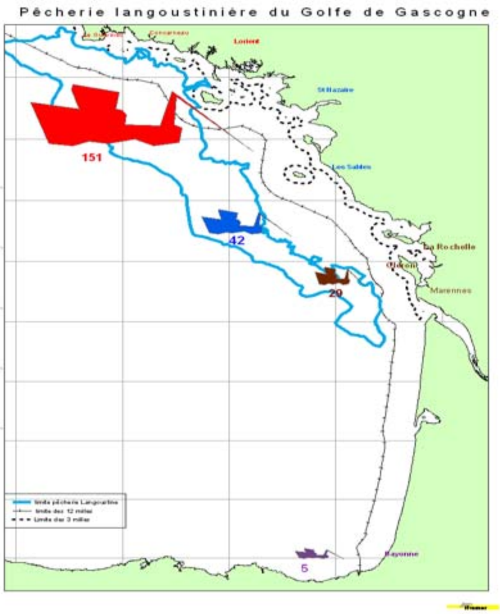
The two experiments are targeting the same fleets. We can therefore use the same data and apply the same methodology in order to complete the cost-benefit analysis.

4.3.3. General presentation of the fishery

The fishery located in the Bay of Biscay has the unusual characteristic that *nephrops* are caught by French bottom trawlers and landed, for the most part, alive. Spanish vessels capture *nephrops* only as a by-catch.

The *nephrops* trawlers operating in the Bay of Biscay are dispersed over the Atlantic coast, from La Cotinière in the southern part of the Bay, to Penmarch, at the south-west foreland of Brittany, in the northern part of the Bay (Figure 4.3.1).

Figure 4.3.1 The fishing areas for *Nephrops* along the French coast



The fleet is not homogeneous throughout the length of the coast. In fact, boats' characteristics (mostly the length) are strongly correlated to the mean distance from their harbour to their fishing grounds. Roughly, the smaller boats (with a length up to 15m) operate mostly in the northern part of the Bay within a 3 to 20 mile zone[4]. Their typical fishing trip is 12 to 16 hours long. *Nephrops* represent half their total gross product (Table 4.3.1).

[4] This is a consequence of the French navigation rules which allow these boats to navigate only at a maximum of 20 miles from the coast, taking into account the fact that such boats are not sufficiently stable to navigate further.

Table 4.3.1 The main boat characteristics in the Bay of Biscay (personal elaboration, landings: IFREMER)

	Regional committees	Local committees	Days at sea	Boat length	Landings
North	Bretagne	Guilvinec *	1-2	10-14m	42%
		Concarneau			10%
		Lorient	2-3	12-18m	30%
	Pays de Loire	Le Croisic			7%
		Les Sables d'Olonne			4%
South	Poitou - Charentes	Marennes-Oléron	3	16-22m	7%

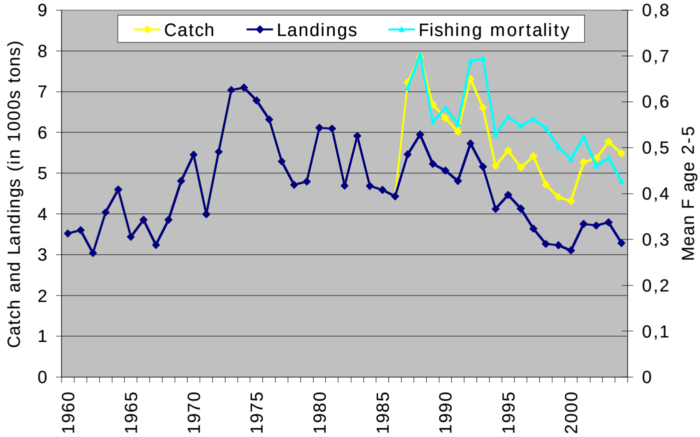
* 4 harbours represented : Saint-Guénolé, Le Guilvinec, Lesconil, Loctudy

The larger boats mainly operate in the southern part of the Bay (from Lorient to La Cotinière). These boats are more polyvalent and less dependent on *nephrops* (which represent only 25% of their gross product, cf. Table 4.3.3). As their fishing journey is longer (between 2 and 3 days), they need to use some specific onboard conservation systems to keep the *nephrops* alive, such as chilled fish-preserves or cold rooms.

Data on *nephrops* landings have been collected since the beginning of the 1960s. According to fishermen, the catches are highly variable, depending on meteorological and environmental variations. *Nephrops* production has been decreasing since 1992 and the trend appears to be continuing (Figure 4.3.2). The fall in nominal fishing effort which occurred over the same period is not the only explanation for this decline and may have been partly or wholly compensated for by technical progress[5]; the fleet is extensively equipped with GPS, twin-trawls and sometimes rockhoppers. The boats have therefore been able to fish in zones where they had never worked before, near rocks or wrecks, especially when they use rockhoppers.

[5] The measure of technical progress is crucial to appreciate the real impact of fishing effort on commercial stocks. An attempt has been made in the case of the French Mediterranean trawler fleet (Kirkley & al.).

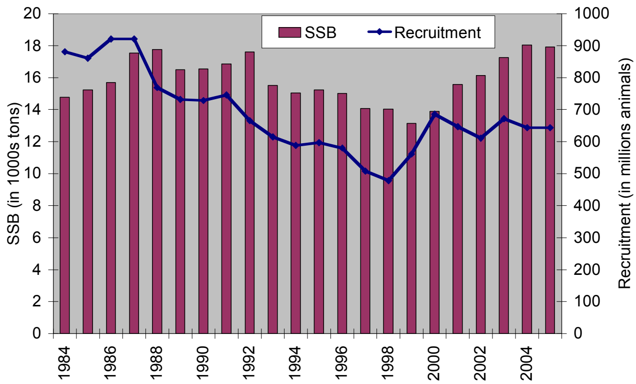
Figure 4.3.2 Nephrops production in the Bay of Biscay and fishing effort



(Source: Ifremer)

The spawning stock biomass has recovered from a historical minimum in 1999 and 2000 and fishing mortality has been decreasing in recent years. Nevertheless, the biologists responsible for the annual stock evaluation consider that the stock is still in danger, especially due to high levels of discards. The current advice is to stabilize production and reduce discarding.

Figure 4.3.3 Spawn stock biomass and recruitment evaluations in the Bay of Biscay



(Source: Ifremer)

4.3.2 Management of the fishery

The *nephrops* fishery has two levels of management:

- several species caught are managed under the EU regulations: the boats apply the TAC/quota system for *nephrops*, hake, and monkfish
- since 2004, a licence system has been implemented (with the agreement of the European Commission).

4.3.2.1 The TAC and quota system

According to the report of the working group on *nephrops* stocks, “there are no management objectives set for this fishery” (ICES 2003), which is due to the fact that the classical biological reference points (such as F0.1) cannot be calculated. ICES thus proposed a precautionary approach be followed to rebuild the spawning stock biomass (SSB) to 18,000 tonnes, its level at the beginning of the 1990s. A large reduction in fishing effort was therefore required and has been proposed for several years.

The TAC was drastically reduced over a five-year period (by 45%, from 1999 to 2003, see Table 4.3.2). Paradoxically, the overexploitation has been exacerbated by market gluts in spring.

Table 4.3.2 TAC for Nephrops harvested in the Bay of Biscay

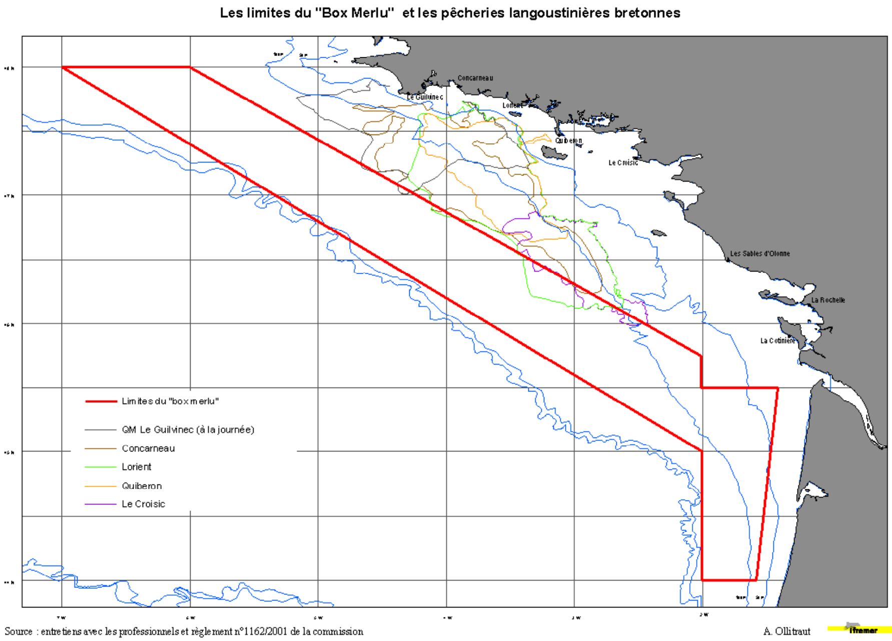
Year	1998	1999	2000	2001	2002	2003	2004	2005
Tonnage	5500	5500	4400	4000	3200	3000	3150	3100

Source: ICES

Currently, this measure is ineffective; actual landings are not constrained by the TAC and before 1999, the TAC was not set at levels intended to constrain fishing activity. Since 2000, the ICES advisory group has suggested lower TACs in order to reverse the negative trend on the spawning stock biomass (ICES 2003).

Nephrops trawlers also land species which are regulated by the EU TAC/quota system; mainly monkfish, hake, megrim and sole. The only species under specific management is hake. The Hake Recovery Plan imposes several restrictions for boats fishing in a specific “Hake Box”, see figure 4.3.4. In this Box, the minimum trawl mesh size was increased from 70mm to 100mm. Between the Box and the coast, boats can use 70mm mesh-size trawls only if hake constitutes less than 20% of their catch.

Figure 4.3.4 The Hake Box in the Bay of Biscay



Source: IFREMER

4.3.2.2 The *nephrops* licence system

Recently, fishermen's representatives pointed out that there could be other ways to manage the *nephrops* fishery and proposed alternatives to the TAC reductions. Thus, in 2004 a licence system was introduced. The first objective of this measure was to evaluate the size of the fleet involved in the fishery, and to identify the different boats catching *nephrops*. This licence system will allow to apply further restrictions such as technical measures (gear modifications), temporary closures or individual quotas[6]. The first measure taken within this framework, in 2005, was the implementation of sorting grids, in accordance with ACFM recommendations.

[6] French fishermen's organisations strongly reject the implementation of Individual Quotas (IQs) or Individual Transferable Quotas (ITQs). Moreover, since 1997 French law has forbidden the transferability of fishing rights.

4.3.2.3 Market regulation

The minimum landings size of *nephrops* is 7.5cm under EU regulations. French Professional Organisations set for some years a market minimum size at 8.5cm. During the 2005 winter, they increased this to 9cm, in order to avoid market gluts during spring.

4.3.3 Fleet costs and earnings

The economic data are provided by the Observatoire Économique Régional des Pêches which has a partnership with the CEDEM. The database covers annual economic data on; landings (quantities and values), gross product, intermediate consumption (fuel, ice, etc), labour costs (wages and social costs), insurance costs, margin, and results, among others.

Unfortunately, we have very poor information on a trip level.

The number of boats covered by the Observatoire depends on the year, but in the database approximately 85 to 90 boats can be identified as *nephrops* trawlers, which corresponds to 35% to 40% of the boats in the *nephrops* fishery.

4.3.3.1 Landings composition

The five most important species for French *nephrops* trawlers are *nephrops*, hake, sole, monk and megrim. Although they appear not to be so important in terms of weight (Table 4.3.3), their value may be (Table 4.3.4). This is due to their high unit value compared to the other species (Table 4.3.5).

Among our case studies, the variability of only *nephrops* and hake landings has been studied by IFREMER (Task 5.2). The three other species will therefore be considered as not relevant to the different fleets (as well as the different unreported species which are aggregated as “Other”).

Table 4.3.3 Percentage landings composition in weight for French Nephrops trawlers, base year 2003

Fleet segment	*Nephrops*	Hake	Monk	Megrim	Sole	Other
< 12m	32.05	17.57	2.78	1.66	4.80	41.14
12-15m	29.03	14.36	5.41	5.08	3.32	42.81
15-18m	24.82	11.63	4.82	4.54	3.68	50.51
18-24m	8.06	4.15	8.16	4.17	3.38	72.08

Table 4.3.4 Percentage landings composition in value for French Nephrops trawlers, base year 2003

Fleet segment	*Nephrops*	Hake	Monk	Megrim	Sole	Other
< 12m	50.05	14.47	3.34	1.60	9.24	21.30
12-15m	49.36	12.10	6.80	5.02	7.09	19.63
15-18m	45.38	10.76	6.93	5.18	8.67	23.08
18-24m	17.39	5.07	13.86	3.79	9.04	50.85

Table 4.3.5 Mean landings price (€/kg), base year 2003.

Fleet segment	*Nephrops*	Hake	Monk	Megrim	Sole	Other
< 12m	7.58	4.00	5.82	4.70	9.34	2.51
12-15m	8.01	3.97	5.93	4.66	10.07	2.16
15-18m	7.70	3.90	6.06	4.81	9.92	1.93
18-24m	7.76	4.39	6.10	3.27	9.61	2.54

4.3.3.2. Economic performance

Table 4.3.6 depicts the different economic indicators of the French trawlers involved in the *nephrops* fishery of the Bay of Biscay. The landings values comprise all species caught. The variable costs comprise fuel, ice, provisions, landing and sales costs. Gross margin is calculated as the difference between the value of landings and variable costs.

The gross margin is shared between the owner and the crew according to a fixed share, which is typical of French artisanal fisheries. This has huge implications for the CBA, because the hypothetical losses are borne not only by the boat owners but also by all the fishermen involved in the fishery. Large losses during the early years could result in a loss of fishermen who would shift to other fisheries. In this CBA, such movements will be ignored. Therefore, the margin is calculated as the difference between the owners' share and the other variables costs.

Table 4.3.6 Costs and earnings at vessel level of French vessels targeting Nephrops, base year 2003, €000

Fleet segment length	Landings value	Variable costs *	Gross margin	Crew share**	Other variable costs	Margin***
< 12m	139	20	119	47.68%	34	29
12-15m	263	55	208	49.66%	63	42
15-18m	329	80	248	49.89%	79	46
18-24m	697	224	473	45.55%	180	77

* Also called "shared costs": variable costs, before remuneration of labour and capital
** The crew share is displayed as a percentage because French fishermen do not receive any fixed wage.
*** Before remuneration of capital.

Prices of *nephrops* and hake are known by grade (Table 4.3.7). For both species, price increases with size. Lowering the mortality for smaller fish should therefore benefit fishermen if the price of those fish do not decrease more than the increase in landing volume.

Table 4.3.7 Price of Hake and Nephrops according to grade, base 2003

	---------------- Hake ----------------		------------- *Nephrops* ---------------	
Grade	Price (€/kg)	kg per fish	Price (€/kg)	Age
1	8.57	> 2.5	13.43	7+
2	6.88	1.2 - 2.5	12.23	5 - 6
3	5.49	0.6 - 1.2	7.15	3 - 4
4	3.41	0.3 - 0.6	6.68	2
5	2.93	0.2 - 0.3		

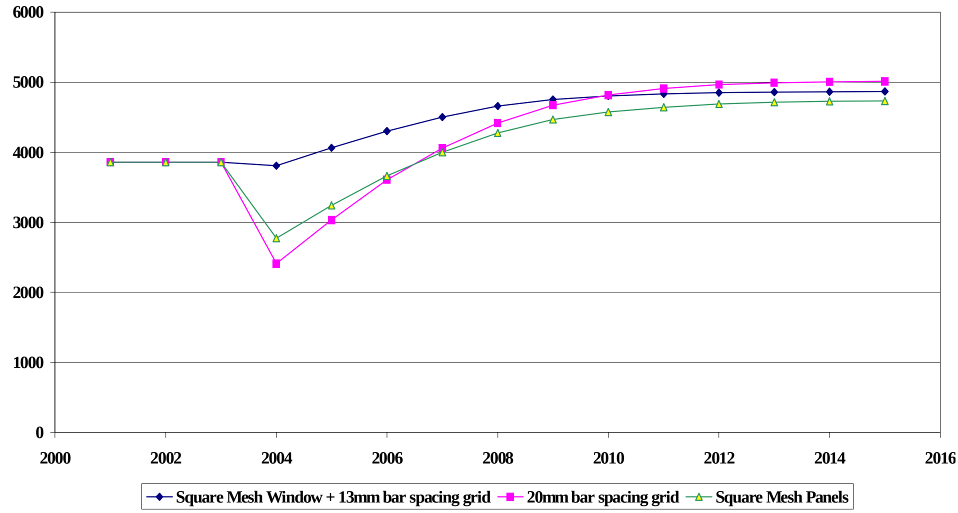
4.3.4 Results of the biological simulations

In the two cases being studied, there is no need to include biological calculations directly in the CBA (as in the Danish case for example) as they are directly integrated as input, based on the different simulations carried out by IFREMER (Task 5.2).

4.3.4.1 *Nephrops* landings

These simulations conclude that the selective devices significantly modify *nephrops* production as reported in Figure 4.3.5. The implementation of a square-mesh panel (Task 3.11, Table 4.0) or a 200mm bar-spacing grid results in a loss of *nephrops* in the short term (during the first years of implementation), but allows higher production in the long term. The combination of a 13mm bar-spacing grid and a square-mesh panel allows an increase in production in the long term, while avoiding a large short-term loss.

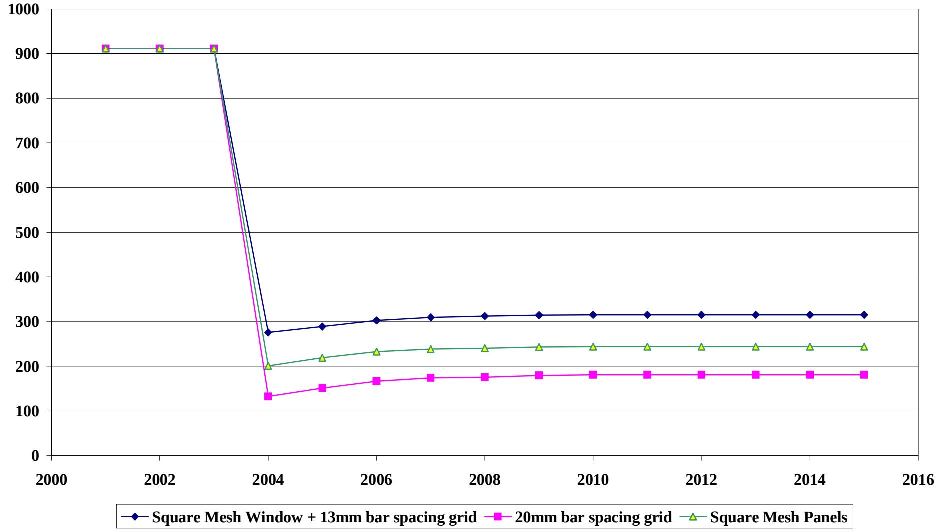
Figure 4.3.5 Trends in Nephrops landings, tonnes



Source: IFREMER

These increases in landings are due to improved gear selectivity, which significantly reduces discards of *Nephrops*. They fall by between two-thirds and three-quarters (Figure 4.3.), depending on the selection device used.

Figure 4.3.6: Trends in Nephrops discards, tonnes



Source: IFREMER

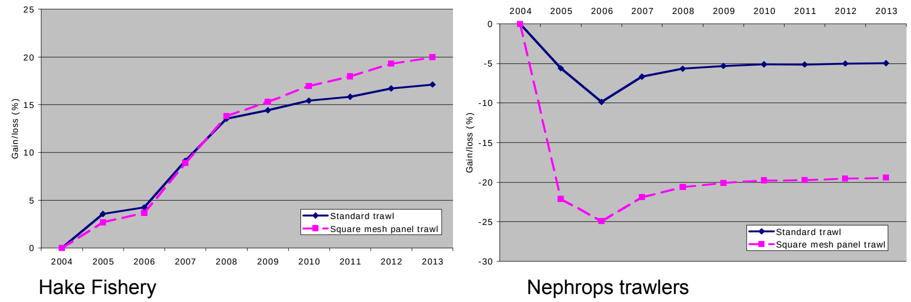
4.3.4.2. Hake landings

As reported in Task 5.2, "the side escape panels (Task 3.11) provided mitigated results on hake escapement while no hake escapement was noted when the *nephrops* grids (Task 3.10) were implemented in the conditions of the tests". For the CBA, this implies that the French *nephrops* fleet will be the only one to be affected by the implementation of these two selective gears.

IFREMER used other data from the national programme ASCGG in order to test the impact on hake stocks of a square-mesh panel on the top of the baitings.

This simulation compares the evolution of hake landings after 2004 between a standard trawl and trawl with a square-mesh panel. Results show growing production in both cases (Figure 4.3.7), which is a consequence of the dynamics of the hake resource under constant effort (ICES 2005).

Figure 4.3.7 Gain/loss (%) of hake catches after the implementation of a square-mesh panel in the Nephrops fishery



The implementation of a square-mesh panel device in the French *nephrops* fishery will only have a differential gain of 3% in terms of landings, which is weak according to the IFREMER conclusions (Task 5.2). This is the result of different factors such as the share of *nephrops* trawlers landings in the whole hake fishery (15% in Areas VIIIa, and b, and 5% overall).

For the *nephrops* trawlers, the implementation of this device would reduce their landings of hake by approximately 15% compared to the simulated status quo.

4.3.5 Results of the cost-benefit analysis applied to the French *Nephrops* fishery

The comparison of the base case, i.e. without gear change, and the case with gear change has been performed by use of the same equations as in the Danish case, except for crew wages. In the French case, wages are not considered to be constant, but directly dependent of the gross margin (GM) and a fixed percentage called crew share:

$$wages = GM * crew\ share$$

A number of simplifying assumptions have been used which are summarized below:

H: landings are constant for all species except *nephrops* and hake.
P: fish prices are constant for all species except *nephrops* and hake, where price is a function of grade
C: variable costs are kept constant (except for crew wages as mentioned above).
G: fixed costs are kept constant.

V: external effects (net) are disregarded i.e. for example, discarding is not considered ecologically or ethically harmful.

U: management costs (information gathering, administration, monitoring, control and enforcement) are kept constant.

I: investments costs in gear are assumed to be the same with and without the gear change for the implementation of square-mesh panels. Implementing the flexible grid has a maximum cost of €1,500 per year (the grid has to be replaced every year). These €1,500 euros are included in the "Other variable costs".

D: the discount rate is fixed at 5%.

T: the time horizon is fixed at 10, 20, and 30 years.

Given these assumptions, the indicator used to calculate the Net Present Value is the margin. A net present value based on the gross revenue would give the same result.

The three situations tested by IFREMER were implemented in the CBA framework:

- 13mm grid and a square-mesh window (Table 4.3.8),
- square-mesh panels (Table 4.3.10),
- 20mm grid (Table 4.3.11).

The economic implications of the ASCGG trials were also tested (Table 4.3.9).

Table 4.3.8 Net present value of the implementation of a 13mm flexible grid (€000)

	Vessel level				Segment level			
Length	10	20	30	Length	No. of vessels	10	20	30
<12m	12.4	27.1	36.1	<12m	49	609	1328	1769
12-15m	27.9	56.6	74.3	12-15m	75	2093	4247	5569
15-18m	30.4	61.4	80.4	15-18m	87	2646	5341	6996
18-24m	19.9	41.3	54.4	18-24m	12	238	495	653

Table 4.3.9 Net present value of the ASCGG trials (€000)

	Vessel level				Segment level			
Length	10	20	30	Length	No. of vessels	10	20	30
<12m	7.9	20.3	27.9	<12m	49	388	996	1369
12-15m	21.2	46.6	62.1	12-15m	75	1592	3493	4660
15-18m	23.7	51.3	68.2	15-18m	87	2060	4460	5933
18-24m	14.3	32.9	44.3	18-24m	12	172	395	532

Table 4.3.10 Net present value of the implementation of a square-mesh panel (€000)

	-------------- Vessel level --------------					---------------- Segment level ----------------		
Length	10	20	30	Length	No. of vessels	10	20	30
<12m	-4.7	7.9	15.7	<12m	49	-231	388	768
12-15m	-0.3	25.1	40.7	12-15m	75	-20	1882	3050
15-18m	0.4	27.9	44.7	15-18m	87	39	2424	3888
18-24m	-2.6	16.2	27.7	18-24m	12	-31	194	332

Table 4.3.11 Net present value of the implementation of a 20mm grid (€000)

	-------------- Vessel level --------------					---------------- Segment level ----------------		
Length	10	20	30	Length	No. of vessels	10	20	30
<12m	-3.5	15.2	26.7	<12m	49	-169	745	1306
12-15m	1.8	37.1	58.7	12-15m	75	134	2780	4404
15-18m	2.6	40.6	63.9	15-18m	87	229	3531	5559
18-24m	-0.9	25.7	42.0	18-24m	12	-11	308	504

These four situations have positive NPVs in the mid- and long-term. However, fishermen could be expected to decline to use a square-mesh panel and the 200mm grid owing to the loss of margin after 10 years, even if these losses are limited compared to the different discounted margin levels.
Two factors drive these positive results:

- The selective gears reduce the amount of *nephrops* discards. This has beneficial repercussions on the stock growth, which allow an increase in production in the mid-term.
- The loss of marketable individuals is relatively low in the short term. Therefore, the fall in the value of landings is limited.

These results have also to be considered with care, considering that the different gears tested do not fit the objective of discard reduction assigned by the NECESSITY project.

The different costs were assumed to be constant during the 30-year period. Any increase would reduce the net present value (Table 4.3.12).

Table 4.3.12 Impact of assumptions

	NPV increase	NPV decrease
C: variable costs increase		X
G: fixed costs increase		X
V: external effects (net) harmful	X	
U: management costs increase		X
I: investments costs in gear increase		X
D: the discount rate increase		X

The discount rate used in these calculations is 5%, which is considered as a standard level for many public projects. However, this rate can be fixed between 3.5% and 20% depending on the source considered. Generally, a private discount rate is estimated to fluctuate between 10% and 20%. In this last case, the NPV would be negative for all the periods and for every fleet segment (Table 4.3.13).

Table 4.3.13 NPV at vessel level for various discount rates (the case of the 200mm grid, €000)

	------------ 3.5% -------------			------------- 10% -------------			---------------- 20% -------------		
Length	10	20	30	10	20	30	10	20	30
<12m	-2.3	20.9	37.3	-6.1	3.2	6.8	-8.4	-5.7	-5.3
12-15m	4.2	48.1	79.2	-4.1	13.6	20.4	-9.7	-4.7	-3.9
15-18m	5.2	52.4	85.9	-3.7	15.2	22.6	-9.9	-4.5	-3.6
18-24m	0.8	33.9	57.4	-5.1	8.2	13.3	-9.0	-5.2	-4.6

References

ICES, 2003, *Report of the Working Group on* Nephrops *Stocks*, 19-27 March 2003 (ICES CM 2003/ACFM:18).

ICES, 2005, Report of the Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim, ICES Document CM 2005/ACFM: 02

IFREMER, 2001, Fiche signalétique langoustine (zone VIII). Décembre 2001 – resultats preliminaries, Système d'informations halieutiques, 9p.

Kirkley J., Morrison Paul C.J., Cunningham S., Catanzano J., 2001, *Technical progress in the Sete trawl fishery, 1985-1999*, Working Paper 01-001, University of California Davis.

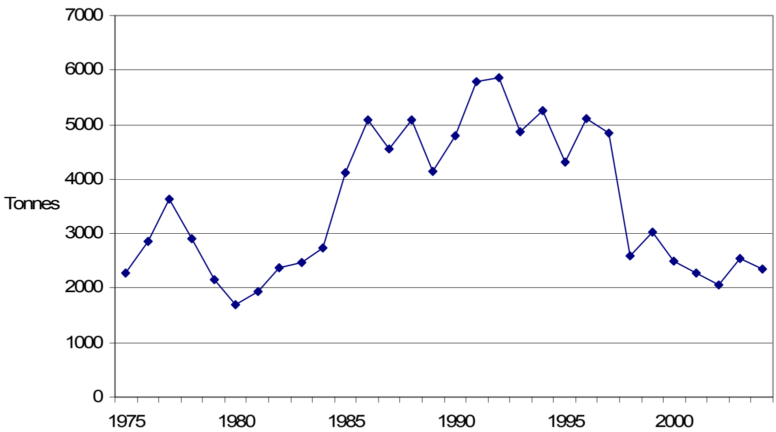
4.4. The Adriatic Sea, Aegean Sea

4.4.1. General presentation of the fishery

The scampi prawn, *nephrops norwegicus*, is found generally in the seas around Italy and Greece. Landings of *nephrops* from the Adriatic and Aegean are the result of targeted fishing in the Adriatic and targeted fishing and by-catch from the hake fishery, among others, in the Aegean. The fishery for *nephrops* is relatively small. Landings of 3,654 tonnes were taken from the whole of the Mediterranean Sea in 2003 with the Italians being by far the most important players with 80% of the catch; Spain took 15% and Greece 8%.

Landings of scampi into Italy were worth some €68m in 2003 and amounted to 4,081 tonnes according to IREPA. FAO figures show 2,550 tonnes but the discrepancy may be due to improved statistical production methods at IREPA.

Figure 4.4.1 Landings of Scampi into Italy from all areas by Italian vessels, 1975 to 2004



Source: FAO

The trend shown in Figure 4.4.1 suggests that the fishery enjoyed exceptional landings in the period from the mid-1980s for some ten years but that since then it has returned to more-normal levels of production. It is not clear whether the trend shown is the result of changes in the fish stock or a consequence of vessels switching into and then out of the *nephrops* fishery as a result of changes in other stocks.

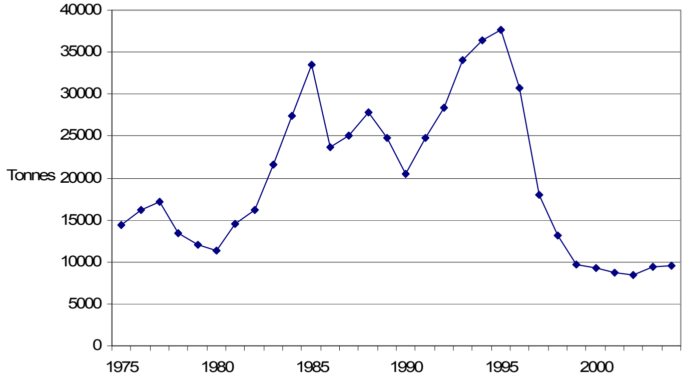
In 2003, 2,866 tonnes of scampi were taken from the Adriatic. The breakdown given in Table 4.4.1 shows that the fishery is mainly concentrated in the central and southern Adriatic with the region of Puglia dominating supply by providing almost 50% of landings.

Table 4.4.1 Landings of Nephrops into Italy from the Adriatic Sea by Italian vessels, by Region, 2003

Region	Quantity (Tonnes)	Value (€m)
Friuli Venezia Giulia	-	-
Veneto	11	0.4
Emilia Romagna	17	0.7
Marche	655	12.9
Abruzzo e Molise	796	10.3
Puglia	1387	15.8
TOTAL Adriatic Sea	2866	40.1

This study has been concerned with by-catches of *nephrops* in the targeted hake fishery. In order to given some comparison of the relative importance of the species, landings of hake by the Italian fleet are shown below in Figure 4.4.2, though the reader is reminded that these figures are for the whole of Italy and include all fleets regardless of whether the landings have been targeted or are by-catch.

Figure 4.4.2 Landings of Scampi into Italy by from all areas by Italian vessels, 1975 to 2004



The hake fishery appears to have enjoyed a period of prosperity in the ten years after 1985, at the same time as the *nephrops* fishery and Table 4.4.2 shows that, as with *nephrops*, the fishery in the Adriatic Sea is concentrated in the central and southern parts.

Table 4.4.2 Landings of Hake into Italy from the Adriatic Sea, by Region, 2003

Region	Quantity (Tonnes)	Value (€m)
Friuli Venezia Giulia	14	0.1
Veneto	135	0.6
Emilia Romagna	283	1.8
Marche	1093	9.4
Abruzzo e Molise	1053	10.5
Puglia	5103	31.0
TOTAL Adriatic Sea	7681	53.4

The two fisheries are of similar importance in the earning of the Italian fleet.

4.4.2. Fleet costs and earnings

4.4.2.1. Composition of Landings

The Italian fishery is characterised by the large number of species, more than 40, that provide a significant contribution to the earnings of the fleet. The six main segments of the fleet are shown below in Table 4.4.3. Mediterranean trawlers, which includes the fleets fishing for hake in the Adriatic and Aegean Seas, are the largest contributor to earnings with 45% of landings by value.

Table 4.4.3 Value of Landings by Vessels Type and Species Group, 2004 (€m)

	Small-Scale Fisheries	Multipurpose Vessels	Mediterranean Trawlers	Purse Seiners	Midwater Pair Trawlers	Dredgers	Total
Anchovies	2.3	4.6	2.7	45.4	35.2		90.2
Pilchards	0.7	2.3	1.3	16.1	6.5		26.9
Marine molluscs	86.9	16	120.9	0.4	0.6	81.3	306.2
Marine crustaceans	24.4	8.1	225.5	0.7	0.3		259
Other fish	235.9	137.2	270.7	46.2	7.3		697.4
Total	350.2	168.2	621.1	108.8	49.9	81.3	1,379.70

The picture of landings volumes, shown in Table 4.4.4, is similar to that of values, though the Mediterranean trawlers are responsible for only 35% of landings by volume, which indicates above average prices for their product. Nevertheless, they remain the most significant segment of the Italian fleet.

Table 4.4.4. Quantity of Landings by Vessels Type and Species Group, 2004 (000t)

	Small-Scale Fisheries	Multipurpose Vessels	Mediterranean Trawlers	Purse Seiners	Midwater Pair Trawlers	Dredgers	Total
Anchovies	0.6	1	3.4	19.9	33.7		58.6
Pilchards	0.4	1	1.2	13.1	6.7		22.4
Marine molluscs	13.5	3.1	19		0.1	23.4	59.1
Marine crustaceans	2	0.8	25.2				28
Other fish	31.9	17.5	53.2	14.4	3.2		120.2
Total	48.4	23.4	102	47.4	43.7	23.4	288.3

4.4.2.2 Economic Performance

In general, the Italian fleet, subdivided by fleet segment, remained profitable in 2004. The financial results and other statistics relevant to their activity are shown in Table 4.4.5. *Nephrops* are mostly caught by the Mediterranean trawlers with contributions from multipurpose vessels and the small-scale fisheries.

The by-catch of *nephrops* resulting from the targeted fishery for hake is taken by the larger vessels which are able to make overnight trips, and voyages of several days into the waters east of Greece.

The two trials in the Adriatic and Aegean have not been subjected to Economic Impact Assessment owing to a lack of data on the effect of the gear modifications required to carry out a CBA and an economic review of the fleets in question.

Table 4.4.5 Economic Performance of the Italian Fleet by Segment, 2004

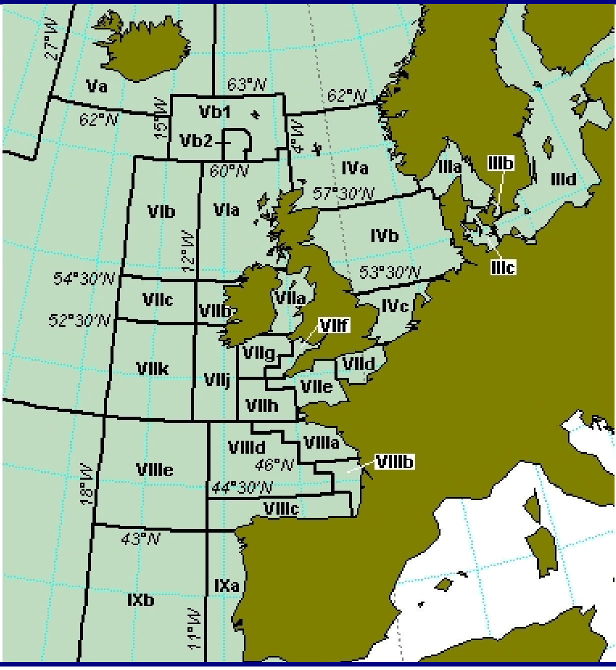
	Total fleet	Fleet segments: Small-Scale Fisheries	Multipurpose Vessels	Mediterranean Trawlers	Purse Seiners	Midwater Pair Trawlers	Dredgers
Economic indicators (€m)							
Value of landings	1380	350	168	621	109	50	81
Gross cash flow	471	148	63	171	36	16	37
Net profit	368	129	49	120	29	12	29
Gross value-added	871	243	111	348	74	32	64
Other economic indicators							
Employment on board (FTE)	35195	15259	4959	10209	2565	774	1429
Invested capital (€m)	2208	426	271	1157	162	69	124
Effort (000 days at sea)	2205	1353	239	484	37	20	72
Capacity indicators							
Volume of landings (000t)	288	48	23	102	48	44	23
Number of vessels	14873	9053	1614	3049	320	124	713
Total GRT (000)	172	23	19	102	15	7	7
Total GT (000)	202	16	21	130	18	9	9
Total kW (000)	1213	224	182	607	80	42	77
Average characteristics of vessels							
GRT (t)	12	3	12	33	47	53	10
GT (t)	14	2	13	43	56	72	13
Engine Power (Kw)	82	25	113	199	251	341	108
Length (m)	10	7	12	18	20	22	14
Age (Years)	27	30	23	25	25	22	19

4.5. The Pelagic Trawl Fishery for Sea Bass in ICES Sub-Areas VIIe, VIIf, VIIIa and VIIIb

4.5.1 General presentation in terms of landings of the fishery covering the trial

Sea bass (*Dicentrarchus Labrax*) may be found over an area of the North-East Atlantic Ocean from Norway, to as far south as Senegal, and in the Mediterranean Sea. The fishery for sea bass in ICES sub-areas VIIe and VIIf, and VIIIa and VIIIb is exploited by the vessels of four countries – the Channel Islands, France, Spain and the United Kingdom. The Channel Islands are outside the European Union. The relevant ICES sub-areas are shown below in Figure 4.5.1. Their defining characteristics are that they are essentially coastal and relatively small.

Figure 4.5.1 Map of Sea Areas defined by the International Council for the Exploration of the Sea

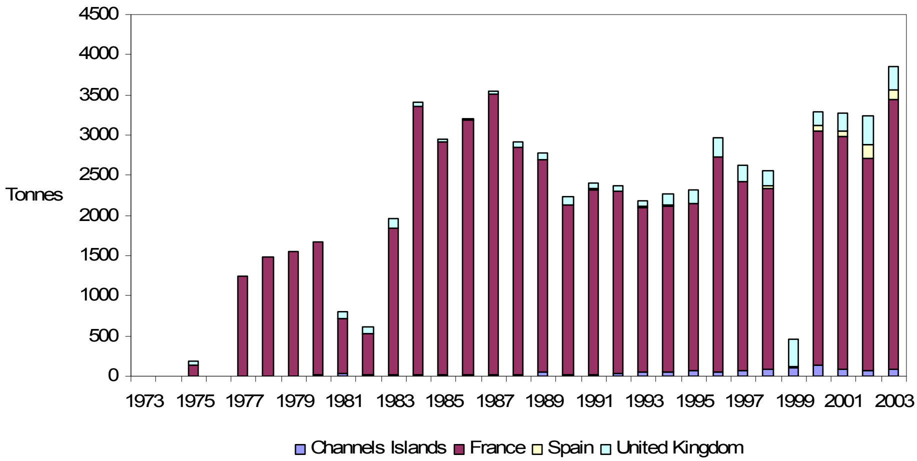


Source: ICES

Not unnaturally, since its coast abuts three of the four sub-areas, France is by far the most dominant among them, landings 87% of the total catch of 3,849 tonnes in 2003, the latest year for which complete figures are available.

Price data available is even more limited, but using the British average price prevailing in 2004 suggests a significant fishery worth some €40million a year. Figure 4.5.2 shows the development of landings of each country's vessels from the four sub-areas.

Figure 4.5.2 Landings of Sea Bass by Country from ICES Sub-Areas VIIe, VIIf, VIIIa and VIIIb, 1973 to 2003



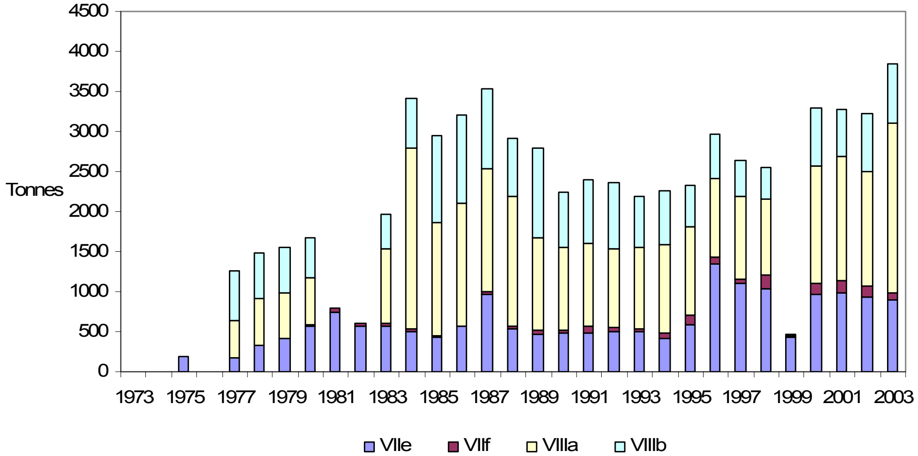
Note that in this and subsequent figures, the exceptionally low figure for 1999 is due to the French landings not being recorded that year. Similarly, there are other omissions and indications of erratic reporting not only from France but also from elsewhere. Nevertheless, the general impressions created by the data appear to be a reflection of a steadily increasing size and relative importance of the fishery. Indeed, over the last thirty years the fishery appears to have tripled in size when measured in landings, though it is probable that the price has been driven down by the increased availability of farmed sea bass from the Mediterranean, so that the economic contribution may not have increased so dramatically. On the other hand, the contribution of factor rents from employment and servicing the fleets in a time of cut-backs in other fisheries must not be overlooked.

Figure 4.5.3 shows the trend in landings of sea bass by sub-area. The concentration of landings is much less marked among the sub-areas than between the countries.

Sub-area VIIIa is the most important providing 55% of landings in 2003 while sub-area VIIe offered 23% and VIIIb 19%. Sub-area VIIf has never provided a large proportion of the catch but thirty years ago the other three sub-areas were of similar importance to each other, though in total the fishery was smaller than that in sub-area VIIIa alone now is.

The principal growth in the fishery has been in sub-areas VIIe and VIIIa and in the last ten years sub-area VIIe has shown a decline. Some caution needs to be exercised with the minutiae of the trends, however, since these could simply reflect improvements in data recording.

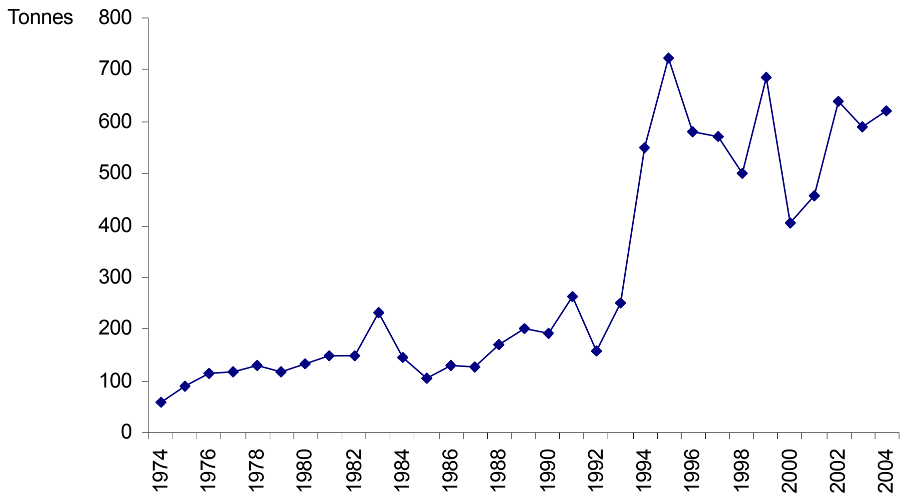
Figure 4.5.3 Landings of Sea Bass by Sub-Area, 1973 to 2003



In the United Kingdom, the sea bass fishery has been growing in importance as a substitute available to fleets under growing pressure where their fisheries have been in decline or subjected to increasing restrictions on quotas and activity. The strong price now being fetched makes it an attractive target see figure 4.5.4.

Complementing this effect, demand for the product has increased as consumers have been introduced to it through its increased availability from fish farms and as a result of consumption while holidaying in the Mediterranean countries. With growing demand promoting strong prices, the sea bass fishery might have displaced other less lucrative pelagic fisheries even without pressure on the TACs and quotas of the other species.

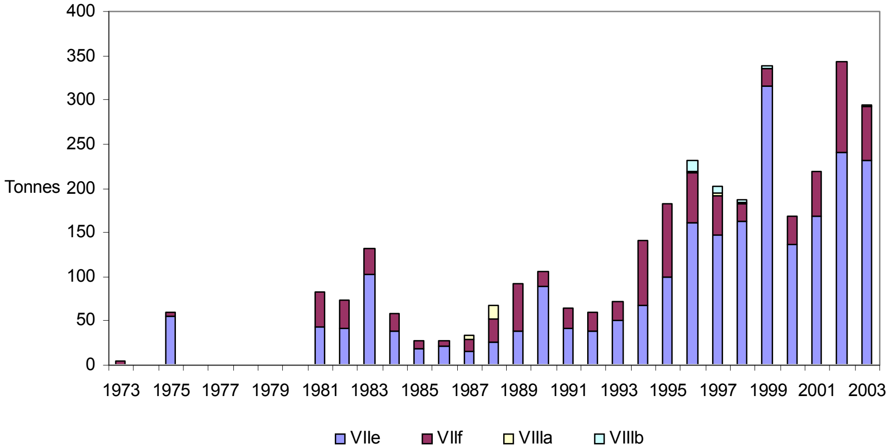
Figure 4.5.4 Shows the progression of landings of sea bass into the United Kingdom by British vessels for the last thirty years.



While sea bass may be caught all round the British Isles, the fishery is mainly located in the Bristol and English Channels (sub-areas VIIe and VIIf) and the northern Bay of Biscay (sub-areas VIIIa and VIIIb). These four sub-areas offered about 50% of the 600 tonnes of sea bass landed in 2003.

The bulk of landings by British vessels from the four sub-areas is taken from sub-area VIIe, some 80%, though sub-area VIIf remains important, providing virtually all the remaining 20%. It can be readily seen from Figure 4.5.5 that the sub-areas in the Bay of Biscay are of little or no significance to the British fleet fishing for sea bass and provided only 2 tonnes in total in the first three years of the new century.

Figure 4.5.5: Landings of Sea Bass by British Vessels by Sub-Area, 1973 to 2003



The sea bass fishery forms part of a wider pelagic fishery and vessels derive their income by switching product as they become seasonally available. The sea bass fishery is a winter operation.

Sea bass is an important sport fish and angling accounts for a substantial catch in addition to the commercial landings. Information on the extent of these landings is very limited.

The number of vessels in the commercial fishery has recently declined sharply. In 2003 there were estimated to have been about 20 pair trawlers, most of which had travelled from Scotland, and a handful of local vessels. By the end of the season in 2007, this number had declined to six with perhaps a dozen local vessels. The number of vessels reflects the progress of the stock, which has declined noticeably and which is now the subject of ongoing discussions regarding plans to protect it.

There is no annual Total Allowable Catch for sea bass set by the European Union under the Common Fisheries Policy and therefore no national quotas among the nations prosecuting the fishery. Similarly, the fishery has not been brought within the Fishing Effort scheme of the CFP and so there are no limitations on the days a vessel may spend at sea fishing for sea bass.

However, it is necessary to hold a licence permitting exploitation of the stocks for commercial purposes and the fishery is also subject to Technical Conservation Measures under the CFP. These comprise protection of nursery areas, and minimum landings sizes for individual specimens.

European Union vessels may fish in any area outside national 12-mile limits and inside the limits of their own member states but not within a number of designated nursery areas. These comprise river estuaries, creeks and harbours inshore in southern England where juvenile stocks congregate.

Until recently, there had been little concern for the future of sea bass stocks but the increased commercial exploitation visible in Figure 4.5.4 and considerable recreational activity by anglers has led to growing disquiet. This has caused a minimum landing size to be introduced which was increased on 6th April 2007 from 36cm to 40cm. The British Fisheries Minister announced that he intends to increase the minimum landing size to 45cm in 2010, subject to a review of the success of the 2007 increase. Accompanying this measure is an increase in the minimum mesh-size for fixed gear for targeted sea bass fisheries from 90mm to 100mm. A report from the Prime Minister's Strategy Unit had recommended that the sea bass fishery should be reserved exclusively for recreational sea angling[7].

Other management measures in the fishery arise from attempts to overcome externalities created by commercial fishing using pelagic trawl nets. These also trap cetaceans (whales, dolphins and porpoises), mostly dolphins, and there has been growing concern that the impact has reached a level which is unacceptable. Greenpeace, not an independent source, has estimated that there may be more than 2,000 dolphins a year being killed after becoming trapped in pair-trawl nets[8].

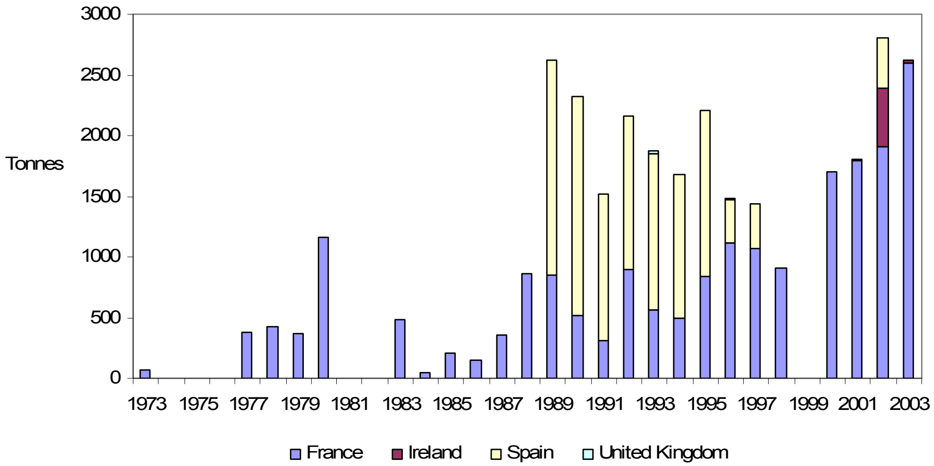
Pingers trialled on the pair-trawl nets were found to be ineffective in deterring dolphins from entering the nets and experiments are reported elsewhere in this report of attempts to design separator or exclusion devises to allow them to escape. In the light of the problem, the British government has banned pair trawling for sea bass inside the 12 nautical mile limit of British territorial waters.

[7] *Net Benefits: a sustainable and profitable future for UK fishing,* Prime Minister's Strategy Unit, Cabinet Office, London, March 2004.

[8] *Cetacean by-catch and pelagic trawling*, Greenpeace, July 2005.

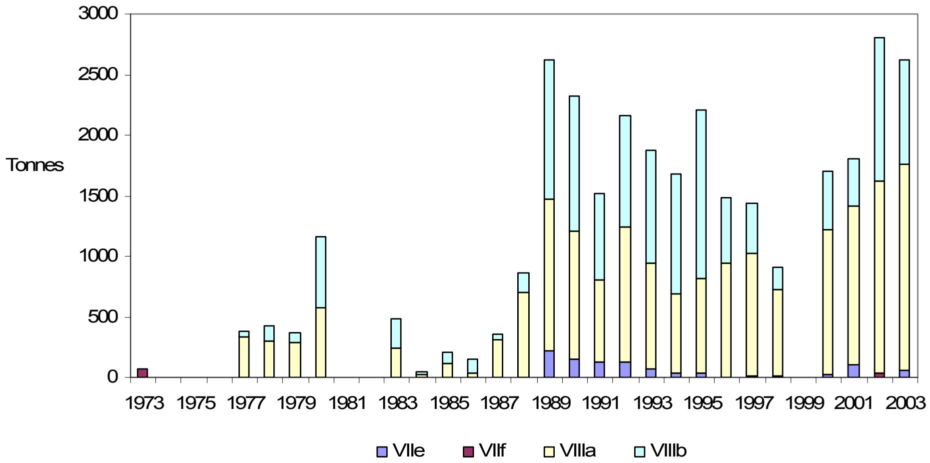
There is also an albacore fishery in these sea areas which is prone to catching cetaceans. Figure 4.5.6 shows that, while the fishery is substantial, it is no longer of importance to the British fleet, though it was prosecuted with some success throughout the 1990s.

Figure 4.5.6 Landings of Albacore by Country from ICES Sub-Areas VIIe, VIIf, VIIIa and VIIIb, 1973 to 2003



The principal participants are French and Spanish fleets reflecting the sources of the catches which are almost entirely in ICES sub-areas VIIIa and VIIIb as shown in Figure 4.5.7.

Figure 4.5.7 Landings of Albacore by ICES Sub-Area, 1973 to 2003



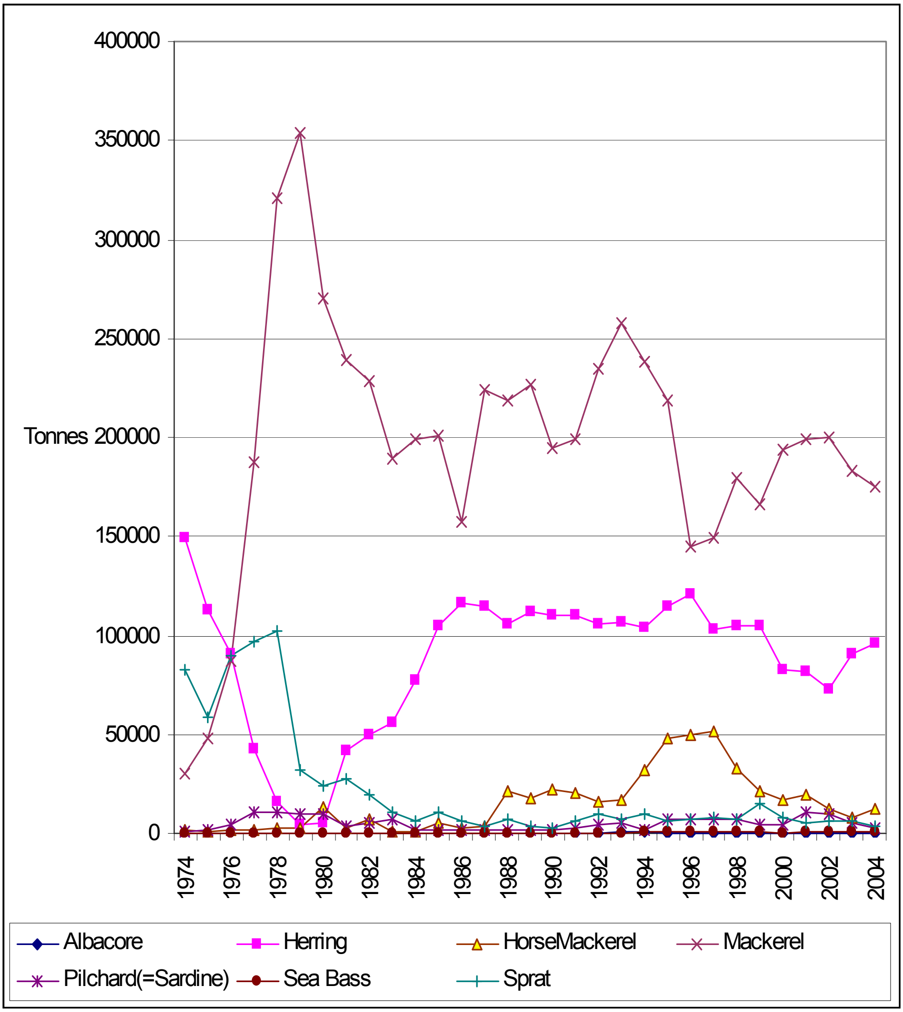
4.5.2 Fleets costs and earnings

4.5.2.1 Landings composition

The British pelagic fleet relies for its income on a small number of species. The pair trawl fishery for sea bass off the south-west of England is fished mainly by Scots vessels. The Scottish pelagic fleet has a history going back hundreds of years of travelling around the British coast to fish for herring and mackerel using drift nets and though the vessels and fishing methods have changed the willingness to sail long distances from the home port in search of a viable fishery has not.

The trends in the dependency of the British pelagic fleet on different species is shown in Figure 4.5.8 which indicates landings from all North East Atlantic waters including the North Sea, Irish Sea, Bristol Channel and English Channel, as well as west of Scotland. Because of the practice of travelling, it is not sensible to try to separate the localities from the point of view of fleet earnings since they all contribute.

Figure 4.5.8 Landings of Pelagic Species from all North East Atlantic Waters, 1973 to 2004



In Figure 4.5.8, the quantity of sea bass can hardly be distinguished from the axis but this does not reflect its importance to the fleet.

Table 4.5.1 shows the contribution of the pelagic species to the earnings from landings of the whole British fleet wherever caught. The fleet is heavily dependent on mackerel and to a lesser extent herring. At the national level, sea bass ranks third in importance among the pelagic species, measured by the value of landings, and yet still only provides just over 3% of the revenue from pelagic species.

Table 4.5.1 Contribution of Species to the Earnings of the British Pelagic Fleet, 2004

Per Cent	Quantity	Value
Albacore	0.0	0.0
Herring	33.2	14.0
Horse Mackerel	4.2	2.1
Mackerel	59.9	78.2
Pilchard (Sardine)	0.9	1.4
Sea Bass	0.2	3.1
Sprat	1.3	0.7
Other	0.4	0.6
Total	100.0	100.0

The situation is less dramatic in the fishery under investigation in that sea bass is the leading pelagic species providing nearly 30% of the fleet income but the dependence on a few species is less marked. This is shown in Table 4.5.2. This means that the fishery is less vulnerable to the loss of its principle species than must be the case in other parts of the British pelagic fishery.

Table 4.5.2 Contribution of Species Caught in ICES Sub-Areas VIId, VIIe, VIIf, VIIg, VIIIa and VIIIb to the Earnings of the British Pelagic Fleet, 2004

Per Cent	Quantity	Value
Albacore	0.0	0.0
Herring	23.9	15.2
Horse Mackerel	27.6	11.8
Mackerel	27.5	22.1
Pilchard (Sardine)	13.3	16.8
Sea Bass	2.8	29.1
Sprat	4.4	3.1
Other	0.4	1.8
Total	100.0	100.0

Further disaggregation of pelagic landings and their value made from ICES sub-areas VIId, VIIe, VIIf, VIIg, VIIIa and VIIIb, is shown in Table 4.5.3, but no complete decomposition can be shown as the data are published at the level of aggregation reported. Further disaggregation is therefore impossible.

Table 4.5.3 Contribution of Species to the Earnings of the British Fleet from ICES Sub-Areas VIId, VIIe, VIIf, VIIg, VIIIa and VIIIb, 2004

	VIIdefg		VIIIab		Total	
Per Cent	Quantity	Value	Quantity	Value	Quantity	Value
Albacore	0.0	0.0	0.0	0.0	0.0	0.0
Herring	28.3	16.8	0.0	0.0	23.9	15.2
Horse Mackerel	29.4	11.8	17.6	12.3	27.6	11.8
Mackerel	17.5	15.8	82.0	83.4	27.5	22.1
Pilchard (Sardine)	15.7	18.6	0.0	0.0	13.3	16.8
Sea Bass	3.3	31.7	0.2	3.9	2.8	29.1
Sprat	5.2	3.4	0.0	0.0	4.4	3.1
Other	0.5	2.0	0.1	0.3	0.4	1.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

In the sea areas abutting the English coast, sub-areas VIId, VIIe, VIIf and VIIg, corresponding to the English Channel, the Bristol Channel and the Celtic Sea, sea bass appears one of the least important by tonnage, but by value, it is the leading species.

The actual level of landings by tonne rather than the percentages shown above are given in Table 4.5.4 below.

Table 4.5.4 Landings by the British Fleet from ICES Sub-Areas VIId, VIIe, VIIf, VIIg, VIIIa and VIIIb, 2004

Quantities (Tonnes)	VIIdefg	VIIIab	Total
Albacore	0	0	0
Herring	4,521	0	4,521
Horse Mackerel	4,700	516	5,216
Mackerel	2,797	2,403	5,200
Pilchard (Sardine)	2,512	0	2,512
Sea Bass	528	7	535
Sprat	836	0	836
Other	73	3	76
Total	15,967	2,929	18,896

The corresponding values of landings are given in Table 4.5.5.

Table 4.5.5	Value of Landings by the British Fleet from ICES Sub-Areas VIId, VIIe, VIIf, VIIg, VIIIa and VIIIb, 2004		
Values (€000)	VIIdefg	VIIIab	Total
Albacore	0	0	0
Herring	2,002	0	2,002
Horse Mackerel	1,403	152	1,554
Mackerel	1,878	1,028	2,906
Pilchard (Sardine)	2,214	0	2,214
Sea Bass	3,781	49	3,830
Sprat	403	0	403
Other	233	4	237
Total	11,913	1,233	13,146

By dividing the values given in Table 4.5.5 by the corresponding quantities reported in Table 4.5.4, it is possible to determine a mean annual price for each of the species for the year 2004. These are given in Table 4.5.6. The different nature of the market for sea bass is spectacularly underlined by the huge difference in price between it and the other pelagic species. It fetches nearly 9 times the price of the nearest, the pilchard, because it goes largely to the restaurant end of the catering trade.

Table 4.5.6	Average Prices Fetched by Landings by the British Fleet from ICES Sub-Areas VIId, VIIe, VIIf, VIIg, VIIIa and VIIIb, 2004		
Prices (€ per Tonne)	VIIdefg	VIIIab	Total
Albacore	0	0	0
Herring	443	0	443
Horse Mackerel	298	294	298
Mackerel	671	428	559
Pilchard(=Sardine)	881	0	881
Sea Bass	7,161	6,946	7,158
Sprat	482	0	482

4.5.3 Economic performance

No survey of the British pelagic fleet has been completed in the last 20 years or more and it is not possible to be certain of the costs and earnings of the fleet. In addition, the fleet has changed it fishing methods very rapidly from drift netting, since the 1960s when the power block was invented to purse seining, to pair trawl and most recently to pelagic mid-water single trawling. The effect of this would mean that were there any costs and earnings data they would rapidly have become obsolete. However, given the nature of the fishing methods used, and practice in other fisheries, we have created an imputed set of costs and earnings figures for the fleet. In some ways this is more valuable than reproducing the financial performance directly as it allows us to isolate the sea bass fishery and attribute costs to it on the basis of a percentage of sales revenue.

Operating costs in a fishery of this nature are normally reported to amount to between 55% and 65% of earnings and we have chosen the mid-point with an increment to 63% owing to the recent steep rise in fuel oil prices. Fuel oil is included as absorbing 20% of earnings. Crew share normally accounts for about 30% of earnings and that figure is used here. A figure of 10% has been allowed for depreciation. Since depreciation is assumed to cover the write-off cost of a vessel, it is assumed that no mortgage is needed and a historically profitable vessel will not require an overdraft for any other purpose; therefore a zero amount for interest is included. The remainder, 17%, represents vessels costs such as insurance, equipment and the like, see Table 4.5.7.

The most difficult figure to determine is the profit after all costs including depreciation have been met. The impression, and it is only an impression, is that the fishery has been performing better than its demersal counterpart. In recent years, there have been fewer problems with stock abundance, although they are by no means absent, and the fleet has operated for some time on a system of quota trading suggesting that it is relatively economically efficient. There have been adequate funds for the fleet to be modernised. On the other hand, if the fishery were so much more profitable than its counterparts there would be a rush to buy licences and quota to take part. Their value would reflect the profitability and capitalise it, reducing the level of profitability to normal levels for the purchasers. We have therefore assumed a level of 10% to represent the pure return to capital.

Table 4.5.7 United Kingdom: National Pelagic Fleet, imputed economic and capacity indicators, 2004

	€000	Percentage of Sales
Value of landings	3830.0	100.0
Fuel costs	766.0	20.0
Other running costs	497.9	13.0
Vessel costs	651.1	17.0
Crew share	1149.0	30.0
Gross cash flow	766.0	
Depreciation	383.0	10.0
Interest	0.0	0.0
Net profit	383.0	10.0
Gross value-added	1915.0	
Employment on board (FTE)	120	
Invested capital (€m)		
Effort (1000 days-at-sea)		
Volume of landings (Tonnes)	535.0	
Fleet - number of vessels	20	
Fleet - total GRT (1000)		
Fleet - total GT (1000)		
Fleet - total kW (1000)		

Employment on board has been derived on the basis of a vessel spending three full months a year in the fishery for a crew member whose annual share is a fraction under €40,000. This gives a total employment over the three months of 120 crew and 20 vessels each with a crew of six.

4.5.4 The Cost-Benefit Analysis Model

The absence of a clear set of costs due to the extended research needed to develop successful separator gear means that a cost-benefit analysis based on findings from trials cannot be performed. The same may be said of the other methods of economic assessment set out earlier in this report.

However, it is possible in spite of this difficulty to make two advances in preparation for the availability of the necessary information. First, it is possible to develop the cost-benefit analysis software in the form of a spreadsheet which identifies the gains and losses that will go into determining the economic consequences of the use of separator gear. These will be both tangible, capable of being calculated as they are based on firm data, and intangible. Secondly, it is possible to use the spreadsheet as a model to determine, under a variety of scenarios, the levels of each of the tangible variables that are necessary for the conversion to separator gears to be deemed an economic success. Given that the fleets face only increased costs, the benefits must be from the fishermen's utility in not killing cetaceans and that also of society as a whole.

One of the primary difficulties that may occur with assessing the viability in socio-economic terms of the installation of separator or acoustic device is of having sufficient experience from history of the likely effect of, for example, changes in tourism levels that may accrue. Even where there is previous experience, the potential effect on tourism or the other benefits may be well outside the sample space of previous observation.

A possible approach when there is a scarcity of information is to change the question so that an observer may offer a qualitative answer. Hence, it is possible to determine what level of improvement in the earnings of tourism might be necessary for the cost-benefit analysis to break even. Then the observer could offer an opinion that the improvement is likely, of marginal likelihood, or unlikely.

A series of Tables below shows the results of using the socio-economic cost-benefit model in this way.

The factors assumed are given in Table 4.5.8. It is assumed that the downstream supply-driven output multiplier for the tourist industry is 1.8. This means that the effect of purchasing by the Tourist industry will be increased by a further 0.8 as a result of additional rounds of expenditure. The demand-driven output multiplier is 2.2, meaning that a further €1.20 will be spent upstream for each initial increment of €1.00. It is assumed that all commercially sold sea bass are caught by pelagic trawlers.

An inflation rate of 4% is assumed and returns are discounted at a social time preference rate of 5%.

Towing the new gear or devices adds only infinitesimally to the amount of fuel used and the acoustic devices cost €300 (two are needed at €150 each). It is assumed that they need to be replaced annually. There is a crew of six to each vessel in the fleet. 90% of the 200 dolphins currently killed are assumed to escape and the contingent value of a dolphin is put at a nominal €1.00. The earnings are discounted over a period of twenty years. At a discount rate of 5% the contribution of each successive year after twenty years to earnings would be negligible.

Table 4.5.8 Factors Assumed in the Cost-Benefit Analysis	
Downstream Output Multiplier (Tourism)	1.80
Upstream Output Multiplier (Tourism)	2.20
Tourism Factor (for solver)	*1.78*
Inflation Rate	4.00
Discount Rate	5.00
Fuel Increase%	0.00
Cost of Gear per year €000	0.30
Crew Size	6
No of Dolphins Killed per year by UK fleet at present	200
% of Dolphins Saved by Separator Gear	90.00
Value of a Dolphin (€)	1.00

The model solves by changing the tourism factor to a level which sets the internal rate of return at zero, and the result is shown in Table 4.5.9. This shows the minimum level of annual earnings needed from tourism to compensate for the cost of the gear change. It should be noted, however, that the benefits accrue to society and tourism, but remain as a loss to the fishing industry. Note that a learning effect has been allowed for in the level of earnings from tourism whereby the earnings grow logarithmically with diminishing returns to time.

Table 4.5.9 Required Improvement in Tourism to Compensate for Cost of Gear Changes

NETT PRESENT VALUE AND INTERNAL RATE OF RETURN FOR SEA BASS FISHERY USING ACOUSTIC DEVICES
€000s

Season Ending	Year of Operation	Discount Factor	Gear Expenditure	Operational Expen-diture	Total Expenditure	TOTAL COST (Discounted)	Benefits from Tour-ism	Benefits from Tour-ism (Discounted)	Aggregated Per-sonal Utility Benefits	Aggregated Per-sonal Utility Benefits (Discounted)	Multiplier Benefits (Discounted)	TOTAL BENEFITS (Discounted)	NETT BENEFITS (Discounted)
2008	1	1.00	6.0	12.0	18.0	18.0	1.8	1.8	0.1	0.1	5.3	7.2	-10.8
2009	2	0.95	6.0	5.7	11.7	11.1	2.4	2.3	0.2	0.2	6.8	9.2	-1.9
2010	3	0.90	5.7	5.7	11.4	10.3	2.7	2.5	0.2	0.2	7.4	10.1	-0.2
2011	4	0.86	5.7	5.7	11.4	9.8	2.9	2.5	0.2	0.2	7.6	10.3	0.5
2012	5	0.81	5.7	5.7	11.4	9.3	3.1	2.5	0.2	0.1	7.5	10.1	0.8
2013	6	0.77	5.7	5.7	11.4	8.8	3.1	2.4	0.2	0.1	7.2	9.8	0.9
2014	7	0.74	5.7	5.7	11.4	8.4	3.1	2.3	0.2	0.1	6.9	9.4	1.0
2015	8	0.70	5.7	5.7	11.4	8.0	3.2	2.2	0.2	0.1	6.6	8.9	1.0
2016	9	0.66	5.7	5.7	11.4	7.6	3.2	2.1	0.2	0.1	6.3	8.5	0.9
2017	10	0.63	5.7	5.7	11.4	7.2	3.2	2.0	0.2	0.1	6.0	8.1	0.9
2018	11	0.60	5.7	5.7	11.4	6.8	3.2	1.9	0.2	0.1	5.7	7.7	0.9
2019	12	0.57	5.7	5.7	11.4	6.5	3.2	1.8	0.2	0.1	5.4	7.3	0.8
2020	13	0.54	5.7	5.7	11.4	6.2	3.2	1.7	0.2	0.1	5.1	6.9	0.8
2021	14	0.51	5.7	5.7	11.4	5.9	3.2	1.6	0.2	0.1	4.9	6.6	0.7
2022	15	0.49	5.7	5.7	11.4	5.6	3.2	1.5	0.2	0.1	4.6	6.3	0.7
2023	16	0.46	5.7	5.7	11.4	5.3	3.2	1.5	0.2	0.1	4.4	6.0	0.7
2024	17	0.44	5.7	5.7	11.4	5.0	3.2	1.4	0.2	0.1	4.2	5.7	0.6
2025	18	0.42	5.7	5.7	11.4	4.8	3.2	1.3	0.2	0.1	4.0	5.4	0.6
2026	19	0.40	5.7	5.7	11.4	4.5	3.2	1.3	0.2	0.1	3.8	5.1	0.6
2027	20	0.38	5.7	5.7	11.4	4.3	3.2	1.2	0.2	0.1	3.6	4.8	0.5
Total			**114.6**	**120.3**	**234.9**	**153.2**	**60.3**	**37.7**	**3.5**	**2.2**	**113.2**	**153.2**	**0.0**
												Nett Present Value (€m) =	0.0
												Internal Rate of Return =	0%

A different question is dealt with in Tables 4.5.10 and 4.5.11. Here the estimate is of the minimum value a dolphin needs to have in the minds of the public for the use of the acoustic devices to become viable. It is assumed that there is no return from improved tourism and that towing the device through the water adds nothing to vessel fuel costs.

Table 4.5.10 The Valuation of a Dolphin

Downstream Output Multiplier (Tourism)	1.80
Upstream Output Multiplier (Tourism)	2.20
Tourism Factor (for solver)	0.00
Inflation Rate	4.00
Discount Rate	5.00
Fuel Increase%	0.00
Cost of Gear per year €000	0.30
Crew Size	6
No of Dolphins Killed per year by UK fleet at present	200
% of Dolphins Saved by Separator Gear	90.00
Value of a Dolphin (€)	*69.00*

This suggests that each dolphin would have to be worth €69 or more in the eyes of the public for the use of acoustic devices to be economically viable. Below that figure, using acoustic devices would amount to a cost to society[9].

[9] It must be emphasised that these figures are fictitious and should not be quoted as genuine. They arise from a series of postulated costs and benefits designed with no other purpose than to show the capabilities of the cost-benefit analysis model.

Table 4.5.11 Required Value of a Dolphin to Compensate for Cost of Gear Changes

Season Ending	Year of Operation	Discount Factor	Gear Expenditure	Operational Expen-diture	Total Expenditure	TOTAL COST (Dis-counted)	Benefits from Tou-rism	Benefits from Tou-rism (Discounted)	Aggregated Perso-nal Utility Benefits	Aggregated Per-sonal Utility Benefits (Discounted)	Multiplier Benefits (Discounted)	TOTAL BENEFITS (Discounted)	NETT BENEFITS (Discounted)
2008	1	1.00	6.0	12.0	18.0	18.0	0.0	0.0	6.2	6.2	0.0	6.2	-11.8
2009	2	0.95	6.0	5.7	11.7	11.1	0.0	0.0	12.4	11.8	0.0	11.8	0.7
2010	3	0.90	5.7	5.7	11.4	10.3	0.0	0.0	12.4	11.2	0.0	11.2	0.9
2011	4	0.86	5.7	5.7	11.4	9.8	0.0	0.0	12.4	10.6	0.0	10.6	0.9
2012	5	0.81	5.7	5.7	11.4	9.3	0.0	0.0	12.4	10.1	0.0	10.1	0.8
2013	6	0.77	5.7	5.7	11.4	8.8	0.0	0.0	12.4	9.6	0.0	9.6	0.8
2014	7	0.74	5.7	5.7	11.4	8.4	0.0	0.0	12.4	9.1	0.0	9.1	0.8
2015	8	0.70	5.7	5.7	11.4	8.0	0.0	0.0	12.4	8.7	0.0	8.7	0.7
2016	9	0.66	5.7	5.7	11.4	7.6	0.0	0.0	12.4	8.2	0.0	8.2	0.7
2017	10	0.63	5.7	5.7	11.4	7.2	0.0	0.0	12.4	7.8	0.0	7.8	0.6
2018	11	0.60	5.7	5.7	11.4	6.8	0.0	0.0	12.4	7.4	0.0	7.4	0.6
2019	12	0.57	5.7	5.7	11.4	6.5	0.0	0.0	12.4	7.1	0.0	7.1	0.6
2020	13	0.54	5.7	5.7	11.4	6.2	0.0	0.0	12.4	6.7	0.0	6.7	0.6
2021	14	0.51	5.7	5.7	11.4	5.9	0.0	0.0	12.4	6.4	0.0	6.4	0.5
2022	15	0.49	5.7	5.7	11.4	5.6	0.0	0.0	12.4	6.1	0.0	6.1	0.5
2023	16	0.46	5.7	5.7	11.4	5.3	0.0	0.0	12.4	5.8	0.0	5.8	0.5
2024	17	0.44	5.7	5.7	11.4	5.0	0.0	0.0	12.4	5.5	0.0	5.5	0.4
2025	18	0.42	5.7	5.7	11.4	4.8	0.0	0.0	12.4	5.2	0.0	5.2	0.4
2026	19	0.40	5.7	5.7	11.4	4.5	0.0	0.0	12.4	4.9	0.0	4.9	0.4
2027	20	0.38	5.7	5.7	11.4	4.3	0.0	0.0	12.4	4.7	0.0	4.7	0.4
Total			**114.6**	**120.3**	**234.9**	**153.2**	**0.0**	**0.0**	**242.2**	**153.2**	**0.0**	**153.2**	**0.0**
												Nett Present Value (€m) =	0.0
												Internal Rate of Return =	0%

Table 4.5.12 and 4.5.13 show yet another way of using the cost-benefit analysis model. Here the break-even factors have been used to set up the model in order to calculate a present value for the net benefits of using acoustic devices on the assumption that each of the minimum requirements is achieved. Thus the tourism factor is set at 1.78 and the value of dolphins at €69.00 each. It has also been assumed that towing the acoustic devices adds 1% to fuel costs – this is probably vastly overstated but is included to show the potential for a broader study of the potential impact of conservation-friendly gear constructions.

Table 4.5.12 Factors Used in Calculating a Present Value and Internal Rate of Return

Downstream Output Multiplier (Tourism)	1.80
Upstream Output Multiplier (Tourism)	2.20
Tourism Factor (for solver)	1.78
Inflation Rate	4.00
Discount Rate	5.00
Fuel Increase%	1.00
Cost of Gear per year €000	0.30
Crew Size	6
No of Dolphins Killed per year by UK fleet at present	200
% of Dolphins Saved by Separator Gear	90.00
Value of a Dolphin (€)	69.00

The impact estimated on the fleet and on the individual participants is also shown in Tables 4.5.14 and 4.5.15.

Finally, a socio-economic Balance Sheet may be drawn up of the costs and benefits. One such balance sheet is shown as Table 4.5.16 for the example given in Tables 4.5.12 and 4.5.13.

Table 4.5.13 Nett Present Value and Internal Rate of Return Calculations

Season Ending	Year of Operation	Discount Factor	Gear Expenditure	Operational Expenditure	Total Expenditure	TOTAL COST (Discounted)	Benefits from Tourism	Benefits from Tourism (Discounted)	Aggregated Personal Utility Benefits	Aggregated Personal Utility Benefits (Discounted)	Multiplier Benefits (Discounted)	TOTAL BENEFITS (Discounted)	NETT BENEFITS (Discounted)
2008	1	1.00	13.7	12.0	25.7	25.7	1.8	1.8	6.2	6.2	5.3	13.3	-12.3
2009	2	0.95	13.7	5.7	19.4	18.4	2.4	2.3	12.4	11.8	6.8	20.8	2.4
2010	3	0.90	13.4	5.7	19.1	17.2	2.7	2.5	12.4	11.2	7.4	21.1	3.9
2011	4	0.86	13.4	5.7	19.1	16.3	2.9	2.5	12.4	10.6	7.6	20.8	4.4
2012	5	0.81	13.4	5.7	19.1	15.5	3.1	2.5	12.4	10.1	7.5	20.1	4.5
2013	6	0.77	13.4	5.7	19.1	14.7	3.1	2.4	12.4	9.6	7.2	19.2	4.5
2014	7	0.74	13.4	5.7	19.1	14.0	3.1	2.3	12.4	9.1	6.9	18.4	4.4
2015	8	0.70	13.4	5.7	19.1	13.3	3.2	2.2	12.4	8.7	6.6	17.5	4.2
2016	9	0.66	13.4	5.7	19.1	12.6	3.2	2.1	12.4	8.2	6.3	16.6	4.0
2017	10	0.63	13.4	5.7	19.1	12.0	3.2	2.0	12.4	7.8	6.0	15.8	3.8
2018	11	0.60	13.4	5.7	19.1	11.4	3.2	1.9	12.4	7.4	5.7	15.0	3.6
2019	12	0.57	13.4	5.7	19.1	10.8	3.2	1.8	12.4	7.1	5.4	14.3	3.4
2020	13	0.54	13.4	5.7	19.1	10.3	3.2	1.7	12.4	6.7	5.1	13.6	3.3
2021	14	0.51	13.4	5.7	19.1	9.8	3.2	1.6	12.4	6.4	4.9	12.9	3.1
2022	15	0.49	13.4	5.7	19.1	9.3	3.2	1.5	12.4	6.1	4.6	12.2	2.9
2023	16	0.46	13.4	5.7	19.1	8.8	3.2	1.5	12.4	5.8	4.4	11.6	2.8
2024	17	0.44	13.4	5.7	19.1	8.4	3.2	1.4	12.4	5.5	4.2	11.0	2.7
2025	18	0.42	13.4	5.7	19.1	8.0	3.2	1.3	12.4	5.2	4.0	10.5	2.5
2026	19	0.40	13.4	5.7	19.1	7.6	3.2	1.3	12.4	4.9	3.8	10.0	2.4
2027	20	0.38	13.4	5.7	19.1	7.2	3.2	1.2	12.4	4.7	3.6	9.5	2.3
Total			**267.8**	**120.3**	**388.1**	**251.4**	**60.3**	**37.8**	**242.2**	**153.1**	**113.3**	**304.2**	**52.8**
												Nett Present Value (€m) =	52.8
												Internal Rate of Return =	30%

Table 4.5.14 Fleet Performance

€000	Value of landings	Fuel costs	Other running costs	Vessel costs	Crew share	Gross cash flow	Depreciation	Interest	Nett profit	Gross value added	Employment on board (FTE)	Volume of landings (Tonnes)	Number of vessels
2007	3830.0	766.0	497.9	651.1	1149.0	766.0	383.0	0.0	383.0	1915.0	120.0	535.0	20.0
2008	3830.0	773.7	497.9	663.1	1149.0	746.3	383.0	0.0	363.3	1895.3	120.0	535.0	20.0
2009	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2010	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2011	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2012	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2013	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2014	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2015	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2016	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2017	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2018	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2019	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2020	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2021	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2022	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2023	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2024	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2025	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2026	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0
2027	3830.0	773.7	497.9	656.8	1149.0	752.6	383.0	0.0	369.6	1901.6	114.0	535.0	19.0

Table 4.5.15 Individual Vessel Performance

€000	Value of landings	Fuel costs	Other running costs	Vessel costs	Crew share	Gross cash flow	Depreciation	Interest	Nett profit	Gross value-added	Employment on board (FTE)	Volume of landings (Tonnes)	Number of vessels
2007	191.5	38.3	24.9	32.6	57.5	38.3	19.2	0.0	19.2	95.8	6.0	26.8	1.0
2008	191.5	39.1	24.9	33.2	57.5	36.9	19.2	0.0	17.8	94.4	6.0	26.8	1.0
2009	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2010	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2011	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2012	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2013	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2014	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2015	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2016	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2017	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2018	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2019	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2020	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2021	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2022	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2023	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2024	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2025	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2026	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0
2027	201.6	40.7	26.2	34.6	60.5	39.6	20.2	0.0	19.5	100.1	6.0	28.2	1.0

Table 4.5.16 Balance Sheet of the Costs and Benefits Arising from Introduction of Separator Gear

COSTS				
	Cost of Gear		171.998	
	Extra Fuel		79.433	
		Sub Total		251.430
		TOTAL		251.430
BENEFITS				
	Value of Cetaceans		153.142	
	Tourism		37.761	
		Sub-Total		190.904
	Multiplier Effects		113.284	
		Sub-Total		113.284
		TOTAL		304.188
BALANCE	Net percent value			**52.758**

Source: Table 4.5.13.

4.6. Alternative gear for reduction of by-catch of cetaceans by Dutch Pelagic Freezer Trawlers

4.6.1. General presentation of the fishery

Dutch pelagic freezer trawlers fish in EU waters as well as those off West Africa (Mauritania and Morocco). The most important target species are herring, horse mackerel, mackerel and blue whiting in EU waters and sardinellas and sardines in African waters.

In 2005, the number of vessels in the pelagic freezer trawler segment fell from 17 to 15 at the end of the year (Table 4.6.1). During the year 2005, 16 vessels took part in the fisheries and the results presented in this report are based on this number of vessels. With 85,000 kiloWatts (kW) this segment of the Dutch fishing fleet accounted for 28% of total Dutch kW. In 2005, total effort of the segment decreased by 10% while effort in African waters decreased to 32% (2004: 43%). The total number of days at sea decreased to 4,200 in 2005. All catches were landed frozen by the vessels and the volume of landings in 2005 increased by more than 5% to 468,000 tonnes of pelagic fish. Total employment on board the vessels decreased in 2005 by almost 9% and varied during the last few years between 560 and 613 persons.

Table 4.6.1 Dutch pelagic freezer trawlers: main indicators

Indicator	2002	2003	2004	2005
Employment on board	586	613	613	560
Invested capital (€m)	209	209	210	185
Effort days-at-sea (000)	4.4	4.7	4.7	4.2
Volume of landings (000 tonnes)	368	441	444	468
Fleet - number of vessels	17	17	17	15
Fleet - total GRT (000)	90	90	90	79
Fleet - total kW (000)	99	99	99	85

4.6.2. Economic performance

4.6.2.1. Landings composition

Total landings in 2005 of the Dutch pelagic freezer trawler fleet amounted to 468,000 tonnes of fish. Table 4.6.2 shows that, by volume, blue whiting and herring were the most important species for the fleet in 2005. These species covered 55% of total landings. Horse mackerel and sardinellas were also important species which together accounted for 31% of the volume of landings. Herring and blue whiting have been more important since 2002 while landings of mackerel decreased during the last four years. Landings of sardinellas fluctuated considerably during this period.

Table 4.6.2 Volume of landings (000 tonnes)

Species	2002	2003	2004	2005
Herring	69	94	126	125
Horse mackerel	67	77	90	73
Mackerel	52	48	35	28
Blue whiting	38	59	78	130
Sardinellas	98	102	54	71
Other fish	44	61	61	41

Source: LEI

4.6.2.2 Fleets costs and earnings

The value of the landings of the pelagic fleet in 2005 increased by almost 5% to more than €136m (Table 4.6.3). Vessel costs decreased by 11% and depreciation costs by 8% while all other costs, more or less, remained the same. Gross cash flow increased by more than 50% to more than €25m and gross value-added increased by 18% to more than €61m. For an average vessel, all costs in 2005 increased, and especially fuel costs. Total fuel costs for the freezer fleet remained about the same in 2005 simply owing to the reduced fleet compared to 2004. On average, the freezer trawler fleet has faced a total loss of €4.5m in the last four years.

Table 4.6.3 Fleet costs and earnings

Indicator (€m)	2002	2003	2004	2005
Value of landings	126.1	143.3	130.7	136.6
Fuel costs	19.1	20.5	20.8	21.0
Other running costs	35.0	34.4	28.8	28.5
Vessel costs	20.8	21.5	29.2	26.0
Crew share	32.3	36.9	35.1	35.5
Gross cash flow	18.9	30.0	16.8	25.6
Depreciation	22.4	23.4	22.4	20.6
Interest	7.2	5.7	4.1	3.8
Net profit	-10.7	0.9	-9.7	1.2
Gross value-added	51.2	66.9	51.9	61.1

Source: LEI

The average value of landings per vessel in 2005 increased by 11% to more than €8.5m (Table 4.6.4). Net profit increased to €75,000 per vessel, whereas the fleet faced a loss in 2004 of €571,000 per vessel.

Table 4.6.4 Costs and earnings (average per vessel)

Average per vessel (€000)	2002	2003	2004	2005
Value of landings	7,418	8,432	7,688	8,538
Gross value-added	3,006	3,937	3,053	3,820
Gross cash flow	1,112	1,710	988	1,600
Net profit	-629	53	-571	75

Source: LEI

4.6.3 Calculations and result

In 2005/2006 an alternative gear for reducing by-catches of cetaceans by pelagic freezer trawlers, was tested by IMARES. These tests, however, have not been conclusive. Therefore, in the cost-benefit analysis, several scenarios have been defined with different effects on catches of target species. For each of these scenarios, the economic consequences of installing the adjusted gear have been elaborated.

4.6.3.1 Definition of scenarios

In all three scenarios, an initial investment in the alternative gear of €10,000 has been assumed. Furthermore, it is assumed that the gear has to be replaced every three years. In Scenario 1, the alternative gear has no effect on catches of the target species. In Scenario 2, catches of all target species are 5% lower than with the original gear. In Scenario 3, the negative effect on catches is assumed to be 10% for all target species.

Table 4.6.5 Cost-Benefit Analysis of alternative gear: three scenarios

	Investment in alternative gear	Change in catches
Scenario 1	€ 10,000 every three years starting in year 1	0% (all species)
Scenario 2	€ 10,000 every three years starting in year 1	-5% (all species)
Scenario 3	€ 10,000 every three years starting in year 1	-10% (all species)

For all three scenarios, the effects on gross revenues, variable costs and margins have been calculated. In the calculations for the different scenarios, price flexibility is assumed to be zero. The prices for these pelagic species are determined on the world market and do not have a direct relation with the fluctuations in landings by the Dutch pelagic freezer trawler fleet.

The Net Present Value of the effect on the margin[10] has been calculated for 10, 20 and 30 years. In the calculations of NPV, a (real) discount rate of 4% has been applied[11]. Economic results for the three scenarios are presented in Section 4.6.3.2

4.6.3.2 Economic results

The Net Present Value (NPV) of the economic effect of altering the gear can be defined as the NPV after the gear change (Equation 1, Section 1.2) minus NPV without the gear change (Equation 2, Section 1.2). In this case, fixed costs and management costs are assumed to be constant. The additional costs of investment in the altered gear are treated as a change in variable costs. Under these assumptions the total (private) economic effect of the gear change is equal to the NPV of the change in the margin.

$$NPV^1 - NPV^0 = \sum_{t=0}^{T} \frac{\sum_{i=1}^{I} H_{i,t}^1 * P_{i,t}^1 - C_t^1 - \left(H_{i,t}^0 * P_{i,t}^0 - C_t^0\right)}{(1+d)^t}$$

In Scenario 1, the costs of the new gear are the only effect as the change in catches is assumed to be zero. In this scenario, the effect on NPV is equal to the change in variable costs. In Scenarios 2 and 3 the negative change in gross revenues as result of the 5% and 10% reduction in catches is added to this effect. Table 4.6.6 presents the economic results in the base year (2005). Table 4.6.7 shows the projected results in the first 10 years after the gear change.

Table 4.6.6 Economic results of Dutch pelagic fleet in the base year 2005, (€000)

	Pelagic freezer trawlers Vessel level	Pelagic freezer trawlers Fleet level
Value of Landings	8,538	136,608
Variable costs	3,283	52,528
Gross margin	5,255	84,080
Labour costs	2,219	35,504
Margin	3,036	48,576

Source: LEI

[10] Margin = gross revenues – variable costs – labour costs

[11] A real discount rate of 4% conforms to present practice in the evaluation of Dutch government investment plans

Table 4.6.7 Projected Results for Dutch pelagic freezer trawlers: Change in margin (vessel level), €000

Nominal values Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Scenario 1	-10	0	0	-10	0	0	-10	0	0	-3
Scenario 2	-437	-427	-427	-437	-437	-427	-427	-437	-427	-430
Scenario 3	-864	-854	-854	-864	-864	-854	-854	-864	-854	-857
Discounted values Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Scenario 1	-10	0	0	-9	0	0	-8	0	0	-2
Scenario 2	-420	-410	-395	-388	-373	-351	-337	-332	-312	-302
Scenario 3	-831	-821	-789	-768	-738	-702	-675	-656	-624	-602

In Scenario 1, the change of margin in the first year of operation is equal to the extra costs of the adjusted gear, €10,000, which represents 0.3% of the margin in the base year. In Scenarios 2 and 3, the change of margin is the sum of the costs of the new gear and the reduction in gross revenues as result of lower catches of the target species with the new gear. In Scenarios 2 and 3, the change in margin in the first year is €437,000 and €864,000 respectively or 14% and 28% of the margin in the base year.

Table 4.6.8 Projected results for Dutch pelagic freezer trawlers: Net present value (NPV) over 10, 20, and 30 years

Vessel level €000	10 years	20 years	30 years	Fleet level €000	10 years	20 years	30 years
Scenario 1	-29	-45	-56	Scenario 1	-456	-719	-897
Scenario 2	-3,621	-5,977	-7,568	Scenario 2	-57,942	-95,632	-121,094
Scenario 3	-7,206	-11,901	-15,072	Scenario 3	-115,296	-190,413	-241,159

Table 4.6.8 presents the NPV of the changes in margin after 10, 20 and 30 years at the vessel level and the fleet level. At the vessel level, the NPV after 30 years varies from €56,000 in Scenario 1 to €15m in Scenario 2. At the fleet level, the NPV varies from €897,000 to €241m. This means that the positive NPV of saving the cetaceans for a period of thirty years will at least have to compensate for these losses in order to make the gear adjustment beneficial from a societal perspective.