Analysing stakeholder preferences on multiple objectives in a bioeconomic model of the fisheries of the English Channel

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Abstract. Fisheries management is characterised by multiple objectives. However, seldomly do bioeconomic models incorporate more than one or possibly two key objectives, typically profit and employment, into an analysis. There are both practical and technical reasons for this. This study considers the incorporation of eight key objectives into a bioeconomic analysis of the fisheries of the English Channel. These objectives include profit, fisher employment, regional employment from fishing, safety issues, sustainability of commercial stocks, bycatch, allocation issues between fishers and relative stability between countries. In surveys that targeted the principal interest groups in the fisheries in both the UK and France, preferences have been developed using the analytic hierarchy process (AHP) to indicate an importance between objectives. These preferences have then been used in an encompassing goal programming based bioeconomic model of the fisheries which may be used to evaluate and analyse the structure of the English Channel fisheries relative to a variety of opinion.

Keywords: bioeconomic modelling, stakeholder preferences, fisheries management, multiple objectives, criteria.

1. INTRODUCTION

The overriding objectives of fisheries management are generally highlighted in national and international fisheries policy documents throughout the world. The issue of maximising sustainable yield is still prominent in such policy (e.g. the FAO Code of Conduct for Responsible Fishing, 1995), and therefore stands out as the most "important" objective. From a purely economic viewpoint, the optimal use of the fisheries resource is to achieve the maximum level of resource rents possible from the fishery (Cunningham, Dunn and Whitmarsh, 1985). However, fisheries management includes a range of objectives (e.g. Crutchfield, 1973; Gulland, 1977; Charles, 1989; and Mardle et al., 2002). In many specific fisheries, rather than just in the general case, other objectives may be considered to be equally or even more important than sustainability of the fish stocks in the day-to-day management of the fishery. That is not to say that sustainability is not the key objective generally, but in some fisheries it may not be as binding as in others. Some of the most commonly declared objectives of fisheries management are: (i) resource conservation; (ii) food production; (iii) generation of economic wealth; (iv) generation of reasonable income for fishers; (v) maintaining employment for fishers; and (vi) maintaining the viability of fishing communities (Charles, 1989).

Further to actual objectives that exist in a fishery, there are generally a variety of interest groups or stakeholders who in most cases have a differing opinion on the importance of individual objectives. The different groups include fishers, biologists, economists, policy makers, fishing organisations, consumer groups and environmental groups. It is clear that the differences of opinion typically develop from the role that these groups play in a fishery. Resultantly, the performance of the policy will therefore be judged against a group's own individual set of priorities. For example, an organisation representing fishers could be expected to be closer to the objectives of maintaining employment and maximising profit than say an environmental group that would be expected to be more detached from these objectives. Lane (1989) highlights this fact noting that conflict between objectives in fisheries management is most generally between long-term biological or conservation objectives and short-term economic objectives. However, administration groups such as policy makers naturally hear the concerns from all groups. Hanna and Smith (1993) note that different goal orientations are a major source of conflict in fisheries management.

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In Europe, much of the criticism of the CFP is largely based on a particular set of objectives not being fulfilled as expected by a particular group. This leads to conflict between the different groups who place different emphasis on the individual objectives. Furthermore, recent studies in compliance in fisheries management suggest that feelings of legitimacy are important if management measures are to be fully accepted. This illustrates the requirement to include views and opinions of different groups in the management process to achieve widely accepted and supported policy schemes. Therefore, the inclusion of preferences from all parts of the industry is a key factor in the development of an objective structure, and attitudes and opinions from all applicable representatives is a necessary task. Incorporation of their goals for management also represents an indication of each group's desired management direction. This paper aims to provide a framework of analysis where the opinions of identified interest groups, with respect to the importance of management objectives, are directly incorporated in a bioeconomic modelling framework. This model may be used to evaluate how differing opinions would affect the structure of the fishery under analysis from an optimal standpoint.

Hence, there are two parts to this framework: the development of preferences towards key management objectives; and the inclusion of the preferences within a multi-objective model to evaluate the structure of the fishery under analysis given the perceived preferences of the different interest groups. Thus, the investigation of many of the relevant management questions and potential effects of management controls can be investigated, particularly looking at the trade-offs that exist between objectives. The methods used in each stage of the analysis are the analytic hierarchy process (AHP) and goal programming (GP), which have been used in combination together in several published case studies, many of which relate to the natural resources (Mardle and Pascoe, 2000). The AHP is based on the concept of pairwise comparison, where objectives and/or attributes are compared in pairs using a 9-point scale of comparison. Goal programming is based on the Simonian concept of satisficing, where objectives are modelled as goals and the achievement of specified target values is measured.

The case study used in this analysis is that of the fisheries of the English Channel, incorporating data from the UK and France. In both countries, key representatives were surveyed to elicit preferences, representing the main interest groups in these fisheries. Generally, preference elicitation methods are developed to analyse the responses of a homogeneous survey set. However, in the case of fisheries management, the interest groups are particularly heterogeneous. The groups surveyed include the main interest groups who work directly in the fisheries (i.e. catching sector), currently provide management for the fisheries (i.e. administration sector), provide scientific/marketing advice (i.e. scientists), and/or have an environmental interest in the fisheries (i.e. environment organisations).[2]

The structure of this paper is as follows. The next section gives a description of the case study developed. The following section presents the results of the preference elicitation surveys of the UK and France English Channel interest groups. The section after, develops the goal programming model. This is followed by the presentation of results for the interest group sectors. The results indicate how the structure of the English Channel fisheries fleet might differ given the alternative opinions elicited. Finally, provisional results are discussed based on the workings of the model using currently known parameters and concluding comments made.

2. BRIEF OVERVIEW OF THE FISHERIES OF THE ENGLISH CHANNEL

The English Channel is defined by ICES sub-regions VIId and VIIe. It contains a number of multi-species multi-gear fisheries dominated by high-value fish and shellfish species such as sole, lobster and scallops. Around 4000 registered boats operate in the fishery ranging in size from 4m to over 30m. The fleet consists primarily of UK and French boats, although a small number of Belgian beam trawlers operate part of the year in the Eastern Channel, and a small fleet from the Channel Islands operate in their adjacent inshore waters. Total employment in the UK component of the fishery was estimated to be about 4,300 excluding indirect employment in industries linked to the fishing industry. In France, about 4,800 are thought to be employed in the fishery. In 1997, the estimated value of landings from the UK and French fleets was approximately €500 million, 60 per cent of which was landed by the French Fleet. Profitability in the UK fleet has generally been low, with economic profits estimated to have been negative over the period 1994/5-1996/7 (Coglan and Pascoe, 2000). In contrast, the French fleet was estimated to have earned positive economic profits in 1997 (Boncoeur and Le Gallic, 1998).

A number of distinct fishing activities (termed métiers) in the Channel have been defined, based on country of origin, fishing gear employed and area fished (Tétard *et al*, 1995). The métiers are broadly based on seven main gear types: beam trawl, otter trawl, pelagic/mid-water trawl, dredge, line, nets and pots. While fleets can also be

[2] It should be noted that in France "environmental" groups were not directly surveyed.

broadly classified on the basis of their main gear type, they are largely multi-purpose, and operate in several different métiers over the year.

Management of the fishery is undertaken at several levels. The European Council imposes total allowable catches (TACs) on several of the key species in the fishery. These are allocated to the individual countries, which manage the uptake of their respective quotas. Over 50 species are caught commercially in the Channel, although only 10 are subject to quota control under the CFP. Management of the other species is largely undertaken through controls on the level and use of inputs in the fishery. Entry to the fishery is limited at the national level, with each boat requiring a licence to operate. Restrictions on the use of gear and limitations on access to particular areas of the fishery are imposed at the European, national and regional level. Technical measures imposed under the CFP include minimum mesh sizes for different fishing activities. These are compounded by other restrictions imposed by the national management authorities as well as regional bodies.

3. MEASURING THE "IMPORTANCE" OF OBJECTIVES

The method adopted for preference elicitation was the analytic hierarchy process (AHP) (Saaty 1977, 2001). The AHP has been used considerably in many fields for the definition and analysis of user (or decision-maker) preferences. It has been applied to a diverse range of applications (see Zahedi 1986)[3]. However, it is only in the last ten years that the AHP has been applied to fisheries to a small degree. Mardle and Pascoe (1999) cite only four applications of the AHP in the field of fisheries.[4] Leung et al. (1998), the most recent of these publications and the only one considering commercial fisheries, evaluated fisheries management options for limiting entry to the Hawaii longline pelagic fishery.

An advantage of the AHP is that it can be used to develop importance structures between criteria. It allows the elicitation of a set of professional judgements for any individual. The key feature is that value judgements are incorporated in the process, giving decision-makers the opportunity to explicitly state their preferences with respect to the identified objectives.

The AHP method is based primarily on pairwise comparisons of sets of objects. Once a hierarchy of objectives/attributes has been defined, the individual alternatives are compared with each other, and the strength of preference for each objective relative to each other objective is elicited. The remaining analysis stage can then be invoked as a 'black box' procedure. The steps of the AHP are given below:

1) develop a hierarchy of interrelated decision elements describing the problem (creating a survey template) – see Mardle et al. (2002);
2) undertake a criteria oriented pairwise comparison based survey (mail; one-to-one or small meetings; or workshop);
3) compute the individuals' relative weights of the decision elements (*e.g.* using the eigenvalue method to solve $(A-\lambda I)w=0$ where A is the reciprocal matrix of pairwise comparisons, I is the identity matrix of dim(A), λ is the largest eigenvalue and w is the vector of relative weights);
4) a. derive the group weights (homogeneous groups); and

   b. derive the social weights (for the complete situation, probably heterogeneous).

The results can be improved through validation and feedback during steps 2-4, where the results are presented to the respondents, and any responses evaluated to be highly inconsistent can be re-assessed and resolved. To ensure interaction with the participants, the interviews conducted were face-to-face. A number of software packages are now available to analyse the results from the surveys. The software used here was ExpertChoice,[5] which forms the industry standard for the AHP.

Two of the most important areas in the AHP are the scale of comparison used and the maximum number of objects that can be included in an analysis. For the former point, it has been shown in comparative studies that in this framework a 9-point scale of comparison most closely simulates human decision making when comparing

[3] There is an online database of applicational papers at the ExpertChoice website (http://www.expertchoice.com) called the Hierarchon.
[4] The results from this study are discussed in more detail in Mardle, Pascoe and Herrero (2001) and Mardle et al. (2002). Note that the latter of these compares results of similar studies for several EU case studies.
[5] www.expertchoice.com

objects (Saaty, 1977). This scale is generally defined between 1 representing "equal importance" and 9 representing "absolute importance". For the latter point, it has been shown in psychological experiments that a decision maker cannot simultaneously compare more than 7 (±2) objects without confusion. This is based on the number of comparisons to be made and the time taken to perform the task relative to the 'accuracy' of the responses. Therefore, there is a natural limit on the number of objectives that can be included in a study. This is indeed the case for all multiple objective analytical methods.

The standard measure of inconsistency (or intransitivity) that is used in the AHP offers a useful guide to the validity of a respondents viewpoint. That is a high inconsistency value will typically point more towards a lack of understanding in the management problem being addressed. It is generally accepted that a consistency ratio (CR) of less than 10% is highly acceptable, although with post-analysis up to 20% may be acceptable. This measure is obtained from comparing the actual A-matrix of pairwise comparisons with the consistent A-matrix derived from the vector of importance weights developed in step 3 of the AHP. This is then compared to an average inconsistency that could be expected based on the number of objectives under consideration to obtain the CR. However, the consistency ratio also indicates the complexity underlying the management problem. As such, this single measure of consistency is the standard measure used, but other measures may be used to further categorise levels of consistency (see Mardle, Pascoe and Herrero, 2001).

3.1 The Importance of Fisheries Management Objectives in the English Channel

From the AHP surveys that took place along the English Channel coasts in the UK and France in 2001, preferences were elicited for seven overlapping objectives. These objectives and the importance attached to each, by group segment in each country, are given in table 1.

	Commercial stocks	*Non-commercial species*	*Safety & labour conditions*	*Employment in fisheries*	*Employment in coastal areas*	*Profitability*	*Conflicts between fishers*
UK:							
Administration	18.5%	9.9%	11.9%	16.3%	18.3%	10.6%	14.5%
Environmental Orgs	13.9%	30.0%	8.8%	6.8%	14.1%	6.1%	20.3%
Catching Sector	18.8%	4.1%	9.5%	21.0%	17.0%	14.4%	15.2%
Scientists/Industry	16.4%	18.7%	8.6%	13.0%	16.2%	15.6%	11.5%
France:							
Administration	20.0%	7.8%	27.8%	11.1%	11.1%	10.0%	12.2%
Catching Sector	22.2%	11.1%	18.9%	16.7%	8.9%	11.1%	11.1%
Scientists	34.8%	23.6%	10.1%	6.7%	10.1%	6.7%	7.9%

Source: Mardle and Pascoe (2002)

Table 1: Elicited importance information of key objectives in the UK and France.

In this paper, the ultimate aim of the work undertaken was to provide an optimal view of the structure of the fisheries from the interest group perspectives. Therefore, preferences have been aggregated to the group level using the arithmetic mean (table 1).

4. MULTIPLE OBJECTIVE MODELLING OF THE FISHERIES OF THE ENGLISH CHANNEL

The multiple objective programming paradigm used for the description of the English Channel fisheries is goal programming (GP). It is probably the oldest of such methodologies belonging to the field of multi-criteria decision-making. The technique is based on the concept of satisficing, where target values (or goals) for the different objectives are established and deviations from these target values measured. The standard weighted goal programming model[6] is given by,

[6] See Ignizio and Cavalier (1994) for a more complete description of the GP definition, including other GP paradgims.

$$\min z = g(n,p) = \sum_{i=1}^{k} (u_i n_i + v_i p_i) \quad (1)$$

subject to

$$f_i(\mathbf{x}) + n_i - p_i = b_i \qquad \forall\, i \quad (2)$$

$$x \in C_s \quad (3)$$

where z is the value of the achievement function, **x** is the set of decision variables, b_i is the target value of objective i, **n** and **p** are the negative and positive deviations respectively from the target value of each objective i, and **u** and **v** are predefined weights. C_s is a set of optional constraints of the same form as those used in linear programmes. As each objective may be expressed in different units (e.g. millions of dollars, kilograms, or simple quantities etc) the deviations from the goal are typically normalised to overcome problems associated with incommensurability (Tamiz, Jones and El-Darzi, 1995).

There are several advantages to using GP for the system described in this paper. GP lends itself directly to the inclusion of *a priori* weights for analysis, which has been shown to provide a practical framework for system evaluation when combining the AHP and GP (Mardle and Pascoe, 2000). Further, there are few methodologies that can accommodate more than 3 or 4 objectives for analysis, a key feature of this study. An additional complication is the scale of the model that is highly nonlinear and large-scale in nature.

4.1 The Basic Model

The basic structure of the model is the same as that developed in Pascoe and Mardle (2001). The model is driven by the effort exerted on the fishery in terms of numbers of vessels. Vessels are described by fleet (i.e. main gear type used and location fished) and size. There are six size classes and six principal gear types (beam trawl, otter trawl, dredge, lines, nets and pots). In total, 55 Channel métiers are explicitly included in the model with the other fishing activities aggregated into 2 'other' métiers (one each for the UK and France). A further 12 external métiers are included in the model, representing the fishing activity of these fleets outside the Channel. The distribution of effort across the different métiers by each sub-fleet is assumed fixed, and was based on the observed distribution of effort of the boats over the period 1993-95. Many of the different métiers are exploited on a seasonal basis. It is assumed that the allocation of effort reflects the changes in abundance and relative profitability of the activities over the year.

A total of 40 species and 53 different stocks are represented in the model. Two categories of stocks were modelled: those that extend beyond the Channel into the North Sea, Irish Sea or Western Approaches and those that fall fully within the English Channel. For the stocks that extend beyond the Channel, an In/Out model was used. This models the impact of the fishing effort on both the portion of the stock that lies within the Channel as well as the portion that lies outside the Channel. Catches of each species are estimated based on the level of fishing activity and the relative catchability in the métier. Effort is applied to a métier rather than individual species. Different combinations of catches in the different métiers are represented through a set of species specific catchability coefficients associated with each métier.

Age-structured biological models were developed for 27 of the stocks. The models were incorporated as equilibrium yield-per-recruit models, with the equilibrium stock structure estimated for the given levels of effort. For the remaining 26 stocks, surplus production yield was estimated from observed catch and effort levels in the fishery. Further details on the biological relationships used in the model are given by Ulrich, Le Gallic and Dunn (1999).

Revenue is estimated based on the level of landings and a constant price. Running costs are determined as a function of revenue and the level of effort. However, fixed costs and capital costs are determined by the fleet size and structure. Cost data were derived from economic surveys of the fishery (Boncoeur and Le Gallic, 1998; Coglan and Pascoe, 2000).

4.2 The Inclusion of the Objectives

The key objectives that were identified in the analysis of the English Channel fisheries (Mardle et al., 2002), were translated into a comprehensive bioeconomic model of the fisheries (Pascoe and Mardle, 2001). The goals were included as follows:

<u>Goal 1: Commercial stocks</u>

This goal relates specifically to the sustainability of commercially targeted stocks. The model is an optimisation model, and as such a solution obtained represents some long-term equilibrium state of the fishery. Due to this fact, and the nature of the biological relationships included in the model, any optimal solution obtained is "sustainable". Clearly there are different degrees of sustainability (i.e. stock biomass levels), however the model as it stands does not incorporate biomass directly. Therefore, this objective is modelled as an inclusive feature of the model and is naturally satisfied on successful optimisation.

<u>Goal 2: Non-commercial stocks</u>

The objective of minimising the effect of the fishing activity on non-commercial stocks (essentially bycatch) was implemented in terms of gear impact on bycatch. A measure of this impact was calculated through an AHP survey, where comparison is made between the relative impact of one gear type against another with respect to bycatch. Here, comparison was made within levels of the hierarchy, for example otter trawl was compared to dredge but not to pots, and mobile gear was compared to static gear. The hierarchy used in this analysis is given in figure 1, and the results obtained presented in table 2.

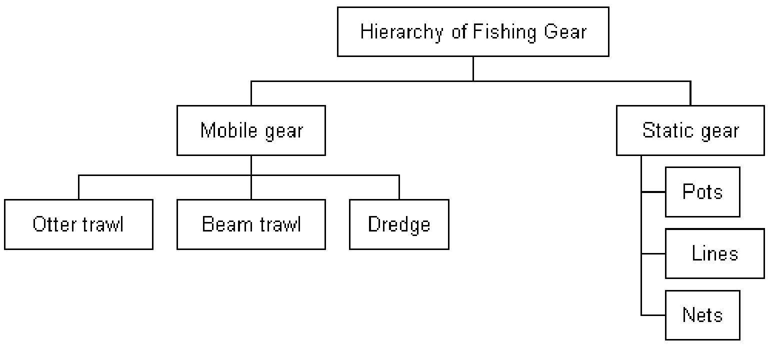

Figure 1: Incorporation of gear impact on bycatch and on fisher safety.

	Bycatch	*Safety*	
		<10m Vessel	*>10m Vessel*
Mobile gear	**0.775**	**0.327**	**0.806**
Otter trawl	0.348	0.177	0.435
Beam trawl	0.177	0.053	0.131
Dredge	0.250	0.097	0.239
Static gear	**0.225**	**0.673**	**0.194**
Pots	0.052	0.068	0.020
Lines	0.014	0.453	0.131
Nets	0.159	0.152	0.044

Table 2: Relative gear impact on bycatch and on fisher safety.

<u>Goal 3: Safety and labour conditions</u>

Similarly to goal 2, safety and labour conditions were modelled through the relative impact of different gear types on the issue of safety. The hierarchy in figure 1 was again implemented, however comparison was made with respect to fisher safety amongst gear types as well as safety over size of vessel (i.e. vessels under 10 metres in length and vessels over 10m) using either mobile or static gear. The results from this initial analysis are presented in table 2.

Goal 4: Employment in fisheries

Employment in fisheries is measured through a level of crew employed on vessels. That is a target value of the current level of number of fishers employed in the fisheries is set in the UK and France, and the difference from this value minimised. An average crew number is used to calculate this employment figure based on vessel size and main gear type used.

Goal 5: Employment in coastal areas

	UK		*France*	
	No. Fishers	*No. Downstream Jobs*	*No. Fishers*	*No. Downstream Jobs*
Eastern Channel	1511	102	3088	707
Western Channel	3332	800	2971	784

Source: MegaPesca (2000), Affaires Maritime (1996)

Table 3: France fishing dependency by area.

The actual number of fishers and downstream jobs (wholesalers and processors) generated from the fishing activity are given in table 3.[7] Except for the UK Eastern Channel, this implies that 1 fisherman on average creates 0.25 of a wholesale/processing job. It should be noted that this is a minimum factor as these figures only represent known jobs deriving from Channel activity. Furthermore, there are upstream activities created that are not included in these figures. For example, in a study undertaken in 1986 for the region of Lower Normandy, a ratio of 1.18 was reported for jobs on the "ground" to 1 fisher.

Goal 6: Profitability

The objective to maximise economic profit was implemented with a target value set through a parametric analysis of the maximum achievable through the model for each country.

Goal 7: Conflict between fishers

The aim behind the modelling of this goal was that reductions in vessels classed as using different main types of gear are affected equally. That is, a reduction of 20% of one gear type should bring about a reduction of 20% of all other gears. Thus giving the effect of maintaining the current structure or *status quo* to the fishery.

Goal 8: Relative stability

Relative stability was not a key objective listed when importance between objectives was surveyed (table 1). However, this is because the concept of relative stability is laid down in the Common Fisheries Policy, and is a necessary goal to be achieved. In the European Union, this compromise has been enshrined under the "principle of relative stability", which ensures that no single member state benefits (or suffers costs) to a greater extent than any other from management decisions concerning the common pool fisheries (Holden, 1994). In the model, this goal is translated through levels of fisher employment in the UK and France, so increases/decreases in fisher employment are proportional.

4.3 The Achievement Function

The achievement function includes the weighted sum of negative deviations from the bycatch, safety, fisher employment, regional employment, profit and conflict goals. In all of these cases, the target value is set at a known maximum level, constrained by a function of the current number of vessels in each fleet, or in the case of profit to the maximum achievable. Hence, in all goals the positive deviational variables are redundant, as it is not possible to exceed the targets set or exceeding the targets may be acceptable. The optimisations performed are to minimise the deviations from the goals set for each country. This has the effect of allocating resources for each country where the structure of the other is ignored. Therefore the goal of relative stability has no influence on the set of results obtained. For completeness, in the relative stability goal, the positive and negative deviations are both penalised in the achievement function.

[7] In table 4, the UK downstream jobs only include processing activity. Also, no. fishers reported is based on actual numbers reported (MegaPesca, 2000)

An important consideration in the achievement function is normalisation. It is clear that goals are measured using different units and scales. This has the effect of penalising or preferring goals resulting in issues of incommensurability. This negates the effect of the imposed weights. Here, a percentage normalisation technique is used to overcome this where the penalised deviational variables are divided by the relevant goal's target value. This translates all deviational variables onto a zero-one scale that can then be more reliably compared. With the number of objectives included in this study, normalisation is a significant issue to resolve.

The importance weights presented in table 1 are included directly in the achievement function as multipliers on the penalised deviations. The model can be run as either a single objective or multi-objective optimisation problem. This is achieved by specifying zero weights for the objectives not being considered.

5. RESULTS

Several runs of the model were performed, where the weights of each of the key sectors involved in management were considered. In the UK the relative positions of four groups are analysed: Administration, including government departments with direct involvement in fisheries; Environment Groups, including government departments with environmental interest and NGOs; the Catching Sector, including Producer Organisations and fisher associations; and Scientists / Industry, including fisheries biologists and industry marketing bodies. In France, Environmental-based groups were not included directly in the analysis.

The results of the optimisations are given in figure 2 for four principal economic indicators: revenue, profit, total capital in the fishery and crew employment.[8] The current situation in each country is presented with the results of the optimisations that represent the optimal structure of the fisheries given the weights imposed on the objectives by the interest groups.

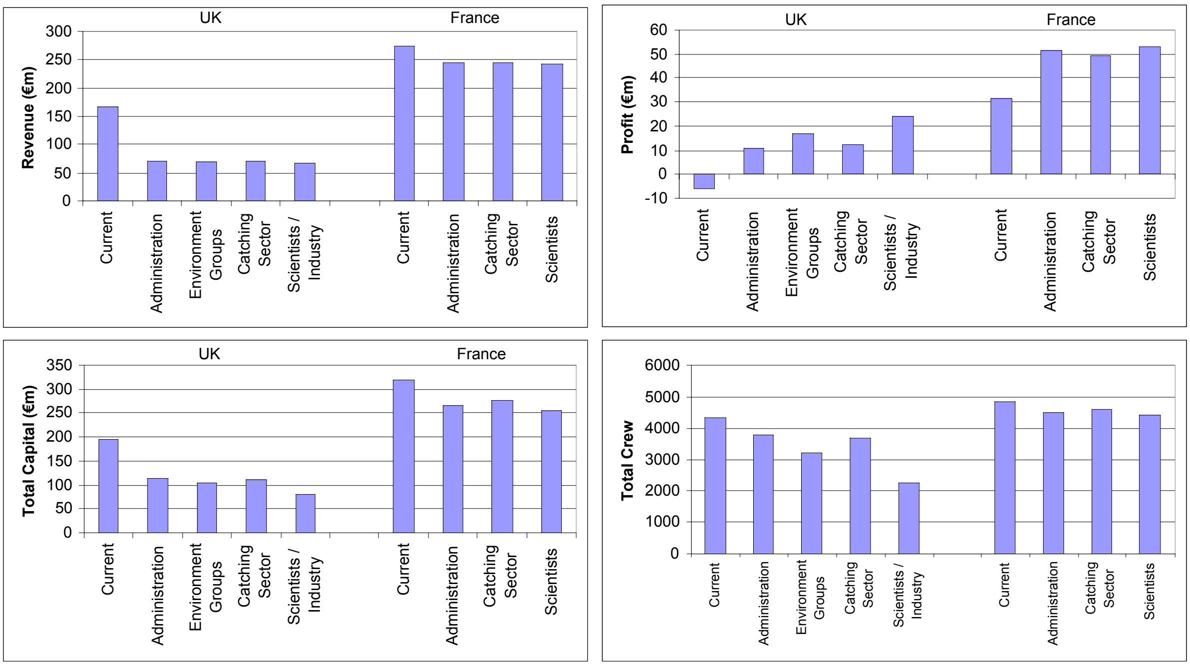

Figure 2: Results by indicator, sector and country.

The differences of the optimal scenarios are shown in figure 2. In both the UK and France, the current situations of revenue, total capital and total crew employed in the fishery are higher than the optimal positions. However, they are not significantly higher. To achieve this, it does result in a reduction of the size of the fleets. In the UK, the >10m vessels are not as profitable as the smaller vessels, but also have a greater effect on the impact on bycatch and safety. In France the weightings imposed have less of an effect over the groups. Optimal revenue in all cases is very similar, due mainly to the necessary condition of sustainability within the model. However, the structure of the fishery has a much greater effect on achievable profits. The profits attained when the weights of the Catching Sectors are imposed are less than the other groups as a result of desire for higher employment

[8] As regional employment is a function of crew employment, this indicator is not considered.

through both of the employment objectives. In France, the safety objective also adds a significant effect. However, the profits achievable are healthy compared to the current situation for all groups. It is also noticeable that the scenario of the Scientists results in far greater profits than the other groups. This is a main effect of reducing direct employment in the fishery, creating smaller fleets that can still catch similar quantities of fish.

The results attained from the optimisation runs can be plotted on a Profit / Employment trade-off curve to graphically present the positions of the groups. Figure 3 shows a trade-off curve developed for the whole fishery (Pascoe and Mardle, 2001). The results for the Administration, Catching Sectors and Scientist groups for the UK and France are aggregated and placed onto this curve.[9]

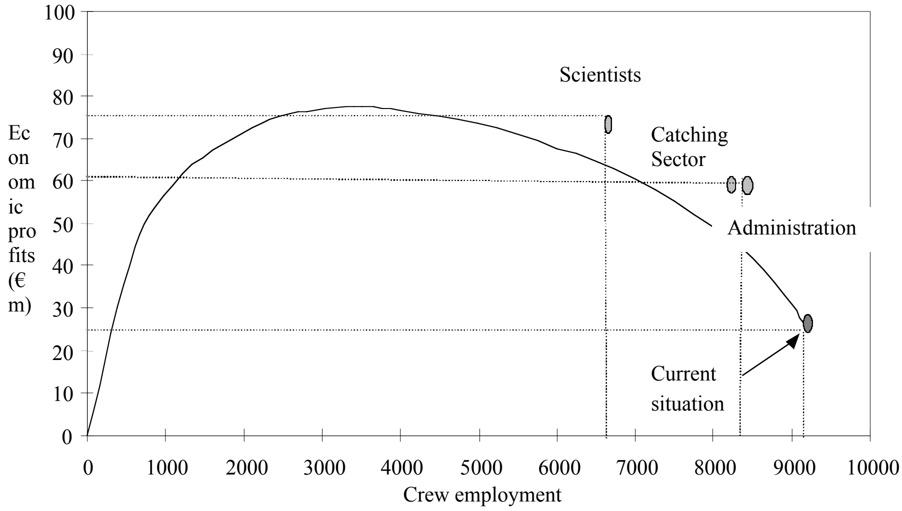

Figure 3: Trade-off between Fisher employment and profit, with indication of group position.

The current situation constrains the problem, and expectedly provides greatest employment at lowest levels of achievable economic profits. The combined results for Administration and the Catching Sector in both countries provide very similar outcomes, with the catching sector indicating slightly less economic profit and a lower crew also. The Scientists' perspective reduces employment considerably more than other groups, providing a greater economic profit.

6. CONCLUSIONS AND RECOMMENDATIONS

The challenge for the successful management of fisheries is to determine strategies that ensure the sustainability of the stocks, improve incomes, and maintain regional communities that depend on fishing. In most cases, these aims cannot be fully achieved simultaneously. For management to be accepted by participants in the fishery, targets must be established that best reflect the trade-offs between the different objectives. In the development of targets, the opinions of interest groups should also be reflected in the process.

This paper has presented a framework of analysis that allows the inclusion of multiple objectives and interest group preferences to analyse how such opinion would affect the optimal structure of the fisheries under analysis. The case study considered of the English Channel is large and highly complex. These complexities are evident in the results presented. The differences in structure of the fisheries between groups, the importance attached to objectives and the trade-offs between them provide a comprehensive tool for investigation of how group opinion could affect the management of the fisheries.

From the analysis presented in this paper, there are several areas for development in the model. Two key methodological areas include the investigation of normalisation used to measure the deviations from goal target values and sensitivity of the model to weighting structures elicited from interest groups. General model

[9] The effects of relative stability would reduce the levels presented for each of the groups to within the curve. However, these results provide maximum levels achievable, and are indicative of relative positions to the curve.

development includes the aim to include more detail within the model to enable more precise features to be analysed, such as regional breakdown of information, as well as analyse multi-level features.

7. ACKNOWLEDGEMENTS

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