

## IMPACT REDUCTION IN DEMERSAL FISHERIES: A MULTI-CRITERIA ASSESSMENT OF OBJECTIVE PRIORITIES

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### ABSTRACT

When attempting to mitigate the environmental impacts of a fishery there are typically multiple criteria against which the performance of any measures can be assessed. If the gains are non-commercial (i.e. non-market) in nature, formally determining how well measures perform becomes more difficult. This study applies the analytic hierarchy process (AHP) to quantify the relative preferences of stakeholder groups for one impact reduction objective over another in the context of European mobile demersal fisheries. The advantage of this methodology is that it allows for the inclusion of non-commercial benefits. Preferences are quantified and allow ranked group-specific weights relating to the reduction of discarding and other *in situ* impacts to be derived. The relative weights placed on the sub-objectives within each of the two objectives are also determined. The variability of preferences at both the intra- and inter-group level is considered and the potential implications with regard to perceptions of success discussed. Establishing a measured order of preference for individual criteria allows the significance of changes in non-market impacts to be determined and alternative measures that result in differing combinations of change to be directly compared. This should facilitate a more targeted and efficient approach to the process of forming impact alleviation policies within these fisheries.

**Keywords:** analytic hierarchy process, fishery impacts, evaluating management measures, stakeholder preferences.

### INTRODUCTION

In the presence of multiple management objectives it is often not possible to fully satisfy all simultaneously. Fishery policy problems and the national and international legislation that aim to tackle these are typically characterised as such [1, 2]. Furthermore, differences in perspective at both the individual and/or group level also tend to result in disparity between the relative priority those involved (i.e. stakeholders) attach to alternative management objectives. Fisheries often have multiple stakeholder groups so when their priorities differ, opinion as to the preferred management option can also differ. By formally determining the priority stakeholders attach to certain objectives it is then possible to explicitly state the perceived effectiveness of any management measures.

In addition to the removal of their target species fisheries often have a number of other impacts on the environment in which they operate. These can be broadly classified into effects on the biota and effects on the habitat/physical environment. Impacts on the biota include; the mortality associated with bycatch i.e. from discards, retained non-target species, and lethal contact with the gear not resulting in capture. Habitat impacts consist of; long/short term changes to the physical structure of the sea bed, or increased turbidity/particulate matter in the water. Last, it is possible all of these may alter predator/prey relationships or the suitability of local habitat and ultimately contribute to longer term shifts in species composition or sustainability.

Such negative impacts are an ongoing matter of concern in Europe and particularly within the towed demersal fisheries. A desire to reduce the unwanted effects fisheries can have has led to a number of research projects within Europe alone<sup>a</sup> and contributed to the understanding and literature surrounding

this matter. Much of the work has been aimed at reducing problems associated with bycatch and tends to focus on the use of technical measures. Whilst the issue of bycatch and discards are immediately visible the effects of other impacts are generally less obvious, harder to observe and significantly more problematic to account for in assessments.

If the relative effectiveness of alternative technical measures is to be determined all the benefits they generate must be considered. Alternative gears have differing combinations of impacts so if they are to be directly compared the perceived value of a reduction in one impact over another needs to be formally determined. Calculating the potential future economic value of commercial organisms saved by a reduction in discarding has been done in a number of studies [3, 4, 5, 6]. However, determining the value of non-market benefits such as reductions in the level of habitat change or the mortality of infauna due to gear passage across the seabed is not so straightforward and, to the best of our knowledge, has not yet been achieved. Furthermore, as the value attached to each benefit is likely to differ by stakeholder group this variation also needs to be accounted for.

This study determines the relative priorities certain stakeholder groups attach to reducing the environmental impacts of mobile demersal gears within Europe. The analytic hierarchy process (AHP) [7, 8] is applied and the priority scores obtained give insight into the relative significance stakeholder groups attach to differing impact reductions. These sets of group specific weights will allow the value of any changes in impacts to be accounted for and aggregated to reflect the total utility derived from a technical measure.

### **THE ANALYTIC HIERARCHY PROCESS (AHP)**

The AHP is a method for structuring, measurement, and synthesis, and allows individual preferences to be converted into ratio-scale weights [9]. It is one of several multi-criteria decision making techniques (MCDM) available<sup>b</sup> and provides a relatively simple yet powerful means of deriving individuals' preferences for one objective over another. It can incorporate qualitative/value judgements and allows the inclusion of any non-commercial benefits modified gears may achieve. It is a flexible methodology that enables either an individual or groups of individuals to define a specific problem based on their own experience of it. Additionally, as the AHP is not a statistical exercise it does not require probabilistic assumptions about the decision alternatives. AHP surveys have not been widely applied in the field of environmental economics and even less so in fisheries management.

In this instance the objective was to quantify the relative importance different groups attach to reducing certain fishing related impacts (creating a ranking). The derived ranking is an indication of the relative weights the respondents place on reducing in-situ impacts and reducing discards. Furthermore it indicates the relative weights the respondents place on the sub-objectives within each of the two objectives (i.e. reduce *in situ* impacts: mortality of infaunal invertebrates in the seabed, mortality of epifaunal invertebrates on the seabed, habitat change. Reduce discard impacts: commercial fish discards, non-commercial fish discards, commercial invertebrate discards, non-commercial discards).

Saaty [10] defines the AHP as having three basic principals; decomposition, comparative judgement, and hierarchic composition/synthesis of priorities. Following previous studies [11, 12, 13] the process was undertaken in four main steps;

1. develop a hierarchy of the factors important in that decision;
2. survey the associated participants to elicit judgements based on pairwise comparisons of the identified criteria;
3. calculate the individuals relative weights of the factors under consideration;
4. determine homogeneous group weights

## METHOD

### Hierarchy of Key Objectives (step one)

The first step when performing an AHP analysis is to develop a hierarchy of the objectives and attributes. It is essential that at this stage the problem is fully described to ensure validity. Figure 1 gives the main goal, major impacts (objectives), and specific impacts (sub-objectives).

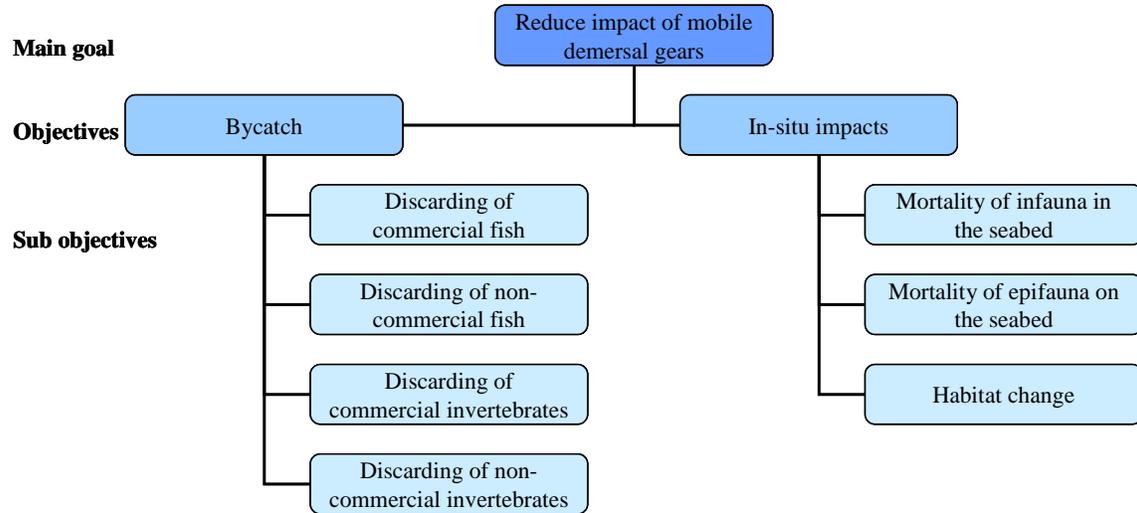


Figure 1. Key objectives in the reduction of mobile benthic gears impacts

### Survey of Preferences (step two)

The majority of AHP surveys are mail-based. However, concerns that these do not allow for sufficient interaction between participants has led a number of studies to undertake their surveys on a face-to-face basis [12, 14, 13, 15]. The pan-European nature of this study meant a face-to-face survey was not feasible. However, in recognition of the concerns raised above and in order to facilitate a level of interaction greater than mail can practically allow, the survey was primarily conducted via e-mail<sup>c</sup>. Valid results also depend on respondents being sufficiently knowledgeable about the matter under consideration, in this case; mobile demersal fisheries and the issues surrounding them. As such a database of suitable ecologists, biologists, economists, gear technologists, industry and fisheries managers from across Europe needed to be constructed prior to the survey being undertaken.

The survey form itself began with; a short introductory paragraph explaining its subject and purpose, an explanation of the scale choices were to be ranked under, and an example and explanation of a completed pairwise choice. Such a clear and careful explanation is important when the survey is not being undertaken on a face-to-face basis. Furthermore, respondents were also asked to make it known if they had any doubts with regard to their understanding of how to complete the survey so that further clarification may be provided. A series of pairwise choices were then presented and respondents asked to state, from their perspective, the importance of one objective relative to another. The pairwise choices were presented in a top-down order; i.e. general objectives first followed by those of greater detail. Whilst

there has been some debate as to what the optimal order of presentation is, i.e. top-down or bottom-up, [16] found no strong or consistent difference in responses under either.

The scale of importance against which preferences are compared must be consistent for each pairwise choice. A nine point scale was used, this is the most commonly applied and has been validated for effectiveness through theoretical comparisons with a number of other scales [17]. The fundamental 9-point scale is outlined in table 1 below. Choosing a value of 1 (middle of range) indicated the respondent considered the elements to be of equal importance. Choosing a higher value, from 2 to 9, indicated that one element was believed to be more important than the other and additionally to what extent.

**Table 1. Scale Used for Pairwise Comparisons**

Importance	Definition	Explanation
1	Equal importance	Reducing both impacts is of equal importance
3	Moderate importance (one over another)	Experience and judgement favour the reduction of one impact over another
5	Strong importance	Experience and judgement strongly favour the reduction of one impact over another
7	Very strong importance	Experience and judgement very strongly favour the reduction of one impact over another
9	Absolute importance	Opinion favouring the reduction of one impact over another is of the highest possible order
2,4,6,8	Intermediate values	When opinion falls between the levels of importance stated above

The hierarchy tree illustrated in figure 1 resulted in three sets of pairwise comparisons; one between the two primary objectives, then; a further two sets comparing the sub-objectives within each objective. The number of pairwise comparisons is dependent on the number of elements (say  $n$ ) to be compared on each occasion, the total number of comparisons is then  $(n/2)$  [14]. This resulted in a total of ten pairwise comparisons. The survey was undertaken during the last quarter of 2007. A total of 150 survey forms were distributed; 47 were ultimately considered usable. The non statistical nature of the method means it is not uncommon for AHP surveys to solicit the opinions of relatively small groups of experts or stakeholders. For example 18 respondents in [18], 12 in [19], 9 in [20], 39 in [13], 31 in [11].

**Calculating the Relative Weights (steps three and four)**

A pairwise comparison matrix [A] was constructed for each set of comparisons (three, one each of the dimensions: 2x2, 3x3 and 4x4) and assumed the following form:

$$A = \begin{bmatrix} w_1 / w_1 & w_1 / w_2 & \cdots & w_1 / w_n \\ w_2 / w_1 & w_2 / w_2 & \cdots & w_2 / w_n \\ \vdots & \vdots & \ddots & \vdots \\ w_n / w_1 & w_n / w_2 & \cdots & w_n / w_n \end{bmatrix} \tag{Eq.1}$$

where A is a square ( $w*w$ ) positive reciprocal matrix in which the vector w (i.e.  $w_1, w_2, \dots, w_n$ ) represents the importance weights for the given set of objectives. Each element in the lower left triangle is the inverse of its counterpart in the upper right triangle ( $w_{ij} = x$  then  $w_{ji} = 1/x$ , where x is not 0), and elements in the diagonal equal 1 ( $w_{ii} = 1$  for all i). As such  $w_i / w_j$  indicates the relative preference of

element  $i$  in relation to element  $j$  in a direct comparison. Its reciprocal property means only  $n(n-1)/2$  pairwise comparisons are required for an  $n \times n$  comparison matrix. AHP scores are commonly calculated using either the eigenvalue method as proposed by [7,8], or the geometric mean advocated by [21]. It has been demonstrated that both methods are comparable [22, 23, 24]. Priority weights were derived for each respondent using the widely applied Expert Choice software (v11) that utilises the right eigenvalue method of Saaty [7, 8].

The subjectivity of making pairwise choices means there will naturally tend to be a certain degree of inconsistency in respondents' choices. For example; if a respondent indicates that B is twice as important as A and C is three times as important as B then, in order to be consistent, C should be six times as important as A. However, in practice it is common that responses do not display such exact preferences and demonstrate inconsistency in; the relative scale of importance between objectives, their rank order or both. Such intransitive relationships are not permissible in alternative MCDM methods (such as Multi-Attribute Utility Theory). The AHP allows for this and the right eigenvalue method as proposed by Saaty [7, 8]:

$$Aw = \lambda_{\max} w \quad (\text{Eq.2})$$

where  $\lambda$  is the largest eigenvalue of matrix  $A$ , and  $w$  the principal eigenvector enables the consistency of respondents choices to be formally tested. The derived weights (vectors) are normalised to sum to one.

The consistency index (CI) is calculated following  $CI = (\lambda_{\max} - n)/(n-1)$  and compared to standard table values [8] denoting the average consistency for  $n$  objects. Perfect consistency occurs where  $\lambda = n$  so the closer  $\lambda$  is to  $n$  the more consistent the responses. A consistency ratio (CR) ( $CR = CI/\text{table value}$ ) of no more than 10% is generally considered acceptable, however within fisheries studies maximum ratios of 10% [12], 20% [25] or more [13] have previously been accepted. In this instance if a ratio was determined to exceed 10% the areas of highest inconsistency in a response were identified and the respondent asked to confirm these choices. Cases in which the consistency ratio was not reduced below 10% were subsequently excluded from the later analysis.

Assumptions relating to how the groups under consideration act affect the stage at which they should be created and the most appropriate form of mean to derive. A decision should be made *a priori* and rests on whether to group individual judgements ( $A_{IJ}$ ) or priorities ( $A_{IP}$ ) as each method has different underlying assumptions [11]. Aggregating  $A_{IJ}$  implies the group essentially 'thinks as one'; whereas, aggregating  $A_{IP}$  assumes increased autonomy at the individual level allowing for within group differences of opinion (Forman and Peniwati, 1998). As opinions relating to fisheries management tend to demonstrate heterogeneity at both the group and individual level we follow [11] in applying the latter method. When aggregating  $A_{IP}$  either the arithmetic or geometric mean can be used as both have been shown to satisfy the AHPs reciprocal property requirement<sup>d</sup> [26]. Respondents were grouped ( $A_{IP}$ ) by area of expertise (as indicated in the survey response i.e. ecology, biology, economics, gear technology, industry and fisheries management) and the arithmetic mean used to determined group level priorities.

## RESULTS

The derived ratio-scale measures can be interpreted as final ranking priorities (weights). Group priorities and the associated standard deviation at every level (i.e. Objective, sub-objective, and global) are presented in table 2. Overall (i.e. global) priority weights for each group are shown in bold text, standard deviations in italics. The impacts indicated to be of greatest concern overall were commercial fish discards, habitat change, and commercial invertebrate discards. Group preferences at the global level are

illustrated in figure 2 where it is clear that in general the groups tend to follow two main patterns; one that demonstrates significant concern for the reduction of commercial fish discards above all else (industry, gear technologists), and one where priorities are more evenly distributed (all others). The main points of disagreement between the sets of groups are those of commercial fish discards and habitat change. However, reducing commercial fish discards ranked in the top three of all groups and reducing habitat change in the top three for all but industry and gear technologists.

### Group Level Priorities

Three groups (economists, gear technologists and industry) considered the reduction of commercial fish discards to be of highest priority followed by reducing commercial invertebrate discards. The remaining three groups indicated a reduction in the level of habitat change was of greatest importance and reducing commercial fish discards was then the second greatest priority.

The fishing industry indicated a very strong preference for the objective of reducing of bycatch (0.808) over that of reducing *in situ* impacts (0.192) and reducing the discards of commercial fish and invertebrates were clear priorities, with global weights of 0.453 and 0.203, respectively. In fact, the reduction of commercial fish discards was indicated to be over twice as important to industry when compared to any group other than technologists. Gear technologists ranked all the abovementioned impacts in the same relative positions and order but the absolute priority values they attached were more moderate; indicating a preference for reducing bycatch (0.734) over *in situ* impacts (0.266), the top two global preferences were reducing commercial fish (0.369) and then invertebrate (0.170) discards. Biologists, ecologists and management attached more even priority to the main objectives of reducing bycatch and reducing *in situ* impacts whilst economists erred slightly more towards that of reducing bycatch. Globally, habitat change and commercial fish discards were most important for biologists, ecologists and management but the absolute size of these priorities were not nearly as large as those observed with industry and technologists. Reducing habitat change was ranked third by economists (0.192) who favoured first reducing commercial fish (0.196) and second commercial invertebrate discards (0.194), the main impacts on revenue. However, as figure 2 illustrates the priorities as indicated by these four groups were much more evenly spread over the seven impacts than seen with industry and gear technologists.

Table 2. Group Level Priority Scores

Obj. Sub obj.	Ecologists			Biologists			Economists			Gear Technologists			Industry			Management		
	Obj.	Sub obj.	Overall	Obj.	Sub obj.	Overall	Obj.	Sub obj.	Overall	Obj.	Sub obj.	Overall	Obj.	Sub obj.	Overall	Obj.	Sub obj.	Overall
<i>In situ</i> impacts	0.452			0.495			0.376			0.266			0.192			0.474		
	<i>Std. dev.</i>	0.229		0.397			0.269			0.192			0.035			0.318		
Mortality of infaunal inverts		0.182	<b>0.082</b>		0.209	<b>0.103</b>		0.195	<b>0.073</b>		0.259	<b>0.069</b>		0.363	<b>0.070</b>		0.154	<b>0.073</b>
	<i>Std. dev.</i>	0.191		0.179			0.114			0.178			0.072			0.088		
Mortality of epifaunal inverts		0.294	<b>0.133</b>		0.371	<b>0.183</b>		0.296	<b>0.111</b>		0.440	<b>0.117</b>		0.287	<b>0.055</b>		0.285	<b>0.135</b>
	<i>Std. dev.</i>	0.171		0.189			0.132			0.244			0.057			0.095		
Habitat change		0.524	<b>0.237</b>		0.421	<b>0.208</b>		0.510	<b>0.192</b>		0.301	<b>0.080</b>		0.350	<b>0.067</b>		0.560	<b>0.266</b>
	<i>Std. dev.</i>	0.215		0.342			0.205			0.202			0.061			0.104		
Bycatch	0.548			0.505			0.624			0.734			0.808			0.526		
	<i>Std. dev.</i>	0.229		0.397			0.269			0.192			0.035			0.318		
Comm. fish discards		0.337	<b>0.185</b>		0.395	<b>0.200</b>		0.315	<b>0.196</b>		0.503	<b>0.369</b>		0.561	<b>0.453</b>		0.261	<b>0.137</b>
	<i>Std. dev.</i>	0.189		0.211			0.165			0.138			0.064			0.202		
Non-comm. fish discards		0.196	<b>0.107</b>		0.258	<b>0.130</b>		0.164	<b>0.102</b>		0.135	<b>0.099</b>		0.088	<b>0.071</b>		0.224	<b>0.118</b>
	<i>Std. dev.</i>	0.080		0.086			0.088			0.074			0.015			0.115		
Comm. invert. discards		0.231	<b>0.127</b>		0.223	<b>0.113</b>		0.312	<b>0.194</b>		0.231	<b>0.170</b>		0.251	<b>0.203</b>		0.259	<b>0.136</b>
	<i>Std. dev.</i>	0.086		0.111			0.146			0.116			0.028			0.158		
Non-comm. invert discards		0.236	<b>0.130</b>		0.124	<b>0.063</b>		0.210	<b>0.131</b>		0.131	<b>0.096</b>		0.100	<b>0.081</b>		0.256	<b>0.134</b>
	<i>Std. dev.</i>	0.170		0.078			0.183			0.104			0.033			0.183		
No. of respondents:	14			4			9			8			8			5		

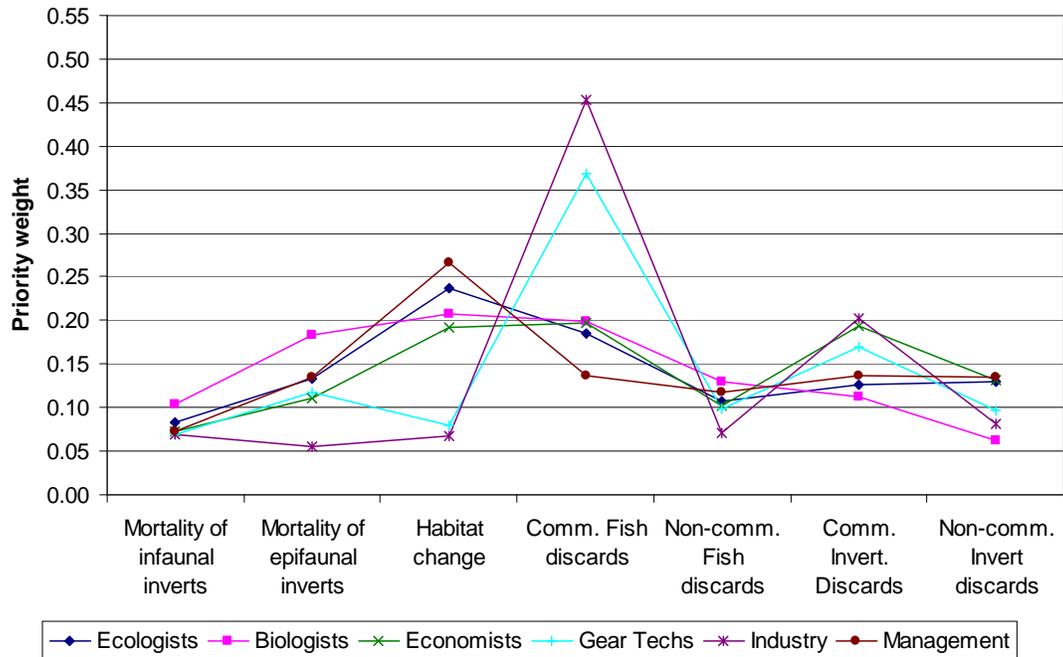


Figure 2. Stakeholder group priorities for reductions in impacts

### Within Group Priorities

The diversity of opinion within groups (coherence) was determined using the dot product method of [27]. Here the angle of difference between individual group members overall preference vectors are calculated and averaged for each group; when vectors are equal the product is 1, when orthogonal 0. Based on the coherence measures of a number of randomly generated groups it was determined that, for this data set  $<0.85$  was low coherence, between  $0.85$  and  $0.88$  was good, and  $>0.88$  was high. Following this most group level scores demonstrated relatively low coherence, one had good coherence (ecologists), and the remaining two high coherence (industry and gear technologists) (table 3). Low coherence is symptomatic of diverse within group opinion and somewhat typical of fisheries, having been observed in a number of previous studies [13, 11, 28, 24].

**Table 3. Group Averages for Perceived Level of Understanding as Indicated by Respondents**

Group	No.	Coherence	Perceived Understanding
Ecologists	14	0.86	7.8
Biologists	4	0.73	7.5
Economists	9	0.84	6.7
Gear Techs	8	0.95	7.9
Industry	8	0.98	9.1
Management	4	0.82	8.2
All	47	0.86	7.8

In addition to the pairwise choices respondents were asked to indicate on a scale of one to ten (where 10 was very familiar/full understanding and 1 was unfamiliar/poor understanding) how well they thought they understood the impacts associated with towed fishing gears. As table 3 illustrates all groups

generally felt that they had a relatively high level of understanding/familiarity with the subject. Industry indicated the highest level of understanding and economists the lowest with average scores of 9.1 and 6.7 respectively. Further analysis was undertaken in which respondents scores were weighted by their indicated level of understanding prior to the group scores being calculated. This resulted in some small changes in the absolute values of individual and, consequentially, group level scores for all groups. The relative ranking of impacts was also seen to change a certain amount for all groups other than the industry and gear technologists. This is primarily due to the fact these groups had much closer preference scores in the first instance (as illustrated in figure 2) so often only small changes in the absolute values were required to result in reversals. This illustrates the fact that when preferences are relatively evenly distributed over a number of impacts and do not focus strongly on one or two (as is the case with industry and gear technologists here) the overall rankings can be very sensitive to small changes. However, whilst something to be aware of, as the priority values were seen to change very little in absolute terms this was not considered to be a significant issue. Lastly, the perceived level of understanding was tested for signs of correlation against individual inconsistency ratio scores. The results were very mixed with no clear sign of correlation between the two.

## **DISCUSSION AND CONCLUSIONS**

As preferences are subjective by nature it is reasonable to expect respondents familiarity with the specific issues under consideration or personal perspectives to come through in their responses [e.g. as seen in 29]. The fact fishermen are primarily concerned by, and consequently attach high priority to reducing the level of commercial discards is as such understandable. This is not necessarily to say the industry is unconcerned by the other impacts but, as financially orientated operations, aspiring to maximise profits by reducing any loss of potential revenue is a natural priority. The level of discard related mortality varies by species and fishery but can be high and is often significant [30, 31, 32] so when vessels bring aboard commercial species they cannot land the subsequent discarding can impose negatively on the resource upon which they (or other fishers) depend.

The similarity of opinion observed between the industry and gear technologists is a possible artefact of the way Europe has concentrated on reducing bycatch through the development of technical measures. As a result gear technologists (and economists) tend to be very familiar with the issues of bycatch whereas attempts to reduce other environmental impacts are a more recent development. Furthermore, gear technologists commonly operate in close connection with the industry so a certain similarity between perspectives can be expected. The more moderate priorities of ecologists, biologists and managers are believed to result from viewing the fishery in a more holistic manner. Ecologists and biologists are likely to take more of an ecosystem perspective where everything is interlinked and changes to both habitat and organism mortality considered significant. Managers are typically required to consider the demands of all involved in the fishery and results in them also having a somewhat more moderate and balanced set of preferences.

Time preferences were not explicitly accounted for in the survey but will also influence preferences, i.e. the industry may be less concerned by impacts such as habitat change because the immediate benefits are less well understood, smaller or harder to see. Confidence that investing in the long term health of the environment offers a good chance of financial returns is necessary if the benefits will not be felt in the relatively short term. The situation currently facing many trawler fisheries is at best uncertain as; if not limited by stock constraints, sustained rises in fuel prices have the potential to make these fisheries economically unviable long before any of the environmental impacts they may generating will. Also, if impacts such as habitat change do not (or at least are not perceived to) directly affect the species they target the mere existence value is likely to be low when compared to potential revenue.

As each group attaches different levels of importance to the individual sub-objectives the benefit of any management measures will be judged accordingly. Furthermore, in instances where the industry is having a significant impact on the environment such differences, and therefore the perceived effectiveness of any management measures tend to be all the more pronounced. By quantifying these preferences into weights the resultant trade-offs of any subsequent and related management decisions can be made explicit and compared with alternatives. For example; if a selection of impact reducing gears were available, each resulting in an alternative combination of reductions, application of the weights would allow the perceived success of each to be derived for each stakeholder group. When stakeholder groups believe measures are tackling issues they deem to be of importance there is a much higher likelihood of acceptance, or compliance in the case of legislation. A significant problem with some technical measures is the ease with which they can be circumvented without a significant risk of detection. If the likely level of acceptability can be determined prior to final policy decisions being made it is possible greater levels of compliance may be achieved whilst also reducing the often non-trivial burden of enforcement.

The goal of this work was to derive sets of weights at the stakeholder group level that quantify the priorities each place on reducing the environmental impacts mobile demersal fisheries can have. Applying the AHP has revealed the individual importance of each contributory objective and sub-objective to various interest groups. Further analysis of the group level results has also indicated opinions tend to follow two general patterns; the majority have relatively moderate preferences whilst the remainder are seen to place far greater priority on reducing the immediately visible commercial impacts. It has also been observed that in the absence of strong preferences the rank of priorities can be sensitive to small changes in the absolute value of preference weights.

The derived preference weights have a potential application in any situation where measurable changes in the impacts of mobile demersal gears are known or can be anticipated. One natural application would be in determining the cost-effectiveness of alternative modified demersal gears; the weights applied to estimates of absolute changes in impacts and then combined with changes in costs.

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## ENDNOTES

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<sup>a</sup> Projects such as; ECODISC, DISCRAN, REDUCE, NECESSITY, DEGREE.

<sup>b</sup> Reviews of the AHP and other MCDM techniques being applied in the fisheries arena can be found in [25, 2].

<sup>c</sup> In a small number of instances surveys were either conducted or completed by phone.

<sup>d</sup> If aggregating  $A_{ij}$  (judgements) only the geometric mean is appropriate [33, 26].