

# **A Conjoint-based Choice Modelling Approach Using the *PHREG* Procedure to Evaluate the Importance of Fisheries Management Objectives**

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## **Abstract**

Experimental modelling to identify the preference structures of management objectives in fisheries management is vital in a sustainable fisheries policy. Furthermore, identification of differences of preferences amongst stakeholders on these objectives provides a basis to justify direction within policy management. In this paper, a conjoint-based choice modelling approach is used to evaluate several overriding fisheries management objectives using the UK fisheries of the English Channel as an example. Using the SAS® System, the multinomial logit model is fitted with the SAS/STAT® procedure PHREG (proportional hazard regression) to identify the importance of fisheries management objectives. The likelihood function of the multinomial logit model has the same form as a survival analysis model fitted using the PROC PHREG. This paper focuses on the statistical techniques for analysing discrete choice data and discusses fitting these models using the PHREG procedure that has been originally developed for the hazard function on survival data.

**Keywords:** PHREG procedure, fisheries, management effectiveness, conjoint analysis, choice-based preferences.

## **Introduction**

In the development of any acceptable and workable resource management policy, consideration must be given to the preferences of stakeholders within the system. This is especially true for fisheries management, where such a large number and diverse range of interest groups exists. At the top of the fisheries management decision-making tree are the administration departments (in Europe, that is principally the European Commission and national governments) who introduce and control the policy respectively. In formulating decisions, particular notice is taken of advice given by fisheries scientists on the biological status of fish stocks. Other groups with direct interest in fisheries typically concentrate on the fishing activity (i.e. the welfare of fishers and fishing communities), marketing of fish, and the protection of the environment. Often, some or all of these groups have conflicting objective preferences towards management direction. Therefore an approach to evaluate stakeholder preferences for inclusion in the decision-making process is highly relevant. This enables the policy makers to justify decisions based on importance and priorities expressed by stakeholders more explicitly.

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Generally in natural resource management cases, objectives are categorised under three main headings: environmental (including biological and conservational), economic and social. However, a fourth objective category of political objectives is sometimes included (see for example Leung *et al.*, 1998). Mardle *et al.* (2001) considered the objective structures of several EU example fisheries of different size and structure. Pope (1997) notes that it is well documented that generally the multiple objectives of fisheries management cannot be simultaneously optimised. However, he observes a key deficiency in policy statements to be that they do “not set priorities or trade-offs between the various objectives nor do they set measurable targets for individual objectives”. This makes it difficult to determine whether the objectives have been achieved or not. It has also been suggested that a major factor in conflicts between groups is caused by a lack of understanding of the importance of objectives held by the various interest groups involved. The development of importance characteristics between objectives in management is a clear way of helping to satisfy these issues.

A number of methods are available for evaluating stakeholder preferences, which are of interest to policy makers. Two of the main classes of methods are stated preference and pairwise comparison methods.

- Stated preference relies on data from surveys in which respondents express preferences in carefully designed hypothetical scenarios (typically applied to markets). One method in this class, and the main focus of this paper, is Conjoint Analysis in which respondents express their preferences through ranking or rating a range of options or scenarios, each with different characteristics. More recently experimental modelling of choice behaviour is slowly emerging as an alternative to modelling of behavioural antecedents, such as attitudes and options.
- Pairwise comparison aims to elicit preferences by comparing objectives and/or attributes by typically rating (or ranking) them in pairs.<sup>2</sup> The analytic hierarchy process (AHP), which uses a 9-point comparison of importance scale, is one of the most popular management tools of this type. In application to fisheries management, a recent study with the AHP was undertaken by Leung *et al.* (1998) for the Hawaiian pelagic fisheries. This study included the main interest groups involved in the fisheries and interviewed about 25 representatives.

The purpose of this paper is to study how different stakeholders would respond to different fisheries management objectives using a stated preference technique: the discrete choice based conjoint experiments. Unlike the pairwise comparison approach, this technique develops preferences for combinations of objectives rather than singularly. However, it is also possible to estimate the importance attached to each individual objective from the results obtained from the choice experiments.

The case study used in this analysis is that of the UK fisheries of the English Channel. The structure of the paper is as follows. Firstly, we explore the possibility of using choice based conjoint methodology to identify the preference structure where objectives of management are of key consideration. We then discuss the application of conjoint methodology to the example of the English Channel fisheries in a framework

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<sup>2</sup> Methods based on the definition of utility preference functions between paired objectives (or attributes) also exist, however where a large number of individuals exists, this becomes difficult to implement due to the high degree of interaction required in the survey.

of analysis. Following this, the actual methodology employed is more thoroughly reviewed. Results of the analysis are then discussed, and finally a discussion and conclusion section on the soundness of the methodology compared to other available techniques is examined.

## **Choice-based conjoint analysis**

Conjoint analysis (CA) is a technique for establishing the relative importance of different attributes, generally in the provision of a good or a service. It assumes that any service can be defined as a combination of levels of a given set of attributes. The total satisfaction or utility that an individual derives from that good or service is thereby determined by the utility to the individual of each of the attributes. The aim of the conjoint analysis technique is therefore to estimate (a) the relative importance of the individual attributes; (b) the trade-offs or marginal rates of substitution that individuals are willing to make between these attributes; and (c) the total satisfaction or utility scores for different combinations of attributes (Ryan, 1996).

The definition commonly used to explain the procedure of the conjoint analysis is that it covers:

*any decompositional method that estimates the structure of a consumer's preferences given their overall evaluations of a set of alternatives that are prespecified in terms of levels of different attributes*

(Green and Srinivasan, 1978).

Under this definition, CA can incorporate a number of approaches, such as choice modelling, paired comparison, contingent rating and contingent ranking.<sup>3</sup> The characteristics of the alternatives that the individual must choose from are multi-attribute in nature.

Choice experiments consider the number of alternatives while either holding the attribute levels associated with each alternative constant, or by varying them, so producing choice sets. Fixed choice set designs are particularly widely used (Hensher, 1994). The choice-based conjoint approach can be used to avoid problems like untestable statistical properties of estimated parameters in ranking data and the cardinal measurement assumption of the rating method. Specifically, one can design choice or allocation experiments to mimic real choice environments closely. There are several advantages and disadvantages with the conjoint choice-based method compared to the other available approaches. This method does not require any assumptions to be made about order or cardinality of measurement. The only condition required is that the response data should be discrete either nominal or classificatory in level of measurement. Unlike rank-order or ratings methods, one can show subjects different sets of alternatives and ask them to choose among them, or allocate resources among them in each set. One can also estimate choice models directly from choice data, and thus avoid the potentially unrealistic *ad-hoc* assumptions about choice behaviour that would be implied by the rating or ranking of a single choice set. Choice experiments are more difficult to design because they require two separate designs to be combined. One design is to create the choice

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<sup>3</sup> In contingent rating and ranking simply rank or rate alternatives in order of preferences.

alternatives (conjoint treatment and /or existing alternatives) and a second design to place choice alternatives (treatments plus possibly other non-designed choice alternatives) into choice sets. Both designs must satisfy certain statistical properties to enable the estimation of parameters and conduct statistical tests efficiently (Louviere and Woodworth, 1983).

In the field of fisheries management, conjoint analysis has not been applied to a great extent. However, Aas *et al.* (2000) showed a choice modelling approach to be particularly useful for evaluating various fisheries management alternatives and programs for harvest regulation in a recreational fishery in Eastern Norway. Specifically, they considered 5 main attributes over 2-3 levels (i.e. 72 possible combinations), 16 orthogonal profiles were chosen for each individual.

## A framework of evaluation for the case study

A choice based conjoint study has been conducted among key stakeholders in the UK fisheries of the English Channel to evaluate three overriding fisheries management objectives. The main aim of this survey and analysis is to study how different stakeholders respond to different attributes of the management objectives. There are several steps and considerations that have been completed in this study, and these form the framework of evaluation.

### 1. Understand the decision problem and environment:

Table 1 shows the model of the key features that stakeholders consider to be most important in the management process of the UK fisheries of the English Channel. This was developed in three stages: looking at current policy documentation to develop an initial structure, reviewing recent policy decisions that have been made and communicating with key stakeholders to accurately reflect current opinion (Mardle *et al.*, 2001). In defining this structure, care was taken to ensure completeness of the system, i.e. that all issues were incorporated in some level.

**Table 1.** Attributes and accompanying target levels.

| <i>Attributes</i>                                       | <i>Level I</i>                                    | <i>Level II</i>                                | <i>Level III</i>                          | <i>Level IV</i>                                      |
|---------------------------------------------------------|---------------------------------------------------|------------------------------------------------|-------------------------------------------|------------------------------------------------------|
| 1. Conserve the fishery and marine environments         | Increase sustainable yields of commercial species | Decrease bycatch of non-commercial species     | Improve quality of the marine environment | –                                                    |
| 2. Improve the fishery socio-economic structure         | Maintain direct fishery employment                | Maintain fisheries-related regional employment | Increase profit in the fisheries          | Increase labour and safety conditions in the fishery |
| 3. Reduce conflict within the fishery (i.e. allocation) | Between inshore/offshore fishermen                | Between towed/fixed gear fishermen             | Between different geographical groups     | –                                                    |

2. *Identify determinant attributes:*

The methodology desegregates the management program into attributes with different potential levels. Considering the attributes given in table 1 the challenge was to develop a questionnaire to capture the determinants of attributes. Appendix 1 contains an example of the questionnaire designed for the choice experiment. It is worth noting that considerable time was given to the terms used in the questionnaire and their underlying implications so that the decision attributes developed were actionable.

3. *Attribute positioning measures:*

Attribute positioning measures, such as ranges of levels, were developed that satisfy research objectives which are meaningful to individuals. A fractional factorial design was used to design a set of profiles, each representing a managerial alternative in terms of the most important features.

4. *Experiment design:*

A conjoint experiment has been designed to understand how the target individuals integrate the decision attributes, that is, how they evaluate multiattribute alternatives.

5. *Generating profiles:*

A full factorial design of the three main attributes identified in this study, where two attributes have three levels and one attribute has four levels yields a total of 36 possible combinations or profiles<sup>4</sup>. Due to the need for a respondent to asynchronously consider all profiles, only a fraction of the possible factorial combinations can be used to estimate the main effects and selected interaction effects. This is achieved by selecting an orthogonal, fractional factorial design. Using SAS<sup>®</sup> orthogonal main effects plan (where all interactions are assumed to be insignificant), 16 profiles were identified for this study. The questionnaire was designed to include all profiles on one card (see appendix 1), where respondents are asked to select the 4 most preferred options out of the 16 presented.

6. *Choice simulation system:*

A choice simulation system was created to forecast how the target individuals are likely to choose among different multiattribute alternatives offered in the choice set.

7. *Implementation of the survey:*

The survey was developed to target at least one individual from each of the organisations/bodies with a key interest in the management of the UK fisheries of the English Channel. Therefore, it was not necessary to sample the “population”, as is the case in most conjoint studies, but to ensure that every organisation was represented. In total, there exists approximately 30 key organisations, and in this study we have surveyed 26.

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<sup>4</sup> Two attributes have three levels and one attribute has four levels; thus there are  $(3^2).(4^1)=36$  possible alternatives.

## PHREG estimation procedure

Choices can be modelled as a function of the attributes of the alternatives relevant to a given choice problem using random utility theory. Multinomial Logit Models (MNL) serve as an error theory to diagnose or test various specifications for the utility function if the choice experiment is designed in such a way as to accommodate the required tests. It is an alternative to CA that is becoming increasingly popular in marketing research, the founding field of CA (Carson *et al.*, 1994). MNL models that satisfy independence from irrelevant alternatives can be fully specified by estimating the marginal choice probabilities for each alternative. The construction of choice sets, that is the total number of choice alternatives (N) of choice sets can be calculated by many factorial and fractional factorial designs (for details, see Louviere, 1988; Louviere and Woodworth, 1983; Adamowicz *et al.*, 1994). The MNL model assumes that the probability that an individual will choose one of the  $m$  alternatives,  $c_i$ , from choice set  $C$  is:

$$p(c_i | C) = \frac{\exp(U(c_i))}{\sum_{j=1}^m \exp(U(c_j))} = \frac{\exp(x_i b)}{\sum_{j=1}^m \exp(x_j b)} \quad (1)$$

where  $x_i$  is a vector of alternative attributes and  $b$  is a vector of unknown parameters,  $U(c_i) = x_i b$  is the utility for alternative  $c_i$  which is a linear function of the attributes. Equation 1 gives the probability value that an individual will choose one of the  $m$  alternatives,  $c_i$ , from choice set  $C$ . This is the exponential of the utility of the alternative divided by the sum of all of the exponential utilities. It is difficult to use SAS procedures such as LOGISTIC to fit such a model. Instead, one can make use of the procedure PHREG (proportional hazard regression) to provide the maximum likelihood estimates of the parameters, by defining a proper censoring variable.

In the SAS<sup>®</sup> system, the MNL model is fitted with the SAS/STAT<sup>®</sup> procedure PHREG with the *ties=breslow* option. The *ties=breslow* option specifies the most efficient and always appropriate way to fit the MNL model. This procedure performs regression analysis of survival data based on the Cox proportional hazards model (Cox, 1972). It assumes a parametric form for the effects of the explanatory variables, but allows an unspecified form for the underlying survivor function. The analysis of survival data requires special techniques because the data are mostly incomplete and familiar parametric assumptions may be unjustifiable. In general, investigators of survival analysis follow subjects until they reach a pre-specified endpoint, such as a death. At times, the event under study is completed before the endpoint is reached. In these cases, the survival times are censored; subjects survived to a certain time beyond which their status is unknown (SAS Institute Inc., 1999). The noncensored survival times are referred to as event times. Any study that would analyse survival time must account for both censored and noncensored data.

In this study, attributes are presented in sets of alternatives to stakeholders who are asked to choose the most preferred alternative. The data for one choice set consists of an observed first choice and  $m - 1$  unobserved subsequent choices.<sup>5</sup> The subjects who have not experienced the event are censored. The exact event time is not known, but it

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<sup>5</sup> In this study,  $m=4$ .

is known to exceed the censored time. In a discrete choice study, first choice occurs at time one, and all or some subsequent choices (second, third and so on) are unobserved or censored.

## Interpretation of parameter estimates

One characteristic common to all generalised linear models as well as probability models is that each estimate gives the partial effect of a coefficient with the effects of other  $x$  variables being controlled. The interpretation of each probability model closely follows that of the generalised linear model and that the only differences are due to the individual link functions and model specifications. In a classical regression model, an  $F$  test is used; however, the likelihood ratio statistics test is the most commonly used test in a probability model. The likelihood ratio statistics test roughly follows the chi-squared distribution, which can indicate that the model  $c^2$  fits the data significantly better than the model with the intercept only. In the PHREG procedure, the “testing global null hypothesis: BETA=0”, contains the overall fit of the model. The  $-2 \text{ LOG L}$  statistic under “with covariates” is used to test the null hypothesis that the attributes do not influence choice, which is given in table 2.

**Table 2:** Summary of the model selection.

| Convergence Status                            |                    |                 |            |
|-----------------------------------------------|--------------------|-----------------|------------|
| Convergence criterion (GCONV=1E-8) satisfied. |                    |                 |            |
| Model Fit Statistics                          |                    |                 |            |
| Criterion                                     | Without Covariates | With Covariates |            |
| -2 LOG L                                      | 133.478            | 108.482         |            |
| AIC                                           | 133.478            | 122.482         |            |
| SBC                                           | 133.478            | 137.484         |            |
| The PHREG Procedure                           |                    |                 |            |
| Testing Global Null Hypothesis: BETA=0        |                    |                 |            |
| Test                                          | Chi-Square         | DF              | Pr > ChiSq |
| Likelihood Ratio                              | 24.9960            | 7               | 0.0008     |
| Score                                         | 22.6407            | 7               | 0.0020     |
| Wald                                          | 17.8383            | 7               | 0.0127     |

Table 2 contains the information of overall fit of the model. The chi-square estimated values for likelihood ratio, score and Wald statistics indicate that the model is very highly significant. At common  $\alpha$  levels such as 0.05 and 0.01 we would reject the null hypothesis of no relationship between choice and the attributes. Note that 133.478 ( $-2 \text{ LOG L}$  without Covariates), which is  $-2 \text{ LOG L}$  for a model with no explanatory

variables, minus 108.482 (-2 LOG L with Covariates), which is -2 LOG L for a model with all explanatory variables, equals 24.996, which is significant at  $\alpha = 0.01$  level.

The analysis of Maximum Likelihood estimates, given in table 3, contains the maximum likelihood estimate of the parameter, its estimated standard error, the Wald chi-square statistic, and the  $p$  value of the Wald chi-squared statistic with respect to a chi-squared distribution with one degree of freedom the risk ratio.

Note that in table 3, descriptive labels for all variables are printed along with the zero coefficients for the reference levels, i.e. *conbyc*, *seis* and *altf*. The other estimated coefficients of the model will have values relative to this zero. So for example, the part-worth utility for the variable *conbyc* is a structural zero, and the part-worth utility for *consus* and *conqh* are larger at 0.65231 and 1.86250. This indicates that stakeholders prefer maximum sustainable yield as a fishery management objective to the objective of minimising bycatch. However, the objective of improving the quality of marine environment is more preferred over both sustainable yield and bycatch objectives in the management attribute of “*conserve the fishery and marine environments*”. The part-worth utility for this variable, *conqh*, is 1.86250 and also significant at  $\alpha = 0.01$  level.

**Table 3:** Maximum Likelihood estimates

| Analysis of Maximum Likelihood Estimates |    |                    |                |            |            |              |                              |
|------------------------------------------|----|--------------------|----------------|------------|------------|--------------|------------------------------|
| Variable                                 | DF | Parameter Estimate | Standard Error | Chi-Square | Pr > ChiSq | Hazard Ratio | Variable Label               |
| conqh                                    | 1  | 1.86250            | 0.63588        | 8.5791     | 0.0034     | 6.440        | Improve Quality of Marine E  |
| consus                                   | 1  | 0.65231            | 0.73861        | 0.7800     | 0.3772     | 1.920        | Maximum Sustainable yield    |
| conbyc                                   | 0  | 0                  | .              | .          | .          | .            | Minimise Bycatch             |
| seif                                     | 1  | 2.48672            | 1.23752        | 4.0379     | 0.0445     | 12.022       | Increase Profit              |
| sefe                                     | 1  | 2.42315            | 1.17245        | 4.2714     | 0.0388     | 11.281       | Maintain Fishery Employment  |
| sere                                     | 1  | 3.29937            | 1.21776        | 7.3407     | 0.0067     | 27.095       | Maintain community Employ    |
| seis                                     | 0  | 0                  | .              | .          | .          | .            | Improve Safety & Labour con. |
| alio                                     | 1  | -0.31986           | 0.46773        | 0.4677     | 0.4941     | 0.726        | Improve Allocation IO        |
| algg                                     | 1  | 0.51322            | 0.52934        | 0.9400     | 0.3323     | 1.671        | Improve Allocation BP        |
| altf                                     | 0  | 0                  | .              | .          | .          | .            | Improve Allocation TF        |

The second management attribute tested in the model was the “*improvement of the fishery socio-economic structure*”. As shown in table 3, all variables in this attribute are significant at  $\alpha = 0.05$  level. The improvements of the fishery’s socio-economic structure, from most preferred to least preferred are maintain community employment, increase profit, maintain fishery employment and improve safety of fishermen. The part-worth utility for improve safety (*seis*) in fishery management is a structural zero, and the part-worth utility for *sefe*, *seif* and *sere* are 2.42315, 2.48672 and 3.29937. The preference for fishery employment and increase profit are more or less the same while the maintaining community employment is more preferred to the improve of safety of the fishermen.

The third management attribute tested in the model was the “*reduction of conflicts within the fishery*” (e.g. allocation issues). As shown in table 3, estimated part-worth

utilities are not significant. However, improve allocation between different geographical groups (*algg*) is preferred to both other objectives, i.e. improve allocation between inshore and offshore fishermen (*alio*) and improve allocation between fishermen using towed and fixed gear (*altf*). The part-worth utility for *altf* in fishery management objectives is a structural zero, however the preference for *alio* is still lower than this. The part-worth utility value of  $-0.31896$  indicates that stakeholder choice for this attribute level is even lower than the reference level of *altf*.

#### Cross alternative effects

The principle of maximum random utility is the governing force of the discrete choice models. Both the generalised and the conditional logit models are based on the assumption that unobserved utility are independently distributed and each follows an extreme maxima value distribution (Hoffman and Duncan, 1988). The ratio of the choice probabilities for any two alternatives for a particular observation is not influenced systematically by any other alternatives. The Independence from Irrelevant Alternatives (IIA) test of the PHREG procedure can be used by fitting a model that contains all the cross-alternative effects and examines the significance of these effects. The cross alternative effects pick up a variety of IIA violations and other sources of error in the model. IIA means that the odds of choosing alternative  $c_i$  over  $c_j$  does not depend on the other alternatives in the choice set (Kuhfeld, 1996). Results of the IIA test are presented in table 4.

**Table 4:**

| Linear Hypotheses Testing Results |                    |    |            |
|-----------------------------------|--------------------|----|------------|
| Label                             | Wald<br>Chi-Square | DF | Pr > ChiSq |
| IIA ( <i>alio</i> , <i>algg</i> ) | 1.9102             | 2  | 0.3848     |

The chi-squared statistic for the Wald test for the variables *alio* and *algg* is 1.9102 indicating cross alternative effects are not statistically significant ( $p=0.3848$ ). It tested the null hypothesis that cross alternative effects *alio* and *algg* are zero. In this case, it appears that IIA is satisfactory, that is few if any of the cross-effect terms are significantly different. These are the only two levels of variables that are not significant in the PHREG analysis.

#### Probability of choice

The parameters estimated in the procedure PHREG are used next to construct the estimated probability for choosing each alternative. Using the stakeholder selection of four most preferred alternatives out of the 16 combinations (given in appendix 1), relevant probability values were constructed. The data step program of PHREG uses the right hand side equality of the equation 1 to create the choice probabilities. It uses the beta values estimated in the PHREG procedure and the stakeholder preferences for the each attributes and levels. The 'OUTEST=' option of the PHREG procedure allows the specification of the name of the SAS data set that contains the parameter

estimates, based on which one can estimate the predicted probabilities of the alternatives. Results of the probability distribution are given in table 5.

As shown in table 5, the most preferred combination of attributes is to concentrate on protecting the marine environment (*conqh*), maintaining regional employment (*sere*) and reducing conflict between inshore and offshore fishermen (*alio*) ( $p=0.2866$ ). Improve the quality of the marine environment (*conqh*) was the best part-worth utility estimated in the PHREG procedure. Improve regional employment (*sere*) was also the best level selected in the attribute of socio-economic improvement. However, the improve allocation of inshore/offshore (*alio*) was the least preferred level of the attribute of allocation. The difference is mainly due to the fact that the probability of choice has considered all four preferences of stakeholders, while the procedure PHREG considered only 3 and censored the 4<sup>th</sup> option. However, the procedures together have given an insight into the process of identification of better management objectives in the Channel fisheries.

**Table 5:**

| Probability of choice |        |      |      |         |
|-----------------------|--------|------|------|---------|
| Obs                   |        |      |      | p       |
| 1                     | conqh  | sere | alio | 0.2866  |
| 2                     | conqh  | seif | altf | 0.2276  |
| 3                     | consus | sere | algg | 0.1179  |
| 4                     | consus | sere | altf | 0.1177  |
| 5                     | conqh  | sefe | alio | 0.1074  |
| 6                     | consus | sefe | algg | 0.0491  |
| 7                     | consus | seif | alio | 0.0379  |
| 8                     | conbyc | sere | alio | 0.0223  |
| 9                     | conbyc | sefe | alio | 0.0111  |
| 10                    | consus | sefe | altf | 0.0098  |
| 11                    | conbyc | seif | algg | 0.0091  |
| 12                    | conqh  | seis | algg | 0.0024  |
| 13                    | consus | seis | alio | 0.0006  |
| 14                    | conbyc | seis | altf | 0.0005  |
| TOTAL                 |        |      |      | 1.00000 |

The second highest probability combination is the improvement in quality of the marine environment (*conqh*), increase profit from fishing (*seif*) and improve allocation between fishermen using towed and fixed gear (*altf*). The probability attached to this combination of attributes is  $p=0.2276$ . All other probability values for the different profiles are listed in table 5. In taking a decision as to which level or attributes are important in managing channel fisheries, different probabilities provide a valuable insight.

Using the choice probabilities developed in table 5, it is possible to get a crude indication to the importance that the consensus has attached to each of the individual objectives. One way of doing this is to take a simple average of probabilities for each objective, the results of which are shown in table 6.

**Table 6:** Rough estimation of the importance attached to each objective

| conqh | sere  | seif  | altf  | alio  | consus | algg | sefe | conbyc | seis |
|-------|-------|-------|-------|-------|--------|------|------|--------|------|
| 22.1% | 19.3% | 13.0% | 12.6% | 11.0% | 7.8%   | 6.3% | 6.3% | 1.5%   | 0.2% |

This estimation confirms the top 3 objectives of management. Further, for both the conservation and socio-economic attributes, the ranking of objectives is as expected. However, for the third attribute concerning conflict reduction, the order of objectives is particularly interesting. Here, conflict reduction between towed and fixed gear (*altf*) is slightly more important than between inshore and offshore fishermen (*alio*) which is more important than between geographical groups (*algg*). This is in contrast to the results achieved with PHREG (table 3), however possibly points to the insignificance found for each objective in the procedure. A more rigorous importance estimation procedure, as well possibly increasing the sample size, would enable a more thorough analysis with respect to this.

## Discussion and conclusions

Choice-based conjoint analysis is a flexible and pragmatic approach to modelling complex trade-offs between multiattributes. The aim of this paper was to investigate the soundness of the conjoint-based choice modelling approach to evaluate three overriding fisheries management attributes in the English Channel. In order to achieve this we have reviewed methodological, theoretical, analytical, and experimental aspects of conjoint analysis. In developing the preference elicitation using such conjoint analysis methods, significant problems are likely to appear in the development of the process. It is crucial to resolve such potential problems and issues when designing and carrying out the study.

A key point to consider in the design of such an analysis is the size of sample population. The significance of the results depends highly on this factor. We have a sample size of 26 in this study, which is above the lower limit of acceptability of the method. In marketing, samples are generally large. However, in management studies it is often the case that there is a limited number of key individuals to add input into the analysis. The results presented here are highly significant, which indicates that the sample has been effective.

Results of the analysis have revealed that conjoint based choice modelling approaches are a useful approach for evaluating management alternatives and programs in the field of fisheries. In conclusion, this study shows that CA based choice modelling has promising advantages over traditional opinion rating and ranking approaches. It provides the opportunity to elicit a deeper understanding of different levels of management attributes that would help to achieve efficient fisheries management options. It is clear that with the multiple, often conflicting, objectives of fisheries management, determining the importance of objectives in the process is key to developing appropriate strategies. This not only enables trade-offs to become more explicit, but also highlights the viewpoints of the various interest groups involved in fisheries.

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## Appendix 1: Choice-based experiments questionnaire

### Questionnaire to survey key interest group representatives for the development of preferences towards management objectives in the UK fisheries of the English Channel

***(Please select the 4 cards that best represent preferred combinations of objectives)***

|                                                                                                                                |                                                                                                                                    |                                                                                                                              |                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| <b>A</b><br>Max. sustainable yield (commercial)<br>Maintain fishery employment<br>Improve allocation (towed / fixed gear)      | <b>B</b><br>Max. sustainable yield (commercial)<br>Improve safety and labour conditions<br>Improve allocation (inshore / offshore) | <b>C</b><br>Min. bycatch in the fishery<br>Increase profit from fishing<br>Improve allocation (between ports)                | <b>D</b><br>Max. sustainable yield (commercial)<br>Maintain community employment<br>Improve allocation (between ports)           |
| <b>E</b><br>Max. sustainable yield (commercial)<br>Maintain community employment<br>Improve allocation (towed / fixed gear)    | <b>F</b><br>Max. sustainable yield (commercial)<br>Increase profit from fishing<br>Improve allocation (towed / fixed gear)         | <b>G</b><br>Min. bycatch in the fishery<br>Improve safety and labour conditions<br>Improve allocation (inshore / offshore)   | <b>H</b><br>Maintain quality of marine environment<br>Increase profit from fishing<br>Improve allocation (towed / fixed gear)    |
| <b>I</b><br>Maintain quality of marine environment<br>Maintain community employment<br>Improve allocation (inshore / offshore) | <b>J</b><br>Max. sustainable yield (commercial)<br>Increase profit from fishing<br>Improve allocation (inshore / offshore)         | <b>K</b><br>Maintain quality of marine environment<br>Maintain fishery employment<br>Improve allocation (inshore / offshore) | <b>L</b><br>Min. bycatch in the fishery<br>Maintain fishery employment<br>Improve allocation (inshore / offshore)                |
| <b>M</b><br>Min. bycatch in the fishery<br>Maintain community employment<br>Improve allocation (inshore / offshore)            | <b>N</b><br>Min. bycatch in the fishery<br>Improve safety and labour conditions<br>Improve allocation (towed / fixed gear)         | <b>O</b><br>Max. sustainable yield (commercial)<br>Maintain fishery employment<br>Improve allocation (between ports)         | <b>P</b><br>Maintain quality of marine environment<br>Improve safety and labour conditions<br>Improve allocation (between ports) |
| 1st Choice = ..... 2nd Choice = ..... 3rd Choice = ..... 4th Choice = .....                                                    |                                                                                                                                    |                                                                                                                              |                                                                                                                                  |