# Identifying functional stakeholder clusters to maximise communication for the Ecosystem Approach to Fisheries Management

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## Abstract

Interaction with ecological models can improve stakeholder participation in fisheries management. Problems exist in efficiently communicating outputs to stakeholders and an objective method of structuring stakeholder differences is lacking. This paper aims to inform the design of a multi-user communication interface for fisheries management by identifying functional stakeholder groups. Intuitive categorisation of stakeholders, derived from survey responses, is contrasted with an evidence-based method derived from analysis of stakeholder literature. Intuitive categorisation relies on interpretation and professional judgement when categorising stakeholders among conventional stakeholder groups. Evidence-Based categorisation quantitatively characterises each stakeholder with a vector of four management objective interest strength values (Yield, Employment, Profit and Ecosystem Preservation). Survey respondents agreed little in forming intuitive groups and the groups were poorly defined and heterogeneous in interests. In contrast the *Evidence-Based* clusters were well defined and largely homogeneous, so more useful for identifying functional relations with model outputs. The categorisations lead to two different clusterings of stakeholders and suggest unhelpful stereotyping of stakeholders may occur with the Intuitive categorisation method. Stakeholder clusters based on literature-evidence show a high degree of common interests among clusters and is encouraging for those seeking to maximise dialogue and consensus forming.

*Keywords:*

Fishing Industry, EAFM, Content Analysis, Hierarchical Clustering, Stakeholder Identification, Decision Support System

# 1. Introduction

Implementing the Ecosystem Approach to Fisheries Management, EAFM [1], requires (a) participation from the stakeholder spectrum [2] and (b) increased use of ecological models to explore management plans, especially in adaptive management [3]. Interaction with ecological models can improve stakeholder participation but model outputs are often sceptically received by stakeholders for two reasons. The first is that stakeholders feel excluded from the modelling process, leading to an "us-and-them" type relationship [4]. The second is that stakeholders often do not have the knowledge required to directly assess model outputs [5,6]. Participatory Modelling [7] attempts to overcome this by involving stakeholders in the creation of models to improve transparency. However, this solution is infrequently available in practice and despite its success, problems remain in adequately communicating model outputs to stakeholders [8].

Different epistemological backgrounds, cognitive styles and personal interests influence stakeholders' interpretation and use of information, including information generated by ecological models [9,10]. This diversity is pertinent to fisheries systems, particularly in the Regional Advisory Councils (RACs) of European waters where two thirds of representatives stem from the fisheries sector and the remaining third represent other interested groups. Benefit may be gained from a bespoke tailoring of communication between the diverse range of stakeholders (without implying the withholding of information) and the models. If the range of stakeholders can be partitioned into clusters, based on similarities in specific stakeholder characteristics, such as their interest in management objectives, model communications can be tailored to identifiable clusters, rendering the problem tractable. This amounts to a systematic structuring of stakeholder diversity, which is proposed here as a necessary step in designing tailored communication of scientific information to support diverse stakeholder participation in fisheries management.

Partitioning of user communities has a long history. In marketing, audience segmentation [11] is a technique used to divide audiences into clusters with similar characteristics. Audience segmentation can be based on lifestyles, motivations and behaviours, etc., and is a valuable tool for product development, distribution, promotion and for communication purposes [12]. It is applicable to fields outside of marketing, where multiple stakeholders are involved, such as in assessing attitudes towards global warming [13]. Whilst differences among stakeholders are intuitively recognised in fisheries management, there is, as yet, no formal and objective means of structuring the differences within the context of stakeholder engagement. In this paper, an objective method is proposed for identifying functional clusters among stakeholders and is contrasted with an intuitively based classification derived from survey responses. In this context 'functional clusters' refer to sets of stakeholders sharing similar interests regarding fisheries management objectives. These functional clusters are identified through a quantitative analysis of their stated 'interest' in specific management objectives.

If functional clusters of stakeholders can be identified, then the design of a Decision Support System (DSS) for participatory fisheries management can match information to identified concerns and preferences of stakeholders: this is the overall aim. Typically, ecological models communicate information via indicators [14], such that trends in indicator values inform adaptive management and thereby influence future regulations and policies [15]. A typical DSS consists of one or more computational models generating indicator values, which are communicated to users via an interface [16]. Hitherto, this interface has been thought of as a single communication channel: presenting the same information in the same way to all stakeholders, irrespective of their interests and epistemological backgrounds [10]. Thus the aim is to inform the design of a multi-user interface that can better match the information generated by the models to identifiably different stakeholders.

The practical implementation of this idea requires an evidence-based and verified method for characterising stakeholders. This is found in 'Stakeholder Analysis', SA: an attempt to evaluate and understand stakeholders from the perspective of an organisation, and/or to determine their relevance to a project or policy [17]. Applying an SA in fisheries management can improve the management system by identifying (i) the stakeholder landscape (ii) relevant stakeholders and their interests, (iii) the position of stakeholders on management plans, (iv) a stakeholder's ability to affect the management process and (v) what impacts stakeholders can have on a management plan [17]. The results from SA pre-empt issues of stakeholder support/opposition and help formulate appropriate management strategies to maximise support. Focusing specifically on item (ii) above, SA can help frame a communication interface between stakeholders and ecological models. Identifying relevant stakeholders and their interests facilitates the creation of functionally meaningful clusters in the context of communicating modelling and its results with stakeholders. The term Evidence-Based categorisation is used in this study to indicate an objective approach for categorising stakeholders. Using this approach, stakeholders are grouped based on their interest strengths in each of the four management objectives of Yield (Y), Employment (E), Profit (P) and Ecosystem Preservation (S) [18].

The increased demand for indicators (i.e. in Europe the MSFD requires indicators of Good Environmental Status, GES [19]) requires a more 'appropriate' communication of indicators and their sources, which can improve participation from a range of stakeholders. Such an improvement would represent a departure from current participation practices in fisheries management, which are typically in the form of consulting and informing [20]. Given the diversity of stakeholders, 'appropriateness' implies tailoring the presentation of information to clusters within which similar interests and epistemological backgrounds are shared, in such a way as to avoid multiple interpretations of outputs [21,22]. But just as stakeholders differ in perspective, so too do the models used in EAFM, which show a wide variety in scale, complexity and level of abstraction. Management is faced with integrating information from: end-to-end and whole ecosystem models, minimally realistic models, individual-based models, bioenergetics and fleet dynamics models, and many more [23]. These different models are intended for different purposes, the relevance of which will depend on the particular stakeholder. As models increase in sophistication, stakeholders tend to feel increasingly alienated [21]. This alienation is not due to lack of education or understanding among stakeholders but results from their epistemological backgrounds and cognitive styles (i.e. how information is processed, stored and structured, [9]). For example, the mathematical nature of information limits its accessibility to only those stakeholders having the required scientific background [24]. Additionally, the uncertainty associated with model outputs is sometimes inadequately explained and may weaken stakeholder support for advice [4,25]. This study starts with the premise that customising model outputs to a stakeholder's 'frame of evaluation' can increase communications, thereby encouraging genuine participation [14]. To achieve this requires a matching of broad stakeholder objectives to the specific and quantifiable indicators generated by models [26] and that may be best achieved by first partitioning the stakeholder spectrum into functional (interest-based) clusters. Finding an objectively justifiable way to do that is the aim of the reported work.

## 2. Methods

The Stakeholder Analysis process [27,28] was used, of which the first step was Stakeholder Identification. Immediately following that, two contrasting methods for categorising stakeholders were investigated: *Intuitive* Categorisation, described in Section 2.2, and *Evidence-Based* Categorisation, described in Section 2.3 and these were compared using statistical analysis of results from literature analysis and questionnaire responses.

## 2.1. Stakeholder Identification

Snowball sampling was the primary method used to identify stakeholders and has been validated as a means of obtaining a representative sample of stakeholders [29]. The identification process operated under a definition adapted from [30] in which a stakeholder is any group, or individual affected by, or able to affect, fishing activities within the context of the EAFM. This definition was supported by that of the FAO [1] which described EAFM as an attempt to "balance diverse societal objectives by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries".

The stakeholder identification process was initiated by identifying conventional stakeholder groups based on common practice and terminology established in the fisheries management literature [26,31,32]. The four groups identified were 'Environmental', 'Research', 'Managers' and 'Fishing Industry', with a fifth, 'Miscellaneous', added to hold unclassified stakeholders. These 'baseline' stakeholder groups formed the starting point of stakeholder identification. By allocating a single baseline stakeholder to each group snowball sampling [29,33] proceeded until a quantitative saturation point was reached [34]. In snowball sampling, the published literature of the baseline stakeholder was searched for reference to further stakeholders. Once identified, these newly identified stakeholders were allocated to one of the five baseline groups (not necessarily that of the "parent" stakeholder, whose literature was being searched). At this stage, the allocation decision was determined by the first author's subjective assessment of the stakeholder's literature. Once the parent literature was exhausted, the literature of the "daughter" stakeholders was searched for a third generation of stakeholders and this process was repeated. The number of times every stakeholder appeared in the searched literature was recorded and if any three stakeholders within a baseline group had appeared more than ten times, the snowball sampling within that baseline group was considered to have reached saturation. At this point, searching for stakeholders associated with that group was terminated

## 2.2. Intuitive Categorisation

Stakeholder identification resulted in 90 stakeholders (Table 1), each provisionally allocated to one of the five baseline stakeholder groups. This allocation is an example of what is termed Intuitive *Categorisation* as it relies on the allocator's interpretation and professional judgement of each stakeholder: the individual's cognitive style [9]. This is likely to differ among individuals and because it is a function of the allocator it results in a subjective categorisation. It is therefore necessary to quantify the inter-observer variability among allocators in categorising stakeholders into baseline groups. Data for this quantification was obtained from a questionnaire survey, emailed to representatives of the stakeholders (hence stakeholders were asked to categorise one another and themselves). In the first part of the questionnaire the respondents were presented with the 90 stakeholder's names and the identification numbers of each baseline group (1 – Environmental, 2 – Research, 3 – Managers, 4 – Fishing Industry, 5 – Miscellaneous). Respondents were asked to allocate each stakeholder to one of the five baseline groups (the second section of the survey is discussed in 2.3). Respondents could place each stakeholder in only one baseline group. Each valid response showed all 90 stakeholders allocated among the five baseline groups. For analysis this was considered as a set of 90 pairwise associations among stakeholders and baseline groups. Having received nine valid responses, there were nine 'trials' (in the statistical sense) of forming associations between stakeholders and baseline groups. The responses were quantitatively aggregated, by summing the number of occurrences of each stakeholder baseline group association, to give the probability that any stakeholder will be associated with any given baseline group. From this data, the 90 stakeholders were re-allocated to baseline groups on the aggregated values of the nine responses. This allocation replaced the provisional allocation previously made by the researcher. Each stakeholder was allocated to the baseline group that was most frequently associated with that stakeholder by the survey respondents. Stakeholder-baseline group associations having the greatest statistical support were chosen as a definitive intuitive allocation of stakeholders. In the case of a tie among associations, the stakeholder concerned was allocated to all the baseline groups sharing the highest frequency of association.

### 2.3. Evidence-Based Categorisation

Stakeholder interest information was gathered from a primary analysis of the publicly available stakeholder literature (official websites of organisations, their publications, letters to the EU and newsletters) in an approach similar to that described by [35] in the context of identifying common themes from interview transcripts. Only material published from 2007 to 2012 was included. This analysis identified 27 topics of interest across the 90 stakeholders (Table 2).

The second section of the survey collected data describing respondents' views on the 27 topics of interest and each topic's relation to management objectives. This section of the survey provided respondents with a definition of each topic and asked them to assess its relevance to the four management objectives of Yield, Employment, Profit and Ecosystem Preservation. Respondents were asked to indicate on a scale of 1-3 (1 – low, 2 – medium, 3 – high) how important they thought a topic was for the performance of an objective. Respondents were free to allocate a topic to more than one objective or with no objective, according to their judgement. The topics presented in the survey were identified from an analysis of the stakeholder literature as topics of interest for the stakeholder collective. It was hoped this would (i) avoid including topics no stakeholders were interested in and (ii) incorporate topics researchers may have overlooked. Hence, for the particular point in time of analysis these topics were assumed to be representative of the potential interests for the 90 stakeholders. Responses were quantified as the frequency of association of each topic with an ordinal value of relevance to each of the management objectives. These frequencies were aggregated over the responses to construct an empirical distribution of high, medium and low relevance of each topic to each management objective. These distributions were used to form a set of definitive associations between interest topics and management objectives. An interest topic was associated with a management objective if the probability of it being allocated high or medium relevance was greater than 0.5. Using these empirically derived associations between topics and management objectives, a codebook was constructed in which each management objective was connected to a set of associated topics, together with their accompanying definitions.

The codebook was used for a secondary analysis of the stakeholder literature, consisting of a Content Analysis [36]. Topic definitions from the codebook were used to match the interests stated in stakeholders' literature to the set of 27 topics. If a stakeholder's literature discussed an issue found among the 27 topics this was considered a match, the presence of which was recorded against that stakeholder. For each of the 27 interest topics in turn, a match was sought in the literature of each of the stakeholders. This resulted in a set of presence / absence records for each stakeholder over the set of 27 interest topics producing a quantitative description of the stakeholders' interests. These stakeholder descriptions were enriched with the information gained from assessing which topics each stakeholder had an interest in for each management objective providing a description of each stakeholder in terms of their interest in the set of management objectives. For each stakeholder, the management objectives were taken in turn and the number of interest topics relevant to that objective found present in the stakeholder's literature was counted. By dividing this count by the total number of topics in that management objective, a ratio was obtained representing the strength of interest the stakeholder held in the management objective. The interest strength was a fraction with a value from 0 to 1, where 1 results from the stakeholder expressing an interest in all the topics of that objective. Interest strengths were calculated for each management objective (four) for each stakeholder (90), resulting in 360 interest strength values, such that every stakeholder may be quantitatively characterised by a vector of four management objective interest strengths.

### 2.4. Analysis of Data

The Evidence-based categorisation of stakeholders resulted in four-dimensional characterisations, from which a distance matrix was calculated. The distances were unitless because they derive from ratios (described in the section above). Agglomerative hierarchical clustering (with Ward's method) used the dissimilarities in the distance matrix to produce a stakeholder dendrogram (Figure 1b). Each cluster in the dendrogram represents a set of stakeholders with similar interests in management objectives. Six clusters were identified by finding the 'elbow' of a scree plot (Figure 1a) [37]. The mean strength of interest in each management objective was calculated from averaging over the interest strengths of stakeholders in each cluster. A topic was considered to be of high importance for a cluster if more than 80% of the stakeholders within that cluster expressed an interest in it.

The distance matrix was presented graphically as a heat map to reveal patterns in similarity among stakeholders. The order in which the stakeholders are placed is critical to the patterns produced and this was used to compare the two categorisation methods by ordering stakeholders into Intuitive groups and Evidence-Based clusters to form two contrasting heat maps.

The results of the Intuitive and Evidence-Based categorisations were compared to determine whether stakeholders were placed in the same cluster regardless of the method used. A Similarity Index, SI, similar to Jaccard's Index of Similarity [38] and Rands Index provided a numerical comparison of the two categorisations. The SI compares the stakeholders found in each Intuitive group with the stakeholders found in each Evidence-Based group. If a stakeholder is found in both the Intuitive and Evidence-Based clusters, a 1 is assigned to that cluster comparison. If the stakeholder is only found in the Intuitive cluster and not the Evidence-Based cluster, a 0 is assigned to that comparison. The SI is calculated as follows

$$SI_{x,y} = \frac{N_{I_x \cap EB_y}}{N_s} \qquad (1)$$

where $I_x$ is an Intuitive cluster with $x$ between 1 and 5, $EB_y$ is an Evidence-Based cluster with $y$ between 1 and 6, $N_{I_x \cap EB_y}$ is the number of stakeholders present in both $I_x$ and in $EB_y$ and $N_S$ is the number of stakeholders in the Intuitive cluster $I_x$. For the Intuitive clusters the Environmental group is 1, Research is 2, Managers is 3, Fishing Industry is 4 and Miscellaneous is 5. Hence for each Intuitive cluster the SI is the proportion of its members that are present in each of the Evidence-Based clusters.

The average distances between and within the six Evidence-Based clusters and between and within the five Intuitive clusters were calculated using the distance matrix (Table 3). The average distance between clusters is the average distance from any stakeholder in one cluster to any stakeholder in the next cluster. The average distance within clusters is the average distance from any stakeholder in the cluster to any other stakeholder within that cluster. These distances are useful when assessing how distinct the clusters are, i.e. greater between cluster distances indicate clusters do not share similar characteristics and small within cluster distances indicate cluster homogeneity.

# 3. Results

## 3.1. Stakeholder Identification

90 different stakeholders were identified by snowball sampling and were unevenly distributed among the five Intuitive groups (Table 4). Environmental and Fishing Industry groups were most populous, with, 27 and 25 stakeholders each respectively, followed by

the Managers group with 16 and the Research and Miscellaneous groups both containing 11 stakeholders each.

### 3.2. Intuitive Categorisation

Survey respondents did not agree in the majority of allocations of stakeholders among the five Intuitive groups (Figure 2). There was full agreement among respondents in the allocation of 36% of the stakeholders among the five Intuitive groups. The proportion of stakeholders in each Intuitive group that the nine respondents agreed belonged to that group was 0.45 for the Environmental, 0.25 for the Research group, 0.29 for the Managers group and 0.5 for the Fishing Industry group. Hence the highest agreement among respondents occurred in allocating stakeholders to the Environmental and Fishing Industry groups. There was never total agreement when allocating stakeholders to the Miscellaneous group. The respondents allocated the remaining 64% of stakeholders to two, three, four or five groups (Figure 3). Five stakeholders were placed in more than one group due to a tie in the stakeholder-group association values from survey respondents (Table 4).

### 3.3. Evidence-Based Categorisation

Survey respondents did not agree in the allocation of topics to objectives nor did they agree on the importance of topics to objectives (Figure 4). The criteria for allocating a topic to an objective (2.3) resulted in the Yield objective having 16 topics, the Employment and Profit objectives both having 10 topics and the Ecosystem Preservation objective having 20 topics (Table 5). Using the results from the content analysis, six stakeholder clusters (Evidence-Based Clusters) were produced. Inspection of the stakeholders in each cluster suggested they were dissimilar to the previous five (Intuitive) groups.

The patterns of the mean interest strengths per cluster (Figure 5) and the mean interest values per cluster (Table 6) exhibit the differences between clusters but also potential areas of interest overlap. The first cluster had the strongest interest in all four objectives. The main interests of the second and fourth clusters were in the Employment and Profit objectives with an intermediate interest in Yield and low interest in Ecosystem Preservation. The interest strengths of cluster 4 were slightly lower than for cluster 2, despite having a similar pattern of management objective interests. Clusters 3 and 6 were interested in Yield and Ecosystem Preservation with low interest in Profit and Employment. Similar to the pattern observed between clusters 2 and 4, the interest strengths of cluster 6 were slightly lower than for cluster 3. Cluster 5 has a low interest in all four objectives. There was no dominating objective in any of the clusters. Instead a moderately balanced interest in objectives is represented with Cluster 1 having an even balance in all objectives. A corollary to this is that there is overlap in interests among the Evidence-Based clusters. The topics for which more than 80% of stakeholders in each cluster expressed an interest in are listed in Table 7. Stakeholders in Cluster 1 had a high interest in 11 topics spanning all four objectives; examples include Reproductive Capacity, Gear Selectivity and Vessel Crew Number. Cluster 2 and cluster 4 had high interest in six and three topics respectively. The topics that overlapped between clusters 2 and 4 (i.e. Vessel Crew Number and Fuel Costs) emphasise the focus of these clusters in the Profit and Employment objectives. For clusters 3 and 6 the overlap in topics occurred with Habitat Protection, Biodiversity and Vulnerable Species emphasising the strong interest of these clusters in the Ecosystem Preservation objective. None of the topics scored higher than 80% interest from the stakeholders in cluster 5.

### 3.4. Analysis of Data

The differences between the Intuitive clusters and Evidence-Based clusters are emphasised in the heat map (Figure 6) with the Evidence-Based clustering showing a more distinctive pattern than the Intuitive clustering. The heat map illustrates (a) the cluster homogeneity resulting from the Evidence-Based categorisation with low distances between stakeholders in the same clusters (0-0.4) and large distances between stakeholders of different clusters (0.6-1); (b) the internal heterogeneity of the Intuitive clusters, reflected in the variability in distances between stakeholders in the same clusters. The map suggests the Evidence-Based clusters are a more justifiable clustering of stakeholders due to the high within cluster homogeneity.

Complimentary to the heat map, the low SI values reinforce the differences between the Intuitive and Evidence-Based categorisations. The range of the SI values was between 0 and 0.6 and 83% of the SI values were less than 0.3 (Table 8). The maximum value was 0.6, between the Intuitive Fishing Industry cluster and Evidence-Based cluster 2, and the minimum value of 0 occurred 7 times. The mean SI across all combinations of Intuitive and Evidence-Based clusters was 0.167. The average distances between and within clusters are shown in Table 3. The average within cluster distance of all six Evidence-Based clusters is

0.126 and the average between cluster distance across all six Evidence-Based clusters is 0.408.

## 4. Discussion

This study has shown that stakeholders show a diverse range of interests in fisheries management and can be partitioned into groups with distinct and consistently associated sets of interests. This supports the aim of tailoring the interfacing of computational models to identifiably different user-groups in an effort to maximise their participation. However, quantitative partitioning, based on evidence that was derived from the published literature of stakeholders, showed that 'intuitive' categorisation might be misleading. It suggests a need for evidence-based categorisation of stakeholders, rather than a reliance on intuition. This result is by definition counter-intuitive and therefore surprising, but is important because the consequence of erroneous categorisation could be loss of engagement and at least a mismatch of information transfer. Even if there is no intention to identify formal groups of stakeholders, the informal notion of stakeholder categories may amount to stereotyping and do a disservice to interested parties. If accepted, the evidence-based technique exposes the risk of such stereotyping. Furthermore, since a substantial overlap was found in interests among the evidence-based clusters, the notion of 'single-minded' stakeholder types is most likely unhelpful. This is encouraging for those seeking to maximise dialogue and consensus forming. The clustering threshold chosen for the Evidence-Based categorisation generated six stakeholder clusters, a manageable number for the design of a multi-user Decision Support System. Scope remains for aggregating clusters into a smaller number if necessary since, although there are differences in interests among the six clusters, there are also substantial overlaps, i.e. between Cluster 2 and 4 and between Cluster 3 and 6.

The Evidenced-Based categorisation was an attempt to objectively and quantitatively categorise stakeholders based on their interests in the four management objectives and thereby reduce the subjectivity associated with Intuitive categorisation. However some may see this as overly reductionist, in that it deliberately ignores the simple prospect of asking stakeholders which category they believe they belong to. It is not without precedent: basing stakeholder categorisation on a content analysis of their literature without any direct contact is an accepted method for assessing stakeholder interests [39]. Interest strengths have previously been used to create stakeholder clusters in the context of water resource management [35]. Additionally, qualitative data collected from stakeholders is subject to personal experiences, beliefs, etc. [40] and may not meet the objectivity requirements of repeatability normally associated with science. Perhaps more seriously, direct questions are especially vulnerable to 'hypothetical bias' (in which answers gained in a hypothetical context, such as a survey, differ from those revealed in a real context). Direct questions offer respondents the opportunity to cast themselves in a particular light [41] and this view may be influenced by their opinion of the researchers and the use to which the results may be put (all these are well recognised problems in, for example, non-market valuation [42]). Direct questioning leaves in doubt the objectivity of results in the sense that they may be influenced by observer effects. For these reasons, despite the reductionism, the Evidence-Based categorisation is valuable in providing an objective method of collecting data based on stated stakeholder interests, where the researchers' presence does not influence stakeholder responses. It offers the further advantage of quantifying the degree of confidence with which each stakeholder can be categorised, allowing for both more specific and more nuanced statements concerning interest groups to be justified. The interest strengths are quantitative descriptions of stakeholders and provide a useful tool in differentiating between stakeholders. The interest strengths of the six Evidence-Based clusters (Figure 5) support the idea that not all stakeholders will be interested in the same objectives and those that are interested in the same objective can vary in degree of interest [43]. The results also support the findings of Stone where stakeholders will not be exclusively interested in one objective but will have a dominant interest with fluctuating interests in other objectives [35]. This highlights the third advantage of the Evidence-based method, which is that it integrates over the time-period of the literature survey, so is less susceptible to the strong influence of whatever issue occupies a stakeholder at the moment of questioning.

In Intuitive categorisation, the fact that among the nine respondents there was agreement over 33 stakeholders and disagreement over 57 stakeholders emphasises the subjective nature of stakeholder categorisation [28]. Multiple interpretations of interests clearly exist when categorising stakeholders. Such individual variation among interpretations and their resulting stakeholder categorisation is not unique in fisheries management. The term 'resilience' carries different meanings across disciplines and without consensus on its meaning, creating testable hypotheses and improving transdisciplinary collaborations is not possible [44]. The individual backgrounds of the respondents and their concept of each of the five groups may have caused the inconsistency in their categorisation. Of the 33 stakeholders for which there was consensus, the respondents showed greatest confidence in allocating stakeholders among the Environmental or Fishing Industry groups. Fishing Industry stakeholders can have specific positions on management plans that are distinct from positions of other stakeholder groups [45], as can environmental stakeholders. Because of this they may be more easily identified than other groups such as Research and Managers. The distribution of individual stakeholders over multiple stakeholder groups suggests that with multiple interests, the defining interests depend on the sorter's interpretation. The issue of multiple objectives among multiple stakeholder groups is well known [1,26] and is particularly a source of bias if the multiple objectives appear to in conflict. This may account for the finding that some stakeholders were intuitively allocated in more than one stakeholder group.

The stakeholders in the six Evidence-Based clusters do not conform to the usual titles of Environmental, Research, Managers, Fishing Industry and Miscellaneous. Two types of stakeholder clusters are apparent in the radar plots: generalists and specialists. Cluster 1 could be termed a high interest generalist as the stakeholders in this group have a high interest in all four objectives. The topics for which more than 80% of the stakeholders in this group have an interest in span the four management objectives. Cluster 5 could be termed a low interest generalist as its members have a low interest in all four objectives with no topic reaching the 80% interest threshold. Of the remaining four clusters 2 and 4 consider the human-related objectives, Profit and Employment, of fishing activities most important and could be called anthropocentric specialists. In contrast, Clusters 3 and 6 are skewed towards the more environmental objectives of Yield and Ecosystem Preservation and could be called ecocentric specialists [46]. The topics of high interest identified for each cluster (Table 7) emphasise the Evidenced-Based titles mentioned above, i.e. the anthropocentric stakeholders are predominantly interested in the Profit and Employment objectives and the ecocentric stakeholders are predominantly interested in the Yield and Ecosystem Preservation objectives.

The interest strengths in the four management objectives provide information as to which indicators from ecological models would be most helpful for each stakeholder cluster. The interest strengths are similar to the weighting preferences used in utility functions, which are assigned to management objectives by stakeholders [47]. The different utility weights of different stakeholders must be defined before utility functions are determined. Stakeholders are usually involved in this process but the Evidence-Based analysis discussed here may provide supplementary information for weight setting. By determining where stakeholders' utility functions converge, areas of consensus on management outcomes can be identified, enabling management plans to be adopted that maximise Joint Stakeholder Satisfaction (JSS [48]). Such consensus forming benefits can also be gained from the Evidence-Based categorisation due to the overlaps of interests between the stakeholder clusters mentioned previously.

SI values provide information on whether the same stakeholders appeared together in clusters irrespective of which categorisation method was used. The low values of SI between the Intuitive and Evidence-Based categorisations show them to be remarkably different. If the quantitative evidence is to be taken seriously this should give pause for though for those thinking they know how to categorise stakeholders. As an illustration, 10 stakeholders were consistently placed in the Fishing Industry group by the respondents. The consensus in placing these 10 stakeholders in the Fishing Industry group might be seen as a reasonable categorisation since they are all directly involved in the capture of marine fish. However, in the Evidence-Based categorisation the same 10 stakeholders were distributed among different clusters, with some having an unexpected interest in the Ecosystem Preservation objective and some placed in clusters for which the Profit objective did not receive a high interest strength value. This supports the idea that profit is not the sole driver for members of the fishing industry and there are other factors influencing fishing behaviour and tactics [49]. The Fishing Industry group of stakeholders may not be as homogeneous as previously expected and differences may depend on the metier of each stakeholder or on the vessel size, as in the case of dragger skippers on the Gulf of St. Lawrence [50]. Similarly some of the stakeholders that were previously termed Environmental stakeholders in the Intuitive categorisation appear to either have interests in the Employment and Profit objectives that were not expected (also found in [35]) or have such low interest strength values in the Ecosystem Preservation objectives that they do not deserve the title of Environmental stakeholders.

Respondents had greater confidence in attributing high importance to topics in the Yield and Ecosystem Preservation objectives than in the Employment and Profit objectives (3.3). The concept of requirements for these objectives could be more widely understood or more easily defined than for the Employment and Profit objectives. It could be influenced by the scope of each objective. Yield and Ecosystem Preservation could be seen as broad objectives encompassing a multitude of issues whereas Employment and Profit have a more selective window of interest.

The low interest strengths of cluster 5 cannot easily be explained. Despite the overall low interest in each of the four objectives, the topics of Fishing Effort and Bycatch and Discards received the highest level of interest across the nine stakeholders in this cluster. This suggests these stakeholders have an interest in the main variable of fisheries management as well as current controversial topics and further studies may reveal why. As the EAFM attempts to be more holistic, both in terms of ecological concepts and stakeholder involvement, the inclusion of these low interest stakeholders is advised. In the past conflicts of interests have occurred between fishing activities and other users of marine resources [51]. Involving a variety of marine resource stakeholders in management systems could help resolve conflicts more effectively than if only a few selected stakeholders were included.

This study did not assess the power and influence of each stakeholder as it was not considered an important factor for communicating information i.e. the neutral and objective position was taken that a stakeholder's access to the information guiding management processes is independent of their social power. Stakeholder analyses outside of fisheries management advise that stakeholders with low interest strengths but high power and influence status should not be excluded from any management system [27,52]. The high power and influence status provides such stakeholders with the resources to disrupt management plans they do not approve of.

As stakeholders gain more understanding and awareness of different issues their interests should also change and, at a later date, may include interests not considered here [53]. To accommodate such evolutions in interests, stakeholder analysis must be a continuous process and reflect the versatile nature of fisheries management. As one issue is resolved another may appear or some issues, such as environmental ones, appear cyclically with environmental fluctuations. The stakeholder clusters and management topics are variables for the Evidence-Based categorisation and can be changed depending on the fishery, ecosystem, management system and other relevant criteria. The stakeholder categories shown here are by no means final and it is expected that the cluster compositions, the variety of topics and the cluster names will vary over time.

Requests for making scientific advice more accessible to stakeholders and creating management tools have already been put forward by stakeholders, like the North Western Waters Regional Advisory Council [54]. Creating such management tools has proven difficult, partly due to treatment of stakeholders as a homogeneous audience. There is an opportunity to contextualise information to the interests of different stakeholder groups and a need for a *Common Language* to facilitate communication and interactions between science and other stakeholders [10,55]. Now that functional stakeholder clusters can be identified from a stakeholder collective, information from ecological models can be customised to match cluster interests. Clusters 2 and 4, the anthropocentric specialists, could be provided with indicators relating specifically to Profit and Employment whereas clusters 3 and 6, the ecocentric specialists, could be provided with indicators relating specifically to Yield and Environment. While clusters 1 and 5 do not have dominant interests in a particular objective, indicators could still be customised for these clusters by identifying which topics were of most interest. In connecting the relevant indicators to stakeholders' interests the uncertainty and assumptions associated with the indicators must be neither overemphasised nor diluted but presented in an unbiased format [56].

There will always be a degree of subjectivity associated with stakeholder analysis due to the characteristics of the research individuals. However, this does not mean that research involving stakeholders is exempt from structured data collection and analysis. This study has highlighted the pitfalls of relying on Intuitive stakeholder categorisation methods and has proposed a more structured method of quantitatively analysing stakeholders' interests using literature-based evidence. While not without limitations the Evidence-Based categorisation can lead to a coherent and homogeneous stakeholder categorisation, which minimises assumptions about stakeholder interests. Management systems can benefit from more reliable assessments of stakeholder interests as it would (i) avoid incorrect categorisation of stakeholders, (ii) prevent important stakeholder issues from being neglected, (iii) identify issues that may previously have been unnoticed and (iv) facilitate the creation of functional stakeholder clusters. Addressing items (i) and (ii) reduces stakeholder opposition to management plans and addressing (iii) and (iv) will assist in the creation of a more inclusive and transparent management system. An accurate and objective assessment of each stakeholders' interests is essential for designing interfaces to models so as to maximise communications.

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## Tables:

Table 1. Stakeholders and IDs

| ID | Stakeholder | ID | Stakeholder |
|---|---|---|---|
| 1 | Marine Scotland | 46 | University Marine Biological Station Millport |
| 2 | Marine Stewardship Council | 47 | National Committee for Marine Fisheries and Aquaculture (Comite National des Peches Maritimes et des Elevages Marins) |
| 3 | Marine Management Organisation, UK | 48 | Balanced Seas |
| 4 | Marine Institute, Ireland | 49 | North Atlantic Fisheries Centre Marine Centre |
| 5 | Marine Strategy Framework Directive | 50 | Dept. for the Environment, Food and Rural Affairs, UK |
| 6 | Centre for the Environment, Fisheries and Aquaculture Services, UK | 51 | Dept. of Agriculture and Rural Development, N. Ireland |
| 7 | Greenpeace | 52 | International Council for the Exploration of the Sea |
| 8 | Marinet – Friends of the Earth | 53 | North East Atlantic Fisheries Commission |
| 9 | Ifremer, France | 54 | Sea Mammal Research Unit, Scotland |
| 10 | North Western Waters Regional Advisory Council | 55 | Joint Nature Conservation Committee |
| 11 | Scottish Pelagic Fishermen's Association | 56 | Seas at Risk |
| 12 | Cornish Fish Producers Organisation | 57 | Irish Sea Conservation Zone |
| 13 | Irish Fish Producers Organisation | 58 | Europeche |
| 14 | European Association of Fish Producers Organisation | 59 | Natural England, UK |
| 15 | Pelagic Regional Advisory Council | 60 | The Crown Estate, UK |
| 16 | Bord Iascaigh Mhara, Ireland | 61 | Dept. of Agriculture, Food and the Marine, Ireland |
| 17 | Celtic Sea Herring Management Advisory Committee | 62 | North Sea Regional Advisory Council |
| 18 | Bycatch Reduction Consortium | 63 | STECF |
| 19 | Coastal Marine Research Centre | 64 | Profet Policy |
| 20 | Partnerships Involving Stakeholders in the Celtic Sea Ecosystem | 65 | World Wide Fund |
| 21 | Marine Conservation Society, UK | 66 | Shark Trust UK |
| 22 | National Federation of Fishermen's Organisations, UK | 67 | Oil and Gas UK |
| 23 | Irish Whale and Dolphin Group, Ireland | 68 | French Fisheries Department (Ministere de l'Agriculture, de l'Agroalimenraire et de la Foret) |
| 24 | SeaWeb | 69 | FAO Fisheries |
| 25 | Scottish Association for Marine Science | 70 | Spanish Fisheries Department (Ministerio de Agricultura, Alimentacion y Medio Ambiente) |
| 26 | Ocean 2012 | 71 | Agri-Food and Biosciences Institute |
| 27 | Future of the Atlantic Marine Environment | 72 | Natural Environment Research Agency |
| 28 | French MPA Agency (Agence des Aires Marines Protégés) | 73 | Bloom Association |
| 29 | Hugh's Fish Fight | 74 | European Commission: Fisheries Directorate General |
| 30 | Oceana Europe | 75 | Responsible Irish Fish |
| 31 | The Black Fish | 76 | Long Distance Fleet Regional Advisory Council |
| 32 | Ocean Conservancy | 77 | New Under 10 Fishermen's Association |
| 33 | EyeOverFishing | 78 | Plymouth Marine Laboratory |
| 34 | SeaFish | 79 | Scottish Fishermen's Organisation |
| 35 | Baltic Sea Regional Advisory Council | 80 | Shetland's Fishermen's Association |
| 36 | Scottish Fishermen's Federation | 81 | NetGain |
| 37 | Finding Sanctuary | 82 | Norwegian Ministry for Fisheries |
| 38 | Royal Society for the Protection of Birds | 83 | Dept. Oceanography and Fisheries, University Azores |
| 39 | British Marine Aggregates Producers Organisation | 84 | Institute for Marine Research, Norway |
| 40 | North Atlantic Salmon Conservation Organisation | 85 | Scottish White Fish Producers Organisation |
| 41 | European Anglers Association | 86 | MarineBio Conservation Society |
| 42 | Irish and South West Fish Producers Organisation | 87 | Birdlife International |
| 43 | Killybegs Fish Producers Organisation | 88 | Deep Sea Conservation Coalition |
| 44 | Irish and South East Fish Producers Organisation | 89 | The Fisheries Secreteriat |
| 45 | Anglo North Irish Fish Producers Organisation | 90 | Scottish Pelagic Sustainability Group |

Table 2. The list of topics and their IDs.

| Topic ID | Topic Name | Topic ID | Topic Name |
|---|---|---|---|
| 1 | Length of Catches | 15 | Fishing Effort |
| 2 | Reproductive Capacity | 16 | Water Quality |
| 3 | Biodiversity | 17 | Production Costs |
| 4 | Trophic Structure | 18 | Fuel Costs |
| 5 | Trophic Interactions | 19 | Subsidies |
| 6 | Predator-Prey Relationships | 20 | Shellfish/Crustaceans |
| 7 | Vulnerable Species | 21 | Forage Fish |
| 8 | Phytoplankton Abundance | 22 | Large Predatory Fish |
| 9 | Energy Flow Rate | 23 | Restricted Areas |
| 10 | Marine Mammals | 24 | Gear Selectivity |
| 11 | Seabirds | 25 | Bycatch and Discards |
| 12 | Commercial Species Status | 26 | Processing Sector |
| 13 | Habitat Protection | 27 | Vessel Crew Numbers |
| 14 | Eutrophication | | |

Table 3. The average distance between (italics) and within (bold) Evidence-Based clusters and the Intuitive clusters.

| Evidence-Based | | | | | | | Intuitive Categorisation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | Env. | Res. | Man. | F. Ind. | Misc. |
| 1 | **0.187** | | | | | | Env. | **0.285** | | | | |
| 2 | *0.343* | **0.163** | | | | | Res. | *0.335* | **0.309** | | | |
| 3 | *0.411* | *0.403* | **0.165** | | | | Man. | *0.390* | *0.455* | **0.347** | | |
| 4 | *0.500* | *0.313* | *0.377* | **0.125** | | | F. Ind. | *0.407* | *0.477* | *0.331* | **0.221** | |
| 5 | *0.642* | *0.578* | *0.405* | *0.308* | **0.120** | | Misc. | *0.277* | *0.300* | *0.423* | *0.464* | **0.186** |
| 6 | *0.558* | *0.519* | *0.266* | *0.308* | *0.228* | **0.114** | | | | | | |

Table 4. The allocation of stakeholders to the Intuitive and Evidence-Based clusters. Stakeholder IDs as in Table 4. IDs in bold indicate the stakeholder was placed in more than one cluster.

| Intuitive Clusters | | | | | Evidence-Based Clusters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Env. | Res. | Mgmt. | Fish. Ind. | Misc. | Clus. 1 | Clus. 2 | Clus. 3 | Clus. 4 | Clus. 5 | Clus. 6 |
| 2 | 4 | 1 | 11 | **5** | 1 | 12 | 3 | 10 | 19 | 9 |
| 7 | 6 | 3 | 12 | **17** | 2 | 13 | 5 | 15 | 31 | 18 |
| 8 | 9 | **5** | 13 | 20 | 4 | 14 | 6 | 16 | 38 | 21 |
| 18 | 19 | 10 | 14 | **37** | 11 | 17 | 7 | 51 | 39 | 23 |
| 21 | 25 | 15 | 16 | 39 | 26 | 22 | 8 | 80 | 49 | 24 |
| 23 | **27** | **17** | 22 | 41 | 33 | 35 | 20 | | 54 | 25 |
| 24 | 46 | 28 | 34 | 64 | 34 | 42 | 30 | | 60 | 27 |
| 26 | 49 | 35 | 36 | 67 | 36 | 43 | 32 | | 66 | 28 |
| **27** | 52 | 50 | 42 | 81 | 47 | 44 | 46 | | 72 | 29 |
| 29 | 54 | 51 | 43 | | 62 | 45 | 50 | | | 37 |
| 30 | 63 | 53 | 44 | | 69 | 56 | 52 | | | 40 |
| 31 | 71 | 60 | 45 | | 71 | 58 | 53 | | | 41 |
| 32 | 72 | 61 | 47 | | 82 | 61 | 59 | | | 48 |
| 33 | 78 | 62 | 58 | | 85 | 63 | 64 | | | 55 |
| **37** | 83 | 68 | 75 | | 89 | 68 | 65 | | | 57 |
| 38 | 84 | 69 | 77 | | 90 | 74 | 70 | | | 67 |
| 40 | | 70 | 79 | | | 75 | 83 | | | 73 |
| 48 | | 74 | 80 | | | 76 | 84 | | | 78 |
| 55 | | 76 | 85 | | | 77 | 86 | | | 81 |
| 56 | | 82 | 90 | | | 79 | 87 | | | |
| 57 | | **89** | | | | 88 | | | | |
| 59 | | | | | | | | | | |
| 65 | | | | | | | | | | |
| 66 | | | | | | | | | | |
| 73 | | | | | | | | | | |
| 86 | | | | | | | | | | |
| 87 | | | | | | | | | | |
| 88 | | | | | | | | | | |
| **89** | | | | | | | | | | |

Table 5. Topics for each objective that received a combined rating of high and medium from majority respondents.

| Yield | | Employment | | Profit | | Ecosystem Preservation | |
|---|---|---|---|---|---|---|---|
| ID | Topic | ID | Topic | ID | Topic | ID | Topic |
| 1 | Length of Catches | 12 | Commercial Species Status | 1 | Length of Catches | 1 | Length of Catches |
| 2 | Reproductive Capacity | 15 | Fishing Effort | 12 | Commercial Species Status | 2 | Reproductive Capacity |
| 3 | Biodiversity | 16 | Water Quality | 13 | Habitat Protection | 3 | Biodiversity |
| 4 | Trophic Structure | 17 | Production Costs | 15 | Fishing Effort | 4 | Trophic Structure |
| 5 | Trophic Interactions | 18 | Fuel Costs | 17 | Production Costs | 5 | Trophic Interactions |
| 6 | Predator-Prey Relationship | 19 | Subsidies | 18 | Fuel Costs | 6 | Predator-Prey Relationship |
| 8 | Phytoplankton Abundance | 20 | Shellfish/Crustaceans | 19 | Subsidies | 7 | Vulnerable Species |
| 9 | Energy Flow Rate | 21 | Forage Fish | 20 | Shellfish/Crustaceans | 8 | Phytoplankton Abundance |
| 12 | Commercial Species Status | 22 | Large Predatory Fish | 21 | Forage Fish | 9 | Energy Flow Rate |
| 13 | Habitat Protection | 26 | Processing Sector | 22 | Large Predatory Fish | 10 | Marine Mammals |
| 14 | Eutrophication | 27 | Vessel Crew Number | 25 | Discards and Bycatch | 11 | Seabirds |
| 15 | Fishing Effort | | | 26 | Processing Sector | 13 | Habitat Protection |
| 16 | Water Quality | | | 27 | Vessel Crew Number | 14 | Eutrophication |
| 18 | Fuel Costs | | | | | 16 | Water Quality |
| 20 | Shellfish/Crustaceans | | | | | 22 | Large Predatory Fish |
| 21 | Forage Fish | | | | | 23 | Restricted Area |
| 22 | Large Predatory Fish | | | | | 24 | Gear Selectivity |
| 23 | Restricted Area | | | | | 25 | Bycatch and Discards |
| 24 | Gear Selectivity | | | | | | |
| 25 | Bycatch and Discards | | | | | | |

Table 6. The mean interest strengths per objective per Evidence-Based Cluster

| | Yield | Employment | Profit | Ecosystem Preservation |
|---|---|---|---|---|
| Cluster 1 | 0.730 | 0.663 | 0.713 | 0.663 |
| Cluster 2 | 0.497 | 0.657 | 0.690 | 0.336 |
| Cluster 3 | 0.538 | 0.290 | 0.350 | 0.561 |
| Cluster 4 | 0.275 | 0.420 | 0.400 | 0.200 |
| Cluster 5 | 0.188 | 0.122 | 0.122 | 0.210 |
| Cluster 6 | 0.339 | 0.179 | 0.184 | 0.389 |

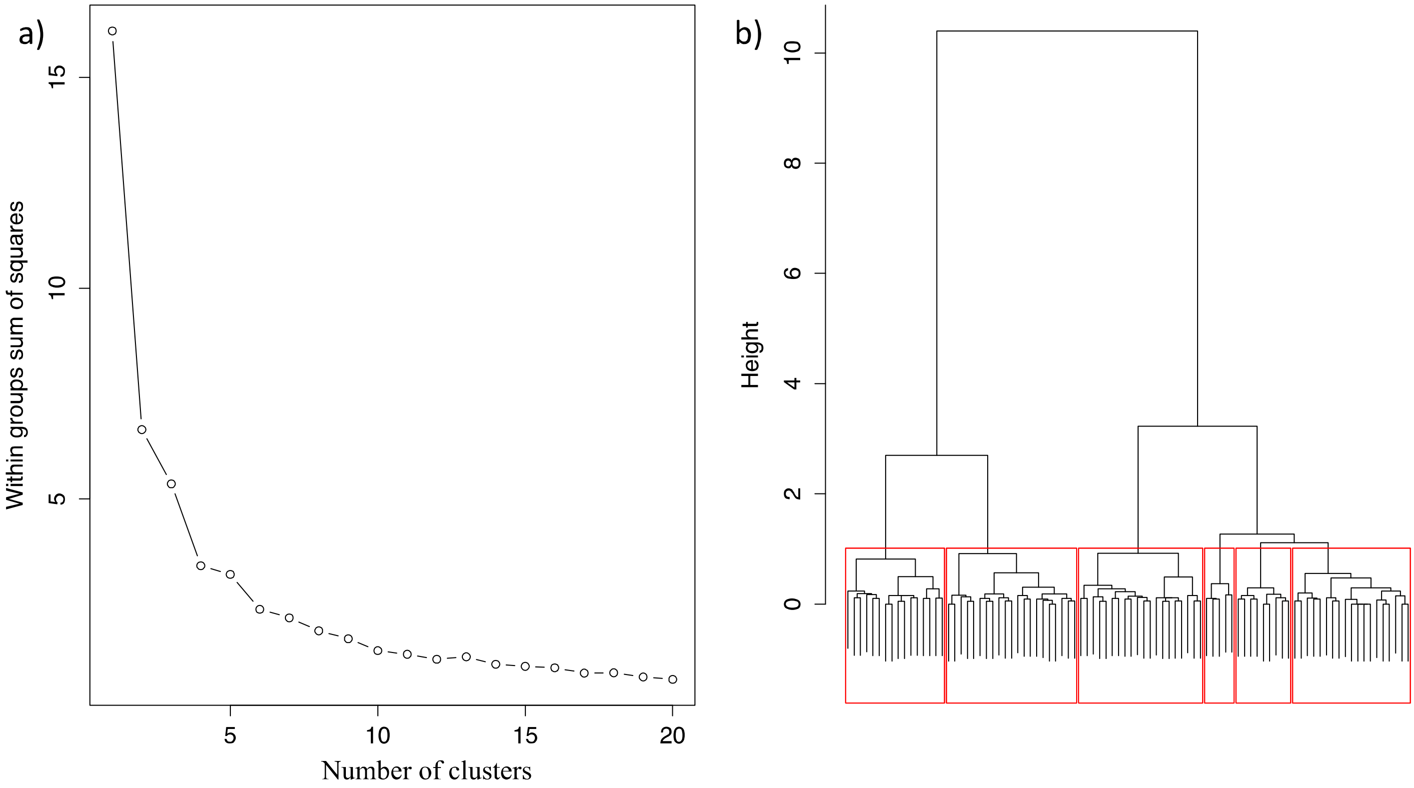
Table 7. The topics for which >80% of the stakeholders in each cluster had an interest in.

| Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | Cluster 5 | Cluster 6 |
|---|---|---|---|---|---|
| Reproductive Capacity | Status Commercial Species | Reproductive Capacity | Status Commercial Species | None >80% | Fishing Effort |
| Status of Commercial Species | Fishing Effort | Status Commercial Species | Fishing Effort | | Biodiversity |
| Habitat protection | Fuel Costs | Habitat Protection | Vessel Crew Number | | Vulnerable Species |
| Fishing Effort | Gear Selectivity | Fishing Effort | | | |
| Large Predatory Fish | Bycatch and Discards | Restricted Areas | | | |
| Gear Selectivity | Vessel Crew Number | Gear Selectivity | | | |
| Bycatch and Discards | | Bycatch and Discards | | | |
| Vessel crew Number | | Biodiversity | | | |
| Biodiversity | | | | | |
| Vulnerable Species | | | | | |
| Marine Mammals | | | | | |

Table 8. Similarity Indices for each combination of Intuitive and Evidence-Based categorisation. Evidence-Based clusters 1-6 down the horizontal and Intuitive groups across the vertical.

| | Env | Res | Man | F. Ind | Misc |
|---|---|---|---|---|---|
| 1 | 0.138 | 0.125 | 0.238 | 0.3 | 0 |
| 2 | 0.069 | 0.0625 | 0.286 | 0.6 | 0.111 |
| 3 | 0.276 | 0.3125 | 0.238 | 0 | 0.333 |
| 4 | 0 | 0 | 0.143 | 0.1 | 0 |
| 5 | 0.103 | 0.25 | 0.047 | 0 | 0.111 |
| 6 | 0.414 | 0.25 | 0.047 | 0 | 0.444 |

Figures:


a)
Within groups sum of squares
15
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Number of clusters
b)
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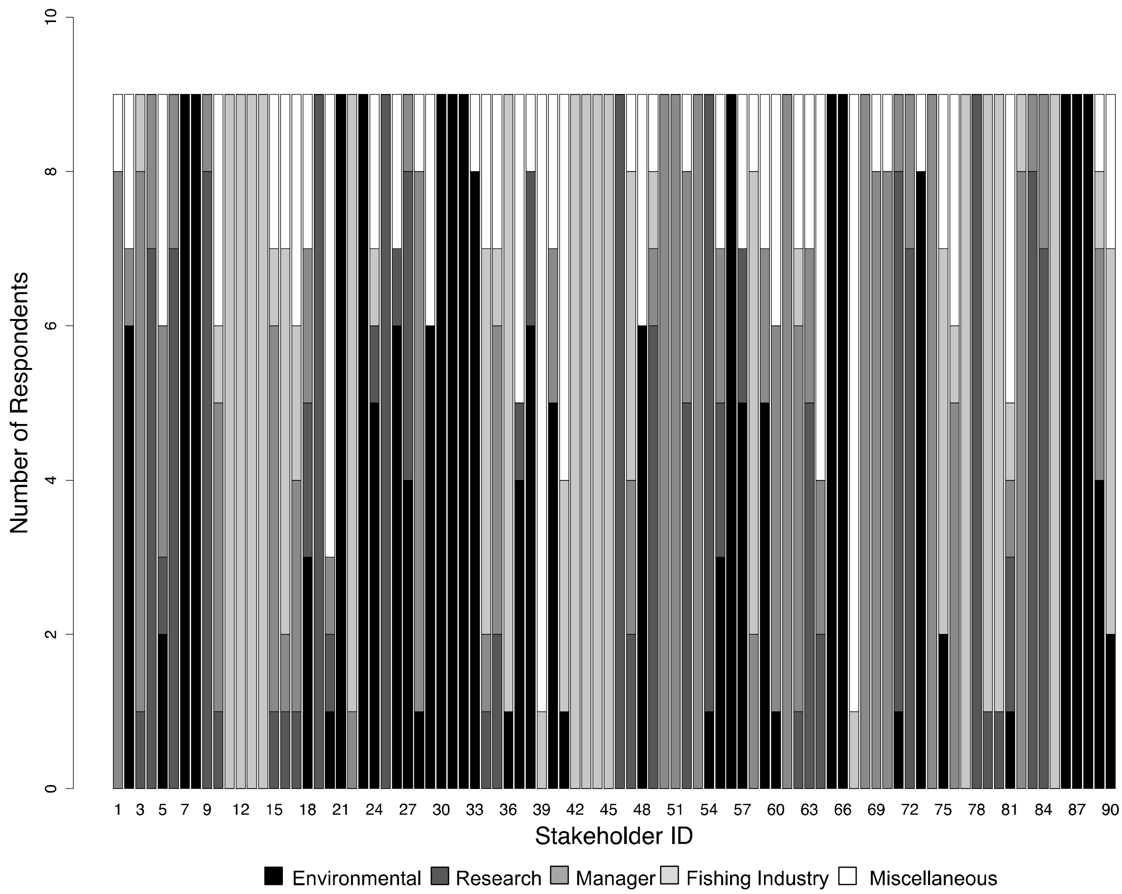



Figure 2. Stacked bar plot of the number of times each stakeholder was assigned to one of the five groups by respondents.

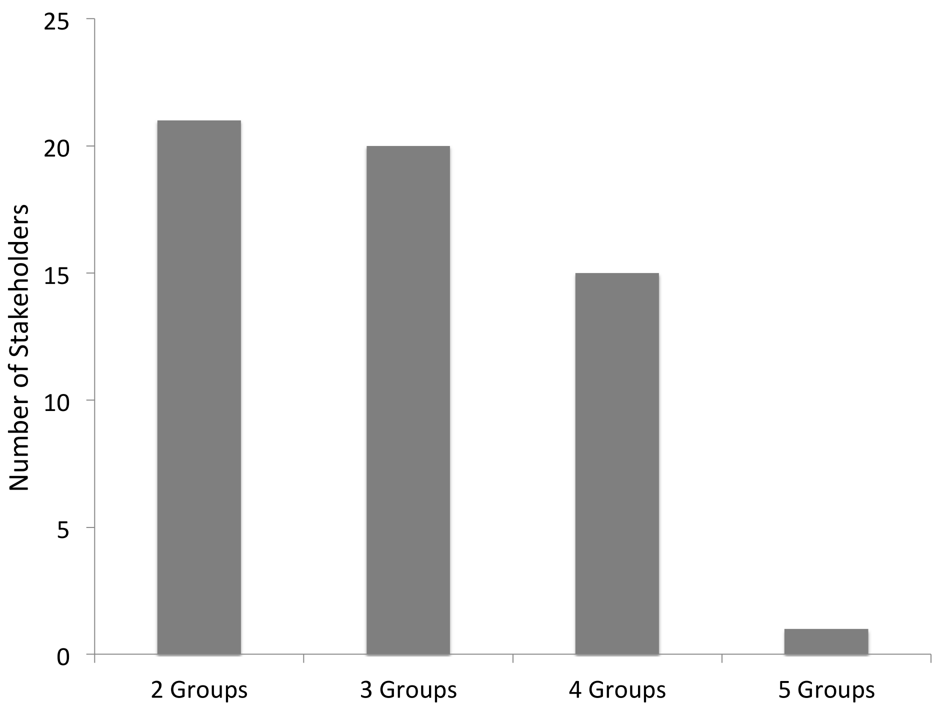
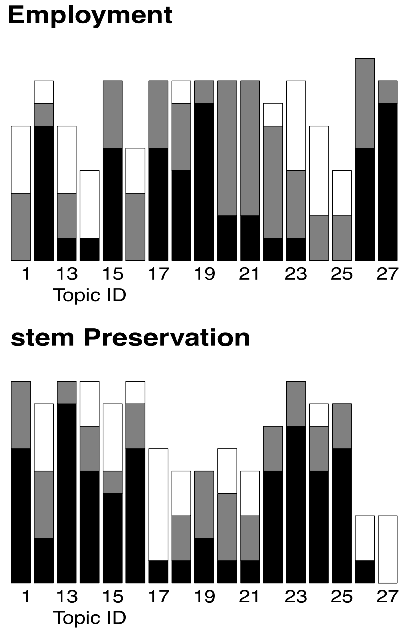



Figure 3. The distribution of the number of stakeholders the respondents placed in two, three, four and five groups respectively.



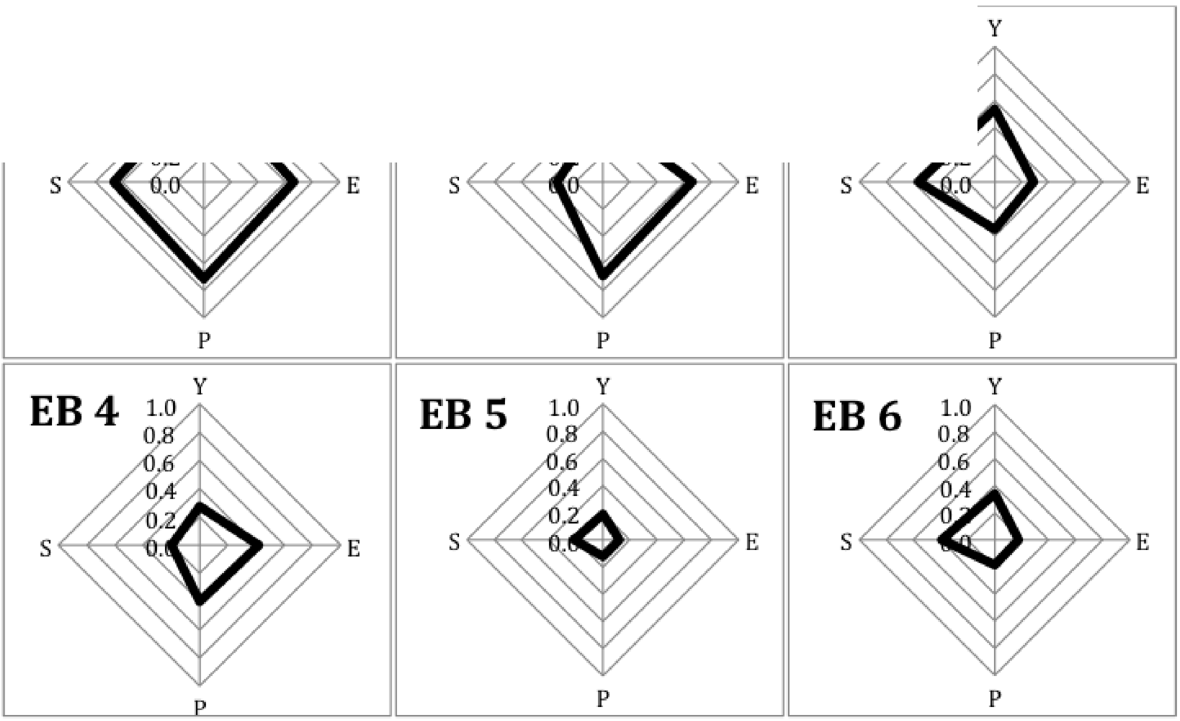




Figure 5. Radar plots for each of the six Evidence-Based (EB) clusters 1-6 with the mean interest strength per objective. Yield – Y, Employment – E, Profit – P and Ecosystem Preservation – S.

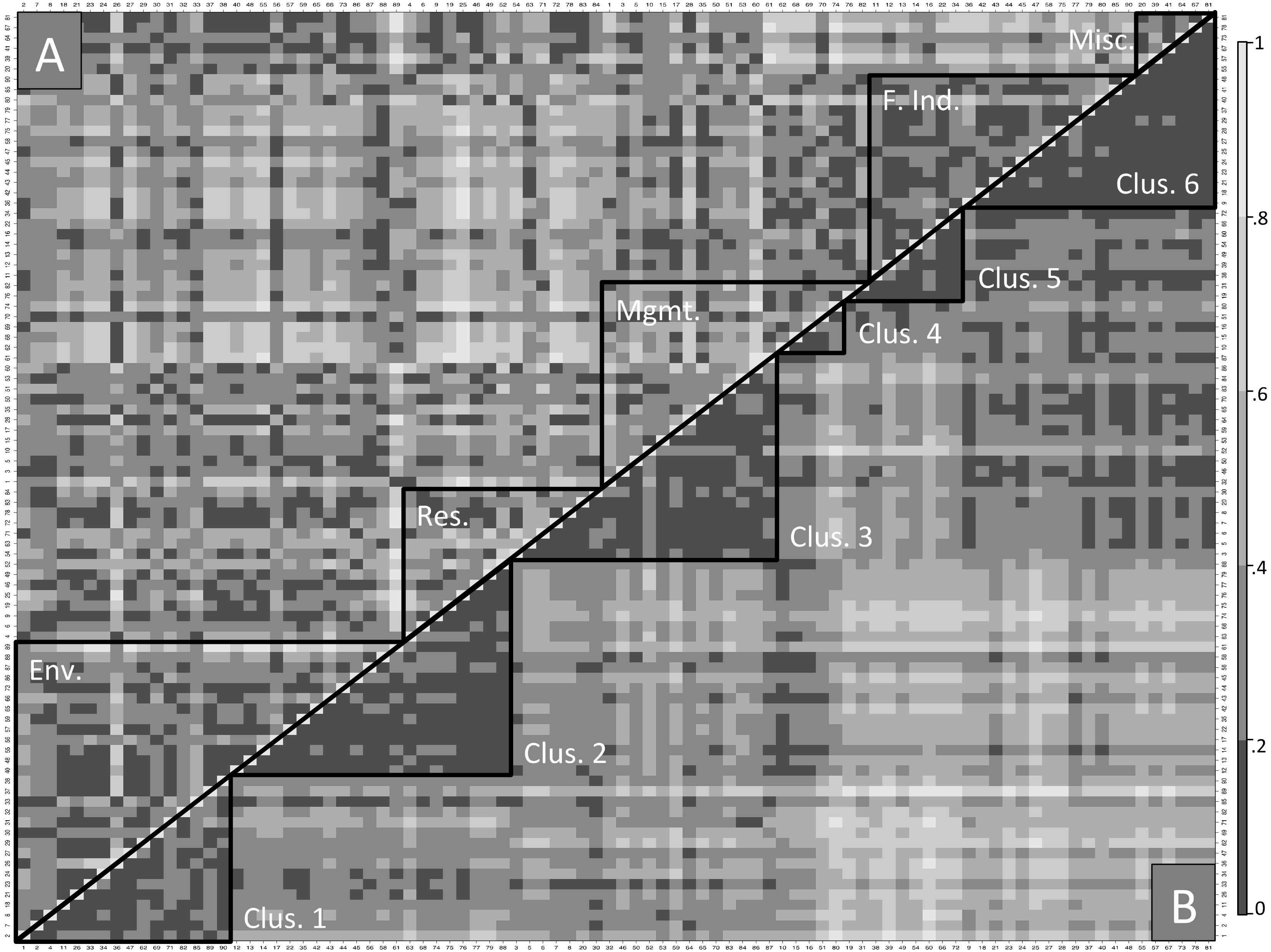



Figure 6.Heat map representation of the stakeholder-interest distance matrix showing the distances between each stakeholder with shading. Stakeholder IDs on the axes are not in ascending numerical order but represent the stakeholder IDs within each group The upper triangle (A) shows the intuitive distance matrix, whilst the lower (B) gives the evidence-based result. Outlined triangles in both halves outline the Intuitive and Evidence-Based clusters respectively.