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# Stakeholder perspectives on ecosystem-based management of the Antarctic krill fishery

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ABSTRACT

Information about stakeholder aspirations is a fundamental requirement for ecosystem-based management, but the detail is often elusive, and debates may focus on simplistic opposing positions. This is exemplified by the Antarctic krill fishery, which, despite a current operational catch limit equivalent to just 1% of the estimated biomass and actual annual catches much lower than this, is the subject of a high-profile debate framed around ambiguous concepts such as sustainability. Q methodology was applied to explore the detailed views of representatives of three stakeholder sectors (the fishing industry, conservation-focused non-governmental organisations (NGOs), and scientists from seven countries involved in research on the krill-based ecosystem). The analysis distinguished two clear groupings, one of which included the views of all NGO participants while the other included the views of fishing industry participants and a subset of the scientists. Key differences between the groups included the priority given to different management measures, and to continued commercial fishing. However, the results also revealed considerable overlap between viewpoints. Both groups prioritised the maintenance of ecosystem health and recognised the importance of defining management objectives. Also, neither group prioritised a decrease in catch limits. This suggests that most participants in the study agree that management should improve but do not perceive a major problem in the ecosystem's ability to support current catch levels. Cooperation to identify shared management objectives based on stakeholder aspirations for the ecosystem might enhance progress, whereas polarised discussions about preferred management measures or ambiguous concepts are likely to impede progress.



## 1. Introduction

Ecosystem-based management (EBM) is an integrated approach that aims to manage natural resources and biodiversity by maintaining ecosystem processes, functions and services [1,2]. Despite widespread support for this approach and progress in some areas, full implementation of EBM for marine systems has yet to be achieved [3]. In attempting to balance the aspirations that different stakeholders (defined here as individuals and groups with an interest in the management of a resource [4]) have for ecosystems, the approach requires the engagement of diverse interest groups to determine what they desire from the ecosystem and the ecosystem states likely to provide this [5–7]. Yet bringing together this range of frequently conflicting viewpoints often introduces tension which may impede the development of EBM [8–10]. Dialogue amongst diverse stakeholders should be encouraged and there are cases where friction has helped to catalyse new research and improve understanding that has successfully guided management [11]. However debates can become reduced to discussions framed around ambiguous or poorly-defined concepts such as sustainability and overfishing [12,13]. Such debates, when characterised by simplistic opposing positions, provide little detail about stakeholder aspirations.

The fishery for Antarctic krill (*Euphausia superba*) in the Scotia Sea and Antarctic Peninsula region (Fig. 1) illustrates this problem. Ninety per cent of the total krill catch in the Southern Ocean has been taken from this region, and since 1997 it has been the only area in which harvesting has occurred [14]. For brevity this fishery's target species is hereafter referred to as krill and its location as the Scotia Sea. Krill are a major food source for many fish, birds and mammals in the Scotia Sea and have been harvested by a commercial fishery since the 1970s. In the 2013/14 season twelve vessels from five nations took part in the fishery and caught approximately 312,000 t of krill, the highest reported catch since 1991 [15].

The fishery is managed by the Commission for the Conservation of Antarctic Living Resources (CCAMLR), an intergovernmental

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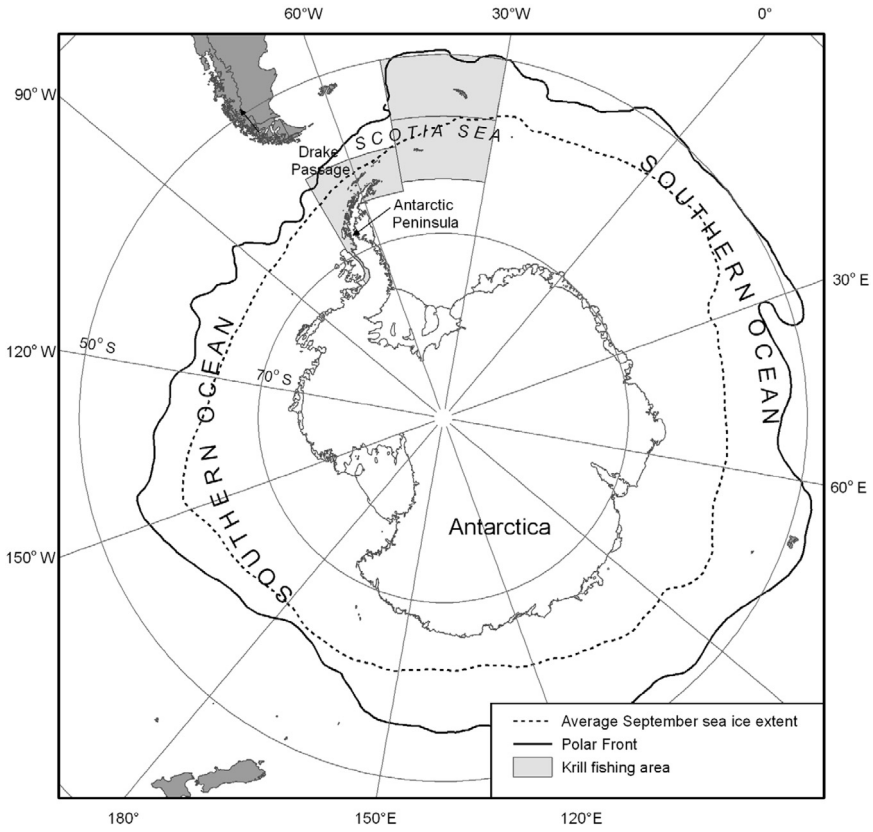


**Fig. 1.** The Southern Ocean showing the krill fishing area in the Scotia Sea and Antarctic Peninsula region. The Polar Front is the ecological boundary of the Southern Ocean.

organisation established in 1982 in response to concern about the impacts of increased krill fishing on the ecosystem [16]. CCAMLR follows “principles of conservation” which map on to those of EBM, allowing “rational use” while aiming to maintain ecosystem productivity, health and resilience [17,18]. Various authors have described CCAMLR as a pioneer of the ecosystem approach to fisheries management [e.g. 16,19], a term whose definition overlaps with that of EBM [20]. Despite progress in many areas, CCAMLR has not yet defined operational objectives for managing the ecosystem impact of the krill fishery and currently uses interim management measures [19,21,22]. These include a low operational catch limit or "trigger level" for krill. The nominal catch limit for the whole of the Scotia Sea is 5.6 million tonnes but the fishery currently cannot exceed the trigger level of 620,000 t which is equivalent to just 1% of the estimated biomass [23]. CCAMLR has also implemented measures intended to reduce competition between the fishery and krill predators including the subdivision of the catch limit across four large subareas, and the establishment of a Marine Protected Area (MPA) on the South Orkney shelf [24,25]. The Scientific Committee which advises CCAMLR is continuing to develop management methods for the fishery, including a “feedback management approach” (FBM) which “will use decision rules to adjust selected activities (distribution and level of krill catch and/or research) in response to the state of monitored indicators” [26]. Although this has not been further defined in practical terms, the ambition to develop FBM is effectively an ambition to further develop EBM.

The Southern Ocean does not border any permanently inhabited landmasses and its ecosystem services therefore have few local beneficiaries; however services such as climate regulation and nutrient cycling are globally important, and its iconic wildlife has a significant public profile [18]. Stakeholders in the krill fishery include direct beneficiaries such as the fishing industry's employees, suppliers and customers, as well as the beneficiaries of other ecosystem services that could be impacted by the fishery [18]. National governments represent the interests of stakeholders through their membership of CCAMLR; members currently include 24 States and the European Union, all of whom must agree to decisions by consensus. Stakeholders may also engage with CCAMLR through special interest groups who are observers to its meetings (but do not participate in decision-making), including the Association of Responsible Krill harvesting companies (ARK), and the Antarctic and Southern Ocean Coalition (ASOC) which represents over 30 conservation-focused non-governmental organisations (NGOs).

CCAMLR's management of the krill fishery follows the principles of EBM, and the CCAMLR process allows stakeholders to present their opinions. Nonetheless representations of the krill fishery in both the popular media and academic literature imply considerable controversy. One point of view suggests that the fishery is well managed e.g. accreditation from two certification bodies; [27,28] and that CCAMLR is an effective Regional Fishery Body [29,30]. The opposing point of view suggests that management is not sufficiently precautionary [31], and that catches are not sustainable [32] or constitute overfishing [33]. Thus the debate appears to be polarised over whether or not management is effective, but it lacks clarity about the meaning of central phrases such as “sustainable” or the specifics of what stakeholders want to achieve [23].

Improved understanding about the aspirations of those who benefit from the Southern Ocean and might be affected by management decisions would be valuable for the further development of krill fishery management. The analysis presented here begins the work of exploring stakeholder aspirations for a fished Southern Ocean ecosystem more than three decades after CCAMLR's original Members agreed their principles of conservation.

The aims of the study were to characterise the diversity of stakeholder opinions on the krill fishery and aspirations for the Scotia Sea ecosystem, and to use these opinions to examine in more detail the apparent controversy surrounding the fishery. Q methodology provides insight into the detailed composition of viewpoints and has applications in health and political science and, increasingly, conservation and environmental research [e.g. 34–38]. It identifies groups of issues that characterise the shared viewpoint of many individuals, and areas where opinions converge and diverge. The method was used to assess the opinions held by representatives of three key stakeholder groups in the management of the krill fishery, namely: the science, conservation-focused non-governmental organisations (hereafter referred to as NGOs), and fishing industry sectors. Rather than focus on terms such as "sustainable" versus "unsustainable", a wide range of issues were explored that are of potential importance to these groups. These issues included the states of specific parts of the ecosystem, management approaches, potential threats, and public perceptions.

## 2. Methods

Q methodology combines qualitative and quantitative methods in the study of subjective values and beliefs [39]. The method is suitable for studies with small numbers of participants, and involves (i) data collection whereby each participant ranks a set of statements (a "Q set") according to how important they consider each statement relative to the other statements, resulting in a "Q sort" (or ranking) which forms a model of their viewpoint on the issue under study, and (ii) the comparison of the rankings using factor analysis to identify shared priorities and viewpoints [40].

The statements, pre-prepared by the authors, were designed to cover a range of potential priorities for stakeholders with an interest in the krill fishery and associated ecosystem in the Scotia Sea region (Table 1). Informed by both author experience and published information from a wide range of relevant sources (the academic and technical literature and popular media), each of the 34 statements [37] framed a single issue and included a standard ending: "…is important for achieving my objectives and

**Table 1**
The 34 Q statements with the columns on the right displaying the "ideal" ranking and z-scores.

| | Statements[a] | Factor 1 | | Factor 2 | |
|---|---|---|---|---|---|
| | | Rank | z-Score | Rank | z-Score |
| 1[x] | Continued commercial fishing of Antarctic marine living resources | −4 | −2.048 | 0 | 0.295 |
| 2[x] | Non-fishing commercial use of Antarctic marine living resources (e.g. eco tourism) | −1 | −0.620 | −3 | −1.514 |
| 3[x] | The state of the Antarctic krill stock | 4 | 1.592 | 4 | 2.305 |
| 4[o] | The states of all fished populations (including krill, toothfish and mackerel icefish) | 1 | 0.645 | 2 | 0.740 |
| 5[o] | The states of species that have previously been depleted by sealing, whaling and fishing | 0 | 0.204 | 2 | 0.680 |
| 6[o] | The states of a limited number of Antarctic krill predators (such as penguin species) | 0 | 0.467 | −1 | 0.040 |
| 7[x] | The states of all species with a demonstrated dependency on krill (e.g. all predators that feed mainly on krill) | 3 | 1.271 | 1 | 0.526 |
| 8[o] | The overall state of the regional ecosystem | 3 | 1.136 | 2 | 0.842 |
| 9[o] | Minimising the risk of irreversible ecosystem change | 3 | 1.283 | 2 | 0.811 |
| 10[o] | Managing fishing to minimise its effects on Antarctic krill and other species that might be killed or injured as a direct result of fishing [b] | 1 | 0.645 | 0 | 0.192 |
| 11 | Managing fishing to minimise its indirect effects on the ecosystem [c] | 2 | 0.899 | 1 | 0.364 |
| 12[o] | More research into how fishing affects the ecosystem | 1 | 0.750 | 1 | 0.529 |
| 13[x] | Managing the potential for invasion by alien species | −1 | −0.522 | −4 | −2.138 |
| 14[x] | More research into the potential for invasion by alien species | −2 | −0.777 | −4 | −1.981 |
| 15[o] | Managing the effects of environmental change | 1 | 0.506 | 0 | 0.141 |
| 16 | More research into the effects of environmental change | 2 | 0.953 | 1 | 0.337 |
| 17[x] | Marine protected areas | 4 | 1.381 | −2 | −1.208 |
| 18 | More research into the effectiveness of marine protected areas | 0 | −0.210 | −2 | −0.821 |
| 19[x] | The profitability of the krill fishery | −3 | −1.458 | 0 | 0.204 |
| 20[o] | Stability of catch limits so that they do not change excessively between years | −1 | −0.615 | −1 | −0.235 |
| 21[x] | Ensuring that the fishery can continue to access traditional krill fishing grounds | −3 | −1.699 | 0 | 0.200 |
| 22[o] | Consumer perceptions of the fishery and its products | −1 | −0.589 | −1 | −0.442 |
| 23[o] | Public perceptions of the state of the ecosystem | 0 | −0.341 | −1 | −0.151 |
| 24[x] | The use of krill fishery products (whether they are used to produce food for people, meal for aquaculture and farming, health supplements, or other products) | −2 | −0.817 | 0 | 0.205 |
| 25[o] | Clearly defined objectives for managing the krill fishery (e.g. clear descriptions of the undesirable states to avoid, or the desirable states to aim for) | 2 | 0.944 | 3 | 1.165 |
| 26[x] | Increasing current catch limits | −4 | −1.872 | −2 | −0.944 |
| 27[o] | Decreasing current catch limits | −2 | −0.889 | −3 | −1.306 |
| 28[o] | Further development of feedback management[d] | 2 | 0.944 | 4 | 1.288 |
| 29[o] | Measures to minimise illegal, unregulated and unreported fishing of Antarctic krill | −1 | −0.349 | −2 | −0.791 |
| 30[o] | More self-regulation by the krill fishing industry | −3 | −1.099 | −3 | −1.377 |
| 31[o] | Independent assessment of the "sustainability" of the Antarctic krill fishery (e.g. Marine Stewardship Council certification) | −2 | −0.746 | −1 | −0.594 |
| 32[x] | Increased cooperation between stakeholder sectors (such as industry, scientists, and conservation organisations) | 0 | 0.391 | 3 | 1.051 |
| 33[o] | Strengthening coordination between CCAMLR[e] and the organisations that provide scientific research into the Southern Ocean and the effects of fishing | 1 | 0.517 | 1 | 0.484 |
| 34[x] | Financial or in-kind support from the fishery for science or management | 0 | 0.165 | 3 | 1.101 |

[a] Note that each statement also included a standard ending (not shown in this table): "is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery."
[b] E.g. other animals that might be caught in krill nets.
[c] E.g. potential reductions in populations of krill predators as a result of removing some of their prey.
[d] As defined by [e]CCAMLR's working group on Ecosystem Monitoring & Management as "using decision rules to adjust selected activities (distribution and level of krill catch and/or research) in response to the state of monitored indicators."
[e] Commission for the Conservation of Antarctic Living Resources.
[o] Indicates an agreement ("consensus") statement, defined as not statistically distinguishable between the two factors at $p > 0.05$.
[x] Indicates a distinguishing statement, defined as statistically distinguishable between the two factors at $p < 0.01$.

aspirations for the krill-based ecosystem and fishery." Colleagues with knowledge about the krill fishery and ecosystem but who did not take part in the study checked the statements to ensure they were clear, balanced and broadly representative of the subject matter.

The data were collected during a two day stakeholder workshop. Structured dialogue and a series of linked exercises led by an independent facilitator explored different stakeholder perspectives on the krill-based ecosystem and identified constructive ways for the sectors to work together [41]. A wide range of potential participants were invited, including representatives of every current krill fishing company and scientists from all CCAMLR Member states that have an active interest in krill fishery management. However not all those invited were able to attend, and the resulting 22 workshop participants comprised four krill fishing industry representatives (three of whom were from companies affiliated to ARK); representatives from seven NGOs; and eleven scientists from nine science organisations. Ten of the scientists are either current or past participants in the Working Group on Ecosystem Monitoring and Management (WG-EMM), CCAMLR's main advisory body on krill fishery issues. The participants were therefore a self-selecting subset of a wider group of representatives but formed a diverse and relevant stakeholder sample. Q Methodology is designed for use with small sample sizes and focuses on the understanding of how opinions are shared by people rather than with their prevalence in a population [37]. Although we recognise that this study forms a partial view of the wider spectrum, the results nevertheless provide a valid insight into the views that would likely also be present in a wider group. The analysis of these views is an important step in considering the range of opinions and how to incorporate them into decision-making.

Participants completed their ranking of the statements during the early stages of the workshop before any sharing of knowledge and opinions occurred. Participants each had a printed grid (Fig. 2.) and the statements on numbered cards that were colour-coded by sector. Participants ranked the statements according to their views of the relative importance of the issues described, from those they considered least important ($-4$) to those they considered most important ($+4$), giving their own views rather than those of their organisations. The design of the grid followed an approximately normal distribution because most people are likely to have strong opinions on a relatively small number of statements [42,43]. Participants were asked to supply and rank additional statements if they identified any issues as being absent.

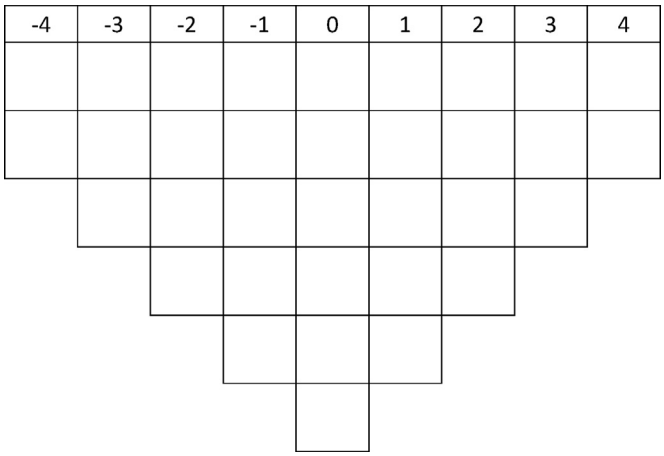


**Fig. 2.** Design of the Q grid, ranging from $-4$ representing least important to $+4$ representing most important.

The results of the ranking exercise were correlated using the dedicated computer package PQMethod [44]. A factor analysis was used to determine the patterns and groupings of responses, incorporating Varimax rotation to help eliminate noise [42,43]. The "Q sorts" or rankings that load significantly on a particular factor do so because they exhibit a very similar sorting pattern suggesting they represent similar viewpoints [37]. The rankings can also be non-significant (i.e. not load significantly onto any factors) or confounded (i.e. load significantly onto more than one factor). An "ideal" ranking for each factor was generated from a weighted average. The ideal ranking includes all the statements that were significant in defining the factor, and the score of these statements (from $-4$ to $+4$) (Table 1), allowing comparison and interpretation of each factor.

To facilitate cross-factor comparisons the total weighted scores were converted into z (standard or normalised factor) scores. These show which statements are "consensus statements" (defined in Q Methodology as not statistically distinguishable between the two factors at $p > 0.05$) and "distinguishing statements" (defined in Q Methodology as statistically distinguishable between the two factors at $p < 0.01$). For those that are neither consensus nor distinguishing, cross-factor comparison is not possible. To avoid potential confusion between consensus as defined by Q Methodology and consensus-based decision making within CCAMLR, we hereafter refer to "consensus statements" as "agreement statements."

## 3. Results

To determine the most appropriate number of factors on which to base the analysis, the results of two, three and four factors were compared [42]. The two factor solution was selected because only these two factors met Brown's criteria (i.e. for a factor to be interpretable its Eigenvalue must be greater than 1 and it must have at least two Q sorts that load significantly upon it alone) [42] and the inclusion of additional factors captured little further variation in viewpoints. These two factors explained 54% of the study variance and fifteen of the 22 Q sorts or rankings loaded significantly ($p < 0.01$) onto one of the two factors, indicating two distinct viewpoints. Six were confounded between the two factors (i.e. they loaded significantly on both), while one was not significant for either (and hence does not exemplify either factor). Ideal rankings were produced for each factor (Table 1).

### 3.1. Areas of agreement

The results demonstrate a relatively high level of agreement between the participants, with 18 of the 34 statements identified as "agreement statements" (Table 2). These indicate that participants' views tended to be shared on issues broadly concerned with the state or health of the ecosystem and management of the fishery. Some of both the highest and lowest ranked statements for both factors were agreement statements (Table 1). Those statements of high relative importance include the overall state of the regional ecosystem (Statement 8), minimising the risk of irreversible ecosystem change (9), further development of feedback management (28) and clearly defined objectives for managing the krill fishery (25). Those statements of low relative importance include more self-regulation by the krill fishing industry (30) and decreasing current catch limits (27). Agreement statements around the midpoint of the distribution indicated that participants did not attach either a high or low priority to public perceptions of the state of the ecosystem, (23) the states of a limited number of krill predators (such as penguin species), (6) or managing the effects of environmental change (15).

**Table 2**
Subset of the statements showing the ideal ranking for the agreement ("consensus") statements only (i.e. those not statistically distinguishable between factors at $p > 0.05$).

| | Statements[a] | Rank | |
|---|---|---|---|
| | | Factor 1 | Factor 2 |
| 28 | Further development of feedback management[b] | 2 | 4 |
| 8 | The overall state of the regional ecosystem | 3 | 2 |
| 9 | Minimising the risk of irreversible ecosystem change | 3 | 2 |
| 25 | Clearly defined objectives for managing the krill fishery (e.g. clear descriptions of the undesirable states to avoid, or the desirable states to aim for) | 2 | 3 |
| 4 | The states of all fished populations (including krill, toothfish and mackerel icefish) | 1 | 2 |
| 12 | More research into how fishing affects the ecosystem | 1 | 1 |
| 33 | Strengthening coordination between CCAMLR[c] and the organisations that provide scientific research into the Southern Ocean and the effects of fishing | 1 | 1 |
| 5 | The states of species that have previously been depleted by sealing, whaling and fishing | 0 | 2 |
| 10 | Managing fishing to minimise its effects on Antarctic krill and other species that might be killed or injured as a direct result of fishing [d] | 1 | 0 |
| 15 | Managing the effects of environmental change | 1 | 0 |
| 6 | The states of a limited number of Antarctic krill predators (such as penguin species) | 0 | −1 |
| 23 | Public perceptions of the state of the ecosystem | 0 | −1 |
| 20 | Stability of catch limits so that they do not change excessively between years | −1 | −1 |
| 22 | Consumer perceptions of the fishery and its products | −1 | −1 |
| 29 | Measures to minimise illegal, unregulated and unreported fishing of Antarctic krill | −1 | −2 |
| 31 | Independent assessment of the "sustainability" of the Antarctic krill fishery (e.g. Marine Stewardship Council certification) | −2 | −1 |
| 27 | Decreasing current catch limits | −2 | −3 |
| 30 | More self-regulation by the krill fishing industry | −3 | −3 |

[a] Note that each statement also included a standard ending (not shown in this table): "is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery."
[b] As defined by CCAMLR's working group on Ecosystem Monitoring & Management as "using decision rules to adjust selected activities (distribution and level of krill catch and/or research) in response to the state of monitored indicators."
[c] Commission for the Conservation of Antarctic Living Resources.
[d] E.g. other animals that might be caught in krill nets.

Thirteen of the 34 statements were "distinguishing statements" (Table 1) indicating where participants' views diverge, for example on issues surrounding the operation of the commercial fishery. The statement on MPAs (17) was the most contentious (based on difference in z-scores) followed by continued commercial fishing of Antarctic marine living resources (1). Other distinguishing statements include ensuring that the fishery can continue to access traditional fishing grounds (21) and the profitability of the krill fishery (19).

### 3.2. Factor interpretation

Despite the considerable agreement, Factor One is clearly distinguished from Factor Two. The ranking of the statements is considered in the ideal ranking (Table 1) with the aim of understanding the viewpoint that each factor captures. Due to the high level of agreement between the factors there is inevitable overlap, with some of the statements being important in defining both factors.

#### 3.2.1. Factor One

The seven participants significantly associated with this factor all came from the NGO sector. For Factor One continued commercial fishing of Antarctic marine living resources (Statement 1, ideal-type rank −4) and increasing current catch limits (26, −4) are of very low importance for achieving objectives and aspirations for the krill-based ecosystem and fishery. Of almost as low importance are the profitability of the krill fishery (19, −3), ensuring that the fishery can continue to access traditional krill fishing grounds (21, −3), more self-regulation by the industry (30, −3), decreasing current catch limits (27, −2) and the use of krill fishery products (24, −2). Thus Factor One places low importance on the operation of the commercial fishery. Conversely, the state of the Antarctic krill stock (3, 4) and MPAs (17, 4) are very important, as are the states of all species with a demonstrated dependency on krill (7, 3), the overall state of the regional ecosystem (8, 3) and minimising the risk of irreversible ecosystem change (9, 3). Statements such as the importance of financial or in-kind support from the fishery for science or management (34, 0), more research into the effectiveness of MPAs (18, 0), the states of species previously depleted by sealing, whaling and fishing (5, 0), the states of a limited number of krill predators (6, 0) and public perceptions on the state of the ecosystem (23, 0) had neither strong high or low priority for Factor One.

Factor One thus places greatest importance on MPAs and the state of the krill stock, together with krill dependent species and the overall regional ecosystem; and low importance on the continuing operation and development of the krill fishery in the region.

#### 3.2.2. Factor Two

Eight participants were significantly associated with this factor; all from the science and industry sectors (five and three participants respectively). The main characteristic that distinguishes Factor Two from Factor One is the high priority afforded to the statements concerned with improving the management of the fishery. The state of the Antarctic krill stock (3, 4) and development of feedback management (28, 4) ranked highest, followed by the need for clearly defined objectives for managing the krill fishery (25, 3), increased cooperation between stakeholder sectors (32, 3) and support from the fishing industry for science or management (34, 3), followed by statements including the states of species other than krill (4, 2; 5, 2), the state of the regional ecosystem (8, 2) and minimising the risk of irreversible ecosystem change (9, 2). Statements assigned neither strong high or strong low priority include the profitability of the fishery (19, 0) and the use of krill-fishery products (24, 0). Those of low importance included issues concerning alien species (13, −4 and 14, −4), decreasing current catch limits (27, −3), non-fishing commercial use of Antarctic marine living resources (e.g. eco tourism) (2, −3). Increasing current catch limits was also of fairly low importance (26, −2).

Thus Factor Two is mainly concerned with improving the management of the fishery, and with the state of the krill stock and the wider ecosystem.

### 3.3. Additional Q sorts and statements

Of the rankings not included in the two factors described above, six were confounded, all of which were from scientists, while the single non-significant sort was from an industry representative.

Half of the participants (eight scientists, one participant from the fishing industry, and two from NGOs) submitted an additional statement (Appendix S1) that they considered to be important but absent from the original set of statement. These did not identify any areas outside the scope of the original statements. The majority were concerned with technical details about how CCAMLR could implement EBM. Others reflected existing statements but included more detail about aspects such as involving the industry in data collection (relating to Statement 34) and incorporating climate change into management (relating to Statement 15).

## 4. Discussion

Information on stakeholder perspectives is a critical requirement for EBM [5,45]. Although the krill fishery is the subject of an ongoing debate, very little information is available about stakeholder aspirations. This analysis provides insight into the detailed views of a diverse and relevant sample of stakeholders, showing that although opinions differ, there is far greater common purpose than the debate implies. Nonetheless, two distinct groupings of opinion emerged, one of which summarises the viewpoints of all participating NGO representatives, and the other summarises the viewpoints of a group of fishing company representatives and scientists.

CCAMLR's principles of conservation, like those of EBM, attempt to balance the benefits that people obtain from using ecological resources against the health of the ecosystem [17,18]. Both groupings that emerged from this analysis agreed on the importance of ecosystem health, expressed in various terms, including the overall state of the regional ecosystem, the states of previously depleted populations and of all fished populations, and minimising the risk of irreversible ecosystem change. They also agreed on the need to improve management of the fishery, including the importance of clearly defined management objectives. Nonetheless, there was also agreement that decreasing current catch limits is not a priority, suggesting that most participants do not perceive a major problem in the ecosystem's ability to support current catch levels.

The issues that distinguished the two groupings revealed differences in attitudes to the operation of the commercial fishery and aspirations for future management measures. Factor One identified continued commercial fishing, profitability and access to traditional fishing grounds as being amongst the least important issues. This is consistent with its composition (conservation-focused NGOs). Each group prioritised a specific management method (MPAs for Factor One and feedback management for Factor Two). However neither group identified research into these management measures as being important.

MPAs and feedback management are potential precautionary measures, which contribute to limiting the probability of unacceptable events occurring in uncertain circumstances [46]. Uncertainty is a major issue in marine EBM [47,48]. It is also an important issue in the management of the krill fishery [22,49] and was reflected in the group of participants, who had a wide range of perceptions about the current state of the ecosystem [41]. Because it is often difficult to assess the state of marine ecosystems it is also difficult to identify how they will respond to particular pressures or management interventions [50,51]. Such uncertainty demands precautionary measures [46]. However, the apparent confidence in specific management approaches contrasts with the high degree of uncertainty.

The debate over the krill fishery is often phrased in terms of ambiguous concepts such as “sustainability”, which can mean different things to different people [33,52] and provides little information about the nature of the issue or ways to resolve it. This analysis found little evidence of a major or highly polarised controversy. Rather, it suggests that a diverse group of stakeholders share concerns about the future management of the krill fishery. Nonetheless, different sectors have different preferred methods for managing the fishery. As with a focus on ambiguous terms, a preference for specific methods is potentially divisive; indeed MPAs have been the subject of highly polarised discussions between CCAMLR Members [53,54]. Acknowledging the potential for disagreement over the preferred means to achieve shared aspirations (including improved management) might help members and stakeholders in the krill fishery to solve or avoid these disagreements, and to focus separately on other approaches where progress might be more straightforward.

## 5. Conclusions

EBM is a complex enterprise which aims to balance the diverse aspirations of many stakeholders and the importance of accounting for social dimensions in managing marine systems is growing in prominence [2,55]. By contrast, communicators often need to present simple messages in the popular media and the academic press [56–58]. Simplistic opposing positions dominate public debate on the krill fishery and many other fisheries issues [11,59,60]. However, this analysis found that a diverse group of stakeholders held complex but broadly complementary positions. Information about these detailed positions allows stakeholders to identify shared goals and important issues for negotiation. This provides a stronger basis for developing practical management solutions than debate around polarised positions.

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## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.marpol.2016.03.006.

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