Bridging the Krill Divide: Understanding Cross-Sector Objectives for Krill Fishing and Conservation

Report of an ICED-BAS-WWF workshop on

UNDERSTANDING THE OBJECTIVES FOR KRILL FISHING AND CONSERVATION IN THE SCOTIA SEA AND ANTARCTIC PENINSULA REGION

held at WWF's Living Planet Centre, Woking, UK on 9th & 10th June 2014

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British Antarctic Survey
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ICED
Integrating Climate and Ecosystem Dynamics in the Southern Ocean

SUMMARY

In June 2014, the ICED programme, the British Antarctic Survey and WWF co-hosted a two day workshop entitled "Understanding the objectives for krill fishing and conservation in the Scotia Sea and Antarctic Peninsula region" which involved participants from the science, conservation, and fishing industry sectors. The workshop used structured dialogue, led by an independent facilitator, to explore each sector's objectives and information requirements for the krill-based ecosystem and to identify constructive ways for the three sectors to work together. The issue of krill fishing has previously provoked passionate debate but participants in this workshop showed broad cross-sector accord. This included shared commitment to maintaining a healthy ecosystem and support for management of the krill fishery that minimises the risk of negative impacts on ecosystem health. Participants generally agreed that current levels of fishing have a low risk of significant impacts but that there is no need to increase catch limits. Participants also agreed that the objectives of management must include a healthy krill stock and a healthy ecosystem. However, they were not able to define ecosystem states that are desirable or healthy. This reflects the gaps in the currently available information and the indirect nature of the links between the krill-based ecosystem and human well being. The workshop produced a range of recommendations including the need to articulate a clear research and development strategy to support progress in the management of the krill fishery, and to improve communication between the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and its stakeholders. The workshop also revealed a cooperative and productive relationship between the various sectors. Further cross-sector work could progress some key tasks such as identifying priority information requirements and assessing the potential future demand for krill catch.

Image: Icebergs seen from Foka Hut, Signy Island (Jessica Royles, British Antarctic Survey)

INTRODUCTION

Antarctic krill are abundant crustaceans that grow up to about 6 cm in length and are found only in the Southern Ocean. They occupy many different habitats: under sea ice, abyssal depths and the surface waters of the open ocean, but the highest concentrations occur near the shallow shelves that surround the islands of the Scotia Sea and the west Antarctic Peninsula (Figure 1). They are a major food source for many fish, birds and mammals. They are also harvested by a commercial fishery which has operated since the 1970s.

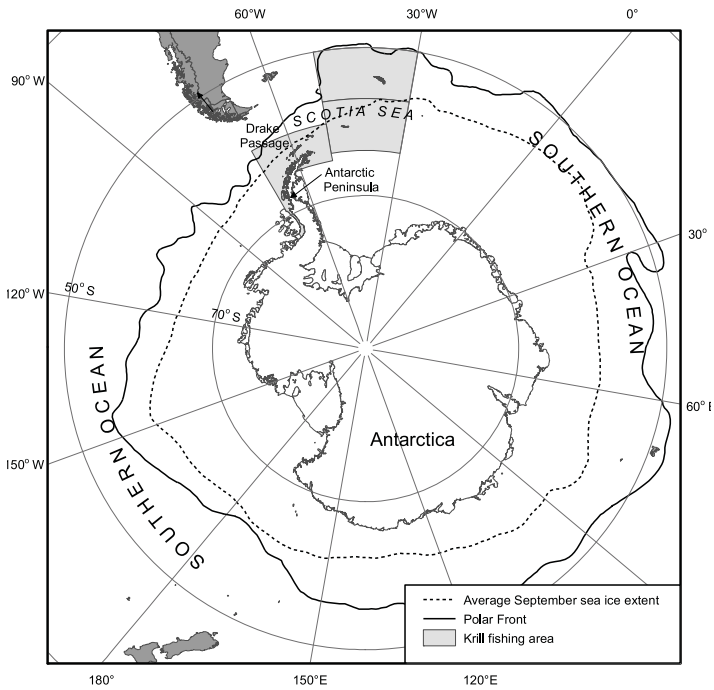

Figure 1. The Southern Ocean and the krill fishing area in the Scotia Sea and Antarctic Peninsula region. The Polar Front is recognised as an ecological boundary of the Southern Ocean.

(Figure prepared by Janet Silk, British Antarctic Survey)

The Antarctic krill fishery is managed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), an intergovernmental organisation established in 1982 (see Figure 2 for information about the organisational structure of CCAMLR). CCAMLR follows a set of principles which require it to manage the impacts of fishing on both the krill stock and the wider ecosystem. To date, each annual catch has been a small fraction (<2%) of the estimated biomass in the area open to fishing. Consequently, CCAMLR has been able to set a low catch limit (known as the "trigger level") for the Scotia Sea and Antarctic Peninsula region and there has never been any pressure from the fishing industry to increase this limit. The current estimate of the krill biomass in this region is 60.3×10^6 tonnes while the catch limit is 6.2×10^5 tonnes (1% of biomass) and annual catches are about 2.1×10^5 tonnes (0.3% of biomass). Nonetheless, CCAMLR recognises that concentration of catches in sensitive locations, such as those used by foraging krill predators, could cause undesirable impacts, so it has also imposed local catch limits for four subareas of the area open to fishing.

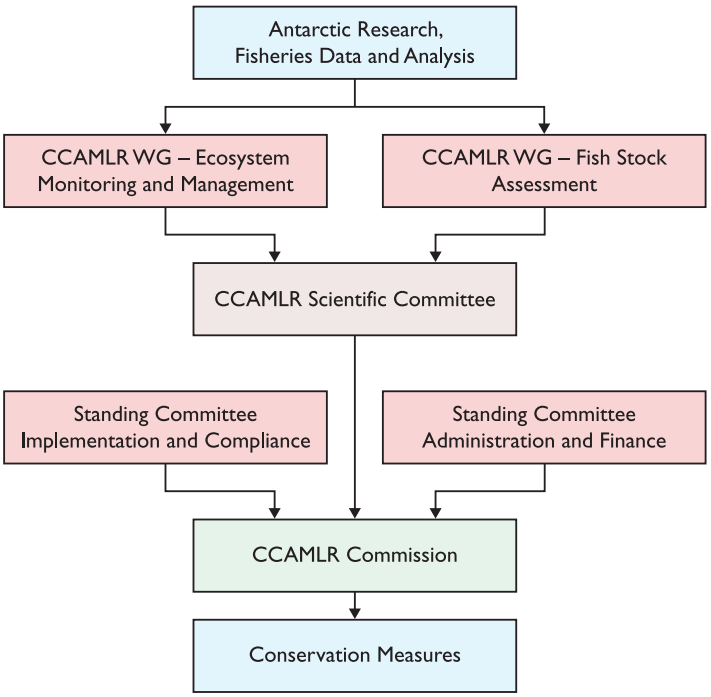

Figure 2. Organisational structure of CCAMLR. The working groups (WGs) and committees (red) advise the Commission (green), a decision-making body which can agree regulations known as Conservation Measures.

(Figure courtesy of Keith Reid, CCAMLR Secretariat)

The Southern Ocean is an important global resource. It plays a major role in absorbing carbon dioxide and

its distinctive wildlife is highly valued by many people, most of whom will never see it in its natural habitat. Some also regard the Southern Ocean, especially the Antarctic krill stock, as a largely untapped source of marine protein and essential fatty acids that could play an important role in global food security. Thus the whole of mankind benefits from the Southern Ocean ecosystem, but these benefits are usually indirect and the beneficiaries do not necessarily perceive their importance.

The task of CCAMLR is to balance the potential demand for higher krill catches with the need to maintain the health and integrity of the wider ecosystem. Consequently, the Scientific Committee which advises CCAMLR is continuing to develop methods that could be used to enhance the management of the fishery. Such enhanced management could allow increases in the catch limit if it also includes appropriate measures to protect the rest of the ecosystem.

The need to balance krill catch with ecosystem health implies a need for information. Scientific research will address some of these information requirements, but the opinions of those who benefit from the Southern Ocean and might be affected by management decisions are also important. It is not feasible to identify the opinions of all beneficiaries, but it is possible to identify stakeholders who are directly concerned with Southern Ocean issues. These stakeholders come from various sectors including, amongst others, the krill fishing industry, conservation-focused non-governmental organisations (hereafter referred to as NGOs) (many of whom represent civil society), and science organisations working on Southern Ocean ecology and management.

In June 2014, the Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) programme, the British Antarctic Survey (BAS) and WWF co-hosted a two day workshop entitled "Understanding the objectives for krill fishing and conservation in the Scotia Sea and Antarctic Peninsula region". The workshop was held at WWF's Living Planet Centre in Woking UK and its objective was to bring together representatives of the krill fishing industry, conservation NGOs and science organisations to:

- identify each sector's objectives and information requirements for the krill-based ecosystem in the Scotia Sea and Antarctic Peninsula region
- explore and agree constructive ways for the three sectors to work together to ensure the responsible management of Antarctic krill
- develop recommendations to help guide CCAMLR in the development of its management approach for the krill fishery

These objectives were addressed through structured dialogue, led by an independent, professional facilitator. This report summarises the methods and outputs of the workshop and makes recommendations for improved knowledge sharing and future progress towards long-term sustainable management of the Antarctic krill fishery.

PARTICIPANTS

The workshop involved participants from three sectors which the organisers identified as stakeholders in the management of the Antarctic krill fishery (Appendix I). These participants included four krill fishing industry representatives, three of whom were from companies affiliated to the Association of Responsible Krill harvesting companies (ARK); representatives from seven NGOs; and eleven scientists from nine science organisations. Ten of the scientists are current or past participants in the Working Group on Ecosystem Monitoring and Management (WG-EMM), CCAMLR's main advisory body on krill fishery issues. One of the scientists participated via video link. There are many other interested sectors which it was not possible to accommodate at the workshop (e.g. the national governments that are Members of CCAMLR).

TERMINOLOGY

The glossary in Appendix II provides definitions of key technical terms mentioned in this report. It is important to recognise that some terms (such as "rational use") do not have consensus meanings and that some terms may be used interchangeably to describe a particular concept. This report presents the viewpoints expressed by a diverse set of participants, who did not generally provide definitions of technical phrases that they used (e.g. the various terms used to describe enhanced management in Step 1). The report aims to give an accurate account of workshop discussions. Consequently text generated during the workshop (which appears in tables and appendices) is presented with minimal editing and some of the technical phrases used by participants have not been defined.

METHODS

The two-day workshop was organised into a series of ten linked steps, each consisting of one or more structured exercises (Figure 3). Each exercise involved facilitated dialogue in small groups or in plenary sessions. Participants represented three sectors (science, industry and NGOs). Some exercises were undertaken in sector groups (i.e. groups composed entirely of participants from the same sector), while participants were divided into cross-sector groups (i.e. groups composed of participants from all three sectors) for others. The outputs from each step fed directly into subsequent steps with the aim of building knowledge and developing priorities throughout the process.

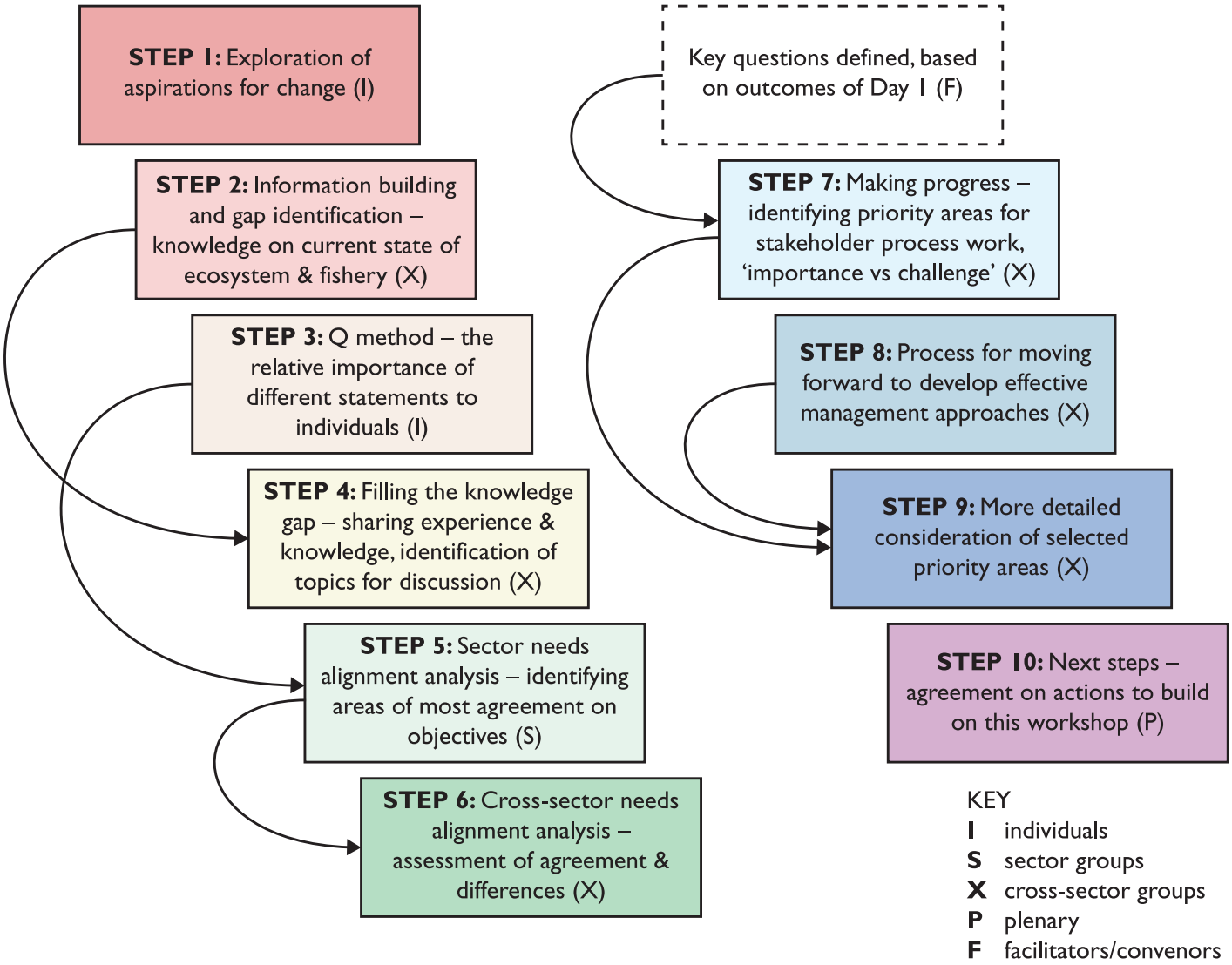

Figure 3. Flowchart illustrating the workshop structure. The exercises in each step informed those in subsequent steps. Arrows indicate where materials generated in one step were used as the starting point for a later step. Different types of exercise were undertaken by different groups of participants (see key).

STEP 1: Exploration of aspirations for change

The aims of the first step or "ice-breaker" were to start the participants thinking about the things that are most important to them regarding krill fishing and conservation in the Scotia Sea and Antarctic Peninsula region; to allow them to make personal connections with most other participants; and to provide instant visual feedback of participants' aspirations and how complementary the various aspirations are to each other.

Each participant was given a piece of card (colour-coded by sector) on which to briefly write a key aspiration for change. They were asked to meet as many other participants as they could within 15 minutes, and to exchange aspirations with them. Each exchange was to take no more than two minutes, and participants were asked to meet people with different coloured cards to ensure that aspirations were shared across, as well as within, sectors. After each exchange, participants recorded on their card whether their aspiration had been complementary or conflicting with that of the other person. At the end of the exercise, all cards were fixed to a wall chart to display the total "complimentary" and "conflicting" scores for each aspiration.

STEP 2: Information building and gap identification

The aim of the second step was to assess the state of participants' knowledge about key relevant issues, and to assess their degree of confidence in this information. The exercise also provided an opportunity for participants to contribute or request additional information on specific topics.

A series of posters were set up around the room, showing questions about key relevant issues (Table 1) with multiple-choice options for responses. Participants toured the question posters, indicating their responses by placing coloured stickers in the relevant option boxes. The stickers were colour-coded by sector, giving an anonymous but sector-specific indication of the level of knowledge on each topic. Options for questions about the state of the ecosystem allowed participants to rate their level of confidence, and the options for a question about potential threats allowed participants to rate the perceived severity of each potential threat.

After indicating their individual responses, participants returned to small cross-sector groups to analyse the outcomes, highlighting areas where there was high or low agreement and confidence, both across and within sectors.

Table 1. Questions used in Step 2 - Information building and gap identification

	Statement	Answers	Confidence level/threat
1.	The krill stock in the Scotia Sea and Southern Drake Passage is:	Healthy, depleted, or over-abundant Increasing or declining More or less abundant than 50 years ago	Low Medium High
2.	The total abundance of penguins is:		
3.	The total abundance of whales is:		
4.	The total abundance of seals is:		
5.	The total abundance of fish is:		
6.	Krill catches are:		
7.	Assessment of the threats to the ecosystem in the next 50 years:	• Legal fishing • Illegal, unregulated & unreported fishing • Invasive species • Climate change • Pollution • Shipping • Tourism • Other human activity in the study area • Other human activity elsewhere	Not a threat Low Medium High
8.	The current krill management system defines objectives for:	• The minimum acceptable abundance of krill • The long term average biomass of krill that balances fishing and ecosystem health • The minimum acceptable abundance of krill predators • The long term average abundance of krill predators that balances fishing and ecosystem health • The profitability of the fishery • The optimal catch of the fishery	
9.	Which of the following measures are currently used to manage the krill fishery?	• Catch limits for the whole fishing area • Catch limits for subareas • Catch limits for smaller areas • Marine protected areas • Seasonal closures • Gear restrictions • Vessel quotas	
10.	The CCAMLR Convention states that Conservation includes "rational use" of Antarctic Marine Living Resources. What do you understand by the term "rational use"?	• Any fishing • Well managed fishing • Any direct use which removes living resources from the ecosystem • Any direct or indirect use of living resources (e.g. including wildlife watching) • There is no consensus on the meaning of "rational use"	

continued ▷

Table 1. Questions used in Step 2 - Information building and gap identification			
Statement		**Answers**	**Confidence level/threat**
11.	In order to manage the current fishery properly we need more information on:	• Incidental krill mortality • Bycatch • Fishing operations • The spatial structure of the ecosystem (e.g. krill distribution, predator foraging ranges) • Krill abundance • The abundance of predators that eat krill • The abundance of other species (e.g. the phytoplankton that krill eat) • Sustainable catch levels • The effects of climate change • Invasive species • The best location for Marine Protected Areas • Actual amounts of krill caught • Ecological relationships (e.g. what predators eat and how predator populations change in response to changes in prey populations) • Stakeholder objectives	

STEP 3: Q method[1] – the relative importance of different statements to individuals

The aim of the third step was to gather robust data on participants' priorities for krill fishing and conservation in the Scotia Sea and Antarctic Peninsula region. These data will be analysed and published separately in a complementary academic paper. The data were also used as the basis for within-sector and cross-sector discussions about priority areas (Steps 5 and 6) in the workshop.

The exercise used the Q method which requires individual participants to arrange a series of statements on a grid (i.e. to complete a Q sort) to indicate their views of the relative importance of issues described in the statements. The organisers compiled the set of statements in advance. These statements addressed a range of potential priorities for stakeholders with an interest in krill fishing and conservation in the Scotia Sea and Antarctic Peninsula region (Table 2). The statements were based on experience and published information from a range of sources (the academic and technical literature and popular media) on the diverse opinions that people express about the krill-based ecosystem and fishery. There were thirty four statements, which is consistent with the Q method but limits the level of detail at which it is possible to explore priorities. For example, it is not possible to assess the relative importance of all species in the ecosystem. The statements aimed at a midpoint between this level of detail and the high levels of ambiguity in phrases such as "ecosystem based management".

[1] See *Doing Q Methodological Research Theory, Method and Interpretation. Simon Watts and Paul Stenner 2012. Sage Publications Ltd. 248pp.*

Table 2. Statements used in the Q method exercise – step 3 (also used in steps 5 and 6)

1.	Continued commercial fishing of Antarctic marine living resources is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	13.	Managing the potential for invasion by alien species is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
2.	Non-fishing commercial use of Antarctic marine living resources (e.g. eco tourism) is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	14.	More research into the potential for invasion by alien species is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
3.	The state of the Antarctic krill stock is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	15.	Managing the effects of environmental change is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
4.	The states of all fished populations (including krill, toothfish and mackerel icefish) are important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	16.	More research into the effects of environmental change is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
5.	The states of species that have previously been depleted by sealing, whaling and fishing are important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	17.	Marine protected areas are important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
6.	The states of a limited number of Antarctic krill predators (such as penguin species) are important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	18.	More research into the effectiveness of marine protected areas is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
7.	The states of all species with a demonstrated dependency on krill (e.g. all predators that feed mainly on krill) are important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	19.	The profitability of the krill fishery is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
8.	The overall state of the regional ecosystem is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	20.	Stability of catch limits so that they do not change excessively between years is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
9.	Minimising the risk of irreversible ecosystem change is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	21.	Ensuring that the fishery can continue to access traditional krill fishing grounds is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
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 (e.g. other animals that might be caught in krill nets) is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	22.	Consumer perceptions of the fishery and its products are important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
11.	Managing fishing to minimise its INDIRECT effects on the ecosystem (e.g. potential reductions in populations of krill predators as a result of removing some of their prey) is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	23.	Public perceptions of the state of the ecosystem are important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
12.	More research into how fishing affects the ecosystem is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	24.	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) is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
		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) are important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.

continued ▷

Table 2. Statements used in the Q method exercise – step 3 (also used in steps 5 and 6) *continued*

26.	Increasing current catch limits is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	30.	More self-regulation by the krill fishing industry is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
27.	Decreasing current catch limits is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	31.	Independent assessment of the "sustainability" of the Antarctic krill fishery (e.g. Marine Stewardship Council certification) is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
28.	Further development of feedback management (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") is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	32.	Increased cooperation between stakeholder sectors (such as industry, scientists, and conservation NGOs) is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
29.	Measures to minimise illegal, unregulated and unreported fishing of Antarctic krill are important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.	33.	Strengthening coordination between CCAMLR and the organisations that provide scientific research into the Southern Ocean and the effects of fishing is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.
		34.	Financial or in-kind support from the fishery for science or management is important for achieving my objectives and aspirations for the krill-based ecosystem and fishery.

STEP 4: Filling the knowledge gap

The aim of the fourth step was to allow participants to establish a common base level of understanding about key aspects of the krill fishery and ecosystem, and to provide them with an opportunity to explore issues and ask questions of fellow participants with expertise in specific issues. In previous steps participants had been asked to provide or use their existing knowledge. From this step onwards discussions were informed by the knowledge gained in this step. The exercise was structured around four key themes:

(1) Changes in the krill stock

(2) Changes in predator populations

(3) Changes in krill fishing

(4) Plans for future management of the krill fishery

Discussions on each of the themes took place on one of four tables, with participants moving between tables (and therefore themes) at intervals. Each table had one facilitator and at least one expert on the particular theme at any one time. Participants were free to choose three of the four themes and attend 20 minute discussion sessions at the relevant table. Participants were encouraged to share information, experience, knowledge and ideas on each theme. Key questions from each group were written on a chart. These questions were then used to structure the discussion around the table. The facilitator noted (i) knowledge that the participants had confidence in and were agreed on, (ii) knowledge and issues on which there was disagreement, and (iii) key knowledge gaps. After 20 minutes, the groups rotated but the facilitator remained in place such that the next group was able to build on and refine the questions and knowledge of the previous group.

STEP 5: Sector needs alignment analysis

The fifth step aimed to use the results of the Q sorts undertaken in Step 3 to identify areas of agreement about priorities within sector groups. One group of NGO representatives, one group of fishing industry representatives, and two groups of scientists each

worked with facilitators to place statements from the Q sorts into the following categories (i) statements which the whole group agreed were important; (ii) statements which the whole group agreed were relatively unimportant; and (iii) statements on which there was no consensus about their importance. Each group then reported their findings in a plenary session.

STEP 6: Cross-sector needs alignment analysis

The sixth step aimed to use the results of the Q sorts undertaken in Step 3 to identify areas of agreement about priorities within cross-sector groups. This step was similar to Step 5, but with cross-sector groups rather than sector groups. Each group worked with a facilitator to place the statements from the Q sorts into the three categories above. Each group then reported their findings in a plenary session.

STEP 7: Making progress – identifying priority areas for stakeholder process work

The aim of the seventh step was to identify priority areas for current and future work by scoring topics on the basis of perceived importance and difficulty (challenge). The organisers identified relevant topics based on the outputs from previous steps. Participants were assigned to new cross-sector groups, which reviewed each of the topics and scored the importance and difficulty of each on a scale of 1 to 10. The groups were also given the opportunity to suggest their own topics, which were also reviewed and scored by each group. Table 3 presents the full set of questions. The topics were displayed on a chart with axes indicating the average importance and challenge scores.

Image: Adélie penguins (Pygoscelis adeliae) on sea ice (Pete Bucktrout, British Antarctic Survey)

Table 3. List of potential priority areas for stakeholder process work	
	Bold text highlights the topic. Questions 1 to 13 were identified by the organisers based on discussions during the first day of the workshop, and questions 14 to 18 (shaded) were added by cross-sector groups during step 7.
1.	What can we do as a cross-sector group to support the development of **additional capacity** and ability within CCAMLR to more effectively manage the krill fishery?
2.	What can we do as a cross-sector group to improve the **understanding of** abundance and dynamics of **the krill stock**, making best use of currently available information?
3.	What can we do as a cross-sector group to **identify research needs, contribute to this work and effectively communicate findings** broadly to CCAMLR and others?
4.	What can we do as a cross-sector group to help **communicate and interpret the science** to other stakeholders in order to achieve a better and more widely shared understanding of the krill based ecosystem and krill fishery management?
5.	What can we do as a cross-sector group to support a commonly agreed **definition of 'rational use'**?
6.	What can we do as a cross-sector group to support a commonly agreed **definition of 'reversible change'**?
7.	What can we do as a cross-sector group to support a commonly agreed **definition of healthy/unhealthy ecosystems**?
8.	What can we do as a cross-sector group to enable **available information and science to be used better** in achieving positive outcomes for the krill fishery and ecosystem management?
9.	What can we do as a cross-sector group to help develop a krill fishery that is both **sustainable and profitable**? *(Overlaps with 1)*
10.	What can we do as a cross-sector group to gather information that would **support an effective feedback management system**?
11.	What can we do as a cross-sector group to enable **industry knowledge** and experience to contribute to / support the science of krill fishery and ecosystem management? *(Similar to 12)*
12.	What can we do as a cross-sector group to identify key questions that could be answered through **cooperation between scientists and the krill fishing industry**? *(Similar to 11)*
13.	What can we do as a cross-sector group to ensure that **stakeholders are fully informed** about the krill fishery management and decision making process? *(Similar to 4)*
14.	**How do we manage the krill fishery using only the currently available information? (Similar to 8)**
15.	**What can we do to identify whether or not MPAs will benefit the management of the krill fishery?**
16.	**Are we happy with the way the krill fishery is managed now?**
17.	**What role does the krill fishery have in potential future global food security?**
18.	**How do we prioritise what the most important things are to focus resources on?**

STEP 8: Process for moving forward to develop effective management approaches

The eighth step aimed to identify stakeholder engagement processes that will have the best chance of achieving implementable agreements for the development of effective krill fishery management. Discussions were based on a selection of topics indentified as important in Step 7. The first part of the exercise asked participants to identify perceived barriers that could be overcome to provide benefits to different sectors. This was followed by facilitated discussion in four cross-sector groups, during which each group was asked to identify and develop short proposals for how and where each sector could add value, for example by developing dialogue, collaborations, or new approaches, to address specific topics.

STEP 9: More detailed consideration of selected priority areas

The ninth step aimed to develop more detailed ideas for addressing a subset of the priority areas identified in Steps 7 and 8. Facilitated discussion took place in four cross-sector groups, each of which addressed its own choice of priority areas. Participants were able to choose which group to join. For each priority area, participants identified the challenges and listed potential actions or measures to overcome those challenges. Participants also discussed the benefits, importance, resources required, and who would be involved in the delivery of each potential action. At the end of the exercise, action plans were shared in a plenary session.

STEP 10: Next Steps – agreement on actions to build on this workshop

The workshop concluded with table discussions in four cross-sector groups that fed into a final plenary discussion about feasible next steps and impressions of the workshop. This discussion, along with the results from Steps 8 and 9, was used to develop a list of recommendations. These recommendations were expressed and discussed at the workshop and were circulated to participants afterwards. However the workshop did not aim to achieve consensus, so individual participants might not support all conclusions.

RESULTS

STEP 1: Exploration of aspirations for change

A total of 21 cards were collected at the end of this brief exercise (note that only two of the four fishing industry participants were present at this time). Several of the cards contained more than one statement. The statements gave an indication of the types of change that the participants were interested in at the outset of the workshop and served as a starting point for subsequent discussions.

Most statements were complementary (but see footnote[2]). Many of the statements made similar points in slightly different ways, which we have summarised in three broad categories as follows: general statements on the ecosystem and fishery; statements on data and information requirements; and statements on management measures and processes (Table 4).

The need to improve information on a range of ecosystem parameters was the most cited issue in terms of frequency and consistency across sectors. The scientific sector more frequently cited the need for improved interpretation of science and more effective mechanisms for incorporating science into management. The NGO sector most frequently cited the need for effective ecosystem-based management. The need for an enhanced management system (variously described as feedback, reactive, responsive, adaptive, flexible, spatio-temporal) for the krill fishery was cited several times by scientists and NGO representatives. The statements from the two fishing industry representatives who were present for this exercise concerned evidence-based catch limits and effective enforcement of these limits. At the end of this ice-breaking exercise participants had shared views with numerous others from different sectors and found that at this early stage there were many shared aspirations.

Table 4. Summary of the key changes that participants would like to see with respect to krill fishing and conservation in the Scotia Sea and Antarctic Peninsula region
General statements on the ecosystem and fishery
Protection of Antarctic biodiversity
Enforcement of binding regulations
Data and information requirements
Improved data collection (including industry-involvement)
Improved information on (i) ecosystem "indicators" e.g. krill biomass, predators, ecosystem "health"; (ii) climate change (including ocean acidification); (iii) population ecology at appropriate scales. With some statements noting this should include utilising multi-year, regional datasets, and some noting that this kind of improved information is required before expansion of the fishery can be considered
Improved interpretation of science about the effects of the krill fishery on the ecosystem (e.g. to reduce conflict between harvested and dependant species) and about environmental change
Increase in predator monitoring, and management linked to this
More frequent and standardised stock assessments based on the fishery and surveys independent to the fishery
Management measures and processes
Cross–sector involvement in management of the fishery
Clearly defined management objectives
Clearly defined ecosystem reference points (so that science and monitoring can support objectives)
Enhanced management system for krill fishery (variously described as feedback, reactive, responsive, adaptive, flexible, or spatio-temporal, responsive to environmental change or signals of change) and effective use of information generated by fishing companies
Subdivision of krill TAC into SSMUs
Large-scale MPAs including predator foraging grounds, and establishment of non-fished control areas to monitor the impact of fisheries
More efficient mechanisms for incorporating science into management
Full observer coverage
Industry funding for sustainable fishery management
Effective ecosystem-based management and application of the precautionary principle underpinned by science

[2]*One NGO representative was not able to attend the workshop in person but did supply a position statement. This was represented in Step 1 by a third party as 'I would question whether there should be any krill fishing in the Southern Ocean at all'. This was the only statement that posed conflict during Step 1. Whilst we acknowledge this viewpoint we were unable to explore it further in subsequent steps as the representative was not present.*

STEP 2: Information building and gap identification

The information-building exercise identified areas of consensus or disagreement for 11 specific categories of information, which are addressed in the numbered subsections below. The exercise also highlighted areas where there were knowledge gaps. Some questions had fewer responses than others, and some did not have responses from all sectors.

1. Krill stock in the Scotia Sea and Antarctic Peninsula region

There was consensus between the science and industry sectors that the stock is currently healthy (with medium confidence), although it was noted that defining a healthy stock is difficult when there is limited information on how that stock interacts with the rest of the ecosystem.

There was consensus across sectors that the stock is declining, and is less abundant than 50 years ago (with low to medium confidence). Scientists generally indicated lower confidence in this than NGO representatives.

2. Total abundance of penguins in the Scotia Sea and Antarctic Peninsula region

None of the participants thought that penguin populations are increasing or more abundant than 50 years ago. There was a high level of confidence amongst NGO representatives that penguins are both in decline and less abundant than 50 years ago. The small number of scientists and industry representatives who responded thought (with medium confidence) that penguin populations are currently healthy. All three sectors agreed on the importance of considering variation between species and locations.

3. Total abundance of whales in the Scotia Sea and Antarctic Peninsula region

All participants agreed (generally with medium confidence) that whale populations are increasing. There was also agreement that whale populations are greater than 50 years ago, but the level of confidence on this varied from low to high. Scientists and NGO representatives agreed (with medium confidence) that whale populations are currently depleted, whereas industry representatives had medium confidence that populations are currently either healthy or over-abundant. All three sectors agreed on the importance of considering variation between species, and noted that there is poor information on some species.

4. Total abundance of seals in the Scotia Sea and Antarctic Peninsula region

The small number of participants who responded agreed (with medium confidence) that seal populations are currently healthy. Most agreed that seal populations are increasing, and that they are greater than 50 years ago, although confidence levels on this ranged from low to high.

5. Total abundance of fish in the Scotia Sea and Antarctic Peninsula region

Only industry representatives thought that fish populations are currently healthy. In contrast, scientists and NGO representatives agreed (with low to medium confidence) that stocks are currently depleted. In general, scientists thought that fish stocks are increasing, whereas NGO representatives thought that they are declining. All participants agreed (with low to medium confidence) that fish stocks are less than they were 50 years ago, although the importance of considering individual species was also noted.

6. Krill catches in the Scotia Sea and Antarctic Peninsula region

There was agreement across sectors (with medium to high confidence) that catches of krill are currently low. There was also agreement (with high confidence) that catches are increasing, but that they remain lower than they were 30 years ago.

7. Assessment of threats to the ecosystem in the Scotia Sea and Antarctic Peninsula region

In this part of the exercise, participants were asked to assess the severity of various potential threats to the

ecosystem (high, medium, low or not a threat). Most participants agreed that climate change and other human activities elsewhere pose a high level of threat (Figure 4). Levels of threat from shipping, mineral exploitation and pollution were generally thought to be lower, although there was less consensus about the severity of these potential threats. All other areas were assessed as low to medium threats (legal fishing; illegal, unregulated, and unreported fishing; invasive species; tourism; and other human activity in the study area). In general, NGO representatives assessed the severity of threats at a higher level than scientists, whereas the small number of industry respondents assessed threats at a greater range from low to high.

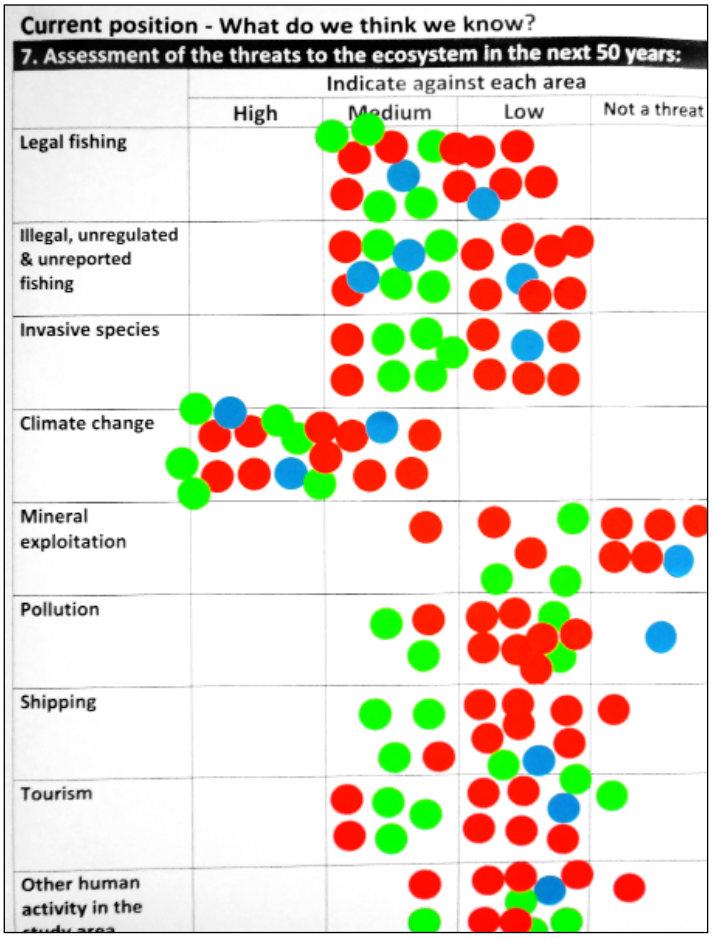

Figure 4. An example of the material generated by workshop participants : Participants' assessment of potential threats to the ecosystem

8. Current krill management system objectives

The majority of participants identified that the operational objectives used in the current management of the krill fishery define a minimum acceptable krill biomass and an appropriate long term krill biomass. A minority of participants thought that the objectives also define a minimum acceptable abundance of krill predators. However this is not the case, reflecting variability in understanding of the management system amongst participants.

9. Which measures are currently used to manage the fishery

All participants agreed that the current management system uses catch limits for individual subareas. Varying numbers of participants suggested that other measures, such as gear restrictions, seasonal closures, marine protected areas, and vessel quotas are used. This reflects variability amongst participants in understanding of the management system. For example, it is the case that the current management system uses catch limits for individual subareas, but it does not use vessel quotas.

10. What do you understand by "rational use"

Most participants suggested that there is no consensus on the meaning of rational use. However, some suggested that it means well-managed fishing, and others suggested that it means any direct or indirect use of living resources.

11. Further information needed to manage the current fishery properly

There was a high level of agreement between participants and across sectors on the importance of information on the spatial structure of the ecosystem, krill abundance, the effects of climate change, and ecological relationships (Figure 5). Industry representatives did not identify information on the following issues as important: bycatch, abundance of krill predators, sustainable catch levels, invasive species, the location of MPAs, the actual amounts of krill caught, or stakeholder objectives. The provision of information on invasive species was considered to be least important by all sectors.

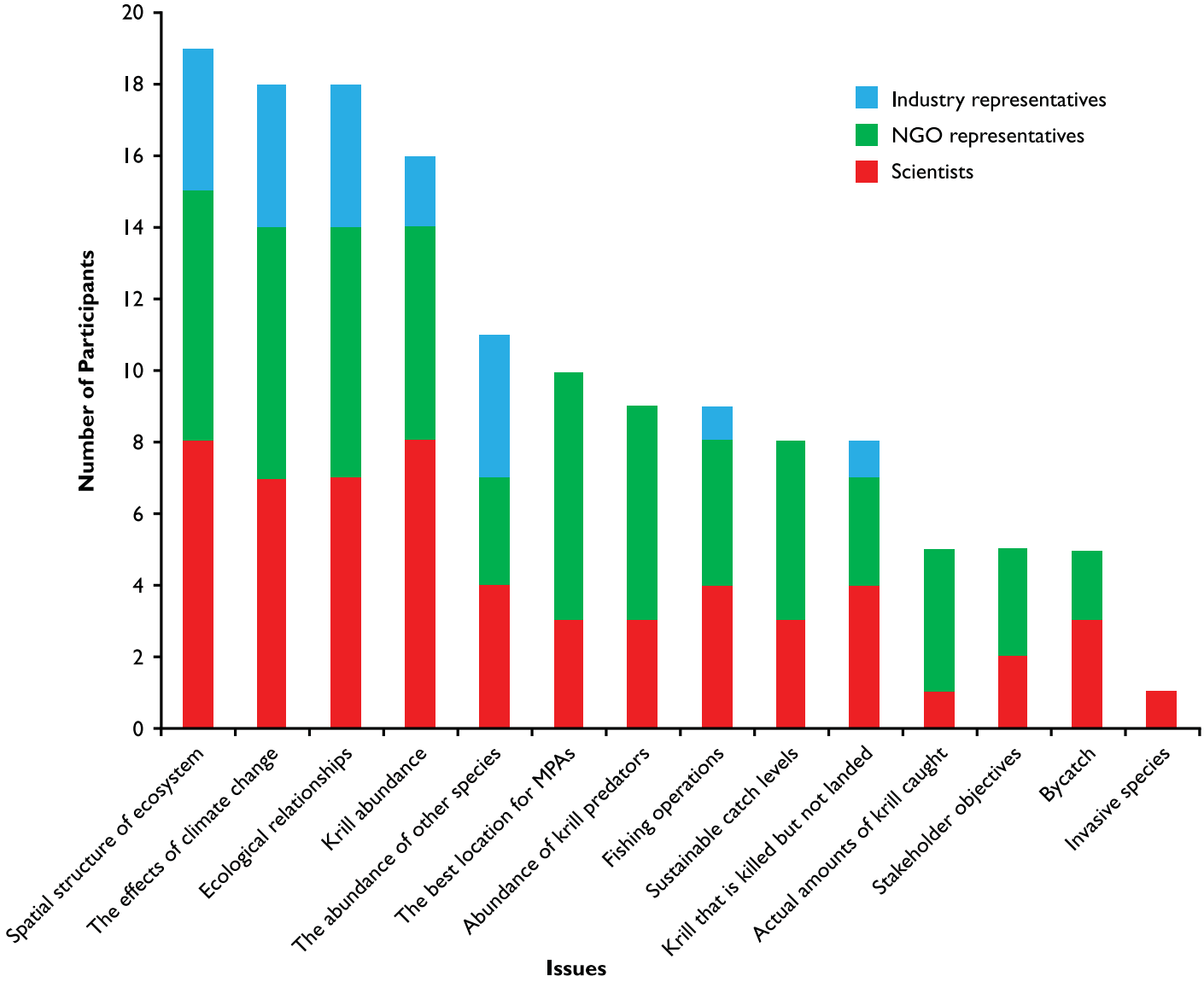

Figure 5. Information requirements indicated by participants at an early stage in the workshop.

Given the varying levels of confidence regarding the current state of the ecosystem and fishery this exercise also served as useful preparation for Step 4 (see below) where knowledge was shared and discussed.

STEP 4: Filling the knowledge gap

This exercise compiled a list of areas of knowledge the participants felt were strong; areas that required more information; and important areas of disagreement for each of four themes: (i) changes in the krill stock, (ii) changes in predator populations; (iii) changes in krill fishing; and (iv) plans for the future management of the krill fishery. The four comprehensive lists have been collated and are included as Appendix III.

The purpose of this exercise was to share information informally following the assessment of knowledge (Step 2) that preceded any such discussions. As such, there are no firm conclusions to be drawn although it was hoped that all participants had a more common understanding of the key issues at the end of this exercise.

There was a good level of agreement on knowledge regarding issues that are associated with clear and readily available evidence. These include:

- The key areas of overlap between predator and krill distributions
- The existence of "good" versus "bad" krill years, and the impact of these on predators
- The ongoing advances in fishing technology and associated changes to the fishery,
- The shift in the market for krill products towards health supplements and associated changes to the fishery, as well as a higher public awareness of the fishery
- That the existing level of fishing is unlikely to affect predator populations

Several important areas of disagreement were also identified although this disagreement was not necessarily cross-sector. For example:

- Some participants felt that there could be a significant future expansion of the krill fishery whereas others were confident that future demand for krill products will not necessitate such an expansion,
- Participants had different opinions on what causes observed changes in predator populations.

Appendix III, which summarises identified knowledge and gaps from this step, provides a useful cross-sector resource to draw upon when considering research priorities for effective management of the krill fishery. Indeed many of the areas of disagreement could be resolved by addressing some of the issues in the second column.

STEPS 5 and 6: Sector and cross-sector needs alignment analyses

The results from Step 3 (i.e. the individual Q sorts) are being analysed separately for publication in a peer-reviewed journal and are not presented here. The rankings of the statements by individuals in Step 3 were used to assess the alignment of needs in sector groups (Step 5) and cross-sector groups (Step 6). Appendix IV tabulates the detailed results of Steps 5 and 6, which are summarised in the following paragraph.

Steps 5 and 6 demonstrated strong cross-sector recognition of the fundamental importance of the state of the Antarctic krill stock and a general commitment to a healthy ecosystem, expressed in various ways (avoiding irreversible change, the states of krill dependent species, the overall state of the ecosystem). There was also strong cross-sector support for managing fishing to minimise its indirect effects on the ecosystem, continued development of feedback management, and better coordination between CCAMLR and its science providers. There was some cross-sector support for clearly defined management objectives and increased cooperation expressed as more industry support for science and management and more cross-sector collaboration. An interesting result is that all sectors, including the fishing industry, did not consider it important to raise the catch limit above current levels.

The exercise also demonstrated the diversity of opinions with most sectors identifying issues on which there was no within-sector consensus and

some striking differences of opinion between sectors. For example, while there was consensus among NGO representatives that MPAs are important for achieving objectives and aspirations for the krill-based ecosystem and fishery, one of two scientist groups reached consensus that MPAs are relatively unimportant for this purpose. Similarly, important issues for the fishing industry (profitability and access to traditional fishing areas) were not considered important by other sectors.

STEP 7: Making progress – identifying priority areas for stakeholder process work

In this step, cross-sector groups were asked to score eighteen topics (Table 3) on a scale of 1-10 for importance and challenge. Only six of the eighteen topics received an "importance" score ≤ 5 (Figure 6). These low scoring topics included those concerning the definition of the terms "rational use" (topic 5), "irreversible change" (topic 6), and "healthy ecosystem" (topic 7); the role of the krill fishery in future food security (topic 17); the level of stakeholder satisfaction with current management of the krill fishery (topic 16); and the broad topic of identifying research needs, contributing to this work and communicating the findings (topic 3). The definition topics were considered challenging (average scores ≥ 8), whereas the remaining low importance topics had average challenge scores ≤ 5.

The topics that scored highly in perceived importance (with a value >8) concerned better understanding of the krill stock (topic 2); supporting effective feedback management (topic 10); prioritising activities (topic 18); developing additional capacity (topic 1); and communicating and interpreting science (topic 4). The topics that scored highly in perceived importance generally had high challenge scores (> 6).

Some of the topics identified as moderately important (scores in the range 6 to 8) were not considered particularly challenging (scores < 4). These concerned using industry knowledge and experience to support science and management (topics 11 and 12) and ensuring that stakeholders are better informed about the krill fishery management and decision making process (topic 13).

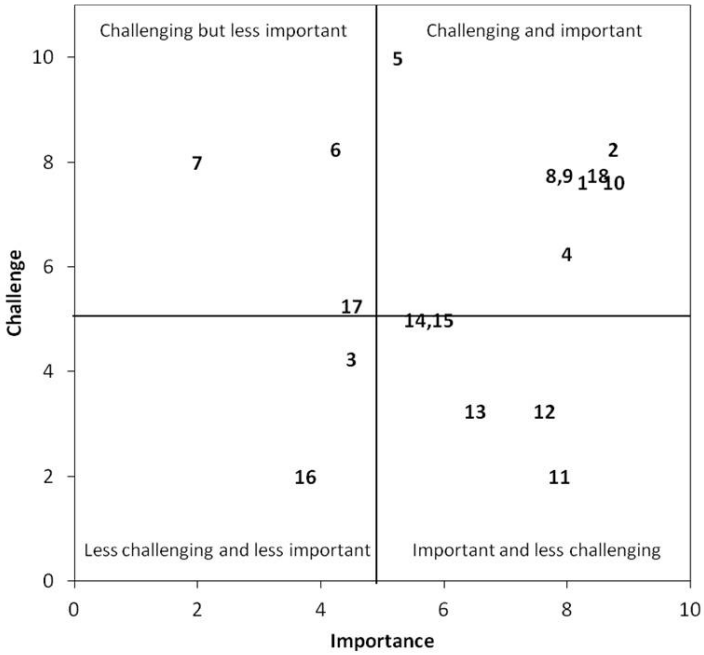

Figure 6: The questions in Table 3 scored by importance and challenge.

STEP 8: Process for moving forward to develop effective management approaches

The groups perceived several barriers to cross-sector engagement, including challenges that do not exist when working within a single sector, and limited opportunities to provide input to CCAMLR. Suggestions for increasing cooperation between sectors included further cross-sector meetings to address priority issues, and producing cross-sector papers to feed in to CCAMLR. Suggestions for better engagement with the management process included stronger links between each sector and CCAMLR Member delegations and changes in the CCAMLR process to promote engagement (e.g. allowing observers into CCAMLR working groups).

The perceived barriers to engagement with national delegations included limited opportunities to contribute relevant work, especially work originating from organisations or sectors not represented on the delegation; and limited funding opportunities for doing work of direct relevance to CCAMLR. Suggestions for improvement included promoting cross-sector representation on national delegations, and feedback from delegations to all those providing relevant work. It was also suggested that formal national cross-sector working groups could be set up to link to national delegations.

The main barrier to engagement in CCAMLR working groups was a perceived lack of transparency and of communication of working group findings back to stakeholders. A suggested solution to this problem was for working groups to allow the participation of experts from sanctioned organisations without requiring them to be part of national delegations.

Perceived barriers to engagement with CCAMLR and its Scientific Committee included the previously identified barriers to engaging with national delegations and CCAMLR working groups, and limited dissemination of information from CCAMLR to stakeholders. It was suggested that the CCAMLR website could have a "Frequently Asked Questions" page that could include information about providing input to CCAMLR. CCAMLR could also engage with a wider range of stakeholders. It was suggested that CCAMLR should identify mechanisms for providing clear information to stakeholders and improving the transparency of its processes.

STEP 9: More detailed consideration of selected priority areas

The outcomes of Steps 7 and 8 were used to guide and develop Step 9. Table 5 summarises seven priority areas (chosen because they ranked as high importance based on the results of Step 7), the key challenges associated with these (influenced by Step 8 and many of the other preceding Steps), and a set of recommended actions and measures that could be used to overcome the challenges.

The priority areas were concerned with effective use of information that is currently available, improving understanding of the dynamics of the krill stock and its dependent predators, improving communication of information from CCAMLR to stakeholders, prioritising research questions, identifying whether MPAs will benefit management of the krill fishery, involvement of the fishing industry in providing data, and ensuring that the krill fishery remains sustainable.

Challenges associated with these priority areas reflect those raised in previous steps and include issues around the potential expansion of the fishery, climate change, standardising data, and the effective engagement of stakeholders in the CCAMLR process.

Suggestions for actions were aimed at a variety of organisations including CCAMLR, its working groups, industry, ARK and other stakeholders. The recommended actions included changing the way that data are collected and analysed; more industry-supported science together with the provision of clear protocols to facilitate this; development of projections of future demand for krill catch; mechanisms for increasing cross-sector stakeholder involvement in the CCAMLR process and drawing on a wider community than is currently represented; and undertaking a cross-sector priority-setting exercise.

Table 5. Challenges and actions for priority areas identified by workshop participants.

Numbers in brackets indicate the number of the corresponding statement in Table 3 and Figure 6.

Priority areas	Challenges	Actions/measures
1. (9) What can we do to help ensure the krill fishery is sustainable?	Potential for rapidly expanding fishery.	Define data needs (collection, interpretation, and analysis) as the fishery expands– clear protocols for industry-supported science. Ensure fishery doesn't expand faster than this can be achieved.
(may include feedback management)	The more the fishery expands, the less certainty there will be about sustainability.	More industry-supported science to support/inform decision making on fishery expansion.
	Ensuring sustainability in a changing climate/ecosystem.	Develop indices/information to project likely expansion. Understand industry expectations and intentions –forecasting long-term plans.
2. (4) What can we do to ensure that stakeholders are fully informed about the krill fishery management and decision making process, and to help communicate and interpret the science to all stakeholders to achieve a better and more widely shared understanding of the krill based ecosystem and krill fishery management?	Many stakeholders – challenge of capacity to reach them all.	'FAQs' on the krill fishery, its management, and the CCAMLR process. Workshop participants to suggest their FAQs and case studies to be passed on to the CCAMLR Secretariat.
	Delegations/members are different in their capacity and/or ability to include stakeholders.	Improve the ability of scientists and observers to participate in the CCAMLR process and facilitate their participation e.g. mentoring/briefing for new participants. Clear language on the rules of procedure. Practical examples and case studies.
	Difficulty of translating CCAMLR reports into accessible language, without losing agreed meaning.	Draw on broader body of scientific knowledge and wider community than is currently represented. Reform Working Group structure and commission work from outside experts.
3. (15) What can we do as a cross-sector group to identify whether MPAs will benefit the management of the krill fishery?	Defining what an MPA means to the stakeholders.	Broader canvassing of stakeholders in the planning process – consulted from the early stages and all subsequent phases.
	The contentious history associated with MPAs.	Review of the MPA process to date, understand what went wrong to help us identify what needs to change. Use case studies.
	How do you broaden the participation in the MPA planning process at all stages?	Cross-sector, independently facilitated, expert workshops on MPAs – learn from existing processes e.g. Convention for Biological Diversity (CBD) and other relevant processes OSPAR, etc.
	Ensuring management frameworks can adapt to environmental change.	Harmonise MPAs and fisheries management frameworks – identify shared and individual objectives.
4. (8) What can we do to enable available information and science to be used more effectively to achieve positive outcomes for the krill fishery and ecosystem management? How do we manage the krill fishery using only the currently available information?	Effort involved in summarising, synthesising and collating datasets.	Design a tractable way of synthesising data for managers (e.g. report card).
	Ecosystem status report to inform feedback management.	Ecosystem status report for 48.1 collated by a group of people working in that area and provide to WG-EMM for inclusion in krill fishery report.
	CCAMLR standard methodology for collecting data – other data perceived as not usable.	Recommend that WG-EMM and Secretariat develop pathways for non-standard data (i.e. data not collected to standard CEMP methods).
	Going beyond monitoring to change the management advice.	WG-EMM should discuss a mechanism for inter-sessional work involving a wider group of participants, and facilitate involvement of non-Members.

continued ▷

Table 5. Challenges and actions for priority areas identified by workshop participants.

Numbers in brackets indicate the number of the corresponding statement in Table 3 and Figure 6.

Priority areas	Challenges	Actions/measures
5. (18) How do we prioritise the most important areas on which to focus resources for krill/ecosystem management?	Different agendas. The need to be open-minded about other sector needs/ wants.	Cross-sector priority-setting exercise – that needs to involve key CCAMLR representatives or to be endorsed by CCAMLR and to involve national delegations. Shared incentives/objectives.
6. (11) What can we do as a cross-sector group to enhance and coordinate/ facilitate industry knowledge and experience and data to contribute to /support the science of krill fishery and ecosystem management?	Working groups cannot currently include the industry sector. Incentivising more engagement from industry in data and information exchange.	ARK as a possible mediator between industry and scientists: identifying information needs for both, consider questions which help both. Compile a list of facilities on each vessel to help inform what is possible. There will likely need to be an easing in/introduction for those in industry who are not yet engaged. This and the ARK workshop will help – similar events could become a regular occurrence. Agreement that such workshop outputs are sent to the CCAMLR Scientific Committee. Assess whether this would be useful and then determine required resources. Recommendation to have more multi-sector representation in working groups that have the technical ability to engage well. Independent voice at CCAMLR from industry would be useful.
7. (2) What can we do to improve understanding of the abundance and dynamics of the krill stock and krill predators, making best use of currently available information?	Standardising data across the region (which is big). How are krill affected by oceanographic changes? How does industry respond to krill dynamics?	Standardising krill monitoring process. Protocol that takes into account differences between fishing vessels Resources involved in the data analysis. Length-frequency data already available but there is also a need for anecdotal information regarding the fishery.

STEP 10: Next Steps – agreement on actions to build on this workshop

Step 10 was a concluding discussion conducted both in cross-sector groups and in plenary. It covered a broad range of topics, generally those which had been discussed in previous steps. The specific recommendations identified by participants during this and previous steps are given in Table 6.

During Step 10, participants also discussed their experience of working with other sectors during the workshop. Some indicated that their existing assumptions about other sectors had been challenged, and that the structured activities and independent facilitator provided an effective way to stimulate and engage in cross-sector dialogue, and to promote positive and open discussions and sharing of knowledge. The degree of agreement across sectors was surprisingly high and suggests that the prospects for future cross-sector cooperation are good. It was felt that future cross-sector events could use the approach of this workshop. There was a general willingness to consider the perspectives of other sectors. Some participants found they had gained a greater understanding of the CCAMLR process, but many felt that transparency and dissemination of information needs to be improved and that CCAMLR should encourage broader participation.

Table 6. Conclusions and recommendations arising from the workshop	
	Note: The workshop did not aim to achieve consensus, so individual participants might not support all conclusions.
1.	**Current and future management of the krill fishery**
1.1	There is broad cross-sector commitment to maintaining a healthy ecosystem and support for management of the krill fishery that minimises the risk of the fishery negatively impacting ecosystem health.
1.2	Current catch levels are unlikely to be problematic, but the risks to ecosystem health, and uncertainties about the impacts of the fishery, increase with catch levels.
1.3	Any long-term increase in catches beyond the current catch limit (the 620 kt "trigger level") would require more information about the state of the ecosystem and its response to fishing than is currently available. CCAMLR should prioritise specification of the information that would be necessary before any long-term increase in catches beyond the "trigger level" can be considered. Such information is likely to include both data and analyses, and to concern the state of the ecosystem and its response to fishing.
1.4	The onus is on the fishing industry to facilitate the data collection and analysis (through provision of funding and access to vessels as a platform for science) necessary to support any request to expand the fishery beyond the "trigger level". The process of collecting, analysing and interpreting these data should be coordinated through CCAMLR to ensure that it is transparent.
1.5	ARK should encourage krill fishing companies to apply for non-state market-based certification (from organisations such as the Marine Stewardship Council or Friend of the Sea), which is complementary to CCAMLR's management of the krill fishery.
2.	**Formulating a research and development strategy to support progress in the management of the Antarctic krill fishery so that the limited available resources can be targeted appropriately**
2.1	Stakeholders should conduct a further cross-sector exercise to identify priority objectives for research and development in support of CCAMLR's management of the krill fishery. This exercise should involve CCAMLR, scientists, fishing companies and conservation NGOs and it should aim to reach cross-sector agreement about these priorities.
2.2	Understanding the potential for increases in fishery demand for krill and the likely rate of such increases is critical. Developing high quality information on future fishing scenarios should be a priority.
3.	**Improving the availability of clear information to improve cross-sector understanding of the state of the ecosystem, the current management approach for the krill fishery and the CCAMLR decision making process**
3.1	A clear, simple summary of key information about the state of the ecosystem, the current management approach for the krill fishery and the CCAMLR decision making process would aid cross-sector communication and understanding of these issues.
4.	**Enhancing CCAMLR working practices to support progress in the management of the Antarctic krill fishery**
4.1	CCAMLR should encourage broader participation in its working groups, especially WG-EMM, to include a wider range of disciplines such as social scientists and economists where appropriate, as well as experts from the fishing industry and conservation NGOs.
4.2	CCAMLR could provide more support for first-time participants in its meetings, including pre-meeting briefings about the key topics and the meeting process, and mentoring during meetings.
4.3	CCAMLR could encourage participation from the broader expert community by providing clear and timely information about which key topics will be discussed at working groups and about procedures for submitting work and obtaining feedback.
4.4	CCAMLR should encourage a wider community, beyond those who attend working group meetings, to participate in inter-sessional work and discussions.
4.5	CCAMLR should make more use of contracted experts to progress priority areas.
4.6	CCAMLR should consider alternative working methods, such as facilitated small-group discussion, to optimise productive dialogue in its working groups

DISCUSSION

This workshop was a first attempt to bring together experts from the fishing industry, conservation, and science sectors to address krill fishing and conservation in the Scotia Sea and Antarctic Peninsula region. Beginning with a simple request for participants to share their main aspirations for change, the structured sequence of group exercises and individual work facilitated the exchange of knowledge and opinions, revealing complementary views from the outset. These discussions led to recommendations for improved knowledge sharing and future progress towards long-term sustainable management of the Antarctic krill fishery. These recommendations are listed in Table 6.

The workshop did not aim to achieve consensus, but it did attempt to identify opinions that were broadly supported within the group of participants, and to identify different viewpoints where they existed. The following discussion therefore reports general outcomes but does not imply unanimity. The Results section and appendices provide more detail on the variety of topics discussed, and a separate paper on the Q method exercise will provide a detailed analysis of both the diversity of views of the participants and their shared ways of thinking.

Despite the diversity of interests amongst participants, and the corresponding diversity of opinion, the structured dialogue revealed much common purpose. This contrasts with and provides insight into the often antagonistic viewpoints that characterise discussion of the krill fishery in traditional and social media. All sectors understand the need for a healthy krill stock and a healthy ecosystem. Most participants agreed that current catch levels are unlikely to have a significant negative impact on the ecosystem and that current catch limits are appropriate. Participants generally shared the concern that raising the current catch limits would increase the risks to the ecosystem. There is therefore a need to establish whether demand for krill products is likely to increase in future, and to identify the information required to manage any increase in catch limits. Participants from the fishing industry did not foresee an increase in demand beyond current catch levels in the short or medium term.

Participants identified some differences of opinion about objectives. Fishing industry representatives understandably identified profitability and access to fishing grounds as priorities while other sectors did not. Although there was support for better defined management objectives and general recognition of the importance of ecosystem state, participants were generally unable to define what constitutes a "healthy" ecosystem (e.g. by specifying desirable ecosystem states). This reflects the uncertainties and gaps in the currently available information. It also emphasises the unique nature of the Southern Ocean, where many people understand the general benefits of a healthy ecosystem but few depend directly on these benefits and are able to identify their personal needs. The workshop's exploration of the types of objectives that participants consider important is a useful step in addressing the challenge of defining management objectives. Notably some of the main disagreements were not about desirable ecosystem states but about the means to achieve this.

Participants generally felt that they and their sectors could contribute positively to the development of krill fishery management. One key step in this development is to define the priority information requirements so that the limited available resources can be appropriately targeted. There was strong support for better coordination between CCAMLR and its science providers, and for using a prioritisation exercise to aid this coordination. Some participants identified limited access to information about the CCAMLR process as a barrier to participation. The exercises also revealed that access to scientific and technical information varies between sectors. This information is required to judge the current state of the ecosystem and the suitability of management. There was evidence that some participants modified their opinions during the course of the workshop in response to improved information.

One of the immediate outcomes of the workshop was that participants agreed to compile a list of key questions about the CCAMLR process, krill fishery management and scientific understanding of the ecosystem and the CCAMLR Secretariat agreed to provide answers to these "Frequently Asked Questions" on the CCAMLR website.

One of the purposes of the workshop was to identify ways for different sectors to work together. Participants were generally supportive of initiatives from ARK to support the science needed to manage the fishery and assess the state of the ecosystem. Participants generally agreed that if demand for krill catch increases in the future, the onus should be on fishing companies to support the information gathering and analysis required to ensure that any such increases are well managed. The cooperative and productive nature of the workshop suggests that the participant sectors have the capacity to work together to lead some key tasks which could feed into CCAMLR and inform the development of CCAMLR's management approach. Relevant tasks identified at the workshop include the prioritisation of information requirements and assessment of the potential future demand for krill catch.

CONCLUSIONS

The Southern Ocean is unique amongst the world's oceans in that it does not border any landmasses with permanent human settlements. Consequently there are few people who directly perceive the benefits it offers and who have clear opinions about the value of these benefits based on personal experience and needs. Nonetheless, the whole of mankind benefits from this ecosystem and it is a global resource that must be managed in the interests of all beneficiaries. The stakeholders represented at this workshop agreed that the objectives of such management must include a healthy krill stock and a healthy ecosystem. Participants generally agreed that the current low levels of krill fishing are unlikely to threaten ecosystem health but that increases beyond the current catch limit will increase the risk. However, participants are not currently able to the define ecosystem states that are desirable or healthy. This reflects the gaps in the currently available information and the indirect nature of the links between this ecosystem and human well being. This workshop's exploration of the types of objectives that participants consider important is a useful step in addressing the challenge of defining management objectives. The workshop produced a range of recommendations, which are summarised in Table 6. One recurring theme was a perceived need to improve communication between CCAMLR and stakeholders. The workshop also revealed a cooperative and productive relationship between the various sectors. This suggests that further cross-sector work could progress some key tasks such as prioritising information requirements and assessing the potential future demand for krill catch.

Image: Workshop participants (Rodolfo Werner)

APPENDICES

Appendix I. Workshop participants		
Name	**Organisation**	**Country**
Facilitator		
Steve Smith	Icarus	UK
Workshop organisers		
Simeon Hill	British Antarctic Survey	UK
Rachel Cavanagh	British Antarctic Survey	UK
Rod Downie	WWF	UK
Workshop facilitators		
Cheryl Knowland	British Antarctic Survey	UK
Susie Grant	British Antarctic Survey	UK
Louise Heaps	WWF	UK
Scientists		
Angus Atkinson	Plymouth Marine Laboratory	UK
Javier Arata	Instituto Antartico Chileno	Chile
Chris Darby	Centre for Environment, Fisheries, and Aquaculture Science	UK
Chris Jones	National Oceanic and Atmospheric Administration	USA
So Kawaguchi	Australian Antarctic Division	Australia
Steve Nicol	University of Tasmania	Australia
Keith Reid	CCAMLR Secretariat	
Georg Skaret	Institute of Marine Research	Norway
Phil Trathan	British Antarctic Survey	UK
Jon Watkins	British Antarctic Survey	UK
George Watters	National Oceanic and Atmospheric Administration	USA
NGO representatives		
Karoline Andaur	WWF	Norway
Claire Christian	Antarctic & Southern Ocean Coalition	USA
Rory Crawford	The Royal Society for the Protection of Birds	UK
Veronica Garcia	Fundación Vida Silvestre	Argentina
Ben Lascelles	Birdlife International	UK
Rodolfo Werner	Pew Charitable Trusts	Argentina
Kate West	Blue Marine Foundation	UK
Industry representatives		
Enrique Gutierrez	Pesca Chile	Chile
Shannon Lee	Insung	South Korea
Sigve Nodrum	Aker Biomarine/Association of Responsible Krill harvesting companies	Norway
Marcos Osuna	Pesca Chile	Chile

Appendix II. Glossary of acronyms and terms	
ARK	Association of Responsible Krill harvesting companies
CBD	Convention on Biological Diversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources, which was established by the similarly named Convention on the Conservation of Antarctic Marine Living Resources.
CEMP	CCAMLR Ecosystem Monitoring Program
MPA	Marine Protected Area
NGO	Non-Governmental Organisation
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
SSMU	Small-scale Management Unit, a spatial area smaller than a subarea which CCAMLR has identified as potentially useful for managing the krill fishery
TAC	Total Allowable Catch (see also Trigger level)
WG-EMM	Working Group on Ecosystem Monitoring and Management, a scientific working group which advises CCAMLR on krill fishery issues inter alia.
Ecosystem based management	A widely used definition states that ecosystem based management is "an integrated approach to management that considers the entire ecosystem, including humans. [Its goal] is to maintain an ecosystem in a healthy, productive and resilient condition so it can provide the services humans want and need" although others have noted that there is no reliable definition of this term.
Feedback management (FBM)	Defined by CCAMLR as a management approach that "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."
Invasive/alien species	A species of plant or animal that is not native to a specific location.
Precautionary principle (precautionary approach)	A management approach which attempts to minimise risks especially in uncertain conditions.
Q method	A research method used to capture the viewpoints of its participants.
Q sort	Grids ranked with participants' views on a set of statements (see Q method).
Rational use	The Convention on the Conservation of Antarctic Marine Living Resources includes the phrase "For the purposes of this Convention, the term 'conservation' includes rational use."
Reference points	A widely used definition describes reference points as states of the ecosystem, or of specific ecosystem components, that are desirable, or at least useful, for achieving management objectives.
Subarea	The Food and Agriculture Organisation of the United Nations divides the world's oceans into 27 areas for statistical purposes (e.g. catch reporting). These areas are further subdivided into subareas. The Antarctic krill fishery of the Scotia Sea and Antarctic Peninsula region is located in subareas 48.1, 48.2, 48.3 and 48.4.
Trigger level	The name used by CCAMLR to define the maximum biomass of krill that the fishery in the Scotia Sea and Antarctic Peninsula region is allowed to catch in a single fishing season. This catch limit is distinct from the "precautionary catch limit", a higher biomass which the fishery could be allowed to catch if certain additional conditions were met.

Appendix III. Knowledge and gaps identified during Step 4 **Theme 1. Changes in Krill Stock** **What we know and agree**	**What we don't know but need to know**	**Important areas of disagreement**
Stock definition is important	How to define stock both ecologically and for management (e.g. advection versus local production) The extent of exchange between stocks There is a need for improved calibration of acoustics and nets There is a need for improved and integrated modelling	Whether density should be considered separately from biomass
There are cycles in variability, dominated by periodic strong cohorts The cycles are large scale with detectible changes in the environment /food webs		
Recruitment is important	There is a need to better define key areas and what causes high recruitment in key areas Improved understand and explanation of the recruitment process	
It is difficult to get time series data, and there is a need to combine methods and approaches	How best to use current information (including small scale surveys)	
There is considerable uncertainty about changes in the krill stock		Whether changes in krill stock are top-down or bottom-up
Distribution of krill is important	What drives vertical distribution, how it affects stock estimates and changes to the stock What influences the location of nursery areas, and how they influence stock distribution (adults) How krill distribution characteristics change in winter, and how this impacts predators	
	Other points questions raised in terms of what we need to know: How climate change may affect krill stocks Identifying the priorities: what do we need to know to manage the fishery? Improving how we obtain information from the fishery Improving how existing data/results are interpreted (e.g. how representative are they of a wider region, wider context....?) What is an appropriate process for making progress in a consensus organisation?	

Appendix III. Knowledge and gaps identified during Step 4 **Theme 2. Changes in Predator Populations** **What we know and agree**	**What we don't know but need to know**	**Important areas of disagreement**
Predators and prey are important in the management of krill/predator management is critical to krill management		Uncertainty regarding the main krill predators
Some of the areas of overlap between predators and krill	How much predators interact with each other	
Information about localised krill dynamics	Wider krill dynamics Krill aggregation dynamics and what predators require in terms of swarm concentrations, etc	
Predator foraging indices are useful ecological indicators.	Foraging behaviour during winter	
Current levels of fishing are at levels that shouldn't affect predator needs/ populations	The impact of removing large quantities of krill from specific areas The impact of the speed of krill removal The level of fishing that would start to impact predators The cumulative krill demand of predators	Data from the last synoptic survey (14 yrs ago) is too localised
Detail is available for krill and predator populations for South Georgia, e.g. – Predators tend to fare badly when krill are not there – Predators are possibly also affected by climate change	How to scale up local knowledge to regional/wider view	
Fish might have been more abundant in the ecosystem in the past		
Common baselines need to be defined	What was happening pre-CCAMLR? Clarify geographic scope and species scope for baselines	
Monitoring programmes should be designed to enable best use of resources and international collaboration should increase		Not enough importance on monitoring by research councils and funders (perhaps put off by the high initial investment)

continued ▷

Appendix III. Knowledge and gaps identified during Step 4 **Theme 2. Changes in Predator Populations**		
What we know and agree	**What we don't know but need to know**	**Important areas of disagreement**
Populations are changing – some increasing, some decreasing	How much do we really need to know what the cause of change is, and what level of uncertainty is acceptable? Why some penguin populations are decreasing? Disentangling climate change and fishing effects Need reference areas to identify effects due to climate change and due to fishing ,plus historical impacts How are changes in predator populations linked to changes in krill populations	Whether predator population changes are only related to krill or also involve other factors, e.g. environmental (sea ice changes, etc) linked to changing climate and/or natural variability The key drivers of change Whether there is an over-abundance of some predators
Information gaps exist between sectors. Need for better communications		
	Efficacy of seasonal closures	
	More information on the life history of predators	
	What is "good enough" in terms of knowledge in terms of management decisions?	
		Whether the science is credible enough to influence the decision makers

Appendix III. Knowledge and gaps identified during Step 4 **Theme 3 Changes in Krill Fishing** **What we know and agree**	**What we don't know but need to know**	**Important areas of disagreement**
The catch (this is known at the end of each season) There has been a slowly increasing trend from approx. 120 kt to 230 kt and since then catches have been relatively stable (and around half the level they were in the mid-1980s)	There is uncertainty – e.g. conversion factors Level of discards – fresh catch that is retained Net escapement Present catches versus instant estimates of biomass The density of krill preferred by the fishery How useful are notifications for gaining a true insight into future fishing trends? Lack of clarity about how this information will be used	Has there been an increase in fishing? Increase in the number of vessels? Variability....
Changes in depth – i.e. fishing is occurring at greater depths	Deeper krill swarms – diurnal? – Need more information – Is it a real change or just improved information?	
Temporal shift (main season is now March to May) for higher quality krill oil product	Ecosystem effects of this shift – predator breeding, etc	
Technology	Potential for fishing in the open ocean Potential reality for future expansion and how to account for this now	
Different fishing patterns (although there are only two continuous trawlers)	Where will fishing take place in the future?	
Change in market/products for krill oil = higher public awareness	What is the potential for human demand for the products?	Future expansion could be significant versus the view that the market is not there for expansion (i.e. we can easily meet demand for krill oil)
Sea ice influences krill and the fishing environment		Sea ice may not be important in terms of fishing patterns within the summer
Composition of nations involved in fishery		
Observer coverage has increased	We need 100% observer coverage	
	More/improved information exchange	

Appendix III. Knowledge and gaps identified during Step 4 **Theme 4 Plans for the future management of the krill fishery**		
What we know and agree	**What we don't know but need to know**	**Important areas of disagreement**
SSMUs agreed but SSMU allocation not agreed		
Fishing only allowed in areas with biomass estimate	How to manage a fishery where key information is unavailable?	Timescale/knowledge required Arbitrary "precautionary management" versus adaptive management
Current monitoring infrastructure and 2000 biomass estimates are inadequate for managing the fishery (expanded in the future)	Several countries have regular small-scale krill surveys What level of knowledge do we need for people to be comfortable with feedback management?	
Commission takes on board non-science issues in decision making		
	The links between dynamics and spatial structure Seasonal, annual, spatial and long term patterns	
	Would localised removal of the depletion of entire trigger level (620kt) affect the ecosystem?	
Conservation measures (CMs) – TAC capped at 620kt – Subarea catch limits – Additional CMs – Observer coverage >70% – 50% mandatory observer coverage ends 2014		
Expansion beyond 620kt or movement to other areas requires more spatial management		
Future feedback management (using CEMP/ krill/fishery/ environment data) could affect catch distribution and TAC		
	Current krill stock biomass and dynamics	
	Appropriate reference points for dynamic environment	
	Which indicators to use for feedback management Appropriate mix of fishery and CEMP indicators	
	Distribution of krill and predators	

Appendix IV. Summary of sector and cross-sector needs alignment analyses (Steps 5 and 6)

Results from Step 3 were referred to in step 5 and 6 to assess the alignment of needs in sector groups (Step 5) and cross-sector groups (Step 6). Different groups approached the exercise in different ways and some groups categorised more statements than others.

Table IV.1: Results of the within-sector needs alignment exercise (Step 5). A statement number in a group column indicates that the group identified the statement as important to all group members (Important – Broad consensus, white cells), important to some but not all group members (Important to some - No consensus, light grey cells), or as less important to all group members (Less important – Broad consensus, dark grey cells). The full text of each statement is given in Table 2.

		Group			
Statement	**Key phrase**	**Scientists (1)**	**Scientists (2)**	**NGOs**	**Industry**
Important - Broad consensus					
1	Continued commercial fishing				1
3	The state of the Antarctic krill stock	3	3	3	3
4	The states of all fished populations ecosystem and fishery.	4	4		
6	The states of a limited number of Antarctic krill predators	6		6	
7	The states of all species with a demonstrated dependency on krill	7		7	
8	The overall state of the regional ecosystem		8		
9	Minimising the risk of irreversible change	9	9	9	
15	Managing the effects of environmental change			15	
16	Research into the effects of environmental change			16	
17	Marine protected areas			17	
19	Profitability				19
21	Continued access traditional krill fishing grounds				21
25	Clearly defined objectives	25	25		
28	Feedback management	28	28	28	
32	Increased cooperation		32	32	
33	Strengthening coordination		33	33	
34	Support from the fishery	34	34		
Important to some - No consensus					
1	Continued commercial fishing	1			
5	Previously depleted species	5			
7	The states of all species with a demonstrated dependency on krill		7		
8	The overall state of the regional ecosystem	8			
10	Minimising the direct effects of fishing		10		
11	Indirect effects of fishing	11			
12	Research effects of fishing	12			
13	Managing alien species			13	
15	Manage effects of environmental change	15			
16	Research effects of environmental change	16	16		
17	Marine Protected Areas		17		

continued ▷

Statement	Key phrase	Group			
		Scientists (1)	Scientists (2)	NGOs	Industry
20	Catch stability		20		
21	Access to traditional fishing grounds	21			
22	Perceptions of ecosystem			22	
29	Minimising illegal, unregulated and unreported fishing	29			
31	NSMB certification		31		
32	Increased cooperation	32			
34	Support from the fishery			34	
Less important - Broad consensus					
1	Continued commercial fishing			1	
2	Other commercial use	2	2		
10	Minimising the direct effects of fishing	10			
13	Managing alien species	13	13		
14	Research alien species	14	14		
17	Marine protected areas	17			
18	Research into Marine protected areas.	18	18		
19	Profitability	19	19	19	
20	Catch stability	20			
21	Access to traditional fishing grounds		21	21	
22	Perceptions of ecosystem	22			
23	Perceptions of fishery	23			
24	Use of fishery products	24			
26	Increase catch limits	26	26	26	26
27	Decrease catch limits	27	27		
29	Minimising illegal, unregulated and unreported fishing		29		29
30	Self-regulation	30	30	30	
31	NSMB certification	31		31	
33	Strengthening coordination	33			

Appendix IV. Summary of sector and cross-sector needs alignment analyses (Steps 5 and 6)

Table IV.2: Results of the cross-sector needs alignment exercise (Step 6). A statement number in a group column indicates that the group identified the statement as important to all group members (Important – Broad consensus, white cells) or as important to some but not all group members (Important to some - No consensus, grey cells). The full text of each statement is given in Table 2.

Statement		Group			
		Cross-sector (1)	Cross-sector (2)	Cross-sector (3)	Cross-sector (4)
Important - Broad consensus					
3	The state of the Antarctic krill stock	3	3	3	3
4	The states of all fished populations			4	
7	The states of all species with a demonstrated dependency on krill	7		7	
8	The overall state of the regional ecosystem		8		
9	Minimising the risk of irreversible change		9	9	9
11	Minimising INDIRECT effects on the ecosystem		11		11
12	Research into how fishing affects the ecosystem		12		
25	Clearly defined objectives			25	
28	Feedback management	28	28		
32	Increased cooperation	32			
33	Strengthening coordination	33			33
34	Support from the fishery				34
Important to some - No consensus					
17	Marine protected areas				17
19	Profitability		19	19	
28	Feedback management				28

Cover images: Antarctic krill (Euphausia superba)
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