COMMISSION FOR THE CONSERVATION
OF ANTARCTIC MARINE LIVING RESOURCES

КОМИССИЯ ПО СОХРАНЕНИЮ
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DE L'ANTARCTIQUE

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REPORT OF THE WORKSHOP ON VULNERABLE MARINE ECOSYSTEMS

(La Jolla, CA, USA, 3 to 7 August 2009)

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REPORT OF THE WORKSHOP ON VULNERABLE MARINE ECOSYSTEMS

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OPENING OF THE MEETING

1.1 The Workshop on Vulnerable Marine Ecosystems (VMEs) was held in La Jolla, CA, USA, from 3 to 7 August 2009. The Workshop was convened by Dr C. Jones (USA) and local arrangements were coordinated by Ms A. Van Cise, Southwest Fisheries Science Center, National Marine Fisheries Service (USA). With the Workshop's agreement, Dr K. Martin-Smith (Australia) withdrew from his role as Workshop Co-convener.

1.2 Dr Jones opened the meeting and welcomed the participants, including three invited experts Drs D. Bowden (New Zealand), J. Gutt (Germany) and S. Schiaparelli (Italy) (Appendix A).

Adoption of the agenda and organisation of the meeting

1.3 The Workshop reviewed the provisional agenda and agreed to consider resistance and resilience, as well as endemism and rarity, in the discussion of life-history attributes (Item 3.1), consider the spatial extent of VMEs under Item 5 (previously Item 3.3), and consider the extent of the impact by different bottom fishing gear under Item 4. The adopted agenda is given in Appendix B.

1.4 The Workshop also considered discussions from two meetings held during the 2008/09 intersessional period:

- meeting of WG-SAM (SC-CAMLR-XXVIII/5, paragraphs 4.12 to 4.15)
- meeting of WG-EMM (SC-CAMLR-XXVIII/3, paragraphs 5.4 to 5.14).

1.5 The Workshop noted the Secretariat's high translation workload (COMM CIRC 09/82) and discussions at CCAMLR-XXVII (CCAMLR-XXVII, paragraph 3.13), and agreed to make every effort to limit the overall size of its report.

1.6 The Workshop agreed to follow WG-SAM's initiative and highlight sections of the report dealing with advice to the Scientific Committee and its working groups, and list the relevant references to paragraphs under Item 7 (Advice to the Scientific Committee).

1.7 While the report has few references to the contributions of individuals and co-authors, the Workshop thanked all the authors of submitted papers for their valuable contributions to the work presented to the meeting. Documents submitted to the Workshop are listed in Appendix C. Dr A. Constable (Australia) gave a teleconference presentation of WG-SAM-09/21.

1.8 The report was prepared by Drs D. Agnew (UK), Jones, S. Lockhart (USA), Martin-Smith, P. O'Brien (Australia), S. Parker (New Zealand), D. Ramm (Data Manager), K. Reid (Science Officer), A. Rogers (UK), B. Sharp (New Zealand) and G. Watters (USA).

INTRODUCTION

2.1 The Workshop reviewed the history of measures to conserve VMEs in CCAMLR, noting that benthic habitat protection measures, such as those contained in Conservation Measure 41-05, introduced in 2002, were used prior to the introduction of the term 'Vulnerable Marine Ecosystem'.

2.2 The Workshop noted efforts to conserve VMEs in the United Nations General Assembly (UNGA), particularly noting the Sustainable Fisheries Resolution 61/105 adopted by UNGA in 2006 and the provisions contained in OP83 of this resolution, and that this and Article II of the CAMLR Convention provided the basis for Conservation Measure 22-06.

2.3 The Workshop further noted the work of CCAMLR to manage bottom fishing practices to prevent significant adverse impacts on VMEs through the work of the Scientific Committee in 2007 and 2008 (SC-CAMLR-XXVI, paragraphs 4.159 to 4.171 and Annex 5, paragraphs 14.1 to 14.50; SC-CAMLR-XXVII, paragraphs 4.207 to 4.284, Annex 4, paragraphs 3.21 to 3.44 and Annex 5, paragraphs 10.3 to 10.109).

2.4 The Workshop noted that some terms, such as destructive fishing practices, the vulnerability of an ecosystem to fishing and what constitutes significant adverse impacts, were proposed in SC-CAMLR-XXVI/10.

2.5 The Workshop recognised that guidelines for the management of deep-sea fisheries, including provisions for the conservation of VMEs, were developed by FAO and presented in *FAO Fisheries and Aquaculture Report*, No. 881 (2009). The Workshop noted that these guidelines provide examples of some VMEs, including deep-sea corals and seamounts, but that this list is not exhaustive and does not encompass all potential VMEs in the Southern Ocean.

2.6 The Workshop noted that cumulative impacts, including those caused by multiple gear types, would be important when considering the effects of bottom fishing.

HABITATS AND HABITAT-FORMING TAXONOMIC GROUPS THAT CONSTITUTE A VME

Life-history attributes, resistance, and resilience of VME taxa in the Southern Ocean

3.1 The Workshop considered which life-history characteristics of benthic invertebrates of the Southern Ocean would be indicative of vulnerability to bottom fishing gear. The Workshop developed several criteria based on the characteristics of VMEs set out in the *FAO Guidelines for Management of Deep Sea Fisheries on the High Seas* (2009) to classify intrinsic factors that contribute to vulnerability to physical disturbance due to bottom fishing. These criteria were then evaluated relative to the life-history attributes of organisms in each taxonomic group based on published literature and expert opinion, including through analogy with related taxa.

3.2 The Workshop agreed that functional roles of VME taxa include, *inter alia*, that they:

(i) significantly contribute to the creation of a complex three-dimensional structure;

(ii) create a complex surface by clustering in high densities;

(iii) change the structure of the substratum (e.g. sponge spicule mats; Bett and Rice, 1992); or

(iv) provide substrata for other organisms (Gutt and Schickan, 1998).

3.3 The Workshop agreed that these functional roles are not limited to creating 'large' structures, noting that encrusting organisms or organisms that create patches of structurally complex sea-floor substrata can also support the existence of additional fauna (Jones et al., 1997).

3.4 An additional intrinsic factor contributing to vulnerability to disturbance is rarity or uniqueness (the term endemism is not used here because it is scale-dependent). For example, rare dense populations of single species or communities (e.g. aggregations of stalked crinoids or chemosynthetic assemblages) could be significantly impacted by a single fishing event, and the effect exacerbated by limited potential for recovery because of isolation from recruitment sources. All of the taxa included in Table 1 were considered to be vulnerable to disturbance by bottom fishing gear.

3.5 The seven criteria included in the evaluation of benthic taxa are defined below:

1. **Habitat-forming** – One of the main characteristics of the structural species within VMEs is the degree to which they create habitat that could be used by other organisms. Organisms that are large, with a strong three-dimensional shape, or which create a complex surface by clustering in high densities, or changing the character of the substratum (e.g. sponge spicule mats), create habitats for other organisms. The relative degree to which organisms contribute to generating this habitat was classified as Low, Medium or High.

2. **Longevity** – Mortality of long-lived organisms can result in long recovery periods to regenerate unfished age structure (possibly more than centuries). CCAMLR's objectives under Article II cannot be achieved if recovery does not occur over a time scale of 20–30 years. Therefore, where estimates of maximum longevity for the members of the taxon were available, they were scaled as Low (<10 years), Medium (10–30 years) and High (>30 years). Thus, longevity was categorised into the three levels with respect to the length of time an ecosystem takes to recover from fishing impacts and how this recovery time relates to the objectives of the Convention.

3. **Slow growth** – Organisms which grow slowly will take a longer time to attain a large size or reproductive maturity. Slow growth rates of organisms are correlated with high longevity, but independent of age, slow growth requires longer times to generate maximum size. Vulnerability related to growth rate was classified as Low for fast growth rates, Medium, and High for slow growth rates.

4. **Fragility** – The potential for damage or mortality resulting from physical disturbance from bottom fishing gear was classified as Low (organisms that are resistant due to their structure or behaviour), Medium, or High (tall, brittle, or otherwise easily damaged).

5. **Larval dispersal potential** – The range of dispersal by larvae and propagules influences the ability of a species to recolonise impacted areas. Species which brood larvae, or otherwise have limited dispersal abilities, are less resilient to fishing disturbance because new recruits may not be available from a nearby source, and recruitment, recolonisation and recovery could be delayed. Organisms with high dispersal potential have a higher probability of supplying larvae to a disturbed area and are therefore more resilient. The reproductive strategies of brooding versus broadcast spawning were summarised for each group. Taxa consisting of brooding species were scored High, broadcast spawners Low, and taxa with a mix of both strategies were scored Medium.

6. **Lack of adult motility** – Motility in itself should not exclude taxa from being vulnerable or less resilient to bottom fishing gear, as organisms which can move to some degree may still meet all the other criteria of vulnerability. However, the lack of motility does add some degree of vulnerability and decreases resilience because as adults those organisms cannot redistribute themselves in response to a direct disturbance, adjust their position if altered in some way, or move into a disturbed area to recolonise. Organisms that are completely sessile were classified as High; those with some limited potential for movement as Medium, and typically motile as Low.

7. **Rare or unique populations** – Vulnerable taxa containing species that create dense, isolated populations are intrinsically vulnerable because they have a more limited potential for recovery. This criterion was classified as High if populations are isolated, and Medium or Low as population patch size or frequency of occurrence increases. Further, this criterion indicates vulnerability to physical disturbance and is independent of the habitat-forming characteristics of the taxon.

3.6 The Workshop recognised that, where coarse taxonomic groups were chosen, these may contain many species with a range of life-history characteristics. In this situation, the most precautionary values were used to characterise the potential vulnerability for the taxonomic group relative to the specific criterion. Coarse taxonomic levels were used to minimise the number of groups involved and to allow the inclusion of information derived from studies from the Southern Ocean or comparable ocean environments if necessary. The Workshop agreed that general relationships derived from meta-analyses of available information, such as those presented in WS-VME-09/12 and WG-EMM-09/35, could be useful where detailed information on particular taxa were lacking.

3.7 The Workshop agreed that Table 1 is a living document that should be periodically reassessed and updated to incorporate the best available science. In cases where the appropriate information was not available for a taxon, no score was given and the Workshop agreed that this was useful in identifying important information gaps.

3.8 The Workshop agreed that the parameters listed in Table 1 relate to the intrinsic vulnerability of VME taxa and that the actual impacts on VMEs depend on fishing intensity and the gear type that is deployed. All bottom fishing gears have the potential to impact seabed communities but have different levels of impact depending on the physical shape and weight of the gear and the way it is deployed (Rogers et al., 2008). However, fishing intensity is also extremely important as impacts of fishing gear on seabed communities are cumulative. Therefore, while some fishing gears may have a moderate or low impact per deployment, the cumulative impact of multiple deployments in a single area will increase damage to seabed communities over time and also negatively influence their recovery.

3.9 The observations from a benthos disturbance experiment in the Weddell Sea in which intensive trawling of a small area did not kill or remove all macrofauna (WS-VME-09/P5) support the view that bottom fishing impacts may not result in total mortality within the area impacted and that recolonisation does not need to occur from sources outside the impacted area. Dr Gutt noted that recent modelling work suggested that the rate of recovery may be strongly influenced by the proportion of surviving organisms remaining in the disturbed area (Potthoff, 2006). However, the Workshop recognised that the population growth potential is crucial to recovery time, and that recruitment dynamics are not well known for these taxa in the Southern Ocean. Also, there is evidence from outside the Convention Area that in some situations (e.g. intensive trawling on the summits of seamounts) VMEs may be totally or near-totally removed and subsequent recovery has not been observed 20 or 30 years post impact (Clark et al., in press).

3.10 The Workshop agreed that vulnerability is a continuum, not a binary characteristic of a species or assemblage. Therefore, designating a list of coarse taxonomic groups as being vulnerable will inevitably exclude some species that are potentially vulnerable to the use of bottom fishing gear, and may include some species that are less vulnerable. Evaluating the intrinsic factors contributing to vulnerability from physical disturbance indicates a number of taxonomic groups could be significantly impacted by bottom fishing activities.

Benthic invertebrate taxa consistent with VMEs

VME habitat-forming organisms and features specified in Annex 22-06/B

3.11 The Workshop recommended that Conservation Measure 22-06, Annex 22-06/B, be restructured to collect information related more directly to research vessel encounters with VME taxa. These changes could be addressed by WG-FSA. Specifically, the Workshop recommended that:

(i) the habitat-forming organisms should be replaced with the VME taxa listed in Table 1, and with the addition of a category for other taxa;

(ii) more details about the type of sampling gear used, and a list of other types of information collected from the site, should be requested;

(iii) because these encounters would likely be by research vessels, there is some potential that additional data could be collected while the vessel is at the site. A list of the high-priority types of data, such as multibeam bathymetry, oceanographic variables, sediment types or video recordings, could be provided to encourage the collection of these additional data;

(iv) sections 4 and 5 of the annex be combined and made less prescriptive;

(v) the annex include a section to provide a rationale and supporting evidence for the notification (see paragraph 6.13).

Review of Benthic Invertebrate Classification Guide

3.12 The Workshop noted the guide to Heard Island and McDonald Islands (HIMI) benthic invertebrates (WS-VME-09/13). The guide has now been finalised and will be made available to interested members. A benthic invertebrate identification guide is also being developed for the Ross Sea (see paragraph 6.6) and will be made available when complete.

3.13 The Benthic Invertebrate Classification Guide for Potentially Vulnerable Marine Ecosystems (WG-EMM-09/8; see also WG-FSA-08/19) was reviewed by the Workshop relative to the list of vulnerable taxa listed in Table 1. The Workshop agreed that this guide was applicable to all regions of the area defined in Conservation Measure 22-06, noting that additional VME taxa may be included in the guide in future revisions as information becomes available. The Workshop also encouraged work to continue to identify and characterise chemosynthetic communities within the CAMLR Convention Area.

3.14 Recognising the utility of the guide described in the preceding paragraph (also see TASO-09/8), the Workshop requested a number of minor improvements, including additional VME taxa columns, additional characteristics through photographs and text to aid in identification, and better contrasting information to distinguish currently confusing taxa. The Workshop noted that additional species codes will need to be developed to aid in recording additional VME taxa. The Workshop also agreed that for the purposes of the guide and of identification of VMEs, all corals (live or dead) should be reported to the taxonomic resolution in the guide. The Workshop agreed that the revised guide be titled the 'CCAMLR VME Taxa Classification Guide' and should be submitted for review by WG-EMM and WG-FSA.

3.15 The Workshop recommended that distributions of VME taxa weights and sizes recorded in both research and observer data be investigated with an aim to provide an additional characteristic to use in the CCAMLR VME Taxa Classification Guide. This would eventually aid vessels in determining when move-on rules that depend on the by-catch of various-sized VME taxa might be triggered.

3.16 The Workshop summarised its advice from discussions under this agenda item as follows:

(i) Scientific evaluation of the presence of vulnerable taxa or of fishery impacts to vulnerable taxa can be made using both fishery-dependent and fishery-independent data, and the vulnerable taxa encountered may be different for different sampling devices (e.g. bottom longline gear, bottom trawl or underwater video).

(ii) Different taxonomic groups have qualitatively different degrees of intrinsic vulnerability to physical disturbance. The degree of impact and potential recovery time is influenced by the spatial overlap of the fishery footprint with the distribution of each vulnerable taxon, the intensity (cumulative effects) of fishing effort in overlapping areas, and those intrinsic factors.

(iii) In addition to intrinsic vulnerability factors, the assessment of bottom fishing impacts should incorporate fishery specific factors, such as spatial overlap between fishing effort and VME distribution, and any correlations between VME taxa and fishery species.

(iv) A single VME Taxa Classification Guide can be developed for use in all CCAMLR areas specified in Conservation Measure 22-06.

EXTENT OF IMPACT BY DIFFERENT BOTTOM FISHING GEAR

4.1 The Workshop acknowledged that currently all of the bottom fishing in the CAMLR Convention Area covered by Conservation Measure 22-06 was by longline. Given the limited overlap in the use of different longline gear (i.e. autoline, Spanish or trotline), there was insufficient data to compare the different impacts on VMEs of these different gear types. However, the Workshop did acknowledge that simply on the basis of the characteristics of the gear, especially the potential for movement of the mainline and hooks during the soak period, there was considerable potential for differences in the interaction of the gear with benthic organisms.

4.2 The Workshop considered WG-SAM-09/P1 which described the use of a flexible framework for estimating the impacts of bottom fishing gear on vulnerable taxa given the uncertainties that exist. The use of this framework to assess the cumulative impacts of fishing in the Ross Sea by New Zealand flagged vessels indicated that a primary factor influencing the potential impact of different longline gear types was the extent of lateral movement of the mainline in contact with the sea floor during line retrieval.

4.3 The Workshop recognised that the use of this framework to derive absolute measures of impact is subject to great uncertainty, but that the framework is valuable for making explicit the consequences of different assumptions, and for estimating the plausible upper and lower bounds of cumulative impact to date or of proposed future fishing activities, given particular assumptions about the spatial distributions of VME taxa. The Workshop noted that in response to SC-CAMLR-XXVIII/5, paragraph 4.9, the authors of WG-SAM-09/P1 had applied the impact assessment in very small areas within which fishing effort distributions appeared uniform or random in space, in order to more closely approximate a condition in which the assumption of no systematic association between fishing distributions and VME taxa is valid. Actual distributions of VMEs remain unknown. The Workshop noted that the approach would be enhanced by efforts to validate this assumption, either by mathematically establishing the random distribution of effort at that scale or by examining actual effort distributions with reference to a range of simulated VME distributions, e.g. using the approach described in WG-SAM-09/21. The Workshop also recognised that the framework was potentially very useful to compare the relative impacts of fishing operations using different gear or operating in different locations.

4.4 Furthermore, the Workshop agreed that the combined use of this framework with that described in WG-SAM-09/21 (see paragraph 4.9) would allow the use of available data indicative of fishing effort and likely impact, and the simulation of other aspects of the risk assessment process for which data does not currently exist, i.e. the spatial distributions of VME taxa.

4.5 The Workshop suggested that the method be investigated as a tool that could be used in the routine impact assessment undertaken by Members in fulfilment of the requirements of the pro-forma notification in Conservation Measure 22-06, Annex 22-06/A. Such an investigation should consider the requirements of assessments of different gear types (Spanish longlines, autolines, droplines, trotline, pots singly, pots on strings) and the tool should operate using data requested from the Secretariat databases.

4.6 Although much of the information relating to fishing impacts to VMEs in the area included in Conservation Measure 22-06 will derive from fishery observations, a comprehensive evaluation of vulnerability might also utilise information from other sources (such as video or photographic data and geomorphologic information).

4.7 The Workshop recognised that there is currently little information available to monitor or evaluate impacts to taxa that may be vulnerable to bottom fishing but have unknown spatial distributions and are not observed in fishery by-catch. An expanded list of taxa could be considered when conducting scientific surveys and experiments using various sampling methods that efficiently collect data on a wider range of species (e.g. vent and seep taxa, or tube-building serpulid worms may not be catchable by bottom longline gear). Vulnerable taxa able to be monitored in the fishery would necessarily be a subset of the list of taxa that might be impacted by the fishery simply due to catchability constraints.

4.8 The Workshop considered additional fishery-specific factors that will modify the threat to VMEs from fishing:

(i) Spatial distribution relative to fishery. The greater the degree of spatial concordance in three dimensions (latitude, longitude and depth) between the occurrence of benthic communities and fishing effort, the greater the impact on those communities from bottom fishing.

(ii) Aggregation relative to fishery. If VMEs are highly aggregated, the likelihood of an encounter with bottom fishing gear may be decreased but the impact may be increased.

(iii) Association with fishery species. A positive relationship between VMEs and fishery target species will increase the threat from bottom fishing while a negative relationship will decrease the threat.

(iv) Gear-specific vulnerability. The proportion of individuals of different VME taxa that are dislodged, damaged or killed will vary depending on gear type, thus affecting potential rates of recovery.

(v) VME area impacted per unit effort. Uncertainties exist concerning the area impacted by many gear types – for example lateral movement of longlines will increase the impact footprint.

4.9 WG-SAM-09/21 presented a simulation model (coded in R) for evaluating management strategies to conserve the ecological structure and function of benthic habitats that had already been considered by both WG-EMM and WG-SAM (SC-CAMLR-XXVIII/3, paragraphs 5.12 to 5.14; SC-CAMLR-XXVIII/5, paragraphs 4.11 to 4.15). The Workshop recognised that several of the suggestions for improvements made by the working groups had been incorporated into the model, as well as the provision of a draft manual, and congratulated the author for these developments.

4.10 The Workshop agreed that the outputs of discussions on resistance and resilience, such as Table 1, could be used as a basis to parameterise the model. Unfortunately the Workshop was unable to provide further commentary due to time constraints but urged further development of this model and its application.

METHODS FOR IDENTIFYING LOCATIONS OF VMEs

Available and potential data sources

Fishing vessels

5.1 The Workshop agreed that longline sets by fishing vessels are the most easily accessible and widely distributed method for sampling VME indicator organisms in areas where the toothfish fishery takes place. Nevertheless, it was recognised that longlines are unlikely to be good samplers of benthic organisms, and there are significant uncertainties about the relative catchability of different taxa by different types of gear and at different depths (SC-CAMLR-XXVII, Annex 5, paragraphs 10.22 and 10.38). Thus, longlines might not be equally good at identifying different types of VME if they are indicated by taxa of varying catchability.

5.2 WS-VME-09/5 analysed vessel-reported VME data and scientific observer data to compare two different metrics for monitoring VME indicator organism catch rates. Although there was a relationship between the number of VME indicator units and the number of VME indicator organisms per thousand hooks by line section, there was a high degree of scatter partially caused by the mix of ‘heavy’ and ‘light’ VME taxa captured on longline segments. Nevertheless, there appeared to be some consistency between taxa associations, for instance triggers with high numbers per thousand hooks generally comprised stylasterids and basket stars.

5.3 The Workshop agreed that it might be important to distinguish between catch rates of different VME taxa in order to interpret what type of community might be indicated by the composition of VME indicator units (paragraphs 6.8 to 6.10).

5.4 WS-VME-09/8 examined the distribution of different VME indicator taxa in the Ross Sea using data from the NIWA Invertebrate Collection, SCAR MarBIN and CCAMLR 2009 observer data. Scientific sampling is concentrated on the shelf, whereas fishing is concentrated on the slope, meaning that data from fishing vessels is important, and often the only source of data, for understanding the overall distribution of VME indicator taxa.

5.5 TASO-09/8 examined the issue of ease of identification of VME taxa by observers and found that observers were able to easily distinguish VME from non-VME taxa using the Benthic Invertebrate Classification Guide (WG-EMM-09/8) without specific training in identification of VME taxa (SC-CAMLR-XXVIII/9, paragraphs 3.9 and 3.10).

5.6 Vessels themselves are required under Conservation Measure 22-07 to report encounters with VME indicator organisms where the volume or weight of the organisms caught in one line segment was greater than five VME indicator units, and additionally were urged to report the VME data from all line segments to the extent possible. WG-EMM-09/8 reported that 30 VME indicator notifications were made in exploratory bottom fisheries in 2008/09 and that 13 of the 18 vessels fishing had reported the additional fine-scale VME data.

5.7 The VME notifications under Conservation Measure 22-07 for the 2008/09 season were:

- Subarea 48.6: 1 notification of >5 units
- Subarea 88.1: 18 notifications of >5 units, including 5 notifications of >10 units
- Subarea 88.2: 11 notifications of >5 units, including 2 notifications of >10 units.

In addition, one VME fine-scale rectangle (an area of 0.5° latitude by 1° longitude) was identified in Subarea 88.2, where eight notifications of >5 units had been made.

5.8 Considering that the requirement for recording and reporting VME data only came into effect this season, and that the reporting of non-trigger VME data was not mandatory, the Workshop congratulated fishing vessels and observers on the quantity of the data that they had been able to report during the season. Data provided by vessels and observers have proven useful in investigating the relationship between fishing, fish catch and VME indicator units undertaken this year (WS-VME-09/5 and 09/7).

5.9 The Workshop agreed that high-resolution data from fishing vessels and observers were necessary to fully understand key issues concerning the impact of fishing on VMEs. Different data can provide key information such as the spatial scale of VME indicator organism occurrence and interaction with gear or associations of different taxa and between VME indicator organisms and fish. Although not all vessels had reported VME data for each line segment, enough data had been reported to demonstrate its utility. Some vessels had reported these data for entire lines, which although still useful, was not directly comparable with the line-segment data.

5.10 The Workshop further agreed that the relationship between data obtained from fishing vessels and observers and actual impacts on VMEs in relation to the effects of bottom fishing remains uncertain. Uncertainty could be reduced through the use of camera gear for example (SC-CAMLR-XXVI/BG/30; WG-FSA-08/58).

5.11 The Workshop noted the importance of distinguishing between nulls (where no observations were made) and zeroes (where observations were made but no VME taxa were found) as this is particularly critical to identify the patch size of VMEs and in habitat suitability modelling (see paragraphs 5.27 to 5.37).

5.12 The Workshop made the following recommendations with respect to data collection on vessels:

(i) vessels should only report total weight of VMEs, not volume;

(ii) reporting of all VME data and fish catch data by line segment should be mandatory for a subset of whole lines for all vessels;

(iii) whenever whole lines are monitored, all catches of VME taxa for every segment should be recorded, including entering a zero catch if no VME taxa were caught;

(iv) observers should be required to identify taxa for VME catches on segments from the same segments as the vessel's subset (see (ii) above);

(v) observers should record both weight and numbers of each VME taxon at the level of the line segment when monitoring VME data (paragraph 5.3);

(vi) vessels and observers should be careful to record geodetic datum[1] information and avoid transcription errors in location data.

Fishery-independent research

5.13 The Workshop considered other methods of locating VMEs using research data.

5.14 WS-VME-09/4 indicated how VMEs might be located by considering physical mechanisms of trophic focusing which are determined by the interactions of oceanographic dynamics and geomorphology.

5.15 WS-VME-09/9 outlined an approach to locating chemosynthetic communities using a range of data acquired through a variety of different surveys such as seismic reflection surveys. The Workshop noted that the SCAR Action Group would also compile a field guide to chemosynthetic communities to allow observers to classify them in by-catch.

5.16 WS-VME-09/10 described the development of an Antarctic-wide geomorphic map of the sea floor for use in locating potential VME sites and for bioregionalisation. The geomorphic map is based on global bathymetric datasets to provide the most uniform coverage of the entire region. The value of the approach to VME detection is that it locates seamounts over 12 km in diameter even in areas lacking ship-based data.

5.17 The Workshop agreed that geomorphic mapping should be made available via the CCAMLR Secretariat so that individual VME locations could be overlaid on it to investigate possible relationships between VME distributions and geomorphology. It was recognised that polygon data like this are difficult to include in statistical modelling exercises that use gridded data. However, the geomorphology does provide seamount locations and insights into environmental characteristics in areas where there are no other data.

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[1] A geodetic datum is the earth model used to locate latitudes and longitudes on the earth surface. The location of a latitude-longitude pair on the earth's surface can vary by hundreds of metres for different geodetic datums. The datum used for a navigation system is specified in the system set-up of GPS units and hydrographic charts specify what datum was used as part of the legend.

5.18 WG-EMM-09/32 presented results from two surveys on the Antarctic Peninsula margin and the South Orkney Islands. The surveys used benthic trawls and video transects to collect benthic samples. VME taxa were common at almost every station so the investigators defined a threshold weight of 10 kg per 1 200 m^2 trawled to be analogous to the trigger set out in Conservation Measure 22-07.

5.19 The Workshop discussed the applicability of a threshold for defining a potential VME identified during research. Conservation Measure 22-06, Annex 22-06/B, requires only presence of VME organisms, but it was recognised that this could apply to almost every station sampled in this study, and that this was not consistent with the spirit of the conservation measure.

5.20 The Workshop recommended that CCAMLR Members develop mechanisms for acquiring non-fisheries research information from national programs and to provide information that could be useful for identifying potential VME areas.

Use of fish diversity as an indicator of VME

5.21 The Workshop noted that results from studies investigating whether the abundance and biomass of fish are enhanced by the presence of epifaunal coral and sponge communities on seamounts or in other deep-sea ecosystems are equivocal. Observations have indicated that catches of commercially valuable species may be higher in and around cold-water coral reefs (Husebø et al., 2002). Research submersibles, ROVs or other scientific methods have recorded significantly higher abundances of fish and crustaceans in coral and sponge versus non-coral and sponge habitats in some cases (Lindberg and Lockhart, 1993; Brodeur, 2001; Koenig, 2001; Krieger and Wing, 2002; Costello et al., 2005; Pirtle, 2005; Stone, 2006; Tissot et al., 2006; Ross and Quattrini, 2007), and not in others (Auster, 2005). In Alaska, 97% of juvenile rockfish and 96% of juvenile golden king crab were associated with emergent epifaunal invertebrates such as corals and sponges (Stone, 2006). In the northeastern Atlantic, visual surveys of areas of the continental margin indicated that 80% of individual fish and 92% of fish species were observed on *Lophelia pertusa* reefs in comparison to non-reef habitat (Costello et al., 2005).

5.22 The Workshop noted that in the Antarctic there are few data relating the distribution of fish species to benthic habitat, particularly VMEs. Unpublished work has identified a specific association between *Patagonotothen guntheri* and sponges, where the eggs of the fish have been repeatedly found in sponge colonies (E. Fitzcharles, BAS, UK, unpublished data). There are also observations that *Trematomus* spp. are often observed in association with sponges (Gutt and Ekau, 1996) and *Lepidonotothen nudifrons* are associated with dense aggregations of bryozoans (C. Jones, pers. obs.).

5.23 Although there is some potential for association of specific fish species and perhaps even overall fish diversity with VMEs, unless these fish were also vulnerable to capture by longlines, examination of fish by-catch rates and diversity may not provide useful indicators of VME presence.

5.24 WS-VME-09/7 described an analysis of VME indicator data reported by vessels and toothfish CPUE in the Ross Sea. The paper found little evidence for a functional relationship between toothfish catch and VME units, and vessel was the most significant factor influencing VME units and VME units declined with depth. Further, catch rates of VME units were higher in the west of Subarea 88.1 close to Cape Adare than in the east.

5.25 The Workshop examined preliminary investigations undertaken by the Data Manager which highlighted the limitations of the current dataset to detect relationships between the catch rates of other fish species – macrourids, rays or *Antimora* – with VME taxa observations.

5.26 The Workshop concluded that, given the evidence to date, it was unknown whether the examination of fish diversity from longline samples would generate useful indicators of VME location. The Workshop agreed that this approach could be further investigated and urged Members to submit analyses to WG-FSA. These studies should consider:

(i) different fish parameters – size, species, density and diversity;

(ii) the relationship between fish catches and the occurrence of each specific VME taxon listed in Table 1;

(iii) issues of the potential saturation of hooks at high levels of VME taxa catch;

(iv) scale issues – for instance, the possibility that toothfish are attracted to a longline from a wider area than the area from which VME data are being collected; and differences in size between VME patches and longline segments;

(v) the variation in catchability of toothfish may be influenced by different aspects of the configuration of gear and habitat compared to the aspects that influence variations in catchability of VME taxa, and these aspects may vary independently;

(vi) the catchability assumptions both in regard of fish and VMEs.

Spatial extent of VMEs

Predicting the locations of VMEs in the absence of direct observations

5.27 The Workshop reviewed WS-VME-09/4, 09/9, 09/10, 09/P1, 09/P2, 09/P3 and 09/P4, as well as Tittensor et al. (2009) that included analytical and statistical options that may be useful for predicting the distributions of VMEs.

5.28 Furthermore, the Workshop noted that data-driven spatial modelling approaches (as in WS-VME-09/P1 to 09/P4) were preferable to hand-drawn geomorphology classifications, as in WS-VME-09/10, for many applications, but that geomorphology data may be better at discerning particular features of interest (e.g. seamounts) and as such may be useful as a stand-alone tool, or to modify the outputs of other modelling efforts.

5.29 The Workshop noted that the data-driven spatial modelling approaches require two kinds of data:

(i) spatially comprehensive environmental data layers (e.g. depth, water temperature);

(ii) biological datasets for the taxa in question (either presence-only, presence–absence, or abundance).

5.30 It was further noted that sufficient environmental data exists at present to effectively run these models (although assembling spatial datasets in useful format is not a trivial task), but that biological data are likely to be limiting. The following spatial modelling methods were judged to be appropriate (as in WS-VME-09/P1), in order of increasing power to make highly resolved predictions, but also increasing demand for quality data:

(i) bioregionalisation (SC-CAMLR-XXVI, Annex 9)
(ii) Environmental Niche Factor Analysis (ENFA) (Tittensor et al., 2009)
(iii) Generalised Dissimilarity Modelling (GDM) (WS-VME-09/P3)
(iv) Maximum Entropy modelling (MAXENT) (Tittensor et al., 2009)
(v) Multivariate Adaptive Regression Splines (MARS) (WS-VME-09/P2)
(vi) Boosted Regression Trees (BRT) (WS-VME-09/P4).

5.31 The Workshop noted BRT has been reviewed by WG-SAM (SC-CAMLR-XXVII, paragraph 2.1(vi)); however, it is unlikely that currently available data are adequate to inform a BRT model for VME taxa at a circumpolar scale.

5.32 The Workshop agreed that there were unavoidable trade-offs involved in the selection of any spatial modelling approach. Approaches with lower data requirements, e.g. bioregionalisation, can be implemented now and will likely produce useable results at larger scales, i.e. large-scale habitat classes within which detectable associations with VME taxa are evident. If CCAMLR requires smaller-scale outputs, i.e. actual predictions of the location of VMEs at scales comparable to VME patch size or fishing effort distributions, then methods that require larger amounts of data will be necessary, possibly requiring the allocation of additional resources to compile and prepare relevant biological datasets.

5.33 The Workshop noted that in some locations and for some environments (e.g. the Ross Sea shelf, or the South Shetland and South Orkney Islands), biological data in datasets already assembled may be adequate to allow the use of some of the more powerful methods (GDM or MARS).

5.34 The Workshop noted that extending VME spatial modelling to other regions or to some important environments (e.g. seamounts, continental slopes) may require collaborative efforts to assemble, combine and/or groom existing biological datasets. Relevant data are currently widely dispersed and stored in formats that may not currently be amenable to a global analysis.

5.35 The Workshop noted possible sources of useful biological data to inform spatial modelling for VMEs included, *inter alia*, the SCAR-MarBIN database and IPY CAML voyages.

5.36 In those areas where currently available environmental and biological data are adequate to inform the use of sophisticated spatial modelling techniques (GDM, MAXENT, MARS or BRT), the Workshop urged Member countries to pursue spatial modelling of VME distributions on smaller scales using these or similar approaches.

5.37 In areas where currently available data are inadequate, Members are encouraged to collaborate to share available environmental datasets, and to combine and assemble relevant biological datasets, to allow this work to proceed. The Workshop advised that additional resources may be required to progress this work.

Scales of Risk Areas

5.38 The Workshop recalled that Conservation Measure 22-07 currently defines the scale of Risk Areas to be defined as circles with radii of 1 n mile (although Members may define larger Risk Areas if required by domestic law). This scale was developed by considering the length of longline segments.

5.39 WS-VME-09/6 summarised analyses that were conducted to evaluate scale-dependent genetic connectivity among populations of benthic invertebrates. Although the Workshop did not identify all of the taxa considered in the paper as VME taxa, animals having a range of larval stage durations were represented in the study. In general, the results in WS-VME-09/6 were consistent with other published work (e.g. Rogers, 2007) and demonstrated that benthic invertebrates rarely demonstrate genetic connectivity across regions (e.g. between the South Shetland Islands, South Orkney Islands and Bouvet Island). Deep water appears to be a significant barrier to gene flow, even for taxa that have long larval stages.

5.40 However, although the results of WS-VME-09/6 mostly demonstrated genetic homogeneity within regions, significant genetic structure can be found even at small spatial scales in species having a pelagic larval phase (Guidetti et al., 2006). Conversely, some species which lack a pelagic larval stage, and therefore are predicted to have localised populations, show genetic homogeneity at regional scales (Hunter and Halanych, 2008). Therefore, inferring realised dispersal range from the duration of the larval phase may not be a reliable way to predict connectivity of populations. It should be noted that present levels of connectivity in populations can be difficult to infer using genetic methods because of strong historical influences on molecular markers or lack of variability of available genetic markers (Rogers, 2007).

5.41 The Workshop agreed that although the results from WS-VME-09/6 and other studies on genetic connectivity are applicable to issues surrounding spatial management to conserve marine biodiversity (e.g. to the delineation of MPAs), at present these studies provide insufficient information to determine the spatial scale of VME Risk Areas. It was noted that, if population genetics data are used to advise on broader spatial management issues, high-resolution mitochondrial markers, such as the mitochondrial control region, and nuclear markers, such as microsatellites, together are most promising for making inferences about population structure.

5.42 The Workshop agreed that taxon- or community-specific information on scales of patchiness of VME would be most useful for delivering advice on the scales of Risk Areas.

Such information might be collected in a variety of ways, including research transects with video or camera equipment or detailed by-catch information from the length of an entire longline set (paragraph 6.11), and Members were encouraged to conduct such work in the future.

5.43 Results presented in WG-EMM-09/32 indicate that VMEs may be found in clusters. The authors of the paper noted that it would be both more precautionary and more easily manageable to consider the areas within and around such clusters as potentially harbouring additional VMEs and therefore suggested that relatively large (as compared to the scale specified in Conservation Measure 22-07) Risk Areas might be defined on the basis of such clusters.

5.44 With regard to scaling Risk Areas on the basis of VME clusters (or non-random distributions of VMEs), the Workshop advised that:

(i) clusters may be shaped such that circular areas might not circumscribe appropriate Risk Areas. For example, stylasterids sometimes occur in long, narrow bands that are located on the shelf break;

(ii) the scales and shapes of clusters will likely depend on the community structure of particular VMEs and whether such communities are dominated by 'heavy' or 'light' taxa. For example, the authors of WG-EMM-09/32 noted an isolated patch of light-bodied *Umbellula* spp. (Cnidaria: Pennatulacea) that was distinct from larger VME clusters dominated by sponge communities;

(iii) inferences about the size and location of VME clusters will be influenced by operational thresholds that may be used to identify VMEs from cumulative catches or collections of VME indicator taxa within sets, hauls or samples. For example, the authors of WG-EMM-09/32 standardised research trawl catches to units of kg per 1 200 m^2 and identified VMEs at locations where catches of indicator taxa were ≥10 such standard units, but the sizes and locations of VME clusters identified by this approach would have been different if catches of, say, five standard units had been used to identify VMEs.

(iv) clusters may indicate mesoscale patchiness of VMEs and thus warrant mesoscale-sized Risk Areas.

5.45 The Workshop agreed that a number of approaches could be taken to characterise the shape and scale of VME clusters after catches or collections of VME indicator taxa have crossed thresholds signifying the likely presence of one or more VMEs. These approaches include drawing simple polygons that enclose likely VMEs (e.g. drawing convex hulls around locations where catches of indicator taxa that are greater than agreed thresholds) and using statistical models (e.g. kernel smoothers and possibly GDMs or BRTs using a variety of predictor variables) to describe local variations in the likely abundance of VMEs by including information from hauls and samples that may have been relatively close in space but yielded catches that were less than agreed thresholds (and include possible zero values). Regardless of which approach is adopted, it was also agreed that as much information as possible should be used to characterise the shape and scale of VME clusters, including environmental information. In this respect, the Workshop acknowledged its previous conclusion that there is an inverse relationship between the data requirements for modelling and the spatial scales on which advice can be provided (paragraph 5.32). Cumulating a network of Risk Areas defined on the basis of VME clusters would be akin to the process used to designate SSRUs for exploratory longline fisheries.

5.46 Following these points, the Workshop noted that the VMEs identified in WG-EMM-09/32 (and which have been notified under Conservation Measure 22-06) occur in distinct geomorphic regions identified by the work described in WS-VME-09/10. The authors of WS-VME-09/10 provided geomorphic maps to the Workshop and these maps showed that clusters of VMEs identified along the southern portion of the Bransfield Strait often occurred in a geomorphic province classified as 'shelf bank' while those identified on the western and eastern sides of the South Orkney Islands often occurred in a geomorphic province classified as 'wave-affected bank' (Figures 1 and 2).

5.47 The Workshop agreed that it may be possible to define Risk Areas for the VMEs identified in WG-EMM-09/32 on the basis of the geomorphic provinces described in WS-VME-09/10 and other information, and that doing so would result in relatively large Risk Areas occurring along the southern Bransfield Strait and around the periphery of the South Orkney Islands.

5.48 The Workshop noted that the scale of Risk Areas which might be defined around the South Orkney Islands can impact the conduct of the exploratory crab fishery which has been notified for Subarea 48.2. Conservation Measure 52-02 currently requires the exploratory crab fishery to be conducted following an experimental harvest regime (Conservation Measure 52-02, Annex 52-02/B) in which fishing effort must be distributed among twelve 0.5° latitude by 1.0° longitude blocks (Annex 52-02/C). Within this experimental harvest regime, Blocks C and E overlap the clusters of VMEs identified in WG-EMM-09/32 and notified under Conservation Measure 22-06.

5.49 Acknowledging that Conservation Measure 52-02 was agreed with an intent to collect data that would facilitate a future assessment of potential crab stocks in Subarea 48.2, the Workshop advised that a number of options should be considered for revising Conservation Measure 52-02 in light of the overlap between Blocks C and E of the experimental harvest regime and the VME clusters identified in WG-EMM-09/32:

(i) eliminate Blocks C and E from the experimental harvest regime;

(ii) redefine the 0.5° latitude by 1.0° longitude blocks used in the experimental harvest regime so that overlap with the VME clusters identified in WG-EMM-09/32 is appropriately minimised;

(iii) define a more highly resolved grid of blocks (i.e. blocks that are smaller than 0.5° latitude by 1.0° longitude) and exclude blocks that overlap with the VME clusters from the experimental harvest regime.

5.50 In advising these options, the Workshop agreed that a precautionary approach to addressing overlap between blocks in the experimental harvest regime and VME clusters is warranted because:

(i) there are multiple ways to construct, configure and fish pots; all of these factors will influence the impact that an individual haul may have on VMEs; and it is unclear how the exploratory fishery may actually be prosecuted;

(ii) a recent report (Edinger et al., 2007) indicated that few VME taxa are retained when pots are hauled on board despite observations demonstrating that pots do damage benthic invertebrates (Stone, 2006). Thus, it will likely be difficult to determine the degree to which such a fishery is impacting VMEs using fishery-dependent data alone.

5.51 The Workshop further acknowledged SC CIRC 09/41, which indicated that Argentina intends (subject to agreement by the Commission) to use pots to fish for *Dissostichus* spp. in Subareas 88.1 and 88.2 during the forthcoming season. It was advised that the issues identified in the preceding paragraph would pertain to this notification, and WG-FSA may wish to consider these points when evaluating the notification.

ENCOUNTERS AND INDICATORS OF VMEs IN THE SOUTHERN OCEAN

Taxonomic resolution required to describe VMEs

6.1 The Workshop agreed that the taxonomic resolution used in the Benthic Invertebrate Classification Guide for Potentially Vulnerable Marine Ecosystems was adequate for the purposes of data collection and analysis for determining potential VME Risk Areas.

6.2 The Workshop recommended that Porifera be separated into Hexactinellida and Demospongiae, but that the option be given to record unknowns at the coarser scale of Porifera. This situation may also be relevant to other groups such as Cnidaria.

6.3 The Workshop recognised the need for additional FAO code assignments. In particular, the need for codes for some of the lower taxonomic ranks already illustrated in the Benthic Invertebrate Classification Guide for Potentially Vulnerable Marine Ecosystems (e.g. Hexactinellida, Demospongiae).

6.4 The Workshop recommended that a hierarchy of codes be made available to scientific observers, who will then be encouraged to use the finest resolution code they are comfortable with. The ability of many observers to record at a finer resolution than absolutely necessary is supported by the analysis in TASO-09/8. The Workshop further recommended that scientific observers be encouraged to record at the finest resolution possible, and instructions to observers should reflect this. The Workshop noted the constraints of the current workload put on scientific observers, and recognised the increase in workload any additional request would create.

6.5 The Workshop suggested that hands-on training for scientific observers would considerably improve the identification of VME taxa. It was recommended that scientific observer technical coordinators liaise with their respective national Antarctic research programs to acquire example material of VME indicator taxa in order to advance this training.

6.6 In addition, the Workshop recommended the distribution of alternate field guides available, such as those produced by the UK, and by Australia for the HIMI region. The Workshop was informed about a benthic invertebrate identification guide for the Ross Sea which is under development, and which will form part of the SCAR-MarBIN field guide initiative, which, when completed over the next two years, will provide an extensive online field guide of Antarctic benthic invertebrates, available and updated through the SCAR-MarBIN website. Such a field guide could be used as an online resource for training purposes.

Indicators used by fishing vessels or during research surveys
that signal when a VME is encountered

6.7 The Workshop considered the information on VME indicators from fishery-dependent and fishery-independent sources contained in WS-VME-09/5, 09/7, WG-EMM-09/8, 09/32 and TASO-09/8 (see sections 3 and 5).

6.8 The Workshop discussed the basis for determining trigger levels used to initiate management actions and noted that the VME indicator taxa reported in 2009 have different densities and therefore agreed that the trigger levels currently in use were likely to be too high for 'light' taxa; but there was insufficient information to suggest an appropriate new level. Examples using 'heavy' and 'light' categories to separate taxa were provided in WG-EMM-09/32 and WS-VME-09/5 (paragraph 5.44). The Workshop also noted that separate trigger levels may also need to be developed for encounters with rare and unique populations (paragraphs 3.4 and 3.5).

6.9 The Workshop agreed that further examination of observer and vessel data could be used to develop revised trigger levels but noted that there was no information currently available on which to make scientific recommendations on appropriate trigger levels for pot fisheries (paragraph 5.50).

6.10 The Workshop agreed that additional data on the number, weight and type of VME indicator taxa per line segment and fish catch on the same line segments (paragraph 5.12), could be used to develop advice on the occurrence and spatial scale of VMEs.

6.11 Although increased data collection adds additional burden to vessels and scientific observers, the Workshop agreed that such collection could be undertaken on a subset of all gear deployments during the course of a single season with a well designed, targeted sampling program.

6.12 The Workshop discussed VME notifications from fisheries-independent research and noted that there are many different forms of evidence that can be used to indicate the presence of a VME including, *inter alia*, photographic images, acoustics and catches from research sampling gear, and suggested that the rationale and as much supporting information as possible should be provided when a VME notification is submitted (paragraph 3.11).

6.13 The Workshop agreed that proposed notifications under Conservation Measure 22-06 should be provided to WG-EMM for assessment and the outcomes of this evaluation should be incorporated by the proposing Member before a VME notification under Conversation Measure 22-06 is submitted to the Secretariat.

6.14 The Workshop recognised that systematic, ecologically-based criteria need to be developed to assist the Scientific Committee in defining areas as VMEs under Conservation Measure 22-06 in an objective manner.

ADVICE TO THE SCIENTIFIC COMMITTEE

7.1 The Workshop identified the following advice to the Scientific Committee and WG-EMM and WG-FSA (as indicated):

(i) Habitats and habitat-forming taxonomic groups that constitute a VME –

- life-history attributes, resistance and resilience of VME taxa (advice to WG-EMM: paragraph 3.7 and Table 1; advice to WG-FSA: paragraph 4.8);
- VME habitat-forming organisms and features specified in Conservation Measure 22-06, Annex 22-06/B (paragraph 3.11);
- review of the benthic invertebrate classification guide (paragraphs 3.13 and 3.16; advice to WG-EMM and WG-FSA: paragraph 3.14).

(ii) Extent of the impact by different bottom fishing gear (paragraphs 4.8 and 4.10).

(iii) Methods for identifying locations of VMEs –

- data from fishing vessels (paragraphs 5.9 and 5.12)
- data from fishery-independent research (paragraphs 5.17 and 5.20)
- fish diversity as indicator of VME (paragraph 5.26)
- scales of Risk Areas (paragraphs 5.44, 5.45, 5.47 and 5.49 to 5.51).

(iv) Encounters and indicators of VMEs in the Southern Ocean –

- taxonomic resolution required to describe VMEs (paragraphs 6.1 to 6.6)
- indicators used by fishing vessels or during research surveys that signal when a VME is encountered (paragraphs 6.8, 6.10, 6.13 and 6.14).

(v) Conservation Measures –

- 22-06 (paragraphs 3.13, 3.11 and 6.14)
- 22-07 (paragraphs 3.13, 5.12, 5.44, 5.45 and 5.51)
- 52.02 (paragraphs 5.49 and 5.50).

ADOPTION OF THE REPORT AND CLOSE OF THE WORKSHOP

8.1 The report of the Workshop was adopted.

8.2 In closing the meeting, Dr Jones thanked the participants and the invited experts for their scientific contributions and fruitful discussions, the rapporteurs for producing a succinct report, and the Secretariat for its support.

8.3 Dr Watters, on behalf of the participants, thanked Dr Jones for his leadership and for motivating focused discussions and resultant advice. The Workshop also thanked Ms Van Cise and the Southwest Fisheries Science Center for providing excellent facilities and Workshop arrangements.

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Table 1: Intrinsic factors contributing to the vulnerability from physical disturbance of invertebrates in the Southern Ocean.

Taxon	Habitat forming	Rare or unique populations	Longevity	Slow growth	Fragility	Larval dispersion potential	Lack of adult motility
Phylum Porifera							
Hexactinellida	H	L	H	H	H	M	H
Demospongiae	H	M	H	H	H	M	H
Phylum Cnidaria							
Actiniaria	L	L	H	L	L	M	M
Scleractinia[1]	H	M	H	H	H	M	H
Antipatharia	M	L	H	H	H	L	H
Alcyonacea	M	L	M	L	M	M	H
Gorgonacea	M	L	H	H	H	M	H
Pennatulacea	L	H	H	M	H	L	M
Zoanthida	L	L			M	L	H
Hydrozoa							
Hydroidolina	L	L			L		H
Family Stylasteridae	H	L	H	M	H	H	H
Phylum Bryozoa	H	L	H	M	H	H	H
Phylum Echinodermata							
Crinoidea: Stalked crinoid orders	L	H	H		H		H
Echinoidea: Order Cidaroida	M	L	H	H	M	H	L
Ophiuroidea: Basket and snake stars	L	L			H	L	M
Phylum Chordata: Class Ascidiacea	M	L		L	L	L	H
Phylum Brachiopoda	L	H	H	L	M	M	H
Phylum Annelida: Family Serpulidae	M	L			H	L	H
Phylum Arthropoda: Infraclass Cirripedia: Bathylasmatidae	L	H	H		M	L	H
Phylum Mollusca: Pectinidae: *Adamussium colbecki*	L	H	H	M	M	L	M
Phylum Hemichordata: Pterobranchia	M	M			M	H	H
Phylum Xenophyophora	L	H			H		H
Chemosynthetic communities	H	H	H	H	H	L	H

[1] As of 2009, almost all records of Scleractinia in the CAMLR Convention Area are of cup corals (*Desmophyllum* and *Flabellum* sp.). However, records of matrix forming scleractinians (*Madrepora oculata* and *Solenosmilia variablis*) do exist in the northernmost areas, as far south as 60°S. Cup corals are typically not habitat-forming, but Scleractinia were classified as 'high' for the habitat-forming criterion to be consistent with the approach of using the precautionary attributes of the members of each taxon.

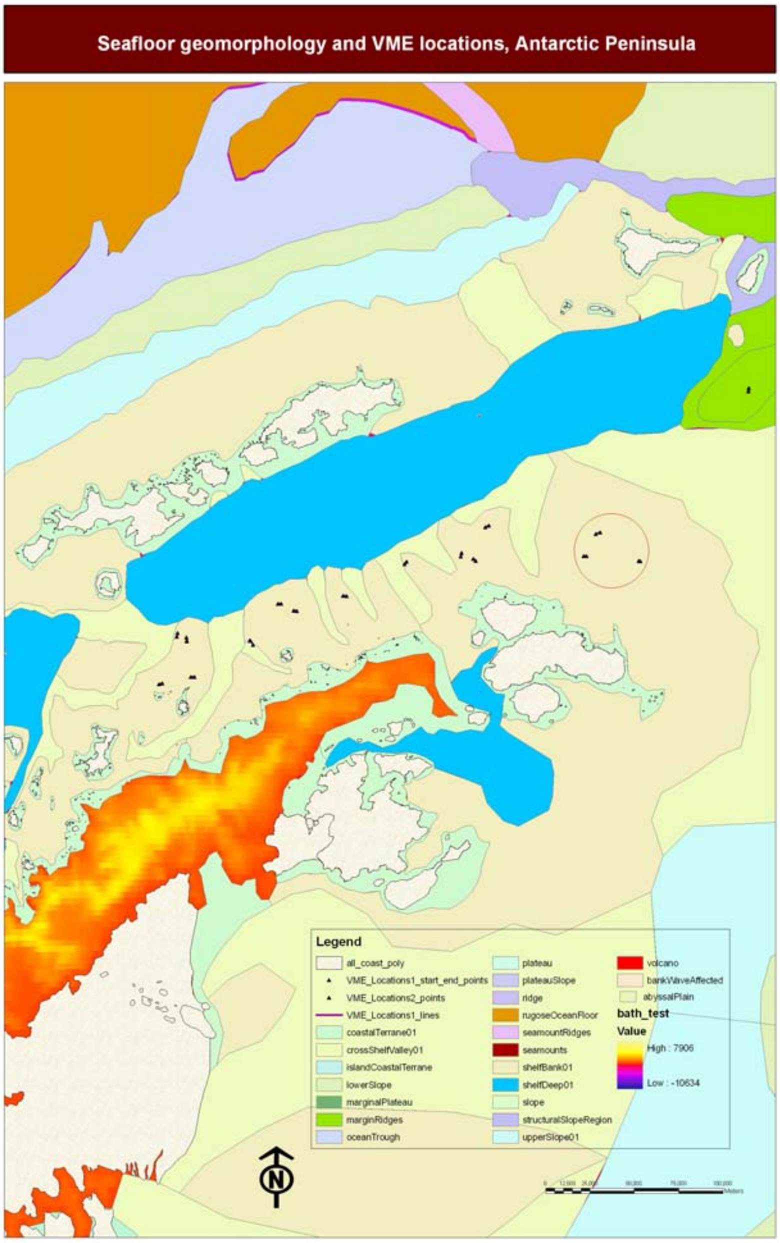

Figure 1*: Geomorphic provinces (irregular coloured polygons) around the Antarctic Peninsula and the locations of VMEs (black triangles identifying both start and end locations). The geomorphic provinces were characterised and mapped following methods described in WS-VME-09/10. The VMEs were identified in WG-EMM-09/32; start and end locations are from research trawls. VME clusters are considered loose groupings of VMEs (e.g. the grouping of VMEs on the shelf bank to the northeast of D'Urville and Joinville Islands that is annotated with a red oval).

* This figure is available in colour on the CCAMLR website.

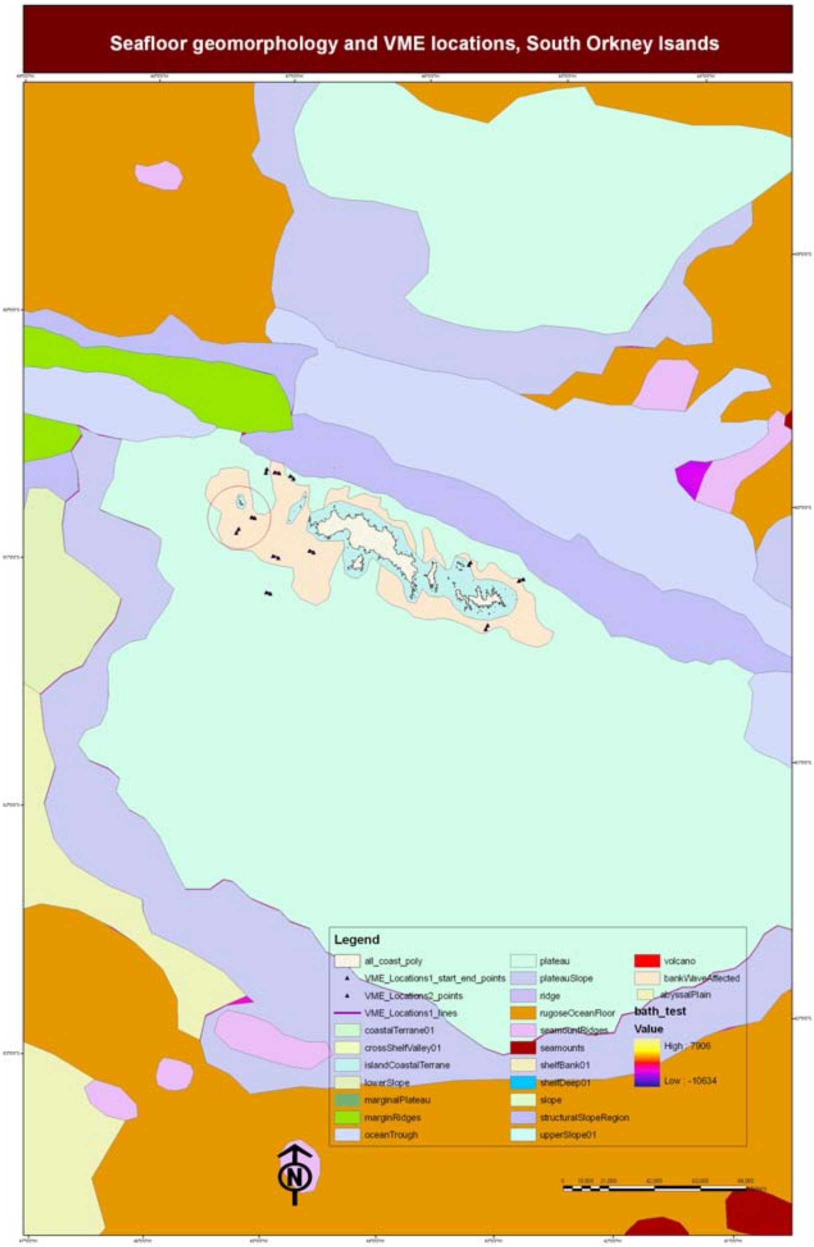

Figure 2*: Geomorphic provinces (irregular coloured polygons) around the South Orkney Islands and the locations of VMEs (black triangles identifying both start and end locations). The geomorphic provinces were characterised and mapped following methods described in WS-VME-09/10. The VMEs were identified in WG-EMM-09/32; start and end locations are from research trawls. VME clusters are considered loose groupings of VMEs (e.g. the grouping of VMEs on the shelf bank to the west of Coronation and Signy Islands that is annotated with a red oval).

* This figure is available in colour on the CCAMLR website.

APPENDIX A

LIST OF PARTICIPANTS

Workshop on Vulnerable Marine Ecosystems
(La Jolla, CA, USA, 3 to 7 August 2009)

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APPENDIX B

AGENDA

Workshop on Vulnerable Marine Ecosystems
(La Jolla, CA, USA, 3 to 7 August 2009)

1. Opening of meeting

2. Introduction
   - 2.1 Review of VMEs and bottom fishing issues in CCAMLR
   - 2.2 Current and interim CCAMLR conservation measures (CM 22-05, 22-07 and 22-07)

3. Habitats and habitat-forming taxonomic groups that constitute a VME
   - 3.1 Life-history attributes, resistance and resilience of VME taxa in the Southern Ocean
   - 3.2 Benthic invertebrate taxa consistent with VMEs
     - 3.2.1 VME habitat-forming organisms and features specified in Annex 22-06/B
     - 3.2.2 Review of Benthic Invertebrate Classification Guide
   - 3.3 Endemism and rarity of taxa

4. Extent of the impact by different bottom fishing gear

5. Methods for identifying locations of VMEs
   - 5.1 Available and potential data sources
     - 5.1.1 Fishing vessels
     - 5.1.2 Fishery independent research
   - 5.2 Fish diversity as indicator of VME
   - 5.3 Spatial extent of VMEs
     - 5.3.1 Predicting locations of VMEs in the absence of direct observations
     - 5.3.2 Scale of Risk Area designation

6. Encounters and indicators of VMEs in the Southern Ocean
   - 6.1 Taxonomic resolution required to describe VMEs
   - 6.2 Indicators used by fishing vessels or during research surveys that signal when a VME is encountered

7. Advice to the Scientific Committee

8. Report adoption and close of Workshop.

APPENDIX C

LIST OF DOCUMENTS

Workshop on Vulnerable Marine Ecosystems
(La Jolla, CA, USA, 3 to 7 August 2009)

WS-VME-09/1	Provisional and Provisional Annotated Agenda for the CCAMLR Workshop on Vulnerable Marine Ecosystems (VMEs)
WS-VME-09/2	List of Participants
WS-VME-09/3	List of Documents
WS-VME-09/4	Physical controls on coral communities on the George V Land slope: some working hypotheses A.L. Post, P.E. O'Brien, R.J. Beaman, M.J. Riddle (Australia) and L. De Santis (Italy)
WS-VME-09/5	Analysis of VME data collected by UK vessels fishing in the Ross Sea during the 2008/09 CCAMLR Season R.E. Mitchell, T. Peatman, J. Pearce and D. Agnew (United Kingdom)
WS-VME-09/6	Using genetic connectivity to identify vulnerable marine ecosystems (VMEs) in Antarctica - the issue of scale N.G. Wilson (USA)
WS-VME-09/7	Is the bycatch of vulnerable invertebrate taxa associated with high catch rates of fish in the Ross Sea longline fisheries? S.J. Parker and S. Mormede (New Zealand)
WS-VME-09/8	Identifying taxonomic groups as vulnerable to bottom longline fishing gear in the Ross Sea region S.J. Parker and D.A. Bowden (New Zealand)
WS-VME-09/9	Detection of cold seeps and hydrothermal vents P.E. O'Brien, A. Jones, G. Logan, N. Rollet and J. Kennard (Australia)
WS-VME-09/10	Antarctic-wide geomorphology as an aid to habitat mapping and locating Vulnerable Marine Ecosystems P.E. O'Brien, A.L. Post and R. Romeyn (Australia)
WS-VME-09/11	A database of life-history attributes for habitat-forming benthic taxa K.M. Martin-Smith (Australia)

WS-VME-09/12	Predicting the vulnerability of bryozoans and sponges to disturbance using life-history characteristics K. Martin-Smith (Australia)
WS-VME-09/13	Field identification guide to Heard Island and McDonald Island (HIMI) benthic invertebrates: a guide for scientific observers aboard fishing vessels T. Hibberd and K. Moore (Australia)

Other Documents

WS-VME-09/P1	Novel methods improve prediction of species' distributions from occurrence data J. Elith, C.H. Graham, R.P. Anderson, M. Dudík, S. Ferrier, A. Guisan, R.J. Hijmans, F. Huettmann, J.R. Leathwick, A. Lehmann, J. Li, L.G. Lohmann, B.A. Loiselle, G. Manion, C. Moritz, M. Nakamura, Y. Nakazawa, J.McC. Overton, A.T. Peterson, S.J. Phillips, K.S. Richardson, R. Scachetti-Pereira, R.E. Schapire, J. Soberón, S. Williams, M.S.Wisz and N.E. Zimmermann (*Ecography*, 29 (2006): 129–151)
WS-VME-09/P2	Predicting species distributions from museum and herbarium records using multi-response models fitted with multivariate adaptive regression splines J. Elith and J. Leathwick (*Diversity Distrib.*, 13 (2007): 265–275)
WS-VME-09/P3	Using generalized dissimilarity modelling to analyse and predict patterns of beta diversity in regional biodiversity assessment S. Ferrier, G. Manion, J. Elith and K. Richardson (*Diversity Distrib*., 13 (2007): 252–264)
WS-VME-09/P4	Variation in demersal fish species richness in the oceans surrounding New Zealand: an analysis using boosted regression trees J.R. Leathwick, J. Elith, M.P. Francis, T. Hastie, P. Taylor (*Mar. Ecol. Prog. Ser.*, 321 (2006): 267–281)
WS-VME-09/P5	Response of Antarctic benthic communities to disturbance: first results from the artificial Benthic Disturbance Experiment on the eastern Weddell Sea Shelf, Antarctica D. Gerdes, E. Isla, R. Knust, K. Mintenbeck, S. Rossi (*Polar Biol*., 31 (2008): 1469–1480 DOI 10.1007/s00300-008-0488-y)
WG-EMM-09/8	Encounters with vulnerable marine ecosystems in the Convention Area Secretariat

WG-EMM-09/32	Detection of vulnerable marine ecosystems in the southern Scotia arc (CCAMLR Subareas 48.1 and 48.2) through research bottom trawl sampling and underwater imagery S.J. Lockhart and C.D. Jones (USA)
WG-EMM-09/35	Predicting the vulnerability of benthic, habitat-forming organisms to disturbance using life-history characteristics K. Martin-Smith (Australia)
WG-SAM-09/21	A simulation model for evaluating management strategies to conserve benthic habitats (vulnerable marine ecosystems) which are potentially vulnerable to impacts from bottom fisheries A.J. Constable (Australia)
WG-SAM-09/P1	An impact assessment framework for bottom fishing methods in the CCAMLR area B.R. Sharp, S.J. Parker and N. Smith (New Zealand) (*CCAMLR Science*, in press)
TASO-09/8	Evaluation of VME taxa monitoring by observers from five vessels in the Ross Sea region Antarctic toothfish longline fisheries during the 2008/09 season S.J. Parker, S. Mormede, D.M. Tracey and M. Carter (New Zealand)
WG-FSA-08/19	Classification guide for potentially vulnerable invertebrate taxa in the Ross Sea longline fishery S. Parker, D. Tracey, E. Mackay, S. Mills, P. Marriott, O. Anderson, K. Schnabel, D. Bowden and M. Kelly (New Zealand)
WG-FSA-08/58	Estimating the swept area of demersal longlines based on *in situ* video footage D. Welsford and R. Kilpatrick (Australia)
SC-CAMLR-XXVI/10	Bottom fishing in high seas areas of CCAMLR Delegations of Australia and the USA
SC-CAMLR-XXVI/BG/30	Demersal fishing interactions with marine benthos in the Southern Ocean: an assessment of the vulnerability of benthic habitats to impact by demersal gears Delegation of Australia

GLOSSARY OF ACRONYMS AND ABBREVIATIONS USED IN SC-CAMLR REPORTS

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AAD	Australian Government Antarctic Division
ACAP	Agreement on the Conservation of Albatrosses and Petrels
ACAP BSWG	ACAP Breeding Sites Working Group (BSWG)
ACC	Antarctic Circumpolar Current
ACW	Antarctic Circumpolar Wave
ADCP	Acoustic Doppler Current Profiler (mounted on the hull)
ADL	Aerobic Dive Limit
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AKES	Antarctic Krill and Ecosystem Studies
ALK	Age–length Key
AMD	Antarctic Master Directory
AMES	Antarctic Marine Ecosystem Studies
AMLR	Antarctic Marine Living Resources
AMSR-E	Advanced Microwave Scanning Radiometer – Earth Observing System
ANDEEP	Antarctic Benthic Deep-sea Biodiversity
APBSW	Bransfield Strait West (SSMU)
APDPE	Drake Passage East (SSMU)
APDPW	Drake Passage West (SSMU)
APE	Antarctic Peninsula East (SSMU)
APEC	Asia-Pacific Economic Cooperation
APEI	Elephant Island (SSMU)
APEME Steering Committee	Steering Committee on Antarctic Plausible Ecosystem Modelling Efforts
APIS	Antarctic Pack-Ice Seals Program (SCAR-GSS)

APW	Antarctic Peninsula West (SSMU)
ASE	Assessment Strategy Evaluation
ASI	Antarctic Site Inventory
ASIP	Antarctic Site Inventory Project
ASMA	Antarctic Specially Managed Area
ASOC	Antarctic and Southern Ocean Coalition
ASPA	Antarctic Specially Protected Area
ASPM	Age-Structured Production Model
ATCM	Antarctic Treaty Consultative Meeting
ATCP	Antarctic Treaty Consultative Party
ATSCM	Antarctic Treaty Special Consultative Meeting
AVHRR	Advanced Very High Resolution Radiometry
BAS	British Antarctic Survey
BED	Bird Excluder Device
BIOMASS	Biological Investigations of Marine Antarctic Systems and Stocks (SCAR/SCOR)
BROKE	Baseline Research on Oceanography, Krill and the Environment
BRT	Boosted Regression Trees
CAC	Comprehensive Assessment of Compliance
cADL	calculated Aerobic Dive Limit
CAF	Central Ageing Facility
CAML	Census of Antarctic Marine Life
CAML SSC	CAML Scientific Steering Committee
CASAL	C++ Algorithmic Stock Assessment Laboratory
CBD	Convention on Biodiversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCAMLR-2000 Survey	CCAMLR 2000 Krill Synoptic Survey of Area 48

CCAMLR-IPY-2008 Survey	CCAMLR-IPY 2008 Krill Synoptic Survey in the South Atlantic Region
CCAS	Convention on the Conservation of Antarctic Seals
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CCSBT-ERS WG	CCSBT Ecologically Related Species Working Group
CDS	Catch Documentation Scheme for *Dissostichus* spp.
CDW	Circumpolar Deep Water
CEMP	CCAMLR Ecosystem Monitoring Program
CEP	Committee for Environmental Protection
CF	Conversion Factor
CircAntCML	Circum-Antarctic Census of Antarctic Marine Life
CITES	Convention on International Trade in Endangered Species
CMIX	CCAMLR’s Mixture Analysis Program
CMP	Conservation Management Plan
CMS	Convention on the Conservation of Migratory Species of Wild Animals
COFI	Committee on Fisheries (FAO)
COLTO	Coalition of Legal Toothfish Operators
CoML	Census of Marine Life
COMM CIRC	Commission Circular (CCAMLR)
COMNAP	Council of Managers of National Antarctic Programs (SCAR)
CON	CCAMLR Otolith Network
CPD	Critical Period–Distance
CPPS	Permanent Commission on the South Pacific
CPR	Continuous Plankton Recorder
CPUE	Catch-per-unit-effort
CQFE	Center for Quantitative Fisheries Ecology (USA)
CS-EASIZ	Coastal Shelf Sector of the Ecology of the Antarctic Sea-Ice Zone (SCAR)

CSI	Combined Standardised Index
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CT	Computed Tomography
CTD	Conductivity Temperature Depth Probe
CV	Coefficient of Variation
C-VMS	Centralised Vessel Monitoring System
CVS	Concurrent Version System
CWP	Coordinating Working Party on Fishery Statistics (FAO)
DCD	*Dissostichus* Catch Document
DMSP	Defense Meteorological Satellite Program
DPM	Dynamic Production Model
DPOI	Drake Passage Oscillation Index
DVM	Diel vertical migration
DWBA	Distorted wave Born approximation model
EAF	Ecosystem Approaches to Fishing
EASIZ	Ecology of the Antarctic Sea-Ice Zone
E-CDS	Electronic Web-based Catch Documentation Scheme for *Dissostichus* spp.
ECOPATH	Software for construction and analysis of mass-balance models and feeding interactions or nutrient flow in ecosystems (see www.ecopath.org)
ECOSIM	Software for construction and analysis of mass-balance models and feeding interactions or nutrient flow in ecosystems (see www.ecopath.org)
EEZ	Exclusive Economic Zone
EIV	Ecologically Important Value
ENFA	Environmental Niche Factor Analysis
ENSO	El Niño Southern Oscillation
EOF/PC	Empirical Orthogonal Function/Principal Component

EoI	Expression of Intent (for activities in the IPY)
EPOC	Ecosystem, productivity, ocean, climate modelling framework
EPOS	European *Polarstern* Study
EPROM	Erasable Programmable Read-Only Memory
eSB	Electronic version of CCAMLR's *Statistical Bulletin*
ESS	Effective Sample Size(s)
FAO	Food and Agriculture Organization of the United Nations
FEMA	Workshop on Fisheries and Ecosystem Models in the Antarctic
FEMA2	Second Workshop on Fisheries and Ecosystem Models in the Antarctic
FFA	Forum Fisheries Agency
FFO	Foraging–Fishery Overlap
FIBEX	First International BIOMASS Experiment
FIGIS	Fisheries Global Information System (FAO)
FIRMS	Fishery Resources Monitoring System (FAO)
FMP	Fishery Management Plan
FOOSA	Krill–Predator–Fishery Model (previously KPFM2)
FPI	Fishing-to-Predation Index
FRAM	Fine Resolution Antarctic Model
FV	Fishing Vessel
GAM	Generalised Additive Model
GATT	General Agreement on Tariffs and Trade
GBM	Generalised Boosted Model
GCMD	Global Change Master Directory
GDM	Generalised Dissimilarity Modelling
GEBCO	General Bathymetric Chart of the Oceans
GIS	Geographic Information System
GIWA	Global International Waters Assessment (SCAR)

GLM	Generalised Linear Model
GLMM	Generalised Linear Mixed Model
GLOBEC	Global Ocean Ecosystems Dynamics Research
GLOCHANT	Global Change in the Antarctic (SCAR)
GMT	Greenwich Mean Time
GOOS	Global Ocean Observing System (SCOR)
GOSEAC	Group of Specialists on Environmental Affairs and Conservation (SCAR)
GOSSOE	Group of Specialists on Southern Ocean Ecology (SCAR/SCOR)
GPS	Global Positioning System
GUI	Graphical User Interface
GRT	Gross Registered Tonnage
GTS	Greene et al., (1990) linear TS versus length relationship
GYM	Generalised Yield Model
HAC	A global standard being developed for the storage of hydroacoustic data
HCR	Harvest Control Rule
HIMI	Heard Island and McDonald Islands
IAATO	International Association of Antarctica Tour Operators
IASOS	Institute for Antarctic and Southern Ocean Studies (Australia)
IASOS/CRC	IASOS Cooperative Research Centre for the Antarctic and Southern Ocean Environment
IATTC	Inter-American Tropical Tuna Commission
ICAIR	International Centre for Antarctic Information and Research
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICED	Integrating Climate and Ecosystem Dynamics in the Southern Ocean
ICES	International Council for the Exploration of the Sea
ICESCAPE	Integrating Count Effort by Seasonally Correcting Animal Population Estimates

ICES WGFAST	ICES Working Group on Fisheries Acoustics Science and Technology
ICFA	International Coalition of Fisheries Associations
ICSEAF	International Commission for the Southeast Atlantic Fisheries
ICSU	International Council for Science
IDCR	International Decade of Cetacean Research
IFF	International Fishers' Forum
IGBP	International Geosphere-Biosphere Programme
IGR	Instantaneous Growth Rate
IHO	International Hydrographic Organisation
IKMT	Isaacs-Kidd Midwater Trawl
IMAF	Incidental Mortality Associated with Fishing
IMALF	Incidental Mortality Arising from Longline Fishing
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research (IGBP)
IMO	International Maritime Organization
IMP	Inter-moult Period
IOC	Intergovernmental Oceanographic Commission
IOCSOC	IOC Regional Committee for the Southern Ocean
IOFC	Indian Ocean Fisheries Commission
IOTC	Indian Ocean Tuna Commission
IPHC	International Pacific Halibut Commission
IPOA	International Plan of Action
IPOA-Seabirds	FAO International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries
IPY	International Polar Year
IRCS	International Radio Call Sign
ISO	International Organization for Standardization
ISR	Integrated Study Region

ITLOS	International Tribunal for the Law of the Sea
IUCN	International Union for the Conservation of Nature and Natural Resources – the World Conservation Union
IUU	Illegal, Unreported and Unregulated
IW	Integrated Weight
IWC	International Whaling Commission
IWC-IDCR	IWC International Decade of Cetacean Research
IWL	Integrated Weighted Line
IYGPT	International Young Gadoids Pelagic Trawl
JAG	Joint Assessment Group
JARPA	Japanese Whale Research Program under special permit in the Antarctic
JGOFS	Joint Global Ocean Flux Studies (SCOR/IGBP)
KPFM	Krill–Predatory–Fishery Model (used in 2005)
KPFM2	Krill–Predatory–Fishery Model (used in 2006) – renamed FOOSA
KYM	Krill Yield Model
LADCP	Lowered Acoustic Doppler Current Profiler (lowered through the water column)
LAKRIS	Lazarev Sea Krill Study
LMM	Linear Mixed Model
LMR	Living Marine Resources Module (GOOS)
LSSS	Large-Scale Server System
LTER	Long-term Ecological Research (USA)
MARPOL Convention	International Convention for the Prevention of Pollution from Ships
MARS	Multivariate Adaptive Regression Splines
MAXENT	Maximum Entropy modelling
MBAL	Minimum Biologically Acceptable Limits
MCMC	Monte Carlo Markov Chain

MCS	Monitoring Control and Surveillance
MDS	Mitigation Development Strategy
MEA	Multilateral Environmental Agreement
MEOW	Marine Ecoregions of the World
MFTS	Multiple-Frequency Method for in situ TS Measurements
MIA	Marginal Increment Analysis
MIZ	Marginal Ice Zone
MLD	Mixed-layer Depth
MODIS	Moderate Resolution Imaging Spectroradiometer
MP	Management Procedure
MPA	Marine Protected Area
MPD	Maximum of the Posterior Density
MRAG	Marine Resources Assessment Group (UK)
MRM	Minimum Realistic Model
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
MV	Merchant Vessel
MVBS	Mean Volume Backscattering Strength
MVP	Minimum Viable Populations
MVUE	Minimum Variance Unbiased Estimate
NAFO	Northwest Atlantic Fisheries Organization
NASA	National Aeronautical and Space Administration (USA)
NASC	Nautical Area Scattering Coefficient
NCAR	National Center for Atmospheric Research (USA)
NEAFC	North East Atlantic Fisheries Commission
NI	Nearest Integer
NIWA	National Institute of Water and Atmospheric Research (New Zealand)

nMDS	non-Metric Multidimensional Scaling
NMFS	National Marine Fisheries Service (USA)
NMML	National Marine Mammal Laboratory (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NPOA	National Plan of Action
NPOA-Seabirds	FAO National Plans of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries
NRT	Net Registered Tonnage
NSF	National Science Foundation (USA)
NSIDC	National Snow and Ice Data Center (USA)
OBIS	Antarctic Regional Ocean Biogeographic Information System
OCCAM Project	Ocean Circulation Climate Advanced Modelling Project
OCTS	Ocean Colour and Temperature Scanner
OECD	Organisation for Economic Cooperation and Development
OM	Operating Model
PAR	Photosynthetically Active Radiation
PBR	Permitted Biological Removal
PCA	Principal Component Analysis
PCR	Per Capita Recruitment
pdf	Portable Document Format
PDF	Probability Density Function
PF	Polar Front
PFZ	Polar Frontal Zone
PIT	Passive Integrated Transponder
PRP	CCAMLR Performance Review Panel
PS	Paired Streamer Line
PTT	Platform Terminal Transmitter

RES	Relative Environmental Suitability
RFB	Regional Fishery Body
RFMO	Regional Fishery Management Organisation
RMT	Research Midwater Trawl
ROV	Remotely-Operated Vehicle
RPO	Realised Potential Overlap
RTMP	Real-Time Monitoring Program
RV	Research Vessel
RVA	Register of Vulnerable Areas
SACCB	Southern Antarctic Circumpolar Current Boundary
SACCF	Southern Antarctic Circumpolar Current Front
SAER	State of the Antarctic Environment Report
SAF	Sub-Antarctic Front
SBDY	Southern Boundary of the ACC
SBWG	Seabird Bycatch Working Group (ACAP)
SCAF	Standing Committee on Administration and Finance (CCAMLR)
SCAR	Scientific Committee on Antarctic Research
SCAR-ASPECT	Antarctic Sea-Ice Processes, Ecosystems and Climate (SCAR Program)
SCAR-BBS	SCAR Bird Biology Subcommittee
SCAR-CPRAG	Action Group on Continuous Plankton Recorder Research
SCAR-EASIZ	Ecology of the Antarctic Sea-Ice Zone (SCAR Program)
SCAR-EBA	Evolution and Biodiversity in Antarctica (SCAR Program)
SCAR-GEB	SCAR Group of Experts on Birds
SCAR-GOSEAC	SCAR Group of Specialists on Environmental Affairs and Conservation
SCAR-GSS	SCAR Group of Specialists on Seals
SCAR-MarBIN	SCAR Marine Biodiversity Information Network

SCAR/SCOR-GOSSOE	SCAR/SCOR Group of Specialists on Southern Ocean Ecology
SCAR WG-Biology	SCAR Working Group on Biology
SC-CAMLR	Scientific Committee for CCAMLR
SC CIRC	Scientific Committee Circular (CCAMLR)
SC-CMS	Scientific Committee for CMS
SCIC	Standing Committee on Implementation and Compliance (CCAMLR)
SC-IWC	Scientific Committee for IWC
SCOI	Standing Committee on Observation and Inspection (CCAMLR)
SCOR	Scientific Committee on Oceanic Research
SD	Standard Deviation
SDWBA	Stochastic Distorted-wave Born Approximation
SEAFO	South East Atlantic Fisheries Organisation
SeaWiFS	Sea-viewing Wide field-of-view Sensor
SG-ASAM	Subgroup on Acoustic Survey and Analysis Methods
SGE	South Georgia East
SGSR	South Georgia–Shag Rocks
SGW	South Georgia West (SSMU)
SIBEX	Second International BIOMASS Experiment
SIC	Scientist-in-Charge
SIOFA	Southern Indian Ocean Fisheries Agreement
SIR Algorithm	Sampling/Importance Resampling Algorithm
SMOM	Spatial Multispecies Operating Model
SO-CPR	Southern Ocean CPR
SO GLOBEC	Southern Ocean GLOBEC
SOI	Southern Oscillation Index
SO JGOFS	Southern Ocean JGOFS

SOMBASE	Southern Ocean Molluscan Database
SONE	South Orkney North East (SSMU)
SOOS	Southern Ocean Observing System
SOPA	South Orkney Pelagic Area (SSMU)
SOS Workshop	Southern Ocean Sentinel Workshop
SOW	South Orkney West (SSMU)
SOWER	Southern Ocean Whale Ecology Research Cruises
SPA	Specially Protected Area
SPC	Secretariat of the Pacific Community
SPGANT	Ocean Colour Chlorophyll-*a* algorithm for the Southern Ocean
SPM	Spatial Population Model
SSB	Spawning Stock Biomass
SSG-LS	The Standing Scientific Group on Life Sciences (SCAR)
SSM/I	Special Sensor Microwave Imager
SSMU	Small-scale Management Unit
SSMU Workshop	Workshop on Small-scale Management Units, such as Predator Units
SSRU	Small-scale Research Unit
SSSI	Site of Special Scientific Interest
SST	Sea-Surface Temperature
STC	Subtropical Convergence
SWIOFC	Southwest Indian Ocean Fisheries Commission
TASO	ad hoc Technical Group for At-Sea Operations (CCAMLR)
TDR	Time Depth Recorder
TEWG	Transitional Environmental Working Group
TIRIS	Texas Instruments Radio Identification System
TISVPA	Triple Instantaneous Separable VPA
ToR	Term of Reference

TrawlCI	Estimation of Abundance from Trawl Surveys
TS	Target Strength
TVG	Time Varied Gain
UBC	University of British Columbia (Canada)
UCDW	Upper Circumpolar Deep Water
UN	United Nations
UNCED	UN Conference on Environment and Development
UNEP	UN Environment Programme
UNEP-WCMC	UNEP World Conservation Monitoring Centre
UNCLOS	UN Convention on the Law of the Sea
UNFSA	the United Nations Fish Stock Agreement is the 1995 United Nations Agreement for the Implementation of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
UNGA	United Nations General Assembly
UPGMA	Unweighted Pair Group Method with Arithmetic Mean
US AMLR	United States Antarctic Marine Living Resources Program
US LTER	United States Long-term Ecological Research
UV	Ultra-Violet
UW	Unweighted
UWL	Unweighted Longline
VME	Vulnerable Marine Ecosystem
VMS	Vessel Monitoring System
VOGON	Value Outside the Generally Observed Norm
VPA	Virtual Population Analysis
WAMI	Workshop on Assessment Methods for Icefish (CCAMLR)
WCO	World Customs Organization
WFC	World Fisheries Congress

WCPFC	Western and Central Pacific Fisheries Convention
WG-CEMP	Working Group for the CCAMLR Ecosystem Monitoring Program (CCAMLR)
WG-EMM	Working Group on Ecosystem Monitoring and Management (CCAMLR)
WG-EMM-STAPP	Subgroup on Status and Trend Assessment of Predator Populations
WG-FSA	Working Group on Fish Stock Assessment (CCAMLR)
WG-FSA-SAM	Subgroup on Assessment Methods
WG-FSA-SFA	Subgroup on Fisheries Acoustics
WG-IMALF	ad hoc Working Group on Incidental Mortality Arising from Longline Fishing (CCAMLR)
WG-IMAF	ad hoc Working Group on Incidental Mortality Associated with Fishing (CCAMLR)
WG-Krill	Working Group on Krill (CCAMLR)
WG-SAM	Working Group on Statistics, Assessments and Modelling
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WSC	Weddell–Scotia Confluence
WS-Flux	Workshop on Evaluating Krill Flux Factors (CCAMLR)
WS-MAD	Workshop on Methods for the Assessment of *D. eleginoides* (CCAMLR)
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization
WWD	West Wind Drift
WWW	World Wide Web
XBT	Expendable Bathythermograph
XML	Extensible Mark-up Language
Y2K	Year 2000
YCS	Year-class Strength(s)