ANTARCTIC TREATY CONSULTATIVE MEETING 2006

Agenda Item: CEP 6b

Presented by: SCAR

Original: English

SCAR Report on Marine Acoustics and the Southern Ocean

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Introduction

1. At XXIII ATCM in 2000 some Parties first expressed an interest in the potential effects of marine acoustic equipment on marine animals in the Southern Ocean, asking for an assessment of the available evidence to guide them in permitting procedures. At that time there were differences between national permitting agencies in assumptions about the level of impact on marine animals that acoustic equipment could have, resulting in differing requirements for environmental impact assessment and mitigation.

2. In order to provide all Parties with an up to date assessment of what was known SCAR convened an international workshop in Cambridge in 2001 from which an Information Paper (IP24) and Working Paper (WP23) were provided to XXV ATCM for discussion.

3. This first assessment reviewed the literature, considered the available evidence for mitigation measures and suggested a number of conclusions. Principal amongst these were that acoustic releases and similar low power sources were not considered any threat, that the evidence available did not justify a ban on seismic surveys or scientific echo-sounders in Antarctic waters, that mitigation strategies should be investigated to evaluate their effectiveness, and that further research and monitoring should be undertaken by the agencies to fill some of the considerable lacuna in the available evidence.

4. The field of marine acoustics is however one of continuing and rapid development at a global scale. Since many of the species about which concern had been expressed (especially cetaceans) are migratory it was considered important to continue to review new evidence and update Parties on its significance. Accordingly SCAR held a second international workshop in Cambridge in 2004, using it to provide IP 78 for XXVII ATCM. In this paper a summary of major advances was provided (dealing specifically with considerations of Temporary Threshold Shift in animal hearing, and lessons drawn from beaked whale strandings) whilst the bulk of the paper provided the first systematic risk evaluation of 10 equipment types, linking the consequences and the likelihood in a matrix system. A much fuller account of the workshop conclusions has been posted as a SCAR Report on the SCAR web site.

5. The discussion engendered at XXVII ATCM by this paper indicated that many Parties wished to be kept up to date with developments in this highly technical field. SCAR was therefore asked to bring a further report to XXIX ATCM, which reflected the latest scientific understandings generally and how these were relevant to the Southern Ocean.

6. To consider the evidence SCAR convened its third international workshop, this time kindly hosted by the University of Cadiz in Spain in January 2006 over a period of three days. The open workshop was advertised through SCAR and COMNAP to all countries active in the Antarctic. Of particular importance was the participation of the Scientific Director of the International Whaling Commission as well as scientists who had taken part in the recent Marine Mammal Commission workshops on marine acoustics as well as ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas) and ASCOBAMS (Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area).

7. In addition SCAR had requested COMNAP to determine as far as possible details of all the marine acoustic equipment currently in use on research and national logistic vessels operating in the Southern Ocean. This has been submitted as an Information paper by COMNAP.

8. The purpose of the Cadiz workshop was to review improvements in knowledge and understanding of the interactions between marine mammals and noise generated by human activities in the Southern Ocean, as well as improving the original risk assessments for particular equipment types and considering the effectiveness of recommended mitigation measures.

9. As well as individual scientific papers the participants had available the draft report from the Marine Mammal Commission International Workshop in London in 2004, the report "Marine mammal populations and ocean noise – determining when noise causes biologically significant effects" published in 2005 by the US National Research Council, various reports submitted to the Scientific Committee of the IWC, a paper detailing the development of an acoustic model for *Polarstern* undertaken by AWI, and a progress report on discussions of a workshop at Oxford in October 2005 on international priorities in marine acoustic research.

Objectives of this paper

10. This paper will provide the Recommendations arising from the discussions at the Cadiz Workshop, which took into account the relevant latest developments from elsewhere in the world. Much of the research elsewhere is on species that do not occur in the Antarctic or on equipment that is not deployed there and this has been not been considered in any detail. Major sources of information were the reports of the Marine Mammal Commission meetings, the National Research Council Report "Marine mammals populations and ocean noise" and scientific papers submitted to IWC Scientific Committee.

11. The COMNAP data is provided in a separate Information Paper. Information was obtained from virtually all the countries operating the 39 ships identified by COMNAP. This of course excludes all fishing and tourist vessels as well as some military vessels operated in support of national programmes. For the purpose of this paper SCAR has assumed that no military activities take place within the area that might require the use of military sonars for locating submarines and has therefore excluded them from the analysis. The risk matrices have been reconsidered in the light of the equipment inventory. The report on the recent detailed studies on *Polarstern* discussed at the Workshop is provided as a separate Information Paper as an example of how national operators can make progress in this field by undertaking dedicated studies to improve predictive capabilities for particular configurations of scientific equipment.

12. The wider aspects of marine acoustics are also discussed in terms of setting the potential impacts within a noise framework that recognises the level of background noise in the environment, the continuing limitations in Antarctic data as Parties have so far not developed any coherent research initiatives, and the importance of setting the correct management objectives before implementing control procedures.

13. The probable effectiveness of mitigation measures is considered in the light of available data and suggestions for future work are outlined.

Setting management objectives

14. In any attempt to consider the implications of additional sound to an ocean area it is necessary to provide a framework of the ambient natural noise levels and patterns against which the significance of the anthropogenic activities can be assessed. The Southern Ocean is driven by major current systems, whipped throughout the year by storms and for almost six months of the year much of it is covered by sea ice. In addition, in the Scotia Sea area especially, and in some other areas, there are continual noises from natural seismic events associated with tectonic plate margins. The break-up of sea ice is a noisy activity as are the sounds produced by icebergs dragging along the sea bottom.

15. In addition to these natural noises and those produced by the animals themselves there are noise inputs from the ships using the Southern Ocean, including that from ships breaking their way through pack ice. Whilst the numbers of ships in the Southern Ocean is still small in absolute terms there is a continuing upward trend from tour ships and from fishing vessels. In many cases the tracks these ships use are limited and repetitive, as are those used by the Antarctic national operators undertaking resupply of the research stations, leading to a seasonal pattern of noise along distinct "highways" with additional limited noise from short term science activities elsewhere.

16. In setting management objectives for marine acoustics it is essential to be clear about what is to be achieved and why. For example, the logical and scientific approach is to define what is believed to be threatened, the extent of the potential impact and the effectiveness of the mitigation measures that could be used in the context of the existing environment. For warm-blooded animals it has been customary to consider the impacts on individuals rather than on populations and yet it is the population that is normally considered for conservation purposes. So far there has been almost no consideration of possible impacts on cold-blooded animals. There has been focussed concern about individual instruments but little discussion of the entire range of anthropogenic noise.

17. The Workshop suggests that decisions by any permitting authority should assess the potential impact of any localised and limited science activities in the context of all other noise sources in the ocean. In examining this environmental context it would be sensible to include all ship-borne activities in the Southern Ocean that have potential impacts on the ecosystem, which would include all fishing activities.

Sound in the Southern Ocean

18. The natural sounds make the Southern Ocean a very noisy environment. Not only is there continuous noise from the waves but also the sounds from sea ice moving and breaking, ice shelves calving and icebergs ploughing the bottom are additional seasonal inputs. There are almost continual seismic noises from along the plate margins as well as underwater volcanic activity around the South Sandwich Trench. Many of these sounds are at low frequencies and can travel considerable distances, affecting wide areas. Characterising this both in terms of frequency, intensity and variability requires some new monitoring initiatives.

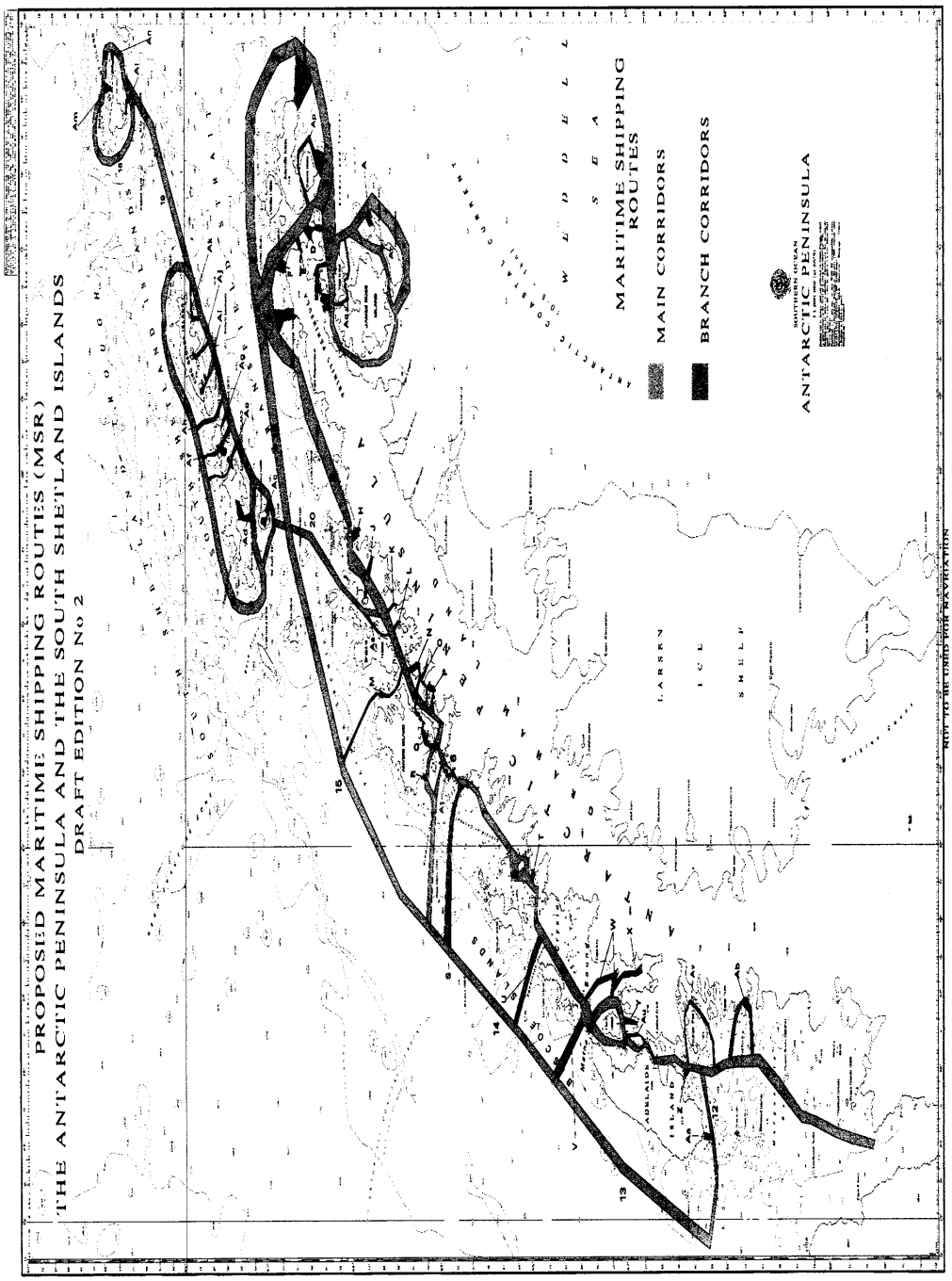
19. Despite the size of the Southern Ocean there are probably few areas that have not been subjected to anthropogenic noise at some time. However there are some areas that are little visited with much of the continuing activity concentrated into a limited number of areas. Any logistics or tourist ships, fishing, scientific whaling, marine scientific research and even helicopters can produce localised acoustic inputs. It is also important to recognise that military activities can legally take place between the Antarctic Polar Front and 60ºS and the effects from these could be felt within the Treaty area.

20. The scientific need is to determine both the background noise and the additional general anthropogenic component in order to allow a dispassionate assessment of the possible effects of the use of individual instruments. No assessment of the pattern of ambient noise for any site within the Treaty area has been published although it is believed that some potentially suitable data may have been collected in previous years during whale monitoring operations. At present there is only one monitoring station in the Treaty area, at Neumayer, although there are plans for passive acoustics for cetacean monitoring around South Georgia, which could yield some background data.

21. The Workshop concluded that what is also needed is more monitoring stations in the more heavily used area of the Peninsula (for example Gerlache Strait) to allow the addition of the summer ship noise to background. It is believed that CCAMLR have data on fishing boat locations that could in principle be mapped on to the tracks of cruise ships and national logistic ships whilst data on the previous location of marine geophysics are also available.

22. Planned hydrographic surveys (under the aegis of the International Hydrographic Bureau) on main tourist routes around the Antarctic Peninsula (indicative tracks are shown in Fig 1) will require the continued use of swath bathymetry for several years to provide a well-charted safe passage. The routes selected will then become the major marine highways for routine use.

23. It is not clear that there is any attempt or any mechanism at present to co-ordinate cruise plans for tourist vessels, scientific surveys, logistic resupply vessels and hydrography to minimise the environmental impact, as is required under Article 3 of the Protocol.


PROPOSED MARITIME SHIPPING ROUTES (MSR)
THE ANTARCTIC PENINSULA AND THE SOUTH SHETLAND ISLANDS
DRAFT EDITION No 2
MARITIME SHIPPING ROUTES
MAIN CORRIDORS
BRANCH CORRIDORS
ANTARCTIC PENINSULA
SOUTHERN OCEAN
WEDDELL SEA
LARSEN ICE SHELF
NOT TO BE USED FOR NAVIGATION

Revised Risk Assessments for acoustic equipment in use in the Southern Ocean

24. Work by a previous SCAR workshop had provided a risk assessment matrix for specific types of acoustic equipment. In revisiting these risk assessments there was extensive discussion at the present workshop of the ability to assess the consequences for populations as well as for individuals. In the light of discussions at other meetings it was concluded that it was not yet possible to draw conclusions on the effects on populations of temporary exposure to any anthropogenic acoustics, and that even at the level of individual animals for most Antarctic species the data remained poor. The workshop concluded that the situation remained largely unchanged from two years ago not least because of the lack of research directed at these questions.

25. A key part of any risk assessment is a consideration of how effectively and accurately can the presence of cetaceans be detected. The most common approach is visual detection (a key basis for some of the mitigation procedures) using trained observers. From the bridge of a ship the effective search width is typically 1-2 km using 25x150 binoculars in good weather conditions. Experienced observers are reported to have sighting rates approximately twice as high as less experienced observers but the ability to detect is also linked to the species of whales (which spend different amounts of time at the surface) and to the sea state. Detection rates drop by an order of magnitude as the sea state deteriorates from Beaufort 1 to Beaufort 5. It is normally easier to see humpbacks and southern right whales than the much smaller beaked whales. Efforts are underway to improve on these human observers and provide 24-hour coverage. Germany is testing a new system of infrared cameras with complex image analysis software that gives an immediate audio alert if a whale is detected.

26. There has been considerable effort put into passive acoustic detection by listening to the sounds that cetaceans make. Since most cetaceans make some sound this method allows their presence to be detected when they are submerged and invisible to the ship-based observer. However, some whales remain silent for long periods so the lack of a signal cannot be assumed always to indicate the absence of animals. Localisation of the animals requires several hydrophones and data processing to determine the bearings and may not be a practical system for continuous track seismic work.

27. Active sonar detection is also possible but detection rates can yield a high level of false returns making this a very unsatisfactory field tool at present. Most recently there have been reports of active sonar detection of fish shoals over large areas and this technology may provide a way forward for widely dispersed cetaceans in due course. Because active sonar increases the acoustic energy in the environment and can be heard by at least some of the animals, its use for mitigation has been questioned.

28. The risk matrix is constructed using qualitative descriptions of impacts or consequences versus qualitative description of likelihood. The key issues are the detailed descriptions of the levels in each matrix and the number of levels. All consequences attempt to address both impacts on individuals and on populations.

Consequences – In defining consequences or impacts, we define injuries as including auditory damage and reduced hearing sensitivity as well as other trauma. Only one of the impacts listed is necessary to be classified at a level.
Likelihood – The likelihood is based on what is known about the equipment, experience with the marine environment and knowledge of the most sensitive species. For the more severe consequences, we have tried to ask the question;
"How could you produce such a result with such equipment?"

This approach is directed at individual surveys in Antarctic waters. Issues of long-term effects are not discussed.

Consequence

Level	Detailed description
1	Individuals show no response, or only a temporary (minutes) behaviour change. No change to environment or populations.
2	Individuals show short term (hours) behaviour change. Temporary displacement of a small proportion of a population; small proportion of habitat affected; no impact on ecosystem function.
3	Longer term (days) simultaneous displacement of a higher proportion of a population; disruption to behaviour; interference with feeding.
4	Simultaneous displacement and disruption over a period of weeks to behaviour and feeding of a large part of a population, a few injuries, some interference with breeding success
5	Long term displacement (months) of much of a population, injuries common, substantial interference in a season's breeding success, fatalities rare
6	Injuries very common, fatalities, population jeopardised, long term displacement from large or important area

Likelihood

Level	Description
A	Expected in almost all instances
B	Will probably occur in most cases
C	Could occur in some cases
D	Could occur in a few cases
E	May occur in exceptional circumstances

29. **Acoustic Release - 7.5-50 kHz**

Acoustic releases are located and released using a sequence of pings over a short time. The source levels are low compared to the level required to produce TTS and the noise might displace one or two animals in unusual circumstances. Regarded as benign by the Berlin Workshop.

Output: 185-190 dB re 1 _Pa @ 1m. Omnidirectional. Pings of millisecond length over about 15 minutes during recovery.

Consequences

Likelihood	1.	2.	3.	4.	5.	6.
A	X					
B						
C						
D						
E						

30. **Bathymetric echo sounder, single beam, 12 kHz**

Bathymetric echo sounders are essential for safe navigation. All vessels are required to carry and operate an echo sounder to reduce the chances of grounding. Echo sounders that record data are essential for production of navigational charts. Bathymetry is essential for mapping sea floor morphology that is a central data set in oceanography, marine geology and marine biology. The echo sounder assessed here is typical of systems widely used for recording single beam data on research vessels worldwide.

Output**:** 232 dB re 1 _Pa @ 1m, pulse lengths of 1 ms.

Main beam vertically below ship, around 10 degree beam width.

Consequences

Likelihood	1.	2.	3.	4.	5.	6.
A	X					
B						
C						
D		X				
E			X			

Calculations of the volume affected by the echo sounder and comparisons between its outputs and TTS data indicate that the chance of TTS is only in a small volume up to a few meters immediately under the transducers, making Level 4 and above impacts inconceivable. Some minor displacement of animals may occur for a short period.

31.**Echo sounder array for mapping krill distributions, single beam, 38, 70 120 and 200 kHz**

Echo sounder arrays such as this one are important tools for research into marine ecosystems. They provide images of the distribution of organisms in the water column and reduce the amount of trawling needed in research that feeds directly into CCAMLR deliberations.

Output: Based on Simrad EK 60 system, 230 dB re 1 _Pa @ 1m, 4 ms pulse length, 7^{o} beam width.

Consequences

Likelihood	1.	2.	3.	4.	5.	6.
A	X					
B						
C						
D		X				
E			X			

Similar to the 12 kHz system above but with a smaller volume affected and greater absorption of the outputs. Again, the volume affected by the echo sounder indicates that the chance of TTS is only in a small volume up to a few meters immediately under the transducers, making Level 4 and above impacts inconceivable. Some minor displacement may occur.

32.**Multibeam echo sounder**
Multibeam echo sounders provide depth soundings in a fan shaped swath beneath the vessel. They provide a better picture of sea floor topography than single beam echo sounders. Typically, they provide 120 soundings per ping compared to one by the single beam system. These data are essential for safe navigation and for the understanding of sea floor habitats and geology.

Output: Frequency, 12 kHz, or 30 kHz systems, ~236 dB re 1 _Pa @ 1m (common seabed mapping tool).

Based on two systems: SIMRAD EM300 multibeam sonar which is a middle depth range system, that operates at a frequency of 30 kHz and a swath width of 150^{o} x 1^{o}. Echo sounder pulses (pings) are emitted every 4-8 seconds depending on water depth and are of short duration (0.7-15 milliseconds).

SEABEAM 2000 multibeam sonar that is a deep water 12 kHz system. It has a swath width of 120^{o} x 1^{o}. Echo sounder pulses (pings) are emitted every 4-8 seconds depending on water depth and are of short duration (2-20 milliseconds).

Consequences

Likelihood	1.	2.	3.	4.	5.	6.
A	X					
B						
C		X				
D						
E			X			

The high output and broad width of the swath abeam of the vessel makes displacement of animals more likely, although the fore and aft beam widths of multibeams are still small and the pulse length is very short making the risk of insonification above TTS levels still quite small, so the likelihood of auditory or other injuries seems low. This should be compared to the likelihood of ship strikes to gain a perspective of the risks. Displacement might occur in the form of displacement from the survey area for days during the systematic mapping of an area.

31. **Sub bottom profiler 3.5 kHz**
Sub-bottom profilers are used to image the near–surface geology of the sea bed. They are an essential tool for sampling marine sediment archives of climate change and for mapping different sea bed types that govern the benthic communities present.
Output: typical sub-bottom profiler with output of 204 dB re 1 _Pa @ 1m, 30^{o} beam width and pulse lengths of 1, 2 and 4 ms.

Consequences

Likelihood	1.	2.	3.	4.	5.	6.
A	X					
B						
C						
D		X				
E			X			

Similar risks to other single beam systems. TTS data indicate that an animal would require 250 to 1000 pulses to produce TTS. The wider beam width of the sub-bottom profiler would mean a larger area ensonified than other higher frequency, single beam echo-sounders. An exception to this would be the parametric arrays now used on some vessels. These echo sounders have dominant frequencies around 3 kHz but have a beam width of less than 10º. Therefore they ensonify a smaller volume of ocean than conventional sub-bottom profilers.

32. **Small seismic system - 2 air guns**.

Airgun seismic reflection systems are used to image sea floor geology deeper than sub-bottom profilers. Small arrays are used to image the top tens of meters of sea floor in moderate detail. These systems are important in palaeoclimate studies.
Output: The air guns in this example (GI guns) use a 45 cu. inch generating chamber. The output from 2 GI guns working together is a maximum of 229 dB re 1 μPa @1 m (0-p). The area > 180 dB re 1 μPa would be approximately 50 m in radius (LGL, 2003).

Consequences

Likelihood	1.	2.	3.	4.	5.	6.
A	X					
B		X				
C			X			
D						
E				?		

The small airgun system considered here would have a similar likelihood of severe impacts to multibeam surveys in that some herding and trapping of animals would be necessary for the impact. Lesser impacts would be more likely than multibeam because of frequency content and the near-omnidirectional nature of the beam; however slow ship speed would facilitate avoidance.

33. **Large airgun array - 8575 cu inches**

Large airgun arrays are used to image deep below the sea floor, sometimes through the earth's crust into the upper mantle. These arrays are used to study the structure of the earth's crust and long-term climate history of the earth. The example used in the risk matrix is the largest array used for scientific purposes. The petroleum industry uses many air gun arrays for exploration that are usually in the range of 3000-4000 cu inches so this example is an "end member" of possible systems.

Output: 256 dB re 1 μPa @ 1 m (0-p) (far field), lines spaced tens of kilometres apart, ship moving at 5 knots. The area > 180 dB re 1 μPa would be approximately 900 m in radius (LGL, 2003). Other large arrays typically have outputs of about 240 dB re 1 μPa @ 1 m (0-p).

Consequences

Likelihood	1.	2.	3.	4.	5.	6.
A		X				
B			X			
C						
D						
E				?	?	

This array is one of the largest operating in a research context and has not been deployed in the Antarctic to our knowledge. Large airgun surveys are certainly known to displace animals ranging from cetaceans to fish. The duration of displacement will depend on survey design. Closely spaced lines in a small area as with 3-D surveys would mean that displacement from a region for the duration of the survey is highly likely, however 3-D surveys are unlikely in the Antarctic for the foreseeable future. A large airgun array produces sound

levels probably in excess of those needed to damage animal hearing although the near-field sound is spread among the 20 airguns over several hundred square meters and source levels do not reach the nominated far-field figure. Animals may still approach the array, possible because airguns sound like breaching whales (McCauley, *et al*., 2000) and because the pulse length is too short for the nervous system to register the full loudness of the signal (McCauley, pers. comm., 2004). Management of individual animals that approach the vessel is an issue here but the Action Group did not think severe impacts on populations likely.

34. **Shipping**

We considered the risk of Antarctic shipping operations to marine life, including noise and the potential for ship strikes. The previous reports considered ship strikes and ship noise together and this is continued here. The level 4 risks for individuals reflect anecdotal evidence for ship strikes, involving pack ice seals and penguins during ice breaking. For cetaceans, ship collisions are regarded as a known risk globally but seem very rare in the Antarctic possibly because ship density is low and resupply, research and tourist vessels are slower than many modern cargo vessels. Risks to populations were considered to be very low.

Sound source levels can reach up to 200 dB re 1 μPa @ 1 m for ice breaking activities. The difference between ship noise and most scientific instruments is that ship noise is continuous for the period the vessel is in an area. Continuous noise has more potential to interfere with communications and can cause TTS at lower levels than pulsed sound

Consequences

Likelihood	1.	2.	3.	4.	5.	6.
A	X					
B		X				
C			X			
D				X		
E						

Most parts of Antarctica receive low numbers of ship visits per year so ship noise is presently unlikely to be a problem. However, COMNAP found that the Antarctic Peninsula received at least 70 ship visits in 2004/2005, many of which were tourist vessels, which tend to visit a few localities. While this number of visits is low compared to other sea ways (e.g. Straits of Gibraltar has 91,000 ship passages per year), Antarctic vessels are concentrated in the summer months. As Antarctic tourism focuses on wildlife, many of these localities are breeding sites. Tourist vessels also try to avoid meeting each other to maintain the "wilderness experience" for passengers. Thus sites could be visited repeatedly by many vessels during the summer. These observations suggested that ship noise from tourist vessels might have the highest potential for longer-term impacts on Antarctic wildlife.

37. **Conclusions of Risk Evaluation**

a. The Workshop concluded that the risks of most ***scientific*** acoustic techniques likely to be used in the Antarctic were less than or comparable to shipping activities on their own.

b. Even airgun seismic surveys were not considered a threat to populations although TTS is certainly possible in some instances.

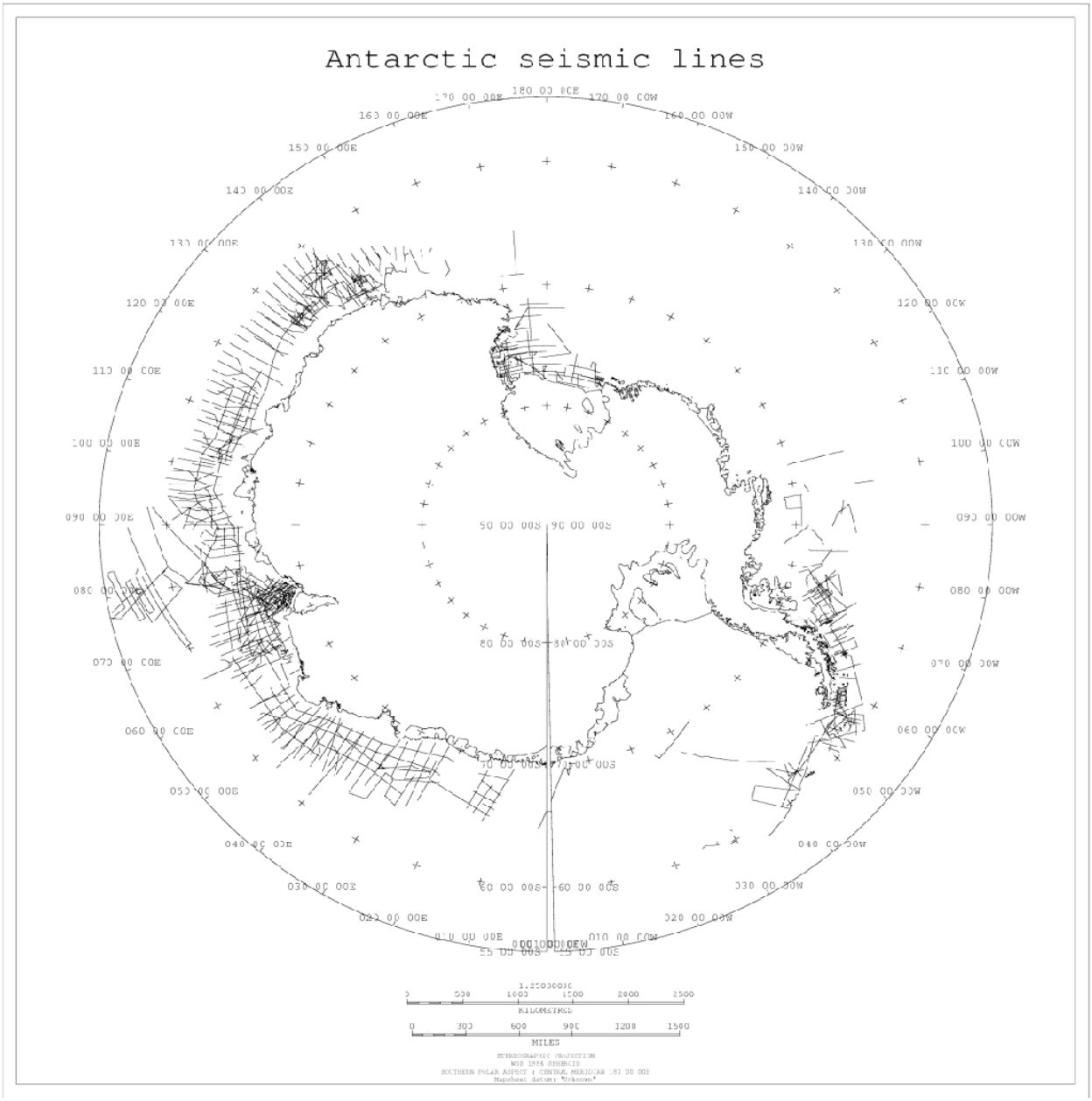
c. Survey planning and mitigation measures could be used to reduce the risk to individual animals but some disturbance may be inevitable as it will not be possible to identify the presence of all marine mammals in the affected zone.

d. Ship noise is not likely to be a problem for most Antarctic waters. However, parts of the Antarctic Peninsula are beginning to experience significant numbers of visits each year so that shipping noise needs to be considered.

38. **Long-term cumulative effects**

There have been concerns expressed about long-term cumulative effects of anthropogenic sound on the marine environment. While some animal populations elsewhere in the world are clearly subjected to persistent high levels of sound, the Action Group recognized that the Antarctic was not heavily exposed to anthropogenic sound. For example, the total amount of seismic data ever collected in the Antarctic represents less than 50% of the total collected every year in the Gulf of Mexico.

39. The Workshop supported the conclusions of the first SCAR report that the best way of mitigating long term, unknown risks from scientific activities is to use data sharing and survey planning to minimize activities in consecutive seasons for higher risk activities such as airgun seismic reflection surveys. A map is provided here of all the previous Antarctic marine geophysics surveys that SCAR has been able to trace. Helpful measures are mostly in place through Treaty and SCAR data sharing provisions but planning could probably be improved. Noise levels produced by shipping activities may need to be considered in the areas with higher traffic around the Antarctic Peninsula. For these areas, sharing of bathymetric data is a priority to minimise survey activity while improving navigational safety.



Mitigation procedures

40. Since the footprint of a seismic survey or a multibeam swath is small and temporary, the frequency of this type of study is limited by the small number of ships with the appropriate equipment and cetaceans are able to move away from such sound foci the chances of an injury to a marine mammal in the Southern Ocean must be low. Nevertheless mitigation measures are normally used to reduce the level of risk.
The most effective form of mitigation is reducing noise output, or separating the source from the animals, temporally or spatially. However this is usually not easily achieved in the Antarctic as most animal activities and human activities need to take place during the ice-free period. Soft-start (or ramp up) allows time for any animals within range to move away. However, the effectiveness of this has been called into question for all cetaceans, as it is unclear that all species are likely to react in the same way.

41. Many surveys use experienced observers detecting cetaceans along the ship's track so that the equipment can be shut down whilst the whales are in the vicinity. Trials have certainly shown that trained observers are much more effective than untrained but detection even with these is only partial, limited at most to within 1 km of the ship and then only in sea states of less than Beaufort 3. Beaked whales are especially difficult to detect yet likely to be the most common cetaceans encountered.
The approach to mitigation should vary for Environmental Impact Assessment (EIA) and for Strategic Impact Assessment (SIA). At present it appears that any SIA proposals will have limited practical value as there are in general inadequate arrangements in place to enforce the necessary co-ordination in planning and use that such mitigation would require. Where such arrangements do exist for prior planning, as in SCAR and COMNAP, the Workshop concluded that they should be strengthened. For example planned hydrographic survey work should be organised to avoid duplication and enhance data sharing through GEBCO. The same already applies to much of the scientific seismic and bathymetric work but further improvements are possible.

42. Reducing the number of ships in the Southern Ocean would certainly reduce the noise but seems unlikely to happen given the economic imperatives of tourism and the current lack of any convincing data that this would be measurably advantageous to the animals. However there are initiatives that could be pursued to assess the likely value of various current mitigation procedures:

a. Compile and analyse existing observer reports from seismic ships to establish how often shut-down occurs, how many animals are seen with seismic on or off.
b. Develop and test technology to address the shortcomings of visual observers – InfraRed, and passive acoustics look most promising although the latter is only useful when whales are vocalising. IR should be more effective in the south due to contrast of the whale temperature and the cold ocean. However this only works when the animals are close to or at the surface, as do radar and LIDAR. Whilst active sonar has also been suggested as a detection method it is as yet too inaccurate and is opposed by some groups as it adds further sound to the marine ecosystem.
c. Since shut down can lengthen surveys and increase the total noise input the parameters for ordering shut down need to be carefully specified as a management objective. If total noise reduction is the objective then do not shut down the equipment; if the objective is protect individual animals when sighted regardless of the total noise input for the sea area as a whole then the equipment should be closed down.
d. Soft-start/ramp up/slow start.
Usefulness uncertain, needs careful definition and more research on particular species.

43. There is a psychological aspect of having onboard observers in raising general awareness of crew to the potential for interactions with marine mammals. This sensitisation has proved very helpful in the commercial geophysical surveys in the Northern Hemisphere but it may not be so important in the Southern Ocean where participating vessels are already staffed with marine scientists. Technical ship noise mitigation is much more difficult than limiting air gun arrays and is a global issue. Propeller noise can be reduced by good design and operation, as can general machinery noise from the engines and hull flow noise. However, at present these are all optimised for economic objectives and there is little prospect in the immediate future of noise mitigation for marine mammals becoming an important element of design.

Recommendation from the workshop

44. In the context of any discussion about the effects of marine acoustics on marine mammals, especially cetaceans, in the Southern Ocean it is essential to recognise that most species spend only a limited period there each year. They may well be exposed to much higher noise levels, as well as other stresses such as pollution, in the northern areas of their migratory range and their behaviour in the Southern Ocean may well be influenced by impacts on them elsewhere.

The workshop made the following recommendations:

1. The natural background noise in the Southern Ocean needs to be adequately described. Without such a context it is difficult to place anthropogenic sounds in a robust framework.
   Whilst it is clear to those who have listened to hydrophones in the Southern Ocean that it is a very noisy environment there is little quantified data to support this or characterise the human addition to it. The proposal by Germany to record and analyse ambient noise near Neumayer is a welcome initiative, but more stations are needed to provide a thorough basis for ambient noise and a clear indication of the additional component attributable to ships. To quantify this it is proposed that acoustic monitoring should be undertaken in Bransfield Strait or Gerlache Strait as these are effectively choke-points for marine traffic down the Peninsula.

2. A preliminary noise map for the Southern Ocean could be constructed from ships tracks and marine geophysics data that would provide a reliable indication of the spatial and temporal components of anthropogenic noise.
   Whilst a map is provided here for the historical marine geophysics data there is considerable effort needed to collate the tracks of logistic ships, tour ships and fishing vessels to provide a more thorough synthesis. Whilst there has been considerable emphasis so far on the individual seismic or multibeam survey there has been little attention to cumulative effects of all noise. It is proposed that the noise maps created should be overlaid on known distributions of cetaceans.

3. The revision of the risk matrices and the listing of all acoustic equipment at present in use in the Southern Ocean provides a clearer picture of the potential for acoustic disturbance. Better co-ordination between national operators through COMNAP and the sharing of acoustic data through SCAR and IHO will reduce the need for future marine acoustics.
   To limit the possible impacts of swath bathymetry and seismic surveys COMNAP and SCAR should work together to improve the planning of any such proposals to ensure that areas are only covered once. Data management and quality control should be improved so that data can be shared more easily and the current SCAR Seismic Data Library should be extended to include all available data.

4. Whilst the mitigation measures recommended last time continue to provide some protection in calm seas there is little prospect of reliable identification of all cetaceans close to the surface within the zone affected without a more automated approach. The recent developments of prototype infra red detectors may offer a significant step forward.
   The review of mitigation measures by the Marine Mammals Commission meetings has suggested that certainly for smaller cetaceans the existing measures are very expensive and of limited value. It is recommended that research on mitigation measures elsewhere in the world is kept under review.

5. Detailed tests under controlled conditions of particular ship/air gun configurations offers new possibilities of managing local impacts through modelling the possible interactions at the assessment stage.
The studies undertaken by Germany to characterise the acoustic ouputs of the equipment on Polarstern *provides a model which can be utilised by others in developing more detailed estimates for their own equipment. These new data show that the potential for exposing animals to unacceptable noise from air gun arrays is very limited and can be further reduced by mitigation measures. The potential for acoustic impact from swath bathymetry is considered very low because of the narrowness of the output beam and the normal transit speed of the vessel.*

6. Relevant research and development in cetacean biology is routinely reported at the IWC but is not made available formally to the CEP. It would be useful in keeping abreast of the science if the many Parties that are also members of the IWC brought relevant material to the discussions in the CEP.
Since the establishment of the Treaty there appears to have been a concern to avoid any discussion of cetaceans at Consultative Meetings in case there was some infringement of the responsibilities of the IWC. The questions raised at CEP over several years on the possible impacts of marine acoustics on cetaceans suggest that it would be helpful in future to ensure that the cetaceans are considered as a key part of the Southern Ocean food chain in future CEP scientific discussions.

7. Research needs to be initiated in the Southern Ocean into acoustics and marine mammals if a sound scientific basis is to underpin any future management of ocean noise.
Targeted research has been suggested in all previous SCAR papers in order that the specific data deficient fields for the Treaty Area are adequately addressed. So far there has been little or no evidence that this research is seen as a major priority.

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ANNEX

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