ANNEX 8

REPORT OF THE FOURTH MEETING OF THE SUBGROUP ON ACOUSTIC SURVEY AND ANALYSIS METHODS

(Ancona, Italy, 25 to 28 May 2009)

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INTRODUCTION

The fourth meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) was held from 25 to 28 May 2009. The meeting was convened by Dr R. O'Driscoll (New Zealand) and Dr J. Watkins (UK) and was held at the Dipartimento di Scienze del Mare (DISMAR), Università Politecnica delle Marche in Ancona, Italy. The local hosts were Dr M. Vacchi and Prof. R. Danovaro (Italy).

2. Dr Vacchi welcomed participants on behalf of the hosts and outlined local arrangements for the meeting.

3. Dr O'Driscoll reviewed the background to the meeting and the terms of reference recommended by the Scientific Committee (SC-CAMLR-XXVII, Annex 8; given in Appendix A). The following specific tasks were identified by the Scientific Committee for 2009. Points (i), (ii) and (iii) were considered to be of highest priority:

(i) to provide advice that will assist in quantifying uncertainties in krill B_0 estimates;

(ii) to document the current agreed protocols for krill B_0 assessment;

(iii) to investigate the use of ancillary acoustic data (e.g. from finfish surveys, exploratory fisheries data and commercial fisheries echo sounders) and the required analytical methods;

(iv) to evaluate acoustic results from IPY surveys in 2008;

(v) to evaluate developments in target strength modelling and other new observations of Antarctic fish species;

(vi) to resolve difficulties identified with the swept-area estimation of icefish abundance.

4. A Provisional Agenda based on these items was discussed and it was agreed to consider the Southern Ocean Sentinel Program under item 4. The agenda was adopted (Appendix B).

5. The list of participants is included as Appendix C and the list of documents submitted to the meeting is included as Appendix D.

6. This report was prepared by the participants.

PROVIDE ADVICE THAT WILL ASSIST IN QUANTIFYING UNCERTAINTIES IN KRILL B_0 ESTIMATES

Review recent results including developments in target strength modelling and observations on krill orientation and material properties

7. SG-ASAM-09/8 reported on activities to acoustically identify krill and estimate size, observe behaviour, and measure target strength *in situ*, and to verify the acoustic measurements biologically, as part of the Antarctic Krill and Ecosystem Studies (AKES) program carried out by Norway in 2008 during the International Polar Year (IPY).

8. Krill were identified from the relative frequency response of a six-frequency hull-mounted echo-sounder system, and specimen size and orientation were estimated acoustically by inversion of several acoustic scattering models implemented in an optimised framework in the Large-Scale Server System (LSSS) post-processing program.

9. The Subgroup discussed several points about how the LSSS post-processing works. In particular, how the training set is developed and how targets are categorised. Questions arose regarding the inability of the inversion method to correctly classify krill in some cases where the categorisation method appeared to work very well.

10. Dr R. Korneliussen (Norway) described how the LSSS program fits the measured frequency response to model predictions, and noted that, on a pixel basis, the inversions indicated that krill exhibited a wide variety of angles within the swarms. He showed that an accurate simplified Stochastic Distorted-Wave Born Approximation (SDWBA) model with a normal orientation distribution with a mean of 15° and a standard deviation (sd) of 15° fitted best.

11. The Subgroup believed the LSSS program was a useful tool from which to classify sound backscatter from krill and to provide estimates of krill length from inversions of scattering models.

12. SG-ASAM-09/13 reported on a submersible multi-frequency acoustic TS-probe used to measure the target strength (TS) of *in situ* Antarctic krill (*Euphausia superba*, herein referred to as ‘krill’) at short range as part of the AKES cruise. The system comprises a Simrad EK60 split-beam echosounder system operating at 38, 120 and 200 kHz. A stereo-still-camera system was also mounted directly on the transducer platform with the purpose of measuring the tilt-angle orientations of the nearby organisms. From tracks of individual scatterers sensed with synchronised detections at the three frequencies, TS frequency responses were estimated for individual animals.

13. The Subgroup noted that there was no overlap between krill photographed and krill insonified by the downward-looking TS-probe, and that there may be considerable differences between the orientation of krill around the TS-probe, and the orientation of krill under the ship during surveys owing to avoidance reactions. Attempts to measure the tilt angle by means of a downward-looking lander, while the ship was passing over, were unsuccessful.

14. The Subgroup endorsed the target-tracking method as a means of reliably identifying individual krill targets for TS estimation of *in situ* animals. This method could also provide data about the orientation angle of tracked animals because orientation angle and swimming speed are inversely related.

15. The Subgroup agreed that the preliminary results from the TS-probe system indicated that it is an important and promising technology that could help to estimate TS of krill and other scatterers. The authors were encouraged to further analyse their data to build a large and more complete database of TS and orientation.

16. WG-EMM-08/56 reported on sound speed and mass density of krill measured during the Antarctic surveys conducted by the Japanese RV *Kaiyo Maru* in 1999/2000 around the South Shetland Islands, and in 2004/05 in the Ross Sea.

17. The Subgroup welcomed these data, given the importance of measurements of density contrast (g) and sound-speed contrast (h) of krill in the determination of krill TS and therefore biomass. WG-EMM-08/56 reported high variability in g and h between regions and times of the year which led to changes in estimated krill TS by 5 dB.

18. However, the Subgroup noted that there was insufficient information in WG-EMM-08/56 to fully evaluate the methods used to make these measurements (particularly organism volume fraction and transmitting pulse form). The Subgroup further suggested that the biological characteristics of krill (e.g. moulting stage, maturity stage) should be reported when making these estimates to further explore the causes of variability.

19. The Subgroup noted that the new density contrast data are consistent with Foote's distribution and also that the new measurements of sound-speed contrast exceed Foote's distribution. In the absence of information about the accuracy of the krill sound-speed measurements, the Subgroup concluded that it should not change the default values currently in place when calculating krill biomass.

20. Noting the apparent level of variability in measurements of g and h in different regions and times of year, their potential covariance (Figure 3 in WG-EMM-08/56), and the importance of these parameters within the SDWBA model, the Subgroup recommended further measurements of these parameters as a high priority.

Collate a set of net-validated acoustic data and evaluate whether current acoustic target identification methods are biased

21. SG-ASAM-09/4 revisited net-validated krill aggregation data initially used to validate the two-frequency classification of the volume backscattering strength (S_v) scheme used in krill identification (Watkins and Brierley, 2002), to empirically investigate the three-frequency SDWBA-derived variable S_v classification used in WG-EMM-07/30 Rev. 1. SG-ASAM-09/4 indicated that using a three-frequency identification window, calculated using SDWBA with an orientation angle $\theta = N(11, 4)$, did not correctly identify all acoustic targets as krill, but that when θ was calculated for each cruise using the inversion method of Conti and Demer (2006), the target identification was substantially improved.

22. Dr O'Driscoll provided a further example by displaying echograms of krill and juvenile Antarctic silverfish (*Pleuragramma antarcticum*) (SG-ASAM-09/5), that non-krill targets may have a similar frequency response to krill, and that the two- or three-frequency dB-difference technique may incorrectly classify targets.

23. The Subgroup discussed the dB-difference technique and recognised that classification errors should be minimised and that constraining the identification window according to the SDWBA (if correctly parameterised) would be one way of achieving this.

24. The Subgroup recognised that a number of alternative target identification techniques exist, including empirically derived dB-difference techniques (Azzali et al., 2004), thresholding, scattering-model inversion techniques (Lebourges-Dhaussy, 2006, in Fernandes et al., 2006), frequency response (SG-ASAM-09/13), and statistical-spectral analysis (Demer et al., 2009). In addition, supplementary information such as time of day, depth of target in the water column and shape of target, may be useful in correctly identifying krill targets.

25. The Subgroup noted that these alternative target identification methods may perform as well as or better than the current dB-difference technique and the Subgroup would welcome submissions examining the success of the different methods. It was noted that the comparison between these methods would be complicated by the resolution of the data on which these analyses would be undertaken, where re-sampling of data over time and space could combine scatter from multiple taxa or species.

26. The Subgroup noted that target identification may be improved by techniques which use pre-classification of high-resolution S_v data, and then aggregate the candidate samples for comparison with empirical or theoretical scattering models. Such pre-classifications can be done using methods such as thresholding, school detection (e.g. as implemented in software such as Echoview or LSSS), or multi-frequency coherence (e.g. Demer et al., 2009).

27. The Subgroup recommended that a library of validated echograms be created that could be used to test alternative techniques of target identification. Dr D. Ramm (Data Manager) indicated that the CCAMLR acoustic database includes a module which contains a prototype echogram library which was based on the framework adopted by the EU project on Species Identification Methods from Acoustic Multifrequency Information (Fernandes et al., 2005). The prototype library may be linked to CCAMLR's existing acoustic database, and contains two primary tables: Echogram – a description of the characteristics of a species' typical echogram; and Echotrace – photographic examples of echotraces (see SG-ASAM-07/4).

28. The Subgroup noted the importance of validation of echograms included in the library and the need to include catch composition information and other metadata (gear type, fishing depth etc). To allow testing of various target identification methods, the validated echograms would need to be linked to acoustic data files.

29. The Subgroup urged Members to provide validated echograms on krill and other species to help populate this library.

Provide direction towards developing a probability density function (PDF) for the estimate of B_0 based on the current understanding of uncertainties in various parameter values

30. The Subgroup recognised that uncertainty in the acoustic estimation of krill biomass has been the subject of previous investigations (Demer, 2004; SC-CAMLR-XXIV, Annex 6). Demer (2004) concluded that the major areas of uncertainty were associated with TS estimation and target identification.

31. However, the Subgroup emphasised that current estimates of B_0 only included the sampling uncertainty (usually expressed as the sampling CV).

32. The Subgroup recognised the importance of quantifying the total uncertainty in the biomass estimation process. It felt that it was appropriate to structure the process into:

(i) a consideration of uncertainty associated with the parameter values used in the present protocol, including possible modifications to these parameter values;

(ii) a brief consideration of new techniques or methods that could substantially reduce uncertainty;

(iii) a brief consideration of validating the components of the acoustic estimates.

Uncertainty associated with parameter values used in the present protocol

33. To fully capture the uncertainty in the present estimates of B_0, the Subgroup provided a list of the major steps in the B_0 estimation process and comments on the degree of uncertainty associated with each of these major steps (Table 1). The Subgroup further recognised that there are varying degrees of covariance between the parameters used in the SDWBA which need to be assessed and quantified.

34. The Subgroup reiterated that krill orientation is presently derived using a model inversion of the dB difference between krill acoustic backscatter at 120 and 38 kHz. As a result, there is a covariance between estimated krill orientation and the SDWBA model predictions of dB differences, and hence target identification. Therefore, any estimate of overall uncertainty will need to take this into account.

35. The orientation distributions that were estimated from the CCAMLR-2000 Survey data (mean scenario with mean = 11° and standard deviation = 4°) were derived by inverting the SDWBA model using measurements of S_v (dB re 1 m^{-1}) at multiple frequencies, averaged over 50 ping (~500 m) and 5 m intervals. By averaging over larger areas, the variance is reduced by the inverse of the number of independent observations. The Subgroup therefore recommended that these values should be corrected to take account of the number of independent acoustic samples in the inversion interval and also the mean number of krill in a sampling volume.

36. The Subgroup also noted that measurements of krill orientation using a towed camera system (Lawson et al., 2006) showed a greater variance to that produced from the model

inversion approach. However, there was recognition that orientation may change as a result of behavioural responses of krill to the towed-camera system and the measured distribution may not represent the behaviour of krill beneath a survey vessel.

37. With respect to acoustic target identification (Table 1, point 2), the Subgroup noted that the dB-difference ranges in the present krill size variable target-identification windows (SC-CAMLR-XXIV, Annex 6, Table 3) are based on the mean values of the SDWBA model parameter settings (Table 2). The Subgroup agreed that these target-identification windows should be recalculated to take account of the ±1 sd ranges for the SDWBA parameter settings once the orientation distribution has been corrected for the effect of averaging (see paragraph 35).

38. In addition, the Subgroup agreed that the present provision of a dB-difference window with 10 mm length classes could be refined to reduce uncertainty. A table with 1 mm size classes would be large. Dr D. Demer (Invited Expert) presented a Matlab-based Graphical User Interface (GUI) for calculating and displaying SDWBA predictions, which is intended to allow users to generate the required dB-difference windows based on user input of model parameters and a range of krill lengths. The Subgroup welcomed access to such a program.

39. With regard to sampling and calibration uncertainty (Table 1, points 3 and 4), the Subgroup agreed that these areas had been previously well characterised in the literature and CCAMLR reports.

40. With regard to uncertainty related to availability of krill to be included in a survey (Table 1, point 5), the Subgroup agreed that in certain specific circumstances, availability of krill to standard acoustic sampling techniques could increase the uncertainty of the overall biomass estimate. Specific circumstances highlighted by the Subgroup for further consideration and assessment of uncertainty include:

(i) krill in unsurveyable areas (e.g. krill under ice is frequently a problem in the Ross Sea);

(ii) environmentally driven changes in krill distribution beyond traditional survey areas;

(iii) occurrence of krill beyond the normal vertical sampling range of the acoustic sampling systems (e.g. surface, benthic and deep-water krill).

41. The Subgroup considered that in addition to the requirements to assess the uncertainty associated with individual elements described in Table 1, there were some additional ways that could provide insight into general levels of uncertainty in the krill biomass estimation process. For instance, the Subgroup recognised that calculating separate biomass estimates for each frequency can provide valuable insights into the biases and uncertainties inherent in the overall estimation process (e.g. Demer, 2004), including TS estimation and target identification. The Subgroup recognised that survey-by-survey measurements of all parameters used in the SDWBA model may not be possible, and in such cases the mean values with the associated ranges given in the present protocol could be used. It was recognised that application of the specific parameter values measured during that particular survey could reduce the overall uncertainty estimated for that survey.

42. The Subgroup recommended that future estimations of krill biomass should explicitly state which elements of the total uncertainty had been included in the estimation process, so that the uncertainty can be considered when comparing results between studies.

New techniques or methods that could substantially reduce uncertainty

43. The Subgroup noted that techniques utilising multi-frequency response curves in the target identification process (see for example SG-ASAM-09/8) are likely to reduce uncertainty associated with target identification and that uncertainty will reduce as more frequencies are used. The further development of these techniques, together with an assessment of their associated levels of uncertainty, was strongly encouraged.

Validating components of the acoustic estimates

44. The Subgroup recognised that other sampling techniques that might be used to validate acoustically estimated biomass (for example the use of net sampling to validate acoustic target identification and estimates of krill-length PDF; or photographic sampling techniques to determine *in situ* krill orientation) also include uncertainty (systematic and random components of measurement and sampling error) which should be estimated in any comparison or validation procedure.

45. There was a recognition that there was a degree of overlap between krill and non-krill targets in the currently used multi-frequency identification procedures. Thus, increasing the krill identification windows to ensure that all krill targets were identified as krill, increases the probability of including non-krill targets in the krill fraction. To understand the magnitude of this problem, the Subgroup recognised that information on the potential biomass contribution of other scattering organisms would be valuable, and encouraged its collection and submission.

DOCUMENT THE CURRENT AGREED PROTOCOLS FOR KRILL B_0 ASSESSMENT

46. The Subgroup recognised that, while CCAMLR had agreed protocols for key parts of the process of estimating B_0, in some instances there was a lack of clarity as to whether the 'recommendations' in the report of SG-ASAM in 2005 (SC-CAMLR-XXIV, Annex 6) were recommendations for immediate implementation of particular methods or for further investigation of the implications of their implementation. This was the subject of considerable discussion during WG-EMM's Workshop to Review Estimates of B_0 and Precautionary Catch Limits for Krill, which was held in 2007 (SC-CAMLR-XXVI, Annex 4), where there was agreement to use the procedure as set out in WG-EMM-07/30 Rev 1.

47. The Subgroup agreed that, following the discussion under subitem 2.3 of the key uncertainties associated with the estimation of B_0, it would consider the agreed current CCAMLR protocols for krill B_0 assessment in two parts:

(i) collate the existing agreed protocols
(ii) review and correct any errors of omission/commission and clarify method details in those protocols.

48. The Subgroup collated the current CCAMLR protocols for the component parts of the production of an estimate of krill B_0 using the framework set out in SG-ASAM-09/12, noting that the protocols for the component parts existed principally in SC-CAMLR-XXIV, Annex 6 and SC-CAMLR-XXVI, Annex 4 (in particular Table 1) and papers describing the methods used in the conduct of the CCAMLR-2000 Survey (e.g. Trathan et al., 2001; Hewitt et al., 2004).

49. The collation of the agreed methods/protocols for components of the process were considered, and clarifications to the material included in the documents referred to above were provided in Appendix E.

50. The Subgroup recognised that there was great value in collating these methods and providing the clarification on the currently agreed protocols. It also recognised that the full development of Appendix E, requiring appropriate cross-referencing etc., could not be undertaken at the time of the meeting and requested that the Secretariat undertake this task and make this information available on the CCAMLR website.

51. The Subgroup noted that several of the values in the SDWBA parameter set in WG-EMM-07/30 Rev. 1 that were used in the analysis undertaken at WG-EMM 2007 to estimate the precautionary catch limit for Area 48, were incorrect owing to the omission of the imaginary parts. Dr Demer provided a corrected parameter set for the simplified SDWBA (Table 3).

52. The Subgroup also noted that in SC-CAMLR-XXIV, Annex 6, Table 1, the values for orientation distributions and seawater sound speed in the ±1 sd scenarios were transposed, and to clarify the process of propagating uncertainties this has been corrected (see Table 2).

USE OF ANCILLARY ACOUSTIC DATA

Review recent research results involving collection of ancillary acoustic data

53. WG-EMM-08/26 described an acoustic estimation of krill abundance near the South Orkney Islands using data collected during a research trawl survey in 1999. Acoustic data were collected while transiting between random trawl stations and were treated as random samples of the krill distribution within the survey area. Survey uncertainty was estimated by bootstrapping within strata (divided by day and night and depth). Because krill were not sampled during the 1999 survey, krill size was estimated from net samples at Elephant Island in the same year. It was demonstrated that the length distributions of krill at Elephant Island and the South Orkney Islands were similar in 2000 and 2008. Dr C. Reiss (USA) reported that this was also the case in 2009.

Document protocols for analysing, processing
and interpreting ancillary acoustic data

54. This item was discussed in relation to the survey design presented in WG-EMM-08/26 and SG-ASAM-09/5, which utilised acoustic data collected while transiting between random sampling stations as a basis for estimating biomass.

55. The Subgroup agreed that such designs could be useful for estimating biomass, provided that the sampling uncertainty could be quantified. The bootstrapping method appears to provide a suitable method for estimating uncertainty, but the Subgroup did not feel that there was suitable statistical expertise within the group to fully assess the methods described.

56. The Subgroup further noted that when estimating krill biomass, other aspects of survey analysis should adhere to currently agreed protocols to the extent possible. Where there is deviation from these protocols, the implications for uncertainty should be assessed.

Determine whether such data can provide krill biomass estimates
from areas that are not regularly surveyed

57. This item was discussed primarily in relation to ancillary acoustic data collected from trawl surveys (e.g. WG-EMM-08/26) and IPY surveys (e.g. SG-ASAM-09/5).

58. The Subgroup recognised that krill biomass estimates could be calculated from ancillary acoustic data and may provide useful information on krill distribution and abundance from regions that are not regularly surveyed.

59. Dr M. Azzali (Italy) noted that the level of survey coverage may be less extensive than expected in research acoustic surveys and that, if the survey coverage was insufficient or non random, important areas for krill may be missed. He proposed a minimum coverage of 5% of the study area and this coverage should include a random component.

60. The Subgroup recognised that this is a fundamental issue about sampling design, namely at what scale estimates of abundance can be scaled up to cover a wider area. Clearly, a survey of only a small part of a much wider region may produce a biased estimate of abundance if the survey area is not representative. The Subgroup further noted that the estimated sampling uncertainty should take account of the survey coverage if calculated appropriately (i.e. less extensive coverage should lead to higher uncertainty).

61. The Subgroup agreed that if the acoustic survey analysis methods were applied appropriately, ancillary/opportunistic acoustic data could provide estimates of krill abundance. Estimates of biomass should be presented along with estimates of total uncertainty including systematic and random components of measurements of sampling error. The Subgroup recognised that decisions regarding the application of these estimates in management advice is not within its terms of reference.

Future needs for acoustic instrumentation in the Antarctic

62. Dr L. Andersen (Norway) provided an overview of current acoustic technology, including multi-frequency echosounders, multi-beam broadband echosounders and matrix sonars, omnidirectional sonars, remotely controlled systems, moored systems and autonomous systems (SG-ASAM-09/9).

63. The Subgroup discussed potential applications in relation to commercial vessels collecting ancillary acoustic data, and the use of moored systems to collect information on krill availability (close to the surface or nearshore) and for long-term monitoring.

Southern Ocean Sentinel Program

64. Dr R. Kloser (Invited Expert) outlined a need identified during the Southern Ocean Sentinel workshop (Hobart, Australia, April 2009) for large-scale observations of the Southern Ocean and the potential for acoustic monitoring to provide relevant ecosystem indicators. This need has also been identified by other groups as needing further development within Climatic Impact on Top Predators (CLIOTOP) and the 2009–2013 ICES Strategic Plan. A large-scale monitoring of mid-trophic level prey organisms, their horizontal and vertical size-resolved distribution and abundance in the pelagic environment system could be achieved through innovative combination of existing components and expertise (e.g. ARGOS buoys, vessels of opportunity, moorings, gliders etc.). Examples of acoustic data collected from ships of opportunity at ocean-basin scale, that have provided indices of total backscatter and micronekton fish biomass to monitor changes over time, and have also provided inputs to ecosystem models and identified key regions for targeted sampling, were presented.

65. The Subgroup noted that technical issues exist relating to calibration, data quality (noise and interference) and data processing, and suggested that data collection protocols should be as rigorous as possible (e.g. ICES, 2007). Such data are already being collected within the Ship of Opportunity Program (SOOP) and other opportunistic national initiatives (e.g. SG-ASAM-07/7 described opportunistic acoustic data collection from fishing vessels in the Ross Sea) and have some information content. However, the power of such observations to detect change has still to be demonstrated. This topic is of broad interest to large regionally focused groups including CCAMLR, the Sentinel Program (Southern Ocean), CLIOTOP (Tuna habitat region) and ICES (primarily the northern Atlantic). It was suggested that this common research area could be advanced with closer linkages between the relevant expert groups within these programs such as SG-ASAM, CLIOTOP-MAAS project (Mid-trophic Automatic Acoustic Sampler) and ICES-WGFAST (Working Group on Fisheries Acoustic Science and Technology) to potentially provide the necessary technical support for a global observing strategy.

EVALUATE RESULTS FROM IPY SURVEYS IN 2008

Review acoustic data and related metadata submitted to CCAMLR

66. SG-ASAM-09/11 described IPY metadata submitted to the Secretariat. The following research vessels were identified by the CCAMLR-IPY Steering Committee in 2007 as

conducting CCAMLR-related activities during IPY (SC-CAMLR-XXVI/BG/3): *G.O. Sars* (Norway); *James Clark Ross* (UK); *Polarstern* (Germany); *Tangaroa* (New Zealand); and *Umitaka Maru* (Japan). Other vessels, such as *Aurora Australis* (Australia) and *L'Astrolabe* (France), were also thought to have opportunities to collect CCAMLR-related data.

67. In February 2009, the Secretariat contacted Parties identified by the Steering Committee, and sought summary information on the availability of acoustic, net and CTD data collected during IPY surveys.

68. Metadata were provided from *G.O. Sars* (Norway), *Tangaroa* (New Zealand) and *Polarstern* (Germany). In SG-ASAM-09/11, four tables were developed to capture metadata of interest to SG-ASAM: Table 1 – general summary of acoustic and related data collected by vessels during IPY surveys; Table 2 – acoustic data; Table 3 – net data; and Table 4 – CTD data. More detailed descriptions of the Norwegian (WG-EMM-08/28) and New Zealand (SG-ASAM-09/5) datasets were also available.

69. The table of acoustic data was updated at the meeting to correct errors for *G.O. Sars* and to include metadata from the US survey using RV *Yuzhmorgeologiya* (Table 4). The Subgroup requested that other Parties which have acoustic data, provide these to the Subgroup for consideration.

Presentation of new results from IPY surveys

70. Dr O'Driscoll presented preliminary acoustic results from the New Zealand IPY survey to the Ross Sea in February–March 2008 (SG-ASAM-09/5). The survey was restricted because of ice conditions. Multi-frequency acoustic data (12, 38, 70 and 120 kHz) were collected throughout the survey. Mark identification was achieved using 11 targeted midwater trawls. Nineteen additional midwater trawls and 23 demersal trawls were carried out at randomly selected locations as part of the core biodiversity survey. The main target species of the acoustic survey work was Antarctic silverfish. Preliminary biomass estimates were also presented for Antarctic krill and ice krill (*E. crystallorophias*). Data were also presented showing marks from the myctophid *Electrona carlsbergi*. The Subgroup noted that the 70 kHz system turned out to be a system well suited for the conditions in the Ross Sea.

71. The Subgroup noted that preliminary krill estimates were not calculated using standard protocols. In particular, marks were identified subjectively based on target trawls (not by dB differencing) and TS was estimated using the model of Greene et al. (1991). Dr O'Driscoll agreed to recalculate estimates using TS from the SDWBA model, and to investigate frequency-based methods of species classification.

72. New results from the Norwegian IPY survey were presented in SG-ASAM-09/8 and 09/13; these are described under subitem 2.1.

Determine whether data can provide krill biomass estimates from areas that are not regularly surveyed

73. This item was discussed in conjunction with subitem 4.3 (see above).

EVALUATE DEVELOPMENTS IN TARGET STRENGTH MODELLING AND OTHER NEW OBSERVATIONS ON ANTARCTIC FISH SPECIES

Target strength of mackerel icefish

74. Dr G. Macaulay (New Zealand) presented the results of an acoustic target strength model of mackerel icefish (*Champsocephalus gunnari*) (SG-ASAM-09/6). In total, target strength estimates from six fish at 38 kHz were presented and compared to existing *in situ* estimates (WG-FSA-SAM-04/9). This model had been partially verified using inshore species from New Zealand and had also been used to generate target strength estimates for several other species, including orange roughy (*Hoplostethus atlanticus*), where it produced estimates that were consistent with *in situ* measurements. Dr Macaulay emphasised that the model has not been fully verified and the results presented here are preliminary.

75. The Subgroup encouraged the offers from Drs Macaulay and S. Fielding (UK) to further this research, including providing CT scans of icefish at smaller and larger lengths than used in the model runs.

Target strength of silverfish

76. Dr O'Driscoll presented target strength results for silverfish (SG-ASAM-09/5) using the same acoustic scattering model as used for the icefish estimates (SG-ASAM-09/6). The tilt-averaged target strength at 38 kHz was estimated for seven fish. The resulting length to target strength relationship was used to derive biomass estimates from acoustic data collected during the New Zealand IPY-CAML voyage in the Ross Sea in 2008 (SG-ASAM-09/5). The model gave very low target strength values for juvenile fish (<11 cm), and this resulted in very high biomass estimates for juvenile fish. The biomass estimate for adult fish appeared to be realistic. When compared to target strength estimates for other species, the values for small silverfish seem unrealistically low and Dr O'Driscoll advised that the results for juvenile fish should be treated with some caution. A comparison of the target strength estimates with the *ex situ* estimates provided by Dr Azzali was made (available in SG-ASAM-09/10). There was good agreement for fish larger than 11 cm.

77. Dr Azzali presented the results of experiments and models to estimate the target strength of silverfish: *ex situ* experiments in the Adriatic Sea using thawed specimens, trawl density/echo integration inversion from data collected in the Ross Sea (juvenile fish only), and a theoretical model based on silverfish material properties (SG-ASAM-09/10). There was general agreement between the *ex situ* measurements and the theoretical model for adult fish, but the agreement for juvenile fish was more variable. The Subgroup noted that a normal orientation distribution with mean of 0 and sd of 15 was used in the theoretical model.

78. The Subgroup noted that as the calibration of the EK500 echosounder used for the *in situ* measurements was carried out in the Adriatic Sea, prior to the vessel departing for the Ross Sea, there was the potential for a change in the echosounder calibration to occur due to a change in water temperature, and that this would affect the *in situ* target strength measurements. It further noted that a correction could be developed and applied to the data.

79. The Subgroup noted that the new results presented under this agenda item significantly advanced our knowledge about the target strength of icefish and silverfish. SG-ASAM

recommended that the TS of icefish, silverfish and associated species continues to be studied using a variety of methods including *in situ* measurements, *ex situ* experiments on individuals and aggregations, and physics-based and empirical models.

ATTEMPT TO RESOLVE DIFFICULTIES IDENTIFIED WITH THE SWEPT-AREA ESTIMATION OF ICEFISH ABUNDANCE

80. In response to the request from WG-FSA to consider the application of the adjustment factor for trawl headline height used in icefish surveys (SC-CAMLR-XXVII, Annex 5, paragraphs 3.26 and 13.20), Dr S. Kasatkina (Russia) presented the findings of a comparison of trawl and acoustic data collected during bottom trawl surveys (SG-ASAM-09/7). The study considered the acoustic density of icefish in 6 m and 8 m depth bands above the bottom and indicated that a 2 m difference in headline height could produce a 1.8-fold difference in the trawl survey biomass estimate for icefish. Overall, the acoustic data revealed large spatial heterogeneity in the icefish distribution that was not apparent in the data from the trawls; furthermore the adjustment of 1.8 varied greatly over both space and time scales.

81. The Subgroup noted that the use of acoustic density data from trawl stations to bootstrap estimates of trawl survey biomass may provide a very useful means to account for this spatial heterogeneity and to improve estimates of uncertainty in the swept-area surveys for icefish.

SUGGESTIONS FOR TIMING/VENUE OF NEXT MEETING

82. The Subgroup agreed that this meeting had once again benefited from being held in conjunction with the meeting of ICES WGFAST (Ancona, Italy, 18 to 22 May 2009). It was agreed that SG-ASAM meetings would be more likely to be attended by acoustic experts if the meetings continue to be held in conjunction with the WGFAST meetings. For example, this year, approximately half of the participants including one of the Co-conveners, would likely have not attended the meeting of the Subgroup had it not been held in conjunction with a meeting of WGFAST.

83. The Subgroup noted that there had been informal discussions within WGFAST regarding the benefits of establishing formal links between WGFAST and SG-ASAM, and more generally ICES and CCAMLR.

84. The Subgroup recognised that a formal link (e.g. a memorandum of understanding) with WGFAST, and other ICES expert groups (such as the Working Group on Fish Technology and Fish Behaviour) would:

(i) enhance common efforts in developing acoustic methods, survey designs and related analyses;

(ii) facilitate attendance of experts at its meetings;

(iii) facilitate meeting arrangements.

85. Further, the field of acoustic science is small and specialised, and established links between focus groups, including joint open science sessions would enhance collaborations and the exchange of knowledge.

86. The Subgroup noted that any formal link with ICES expert groups would need to remain flexible and allow for stand-alone meetings, or alternative arrangements, when ICES meetings are held in non-CCAMLR Member countries.

87. The Subgroup recommended that the Scientific Committee consider the benefits of establishing a formal link with ICES and its expert groups.

88. The Subgroup agreed that future meetings would be required to consider the results of ongoing acoustic research and new surveys, and developments in TS modelling and measurements, mark identification and estimation of uncertainty. It was anticipated that substantial developments would be achieved within the next 12 months, particularly with *in situ* TS analyses using IPY data and estimation of total uncertainty.

89. The Subgroup recommended that the Scientific Committee consider the requirements for the next meeting of SG-ASAM in the light of the developments achieved during the fourth meeting of SG-ASAM and feedback and advice from the working groups. The Subgroup noted that the next meeting of WGFAST was likely be held from 26 to 30 April 2010 in La Jolla, USA.

RECOMMENDATIONS TO THE SCIENTIFIC COMMITTEE

90. The Subgroup recommended that:

(i) measurements of density, and sound-speed contrast and krill shape and orientation be undertaken where possible during future krill surveys to further constrain these parameters for the SDWBA model (paragraphs 20 and 41);

(ii) a library of validated echograms be created that could be used to test alternative techniques of target identification (paragraphs 27 to 29);

(iii) the ±1 sd orientation values should be corrected to take account of the number of independent acoustic samples in the inversion interval and also the mean number of krill in a sampling volume (paragraph 35);

(iv) the target identification windows should be recalculated to take account of the ±1 sd ranges for the SDWBA parameter settings once the orientation distribution has been corrected for the effect of averaging (paragraph 37);

(v) future estimations of krill biomass should explicitly state which elements of the total uncertainty had been included in the estimation process so that the uncertainty can be considered when comparing results between studies (paragraphs 42, 43 and 45);

(vi) the TS of icefish, silverfish and associated species continues to be studied using a variety of methods, including measurements on *in situ* and *ex situ* individuals and aggregations, and physics-based and empirical models (paragraphs 75 and 79);

(vii) the Scientific Committee consider the benefits of establishing a formal link with ICES and its relevant expert groups, including WGFAST (paragraph 87);

(viii) the Scientific Committee consider the requirements for the next meeting of SG-ASAM in the light of the developments achieved during the fourth meeting of SG-ASAM and feedback and advice from the working groups (paragraph 89).

91. The Subgroup also requested that the Secretariat undertake full development of Appendix E, including appropriate cross-referencing, and make this information available on the CCAMLR website (paragraph 50). The Subgroup also requested that other IPY Parties which have acoustic data provide these to the Subgroup for consideration (paragraph 69).

ADOPTION OF THE REPORT

92. The report of the fourth meeting of SG-ASAM was adopted.

CLOSE OF MEETING

93. Drs O'Driscoll and Watkins thanked participants for their contribution, and Dr Vacchi, Prof. Danovaro and staff at DISMAR for their warm hospitality and assistance with meeting arrangements. Dr Korneliussen, on behalf of the Subgroup, thanked the Co-conveners for their excellent work. The Subgroup also thanked the invited experts[1] (Drs Demer, Kloser and G. Lawson) for their valuable contributions. The meeting was closed.

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[1] Dr I. McQuinn (Canada) had also been invited to attend the meeting as an invited expert, but was unable to attend.

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Watkins J.L. and A.S. Brierley. 2002. Verification of the acoustic techniques used to identify Antarctic krill. *ICES J. Mar. Sci.*, 59: 1326–1336.

Table 1: Summary of uncertainties associated with the key stages in the estimation of krill biomass.

Major steps in B_0 estimation process		Comments on level of uncertainty
Target strength estimation using the SDWBA model (see SG-ASAM-05* for further details)	Animal shape	No new data provided at meeting. Noting that there was no standard method for the measurement of krill girth.
	Density contrast (g)	New values WG-EMM-08/56 but current protocol values still considered appropriate.
	Sound speed contrast (h)	New values WG-EMM-08/56 outside current range but current protocol values still considered appropriate given concerns over regional differences and technical clarifications.
	Orientation (θ, sd)	sd of distributions to be corrected to take account of size of sampling volume and number of krill in sampling volume.
Target identification	Frequency difference window	Uncertainty in TS will drive uncertainty in frequency difference window. Current levels based on mean scenario Table 2. New window ranges will be produced to take account of ±1 sd scenarios with correction for sampling volume as detailed above.
	Krill length PDF	Sampling of krill to generate krill length PDF also subject to uncertainty. Uncertainty of overall representativeness of net sampling process needs to be incorporated.
Sampling design	Jolly and Hampton modified method	Currently only element of uncertainty routinely provided in estimates of biomass.
Calibration	See CCAMLR-2000 Survey protocols	See for instance Demer (2004).
Availability (in time and space)	Krill occurring in unsurveyed regions	• Under ice, e.g. Ross Sea • Population movements in response to environment
	Krill occurring beyond sampling range of echosounder	• In surface layer • Close to bottom • Deep krill

* SC-CAMLR-XXIV, Annex 6

Table 2: Parameters used in the SDWBA model to estimate error in the prediction of krill TS, where number of cylinders (n_0) = 14, krill length (L_0) = 38.35 mm, and phase variability (φ_0) = $\sqrt{2}/2$. Note that the orientations and sound speeds have been swapped relative to SC-CAMLR-XXIV, Annex 6, Table 1, because the SDWBA TS are inversely proportional to the mean incidence angle and the sound speed in water.

	–1 sd	Mean	+1 sd
Radius of cylinders (r_0)	1	1.4	1.7
Density contrast (g)	1.029	1.0357	1.0424
Sound-speed contrast (h)	1.0255	1.0279	1.0303
Orientation (mean θ, sd)	N(15°, 4°)	N(11°, 4°)	N(7°, 4°)
Sound speed in water (c; m s^{-1})	1461	1456	1451

Table 3: Coefficients and reference length (L_0) for the simplified SDWBA model of krill TS (Equation 1), averaged over krill orientation distributions of $\theta = N(11°, 4°)$. Note the necessary imaginary parts in *A*, *B* and *C* not included in SC-CAMLR-XXIV, Annex 6, Table 2 and Conti and Demer (2006, Table 2). The coefficients can be used for values of *kL* smaller than 200, with a mean error δ in decibels between the exact and the simplified SDWBA.

	N(11°, 4°)
A	6.6455874521e+00 –2.3282404324e+01i
B	1.2790907635e–01 –3.7077142547e–02i
C	4.4631814583e–01 –2.0095900992e–01i
D	–1.1920959143e–11
E	7.4232471162e–09
F	–1.7391623556e–06
G	1.8632719837e–04
H	–8.6746521481e–03
I	1.3214087326e–01
J	–8.1337937326e+01
L_0	38.35e–003 m
δ	2.18 dB

Table 4: Summary of acoustic data collected by vessels during CCAMLR-related IPY surveys.

Parameter			Date		Latitude		Longitude		Length (n mile)
			Start	End	Start	End	Start	End	
(a) *Polarstern*									
Transducer									
	Type	EK60							
	Frequency (kHz)	38, 70, 120, 200							
	Transducer depth (m)	10							
	Ping interval (s)	2.0–3.0							
	Depth range (m)	10–1000							
Calibration									
Pre-survey	Date								
	Location								
Post-survey	Date	07–08 Jan 08							
	Location	69.4S 1.0E							
Transects									
	Area	Lazarev Sea							
		1	10 Dec 07	13 Dec 07	–62.00	–70.00	1.60	–6.90	522
		2	23 Dec 07	29 Dec 07	–69.90	–62.00	–3.00	–3.00	474
		3	30 Dec 07	01 Jan 08	–62.00	–62.00	–3.00	3.00	169
		4	01 Jan 08	06 Jan 08	–62.00	–68.50	3.00	3.00	390
		5	17 Jan 08	21 Jan 08	–69.50	–62.00	0.00	0.00	450
(b) *Tangaroa*									
Transducer									
	Type	EK60							
	Frequency (kHz)	12, 38, 70, 120							
	Transducer depth (m)	6							
	Ping interval (s)	variable (1.5 on shelf)							
	Depth range (m)	0–1000							
Calibration									
Pre-survey	Date	12 Feb 2008							
	Location	near Cape Washington, Ross Sea							

(continued)

Table 4 (continued)

Parameter			Date		Latitude		Longitude		Length (n mile)
			Start	End	Start	End	Start	End	
Post-survey	Date Location	12 kHz not calibrated							
Transects									
	Area	Ross Sea							
		1	10 Feb 08	10 Feb 08	–73.13	–73.22	174.31	174.00	14
		2	10 Feb 08	10 Feb 08	–73.18	–73.89	174.24	171.71	112
		3	10 Feb 08	10 Feb 08	–73.89	–74.07	171.70	171.05	28
		4	11 Feb 08	11 Feb 08	–74.12	–74.58	170.83	170.46	52
		5	11 Feb 08	12 Feb 08	–74.59	–74.65	170.24	168.97	38
		6	12 Feb 08	12 Feb 08	–74.65	–74.79	168.97	167.00	60
		7	13 Feb 08	13 Feb 08	–74.74	–74.94	167.14	168.10	36
		8	13 Feb 08	13 Feb 08	–74.96	–75.61	168.20	169.70	84
		9	14 Feb 08	14 Feb 08	–75.63	–75.64	169.70	166.98	75
		10	14 Feb 08	14 Feb 08	–75.65	–76.54	167.38	167.70	100
		11	15 Feb 08	15 Feb 08	–76.56	–76.74	167.74	167.82	21
		12	15 Feb 08	15 Feb 08	–76.74	–76.58	167.94	170.29	63
		13	15 Feb 08	15 Feb 08	–76.59	–76.19	170.29	176.14	159
		14	15 Feb 08	16 Feb 08	–76.21	–76.75	176.18	179.89	61
		15	16 Feb 08	16 Feb 08	–76.81	–76.76	179.99	179.25	19
		16	16 Feb 08	16 Feb 08	–76.77	–76.62	179.33	176.62	72
		17	17 Feb 08	17 Feb 08	–76.60	–76.19	176.77	176.38	47
		18	18 Feb 08	18 Feb 08	–76.15	–75.75	176.27	176.59	46
		19	18 Feb 08	18 Feb 08	–75.74	–74.51	176.63	177.59	140
		20	18 Feb 08	18 Feb 08	–74.55	–73.27	177.51	178.76	147
		21	19 Feb 08	19 Feb 08	–73.27	–72.92	178.73	177.10	35
		22	19 Feb 08	19 Feb 08	–72.77	–72.59	177.22	175.34	66
		23	21 Feb 08	21 Feb 08	–72.59	–72.36	175.34	175.48	26
		24	21 Feb 08	21 Feb 08	–72.33	–72.08	175.53	175.52	28
		25	22 Feb 08	23 Feb 08	–72.12	–71.93	175.51	173.27	80
		26	23 Feb 08	23 Feb 08	–72.05	–71.96	173.24	173.37	11
		27	23 Feb 08	23 Feb 08	–71.98	–72.02	173.32	173.26	5

(continued)

Table 4 (continued)

Parameter			Date		Latitude		Longitude		Length (n mile)
			Start	End	Start	End	Start	End	
		28	24 Feb 08	24 Feb 08	–72.03	–72.08	173.06	173.06	6
		29	24 Feb 08	25 Feb 08	–72.08	–71.89	172.90	173.75	36
		30	25 Feb 08	25 Feb 08	–71.79	–71.47	173.86	174.58	44
		31	26 Feb 08	26 Feb 08	–71.37	–70.90	174.75	176.59	46
		32	26 Feb 08	28 Feb 08	–70.90	–69.24	176.59	181.43	260
		33	29 Feb 08	29 Feb 08	–69.39	–69.31	181.35	181.40	10
		34	29 Feb 08	01 Mar 08	–69.31	–68.52	181.40	181.56	88
		35	02 Mar 08	02 Mar 08	–68.51	–68.25	181.61	181.05	37
		36	02 Mar 08	02 Mar 08	–68.22	–68.12	180.97	180.67	17
		37	04 Mar 08	04 Mar 08	–68.09	–67.85	–179.11	180.41	18
		38	05 Mar 08	05 Mar 08	–67.80	–67.60	180.45	181.15	37
		39	06 Mar 08	07 Mar 08	–67.63	–67.41	181.15	180.19	48
		40	08 Mar 08	09 Mar 08	–67.35	–66.87	180.04	170.98	395
		41	11 Mar 08	11 Mar 08	–67.14	–66.70	171.15	171.22	49
(c) *G.O. Sars*									
Transducer									
	Type	EK60							
	Frequency (kHz)	18, 38, 70, 120, 200, 333		also	TS probe		EK60	38, 120, 200 kHz	
	Transducer depth (m)	8			Downward lander		EK60	38, 200 kHz	
	Ping interval (s)	variable			Upward lander			38 kHz	
	Depth range (m)	10–750 (for selected frequencies)			Sonar		M570	75–112 kHz	
Calibration									
Pre-survey	Date	16 Jan 08							
	Location	Stromness Bay							
Post-survey	Date								
	Location								
Transects									
	Area	Scotia Sea	06 Jan 08	23 Mar 08		See WG-EMM-08/28			

(continued)

Table 4 (continued)

Parameter			Date		Latitude		Longitude		Length (n mile)
			Start	End	Start	End	Start	End	
(d) *Yuzhmorgeologiya*									
Transducer									
	Type	EK60							
	Frequency (kHz)	38, 70, 120, 200							
	Transducer depth (m)	7							
	Ping interval (s)	2							
	Depth range (m)	7–500							
Calibration									
Pre-survey	Date	14 Jan 08				11 Jan 09			
	Location	Admiralty Bay, Ezcurra Inlet				Admiralty Bay, Ezcurra Inlet			
Post-survey	Date	09 Mar 08				07 Mar 09			
	Location	Admiralty Bay, Ezcurra Inlet				Admiralty Bay, Ezcurra Inlet			
Transects									
	Area	South Orkney Islands				South Orkney Islands			
	Start date	18 Feb 08				09 Feb 09			
	Start position	59.9970S	47.4911W	Top corner		59.9970S	47.4911W	Top corner	
	End date	26 Feb 08				04 Mar 09			
	End position	61.7530S	43.9915W	Bottom corner		61.7530S	43.9915W	Bottom corner	
	Length (n mile)	32 031 km^2	500 n miles of transects			32 031 km^2	500 n miles of transects		

APPENDIX A

TERMS OF REFERENCE

Subgroup on Acoustic Survey and Analysis Methods
(Ancona, Italy, 25 to 28 May 2009)

The Scientific Committee recommended the following terms of reference for the meeting of SG-ASAM in 2009 (SC-CAMLR-XXVII, Annex 8).

The following are general tasks for the subgroup:

(i) to develop, review and update as necessary, protocols on:

(a) the design of acoustic surveys to estimate the abundance index of nominated species, including surveys and data collection using commercial krill trawlers;

(b) the analysis of acoustic survey data to estimate the biomass of nominated species, including estimation of uncertainty (bias and variance) in those estimates;

(c) the archiving of acoustic data, including data collected during acoustic surveys, acoustic observations during trawl stations, and *in situ* target strength measurements.

The following specific tasks have also been identified by the Scientific Committee. Points (ii), (iii) and (iv) are considered to be of highest priority:

(ii) to provide advice that will assist in quantifying uncertainties in krill B_0 estimates, including:

- evaluate developments in target strength modelling and other new observations on krill (SC-CAMLR-XXVI, Annex 8, paragraph 84);
- validate acoustic identification techniques – by collating a set of net-validated acoustic data and evaluating whether acoustic target identification methods are biased;
- evaluate and consider available information and current methods for the measurement of krill orientation and material properties, and using analyses of tilt angle from recent research cruises;
- develop a probability density function of the estimate of B_0 based on the current understanding of uncertainties in various parameter values;

(iii) to document the current agreed protocols for krill B_0 assessment;

(iv) to investigate the use of ancillary acoustic data (e.g. from finfish surveys, exploratory fisheries data and commercial fisheries echo sounders) and the required analytical methods with a view to:

- documenting protocols for and analysing data from exploratory fisheries acoustic data processing and interpretation;

- providing krill biomass estimates from areas that are not regularly surveyed;

(v) to evaluate acoustic results from IPY surveys in 2008, supported by a summary of all IPY acoustic data and related metadata submitted to CCAMLR to be prepared by the Secretariat (SC-CAMLR-XXVI, Annex 8, paragraph 84; SC-CAMLR-XXVI/BG/3, paragraph 22) and to provide specific advice to the Scientific Committee on the value of IPY acoustic data, and their analysis, for krill biomass estimation (SC-CAMLR-XXVI/BG/3, paragraph 22);

(vi) to evaluate developments in target strength modelling and other new observations of Antarctic fish species, including icefish and myctophids (SC-CAMLR-XXVI, Annex 8, paragraph 84);

(vii) to resolve difficulties identified with the swept-area estimation of icefish abundance, including the application of the adjustment factor for trawl headline height used in surveys for *C. gunnari* (SC-CAMLR-XXVII, Annex 5, paragraphs 3.26 and 13.20).

APPENDIX B

AGENDA

Subgroup on Acoustic Survey and Analysis Methods
(Ancona, Italy, 25 to 28 May 2009)

1. Introduction

   1.1 Opening of meeting
   1.2 Meeting terms of reference and adoption of the agenda

2. Provide advice that will assist in quantifying uncertainties in krill B_0 estimates

   2.1 Review recent research results including developments in target strength modelling and observations on krill orientation and material properties

   2.2 Collate a set of net-validated acoustic data and evaluate whether current acoustic target identification methods are biased

   2.3 Provide direction towards developing a probability density function for the estimate of B_0 based on the current understanding of uncertainties in various parameter values

3. Document the current agreed protocols for krill B_0 assessment

4. Discuss the use of ancillary acoustic data (e.g. from finfish surveys, exploratory fisheries data and commercial fisheries echosounders)

   4.1 Review recent research results involving collection of ancillary acoustic data

   4.2 Document protocols for analysing, processing, and interpreting ancillary acoustic data (e.g. data collected during exploratory fisheries)

   4.3 Determine whether such data can provide krill biomass estimates from areas that are not regularly surveyed (link to subitem 5.3)

   4.4 Discuss future needs for acoustic instrumentation in the Antarctic

   4.5 Southern Ocean Sentinel Program

5. Evaluate results from IPY surveys in 2008

   5.1 Review acoustic data and related metadata submitted to CCAMLR

   5.2 Presentation of new results from IPY surveys

5.3 Determine whether data can provide krill biomass estimates from areas that are not regularly surveyed (link to subitem 4.3)

6. Evaluate developments in target strength modelling and other new observations on Antarctic fish species

6.1 Presentation of new results (may be linked to subitem 5.2)

7. Attempt to resolve difficulties identified with the swept-area estimation of icefish abundance

7.1 Discuss appropriate application of the adjustment factor for trawl headline height used in surveys for *Champsocephalus gunnari*

8. Suggestions for timing/venue of next meeting

9. Recommendations to the Scientific Committee

10. Adoption of report

11. Close of the meeting.

APPENDIX C

LIST OF PARTICIPANTS

Subgroup on Acoustic Survey and Analysis Methods
(Ancona, Italy, 25 to 28 May 2009)

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APPENDIX D

LIST OF DOCUMENTS

Subgroup on Acoustic Survey and Analysis Methods
(Ancona, Italy, 25 to 28 May 2009)

SG-ASAM-09/1	Agenda
SG-ASAM-09/2	List of Participants
SG-ASAM-09/3	List of Documents
SG-ASAM-09/4	Net-based verification of acoustic techniques used to identify Antarctic krill J. Watkins and S. Fielding (United Kingdom) (*CCAMLR Science*, submitted)
SG-ASAM-09/5	Preliminary acoustic results from the New Zealand IPY-CAML survey of the Ross Sea region in February–March 2008 R. O'Driscoll, G. Macaulay, S. Gauthier, M. Pinkerton and S. Hanchet (New Zealand)
SG-ASAM-09/6	Target strength of mackerel icefish (*Champsocephalus gunnari*) from a scattering model G. Macaulay (New Zealand)
SG-ASAM-09/7	Analysis of icefish (*Champsocephalus gunnari*) spatial distribution for optimisation of the bottom trawl survey sampling S. Kasatkina (Russia)
SG-ASAM-09/8	Acoustic identification and size estimation of euphausiids R. Korneliussen and G. Skaret (Norway)
SG-ASAM-09/9	Underwater acoustic instrumentation for Antarctic applications L. Andersen (Norway)
SG-ASAM-09/10	Target strength studies on Antarctic silverfish (*Pleuragramma antarcticum*) in the Ross Sea M. Azzali, I. Leonori, I. Biagiotti, A. De Felice, M. Angiolillo, M. Bottaro and M. Vacchi (Italy) (*CCAMLR Science*, submitted)
SG-ASAM-09/11	Summary of acoustic data and related data collected during IPY surveys Secretariat

SG-ASAM-09/12	Towards a CCAMLR protocol for the estimation of krill biomass T. Jarvis (Australia) and K. Reid (Secretariat)
SG-ASAM-09/13	Applying a TS-probe for measuring Antarctic krill (*Euphausia superba*) target strength *in situ*: procedures and data analysis G. Skaret, L. Calise and E. Ona (Norway)

APPENDIX E

LIST OF PROTOCOLS

This is a list of clarifications and insertions where SC-CAMLR-XXVI, Annex 4, Table 1 and SC-CAMLR-XXIV, Annex 6 were unclear. This list will form the basis for a more complete document with full cross-referencing that will be made available on the CCAMLR website.

1. Survey Design
   Random stratified parallel transects during daytime

2. Data Collection
   Frequencies – 38, 120 and 200 kHz with ping transmit interval at 2 s, pulse duration of 1 ms and power settings not to exceed the limits defined by Korneliussen et al. (2008)
   Collect net samples of krill during survey
   Collect under way ambient noise measurement
   CTD measurement in survey area

3. Acoustic data processing and analysis
   (a) Processing
      Calibration following CCAMLR-2000 Survey protocols
      Sound-speed and α measured during survey
      Noise estimation and subtraction following CCAMLR-2000 Survey protocols
      No thresholding
      Removal of unwanted/bad data according to Hewitt et al. (2004), including:
         Surface reverberation
         Bottom (seabed)
         Data beyond start/end of transects
         Noise spikes
      Quality control
   (b) Analysis
      Target identification using the SDBWA model to estimate pairwise dB difference between 120 and 38 kHz, and 200 and 120 kHz using mean size parameters.
      Examine length frequency of krill from trawls and include the range of lengths of krill that includes ≥95% of the krill PDF and achieve the smallest δS_v window in order to define dB difference from SC-CAMLR-XXIV, Annex 6, Table 3.
      Re-sampling frequency of 50 pings at 2 s ping rate over 5 m (noting that 50 pings at 2 s at 10 knots is approx. equal 500 m)

4. Echo Integration
   120 kHz primary frequency (use other frequencies for uncertainty estimates)
   EDSU – 1 n mile horizontal normalised on-track distance
   Nominally to 500 m (or 1 m above bottom) dependent on the signal to noise ratio

5. Conversion of acoustic backscatter to area biomass estimate
   Weight-at-length measured on survey – or use values from literature noting Hewitt et al. (2004) for the Scotia Sea
   Target strength – using the simplified SDBWA with the revised parameters (Table 2)

6. Estimation of Total Biomass from Biomass Density
   Jolly and Hampton (1990)
   Conversion factors from the SDBWA model and the length PDF of krill sampled during the survey

7. Estimation of Sampling Errors
   The Jolly and Hampton (1990) methods for estimating sampling uncertainty.