ANNEX 8

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

(Cambridge, UK, 30 April to 2 May 2007)

CONTENTS

REPORT OF THE THIRD MEETING OF THE SUBGROUP ON ACOUSTIC SURVEY AND ANALYSIS METHODS
(Cambridge, UK, 30 April to 2 May 2007)

INTRODUCTION

The third meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) was held from 30 April to 2 May 2007. The meeting was convened by Drs R. O'Driscoll (New Zealand) and M. Collins (UK) and was held at the British Antarctic Survey in Cambridge, UK.

2. Dr Collins welcomed participants on behalf of the host institute 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-XXV, paragraph 13.39, Annex 5, paragraphs 13.16 to 13.19 and Annex 4, paragraph 6.50; given here in Appendix A). The meeting focused on the development of methodologies for acoustic surveys of icefish (*Champsocephalus gunnari*) and the review of the acoustic sampling protocols for krill (*Euphausia superba*) for use by CCAMLR-IPY projects. Discussion of acoustic protocols for krill in IPY surveys was carried out on 2 May 2007 in conjunction with members of the CCAMLR-IPY Steering Committee which met in Cambridge from 2 to 4 May 2007. A provisional agenda was introduced, discussed and adopted (Appendix B).

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

5. This report was prepared by the participants.

REVIEW OF THE FINDINGS OF TWO PREVIOUS MEETINGS OF SG-ASAM

6. Dr O'Driscoll summarised the major findings and recommendations of the previous two meetings of SG-ASAM.

7. The first meeting of SG-ASAM was held at the Southwest Fisheries Science Center (SWFSC) in La Jolla, USA, from 31 May to 2 June 2005 (SC-CAMLR-XXIV, Annex 6). The terms of reference for this meeting were restricted to two issues relating to hydroacoustic surveys of krill, namely: (i) models of krill target strength (TS); and (ii) classification of volume backscattering strength (S_v).

8. With respect to these two issues, SG-ASAM recommended for CCAMLR hydroacoustic surveys to estimate krill B_0 that:

- the simplified SDWBA model with constrained parameters be used to define krill TS as a function of length at a given frequency;

- the minimum and maximum TS values from the subgroup's agreed run of the simplified SDWBA (SC-CAMLR-XXIV, Annex 6, Figure 4) should be used as a first estimate of the error associated with krill TS;

- the classification of S_v to filter out non-krill targets should be undertaken using the ΔS_v technique, with the ΔS_v windows constrained for the appropriate size range of krill.

9. The subgroup made two further recommendations for further research relating to TS models and S_v classification of krill:

- The subgroup emphasised the importance of understanding the orientation distribution, sound-speed contrast, density contrast and animal shape for krill under the surveying vessel. The subgroup encouraged further work on these topics as a high priority.

- The subgroup recognised that the use of 70 kHz transducers should improve krill detection, classification and estimation of B_0 and recommended their use during krill surveys whenever possible.

10. The second meeting of SG-ASAM was held at the CCAMLR Secretariat, Hobart, Australia, on 23 and 24 March 2006 (SC-CAMLR-XXV, Annex 6). The terms of reference for this meeting were focused on issues with respect to surveys of icefish, namely: (i) frequency-specific definition of icefish target strength; and (ii) classification of volume backscattering strength attributed to icefish versus other taxa. The Scientific Committee also requested more general advice on the conduct of acoustic surveys, namely: (i) survey design; (ii) documentation of survey methods; (iii) presentation of results; and (iv) protocols for archiving data.

11. The subgroup made the following recommendations to the Scientific Committee, that:

(i) multiple frequencies, including 38, 70 and 120 kHz, be used in acoustic surveys of icefish and krill whenever possible to improve mark classification. The utility of higher and lower frequencies should also be investigated;

(ii) the efficiency of the current Δ120–38 kHz S_v dB difference method of taxa delineation be further evaluated in relation to discrimination of icefish from associated species;

(iii) the TS of icefish 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;

(iv) data be collected on icefish orientation, including changes in orientation due to vertical migration or in response to survey vessels;

(v) icefish behaviour should be further investigated, including vertical distribution and response to survey vessels, as they impact on survey design, fish orientation, target strength determination and species delineation;

(vi) a library of echograms with associated TS, catch and biological data for icefish and associated species should be available from CCAMLR. This library should be incorporated into the existing CCAMLR acoustic database;

(vii) the Secretariat investigate the feasibility of archiving data in the HAC[1] (or other suitable) format, and that other types of data, such as calibration parameters, should be archived by the Secretariat.

NEW INFORMATION ON ICEFISH ACOUSTICS

12. Dr S. Fielding (UK) presented the results of the preliminary analyses of acoustic data obtained from a research survey and a commercial icefish fishing vessel at South Georgia (Subarea 48.3) in January 2006 and January 2007 respectively (SG-ASAM-07/5).

13. Dr Fielding first presented uncalibrated ES60 38 kHz echosounder data collected opportunistically from the fishing vessel *New Polar* during January 2007. The NASC (m^2 n $mile^{-2}$) was calculated for the depth layer fished by the *New Polar* (115–180 m), where the catch data confirmed the presence of icefish. Highest NASC values were observed within the fishing layer around dawn and in water depths between 200 and 250 m. Both echograms and the catch data from the *New Polar* show that icefish were present midwater during the day. Food availability was suggested as a cue for their presence, and echograms were shown of icefish schools occurring midwater below krill swarms. However, comparison of surface (10–50 m) and fishing depth NASC did not show a relationship.

14. Identification of mackerel icefish marks was investigated using EK500 38 and 120 kHz, collected from the FPV *Dorada* during the South Georgian groundfish survey. A Δ120–38 kHz S_v dB difference of between 0 and 14 dB was observed consistently in trawl-verified icefish acoustic marks and suggested as a means to identify them. A schools analysis was performed on the echograms to identify krill and icefish marks; these could be separated using a combination of depth within the water column and different thresholds. Krill swarms occurred in the surface 0–100 m and were identified by a threshold greater than –60 dB, whereas icefish schools were only observed below 50 m depth and S_v ranged between –85 and –60 dB. A tentative estimate of TS at 38 kHz for icefish was presented, calculated from measurements of icefish density from bottom trawl data (11 trawls where more than 80% of the total catch biomass was icefish) compared with mean S_v within the region of the trawl.

15. SG-ASAM noted that the study had provided a considerable amount of new information on the distribution of icefish in the water column and had gone some way to providing reliable information for the morphological identification of icefish acoustic marks. Dr Fielding indicated that simple thresholding using the Echoview's schools detection algorithm could be employed to identify icefish marks from krill. Dr T. Jarvis (Australia) noted that in scenarios of low krill densities the discrimination of such marks might not be straightforward.

16. SG-ASAM also noted that, broadly speaking, there was little apparent depth overlap between krill and icefish marks with icefish generally located below 100 m and krill above

[1] A global standard being developed for the storage of hydroacoustic data.

50 m. However, icefish feed predominantly on krill and therefore must, at some time, have an overlapping depth distribution. Further fishing effort is required in the depths between 50 and 100 m to investigate the krill and icefish overlap.

17. Dr O'Driscoll expressed concern that mark identification based on the presence of 'clean' commercial catches that comprise overwhelmingly the target species may not be appropriate if fishing gear selectivity leads to catch composition not being representative of the composition of the mark. However, SG-ASAM noted that icefish had dominated catches when a finer-meshed research trawl had been deployed to fish targets on previous research surveys at South Georgia and as such the species composition of commercial trawl catches were likely to accurately represent the composition of acoustic marks.

18. SG-ASAM noted that considerable uncertainty exists around the estimation of the relationship between TS and fish length for icefish. Several participants highlighted the difficulties associated with efforts to accurately match net and acoustic data, and it was agreed that TS estimation, using the methods outlined in SG-ASAM-07/5, was likely to be unreliable.

19. It was pointed out that it was difficult to collect *in situ* data on icefish TS with the current ship-mounted acoustic devices because of the depth distribution of the fish. There was also concern about previous *in situ* estimates of icefish TS (WG-FSA-SAM-04/9) because of uncertainty about target identification. Alternative technologies may be required to estimate TS *in situ*. Dr R. Korneliussen (Invited Expert) indicated that Norway planned to use a three-frequency 'drop TS' system during the forthcoming IPY survey of the Scotia Sea scheduled for 2008 from which more reliable estimates of TS might be made.

RECOMMENDATIONS FOR FUTURE WORK ON ICEFISH

20. SG-ASAM noted that questions relating to species classification and target strength need to be further resolved before it could consider the terms of reference relating to the combination of trawl and acoustic indices for a stock assessment of icefish in Subarea 48.3 (SC-CAMLR-XXV, Annex 5, paragraph 13.19).

Mark identification

21. SG-ASAM noted that acoustic scattering was a function of multiple properties of the target and of interplay with acoustic wavelength. Information on frequency response was required not only for fish of different lengths but for fish located at different depths, from different mark structures, of different composition (e.g. variable reproductive state) and at different orientations to further evaluate the discrimination of icefish from associated species.

22. Dr D. Demer (USA) suggested that the optically assisted acoustic survey technique developed at the NOAA SWFSC for surveying rockfishes in the Southern California Bight could be used to survey icefish (SG-ASAM-07/7). Similar to icefish, rockfish reside over thousands of n miles^2 on or near the sea floor at depths of 80–350+ m, are found in low densities and their habitats are largely uncharacterised. Succinctly, the method uses multiple-frequency echosounders to map the scattering from demersal fish, and cameras deployed from

a remotely operated vehicle to quantify the mixture of species and estimate their length probability distribution functions. This information, coupled with appropriate TS models can be used to derive estimates of fish abundance, by species, in a non-lethal manner.

TS estimation

23. Dr G. Macaulay (Invited Expert) informed the subgroup that attempts to model the TS of icefish using computed tomography (CT) scanning methods had not been possible during the last year. Transfer of CT scan data between the UK (where frozen icefish samples were located) and New Zealand had proved impossible as the scanning facility was not able to provide a file format that contained the necessary scan data. However, it was noted that it was now possible for icefish samples collected by the Australian Antarctic Division to be CT-scanned in Hobart and for data to be sent to New Zealand's National Institute of Water and Atmospheric Research (NIWA) for subsequent analysis. It is expected that the scanning will occur in May 2008. Modelling of target strength at a range of frequencies will then follow.

24. A new technique has been developed for measuring the broad bandwidth sound scatter of live animals in highly reverberant tanks in a laboratory or on board vessels (Demer et al., 2003; Demer and Conti, 2003; Conti and Demer, 2003; Conti et al., 2005). The data are used to validate scattering models for harvested and cohabitant species. The models are used to improve acoustical identification of species and sizes, and improve estimates of TS – thus improving the accuracy and precision of survey estimates. The method has been used to measure the sound-scattering spectra of many species such as anchovy and sardine, Antarctic krill, northern krill, mysids, shrimp, bocaccio rockfish and even humans. Dr Demer proposed that the multiscattering technique could be used for measuring the broad bandwidth sound scatter from mackerel icefish and coexisting species *ex situ* (SG-ASAM-07/7).

25. In 2002, the multiscattering technique was used to measure the total target strengths (TTS) of *E. superba*, *Electrona antarctica* and a squid of unknown species. TTS is the total scattering cross-sectional area (m^2) averaged over all angles of incidence. The preliminary results, documented in the report of the US AMLR 2001–2002 Survey, show that TTS from 38 to 202 kHz ranged roughly from –85 to –75 dB for *E. superba*, –65 to –55 dB for *E. antarctica*, and –60 to –50 dB for the squid species. The fish and squid lengths were not provided, their sample sizes were 6 and 1 respectively, and the TTS below about 50 kHz had a low signal-to-noise ratio. The data were presented to illustrate the potential of the multi-scattering method and to give an indication of the relative TTS between these taxa. TTS and TS are similar when the wavelength is large compared to the animal size and vice-versa.

26. SG-ASAM thanked Dr Demer for this presentation and agreed that the broadband reverberation method had considerable potential for estimating TTS of mackerel icefish and other Antarctic species. Dr Collins pointed out that icefish were often moribund when caught in trawls, but some may be in suitable condition to allow *ex situ* TS measurements on the research vessel.

27. Dr Macaulay noted the TS models are still required to allow for the conversion of TTS measurements to estimates of backscattering TS.

28. There are currently few data available on the density values of mackerel icefish, which are required for TS modelling. SG-ASAM recommended that further work be undertaken to obtain density and sound-speed measurements for a range of Antarctic fish species, including icefish and myctophids.

OTHER ACOUSTIC SURVEYS IN CCAMLR WATERS

29. Dr O'Driscoll presented results from acoustic data collected opportunistically from New Zealand longline vessels participating in the exploratory fishery for toothfish in the Ross Sea (SG-ASAM-07/8). Fishing vessels were equipped with Simrad ES60 echosounders with 12 or 38 kHz transducers, but were not calibrated. Additional data were collected by the RV *Tangaroa* during a research cruise from February to March 2006 using an EA500 with 12, 38 and 120 kHz transducers.

30. Acoustic data were used to study the distribution of mesopelagic prey species in the Ross Sea. Total acoustic backscatter in the upper 1 000 m and the variety of mark types decreased from north to south. Common marks north of 67°S included a surface layer at less than 50 m depth, schools and layers centred on about 200 and 400 m depth, and a diffuse deep scattering layer centred at 750 m depth. South of 70ºS, average acoustic density was much lower and most of the backscatter was from schools and layers shallower than 100 m. Near-bottom marks were associated with areas shallower than 1 000 m on the Ross Sea shelf edge. In general, the amount of backscatter observed in the Ross Sea was much lower than that observed in shelf areas off New Zealand.

31. Little direct information is available on the species composition of different mark types in the Ross Sea. However, different marks exhibited different acoustic responses across the three frequencies examined which provided some clues about the likely identity of the key scatterers. Marks shallower than 100 m depth were stronger on 120 kHz than on 38 kHz, and weak on 12 kHz. This type of acoustic response is typical of krill or other large zooplankton. Schools and layers at 200–400 m depth showed a more consistent response across all three frequencies and may have been associated with small fish.

32. This study identified key areas and mark types for further research, including directed sampling, and showed how fishing vessels could be used to opportunistically collect acoustic data for ecosystem studies.

33. Dr O'Driscoll questioned whether Members had validated echograms of *Pleuragramma* spp. Dr Jarvis indicated that Australia had some echograms which it believed were most likely to be *Pleuragramma* spp., based on their geographical location and the absence of krill in RMT catches. He agreed to make these available.

34. Dr Fielding described the British Antarctic Survey's cruise program in the Scotia Sea. Three cruises (spring, summer and autumn) are planned as part of the Discovery 2010 science program, the first of which took place in October–December 2006 (austral spring). The cruises are designed to investigate seasonal variability in food-web structure across latitudinal and productivity gradients, with a main transect running from the ice-edge (south of the South

Orkney Islands) to the Polar Front (north of South Georgia). Acoustic data will be collected along transect, with mesoscale acoustic transects undertaken at each of approximately eight main stations.

35. Dr Collins presented details of a cruise (*James Clark Ross* cruise 100) undertaken to the northwest of South Georgia in March 2004 to investigate the distribution and ecology of mesopelagic fish (SG-ASAM-07/8). Data on the vertical distribution (day and night) of the nine most abundant myctophid species were presented. Echograms attributed to *E. carlsbergi*, *Protomyctophum choriodon* and the notothenid *Patagonotothen guntheri* were displayed and discussed.

36. SG-ASAM noted the prevalence of myctophids in Antarctic waters and the importance for acoustic estimation of knowing which myctophid species possessed swim bladders. Dr Collins prepared Table 1 to provide preliminary information on the size and swim bladder characteristics of abundant myctophids in the Scotia Sea. The subgroup was also referred to an early report on swim bladder form by Marshall (1960).

GENERAL ISSUES RELEVANT TO ACOUSTIC SURVEYS IN CCAMLR WATERS

Collection of acoustic data from commercial vessels

37. SG-ASAM recognised an increasing interest from Members in the collection of acoustic data from commercial vessels (e.g. SG-ASAM-07/5, 07/7).

38. In 2003, ICES established a Study Group on the Collection of Acoustic Data from Fishing Vessels (SGAFV) to evaluate the collection of acoustic data from fishing vessels and provide appropriate recommendations. Experts from 12 countries participated in the work of the study group during its three-year term. SGAFV prepared a written report during its three annual meetings and by correspondence between meetings which will be published as an *ICES Cooperative Research Report* in July 2007. Dr O'Driscoll described the contents of this report and referred interested Members to it.

Data archiving

39. At its 2006 meeting, SG-ASAM requested that the Secretariat:

(i) develop a library of echograms with target strength, catch and biological data for icefish and associated species (SC-CAMLR-XXV, Annex 6, paragraph 50);

(ii) develop an archive of calibration and configuration parameters to allow detailed analysis (and reanalysis) of acoustic survey data (SC-CAMLR-XXV, Annex 6, paragraph 62);

(iii) investigate the feasibility of archiving data in the HAC format, and obtain documentation on SonarData's ek5 and Echoview EV formats (SC-CAMLR-XXV, Annex 6, paragraph 61).

Dr Ramm presented SG-ASAM-07/4 which reported on progress with these tasks.

40. The existing database model has been expanded to include a new module which contains a prototype echogram library. The prototype library was based on the framework adopted by the EU project on Species Identification Methods from Acoustic Multifrequency Information (SIMFAMI, EU project Q5RS-2001-02054, Final Report 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.

41. SG-ASAM 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.). These might be added as a further linked table.

42. Dr Macaulay suggested including the slope and intercept of the TS-to-length relationship instead of B20 in the Echogram table as many species have been demonstrated to have TS-to-length relationships with slopes different to 20.

43. The Secretariat requested some example data to help develop the prototype library and Dr Fielding agreed to provide some echograms.

44. The existing database model was further expanded to include a new module which contains prototype tables to archive data on transducer configuration, echosounder configuration and calibration parameters. The Secretariat sought advice on which calibration parameters should be included in the database table. SG-ASAM suggested that the parameters given in Table 2 be included.

45. SonarData has provided information to the Secretariat on the SonarData ek5 file format specification and the feasibility of archiving Echoview data in the HAC format (I. Higginbottom, Director, SonarData, pers. comm., April 2007).

46. SG-ASAM noted that there are two possible levels of archiving existing data: raw data files (which contain variables such as position, S_v and phase) and processed data (such as bottom definition lines and regions).

47. The conversion of data files to the HAC format is relatively straightforward, but may not be necessary as long as the format of the archived data files is well documented. Some current file formats (such as EK60 raw files) have appropriate documentation and SG-ASAM recommended that this should be archived along with the data files.

48. Archiving of processed data is more problematic. For example, there is information in EV files which is not supported by HAC files, and cannot be written to HAC or other files. SG-ASAM agreed that the post-processing software and file structure should be documented along with the processed data. Where adequate documentation is not available (e.g. proprietary software), the version of the software used for processing should be archived along with the processed data file. This may have financial implications for the Secretariat, but SG-ASAM noted that read-only (demonstration) versions of software were freely available from some manufacturers (e.g. SonarData Echoview).

49. SG-ASAM urged that standard well-documented file structures and procedures for exporting and archiving of processed data (such as ASCII data strings defining the bottom definition line and regions) should be considered by software manufacturers.

Calibration

50. At the 2007 meeting of ICES WG-FAST, the issue of consistency of calibration between different users was raised, particularly in reference to the Simrad EK60 echosounder system and the calibration protocols described in the Simrad manual. A topic group was established to collate the current calibration protocols employed by users, and to prepare a report to ICES providing guidelines for EK60 calibration procedures within the next two years. Dr Jarvis is one of the co-chairs of the topic group and will keep SG-ASAM informed on its progress.

NEW INFORMATION AVAILABLE ON KRILL ACOUSTICS

51. Dr Jarvis presented the methods and results of Australia's 2006 BROKE-West acoustic krill-biomass survey of Division 58.4.2 as a follow-up to WG-EMM-06/16 (SG-ASAM-07/9). CCAMLR-agreed protocols for the steps required to report on and produce an estimate of B_0 from acoustic data were highlighted (e.g. SC-CAMLR-XV, Annex 4, Appendix D; SC-CAMLR-XIX, Annex 4, Appendix G, paragraphs 3.1 to 3.6). Dr Jarvis also pointed out that: (i) while there are numerous discussions of acoustic methods throughout the CCAMLR literature, no single document exists for ease of reference, and (ii) recent methodological advances have also been discussed by CCAMLR since this time (e.g. SC-CAMLR-XXIV, Annex 4, paragraphs 4.55 to 4.60, 4.66 and 4.67).

52. It was agreed that many acoustic protocols and guidelines have been discussed by CCAMLR working groups over the years. Collation of all such information into a single source would be extremely valuable. As a step in this direction, Dr Jarvis presented a flowchart which attempts to summarise and illustrate the general steps involved from acoustic data collection to krill biomass estimation. This flowchart is reproduced here (Figure 1) on the recommendations of the subgroup.

53. The BROKE-West acoustic survey methodology adhered to the protocols of the BROKE (Pauly et al., 2000) and the CCAMLR-2000 Survey (Hewitt et al., 2004) surveys wherever possible. This included application of the same length:weight ($L:W$) and target strength (TS) models, and similar application of a modified version of the Jolly and Hampton (1990) method for estimating B_0 and its associated variance.

54. Calibration of the echosounder system during BROKE-West revealed transducer gain (TS gain) differences of up to ~0.5 dB when using Simrad versus Echoview processing routines. The Simrad 'EK model' results were subsequently used during post-processing of the survey data. Some discussion was held on the differences in quality between the 120 kHz transducer model used during BROKE-West (Simrad ES120-7) and Simrad's newer composite model (ES120-7C). It was reiterated that calibration protocols for the EK60 echosounder are currently being addressed by an ICES topic group, co-chaired by Drs G. Pedersen (Norway) and Jarvis, the results of which will be communicated to SG-ASAM in due course. WG-EMM-96 lists some information to be documented for calibrations from each survey (SC-CAMLR-XV, Annex 4, Appendix D; SC-CAMLR-XIX, Annex 4, Appendix G, paragraphs 3.1 to 3.6). The subgroup agreed to revisit this table and update it as necessary.

55. The post-processing steps for the BROKE-West acoustic data included: (i) removal of surface noise, transducer ring-down and spikes; and (ii) species ID using dB differences (2–16 dB for Δ120–38 kHz S_v). The weighted mean density of krill for the survey was thus estimated as 9.48 g m^{-2}; B_0 = 14.85 million tonnes; with a CV = 15.15%. The CV reported in WG-EMM-06/16 was erroneous, and will be revised and reported to CCAMLR.

56. The BROKE-West acoustic krill densities have been characterised thus far using cumulative density functions, and distributions of densities further described relative to the 1 000 m contour. Results indicated that much of the krill was found in very low densities (<1 g m^{-2}), and much of the cumulative density was found in association with the 1 000 m contour (shelf break). Also, 90% of the krill resided in the top 100 m, as noted in the CCAMLR-2000 Survey. These analyses were part of a larger ongoing investigation of covariations in biotic and abiotic components of the ecosystem.

57. There was some discussion about survey area definition. Dr J. Watkins (UK) noted that the area of interest is generally defined *a priori*, and sampling design follows that decision. Dr Demer agreed that the area definition could be defined on the basis of a management area (e.g. FAO statistical area), or the area defining a stock. The choice depends on the objective of the survey. Dr Jarvis noted that during the BROKE-West survey, real-time decisions were also required on how close to the coast to survey in order to cover the krill stock.

58. Dr Jarvis noted that survey designs can be optimised for biomass estimation or stock dispersion, but compromises are generally necessary when the survey has multiple objectives.

59. The subgroup recalled that in 2005, SG-ASAM recommended using smaller ranges of dB-differences as suggested by the krill length-frequency distributions in the sub-survey areas during the times of those surveys.

60. It was noted that the echo-energy to density conversion factor derived from the ratio of the mass per krill and the TS per krill should be derived by weighting both the numerator and the denominator by the length-frequency distributions prior to calculating the ratio.

RECOMMENDATIONS FOR FUTURE WORK ON KRILL

61. SG-ASAM discussed its terms of reference from WG-EMM (SC-CAMLR-XXV, Annex 4, paragraph 6.50). The subgroup was asked to review the method for estimating the CV for the biomass estimate provided by Demer and Conti (2005) and consider whether this is sufficient to determine the uncertainty in B_0 more generally. SG-ASAM believed that the correct reference is Demer (2004), where a multiple-frequency Monte Carlo simulation was used to estimate total random error.

62. Demer (2004) concluded that the random component of the measurement error was negligible compared to the sampling error. However, many sources of bias are appreciable, and vary on time and space scales. Dr O'Driscoll noted that if biases are consistent in time and space then the data can be considered relative and used as indices.

63. SG-ASAM noted that mark identification, TS, length–weight model and sampling are the biggest four sources of uncertainty determined by Demer (2004), and each of these, and

possibly other sources, need to be quantified, compared and minimised. The subgroup identified that quantifying these errors was perhaps more important than the methods with which the errors were combined.

64. SG-ASAM identified that the Monte Carlo method for estimating total error has now been used by multiple investigators and appears to be a reasonable way to account for combining uncertainty. SG-ASAM recommended that a list of potential sources of error be created and that an accompanying list of protocols be provided to help resolve these errors.

65. SG-ASAM was also asked by WG-EMM to consider 'what is the most appropriate method for estimating B_0 from survey data, considering design-based versus model-based estimation methods?' (SC-CAMLR-XXV, Annex 4, paragraph 6.50). SG-ASAM recognised that the necessary expertise was not present to discuss the validity of the various data- or model-based estimation schemes (e.g. maximum entropy, kriging, Jolly and Hampton (1990) methods etc.), and that ICES and other groups have been discussing this for years. There may be more statistical expertise at the B_0 workshop associated with WG-EMM's 2007 meeting (Christchurch, New Zealand) to deal with this issue.

66. SG-ASAM discussed its previous recommendations regarding the use of the SDWBA for krill biomass estimations. The subgroup noted that these recommendations have not been applied consistently in recent surveys. The subgroup acknowledged that analysis using the new method complicates comparison with historic data.

67. SG-ASAM further discussed whether generic parameter values could be used for the SDWBA. Dr Demer identified that a sensitivity analysis of the model to these parameters was undertaken as part of SG-ASAM-05 (SC-CAMLR-XXIV, Annex 6), where it was identified that further constraints of the model parameters would be highly beneficial. Dr Jarvis reported that several of these parameters had been constrained during the BROKE-West survey (SG-ASAM-07/9).

68. The various methods available for the measurement of density and speed of sound contrasts were discussed. Rather than constraining the community to one method, several papers pertaining to these measurements were suggested for reference (e.g. Chu and Wiebe, 2005; WG-EMM-05/36). SG-ASAM recommended that Members be encouraged to undertake density and sound-speed measurements during IPY surveys.

69. Dr T. Knutsen (Norway) suggested examining the methods for delineating between plankton groups, i.e. identifying other components of the ecosystem using acoustics. This resulted in a discussion as to whether the Δ120–38 kHz S_v difference of 2–16 dB identified in the CCAMLR-2000 Survey was justified. Dr Jarvis identified that it covered the range of krill sizes (10–60 mm) typically observed during the Australian krill surveys. Dr Collins noted that this range was very broad and could represent all the acoustic biomass in some areas. Dr Demer commented that SG-ASAM-05 (SC-CAMLR-XXIV, Annex 6) had agreed to a recommendation that the Δ120–38 kHz S_v range was constrained based on net-sampled information of the krill sizes present. Drs Watkins and Jarvis identified the need to sample a representation of the populations, indicating the difference between stratified and targeted hauls for length-frequency estimation.

70. SG-ASAM suggested that a calculation of biomass is undertaken on total backscattering as well as the component of backscatter attributed to krill by the dB difference method to check what proportion of the total backscatter is attributed to krill.

71. SG-ASAM then discussed diurnal variations in acoustic estimates of krill resulting from either the variation in TS with tilt angle (or the variation of tilt angle over a diurnal cycle) or the removal of krill to the near-surface 'blind zone'. Dr Korneliussen suggested that future surveys should include measurements from upward-looking or side-looking sonar.

JOINT SESSION REVIEW OF THE ACOUSTIC SAMPLING PROTOCOLS FOR KRILL FOR USE BY CCAMLR-IPY PROJECTS

72. Mr S. Iversen (Co-convener, CCAMLR-IPY Steering Committee) welcomed participants to the joint session held on 2 May 2007 and outlined the background behind the formation of the CCAMLR-IPY Steering Committee.

73. At the start of the meeting, four Members (Germany, Japan, New Zealand and Norway) had notified the CCAMLR-IPY Steering Committee of their intention to undertake surveys during IPY. Other Members (Argentina, Brazil, India, Italy) and Peru have previously expressed an interest in participation in CCAMLR-IPY surveys. In addition, Dr Watkins indicated that the UK will be undertaking acoustic survey work which will have relevance to IPY programs.

74. The joint session noted that these IPY surveys will have varied objectives under CAML, ICED and national programs and will not be part of a dedicated CCAMLR research program such as the CCAMLR-2000 Survey. Therefore, acoustic protocols cannot be too rigorous and prescriptive.

75. Dr Watkins proposed hierarchical protocols to be inclusive of all IPY participants. He pointed out that even opportunistic acoustic observations may be valuable, especially in areas where there is little previous information (e.g. Bellingshausen Sea). The joint session agreed with this proposal.

76. The joint session noted that it is important to match the level of protocols with the study requirements. For example, qualitative description of mark types requires a lower level of equipment and protocols than quantitative analysis of backscatter. The most rigorous protocols are required for acoustic data used for biomass estimation and stock assessment.

77. The joint session agreed to a protocol framework that defined the minimum, desirable and optimal requirements for acoustic data collected during IPY surveys (Table 3). These categories correspond to the study requirements for descriptive analysis, quantitative analysis of backscatter and biomass estimation.

78. The joint session recommended that Members carrying out IPY surveys refer to, and follow, the acoustic protocols in Table 3. Protocols should be matched to the particular study requirements of the acoustic data. There may also be opportunities for collection of acoustic data from fishing vessels in CCAMLR waters and the joint session encouraged this collaboration. The joint session recognised that these protocols may be useful for other groups undertaking IPY surveys.

79. The joint session emphasised the need for centralised data archiving of raw acoustic data and metadata collected during IPY surveys. The joint session recommended that protocols and arrangements for data archiving be discussed and agreed between relevant IPY parties (e.g. CAML, CCAMLR, ICED).

80. The joint session did not specifically address protocols for acoustic data processing from IPY surveys. It recommended that a future workshop be held with all interested parties to discuss processing of data from IPY surveys in general, as well as specific CCAMLR study requirements (e.g. krill biomass estimates).

SUGGESTIONS FOR TIMING/VENUE OF NEXT MEETING

81. SG-ASAM agreed that this meeting had benefited from being held in conjunction with a meeting of ICES's WG-FAST in Dublin, Ireland, from 23 to 27 April 2007. 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 WG-FAST meetings.

82. SG-ASAM agreed that future meetings would be required to consider the results of ongoing acoustic research and new surveys, particularly those associated with IPY activities.

83. ICES is sponsoring a Symposium on the Ecosystem Approach with Fisheries Acoustics and Complimentary Technologies (SEAFACTs), to be held in Bergen, Norway, from 16 to 20 June 2008. WG-FAST is meeting for one day following this symposium (probably 23 June 2008). Dr O'Driscoll noted that there were already ICES subgroups planning meetings before and after SEAFACTs, and pointed out that it may be difficult to schedule an associated meeting of SG-ASAM in 2008.

84. SG-ASAM therefore recommended that its next meeting be held close to the time and location of the WG-FAST meeting in April 2009. The terms of reference should include evaluation of acoustic results from IPY surveys in 2008, development in TS modelling and other new observations. The suggested timing would allow Members additional time to analyse results from IPY surveys. Dr Demer indicated that the WG-FAST meeting in 2009 would likely be held in Sicily, Italy.

85. Notwithstanding the above recommendation, SG-ASAM would be willing to meet in 2008 if directed to do so by the Scientific Committee.

86. SG-ASAM recommended that the Data Manager attend future meetings of SG-ASAM, and that the Secretariat cost associated with attending meetings away from Hobart be included in the Scientific Committee's budget.

RECOMMENDATIONS TO THE SCIENTIFIC COMMITTEE

87. SG-ASAM recommended that the acoustic frequency response of icefish be investigated in relation to school structure, depth, time of day and other variables to further evaluate the discrimination of icefish from associated species (paragraphs 21 and 22).

88. SG-ASAM recommended that the TS of icefish and associated species continue 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 (paragraphs 23 to 26).

89. SG-ASAM recommended that further work be undertaken to obtain density and sound-speed measurements for a range of Antarctic fish species, including icefish and myctophids, for input into TS models (paragraph 28).

90. SG-ASAM noted that icefish behaviour will impact on survey design, fish orientation, target strength determination and species delineation, and recommended further research on icefish behaviour using a range of technologies and observation methods (paragraphs 15 to 19).

91. SG-ASAM requested that Members provide validated echograms with associated TS, catch and biological data for icefish and associated species for inclusion in the CCAMLR acoustic database library (paragraph 43).

92. SG-ASAM re-emphasised the need for appropriate documentation and archiving of acoustic survey data, including raw and processed data. Where adequate documentation is not available (e.g. proprietary software), the version of the software used for processing should be archived along with the processed data files (paragraphs 46 to 49).

93. SG-ASAM recommended collation of all acoustic protocols and guidelines for krill surveys previously discussed by CCAMLR working groups into a single document (paragraph 52).

94. SG-ASAM recommended that measurements of density, speed of sound contrast and tilt angle be undertaken where possible during future krill surveys to further constrain these parameters for the SDWBA model, and that the taking of these measurements be a goal for those Members undertaking IPY studies to generate typical variability in these measurements (paragraph 68).

95. SG-ASAM recommended continued investigation into the diel variability in krill biomass – caused either by variations in TS with tilt angle and diel cycle or removal of krill to the near-surface zone within the blind zone of hull-mounted echosounders (paragraph 71).

96. SG-ASAM recommended that protocols be reviewed and developed to resolve the major sources of uncertainty in krill surveys. These uncertainties should then be routinely quantified, compared over space and time and minimised (paragraph 63).

97. SG-ASAM recommended that a fourth meeting of the subgroup be held in conjunction with the ICES WG-FAST meeting in 2009 to consider acoustic results from IPY surveys, development in TS modelling and other new observations (paragraph 84).

98. SG-ASAM recommended that the Data Manager attend future meetings of SG-ASAM, and that the Secretariat cost associated with attending meetings away from Hobart be included in the Scientific Committee's budget (paragraph 86).

99. The joint session (SG-ASAM and the CCAMLR-IPY Steering Committee) recommended that Members carrying out IPY surveys refer to, and follow, the acoustic protocols for data collection provided by the subgroup (Table 3). Protocols should be matched to the particular study requirements of the acoustic data (paragraph 78).

100. The joint session recommended that protocols and arrangements for archiving acoustic data from IPY surveys be discussed and agreed between relevant IPY parties (e.g. CAML, CCAMLR, ICED) (paragraph 79).

101. The joint session recommended that a future workshop be held with all interested parties to discuss acoustic and other data processing from IPY surveys (paragraphs 80 and 82).

ADOPTION OF THE REPORT

102. This report was adopted by SG-ASAM at the meeting.

CLOSE OF MEETING

103. Dr O'Driscoll thanked participants for their contribution and closed the meeting.

REFERENCES

Chu, D. and P.H. Wiebe. 2005. Measurements of sound-speed and density contrasts of zooplankton in Antarctic waters. *ICES J. Mar. Sci.,* 62 (4): 818–831.

Conti, S.G. and D.A. Demer. 2003. Wide-bandwidth acoustical characterization of anchovy and sardine from reverberation measurements in an echoic tank. *ICES J. Mar. Sci.,* 60 (3): 617–624.

Conti, S.G., D.A. Demer and A.S. Brierley. 2005. Broad-bandwidth, sound scattering, and absorption from krill (*Meganyctiphanes norvegica*), mysids (*Praunus flexuousus* and *Neomysis integer*) and shrimp (*Crangon crangon*). *ICES J. Mar. Sci.,* 62 (5): 956–965.

Demer, D.A. 2004. An estimate of error for CCAMLR 2000 survey estimate of krill biomass. *Deep-Sea Res.*, II, 51: 1237–1251.

Demer, D.A. and S.G. Conti. 2003. Validation of the stochastic distorted-wave, Born approximation model with broad bandwidth total target strength measurements of Antarctic krill. *ICES J. Mar. Sci.*, 60: 625–635. Erratum, 61: 155–156 (2004).

Demer, D.A. and S.G. Conti. 2005. New target-strength model indicates more krill in the Southern Ocean. *ICES J. Mar. Sci.,* 62: 25–32.

Demer, D.A., S.G. Conti, J. De Rosny and P. Roux. 2003. Absolute measurements of total target strength from reverberation in a cavity. *J. Acoust. Soc. Am.*, 113 (3): 1387–1394.

Foote, K.G., H.P. Knudsen, G. Vestnes, D.N. MacLennan and E.J. Simmonds. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. *ICES Coop. Res. Rep.*, 144: 57 pp.

Hewitt, R.P., J. Watkins, M. Naganobu, V. Sushin, A.S. Brierley, D. Demer, S. Kasatkina, Y. Takao, C. Goss, A. Malyshko, M. Brandon, S. Kawaguchi, V. Siegel, P. Trathan, J. Emery, I. Everson and D. Miller. 2004. Biomass of Antarctic krill in the Scotia Sea in January/February 2000 and its use in revising an estimate of precautionary yield. *Deep-Sea Res.*, II, 51: 1215–1236.

Hulley, P.A. 1990. Family Myctophidae (lanternfishes). In: Gon, O. and P.C. Heemstra (Eds). *Fishes of the Southern Ocean.* J.L.B. Smith Institute of Ichthyology, Grahamstown, South Africa: 146–178.

Jolly, G.M. and I. Hampton. 1990. A stratified random transect design for acoustic surveys of fish stocks. *Can. J. Fish Aquat. Sci.*, 47: 1282–1291.

Korneliussen, R.J., N. Diner, E. Ona and P.G. Fernandes. 2004. Recommendations for the collection of multi-frequency acoustic data. ICES CM2004/R:36.

Marshall, N.B. 1960. Swimbladder structure of deepsea fishes in relation to their systematics and biology. *Discovery Rep.*, 31 (1): 1–122.

Pauly, T., S. Nicol, I. Higginbottom, G. Hosie and J. Kitchener. 2000. Distribution and abundance of Antarctic krill (*Euphausia superba*) off East Antarctica (80–150°E) during the Austral summer of 1995/1996. *Deep-Sea Res.*, II, 47: 2465–2488.

Table 1: Size ranges (standard length) and swim bladder form for myctophid fish caught in the Scotia Sea (JR161: Oct–Nov 2006) and South Georgia (JR100: Mar 2004) regions. Maximum reported size from Hulley (1990) or Collins (unpublished); Scotia Sea size ranges from Collins (unpublished); swim-bladder data from Marshall (1960) and Collins (unpublished); PF – Polar Front; SACCF – Southern Antarctic Circumpolar Front.

Species name	Max. rep. size	Min. SL (mm)	Max. SL (mm)	Distribution (Scotia Sea/NW South Georgia)	Swim bladder form
Electrona antarctica	113	30	113	Abundant ice-edge to PF; surface–1 000 m	Gas-filled swim bladder; relatively smaller in adults
Electrona carlsbergi	96	48	93	Abundant north of SACCF; 200–400 m	Gas-filled swim bladder
Electrona subaspera	127	107	107	Rare	Gas-filled swim bladder
Gymnoscopelus bolini	280	106	231	Large species; abundant near South Georgia	Residual swim bladder in juvenile fish; absent in adults
Gymnoscopelus braueri	139	30	139	Abundant ice-edge to PF; surface–800 m	Swim bladder highly reduced or absent in adult fish
Gymnoscopelus fraseri	115	60	115	Abundant north of SACCF	Swim bladder highly reduced or absent in adult fish
Gymnoscopelus microlampus	117	70	70	Rare	No data
Gymnoscopelus nicholsi	165	34	165	Abundant ice-edge to PF; surface–1 000 m	Residual swim bladder in juvenile fish; absent in adults
Gymnoscopelus opisthopterus	168	52	168	Rare	No data
Gymnoscopelus piabilis	155	80	155	Rare	No data
Krefftichthys anderssoni	74	25	74	Abundant north of SACCF	Gas-filled swim bladder
Lampanyctus achirus	153	43	155	Abundant 400–1 000 m	No data
Protomyctophum andreyeshevi	52	44	52	Rare	No data
Protomyctophum bolini	67	25	66	Abundant 200–400 m	Gas-filled swim bladder
Protomyctophum choriodon	95	43	85	Seasonally abundant (March) north of SACCF; surface to 400 m	Gas-filled swim bladder
Protomyctophum gemmatum	86	54	62	Infrequently caught	No data
Protomyctophum luciferum	61	33	33	Infrequently caught	No data
Protomyctophum parallelum	53	24	53	Infrequently caught	No data
Protomyctophum tenisoni	55	39	55	Common	Gas-filled swim bladder

Table 2: Suggested calibration parameters to be included as data fields on the CCAMLR acoustic database.

Category/name	Units and comments	Suggested min. precision
Transceiver:		
Manufacturer		
Model number		
Serial number		
Pulse duration	µs	1
Transmit power	W	10
Ping rate	Hz	0.1
Firmware version		
Software name		
Software version		
Operating frequency	Hz	100
Transceiver bandwidth	Hz	100
Transducer (values at main resonance):		
Fore/aft beam angle (3 dB)	degrees	0.1
Port/stbd beam angle (3 dB)	degrees	0.1
Equivalent 2-way beam angle (ψ)	dB re 1 steradian	0.1
Transmitting current response	dB re 1 µPa/A at 1 m (or TCR)	0.1
Transmitting voltage response	dB re 1 µPa/V at 1 m (or TVR)	0.1
Receive voltage response	dB re 1 V/µPa	0.1
Angle sensitivity	dimensionless	0.1
Bandwidth	Hz	100
Q factor	dimensionless	1
Main resonance frequency	Hz	100
Transducer aperature area	m^2	1.0e-5
Transducer efficiency at resonance	%	1
Calibration inputs:		
Sphere material	material (e.g. Cu,WC with 6% Co)	
Sphere diameter	mm	0.1
Sphere TS (estimated)	dB re 1 m^2	0.1
Sphere target frequency(ies)	Hz	100
Sphere target bandwidths	Hz	100
Transducer depth	m	0.1
Range to centre of calibration sphere	m	0.1
Transducer temperature	°C	0.5
Water temperature	°C	0.5
Water salinity	psu	0.1
Sound speed	m/s	1.0
Sound-speed method	(e.g. estimated from CTD)	
Acoustic absorption	dB/m	1.0e-4
Calibration data filename(s)		
Description of apparatus	(e.g. rigging of sphere and weight)	

(continued)

Table 2 (continued)

Category/name	Units and comments	Suggested min. precision
Ancillary data:		
Calibration start date/time	UTC	minute
Calibration end date/time	UTC	minute
Calibration location (lat/long)	degrees	0.1
Vessel rigging	(e.g. drifting, forward anchor only, fore/aft anchor etc.)	
Wave height	m	0.5
Average wind speed	knots	5
General weather description		
System-specific calibration outputs:		
TS_Gain (EK500 only)	dB	0.1
Std. TS_Gain (EK500 only)	dB	0.1
Sv_Gain (EK500 only)	dB	0.1
Std. Sv_Gain (EK500 only)	dB	0.1
G_0 (EK60 only)	dB	0.1
Std of G_0 (EK60 only)	dB	0.2
Sa_corr (EK60 only)	dB	0.1
Std of Sa_corr (EK60 only)	dB	0.2
Passive noise	dB	1.0

Table 3: Recommended protocols for acoustic surveys in CCAMLR-IPY projects.

Study requirements	Descriptive	Quantitative analysis of backscatter	Biomass estimations
Frequency	Any, single	Single or multiple; preferably 38 and 120 kHz with 70, 200, 18 or others.	38 and 120 kHz essential; others (e.g. 70, 200, 18) desirable
Calibration*[1]	Instrument recently calibrated	Calibrated within survey period; record raw calibration files and data.	Multiple calibrations in survey period; history of stable performance
Echosounder settings	Documented	Power*[2] (25 kW m^{-2}) Pulse length 1 ms Ping interval ≤4 sec	Power*[2] (25 kW m^{-2}) Pulse length 1 ms*[3] Ping interval optimised for study requirements
Data depth	Sea floor or minimum of 1 000 m	Sea floor or minimum of 1 000 m	Sea floor or minimum of 1 000 m
Noise		<90% good pings triggers remedial action (e.g. slowing speed, locating and eliminating source of noise)	Minimise noise. Noise recordings required
Ancillary data	GPS	GPS Meteorological data	GPS Transducer motion Meteorological data Record relative (3-D) position of transducers
System integration	Time synchronised	Synchronised acoustic systems or turning off interfering equipment	Synchronised acoustic systems or turning off interfering equipment
Data format	Raw, un-thresholded ping-by-ping sample data	Raw, un-thresholded ping-by-ping sample data	Raw, un-thresholded ping-by-ping sample data
Survey type	Opportunistic	Transect(s)	Designed survey
Additional acoustic-related data			*In situ* and/or *ex situ* TS measurements; parameters required for TS model (e.g. observations on tilt; density and sound-speed measurements)
Biological sampling		Target and/or stratified net hauls	Target net hauls with opening and closing nets
Biological sample processing		Species composition	Species composition; length-frequency data for target species; length–weight relationship for target species
Oceanographic data	Typical salinity and temperature data required for calibration	Observations of temperature and salinity to sampling depth during cruise	Multiple, on-transect measurements of temperature and salinity to sampling depths
Vessel speed		Constant speed if possible	Constant (optimised for survey coverage and to minimise noise)

*[1] Calibration should be undertaken using standard methods (Foote et al., 1987) with sphere at a depth of 15–25 m below transducer and be fully documented.

*[2] Maximum power should not exceed 25 kW m^{-2}. Recommended power settings: 18 kHz with 11° beam angle (2 kW); 38 kHz (2 kW); 70 kHz (750 W); 120 kHz (250 W); 200 kHz (110 W); 333 kHz (40 W) all with 7° beam angle. Source Korneliussen et al. (2004).

*[3] A shorter pulse length will be necessary for *in situ* target strength measurements.

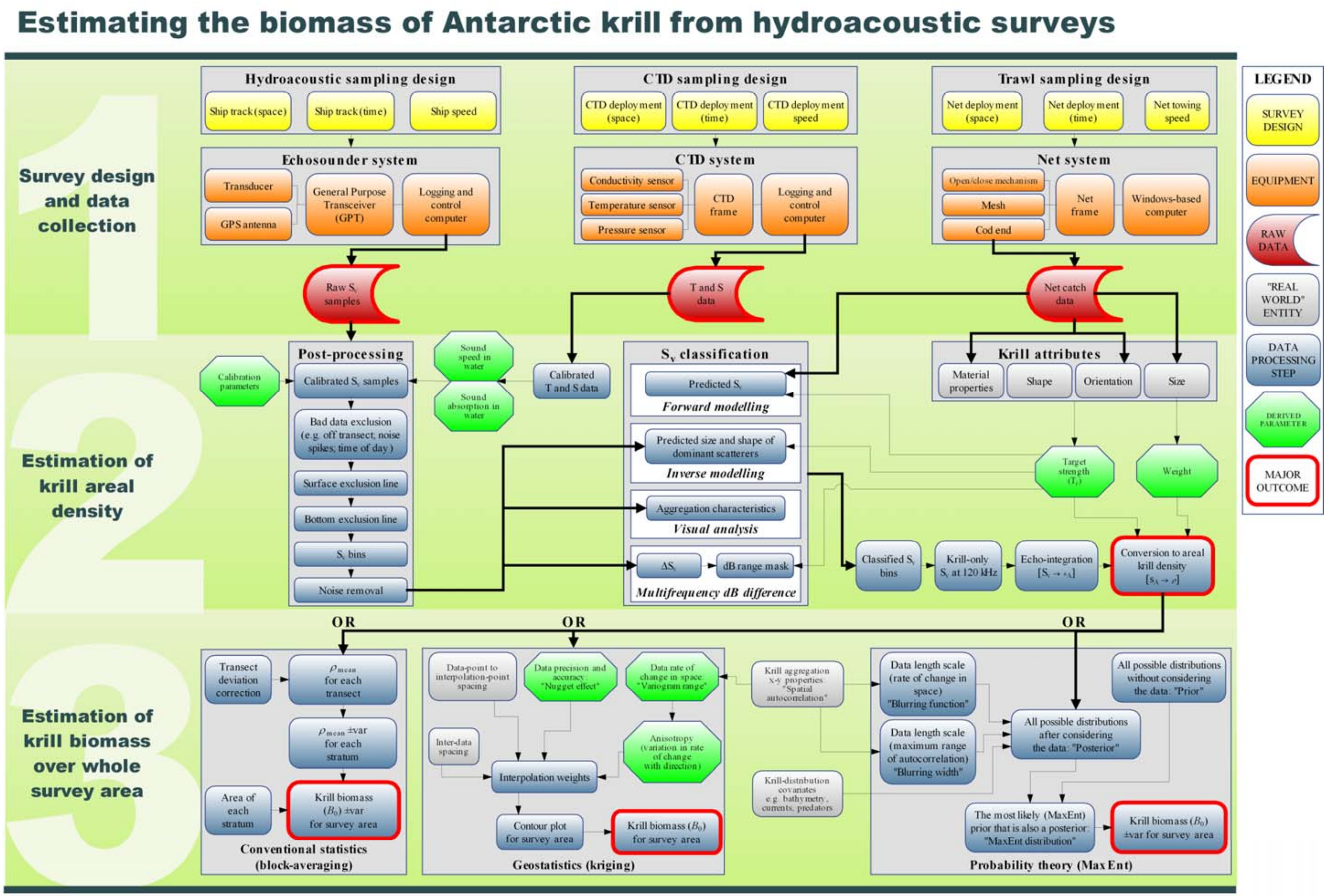

Figure 1: Flow chart outlining typical steps for acoustic data collection and analysis of krill surveys.

APPENDIX A

TERMS OF REFERENCE

Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM)
(Cambridge, UK, 30 April to 2 May 2007)

WG-FSA recommended the following terms of reference for SG-ASAM (SC-CAMLR-XXV, Annex 5, paragraphs 13.16 to 13.19):

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

(a) the design of acoustic surveys to estimate the abundance index of nominated species;

(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;

(ii) to evaluate results of acoustic surveys carried out in the CCAMLR Convention Area in previous years;

(iii) to estimate target strength and its statistical characteristics for key species in the CCAMLR Convention Area;

(iv) to use data from acoustic surveys to investigate ecological interactions and produce information for ecosystem monitoring and management.

2. WG-FSA noted that the focus of SG-ASAM regarding the work of WG-FSA should remain with resolving difficulties identified with the estimation of icefish abundance. However, it also recognised that estimates of the abundance and distribution of pelagic species are needed (namely, *Pleuragramma* spp., myctophid spp.), when developing ecosystem models (SC-CAMLR-XXIII, Annex 4, paragraph 6; SC-CAMLR-XXIV, Annex 4, Appendix D).

3. WG-FSA recommended that an immediate issue for WG-FSA to be further addressed by SG-ASAM is the acoustic protocol for assessing *C. gunnari* in Subarea 48.3, including:

(i) classification of volume backscattering strength attributed to *C. gunnari* versus other taxa with special attention to multiple-frequency acoustic methods;

(ii) further improvements in target strength estimates for *C. gunnari* using a variety of methods including physic-based and empirical models, *in situ* measurements and *ex situ* measurements;

(iii) combination of trawl and acoustic indices for stock assessment;

(iv) uncertainty assessment for *C. gunnari* biomass and abundance indices from combining trawl and acoustic surveys;

(v) protocols for archiving data.

4. WG-FSA recommended that the issues relevant to application of acoustic methods for pelagic finfish estimates should be addressed to SG-ASAM, including:

(i) frequency-specific definition of myctophid spp. target strength;

(ii) classification of volume backscattering strength of myctophid spp. versus other taxa with special attention to multiple frequency acoustics methods.

5. The Scientific Committee agreed to extend the above terms of reference for SG-ASAM to include the development of acoustic sampling protocols for the CCAMLR-IPY projects, and agreed that the CCAMLR-IPY steering group hold a planning meeting in association with SG-ASAM (SC-CAMLR-XXV, paragraph 13.39).

6. WG-EMM also requested SG-ASAM to provide input to its krill workshop on what is the most appropriate method for estimating B_0 from survey data, considering design-based versus model-based estimation methods. It also requested SG-ASAM to review the method for estimating CV for the biomass estimate provided by Demer and Conti (2005) and consider whether this is sufficient to determine the uncertainty in B_0 more generally (SC-CAMLR-XXV, Annex 4, paragraph 6.50).

APPENDIX B

AGENDA

Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM)
(Cambridge, UK, 30 April to 2 May 2007)

1. Introduction
   - 1.1 Opening of meeting
   - 1.2 Meeting terms of reference and adoption of the agenda
   - 1.3 Review of the findings and recommendations of previous meetings of SG-ASAM

2. New information available on icefish acoustics

3. Recommendations for future work on icefish

4. Presentations on other acoustic surveys in the CCAMLR area

5. General issues relevant to acoustic surveys in CCAMLR waters

6. New information available on krill acoustics

7. Recommendations for future work on krill

8. Suggestions for timing/venue of next meeting

9. Preparation and adoption of report (part 1)

10. Joint session review of the acoustic sampling protocols for krill for use by CCAMLR-IPY projects, including: (i) survey design; (ii) documentation of survey methods; (iii) presentation of results; and (iv) protocols for archiving data

11. Preparation and adoption of joint session report (part 2)

12. Close of the meeting.

APPENDIX C

LIST OF PARTICIPANTS

Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM)
(Cambridge, UK, 30 April to 2 May 2007)

BELCHIER, Mark (Dr)	British Antarctic Survey High Cross Madingley Road Cambridge CB3 0ET United Kingdom markb@bas.ac.uk
COLLINS, Martin (Dr) (Co-convener)	British Antarctic Survey High Cross Madingley Road Cambridge CB3 0ET United Kingdom macol@bas.ac.uk
DEMER, David (Dr)	National Marine Fisheries Service Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla , CA 92037 USA david.demer@noaa.gov
FIELDING, Sophie (Dr)	British Antarctic Survey High Cross Madingley Road Cambridge CB3 0ET United Kingdom sof@bas.ac.uk
IVERSEN, Svein (Mr)	Institute of Marine Research Pelagic Fish Group Nordnesgaten 50 PB Box 1870 Nordnes 5817 Bergen Norway sveini@imr.no

JARVIS, Toby (Dr)	Australian Antarctic Division Department of the Environment and Water Resources Channel Highway Kingston Tasmania 7050 Australia toby.jarvis@aad.gov.au
KORNELIUSSEN, Rolf (Dr) (Invited Expert)	Institute of Marine Research Research Group Observation Methodology Nordnesgaten 50 PB Box 1870 Nordnes 5817 Bergen Norway rolf@imr.no
KNUTSEN, Tor (Dr)	Institute of Marine Research Research Group Plankton Nordnesgaten 50 PB Box 1870 Nordnes 5817 Bergen Norway tor.knutsen@imr.no
MACAULAY, Gavin (Dr) (Invited Expert)	National Institute of Water and Atmospheric Research (NIWA) Private Bag 14-901 Kilbirnie Wellington New Zealand g.macaulay@niwa.co.nz
NAGANOBU, Mikio (Dr)	Southern Ocean Living Resources Research Section National Research Institute of Far Seas Fisheries 2-2-14 Fukuura Kanazawa-ku Yokohama, Kanagawa 236-8648 Japan naganobu@affrc.go.jp
O'DRISCOLL, Richard (Dr) (Co-convener)	National Institute of Water and Atmospheric Research (NIWA) Private Bag 14-901 Kilbirnie Wellington New Zealand r.odriscoll@niwa.co.nz

WATKINS, Jon (Dr) | British Antarctic Survey
High Cross
Madingley Road
Cambridge CB3 0ET
United Kingdom
j.watkins@bas.ac.uk

Secretariat:

David RAMM (Data Manager) | CCAMLR
PO Box 213
North Hobart 7002
Tasmania Australia
david@ccamlr.org

APPENDIX D

LIST OF DOCUMENTS

Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM)
(Cambridge, UK, 30 April to 2 May 2007)

SG-ASAM-07/1	Agenda
SG-ASAM-07/2	List of Participants
SG-ASAM-07/3	List of Documents
SG-ASAM-07/4	CCAMLR acoustic database: 2007 update Secretariat
SG-ASAM-07/5	Improved target identification of mackerel icefish using commercial and scientific observations (Powerpoint presentation) S. Fielding, M. Collins, I. Everson and A. Reid (UK)
SG-ASAM-07/6	Collaborative optical-acoustic survey technique (COAST) applied to rockfish in the SCB (Powerpoint presentation) D. Demer, J. Butler, D. Pinkard and K. Franke (USA)
SG-ASAM-07/7	Descriptive analysis of mesopelagic backscatter from acoustic data collected in the Ross Sea (Powerpoint presentation) R. O'Driscoll (New Zealand)
SG-ASAM-07/8	South Georgia myctophid survey, March 2004 (Powerpoint presentation) M. Collins (UK)
SG-ASAM-07/9	The 2006 BROKE-West acoustic survey of krill distribution and abundance in CCAMLR Division 58.4.2 (Powerpoint presentation) T. Jarvis, N. Kelly, E. van Wijk, S. Kawaguchi and S. Nicol (Australia)

Other Documents

SC-CAMLR-XXIV	SC-CAMLR. 2005. Report of the First Meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM). In: *Report of the Twenty-fourth Meeting of the Scientific Committee (SC-CAMLR-XXIV),* Annex 6. CCAMLR, Hobart, Australia: 563–585.

SC-CAMLR-XXV	SC-CAMLR. 2006. Report of the Second Meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM). In: *Report of the Twenty-fifth Meeting of the Scientific Committee (SC-CAMLR-XXV),* Annex 6. CCAMLR, Hobart, Australia: 479–501.
WG-FSA-03/14	Report of the Subgroup on Fisheries Acoustics (British Antarctic Survey, Cambridge, UK, 18 to 22 August 2003)
WG-FSA-SAM-04/9	Application of the bootstrap-method in assessment of target strength regression parameters on the basis of *in situ* measurements P.S. Gasyukov and S.M. Kasatkina (Russia)
WG-EMM-05/36	Preliminary report of sound speed contrast and density of krill measured on board RV *Kaiyo Maru* Y. Takao, H. Yasuma, R. Matsukura and M. Naganobu (Japan)
WG-EMM-06/16	Biomass of Antarctic krill (*Euphausia superba*) off East Antarctica (30–80°E) in January–March 2006 T. Jarvis, E. van Wijk, N. Kelly, S. Kawaguchi and S. Nicol (Australia)