ANNEX 6

REPORT OF THE SECOND MEETING OF THE SUBGROUP ON ACOUSTIC SURVEY AND ANALYSIS METHODS
(Hobart, Australia, 23 and 24 March 2006)

CONTENTS

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INTRODUCTION

The second meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) was held on 23 and 24 March 2006. The meeting was convened by Dr R. O'Driscoll (New Zealand) and was held at the CCAMLR Headquarters in Hobart, Australia.

2. Dr D. Ramm (Data Manager) welcomed participants on behalf of the Secretariat 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-XXIV, paragraphs 13.26 to 13.30). A provisional agenda was introduced and discussed. A subitem on future work was added to Item 6 and the agenda was adopted (Attachment A).

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

5. This report was prepared by the participants. Two invited experts, Drs R. Korneliussen (Norway) and G. Macaulay (New Zealand), also provided brief, independent reports as was requested in their terms of reference (Attachment D).

REVIEW OF THE FINDINGS OF THE CAMBRIDGE WORKSHOP

6. Dr O'Driscoll summarised the major findings of the meeting of WG-FSA's Subgroup on Fisheries Acoustics (WG-FSA-SFA) that was held in Cambridge, UK, from 18 to 22 August 2003, to discuss acoustic estimates for icefish (*Champsocephalus gunnari*) (SG-ASAM-06/4).

7. WG-FSA-SFA made the following recommendations to WG-FSA (WG-FSA-03/14):

(i) Multiple-frequency acoustic methods be used to estimate the biomass of icefish in the pelagic zone of Subarea 48.3 and other parts of the CCAMLR Convention Area, incorporating the following:

  (a) pelagic trawl sampling of acoustic marks;

  (b) *in situ* determination of target strength;

  (c) compilation of a trawl-validated echogram library (for target and non-target species);

  (d) if possible synchronise bottom trawl and acoustic surveys (simultaneous surveys with two vessels or interchangeable bottom and pelagic trawls);

(e) calculate biomass and associated variance using acoustic data from each frequency.

(ii) Acoustic data are not used at the present time to adjust the biomass estimates from bottom trawl catches in the bottom 8 m.

(iii) A variety of methods (e.g. echoic chamber, physics-based and empirical models, *in situ* measurements of individuals and aggregations, and caged aggregations), be undertaken to reduce the uncertainty in estimates of target strength (TS) of icefish, and to improve scattering models.

(iv) Experimental work be undertaken to determine frequency-dependent target strength of other abundant species in the CCAMLR area.

(v) The efficiency of the dB difference method of taxa delineation be evaluated in relation to the range dependent signal to noise ratio.

(vi) Trawl selectivity and catchability be investigated as they impact on target strength determination, species delineation and observation volume.

(vii) Stratification of Subarea 48.3 be reviewed for trawl and acoustic surveys to reduce the variance associated with biomass estimates and length–age structure.

Dr O'Driscoll also reviewed acoustic work on icefish carried out since the WG-FSA-SFA meeting in Cambridge (SG-ASAM-06/4).

8. In January 2004, a short acoustic survey off South Georgia (WG-FSA-SAM-04/20) showed that icefish of all age classes spend time in midwater and reinforced the evidence that a bottom trawl survey can significantly underestimate biomass. This survey also showed that the dB differencing method may not be reliable at distinguishing icefish from krill. Some large catches of icefish were taken from 'krill-like marks' (i.e. on trawls through shoals that had MVBS values between 4 and 6 dB higher on the 120 kHz than on 38 kHz).

9. An extensive acoustic survey of the commercial fishing grounds to the northwest of South Georgia in January 2005 (WG-FSA-05/79) failed to locate significant aggregations of icefish in the water column. Commercial vessels that had fished in the area in December 2004 and January 2005 also did not catch commercial quantities of icefish. However, a number of targeted pelagic trawls were made which assisted in the identification of acoustic marks at South Georgia. These trawls suggested that (non-swimbladder) nototheniid fish, such as *Patagonotothen guntheri*, may also appear stronger on 120 kHz than on 38 kHz. Other targeted trawls caught krill (*Euphausia superba*) and the myctophid *Protomyctophum choriodon*.

10. WG-FSA-SAM-04/9 applied a bootstrap method to refine estimates of *in situ* TS for icefish using the same data from the 2002 Russian survey that were considered by WG-FSA-SFA. A mean B_{20} of –83.61 dB with a standard deviation of 0.068 dB was estimated from full (untruncated) PDF distributions of TS and fish length. B_{20} is the intercept of the TS to fish length relationship with slope of 20 (i.e. $TS = 20 \log_{10}(\text{length}) + B_{20}$). There were considerable differences in the estimates of B_{20} obtained for small and large fish, suggesting

that a slope of 20 for the TS–length relationship may not be appropriate for icefish. Application of the new target strength estimates gave a higher biomass for the 2002 survey than that used in the stock assessment by WG-FSA in 2003 (WG-FSA-SAM-04/10).

11. SG-ASAM noted that estimates of B_{20} presented in WG-FSA-02/44, 03/14 and WG-FSA-SAM-04/9 were very similar. The main differences in the estimates obtained from the different TS analysis methods (least-squares and bootstrap, truncated and untruncated data) were between the estimates of standard deviation of B_{20}. The estimate of standard deviation affects survey uncertainty and therefore the lower 95% confidence interval on the biomass estimate.

12. Dr O'Driscoll pointed out that Dr D. Demer (USA) modelled the expected TS for icefish versus frequency and orientation angle at the WG-FSA-SFA meeting in Cambridge using the Kirchoff Ray Mode model and an icefish mass density estimate provided by Dr C. Jones (USA). The report stated that the 'model generally agrees with observed TS measurements if some assumptions are made about the fish orientation distribution. The results from this model also suggest that the dB difference boundary used is plausible for icefish discrimination' (WG-FSA-03/14, paragraph 6.15). SG-ASAM was unable to find further documentation of the TS modelling carried out by Dr Demer and so was not able to evaluate or discuss this.

13. SG-ASAM urged Members with data on icefish TS and modelling to document this so that it is available for consideration by future meetings of SG-ASAM.

NEW INFORMATION ON ICEFISH ACOUSTICS

14. Dr S. Fielding (UK) presented preliminary results from the South Georgia groundfish survey carried out from 4 January to 1 February 2006 on board the FPV *Dorada* (SG-ASAM-06/5). Sixty-five randomly stratified bottom trawls were undertaken around South Georgia for icefish stock assessment. Concurrent acoustic data were collected with the trawls using a two-frequency (120 and 38 kHz) calibrated Simrad™ EK500 echosounder. During the last two days of the cruise (restricted due to weather) acoustic transects were run at night across areas of high icefish density, identified from both the bottom trawl survey and from the presence of commercial fishing vessels reporting good catches. Targeted tows using an International Young Gadoids Pelagic Trawl (IYGPT) were undertaken during daytime working hours to 'ground truth' water column acoustic marks.

15. Six of the 65 bottom trawls caught greater than 90% by weight (not including benthos) of icefish. Echograms from these trawls indicated that, whilst strong marks persisted near the sea bottom, some icefish undertook excursions from the bottom into the water column during the day. Targeted IYGPT trawls confirmed that water column acoustic marks below 50 m depth were icefish, whilst overlying strong marks (at less than 50 m depth) were krill. Night-time transects across the regions of daytime icefish marks exhibited little visual similarity to daytime marks and it is uncertain whether this resulted from the movement of icefish to the surface or whether icefish remained at depth in a more dispersed form. Most icefish caught during the survey ranged in length between 20 and 30 cm.

16. Δ120–38 kHz S_v dB differences were calculated for all acoustic data during the trawls and indicated that pelagic marks, confirmed to be icefish from the IYGPT trawl, could have a Δ120–38 kHz S_v within the range of 2–12 dB, which is the range associated with krill detection. The Δ120–38 kHz S_v dB difference of icefish marks near the sea bottom were more variable and the difference was often less than 2 dB, i.e. values more typically associated with fish discrimination.

17. Acoustic data from the 2006 UK survey were made available to SG-ASAM to look at during the meeting.

18. Dr Korneliussen reported that the average relative frequency response of Atlantic mackerel (*Scomber scombrus*) was variable around 120 kHz and seemed to be dependent on fish size (see paragraph 34). SG-ASAM noted that if this was also the case for mackerel icefish, then this could explain the variability in the dB difference between different icefish marks.

19. Dr Macaulay questioned whether the survey bottom trawl would catch krill if these were associated with icefish close to the bottom. Dr Fielding was uncertain. The mesh size of the bottom trawl was probably too large to retain krill, but some might be expected to be stuck in the meshes.

20. Dr O'Driscoll noted that, although the catch rates of icefish from midwater marks were relatively low (only 50 kg in 1 hour tow), it was reassuring that the IYGPT trawl did not catch any krill during the tow on these marks. The same net made a large catch of krill (800 kg in 30 min) in a tow on surface layers above the icefish marks.

21. There is potential to look at TS data collected from icefish marks during the 2006 survey, although densities may have been too high to successfully detect individual targets. Sample power and angle data were also collected so target detection can be done independently of the EK500 algorithm.

22. Because of the large difference in acoustic marks between day and night, Dr O'Driscoll suggested that it would be useful to compare acoustic densities to determine whether total backscatter decreased at night or whether the change in mark type could be explained by dispersal of aggregations.

INFORMATION FROM OTHER SPECIES RELEVANT TO ISSUES IN ICEFISH ACOUSTICS

Target strength

23. Dr Macaulay gave an overview of methods for measuring and modelling acoustic TS (SG-ASAM-06/6). He described recent advances in TS modelling of non-swimbladder fish using realistic density profiles from computed tomography (CT) scans and showed an example of orange roughy (*Hoplostethus atlanticus*).

24. Dr Macaulay noted that the assumption of a linear relationship between TS and $\log_{10}$(length) is sometimes not supported by TS model results.

25. The TS modelling method based on CT scans is to be applied to icefish. The UK will provide CT scans of icefish collected at South Georgia to Dr Macaulay. There have been some initial problems with formatting of sample CT data, but these appear to have been resolved. Dr Macaulay indicated that CT scanning of icefish should begin soon and that modelling would probably be carried out before the end of 2006.

26. SG-ASAM welcomed this development and looked forward to seeing the results. SG-ASAM requested that TS models be run over a range of frequencies, in particular at 38, 70, 120 and 200 kHz to investigate the frequency dependence of acoustic scattering for icefish. This would potentially assist with multi-frequency identification of icefish marks (see paragraphs 35 to 39).

27. Dr Macaulay pointed out that surveys for abundance estimation require tilt-averaged TS. For model results to be applied, it is also necessary to have estimates of pitch and roll angles of fish under the survey vessel. SG-ASAM discussed possible methods of estimating fish tilt angles *in situ*. These include:

(i) direct observation using cameras

(ii) deriving tilt angles by comparing *in situ* and model TS results

(iii) estimating swimming angle from *in situ* acoustic observations with multiple pings of the same target. Swimming angle may be used as a proxy for tilt angle.

28. Dr D. Welsford (Australia) questioned whether differences in orientation could explain the variability in dB differences observed from different types of icefish marks. Dr Macaulay replied that differences in tilt angle could easily lead to 10 dB differences in icefish TS and changes with tilt angle were frequency dependent. Dr Fielding further noted that variability in tilt has greater effect at higher frequencies.

29. SG-ASAM considered the potential influence of the survey vessel on the tilt-angle distribution of icefish. It seems likely that icefish respond to trawls by diving, and it is possible that they may also react to the survey vessel. Dr Fielding reported that acoustic marks in the upper 50 m could be observed diving in response to the winches on the survey vessel being turned on during the 2006 UK survey, but noted that these marks were most likely not icefish. There was no information currently available on the response of icefish to a survey vessel.

30. Measurements of sound speed in icefish flesh and bone could potentially refine model estimates of icefish TS, which, at present, will rely on relationships between density and sound speed from the literature.

31. SG-ASAM emphasised that the proposed TS modelling will not provide a simple ‘answer’ to the question of icefish TS, and urged further collection of *in situ* TS data, *ex situ* experimental work and modelling. All of these methods require assumptions and may provide logistical challenges. SG-ASAM noted that acoustic TS is a difficult question and that it can take many years to get a robust and reliable estimate.

MARK IDENTIFICATION

32. Dr Korneliussen reviewed species identification using multi-frequency acoustics (SG-ASAM-06/7).

33. Several acoustic features and other features may be used alone or in combination to identify acoustic categories. Some of these features are the volume backscattering coefficient at 38 kHz, $s_V(38)$, the relative frequency response, $r(f) = s_V(f)/s_V(38)$, diurnal variation of the Nautical Area Scattering Coefficient, s_A or NASC, temperature variation, seasonal variation, geographical area, and general behaviour. r(f) seem to be the feature that best separates acoustic categories.

34. Backscatter from the swimbladder represents more than 90% of the total backscatter from those fish that have swimbladders. For non-swimbladder fish, the flesh, backbone and skull are the potential dominating scatterers. Atlantic mackerel is one of the fish species without swimbladder that have been investigated most. r(f), shown in Figure 1(c), is especially efficient at distinguishing mackerel from fish with swimbladders. Backscatter for mackerel at 200 kHz is four times larger than at 38 kHz. The frequencies 18 and 70 kHz are used to show that there is a lower frequency independent level. Note that the measurements of r(120 kHz) show especially large uncertainty compared with other frequencies. This may be explained by the thickness of the backbone. The thickness of the backbone depends on the size of the fish.

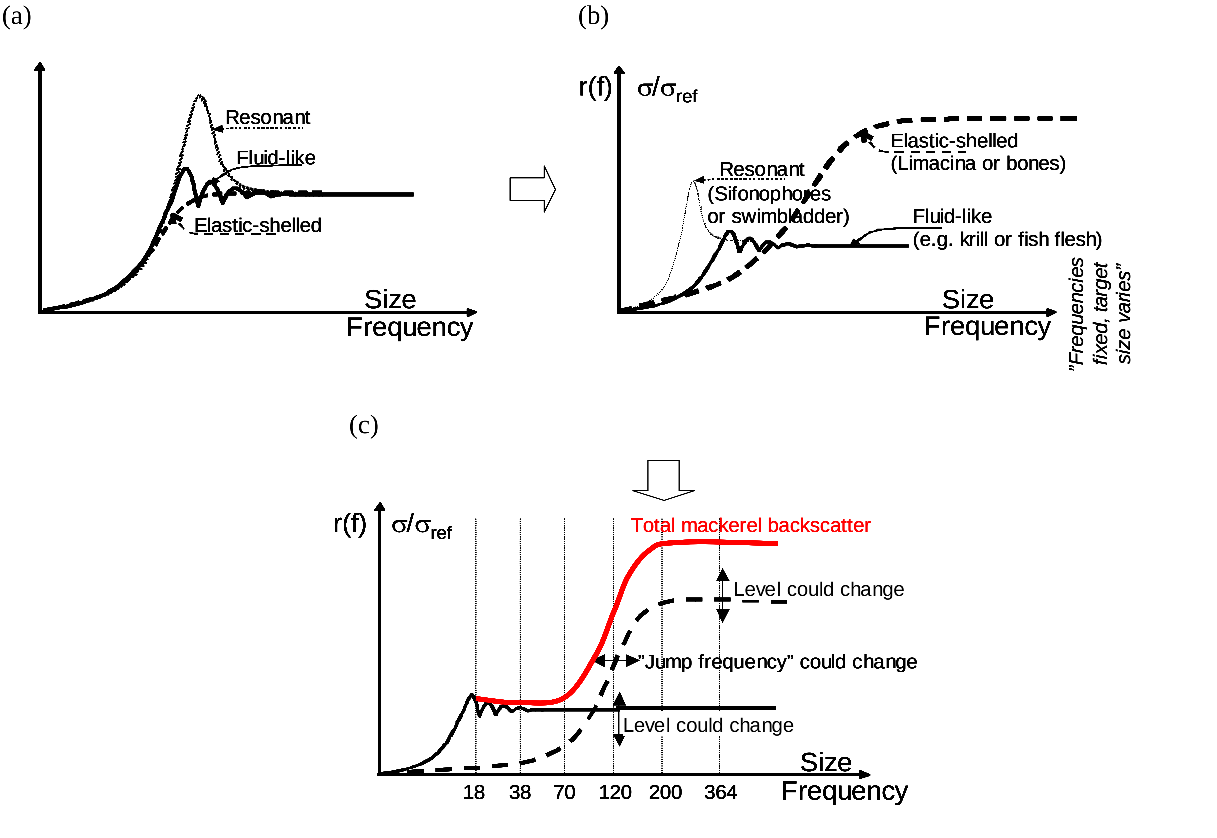

Figure 1: The three different backscattering mechanisms applied to Atlantic mackerel (*Scomber scombrus*): (a) general models: three scattering classes; (b) scattering from each class adjusted to comparable sizes; and (c) backscattering mechanisms of mackerel (intuitive). In (c), the thin solid line represents flesh, the thick dashed line represents bone, and the thick solid line represents the total mackerel backscatter.

35. Icefish like Atlantic mackerel does not have a swimbladder. The skull, however, is thought to be larger for icefish than for mackerel. Thus, the first ‘jump frequency’ where r(f) increases most rapidly could be expected to start at a lower frequency for icefish than for similar sized mackerel. The use of the frequencies 18, 70 and 200 kHz in addition to 38 and 120 kHz could identify the frequency-span where the average backscatter is frequency independent, and could also be used to distinguish icefish from krill.

36. SG-ASAM agreed that more than two frequencies would be highly advantageous for discriminating icefish from other species.

37. Where the major problem is separating icefish from krill, 70 kHz would be the most useful additional frequency. SG-ASAM recalled the advice of its previous meeting that the use of 70 kHz transducers would improve krill detection, classification and estimation of B_0 (SC-CAMLR-XXIV, Annex 6, paragraph 39), and reiterated its recommendation that 70 kHz be used during acoustic surveys for both krill and icefish whenever possible.

38. If separating icefish from myctophids, it may be useful to have a lower frequency (e.g. 12 or 18 kHz) as fish with small swimbladders have been observed to resonate at these frequencies (Korneliussen and Ona, 2002). A problem with lower-frequency transducers is that they tend to have wider beam angles (since they otherwise would be very large). SG-ASAM noted the importance of having the same beam width for transducers of all frequencies to ensure backscatter is compared from the same sample volume.

39. Higher frequencies, such as 200 kHz, have been shown to be useful for separating Atlantic mackerel from fish with swimbladders. Members of SG-ASAM noted that it may not be possible to obtain 200 kHz data at the depths typically occupied by icefish (150–300 m). Dr Korneliussen reported that they had successfully collected 200 kHz data on mackerel down to almost 300 m from the Norwegian research vessels *G.O. Sars II*, *G.O. Sars III* and *Johan Hjort* with the transducer mounted on a drop keel. This large range relies on smoothing and noise-removal of the data (Korneliussen, 2000; Korneliussen and Ona, 2002, 2003). The maximum usable range for a 200 kHz hull-mounted transducer is likely to be shallower on other vessels. SG-ASAM discussed ways of reducing noise by mounting the transducer below the keel or in a towed body.

40. Dr Fielding pointed out that the UK research vessel *James Clark Ross* has collected acoustic data at 38, 120 and 200 kHz for seven years during krill surveys of the ‘western core box’, which is in the same area as high-density icefish marks were observed. SG-ASAM examined some 200 kHz data from the most recent survey and found that the depth range of acoustic data from the 200 kHz transducer on the *James Clark Ross* is not as extensive as that observed by Dr Korneliussen on the *G.O. Sars*. An alternative method of noise removal advised by Dr Korneliussen will be investigated to extend the range of the 200 kHz data. If possible, the 2006 western core box acoustic data will be examined with a view to locating icefish-like marks at 120 and 38 kHz and examining the 200 kHz data from these marks.

41. Dr O’Driscoll questioned whether a broadband acoustic system could be used to collect acoustic data across a range of frequencies. Dr Korneliussen pointed out that a major difficulty with most broadband systems was that they produced different beam widths at different frequencies, which makes quantitative comparison between frequencies difficult. He noted that there had been some attempts to build transducers with the same beam-width over a range of frequencies, but that these were generally inefficient.

42. SG-ASAM noted that, while there was a significant cost associated with installing additional transducers on a research vessel, this cost is low relative to the overall cost of carrying out an acoustic survey. Where additional frequencies are essential to the success of the survey, then their installation should be a priority.

43. SG-ASAM further noted that many issues with respect to mark identification are common to surveys of both krill and icefish. Improving mark identification of icefish would also improve the reliability of acoustic estimates of krill.

RECOMMENDATIONS FOR FUTURE WORK ON ICEFISH

44. SG-ASAM welcomed the TS modelling work in progress on icefish (see paragraph 25) and urged that the model is run for a range of frequencies including 38, 70, 120 and 200 kHz to investigate the frequency dependence of acoustic scattering by icefish.

45. SG-ASAM recommended that TS of icefish continues to be investigated using a variety of methods including *in situ* measurements, *ex situ* experiments on individuals and aggregations, and physics-based and empirical models.

46. SG-ASAM noted that estimates of TS depend on the *in situ* tilt-angle distribution of icefish. It therefore recommended that data be collected on icefish orientation, including changes in orientation due to vertical migration or in response to survey vessels.

47. SG-ASAM reiterated the recommendation of WG-FSA-03/14 (paragraph 9.4) that experimental work also be undertaken to determine frequency-dependent target strength of other abundant species in the CAMLR Convention Area. It noted that myctophids may be a particularly complicated group because of interspecific and intraspecific differences in physiology.

48. SG-ASAM recognised the difficulty of making measurements of *in situ* TS and orientation and encouraged further development of technology such as autonomous TS acoustic systems and net-mounted cameras and transducers.

49. SG-ASAM recommended that multiple frequencies be used in acoustic surveys of icefish, including 38, 70 and 120 kHz. The utility of higher and lower frequencies should also be investigated. It noted that it is important that the same beam angle and suitable power settings (Korneliussen and Ona, 2004) are used on all frequencies to ensure comparability of data between frequencies.

50. SG-ASAM recommended that a library of echograms with associated TS, catch and biological data for icefish and associated species should be available from CCAMLR. This library might adopt the framework adopted by the Species Identification Methods from Acoustic Multifrequency Information (SIMFAMI) project (EU project Q5RS-2001-02054) and could be incorporated into the existing CCAMLR acoustic database.

51. Icefish behaviour, including vertical distribution and response to survey vessels, should be further investigated as they impact on survey design, fish orientation, target

strength determination and species delineation. Repeated transects over the same aggregation during a 24-hour cycle would be a useful way of investigating diurnal changes in vertical distribution, mark type and TS.

52. SG-ASAM encouraged the experimental use of different types of trawl gear to investigate trawl selectivity and relative catchability of icefish and associated species.

GENERAL ISSUES RELEVANT TO ACOUSTIC SURVEYS IN CCAMLR WATERS

Survey design

53. In the absence of any krill acoustic experts at the meeting, SG-ASAM agreed to limit the discussion on survey design to studies of fish biomass. Specific recommendations for improvements to icefish surveys are described above (paragraphs 44 to 52). However, the group agreed that the components of an acoustic survey design are similar in most cases, with the major requirements being:

(i) the use of multiple frequencies
(ii) mark identification using directed trawls or other ground truthing methods
(iii) target strength determination by *in situ* measurements
(iv) calibration of acoustic gear used in the survey.

Documentation of survey methods

54. The documentation of survey methods is closely linked to the presentation of results. SG-ASAM noted that documentation of previous acoustic surveys had in general been better than for trawl surveys. WG-FSA-SAM has agreed to assemble a report this year on the protocols required to conduct and document trawl surveys. The minimum requirement for any survey report should be to provide sufficient details to allow independent assessment of the survey results.

55. Dr Fielding raised the issue of consistent definition of terminology in acoustic studies and referred the group to MacLennan et al. (2002) as an example. The group supported the need for consistent reporting and suggested this paper be used as a standard text to ensure consistency of CCAMLR acoustic reports with the wider acoustic community.

56. The only acoustic survey data held in the CCAMLR acoustic database was from the CCAMLR 2000 Krill Synoptic Survey of Area 48. There was insufficient time available to compare the CCAMLR documentation of the CCAMLR-2000 Survey (SC-CAMLR-XIX, Annex 4, Appendix G) with the standards proposed by MacLennan et al. (2002).

Presentation of results

57. The methodology and results need to be adequately described to allow the reliability of the surveys to be evaluated. SG-ASAM concluded that these requirements should be discussed jointly for krill and fish.

Protocols for archiving data

58. Dr Ramm outlined recent developments in the CCAMLR acoustic database. The acoustic data are held within CCAMLR's survey database, and the overall objective of that database was to provide a secure archive of survey datasets of relevance to the Scientific Committee's work, and to provide sufficient data and information in a standard format to enable working groups and subgroups to undertake their analyses.

59. Following discussions during the WG-FSA-SFA meeting in Cambridge, UK, in 2003, the acoustic database had been developed using an event-driven model, with each event representing an acoustic transect, or a net tow, or a CTD cast. Other data in the survey database (e.g. trawl survey data) are also held using the event-driven model.

60. The CCAMLR-2000 Survey dataset is the only acoustic dataset currently held in the database. The CCAMLR-2000 Survey data are held in three formats:

- ping-by-ping data (ek5 files) which contain the direct binary output from the echo sounders. Currently these data are stored in a large number of files which are held in secure storage;

- EchoView files (EV files), also securely stored, contain processed data derived from ek5 files. Each EV file also contains information specific to the survey transects;

- tables in secure database format which contain the output from the EchoView analyses.

61. SG-ASAM was concerned that survey data were archived using proprietary formats (e.g. SonarData's ek5 and EV formats), and recommended that the Secretariat investigate the feasibility of archiving data in the HAC format (a global standard being developed for the storage of hydroacoustic data), and obtaining documentation on the ek5 and EV formats.

62. SG-ASAM agreed that other types of data should be archived by the Secretariat so as to allow detailed analysis (and reanalysis) of acoustic survey data. These additional data include:

(i) transducer configuration
(ii) echosounder configuration
(iii) calibration parameters
(iv) echogram library (paragraph 50).

Future work

63. Dr Ramm noted that another synoptic survey of krill is proposed for the International Polar Year (2007/08). SG-ASAM recommended that acoustic data are collected on at least four frequencies (38, 70, 120 and 200 kHz) whenever possible during the synoptic survey to improve classification of krill, icefish and other species (paragraph 49).

64. Dr O'Driscoll briefly outlined progress on acoustic data collection in the Ross Sea. Acoustic data were logged on two New Zealand longline vessels participating in the exploratory toothfish fishery in Subarea 88.1 from December 2005 to February 2006. Data were from uncalibrated commercial Simrad ES-60 echo sounders with hull-mounted 38 kHz transducers and were collected during normal fishing operations. Acoustic data were also collected during a swath-mapping and geological survey of the Ross Sea by the New Zealand research vessel *Tangaroa* in February–March 2006. Only 120 kHz data were available from the *Tangaroa* because other frequencies interfered with swath-mapping equipment. Some plankton trawls were carried out in conjunction with the acoustic data collection, and these caught mainly krill. All available acoustic data from the Ross Sea will be examined to qualitatively describe mesopelagic mark types.

SUGGESTIONS FOR TIMING/VENUE OF NEXT MEETING

65. SG-ASAM agreed that this meeting had benefited from being held in conjunction with a meeting of ICES's Working Group on Fisheries Acoustics, Science and Technology (WG-FAST). The SG-ASAM meeting had received significant contributions by two invited experts who were primarily in Hobart for the WG-FAST meeting. However, SG-ASAM also agreed that the high cost and time of travel to Hobart from the northern hemisphere had probably contributed to the low number of CCAMLR participants at its meeting.

66. SG-ASAM agreed that future meetings would be required to consider the results of ongoing acoustic research and new surveys. However, SG-ASAM was unable to determine the extent of new contributions by CCAMLR Members who were unable to attend the second meeting. Nevertheless, and in the light of the significant progress made during its second meeting, SG-ASAM recommended that a third meeting should be held in 2007 to consider development in TS modelling (paragraph 25) and contributions by CCAMLR Members who were unable to attend the second meeting.

67. SG-ASAM considered how it may be able to attract a wider range of participants at future meetings. It was agreed that SG-ASAM meetings would be more likely to be attended by acoustic experts if the meetings were held in conjunction with WG-FAST meetings, or other gatherings of acoustic experts (e.g. ICES Acoustic Conference, Bergen, Norway, 2008). It was understood that the 2007 meeting of WG-FAST was scheduled to be held in March–April 2007 in Ireland, and SG-ASAM recommended that its 2007 meeting should be held close to the time and location of the WG-FAST meeting.

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

69. SG-ASAM recognised that the development of the survey design and methodology for the proposed CCAMLR-IPY synoptic survey of krill in 2008 may require a planning meeting, and that such a meeting may be able to be held in association with the 2007 meeting of SG-ASAM. The survey design and related matters may also become a priority for SG-ASAM in 2007.

RECOMMENDATIONS TO THE SCIENTIFIC COMMITTEE

70. SG-ASAM recommended that 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.

71. SG-ASAM recommended that the efficiency of the current (120–38 kHz) dB difference method of taxa delineation be further evaluated in relation to discrimination of icefish from associated species.

72. SG-ASAM recommended that 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.

73. SG-ASAM noted that estimates of TS depend on the *in situ* tilt-angle distribution of icefish. It therefore recommended that data be collected on icefish orientation, including changes in orientation due to vertical migration or in response to survey vessels.

74. SG-ASAM recommended that 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.

75. SG-ASAM recommended that 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.

76. SG-ASAM emphasised the need for appropriate documentation and archiving of acoustic survey data, including consistency of terminology. It recommended that the Secretariat investigate the feasibility of archiving data in the HAC format, and agreed that other types of data, such as calibration parameters, should be archived by the Secretariat.

77. SG-ASAM recommended that a third meeting should be held in 2007 to consider developments in TS modelling and contributions by CCAMLR Members who were unable to attend the second meeting. The survey design and methodology for the proposed CCAMLR-IPY synoptic survey of krill in 2008 may also become a priority for SG-ASAM in 2007.

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

ADOPTION OF THE REPORT

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

CLOSE OF MEETING

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

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ATTACHMENT A

AGENDA

Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM)
(Hobart, Australia, 23 and 24 March 2006)

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

2. Review of the findings of the Cambridge Workshop (WG-FSA-03/14)

3. New information available on icefish acoustics

4. Information from other species relevant to issues in icefish acoustics
   4.1 Target strength
   4.2 Mark identification

5. Recommendations for future work on icefish

6. General issues relevant to acoustic surveys in CCAMLR waters
   6.1 Survey design
   6.2 Documentation of survey methods
   6.3 Presentation of results
   6.4 Protocols for archiving data
   6.5 Future work

7. Suggestions for timing/venue of next meeting

8. Recommendations to Scientific Committee

9. Adoption of report

10. Close of the meeting.

LIST OF PARTICIPANTS

Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM)
(Hobart, Australia, 23 and 24 March 2006)

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ATTACHMENT C

LIST OF DOCUMENTS
Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM)
(Hobart, Australia, 23 and 24 March 2006)

SG-ASAM-06/1	Agenda
SG-ASAM-06/2	List of Participants
SG-ASAM-06/3	List of Documents
SG-ASAM-06/4	Introduction to icefish acoustics. Powerpoint presentation R.L. O'Driscoll
SG-ASAM-06/5	South Georgian groundfish survey 2006: *C. gunnari* acoustics. Powerpoint presentation S. Fielding, M. Collins, T. North, C. Jones, J. Moir-Clarke, J. Watts and W. Reid
SG-ASAM-06/6	Introduction to acoustic target strength estimation. Powerpoint presentation G.J. Macaulay
SG-ASAM-06/7	Species identification using multifrequency acoustics. Powerpoint presentation R.J. Korneliussen

Other Documents

WAMI-01/5	Acoustic assessment of potential bias in abundance estimates of mackerel icefish from trawl surveys E. van Wijk, T. Pauly, A. Constable and R. Williams (Australia)
WG-FSA-02/44	Mackerel icefish biomass and distribution on the results of acoustic survey carried out in February–March 2002 S.M. Kasatkina, V.Yu. Sunkovich, A.P. Malyshko and Zh.A. Frolkina
WG-FSA-02/56	A study of UK and Russian surveys using acoustics to augment trawling methods in shelf waters off South Georgia (Subarea 48.3) S. Kasatkina, P. Gasyukov (Russia), C. Goss, I. Everson, M. Belchier, T. Marlow, A. North and M. Collins (United Kingdom)
WG-FSA-03/4	Species profile: mackerel icefish I. Everson (United Kingdom)

WG-FSA-03/14	Report of the Subgroup on Fisheries Acoustics (British Antarctic Survey, Cambridge, 18 to 22 August 2003)
WG-FSA-SAM-03/6	Methodical problems of trawl and acoustic surveys in mackerel icefish stock assessment S.M. Kasatkina, P. Gasyukov and Zh.A. Frolkina (Russia)
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-FSA-SAM-04/10	Revision of icefish (*C. gunnari*) stock estimate in the South Georgia area on the basis of the Russian acoustic trawl survey 2002 S.M. Kasatkina and P.S. Gasyukov (Russia)
WG-FSA-SAM-04/20	Does the current South Georgia groundfish survey accurately estimate the standing stock of mackerel icefish? M. Collins, J. Xavier, K. Reid, M. Belchier, C. Goss and D Agnew (United Kingdom)
WG-FSA-05/79	Experimental acoustic survey of icefish resources in Subarea 48.3, 2005 M. Belchier, M. Collins (United Kingdom), R. O'Driscoll (New Zealand), S. Clarke and W. Reid (United Kingdom)

ATTACHMENT D

REPORTS FROM INVITED EXPERTS
Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM)
(Hobart, Australia, 23 and 24 March 2006)

Report from Dr R. Korneliussen

The meeting targeted identification and target strength (TS) of one of the resources of the Antarctic Ocean, namely the mackerel icefish (*Champsocephalus gunnari*). There is strong evidence that bottom trawl surveys significantly underestimate *C. gunnari* biomass.

Dr G. Macaulay (NIWA, New Zealand) was invited as an expert on TS modelling and Dr R. Korneliussen (IMR, Norway) was invited as expert on species identification. Dr R. O'Driscoll (NIWA, New Zealand) chaired the meeting. Other participants of the meeting were Drs D. Ramm (CCAMLR), S. Fielding (BAS, UK), K. Sullivan (Ministry of Fisheries, New Zealand) and D. Welsford (AGAD, Australia).

Although there were only seven participants at the meeting, it seemed to be sufficient to reach the intended goal of the meeting. The meeting facilities were adequate. The meeting proceeded very harmoniously, and ran according to plan. The final report was discussed and adopted at the end of the meeting.

Dr Macaulay outlined the principles for modelling TS. He had used CT scans to visualise internal organs of fish, and used the morphology of these organs in modelling TS. The behaviour, i.e. tilt-angle distribution, was included in the modelling of average TS. Dr Macaulay emphasised the need for sound speed measurements of different parts of fish flesh to be able to model TS of any fish. Dr Fielding will provide CT scans for *C. gunnari* with modelling TS in mind.

Dr Korneliussen showed principles for identification of Atlantic mackerel (*Scomber scombrus*). Like *C. gunnari*, *S. scombrus* does not have a swimbladder, and the similarities between these two species were therefore considered to be close enough to be able to benefit species identification of *C. gunnari* from the experiences of *S. scombrus*.

Dr Korneliussen informed the group that there are three parts of a mackerel that are thought to be important: the flesh, the backbone and the skull. Although the sound-speed and the density of flesh are close to those of seawater and therefore give relatively low backscatter, the fish flesh is still important due to its size. Modelled backscatter shows strong fluctuations at low frequencies (<40 kHz), but averaged over the size distribution in a school, it is frequency independent. The backbone of a mackerel has a size that makes r(f) frequency dependent. r(f) is frequency independent below 100 kHz, and is predicted to be relatively frequency independent above 200 kHz, and although there are indications of this, it is not yet fully proven. r(f) = 1 < 100 kHz; r(f) = 4 > 200 kHz, but r(f) is predicted to increase rapidly with frequency between 100 and 200 kHz where the 'jump' is thought to depend on the thickness of the backbone, i.e. the size of the mackerel. The size of the skull indicates that backscatter from the head is not very frequency dependent, although the frequency dependency of the backscatter could to some extent depend on tilt-angle distribution.

The frequency dependency of the backscatter for *C. gunnari* is expected to follow the same lines as *S. scombrus*. Potential differences in r(f) between equally sized *C. gunnari* and mackerel could be due to the thickness of the backbone, size of the skull and differences in the flesh. In practice these differences could lead to a different frequency of most rapid increase in r(f), the ‘jump frequency’, and possibly also to an additional ‘jump frequency’. Since the use of additional frequencies is important for identifying *C. gunnari*, the recommendation from SG-ASAM of adding frequencies for acoustic investigations in the Southern Ocean is considered important. The recommendation of adding especially the frequency 70 kHz was also recommended by SG-ASAM with identification of Antarctic krill (*Euphausia superba*).

Figures 1 and 2 illustrate the backscattering mechanisms, although only intuitive.

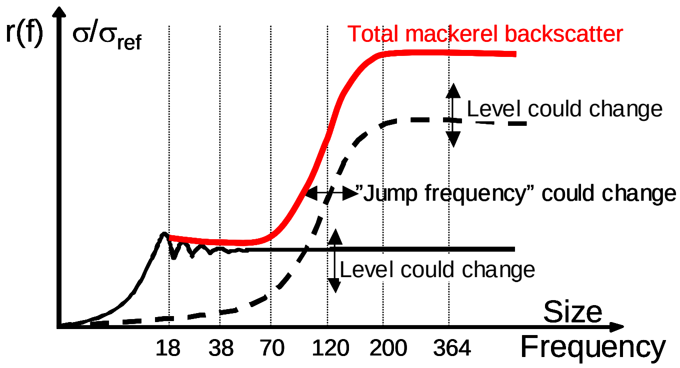

Figure 1: Backscattering mechanisms of Atlantic mackerel (*Scomber scombrus*) (intuitive).

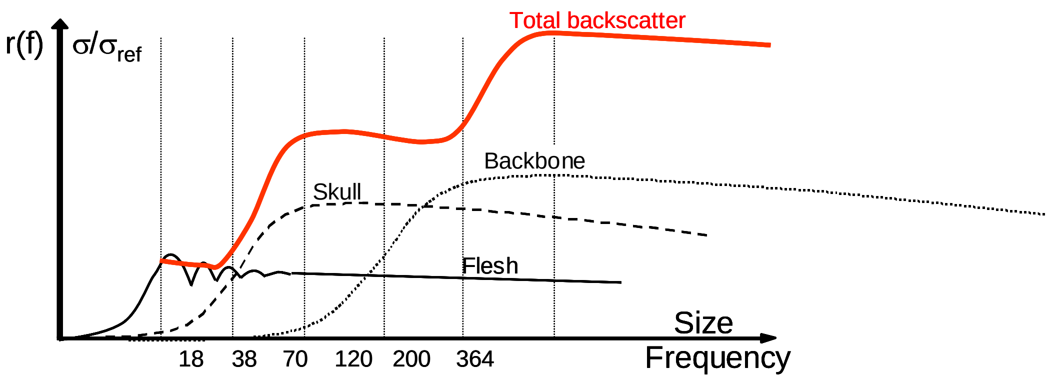

Figure 2: Potential backscattering mechanisms of *Champsocephalus gunnari* (intuitive).

Report from Dr G. Macaulay

The agenda for this meeting included consideration of future work on acoustic surveys of mackerel icefish (*Champsocephalus gunnari*). My expertise in this area is the estimation of target strength, particularly fish without a gas-filled swimbladder, as well as acoustic surveys in general and management of the resulting data.

The recommendations in the subgroup report are reasonable and realistic and, if carried out, will advance the knowledge of *C. gunnari* target strength, and thence estimates of biomass.

Estimates of target strength of fish take some time to obtain, and to develop confidence in. The only *in situ* target strength data available for *C. gunnari* comes from some measurements taken in 1975 (Orlowski, 1984, Hydroacoustic investigations of the Kerguelen Islands area. *Reports of the Sea Fisheries Institute*, 19: 101–108) and 2002 (see WG-FSA-02/44). These appear to have been done in a reasonable manner, but should not be regarded as a definitive answer. There are many factors that can affect the target strength of fish and a number of measurements taken over time are required to give confidence in the results, and it is convenient and prudent to take *in situ* measurements during each survey.

I am in the process of running models of *C. gunnari* target strength at a range of frequencies and this will provide additional data. However these are for individual fish and the dB difference observed between two different schooling behaviours of the fish (as presented by Dr Fielding at the meeting) suggested that the results for isolated *C. gunnari* may not be universally applicable to aggregations.

In my view the meeting worked well, the participants each made a worthwhile contribution to the discussion and the meeting provided a clear statement of the work that is now required to improve acoustic surveys of *C. gunnari*.