Annex 4

Report of the Meeting of the Subgroup
on Acoustic Survey and Analysis Methods
(Qingdao, People's Republic of China, 15 to 19 May 2017)

Contents

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Introduction

1.1 The 2017 meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) was held at the Qingdao National Laboratory for Marine Science and Technology (QNLM), Qingdao, China, from 15 to 19 May 2017. The Convener, Dr X. Zhao (China) welcomed the participants (Appendix A) and noted that this was the 10th meeting of the Subgroup. The Co-convener, Dr C. Reiss (USA), was unable to attend the meeting.

1.2 Mr Z. Wang (Executive Director of the QNML) welcomed the participants. He described how the 42 hectare site of the QNML brought together five Chinese universities and institutes to create a collaborative and coordinated centre of excellence for marine research. Mr Wang recalled that Antarctic research and resource management was an important element of marine research at QNML and he wished the meeting participants a successful and productive meeting and a pleasant stay in Qingdao.

1.3 The meeting's provisional agenda was discussed, and the Subgroup adopted the proposed agenda without any changes. The meeting agenda is in Appendix B.

1.4 Documents submitted to the meeting are listed in Appendix C. The Subgroup thanked the authors of papers and presentations for their valuable contributions to the work of the meeting.

1.5 This report was prepared by A. Cossio (USA), M. Cox (Australia), K. Reid (Secretariat) and G. Skaret (Norway). In this report, paragraphs that provide advice to the Scientific Committee and WG-EMM have been highlighted; these paragraphs are listed in Item 7.

Protocols for the collection and analysis of krill acoustic data from fishing vessels, with emphasis on Simrad echosounders (EK60, ES60/70)

2.1 The Subgroup agreed that the priority area of work was to establish an automated method for processing acoustic data collected by commercial krill fishing vessels to support CCAMLR's management of the krill fishery, including the feedback management (FBM) strategy.

2.2 The Subgroup also recalled that an important element of this was to develop the methodology and protocols that enable CCAMLR to reliably reflect changes in krill availability in the areas in which the fishery operates throughout the fishing season. Acoustic data from both dedicated transects and data collected during fishing operations can provide useful information, however, the current priority was focused on transect data (SC-CAMLR-XXXV, Annex 4, paragraph 2.2).

2.3 The Subgroup recognised that CCAMLR has a well-established protocol for krill identification and biomass estimation from scientific acoustic surveys. However, the fundamental differences between the current priority and scientific surveys require a different approach to the design and protocols for data processing routines, including krill identification and biomass assessment.

Analysis of acoustic data collected from fishing vessels

2.4 Prof. K. Lee (Republic of Korea) presented SG-ASAM-17/04 that described a survey to estimate the density and biomass of krill around the South Shetland Islands from the surveys conducted on the krill fishing vessels *Kwang Ja Ho* in April 2016 and *Sejong Ho* in March 2017. The analysis included a comparison of dB difference values between the integrated cell (50 ping × 5 m) of krill swarms from krill target sampling and the recommended range values by sampled krill size (SC-CAMLR-XXIX, Annex 5). The density estimates from the surveys were consistent with scientific surveys conducted in this subarea in previous years. The authors of SG-ASAM-17/04 are planning to analyse the data from the two surveys following the swarm-based approach developed at this meeting.

2.5 The authors of SG-ASAM-17/04 noted that the sea-surface temperature (SST) in 2017 was 1–1.5°C warmer than in 2016 and that there was an increase in the frequency of salps in scientific and commercial catches in 2017. They also described evidence for vertical size stratification of krill in 2016 with larger krill being found at greater depths.

2.6 The Subgroup warmly welcomed the details of these two surveys conducted by Korean scientists that represented a significant advance in the use of krill fishing vessels to conduct surveys in this subarea. The Subgroup encouraged the authors to submit the updated results and discussion to WG-EMM.

2.7 Dr Cox presented SG-ASAM-17/02 that compared swarm integration and interval integration based on data from a transect-based survey in a 65 km × 60 km area off Mawson research station, East Antarctica. The data were processed and analysed following CCAMLR standard protocols for noise removal, krill identification and biomass estimation. Echoview v 8.0.7 was used for data processing and the SHAPES module within that software for swarm identification and delineation. Mean areal krill density and associated variance was estimated using the random sampling theory estimator of Jolly and Hampton (1990). There was a 61% overlap between the variance estimates for conventional grid-based and swarm-based krill density. The processing time of the swarm-based approach was half that of the standard grid-based technique.

Echosounder calibration using seabed as reference target

2.8 Dr S.-G. Choi (Republic of Korea) introduced SG-ASAM-17/P01 which described the difference between the bottom backscattering strength of the commercial echosounder (i.e. ES70) and a standard sphere calibrated scientific echosounder (i.e. EK60) on board the Korean fishing vessel *Kwang Ja Ho* during a krill survey conducted in Subarea 48.1 in April 2016. The vessel was equipped with ES70 echosounders with operating frequencies of 38 and 120 kHz, but the ES70 General Purpose Transceivers (GPTs) were replaced with EK60 GPTs for the period of the survey for the purpose of krill monitoring and estimation of krill biomass. The system set up with EK60 GPTs was calibrated according to the standard sphere method. In order to calibrate the ES70 system, two transect lines were completed twice, first using the calibrated system with EK60 GPTs, then using the system connected to ES70 GPTs. Seabed echo along the transects were integrated using both systems and the gain settings of the ES70 system were adjusted based on the relative difference in seabed echo intensity with the EK60 system. Using the uncalibrated ES70, only 26.95% of the krill swarm signals were in the 2–12 dB range, however, 92.04% of the krill swarm signals were in the 2–12 dB range with the calibrated ES70 data.

2.9 The Subgroup thanked the authors of SG-ASAM-17/P01 for this work and recalled that the approach of using seabed integration for echosounder calibration had been addressed previously in SG-ASAM as an alternative method to standard sphere calibration. Previous work had shown that integration values are sensitive to changes in bottom features and sensitive to slight changes in vessel track and direction when the bottom is not entirely homogenous and flat. Ideally, a hard and flat stretch of seabed should be used for calibration. For comparison of two or more GPTs connected to the same transducer, a multiplexer can allow for alternate pinging with the two GPTs and a ping-by-ping comparison of integration results. In this case, an inter-calibration on a krill layer or large swarm might be preferable.

2.10 The Subgroup encouraged Members to go through existing acoustic data from surveys and fisheries acquired in the Bransfield Strait area in order to look for candidate locations with appropriate depth and flat bottom for carrying out bottom calibration on different frequencies. In general, the Subgroup encouraged the use of the standard sphere calibration also for ES70 as described in 2015 (SC-CAMLR-XXXIV, Annex 4, paragraph 3.24).

Noise reduction

2.11 Mr X. Wang (China) presented SG-ASAM-17/03 using data from two krill fishing vessels, the *Fu Rong Hai* (China) and the *Saga Sea* (Norway) to evaluate the quality of the acoustic data collected from krill fishing vessels and to validate various spike noise mitigation techniques on such data. Noise spikes from instrument cross-talk was the most important source of noise during normal fishing operations and totally dominated the backscatter on the 38 kHz in the *Fu Rong Hai* data and partly on the 120 kHz in the *Saga Sea* data. Background noise was prominent and changed rapidly with time in the *Saga Sea* data. Other issues causing reduced data quality were 'false bottom' noise, missing bottom detection and inclusion of bottom echo in the integrated regions, surface bubble noise and missing pings under bad weather conditions. Background noise was estimated based on data from a transect survey conducted around the South Shetland Islands with the *Fu Rong Hai* using the method described in de Robertis and Higginbottom (2007). The results showed that the background noise level increased with increasing vessel speed, and the background noise was shown to limit the effective acoustic sample range for a given frequency and vessel speed.

2.12 Four spike noise removal algorithms were tested on a presumed clean dataset from a scientific survey on the *Saga Sea*; the outputs after filtering were compared to the unfiltered output to assess potential bias introduced by the filters (assuming the unfiltered data to be unbiased). All the spike noise removal methods reduced both mean and standard deviation of the nautical area scattering coefficient (NASC). When using the swarm integration, instead of the full dataset integration, on presumed clean data, all algorithms reduced NASC when compared to the unfiltered data, but none of them reduced this by more than 10%. Also, for the noisy data collected during fishing operations, there was less difference between filtered and unfiltered data when using swarm integration than interval integration, presumably because noisy segments of the data were excluded by using the swarm integration approach.

2.13 The Subgroup acknowledged the comprehensive evaluation of spike noise reduction algorithms for acoustic data presented in SG-ASAM-17/03, and agreed that both background noise removal and spike noise removal should be incorporated as parts of the standard processing of transect data from krill fishing vessels. It was agreed that the results and conclusions from SG-ASAM-17/03 should be used to guide the recommendation of the Subgroup on choice of noise removal algorithms.

Day/night variability in krill backscatter and optimal frequency for krill abundance estimation

2.14 Dr O.R. Godø (Norway) presented preliminary results from acoustic observations of krill swarms during a survey on the R/V *James Clark Ross* off the South Orkney Islands in 2016. Data collected on the frequencies 38, 70, 120 and 200 kHz both during daytime and night-time were available for analysis. The data showed large variation in frequency response ($NASC_i/NASC_{38kHz}$) over day and night and within and between swarms likely due to diel differences in krill behaviour. He underlined that the CCAMLR protocol for data collection and biomass estimation from acoustic surveys was developed based on the CCAMLR-2000 Survey for data collected during daytime in austral summer conditions only, whereas the protocol when applied to fishing vessel transect data should also consider different conditions for data collection.

2.15 The data presented by Dr Godø also indicated that 70 kHz was the optimal frequency for krill monitoring of those available on the *James Clark Ross*. With the broadband technique, 70 kHz will cover the most dynamic frequency range for krill and is likely to produce optimal data for target identification for krill biomass estimation as it is less sensitive to variability in behaviour and tilt angle of krill compared to 120 kHz, and less susceptible to issues with false bottom detection and low backscatter of krill at 38 kHz.

2.16 The Subgroup recalled that 70 kHz had been acknowledged as the optimal frequency for krill biomass estimation by the Subgroup several times before. The continued use of 120 kHz as *de facto* frequency for krill biomass estimation is likely a consequence of the presently limited number of 70 kHz echosounders installed for data collection. However, as more vessels now have 70 kHz echosounders, including three Chinese krill fishing vessels, the Subgroup recommended continued effort to facilitate the implementation of 70 kHz for krill monitoring. The Subgroup noted that no empirical validation of the stochastic distorted-wave Born approximation (SDWBA) model parameter settings for target strength estimation for 70 kHz data has been carried out like it has for 38 and 120 kHz (Demer and Conti, 2005).

Analysis of data collected from fishing vessels

Data analysis using the swarm-based approach

3.1 The Subgroup acknowledged that SG-ASAM-17/02, 17/03 and 17/04 indicated that the krill density estimation is sensitive to the dB difference window technique for krill identification. However, krill identification based on swarm detection and delineation can be used without or with a very wide dB difference window if the risk associated with identifying all detected swarms as krill swarms is acceptable.

3.2 The Subgroup acknowledged several potential advantages of the swarm-based method compared to interval integration when applied to data collected from fishing vessels:

(i) it is not dependent on data from a specific set of acoustic frequencies which is required when setting the dB difference window for krill identification following the CCAMLR protocol

(ii) it reduces the risk of integrating noise-contaminated segments of the data

(iii) it provides potentially interesting information about swarm dynamics and swarm characteristics which would not be available from standard interval integration

(iv) it potentially reduces data processing time.

3.3 The Subgroup recommended that the swarm-based approach should be used for krill density estimation from data collected along transects by krill fishing vessels following the procedure agreed below (paragraphs 3.4 to 3.18).

Echoview template for automatic data processing

3.4 Dr Cox presented the Echoview template 'CCAMLR_SWARM.EV' that was uploaded on the SG-ASAM e-group. This template was developed to support the automation of acoustic data processing. He described and demonstrated the function of each acoustic variable in the template.

3.5 The Subgroup noted that the template is currently designed for 38 and 120 kHz data and that the template is designed to output integrated 120 kHz krill swarm data in 250 m depth × 1 n mile intervals for either NASC or krill density.

3.6 The Subgroup recommended that the template be used with calibrated data, but recognised that schools detection can be performed on uncalibrated data, although echo integration cannot. The Subgroup noted that estimates of swarm characteristics from uncalibrated data might provide useful information in support of assessments from calibrated data. Furthermore, the template can be adapted for use with different frequencies, but currently this must be carried out manually.

3.7 The Subgroup tested the Echoview template using calibrated 38 and 120 kHz data collected by the *Saga Sea* from 13 to 15 February 2016 in Subarea 48.2 to detect krill swarms and integrate krill echoes to obtain NASC values; in all tests (n = 5) identical results were obtained. The Subgroup wrote a manual for the use of the template (Appendix D).

3.8 The final Echoview template incorporated the following data processing steps:

(i) spike noise removal
(ii) background noise removal
(iii) automated seabed detection

(iv) krill swarm detection
(v) dB differencing
(vi) integration and export of NASC attributed to krill and krill areal density.

Default parameters for the template are given in Table 1.

Spike noise removal

3.9 The spike noise removal algorithm of Wang et al. (2016), presented in SG-ASAM-17/03 was included in the Echoview template. The Wang et al. (2016) algorithm was selected because it has been tested on acoustic data collected using krill fishing vessels in the Antarctic and only requires two parameters (minimum and maximum data S_v threshold; Table 1). The Subgroup recommended that the same minimum data S_v threshold should be applied to the spike noise removal and to the schools detection.

Background noise removal

3.10 The Subgroup agreed to use the method of de Robertis and Higginbottom (2007) to remove background noise. The Subgroup noted that, with the exception of the maximum noise parameter, values of the background noise removal parameter settings were taken from de Robertis and Higginbottom (2007). Maximum noise parameter settings were –105 dB and −135 dB for the 38 and 120 kHz frequencies respectively. The maximum noise parameter values were determined from analysis of the data presented in SG-ASAM-17/02.

Automated seabed detection

3.11 The Subgroup agreed to use the 38 kHz frequency for seabed detection and to use the 'best bottom candidate line pick' algorithm implemented in Echoview. The Subgroup noted that refinement of the best bottom candidate line pick parameters might be necessary and recognised two ways to aid in bottom detection:

(i) that bottom depths from the transect lines be provided to the Secretariat from previous surveys

(ii) to implement the seabed detection approach of Renfree and Demer (2015).

Krill swarm detection parameters

3.12 The sensitivity of mean areal krill density estimates to the swarm detection parameters was investigated using the 38 and 120 kHz EK60 data collected from the Australian research vessel, the *Aurora Australis*, in East Antarctica (SG-ASAM-17/02). Dr Cox used schools detection parameters taken from SG-ASAM-17/02 and 17/03; Cox et al., 2011; Tarling et al., 2009; Woodd-Walker et al., 2003 (Table 2) and estimated mean real krill density (Figure 1). The Subgroup agreed that the different schools parameters are not sensitive with dB differencing removed.

3.13 The Subgroup noted that, in future, schools parameters could be adjusted to account for ping interval and vessel speed. The Subgroup noted that SG-ASAM had suggested survey settings, assuming a vessel speed of 10 knots, to be used by fishing vessels during line transect surveys in earlier meetings.

dB differencing

3.14 The Subgroup noted that the template has 'dB differencing' for 38 kHz – 120 kHz. The Echoview template default settings have a –20 to 20 dB difference range. The Subgroup recognised that this wide default dB difference range will avoid krill being excluded but may potentially also include non-krill echoes. However, the Subgroup agreed that the swarm detection step in the template is sufficient to delineate krill from other organisms and avoid the inclusion of the majority of non-krill echoes.

3.15 The dB difference option is retained in the template to enable future research to be carried out on the sensitivity of swarm-based approaches to krill length-frequency data. To support this future work, Dr Cox agreed to edit the R Markdown file used in SG-ASAM-16/01 to set the dB difference (38 – 120 kHz) and convert NASC to areal krill density using the conversion factor (C), as described in WG-EMM-16/38, automatically and to provide this to the SG-ASAM e-group.

Integration and export

3.16 The template has two output variables for 120 kHz. One variable 'Krill NASC from mean Sv', produces an output of NASC (m^2 n $mile^{-2}$) at 250 m depth × 1 n mile interval. The other variable 'krill areal density' produces an output of density (g m^{-2}) at 250 m depth × 1 n mile interval. The default value for the conversion factor (C) used to produce krill areal density is set to 0. This can be changed once a conversion factor is calculated.

Automation of data processing

3.17 Dr Cox presented EchoviewR, an R software package used to help automate acoustic data processing using Echoview. The software package is currently located on the Github website (https://github.com/AustralianAntarcticDivision/EchoviewR). The Subgroup agreed that EchoviewR was a powerful tool that could be used with Echoview to help automate processing of large datasets and to conduct sensitivity analyses. The Subgroup agreed that using EchoviewR will enable acoustic data processing to be conducted in a reproducible manner, and when run using R Markdown documents will enable data processing steps to be version-controlled.

3.18 The Subgroup requested that the Secretariat hold a 'forked' copy of EchoviewR on its Github site in order to ensure appropriate version control and documentation. The Subgroup also requested that the Secretariat maintain the Echoview template in a version-controlled information management system to ensure transparency in the future use and modification of the template.

Survey design

4.1 The Subgroup reiterated its request for krill fishing vessels to collect acoustic data along the nominated transects (SC-CAMLR-XXXV, Annex 4, paragraphs 2.1 and 2.2). The Subgroup agreed that the collection of acoustic data by each vessel in the fishery from at least one nominated transect each month would contribute greatly to understanding temporal variability in krill abundance, distribution and swarm characteristics.

4.2 The Subgroup noted that, while acoustic data was being collected by krill fishing vessels as part of dedicated surveys (e.g. SG-ASAM-17/04), there has been relatively little repeated collection of acoustic data from the nominated transects reported to the Secretariat. The Subgroup recalled its advice from last year that it may be potentially beneficial to examine mechanisms to provide incentives for vessels to collect acoustic data along the nominated transects (SC-CAMLR-XXXV, Annex 4, paragraph 1.5).

4.3 The Subgroup encouraged the evaluation of potential alternative locations for new transects that could be occupied repeatedly, especially where these transect locations might achieve a greater degree of overlap with areas of fishing operations.

Other business

Japanese dedicated krill survey proposal

5.1 Dr H. Murase (Japan) presented SG-ASAM-17/01 that described a proposal for a dedicated krill survey in Division 58.4.1 in 2018/19. The plan proposed to repeat the BROKE survey in order provide an updated estimation of krill biomass to provide a revised estimate of B_0 used by CCAMLR for setting catch limits in this area and also to collect oceanographic observations to detect long-term changes.

5.2 The Subgroup noted that SG-ASAM-17/01 was based on a proposal for a dedicated krill survey that was originally presented in WG-EMM-15/43 and the Subgroup thanked Dr Murase for his very comprehensive presentation on the design and planned implementation of the survey that used the CCAMLR-agreed protocol for the estimation of krill biomass. The Subgroup recalled the invitation from Japan for scientists to participate in the survey (COMM CIRC 17/33–SC CIRC 17/26) and was delighted to hear that discussions between Subgroup participants were ongoing in this regard.

5.3 The Subgroup noted that Japan was proposing to use broadband acoustics during the survey, including 70 kHz, and that this would likely provide a useful contribution to the evaluation of the use of this frequency in the collection of acoustic data by fishing vessels (see paragraph 6.6). The Subgroup encouraged the presentation of details of density contrast and sound-speed contrast measurement methods to SG-ASAM-18.

US AMLR Program

5.4 Mr Cossio provided an update on the proposal to revise at-sea research within the US AMLR Program to better address questions necessary for understanding the consequences of overlap among krill, predators and the krill fishery. This includes the movement away from ship-based research to an instrument-based (moorings and gliders) program of oceanographic and ecological observations and research to support the US commitment to CCAMLR and ecosystem science in the Southern Ocean.

Location of next SG-ASAM meeting

5.5 In encouraging Members to consider hosting future meetings of SG-ASAM, the Subgroup recognised the great value of increased attendance and engagement in the work of CCAMLR that was provided to acousticians from the Member hosting the meeting. This had been particularly evident in the current meeting and also in the meeting hosted by the Republic of Korea in 2015.

Future work

6.1 The Subgroup reviewed the default settings for the swarm-based Echoview template and highlighted the following areas of future work:

(i) Spike noise reduction parameters –

  (a) review the reduction in NASC as a result of application of the spike noise algorithm to clean data, i.e. data with no spike noise

  (b) evaluation of the impact of the maximum S_v threshold value on a case-by-case basis for specific noise signals and vessel-specific noise characteristics

  (c) review the impact of frequency dependent spike noise removal on the dB difference method.

(ii) Background noise removal parameters –

  (a) measure background noise of a vessel, including by using passive mode, to optimise the background noise removal parameters for an individual vessel.

(iii) Swarm detection parameters –

  (a) frequencies other than 120 kHz (for example 70 kHz) should be evaluated for swarm detection and the associated parameters evaluated.

(iv) 38 – 120 kHz dB difference parameters –

  (a) krill length-frequency data can be used to refine the dB difference parameters (see paragraph 6.2)

  (b) frequencies other than 38 – 120 kHz (for example 70 kHz) should be evaluated for target identification.

(v) 1 n mile × 250 m export parameters –

  (a) krill length-frequency data can be used to determine the conversion factor from NASC to density (see paragraph 6.2).

Krill length-frequency data

6.2 Data on the length frequency of krill is relevant to the dB difference and the conversion factor and the Subgroup recommended that an evaluation of the use of observer-collected length-frequency data be undertaken to determine the appropriate spatial and temporal scale over which length samples of krill should be pooled to characterise the length frequency of the krill population in the acoustic survey (and individual transects). The Subgroup noted that the selectivity of some commercial krill trawls has been studied and the selection curve estimated (Krag et al., 2014). Such selection curves can be useful in future work studying the potential impacts of net selectivity on length-frequency data used in the estimates of conversion factors and dB differences.

Evaluation of the use of the swarm-based approach rather than gridded data

6.3 The Subgroup recommended that the differences in biomass estimates from the scientific acoustic surveys using the CCAMLR-agreed method and the swarm-based approach should be evaluated for existing data from Subareas 48.1 and 48.2, noting that this comparison has been undertaken for the surveys in Subarea 48.3 (Fielding et al., 2014).

Other noise reduction algorithms

6.4 The recommended Echoview template for processing of transect data collected by fishing vessels presently includes algorithms to automatically handle background noise and spike noise. Methods to evaluate the implications of other issues reducing the quality and biasing the output of the processing step (SG-ASAM-17/03), including missed bottom detection and inclusion of bottom echo in integrated region, false bottom echo, variable background noise level, surface bubble noise and missing pings due to bad weather condition, should be developed in the future.

Survey design

6.5 In addition to the suggestion to evaluate potential alternative locations for new transects that could be occupied repeatedly (see paragraph 4.3), the Subgroup also noted the potential to carry out a combined trawl acoustic survey in selected areas with the objective of developing and checking existing methods as well as to assess local krill density.

New echosounders and frequencies

6.6 The current approaches to the estimation of krill biomass from krill fishing vessels are focused on the use of 38 and 120 kHz with Simrad ES60 echosounders. However, other frequencies, such as 70 kHz, are now becoming more routinely available and new echosounders, such as the EK80 and ES80, are being installed on research and fishing vessels. Therefore, there is a need to evaluate the use of these developments in the estimation of krill biomass used in CCAMLR.

Automated data processing

6.7 The Subgroup noted that it is possible for fishing vessels to use the template and send the NASC outputs to the Secretariat and recommended that an implementation plan be prepared to allow NASC and/or raw data to be processed either on vessels, by Member scientists or by the Secretariat.

Advice to the Scientific Committee and WG-EMM

7.1 The Subgroup recommended that the swarm-based approach should be used for krill density estimation from data collected along transects by krill fishing vessels (paragraph 3.3) following the procedure set out in paragraphs 3.4 to 3.18.

7.2 The Subgroup agreed on the value of the collection of acoustic data by each vessel in the fishery from at least one nominated transect each month (paragraph 4.1) and the benefit of examining mechanisms to provide incentives for vessels to collect acoustic data along the nominated transects (paragraph 4.2).

Adoption of the report and close of the meeting

8.1 The report of the meeting was adopted.

8.2 At the close of the meeting Dr Zhao thanked all participants for their patient, painstaking and productive contributions to the work of SG-ASAM. Dr Zhao also thanked the Secretariat for its efficient support to the meeting, both those attending the meeting and, in particular, those providing support from Hobart.

8.3 On behalf of the Subgroup, Dr Godø thanked Dr Zhao for his efficient and hard work in convening the meeting and also for the very efficient hospitality in hosting SG-ASAM-17 that had led to this meeting making great progress in the use of fisheries acoustics data.

8.4 The Subgroup noted its gratitude to Echoview for generously loaning five licence 'dongles' to the Secretariat for use at the meeting; these had greatly enhanced the productivity of the meeting.

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Table 1: Default settings for the swarm-based Echoview template. NB all dB values re 1 m^{-1}.

Spike noise reduction parameters (Wang et al., 2016)		
	38 kHz	120 kHz
Minimum data threshold (S_v)	–80 dB	–70 dB
Maximum data threshold (S_v)	–50 dB	–40 dB
Background Noise removal parameters (de Robertis and Higginbottom, 2007)		
	38 kHz	120 kHz
Horizontal extent (pings)	20	20
Vertical extent (samples)	5	5
Vertical overlap	0%	0%
Maximum noise	–105 dB	–135 dB
Minimum signal to noise (SNR)	12 dB	12 dB
Seabed detection parameters		
Run on unprocessed 38 kHz data (the 'fisheries: Sv raw pings T1' virtual variable in the Echoview template)		
	38 kHz	
Start depth	20 m	
Stop depth	1 000 m	
Minimum S_v for good pick	–60 dB	
Apply backstep:		
Discrimination level	–70 dB	
Backstep range	15 m	
Peak threshold	–50 dB	
Maximum dropouts	2 samples	
Window radius	50 samples	
Minimum peak asymmetry	–1	
Swarm detection parameters		
Run on 120 kHz 3 × 3 dilation that has been through the spike and background noise reduction processes above (the '120 Dilation filter 3×3 (detect schools here)' virtual variable in the Echoview template)		
	Parameter value	
Minimum candidate length	15 m	
Minimum candidate height	3 m	
Maximum horizontal linking distance	15 m	
Maximum vertical linking distance	5 m	
Minimum total length	15 m	
Minimum total height	3 m	
Minimum data threshold	–70 dB	
38 – 120 kHz 'dB difference' parameters		
Minimum dB difference	–20 dB	
Maximum dB difference	20 dB	
1 n mile × 250 m export parameters		
Minimum data threshold (S_v)	none	
Conversion factor (NASC to areal density)	0	

Table 2: Schools detection parameters used in the sensitivity analysis of mean areal krill density.

Schools detection parameter	Woodd-Walker et al. (2003)	Tarling et al. (2009)	Cox et al. (2011)	SG-ASAM-17/02	SG-ASAM-17/03	SG-ASAM-17 meeting settings
Maximum horizontal linking distance (m)	15	15	30	15	15	15
Maximum vertical linking distance (m)	3	5	10	3	5	5
Minimum candidate height (m)	3	1	10	3	1	3
Minimum candidate length (m)	10	10	30	10	10	10
Minimum school height (m)	3	2	10	3	2	3
Minimum school length (m)	15	15	30	15	15	15
Minimum data S_v threshold (dB re 1 m^{-1})	–80	–70	–80	–65	–70	–70
Estimated inter ping distance (m)	12.5	7.5	12.5	10	Undefined	Undefined
Image processing acoustic variable type	None – as observed	Convolution 7 × 7	Convolution 3 × 3	Dilation 3 × 3	None – as observed	Dilation 3 × 3

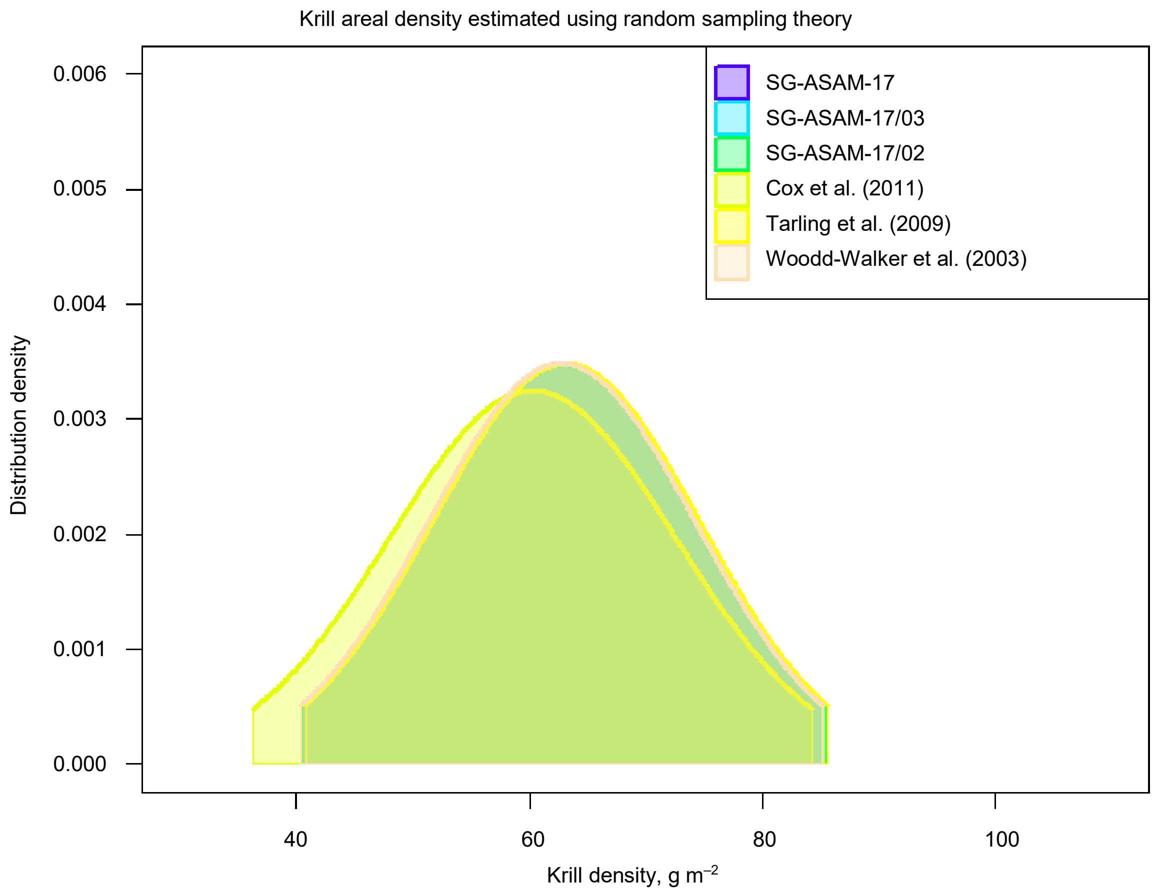


Figure 1: The sensitivity of mean krill density estimates to varying school detection parameters with no dB differencing applied. The figure legend references are: SG-ASAM-17 – school detection parameters selected during SG-ASAM-17; SG-ASAM-17/02 and 17/03 – working group papers; Cox et al. (2011), Tarling et al. (2009) and Woodd-Walker et al. (2003) are cited in the reference section.

Appendix A

List of Participants

Subgroup on Acoustic Survey and Analysis Methods
(Qingdao, People's Republic of China, 15 to 19 May 2017)

Convener	Dr Xianyong Zhao Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences People's Republic of China zhaoxy@ysfri.ac.cn
Australia	Dr Martin Cox Australian Antarctic Division, Department of the Environment martin.cox@aad.gov.au
China, People's Republic of	Mr Shuai Chen East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences yangpu79@qq.com
	Mr Hongliang Huang East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences ecshhl@163.com
	Dr Jianfeng Tong Shanghai Ocean University jftong@shou.edu.cn
	Dr Teng Wang Shanghai Ocean University d150301032@st.shou.edu.cn
	Mr Xinliang Wang Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences wangxl@ysfri.ac.cn
	Dr Jun Xie Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences a13012510813@126.com

Dr Xiaotao Yu
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences
yuxt@ysfri.ac.cn

Mr Jichang Zhang
Yellow Sea Fisheries Research Institute
zhangjc@ysfri.ac.cn

Dr Guoping Zhu
Shanghai Ocean University
gpzhu@shou.edu.cn

Japan

Dr Koki Abe
National Research Institute of Fisheries Engineering, Fisheries Research Agency
abec@fra.affrc.go.jp

Dr Hiroto Murase
National Research Institute of Far Seas Fisheries
muraseh@affrc.go.jp

Korea, Republic of

Dr Seok-Gwan Choi
National Institute of Fisheries Science (NIFS)
sgchoi@korea.kr

Professor Kyounghoon Lee
Chonnam National University
ricky1106@naver.com

Norway

Dr Olav Rune Godø
Institute of Marine Research
olavrune@imr.no

Dr Georg Skaret
Institute of Marine Research
georg.skaret@imr.no

Ukraine

Dr Kostiantyn Demianenko
Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
s_erinaco@ukr.net

United States of America

Mr Anthony Cossio
National Marine Fisheries Service
anthony.cossio@noaa.gov

Secretariat

Dr Keith Reid
Science Manager
keith.reid@ccamlr.org

Appendix B

Agenda

Subgroup on Acoustic Survey and Analysis Methods
(Qingdao, People's Republic of China, 15 to 19 May 2017)

1. Opening of the meeting
2. Protocols for the collection and analysis of krill acoustic data from fishing vessels, with emphasis on Simrad echosounders (EK60, ES60/70)
3. Analysis of data collected from fishing vessels
4. Survey design
5. Other business
6. Advice to the Scientific Committee
7. Adoption of report and close of meeting.

List of Documents

Subgroup on Acoustic Survey and Analysis Methods
(Qingdao, People's Republic of China, 15 to 19 May 2017)

SG-ASAM-17/01	An outline of the proposed dedicated krill survey for CCAMLR Division 58.4.1 during 2018/19 season by the Japanese survey vessel, *Kaiyo-maru* H. Murase, K. Abe, T. Ichii and A. Kawabata
SG-ASAM-17/02	Describing krill: swarms or integration intervals? M.J. Cox
SG-ASAM-17/03	Evaluation of some processing techniques applied to acoustic recordings from two krill fishing vessels X. Wang, G. Skaret and O.R. Godø
SG-ASAM-17/04	Density and biomass of Antarctic krill around South Shetland Islands using by 2-dB difference method S.-G. Choi, K. Lee and D. An
	***************
SG-ASAM-17/P01	A study on calibration for commercial echosounder using bottom backscattering strength in Antarctic S.-G. Choi, H. Lee, K. Lee and J. Lee *Fisheries Technology in Korea*

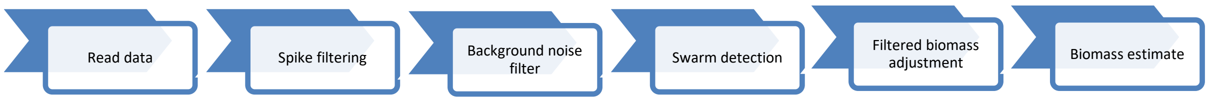
Appendix D

Swarm-based Echoview template user manual

Version 1 May 2017

Background

The Echoview swarm template is developed to pursue an alternative approach to the CCAMLR procedure for biomass estimation from transect line acoustic surveys. All available information indicates that a very high percentage of the krill will be concentrated in swarms which are almost exclusively krill. The basis of the method is, therefore, to identify the swarms and assess their biomass after cleaning the data for various types of noise. To prepare the acoustic data from fishing vessels for assessment purposes, a sequential data automatic data processing routine is developed in Echoview (see figure below).



The following template provides guidance on how the developed protocols can be applied and adjusted.

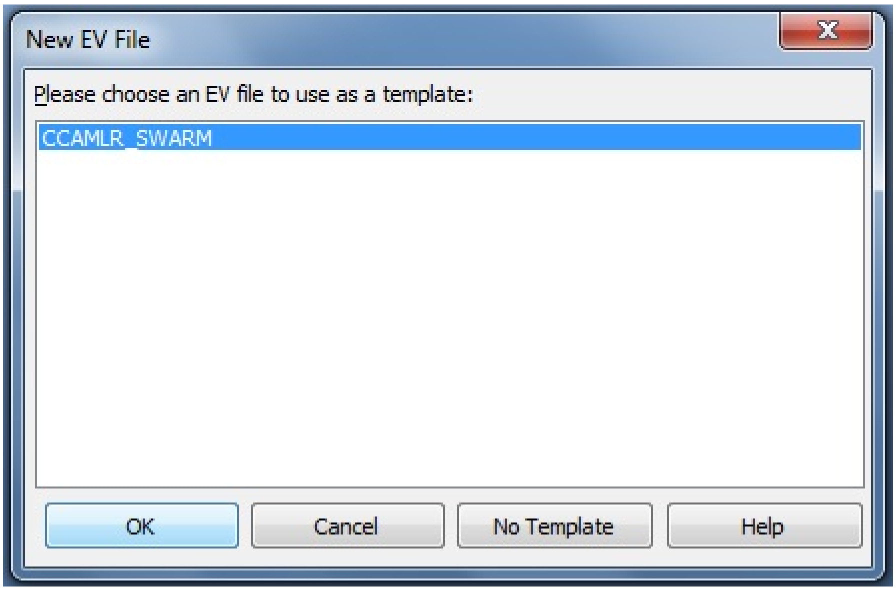
The following template is designed for use with 38 and 120 kHz only. The default parameters for the template are provided in Table 1. The process for using the EchoviewR package is illustrated in the R Markdown document 'Saga Sea EchoviewR example' that was developed during SG-ASAM-17 (see Attachment 1).

How to use the swarms template

Place the 'CCAMLR_SWARM.EV' file in C:\Program Files\Echoview Software\Echoview 8.0\Echoview\Templates. Administrator permissions are needed to do this. If you cannot get access to the Templates folder, you will have to open the Echoview program first. Go to 'File' then 'Configuration'. Click the tab on the left marked 'File Locations'. On the right side, select 'Templates' under 'File Type'. Click 'Edit' and then navigate to the folder location where 'CCAMLR_SWARM.EV' is located.

Open the Echoview program.

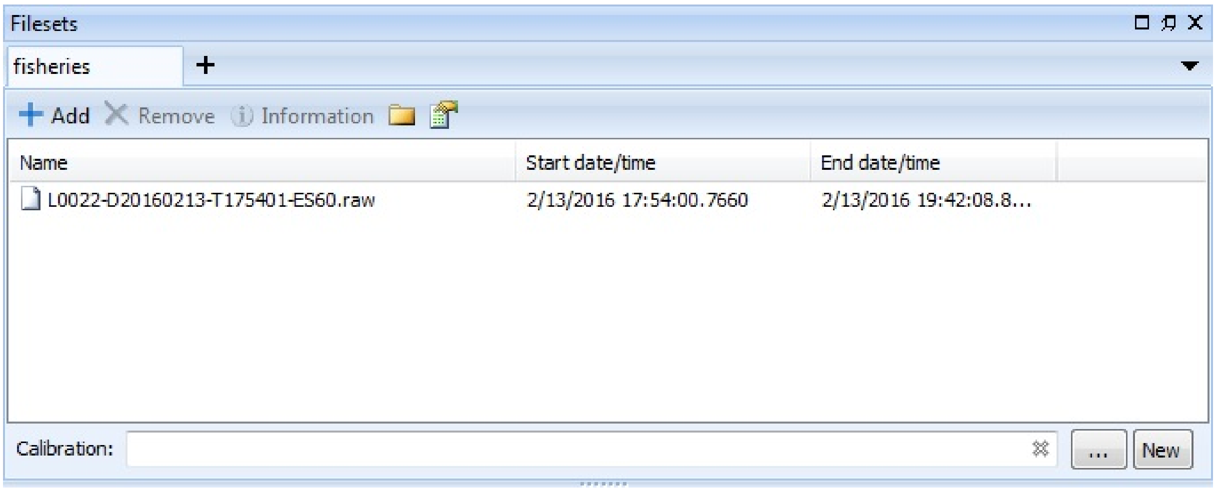
Click on 'File' and select 'New'.



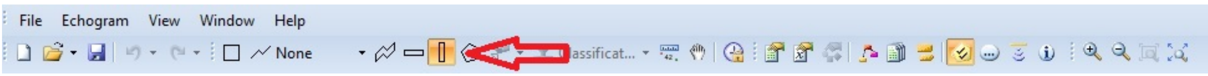
Select ‘CCAMLR_SWARM’ and press ‘Ok’.

Add your survey data to the file set. Press the ‘+Add’ button and select your acoustic data. Then press ‘Ok’.

Double-click ‘SV raw pings T1’ to visually check your data.

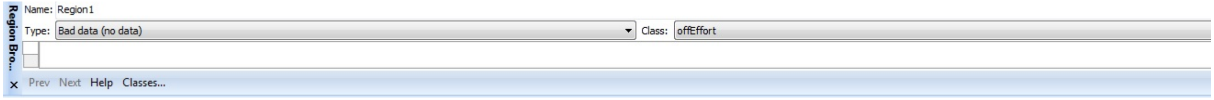


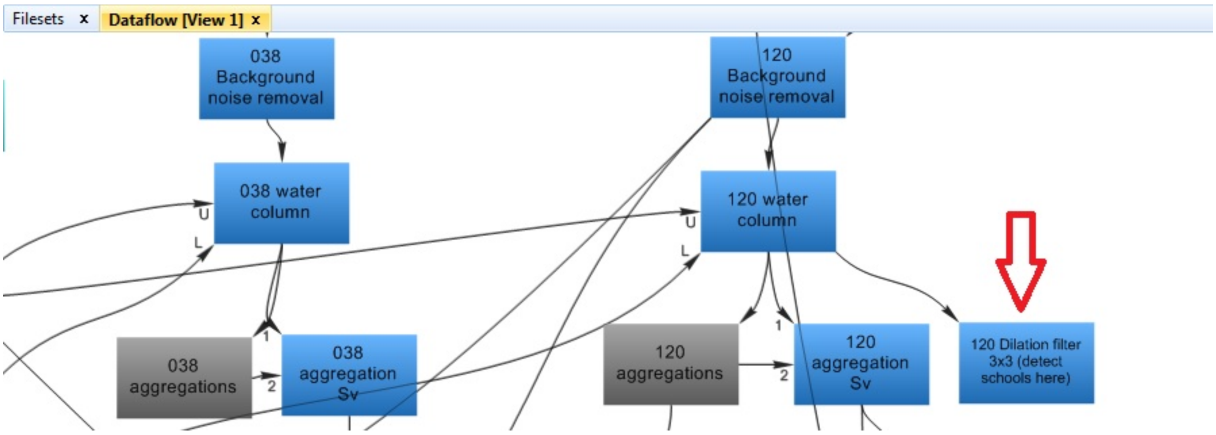
Now add the calibration file for your fishing vessel. Press ‘. . .’ and add your calibration file. If you do not have one, you can create one. To create a new calibration file, press ‘New’. Once you have named your calibration file press ‘Save’. You should now see your calibration file in the box next to ‘Calibration:’.



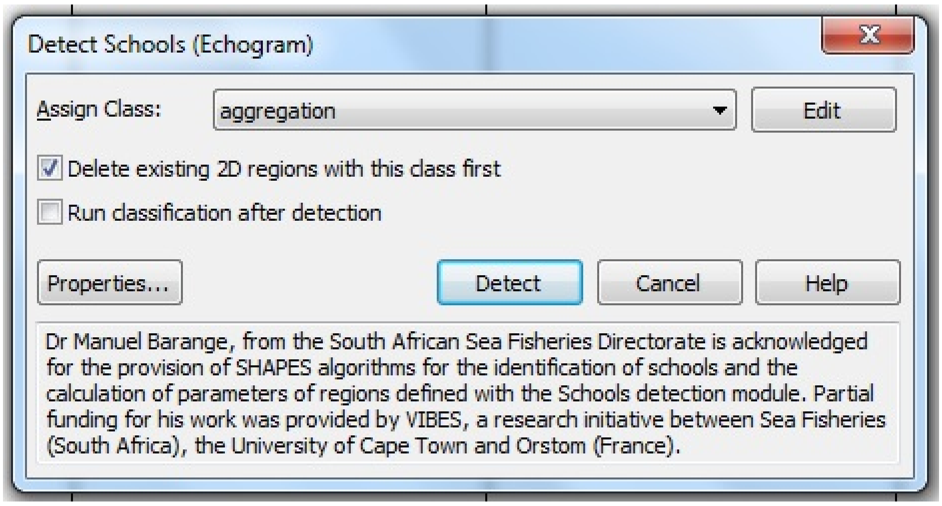
If you still have SV raw pings T1 open, select the ‘Vertical band’ tool. This can be used to select data that is not part of the transect line. Press and hold the left mouse button to size the area. Next, click the right mouse button and select ‘Define Region’. Make sure the ‘Type’ says

‘Bad Data (no data)’. The ‘Class’ should be selected to ‘offEffort’. Do this for each section of data that is not part of the transect line (i.e. turns, net tows, etc.). The area should turn purple.



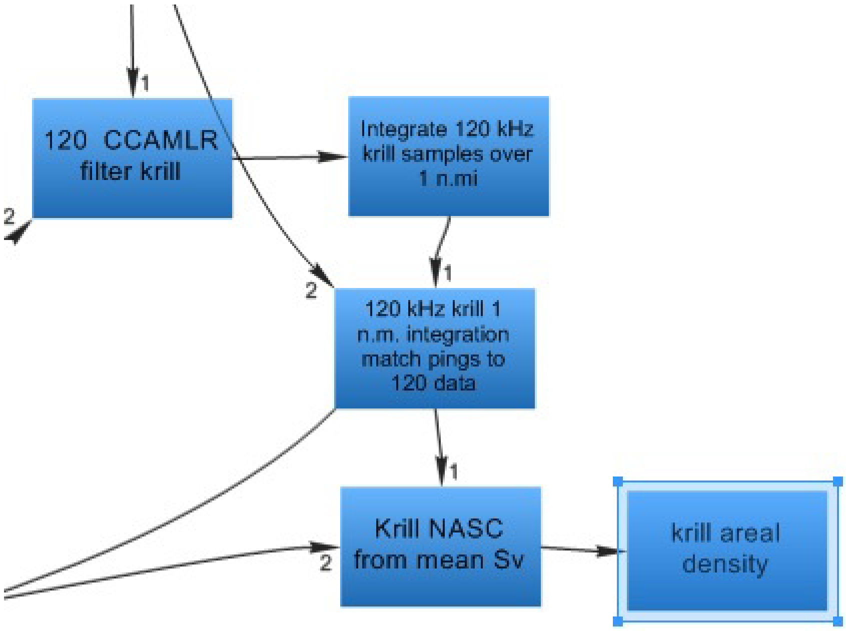


In the Dataflow window, double-click to open ‘120 Dilation filter 3×3 (detect schools here)’.



On the menu bar, select ‘Echogram’ and select ‘Detect Schools…’.

Where it says ‘Assign Class’ pull down and select ‘aggregation’. Make sure that you check ‘Delete existing 2D regions with this class first’. Then select ‘Detect’. This step will take several minutes.



For an output of nautical area scattering coefficient (NASC) values (m^2 n miles^{-2}), open the ‘Krill NASC from mean Sv’ by double-clicking the left mouse button. This step will take several minutes. On the menu bar, select ‘Echogram’ then ‘Export’ then ‘Analysis by Cells’ then ‘Integration’. Save the file as comma-separated values (csv).

For an output of density estimates (g m^{-2}), open the ‘krill areal density’ variable by double-clicking the left mouse button. This step will take several minutes. On the menu bar, select ‘Echogram’ then ‘Export’ then ‘Analysis by Cells’ then ‘Integration’. Save the file as csv. The initial settings are set at 0 until a conversion factor is put in place. To put in a conversion factor, right-click on the ‘krill areal density’ and select ‘Variable Properties’. Open the tab to ‘Constant Multiply/Divide’. Enter your conversion factor calculated from the krill length frequency.

Output

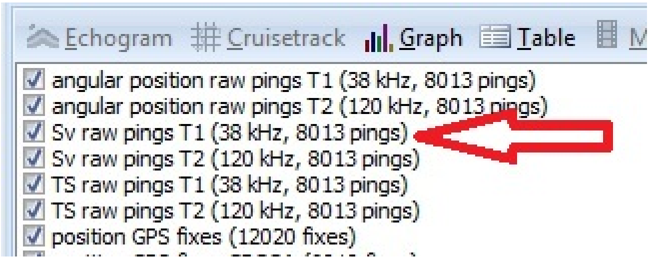
The output of both the ‘Krill NASC from mean Sv’ and the ‘krill areal density’ is in 250 m depth × 1 n mile intervals.

The fourth column of the exported csv file is labelled as ‘Sv_mean’. This is actually NASC if your output file is from ‘Krill NASC from mean Sv’, not the column titled ‘NASC’. The fourth column of the csv file from ‘krill areal density’ labelled ‘Sv_mean’ is the density output.

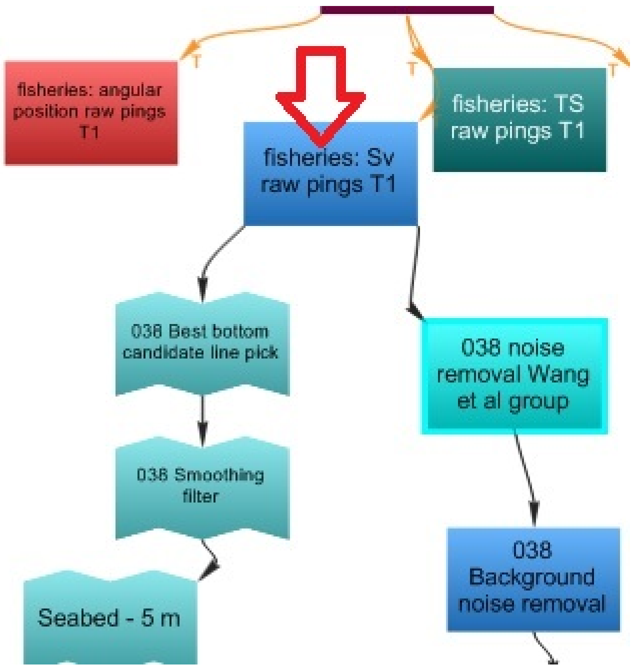
Troubleshooting

Assigned frequencies

The template is designed for S_v raw T1 to be 38 kHz and S_v raw T2 to be 120 kHz. If S_v raw T1 is not 38 kHz, you will have to manually change the variables in the Dataflow window.



You can see what frequency is assigned to T1, it will show up to the right of 'Sv raw pings T1'. This can be done for each frequency.



Schools detection

To change the schools detection parameters, open the 'Properties' button in the 'Detect Schools'.

Conversion factor

The conversion factor to transform NASC into density is documented in SG-ASAM-16/01. Length frequency of krill caught in the area that the transect lines were performed can be used to determine the conversion factor. The length frequencies collected from the observers on krill fishing vessels from the previous seven days can be aggregated.

Default settings

Default schools parameter	Default value
Maximum horizontal link	15 m
Maximum vertical link	5 m
Minimum candidate height	3 m
Minimum candidate length	10 m
Minimum school height	3 m
Minimum school length	15 m
Data threshold	–70 dB

The default settings for the noise reduction is found in Wang et al., 2015.

Default settings for 38 – 120 kHz dB difference filter are:

minimum in-range: –20 dB
maximum in-range: 20 dB.

The conversion factor found in the krill areal density is set to zero.

Table 1: Default settings for the swarm-based Echoview template. NB all dB values re 1 m^{-1}.

Spike noise reduction parameters (Wang et al., 2016)		
	38 kHz	120 kHz
Minimum data threshold (S_v)	–80 dB	–70 dB
Maximum data threshold (S_v)	–50 dB	–40 dB
Background Noise removal parameters (de Robertis and Higginbottom, 2007)		
	38 kHz	120 kHz
Horizontal extent (pings)	20	20
Vertical extent (samples)	5	5
Vertical overlap	0%	0%
Maximum noise	–105 dB	–135 dB
Minimum signal to noise (SNR)	12 dB	12 dB
Seabed detection parameters		
Run on unprocessed 38 kHz data (the 'fisheries: Sv raw pings T1' virtual variable in the Echoview template)		
	38 kHz	
Start depth	20 m	
Stop depth	1 000 m	
Minimum S_v for good pick	–60 dB	
Apply backstep:		
Discrimination level	–70 dB	
Backstep range	15 m	
Peak threshold	–50 dB	
Maximum dropouts	2 samples	
Window radius	50 samples	
Minimum peak asymmetry	–1	
Swarm detection parameters		

(continued)

Table 1 (continued)

Run on 120 kHz 3 × 3 dilation that has been through the spike and background noise reduction processes above (the '120 Dilation filter 3×3 (detect schools here)' virtual variable in the Echoview template)	Parameter value
Minimum candidate length	15 m
Minimum candidate height	3 m
Maximum horizontal linking distance	15 m
Maximum vertical linking distance	5 m
Minimum total length	15 m
Minimum total height	3 m
Minimum data threshold	–70 dB
38 – 120 kHz 'dB difference' parameters	
Minimum dB difference	–20 dB
Maximum dB difference	20 dB
1 n mile × 250 m export parameters	
Minimum data threshold (S_v)	none
Conversion factor (NASC to areal density)	0

Saga Sea EchoviewR example created in R markdown

Martin J Cox martin.cox@aad.gov.au

19 May 2017

Here I provide an example of how to use EchoviewR to control Echoview from R and to detect swarms and export the resulting echo integration. In this example, I use ES60 data from the Saga Sea, collected in February 2016 and provided by Norway during the 2017 SG-ASAM meeting.

At the end of this document, I provide an example of how to automate this approach by controlling Echoview within a loop.

Data locations

To run this example, you will need to set the ES60 RAW data directory and The data directory that is specific to your own computer. The directory in the `R` object, `wd` must contain the ES60.RAW files.

Find RAW files

We start by loading the RAW file locations into the `R` workspace and do this using the `R` function `list.files()`.

```
wd='C:/Users/martin_cox/Documents/ASAM/sagaSea-raw/' #Change the data dire
ctory here.
rawFiles=list.files(wd,pattern='.raw',full.names = TRUE)
```

There are `17` ES60 RAW data files in the data directory.

Calibration file directory and filename

Next, we specify the Echoview calibration (.ECS) file directory and location:

```
calFile='C:/Users/martin_cox/Documents/2017/sagaSea/raw/SimradEK60Raw.ecs'
```

Echoview template file directory and filename

Finally, I specify the location of the Echoview template file that we will use for the acoustic processing. This Echoview template was developed during SG-ASAM17 for swarm-based analysis.

```
EVtemplate='C:/Users/martin_cox/Documents/mawsonBox/CCAMLR_SWARMR06.EV'
```

Load EchoviewR library into R

Now we have specified the locations of the ES60.RAW data files, the Echoview format calibration file, and the Echoview template file we can load the `EchoviewR` package version `1.0` into the `R` workspace.

```r
library(EchoviewR,quietly = TRUE)
```

Start Echoview remotely

Here, we establish a link between R and Echoview. If the link fails, please see the resolved issues on the EchoviewR git hub website.

```r
EVAppObj=COMCreate('EchoviewCom.EvApplication')
```

The COM address of the Echoview program is now available in the R workspace and can be used to control Echoview remotely from R.

Load the RAW data into Echoview using EchoviewR

In this section we load the ES60 RAW data files into the template and save the template as an Echoview .EV file. We specify the output .EV file directory and name as:

```r
outputDVFile=paste(wd,'SagaSeaTestWithTemplateR06.EV',sep='')
```

Now we are ready to add the ES60 RAW data files. The EchoviewR package has a function EVCreateNew() function that will let us add files. Recall, the ES60.RAW file directory and file names are stored in the R workspace in the rawFiles object. We are going to add the files in the rawFiles object to the fisheries Echoview fileset. We specify Echoview specify fileset allocation using the filesetName argument in the EVCreateNew() function.

```r
EVFile=EVCreateNew(EVAppObj=EVAppObj,
                   templateFn=EVtemplate,
                   EVFileName=outputDVFile,
                   filesetName="fisheries",
                   dataFiles=rawFiles,
                   CloseOnSave = FALSE)$EVFile
```

After running the EVCreateNew() function, we have created an Echoview (.EV) file. The COM object address is now assigned to the EVFile object in the R workspace.

Load calibration file

Next, we add the calibration file to the Echoview file using the EchoviewR function EVAddCalibrationFile(). Again, we use the filesetName argument in the EVAddCalibrationFile() to specify the Echoview fileset to which the calibration file will be assigned.

```r
EVAddCalibrationFile(EVFile=EVFile, filesetName='fisheries', calibrationFi
le=calFile)
```

Save the Echoview File

In order to retain the link to the calibration file, we now save the Echoview file.

```r
EVSaveFile(EVFile=EVFile)
```

Detect krill swarms

We are now ready to carry out swarms detection. The `EchoviewR` package has a function, `EVSchoolsDetect()`, to run the SHAPES algorithm. We run the SHAPES algorithm on the Echoview virtual acoustic variable called '120 Dilation filter 3x3'. The detected swarms are allocated to the Echoview region class called 'aggregation'. This is specified using the `outputRegionClassName` argument in the `EVSchoolsDetect()` function. Remember swarms detection might take five minutes to run.

```
swarmDetResults=EVSchoolsDetect(EVFile = EVFile,
                    acoVarName='120 Dilation filter 3x3',
                    outputRegionClassName = 'aggregation',
                    deleteExistingRegions = TRUE,
                    distanceMode = "GPS distance",
                    maximumHorizontalLink = 15, #m
                    maximumVerticalLink = 5,#m
                    minimumCandidateHeight = 3, #m
                    minimumCandidateLength = 15, #m
                    minimumSchoolHeight = 3, #m
                    minimumSchoolLength = 15, #m
                    dataThreshold = -70)#dB re 1 m^-1
```

Export the data in 1 n mile x 250 m depth intervals

After swarm detection we integrate the swarms in 1 n mile x 250 m intervals. Currently, we have two options for integration export. Firstly, we integrate the swarms, export the integration results as NASC. In the example below, we export the NASC result to the file 'krillNASCfromTemplateR06.csv'.

```
exportFileName=paste(wd,'krillNASCfromTemplateR06.csv',sep='')
EVExportIntegrationByCells(EVFile= EVFile,
                           variableName='Krill NASC from mean Sv (export h
ere for NASC values)',
                   filePath=exportFileName)
```

If we know the krill length frequency distribution, we can calculate the NASC to areal density conversion factor, C (see SG-ASAM16/01) and enter the value into the Echoview virtual variable 'krill areal density (enter conversion factor before export)'. We can export mean areal krill density, gm^{-2}, over 1 n mile x 250 m intervals to the file 'krillArealDensityfromTemplateR06.csv'

```
exportFileName=paste(wd,'krillArealDensityfromTemplateR06.csv',sep='')
EVExportIntegrationByCells(EVFile= EVFile,
                           variableName='krill areal density (enter conver
sion factor before export)',
                   filePath=exportFileName)
```

Creating multiple Echoview (.EV) files using a loop

We can also use `EchoviewR` within a loop to create multiple Echoview files. For example, we could create one Echoview .EV file per transect. The *Saga Sea* example data has two transects, so in the example below, we will create two Echoview .EV files.

Here, we assign ES60.RAW files from working directory `C:/Users/martin_cox/Documents/ASAM/sagaSea-raw/` to one of two transects:

```
fileDataFrame=data.frame(fileName=rawFiles,transect=1)
#manually add transect 2:
fileDataFrame$transect[6:14]=2
```

Next, we make a variable that holds the unique transect numbers.

```
uniqueTransect=unique(fileDataFrame$transect)
```

We will loop over the `1, 2` object and create an Echoview EV file containing transect specific ES60.RAW data and the Echoview format calibration (.ECS) file.

At the start of each iteration we assign transect-specific ES60 RAW file directory and names to the `R` object `TMPtransect`.

With the exception of the `EVFileName` argument, the `R` code in the loop follows the example code given in the examples above. The `EVFileName` argument is changed to create a unique .EV file name for each transect.

```
for(i in 1:length(uniqueTransect))
{
  TMPtransect=as.character(fileDF$fn[fileDF$transect==uniqueTransect[i]])
  EVFile=EVCreateNew(EVAppObj=EVAppObj,
                  templateFn=EVtemplate,
                  EVFileName=
                    paste(wd,'SagaSeaTestWithTemplateR06-transect',uniqueTr
ansect[i],'.EV',sep=''),
                  filesetName="fisheries",
                  dataFiles=TMPtransect,
                  CloseOnSave = TRUE)$EVFile
  EVAddCalibrationFile(EVFile=EVFile, filesetName='fisheries', calibration
File = calibrationFile=calFile)
  EVSaveFile(EVFile=EVFile)
}
```