Annex 5

Report of the Working Group
on Acoustic Survey and Analysis Methods
(Virtual meeting, 30 May to 3 June 2022)

Content

Page

Opening of the meeting 149

Standardised procedures for survey design, data analysis and quality control of acoustically derived areal krill biomass estimates to CCAMLR 149

Biomass estimates 151
Area 48 151
Local-scale biomass estimates within subareas relevant to the area of operation of the krill fishery 152
Subarea 48.1 strata and biomass estimates 153

Acoustic observations of krill to inform spatial and temporal dynamics of krill ... 154
Surveys on nominated transects by fishing vessels 154
Acoustic observation from various platforms 155

Other business 156
Chair's report of the Scientific Committee Symposium 156
Development of an acoustic data repository 156
Data access rules (Data Services Advisory Group) 157

Adoption of the report and close of the meeting 157

References 157

Tables 158

Figures 163

Appendix A: List of Participants 166

Appendix B: Agenda 170

Appendix C: List of Documents 171

Report of the Working Group on
Acoustic Survey and Analysis Methods
(Virtual meeting, 30 May to 3 June 2022)

Opening of the meeting

1.1 The 2022 meeting of the Working Group on Acoustic Survey and Analysis Methods (WG-ASAM) was held online from 30 May to 3 June, starting at 0800 UTC. The Co-conveners, Dr S. Fielding (UK) and Dr X. Wang (China) welcomed the participants (Appendix A).

1.2 The meeting's provisional agenda was discussed and the Working Group adopted the agenda (Appendix B).

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

1.4 This report was prepared by the Secretariat and the Co-conveners. Sections of the report detailing advice to the Scientific Committee and other working groups are highlighted in Agenda Item 3.

Standardised procedures for survey design, data analysis and quality control of acoustically derived areal krill biomass estimates to CCAMLR

2.1 WG-ASAM-2022/02 presented R code to aid in the creation of CCAMLR management strata and the computation of their areas, aiming at establishing an agreed approach to ensure consistency and transparency in the future.

2.2 The Working Group welcomed the proposed methodology which was clear, simple and transparent. It noted that the strata boundaries shown in the paper were solely used as an example to demonstrate the method's application and discussed the importance of using version control for projections and geographical boundaries as data layers may evolve with time. The Secretariat indicated that version control of geo-referenced data, including coastlines, will be part of the future redevelopment of the online CCAMLR geographic information system.

2.3 WG-ASAM-2022/07 presented proposals towards the standardisation of methods for processing and reporting future acoustic survey results, with a particular focus on data processing (i.e. dB difference vs swarms-based krill identification methods) and survey design (time of measurements, direction of transects, frequency of synoptic and regional surveys). The authors noted the need for clear and standardised guidelines for all aspects of krill acoustic surveys in the Convention Area.

2.4 The Working Group noted that this study highlighted the importance of documenting and comparing the different methods and steps taken to estimate biomass in all surveys. Recalling that such comparisons had been undertaken in the past (e.g. SG-ASAM-18/04 Rev. 1, SG-ASAM-2019/10), the Working Group noted that both the dB difference and swarms-based krill identification methods had been agreed for estimating biomass. Given that the true biomass is unknown, it is important to continue using different target identification methods, to recognise their strengths and weaknesses (see Table 1) and to compare their results. Regarding the term ‘synoptic’ highlighted in the study, the Working Group recalled that the International 2019 Area 48 Survey had encountered issues of timing that should be an area to focus on in the future.

2.5 WG-ASAM-2022/08 presented an analysis comparing krill length composition between research and commercial samples in Subarea 48.2 to investigate variability in length compositions among vessels. Noting the difference in fishing tactics, local areas and gears between research and commercial vessels, the authors highlighted the lower relative occurrence of both the smallest and largest individuals in fishery samples compared to research trawl samples from the RV *Atlantida*. They advocated for the standardisation of trawl sampling protocols and the use of research trawls during acoustic surveys, as well as improvements in observer length distribution sampling requirements in the krill fishery.

2.6 The Working Group recalled SG-ASAM-2019/10, which investigated the potential effects of selectivity in trawl nets used for the 2019 Area 48 Survey, and noted the findings from this study and WG-ASAM-2022/08 that both scientific trawl and commercial trawl nets were able to catch all size classes of krill. However, a significant difference in the krill size composition of catches was revealed both between the scientific and commercial trawls, and between commercial trawls with different designs. The most sensitive krill length classes to the gear design and fishing method are recruits and large krill.

2.7 The Working Group further noted that the design of krill sampling requirements may differ depending on the intended use of the data as well as season and location. For example, length sampling requirements (sample size) should be targeted at providing appropriate estimates of size at recruitment accounting for gear selectivity, or appropriate estimates of biomass for acoustic surveys. The Working Group also noted that because fishing vessels use trawls with different characteristics, using the length distribution data needs to take gear selectivity into account.

2.8 WG-ASAM-2022/10 presented an analysis of the effect of the krill length-to-weight relationship on the conversion factor, C, that scales nautical area scattering coefficient (NASC) values of krill echoes to krill areal biomass density. Using example data from the East Antarctic, the authors used a linear mixed effects model to estimate weight at length along with its uncertainty, and used the resulting predictions to estimate C and its uncertainty.

2.9 The Working Group welcomed this analysis and discussed the possibility of accounting for maturity stage and sex in the model as these affect length–weight relationships, recognising that this would render the model more difficult to scale up to the population. Given the range of predicted C, the Working Group expressed interest in comparing this range to values of C reported in other studies.

2.10 The Working Group noted an ongoing experiment to measure the weight at length of krill on board a Chinese krill fishing vessel by grouping krill specimens in specific length classes and weighing them together to reduce the impact of vessel movement.

2.11 Noting the difficulty of weighing krill on board vessels, the Working Group discussed the possibility of freezing specimens to subsequently weigh them on land. The Working Group also discussed the methodology used by the authors, which involved calibration weights used in conjunction with an accelerometer to correct for effects of ship motion.

2.12 WG-ASAM-2022/13 presented a proposal for standardised metadata and maps and diagnostic plots to be included with acoustic krill biomass survey results presented to CCAMLR and proposed a verification report that could be used to validate the processing method that had been used to obtain the biomass results.

2.13 The Working Group welcomed this paper and agreed that results of acoustic krill biomass surveys presented to CCAMLR should be accompanied with standardised metadata describing the data collection and data processing methods and that the computer programs used to derive the biomass estimates should be validated against a reference dataset. The reference dataset should be available in open access and should consist of raw acoustic data files, krill length-frequency data, conductivity temperature depth probe data, and the output from the processing methods that have been endorsed by CCAMLR. The Working Group noted with appreciation the offers by Australia and the UK to contribute such datasets.

2.14 The Working Group welcomed the suggestion to use the Secretariat as a central repository for metadata from acoustic surveys for which the estimates were presented to CCAMLR and reflected on the need to expand the metadata reporting requirements when CCAMLR starts adopting the use of novel technologies such as echosounders deployed on gliders, moorings, penguins and seals.

2.15 Tables 2 to 8 document the metadata and illustrations that are to accompany the results of acoustic krill biomass surveys presented to CCAMLR. If parameters are not available for particular datasets, then the relevant field(s) can be given as N/A. For example, 'Krill identification method' and 'Krill biomass per survey' may not be relevant to data from a moored echosounder.

Biomass estimates

Area 48

3.1 WG-ASAM-2022/05 presented a proposal to conduct a local acoustic trawl survey of mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.2 in the shelf and slope regions of the South Orkney Islands. Objectives of the research include estimating the pelagic biomass in the survey area, improving information on biological parameters, and further understanding of the spatial and bathymetric distribution of by-catch species.

3.2 The Working Group recalled discussions and the request of WG-SAM for WG-ASAM to review this proposal (WG-SAM-2021, paragraphs 8.6 to 8.7), including the choice of appropriate acoustic frequencies and the methodology to identify icefish from krill in acoustic data.

3.3 The Working Group noted that the acoustic equipment proposed for the survey design used two high frequencies (120 and 200 kHz) and considered whether they would be appropriate for identifying icefish targets. The Working Group noted that a previous study had identified icefish using 120 kHz backscatter data and a random forests classification analysis (Fallon et al., 2016), and SG-ASAM-09/06 introduced the target strength of *C. gunnari* from a scattering model. The Working Group welcomed any potential improvements to methods to discriminate pelagic icefish and krill in acoustic data from this survey.

3.4 Dr K. Demianenko (Ukraine) expressed his gratitude at the offer from Dr M. Cox (Australia) for the loan of a 38 kHz split-beam transceiver.

3.5 The Working Group noted the experimental nature of an acoustic survey for icefish in terms of obtaining target identification and subsequently converting target strength to a biomass estimate.

3.6 The Working Group further noted that clarity was required regarding the survey design to understand if a trawl would be conducted only for acoustic target identification, or if trawls were to be conducted at every survey station regardless of the acoustic findings at an individual station.

3.7 The Working Group noted that a 30-minute trawl duration may be excessive to simply sample acoustic marks for target identification, if the focus of the survey is for acoustic biomass estimation, not to catch large quantities of icefish.

3.8 Dr Demianenko clarified that the experimental design involved targeted trawl transects of marks on the echosounder for identification purposes. Dr Demianenko also suggested the potential of combining acoustic collection of data to aid scientific evaluation and remains open to dialogue on other aspects of the proposed research.

Local-scale biomass estimates within subareas relevant to the area of operation of the krill fishery

3.9 WG-ASAM-2022/09 presented preliminary results from Antarctic krill (*Euphausia superba*) surveys around the South Shetland Islands, conducted by Chinese fishing vessels during May and June 2021 and in April 2022. For the 2021 survey, krill swarms were found in the west of Bransfield Strait and in waters close to the Antarctic Peninsula, while few krill swarms were encountered in waters to the northwest of the South Shetland Islands. During the 2022 survey, krill swarms were more frequently observed than during the 2021 survey and were found in waters close to Joinville Island, the west of Bransfield Strait and King George Island.

3.10 The Working Group welcomed the use of the 'RapidKrill' software, noting the utility of the software for producing effective and near real-time results from surveys, and its ability to operate on less powerful computers, and encouraged continuing its development.

3.11 The Working Group noted that the surveyed areas extended into the Gerlache Strait stratum (paragraph 3.18) and encouraged the continuation of these surveys as the Gerlache Strait stratum has far fewer acoustic surveys than the strata around the northern Antarctic Peninsula.

3.12 WG-ASAM-2022/14 presented results from the annual Norwegian Institute of Marine Research survey covering five north/south transects off the South Orkney Islands. The average krill NASC in the study area was 293 m^2 n $mile^{-2}$ at 120 kHz (25.6% coefficient of variation (CV)) and the corresponding average krill density was 97.1 g m^{-2}.

3.13 The Working Group welcomed the preliminary results of the surveys and noted that consideration on inclusion of preliminary survey data would be required if the results were to be integrated as part of any assessment framework.

3.14 The Working Group noted that net-sampled krill length-frequency data were not available due to technical issues with operating the krill sampling gear. It noted that identifying suitable alternatives to net-sampled krill length-frequency distributions should be part of the standard protocols, as this requirement could also apply to other platforms such as moorings and gliders.

3.15 WG-ASAM-2022/04 presented preliminary findings from analyses of three mooring deployments spanning four summers, from 2018/19 to 2021/22. Results of the study show that biomass density is highly variable among years and within individual seasons. This was observed by declines in biomass through time along with some occasional increases in biomass, resulting in variable mean and median biomass densities. Biomass density variability may also relate to the success of krill-dependent predators, environmental variability and the dynamic nature of the krill fishery.

3.16 The Working Group noted the potential of conducting a periodogram analysis to quantitatively determine whether there is an effect of tidal or lunar cycles on the observed biomass density estimates. This may be especially relevant given the potential effect of environmental drivers on seasonal cycles in krill biomass.

3.17 The Working Group received with great interest the results from these novel techniques that seek to estimate krill density and flux from a series of moorings. The Working Group noted the challenge in how these data could be integrated with ship-based surveys data and looked forward to progress in this effort.

Subarea 48.1 strata and biomass estimates

3.18 The Working Group recalled the progress made last year regarding the update of Conservation Measure (CM) 51-07, through effective scientific collaboration on the three elements of the revision of the krill management strategy (acoustic biomass estimates, generalised R yield model (Grym) yield estimates, and risk assessment). The Working Group further recalled the management areas proposed by SC-CAMLR-40/11 and noted the methodology presented by WG-ASAM-2022/02 to refine these boundaries and calculate their areas. It noted that the ‘outer’ stratum was spatially separated by other strata, and therefore suggested to split it into a western stratum which was named ‘Drake Passage’ and an eastern stratum which was named ‘Powell Basin’. The Working Group further suggested to rename the ‘extra’ stratum as ‘Gerlache Strait’ stratum.

3.19 The Working Group considered biomass estimates for these strata and recalled the previous discussions on this topic (WG-EMM-2021, paragraphs 2.23 to 2.29). Considering the availability of survey data in the different areas, and the high levels of interannual variability within areas, the Working Group summarised the biomass estimates relative to four time periods over which biomass estimates could be averaged (all years available, all years since the implementation of CM 51-07 in 2009, the last five years from 2015 to 2020, and the last three years from 2018 to 2020 (Table 9)).

3.20 The Working Group highlighted that that the CVs reported in Table 9 were based on the CVs from surveys (krill biomass metadata table) using the Jolly and Hampton (1990) method and as such were representative of the survey CVs only (sampling variability), not the total uncertainty in the biomass estimate. The Working Group noted previous attempts to estimate this (Demer, 2004) for the CCAMLR 2000 Krill Synoptic Survey of Area 48 and suggested future work to estimate a total reflection of uncertainty from the data.

3.21 The Working Group discussed the amount of data available associated with these averaged estimates with the aid of maps (Figure 1) and plots of biomass time series (Figure 2). It noted that while this represented the best available data at this time, it was important to recognise that these averages were obtained by combining results from surveys that used different methodologies, krill identification methods and trawl designs, among other characteristics, which warranted caution.

3.22 The Working Group agreed that the estimates provided in Table 9 represented the best available science. However, until more analysis of the impacts of differences among surveys, and more standardisation was brought to survey methodologies, an open question to be considered in the future, these estimates should be considered with caution.

3.23 The Working Group agreed that standardisation of acoustic survey methodologies in the future would be beneficial and increase confidence in estimates obtained by averaging results from different surveys. It further noted the need to examine how the methodology of acoustic surveys affects their results to clarify the degree of uncertainty of average biomass estimates combining different surveys. Such studies should facilitate informed decisions regarding the practical use of these average biomass estimates.

3.24 The Working Group recalled that CCAMLR uses the lower bound of the 95% confidence interval of the biomass estimate to provide precautionary advice in the case of icefish that is assessed using acoustic surveys. Application of this approach may provide a short-term, precautionary advice, while further work is developed to address the potential impact of the issues noted (paragraph 3.21).

Acoustic observations of krill to inform spatial and temporal dynamics of krill

Surveys on nominated transects by fishing vessels

4.1 WG-ASAM-2022/12 Rev. 1 presented acoustic data collected by four fishing vessels along CCAMLR nominated transects at South Georgia during the winter period. These surveys are the first nominated CCAMLR transects collected by fishing vessels in Subarea 48.3 and provide an important source of information especially in a year where the fishery did not take substantial catches due to a low krill abundance. The study also provides important information on the winter distribution of krill near South Georgia.

4.2 The Working Group welcomed the collaboration with fishing vessels to obtain winter survey data in Subarea 48.3 and thanked the Association of Responsible Krill harvesting companies (ARK) for coordinating the vessels involved. The Working Group noted that if any ancillary environmental data were collected by the vessels, these data may be useful in identifying potential causes for the low krill abundance observed in the Subarea 48.3 commercial fishery that year.

4.3 The Working Group noted that the fishing vessel echosounders had not been calibrated using standard techniques. They considered attempts to use a seabed calibration from previous

ASAM meetings (SG-ASAM-2014 and SG-ASAM-17/P01). The Working Group further noted that the bottom calibration method undertaken by the vessels was not yet proven and the acoustic scattering properties of seabed are more complex than the reference target used for the standard sphere calibration method.

4.4 WG-ASAM-2022/06 presented results from acoustic transects undertaken by a Chinese krill fishing vessel in Subarea 48.3 in June and August 2021. Preliminary analysis showed that only a small number of krill swarms with low density were observed. The study recommended vessels update echosounder software frequently and run internal checks. It also recommended that an update of the agreed protocols for acoustic instrument settings, to ensure consistency between Members and vessels, should be considered by WG-ASAM.

4.5 The Working Group welcomed the survey results and highlighted that coordination of fishing vessel survey effort would facilitate collecting timely information over a fishing season. The Working Group recommended that WG-ASAM discuss how to update the acoustic instrument instructions for unsupervised acoustic data collection on-board fishing vessel surveys and examine how to use the automatic data processing technique (such as RapidKrill) for on-board processing of acoustic data in the WG-ASAM e-group.

Acoustic observation from various platforms

4.6 WG-ASAM-2022/03 presented the ROSSKRILL project, a large-scale acoustic survey performed by the Italian RV *Laura Bassi* in January 2022 in the western Ross Sea. The project also installed an autonomous echosounder on top of the Ross Sea marine observatory 'Mooring B' that will operate throughout the year, gathering useful information of the ecosystem under the winter sea-ice. The results of the ROSSKRILL project aim to allow a comparison of the abundance and spatial distribution of krill throughout the year in relation to environmental parameters.

4.7 The Working Group noted that this study contributed to the monitoring requirement of the Ross Sea region marine protected area and that the results would provide acoustic information from Area 88, which, when combined with the acoustic surveys undertaken in Areas 48 and 58, represents the first circumpolar snapshot of krill density. The Working Group encouraged the collection of ancillary environmental data for further comparison with other *E. superba* habitats.

4.8 WG-ASAM-2022/P01 presented observations of krill biomass and flux in Subarea 48.1 (paragraphs 3.15 to 3.17), collected in summer using arrays of six submerged moorings equipped with echosounders and acoustic Doppler current profilers (WG-ASAM-2022/04).

4.9 The Working Group noted the utility of the mooring system for localised krill monitoring and the potential for large-scale ecosystem monitoring if several moorings were deployed with a wide geographic spread.

4.10 The Working Group further noted that novel acoustic devices and technologies would potentially require the development of acoustic data collection protocols and definition of common terminologies by WG-ASAM, to ensure integration with vessel-based acoustic surveys for fishery and ecosystem management purposes.

Other business

Chair's report of the Scientific Committee Symposium

5.1 On behalf of the Chair of the Scientific Committee, Dr S. Parker (Secretariat) presented the report of the CCAMLR Scientific Committee Symposium that met virtually on 8 and 10 February 2022 (WG-ASAM-2022/01). The informal Scientific Committee meeting discussed the progress and outcomes from the first CCAMLR Scientific Committee's workplan (SC-CAMLR-XXXVI/BG/40) and provided an opportunity for participants to propose long-term priorities and strategies to inform the development of the next five-year strategic plan (2023–2027). Recommendations and plans will be refined during the intersessional period by all working groups and agreed at SC-CAMLR-41 according to the Scientific Committee's Rules of Procedure.

5.2 The Working Group welcomed and endorsed such an approach that will enable the working groups and the Scientific Committee to identify and focus their efforts on the priorities. The Working Group undertook to review the priority research topics presented in Table 2 of the document and preliminary discussions and recommendations for work sequencing took place, however, due to the time constraints of the meeting, the review was only partially completed. The Working Group undertook to continue progressing the review through the WG-ASAM e-group, with results to be presented at SC-CAMLR-41 by the WG-ASAM Co-conveners.

Development of an acoustic data repository

5.3 The Secretariat presented WG-ASAM-2022/11, an overview of the raw acoustic data collected by fishing vessels along CCAMLR nominated transects currently held at the Secretariat. The authors recommended that WG-ASAM consider the collection and reporting of additional metadata attributes along CCAMLR nominated transects and the development of a data exploration tool.

5.4 The Working Group welcomed this contribution and thanked the Secretariat for developing the database. The Working Group recommended that interested participants work together with the Secretariat in the WG-ASAM e-group to review the metadata collection and reporting requirements for fishing vessels, taking into account the metadata table developed at this meeting (see Table 2) for data collection in acoustic surveys, and provide an updated 'Instruction manual for the collection of fishing-vessel-based acoustic data' for consideration at the next WG-ASAM meeting.

5.5 The Working Group welcomed the suggestion to develop a data exploration tool using the R package Shiny and recommended that the Secretariat include detailed position data which it can extract from the raw data files using open-source software such as the python library Echopy. The Working Group requested the Secretariat consider interoperability with acoustic databases of other organisations, including the US National Oceanic and Atmospheric Administration.

Data access rules (Data Services Advisory Group)

5.6 The Working Group noted WG-ASAM-2022/15 which describes the implementation of the Rules for Access and Use of CCAMLR Data into the CCAMLR data request procedure, and the procedure for publication of derived materials in the public domain. However, due to the time constraints, the Working Group was unable to consider the paper. The Working Group undertook to discuss it in the WG-ASAM e-group, with comments to be presented to SC-CAMLR-41.

Adoption of the report and close of the meeting

6.1 The report of the meeting was adopted.

6.2 At the close of the meeting, Dr Fielding and Dr Wang thanked all participants for their hard work and collaboration that had contributed greatly to the successful outcomes from WG-ASAM this year, and the Secretariat and the Interprefy team for their support.

6.3 On behalf of the Working Group, Dr X. Zhao (China) thanked the Co-conveners and the Secretariat for successfully guiding the WG-ASAM discussions and the report adoption process.

References

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

Fallon, N.G., S. Fielding and P.G. Fernandes. 2016. Classification of Southern Ocean krill and icefish echoes using random forests. *ICES J. Mar. Sci.*, 73 (8): 1998–2008.

ICES. 2016. A metadata convention for processed acoustic data from active acoustic systems. *Series of ICES Survey Protocols SISP 4-TG-AcMeta*, doi: https://doi.org/10.17895/ices.pub.7434.

Jolly, G.M. and I. Hampton. 1990. A stratified random transect design for acoustic surveys of fish stocks. *Can. J. Fish Aquat. Sci.*, 47 (7): 1282–1291.

Table 1: Pros and cons of two methods used to identify krill during acoustic biomass estimation. The reliance on target strength model parameters to scale krill echoes to krill biomass impacts both methods.

Method	Pros	Cons
dB-difference (2 or 3 frequencies)	• Based on a validated acoustic scattering model implemented at different frequencies. • Has been tested, validated and applied in CCAMLR working group and primary literature papers. • Has a standardised acoustic data processing procedure (workflow) endorsed by WG-ASAM.	• Rely on many target strength model parameters to identify krill echoes (e.g. acoustic material properties, orientation, size composition) which may be difficult to estimate accurately. • If 3 frequencies, i.e. 200 kHz is also used, the effective working depth for surface-based platforms may be limited by this frequency to 150 to 200 m depth, although it is well known that krill may be found deeper than 300 m.
Swarms-based	• Can be undertaken on single frequency 120 kHz datasets, thus more echosounder platforms can be used and estimates of krill density or biomass can be attained with lower cost or shorter time, spanning even the entire fishing season. • Allows an automated and unsupervised standardised processing. • Has been tested, validated and applied in CCAMLR working group and primary literature papers. • Has a standardised acoustic data processing procedure (workflow) endorsed by WG-ASAM.	• Other organisms in schooling form can be mistaken as krill, whereas dispersed krill targets will be excluded.

Table 2: Recommended echosounder metadata. Where an ICES name exists, there is greater explanation in the ICES report for what is required.

Parameter	Units	ICES (2016) name
Operating frequency	kHz	instrument_frequency
Transducer location		instrument_transducer_location
Transducer manufacturer		instrument_transducer_manufacturer
Transducer model		instrument_transducer_model
Transducer depth	m	instrument_transducer_depth
Transducer orientation		instrument_transducer_orientation
Transducer equivalent beam angle	dB	instrument_transducer_psi
Transducer beam angle major (athwartship, where applicable)	degrees	instrument_transducer_beam_angle_major
Transducer beam angle minor (alongship, where applicable)	degrees	instrument_transducer_beam_angle_minor
Transceiver manufacturer		instrument_transceiver_manfacturer
Transceiver model		instrument_transceiver_model
Transceiver serial		instrument_transceiver_serial
Transceiver firmware version		instrument_transceiver_firmware
Calibration date		calibration_date
Calibration method		calibration_acquisition_method
Calibration processing method		calibration_processing_method
Calibration accuracy estimate		calibration_accuracy_estimate
Calibration location		
Acquisition software name		data_acquisition_software_name
Acquisition software version		data_acquisition_software_version
Echosounder platform type		platform_type, restricted to values given by https://vocab.ices.dk/?ref=311
Echosounder platform name(s)		
Echosounder platform flag country		
Echosounder platform length	m	

Table 3: Recommended echo-integration metadata. Where an ICES name exists, there is greater explanation in the ICES report for what is required.

Parameter	Units	ICES (2016) name
Processing software name		data_processing_software_name
Processing software version		data_processing_software_version
Minimum echo-integration depth	m	
Maximum echo-integration depth	m	
Echo-integration cell horizontal units		data_ping_axis_interval_type
Echo-integration cell horizontal size		data_ping_axis_interval_value
Echo-integration cell vertical size	m	
Echo-integration frequency	kHz	
Krill identification method		
Krill identification parameters		

Table 4: Recommended metadata for conventional transect/strata-based surveys.

Parameter
Survey design methodology
Number of survey transects per strata
Number of strata

Table 5: Recommended krill length sampling metadata.

Parameter	Description
Method by which the krill were obtained	(e.g. trawl, predator diet sample)
Sampling gear parameters (e.g. mesh size, opening area)	Details on the sampling methodology used
Method for overall length probability density function construction	

Table 6: Recommended krill target strength stochastic distorted-wave Born approximation model metadata.

Parameter	Units
Number of cylinders	
Krill length	mm
Phase variability standard deviation	rad
Fatness coefficient	
Density contrast	
Sound speed contrast	
Sound speed in water	m s^{-1}
Orientation mean	degrees
Orientation standard deviation	degrees

Table 7: Recommended biomass result metadata.

Parameter	Units
Start date of acoustic data used to estimate biomass	ISO 8601
End date of acoustic data used to estimate biomass	ISO 8601
Time of day of acoustic data used to estimate biomass (e.g. day/night only, day and night)	
Biomass area (e.g. strata) names	
Biomass area (e.g. strata) areas	km^2
NASC to biomass conversion factor	g m^{-2} n $mile^{-2}$
Mean krill density per area (e.g. strata)	g m^{-2}
Krill biomass per area (e.g. strata)	tonnes
Mean krill density per survey*	g m^{-2}
Krill biomass per survey*	tonnes
Survey sampling coefficient of variation per survey	%

* 'survey' is used to mean a period of time from which data have been used to generate a biomass estimate. This can be a conventional moving platform survey with strata and transects, or, for example, a biomass generated from analysis of data from stationary platforms.

Table 8: Recommended illustrations.

Illustration	Description
Overview map	A map showing the krill nautical area scattering coefficient or area backscattering coefficient locations, any conductivity temperature depth probe stations, and any trawl locations. The map should include coastlines and a latitude/longitude grid. Locations should visually distinguish between data collected during the night and during the day.
Krill lengths	Histogram(s) of the krill length distributions used in the conversion of krill backscatter to krill biomass.
Krill areal density	Map(s) showing krill areal density (in units of g m^{-2}) in the survey area. The map(s) should include coastlines and a latitude/longitude grid.
Effect of noise removal threshold	A plot showing the effect of changing the maximum threshold value in the CCAMLR swarms Echoview template on the biomass results.

Table 9: Updated strata krill biomass estimates based on Table 2.6 in WG-EMM-2021/05 Rev. 1 and SC-CAMLR-40/11 using the strata area calculation method provided in WG-ASAM-2022/02. The revised values are shown in **bold**. Where multiple surveys, the overall coefficients of variation (CVs) were calculated as in WG-EMM-21/05 Rev. 1. Time periods: yall – all available years 1996–2020, y5107 – since implementation of Conservation Measure 51-07 (2009–2020), y5 – 5 years (2015–2020) and y3 – 3 years (2018–2020).

Strata	Density (g m^{-2})	Variance of weighted density	CV of weighted density (%)	**Revised strata area based on WG-ASAM-2022/02**	**Biomass (tonnes) based on revised strata area**	CV biomass (%)	Years included for averaging biomass	Number of years with surveys	Number of surveys
Joinville (JI)[1]	83.01	723.28	32.40	**23 001**	**1 909 313**	32.40	y3	1	1
Joinville (JI)[1]	83.01	723.28	32.40	**23 001**	**1 909 313**	32.40	y5	1	1
Joinville (JI)	51.85	750.75	47.60	**23 001**	**1 192 602**	47.60	y5107	4	4
Joinville (JI)	37.42	410.24	46.86	**23 001**	**860 697**	49.51	yall	8	11
Elephant (EI)	85.48	253.13	22.31	**51 648**	**4 414 871**	22.31	y3	2	2
Elephant (EI)	85.48	253.13	22.31	**51 648**	**4 414 871**	22.31	y5	2	2
Elephant (EI)	78.45	250.21	18.64	**51 648**	**4 051 786**	18.65	y5107	5	5
Elephant (EI)	65.49	487.64	26.69	**51 648**	**3 382 428**	26.92	yall	18	27
Bransfield (BS)	69.34	241.74	24.20	**34 732**	**2 408 317**	24.20	y3	3	4
Bransfield (BS)	54.36	204.27	30.30	**34 732**	**1 888 032**	30.30	y5	5	6
Bransfield (BS)	39.85	154.41	32.35	**34 732**	**1 384 070**	33.81	y5107	9	11
Bransfield (BS)	34.19	343.83	41.28	**34 732**	**1 187 487**	42.83	yall	21	30
South Shetland Islands West (SSIW)	59.12	219.96	21.89	**47 066**	**2 782 542**	26.75	y3	3	4
South Shetland Islands West (SSIW)	47.08	166.29	26.93	**47 066**	**2 215 867**	29.85	y5	5	6
South Shetland Islands West (SSIW)	41.05	109.99	23.68	**47 066**	**1 932 059**	25.30	y5107	9	10
South Shetland Islands West (SSIW)	53.45	326.48	32.86	**47 066**	**2 515 678**	36.27	yall	21	29
Gerlache Strait (GS)[2]	58.53	**1364.31**	63.11	**44 198**	**2 586 908**	63.11	yall	1	1
Powell Basin (PB)[1]	**32.73**	**155.74**	**38.13**	**144 680**	**4 735 100**	**38.13**	yall	1	1
Drake Passage (DP)[1]	**41.53**	**40.56**	**15.33**	**294 531**	**12 233 000**	**15.33**	yall	1	1

[1] Single survey: 2019 Area 48 Survey (WG-ASAM-2019).
[2] Single survey: 2020 *Atlantida* survey (WG-ASAM-2021/04 Rev. 1).

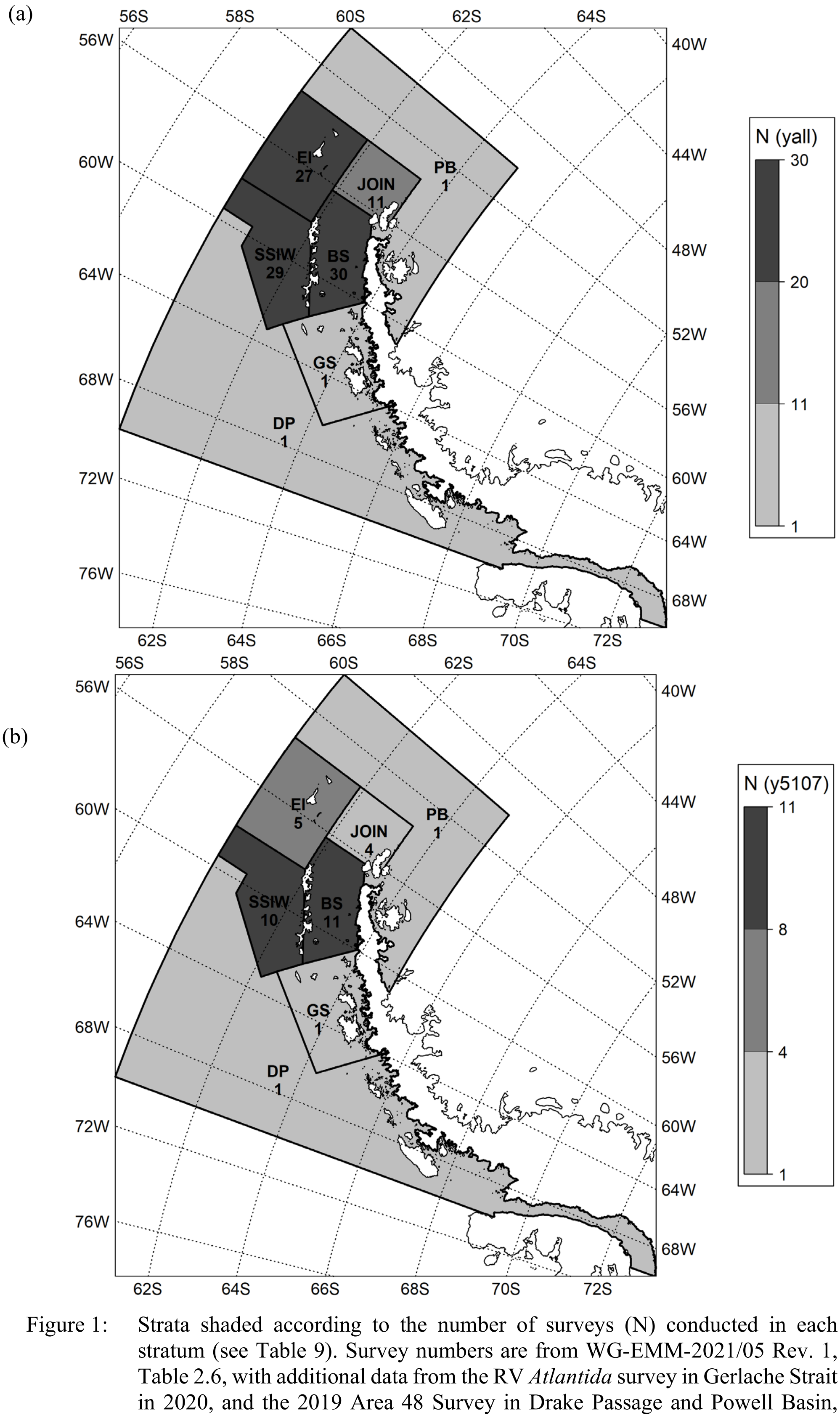
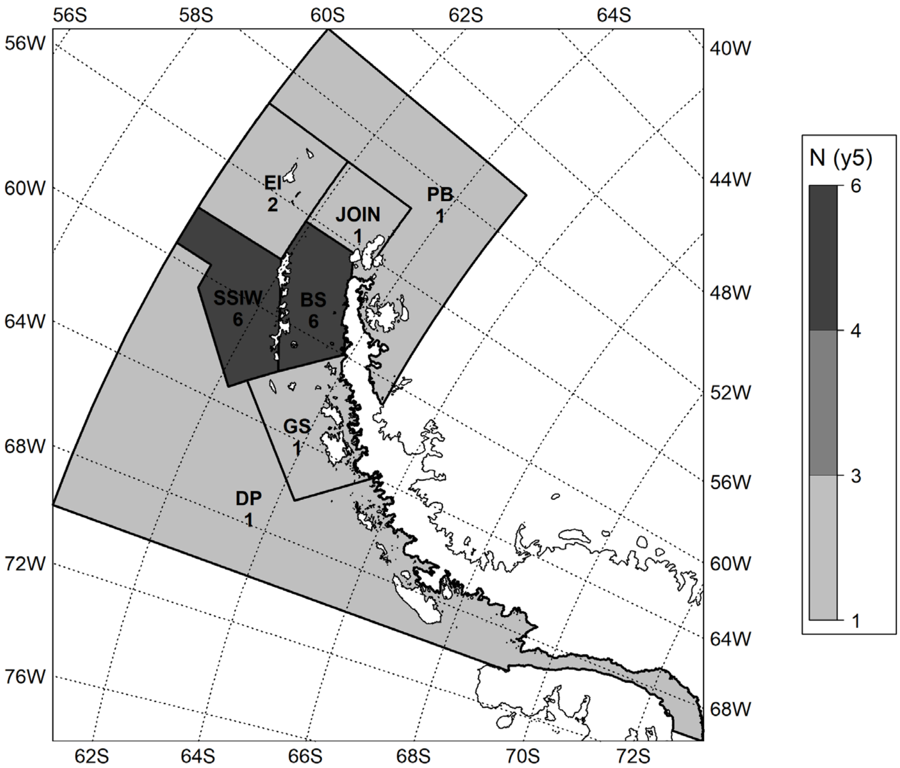


Figure 1: Strata shaded according to the number of surveys (N) conducted in each stratum (see Table 9). Survey numbers are from WG-EMM-2021/05 Rev. 1, Table 2.6, with additional data from the RV *Atlantida* survey in Gerlache Strait in 2020, and the 2019 Area 48 Survey in Drake Passage and Powell Basin, based on re-worked information provided in SC-CAMLR-40/11. EI – Elephant Island, JOIN – Joinville, BS – Bransfield Strait, SSIW – South Shetland Islands West, GS – Gerlache Strait, DP – Drake Passage, PB – Powell Basin.
Time period: (a) yall – all available years 1996–2020 and (b) y5107 – since implementation of Conservation Measure 51-07 (2009–2020).

(c)



(d)

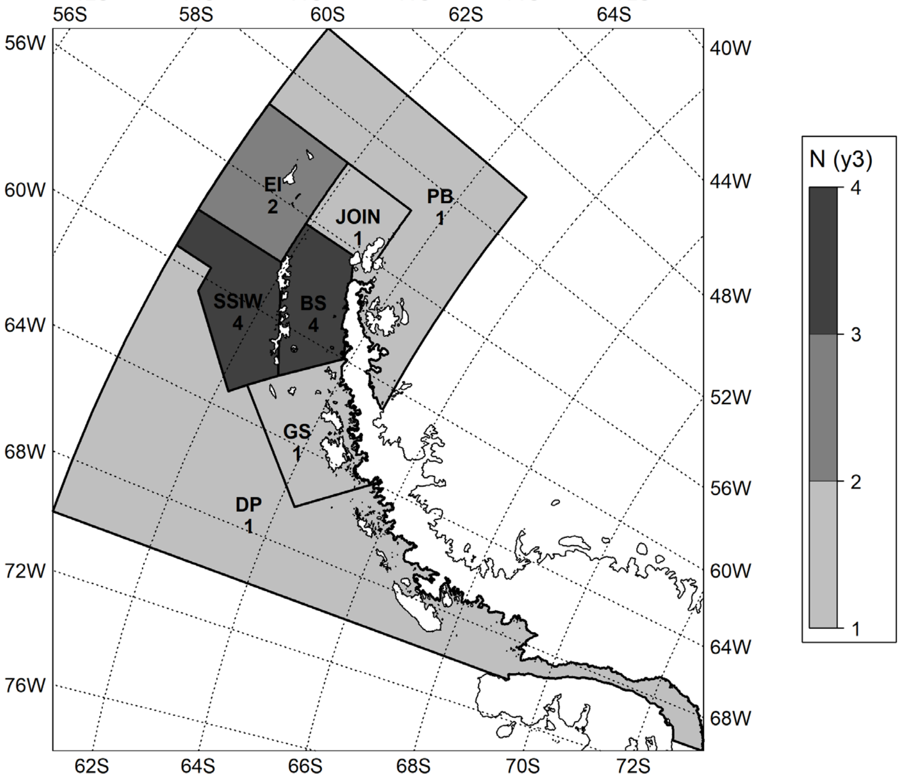


Figure 1 (continued)
Time period: (c) y5 – 5 years (2015–2020) and (d) y3 – 3 years (2018–2020).

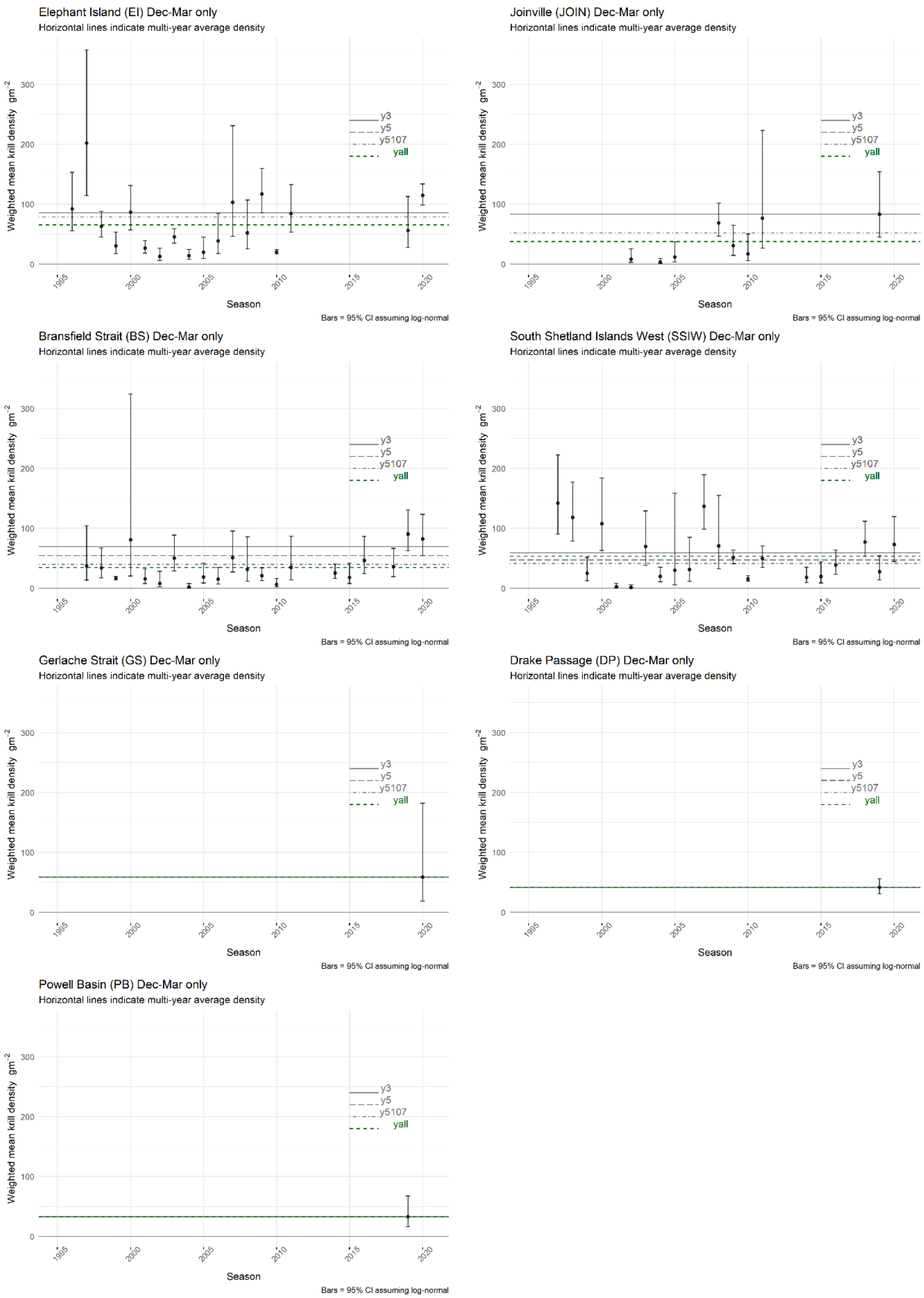


Figure 2: Timeseries of krill biomass density estimates for each stratum in Subarea 48.1 for the December to March period from 1995 to 2020. Error bars show the 95% confidence interval. Horizontal lines indicate the average density across different periods; yall – All available years 1996–2020, y5107 – since implementation of Conservation Measure 51-07 (2009–2020), y5 – 5 years (2015–2020) and y3 – 3 years (2018–2020). Stratum names correspond to the strata map in Figure 1 (see 'Krill biomass estimates from acoustic surveys' e-group).

Appendix A

List of Participants

Working Group on Acoustic Survey and Analysis Methods
(Virtual Meeting, 30 May to 3 June 2022)

Co-conveners	Dr Sophie Fielding British Antarctic Survey
	Dr Xinliang Wang Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science
Australia	Dr Martin Cox Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
	Dr So Kawaguchi Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
	Ms Abigail Smith University of Tasmania
Chile	Professor Patricio M. Arana Pontificia Universidad Catolica de Valparaíso
	Dr César Cárdenas Instituto Antártico Chileno (INACH)
	Mr Mauricio Mardones Instituto de Fomento Pesquero
	Mr Francisco Santa Cruz Instituto Antártico Chileno (INACH)
China, People's Republic of	Dr Qing Chang XU Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences
	Dr Yi-Ping Ying Yellow Sea Fisheries Research Institute
	Mr Jichang Zhang Yellow Sea Fisheries Research Institute

	Dr Yunxia Zhao Yellow Sea Fisheries Research Institute
	Dr Xianyong Zhao Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science
	Professor Guoping Zhu Shanghai Ocean University
France	Dr Sara Labrousse Sorbonne Université
Italy	Dr Ilaria Biagiotti IRBIM - CNR
	Dr Andrea De Felice CNR-IRBIM
	Dr Marino Vacchi IAS – CNR
Japan	Dr Koki Abe Japan Fisheries Research and Education Agency
	Dr Taro Ichii Fisheries Resources Institute, Japan Fisheries Research and Education Agency
	Dr Hiroto Murase Tokyo University of Marine Science and Technology
	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Korea, Republic of	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)
	Dr Hyoung Sul La Korea Ocean Polar Research Institute (KOPRI)
	Dr Haewon Lee National Institute of Fisheries Science
	Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)

Norway	Dr Gavin Macaulay Institute of Marine Research
Russian Federation	Dr Svetlana Kasatkina AtlantNIRO Mr Aleksandr Sytov FSUE VNIRO
South Africa	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
Ukraine	Dr Kostiantyn Demianenko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine Dr Leonid Pshenichnov Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
United Kingdom	Dr Chris Darby Centre for Environment, Fisheries and Aquaculture Science (Cefas)
United States of America	Mr Anthony Cossio National Marine Fisheries Service Dr George Cutter National Marine Fisheries Service, Southwest Fisheries Science Center Dr Christian Reiss National Marine Fisheries Service, Southwest Fisheries Science Center

CCAMLR Secretariat	Belinda Blackburn Publications Officer
	Dane Cavanagh Web Project Officer
	Daphnis De Pooter Science Data Officer
	Gary Dewhurst Data and Information Systems Manager
	Doro Forck Communications Manager
	Isaac Forster Fisheries and Observer Reporting Coordinator
	Angie McMahon Human Resources Officer
	Ian Meredith Systems Analyst
	Dr Steve Parker Science Manager
	Alison Potter Data Administration Officer
	Dr Stephane Thanassekos Fisheries and Ecosystems Analyst
	Robert Weidinger IT Assistant
	Thomas Williams Database Administrator/Technical Analyst
	Claire van Werven Research, Monitoring and Compliance Analyst

Appendix B

Agenda

Working Group on Acoustic Survey and Analysis Methods
(Virtual meeting, 30 May to 3 June 2022)

1. Opening of the meeting

2. Standardised procedures for survey design, data analysis and quality control of acoustically derived areal krill biomass estimates to CCAMLR

    2.1 Dedicated surveys

3. Krill biomass estimates

    3.1 Area 48
        3.1.1 Subarea biomass estimates
        3.1.2 Local-scale biomass estimates within subareas relevant to the area of operation of the krill fishery

    3.2 Area 58

4. Acoustic observations of krill to inform spatial and temporal dynamics of krill

    4.1 Survey on nominated transects by fishing vessels
    4.2 Acoustic observation from various platforms

5. Other business

    5.1 Chair's report of the SC-Symposium
    5.2 Development of an acoustic data repository
    5.3 Data Access Rules (DSAG)

6. Adoption of the report and close of the meeting.

Appendix C

List of Documents

Working Group on Acoustic Survey and Analysis Methods
(Virtual Meeting, 30 May to 3 June 2022)

WG-ASAM-2022/01	Report of the Chair of the Scientific Committee on the CCAMLR Scientific Committee Symposium Chair of the Scientific Committee
WG-ASAM-2022/02	Strata creation and area calculation – a template Secretariat
WG-ASAM-2022/03 Rev. 1	Monitoring krill in the Ross Sea MPA A. De Felice, G. Canduci, I. Biagiotti, G. Giuliani, I. Costantini and I. Leonori
WG-ASAM-2022/04	Krill biomass and flux in Subarea 48.1 near Cape Shirreff during four austral summers G. Cutter, C. Reiss and G. Watters
WG-ASAM-2022/05	Proposal to conduct a local acoustic-trawl survey of the *Champsocephalus gunnari* in the Statistical Subarea 48.2 Delegation of Ukraine
WG-ASAM-2022/06	Acoustic transects survey undertaken by a Chinese krill fishing vessel in Subarea 48.3 in June and August 2021 X. Wang, J. Zhu, Y. Ying and X. Zhao
WG-ASAM-2022/07	Proposals to standardise the collection and processing of krill acoustic survey data S. Kasatkina and A. Abramov
WG-ASAM-2022/08	Comparison analysis of krill length compositions from catches obtained by research and commercial gears S. Kasatkina and S. Sergeev
WG-ASAM-2022/09	Preliminary results from the Antarctic krill surveys around the South Shetland Islands conducted by the Chinese fishing vessels during May to June 2021 and April 2022 X. Wang, G. Fan, B. Yuan and X. Zhao
WG-ASAM-2022/10	The effect of the krill length to wetmass relationship on the scaling of acoustic data M.J. Cox and S. Wotherspoon

WG-ASAM-2022/11 Rev. 1	Repository of acoustic data collected by fishing vessels along CCAMLR nominated transects Secretariat
WG-ASAM-2022/12 Rev. 1	CCAMLR nominated acoustic transects undertaken by fishing vessels at South Georgia in 2021 S. Fielding and J. Arata
WG-ASAM-2022/13	Proposal for standardised methods for processing and reporting krill acoustic survey results G. Macaulay
WG-ASAM-2022/14	Distribution and abundance of Antarctic krill off South Orkney Islands, February 2022 S. Menze, B. Krafft and G. Macaulay
WG-ASAM-2022/15	Review of the Rules for Access and Use of CCAMLR Data Chair of the Data Services Advisory Group (DSAG)

Other Documents

WG-ASAM-2022/P01	Antarctic krill biomass and flux measured using wideband echosounders and acoustic doppler current profilers on submerged moorings G. Cutter, C. Reiss, S. Nylund and G. Watters *Front. Mar. Sci.*, 9 (2022): 784469, doi: 10.3389/fmars.2022.784469
WG-ASAM-2022/P02	Estimating the average distribution of Antarctic krill *Euphausia superba* at the northern Antarctic Peninsula during austral summer and winter V. Warwick-Evans, S. Fielding, C.S. Reiss, G.M. Watters and P.N. Trathan *Polar Biol.*, 45 (2022): 857–871