

ICES SGASC Report 2006

ICES Fisheries Technology Committee

ICES CM 2006/FTC:03,
Ref. MHC, ACE, WGFAST

Report of the Study Group on Acoustic Seabed Classification (SGASC)

31 March to 2 April 2006

Hobart, Australia



International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Recommended format for purposes of citation:

ICES. 2006. Report of the Study Group on Acoustic Seabed Classification (SGASC), 31 March to 2 April 2006, Hobart, Australia. ICES CM 2006/FTC:03, Ref. MHC, ACE, WGFAST. 11 pp. <https://doi.org/10.17895/ices.pub.9646>

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Executive Summary

The Study Group on Acoustic Seabed Classification (SGASC) met at the CSIRO Marine and Atmospheric Research, Hobart, Tasmania from 31 March to 2 April 2006. John Anderson (Canada) chaired the meeting and also served as Rapporteur. There were nine participants in the final meeting of the Study Group (Annex 1). The Terms of Reference were to draft and complete a final version of a report on the state of the science of acoustic seabed classification techniques and methodologies as an important reference and guide to this emerging scientific discipline. Thirteen authors had worked by correspondence during the previous year drafting the previously defined chapters of the report on acoustic seabed classification. A detailed review of the chapter drafts was carried out by participants at the meeting. The participants focused on identifying redundancies among the chapters, consistency of terminology and accuracy of the information. Revisions to the chapters and final editing will be carried out by the report authors during the coming year via correspondence. The final version of the report will be submitted to ICES for publication as an *ICES Cooperative Research Report (CRR)*.

- The Working Group on Marine Habitat Mapping (WGMHM) should be notified of the completion of this work due to their ongoing interest in the subject of acoustic seabed classification.
- Acoustic seabed classification is an emerging technology that has already developed into an important method to classify and map marine landscapes.

1 Introduction

The ICES Study Group on Acoustic Seabed Classification (SGASC) met at the CSIRO Marine and Atmospheric Research, Hobart, Tasmania from 31 March to 2 April 2006. John Anderson (Canada) chaired the meeting and served as Rapporteur. There were nine participants in the final meeting of the Study Group (Annex 1). One member participated via video conference for a portion of the meeting. The agenda was reviewed and accepted with respect to the Terms of Reference for the meeting (Annex 2). Thirteen authors had worked by correspondence during the previous year completing the previously identified chapters of the report. A detailed review of the chapter drafts was carried out at the meeting. The participants focused on identifying redundancies among the chapters, consistency of terminology and accuracy of the information. Individual chapters were assigned to participants to lead in the detailed reviews. The detailed reviews were carried out using hardcopies of the draft CRR and editing comments were provided on the hardcopies to aid authors in the final revisions of each chapter.

The chair reviewed progress made during the previous year by correspondence. All of the intended chapters had been written in draft form prior to the study group meeting. Some changes had occurred in the structure of the planned *Cooperative Research Report* (CRR). In particular, the chapter originally proposed as an overview of the science of acoustic seabed classification was dropped as this appeared to be redundant and unnecessary. Further, it was agreed that the references for all of the chapters would be included at the end of the ICES *Cooperative Research Report* (CRR). There had been discussions with Adi Kellermann of the ICES Secretariat regarding publication of the report outside of ICES. Several conditions would have to be met to do this which would include finding a publisher, arranging for financing, getting approval by ICES and the associated committees as well as all of the participating authors. John Simmonds suggested a suitable publisher would be Blackwell Science. It was recommended that a decision on publication outside of ICES be given further consideration through correspondence following the meeting, where all of the authors were not in attendance. Finally, it was suggested that consideration be given to publication of a research paper in the ICES Journal of Marine Science focusing on the highlights of the report in order to give the work a wider circulation within the scientific community.

The title and authorship of the (CRR) was discussed. It was agreed that the title for the CRR should be “Acoustic Seabed Classification of Marine Physical and Biological Landscapes”, as originally proposed. It was suggested that the authorship for the individual chapters be listed in the Index of the CRR. The editorship for the CRR will remain as originally proposed.

2 CRR chapter reviews

The review of Chapter 1 “Introduction to Acoustic Seabed Classification” was lead by Robert Kieser. It is necessary to standardize the terminology used in the report. Terms such as coherent and incoherent acoustic signals should be used. Terms such as hardness and roughness are commonly used in the scientific literature and should be included. Acronyms for single beam (SBES) and multibeam (MBES) acoustic systems should be standardized throughout the report. The term acoustic ground discrimination system (AGDS) is widely used by some investigators in Europe but is generally not used by other researchers. This term should also be defined in the Introduction. Figure 1, a schematic representation of acoustic energy returned from the seabed was referenced to Dr. R. Courtney, Bedford Institute of Oceanography, Canada. However, it was not known if this figure was published in the scientific literature. A suitable figure is available from a recent publication by Sternlicht and de Moustier (2003, J. Acoust. Soc. Am. 114: 2709-2725, Figure 1) and it was suggested that this figure be included, or substituted, in the CRR.

The review of Chapter 2 “Theory of Sound Scattering from the Seabed” was lead by John Simmonds. There was some confusion over the hierarchy of the sub-headings within the chapter. This resulted from editing previously carried out on the chapter. In discussions with the chapter author, Van Holliday, it was agreed that a corrected version of the sub-headings would be provided. It was suggested that a guide to the rest of the chapter should be provided in the first section of the report, Section 2.1 (p. 16). Such a guide would be considered as a “road map” to the rest of the chapter. It was suggested that a summary should be provided at the end of the chapter that was specific to the frequency range that was being addressed in the chapter. There was some confusion between what constituted theoretical versus empirical models within the chapter and this should be clarified. The original version of this chapter was much longer and included an extensive list of references. It was agreed that this compiled reference list is valuable and that it should be included in its entirety as an appendix of the CRR.

The review of Chapter 3 “Acquiring and Preparing Acoustic Data” was lead by Rudy Kloser. The terminology within the chapter must be standardized, for example sonar versus echosounder or acoustic impedance and scattering volume versus seabed backscatter. Further examples were provided on the hardcopy review. It was suggested that Figure 3.4 be deleted as it was unnecessary. There was a discussion of the terms properties, attributes and features. It was suggested that properties referred to the physical quality being measured, such as the grain size of the sediment. Attributes define a specific object or entity. A feature is something that is measured but not easily defined. These three terms should be clarified in the glossary of the CRR. A review of the literature cited within the chapter indicated inconsistencies. In particular, the availability of some cited sources was questioned and it was agreed that all referenced publications should be readily available to the scientific community.

The review of Chapter 4 “Classification Methods and Criteria” was lead by Robert Kieser. A number of specific comments were provided on the hardcopy regarding terminology and clarification. There was a further discussion on the use of the terms properties, attributes and features that can be clarified by common definitions outlined within the glossary. There were missing references in the draft that need to be added. Finally, it was suggested that a paragraph be added that advised on the most appropriate methods to use for classification as well as any methods that should not be used.

The review of Chapter 5 “Accounting for Spatial and Temporal Scales and Interpolation in AGDS Surveys” was lead by John Anderson. It was suggested that the title be changed to drop the term ADGS in favour of acoustic seabed classification. The topic of scales is linked to issues in other chapters, in particular chapters on data collection, quality and display (Chapter 7), verification methods (Chapter 8) and survey design (Chapter 9). An important feature of this chapter is the acoustic footprint which was discussed at length. Specific comments relating to the concept of footprint included the effect of pulse length, range (typically water depth), the angle of incidence and beam width. In fisheries acoustics 3 dB off-axis typically is used as a reference for analyses of acoustic data. In acoustic seabed classification the off-axis data typically exceeds this range. The concept was discussed that the initial acoustic footprint can be represented by a circle on the seabed but with time it becomes an expanding and narrowing annulus. It is important that this concept was identified and cross referenced to other chapters. The second table could be simplified to represent a subset of ranges, such as 10, 30, 100 and 200 m with reference to the footprint diameter and area. This table should be cross-referenced to Table 7.2 in Chapter 7. Table 3 summarized sampling areas for multibeam and single beam systems. It was suggested that a sidescan sonar system be added to the table for completeness. It was suggested a figure that included a variogram be inserted into Section 6.2.3. There was considerable discussion with respect to the Section 6.2.5 on interpolation between transects. Clarification should be provided in the introduction to this section noting that the CRR does not deal with mapping which is beyond the stated objectives of the study

group. However, measurement scale and interpolation of these measurements is an important component of acoustic seabed classification technologies. There appeared to be a focus on the E1 and E2 variables generated by the Roxann system and it was felt that there should be an attempt to generalize the discussion to generic acoustic seabed classification, with reference to E1 and E2. It was felt that Table 4 which summarized six spatial scales should be cross-referenced and standardized with the five scales outlined in Table 1. Within the section on temporal scales it was suggested that the floral component should stand as a separate subsection. It was suggested that Table 7 in the publication of Kenny et al. (2000) be referenced with respect to geological processes operating at different time scales. There was a suggestion to include a space-time figure that would tie together processes operating across the range of scales referred to in the chapter. This would include things such as tides, diurnal variation, seasons and years.

The review of Chapter 6 “Review of Acoustic Seabed Classification Systems” was lead by John Anderson. It was generally felt that the chapter was too long and could be shortened. In particular, there was an over emphasis on sidescan systems which could be reduced in its extent without losing the relevant information as a description of these systems. In addition, it was felt there was a need to explain the functional issues of the different systems without going into too much technical detail. There were a number of schematic figures that represent the different acoustic seabed classification systems. These were thought to be an excellent way of demonstrating how these systems worked and how they differed. There were, however, a number of suggestions for improving the technical nature of the figures. These included the concept of the side lobes and how they impact on the seabed. In addition, the time course of sampling in the figures could be modified to better represent the actual data collection process. There were specific questions about the difference between interferometric and multirow sidescan sonar systems that needs to be clarified. There should be mention of sound velocity profiles to resolve the outer beams of multibeam systems. With respect to the different acoustic seabed classifications available commercially it was recommended that all information in the CRR reference each manufacturer’s published documentation, including information available on the web site. It was suggested the section of the chapter that summarized commercial systems be ordered by system type, such as single beam echosounders, sidescan sonars and multibeam systems. The chapter should be reviewed for technical accuracy.

The review of Chapter 7 “Data Collection, Quality and Display” was lead by Yvan Simard. There was an in depth discussion with respect to the sonar equations referenced in the chapter. It was clarified that we are trying to resolve phase in the energy domain versus the time domain. There was a further discussion related to the acoustic footprint and the area of the seabed ensonified as a function of incident angle and how this relates to data quality. It was generally felt that the introduction Sections, 7.1, 7.1.1 and 7.1.2, were a good summary of the acoustic issues that are addressed in other chapters. It was also felt that the issues of data collection, quality and display were fundamental to the broader subject of acoustic seabed classification. For these reasons, it was suggested that this chapter be moved to an earlier section of the CRR to improve the chronology of chapters.

The review of Chapter 8 “Verification of Acoustic Classes” was lead by Andrzej Orłowski. It was felt that there needed to be a paragraph added to the chapter that would summarize the sampling strategies of the various verification methods. This summary should be referenced to different sampling depths for differing surveys. There was a need to clarify the context of the spatial scales of acoustics compared to the spatial scales of the verification methods, where there is typically a large mis-match in the sampling scales. In Section 8.5 on positioning issues clarification is needed in a number of instances where it was not clear if it was the position of the ship or the position of the sampling gear that was being discussed. It was noted that all references should be available to as a wide scientific audience as possible.

The review of Chapter 9 “Survey Designs” was lead by Yvan Simard. It was felt there should be an expansion on the section that addressed the stratification of survey design. In particular, this should reference a standard textbook on survey designs, such as Cochran.

The review of Chapter 10 “Utilization of Acoustic Seabed Classification Products” was lead by John Simmonds. It was felt that the chapter needed to be more focused. The approach should be to address questions as opposed to stating questions without necessarily answering or addressing these questions. It was suggested that perhaps this chapter should concentrate on future issues that have been identified during the course of the study group on acoustic seabed classification. This would help to direct attention to issues arising within the field of acoustic seabed classification. It was agreed that discussions would be held via correspondence on further development of this final chapter.

The review of Chapter 11 “Glossary” was lead by Andrzej Orlowski. It was agreed that the glossary was still under development. Many of the terms were listed in the glossary draft. It was felt that more terms would be identified in the final edit of the CRR once it had been brought together. As lead author, Yvan Simard would continue to collate the various terms and provide definitions. The final review of the glossary would be carried out via correspondence.

3 Recommendations

It was felt that the report on acoustic seabed classification was fully developed and only required modifications based on the chapter reviews as well as final editing to ensure consistency in terms and format. It was **recommended** that the revisions to each chapter be done by the various chapter authors based on comments received from the reviews conducted during study group meeting. When revised, the final version of the chapter should be sent to the Chair, John Anderson, for collating and editing. It was **recommended** that the final version of the chapter should be reviewed by the various authors for completeness prior to submission to the ICES Secretariat for publication as a cooperative research report. This work can be carried out via correspondence over the coming months. It was **recommended** that completion of the report fulfilled the terms of reference for the Study Group on Acoustic Seabed Classification and that this group could now be disbanded.

Annex 1: Participants in the SGASC meeting, Hobart, Tasmania 2006

NAME	ORGANIZATION	COUNTRY
Anderson, John (Chair)	Department of Fisheries and Oceans	Canada
Karl-Johan Staehr	Danish Institute for Fisheries Research	Denmark
Kieser, Robert	Department of Fisheries and Oceans	Canada
Kloser, Rudy	CSIRO	Australia
Lundgren, Bo	Danish Institute for Fisheries Research	Denmark
Orlowski, Andrzej	Sea Fisheries Institute	Poland
Simard, Yvan	Universite Rimouski/DFO	Canada
Simmonds, John	FRS Marine Laboratory	United Kingdom

Annex 2: Terms of Reference for SGASC 2006

The **Study Group on Acoustic Seabed Classification** [SGASC] (Chair: John Anderson, Canada) will meet in Hobart, Tasmania, from 31 March to 2 April 2006 to:

- a) review and evaluate progress in:
 - i) acoustic seabed classification systems, acoustic technologies, theoretical complexities and limitations,
 - ii) acoustic data collection procedures and groundtruthing methods for supervised and unsupervised classification of seabeds and habitats, considering issues of measurement scale and integration of data products,
 - iii) metadata standards for acoustic systems, including single beam (SBS), multibeam (MBS) and sidescan sonars (SSS),
 - iv) practical applications of acoustic seabed classification (ASC) products in the management and conservation of coastal resources,
- b) intersessionally prepare a draft report and make it available for the WGFAST meeting of 27-30 March and receive and include comments from WGFAST;
- c) finalize draft of the Cooperative Research Report on “Acoustic Seabed Classification of Coastal and Continental Shelf Ecosystems”, taking comments by WGFAST into account.

SGASC will report by 1 May 2006 for the attention of the Fisheries Technology Committee, the Marine Habitat Committee, as well as ACE and the Working Group on Fisheries Acoustics and Science Technology.