

ICES Fisheries Technology Committee  
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## Report of the Study Group on Acoustic Seabed Classification (SGASC)

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18–19 April 2004  
Gdynia, Poland

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International Council for the Exploration of the Sea  

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## Executive Summary

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The second meeting of the ICES Study Group on Acoustic Seabed Classification (SGASC) was held at the Sea Fisheries Institute (MIR), Gdynia, Poland 18–19 April 2004. A total of twenty nine delegates and observers participated in the two day meeting, representing eleven countries and five industry groups. The meeting was chaired by John Anderson (Canada). Since the inaugural meeting in 2003, members of the Study Group have been working by correspondence to develop a detailed outline for an *ICES Cooperative Research Report* (CRR) on acoustic seabed classification. Lead authors were identified to develop the report chapters adopted last year and to recruit further experts as required in order to meet the terms of reference originally identified for the Study Group. The Study Group reviewed presentations by lead authors and developed timelines over the next year for the writing and editing of the CRR on Acoustic Seabed Classification. The Study Group will meet next year, 2005, in association the Working Group on Fisheries Acoustics and Science Technology (WGFAST) to review and finalize the CRR. The Study Group now has a direct contact with the Working Group on Marine Habitat Mapping (WGMHM) through Dr. R. Coggan (United Kingdom).

Ecosystem based management of marine resources will require that natural regions be identified and mapped over a range of hierarchically nested scales. Acoustics is regarded as the remote sensing tool that will provide the basis for classifying and mapping ocean resources. Existing acoustic systems can measure seabed sediment properties and bedform morphology from scales of boulders ( $< 1 \text{ m}^2$ ) to the scale of shelves ( $> 100,000 \text{ m}^2$ ). Acoustic metrics relating to seabed habitats can be regarded as proxy measures, or surrogates, of seabed habitats that can be collected in a cost effective manner continuously across broad scales. Acoustic systems considered by the Study Group include vertical incidence single beam echosounders (SBES), oblique incident sidescan sonar systems (SSS) and multibeam echosounder systems (MBES).

The aim of the *ICES Cooperative Research Report* is to review the state-of-the-art in acoustic seabed classification (ASC). The report will provide an overview of the major issues and applications in this field and a comprehensive review of the technologies and techniques used to investigate these. Acoustic technology and classification science is rapidly evolving to meet the needs of nations to manage and conserve coastal resources. As such, the *ICES Cooperative Research Report* must be seen as representing a snap-shot of the discipline at this point in time. While we anticipate that new developments will occur regularly and that this subject must be revisited in the future, we hope that the CRR will form a basis of our current understand and will provide guidelines for the coordination of scientific developments in this field.

# 1 Introduction

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The second meeting of the ICES Study Group on Acoustic Seabed Classification (SGASC) was held at the Sea Fisheries Institute (MIR), Gdynia, Poland from the 18–19 April 2004. A total of twenty nine delegates and observers participated in the two day meeting, representing eleven countries and five industry groups (Annex 1). The meeting was chaired by John Anderson (Canada). The terms of reference were reviewed and accepted by the Study Group (Annex 2). Since the inaugural meeting in 2003 members of the Study Group have been working by correspondence to develop a detailed outline for an *ICES Cooperative Research Report* (CRR) on acoustic seabed classification (ASC). Lead authors were identified to develop the report chapters adopted last year and to recruit further experts as required in order to meet the terms of reference originally identified for the Study Group. The SGASC reviewed presentations by lead authors and developed timelines over the next year for the writing and editing of the CRR on acoustic seabed classification. The SGASC will meet next year, 2005, in association the WGFASST meeting to review and finalize the CRR. The Working Group on Marine Habitat Mapping (WGMHM) has a direct interest in acoustic seabed classification products. To that end WGMHM has appointed Dr. R. Coggan (United Kingdom) as a direct contact with the SGASC. The SGASC will endeavour to keep WGMHM informed of progress and issues through Dr. Coggan.

## 2 Acoustic Seabed Classification

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The natural world is structured hierarchically and processes within natural regions operate across a number of spatial and temporal scales. Managing marine ecosystems requires that natural regions be identified and mapped over a range of hierarchically nested scales. Management of resources across multiple scales will require a classification system. Acoustics is increasingly regarded as the remote sensing tool that will provide the basis for classifying and mapping ocean resources. Existing acoustic systems can measure seabed sediment properties and bedform morphology from scales of meters to kilometres. Acoustic metrics relating to seabed habitats can be regarded as proxy measures, or surrogates, of seabed habitats that can be collected in a cost effective manner continuously across broad scales. Acoustic systems considered by the Study Group include vertical incidence single beam echosounders (SBES), oblique incident sidescan sonar systems (SSS) and multibeam echosounder systems (MBES). Combined use of these different acoustic systems is providing the opportunity to classify and map seabed features from the scale of boulders ( $< 1 \text{ m}^2$ ) to the scale of shelves ( $> 100,000 \text{ m}^2$ ).

## 3 Cooperative Research Report

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To meet the terms of reference of the Study Group it was felt that a review of existing knowledge and technologies was necessary. A revised outline of the *ICES Cooperative Research Report* provided in Annex 3. We will conduct a broad overview of the current science of acoustic seabed classification methods and products. We will review the existing theory of sound scattering from seabeds as a background for this work. We will review the effectiveness of data to develop seabed classifications in the context of the precision, repeatability and comparability among systems and frequencies. We plan to address the issue of defining the relevant scales of operation with respect to fisheries conservation, ecosystem based management and biodiversity issues, both from theoretical and acoustic application perspectives. Defining the relevant spatial and temporal scales was thought to be a necessary step towards understanding *a priori* the types of management questions that we are trying to address with acoustic seabed classification technologies. We intend to review existing and emerging acoustic seabed classification technologies and assessed their capabilities to objectively classify marine habitats in relation to previously defined scales of operation. The review should include all acoustic technologies deemed capable of classifying seabed habitats from the perspective of sediment properties (fine scale) to geomorphologic features associated with bedforms (coarse scale). These technologies will include single beam echosounders (SBES), multi-beam echosounders (MBES), sidescan sonar and calibrated phase-difference bathymetric sidescan sonar systems (SSS). Acoustics is a remote sensing device that

requires both calibration and standardization in terms of system design and properties. These issues will be reviewed and summarized. The discipline of acoustic seabed classification is both new and rapidly evolving. Issues of data collection, quality and display will be reviewed and standardization methods should be developed. Acoustic data must be interpreted to be of use to marine scientists and managers. This interpretation can be either subjective or objective. Subjective interpretation of sidescan and multibeam mosaics, combined with groundtruthing data, forms the basis of existing geological and habitat mapping. It is desirable to develop methods that are objective and repeatable for both supervised and unsupervised classifications of marine habitats. Because acoustics is a remote sensing technique it is always necessary to verify exactly what the data are classifying in terms of habitats. To this end we plan to review the existing and emerging techniques that can be used to ground-truth acoustic proxy measurements. Combining single beam acoustic systems with multi-beam swath systems that must be ground-truthed based often on point data collections requires a careful consideration of survey design and an evaluation of the effectiveness and limitations that researchers must address. The Study Group felt there was a need to address how acoustic seabed classification products can and should be utilized in the context of habitat mapping and conservation management. Many nations are now setting up programmes to map their coastal environments and we attempt to provide some guidance for the use of acoustic seabed classification in national programmes. Finally, we will provide a glossary for clarification and standardization of terms and concepts used in the report.

The aim of the *ICES Cooperative Research Report* is to review the state-of-the-art in acoustic seabed classification (ASC). The report will provide an overview of the major issues and applications in this field and a comprehensive review of the technologies and techniques used to investigate these. Acoustic technology and classification science is rapidly evolving to meet the needs of nations to manage and conserve coastal resources. As such, this report must be seen as representing a snap-shot of the discipline at this point in time. While we anticipate that new developments will occur regularly and that this subject must be revisited in the future, we hope that the *ICES Cooperative Research Report* will form a basis of our current understanding and will provide guidelines for the coordination of scientific developments in this field.

## 4 Annexes

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### Annex 1 Participants in the SGASC meeting, Gdynia, Poland 2004

NAME	ORGANIZATION	COUNTRY
Anderson, John	Department of Fisheries and Oceans	Canada
Anthony, Dennis	Royal Danish Admin. of Nav. and Hydro.	Denmark
Berger, Laurent	IFREMER	France
Byham, Paul	Systems Engineering & Assessment Ltd.	United Kingdom
Condiotty, Jeff	Simrad	United States
Cross, Cathy	British Antarctic Survey	United Kingdom
Demer, David	Southwest Fisheries Science Center	United States
Diner, Noel	IFREMER	France
Forbes, Hamish	Seatronics	United Kingdom
Holliday, Van	BaeSystems	United States
Horne, John	University of Washington	United States
Kieser, Robert	Department of Fisheries and Oceans	Canada
Kloser, Rudy	CSIRO	Australia
Larson, Niklas	Institute of Marine Research	Sweden
Lipsky, Jessica	Southwest Fisheries Science Center	United States
Lundgren, Bo	Danish Institute for Fisheries Research	Denmark
MacCaulay, Gavin	NIWA	New Zealand
Michaels, William	National Marine Fisheries Service, NOAA	United States
Moszynski, Marek	Gdansk University of Technology	Poland
Orlowski, Andrzej	Sea Fisheries Institute	Poland
Pauly, Tim	Sonardata Ltd.	Australia
Preston, Jon	Quester Tangent Corporation	Canada
Reid, Dave	Marine Laboratory	United Kingdom
Ryan, Tim	CSIRO	Australia
Severin, Vladimir	AtlantNIRO	Russia
Simard, Yvan	Universite Rimouski/DFO	Canada
Stepnowski, Andrzej	Gdansk University of Technology	Poland
Svetlana, Kosatkina	AtlantNIRO	Russia
Tegowski, Jaroslaw	Institute of Oceanology	Poland



## **Annex 2 Terms of reference for SGASC 2004**

The **Study Group on Acoustic Seabed Classification** [SGASC] (Chair: John Anderson, Canada) will meet in Gdynia, Poland, on 18–19 April 2004 to:

- a) review and evaluate progress in:
  - i) the theory of sound scattering from the seabed and the application of acoustic seabed classification systems,
  - ii) the development of standardized survey designs and verification methods,
  - iii) the development of standardized protocols for data collection, data quality and display, data effectiveness for classification, segmentation and classification methods and criteria,
  - iv) the utilization of acoustic seabed classification products in habitat mapping and other marine activities;
- b) evaluate progress towards publishing a *Cooperative Research Report* on “Acoustic Seabed Classification in Marine Environments”.

SGASC will report by 31 May 2004 for the attention of the Fisheries Technology and the Marine Habitat Committees, and ACE.

### **Annex 3    Revised draft Table of Contents for the development of an *ICES Cooperative Research Report***

<b>Section</b>	<b>Page</b>
1 Introduction ..... ( <i>J. Anderson</i> )	
2 Acoustic Classification Overview ..... ( <i>J. Galloway</i> )	
3 Theory of Sound Scattering from the Seabed ..... ( <i>V. Holliday</i> )	
4 Data Effectiveness for Classification..... ( <i>A. Orłowski</i> )	
5 Scales of Observation ..... ( <i>D. Reid, R. Kloser</i> )	
6 Review of Acoustic Seabed Classification Systems ..... ( <i>W. Michaels, P. Byham</i> )	
7 Acoustic System and Calibration Requirements..... ( <i>R. Kieser, J. Preston, R. Chapman</i> )	
8 Data Collection, Quality and Display ..... ( <i>R. Kloser, R. Courtney</i> )	
9 Classification Methods and Criteria ..... ( <i>Y. Simard, A. Stepnowski</i> )	
10 Verification Methods of Acoustic Classes..... ( <i>C. Brown</i> )	
11 Survey Design..... ( <i>John Simmonds</i> )	
12 Utilization of Acoustic Seabed Classification Products..... ( <i>J. Anderson, V. Holliday, R. Kloser, D. Reid, Y. Simard</i> )	
13 Glossary ..... ( <i>Y. Simard</i> )	

#### Annex 4 2005 Draft resolutions

XXXX The **Study Group on Acoustic Seabed Classification** [SGASC] (Chair: John Anderson, Canada) will meet in Rome, Italy, on April 23-24 2005 to:

- a) To review and evaluate progress in:
  - i) data and methodologies for classification of seabed properties in relation to scientific theory;
  - ii) the development of standardized procedures for data collection, interpretation and reporting including a glossary of terms and conditions;
  - iii) the existing commercial data classification systems;
  - iv) the utilization of acoustic seabed classification products in habitat mapping and other marine activities.
- b) evaluate progress towards publishing a *Cooperative Research Report* on “Acoustic Seabed Classification in Marine Environments”.

SGASC will report by 31 May 2005 for the attention of the Fisheries Technology and Marine Habitat Committees.

#### Supporting Information

Priority	Acoustic remote sensing of seabed characteristics for fish and shellfish habitat classification and abundance estimation is a rapidly evolving multidisciplinary research area that is becoming more and more used for stock estimation, effects of fishing gears on benthic community, ecosystem research and habitat protection and management.
Scientific Justification and relation to Action Plan	<p>Action Item 1.4, 1.4.3, 1.10, 1.12.5 - a Action Item 5.4, 6.3 - b</p> <p>The use of acoustics for remotely measuring biological and physical characteristics of fish seabed habitats is a new and rapidly developing area of scientific research. Classification and mapping of marine habitats has been featured in theme sessions at the 2000 and 2002 Annual Science Conferences and will be re-visited again at the 2004 ASC. Several papers on this topic have been published recently as part of the 2002 ICES Symposium on Acoustics in Fisheries and Aquatic Ecology. Results from acoustic seabed classification studies are now widespread and making their way into management processes. Other ICES groups and organizations, notably those making use of the results, are also interested in the development and standardization in this area of research. A review of the terms of reference confirmed that research activity in this field required a thorough review and evaluation.</p> <p>Term of Reference a-i) A thorough review is necessary in order to understand the application of seabed classification in terms of the data quality and how these data are interpreted in terms of seabed habitats.</p> <p>Term of Reference a-ii) It is necessary to develop standard procedures for data collection and dissemination in order that acoustic seabed classification products can be widely used by the marine community.</p> <p>Term of Reference a-iii) A number of commercial classification systems are currently available requiring a thorough review of their capabilities in the context of the Study Group’s mandate.</p> <p>Term of Reference a-iv) Interpretation of acoustic seabed classification technologies in fisheries science must be integrated with ongoing habitat mapping and marine assessment activities.</p> <p>Term of Reference b) Publication of the issues previously identified for acoustic seabed classification will establish our current level of understanding and provide guidelines for future fisheries research and management application .</p>

Resource requirements	No new resources will be required at this time. Having overlaps with other meetings of Working, Planning and Study Groups of the Fisheries Technology Committee increases efficiency and reduces travel cost. WGFAST members of the Study Group have considerable experience in acoustics and in implementing operational solutions responding to such needs for understanding and the establishment of standardization guidelines
Participants	Approximately 30 members are expected to participate in the Study Group. Members from other Committees or Working Groups interested in acoustic seabed classification, especially the Working Group on Marine Habitat Mapping will be notified and encouraged to participate in this SG.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to Advisory Committees	ACE
Linkages to other organisations	-
Linkages to other Committees or Groups:	The work of this Study Group is closely aligned with the work of WGFAST and WGFTFB. This work is complementary to the work of the Marine Habitat Committee, in particular WGMHM and WGEXT.
Cost Share	ICES 100%