WORKING GROUP ON FISHERIES ACOUSTICS, SCIENCE AND TECHNOLOGY (WGFAST)

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Contents

i Executive summary

The Working Group on Fisheries Acoustics, Science and Technology (WGFAST) focuses on the development and application of science and technology to observe the marine environment. In this report, WGFAST describe their appreciation for David MacLennan, who was a founding member of WGFAST, and who's pioneering work on several theoretical and practical elements of fisheries acoustics were compiled in the seminal book on Fisheries Acoustics that he co-authored. The report also addresses 'big data' as the next frontier in fisheries acoustics; the WGFAST strategy to respond to a request from the Working Group on International Pelagic Surveys (WGIPS) on the acoustic detection of herring; updates from the Topic Group on Collecting Quality Underwater Acoustic Data (TGQUAD) that is writing an ICES Co-operative Research Report in this topic; updates from the Topic Group on Acoustic Metadata (TGMETA) on the development of acoustic metadata guidelines (AcMeta); and progress by the newly formed Working Group on Acoustic Trawl Data Portal Governance (WGAcousticGov) to establish a governance framework for the ICES Acoustic Trawl Data portal. WGFAST identified Dr Toby Jarvis as a new representative on the International Organization for Standardization (ISO) Liaison Committee linked to ongoing ISO work on underwater acoustics.

This report also summarizes WGFAST considerations of acoustic scattering properties of organisms and open-source acoustic backscatter models; the Sonar-netCDF4 open source data format for acoustic data; open-source software to read, process, and analyse acoustic data; and applications of artificial intelligence (AI) and machine learning (ML) methods to acoustic data.

In relation to "big data" as the next frontier in fisheries acoustics, WGFAST note that many fisheries institutions and agencies now have terabytes of data recorded over decades, and are collecting data at astonishing rates. Efficient discovery, access, processing, and analysis of these data will require open and available data repositories with transparent and efficient ways to discover and access data, data recorded and archived in open formats, and open-source software so that these data can be available to the scientific community beyond fisheries acousticians. Application of advanced methods such as AI and ML will expand the utility of fisheries acoustic data beyond stock assessment to inform conservation and management of ecosystems.

ii Expert group information

Expert group name	Working Group – Fisheries Acoustics Science and Technology (WGFAST)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/3
Chair(s)	Michael Jech, USA
Meeting venue(s) and dates	22 April 2020, by correspondence, (120 participants)

1 Report on Terms of Reference

1.1 ToR a)

The report collating information on acoustic-related research and surveys is due in year 3. During the meeting, WGFAST discussed requesting additional information from members on their connections to ecosystem and assessment expert groups (EGs) as part of this ToR. A number of members are currently participating in or have ties to other ecosystem and stock assessment expert groups. WGFAST recommended to modify this ToR to "Collate information on acoustic related research and surveys, **and interactions with ecosystem and assessment expert groups**." (Bold font indicates new text). This information will be added to the report and collated in year 3.

1.2 ToR b)

Present recent work in fisheries acoustics

A large component of the WGFAST meeting is devoted to this ToR in the form of scientific presentations. Unfortunately, due to the COVID-19 pandemic, the physical meeting was not conducted and the decision was made to not give the presentations remotely this year. The hope is to have a physical meeting in 2021 and resume the normal practice of scientific presentations. If the meeting ends up being remote again, WGFAST will discuss options for hosting scientific presentations.

In lieu of the scientific presentations, five discussion sessions were held to address information and data gaps and new applications and analysis methodologies in fisheries acoustics. These discussion sessions are detailed below in Section 2 – **Error! Reference source not found.**.

Training opportunities

In the past, the Institute of Marine Research (IMR) in Bergen, Norway has conducted a broadband acoustic course. The course was well received, but due to logistic constraints, IMR does not have plans to continue this course.

A fisheries acoustic training course was conducted by John Horne and Paul Fernandes as part of ICES-sponsored training courses. At this time no plans are to continue this course.

As a result of our discussions during the meeting, WGFAST will review whether training opportunities (e.g. ICES training courses) in the use of acoustic backscatter models and applications of AI and ML to fisheries acoustic data as these two fields mature will be developed in 2021 or 2022.

Data and information gaps

During the meeting, discussions (See Section 2 – **Error! Reference source not found.**) highlighted gaps in knowledge and how these gaps lead to uncertainty in acoustic measurements and estimates. WGFAST discussed how these gaps can be used to prioritize challenges in fisheries acoustics. We will continue to discuss and evaluate these topics as potential training opportunities as they mature.

1.3 ToR c)

This ToR was discussed as another way (see ToR a) to facilitate interaction among WGFAST and the other ecosystem and assessment EGs. During the discussion, a number of WGFAST members expressed that they already interact in some way with these other EGs. WGFAST has evolved from a group solely dedicated to acoustics and evaluating acoustic instrumentation to one that needs to deal with "big" data, e.g. decades-long time-series, and application of those data to ecosystem monitoring and assessment. A session, joint with WGFAST and select ecosystem expert groups will provide a forum for reviewing the state-of-the-art and pathways forward to inte-grate advanced technologies and ecosystem monitoring and assessment. WGFAST agreed that we would work with these contacts to organize a joint session at the 2021 or 2022 ICES Annual Science Conference.

1.4 ToR d)

WGFAST received an update from TGMETA on its progress in updating acoustic metadata and the AcMeta convention (see Section 2.6 – TGMETA Update). This is an ongoing effort that continually evolves with the needs of the community. The current effort is to transition the AcMeta convention to GitHub, and TGMETA is working with the ICES data office to make this transition efficient and transparent.

1.5 ToR e)

TGQUAD intended to meet physically the weekend prior to the WGFAST meeting in Bergen, but due to the COVID-19 pandemic, postponed this meeting to a remote meeting during summer 2020. Interactions have continued remotely and progress is steady on the CRR. The group is on schedule to submit a draft CRR by fall 2020.

2 Discussion Topics

2.1 David MacLennan Appreciation

Sadly, Dr David MacLennan passed away in April 2020 and Paul Fernandes gave a moving appreciation of his scientific achievements and personal impacts on WGFAST, its members, and the broader fisheries community. WGFAST discussed ways to formally show our appreciation of David's efforts and achievements, which included creating an ICES or WGFAST award in his honour and/or nominating him for one of ICES top awards. After discussion with the ICES Secretariat, we decided to nominate David for the ICES Prix d'Excellence. The Prix d'Excellence is the highest honour ICES bestows upon scientists who have had lasting and broad-ranging influence on fisheries science. John Horne, Paul Fernandes, and Michael Jech submitted an initial nomination letter to the ICES Award Committee on behalf of WGFAST, which was accepted for a full nomination. A full nomination package was collated and submitted to the award committee for review. We are awaiting word on the final decision.

A copy of David's "Food for Thought" article in the ICES Journal of Marine Science has been uploaded to the WGFAST SharePoint site, in Background Documents.

Our initial nomination letter was as follows:

David spent his career working on the sustained use and conservation of marine ecosystems throughout his association with the Scottish Marine Laboratory in Aberdeen (1967 through 1995) culminating in the appointment of Deputy Director; as Chief Technical Advisor to the Lake Victoria Fisheries Research Project (LVFRP) in Uganda (2000-2002); and as an honorary Reader at the University of Aberdeen. David started as a fishing-gear technologist conducting work on vessel performance, gear technology, and fish behaviour. He is credited with the design and build of Europe's first tank used to study fish behaviour and conducted pioneering work on fishing selectivity, which was then applied to stock assessment.

In the late 1970s he transitioned to work on Fisheries Acoustics where he laid the foundations of several theoretical and practical elements (e.g. calibration, community nomenclature, abundance measurements) that, in addition to being published in the primary literature, were summarized in two resource/text books that remain essential reading. In Lake Victoria, he ran the acoustic survey programme providing new insights on the distribution and abundance of its fish populations and built the local capacity to conduct acoustic surveys.

In the late 2000's his efforts turned to editing, working with the journal Fisheries Research, and collating and editing papers from international conferences such as the 2008 ICES Symposium on the Ecosystem Approach with Fisheries Acoustics and Complementary Technologies and the 2010 ICES Symposium on Fishery-Dependent Information.

David's scientific leadership, innovation, teamwork, and mentoring are all attributes which have been demonstrated throughout his career. He has a long collaborative history with international organizations such as ICES, the EU, and FAO, as well as many colleagues all over the world. David sadly passed away on 7 April 2020, but we believe he is truly deserving of this award posthumously. We can think of no better tribute than to present the award to his wife Sheila who has accompanied him to many conferences, courses, and fieldwork, and is thus well known throughout the scientific community.

The discussion of David's appreciation led to a broader discussion about how WGFAST can recognize members as they retire. We agreed to have recognitions at the annual WGFAST meeting banquet, with current members providing short appreciations of retired members.

2.2 WKREO Update and WGFAST realignment

An effort is underway at the ICES Secretariat to improve communication among the expert groups who collect survey data, those who use the data for ecosystem and stock assessments, regional coordination councils, and the ICES Secretariat. Michael Jech attended a workshop (Workshop on the Realigning of the Ecosystem Observation Steering Group, WKREO) to develop an organizational realignment among these groups, as well as recommend improvements to communication channels among these groups. Three action items were set for WGFAST:

- As part of ToR a), WGFAST will collect and tabulate information from members as to their connections to ecosystem and assessment expert groups.
- As part of ToR c), WGFAST will explore connections to ecosystem and assessment expert groups to host a joint session at the ICES Annual Science Conference in either 2021 or 2022.
- As part of the realignment, WGFAST is proposed to move to a new steering group, the Data Science and Technology Steering Group. The Data Science and Technology Steering Group will be responsible for guiding and supporting expert groups that are developing, assessing and applying new and emerging technologies to challenges in marine science, as well as advancing data science, systems management, quality assurance and data governance. It will give technology and data science a much higher profile within and beyond the ICES system, consistent with the emphasis now given to these topics in the ICES Science and Advisory Plans.

2.3 Liaison to ISO

A member of WGFAST has represented ICES in the International Organization for Standards (ISO) for the past several years. The ISO is the international body responsible for developing and maintaining standards for a variety of scientific and engineering fields. The ICES liaison has been a member of ISO/TC 043/SC03 "Underwater Acoustics" which includes WG 02 "Underwater acoustic terminology" and WG 04 "Standard-target method of calibrating active sonars". The current member, Gavin Macaulay, is no longer able to serve as liaison, so Toby Jarvis of Tasmania volunteered to be the ICES representative. WGFAST approved Toby's nomination to be the ICES liaison to the ISO. Toby submitted his nomination package to the ISO and is awaiting word of their approval. In addition, Geir Pedersen will be Norway's liaison to ISO.

2.4 Recommendation from WKSCRUT2

We have a request from WGIPS (International Pelagic Surveys) on behalf of WKSCRUT2 to provide guidance on "...whether there is any difference in the probability of acoustic detection of shallow (herring) schools (< 50 m depth) with a survey speed of e.g. 10 vs. 12 knots, or in other words does the higher survey speed result in less detection probability."

The survey in question (IESSNS) is a swept-area survey for mackerel in Nordic seas. It is not designed as a typical acoustic survey, but primarily as a trawl survey where vessel speeds between stations can exceed 12 knots. Atlantic herring and blue whiting are observed in the acoustic echograms, and these data are recorded opportunistically during inter-station transects (trawl stations being 30-60 nautical mile apart). The survey is designed in such a way that it resembles an acoustic survey design with parallel transects, etc., just with regular stopping to trawl at predefined stations. The survey group would like to develop an acoustic index for both blue whiting and herring using acoustic data from this survey. The herring are often < 50 m depth, therefore there is a concern whether the higher speed would unacceptably bias an acoustic survey index.

At the WKSCRUT2 in 2020 a question was raised whether a high survey speed might influence the herring estimate by reducing the chance of detecting shallow schools and thereby underestimate the biomass.

WGFAST developed a strategy to address this request, and has 4-5 volunteers to develop a response to this recommendation. WGFAST will submit the response by year-end 2020.

2.5 TGQUAD Update

The Topic Group on Collecting Quality Underwater Acoustic Data during Inclement Weather (TGQUAD) intended to meet physically the weekend prior to the WGFAST meeting in Bergen, Norway, but was unable to do so due to the COVID-19 pandemic. Co-chair, Michael Jech, provided an update of the group's progress. TGQUAD agreed to a remote meeting in summer 2020. Progress on the CRR is steady and the group intends to submit the CRR by fall 2020.

2.6 TGMETA Update

Tim Ryan, the chair of TGMETA, provided an update. The acoustic metadata guidelines (AcMeta) now reside on the ICES Publications GitHub site (currently https://github.com/ices-publications/AcMeta). The version 2 working document on GitHub has been generalized to allow any platform from ICES controlled vocabulary to be used. TGMETA is working with ICES Information and Technology and Data group to establish a streamlined publication path to take the document to an official ICES document.

AcMeta is a dynamic document that is designed to adapt and evolve with the scientific community as advancements in data acquisition, technology, and analytical methods improve. Because of the dynamic nature of this document and its public availability on GitHub, additions and modifications can be recommended by anyone. Quality control of the document follows GitHub procedures, with commits reviewed by coordinators. These coordinators are currently members of WGFAST: Tim Ryan, Gavin Macaulay, Erin LaBrecque, and Hassan Moustahfid. The dynamic nature of this document is fairly new to ICES and WGFAST is working with the ICES Secretariat on how to maintain the highest level of quality control in the document, while retaining the ability to continually evolve.

2.7 WGAcousticGov

Ciaran O'Donnell (chair of WGAcousticGov) gave an introduction to WGAcousticGov– Working Group on the Acoustic Trawl Data Portal Governance. The aim of WGAcousticGov is to establish a governance framework for the ICES Acoustic Trawl Data portal. This portal will provide links among acoustic and trawl data with the goal of improving access and discovery of these data. As data portal users and endpoint data users, your input into the development of the portal is critical. Acoustic survey planning group and assessment working group chairs will be involved and/or will nominate members to participate in the governance WG. The group will meet through short online quarterly meetings with one physical meeting annually, should it be required.

2.8 Acoustic Backscattering Models

Sven Gastauer led a discussion on developing an effort to improve our understanding of the acoustic scattering properties of marine organisms, with special emphasis on broadband and the influence of behaviour and physiological and anatomical conditions of organisms.

With the emergence of broadband technology as a standard sampling tool, processing and interpretation of acoustic data need a better understanding of the sound-scattering properties of marine organisms including acoustic impedance (dependent on species, location, condition, life cycle stage etc.) and behaviour (including orientation, depth dependence, etc.). Through the use of modelling, we can work towards an improved understanding of the scattering properties of marine organisms, leading to improved inversion methods and ultimately improved abundance and biomass estimates. With the potential of improved species identification and sizing, this would also work towards a reduction of needed biological samples.

WGFAST decided to propose a workshop to be held in 2021 in conjunction with the WGFAST meeting in Bergen, Norway. Michael Jech and Sven Gastauer developed an "Expert Group Meeting Resolution (Category 2)" and a new ToR to WGFAST and submitted to ICES secretariat.

2.9 Sonar-netCDF4 Data Format

Laurent Berger provided an overview of the Sonar-netCDF4 open data format effort that has been ongoing through WGFAST. The goal of this effort is to have a standardized open data format for unambiguous quantitative use of backscatter data for a large number of scientific sonar systems. These data include raw backscatter data and metadata for sonar systems and platforms, gridded (integrated) backscatter data, interpreted (scrutinized) backscatter data, and processed manufacturer data such as bathymetry or current velocities from Acoustic Doppler Current Profilers (ADCPs).

Version 1 was published in 2018 as an ICES Cooperative Research Report (Macaulay, G. and Pena, H. (Eds). 2018. The SONAR-netCDF4 convention for sonar data, Version 1.0, ICES Cooperative Research Report #341, 38p.), which supported only omnidirectional sonar systems. Current and future efforts include developing support for echosounders, multibeam, and ADCP systems. The expectation is that a common data format will expedite application of artificial intelligence and machine learning methods on acoustic data stored locally and in the cloud. Currently LSSS, MOVIES3D, and GLOBE processing software packages support Sonar-netCDF4 format, and Echoview is currently developing modules.

In addition to the scientific community, key partners will be the manufacturers and developers of scientific acoustic systems. Several manufacturers have agreed to contribute to the effort by providing data in Sonar-netCDF4 format (e.g. Kongsberg/Simrad, Furuno, and ASL).

Development and dissemination of documentation and software is on the ICES GitHub site: https://github.com/ices-publications/SONAR-netCDF4. A link to this effort will be placed on the WGFAST website. Gavin Macaulay is the lead on this effort.

2.10 Open-Source Software

Wu-Jung Lee provided an introduction to Echopype, which is an open-source Python software package built to enhance interoperability and scalability of fisheries acoustic data (https://echopype.readthedocs.io). Echopype converts raw data files from different echosounders to an interoperable format consistent with the ICES Sonar-netCDF4 convention, and performs all subsequent computation in the converted format that allows random access and is suitable for processing at scale on the cloud. The package currently supports conversion and calibration for data from EK60 and AZFP echosounders, and will soon supports EK80 data. This is an open-source project, because we believe it is important for scientists to look "under the hood" for all algorithms and collaborate as a community. Echopype is at the stage of incorporating more analysis tools and welcomes input from the community.

This presentation led to a broader discussion of open-source software for processing, analysing, and visualizing fisheries acoustics data. There are a number of ongoing efforts to develop and implement open-source software within and outside WGFAST. WGFAST agreed to compile a list of these efforts and post this list to the WGFAST GitHub site, https://github.com/ices-eg/wg_WGFAST. The format of this list has been developed in spreadsheet and JSON formats and has been disseminated to WGFAST members for inclusion.

2.11 Artificial Intelligence and Machine Learning

Nils Olav Handegard led a discussion on applications of artificial intelligence (AI) and machine learning (ML) methods with a goal of implementing automated acoustic processing and analysis applications to fisheries acoustic data. Establishing standards for data and annotations to efficiently move automated processing/analysis forward were discussed. This effort should be driven by the community and parallels the evolution of open-source data formats and processing software. Coordination is a key component of implementing AI and ML, and these methods can advance and evolve more efficiently with shared resources across different companies/institutions than through solo individual efforts. Definitions of clearly different stages of processing for fisheries acoustics data, in addition to defining the variables (raw data, derived variables, metadata) need to be developed.

WGFAST decided that a discussion session in conjunction with the WGFAST meeting in 2021 would be a good way to move forward.

3 Next meeting: location and dates

The next meeting of WGFAST is scheduled for 19-23 April 2021 in Bergen, Norway. The meeting is planned to be joint with WGFTFB.

4 Science Highlight

Long gone are the days when echosounders recorded data on paper charts and analogue tape recorders or were only displayed for a fleeting moment on a monitor. Modern day acoustic instruments can collect data 24/7, 365 days a year for multiple years at astonishing spatial and temporal resolutions. In addition, fisheries institutions can now measure their acoustic time-series in decades. These data provide unprecedented observations of the physical, biological, and geological environments. These data are potentially a boon to ecosystem and stock assessment scientists, but this abundance of data comes with costs, and those costs include storage, access and discoverability, processing and analysis, and interpretation. How does one find data that may be of interest, read those data, process and analyse those data, to ultimately interpret those data in a biologically or ecologically meaningful context? WGFAST has been a leader in the international fisheries acoustic community and continues to adapt to meet the community's needs. "Big" data is one of the next steps in the evolution of fisheries acoustics.

As an example, over 125 TB of raw fisheries acoustic data are stewarded and freely accessible to the world through the NOAA water column sonar archive. To facilitate immediate access and processing "in the cloud", archived data will be hosted on an Amazon Web Services (AWS) S3 bucket for free until 2021 through the AWS Public Dataset Program. A community-led effort to develop open data formats (e.g. Sonar-netCDF4) and open-source software is forging ahead to read, process, and analyse acoustic data. These data provide opportunities to study marine ecosystems over a much broader spectrum of spatio-temporal scales than was previously possible. The advent of open source formats and software allows access of these data to a much broader community – these data are now "out in the sunlight" for all to visualize and apply advanced methods such as artificial intelligence (AI) and machine learning (ML).

With unsupervised access comes the challenge of correctly using and interpreting these data. WGFAST can take a leadership role in facilitating access, discovery, and analysis, and providing authority to help ensure correct interpretation of these data. "Data" is the next step in the evolution of WGFAST, where it will continue to be an authoritative voice in developing and evaluating new technologies, but will expand its role to promote use of these data for ecosystem research, monitoring, and management.

This science highlight addresses the ICES science priorities: ecosystem science, emerging techniques and technologies, and conservation and management science. This will be an international effort.

Annex 1: List of participants

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Because of the remote meeting, we only have the participants Webex login name and their e-mail address for some participants.

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Annex 2: Resolutions

2019/FT/EOSG09 A **Working Group on Fisheries Acoustics, Science and Technology** (WGFAST), chaired by J. Michael Jech*, USA, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2020	22 April	By correspondence	Interim report by 22 May 2020 to ACOM-SCICOM	Michael Jech takes over as chair
Year 2021	19-23 April	Bergen, Norway	Interim report by 30 June 2021 to ACOM-SCICOM	
Year 2022	TBD	TBD	Final report by 30 June 2022 to ACOM-SCICOM	

ToR descriptors[1]

ToR	Description	Background	Science plan codes	Duration	Expected Deliverables
a	Collate information on acoustic related research and surveys, and interactions with ecosystem and assessment expert groups.	a) Science Requirements b) Advisory Requirements A summary of the information will be presented in the final report	3.1, 3.2, 3.4	3	
b	Review presented recent work within the topics: "Acoustic methods to characterize populations, ecosystems, habitat, and behaviour"; "Acoustic characterization of marine organisms"; and "Emerging technologies, methodologies, and protocols". Provide guidance by identifying: (1) where training opportunities could be developed; and (2) gaps in knowledge and challenges that should be prioritized by the community.	Create a venue for informing the group members on recent activities and seeking input to further development. An overview of the different contributions and guidance will be presented in the annual report	3.3, 4.1, 4.4	1, 2, 3	

c	Organize a conference session on integrating fisheries acoustics with ecosystem assessment and monitoring at an international scientific meeting such as ASC.		3.1, 3.2, 4.1	2 or 3	
d	Develop, and maintain acoustic metadata and data format conventions and coordinate with acoustic survey groups.	Data format conventions for acoustic metadata and data are required for efficient data interchange and processing of acoustic data, but are lacking in the fisheries acoustics field. CRR 341 (2018) and SISP 4 (2016) have partially addressed this need, but further types of data and acoustic equipment need to be supported.	3.2, 3.5, 4.2	1, 2, 3	Updated metadata convention publication (new guide/handbook series) Revised sonar-netcdf4 convention publication that includes echosounder data (new guide/handbook series
e	Develop and recommend procedures for collecting and processing quality acoustic data in inclement weather.	Acoustic data are collected from a variety of vessels that respond to inclement weather in diverse ways. Procedures are needed to provide quality control for data collected in inclement weather to stock assessment.	3.3, 3.6	1	CRR; recommendations on methodology improvements to acoustic survey coordination groups to implement on surveys and update SISPs

Summary of the Work Plan

Year 1	Produce the annual overview of recent developments within the field. Produce an ICES CRR recommending procedures for collecting and processing quality acoustic data in inclement weather. Develop and maintain metadata and acoustic data formats.
Year 2	Produce the annual overview of recent developments within the field. Propose a conference session at an international scientific meeting. Develop and maintain metadata and acoustic data formats.
Year 3	Produce the annual overview of recent developments within the field. Collate information on acoustic related research and surveys. Develop and maintain metadata and acoustic data formats. Publish new guides with updated metadata convention and revised sonar-netcdf4 convention publication that includes echosounder data.

Supporting information

Priority	Fisheries acoustics and complementary technologies provide the necessary tools and methods to implement the ecosystem approach to fisheries management within ICES and research into their application and further development is vital.
Resource requirements	No new resources will be required. Having overlaps with the other meetings of the Working, Planning, Study and Topic Groups increases efficiency and reduces travel costs.
Participants	The Group is normally attended by some 60-100 members and guests.
Secretariat facilities	None.
Financial	No financial implications.

Linkages to ACOM and groups under ACOM	Stock assessment groups using acoustic abundance indices.
Linkages to other committees or groups	The work in this group is closely aligned with complementary work in the FTFB Working Group. The work is of direct relevance to a number of data collection and coordination groups within EOSG (e.g. WGIPS, WGBITS, WGISUR)
Linkages to other organizations	The work of this group is closely aligned with similar work in FAO, the Acoustical Society of America, the South Pacific Regional Fisheries Management Organization, the Commission for the Conservation of Antarctic Marine Living Resources, and the American Fisheries Society.