

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

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Volume 5 | Issue 90

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i Executive summary

The WGFAST meeting in 2023 was a mid-day business meeting, following the ICES Fisheries and Plankton Acoustics Symposium: “From Echosounder to the cloud. Transforming Acoustic Data to Information” which brought together 150 participants from 26 countries. The Symposium was organized around four theme sessions: Organism Detection: Models, Measures, and Classification; Advancements in Acoustic Devices, Platforms, and Combined Technologies; Data Integration: Analytics; and Data Integration: Application to Ecosystem, Conservation, and Society. Use of various autonomous platforms and machine learning appear in large expansion, large-scale ecosystem studies are well represented, and scattering modelling is still very much in evidence. The impact of acquisition parameters or sampling strategies on the quality of results is still being studied. Three keynote speakers were invited, who provided their view about: 1/the boom of offshore wind development in the United States and its potential impact on fisheries and the ecosystem; 2/the ecosystem approach to living marine resource management; 3/the effects of climate change and fishing on the ecosystem and the human dimension of managing fisheries. They provided guidance on what information is needed to manage ecosystems for resource utilization or other societal needs of aquatic environments where advanced technologies can provide information.

The WGFAST meeting itself focused on updates on data and metadata conventions, on shared processing and modelling open tools. Several needs were highlighted: consistency of underwater-acoustics terminology used by the WGFAST community with international standards; to agree on a methodology for evaluating Sound Exposure Level (SEL) for marine mammals, aiming at quantify and mitigate risk for animals; to have a review of fisheries acoustics training courses. The development of large-scale studies leads to encouragement to fill in spatial and temporal coverage of high seas acoustics databases worldwide.

ii Expert group information

Expert group name	Working Group on Fisheries Acoustics, Science and Technology (WGFAST)
Expert group cycle	Multiannual fixed term
Year cycle started	2023
Reporting year in cycle	1/3
Chair	Anne Lebourges-Dhaussy, France
Meeting venue and date	31 March 2023, Portland, USA (47 participants)

1 Terms of reference (ToRs)

1.1 ToR descriptors (year 1/3)

ToR	ToR Description	Progress in relation to ToR	Status of term of reference
c	Promote data dissemination within ICES acoustic survey group and beyond by developing and maintaining standardized and open acoustic data and metadata conventions (e.g. AcMETA data conventions and SONAR-netCDF4) and maintain a list/overview of open source data processing tools	<p>Updated metadata convention publication is available on ICES Library Publication GitHub repository. Update of mailing list of the TG-AcMETA data conventions will be made.</p> <p>Updated SONAR-netCDF4 convention publication that includes echosounder data on ICES Library Publication GitHub repository. Discussions on some simplifications of the required informations for gridded data has raised. A deadline will be proposed to amend the convention. Data format convention modifications may cause difficulties for data processing open-source tools. This point will be discussed online on GitHub and may be furthered discussed during a workshop organized at next WGFAST meeting.</p> <p>Updated list of open-source efforts on WGFAST GitHub site has been provided.</p>	on track
e	Review the state-of-the-art in monitoring offshore wind development areas using advanced instrumentation and platforms.	A keynote on that subject during the symposium and several presentations on the industrialization of the sea and the monitoring of these areas. This topic will remain highlighted for next years.	on track

1.2 Summary of the Work Plan (year 1/3)

YEAR 1	Convene an international symposium. Produce an annual overview of recent developments within the field. Maintain a metadata convention, open-source data formats, and a comprehensive list of open-source data processing and analysis efforts.
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2 Report on Terms of Reference

2.1 ToR c)

Promote data dissemination within ICES acoustic survey group and beyond:

- The AcMeta convention is now available on the ICES GitHub site: <https://github.com/ices-publications/AcMeta>. Erin Labrecque is chair for this task.
- SONAR-netCDF4 convention is available on the ICES Library Publication GitHub repository (incharge: Nils Olav Handegard, Laurent Berger, and Gavin Macaulay). While formal writing is necessary to avoid notational ambiguities, possible simplifications for gridded data are discussed to facilitate the conversion to this format of data that for example do not have all the required metadata. The connection with data processing software or open sources must be close at hand, to avoid problems of compatibilities. This point will be discussed online on GitHub and may be furthered discussed during a workshop organized at next WGFAST meeting.

Updated list of Acoustic Backscatter Modelling tools (Sven Gastauer)

Boundary Element Methods

Coupled BEM:

https://github.com/elavia/coupled_bem_acoustic

Ref.: Gonzalez, J. D., Lavia, E. F., Blanc, S., Maas, M., & Madirolas, A. (2020). Boundary element method to analyze acoustic scattering from a coupled swimbladder-fish body configuration. *Journal of Sound and Vibration*, 486, 115609.

BEM++

<https://bempp.com/>

Ref.: T. Betcke & M. W. Scroggs. Bempp-cl: A fast Python based just-in-time compiling boundary element library, *Journal of Open Source Software* 6(59) (2021) 2879. doi.org/10.21105/joss.02879

Distorted wave Born approximation (DWBA) Implementations

ZooScatR Circular Shape elements:

<https://github.com/AustralianAntarcticDivision/ZooScatR>

Ref.: Gastauer, S., Chu, D., & Cox, M. J. (2019). ZooScatR—An R package for modelling the scattering properties of weak scattering targets using the distorted wave Born approximation. *The Journal of the Acoustical Society of America*, 145(1), EL102-EL108.

Stochastic Phase Compensated (S)DWBA:

CCAMLR model for Antarctic krill (Matlab): https://github.com/ccamlr/SDWBA_TS/tree/master/SDWBApackage

Julia implementation: <https://github.com/EIOceanografo/SDWBA.jl>

Ref.: Conti, S. G., & Demer, D. A. (2006). Improved parameterization of the SDWBA for estimating krill target strength. *ICES Journal of Marine Science*, 63(5), 928-935.

3D Phase Tracking (PT)DWBA:

<https://github.com/gavinmacaulay/FishAcoustics/blob/main/dwba/dwba.py>

Ref.: Jones, B. A., Lavery, A. C., & Stanton, T. K. (2009). Use of the distorted wave Born

approximation to predict scattering by inhomogeneous objects: Application to squid. *The Journal of the Acoustical Society of America*, 125(1), 73-88.

3D Tetrahedron DWBA

<https://cran.r-project.org/web/packages/tetrascatt/index.html>

Kirchhoff Ray Mode Model:

<https://github.com/SvenGastauer/KRMr>

Ref.: Clay, C. S., & Horne, J. K. (1994). Acoustic models of fish: the Atlantic cod (*Gadus morhua*). *The Journal of the Acoustical Society of America*, 96(3), 1661-1668.

Update about echopype package (Wu-Jung Lee):

Link to the package: <https://github.com/OSOceanAcoustics/echopype>

And to the documentation: <https://echopype.readthedocs.io/en/stable/>

Other packages in earlier development stages:

- echoshader: <https://github.com/OSOceanAcoustics/echoshader> (visualization)
- echoregions: <https://github.com/OSOceanAcoustics/echoregions> (interfacing echogram annotations from Echoview or ML predictions)
- echoflow: <https://github.com/OSOceanAcoustics/echoshader>

The EchoPro package currently at <https://github.com/uw-echospace/EchoPro>

2.2 ToR e)

Review the state-of-the-art in monitoring offshore wind development areas using advanced instrumentation and platforms.

A keynote has been provided during the symposium on that subject and several presentations addressed not only the issue of offshore wind development areas, but more generally the industrialization of the sea and the monitoring of these areas with the development of autonomous platforms where accessibility is limited. Papers from this topic will be published as part of the symposium proceedings in the ICES Journal of Marine Science if accepted. This topic will remain highlighted for next years.

2.3 Complementary points

Facing the increasing complexity and quantity of acoustic data, machine learning approaches are more extensively used. A session “Processing and interpreting big data using machine learning: Acoustic, optic, and other observations in marine environments” was co-convened at the 2022 ICES ASC by WGMLEARN and WGFAS T (Nils Olav Handegard for WGFAS T).

The comparison of underwater-acoustics terminology used by the WGFAS T community with international standards shows that there are still different definitions of basic parameters that must be clarified. Concertation could be done with passive acoustics community, for which WGFAS T have increasing interest. It may be a huge task, considering the entire terminology is involved (Toby Jarvis).

It is necessary to produce a report on fishery surveys in regards of noise risks for marine mammals (chairs: J. Warren & L. McGarry) to agree on a methodology for evaluating Sound Exposure

Level (SEL) for marine mammals based on the settings used for acoustic equipment during surveys (frequencies, levels, directivity, ping rate, speed, ...), aiming at quantify and mitigate risk for animals and to have the authorizations to conduct surveys at sea.

WGFAST is solicited by the WGFTFB for a common meeting in 2025.

3 Symposium “From Echosounders to the Cloud: Transforming Acoustic Data to Information”

Venue and dates: Portland, Maine, USA, 27–30 March 2023

Conveners: Michael Jech, Anne Lebourges-Dhaussy, Gayle Zydlewski, Justin Stevens

Hosts: NOAA/NEFSC, Woods Hole, USA and UMaine Sea Grant, Orono, USA

The symposium was organized on four theme sessions (see https://www.ices.dk/events/symposia/Pages/Echosounders_to_Cloud.aspx or the ICES report of the Symposium – in prep).

Scientific Steering Committee

- Organism detection: models, measures, and classification - Babak Khodabandelloo, Gavin Macaulay, Naig LeBouffant, Sven Gastauer
- Advancements in acoustic devices, platforms, and combined technologies - Haley Viehmann, Tim Ryan, Joe Warren, Alina Madita Wiczorek
- Data Integration: Analytics - Wu-Jung Lee, Nils Olav Handegard, Carrie Wall, Patrick Sullivan
- Data Integration: Application to ecosystem, conservation, and society - Alejandro Ariza, Aurore Receveur, Ndagoue Diogoul, Serdar Sakinan

Organism Detection: Models, Measures, and Classification

Presentations on the effects of model parameterization on Acoustic scattering models outputs were investigated in detail, new species were modelled, and the acoustic method was extended to ecosystems and species where it has not previously been used, from zooplankton to mesopelagic communities to the largest fishes. Target strength (TS) of several new species at different length or life stages were presented from both *in-situ* and *ex-situ* environments. The impact of target orientation, depth, and changes in TS due to natural behaviour or physiology was also discussed. Comparisons between scatter model results and existing target strength relationships that bridge the traditional way of estimating animal length to new and innovative methods were presented. Machine learning and artificial intelligence methods addressing acoustic target classification are the future for analysing acoustic data as corroborated by inclusion in several presentations. The influence of different biological validation methods on classification was discussed, and sampling uncertainties for different surveys were presented. Broadband signals and data are now ubiquitous and several presentations highlighted progress in the processing techniques of broadband signals.

Advancements in Acoustic Devices, Platforms, and Combined Technologies

Presentations highlighted how new and existing technologies can be utilized to address familiar and arising challenges in fisheries acoustic research. One of these challenges is the differentiation of organisms within multispecies aggregations, as is often found in deep scattering layers. Environmental DNA sampling and acoustic observations from submersible broadband echosounders

are promising tools for addressing this challenge. Presentations included examples of emerging benefits of these tools, as well as discussion of potential issues, such as: organism identification, interpretation of environmental DNA signals, and appropriate calibrations for submersible broadband echosounders.

Another widely addressed topic was how unmanned submersibles and surface vehicles can be used to augment and, in part, replace traditional (hull-mounted) methods for hydroacoustic sampling. The use of these remote platforms was mainly driven by specific research questions, including increased survey coverage, targeting difficult-to-survey areas such as in and around offshore wind farms, and increasing the range, resolution, or quality of survey data.

Outside these overarching topics, presentations included insights on the use of seafloor backscatter for single beam echosounder calibration, the use of multibeam data to elucidate fish positioning, light avoidance by fish and other organisms, and monitoring gas bubbles from CO₂ injection sites.

Data Integration: Analytics

Open-source software, data preparation, and data accessibility are the critical first steps towards formatting and collating data so that they can be used in analytical models. Approaches to extract signal from noise are necessary for ensuring quality control of data. Application of artificial intelligence and machine learning models and methods are at the forefront of “big data” analytics. The importance of understanding the impacts of uncertainty, errors, noise and sampling methods was highlighted from a methodology perspective as well as when implementing these analytical methods and results in population and ecosystem assessments.

This session contributes to an essential intermediary step transforming acoustic data to information.

Data Integration: Application to Ecosystem, Conservation, and Society

Large-scale distribution patterns of micronekton using acoustic surveys were important topics in this session. Interesting observations about the lack of fish with resonance and gas-filled swimbladders in high-latitude systems and the contribution of siphonophore resonance to global acoustic backscatter was highlighted. Publicly available and discoverable acoustic databases were addressed as a vital need for the community to share data. Moored or drifting echosounders, and autonomous vehicles that can be used to monitor ecosystems and the impact of human intervention on marine fauna were excellent examples of the application of new technology to address scientific questions. Stock assessment of small pelagic fish and assessment of tuna species were examples of management and conservation of living marine resources. Observations of individual and group behavior using acoustics and observations of reef fish using dual optic-acoustic systems or imaging sonar demonstrated the utility of acoustical and optical methods for shallow-water and reef environments.

Annex 1: List of participants

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Annex 2: Resolution

2022/FT/DSTSG01 A Working Group on Fisheries Acoustics, Science and Technology (WGFAS T), chaired by Anne Lebourges-Dhaussy, France, will work on ToRs and generate deliverables as listed in the Table below.

	MEETING DATES	VENUE	REPORTING DETAILS	COMMENTS (CHANGE IN CHAIR, ETC.)
Year 2023	31 March	Portland, Maine, USA	Interim report by TBD to ACOM_SCICOM	Anne Lebourges-Dhaussy takes over as chair
Year 2024	8-12 April	Brest, France	Interim report by TBD to ACOM_SCICOM	
Year 2025	TBD	TBD	Final report by 30 May to ACOM_SCICOM	

ToR descriptors

TO R	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, 4.1	3	Tables providing members of the ICES community with data and information about operational acoustic surveys and research, and connections among WGs.
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 reports. Year 1 will be part of ToR 3 (symposium)	4.2, 4.3, 4.4	2,3	Collated abstracts describing the state-of-the-art research by members of WGFAS T provided in the annual (e-evaluation) reports.

c	Promote data dissemination within ICES acoustic survey group and beyond by developing and maintaining standardized and open acoustic data and metadata conventions (e.g. SONAR-netCDF4 and AcMETA data conventions) and maintain a list/overview of open source data processing tools	This ToR fills the need to develop and maintain open data conventions and guidelines for acoustic data to be accessible and available to the broader scientific community. These conventions require coordination with sonar manufacturers, software developers, and the scientific community to implement acoustic data conventions and establish standard processing chains from raw data to interpreted data using automation.	3.1, 3.3, 4.2	1, 2, 3	Updated metadata convention publication on ICES Library Publication GitHub repository. Updated SONAR-netCDF4 convention publication that includes echosounder data on ICES Library Publication GitHub repository. Updated list of open-source efforts on WGFASST GitHub site.
e	Review the state-of-the-art in monitoring offshore wind development areas using advanced instrumentation and platforms.	A theme session will be organized as part of the Fisheries Acoustics Symposium (ToR d) dedicated to monitoring offshore wind development (i.e. offshore wind farms) using advanced acoustic instrumentation (e.g. wideband echosounders and sonars) and remotely operated and autonomous platforms. A keynote speaker will be selected to address scientific and sociological impacts of offshore wind.	2.1, 3.1, 3.2	1	Selected papers from this theme session will be published as part of the symposium proceedings in the ICES Journal of Marine Science.
f	Collate resources that document operational settings, parameters, and characteristics of echosounders and sonars used during fisheries acoustic's surveys and research.	Marine mammal interactions, marine protected areas, environmental impact statements interactions will require permitting of echosounders and sonars. More countries are requiring scientific acoustic instrumentation to have permits or environmental impact evaluations. WGFASST will develop guidelines to assist with generating the required information needed for operational permits.	2.1, 3.1, 4.1	3	Report that will reside on the ICES Library Publication GitHub repository.

g	Review the underwater-acoustics terminology used by the WGFAS community and how it relates to international standards.	The underwater-acoustics terminology used by the WGFAS community has evolved somewhat separately to international standards. WGFAS will evaluate adoption of a common language, which can facilitate communication among instrument manufacturers, software developers, and data scientists, provide accurate comprehension of the data, and promote utility of the data for resource conservation.	3.2, 3.5, 4.2	3	Recommendations provided in the WGFAS science report..
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Summary of the Work Plan

Year 1	Convene an international symposium. Produce an annual overview of recent developments within the field. Maintain a metadata convention, open-source data formats, and a comprehensive list of open-source data processing and analysis efforts.
Year 2	Produce a symposium proceedings. Produce an annual overview of recent developments within the field. Maintain a metadata convention, open-source data formats, and a comprehensive list of open-source data processing and analysis efforts.
Year 3	Produce the annual overview of recent developments within the field. Collate information on acoustic related research and surveys. Maintain a metadata convention, open-source data formats, and a comprehensive list of open-source data processing and analysis efforts. Produce reports that document and review operational setting, parameters, and characteristics of echosounders and sonars, and underwater acoustic symbols and definitions.

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 for annual meetings and operations.
Participants	The Group is normally attended by some 60–100 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and group 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, WGBIFS, WGACEGG, WGIDEEPS) and HAPISG (e.g. WGOORE, WGOWDF), and to advanced statistical and analytical methods (e.g. WGMLEARN).
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 Western Indian Ocean Marine Science Association, the Commission for the Conservation of Antarctic Marine Living Resources, and the American Fisheries Society.