

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

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Editors

Richard L. O' Driscoll

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i Executive summary

The ICES Working Group on Fisheries Acoustics, Science and Technology (WGFAST) is the major international forum where individuals working in fisheries acoustics network to discuss ongoing developments in the technique. As such, it is highly successful, attracting 93 participants from 21 countries to its 2019 meeting in Galway, Ireland from 29 April – 2 May.

Highlights

The major themes addressed during the WGFAST meeting included:

- Behaviour;
- Acoustic properties of marine organisms;
- Emerging technologies, methodologies, and protocols;
- Applications of acoustic methods to characterize ecosystems.

A separate session was held for each theme, where the participants first presented the latest results of their work, followed by a discussion. The abstracts and discussion summaries are given in the report. The contributions highlighted the wide range of applications of acoustics for ecosystem characterization and monitoring, as well as for abundance surveys. Advancing acoustic technology and alternative sampling platforms (e.g. autonomous vehicles, ocean observatories) have led to increases in the volume of acoustic data being collected. This has created opportunities for wider ecosystem research, but also challenges for data processing and storage.

Several presentations highlighted research and increasing applications of acoustic wideband technologies. WGFAST organised training courses on 'Principles and Methods of Broadband/Wideband Technologies: Application to fisheries acoustics' in 2017 and 2018, with another planned in December 2019. Wideband systems are expected to replace the current standard narrowband scientific echosounders, and recent research quantified the impact of this change on abundance surveys.

There is increasing interest in using acoustics to characterize and monitor other ecosystem components, particularly mesopelagic organisms. Mesopelagic resources are large, relatively poorly known, and there is considerable interest in commercial exploitation. Presentations highlighted challenges for acoustics, and the need to apply multiple complementary technologies (acoustics, optics, net sampling) to improve our understanding. A workshop on the development of practical survey methods for measurements and monitoring in the mesopelagic zone (WKMesoMeth) was held in conjunction with the 2019 WGFAST meeting.

A joint session was held with the South Pacific Regional Fisheries Management Organization (SPRFMO) Habitat Modelling Working Group during the WGFAST meeting on 30 April 2019. The Ambassador of Peru to Ireland, Ms Ana Sánchez, visited during the meeting.

WGFAST co-chaired theme session J at the 2018 ICES Annual Science Conference on "Survey data products for stock and ecosystem assessments: challenges and future directions". This session had 24 oral presentations and 8 posters and was attended by about 80 people. Key themes were survey design and the use of survey products in stock assessment. The group concluded that survey scientists and stock assessment modellers need to work in close collaboration to ensure correct model specifications and interpretations accounting for survey design and methodology. The second meeting of the topic group on 'Collecting Quality Underwater Acoustic Data in Inclement Weather' (TG-QUAD) was held in conjunction with the 2019 WGFAST meeting and good progress was made towards production of a Cooperative Research Reports (CRR).

ii Expert group information

Expert group name	Working group Fisheries Acoustics, Science and Technology (WGFAST)
Expert group cycle	Multiannual fixed term
Year cycle started	2017
Reporting year in cycle	3/3
Chair	Richard O'Driscoll, New Zealand
Meeting venues and dates	4-7 April 2017, Nelson, New Zealand (63 participants)
	20-23 March 2018, Seattle, USA (91 participants)
	29 April-2 May 2019, Galway, Ireland (93 participants)

Terms of Reference a) – g)

ToR	Description	Background	Duration	Expected Deliverables
a	Collate information on acoustic related research and surveys by Country represented in WGFASST.	a) Science Requirements b) Advisory Requirements	3	Filled in template for WGFASST report
b	Present recent work within the topics “Applications of acoustic methods to characterize ecosystems”, “Acoustic properties of marine organisms”, “Behaviour”, and “Emerging technologies, methodologies, and protocols”.	Create a venue for informing the group members on recent activities and seeking input to further development. An overview of the different contributions will be presented in the annual report	1, 2, 3	Report
c	Organize training session on use of acoustics for biomass estimation	Introductory course on use of acoustic for abundance estimation, including survey design and data analysis	1	ICES training course
d	Provide guidance for calibrating echosounders on fishing vessels (topic group)	Fishing vessels increasingly collect acoustic data. To allow quantitative use of these data, suitable calibration procedures for fishing conditions are needed	1 or 2	Report
e	Organize joint sessions at ICES ASC		2 or 3	Topic session at ICES ASC
f	Define a data format for omni fisheries sonars.	Increasingly use of omni fisheries sonars in research requires a data format defined by the scientific community. Format definition will involve also software producers and equipment manufacturers.	1, 2	ICES CRR
g	Work towards developing and recommending 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.	2, 3	Review paper(s) and/or CRR; updates of relevant SISP manuals (to be produced in the first year of the next WG cycle)

Recommendations from other groups

Sender of the recommendation	Recommendation	Year
Recommendation from WKQUAD	Compile information on transducer location and vessel trim, and collect vessel motion (pitch, roll, heave) data at a sampling rate of at least twice the frequency of the vessel motion ($<1/2$ the period), i.e. Nyquist sampling rate. A typical rate is 3 Hz.	2017
Recommendation from WKQUAD	Collect meteorological data, e.g. windspeed and direction, swell, sea state, wave height during the surveys.	2017
Recommendation from JFATB	<p>JFATB recommends the development of terms of reference for a joint session of WGFAS T and WGFTFB in April/May of 2020.</p> <p>The Terms of Reference are to be mutually decided by the Working Group Chairs and new joint session chairs. WGFAS T proposes Stéphane Gauthier (Canada) and WGFTFB proposes Michael Pol (USA) as new chairs of JFATB. We recommend that WGFTFB investigate 'improved methods to refine survey gear, and quantify trawl selectivity across a broad range of species and sizes'. This may lead to improved survey estimates of species and size distributions, which is a key source of uncertainty in acoustic-trawl surveys. Survey groups WGIPS, WGBIFS, WGACEGG should be included in planning for this session as establishing survey trawl selectivity is important for these surveys.</p> <p>The joint session should review existing knowledge and recent developments in this area, with a focus on trawls used to sample pelagic organisms, and practical approaches to estimate trawl selectivity. A subset of WGFTFB and WGFAS T members and members of survey groups (WGIPS, WGBIFS, WGACEGG) have expertise that is relevant in this area.</p>	2017
Recommendation from WGIPS	<p>Proposal to undertake a WK to coordinate the development of standardised protocols</p> <p>Aim: To coordinate the development of standardised protocols for the acoustic assessment of resources in the mesopelagic zone.</p> <p>Open ocean acoustic surveys frequently encounter significant biomass within the mesopelagic zone. This zone contains a complex mixture of organisms, visible from acoustic sensors as multi-species scattering layers, DSL (deep scattering layer), diel mixing layers and single species fish schools. Classification of biomass into useful biological groups is no doubt a complex processes, but is nonetheless necessary for reliable measurements. The complexities of such classification are recognised as are the limitations of vessel based acoustic measurements and the collection of biological samples using existing survey trawl designs.</p> <p>Several international surveys coordinated by WGIPS (e.g., IBWSS, IESSNS and IESNS) cover areas where extensive mesopelagic layers are present, providing an opportunity for routine measurement. The recent WKMESO workshop (Workshop on monitoring technologies for the mesopelagic zone) discussed some of the limitations and opportunities afforded from utilising existing survey programs for data collection and developments in wide band acoustics, biological and optical sampling technologies.</p> <p>To improve the understanding within WGIPS it is proposed that a workshop is undertaken under guidance of WGFAS T to bring together experts</p>	2018

in the field on biology and acoustic properties of assemblages within the DSL. The ubiquitous nature of DSL and its understanding may appeal to the wider community.

Summary of work plan

Year	Summary
Year 1	Produce the annual overview of recent developments within the field; organize training session on use of acoustics for biomass estimation; provide guidance for calibrating echosounders on fishing vessels; provide guidance for calibrating echosounders on fishing vessels; collate information on acoustic related research and surveys by country to which WGFASST contributes.
Year 2	Produce the annual overview of recent developments within the field; provide guidance for calibrating echosounders on fishing vessels; collate information on acoustic related research and surveys by country to which WGFASST contributes
Year 3	Produce the annual overview of recent developments within the field; collate information on acoustic related research and surveys; collate information on acoustic related research and surveys by country to which WGFASST contributes.

1 List of Outcomes and Achievements of the WG during 3-year term

Publications:

- Demer, D. A., Andersen, L. N., Bassett, C., Berger, L., Chu, D., Condiotty, J., Cutter, G., R., *et al.* 2017. 2016 USA–Norway EK80 Workshop Report: Evaluation of a wideband echosounder for fisheries and marine ecosystem science. ICES Cooperative Research Report No. 336. 69 pp. <http://doi.org/10.17895/ices.pub.2318>
- Macaulay, G. and Peña, H. (Eds.). 2018. The SONAR-netCDF4 convention for sonar data, Version 1.0. ICES Cooperative Research Report No. 341. 33 pp. <http://doi.org/10.17895/ices.pub.4392>
- Korneliussen, Rolf J. (Ed.). 2018. Acoustic target classification. ICES Cooperative Research Report No. 344. 104 pp. <http://doi.org/10.17895/ices.pub.4567>

A list of publications by WGFAST members during the current 3-year cycle is given in Annex 5.

Data Portals:

- Processed acoustic and biotic data collected on acoustic trawl surveys in the Northeast Atlantic and Baltic Seas. <http://www.ices.dk/marine-data/data-portals/Pages/acoustic.aspx>
- Raw acoustic data collected on fisheries and research surveys in waters throughout the U.S. and internationally are archived at the NOAA National Centers for Environmental Information. The main data contributor is the NOAA National Marine Fisheries Service. https://maps.ngdc.noaa.gov/viewers/water_column_sonar/

Activities initiated by WGFAST:

- ICES ASC session on “Survey data products for stock and ecosystem assessments: challenges and future directions” was held in Hamburg in September 2018. This session had 24 oral presentations and 8 posters and was attended by about 80 people. Key themes were survey design and the use of survey products in stock assessment. The group concluded that survey scientists and stock assessment modellers need to work in close collaboration to ensure correct model specifications and interpretations accounting for survey design and methodology.
- Training courses on 'Principles and Methods of Broadband/Wideband Technologies: Application to fisheries acoustics' were held in Bergen, Norway, in December 2017 and 2018. The 2017 course was organized by ICES with 20 participants from 13 countries. The 2018 course was an Institute of Marine Research (IMR) academy course with 20 participants from 5 countries. Due to high demand, another ICES course will be run in December 2019
- ICES Training course on 'Introduction to abundance estimation from fisheries acoustic surveys' (ICES Secretariat, Copenhagen, Denmark, June 2017). There were 25 participants from 14 countries.

- Topic group on 'Collecting Quality Underwater Acoustic Data in Inclement Weather' (TGQUAD) met in Seattle, USA, 17-19 March 2018 and in Galway, Ireland from 3-5 May 2019. In 2019, there were 26 participants from 11 countries. The group established a framework for developing metrics and indicators of degraded data quality due to inclement weather. This framework will help direct data investigations by focusing analyses on the effects of inclement weather on abundance estimates, and developing and testing metrics that indicate degraded data quality and ultimately increased bias in abundance estimates. The group will provide recommendations to other ICES expert groups and produce an ICES Cooperative Research Report.
- A workshop on the development of practical survey methods for measurements and monitoring in the mesopelagic zone (WKMesoMeth) was held in Galway, Ireland on 27-28 April 2019, before WGFAST. There were 33 participants from 15 countries, with 18 presentations.
- USA-Norway EK80 Workshop. An international Workshop was held in La Jolla, California, USA, 6-23 September 2016. This was attended by 18 participants from USA, Norway, France, and Australia. ICES Cooperative Research Report No. 336 outlining the results of this workshop has been published.
- ICES WGFAST Topic Group on 'Defining a data format for omni fisheries sonars' published a Cooperative Research Report describing a netCDF4 file format.
- TG-Meta continues to meet alongside WGFAST, with the most recent meeting on the afternoon of 2 May involving 10 participants from 6 countries, chaired by Tim Ryan (Australia). This group has published and now maintains the ICES SISP publication "A metadata convention for processed acoustic data from active acoustic systems", current version is 1.10 8 <http://www.ices.dk/sites/pub/Publication%20Reports/ICES%20Survey%20Protocols%20%28SISP%29/SISP-4%20A%20metadata%20convention%20for%20processed%20acoustic%20data%20from%20active%20acoustic%20systems.pdf>. The TG-Meta convention has been implemented in the ICES Acoustic trawl database (<http://www.ices.dk/marine-data/data-portals/Pages/acoustic.aspx>). Discussion focussed primarily on development of new attributes for platform types that are not currently supported (e.g. gliders, unmanned vehicles), methods to improve intersessional collaboration and improve publication method ensuring efficient processes and high visibility of the completed document. To this end TGMeta will develop a github repository that will provide version control and multi-user input. Attributes for new platform types will be developed in the github environment via multi-user input and review. As much as possible, TG-Meta will make use of existing controlled vocabulary to ensure compatibility and consistency. An updated metadata document will be submitted to ICES for publication once new platform attributes have been developed and agreed to by participants. Metadata endeavours will be included along with data format conventions in a new terms of reference for 2020–22 (see Annex 2)
- A joint session was held with the South Pacific Regional Fisheries Management Organization (SPRFMO) Habitat Modelling Working Group during the WGFAST meeting on 30 April 2019. This included 7 presentations from scientists from Peru and Chile. The Ambassador of Peru to Ireland, Ms Ana Sánchez, visited during the meeting.

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2 Final report on ToRs and workplan

2.1 Progress and fulfilment by ToR

ToR a Produce a list of papers originating from the community of the WGFASST working group

A list of publications by WGFASST members during the current 3-year cycle is given in Annex 5.

A summary of acoustic related research and surveys by country is given in Annexes 6 and 7.

ToR b Present recent work in fisheries acoustics

The meeting agenda for the 2019 WGFASST meeting is in Annex 3. Abstracts for all work presented in 2019 are found in Annex 4.

Behaviour

There were five presentations. The session focused on how behaviour influences estimates of abundance in acoustic surveys, and presented new technologies to study the behaviour of target species and quantify the associated biases. Presentations addressed the avoidance of mesopelagic organisms to underwater sampling equipment and the use of moored echosounders to study migration of fish stocks and the implications for acoustic surveys.

Fernandes & Scouling showed how behaviour could explain the discrepancies between the assessment results and catches for north east mackerel that led to the discontinuation of the acoustic surveys in the early 2000s. Changes in mean tilt angle of this species could explain a reduction in the mean TS, relative to previous estimates used in the assessment, leading to bias in the assessment. Gauthier & Ens used stationary bottom-mounted echosounders to study temporal dynamics of Pacific hake migration between Californian and Canadian waters and the possible influence of offshore-inshore movements on survey results. Johnsen et al. studied the potential bias of using vessel-mounted echosounders due to vessel avoidance and surface blind zone, by monitoring a shallow night-time layer of herring with four alternative methods/sensors: (i) vessel echosounders, (ii) an echosounder mounted at a silent kayakDrone, (iii) a WBAT on a drifting buoy and (iv) a “phantom” echosounder beam made using a specific mode of the keel-mounted MS70. Kloser et al. used a Profiling Lagrangian Acoustical and Optical System (PLAOS) to study the scattering properties and composition of the organisms in the deep scattering layers. They compared acoustic data from a hull-mounted system to the PLAOS and observed attraction and avoidance reactions of biota at ranges 1-100 m from the probe. Thomas et al. investigated historical acoustical hake data during diel periods from historical survey data, finding consistent changes in backscattering and aggregation depth following survey and before sunset and, hence, implying tilt-, behaviour- and pressure-induced changes in TS of this species.

The session highlighted that behaviour is both a potential source of bias, and a potential source of information, when studying ecosystems. The group discussion emphasised behaviour remains a key topic in fisheries acoustics despite the low number of contributions.

Acoustic properties of marine organisms

There were five presentations. The main topics covered in the session were (1) species discrimination (using narrowband and wideband techniques), (2) target strength measurements, (3) target sizing and (4) the internal acoustic properties or impedance of marine organisms.

There were two talks about the acoustic properties of tuna. Boyra et al. showed the development of methods to discriminate between three tuna species around fish aggregation devices (FADs). Uranga et al. was concerned with the establishment of a TS-L relationship for bluefin tuna using in situ measurements.

Matsukua et al. investigated the sound velocity (h) and density contrast (g) of krill (*E. superba* and *T. macrura*) using an acoustic probe, measuring the time of flight for h and a density bottle setup to estimate g. Estimates of material properties were required to estimate TS for a research survey in Antarctica.

Two presentations focused on broadband acoustics and how this technology can be used for species discrimination and fish sizing, as well as gaining further insights into the internal structure of marine organisms. Dunning et al. showed that low frequency data can be used to discriminate between species and even size classes in certain situations. Further, Kubilius et al. suggested that broadband acoustics has potential to investigate the internal structure of target bodies given the consistent pattern observed on the acoustic spectra within the fish body.

During the discussion, the use and challenges of broadband acoustic signals for target identification was acknowledged by the group. The group agrees that further theoretical studies, paired with in situ and ex situ measurements to further understand the received signal are needed. The effects of acoustic boundaries due to changes in acoustic impedance have to be understood better to allow for an improved interpretation of recorded acoustic broadband signals. Within the discussion the use of omnidirectional sonar as a tool for species identification of target quantification was discussed. While the number of studies analysing this has been limited so far, the usefulness of omnidirectional sonars to estimate abundance and biomass as well as the analysis of behavioural effects, such as vessel avoidance was acknowledged.

Emerging Technologies, Methodologies, and Protocols

There were 26 presentations. Several talks were given on calibration procedures. Unwanted variation in target sphere echoes, particularly at higher frequencies, may be related to use of braided suspension lines (possibly containing air bubbles), as well as and temperature changes on transducers and calibration spheres (Ryan, Berger). The problems presented by calibration of transducers over large depth ranges were revisited (Pearce). The possibility of these effects and recommended practices are given in the recent ICES CRR on calibration procedures. Calibration of commercial sounders on fishing vessels is necessary for quality results but presents some additional difficulties in execution compared with calibration of research vessels (Santivañez-Yuffra).

Novel applications of acoustics may be used to monitor abundance, size, and composition during commercial fishing operations and make fishing decisions to help with harvest, reduce unwanted bycatch, or produce in-season information for fishery management (Espinosa, Pérez-Arjona, Berges, Macaulay, Ariza).

Assessment and assurance of data collection remains an important concern, and new/alternative platforms such as drones, gliders, and buoys may present particular challenges (Bristow). Use of broadband data for classification and the problems of noise monitoring during such data collection were presented (Le Bouffant, Berges). Due to the complexity of broadband processing and additional information available, adaptation and revision of current methods will be needed. Color maps used for data visualization affect our perception of echogram (or other visual) patterns and probably should be tailored to improve interpretation and maximize usefulness (Blackwell).

A number of talks on acoustic assessment of mesopelagic species were presented (Peña, Jech, Proud). This topic is presently a pressing one within and outside ICES, connecting with the recent work by WK-MesoMeth as well. Difficulties in determining size, species composition, relative abundance, and target strength for mesopelagic deep scattering layers produced substantial discrepancies between acoustic and net capture results, will lead to large uncertainties in biomass and abundance estimates at present for these taxonomically and acoustically diverse communities.

The group discussed applications of acoustics to improve fisheries and surveys by reducing bycatch. This is a topic of common topic interest with WGFTFB that can be explored during the planned 2020 joint meeting, e.g., reducing bycatch through technology, length and species selectivity for commercial capture and survey capture. Applications of commercial tools (e.g. tuna buoy) for science, and scientific tools for commercial operations, present continuing opportunities as uses of technology pass back and forth between industry and fisheries science. Perhaps new technologies and new people and ideas will help us with some of the difficult problems presented during the session.

Age-old challenges continue with respect to good acoustics practice. For example, we have good protocols for calibration, but we still experience problems in practice such as unwanted echoes from suspension lines and bubbles, and nonlinearity in amplification with a modern echosounder. Calibration and linear amplification across the dynamic range of the measurements should be assured, and we should deal properly with variability in standard spheres by tracking and verifying their TS (or size and density).

Acoustic assessment of mesopelagic nekton and plankton communities is an emerging/topic. We need to take care with terminology and definitions as we work on this (for example, some terminology differed between some presentations during our session and during WK-MesoMeth). We need to collect the biological information (e.g., size, species, acoustical properties) needed for proper attribution of backscatter to species, which may be very difficult. Acoustic methods and expertise of the WGFAST community are in demand, and are now undertaking very difficult problems, harder than those that this community was founded to address (e.g., acoustic surveys of abundant and commercially important species are likely to be easier than surveys of taxonomically and acoustically diverse mesopelagic communities). Easy answers are not likely to be obtained with other techniques, however, and our methods may present one of several good approaches. The group agreed that we should not get discouraged by the difficulty of the problems and enjoy both incremental and large advances as they are made.

Applications of acoustic methods to characterize ecosystems

A total of 15 talks were given in this session, covering a wide range of applications to characterise ecosystems using acoustic methods. Studies ranged in scale from small Scottish lochs (McGowan-Yallop et al.) to large regional studies (Geoffroy et al.), from hourly (Gonzalez et al.) to annual time-series (Kapelonis et al.), and from sizing single species (Gastauer et al.) to analysing the distribution patterns of large communities (Receveur et al.).

The majority of talks focused on mid-trophic-level species (e.g. small fish, zooplankton etc.) found both in the epipelagic (0-200 m) and mesopelagic (200-1000 m) depth zones using narrow-band (Berges et al.; Reidy et al.; Gonzalez et al.) and/or broadband acoustics (Gastauer et al., McGowan-Yallop et al., Kapelonis et al., Blanluet et al.). Acoustic data were typically combined with CTD profiles (Kapelonis et al.; Geoffroy et al.) and trawl/net samples (Geoffroy et al.; Kapelonis et al.; Blanluet et al.; Escobar-Flores et al.; Receveur et al.; Sakinan et al.), but it was often highlighted that optics/eDNA data could potentially improve species classification methods and/or reduce uncertainty in estimates of species biomass/abundance (Sakinan et al.; Geoffroy et al.).

Machine learning techniques, e.g. supervised (Escobar-Flores et al.; Receveur et al.) and unsupervised learning (Blanluet et al.), geo-statistics (e.g. kriging; Gastauer et al.), and frequency response methods (e.g. dB differencing; LaBrecque et al., Pezacki et al., Gonzalez et al., Geoffroy et al.), were used to categorise species/groups of organisms. Biological features such as schools (Berges et al.) and sound scattering layers (SSLs; Kapelonis et al.; Geoffroy et al.) were identified in echosounder data and summarised using biometrics, describing their size, shape, vertical arrangement (Kapelonis et al.; Receveur et al.) and dynamics (e.g. migration; Kapelonis et al.), to characterise ecosystems. Echo energy was also modelled and linked to environmental drivers (e.g. *chl-a*, Sakinan et al.; sea ice, Gonzalez et al.) to map backscattering intensity in space and time. To convert echo energy to abundance/biomass, some studies used acoustic scattering models (e.g. DWBA and SDWBA models, McGowan-Yallop et al. and Ressler et al.) to predict target strength. Drivers of uncertainty in biomass estimates were also explored including avoidance behaviour (e.g. of krill, Ressler et al.), acoustic properties of organisms and TS model error (Ressler et al.).

Several talks focused on the horizontal and vertical arrangement of prey species and links to predator-prey studies (LaBrecque et al.; Reidy et al.; Receveur et al.). Summary metrics of water-column echo intensity, SSLs and schools (Berges et al.) provide important information for conservation and can support environmental assessments (LaBrecque et al.) e.g. evaluating the impact of methane gas bubble release on surrounding ecosystems (Pezacki et al.). Sakinan et al. identified pteropods as a main source of echo energy in echosounder observations off the East coast of England and Scotland, but did not consider contribution of gas-bladdered zooplankton (e.g. physonects), which Blanluet et al. found to be the main source of echo energy in 38 kHz SSLs in the Bay of Biscay; other possible sources were discussed by the group, such as gas trapped by chain-forming phytoplankton and suspension of gas bubbles in detrital material.

In the discussion, it was emphasised that to characterise ecosystems, acoustic observations alone are not enough, and that other types of observations are needed (e.g. optics, eDNA, trawl samples etc.). It was noted that echosounders, like other survey methods, are both selective and biased, and that present/previous studies typically focused on the dominant scattering groups (e.g. fish). Whilst mixed species assemblages can be difficult to resolve, acoustic data is additive, and therefore it is possible to estimate the biomass of weaker scattering groups. The group also discussed the possibility of linking echosounder observations with ecological models, providing either a means of constraining or assessing the mid-trophic-level components of these models.

However, it is not clear how exactly this could be achieved since modellers typically group organisms in ecosystem models at very coarse taxonomic scales, which would be difficult to replicate using acoustic methods.

South Pacific Regional Fisheries Management Organization (SPRFMO) Habitat Modelling Working Group

There were 7 presentations in this special session.

The use of fishers' acoustic data as a source of environmental information has been considered in the South Pacific Regional Fisheries Management Organization (SPRFMO) since 2009 after an initiative led by WGFASST members. In 2014 a task group on "fishing vessels as scientific platforms" was created by SPRFMO for a duration of 3 years. It produced reports on calibration procedure for acoustic equipment aboard fishing vessels and on target strength (TS) measurements for Chilean jack mackerel (CJM). The task group recommended creation of a working group on the theme of habitat monitoring. The proposal for the creation of the Habitat Monitoring Working Group (HMWG) was approved by the SPRFMO Scientific Committee (SC) during September 2018, assigning the CJM as first study case.

The HMWG will act as a management tool and provider of indicators obtained from the monitoring of the environment. The pieces of information required for such work come from diverse sources: the fishery, the acoustic surveys (scientific and from the fishery), oceanographic and biological surveys, remote sensing data etc. Examples presented in this session showed that this series of data allows construction of descriptive models on the dynamics of CJM habitat (Gerlotto & Yanez, Sepulveda & Alegria, Peraltilla). The contribution of the fishing industry at various levels was acknowledged as essential (Gutierrez & Sepulveda).

The CJM habitat is mostly determined by the trophic interactions within the ecosystem. The groups that contribute most to this in the pelagic environment are the macrozooplankton (e.g. krill), and mesopelagic fish, among which lantern fish (*Vinciguerria lucetia*) is the most important species. In the case of the northern Humboldt Current System some studies on the distribution, behaviour patterns and biology of *V. lucetia* exist (Santivanex-Yuffra & Gutierrez).

As a case example, a description of habitat design and analysis was given for the Peruvian anchovy (Castillo et al.). Apart the expected relationships between the fish and the environment, the plasticity and tolerance of anchovy to changing conditions have been evaluated. Some of the used methods and models could be applied to the CJM.

The variety of data sources and volume of data require techniques and methods to collect, process and analyse data automatically. Some pieces of equipment have been designed and are installed aboard European pelagic trawlers. A device has been developed (Oceanbox) to allow an automation of the different steps involved, from the calibration procedure until data analysis and calculation and results (Pastoor & Ybema).

The discussion concluded that the conditions for developing research on "habitat monitoring" were present (at least for the CJM): the techniques of data collection; the sources of information; the existence of oceanographic and climatic models; the knowledge on the biology of CJM; tools for habitat modelling. Therefore, most of the data and knowledge needed for accomplishing the objectives of the ToR are already available. The next challenge will be to define and extract the pertinent indicators for achieving the main goals (stock management and habitat monitoring) defined in the ToR.

ToR c Organize training session on use of acoustics for biomass estimation

An ICES Training course on 'Introduction to abundance estimation from fisheries acoustic surveys' took place 12-16 June 2017 at ICES Secretariat, Copenhagen, Denmark, with course instructors John Horne and Paul Fernandes. A total of 25 participants attended from 14 countries (Australia, Cabo Verde, Canada, Denmark, France, Germany, Greece, Italy, Kenya, Latvia, Northern Ireland, Portugal, UK (Scotland), USA). The course consisted of 10 presentations, 4 practical sessions and discussion sessions. The presentations covered a range of theoretical and logistical concerns relating to conducting and analysing an acoustic survey. Presentations included: underwater sound; sound as a sensor; fish and zooplankton as targets; survey design; geostatistics; the sonar equation; acoustic data processing; target classification; calibration; and abundance estimation. The practical sessions consisted of problems sets, a paper based survey design exercise, a session on basic post-processing in Echoview (run, with thanks, by Briony Hutton) and a computer based practical on abundance estimation using code written in the statistical programming language, R.

On the basis of the 17 evaluation forms that were completed, the course was generally well received. Participants were neutral about the balance of theory and practical work, with one suggesting that the course was "...a bit too advanced" and another that it was "too short". Most participants would have preferred more practical sessions, which is in keeping with the general student learning experience and preference for more active learning. Participants agreed that the instructors were helpful and approachable, and the quality of teaching was rated in the top two categories (of 5). Overall, 12 participants rated the training course highly and 4 were neutral; none were dissatisfied. Final comments reiterated the preference for practical work and many were pleased to have received computer code to analyse data which they thought they could use in future. The instructors experience was also positive and it was taken on board that fewer lectures may be appropriate if this were to be repeated, with the possibility of considering a basic and advanced course.



Participants and instructors on ICES Training course on 'Introduction to abundance estimation from fisheries acoustic surveys' held from 12-16 June at ICES Secretariat, Copenhagen, Denmark.

ToR d Provide guidance for calibrating echosounders on fishing vessels

ICES Cooperative Research Report No. 326 by Demer et al. (2015) on 'Calibration of acoustic instruments' provides guidance on calibration of a range of acoustic instruments currently used in fisheries research, including some systems (e.g., Simrad ES60 and ES70) used on fishing vessels. Section 4.1.7 of CRR 326 provides a 'quick-start' guide to calibrating Simrad EK60, ES60, and ES70 echosounders which was intended to be of use to the wider community.

The South Pacific Regional Fishery Management Organisation (SPRFMO) created a task group on 'Fishing Vessels as Scientific Platforms'. At its meeting in Lima, Peru in September 2015, this group carried out a 3-day workshop considering the 'Calibration procedure for acoustic devices aboard fishing vessels'. The report of this website, including Annex 2 which defines a calibration protocol for fishing vessels is available publically on the SPRFMO website: <http://www.sprfmo.int/assets/Meetings/Meetings-2013-plus/SC-Meetings/3rd-SC-Meeting-2015/Papers/SC-03-11a-Acoustic-Task-group-1st-workshop-report.pdf>

WGFAST reviewed the SPRFMO calibration protocol. While recognising the need for sets of instructions for specific calibration situations, it was unclear whom the SPRFMO protocols were written for (acoustics scientists, fisheries biologists, technicians, or commercial fishers). The SPRFMO protocols also contain simplifications that might not be appropriate in all situations. WGFAST noted that individual experts within the group could be invited by SPRFMO to provide specific guidance.

Ten members of the SPRFMO habitat modelling working group attended a special session at the 2019 meeting.

ToR e Organize joint sessions at ICES ASC

WGFAST jointly chaired ASC session J in Hamburg, Germany in September 2018 to consider 'Survey data products for stock and ecosystem assessments: Challenges and future directions'. This session was convened by Verena Trenkel (France) in conjunction with Sven Kupschuss (United Kingdom) and Stan Kotwicki (USA). This session had 24 oral presentations and 8 posters and was attended by about 80 people. Key themes were survey design and the use of survey products in stock assessment. There were few talks on the use of survey products for wider ecosystem assessment.

The group concluded that survey scientists and stock assessment modellers need to work in close collaboration to ensure correct model specifications and interpretations accounting for survey design and methodology. They noted that wider use of survey data on ecosystem level needs to be promoted

ToR f Define a data format for omni fisheries sonars

A convention for the storage of omni-sonar data in netCDF4-formatted computer files has been produced by the WG-FAST Topic Group for Defining a data format for omnidirectional fisheries sonar. The convention specification has been published as CRR 341. The name of the convention is SONAR-netCDF4.

ToR g Work towards developing and recommending procedures for collecting and processing quality acoustic data in inclement weather

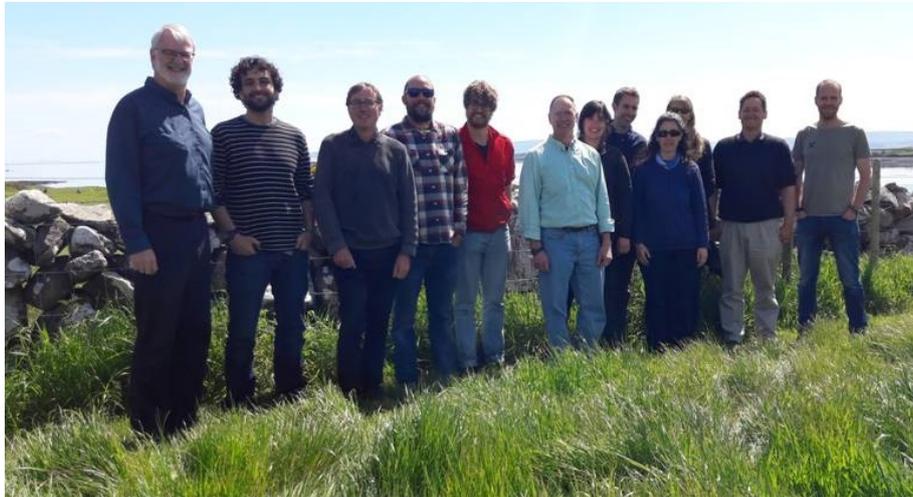
The Topic Group on Collecting Quality Underwater Acoustic Data in Inclement Weather (TGQUAD) met in Seattle, USA from 17-19 March 2018 and in Galway, Ireland from 3-5 May 2019. TGQUAD was created following a Workshop on Collecting Quality Underwater Acoustic Data in Inclement Weather (WKQUAD) held from 31 March – 2 April 2017 in Nelson, New Zealand. WKQUAD was in response to Workshop on Scrutiny Procedures for Pelagic Ecosystem Surveys (WKSCRUT).

Twenty six representatives from 11 countries participated in the 2019 TGQUAD meetings. The participants focused on the CRR that will be one output of the group. The group continued to investigate standard procedures and methods for identifying unsuitable survey conditions, propose methods for dealing with degraded data, and compare procedures and methods on selected data sets. Diagnostics and metrics that are independent of a specific vessel, i.e., based on effects on the acoustic data were evaluated. Each vessel responds differently to wind and sea state, so the group is developing and evaluating general criteria that can be applied broadly, in relative terms. Their priority is single-beam narrow bandwidth (18, 38, 70, 120, and 200 kHz) echosounder data that are used in stock assessment. In addition to data collected on research or commercial fishing vessels, the rapid utilization of unoccupied (i.e., unmanned, autonomous) surface vessels for collecting acoustic data led the group to incorporate evaluation of these vehicles as suitable platforms for collecting assessment-quality data. Currently broad bandwidth echosounders are used in narrowband mode and the same criteria apply for either system. The group recognizes that effects of inclement weather on broad bandwidth echosounders operating in broadband mode will need to be addressed in the future. The group will not address multibeam water column systems or multibeam bathymetric systems, because they are not currently used for abundance estimates.

The group established a framework for developing and evaluating metrics that are calculated from acoustic, vessel motion, and meteorological data that can be used either directly or as indicators of degraded data quality. Data metrics include the number or proportion of “ping drop-outs”, bubble layer backscattering strength and thickness, vessel motion periodicity, seabed backscattering strength, variability in the transmit pulse “ring down”, measures of impedance, and changes in frequency response.

Outputs from TGQUAD comprise recommendations to other ICES expert groups, and an ICES CRR. The group revised the CRR structure based on the expertise of the group and the overall framework of developing and evaluating metrics and indicators to quantify effects of inclement weather on acoustic data that provide abundance estimates for stock assessment. The CRR is structured with a literature review that transitions to data needs and case studies highlighting effects of weather on data quality, and ending with diagnostics, criteria, and recommendations for evaluating data quality.

TGQUAD will meet again in 2020 associated with the WGFAST meeting in Bergen, Norway to finalise production of the CRR.



Participants of the 2019 meeting of TGQUAD in Galway, Ireland.

2.2 Other ToRs

Recommendations from WKQUAD

Compile information on transducer location and vessel trim, and collect vessel motion (pitch, roll, heave) data at a sampling rate of at least twice the frequency of the vessel motion ($<1/2$ the period), i.e. Nyquist sampling rate. A typical rate is 3 Hz.

Collect meteorological data, e.g. windspeed and direction, swell, sea state, wave height during the surveys

Both the recommendations were passed onto members of WGFAST in 2018.

Recommendation from JFATB

JFATB recommends the development of terms of reference for a joint session of WGFAST and WGFTFB in April/May of 2020.

WGFAST supports the development of terms of reference for a joint session to be held in Bergen, Norway in April 2020. WGFAST has nominated Stéphane Gauthier (Canada) and WGFTFB has nominated Michael Pol (USA) as co-chairs of JFATB. The joint session should review existing knowledge and recent developments in this area, with a focus on practical approaches to identify and quantify the uncertainty introduced by trawl size and species selectivity in multispecies surveys (acoustic, trawl, and others). Another theme is the use of acoustic and optical technologies for observing fish and gear behaviour.

Stéphane Gauthier presented an update on the activities of WGFTFB, which recently had their meeting in Shanghai, China. One of the themes of particular interest to WGFAST was the discussion of optical and acoustic imaging of fish in trawls and seines. WGFTFB has nominated Daniel

Stepputis (Germany) as their new chair. For the first time, WGFTFB also nominated a vice chair, Antonello Sala (Italy).

Following this update, terms of reference for the 2020 JFATB meeting were proposed: 1) Methods to identify and quantify the uncertainty introduced by trawl size and species selectivity in multispecies surveys, and 2) the use of acoustic and optical technologies for observing fish and gear behavior. There were also discussions during the WKMesoMeth to develop a special session on sampling methods for mesopelagic species, which was supported by the current chair of WGFTFB.

Another recommendation for the JFATB was to invite keynote speakers covering technical tutorials or reviews of common areas of interest to foster common understanding and areas of potential mutual assistance. It was suggested during the WGFAST that an expert on fish vision would be pertinent, and/or experts on fishing gear design (perhaps from local industries in Norway).

Recommendation from WGIPS

Proposal to undertake a WK to coordinate the development of standardised protocols for the acoustic assessment of resources in the mesopelagic zone.

A workshop on the development of practical survey methods for measurements and monitoring in the mesopelagic zone (WKMesoMeth) was held in Galway, Ireland on 27-28 April 2019, chaired by Ciaran O'Donnell (Ireland) and Gavin Macaulay (Norway).

The two-day workshop was held prior to the main WGFAST meeting and attracted 33 participants from 15 countries. The WK had five core terms of reference. During day one, a catalogue of current global open ocean surveys was provided (*ToR a*) by means of 18 presentations on surveys currently collecting acoustic and biological data in the mesopelagic zone and surveys with the capacity to do so in the future. Current research was provided by means of recent publications and dedicated mesopelagic projects currently underway or scheduled to begin shortly were presented (including MESSOP, MesoBED, SUMMER and MESSO), (*ToR b*). During the second day, due to the short time period of the WK, and the complexity of the task at hand, the WK split into two groups. Group one (led by Gavin Macaulay) was tasked with reviewing the opportunities and limitations posed by current ship based surveys and what is achievable within existing survey programs (*ToR c*). Group two (led by Ciaran O'Donnell) examined the minimum requirements in terms of hardware and sampling equipment required for meaningful abundance measurements, and determine the components of the mesopelagic zone to which this applies (*ToR e*). Using the information provided during the WK to evaluate the potential to develop methods to establish abundance monitoring within WGIPS (and other ICES) coordinated surveys (*ToR d*) will be undertaken post the WK in collaboration with WGIPS members.

3 Science Highlights

ICES ASC session on “Survey data products for stock and ecosystem assessments: challenges and future directions”

See Section 2.1

ICES Training course on ‘Introduction to abundance estimation from fisheries acoustic surveys’

See Section 2.1.

Joint session with the South Pacific Regional Fisheries Management Organization (SPRFMO) Habitat Modelling Working Group

This was held during the 2019 WGFAST meeting. The session included 7 presentations from scientists from Peru and Chile and is summarised in Section 2.1 under ToR b. The Ambassador of Peru to Ireland, Ms Ana Sánchez, visited during the meeting.



Ambassador of Peru to Ireland, Ms Ana Sánchez visits with members of SPRFMO and WGFAST and representatives of the Marine Institute during 2019 WGFAST meeting.

Training courses on 'Principles and Methods of Broadband/Wideband Technologies: Application to fisheries acoustics'

Courses were held on R/V G.O. Sars, Bergen, Norway in December 2017 and 2018. The 2017 course was an ICES course with 20 participants from 13 countries. The 2018 course was an Institute of Marine Research (IMR) academy course with 20 participants from 5 countries. Topics covered included:

- 1) Theory on broadband technologies
 - a. Background on narrow band and broadband signals
 - b. Understanding the temporal, spatial, and spectral aspects of the complex broadband signals
- 2) Overview of the specifications and data flow of commercially available and most commonly used broadband systems – Simrad EK80
- 3) Knowledge on EK80 system operation and hands-on experiences
 - a. System configuration
 - b. Calibration procedures
 - c. Data collection and preliminary processing
- 4) Data Processing
 - a. Calibration quantities as a function of frequency
 - b. $TS(f)$ of tracked individual targets
 - c. $Sv(f)$ of a scattering layer
 - d. Cross-channel talk

Another ICES-sponsored course is being considered for 2019.



Participants and instructors on IMR Training course on 'Principles and Methods of Broadband/Wideband Technologies: Application to fisheries acoustics', R/V G.O. Sars, Bergen, Norway, December 2018.

4 Cooperation

4.1 Cooperation with other WGs

The Topic Group on Collecting Quality Underwater Acoustic Data in Inclement Weather (TGQUAD) met in Seattle, USA from 17-19 March 2018 and in Galway Ireland from 27-28 April 2019 (see Section 2.2). TGQUAD was created following a Workshop on Collecting Quality Underwater Acoustic Data in Inclement Weather (WKQUAD) held from 31 March – 2 April 2017 in Nelson, New Zealand. WKQUAD was in response to Workshop on Scrutinisation Procedures for Pelagic Ecosystem Surveys (WKSCRUT).

A workshop on the development of practical survey methods for measurements and monitoring in the mesopelagic zone (WKMesoMeth) was held in Galway, Ireland on 27-28 April 2019, chaired by Ciaran O'Donnell (Ireland) and Gavin Macaulay (Norway).

On 3 April 2017, a joint meeting (JFTAB) took place with the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) in association with the WGFAST meeting in Nelson, New Zealand. Another joint meeting is scheduled for April 2020 in Bergen, Norway co-chaired by Stéphane Gauthier (Canada) and Michael Pol (USA). A subset of WGFTFB and WGFAST members and members of survey groups (WGIPS, WGBIFS, WGACEGG) have expertise that is relevant in this area.

The TG-Meta convention has been implemented in the ICES Acoustic trawl database (<http://www.ices.dk/marine-data/data-portals/Pages/acoustic.aspx>)

4.2 Cooperation with advisory structures

The TG-Meta convention has been implemented in the ICES Acoustic trawl database (<http://www.ices.dk/marine-data/data-portals/Pages/acoustic.aspx>)

4.3 Cooperation with other IGOs

Several WGFAST members are also members of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM). SG-ASAM met in May 2018 in Punta Arenas, Chile. Items considered included consideration of, and planning for, two large scale krill acoustic surveys in Area 48 (carried out by Chile, China, Korea, Norway, UK, Ukraine) and Area 58 (carried out by Japan), as well as other items related to acoustic assessment of krill abundance and distribution. The results from these surveys will be initially presented at the 2019 CCAMLR Working Group on Ecosystem Monitoring and Management (WG-EMM) meeting (24 June-5 July, Concarneau, France) and further considered at the 2019 meeting of SG-ASAM, which will be held in Bergen, Norway (26-30 August 2019). The SG-ASAM meeting will also review the collection and analysis of krill acoustic data from fishing vessels and other items related to the use of acoustics in CCAMLR areas.

As described in Section 2.1, WGFAST hosted a joint session with the South Pacific Regional Fisheries Management Organization (SPRFMO) Habitat Modelling Working Group during the WGFAST meeting on 30 April 2019. The Ambassador of Peru to Ireland, Ms Ana Sánchez, visited the Marine Institute during meeting. WGFAST also reviewed the South Pacific Regional Fishery Management Organisation (SPRFMO) calibration protocol to assess its consistency with ICES CRR 326.

WGFAST members from CSIRO (Australia) have been engaged with the South Indian Ocean Fisheries Agreement (SIOFA) to determine whether unsupervised industry collected acoustic data on orange roughy can be used for stock assessment and target strength purposes. The findings were summarised in a report which is being considered by the SIOFA scientific committee.

5 Future direction

A resolution to continue the work of WGFASST for the next three-year term (2020-22), with chair J. Michael Jech (USA) has been submitted (Annex 2). WGFASST proposes that its 2020 meeting will be in Bergen, Norway from 20-24 April 2020. This meeting will be held in association with WGFTFB and JFTAB.

Annex 1: List of participants

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Participants in WGFAST meeting in Galway, Ireland, April 2019 (photo Rachael Brown)

Annex 2: Resolutions

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.

Year	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2020	20-24 April 2020	Bergen, Norway	Interim report by 30 June 2020 to ACOM-SCICOM	Michael Jech takes over as chair
Year 2021	TBD	TBD	Interim report by 30 June 2021 to ACOM-SCICOM	
Year 2022	TBD	TBD	Final report by 30 June 2022 to ACOM-SCICOM	

ToR descriptors¹

ToR	Description	Background	Science plan codes	Duration	Expected Deliverables
A	Collate information on acoustic related research and surveys	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 discussion will be presented in the annual report	3.3, 4.1, 4.4	1, 2, 3	
C	Organize a conference session on fisheries acoustics at an international scientific meeting such as ASC.		3.1, 3.2, 4.1	2 or 3	

¹ Avoid generic terms such as “Discuss” or “Consider”. Aim at drafting specific and clear ToR, the delivery of which can be assessed

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; updates of relevant SISP manuals

Summary of the Work Plan

Year	Summary
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.

Annex 3: Meeting agenda

Working Group on Fisheries, Acoustics, Science and Technology (WGFAS)

Marine Institute, Galway, Ireland, 29 April – 2 May 2019

AGENDA

MONDAY 29 April 2019		Session
8:45-9:30	House-keeping & registration	WGFAS business Chair: Richard O'Driscoll
9:30-9:50	WGFAS opening <i>Ciaran O'Donnell and Richard O'Driscoll</i>	
9:50-10:30	Introduction slides	
10:30-11:00	COFFEE BREAK	
11:00-11:10	Remembering John Ehrenberg <i>John Horne</i>	
11:10-11:30	Why we are here - update on WGFAS TORs <i>Richard O'Driscoll</i>	
11:30-11:40	Annual Science Conference session: Survey data products for stock and ecosystem assessments: challenges and future directions <i>Verena Trenkel and Richard O'Driscoll</i>	
11:45-12:00	Mackerel at full tilt: how knowledge of behavior influences our estimates of abundance, just when we need it <i>Paul G. Fernandes and Ben Scoulding</i>	Behaviour Chair: Pablo Escobar-Flores
12:00-12:15	Acoustic measurements of herring close to the sea surface <i>Espen Johnsen, Atle Totland, Rokas Kubilius and Egil Ona</i>	
12:15-12:30	New insights into mesopelagic behaviour with a Profiling Lagrangian Acoustic Optical Probe (PLAOS) <i>Rudy J. Kloser, Haris Kunnath, Tim Ryan, Ben Scoulding & Caroline Sutton</i>	
12:30-12:45	Bottom-moored echosounders for continuous monitoring of Pacific Hake migration <i>Stéphane Gauthier and Nicholas Ens</i>	
12:45-13:00	Sunrise and sunset considerations for daytime surveys <i>Rebecca Thomas, Dezhang Chu, Stephane Gauthier, and Sandra Parker-Stetter</i>	
13:00-14:00	LUNCH BREAK Simrad News & Update <i>Lars Nonboe Andersen</i>	Emerging technologies A
14:00-14:30	DISCUSSION: BEHAVIOUR	
14:30-14:45	Bubble trouble <i>Ben Scoulding, Rudy J. Kloser, Tim E. Ryan and Sven Gastauer</i>	
14:45-15:00	Discrimination and characterization of gasses in the ocean using broadband acoustics <i>Yoann Ladroit, Tom Weber and Geoffroy Lamarche</i>	
15:00-15:30	COFFEE BREAK	0

15:30-15:45	Towards acoustic discrimination of tropical tuna associated with Fish Aggregating Devices Guillermo Boyra, Gala Moreno, Igor Sancristobal, Udane Martinez, Bea Sobradillo, Blanca Orue, David Itano, Victor Restrepo	
15:45-16:00	Measurements of in situ target strength of Atlantic bluefin tuna (<i>Thunnus thynnus</i>) onboard a fishing baitboat vessel in the Bay of Biscay. Jon Uranga, Iann Godard, Guillermo Boyra and Nicolas Goñi	
16:00-16:15	Detecting Rayleigh, resonant and geometric scattering in fish schools: the pros and cons of low frequency broadband James Dunning, Alan J. Fenwick, and Paul G. Fernandes	
16:15-16:30	Broadband backscattering from tethered Atlantic mackerel Rokas Kubilius, Gavin Macaulay, Egil Ona, Atle Totland and Tonje Forland	
16:30-16:45	Measurements of mass density and sound-speed contrasts for target strength estimation of krill in Antarctic waters Ryuichi Matsukrua, Hanae Doiguchi, Natsuki Yamamoto, Tohru Mukai, Koki Abe, Hiroko Sasaki, and Hiroto Murase	
16:45-17:15	DISCUSSION: ACOUSTIC PROPERTIES & BUBBLES	
18:00-20:00	Icebreaker Reception at Galway Golf & Country Club	

TUESDAY 30 April 2019		Session
9:00-9:30	House keeping	
9:30-9:45	Broadband acoustic evidence of the mesoscale distribution of gas bearing siphonophores in the eutrophic Bay of Biscay Arthur Blanluet, Mathieu Doray, Laurent Berger, Jean-Baptiste Romagnan, Pierre Petitgas	Chair: Martina Bristow Applications to characterize ecosystems
9:45-10:00	Acoustic assessment of the spatio-temporal variability of the mesopelagic fish community on the Chatham Rise, New Zealand Pablo C. Escobar-Flores, Yoann Lacroix, Richard L. O'Driscoll	
10:00-10:15	Forecasting vertical distribution variability of pelagic forage fauna in the south Pacific Aurore Receveur, Christophe Menkes, Valerie Allain, Anne Lebourges-Dhaussy, David Nerini, Morgan Mangeas, Frederic Menard	
10:15-10:30	Contrasting deep scattering layers from the Labrador and Barents Seas Maxime Geoffroy, Julek Chawarski, David Cote, Merhdad Hajibabaei, Jørgen Berge and Stig Falk-Petersen	
10:30-11:00	COFFEE BREAK	
11:00-11:15	From acoustic abundance estimates to habitat monitoring: the example of the Jack Mackerel <i>Trachurus murphyi</i> Francois Gerlotto and Eleuterio Yañez	Chair: Mariano Gutierrez SPRFMO Habitat Monitoring Working Group
11:15-11:30	Terms of Reference of the SPRFMO Habitat Monitoring Working Group Mariano Gutierrez and Aquiles Sepúlveda	
11:30-11:45	Habitat Monitoring of Chilean Jack Mackerel using opportunity vessels off South-Central Chile Aquiles Sepúlveda and Nicolás Alegría	
11:45-12:00	Observation of the pelagic habitat off Peru from an ecosystem perspective Salvador Peraltilla	

12:00-12:15	Spatio-temporal patterns of lightfish (<i>Vinciguerria lucetia</i>) and its relationship with the shelf break in the Peruvian Sea (1998–2015) Martin Santivañez-Yuffra and Mariano Gutiérrez-Torero	
12:15-12:30	Anchovy distribution off Peru in relation to abiotic parameters: A 32 year time-series from 1985 to 2017 Ramiro Castillo, Luciano Dalla Rosa, Walter García Díaz, Lauro Madureira, Mariano Gutierrez, Luis Vásquez, and Rolf Koppelman	
12:30-12:45	The OceanBox: a new technology to make collecting and processing of scientific sensor data on commercial trawlers feasible and useable. Martin A. Pastoor and M.S. Ybema	
12:45-13:00	DISCUSSION : SPRFMO	
13:00-14:00	LUNCH BREAK Echoview News & Update <i>Briony Hutton and Geoff Matt</i>	
14:00-14:15	Temporal patterns in densities and vertical distributions of pelagic fish and macrozooplankton in an Arctic ecosystem Silvana Gonzalez, John K. Horne, and Seth Danielson	
14:15-14:30	Acoustic biomass estimation and aggregation patterns of mesopelagic fish assemblages in Corinthiakos gulf (Eastern Mediterranean Sea) Zacharias Kapelonis, Konstantinos Tsagarakis, Maria Myrto Pyrounaki, Athanasios Machias Stylianos Somarakis and Marianna Giannoulaki	Chair: Martina Bristow Applications to characterize ecosystems
14:30-14:45	Backscattering properties of biological objects in Gulf of Gdańsk (southern Baltic Sea) Patryk Damian Pezacki, Natalia Gorska and Jakub Idczak	
14:45-15:00	Use of high frequency acoustic profiler to investigate zooplankton patterns in the North Sea Serdar Sakinan, Dirk Burggraaf, Bram Couperus, Benoit Berges	
15:00-15:30	COFFEE BREAK	
15:30-15:45	How many krill are there in the eastern Bering Sea and Gulf of Alaska? Patrick H. Ressler, Joseph D. Warren, Brandyn M. Lucca, H. Rodger Harvey, Georgina A. Gibson	
15:45-16:00	Mapping prey fields of foraging humpback whales in British Columbia Rhonda Reidy, Stéphane Gauthier, and Francis Juanes	
16:00-16:15	Resolving two species of calanoid copepod in wideband acoustic data Chelsey McGowan-Yallop, Kim S. Last, Finlo R. Cottier, Sophie Fielding, and Andrew S. Brierley	
16:15-16:30	Spatial distribution of fish-like and fluidlike zooplankton acoustic categories across the Mid-Atlantic Bight shelf break, USA Erin LaBrecque and J. Michael Jech	
16:30-16:45	Small scale acoustic surveys, mapping prey fields and sizing fish – Portable and on a budget Sven Gastauer, Lachlan Philipps, Adam Wilkins, Robert Harcourt, Ian Jonsen, Gemma Carroll, Ben Pitcher, Dezhang Chu, Martin Cox	
16:45-17:00	Use of Acoustic Zooplankton Fish Profilers (AZFP) to investigate pelagic communities in Offshore Wind Farms Benoit Berges, Serdar Sakinan, Dick de Haan, Elisabeth Debusschere, Jan Reubens, Annebelle Kok, Hans Slabbekoorn	

17:00-17:30	DISCUSSION: ECOSYSTEMS	
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WEDNESDAY 1 May 2019		
9:00-9:15	House-keeping	
9:15-9:30	A preliminary report of Japanese Antarctic krill survey in 2018/19 austral summer season using narrowband and broadband signals by the EK80 <i>Koki Abe, Natsuki Yamamoto, Kazuo Amakasu, Ryuichi Matsukura, Hiroko Sasaki, and Hiroto Murase</i>	
9:30-9:45	Amplifier linearity accounts for discrepancies in echo-integration measurements from two widely used echosounders <i>Alex De Robertis, Christopher Bassett, Lars Nonboe Andersen, Ivar Wangen, Scott Furnish, Michael Levine</i>	Chair: Geir Pedersen Emerging technologies, methodologies, and protocols
9:45-10:00	Comparing wideband data (EK80: WBT) and narrowband data (EK60:GPT) <i>Tomohito Imaizumi, Kohei Hasegawa, Tohru Mukai, and Kouichi Sawada</i>	
10:00-10:15	Comparison of EK60 and EK80 from the data collected during summer North Sea herring survey <i>Serdar Sakinan, Dirk Burggraaf, Bram Couperus, Benoit Berges</i>	
10:15-10:30	DISCUSSION EK60 & EK80	
10:30-11:00	COFFEE BREAK	
11:00-11:15	Echosounders, Gliders, and Acoustic Brains: Challenges of integrating components and sample designs <i>John K. Horne, Christian Reiss, Chad Lembke, Alex Silverman, Kevin M. Boswell, J. Christopher Taylor, and George Cutter</i>	
11:15-11:30	The Wave Glider as an acoustic platform – preliminary results on data quality from a case study in the North Sea <i>Martina Bristow, Angus Atkinson, Fabio Campanella, Sophie Fielding, Karen Heywood, Tom Hull, David Pearce, Bastien Y. Queste, Jeroen Van Der Kooij</i>	
11:30-11:45	Fisheries 2.0 – Using XOCEAN Unmanned Surface Vessels for acoustic fisheries research <i>Andrew Carlisle</i>	
11:45-12:00	2018 Unmanned Surface Vehicle (Saildrone) acoustic survey off the west coasts of the United States and Canada <i>Dezhang Chu, Sandra Parker-Stetter, Lawrence C. Hufnagle, Stéphane Gauthier</i>	
12:00-12:15	Evaluation of Saildrones for Fisheries and Ecosystem Investigations <i>David A. Demer, Kevin Stierhoff, Danial K. Palance, Josiah S. Renfree, Juan P. Zwolinski, Thomas S. Sessions, David Murfin, John Crofts, and Toby Garfield</i>	
12:15-12:30	Autonomous surface vehicles for persistent acoustic monitoring of a highly productive shelf area <i>Geir Pedersen, Stig Falk-Petersen, Katherine Dunlop, Lionel Camus, Malin Daase, Sünne Linnéa Basedow, Kanchana Bandara, Vigdis Tverberg, Joel Pederick, and David Peddie</i>	
12:30-12:45	DISCUSSION: Gliders	
12:45-13:00	Recent developments with the Acoustic Zooplankton Fish Profiler <i>Steve Pearce, David Lemon, Jan Buermans</i>	
13:00-14:00	LUNCH BREAK	

	ESP3 software demonstration <i>Yoann Ladroit and Pablo Escobar-Flores</i>		
14:00-14:15	Report from Workshop on development of practical survey methods for measuring and monitoring in the mesopelagic zone (WKMesoMeth) Ciaran O'Donnell	WGFAST business Chair: Richard O'Driscoll	
14:15-14:30	Report from Topic Group on Acoustic Meta Data (TG-Meta) Tim Ryan		
14:30-14:45	Report from Topic Group on Collecting Quality Under-water Acoustic Data in Inclement Weather (TG-QUAD) Mike Jech		
14:45-15:00	Report from Broadband Acoustic Course December 2018 Egil Ona		
15:00-15:30	COFFEE BREAK		
15:30-15:45	How loud is a piece of string (and its implications for acoustic calibration)? Tim E Ryan, Rudy Kloser and Ben Scoulding	Emerging technologies, methodologies, and protocols Chair: Rokas Kobilius	
15:45-16:00	Precision and accuracy for sphere calibration of broadband echosounders Laurent Berger, Dung Nguyen and Naig Le Bouffant		
16:00-16:15	Calibration of commercial echosounders: a case study of a Peruvian industrial fishing fleet Martin Santivañez-Yuffra, Nathaly Pereira-Letona and Cynthia Vasquez-Paredes		
16:15-16:30	Acoustic measurements of bluefin tuna: from cage monitoring and catch control, in the way to sonar biomass estimates Víctor Espinosa, Vicent Puig-Pons, Isabel Pérez-Arjona, Pau Muñoz-Benavent, Susana Llorens, Patricia Ordóñez, Gabriela Andreu-García, José M. Valiente-González, Vicente Atienza-Vanacloig, Fernando de la Gándara and Aurelio Ortega		
16:30-16:45	Application of the Method of Fundamental Solutions to Target Strength calculation from near to far field of the target Isabel Pérez-Arjona, Víctor Espinosa, Anderson Ladino, Luis M.C. Godinho		
16:45-17:00	Automatic noise monitoring and noise impact assessment on echosounder data Naig Le Bouffant and Laurent Berger		
17:00-17:15	<i>Colour maps for fisheries acoustic echograms</i> Robert Blackwell, Richard Harvey and Sophie Fielding		
17:15-17:30	Calculation and usage considerations of the frequency response graph generated from wideband echosounder data Geoff Matt		
19:30	WGFAST Social Dinner at The Galmont Hotel and Spa		

THURSDAY 2 May 2019		Session
9:00-9:15	House-keeping	WGFAST Chair: Richard O'Driscoll
9:15-9:30	Appointment of next WGFAST chair	
9:30-9:50	Self-evaluation of WGFAST, new ToRs, next meeting, ...	
9:50-10:00	Joint WGFAST/WGFTFB session 2020 <i>Stephane Gauthier</i>	
10:00-10:30	Other initiatives and business	
10:30-11:00	COFFEE BREAK	
11:00-11:15	Reducing bias in estimates of ocean biomass <i>Roland Proud, Rudy J. Kloser, Nils Olav Handegard, Martin J. Cox & Andrew S. Brierley</i>	Emerging technologies, methodologies, and protocols Chair: Rokas Kulbilius
11:15-11:30	Identifying mesopelagic layers combining acoustic data and light avoidance <i>Marian Peña, Jorge Cabrera, and Antonio Domínguez</i>	
11:30-11:45	Development of acoustic catch monitoring methods for purse seine fisheries <i>Gavin J. Macaulay, Maria Tenningen, and Jan Tore Øvredal</i>	
11:45-12:00	Comparison of net catches and acoustic abundance estimates of the deep-scattering layers <i>Michael Jech, Andone Lavery, Peter Wiebe, and Tim Stanton</i>	
12:00-12:15	Practical implementation of real-time fish classification from acoustic broadband echo sounder data <i>Benoit Berges, Jeroen van de Sande, Benoit Quesson, Serdar Sakinan, Edwin van Helmond</i>	
12:15-12:30	RapidKrill: delivering real-time krill density to fisheries managers <i>Alejandro Ariza, Rob Blackwell, and Sophie Fielding</i>	
12:30-13:00	DISCUSSION: EMERGING TECHNOLOGIES	
13:00-14:00	LUNCH BREAK	
14:00-15:00	<i>Meeting close-up</i>	
15:00-15:30	COFFEE BREAK	
15:30-17:30	Topic Group on Acoustic Meta Data (TG-Meta) <i>Tim Ryan</i>	

Sponsors




Annex 4: Abstracts of contributions

WGFAS 1. Applications of acoustic methods to characterize ecosystem

A preliminary report of Japanese Antarctic krill survey in 2018/19 austral summer season using narrowband and broadband signals by the EK80

Koki Abe¹, Natsuki Yamamoto², Kazuo Amakasu², Ryuichi Matsukura³, Hiroko Sasaki⁴, and Hiroto Murase⁴

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Japanese Antarctic krill survey was carried out in the Indian sector of the Antarctic (CCAMLR Division 58.4.1) in 2018/19 austral summer season. Multidisciplinary (e.g. oceanographic and biological) data sets were collected to elucidate the marine ecosystem. Narrowband continuous wave signals (CW) for echo integration along 18 line transects with a total distance of 2,519 n.miles were recorded while broadband frequency modulated signals (FM) for body length and orientation angle estimation of Antarctic krill were recorded during RMT (Rectangular Midwater Trawl) target tows at 24 stations. EK80 connected to WBTs of 4 central frequencies (38, 70, 120 and 200 kHz), and signals were transmitted in 2 s interval by CW mode while the vessel steamed on the tracklines with 10 knots. When swarms were detected, EK80 was switched to FM mode with 0.4 s sequential pinging and targeted RMT sampling was conducted. Narrowband and broadband data were preliminary analyzed by Echoview version 9.0.333. on the vessel. CCAMLR SWARM algorithm was employed for CW signals and calculated NASC for each 1 n.mile interval. The results indicated that distributions of Antarctic krill were concentrated around the continental shelf break although further details analysis is required before making any conclusion. Preliminary results of an analysis using FM signals revealed that SV spectra could depend on length and species. Estimation of body length and orientation angle of Antarctic krill is now in progress using FM signals. Detailed results of analyses will be presented to WGFAS in the near future.

Use of Acoustic Zooplankton Fish Profilers (AZFP) to investigate pelagic communities in Off-shore Wind Farms

Benoit Berges¹, Serdar Sakinan¹, Dick de Haan¹, Elisabeth Debusschere², Jan Reubens², Annebelle Kok³, Hans Slabbekoorn³

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There is a steady progress in the number of operational Offshore Wind Farms (OWF) in the Netherlands, Belgium, Europe and worldwide. There are many ecological changes associated with the installation and operation of OWFs, such as altered substrate and current conditions and an increase of anthropogenic noise (e.g. from pile driving or seismic survey activities). Most work to date has focused on alterations in the benthic community, while effects on the pelagic community remain relatively unexplored. Along the Belgian and Dutch coast, a lot of knowledge has been gathered but data on the density and diversity of pelagic fish and zooplankton within and around OWFs is needed to complement current insights. In 2018, two ASL Acoustic Zooplankton Fish Profilers (AZFP) were deployed off the Dutch and Belgian coast. These were deployed sequentially in three different OWFs (1 month monitoring period each), consisting of: (1) a baseline deployment, (2) a deployment coinciding with high level of piling noise (OWF construction), and (3) a deployment coinciding with an experimental, full scale seismic survey (PCAD4Cod JIP-project). In the current study, we investigated the potential use of acoustic profilers in shallow turbid water to monitor the pelagic animal community for presence and responsiveness to anthropogenic noise.

Broadband acoustic evidence of the mesoscale distribution of gas bearing siphonophores in the eutrophic Bay of Biscay

Arthur Blanluet¹, Mathieu Doray¹, Laurent Berger², Jean-Baptiste Romagnan¹, Pierre Petitgas¹

¹Unité Écologie et Modèles pour l'Halieutique, Ifremer Nantes, Rue de l'Île d'Yeu, BP 21105,44300 Nantes Cedex 3, France, arthur.blanluet@ifremer.fr, mathieu.doray@ifremer.fr, pierre.petitgas@ifremer.fr ; ²Service Acoustique Sous-marine et Traitement de l'Information, Ifremer Brest, Brest, France, laurent.berger@ifremer.fr .

Intermediate trophic components of pelagic ecosystem (from mesozooplankton to micronekton) are supposed to be important contributors to the ubiquitous Sound Scattering Layers (SSLs). Yet, the SSLs taxonomic composition remains largely unknown. The aim of our work was to describe the composition and repartition of dense SSLs observed in the Bay of Biscay (France) in spring, using broadband acoustics, nets and videos. As a first step, we applied a forward approach to characterize the composition of SSLs sampled in spring 2016 at small scale, by comparing in situ frequency responses to predictions of scatterer models parameterized with biological sampling data. In the second step we applied unsupervised classification methods and a supervised discriminant analysis to delineate the spatial distribution of a SSL displaying a peculiar dome shaped frequency response between 38 and 120 kHz. We showed that this SSL was most likely composed of gas-bearing siphonophores, whose backscatter dominated the frequency spectra at low frequencies (18-150 kHz). We showed that these siphonophores were distributed over a meso-scale area (~100 km) in spring 2016 in the northern Bay of Biscay. Our results suggest that siphonophores might be more abundant, and play a broader ecological role in eutrophic ecosystems than suspected so far.

Acoustic assessment of the spatio-temporal variability of the mesopelagic fish community on the Chatham Rise, New Zealand

Pablo C. Escobar-Flores¹, Yoann Lacroix, Y. ¹, Richard L. O'Driscoll¹

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Mesopelagic fish are a key component of the pelagic food web of the Chatham Rise east of New Zealand. The Chatham Rise is an important fishing area for hoki (*Macruronus novaezelandiae*), New Zealand's largest finfish fishery. Four fisheries oceanographic voyages provided multi-frequency acoustic data (18, 38, 70, 120 and 200 kHz) and midwater trawls, which were used to define a classification tree to separate mesopelagic groups. We carried out validation and sensitivity analyses that showed that we were able to confidently classify pearlside (*Maurolicus australis*) and euphausiids. Other mesopelagic targets (mainly myctophids) were classified together based on their acoustic frequency response. Using scripting in the open-source software ESP3, we applied our classification tree to a time series of acoustic data from trawl surveys on the Chatham Rise between 2009 and 2018. Our methodology allowed us to study temporal and spatial patterns of *M. australis*, euphausiids and total backscatter in the water column. Our results suggest that while total backscatter associated with mesopelagic fish has varied over the last ten years, there has been no clear trend. Abundance of *M. australis* showed a decreasing trend since 2012, though this was not significant. The abundance of euphausiids showed a significant decreasing trend over the last ten years. This work contributes to on-going efforts to monitor and detect changes in the pelagic ecosystems.

Small scale acoustic surveys, mapping prey fields and sizing fish – Portable and on a budget

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The use of acoustics as a non-invasive sampling technique to monitor marine resources has largely been accepted. A main limitation of the technology is that it generally requires large, expensive research vessels. Besides the economic limitations, this also limits surveys to the open ocean. Yet inshore coastal systems are ecologically and economically important. We present a portable system that can be easily transported and mounted on small (>5m) boats to enable acoustic surveys to be run without the need for a dedicated, scientific survey vessel. The usefulness of small-scale surveys is illustrated based on an acoustic prey-field survey for foraging penguins. Further the variability of high- and low-density single targets on broadband data will be illustrated and methods on how to determine fish size based on acoustic data only will be demonstrated.

Contrasting deep scattering layers from the Labrador and Barents Seas

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Deep sound scattering layers (DSL) are ubiquitous in all oceans and pelagic organisms within the DSL play important roles as prey for top predators and in climate regulation through the biological carbon pump. Because of climate change, pelagic fish and zooplankton extend their range northwards, potentially modifying the composition of DSL. We assessed the biomass, species assemblage and distribution of DSL at two different Atlantic-Arctic gateways, in the Labrador Sea and the Barents Sea. Using multifrequency echosounders and midwater trawls, we demonstrated that the biomass and species richness were higher in the Barents Sea, most likely because of a strong inflow of Atlantic water. In the Labrador Sea, deep water convection potentially impacts the vertical distribution of pelagic organisms and increases the complexity of the DSL by forming multiple aggregations through the water column. We further tested the possibility of ground-truthing the acoustic signal using environmental DNA (eDNA). Preliminary results indicate that eDNA provides useful information on the species richness within DSL, but net deployments are still required to obtain the full inventory.

Temporal patterns in densities and vertical distributions of pelagic fish and macrozooplankton in an Arctic ecosystem

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Quantifying temporal patterns and understanding underlying processes in abundances and behaviors of pelagic animals are required to detect and predict biological responses to environmental change. Characterizing temporal patterns in pelagic communities requires high-scope (i.e. long term and high resolution) biological data—a challenging task in high latitude environments. In this study, we characterize temporal variability in densities and vertical distributions of fish and zooplankton at the Chukchi Ecosystem Observatory using four years of active acoustic data from a multifrequency, ASL Acoustic Zooplankton Fish Profiler. Four metrics were used to characterize temporal variability of fish and zooplankton densities distributions: mean volume backscattering strength, center of mass, inertia, and an aggregation index. Wavelets were used to describe the temporal scales of variability for each metric. We observed interannual and seasonal variations in backscattering strength that are attributed to sea ice formation and melt cycles. Presence and amplitude of diel vertical migrations varied seasonally with day length. The quantification of temporal patterns in densities and behaviors of pelagic animals in Arctic ecosystems at multiple scales can inform resource management and monitoring in the face of climate change.

Acoustic biomass estimation and aggregation patterns of mesopelagic fish assemblages in Corinthiakos gulf (Eastern Mediterranean Sea)

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Data of a late-autumn 2018 acoustic survey was used to estimate the distribution, abundance, and biomass of two mesopelagic fish in Corinthiakos Gulf (Eastern Mediterranean Sea). Corinthiakos Gulf is a closed basin with limited water exchange with the Ionian Sea, and presents a

distinctive bathymetric asymmetry (maximum depth 935 m). We used a Simrad EK80 echosounder operating three calibrated split-beam transducers (38, 120 and 200 kHz) and exploited only daylight acoustic data to minimize complications from diel vertical migration behavior. Ground-truthing of species composition was performed by means of a small midwater trawl; a MultiNet plankton sampler and a Methot frame trawl were also used to obtain ancillary information. Hydrographic data were collected at stations along the acoustic transects. Amongst more than nine mesopelagic species encountered, *Maurolicus muelleri* and *Argyropelecus hemigymnus*, produced nearly monospecific echotraces. Mesopelagic schools of *M. muelleri* occurred typically near the shelf break at 70–280 m depth during the day and 13 m off the bottom on average. A persistent layer of *A. hemigymnus* was recorded at 160 – 270 m depth and 320 m off the bottom on average. Geostatistical analysis was applied in a further step to define the aggregation patterns of these two species.

Spatial distribution of fish-like and fluidlike zooplankton acoustic categories across the Mid-Atlantic Bight shelf break, USA

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To better understand the fine scale distributions of lower trophic levels and their spatial linkages within the dynamic shelf break ecosystem in the US Atlantic Ocean, we analyzed epipelagic, daytime acoustic backscatter data collected using multifrequency Simrad EK60 echosounders on the NOAA ship *Henry B. Bigelow* during the 2011 summer (June/July) AMAPPS cruise. The EK60 system consists of five split-beam transducers operating at 18, 38, 70, 120, and 200 kHz. We cleaned and processed 15 shelf break transects with the multifrequency indicator developed by Trenkel and Berger (2013) to identify the horizontal spatial patterns of two acoustic categories: swim bladder fish/large bubbles and fluidlike zooplankton. Both swim bladder fish and fluidlike zooplankton categories were present among all sections (shelf, shelf break offshore) of each transect. Median intensity and variability of backscatter volume (S_v) varied among sections and between transects. Fluidlike zooplankton had the greatest median S_v in the shelf break and offshore sections of most transects, while swim bladder fish S_v median values were highest in the shelf sections. For both acoustic categories, variability in S_v was greatest in the shelf break sections, possibly due to the presence of the shelf break frontal system.

Resolving two species of calanoid copepod in wideband acoustic data

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Acoustic classification of zooplankton is typically limited to broad morphological or taxonomic groups. Though narrowband acoustic methods have improved biomass estimates, and enabled novel insights into population-scale behaviours, often the identity of zooplankton targets remains ambiguous. Wideband echosounders offer the potential for improved target classification, by measuring the frequency response of targets over a continuous frequency range. In Loch

Etive, Scotland, the zooplankton community is dominated by two species of calanoid copepod: *Calanus finmarchicus*, and *Paraeuchaeta norvegica*. Preliminary modelling based on the Distorted Wave Born Approximation indicates that acoustic discrimination of these species is possible, owing to their marked differences in size. *C. finmarchicus* adults in Loch Etive have a maximum prosome length of ~2.8mm, compared to ~5.9mm for *P. norvegica*. An autonomous wideband echosounder mooring, installed at 60m depth and operating over a near-continuous frequency range of ~160-450 kHz, will be used as a test-bed. Using both measured and modelled frequency response curves, and ancillary parameters such as swimming speeds, a range of classification approaches will be tested to establish the feasibility of *in-situ* discrimination of these calanoid copepods.

Backscattering properties of biological objects in Gulf of Gdańsk (southern Baltic Sea)

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Much of the potential of the broadband hydroacoustic classification techniques has not yet been fully used in the past studies of unique ecosystem of the Gulf of Gdańsk, the coastal area of the semi-enclosed Baltic Sea. There are still many gaps in the knowledge on backscattering characteristics of the biological objects, e.g.: (i) the acoustic frequency response of biological aggregations for particular ecological formations as well as (ii) the important detailed features of acoustic spatial image for non-commercial species of fish, zooplankton and benthos, have not been investigated yet. The main purpose of the proposed pilot interdisciplinary research was to improve the understanding of backscattering properties of biological aggregations in the Gulf of Gdańsk. Hydroacoustic measurements were performed using three broadband split-beam echosounders (38, 120 and 333 kHz-central frequencies) and acoustic Doppler current profiler (ADCP, 600 kHz). The measurements were accompanied by the environmental data collection. Visual remotely operated underwater vehicle (ROV) inspection was done. Characteristic features of backscattering and their variability over the different temporal and spatial scales were determined. This pilot study would make the first step in the development of the "hydroacoustic metrics", which would benefit the description of the Gulf of Gdańsk ecosystem.

Forecasting vertical distribution variability of pelagic forage fauna in the south Pacific

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We analyze acoustic vertical profiles from a 38kHz EK60 dataset undertaken in the south-west Pacific to assess environmental drivers of the micronekton vertical distribution. By combining various statistical methods, the main micronekton vertical distribution patterns are described as well as their link to environmental covariates. We find two Shallow Scattering Layers between 0 and 150m and one large Deep Scattering Layer around 550m. After the sun inclination

(day/night) that is, as expected, the most structuring factor in the vertical profile shape, the next most important factors are the 0-600m mean oxygen and the bathymetry. We find no link between the vertical profile shapes and water masses presence. An innovative statistical tool is used to rebuild echograms at the scale of the New Caledonian EEZ by month with an accuracy equal to 84%. At this scale, layers intensities, rather than their vertical positions, shape the spatial changes, dominated by a north-south spatial pattern. The DSL_{day}-SSL_{night} migrants' proportion, ranging from 40% to 85%, shows a spatial pattern with a higher ratio in the north. By predicting the spatiotemporal prey vertical distribution, we offer a promising perspective to understand interactions between predators and their prey at different depths according to the month.

Mapping prey fields of foraging humpback whales in British Columbia

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Over the last decade, humpback whales have rapidly recolonized southern BC, showing striking increases in numbers and using a wide variety of habitats. Two distinct humpback whale feeding grounds occur in northern and southern BC and adjacent waters. Humpback whales are observed surface-feeding on Pacific herring off northeast Vancouver Island. In contrast, observations of deep foraging on unknown prey in southern waters suggest that either the feeding groups differ in their prey choice, or the feeding areas differ with respect to prey availability. In this study, we investigate a variety of surface and deep-water prey characteristics in spatially-explicit humpback whale feeding areas off northern and southern Vancouver Island. We are using fine-scale, small-vessel acoustic surveys that are adaptive and systematic, conducted in daylight hours in areas with and without foraging humpback whales. We use a vessel-mounted Acoustic Zooplankton and Fish Profiler with 4 frequencies. Acoustic data will be linked to foraging behaviour of tagged whales, and corroborated by regional mid-water prey sampling during DFO surveys, while fecal sampling will provide additional information about which prey species are actually consumed.

How many krill are there in the eastern Bering Sea and Gulf of Alaska?

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Euphausiids ('krill') are a globally zooplankton group and key prey for important fishes. Data from acoustic-trawl surveys of walleye pollock (*Gadus chalcogrammus*) are used to estimate krill (mainly *Thysanoessa* spp.) abundance and distribution in the Bering Sea and Gulf of Alaska. We hypothesized that major reasons for differences between net capture and acoustic-trawl estimates of krill abundance included avoidance of towed samplers and negative bias in krill target strength (TS) from scattering models. To evaluate these hypotheses, we conducted paired trawls with/without flashing strobe lights to assess net avoidance; parameterized, modelled, and measured the TS of live krill aboard ship; and analysed intact lipid class content of the same specimens. Krill catches in trawls (g/m³) with strobe lights averaged 2.4x higher, consistent with the effects of net avoidance. Measured TS was substantially higher (5.6 dB or 3.6x) than model

(SDWBA) estimates at 120 kHz, the frequency used for abundance estimates. Also, we estimate that use of the SDWBA will increase mean target strength by 3.3 dB (or 2.1x) from DWBA model TS estimates used previously. Total lipid content (mg/g) did not appear correlated with animal density. These results will improve survey estimates of krill abundance and input to ecosystem models.

Use of Use of high frequency acoustic profiler to investigate zooplankton patterns in the North Sea

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The wideband functionality of Simrad EK80 allowing for very fine range resolution as well as broad frequency spectrum makes it interesting for detecting and identifying targets such as zooplankton. While possibility of detecting very thin layers is advantageous in discerning zooplankton aggregations, the upper frequency range can be still limiting for identification with respect to frequency response. High frequency acoustic profilers such as TAPS (Tracor Acoustic Profiling System) has long been utilized to infer zooplankton biomass. In this work, a trial to incorporate such high-frequency profiler measurements into plankton sampling during International Herring Larvae Survey (IHLS) was carried in the North Sea in September 2019. Aquascap 1000R system working at four frequencies (500kHz- 4 MHz) was used along with Gulf7 plankton sampler. The measurements, coupled with the ship based EK80(FM) measurements to identify different layers that can be associated with zooplankton. The results showed that this combination can be useful to interpret the size distribution within the observed zooplankton layers. However a standard-sphere calibration would be prerequisite in order to combine profiler measurements with the ship based measurements. For this a tank measurements were carried out to calibrate the system. Here we present some results from the field measurements and the tank calibration trial.

WGFAST 2. Acoustic properties of marine organisms

Towards acoustic discrimination of tropical tuna associated with Fish Aggregating Devices

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Tropical tuna support some of the largest and most valuable artisanal and industrial fisheries worldwide, supported largely by Fish Aggregating Devices (FADs). Yellowfin, bigeye and skipjack are the main tuna species found in mixed aggregations around FADs. One of the key challenges that face purse seine fleets fishing with FADs in all oceans is to be able to target species for which stocks are estimated to be in healthy condition such as skipjack, while reducing their impact on less healthy species, as bigeye and yellowfin, in areas where there is a need to reduce

fishing pressure. The present work explores a technical solution for selective fishing at FADs by means of acoustic equipment used by purse seiners. Acoustic frequency response of skipjack and bigeye tuna were determined at 38, 120 and 200 kHz. Skipjack showed stronger response at higher frequencies. This work demonstrates the potential to characterize tuna aggregations using purely acoustic measures by building generalized linear models to predict abundance and species proportions based on frequency response and other echosounder-based acoustic parameters. The significant relationships obtained open the potential for discrimination of tuna species at FADs. Ongoing and upcoming work in this line of research will be presented.

Detecting Rayleigh, resonant and geometric scattering in fish schools: the pros and cons of low frequency broadband

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The advent of broadband echosounders has the potential to provide more information on the frequency response of underwater targets by providing complete spectra across particular bandwidths. However, most systems operate in medium to high bandwidths (30 kHz +) which are in the geometric scattering region for most fish species. Here, we provide spectra at low to medium frequencies (6 - 65 kHz) derived from an Edgetech sub-bottom profiler which was adapted to operate as a broadband echosounder. We detected schools of pearlides (*Maurolucus muelleri*), Atlantic herring (*Clupea harengus*) and whiting (*Merlangius merlangus*), and mackerel (*Scomber scombrus*), providing examples of resonant, geometric, and Rayleigh scattering respectively. Additional evidence of the species and size composition of these schools was provided by trawl samples and video cameras. We identify several challenges in determining these spectra, such as low signal-to-noise ratios and transducer equivalence in estimating absolute scattering from the three broadband channels we used. We discuss how we tackled these and others that still need to be resolved in order to achieve the goal of species recognition and estimating the mean length based upon broadband spectral analysis. Such goals are relevant not only for surveys of these commercially and ecologically important fish species, but also for discard mitigation as fishermen have strict size requirements to maximise profits from their catch.

Broadband backscattering from tethered Atlantic mackerel

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Due to size-dependent pricing and regulations, pre-catch sizing of pelagic fish is desirable in a range of fisheries. High-resolution broadband echo sounders are potentially capable of direct remote fish sizing in relatively dense concentrations, as typically found during purse seining. The increased spatial resolution of pulse compressed broadband echoes and narrow beamwidth transducers provide the ability to resolve not only the target strength and echo spectrum, but also scattering from different parts of the fish body and hence measure the body size. We measured broadband scattering from tethered mackerel of varying sizes as a function of orientation angle to test the feasibility of this sizing method. Fish was caught on site and killed in a bath with lethal dose of Finquel compound just prior to the measurement. Mackerel was handled with no contact with air. Fish size ranged from 29-46cm. A motorized apparatus was used to suspend the individual fish in the acoustic beam of two laterally oriented transducers (45-90 kHz, 160-260 kHz, 13 m range), with precise control of rotation angle. Under these controlled conditions the

fish targets could be directly sized with varying degree of success. Measurements using fish with swimbladders will be carried out in 2019.

Measurements of mass density and sound-speed contrasts for target strength estimation of krill in Antarctic waters

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Mass density and sound-speed contrasts against surrounding seawater of live krill were measured during Japanese dedicated krill survey in the Indian sector of the Antarctic (CCAMLR Division 58.4.1) in 2018/19 season. The mass density measurements based on the density bottle method, and the sound-speed contrast measurements based on the time of the flight method using T-Tube, bathed in a temperature-controlled tank were conducted. The sound-speed contrasts were determined for the mean temperature where the nets were towed. For *Euphausia superba*, the mass density contrast was between 1.025 to 1.072, with mean value 1.0453 and standard deviation 0.0082 ($n = 371$). For *Thysanoessa macrura*, the mass density contrast was between 1.022 to 1.046, with mean value 1.0302 and standard deviation 0.0050 ($n = 49$). For *E. superba*, the determined temperature was between -1.3 to 1.2 °C, and the sound-speed contrasts was between 1.033 to 1.055, with mean value 1.0446 and standard deviation 0.0057 ($n = 1878$). For *T. macrura*, the determined temperature was -0.4 °C, the sound-speed contrast was 1.038 ($n = 1092$). Both values were larger in *E. superba* than *T. macrura*. The variation of the material properties related to species, size and, maturity is discussed.

Measurements of in situ target strength of Atlantic bluefin tuna (*Thunnus thynnus*) onboard a fishing baitboat vessel in the Bay of Biscay.

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This work presents in situ measures of target strength (TS; dB re 1 m²) and models of TS vs. fork length (L; cm) for bluefin tuna measured using a 38-kHz split-beam echosounder onboard a fishing baitboat vessel in the Bay of Biscay. To mitigate potential bias due to double counting, TS measurements were selected with fish tracking. The tuna body length distributions were obtained by live bait fishing and/or size measurements obtained using a high frequency Simrad M3 multibeam sonar that were tested for consistency with captured sizes. Mean TS in dB for a mean tuna body length resulting in a TS-length relationship is presented.

WGFAS 3. Behaviour

Mackerel at full tilt: how knowledge of behavior influences our estimates of abundance, just when we need it

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The stock of North East Mackerel is the subject of Europe's most valuable fishery, which in 2011 peaked at a spawning stock biomass of 4.8 million tonnes, with catches worth about US\$1 billion. The population has since been in decline and stock assessments are uncertain due to conflicting signals in fishery independent data. Attempts to carry out acoustic surveys for mackerel were made in the autumns of 2002 to 2004, but these were discontinued due to concerns about survey bias. Here, we explain the reasons for these biases, bringing together recent work on behaviour, in-situ target strengths, target strength modelling, and population estimation. The major reasons for earlier biases were an overestimate of target strength due to the failure to account for the large tilt angles these animals exhibit at the time of the surveys, and an over reliance on frequency response information which led to an underestimate of the amount of mackerel in schools. We argue for a re-analysis of the historic data, and for a revival of these surveys, both of which require international co-operation. This comes at a time when the need for additional fishery independent data to include in the stock assessment of NEA mackerel has never been greater.

Bottom-moored echosounders for continuous monitoring of Pacific Hake migration

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Pacific Hake ranges from southern California to northern British Columbia. It is a migratory species that is thought to mainly spawn off the southern to central California coast during January to March. Adult hake migrate north in the spring and by the summer can be detected in large aggregations all along the coast. Surveys assume a relatively slow and constant northward migration of Pacific Hake so that double-counting and missing counts are minimal. However there are concerns that the migration timing and behaviour of Pacific Hake might be highly variable, and that offshore-inshore movements (in and out of the survey boundaries) may bias survey results. This project aims at better understanding the temporal dynamics of Pacific Hake migration into Canadian waters by using stationary bottom-mounted echosounders. Three Acoustic Zooplankton and Fish Profilers operating at various acoustic frequencies were deployed at strategic locations along the west coast of Vancouver Island, Canada, to intercept migrating aggregations of Pacific Hake. The systems were deployed in September 2017 and 2018 to capture more than one migration cycle. Preliminary results and challenges in analyses and interpretations will be discussed.

Acoustic measurements of herring close to the sea surface

Espen Johnsen, Atle Totland, Rokas Kubilius and Egil Ona

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Ordinary fishery acoustic surveying methods with hull-mounted transducers may have problems when the surveyed population is situated close to the sea surface. The inability to measure fish in the echo sounder blind zone is obvious and fish vessel avoidance may in these situations negatively bias the density estimate. Here we present measurements on typical, shallow night-time layer of herring by four different methods. The layer was measured by the vessel echo sounders at 18, 38, 70, 120 and 200 kHz, mounted on the drop keel at 6 m depth. In parallel, we have used an electrically propelled, silent KayakDrone, carrying one 200 kHz scientific echo sounder (1m deep keel), one drifting Simrad WBAT buoy, deployed at 70 m depth, pinging at two frequencies, 70 and 200 kHz, towards the sea surface, and one free floating Tuna-buoy with two echo sounders (38 and 200 kHz) pinging from surface (0.2 m) to 100 m depth. The vessel keel-mounted MS70 scientific multibeam sonar was also set up in a specific mode for laterally ensonifying the shallow herring layer at short range. The data from the different instruments were interpreted and compared.

New insights into mesopelagic behaviour with a Profiling Lagrangian Acoustic Optical Probe (PLAOS)

Rudy J. Kloser, Haris Kunnath, Tim Ryan, Ben Scoulding & Caroline Sutton

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Knowledge of the mesopelagic zones micronekton (~2 to 20 cm sized organisms) is inferred through observations by nets, acoustics and optics. Each of these sampling methods has bias and uncertainty that need to be quantified prior to attributing distribution, biomass and change over time and between regions. In particular for the gelatinous community that covers a wide range of taxonomic and energetic groups that are difficult to sample with nets. A Profiling Lagrangian multi/broad-frequency Acoustic and Optical System (PLAOS) was used to compare with the vessel mounted multi-frequency acoustics and depth stratified net sampling of micronekton. The PLAOS's 1000 m depth profiling method is Lagrangian that enables the downward facing acoustic and optical data to be linked at varying sampling ranges to explore species behaviour and an oblique camera to quantify density and depth distributions of larger gelatinous organisms (e.g. physonect siphonophore). Based on the profiles it was possible to demonstrate both "attraction" and avoidance of biota at ranges from 1 to 100 m's. Avoidance responses of organisms at > 100 m range to PLAOS could impact the interpretation of net sampling, whilst change in behaviour of organisms due to lights has implications for optical, acoustic and net samplers.

Sunrise and sunset considerations for daytime surveys

Rebecca Thomas¹, Dezhang Chu², Stephane Gauthier², and Sandra Parker-Stetter

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Acoustic surveys are generally designed to match times of day/night when fish are aggregated and acoustically available. However, fish and other organisms may still be vertically migrating during this time period, causing changes in their target strength and ensuing biomass estimate. For Pacific Hake during the summer months, the fish aggregate during the daytime, and the survey is conducted from sunrise to sunset. Changes in Hake backscatter and depth during the initial post-sunrise and final pre-sunset periods were investigated using survey data spanning 15 years. Amid considerable variability, consistent changes in backscatter and aggregation

depths were found in the time periods following sunrise and before sunset. The change in TS implied by these changes is presented, and contributions from tilt/behavior and swimbladder pressure are considered. Finally, some practical considerations for the survey are discussed.

Mackerel at full tilt: how knowledge of behavior influences our estimates of abundance, just when we need it

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The stock of North East Mackerel is the subject of Europe's most valuable fishery, which in 2011 peaked at a spawning stock biomass of 4.8 million tonnes, with catches worth about US\$1 billion. The population has since been in decline and stock assessments are uncertain due to conflicting signals in fishery independent data. Attempts to carry out acoustic surveys for mackerel were made in the autumns of 2002 to 2004, but these were discontinued due to concerns about survey bias. Here, we explain the reasons for these biases, bringing together recent work on behaviour, in-situ target strengths, target strength modelling, and population estimation. The major reasons for earlier biases were an overestimate of target strength due to the failure to account for the large tilt angles these animals exhibit at the time of the surveys, and an over reliance on frequency response information which led to an underestimate of the amount of mackerel in schools. We argue for a re-analysis of the historic data, and for a revival of these surveys, both of which require international co-operation. This comes at a time when the need for additional fishery independent data to include in the stock assessment of NEA mackerel has never been greater.

Bottom-moored echosounders for continuous monitoring of Pacific Hake migration

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Pacific Hake ranges from southern California to northern British Columbia. It is a migratory species that is thought to mainly spawn off the southern to central California coast during January to March. Adult hake migrate north in the spring and by the summer can be detected in large aggregations all along the coast. Surveys assume a relatively slow and constant northward migration of Pacific Hake so that double-counting and missing counts are minimal. However there are concerns that the migration timing and behaviour of Pacific Hake might be highly variable, and that offshore-inshore movements (in and out of the survey boundaries) may bias survey results. This project aims at better understanding the temporal dynamics of Pacific Hake migration into Canadian waters by using stationary bottom-mounted echosounders. Three Acoustic Zooplankton and Fish Profilers operating at various acoustic frequencies were deployed at strategic locations along the west coast of Vancouver Island, Canada, to intercept migrating aggregations of Pacific Hake. The systems were deployed in September 2017 and 2018 to capture more than one migration cycle. Preliminary results and challenges in analyses and interpretations will be discussed.

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Special session: Habitat Monitoring Working Group of South Pacific Regional Fisheries Management Organization (SPRFMO)

Anchovy distribution off Peru in relation to abiotic parameters: A 32 year time-series from 1985 to 2017

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Collected acoustic data show a high seasonal variability in anchovy distribution related to differences of environmental parameters as well as changes in distribution after the very strong El Niño event in 1997-1998. Geostatistic variograms were used to describe the seasonal variability and Generalized Additive Models were applied to study the relationships between anchovy and oceanographic parameters. The dependent variable was NASC and tested covariates were: temperature, salinity, and dissolved oxygen at the sea. The results show a high anchovy variability with seasonal differences in its distribution. Preferred abiotic conditions (temperature, salinity, oxygen) of anchovy were 17.6-23.7 °C, 32.30-35.14 and 5.9-8.7 mL L⁻¹ in summer and 14.5-18.8 °C, 34.81-35.12 and 5.2-6.3 mL L⁻¹ in winter. Anchovy was detected at higher values after the 1997-1998 El Niño event.

From acoustic abundance estimates to habitat monitoring: the example of the Jack Mackerel *Trachurus murphyi*

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Large pelagic fish stocks may suffer huge changes in abundance. For instance, the biomass of the Chilean Jack Mackerel *Trachurus murphyi* (CJM) varied from around 30 million tons during the 1980s-90s to less than 5 million tons in the late 2000. Moreover the distribution area may vary in surface and location. Such populations are difficult to monitor. The first abundance estimates for CJM were achieved by the Soviet fishery in the early 1970s. Later Chilean and Peruvian acoustic research programs were developed, followed by EU and China. More recently, data bases were enriched by acoustic information from fishing vessels. Still, there is need for more integrative research, and the concept of habitat is one possible solution for monitoring the dynamics of fish populations. The SPRFMO created in 2018 a working group dedicated to “Habitat Monitoring”, firstly focused on CJM. This paper describes the history and objectives of the WG. The WG is fed with data from acoustic surveys and fisheries, as well as hydrologic, oceanographic and fishing data. The goal for the WG is to develop a specific model of habitat for the CJM, with the objectives of producing predictive information in terms of abundance and location.

Terms of Reference of the SPRFMO Habitat Monitoring Working Group

Mariano Gutierrez¹, Aquiles Sepúlveda²

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Under a recommendation of the Scientific Committee of the South Pacific Regional Fisheries Management Organization (SC-SPRFMO) it has been created a Habitat Monitoring Working Group (HMWG) with the main objective of providing environmental indicators associated to the habitat of the main commercial resources exploited in the SPRFMO area to complement decision making of fisheries management (e.g. Chilean Jack Mackerel –CJM–, whose habitat will be determined, characterized and monitored within an ecosystem approach). For the period 2018-2019, the SC recommended that the HMWG will: (1) Review the state of the art of habitat research in order to recommend specific lines of investigation in this topic within the framework of the SPRFMO; (2) Explore the concept of CJM habitat through retrospective analysis including bibliographical analysis; (3) Define a list of existing environmental data: satellite, acoustic surveys, acoustic fisheries surveys, fishing data, fishing vessel data (VMS, Observers in time and space that already exist inside the SPRFMO area; (4) Explore possibilities to organize a symposium on the topic of pelagic habitat in the 2020s; and (5) Organize a workshop on the state of the art of habitat research in the same place as, and immediately before, the SC 2020 meeting.

The OceanBox: a new technology to make collecting and processing of scientific sensor data on commercial trawlers feasible and useable.

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A major challenge in dealing with acoustic data from commercial vessels is coping with the logistics of fishing operations and the scale of the information that could be collected. The OceanBox consists of a combination of hardware components and associated software that allows for continuous processing of sensor data. Automated procedures convert Simrad acoustic data into NASC values by time-intervals (minute) and by depth layers (10 m). This summarized information, together with other sensor information is sent to the secured cloud taking into account irregular satellite bandwidth. The system is currently being tested on four pelagic trawlers (including one operating in the South Pacific). Once proven successful, this system can be scaled up

with relatively modest efforts to cover a substantial number of vessels in the pelagic fleet. In remote areas like the South Pacific this method could greatly enhance the data basis behind the estimates of stock abundance and habitat composition by effectively utilizing the scientific-quality instruments on board of commercial vessels.

Observation of the pelagic habitat off Peru from an ecosystem perspective

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The Peruvian main fisheries by volume are pelagic: anchovy, jack mackerel and mackerel. However the habitat is subject of a large variability in several time and space scales. Particular conditions have evolved in the last 10 years due to an increase of El Niño-like events, and the most related aspect is an overall increase of the sea surface temperature. At the same time monitoring capabilities have evolved to allow the fleet to continuously collect scientific quality data. Skippers and fishermen have been trained to collect several sources of information (oceanographic, acoustics, biology, ETP species etc) to contribute to the study and management of fisheries and the ecosystem itself. Industry vessels participate in routine in surveys since 1966, and since 2015 their acoustic data is integrated into the IMARPE's acoustic surveys for fish stock assessment. Models based on satellite data are also used to monitor the fishery performance to habitat changes and relate them to direct measurements such as the depth of the upper limit of the oxygen minimum zone (ULOMZ) and sub-meso scale vorticity.

Spatio-temporal patterns of lightfish (*Vinciguerria lucetia*) and its relationship with the shelf break in the Peruvian Sea (1998–2015)

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The aim of this work is to describe the spatio-temporal patterns of lightfish and its relationship with the shelf break in the Peruvian Sea. It was analyzed data collected in 47 acoustic surveys performed by the Peruvian Marine Research Institute (IMARPE) from 1998 to 2015. For each survey it was calculated 5 population indices: total acoustic biomass (sA), occupied area (ISO), spatial gravity center (latitudinal: GCy, longitudinal: GCx) and concentration/dispersion (I). Lightfish echo-traces were scrutinized using a bi-frequency algorithm (38 kHz and 120 kHz) and mid-water trawl catch samples. Time series were generated from each obtained index. The trend of each series was estimated by applying a local polynomial regression function. At local scale (1 nautical mile) the lightfish relationship between distribution, abundance and the distance to the shelf break were studied through histograms and generalized additive models. Two patterns were found for GC series (1998-2005 and 2005-2015), and three patterns for I (1998-2002, 2002-2008 and 2008-2015) and ISO (1998-2004, 2004-2011 and 2011-2014). The sA series showed a single peak in 2006-2008. The local-scale results reveal that even though *V. lucetia* was often found around the shelf break (~74.5% of the total occupied area), the highest biomasses were found near the coast.

Habitat Monitoring of Chilean Jack Mackerel using opportunity vessels off South-Central Chile Aquiles Sepúlveda¹ and Nicolás Alegría¹

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Since year 1999, digitised acoustic data has been collected during annual fishing seasons of operation from fishing vessels of the purse seine fleet of Central Chile equipped with 38 KHz calibrated EK-60 and ES-60 Echosounders. This acoustic data was processed in the lab jointly with size structure and biological data collected by observers on board of the vessels and/or samplings program at landings. The aim of this study is to summarise different factors and indicators considered in the characterisation of the habitat of Chilean Jack Mackerel (CJM). Distribution of CJM, modelled mean density and movements of this species by month were related with some oceanographic features. Due to the extent of the information interannual variability and changes in the habitat of CJM can be explored and related with El Niño/La Niña events. Under the analysis of this information, some considerations about the concept of CJM habitat are made and the main dimensions that restrict distribution are explored. A list of existing environmental data, including satellite, acoustic surveys, acoustic fisheries surveys, fishing data and biological data is made.

Annex 5: Publications by WGFAST members

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Annex 6: Summary of acoustic related research by country

COUNTRY	INSTITUTE	BEHAVIOUR	EMERGING TECHNOLOGIES, METHODOLOGIES AND PROTOCOLS	ACOUSTIC PROPERTIES OF MARINE ORGANISMS	APPLICATIONS OF ACOUSTIC METHODS TO CHARACTERIZE ECOSYSTEMS
Brazil	<p>Instituto de Pesquisa e Desenvolvimento (IRD)</p> <p>Universidade Federal de Pernambuco (UFPE)</p> <p>Universidade Federal Rural de Pernambuco (UFPE)</p>	Diel behaviour of pelagic and demersal communities	Combination of multifrequency acoustics and a variety of optical methods (towed video, ROV-mounted video, stereo-video)	<p>Fish TS and multifrequency discrimination of scatters (gelatinous, etc.);</p> <p>Physical properties: extraction of the thermohaline structure from multifrequency echograms</p>	Comprehensive 3D characterisation of multiple ecosystem components from physics to apex predators
Canada	Fisheries and Marine Institute of Memorial University / Université Laval / Fisheries and Oceans Canada	Diel behaviour of pelagic species in the Arctic	Applications of bottom-moored and ice-tethered echosounders. Use of fisheries sonars to detect marine mammals.	Studies on target strength of marine mammals and polar cod.	Assessment of interannual and seasonal changes in abundance and distribution of pelagic and mesopelagic fish in the Canadian Arctic and the Labrador Sea.
	DFO Institute of Ocean Sciences	Migration behaviour and movement of stocks and its implication for fisheries surveys.	<p>Develop methodologies to conduct fisheries acoustic surveys using Unmanned Surface Vessels (USVs), Sail-drones and estimate biomass of pacific hake.</p> <p>Classification of fish and zooplankton species using broadband echosounder data.</p>	<p>In situ target strength measurements.</p> <p>Broadband characterization of pelagic species.</p>	<p>Ecosystem-based acoustic surveys on pelagic-demersal fish (pacific hake), rockfish, zooplankton, and mesopelagic species.</p> <p>Environmental impacts on fish/zooplankton ecology.</p> <p>Salmon migration and effects of aquaculture on wild stocks.</p> <p>Predator-prey interactions.</p>

			<p>Use of machine learning to classify acoustic data.</p> <p>Development of optical methods and imaging techniques to assist in the interpretation of fisheries acoustics data.</p>		
France	Ifremer	<p>Study of small pelagic fish aggregative behaviour based on multibeam echosounder 3D schools</p>	<p>Fish biomass assessment with horizontal beaming echosounders.</p> <p>Development of EchoR R package for fish biomass acoustic assessment.</p> <p>Geostatistics for mapping fish distributions in space and time.</p> <p>Applications of bottom-moored and shipborne broadband echosounders to monitor coastal pelagic ecosystems and assess the impact of marine renewable energy</p>	<p>In situ measurements of European anchovy and sardine, mesozooplankton and micronekton TS</p> <p>Modelling fish TS</p>	<p>Multidisciplinary integrated surveys to monitor pelagic ecosystems. Small pelagic fish habitat and ecosystem mapping, ecosystem state indices</p>
Greece	Hellenic Centre for Marine Research	<p>Diurnal migration patterns of small pelagic species</p> <p>Diurnal migration patterns of mesopelagic species</p> <p>Habitat compression induced by dissolved oxygen stratification</p>		<p>In situ TS estimation of small pelagic and mesopelagic fish</p>	<p>Annual assesment of the abundance and distribution of small pelagic fish in GSA 20 and 22 (east. Mediterranean) as part of the MEDIAS.</p> <p>Habitat modelling for the spatio-temporal study of the anchovy and sardine biomass distribution.</p> <p>Surveys for the seasonal study of mesopelagic assemblages at specific locations of eastern Mediterranean Sea.</p>

Iceland	Marine and Freshwater Research Institute	Studies of spatial and temporal dynamics of capelin	Development and use of underwater cameras for observations of fish, and other organisms, as well as habitats.	Concurrent acoustic and optic observations of euphausiids, aiming at estimation of in situ average target strength. In situ target strength measurements of pelagic and mesopelagic fish	Marine ecosystem acoustic surveys in fjords and open ocean
New Zealand	National institute of Water & Atmospheric Research Ltd	Observation of spawning migration with bottom-moored echosounders Characterization of diurnal migration of mesopelagic fish	Applications of bottom-moored echosounders Optical/acoustic surveys including trawl cameras Acoustic deployments on sea-ice, Acoustic characterization of gas seeps Estimation of uncertainty for acoustic indices in Bayesian assessments Development of ESP3 analysis software Calibration and comparison of FCV30 and EK60 echosounders	In situ measurements of fish tilt angle and TS	Using acoustics to evaluate and predict abundance of mid-trophic level organisms for ecosystem modelling Monitoring Ross Sea Marine Protected Area using vessels of opportunity, sea-iced based deployments, and moorings
Norway	Institute of Marine Research	Observations of cod spawning migration with bottom mounted observatory (Love) Direct measurement of blind zone problem and fish avoidance during pelagic fish surveys Measuring behaviour of schools in the catch situation, before and after purse sein catching	Bottom mounted systems. Acoustic probes using broad band echo sounders. Development and trials of new multibeam sonar systems. Trial of acoustics from drone systems, like KayakDrone, saildrone and Hugin.	Experiments with wideband measurements on single targets for understanding the backscattered spectrum. In situ measurements of mean target strength in lateral aspect. (to convert sonar school measurements to biomass). TS measurements of mesopelagic fish.	Ecosystem acoustic surveys in Arctic, Antarctic areas, as well as within Norwegian EEZ. Ecosystem surveys within African waters. Development of direct photographic system in cod end: DeepVision system, and interfacing this with LSSS interpretation system.

		Measuring the behaviour of spawning cod during sounds from seismic air gun sounds.	Further development of broadband analysis in LSSS postprocessing software. Comparing FM and CW surveying results		
	UiT The Arctic University of Norway	Diel behaviour of pelagic species in the Arctic. Artificial light avoidance.	Applications of bottom-moored and ice-tethered echosounders.		Assesment of seasonal changes in abundance and distribution of pelagic and mesopelagic fish in the European Arctic.
Peru	Peruvian Marine Research Institute (IMARPE)	Characterization of diurnal migration of mesopelagic fish Characterization of the relationship between mesopelagic organisms (e.g. predator-prey)	Echocounting experiments using a IxBlue Seapix multibeam sonar	In situ measurements of fish tilt angle and TS	Using acoustics to evaluate the abundance of low trophic level organisms for ecosystem modelling. Characterization of the interaction between biotic (oxycline) and abiotic (biological fields) parameter
	Federico Villarreal University (UNFV)		Acoustic characterization of gas seeps.		
	Humboldt Institute of Marine and Aquaculture Research (IHMA) - UNFV				Protocol for estimating fish and zooplankton abundance using industry vessels' acoustic data. Relationship between sea surface level anomaly, vorticity, internal waves and acoustic abundance of organism. Identification of convergence and divergence processes based on the acoustic detection of the minimum oxygen zone.

Poland	Institute of Oceanography, Faculty of Oceanography and Geography, University of Gdańsk			Studies of herring TS and multifrequency discrimination of scatters (theoretical modelling and measurements)	Marine ecosystem acoustic surveys in Gulf of Gdańsk (southern Baltic Sea)
Spain	AZTI	Tilt angle distribution of anchovy Tilt angle distribution of bluefin tuna Study of avoidance of mesopelagic species to pelagic trawl	Size discrimination of tuna based on Kongsberg M3 Size discrimination of tuna based on broadband acoustics	In situ TS of European anchovy In situ TS of Maurolicus muelleri In situ TS of Bluefin tuna	Multidisciplinary oceanographic surveys to study the pelagic ecosystem
	IEO. Centro de Baleares.	Characterization of diurnal migration of mesopelagic fish. Avoidance reactions of mesopelagic fish. Identification of acoustic layers with avoidance.	AZFP & EK80, horizontal beaming, rosette deployment. Using machine learning and AI to perform species identification.	Mesopelagic species modelling	Mesopelagic and bathypelagic ecosystem.
United Kingdom	MASTS (Marine Alliance for Science & Technology Scotland), University of Aberdeen	Tilt angle distribution of mackerel	Low frequency broadband scattering of fish Geostatistical conditional simulations for error propagation in acoustic surveys Optical methods for alternative evidence of species identification Mesopelagic fish biomass estimation using an acoustic-driven and observation-based open-ocean biomass framework. Using machine learning and AI to perform species identification.	In situ measurements of fish TS Modelling fish TS	Predator prey relationships in a heavily exploited ecosystem Deep scattering layer in the Antarctic Prey surveys around foraging whale sharks. Global mesopelagic biogeography based on deep scattering layers. Fine-scale vertical structure of mesopelagic communities and links to deep-diving predators. Linking echosounder observations to ecological models.

	<p>CEFAS (Centre for Fisheries and Aquatic Sciences)</p>	<p>Observations of plankton behaviour and patchiness using surface gliders; vertical and horizontal migration and stock structure of pelagic fish and meso pelagic fish using gliders and RV</p>	<p>Wavegliders as platforms for echosounders</p>	<p>Habitat selection in foraging seabirds, cetaceans and bluefin tuna;</p> <p>Predator prey habitat use in subtropical reefs; predator-prey habitat use in seamounts</p>
	<p>SPFA (Scottish Pelagic Fishermens Association)</p>			<p>Herring survey to distinguish stock structure of European western herring</p>
	<p>Queen's University Belfast</p>		<p>M3 multibeam sonar imaging of marine fauna. ADCP, AZFP & EK80 (broadband), deployments (bottom-mounted and mobile surveys) in high-flow environments to discriminate physics (e.g. bubbles) from biological targets.</p>	<p>Foraging habitat of seabirds, marine mammals and sharks (fine-scale)</p>
	<p>Bangor University</p>	<p>Understanding the depth distribution of fish schools and its drivers in high current areas. Responses of fish schools to operating marine renewable energy devices.</p>		<p>Combined use of bottom mounted upward looking and vessel mounted downward looking echosounders to characterise water column use in high current areas.</p>
<p>United States of America</p>	<p>NOAA Alaska Fisheries Science Center, Midwater Assessment and Conservation Engineering (MACE) Program</p>	<p>Investigation of formation of spawning aggregations, movement of target species, <i>in situ</i> orientation, fish capture processes, fish response to underwater lights and instrumentation packages.</p>	<p>Bottom mounted echosounder deployments in survey areas to understand movement of target species, spawning aggregations, and survey timing.</p> <p>Saildrone deployments to develop onboard use of fisheries echosounders, characterize prey field for northern fur</p>	<p>Target strength of walleye pollock (<i>Gadus chalcogrammus</i>), target strength and material properties of euphausiids (<i>Thysanoessa</i> spp.)</p> <p>Improvement to methods for stock assessment surveys, particularly allocation of backscatter among species, trawl selectivity and fish capture processes, echosounder comparisons (EK80/EK60).</p> <p>Catchability of rockfish (<i>Sebastes</i> spp.) using split beam, multibeam, and underwater camera observations.</p>

			<p>seals, compare with survey vessel measurements.</p> <p>Evaluation of new echosounder instrumentation (EK60/EK80).</p> <p>Development and use of underwater stereo cameras for observations of fish, zooplankton, and habitat.</p>		Use of survey products (krill abundance index) in ecosystem approach to fisheries management
<p>NOAA National Centers for Coastal Ocean Science</p> <p>Florida International University</p>	<p>Reef fish spawning aggregations; predator/prey interactions</p> <p>Spatial and temporal dynamics of spawning aggregations of sub-tropical reef fish</p>	<p>Echosounders in ocean gliders</p> <p>Application of narrowband, broadband and imaging sonar methodologies for quantifying spawning aggregations in coastal reefs</p>	<p>Broadband modelling and field observations for differentiating diverse fish communities</p> <p>In situ tilt angle, scattering properties, modelling orientation specific fish TS</p>	<p>Marine ecosystem acoustic surveys in marine sanctuaries and marine reserves; multi-trophic level surveys of fish and zooplankton over coral reefs; seafloor habitat mapping</p> <p>Enhance fisheries independent survey methodologies for reef fish management in Southeast US.</p>	
<p>NOAA Northwest Fisheries Science Center, Fisheries Engineering and Acoustic Technologies (FEAT) Team</p>	<p>Spatial and temporal distribution of important fish and zooplankton species off the west coasts of US and Canada</p>	<p>Develop methodologies to conduct fisheries acoustic surveys using Unmanned Surface Vessels (USVs), Saildrones and estimate biomass of Pacific hake</p> <p>Classification of fish and zooplankton species using broadband echosounder data</p>	<p>Shipboard measurements of acoustic properties of zooplankton (g & h)</p> <p>Develop scattering models of a variety of fish and zooplankton species</p>	<p>Ecosystem-based acoustic surveys on pelagic-demersal fish (Pacific hake), rockfish, zooplankton, and mesopelagic species</p> <p>Environmental impacts on fish/zooplankton ecology</p>	
<p>NOAA Northeast Fisheries Science Center</p>	<p>Diel behaviour of mesopelagic species</p>	<p>Wideband acoustic (1-500 kHz) and optical (cameras, holographic imaging) characterization of the deep scattering layers.</p>	<p>Development and application of acoustic scattering models for abundance and biomass estimates of marine organisms.</p>	<p>Investigation of the catchability and selectivity of pelagic trawls for the mesopelagic community.</p> <p>Investigation of Atlantic herring consumption on krill.</p>	

Development of open-source code for processing and analyzing acoustic data.

Integration of acoustic estimates of krill abundance and biomass in ecosystem models.

Annex 7: Summary of acoustic surveys

Country	Institute	Survey name	Target stock(s)	Species [latin names]	Area	Survey date [month(s)]	Output(s)
Australia	CSIRO	NZ orange roughy	Orange roughy	<i>Hoplostethus atlanticus</i>	New Zealand Mid East Coast, Cook Canyon and Challenger Plateau	June/July 2017/2017	Biomass estimate
Australia	CSIRO	Southern Ocean Time Series (SOTS)	Mesopelagics	Multiple	Southern Ocean	April 2017, 2018	Census of mesopelagic species using optics and acoustics, behavioural observations in response to platform
Australia	CSIRO	Indian ocean orange roughy TS	Orange roughy	<i>Hoplostethus atlanticus</i>	Indian Ocean high seas	August 2018	TS estimates
Australia	CSIRO	Carbon sequestration study side	Pelagic species and bubble event detection	Multiple	SE Australia	Dec 2017, May 2018, Nov 2018, May 2019	Characterisation of pelagics at study site, develop methods for bubble seep detection
Australia	CSIRO	IMOS Biological ship of opportunity	Pelagic and mesopelagics to 1000 m	Multiple	Indian Ocean, Southern Ocean, Tasman Sea, Pacific Ocean	2017-2019 opportunistic collection of bio-acoustic data from 10 vessels	NetCDF of quality controlled echointegration data of ocean-basin scale acoustic backscatter posted on public repository (www.imos.org.au)
Brazil	Instituto de Pesquisa para o Desenvolvimento (IRD) Universidade Federal	ABRAÇOS 2 (Acoustic Along the Brazilian Coast) http://dx.doi.org/10.17600/17004100	Ecosystem	Multiple	Northeast Brazil	April-May 2017	Comprehensive 3D characterisation of the demersal and pelagic ecosystems in Northeast Brazil

	de Pernambuco (UFPE)						
	Universidade Federal Rural de Pernambuco (UFRPE)						
Brazil	Instituto de Pesquisa para o Desenvolvimento (IRD) Universidade Federal de Pernambuco (UFPE)	FAROFA (Fish acoustic around Fernando de Noronha)	Multiple	Multiple including <i>Melichtys niger</i> <i>Canthidermis sufflamen</i> <i>Sphyræna barracuda</i>	Oceanic Island off Northeast Brazil	September 2017 April 2018 April 2019	Comprehensive 3D vision of fish distribution in an oceanic tropical island
Canada	DFO Institute of Ocean Sciences	Joint U.S.-Canada Pacific hake survey	Pacific hake	<i>Merluccius productus</i>	West coast of North America	June-September 2017, 2019	Index of abundance at age (age 2+), age-1 index.
Canada	DFO Institute of Ocean Sciences	Joint U.S.-Canada Pacific hake survey	Pacific hake	<i>Merluccius productus</i>	West coast of North America	August-September 2018	Research on Pacific Hake migration
Canada	DFO Institute of Ocean Sciences	La Perouse zooplankton surveys	Zooplankton	Multiple	West coast Vancouver Island	May and September 2017, 2018, 2019	Index of zooplankton abundance
Canada	DFO Pacific Biological Station	IPES Integrated Pelagic Ecosystem Surveys	Pacific herring and other pelagics	Multiple	West coast Vancouver Island	July 2017, 2018, 2019	Index of abundance for pelagic species

Canada	DFO Pacific Biological Station	Seamounts surveys	Zooplankton and pelagic species	Multiple	Offshore West coast of Canada	July 2017, 2018, 2019	Abundance and distribution of pelagic species in seamounts areas of interest
Canada	DFO Institute of Ocean Sciences	Line P survey	Zooplankton and pelagic species	Multiple	West coast Canada	May, September, and February 2017, 2018, 2019	Long time series of zooplankton and fish abundance
Canada	Fisheries and Marine Institute of Memorial University/Université Laval/Fisheries and oceans Canada	ArcticNet	Polar cod	<i>Boreogadus saida</i>	Canadian Arctic	July-October 2004-present	Index of abundance (age-0 and age-1+). Target Strength.
Denmark Germany Ireland Netherlands Norway UK (Scotland)	DTU-Aqua (DK), Thünen-Institute of Sea Fisheries (GER), Marine Institute Ireland (IRL), WMR-Wageningen Marine Research (NL), IMR - Institute of Marine Research (NOR), Marine Scotland Science (UK-SCO)	The ICES Coordinated Acoustic Survey in the Skagerrak and Kattegat, the North Sea, West of Scotland and the Malin Shelf area (HERAS)	North Sea Autumn Spawning Herring NSAS, Western Baltic Spring Spawning Herring WBSS, West of Scotland autumn spawning Herring (VlaN), Malin Shelf Herring (MSHAS); North Sea Sprat (Sub-area 4); Sprat in Div3a.	<i>Clupea harengus</i> , <i>Sprattus sprattus</i> , <i>(Engraulis encrasicolus</i> , <i>Sardina pilchardus)</i>	Continental shelf of North Sea north of 52°N incl. West of Scotland and Ireland to northern limit of 62°N	June/July	Biomass Index Abundance Index Age structure Mean weight at age Maturity

<p>Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, Sweden</p>	<p>Danish Technical University, National Institute of Aquatic Resources; University of Tartu, Estonian Marine Institute; Natural Resources Institute Finland; Thünen-Institute of Baltic Sea Fisheries; Institute of Food Safety, Animal Health and Environment (BIOR), Fish Resources Research Department; Marine Research Institute; Klaipeda University; National Marine Fisheries Research Institute; AtlantNIRO; Swedish University of Ag-</p>	<p>BIAS (Baltic International Acoustic Survey)</p>	<p>Baltic sprat and herring (spr.27.22-32, her.27.20-24, her.27.25-2932)</p>	<p><i>Clupea harengus membras</i>, <i>sprattus sprattus</i></p>	<p>Baltic Sea (IIIb-d)</p>	<p>September/October</p>	<p>Age stratified index of abundance</p>
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	gricultural Sciences, Department of Aquatic Resources						
Estonia, Germany, Latvia, Lithuania, Poland, Russia	University of Tartu, Estonian Marine Institute; Thünen-Institute of Baltic Sea Fisheries; Institute of Food Safety, Animal Health and Environment (BIOR), Fish Resources Research Department; Marine Research Institute Klaipeda University; National Marine Fisheries Research Institute; AtlantNIRO	BASS (Baltic Acoustic Spring Survey)	Baltic sprat stock (spr.27.22-32)	<i>Sprattus sprattus</i>	Baltic Sea (IIIb-d)	May/June	Age stratified index of abundance
Estonia, Latvia	University of Tartu, Estonian Marine Institute; Institute of Food Safety,	GRAHS (Gulf of Riga Acoustic Herring Survey)	Gulf of Riga herring stock (her.27.28)	<i>Clupea harengus membras</i>	Gulf of Riga in Baltic Sea (ICES SD 28.1)	July/August	Age stratified index of abundance

	Animal Health and Environment (BIOR)						
France	IFREMER	PELGAS	Anchovy, sardine	<i>Engraulis encrasicolus</i> , <i>Sardina Pilchardus</i> ,	Bay of Biscay	May, annually	Age stratified index of abundance, distribution
France	IFREMER	PELGAS	Horse mackerel, mackerel, sprat, boarfish	<i>Trachurus trachurus</i> , <i>Sprattus sprattus</i>	Bay of Biscay	May, annually	Abundance index, distribution
France	IFREMER	PELMED	Anchovy, sardine,	<i>Engraulis encrasicolus</i> , <i>Sardina Pilchardus</i> ,	Gulf of Lion	July, annually	Age stratified index of abundance
France	IFREMER	PELMED	Horse mackerel, sprat	<i>Trachurus trachurus</i> , <i>Sprattus sprattus</i>	Gulf of Lion	July, annually	Abundance index, distribution
Germany	Thünen-Institute of Sea Fisheries/Thünen-Institute of Baltic Sea Fisheries	German Acoustic Autumn Survey (GERAS)	Western Baltic Spring Spawning Herring WBSS, Central Baltic Herring CBH, Baltic Sea Sprat (SD22-32)	<i>Clupea harengus</i> , <i>Sprattus sprattus</i> , (<i>Engraulis encrasicolus</i>)	Kattegat, Western Baltic Sea, Öresund (ICES SD 21-24)	October	Biomass Index Abundance Index Age structure Mean weight at age Maturity
Greece	Hellenic Centre for Marine Research (HCMR)	MEDIAS (GSA 20 and 22)	European anchovy and Sardine	<i>Engraulis encrasicolus</i> <i>Sardina pilchardus</i>	Aegean Sea & eastern Ionian Sea	Jun-Jul (Aegean Sea) Sep-Oct (east. Ionian Sea)	Index of abundance at age

Iceland	Marine and Freshwater Research Institute	International summer survey in Nordic Seas (IESSNS). Pelagic ecosystem survey (surface to 500 m).	Mackerel (swept area), blue whiting and Norwegian spring-spawning herring (acoustics).	<i>Scomber scombrus</i> , <i>Clupea harengus</i> , <i>Micromesistius poutassou</i>	Icelandic exclusive economic zone and further southwards to latitude 60N and somewhat further northward into Greenland waters.	All of July. 5 countries participate in the survey.	Age-segregated index for stock assessment of mackerel (swept area) and aim for such index for blue whiting and herring in the near future (acoustic).
Iceland	Marine and Freshwater Research Institute	Acoustics, Video Plankton recording and net sampling of euphausiids	Euphausiids	<i>Thysanoessa raschii</i>	Isaf-jardardjup, West fjord peninsula of Iceland	October 2018, (4 days)	Comparative measurements by three different methods
Iceland	Marine and Freshwater Research Institute	Spring cruise	Euphausiids, (myctofids)	<i>Thysanoessa raschii</i> , <i>Th longaudata</i> , <i>Meganycitifanes Norwegica</i> and more	Icelandic continental shelf?	May 2018	Distribution and index of abundance of euphausiids
Iceland	Marine and Freshwater Research Institute	Survey on Icelandic summer-spawning herring (IS-Her-Aco-Q4/Q1)	Icelandic summer-spawning herring (i.e. the fishable stock)	<i>Clupea harengus</i>	Continental shelf and coastal areas east, south and west of Iceland	Varies between years, Nov.-March	Age-structured acoustic survey index of the target stock
Iceland	Marine and Freshwater Research Institute	Survey on Icelandic summer-spawning herring juveniles	Icelandic summer-spawning herring juveniles	<i>Clupea harengus</i>	Fjords west and north of Iceland	October	Acoustic survey index of number at age 1

Iceland (+ Norway, EU, Faroe Is- land and Rus- sia)	Marine and Freshwater Research In- stitute	International Ecosystem survey in the Nor- wegian Sea (IESNS)	Norwegian spring- spawning herring (main target spe- cies), blue whiting	<i>Clupea ha- rengus</i> , <i>Mi- cromesistius poutassou</i>	Norwegian Sea	May	Age-structured acoustic survey index of the target species+Zooplankton in- dex+Environmental condition
Iceland	Marine and Freshwater Research In- stitute	Winter survey on capelin in Iceland-East Greenland – Jan Mayen area	Iceland-East Greenland – Jan Mayen capelin spawning stock	<i>Mallotus villosus</i>	Icelandic con- tinental shelf	January-Feb- ruary	Index of abundance at age and maturity, distribution, in situ TS, temperature, sa- linity.
Ireland	Marine Insti- tute	Celtic Sea herring acoustic survey (CSHAS)	HER, SPR	Herring (<i>Clupea harengus</i>) Sprat (<i>Sprattus sprattus</i>)	Celtic Sea, Ire- land	October, an- nually	Age stratified index of abundance
Ireland	Marine Insti- tute	International blue whiting spawning stock survey (IBWSS)	WHB	Blue whiting (<i>Micromesistius poutassou</i>)	W of Ireland & Scotland	March-April, annually	Age stratified index of abundance
Ireland	Marine Insti- tute	Western European Shelf Pelagic Acoustic Survey (WESPAS)	HER, BOC,HOM(W)	Herring (<i>Clupea harengus</i>), Boarfish (<i>Ca- pros aper</i>), Horse mackerel (<i>Trachurus tra- churus</i>)	W of Ireland & Celtic Sea	June-July, an- nually	Age stratified index of abundance
Ireland and UK (Scotland)	Marine Insti- tute and Ma- rine Scotland Science	6a7bc herring industry survey	HER, HOM	Herring (<i>Clupea harengus</i>)	W of Ireland & Scotland	Aug/Sept (au- tumn spawn- ing) and	Age stratified index of abundance

					Horse mackerel (<i>Trachurus trachurus</i>)	Nov/Dec (winter spawning) annually	
New Zealand	National Institute of Water & Atmospheric Research Ltd	Cook Strait hoki	HOK1	<i>Macruronus novaezelandiae</i>	Cook Strait, New Zealand	July-August 2017, 2019	index of abundance
New Zealand	National Institute of Water & Atmospheric Research Ltd	West coast South Island hoki	HOK1	<i>Macruronus novaezelandiae</i>	West coast South Island, New Zealand	July-August 2018	index of abundance
New Zealand	National Institute of Water & Atmospheric Research Ltd	Bounty southern blue whiting	SBW6B	<i>Micromestius australis</i>	Bounty Plateau, New Zealand	August 2017, 2018, 2019	index of abundance
New Zealand	National Institute of Water & Atmospheric Research Ltd	Campbell southern blue whiting	SBW6I	<i>Micromestius australis</i>	Campbell Plateau, New Zealand	September 2019	index of abundance at age
New Zealand	National Institute of Water and Atmospheric Research Limited	Chatham Rise middle depths trawl survey	HOK1, LIN3/4, HAK1/4	Hoki (<i>Macruronus novaezelandiae</i>), ling (<i>Genypterus blacodes</i>), hake (<i>Merluccius australis</i>)	Chatham Rise, New Zealand	January 2018	Index of abundance at age
New Zealand	National Institute of Water and Atmos-	Sub-Antarctic middle depths trawl survey	HOK1, LIN5/6, HAK1	Hoki (<i>Macruronus novaezelandiae</i>), ling (<i>Genypterus</i>)	Southland and Sub-Antarctic, New Zealand	November-December 2018	Index of abundance at age

	pheric Research Limited				<i>blacodes</i>), hake (<i>Merluccius australis</i>)			
New Zealand	National Institute of Water and Atmospheric Research Limited	Ross Sea Marine Protected Area monitoring			Silverfish (<i>Pleuragramma antarctica</i>), krill (<i>Euphausia superba</i>)	Ross Sea, Antarctica	February-March 2018, Jan-Feb 2019	Index, distribution
New Caledonia (France)	IRD and SPC (pacific community)	NECTALIS	?	?		Coral sea (south west pacific)	July 2011, December 2011, december 2014, October 2015 and December 2016	
Norway	Institute of Marine Research	WGIPS (2019831)		Blue whiting	<i>Micromesistius poutassou</i>	Atlantic Ocean, west of Ireland	March-April	Index of abundance
Norway	Institute of Marine Research	HERAS-NORACU (2019207)		Herring	<i>Clupea harengus</i>	North Sea	May-June	Index of abundance
Norway	Institute of Marine Research	Sandeel survey (2019847)		Sandeel	<i>Ammodytes marinus</i>	North Sea, Norwegian EEZ	April-May	Index of abundance
Norway	Institute of Marine Research	Ecosystem survey Barents Sea (2019209)		Capelin	<i>Mallotus villosus</i>	Barents Sea	September	Index of abundance
Norway	Institute of Marine Research	2019809		Capelin	<i>Mallotus villosus</i>	Barents Sea, Finnmark coast	March	Spawning biomass

Norway	Institute of Marine Research	WGIPS (2019107)	Herring	<i>Clupea harengus</i>	Norwegian Sea	May-June	Index of abundance
Norway	Institute of Marine Research	Spawning survey NVG herring (2019840, 841, 842)	Herring	<i>Clupea harengus</i>	Norwegian Coast	February	Spawning biomass
Peru	Peruvian Marine Research Institute	Pelagic fishes	Small Pelagic species (e.g. anchovy)	<i>Engraulis ringens</i>	Northern Humboldt Current System	All years: February to April, August to September, October to November	index of abundance and distribution
Peru	Peruvian Marine Research Institute	Demersal fishes	Demersal species (e.g. hake)	<i>Merluccius gayii</i>	Northern Humboldt Current System	All years: May to June	index of abundance and distribution
Peru	Peruvian Marine Research Institute	Coastal fishes	Coastal species (e.g. Chilean silver-side)	<i>Odonthestes regia</i>	Northern Humboldt Current System	All years: August	index of abundance and distribution
Peru	Peruvian Marine Research Institute	Giant squid	Giant squid	<i>Dosidicus gigas</i>	Northern Humboldt Current System	All years: December to January	index of abundance and distribution
Peru	Peruvian Marine Research Institute	Antarctic krill	Antarctic krill	<i>Euphasia superba</i>	Bransfield Strait, Area 48, Antarctica	All years: January	index of abundance and distribution
Peru	Peruvian Marine Research Institute	Freshwater fishes	Freshwater species (e.g. Ispi)	<i>Orestias mooni</i>	Titicaca Lake	All years: May	index of abundance and distribution

Spain	AZTI	JUVENA (Acoustic survey for juvenile anchovy)	Bay of Biscay Anchovy	<i>Engraulis encrasicolus</i>	Bay of Biscay	August/September	Age stratified index of abundance
Spain	AZTI	BFTIndex	Atlantic Bluefin tuna	<i>Thunnus thynnus</i>	Bay of Biscay	June/July	Relative abundance index
United Kingdom	MASTS (Marine Alliance for Science & Technology Scotland), University of Aberdeen	North Sea Mackerel acoustic survey	NEA mackerel	<i>Scomber sombrus</i>	Northern North Sea	Oct	In situ TS, tilt angle distributions, Broadband measurements Abundance index (in prep)
United Kingdom	CEFAS	PELTIC Pelagic Ecosystem Survey	English Channel (ICES area 7e) sprat, sardine, anchovy	<i>Sprattus sprattus</i> , <i>Sardina pilchardus</i> , <i>Engraulis encrasicolus</i> (<i>Trachurus trachurus</i> , <i>Scomber scombrus</i> , <i>Capros aper</i>)	Celtic Sea and Western Channel, ICES area 7d,e,f	Q4	Age stratified index of abundance for sprat, sardine, anchovy, ecosystem indicators (phytoplankton, eutrophication)
United Kingdom	CEFAS	IBTS North Sea	Specifically North Sea Mackerel	<i>Scomber scombrus</i>	ICES area 4	August	Opportunistic: Biomass estimates (R&D)
United Kingdom	CEFAS	Discovery Seamount survey	Mesopelagics	Many (<i>Maurollicus muelleri</i>)	S. Atlantic Tristan de Cunha & St Helena	March / April	Biomass estimates; predator prey
United Kingdom	Marine Scotland Science	Herring Acoustic survey	North Sea herring	<i>Clupea harengus</i>	ICES area IV	July	Index at age for herring
United Kingdom	MASTS (Marine Alliance for Science & Technology Scotland),	Lake Victoria acoustic survey	Nile perch and dagaa	<i>Lates niloticus</i> <i>Rastrineobola argentea</i>	Entire Lake Victoria	?	Biomass estimates

	University of St Andrews						
UK (Scotland)	Marine Scotland Science & University of Aberdeen	Clyde herring	Herring, sprat	<i>Clupea harengus</i> , <i>Sprattus sprattus</i>	Clyde Sea, W of Scotland	October 2017, 2018	Biomass index for the fish species and krill
UK (Scotland)	Scottish Pelagic Fisheries Association	6aN herring -industry survey	Herring	<i>Clupea harengus</i> ,	West of Scotland		Age-disaggregated estimate of biomass. Stock identity separation (morphometrics & genetics). Commercial catch age composition.
United States	NOAA Alaska Fisheries Science Center	Winter acoustic-trawl survey of Shumagin Islands, Sanak Trough, Pavlof and Morzhovoi Bays (DY1702)	Walleye pollock	<i>Gadus chalcogrammus</i>	Gulf of Alaska	February 2017	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Winter acoustic-trawl survey of Kenai Bays and Prince William Sound (DY1703)	Walleye pollock	<i>Gadus chalcogrammus</i>	Gulf of Alaska	February-March 2017	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Winter acoustic-trawl survey of Shelikof Strait, Marmot Bay, Chirikof Shelf Break (DY1704)	Walleye pollock	<i>Gadus chalcogrammus</i>	Gulf of Alaska	March 2017	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Summer acoustic-trawl survey of the Gulf of Alaska (DY1706)	Walleye pollock, euphausiids	<i>Gadus chalcogrammus</i> , <i>Thysanoessa spp.</i>	Gulf of Alaska	June-August 2017	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Acoustic vessels of opportunity (AVO) index of midwater pollock abundance	Walleye pollock	<i>Gadus chalcogrammus</i>	Bering Sea	June-August 2017	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Winter acoustic-trawl survey of Shumagin Islands, Sanak Trough, Pavlof and Morzhovoi Bays (DY1802)	Walleye pollock	<i>Gadus chalcogrammus</i>	Gulf of Alaska	February 2018	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Winter acoustic-trawl survey of Bogoslof Island area (DY1803)	Walleye pollock	<i>Gadus chalcogrammus</i>	Bering Sea	March 2018	Index of abundance

United States	NOAA Alaska Fisheries Science Center	Winter acoustic-trawl survey of Shelikof Strait, Marmot Bay, Chirikof Shelf Break (DY1804)	Walleye pollock	<i>Gadus chalcogrammus</i>	Gulf of Alaska	March 2018	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Summer acoustic-trawl survey of the eastern Bering Sea (DY1806)	Walleye pollock, euphausiids	<i>Gadus chalcogrammus</i> , <i>Thysanoessa spp.</i>	Bering Sea	June-August 2018	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Acoustic vessels of opportunity (AVO) index of midwater pollock abundance	Walleye pollock	<i>Gadus chalcogrammus</i>	Bering Sea	June-August 2018	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Winter acoustic-trawl survey of Shelikof Strait, Marmot Bay, Chirikof Shelf Break (SH1904)	Walleye pollock	<i>Gadus chalcogrammus</i>	Gulf of Alaska	March 2019	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Summer acoustic-trawl survey of the Gulf of Alaska (DY1906)	Walleye pollock, euphausiids	<i>Gadus chalcogrammus</i> , <i>Thysanoessa spp.</i>	Gulf of Alaska	June-August 2019	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Acoustic vessels of opportunity (AVO) index of midwater pollock abundance	Walleye pollock	<i>Gadus chalcogrammus</i>	Bering Sea	June-August 2019	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Bottom-mounted echosounders, eastern Bering Sea	Walleye pollock	<i>Gadus chalcogrammus</i> , <i>Thysanoessa spp.</i>	Bering Sea	July 2019-July 2020	Index of abundance
United States	NOAA Alaska Fisheries Science Center	Arctic moorings	Arctic cod	<i>Boreogadus saida</i>	Chukchi Sea	August 2017 – July 2018; July 2018 – August 2019	Seasonal abundance change
United States	NOAA Alaska Fisheries Science Center	Arctic Integrated Ecosystem Research Program (AIERP) fieldwork	Arctic cod	<i>Boreogadus saida</i>	Northern Bering, Chukchi Sea	August – September 2017	Index of abundance

United States	NOAA Alaska Fisheries Science Center	Sanak mooring	Walleye pollock, euphausiids	<i>Gadus chalcogrammus</i> , <i>Thysanoessa spp.</i>	Gulf of Alaska	November 2016 – May 2017	Timing of spawning
United States	NOAA Northeast Fisheries Science Center	Annual spring bottom trawl survey	Atlantic herring	<i>Clupea harengus</i>	Gulf of Maine	March-May 2017-2019	Index of abundance
United States	NOAA Northeast Fisheries Science Center	Annual fall bottom trawl survey	Atlantic herring	<i>Clupea harengus</i>	Gulf of Maine	September-November 2017-2019	Index of abundance
United States	NOAA Northeast Fisheries Science Center	Deep-See mesopelagic exploration	Numerous	Multiple	Oceanic waters of the US mid-Atlantic and New England	July-August 2018-2019	
United States and Canada	NOAA Northwest Fisheries Science Center	Joint U.S.-Canada Pacific hake survey	Pacific hake	<i>Merluccius productus</i>	West coast of North America	June-September 2017, 2019	Index of abundance at age (age 2+), age-1 index.

Annex 8: End of term e-evaluation

1 Working Group information

Expert group name	Working Group on Fisheries Acoustics, Science and Technology (WGFAST)
Resolution code	2016/MA2/SSGIEOM02
Names of chairs	Richard O’Driscoll, New Zealand
Year cycle started	2017
Year of evaluation	2019
Meeting venue(s) and dates during evaluation year	4-7 April 2017, Nelson, New Zealand (63 participants)
	20-23 March 2018, Seattle, USA (91 participants)
	29 April-2 May 2019, Galway, Ireland (93 participants)
Name(s) of person(s) completing form	Richard O’Driscoll, New Zealand

2 Analysis of progress in relation to terms of reference

ToR	ToR Description (copy from resolution)	Progress in relation to ToR (maximum 200 words per ToR)	Status of term of reference (select text)	Science Plan codes addressed
a	Collate information on acoustic related research and surveys by Country represented in WGFAST.	Annexes summarising acoustic related research and surveys by country summarised in final report.	Completed	3.1, 3.2, 3.4
b	Present recent work within the topics “Applications of acoustic methods to characterize ecosystems”, “Acoustic properties of marine organisms”, “Behaviour”, and “Emerging technologies, methodologies, and protocols”.	A separate session was held for each theme, where the participants first presented the latest results of their work, followed by a discussion. The abstracts and discussion summaries are given in the interim and final reports. An annex listing publications by WGFAST members provided in final report.	Completed	3.3, 4.1, 4.4
c	Organize training session on use of acoustics for biomass estimation	An ICES Training course on ‘Introduction to abundance estimation from fisheries acoustic surveys’ took place 12-16 June 2017 at ICES Secretariat, Copenhagen, Denmark, with course instructors John Horne and Paul Fernandes. A total of 25 participants attended from 14 countries	Completed	3.1
d	Provide guidance for calibrating echosounders on fishing vessels (topic group)	ICES Cooperative Research Report No. 326 by Demer et al. (2015) on ‘Calibration of acoustic instruments’ provides guidance on calibration of a range of acoustic instruments currently used in fisheries research, including some systems (e.g., Simrad ES60 and ES70) used on fishing vessels. Section 4.1.7 of CRR 326 provides a ‘quick-start’ guide to calibrating Simrad EK60, ES60, and ES70 echosounders which was intended to be of use to the wider community.	Completed	3.6
e	Organize joint sessions at ICES ASC	WGFAST co-chaired theme session J at the 2018 ICES ASC meeting on “Survey data products for stock and ecosystem assessments: challenges and future directions”. This session had 24 oral presentations and 8 posters and was attended by about 80 people.	Completed	3.1, 3.2, 4.1
f	Define a data format for omni fisheries sonars.	A convention for the storage of omni-sonar data in netCDF4-formatted computer files has been produced by the WG-FAST Topic Group for Defining a data format for omnidirectional fisheries sonar. The convention specification has been published as CRR 341. The name of the convention is SONAR-netCDF4.	Completed	3.2, 3.5, 4.2
g	Work towards developing and recommending procedures for collecting and processing quality acoustic data in inclement weather.	The Topic Group on Collecting Quality Underwater Acoustic Data in Inclement Weather (TGQUAD) met in Seattle, USA from 17-19 March 2018 and in Galway, Ireland from 3-5 May 2019. TGQUAD will meet again in 2020 associated with the WGFAST meeting in Bergen, Norway to finalise production of the CRR.	On track	3.3, 3.6

Annex 9: Analysis of progress by working group and future plans

1. Summarise briefly the major achievements of the working group and how it has contributed to the ICES vision and mission (200 word limit)

WGFAST is the major international forum where individuals working in fisheries acoustics network to discuss ongoing developments in the technique. As such, it is highly successful. There are over 250 members of the group, with 93 participants from 21 countries at the 2019 meeting. WGFAST members are involved in over 90 surveys in 21 countries, contributing to stock and ecosystems assessments. Outputs include 3 CRRs and over 70 related primary publications by members during the three-year term. WGFAST organised an ICES Training course on 'Introduction to abundance estimation from fisheries acoustic surveys' in June 2017, and three training courses on 'Principles and Methods of Broad-band/Wideband Technologies: Application to fisheries acoustics' in 2016-18, with another planned in December 2019. WGFAST co-chaired theme session J at the 2018 ICES ASC meeting on "Survey data products for stock and ecosystem assessments: challenges and future directions".

2. List outputs of the working group (other than working group reports). These would include, for example, peer review papers, code, contributions to databases (400 word limit). For peer reviewed papers please confirm if details and ideally a pdf have been sent to ICES publications.

Demer, D. A., Andersen, L. N., Bassett, C., Berger, L., Chu, D., Condiotty, J., Cutter, G., R., et al. 2017. 2016 USA–Norway EK80 Workshop Report: Evaluation of a wideband echosounder for fisheries and marine ecosystem science. ICES Cooperative Research. Report No. 336. 69 pp. <http://doi.org/10.17895/ices.pub.2318>

Macaulay, G. and Peña, H. (Eds.). 2018. The SONAR-netCDF4 convention for sonar data, Version 1.0. ICES Cooperative Research Report No. 341. 33 pp. <http://doi.org/10.17895/ices.pub.4392>

Korneliussen, Rolf J. (Ed.). 2018. Acoustic target classification. ICES Cooperative Research Report No. 344. 104 pp. <http://doi.org/10.17895/ices.pub.4567>

Details of over 70 relevant peer-reviewed papers by WGFAST members in 2017-19 are summarised in Annex 5 of final report.

Processed acoustic and biotic data collected on acoustic trawl surveys in the Northeast Atlantic and Baltic Seas. <http://www.ices.dk/marine-data/data-portals/Pages/acoustic.aspx>

Raw acoustic data collected on fisheries and research surveys in waters throughout the U.S. and internationally are archived at the NOAA National Centers for Environmental Information. The main data contributor is the NOAA National Marine Fisheries Service. https://maps.ngdc.noaa.gov/viewers/water_column_sonar/

3. List any outreach activities or external achievements of the working group such as winning of, or engagement in, funded projects, scientific/stakeholder meetings or conferences organised, contributions to the activities of other organisations (400 word limit)

A joint session with the South Pacific Regional Fisheries Management Organization (SPRFMO) Habitat Modelling Working Group was held during the 2019 WGFAST meeting. The session included 7 presentations from scientists from Peru and Chile. The Ambassador of Peru to Ireland, Ms Ana Sánchez, visited during the meeting.

Several WGFAST members are also members of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM).

WGFAST members have been engaged with the South Indian Ocean Fisheries Agreement (SIOFA) to determine whether unsupervised industry collected acoustic data on orange roughy can be used for stock assessment and target strength purposes.

Members are engaged in a number of EU-funded projects on mesopelagic resources (MESOOP, SUMMER, MEESO).

On 3 April 2017, a joint meeting (JFTAB) took place with the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) in association with the WGFAST meeting in Nelson, New Zealand. Another joint meeting is scheduled for April 2020 in Bergen, Norway. A workshop on the development of practical survey methods for measurements and monitoring in the mesopelagic zone (WKMesoMeth) was held in Galway, Ireland on 27-28 April 2019 in conjunction with WGFAST.

4. Please identify any challenges faced by the working group and any actions taken to overcome them (400 word limit)

WGFAST has expanded during the current term, with over 90 members attending meetings in 2018 and 2019 compared to 60-70 in 2014-17. The time for individual presentations and discussion have reduced. Consideration has been given to extending the duration of the meeting and also for accepting poster presentations. WGFAST members agreed that it was undesirable to have concurrent sessions.

5. Does the working group wish to begin a new term under the same name? (yes/ no)

Yes.

6. If your working group does wish to begin a new term under the same name then please describe any resource issues that need to be addressed to secure adequate attendance and the actions being taken to address them (200 word limit)

No specific resource issues.

7. If your working group does not wish to begin a new term under the same name then are there science or advice needs in your area of expertise that need to be pursued in a new working group? (select options yes/ no)

Not applicable.

8. Please describe your reasons for seeking or not seeking a continuation of the existing group or proposing a new working group. If you do not wish to begin a new term

under the same name then please describe any science or advice needs in your area of expertise that need to be pursued in a new working group. If a continuation or new working group is proposed a draft resolution should be submitted (400 word limit).

A draft resolution for continuation of WGFAST will be submitted.

Fisheries acoustics is an international field of applied science which requires an interdisciplinary approach bringing together expertise in biology, engineering, and physics. The field provides techniques to detect fish and other underwater resources, and to quantify their abundance and distribution. As such it is a vital component for the accurate resource assessment which is required for effective management. Increasingly the technique is being directed to a broader range of applications (e.g. studies of abundance, distribution and behaviour of fish around offshore energy sites; and in broader ecological studies of e.g. predator prey interactions). The specialised expertise required is highly dispersed, because most nations provide resources for only one or two locations with one or two individuals working in any of the aforementioned fields.

ICES WGFAST is the only international forum where such individuals can network to discuss ongoing developments in the technique. As such it has been highly successful. There are over 250 current members, and the two most recent meetings attracted over 90 participants. WGFAST has met annually since 1984.

A measure of WGFAST success is the wide participation beyond the ICES community: regular participants include those from Australia, New Zealand, Japan, and the west coast of the USA and Canada. Without this WG, the fisheries acousticians in each member and observer state will be more isolated and have to rely on sporadic international conferences which do not have fisheries (and marine resource related) applications at heart: this would be a major loss to the ICES community and would jeopardize the quality of associated surveys and the relevant underwater acoustics research worldwide.