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Report of the Joint Workshop of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) and the Working Group on Fisheries Acoustics Science and Technology (WGFAST)

3 April 2017

Nelson, New Zealand

ICES
International Council for the Exploration of the Sea

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Executive summary

The Joint Workshop of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour [WGFTFB] and the Working Group on Fisheries Acoustics Science and Technology [WGFAST] (JFATB) chaired by Paul Winger (Canada) and Alex De Robertis (USA) met in Nelson, New Zealand on 3 April 2017 in conjunction with the meetings of WGFTFB and WGFAST to a) examine the observer effect: how platforms and instruments affect the behaviour of aquatic fauna, b) review recent progress in image analysis and machine learning techniques for efficient data processing in aquatic research, and c) facilitate links between WGFTFB and WGFAST as well as other research organizations with expertise in gear technology, optical and acoustic sampling methods, and fish behaviour. The meeting consisted of 10 presentations of novel research that stimulated discussion on a broad range of subjects in areas relevant to the membership of both working groups. There were a total of 68 participants from 16 nations.

Highlights:

Technological development of optical and acoustic techniques is generating large amounts of observations, which necessitates continued development of analysis techniques facilitating 1) efficient storage, processing and interpretation of large datasets, and 2) the display, analysis, and synthesis of data from multiple sources. There is a need to integrate these emerging methods into abundance surveys.

There is a recognized need for improved methods to quantify the selectivity of survey trawls across a broad range of species and sizes to help develop multispecies surveys. A subset of WGFTFB and WGFAST members and others from outside the group have expertise that is relevant to developing practical methods to quantify the species and size selectivity of survey trawls. Improved methods for quantification of survey trawl selectivity will result in improved trawl designs, and reduced uncertainties in survey abundance indices.

There was substantial discussion about the future of JFATB, both at the JFATB meeting and during the WGFAST and WGFTFB. Members of WGFAST and WGFTFB concur that JFATB should continue to meet on a triennial basis. The next meeting of the JFATB should be in 2020. WGFAST proposesStéphane Gauthier (Canada) and WGFTFB proposes Michael Pol (USA) as the new chairs of JFATB.

1 Opening of the meeting

1.1 Opening and Welcome

Richard O'Driscoll, the head of the local organizing committee opened the meeting. He welcomed the participants to New Zealand and explained the relevance of fishing to Maori culture. Fishing figures prominently in creation myths of New Zealand: The North Island stems from a fish, the South Island from a canoe. He then introduced a series of speakers who provided a local context to fisheries and the activities of the working group from several perspectives.

Archdeacon Harvey Ruru presented a traditional Maori welcome and welcomed the participants to the South Island of New Zealand. He acknowledged the importance of the work done by the working groups to sustain the fisheries of this island nation.

Rachel Reese, the mayor of Nelson welcomed the participants to Nelson. She stressed that fishing is a major employer in the city and at the heart of the city's economy. She reviewed the importance of science and innovation in maintaining sustainable fishing, and the importance of the fishing industry in the nation. She wished for a successful conference and underscored the importance of engaging with the public and industry.

Richard Bradley, chairman of Te Tau Ihu customary fishery forum gave an overview of Maori fishing rights, and offered the perspective of the Maori in terms of fisheries. He described the long history of 3000 years of Maori fishing activity which is supported by archeological evidence, discovery of fisheries, recognition with settlers, treaties with Great Britain, and New Zealand law.

Pamela Mace, the principal adviser for fisheries science, ministry for primary industries described New Zealand's fisheries management structure and the individual transferrable quota (ITQ) system that has increased sustainability and value of fisheries. She emphasized the need to embrace new and innovative technologies and pointed out that New Zealand is a pioneer in deep-water acoustic surveys and reduction of seabird bycatch. She stressed the contributions of ICES and FAO to fisheries science in New Zealand, and importance of New Zealand's scientific engagement in ICES.

George Clement, chief executive of Deepwater Group Limited gave a perspective from the view of a fishing company. He emphasized the importance of fishing gear selectivity and acoustic species identification, both issues close to the work of WGFTFB and WGFAST, in management the of the orange roughy fishery in New Zealand.

Finally, the chairs of JFATB opened the meeting and expressed their appreciation on behalf of JFATB, WGFAST, and WGFTFB for the hard work on the part of the local organizing committee which made the meeting, which was the first ICES meeting to be hosted in New Zealand possible. They also expressed their appreciation to New Zealand's National Institute of Water and Atmospheric Research (NIWA), and the meeting sponsors for hosting the meeting.

1.2 Participants

A list of participants appears in Annex 1.

2 Adoption of the agenda

The motivation for the theme of the 2017 meeting of the JFATB was based on recognition of 1) the importance of the observer effect, i.e. that aquatic organisms react to the platforms and instruments used to measure their abundance and behaviour, and 2) that new technologies are generating large volumes of data and that the ability to collect data is often rapidly outstripping our ability to store and process these data. This session (see section 3) was designed to provide an opportunity to disseminate latest developments in these areas.

The primary goal of the session was to invite presentations and stimulate discussion exploring challenges associated with the observer effect on measurements of the abundance, distribution and behaviour of aquatic organisms and review recent progress in image analysis and machine learning techniques for efficient data processing in aquatic research. The membership of WGFTFB and WGFAST has long specialized in developing novel sampling methods to characterize marine populations and their behaviour, as well as the uncertainties associated with survey gear (e.g. trawls, acoustics).

The terms of reference for the meeting were as follows:

The Joint Workshop of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour [WGFTFB] and the Working Group on Fisheries Acoustics Science and Technology [WGFAST] (JFATB), chaired by Paul Winger (Canada) and Alex De Robertis (USA), will meet on 3 April 2017 in Nelson, New Zealand in conjunction with WGFTFB and WGFAST annual meeting to:

a) Review the observer effect: how platforms and instruments affect the behaviour of aquatic fauna.

b) Review recent progress in image analysis and machine learning techniques for efficient data processing in aquatic research.

JFATB will report by June 30, 2017 for the attention of WGFAST, WGFTFB, ACOM and SCICOM.

Supporting information

Priority	WGFAST and WGFTFB have joint interests in the effects of observation methods on behaviour of fish and other marine organisms and the use of image analysis methods.
Scientific justification	Term of Reference a) All observation methods and platforms affect fish behaviour and consequently acoustic measurements and fishing gear catch performance. A group of acoustic and fishing technology experts is therefore well suited to discuss progress in the field from different perspectives. Term of Reference b) Optical imaging methods are increasingly used as auxiliary methods in various fields, including fisheries acoustic and gear technology studies. Both groups of experts can benefit from sharing their diversity in collecting and analysing optical data.

See Annex 2 for agenda.

3 Presentations

3.1 Mackerel behavioral responses to crowding and reduction in oxygen

Nils Olav Handegard, Maria Tenningen, Kirsten Howarth, Neil Anders, Guillaume Rieaucau, Michael Breen

Abstract

The selectivity of fishing gears with respect to species and size are important, both for management and fishing operations. Purse seining is an efficient fish capture methodology, but is not selective after the net is set. A common practice is to haul the seine to a point where physical samples or inspections of the catch composition can be made, followed by a decision to keep or release the catch. This process is called slipping and may lead to fish mortality. The objective of this study was to simulate a crowding situation and investigate how schooling behaviour, swimming speed, space occupancy, fish density and predator avoidance are affected in response to increased density, decreased oxygen, or a combination of the two, and to see if there is a behavioural proxy that can be used to set safe crowding limits. The experiment was conducted on Mackerel held in net pens. The bottom panel was lifted to increase the density, and a plastic bag was wrapped around the pen to reduce the oxygen levels. The density and space occupancy was assessed using an upward looking echosounder, the schooling behaviour and the predator avoidance was assessed using an acoustic camera, and the oxygen levels was monitored continuously during the experiment. The result shows that the schooling function, was significantly reduced during crowding, but that the effect of oxygen depletion was less clear.

3.2 The effect of visual capacity and swimming ability of fish on the performance of light-based bycatch

Darcie E. Hunt, John Purser, Nick J. F. Rawlinson, Giles A. Thomas, Jennifer M. Cobcroft

Abstract

Reducing bycatch is a major reason for ongoing research into Bycatch Reduction Devices (BRDs). Two designs of light BRDs were developed and tested. There was a 50% reduction in total fish bycatch in Tasmania but no evidence of a significant difference in Queensland. On a species-specific basis, most species were found to decrease in catch with the use of light by up to 75%. Only two species, *T. declivis* and *P. melbournensis*, had significantly different length frequency distributions with the use of artificial light. To explain species-specific changes in catch rates, the visual and swimming capabilities of a range of bycatch species were studied. The potential visual acuity (VA) was quantified using histological techniques. Higher densities of low-light sensitive photoreceptors (rods) in the eye were correlated with maximum fish habitat depths. *Parequula melbournensis* had the greatest potential ability for detecting fine detail based on eye anatomy. The stride length and maximum swimming speeds were estimated. *Trachurus declivis* had the fastest maximum swimming speed. There was a linear relationship between the both factors (VA and swim speed) and percent change in catch. Maximum swimming speed explained 83% and 88% of the change in weight and numbers, respectively; specifically, higher maximum speeds were associated with lower bycatch when light BRDs were employed. Potential visual acuity only explained 5% and 23% of the change in weight and numbers, respectively. When combining the two factors, they accounted for 74% and 82% of the change in weight and number of fish,

respectively. This study concludes that maximum swimming speed is sufficient for predicting the percent change in catch when using artificial light.

3.3 Acoustic observations of fish reactions to underwater camera systems in the North and South Pacific

Stéphane Gauthier, Jennifer Boldt, Billy Ernst

Abstract

Acoustic surveys rely on regular sampling to verify species composition and size distribution of organisms that produce the observed backscattering response. This is particularly challenging in untrawlable areas or under conditions where nets and physical sampling tools are difficult or impossible to effectively deploy. A solution to this challenge involves the use of optical sampling tools, such as cameras on towed or dropped underwater frames, and remotely-operated vehicles (ROV). Because of their relatively short visual range, these instruments need to be deployed in close proximity to the aggregations, often assisted with artificial lighting, which can both potentially affect the targeted organisms through avoidance or attraction. These behavioural effects are likely to be species-specific and need careful evaluation. In this presentation, we present acoustic observations of fish reactions to a range of optical instruments deployed under various conditions and in different ecosystems, ranging from large mono-specific aggregations on the Northern Canadian Pacific Shelf, to small multispecies reef aggregations in the Juan Fernández Archipelago off central Chile.

3.4 The mystery of the Morgue and other experiences with fish behaviour around moorings

Richard L. O'Driscoll, Yoann Ladroit

Abstract

NIWA has used moored cameras and echosounders to measure tilt angle distributions for orange roughy (*Hoplostethus atlanticus*), hoki (*Macruronus novaezelandiae*), and southern blue whiting (*Micromesistius australis*), and also to estimate species' composition on seamounts. The behavioural response of fish to mooring components and lights varies between species. Orange roughy and southern blue whiting appear to habituate to mooring components, but respond strongly to light by diving. Hoki also dive, but are initially attracted to lights. Estimates of fish orientation when lights first turn on provide the best available estimates of orientation in situ. Moored acoustic observations also suggest the presence of other species associated with orange roughy on seamounts, which were not observed on cameras. This work emphasizes the need to understand fish behaviour so that we do not misinterpret data from acoustic surveys and target strength studies.

3.5 Observing, minimizing and exploiting avoidance to improve biomass estimates of deep-water fish

Tim Ryan, Rudy Kloser, Jeff Cordell, Matthew Sherlock

Abstract

Acoustic-based biomass estimates of deep-water fish species present unique challenges. At depths of up to 1200 m the use of deeply deployed platforms brings benefits of multifrequency species identification, reduced dead zone and absorption uncertainty, and improved data quality through elimination of weather effects. Net-attached

Acoustic Optical Systems (AOSs) towed in the midwater have proven to be effective for transect biomass surveys of deep-water fish, but the influence of the platform on behaviour is a key consideration. Comparisons between vessel and towed systems were conducted to better understand potential biases due to behaviour. At ranges less than 200 m the key commercial species, orange roughy (*Hoplostethus atlanticus*) will actively avoid foreign objects while co-occurring species do not. We exploit such species-specific reactions to help identify species, complementing our multifrequency identification methods. A recent advance has been the addition of fibre optic connectivity which has allowed real-time observation of species and their behaviour either optically or inferred from the acoustics. A second advance has been improvements to the noise-floor of the 120 kHz acoustic system, improving the effective range from ~350 m to ~500 m. This means that the AOS platform can be towed at a greater distance from the target species, reducing survey duration while minimizing the chance of fish avoidance.

3.6 Avoidance of an AUV by deep-sea bentho-pelagic animals, inferred from observation with a MBES

Toby Jarvis, Katherine M. Dunlop, Kelly J. Benoit-Bird, Chad M. Waluk, David W. Caress, Hans Thomas, Kenneth L. Smith Jr

Abstract

Multibeam echosounders (MBES) deployed on autonomous underwater vehicles (AUVs) represent a promising technology for monitoring deep-sea bentho-pelagic animals at relatively high spatial and temporal resolution. However, application of this remote-sensing technology to the study of small (relative to the sampling resolution), dispersed and mobile animals at depth does not come without significant challenges with respect to data collection, data processing and vessel avoidance. As a proof of concept, we used data from a downwards-looking RESON SeaBat 7125 MBES mounted on a Dorado-class AUV to detect and characterize the location and movement of backscattering targets (which were likely to have been individual fish or squid) within 50 m of the seafloor at ~800 m depth in Monterey Bay, California. The results revealed a consistent movement of targets away from the AUV that we interpreted as an avoidance response. The large volume and complexity of the data presented a computational challenge, while noise and reverberation in the data coupled with a marginal sampling resolution relative to the size of the targets caused difficulties for reliable and comprehensive target detection. Nevertheless, the results demonstrate that an AUV-mounted MBES has the potential to provide unique and detailed information on the in situ abundance, distribution, size, and behaviour of deep-sea bentho-pelagic animals. We consider future directions for deep-sea water column echosounding, and reinforce the importance of measures to mitigate vessel avoidance in studies of aquatic ecosystems.

3.7 Use of an autonomous sailing vehicle to measure fish abundance and vessel avoidance reactions

Alex De Robertis, Noah Lawrence, Richard Jenkins, Ivar Wangen, Calvin Mordy, Christian Meinig, Dave Peacock, Mike Levine

Abstract

Advances in technology are making the use of autonomous vehicles for long-term acoustic measurements of fish abundance more accessible. We instrumented two saildrone unmanned surface vehicles with recently developed low-power 70 kHz echosounders, and deployed them in the eastern Bering Sea to make acoustic observations

of the abundance and distribution of walleye pollock for >100 days. The saildrones proved to be a suitable platform for measurements of fish backscatter: high-quality echosounder measurements at windspeeds of <~25 knots were made throughout the deployment. In two instances, pollock backscatter measured from a saildrone was compared with that observed from a noise-reduced research vessel, which trailed the saildrone by 500 m in a follow-the-leader arrangement. In one case, pollock were shallowly distributed (30–100 m), and there was clear evidence of depth-dependent reactions to the trailing survey vessel. That is, the saildrone observed higher backscatter and a shallower vertical distribution than research vessel. These behaviours were not evident in a second comparison, with fish primarily distributed at >90 m. Autonomous surface vehicles equipped with echosounders, which like all platforms have inherent strengths and weaknesses, have the potential to complement traditional ship-based surveys by increasing the frequency and duration of acoustic observations. In addition, they are a useful tool to characterize the hard to quantify survey biases introduced by fish reactions to approaching survey vessels.

3.8 Clustering multifrequency data: means, variances and algorithms

Marian Peña

Abstract

Clustering is a useful technique for the identification of acoustic groups with different frequency response in multifrequency echograms. K-Means is the most known clustering technique but has strong requirements such as clusters of equal size and spherical shape. Initialization is a common problem in clustering as only local minima is usually guaranteed, and thus initialization must locate the centroids near the global minimum. K-Harmonic Means is another technique that suffers less from initialization due to the reinforcement of points farther away from all clusters on the following iteration. Expectation-Maximization (EM) clustering also requires a good set of initial centroids but allows to find clusters with different statistical distributions. This work presents the comparison of these three techniques applied to a particularly difficult case, with different acoustic signatures of different cluster sizes and distributions. The following issues will be discussed: preprocessing of acoustic data for clustering, initialization of centroids with theoretical scattering models and the need to consider the geometry of the clusters.

3.9 Leveraging big data: how central repositories facilitate ecosystem research

Carrie Wall, Charles Anderson, J. Michael Jech

Abstract

The National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI) has developed a national archive for the long-term stewardship of fisheries acoustic data. Water column sonar data have been collected by government and academic fleets over large spatial and temporal scales, and archived at NCEI since 2013. To date, over 32 TB of raw acoustic data from eight sonar systems have been made available to the public through a data access webpage. Due to the complexity and ephemeral nature of the marine organisms often targeted during the acoustic surveys, tracklines do not inform users of the quality or composition of the backscatter data within. Visualization imagery illustrating the acoustic target classification algorithm developed by Jech and Michaels (2006) transforms large volumes of

multiple frequency EK60 data into a digestible image. These images have been integrated into the data access page to assist users of varying backgrounds in understanding the data. These images also help experienced scientists target specific datasets or files that address their research needs, from mapping methane seeps to the sound-scattering layer, prior to downloading the data. Ecosystem characterization is currently limited to illustrative and thus qualitative measures. However, initial results of a quantitative analyses to detect and track the acoustic scattering layer by extrapolating the Cade and Benoit-Bird (2014) algorithm will be presented.

3.10 Automated measurement of halibut catch to enable bycatch reduction by Alaska groundfish trawl fisheries

Craig S. Rose, J-N. Hwang, T-W. Huang, G. Wang, F. Wallace, S. Romain, and J. Sagmiller

Abstract

Halibut bycatch limits significantly constrain groundfish trawl fisheries in Alaska waters. Bycatch is monitored based on the proportion of halibut appearing in catch samples taken by on-board observers extrapolated to unsampled portions of those catches, as well as to catches from unsampled tows and unobserved trips. Improving the precision and timeliness of halibut bycatch data would facilitate both bycatch tracking for management and the efforts of the fishing fleet to reduce or avoid halibut bycatch. The Electronic Monitoring Innovation Group at the Alaska Fisheries Science Center, working with the Information Processing Lab of the Department of Electrical Engineering at the University of Washington, have developed a camera chute system that automatically images, measures and reports halibut numbers and weight at the conclusion of catch sorting. We describe the imaging, lighting, triggering, and background systems needed to obtain image data, as well as the processing system and analysis software to produce valid measurements and estimated weight. A range of advanced algorithms have been developed to separate halibut from backgrounds (segmentation). Extensive at-sea testing has motivated improvements to assure consistent operation in the challenging and varied environments encountered onboard Alaska trawlers. We also describe related developments to add species identification and for similar monitoring of longline catches.

4 Synthesis and Discussion

The 7 presentations on the observer effect produced significant discussion, making it evident that this is an area of substantial interest and active research. Recent work on the observer effect has demonstrated how a wide variety of platforms (ships, autonomous vehicles, moorings) and instruments (trawls, cameras, purse-seines, affect the behaviour of aquatic fauna. Many of these behaviours can now be described in qualitative terms, but a quantitative understanding of the impact of these methods on measurements (e.g. abundance estimates) is generally lacking. Practical methods are needed to quantify the degree to which these reactions affect the measurements being made. For example, methods to quantify the impact of trawl selectivity on multispecies acoustic-trawl surveys are needed. This will lead to the development of less biased sampling gear and reduced uncertainty in survey estimates.

Three presentations were focused on methods for archival storage, and analysis of large datasets. This is a timely topic as a major challenge associated with recent advances in optical and acoustic technologies is that these instruments are increasingly producing large volumes of data. In many instances, the ability to collect data is outstripping the ability to interpret the data using currently available methods. For example, commercially available broadband echosounders, which are being introduced into acoustic surveys generate 1–2 orders of magnitude more data than the narrowband instruments they replace. Similarly, the recent proliferation of digital video in aquatic research is producing very large datasets. Although these instruments are providing substantial new capabilities, the ability to generate data is currently outstripping the ability to store, archive, process, and interpret these datasets. New methods such as machine learning are needed for efficient handling and interpretation of these data. This is a significant challenge and an active area of research in WGFTFB and WGFAST for the foreseeable future.

There was extensive discussion both within JFATB as well as during the subsequent WGFAST and WGFTFB meetings about future JFATB meetings, and suggestions for improvement. It was pointed out that although WGFAST and WGFTFB meet jointly as JFATB on a triennial basis to accommodate the WGFTFB meeting with FAO, all WGFAST and WGFTFB meetings were historically held jointly in the 1980s and 1990s. It was recognized there is currently less overlap between the groups than in the past, partly because WGFTFB is less active in the area of survey trawl technology at the present time. It was recognized that that joint session puts more of a burden on hosts due to the larger number of participants. The idea that JFATB meet more infrequently was raised, but after substantial discussion this was not supported by the working groups. The consensus was that the meeting was useful for both WGFTFB and WGFAST, well-attended, and that the presentations were of a high standard and of common interests to both working groups. It was broadly recognized that the members of the working groups are long-standing experts in gear technology and acoustics and that there are important synergies between the groups. The merits of continuing to meet as a joint session every 3 years were discussed extensively, and the consensus was to meet again in 2020 as scheduled under new chairs proposed by the working groups. WGFAST proposes Stéphane Gauthier (Canada) and WGFTFB proposes Michael Pol (USA) as the new chairs of JFATB.

The group explored several ideas to improve JFATB in a wide-ranging discussion. Suggestions included:

1. identify chairs well before the next scheduled meeting (2–3 years in advance) and have them develop the joint session over intervening years based on feedback received at the more regular WGFTFB and WGFAST meetings;
2. hold JFATB meeting in the middle of the week rather than on the first day to allow for issues emerging during that year's WGFTFB and WGFAST meetings to be addressed during the JFATB meeting;
3. invite keynote speakers covering issues germane to both working groups (e.g. technical tutorials or reviews of common areas of interest) to JFATB in order to foster common understanding across working groups and raise interest in areas where the working groups can assist each other;
4. provide a brief presentation at annual WGFTFB and WGFAST meetings updating the groups on their respective activities and sharing of working group reports toward the goal of fostering linkages and connectivity.

Finally, one area of common interest identified for the 2020 JFATB meeting was development of methods to quantify the uncertainly introduced by trawl size and species selectivity in multispecies acoustic surveys. This was identified as an important avenue of research needed to support multispecies surveys. Members are increasingly attempting to quantify the catch efficiency of their survey trawls. As the focus of acoustic-trawl surveys has broadened to targeting multiple species during a survey, and assessment of more diverse ecosystems, it is becoming increasingly clear that trawl selectivity has important effects on acoustic-trawl surveys. WGFAST and ICES survey groups active in acoustic surveys (WGIPS, WGBIFS, WGACEGG) could benefit directly from the expertise of WGFTFB, which has long-standing experience in studies of trawl catchability can help with design of appropriate studies. Methods for rapid integration of knowledge of trawl catchability in the design and analysis of surveys, promises to become an increasingly important area of research activity, and these methods will be of use to ICES survey groups.

Annex 1: List of participants

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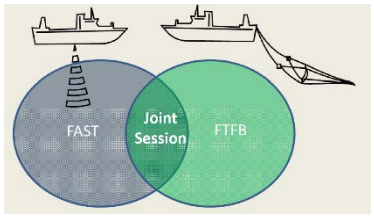
Annex 2: Agenda



Joint Session of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) and the Working Group on Fisheries Acoustics Science and Technology (WGFAST) – (JFATB)

Rutherford Hotel, Nelson, NZ. Monday April 3rd 2017

8:00 am. Registration. Matai 1

9:00 am. Official Opening. Matai 2 theatre

Mihi Whakatau (a traditional Māori welcome ceremony) from *Archdeacon Harvey Ruru*

Welcome from *Rachel Reese, Mayor of Nelson*

Welcome from *Dr Pamela Mace, Principal Adviser Fisheries Science, Ministry for Primary Industries (MPI)*

Welcome from *Richard Bradley, Chairman, Te Tau Ihu Customary Fisheries Forum*

Welcome from George Clement, Chief Executive, Deepwater Group Limited

9:45 am. Introduction from JFATB facilitators, Alex De Robertis and Paul Winger

10:00 am. Coffee break. Matai 1

10:30 am. Mackerel behavioral responses to crowding and reduction in oxygen *Nils Olav Handegard, Maria Tenningen, Kirsten Howarth, Neil Anders, Guillaume Rieaucau, Michael Breen*

10:55 am. The effect of visual capacity and swimming ability of fish on the performance of light-based bycatch *Darcie E. Hunt, John Purser, Nick J. F. Rawlinson, Giles A. Thomas, Jennifer M. Cobcroft*

11:20 am Acoustic observations of fish reactions to underwater camera systems in the North and South Pacific *Stéphane Gauthier, Jennifer Boldt, Billy Ernst*

11:45 am. The mystery of the Morgue and other experiences with fish behaviour around moorings *Richard L. O'Driscoll, Yoann Ladroit*

12:10 -1:45 pm. Lunch. Participants to make own arrangements

1:45 pm. Observing, minimizing and exploiting avoidance to improve biomass estimates of deep-water fish *Tim Ryan, Rudy Kloser, Jeff Cordell, Matthew Sherlock*

2:10 pm. Avoidance of an AUV by deep-sea bentho-pelagic animals, inferred from observation with a MBES *Toby Jarvis, Katherine M. Dunlop, Kelly J. Benoit-Bird, Chad M. Waluk, David W. Caress, Hans Thomas, Kenneth L. Smith Jr*

2:35 pm. Use of an autonomous sailing vehicle to measure fish abundance and vessel avoidance reactions *Alex De Robertis, Noah Lawrence, Richard Jenkins, Ivar Wangen, Calvin Mordy, Christian Meinig, Dave Peacock, Mike Levine*

3:00 pm. Coffee break. Matai 1

3:30 pm. Clustering multifrequency data: means, variances and algorithms *Marian Peña*

3:55 pm. Leveraging big data: how central repositories facilitate ecosystem research *Carrie Wall, Charles Anderson, J. Michael Jech*

4:20 pm. Automated measurement of halibut catch to enable bycatch reduction by Alaska groundfish trawl fisheries *Craig S. Rose, J-N. Hwang, T-W. Huang, G. Wang, F. Wallace, S. Romain, and J. Sagmiller*

4:45-5:15 pm. Discussion including self-evaluation of JFATB, new ToRs, next meeting.

7:00– 9:30 pm. Welcome function Anchor Bar and Restaurant, 62 Vickerman Street Nelson

Annex 3: JFATB terms of reference for the next meeting (2020)

Draft resolutions for the 2020 meeting of the of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour [WGFTFB] and the Working Group on Fisheries Acoustics Science and Technology [WGFAST] will be discussed at the WGFAST and WGFTFB meetings in 2018 and 2019 prepared by correspondence (see Annex 4) and will be submitted in 2019 in preparation for the next meeting of JFATB in 2020.

Annex 4: Recommendations

RecommendationS	Adressed to
JFATB recommends the development of terms of reference for a joint session of WGFAST and WGFTFB in April/May of 2020. The Terms of Reference are to be mutually decided by the Working Group Chairs and new joint session chairs. WGFAST 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. 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 WGFAST members and members of survey groups (WGIPS, WGBIFS, WGACEGG) have expertise that is relevant in this area.	WGFTFB, WGFAST, WGIPS, WGBIFS, WGACEGG