Fisheries Technology Committee **ICES CM 2001/B:06**

Report of the

Working Group on Fisheries Acoustics Science and Technology

Seattle, USA
24–27 April 2001

https://doi.org/10.17895/ices.pub.9598
International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

TABLE OF CONTENTS

Section **Page**

Section **Page**

1 TERMS OF REFERENCE

In accordance with the ICES Resolutions adopted at the 88th Statutory Meeting, the Working Group on Fisheries Acoustics Science and Technology (Chair: Yvan Simard, Canada) met in Seattle, USA, on the 24, 26-27 April 2001 to:

a) Review current techniques in acoustic methods of species identification;

b) Review ecosystem studies based on acoustic survey data;

c) Evaluate the effect of fish avoidance during surveys.

WGFAST will report to the Fisheries Technology Committee at the 2001 Statutory Meeting.

Other points:

- Review of the reports of the planning group on the HAC data exchange format (PGHAC, Chair: Dave Reid) and of the study group on target strength estimation on Baltic herring (SGTSEB, Chair: Frederik Arrhenius)
- Organisation of WGFAST webpage and services
- Planning for future work
- Planning for 2002 meeting
- Report from the organisers of the 2002 Symposium on Fisheries Acoustics (Montpellier, France)

2 MEETING AGENDA AND APPOINTMENT OF RAPPORTEUR

The Chair opened the meeting and Gordon Swartzman of the Applied Physics Lab., Univ. of Washington, was appointed as rapporteur.

The following agenda items were adopted:

Session A "Acoustic methods of species identification"
Session B1 "Ecosystem studies based on acoustic survey data"
Session B2 "Ecosystem studies based on acoustic survey data: bottom classification"
Session C "Evaluation of effects of fish avoidance during surveys"
Session D "Review of study group on target strength estimation on Baltic herring SGTSEB report"
Session E "Review of data exchange format PGHAC report".
Session F "Methods and techniques"

A list of participants appears as Appendix A.

3 SESSION A "ACOUSTIC METHODS OF SPECIES IDENTIFICATION"

3.1 Noël Diner. Problems of echo-trace classification

MOVIES+ software offers the possibility of school echo-integration. But before undertaking any echo-trace classification, it is necessary to observe the echograms so as to withdraw all "false" detections which obviously are not fish echoes: parasites, bottom echoes, mainly due to the beam effect, the same in *situ* situation can be recorded by very different images. A priori corrections seem thus necessary before any echo-trace classification. We studied the effects of multiple proximate schools, which, without correction, are often indistinguishable in the echotrace.

3.2 Valérie Mazauric. Analysis of echo-traces variability due to equipment performances and vessel/shoal attitudes

Presentation of a numerical model developed in order to show echo-traces variability due to equipment performances and vessel/shoal attitudes. Vertical echosounder and multibeam echosounder are simulated, with and without compensation of vessel attitudes (pitch and roll). Fish shoal moves linearly in the water column and is composed of multiple scatterers (with omnidirectional and *in-situ* measured target strength); each animated with a random movement. Having pitch and roll can, with deeper shoals separate shoals into several shoals in the echograms.

3.3 Gordie Swartzman. Using multi-frequency acoustic backscatter data to classify zooplankton patches by size/species groups

We (G.L. Swartzman, D.V.Holliday, J. Napp, K. Coyle, J. Horne, A. Winter, R. Goddard) evaluate methods for classifying plankton patches into size/species groups based on backscatter data collected at 4 frequencies (43, 120, 200 and 420 kHz). The methods combine the use of geometric backscatter models with the use of thresholds and morphological filters on the backscatter images to identify patches which are likely zooplankton. MOCNESS data, collected during the survey provided a set of potential species/size groups for considerations. Three methods were investigated: 1. Use geometric models appropriate to the size/species groups to predict individual backscatter at each frequency from these groups. Then 'solve' the equation (using optimisation methods) for the densities of each size/species group leading to the observed backscatter at each frequency for each pixel in the patch. The ensemble predicted size distribution for each pixel in the patch then gives an overall size/species density distribution for the patch. 2. Use the same approach as above but instead estimate only the mean species/size distribution for the entire patch and the overall abundance for each pixel in the patch. This method, solved using optimisation requires a model for the backscatter covariance between pixels in the patch. 3. This totally empirical method uses canonical correlation to estimate correlation between each size/species group abundance in the MOCNESS and backscatter at each frequency for all the pixels 'fished' by the MOCNESS. The correlation coefficients between each size group and the principal component of the empirical backscatters is applied to backscatter data for the entire transect.

3.4 Andreas Winter and Gordon Swartzman. Correlations of net sample densities with acoustic backscatter from survey transects near the Pribilof Islands, Alaska

Fishery surveys were conducted in September 1994 - 1999 in the Bering Sea near the Pribilof Islands, Alaska. These surveys collected acoustic data along designated transects at 38, 120 and 200 kHz, with an EK-500 split beam echosounder system. Image processing methods applied to the multi-frequency data are used to distinguish between aggregations of juvenile pollock and of zooplankton, and map these aggregations onto plots of the survey transect. While this enables us to determine the distributions of pollock shoals and zooplankton patches, it remains a challenge to estimate the absolute abundance, or biomass, of the organisms. We present here results of a method for opportunistically correlating acoustic abundance with densities from survey trawls, and compare our results to methods that involve target strength modelling. The Pribilof Islands surveys included net tows for capturing pollock and zooplankton, but these tows were never specifically targeted to calibrate acoustic soundings. We have therefore taken the approach of averaging all available acoustic backscatter data within radii of up to several km and several hours around given tows, and using these averages as the basis of correlating the two sample types. Average acoustic abundance and net tow abundance were each converted to standardised density indices. Linear regressions between these indices gave significantly positive regression slopes in some individual survey years, and consistently significant slopes when data from all survey years were combined. We conclude that the approach is valid for producing order-of-magnitude estimates of actual abundance from the acoustic data, and useful as a complement to relative biomass indices and target strength models.

3.5 Denise McKelvey. Using 38 and 120 kHz acoustic data to characterise fish and zooplankton scattering layers

Acoustic scattering layers were evaluated for species classification using 38 and 120 kHz mean volume backscattering strength (SV) collected during a 1995 acoustic-trawl survey of Pacific hake (Merluccius productus) off the west coast of the United States and Canada. Selected scattering layers were shallower than 150 m, and analysed using a -79 dB SV threshold. Hake, euphausiids, or a hake/euphausiid mix dominated the layers, although “other” scatterers (e.g., unidentified, non-hake, non-euphausiid) were also included in the analyses, if present. The overall mean difference in backscatter (□SV = SV 120 kHz – SV 38 kHz) was computed for each layer. Results varied depending on the species composition of the scattering layer (i.e., hake = -6.3 dB, euphausiid = 12.3 dB, hake/euphausiid = 3.5 dB, other = 0.6 dB). Backscatter was also classified into species groups using a discriminant classification model, which obtained an overall correct classification rate of 84 %. Information from the two frequencies facilitated the characterisation of fish and zooplankton acoustic scattering layers.

3.6 Ian Higginbottom. Virtual echograms for visualization and post-processing of multiple frequency echosounder data

The application of acoustic methods for species identification to survey data sets requires flexible tools to implement and experiment with new analysis techniques as they are developed. SonarData Echoview (version 2) released in October 2000 is new software that uses virtual echograms for visualisation and processing of multiple-frequency data sets. Virtual echograms are generated by applying mathematical operators to echosounder data and/or to other virtual echograms. Virtual echograms are linked to create advanced analyses. A range of generalised operators are provided for image processing (e.g. 3X3, 5X5 and 7X7 convolution kernels), arithmetic manipulation of multiple frequency data (e.g. minus, linear minus), single target detection (single beam and split beam), data visualisation (e.g. echogram overlays) and the like.

The results of changing the parameters of operators (or algorithms) can be visualised almost immediately, allowing the researcher to use empirical as well as theoretical approaches to the development of a specific analysis. An example analysis based on a two frequency "dB difference" technique for species classification will be presented to illustrate the use of virtual echograms. Virtual echogram analysis can be undertaken with data from diverse sources including Simrad EK60 and ES60 raw data, Kaijo KFC 3000, SM2000 multibeam and HAC generic tuples as well as older formats from several manufacturers. Virtual echograms in Echoview 2 provide powerful techniques for analysis of fisheries acoustic data to researchers using most common echosounder and data formats.

3.7 Rudy Kloser. Acoustic species identification in deep water using an empirical multiple frequency method: importance to biomass, target strength and ecosystem studies

Remote species identification is a major challenge in attempting to quantify the distribution and abundance of deep-water orange roughy populations using the acoustic echo integration method. Orange roughy have a wax ester swim bladder and an associated low TS compared to the other dominant species that have gas-filled swim bladders. Orange roughy also form large aggregations that extend up to 150 m in to the water column and hence both near bottom and mid-water marks need to be identified. Traditionally demersal and pelagic trawling is used to identify fish species to allocate to the echo integrated return. The catchability of the two types of gear is very different and it is difficult to incorporate the species caught in different parts of the water column. The use of multi-frequency 12, 38 and 120 kHz acoustics to identify species in the water column is a very attractive alternative. We fitted these frequencies to a deep-water towed body and tried the technique on several spawning populations of orange roughy. The results from the multi-frequency technique were difficult to interpret by looking at the individual echograms. Amplitude mixing of the frequencies in our software package ECHO extracted out features of interest in the combined echograms. This method of frequency mixing showed up three distinct acoustic species groupings based on size and swimbladder type as myctophids, whiptails/morids and orange roughy. These three groups are the dominant species caught in the demersal and pelagic trawls. Our species identification method has led to better estimates of snapshot biomass estimates of orange roughy and indicates that the orange roughy stock is still declining at a key spawning site. This decline in population is occurring at a time when the population models indicate they should be in a rebuilding phase. Better discrimination of species and of stock size is greatly assisting in the proper management of the resource.

3.8 Cathy Goss, David Middleton, Inigo Everson. Demersal aggregations of Patagonian Toothfish on the Falklands Shelf

The Patagonian Toothfish (Dissostichus eleginoides) is the subject of a long-line fishery in the South Atlantic and trawl fishery in the Kerguelen and Heard Island regions of the Southern Ocean. The longline fishery is predominantly conducted in deep waters at shelf margins, the catch consisting of large individuals (>1m length). Only limited information is available about the earlier life stages of this species. During a bottom trawl survey of the Falklands Shelf, 2.5 tonnes of this species were caught in a single haul at around 200m depth, and these individuals had a mean total length of 0.58 m. Aggregations visible on the ship's EK500 echochart during this catch have been analysed to determine whether these marks are sufficiently distinctive to permit the use of acoustics as a method for surveying populations of this species.

3.9 Jean Guillard, and Anne Lebourges-Dhaussy. Compared acoustical measurements made in the Lake of Annecy at 70 and 129 kHz

During October 2000, measurements have been done in the Lake of Annecy in order to compare the results produced by two portable equipment pieces at different frequencies: a split-beam Simrad EY500 at 70 kHz and a dual-beam Biosonics DT5000 at 129 kHz. The acquisitions were made simultaneously during the transects. Hydrologically, the lake was well structured with a marked thermocline around 20 meters. This causes a strong vertical organisation of fish according to the species. Above the thermocline fish population is composed of only two main species (*Rutilus rutilus* (23%) and *Perca fluviatilis* (77%)) ; they were "young of the year" (YOY) at this season, with close sizes. Fish are in schools during daytime, allowing to make comparative echo integration on well identified structures and they evolved at dusk towards layers of scattered fish during the night, allowing to make target strength measurements. Biological samples were caught at night with a pelagic trawl. The results of this experiment, presented here, show no significant difference for the Sv as well as for the mean TS, between 70 and 129 kHz, for the sizes and species considered here. Actually, these results are in good accordance with the TS calculations resulting from Love's equation.

3.10 William L. Michaels, David A. Demer, and J. Michael Jech. Acoustical target strength of Atlantic herring using a multifrequency approach

An *in-situ* experiment was conducted in the Gulf of Maine during late August 1997 to define the individual target strength (TS) measurements of Atlantic herring. Acoustical data were collected using an EK500 operating three hull-mounted transducers (12 kHz single beam, and 38 and 120 kHz split-beams). High Speed Midwater Rope Trawl and Method trawling operations were conducted to determine fish and macrozooplankton composition, while underwater static video provided direct observations of the acoustical targets. The biological composition contributing to the acoustical data was almost entirely Atlantic herring (*Clupea harengus*), euphausiids (*Meganyctiphanes norvegica*), and ctenophores. Omni-directional sonar provided spatial information of the herring aggregations. EK500 data were processed using the BI500 post-processing software. The compensated target strengths, target depths, and offset angles from the 38 and 120 kHz data were used to remove potential false individual targets from derived slant range and angle discrepancies. This multifrequency filter removed about 98-99% of the TS measurements in an effort to reduce the multiple target problem associated with tightly aggregated fish such as herring. Although the filter appeared to remove multiple targets and lowered the overall TS measurements, the average TS for Atlantic herring in the Gulf of Maine region appears to be high relative to the literature. Herring TS measurements during the day were also significantly higher than the night-time and twilight periods. EK500, omni-directional sonar, midwater trawling, and underwater video sampling operations indicated that herring undergo daily vertical migration from near bottom during the day into the water column at night. The high TS for herring may be attributed to their diel behavioural patterns, orientation, and enlarged gonads.

3.11 J. Michael Jech and D. Benjamin Reeder. Acoustic broadband backscattering measurements and models of alewife (*Alosa pseudoharengus*)

The advent of non-traditional underwater acoustic instrumentation (e.g., multibeam and sector-scanning sonar) and incorporation of fish behaviour in quantitative fisheries assessments require that backscatter be measured and modelled at a variety of aspect angles. A series of backscattering measurements using live, adult alewife (*Alosa pseudoharengus*) were conducted in a 7x7x7m tank. A greater-than-octave bandwidth (40-100 kHz), shaped, linearly swept, frequency modulated signal was used to insonify individual alewife. An individual alewife for each series of measurements was tethered and rotated in two planes of orientation (dorsal/ventral and lateral). The alewife were insonified by using bistatic scattering geometry and were rotated in one-degree increments. Dominant acoustic scattering mechanisms were identified through both spectral and time-domain (pulse compression) analyses. Results demonstrate the dependence of scattering strength upon frequency and angle of orientation in the lateral (horizontal) and dorsal/ventral aspects. The pulse compression processing of the echoes from the animals temporally resolves multiple returns from an individual which are correlated with size and orientation. Backscattering amplitudes for all angles of orientation were modelled by using a Kirchhoff Ray-Mode model and digital images of the fish body and swimbladder morphometry. Comparisons of backscattering amplitudes from the model and measurements along the dorsal/ventral and lateral planes are given. The utility of broadband measurements for fish backscattering amplitude measurements and the integration of acoustic models in fisheries assessments are discussed.

3.12 Yvan Simard. "Echo-system" classification: where are we going?

Acoustics is a very unique tool to unselectively and remotely sample a large fraction of aquatic ecosystem life that can be automated for classifying the organisms by functional or taxonomic groups. Several methods have been developed in the last decade to automatically classify the echo traces recorded by scientific echosounders. They were tested in various environments to classify, with variable success, a selected fraction of all potential echoes in the insonified volume: schools, single targets, scattering layers. With the increasing request to study the ecosystem as a whole, instead of just selected components of it, how could these classification methods be effectively combined to produce a validated polychromatic view of the ecosystem composition and organisation? This idea is presented with examples from a simple case study in the St. Lawrence using standard two-frequency (38 and 120 kHz) acoustic gears.

3.13 Conclusion on topic A

The discussion on this topic turned around the facts the ecosystem is composed of a large diversity of taxonomic components, strongly autocorrelated in space and time, and it is difficult to have a general solution isolate a particular species or taxa. This statement is especially true when the amount of variability inherent to the data is considered. The approach used up to now has always been to choose the optimal conditions for applying the acoustic technology to solve clearly defined questions. Because of the complexity and diversity of aquatic systems, it should continue to be so in the future. Questions that acoustic methodology can answer must be carefully chosen. Biomass estimation has been the traditional focus of fisheries acoustics. Other questions where acoustics can play an important role, such as the distribution or niche of the species, may be as much important for understanding and the conservation of species. The application of the ecosystem approach, largely adopted by the ICES countries, requires recording information on more than a single species at a time. This asks for efficient and accurate echo classification. The acoustic community should define what can be its contribution to this approach in order to help the management community precise what this largely adopted new ecosystem-based management ought to be. It must be pointed out that acoustic surveys are not given resources to reference abundance estimation into an ecosystem reference. Research have been constantly pushing the limits of fisheries acoustics in the past and moving into multi-species distributions is one more step along the same direction. Adding information to the classification process, such as the number of frequencies has made significant progress, but we have not got acoustic-based species identification yet. This need not stop us from proceeding with ecological questions though.

4 SESSION B1 "ECOSYSTEM STUDIES BASED ON ACOUSTIC SURVEY DATA"

4.1 Gordie Swartzman, Andreas Winter and Lorenzo Ciannelli. Acoustically-based evidence for zooplankton prey depletion by juvenile walleye pollock near the Pribilof Islands, Alaska

Mapping of the distribution and abundance of juvenile pollock shoals and zooplankton patches (i.e. euphausiids) was effected through image processing methods applied to acoustic data collected at 38 and 120 kHz using an EK-500 split beam echosounder system. These data were collected in September 1994-1999 on four transects in the Bering Sea near the Pribilof Islands, Alaska. In 1996, the year of highest and most pervasive juvenile pollock abundance, zooplankton abundance was the lowest of all survey years, zooplankton acoustic sign at study frequencies being almost absent on one transect (several passes of this transect were made, both day and night). This alone is insufficient evidence for prey depletion, especially since the pervasive nature of the pollock in the water column made it difficult to acoustically detect plankton patches. However, the same area was visited a month earlier in 1996, by a ship using the same echosounder system, and the study transects were approximately followed on the earlier season survey. Identical methods to locate fish shoals and zooplankton patches indicated higher zooplankton abundance earlier in the season, with the difference in zooplankton abundance (patch acoustic biomass per 250 m ESDU) being highest on transects with the highest fish abundance and reduction being inversely proportional to fish abundance. We present results to substantiate these observations. Current research involves modelling the August to September time period to ascertain whether the reduction in zooplankton abundance over this time period was consonant with pollock feeding based on energetics and prey abundance. To implement this model we converted acoustic biomass to absolute biomass density using target strength models and net data for fish and zooplankton size distributions.

4.2 Yvan Simard and Diane Lavoie. Use of two-frequency acoustics (38 and 120 kHz) to unravel the complex aggregation of krill at a unique and rich traditional whale feeding ground of the western Atlantic: the Saguenay-St. Lawrence Marine Park

The krill aggregation at a traditional whale feeding ground at the head of the main channel of the eastern Canadian continental shelf has been surveyed with 38 and 120 kHz hydroacoustics, ground truthed with direct sampling, in the summer of 1994 and 1995. Fish echoes were separated from krill echoes using the difference in the sound scattering volume strength at the two frequencies. Both species of krill present were essentially composed of 2-y old individuals. The geostatistical biomass estimates obtained from the 8 surveys showed that the area is the richest documented krill aggregation ground in the north-west Atlantic. The associated maps presented recurrent spatial patterns attributable to the 3-D current structure, partially driven by the topography, and the fortnight tidal cycle. Large biomass variations occurred on small time scales of a few days, in response to the transport in and out of the region. The aggregation mechanism is related to the two-layer estuarine circulation of the St. Lawrence, the negative phototactism of krill, the concentrating and piling-up of krill scattering layers under the intense positive and negative vertical currents, the blocking dynamics at the upstream sills, and local topographic features. This complex mechanism, which integrates processes occurring over a broad scale spectrum, could not have been investigated without exploiting efficient, penetrating and fast sampling gears such as acoustics.

4.3 Anne Lebourges-Dhaussy, and Gisèle Champalbert. Zooplankton spatial distribution and composition, in the context of the Tropical Atlantic hydrologic system, as described by multifrequency acoustics and plankton nets

The PICOLO programme has been performed in an area of the tropical Atlantic regularly submitted to the propagation of long waves at the friction between the North Equatorial counter-current and the South Equatorial current (0°-5°N / 10°-20°W). These waves propagate during July and August. The purpose of the program was to evaluate the enrichment resulting a few months later, in order to explain the presence of a tuna fishery from November to February. During the Picolo P3 survey (July-August 97) four fixed station (48 h) were performed along the longitude 16°W, in relation with the wave passage. The first one at 2°N stays within the wave area; the second one is at 0° within the equatorial divergence; the third one at 2°N again in the convergence but after the wave passage; and the fourth station stays at 4°N within a classical tropical situation. Currents, temperature, salinity, fluorescence, light, zooplankton, micronekton, were regularly sampled along each fixed station by two daytime and two night-time full operations set. In particular, the zooplankton was studied not only by sampling nets but also through a multifrequency equipment (the TRACOR Acoustical Profiler Sensor - TAPS™). The validation of the TAPS's method has been done a long time ago, nevertheless it was its first application in this geographical area. Within the PICOLO program, the vertical distribution of the zooplankton by size classes was useful to make linkages with the local micronekton diet. The first point is that there is a good coherence between the TAPS results and the net results. Then, the results show the enrichment produced by the wave passage, with biomass remaining however lower than at the equator, but higher than northern. For the class of the small copepods, their relationship with the hydrology is not obvious. On the other hand, the large ones appear to be well correlated with the fluorescence.

4.4 Arnaud Bertrand and Erwan Josse. Acoustics for ecosystem research: synthesis of a program focusing on tuna - environment relationship

Fisheries management now extends from stock towards ecosystem. In that context acoustic becomes essential, as it is the only tool providing simultaneous observation on predators, prey and when necessary, substratum characteristics, at small and meso scale. An echosounder was routinely used to observe directly and simultaneously tuna and their prey within the framework of a large program focusing on the Central Pacific pelagic ecosystem. Coupled with other observation aids (i.e. instrumented longline, pelagic trawls, CTD probe and ultrasonic tagging), acoustics allowed improving knowledge on tuna and prey distribution, space occupation and behaviour; as well as on tuna-prey relationships and tuna catchability. However acoustics is not yet commonly used and some suggestions are made to facilitate the use of acoustics methods for non-fisheries acousticians in an ecosystem approach.

4.5 Andone Lavery. D. Chu, K. Foote, B. Reeder, T.K. Stanton, J. Warren,and P. Wiebe. Bioacoustics of Zooplankton and Fish at WHOI: recent modelling, laboratory measurements, and field surveys results

Over the last decade the active-acoustics Woods Hole Oceanographic Institution (WHOI) bioacoustics group has developed a broad programme involving fieldwork, laboratory measurements, and theoretical modelling for acoustic scattering. A synthesis of the progress and key results obtained in the last year in each of these different areas is presented here. On the modelling front, a fully three-dimensional acoustic backscattering model for decapod shrimp has been developed in this last year. High-resolution computerized tomography scans of live decapod shrimp have been used as input to the scattering model to accurately represent the three-dimensional outer shape of the animals. Though the primary focus of the research at WHOI has been on zooplankton, the laboratory program has recently been extended to include the investigation of scattering from swim bladdered fish. Broadband laboratory backscattering measurements of target strength of live tethered fish have been performed. Using pulse compression techniques previously developed at WHOI, it has been possible to resolve echoes from different parts of the fish, e.g. echoes from the swimbladder and head. Other new laboratory results include the pressure and temperature dependent sound speed and density measurements of various organisms, including fish larvae.

Finally, a series of five field surveys performed in the Gulf of Maine using the multi-frequency acoustic instrument platform BIOMAPER-II has been completed. Analysis of those data is currently underway. Progress this last year on analysis and interpretation of the field data has included evidence that multi-frequency acoustics can be used to discriminate between backscattering from marine organisms and turbulent microstructure.

4.6 David Demer. Long-term studies that integrate acoustical assessments of pelagic animals with multi-disciplinary surveys of their environment: The United States Antarctic Marine Living Resources Program (AMLR); and the Middle Trophic Level Studies (MTL) of NATO SACLANT Center's Sound, Oceanography, and Living Marine Resources (SOLMaR) Program

A goal of AMLR is to describe the functional relationships between krill, their predators, and key environmental variables in the vicinity of the South Shetland Islands. Multi-disciplinary mapping of these waters during the Austral summers of 1991 through 2001 have shown that several water masses converge in the area, forming a persistent hydrographic front along the shelf break north of the archipelago. High densities of phytoplankton and krill are associated with the position of the frontal zone, although seasonal timing of their appearance can vary by several weeks. AMLR has also documented large year-to-year variability in the reproductive success of krill and associated this variability with multi-year trends in the physical environment. AMLR has also surveyed the near-shore-prey and habitat within the foraging ranges of seals and penguins that were concurrently monitored via satellite tags at Cape Shirreff, Livingston Island,

Antarctica. A small-craft was purpose-built for this multidisciplinary survey that describes the prey-field within the immediate vicinity of land-breeding predators and allowed exploration of the physical oceanographic, bathymetric, and meteorological conditions that may influence the variability in the neritic dispersion and abundance of the prey.

NATO's SACLANT Center and the U.S. Office of Naval Research created SOLMaR in response to increasing concern over possible effects of man-made low frequency underwater sounds on marine mammals. The primary objective of SOLMaR is to characterise whale behaviour in the context of a habitat relatively unperturbed by man-made noise so that subsequent examination of marine mammal response to high intensity sounds may be examined scientifically. Towards this end, the MTL of SOLMaR aims to: 1) identify the features of the whales' natural environment that guide their behaviour; and most importantly 2) characterise the variability in the environment that normally directs their behaviour, dispersion, and abundance.

4.7 Pablo Carrera, David Brochers, Steve Coombs, Vitor Marques, Jacques Massé and Andrés Uriarte. An approach to extensive studies of the ecosystem: relating acoustic back-scattering energy with eggs and environmental variables under the PELASSES project

Main goal for this project, partly funded by EU (DG XIV) under the PCP, is to try to combine different assessment methods and sampling techniques in a single research vessel in order to achieve an improvement of the abundance estimates but also a general knowledge of the ecosystem provided from extensive sampling techniques. First idea, as stated in the scientific background of the work program, was to improve the acoustic assessment of the most important pelagic fish species in South West Europe (i.e. Atlantic waters of the Iberian Peninsula and the Bay of Biscay), specially those populations of sardine and anchovy. Major problems were identified in the acoustic procedure from the ICES Planning Group for Acoustic Surveys in VIII and IX which can be summarised as follows: a) Problems in identifying echo-traces; b) Masking backscattering energy of fish form that of plankton organisms; c) Distribution and abundance might be related with environment conditions; and d) Possible underestimation due to avoidance or near surface school behaviour. To solve that, an increase in auxiliary variables such as environmental data was needed as well as a deeper post-processing analysis, including at least two acoustic frequencies. In such sense the acoustic estimates, would greatly be improved if information from earlier development stages (mainly eggs) is gathered at the same time as the acoustic records. The recent development of the Continuous Underway Fish Egg Sampler allows to attempt combining egg and acoustic data to improve the estimation of fish abundance using the echo-integration method. Concurrent with pumping, data are logged periodically from a GPS (date, time and, position), from a thermo-salinometer and fluorometer. In addition, CUFES as egg sampler could be used as an absolute estimator of the egg abundance. Several models have been used to describe the vertical distributions of fish eggs and could allow in the future, once CUFES was calibrated, to perform simultaneously acoustic and the DEPM methods on a single R/V. Since the surveys will be conducted at the spawning time and egg distribution can be used to improve the spatial distribution of adults. These are clearer when fish are distributed in the blind areas of the acoustic transducer (i.e. close to the sea surface or close to the sea bottom) or when avoidance reactions are strong. Accordingly, the surveys will give an improved estimation of the abundance of pelagic fish present in the North-east Atlantic waters in spring which is the spawning period for these fish species, but focussing in sardine and anchovy. Complementary to this main objective the survey design and strategies will allow the environment be characterised by recording different variables (i.e. temperature, salinity, fluorescence, plankton, winds or air temperature) in vertical and horizontal profiles along the surveyed area with no noticeable extra-effort. As it was pointed out, these variables will help the acoustic estimations be improved whilst an extensive environment characterisation at the spawning time will be done.

4.8 Juan José Cardenas L., Jean Guillard, and Alina Achury. Spatio-temporal evolution of fish populations in a tropical estuary (Orinoco delta, Venezuela). POSTER

Within the context of the ECOS-Nord / CONICIT agreement (V99U02) and the 'Programa Warao Punta Pescador' aiming the environmental assessment of the Orinoco delta (Venezuela) and specially Indian traditional fisheries, several acoustic surveys have been performed following transects from a fresh water zone to a open sea zone, from October 1999 to November 2000. A SIMRAD EY 500 split-beam sounder at 120 kHz was used for the surveys and for 24 hours fixed points horizontal insonification (nycthemeral evolution of fish occupation in a sampled constant volume). We observed a stability of fish densities between one-season surveys, but at a smaller time scale, values increased related to low tide periods in this semi-diurnal tide region. Higher densities are always found in the interface between the river and the sea, independently of the season. The highest values are associated with dry season, when structure population changes occur with the increase of strictly marine species, appearing even in upstream waters.

4.9 Andrés Uriarte, Yolanda Sagarminaga, Víctor Valencia, Carla Scalabrin, Jim Churnside, Jim Wilson, Jose A. Gómez, Eduardo de Miguel, Alix Fernández-Renau, Pablo Carrera, Jose Manuel Cabanas, Carmela Porteiro, Graça Pestana, Vitor Marques, Miguel Santos. Application of LIDAR, acoustic, remote sensing and GIS techniques in the framework of JUVESU project (FAIR CT97-3374)

Sardine and anchovy are the most important pelagic fish species around the Atlantic waters of the Iberian Peninsula and in the Bay of Biscay. Both species support one of the oldest fisheries in this area. Because of their social and economic importance and being short-lived fish species, an accurate assessment, specially on the strength of the incoming year class (i.e. recruitment at age 0) is considered to be crucial in getting advice for fisheries management. In the case of short living species such as sardine and anchovy, an accurate and precise assessment of the juvenile fraction results on an improvement on the sustainability of the fisheries. In this context, successful harvest control rules were established on the estimates of juveniles from direct surveys. In order to study the distribution of juvenile fish and their relationship with the environment conditions, a series of combined cruises using ship and airborne devices was programmed in the western part of the Iberian Peninsula and in the Bay of Biscay at the recruitment time (i.e. end of August-September) of sardine and anchovy. This project was carried out under the frame of the FAIR project "Experimental Surveys for the Assessment of Juveniles", JUVESU (FAIR CT97-3374). Ship equipment, such as echo sounder, sonar and continuous records of SSS, SST, fluorometry and CTD casts were combined with airborne devices and satellite images (SeaWiFS). The radiometric LIDAR (Light Detecting and Ranging) is used from an aeroplane for the detection of juveniles occupying the upper layers of waters. while a concurrent acoustic (Sonar and Echo sounding) and fishing survey expand the surveying to deeper waters and serve to check for the performance of the LIDAR system regarding the spatial (horizontal and vertical) distribution of juveniles providing, at the same time, the identification of the species composition. The experimental surveys were planned to be carried out for two consecutive years at the south of Europe, in the Bay of Biscay and Atlantic coasts of the Iberian Peninsula, where significant recruitment of sardine, anchovy, mackerel and horse mackerel are known to occur. This paper analyses the preliminary results of these experimental surveys.

4.10 Carlos Robinson. Hydroacoustical observations of small pelagic fish behaviour in the West Coast of Baja California, Mexico

From December 1993 to December 2000, sixteen oceanographic surveys using hydroacoustics have been done to the West Coast of Baja California, Mexico. Observations are made on board the R/V El Puma with the aim of study behaviour and distribution of small pelagic fish as anchovies and sardines related to the pelagic ecosystem of the West Coast of Baja California, Mexico. We use simultaneously two hydroacoustic systems. A Simrad EY-200 single beam echosounder 200 kHz, and a Simrad EY-500 split-beam echosounder 120 kHz. Two areas are covered, Northern from Punta Collate to Punta Baja (30° 54', 116° 40' W to 29° 26' N 115° 29' W) and Southern area from Punta Eugenia to Bahia Tortugas (27° 29' N 115° 22' W to 26° 47' N113° 55' W). Results show that since 1993 echo counting has been reduced significantly in both areas. In the northern area, in the 5 to 25 m depth layer, there is no evidence of recovering in the abundance of echoes. However, an increase of echoes observed in March 2000, may suggest a possible change in the tendency. In the southern area, echograms with no echoes in the 5 to 25 m depth layer remain high. However, the number of echoes increased significantly in March 2000, A change in the tendency? Before El Niño 1997-98, echo-counting was, either high in the 5 to 25 m layer or similar as the observed in the lower stratum in both areas. The behaviour is reverted during El Niño 1997-98 event.

4.11 Conclusion on topic B1

The above contributions on ecosystem studies based on acoustics clearly showed that this technology to look into the system has been thoroughly incorporated in several research programs throughout the world. Applied on several trophic levels, it has become the main tool for observing, sampling and understanding of the relevant ecosystem structures (including the bottom characteristics) and species behaviour over a wide range of scales in many environments. If this is true for the acoustically informed community, it may not be the case for the larger part of the aquatic ecosystem community. The discussion turned around the actions that could be undertaken to widen the audience and users, insure a better visibility of this research, and to encourage interactions with researchers with a broader perspective than fisheries acoustics, while maintaining a balance between techniques and applications.

A proposal to publish a series of case studies demonstrating the uniqueness and various uses of the technology for ecosystem research in a special issue of a Journal was presented by the Chair as a possible way to enhance the visibility. It was decided that the timing for such an action was not ideal because of the coming 2002 Montpellier Symposium, for which most of the members would work this year to prepare a contribution, and which will be our big event in fisheries and plankton acoustics. Such a special issue of a Journal would be more focused, though, than the Symposium proceedings, which would only accommodate a limited number of short papers, mostly on the technology. The question of the right Journal to choose was raised, including a suggestion to pursue the Symposium volume. The following recommendation ended the discussion.

Recommendation: at the 2002 WGFAST meeting, an agenda item should be to discuss the possibility of preparing a special issue of a Journal to produce a synthesis of ecosystem study contribution of acoustics.

Another possible action that was suggested was to write a review article on use of acoustics for bottom classification. Such an action was strongly supported for this special application of acoustics to ecosystem study where good integrated summary papers are lacking. This proposition will be part of next year meeting discussion on this issue.

5 SESSION B2 "ECOSYSTEM STUDIES BASED ON ACOUSTIC SURVEY DATA: SEA BED CLASSIFICATION"

5.1 Darrell R. Jackson. Physical models for acoustic sea bed classification

In the last 15 years, significant progress has been made in the understanding of acoustic backscatter from the sea bed. This has included theoretical work that includes scattering by both sea bed roughness and sediment heterogeneity. Improved scattering models incorporate elasticity, poroelasticity, gradients, layering, and span a wide range of frequencies and angles. Experiments to test these models have become increasingly rigorous, supporting their use to infer sea bed properties. The range of applicability of several new models will be sketched, recent experimental tests will be outlined, and problem areas will be identified. Finally, recent work aimed at using such models for sea bed classification will be discussed.

5.2 William T. Collins and Jon M. Preston. Quantifying sea floor diversity with acoustic seabed classification

The most useful value-added product from a set of sea-floor echoes or a set of backscatter data is acoustic seabed classification. Of the methods and processes available, some assess sediment geophysical characteristics using deterministic methods and others, statistically based, respond primarily to acoustic diversity. The acoustic diversity of sediments in a region depends on physical characteristics such as grain size, and also can vary with environmental details such as vegetation and current. Of these two general approaches, classifications based on acoustic diversity appear to be better suited to ecological applications. Acoustic seabed classification involves an investigation of echoes so that a characterisation of the substrate can be made. There are several techniques for statistical classification of echoes from echo sounders and of backscatter images from side-scans or multibeam systems. Generally, they involve analyses of the echo envelope or segments of an image, followed by the generation of descriptors that have been selected to correlate with seabed characteristics. The utility of this approach depends on several assumptions:

- Seabed character information is contained in the echo trace from the sea floor.
- The quality of this information represents the range of sea floor characteristics to the level required by the user.
- The seabed information can be systematically, accurately, and repeatedly extracted from the echo trace.
- The classifications can be presented suitably for integration with other spatial data.

For a survey system to be practical and useful, operational issues must be addressed. These include:

- The classification system must be sufficiently robust and versatile to operate on a wide variety of platforms and with many sonar systems.
- The process and its classification results must be repeatable through the range of environmental conditions.
- If such a system is to be used to acquire data of national strategic interest, what are the standards and metadata requirements?

Over the years, enough experience has been acquired with Quester Tangent Corporation (QTC) equipment and processing to assert that the assumptions are valid and the operational issues have been addressed over a useful range of sonar and environmental conditions. The empirical test is whether QTC classes are valid and useful for the purposes of the particular study or survey, and that test has been met on many occasions.

QTC equipment and processes will be described briefly, and contrasted with competing technologies. Some examples will be presented, particularly to illustrate conditions in which the assumptions are valid.

The future direction of research by QTC and partners (including the new Canadian Marine Acoustic Remote Sensing Facility – C-MARS) will also be discussed. Research issues include the appropriate amount of detail in the classifications, and how the results can best be used for habitat characterisation.

5.3 Jan Ove Bakke. Single- and multi-beam classification systems from Kongsberg Simrad

Presentation of Single- and Multi- Beam Seabed Classification Systems.

- Multi Beam Classification (Triton). Description of theory behind the system, and the process from raw data to classified seafloor.

- Pre-processing. Using information from the bathymetry, we can adjust the dB values for important factors as range and incidence angle with terrain.

- Extract. The seafloor is divided into geographical "bins", where every bin will have ca. 4000 side-scan values. Using statistics, 5 features are extracted to define the bin.

- Training. This module can best be described as an expert system. The user selects an region (any shape) with "uniform" seafloor in a geographical user interface. This region will contain 5d-vectors from the extract process. Computing a class Mean vector and Covariance matrix then describes this class. If the user is satisfied, the seabed class can then be given a meaningful name and added to the library.

- Classification. Vectors from extract is compared with class library and assigned a seabed class. Seafloor characterisations unknown to the system will be named as outliers. Large regions with outliers will signal an under trained system, and the operator should maybe return to the training module. Interpolation/smoothing is also available.

- Similar presentation of our system for Single Beam echo sounder. Similar to MB-classification, but differs in the extract process.

    - Summary : Future possibilities. Merging of data from both multi- and single-beam. Better algorithm's for both extraction and classification etc.

5.4 Bob Wilkinson. RoxAnn, leading to the future

The RoxAnn system has been used world wide, for more 15 years, to determine seabed material by analysing the information in a vessels echosounder signals. Approximately 700 single beam RoxAnns have been sold in 34 countries into the military, hydrographic survey, oil and gas industry and the scientific communities. The history and operation of the standard RoxAnn System range will be reviewed and examples of data collected will be shown. Variants of RoxAnn will also be described which include "RoxAnn Groundmaster" - a portable unit primarily for small boat surveys and "Stereo RoxAnn" - a dual frequency unit for investigation of sediment thickness and content. Stenmar SonaVision's view of the future for seabed classification techniques will also be presented and new products will be described which show that the RoxAnn technology is meeting industries future needs. These products, such as Swathe RoxAnn and RoxROV, will provide the means of collecting real time, wide area, high density and detailed seabed survey data in a variety of environments.

5.5 Panel discussion on sea bed classification

Questions asked after the individual talks (when time permitted) concerned first the sensitivity analysis of the physical models on the various parameters involved, for which not much has been done yet, and the way of using these models for automatic bottom classification. The panel discussion pursued with questions related to the invited talks. Several points concerned critical technical aspects of the present practise of automatic bottom classifications. The difficulty of adequately controlling for parts of bottom echo that vary with range/time (e.g. E1 parameter in Roxann algorithm) was raised. The maintenance of the same angle of acceptance regardless of range/time was suggested as a way to limit the influence of this problem on E1 parameter. The use principal components analysis (PCA) to analyse a high number of extracted acoustic features of the bottom that are not independent and the interpretation of the results in the context of information redundancy were questioned. Is the extraction of more features better? Yes if the added information rises above the noise, but in general there is only a subset of useful features. There is also a point where adding features brings diminishing returns in multivariable analysis. The attempts to use all features lead to instability in the results. There was advice that the actual discriminant information often reduces to as few as three parameters. The extraction of fractal dimensions of the backscatter envelope to discriminate substrate was also mentioned. The use of other methods than PCA have been evoked, including spatial analysis and the incorporation of the classification probability. The interest of using multifrequency to better describe the substrate to classify was questioned. The necessity of sampling the same substrate unit (foot print) with each frequency to allow rigorous comparisons was recalled as well as the increase in complexity because of the requirements in data collection, quality control, processing and interpretation. The importance of quality control and repeatability of measurement issues were particularly identified. The assumption in acoustic habitat mapping is that echo signal diversity represents habitat diversity. Doubts on the entire validity of this assumption were clearly expressed, especially when the variability in the measurement process are taken into account. This raised the point of the necessity of rigorous calibration methods in that acoustic field, similar to what has been by the WGFAST for water column acoustics. This calibration issue is a point that should be addressed by the group. Some were on the advice that it should include the effect of the hardware (sounder, transducer) on the echo shape and the data quality issue should be considered all the way through the analysis. Different systems handle these questions differently. Many facets of the systems need to be controlled to allow comparability. Subtle details (angle of transducer on hull, vessel trim, motion, etc.) can render data not comparable. Current work is around what can be found out from signal rather than how to control signal. What type of calibration is required for this particular application of acoustics? What can be done with relative rather than or compared to absolute data? What fine details profoundly influence perceptions of the information? These should be challenges for future WGFAST work. The issues of what standard information to collect in routine surveys, what format to use to properly store and archive it, what comparable descriptors of habitat are required, at what spatial resolution (including nested classifications), with what classification probability were also raised. New management approaches demand this kind of habitat mapping information for various description, exploitation and conservation uses. There are expectations that the WGFAST would be asked to address such mapping. With the present approach, there is a danger of producing inadequate and unverifiable maps. The need to build connections with the other groups (in biology, geology, hydrography) that are also working on bottom habitat mapping and with the new national and international initiatives in this field was pointed out. The WGFAST Chair suggested bringing this matter at a higher ICES level for directive or direction for building collaboration with these other groups.

5.6 Conclusion on topic B2

Recommendations:

- that the WGFAST establishes formal contact with other ICES Working Groups involved with seabed classification and mapping.
- that a special joint/theme session be organised on the topic of: “Acoustic seabed classification – Applications in fisheries science and ecosystem studies”. The joint session could be convened in collaboration with other relevant ICES committees.
- that Dave Reid be a co-convener of this session and work to making it happen.
- that WGFAST initiates work to evaluate acoustic seabed classification technologies and applications with reference to: scales of observation, data quality and management, theory of acoustic seabed classifications, classification methods and criteria, and ground-truthing standards.

6 SESSION C “EVALUATION OF EFFECTS OF FISH AVOIDANCE DURING SURVEYS”

6.1 François Gerlotto, Marc Soria and Patrice Brehmer. Comparative observation of school lateral avoidance using multibeam sonar

Pelagic fish schools were observed on the side of the vessel using a multibeam sonar deployed perpendicularly to the vessel path in the vertical plan. The observations were done during several surveys in different countries (Senegal, Ivory Coast, Mexico, Venezuela, Spain and Italy). The results shows two different avoidance patterns: a general one, where fish schools clearly avoid the vessel following the "double wave of avoidance", and a less clear pattern, where avoidance is weak and limited to the nearest schools. Two hypothesis are proposed to explain this difference, related to shallow water effect: a biological one, where fish changes its avoidance behaviour in shallow waters, and a more likely acoustic one, where the difference represents a bias due to background noise and signal-to-noise ratio.

6.2 Andrew Brierley and Paul Fernandes. Avoidance of RRS James Clark Ross by Antarctic krill?

We present an preliminary comparison of acoustic data collected by the autonomous underwater vehicle (AUV) Autosub-2 and by RRS James Clark Ross (JCR) as she followed the AUV along transects surveying for Antarctic krill. Autosub-2 is exceedingly quiet and is not expected to disturb krill: in comparison JCR is much noisier. A reduction in the amount of krill detected by JCR compared to the AUV could indicate that krill are able to avoid the ship, or that their behaviour is altered by the presence of the ship (e.g. change in tilt angle) in such a way that their apparent abundance is reduced.

6.3 Pall Reynisson. Preliminary results from underwater noise measurements of a new Icelandic research vessel

Last year a new research vessel was taken in use at the Marine Research Institute in Iceland. This is a trawler type vessel, intended for general oceanic research. A short description of the vessel and its equipment will be given. Preliminary results from measurements of the underwater noise generated by the vessel will be presented.

6.4 Chris Wilson and David Demer. Buoy measurements of underwater-radiated vessel noise to explain variation in possible fish avoidance reactions

Fieldwork with a free-drifting acoustic-buoy has been conducted since 1998 to investigate whether walleye pollock and pacific hake exhibit an avoidance response to underwater-radiated vessel noise. Neither species has exhibited a consistent, strong avoidance response to noises generated by the research survey vessel, NOAA ship Miller Freeman, when it is conducting free-running passes by the buoy at the standard survey speed of 11-12 knots. The fact that fish "responses" were observed on only certain passes, has suggested several explanations: a) the buoy may have simply drifted off of the fish aggregation ("buoy drift") about the time the vessel passed near the buoy to produce results which could be misinterpreted as a fish response; or b) the threshold level for the fish response was near the Miller Freeman's noise level so a response might not have always occurred ("noise threshold response"). The latter explanation is supported by limited data (n=2 passes) from a buoy experiment with a commercial fishing vessel which was assumed to be noisier than the Miller Freeman, and which produced strong, consistent avoidance reactions by the fish. Direct measurements of vessel noise levels during subsequent buoy experiments would provide valuable information to interpret whether the "noise threshold response" could explain some of the variation among passes for walleye pollock. Although vessel noise levels for the Miller Freeman have been determined during trials at the NSWC/CD acoustic range in Behm Canal, Alaska, the extent that the levels could be modulated by weather conditions, propeller pitch/engine speed, bottom depth/type and so forth is unknown. The actual radiated noise level from the commercial vessel that elicited the consistent fish reactions (above) is also unknown but would be invaluable for comparison with the Miller Freeman results. To characterise radiated noise from the Miller Freeman (and other vessels) under different operating conditions, a passive acoustical system was added to the buoy. A single broad-bandwidth omnidirectional hydrophone was deployed on three occasions to compare noise spectra of the vessel among buoy passes. A two-hydrophone system was subsequently used to estimate the distance between the vessel and buoy, thus providing both relative noise spectra and intensities from pass-to-pass. Methods and results will be discussed.

6.5 Michael A. Guttormsen and Christopher D. Wilson. Using target strength measurements from a buoy to characterise fish response to vessel noise

A free-drifting acoustic buoy containing an echosounder and split-beam transducer operating at 38 kHz was used to evaluate the response of subadult walleye pollock (*Theragra chalcogramma*) to underwater radiated noise, generated by the NOAA research ship Miller Freeman when free-running at the standard survey speed of 11-12 knots. The experiment was conducted in the Gulf of Alaska during March 1998. Earlier analyses indicated that a reduction in the nautical area scattering coefficient (sA) occurred in some of the passes from this deployment as the vessel approached the buoy. Because the pollock were present in well-dispersed night-time aggregations higher in the water column than typically observed during pollock surveys, it was possible to examine tracked individual targets to determine whether changes occurred in the number of targets or in estimates of mean target strength, which corresponded to reductions in sA. The number of targets between depths of 50-100 m decreased as the vessel approached the buoy. Trends in the mean target strength estimates were slight. These results suggest that walleye pollock within the upper portions of the water column may exhibit a response to vessel noise from the Miller Freeman, although further work is needed to verify these results.

6.6 J. Hedgepeth, J. Burczynski, G. Johnson, T. Acker, S. Tomich. Active fish tracking sonar (AFTS) for assessing fish behaviour

Fish behaviour (including avoidance reactions to a survey vessel on the Fraser River) has been assessed in rivers using an active fish tracking sonar (AFTS) over the past five years. This instrument provides three-dimensional fish tracks over large volumes by using a split-beam transducer to drive the axis of the transducer to the fish using high-speed motors. BioSonics designed the motor armature to work with both BioSonics and Simrad split-beam systems. Error analysis during a spring-summer 2000 study on the Columbia River indicates new software and hardware improvements begun at BioSonics in Seattle. This system can be deployed from a boat or ship for studying of fish behaviour.

6.7 Conclusion on topic C

Three points emerged from discussion on the evaluation of the effects of fish avoidance during surveys. First, fish behaviour is complex and variable in time and space, over a wide range of scales. It involves multiple components, learning and habituation. It is therefore doubtful that solutions developed for a given situation could be generalised everywhere. Second, the means of studying the fish behaviour around a survey vessel are still very limited and the measurements are noisy. For example, the delimitation of school shape from multibeam sonar data is affected by the 3-D directionality of the TS of its members and by the reliability of the measures along all beams. Measuring the actual 3-D noise pattern around a moving ship in stratified waters is not an easy task. Non-invasive observation tools such as instrumented buoys and AUVs may be required to reduce the possibility to alter actual studied behaviour. Third, the use of silent research ships has proved to be an important primary condition to minimize the effect of fish avoidance during surveys.

Recommendation: WGFAST considers that avoidance behaviour is important from several points and view and recommends that this be considered as a topic for the 2003 fish behaviour meeting in Bergen.

7 SESSION D "REVIEW OF THE REPORT OF THE STUDY GROUP ON TARGET STRENGTH ESTIMATION ON BALTIC HERRING SGTSEB"

7.1 Report of the Study Group on target strength estimation on Baltic herring (SGTSEB).

The terms of reference for the meeting in Seattle were:

a) To prepare and disseminate as soon as possible a protocol for TS measurements on the Baltic herring, based upon the state of the art and especially the recommendations of the CRR (on TS measurements, 1999 (ICES, 1999)), adapting these recommendations to the special case of the Baltic Sea.

b) Establish a list of the main factors affecting the herring TS and study the effects through comparative analysis and measurements on various herring stocks (e.g., Baltic and Norwegian spring spawning herrings);

c) Collate the existing information and measurements on herring TS;

d) Apply modelling methods on the case of the herring and compare their results to the existing information;

e) From the databases available from the WGFAST members, measure the variability of TS in situ under various conditions (day-night, winter-summer, etc.);

f) Encourage experimental measurements through conventional and non-conventional methods.

Progress made at this 2001 Seattle meeting:

- Points evaluated: background of the stocks; review of existing TS measurements; discussion of main factors affecting TS; how we can get forward; protocol for measurements

- Future work: measurements of variability; modelling – KRM; experimental measurements

The WGFAST acknowledged the report of the SGTSEB group. The report of this Study Group is available as CM2001/B:02.

7.2 Conclusion on the SGTSEB progress report

The discussion on the work of this study group was related to the following technical points and advice: need to look at the variability and consistency of the measurements and include their signal to noise information; fat content will be measured, but measuring density of the fish material was not considered; the swimbladder shape will be measured at the surface, the idea being to use surface adapted fish as a reference level; since changes in depth effect are a problem, in past the samples were bottled at depth to maintain the swim bladder shape and prevent venting; if fish can be obtain at depth, the pressure method can be used for the swim bladder, to see if the surface adapted fish were different; fish could be freeze in a pressure chamber, but there are no plans for this at present; latex casts for obtaining swimbladder shape is another possibility that was suggested; the 20logR assumption was not looked at but there are some data suggesting this assumption is correct; measurements will be done at 38 kHz, there are no plans to measure TS at other frequencies; this group reports to WGFAST, Baltic Committee and Fish Technology Committee. The SGTSEB results will be discussed with Baltic acoustic colleagues at the next ICES Working Group on Baltic International Fish Surveys (WGBIFS) meeting in April 2002.

Recommendations:

Next meeting time and venue:

The WGFAST recommends that the Study Group on target strength evaluation of Baltic herring (Chair: Frederik Arrhenius, Sweden), will meet in Montpellier or Sète, France, on 7 and 8 June 2002, in connection with the ICES Symposium meeting, to:

a) discuss the results of the biological properties that affect backscattering of Baltic fish i.e. swimbladder volume and shape, fat content and stomach content and fullness;

b) discuss the results of backscatter models especially the changes in biological and physiological factors affecting the TS;

c) evaluate the single target TS measurements on herring and sprat during the surveys in 2001 in the Baltic;

d) review the latest literature of TS of herring and sprat;

e) review current information of diel cycles of fat content and stomach fullness in different part of the Baltic area.

8 SESSION E "REVIEW OF THE REPORT OF THE PLANNING GROUP ON HAC STANDARD DATA EXCHANGE FORMAT PGHAC"

8.1 Report of the Planning Group on the HAC standard data exchange format (PGHAC)

The WGFAST acknowledged the report of the planning group presented by its Chair, Dave Reid. The PGHAC report is presented in CM2001/B:03.

8.2 Conclusion on the PGHAC progress report

A new version of the HAC standard data format should be available in two months. Versions are backward compatible in the sense that all the information present in the previous version is also found in the next one. Some tuples could become obsolete though, when more complete new ones replace them. The Simrad EK60 Mark 1 does not have the ability to use the HAC standard data format but the EK60 will. The addendum produced to update the format will only include the tuples that have changed since the original report (HAC version 1.0). The possibility to also have a complete amended version of the format on the WGFAST web site, and a web site document cross-referenced by tuple with an index were also considered. Some HAC translators were written for other data formats, but they are not well documented. The web site can provide a hot link for supporting software or freeware.

Recommendation:

Next meeting time and venue:

The WGFAST recommends that the Planning Group on the HAC standard data exchange format [PGHAC] (Chair: Dave Reid, Scotland) will meet in Montpellier or Sète, France, on 7 and 8 June 2002, in connection with the ICES Acoustic Symposium, to coordinate the development of the HAC standard data exchange format.

9 SESSION F "METHODS AND TECHNIQUES"

9.1 Robert Kieser. Investigation of split-beam TS measurement bias at low signal to noise

Accurate split-beam target strength measurements depend on a high signal to noise, SN, level. Earlier work by Ehrenberg and practice indicate that useful results for fisheries stock assessment can be obtained when SN is 20 dB or better for an on axis target. Measurements of Pacific hake TS and tracking of salmon in rivers in moderate to low SN conditions has forced us to look more closely at the split-beam measurement process. Interesting and useful results have been obtained for the split-beam angle measurement bias for targets at a fixed range (Kieser R., Mulligan T., Ehrenberg J. 2000. Observation and explanation of systematic split-beam angle measurement errors. Aquat. Living Resour. 13(5):275-281). The discussion presented here has evolved from this work. A new model for TS bias as a function of range (target depth) is presented and measurement and model results are discussed to provide an understanding for the potential split-beam TS measurement bias at low SN. Practical guide lines for TS measurement at low SN can now be developed.

9.2 John Horne and R.H. Towler. Sensitivity of Kirchhoff-ray Mode backscatter predictions to c, g, and h parameter values

Target strength estimates from numeric backscatter models use measurements or guesstimates of density (g) and sound speed (h) contrasts between target organisms and the surrounding medium. Standard techniques are available to measure material properties of water but measuring sound speeds and densities of swimbladders and fish flesh is more difficult. The range of c, g, and h values reported for teleost fish in marine environments were used in Kirchhoff-ray mode models to examine variability in predictions of target strength for adult (41-49 cm) walleye pollock (*Theragra chalcogramma*). Predicted backscatter from swimbladders varied little from reference values. Predicted backscatter from fish bodies differed by as much as 20 dB from reference values depending on the size of the animal and the acoustic frequency (12-200 kHz). Variations in whole fish predicted target strengths increased with increasing frequency but were much lower than changes predicted for fish body target strengths (max. 5 dB). Predictable patterns in target strength variation, as a function of animal size, did not exist. Complexity and amplitudes of target strength variation increased with increasing frequency. Direct measurement of fish body and swimbladder material properties will improve accuracy of backscatter model predictions.

9.3 Neal Williamson. Impact of transducer motion on echo integration during winter and summer acoustic surveys in Alaska

In the summer of 1999, an inertial navigation and motion measurement system was made operational on the NOAA Ship Miller Freeman. This vessel serves as the primary platform for fisheries acoustics surveys conducted by the Alaska Fisheries Science Center. A 38 kHz survey transducer is mounted on the bottom of the vessel's centerboard - approximately 4 m from the hull. Previous research has demonstrated that under certain conditions, excessive transducer motion can bias echo integration measurements – resulting in an underestimate of biomass. This theory is applied to transducer pitch and roll data collected during winter (severe weather) and summer (mild weather) field seasons in the Bering Sea and Gulf of Alaska. The magnitude of the error due to transducer motion is evaluated and ways to minimize the error are proposed.

9.4 Eckhard Bethke. The forgotten filter or the big bug

The band filter and amplifier of the EK500 was tested with a wideband and a narrowband signal. Depending upon the amplitude of the test signal a large step of the integrated values at the output was detected. Under certain condition this can lead to considerably errors using the EK500 in a survey.

9.5 François Gerlotto and Patrice Brehmer. Acoustic monitoring of mussel longline grounds using vertical echo sounder and multibeam sonar

Mussel aquaculture on longline along the French Mediterranean coast has been suffering heavy predation by fish (especially ilthead bream) since 1996. In order to evaluate the impact

Of predation and to help monitoring the longline ground, a survey with a vertical dual beam echo sounder and a multibeam sonar has been performed in August 2000. The multibeam sonar allows one to map the area, to reconstruct in 3 dimension the longline structure, and to observe and measure in 3D the fish schools. The vertical echo sounder is not usable alone, as it cannot discriminate between the fish and the artefacts in midwater. But when used jointly with the sonar, echo sounding is able to provide TS and density values in the sectors, which have been proven by the sonar observation, be free of such artefacts. The paper presents the methodology and gives some preliminary data.

9.6 Jim Galloway. Practical Stock Assessment with Multibeam Sonars

Application of multibeam hydroacoustic sonar technology as a stock assessment and behavioural study tool, with its wide swath and enhanced resolution, offers an opportunity to improve surveying effectiveness. This new capability will increase the accuracy and speed with which biomass can be estimated. These systems can be used to detect and quantify anadromous, pelagic, and benthic stocks, and may be used to assess individual fish or stock aggregations. The fact that multibeam sonars exhibit wide swaths creates special problems and opportunities:

- The target strength (TS) beam pattern of individual fish varies considerably with incidence angle of the sonar signal. In-situ calibrations can establish confidence limits of S_a as a function of incidence angle.
- Beamwidths of most multibeam sonars vary with angle. This can be accounted for in a system calibration; care must be taken to ensure that this measurement is made in the far field.
- Schooling fish often exhibit a highly correlated swim pattern, similar to flocking birds, such that TS deviations with aspect for the whole aggregation can become important.
- Aggregations of pelagic fish can exhibit vessel avoidance under some survey and harvest conditions. Multibeam sonars can estimate the degree of avoidance by orienting the beams to line up with a vessel track then measuring changes in school structure in front of, beneath, and behind the survey platform.
- Most multibeam sonars beamform on receive only, thus lowering the acoustic gain achieved through a reduced directivity index as compared to conventional single beam sonars.
- Acoustic extinction effects increase in importance with incidence angle for a multibeam sonar.
- The potential now exists to study behavioural aspects for schooling fish since multibeam systems insonify 100% of the spatial features of an aggregation.
- Field results will be presented to address many of the potential problems and features above.

10 SESSION G “WGFAST WEBPAGE: USAGE AND SERVICES”

The discussion concerning the WGFAST web site is presented in the report of the Joint Session with the WGFTFB. Note that the FAST web site is about to move to http://161.55.120.140/fast.

11 OTHER RECOMMENDATIONS AND SPECIAL TOPICS FOR 2002

In addition to the recommendations on ecosystem studies with acoustics (section 4.11), seabed classification (section 5.6), fish avoidance during survey (Section 6.7), SGTSEB (Section 7.2), and PGHAC (Section 8.2), the WGFAST proposes the following.

Recommendations:

The WGFAST recommends that:

WGFAST develop recommendations for the collection and analysis of hydroacoustic and ancillary data aboard commercial fishing vessels and review advantages and limitations of such work; and papers on this topic be entertained for the 2003 meeting.

Justification: Scientists and managers in several ICES member nations are being asked to develop methods for collecting hydroacoustic data from commercial vessels. However, concerns regarding equipment performance and stability, calibration, radiated vessel noise, trawling and other methods of biological sampling, survey design, and data interpretation must be considered in relation to the objectives associated with the collection of this type of data. Since WGFAST has played a leading role in identifying and addressing the aforementioned issues relative to survey assessment by research vessels, it is appropriate for the working group to provide guidance regarding collection of hydroacoustic data from commercial vessels.

Next WGFAST meeting be organised in Montpellier France in June 2002. The FAST will meet on June 16-17th in Montpellier (only the first of these days if there is insufficient interest in a bottom classification theme session) to:

- discuss the results presented at the Symposium;

- plan for the 2003 working subjects and meeting topics.

There will be no Joint Session with the FTFB group in 2002.

12 CLOSURE OF MEETING

A report of the activities of the Steering Committee for the 2002 Symposium in Montpellier, France, was presented to the FAST and approved.

The Chair thanked the local hosts in Seattle, USA, for their hospitality, and closed the meeting.

ANNEX A: LIST OF PARTICIPANTS

The following addresses have been checked by the participants and should be up to date, for April 2001:

Bill Acker
Biosonics
Seattle
Tél. : 206-782-2211
Backer@Biosonicsinc.com

John T. Anderson
Dept. of Fisheries & Oceans
P.O. Box 5667
St John's
Newfoundland A1C 5X1
Canada
Tel.: 709-772-2116
Fax: 709-772-4188
andersonjt@dfo-mpo.gg.ca

Lars Nonboe Andersen
Simrad, Inc
P.O. Box 111
Horten
Norway 3191
Tel.: +47 33 03 44 62
Fax: +47 33 04 29 87
Lars.Nonboe.Andersen@simrad.com

Frederik Arrhenius
Institute of Marine Research
National Board of Fisheries
P.O. Box 4
Lysekil
453 21
Sweden
Tel.: +46523 18746
Fax: +46 523 13977
fredrik.arrhenius@fiskeriverket.se

Arnaud Bertrand
IRD
Centre Halieutique Mediterraneen et Tropical
Rue Jean Monnet, BP 171
34207 Sète Cedex
France
Tel. : +33 (0)4 99 57 32 13
Fax : +33 (0)4 99 57 32 95
Arnaud.Bertrand@mpl.ird.fr

Andrew Brierley
University of St Andrews
Gatty Marine Laboratory
St Andrews, Fife
Scotland, UK
Tel.: +44 (0)1334 463458
Fax: +44 (0)1334 463472
andrew.brierley@st-andrews.ac.

Pablo Carrera
Instituto Espanol de Oceanografia
Muelle de animas s/n 15001 A Coruña Spain
P.O. Box 130 15080 A Coruña
La Coruña
Spain 15001
Tel.: 34 981 205 362
Fax: 34 981 229 077
pablo.carrera@co.ieo.es

Jeff Condiotty
Simrad, Inc..
19210 33rd Ave. West Suite A
Lynnwood,Washington
USA 98036
Tel.: 425 778 8821
Fax: 425 771 7211
jeff.condiotty@simrad.com

Jim Dawson
Biosonics
4027 Leary Way NW
Seattle, WA 98107
Tel.: 206-782-2211
Fax: 206-782-2244
jdawson@biosonicsinc.com

David A. Demer
Advanced Survey Technologies Program
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
PO Box 271
La Jolla, CA 92038, U.S.A.
Tel.: 858-546-5603
Fax: 858-546-5608
ddemer@ucsd.edu
david.demer@noaa.gov

Gerald F. Denny
Scientific Fishery Systems, Inc.
825 Lofall Rd.
Poulsbo, WA 98370, USA
Tel : 360-598-4890
Fax : 360-509-6727
Jdenny@worldfront.com
Skip@scifish.com

Noël Diner
IFREMER
Centre de Brest
TMSI/TP, BP 70
F-29280 Plouzané
France
Tel.: 33 2.98.22.41.77
Fax: 33 2.98.22.46.50
noel.diner@ifremer.fr

Martin Dorn
Alaska Fisheries Science Center
7600 Sand Point Way NE
Seattle, WA
USA
98115
Tel.: 206-526-6548
Fax:
Martin.Dorn@noaa.gov

Greg Englin
Scientific Fishery Systems
16253 Agate Point Rd NE
Bainbridge Island, WA. 98110
Tél. : 206-855-8678
Scifish@seanet.com

Paul Fernandes
Fisheries Research Services
Marine Laboratory
P.O. Box 101
Victoria Road
Aberdeen AB11 9DB
United Kingdom
Tel.: +44 1224 295403
Fax: +44 1224 295511
fernandespg@marlab.ac.uk

James L. Galloway
Canadian Hydrographic Service
Institute of Ocean Sciences
9860 West Saanich Road
Sidney BC V8L 4B2
Canada
Tel.: 1 250 363 6316
Fax: 1 250 363 6323
gallowayj@pac.dfo-mpo.gc.ca

François Gerlotto
IRD
Casilla 53390
Correo Central Santiago1
Chili
Fgerlotto@ifop.cl

Eberhard Goetze
Institute for Fishery Technology and Fish Quality
Palmaille 9
Hamburg
Germany
22767
Tel.: +49 40 38905 202
Fax: +49 40 38905 264
goetze.ifh@bfa-fisch.de

Cathy Goss
British Antarctic Survey
High Cross
Madingley Road
Cambridge CB3 OET
United Kingdom
Tel.: +44 (0)1223 221562
Fax: +44 (0)1223 362616
cg@bas.ac.uk

Michael Guttormsen
National Marine Fisheries Service
Alaska Fisheries Science Center
BIN C15700
7600 Sand Point Way NE
Seattle;Washington 98115-0070
Tel.: 206 526 4163
Fax: 206 526 6723
mike.guttormsen@noaa.gov

Eric Gyselman
Fisheries and Oceans Canada
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba, R3T 2N6
Canada
Tel.: 204-983-5286
Fax: 204-984-2403
gyselmane@dfo-mpo.gc.ca

Elliott Hazen
University of Washington
School of Aquatic and Fishery Sciences
1122 Boat St.
Box 355020
Seattle, WA 98195
USA
Tel.: (206) 221-6864
Fax: (206) 221-6939
ehazen@u.washington.edu

David Heatley
SonarData Pty Ltd
GPO Box 1387
Hobart,Tasmania
Australia 7001
Tel.: +61 3 6231 5588
Fax: +61 3 6234 1822
dave@sonardata.com

Ian Higginbottom
SonarData Pty Ltd
GPO Box 1387
Hobart, Tasmania
Australia 7001
Tel.: +61 3 6231 5588
Fax: +61 3 6234 1822
ian@sonardata.com

Van Holliday
BAE SYSTEMS
4669 Murphy Canyon Road, Suite 102
San Diego, CA 92123
USA
Tel.: 858-268-9777
Fax: 858-268-9775
van.holliday@baesystems.com

Taina Honkalehto
NOAA / NMFS
Alaska Fisheries Science Center
7600 Sand Point Way NE, Bldg. 4
Seattle;WA 98115
USA
Tel.: 206 526 4237
Fax: 206 526 6723
taina.honkalehto@noaa.gov

John K. Horne
University of Washington
School of Aquatic and Fishery Sciences
Box 355020
Seattle, WA 98195-5020
USA
Tel.: 206-221-6890
Fax: 206-221-6339
jhorne@u.washington.edu

Ingvar Huse
Institute of Marine Research/European Commission
36 Avenue de Mai
1200 Woluwe St. Lambert
Brussels
Belgium
1200
Tel.: +3222996761
Fax: +3222957862
ingvar.huse@cec.eu.int
ingvar.huse@imr.no

J. Michael Jech
Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543
Tel.: 508-495-2353
Fax: 508-495-2258
michael.jech@noaa.gov

Erwan Josse
IRD
Centre de Bretagne, B.P. 70
Plouzané
France
29280
Tel.: +33 2 98 22 45 60
Fax: +33 2 98 22 45 14
Erwan.Josse@ird.fr

William Karp
NOAA/NMFS
Alaska Fisheries Science Center
Resource Assessment and Conservation Engineering Division
7600 Sand Point Way NE
Seattle, Washington 98115-0070
Tel.: 206 526 4164
Fax: 206 526 6723
bill.karp@noaa.gov

Robert Kieser
Department of Fisheries and Oceans
Pacific Biological Sation
Hammond Bay Road 3190
Nanaimo, BC
Canada
V9R 5K6
Tel.: 250-756-7181
Fax: 250-756-7053
kieserr@pac.dfo-mpo.gc.ca

Rudy Kloser
CSIRO Marine Research
P.O. Box 1538
Hobart, Tasmania
Australia 7001
Tel.: 61 3 62325222
Fax: 61 3 62325000
rudy.kloser@marine.csiro.au

Hans Petter Knudsen
Institute of Marine Research
P.O. Box 1870 Nordnes
N-5817 Bergen
Norway
Tel.: +47 55 238450
Fax: +47 55 238532
hansk@imr.no

Chris Lang
Dept. of Fisheries & Oceans
P.O. Box 5667
St John's, Newfoundland A1C 5X1
Canada
Tel.: 709-772-4952
Fax: 709-772-4105
LangCh@dfo-mpo.gc.ca

Andone Lavery
Woods Hole Oceanographic Institution
Department of Applied Ocean Physics and Engineering
MS12, Woods Hole, MA 02543
USA
Tel.:508-289-2345
Fax: 508-457-2194
andone@whoi.edu

Anne Lebourges-Dhaussy
IRD
Centre de Bretagne
BP 70, 29280, Plouzané,
France
Tel.: +33-2-98 22 45 05
Fax: +33-2 98 22 45 14
lebourge@ird.fr

Elizabeth Logerwell
Alaska Fisheries Science Center
F/AKC3
P.O. Box 15700
Seattle
USA
98115-0070
Tel.: 206-526-4231
Fax:
Libby.Logerwell@noaa.gov

Bo Lundgren
Danish Institute for
Fishery Research, Dep. Marine Fisheries
North Sea Center
P.O. Box 101
DK-9850 Hirtshals
Denmark
Tel.: +45 33963200
Fax: +45 33963260
bl@dfu.min.dk

Valerie Mazauric
IFREMER
TMSI/AS, BP 70
Plouzané
France
29280
Tel.: 33 2 98 22 49 86
Fax: 33 2 98 22 44 52
Valerie.Mazauric@ifremer.fr

Denise McKelvey
NOAA / NMFS
Alaska Fisheries Science Center
7600 Sand Point Way NE, Bldg. 4
Seattle;Washington 98115
USA
Tel.: 206 526 4167
Fax: 206 526 6723
denise.mckelvey@noaa.gov

Ian H. McQuinn
Fisheries & Oceans Canada
Institut Maurice-Lamontagne
850, route de la Mer
C.P. 1000, Mont-Joli
Québec G5H 3Z4
Canada
Tel.: 418-775-0627
Fax: 418-775-0740
mcquinni@dfo-mpo.gc.ca

William Michaels
Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543
USA
Tel.: 508-495-2259
Fax: 508-495-2258
william.michaels@noaa.gov

Ole Arve Misund
Institute of Marine Research
P.O. Box 1870 Nordnes
N-5817 Bergen
Norway
Tel.: +47 55 23 84 97
Fax: +47 55 23 84 85
olem@imr.no

Patrick Nealson
Hydroacoustic Technology Inc.
715 NE Northlake Way
Seattle, WA 98105
USA
Tel.: 206-633-3383
Fax: 206-633-5912
support@htisonar.com

Hans Nicolaysen
Simrad AS
P.O. Box 111
3191 Horten
Norway
Tel.:
Fax:
hans.nicolaysen@simrad.com

Kjell Kristian Olsen
The Norwegian College of Fishery Science
University of Tromsø
Breivika
N-9037 Tromsø
Norway
Tel.: 47 77646001
Fax: 47 77646020
kjello@nfh.uit.no

Pall Reynisson
Marine Research Institute
P.O. Box 1390
Skúlagata 4
IS-l21 Reykjavík
Iceland
Tel.: +354 5111275
Fax: +354 5111277
pall@hafro.is

Patrick Schneider
C./San Antonio María Claret,
186,4-2 08025 Barcelona
Spain
Tel.: +34-934 360 810
Fax: +34-932 217 340
ps@wol.es

Leon Smith
Faroese Fisheries Lab
P.O. Box 3051
Noatun 1
Torshavn
Faroe Islands
FO-110
Tel.:+298 315092
Fax: +298 318264
leonsmit@frs.fo

Karl-Johan Stæhr
Danish Institute for Fishery Research
Nordsoecentret
P.O. Box 101
DK-9850 Hirtshals
Denmark
Tel.: +45 33963206
Fax: +45 33963260
kjs@dfu.min.dk

Gordon Swartzman
Applied Physics Laboratory
Box 355640
University of Washington
Seattle, WA 98105
USA
Tel.: 206-543-0061
Fax: 206-543-6785
gordie@apl.washington.edu

Dave G. Reid
Fisheries Research Services
Marine Laboratory
P.O. Box 101
Victoria Road
Aberdeen AB11 9DB
United Kingdom
Tel.: +44 1224 295363
Fax: +44 1224 295511
reiddg@marlab.ac.uk

Carlos Robinson
UNAM
Instituto De Ciencias Del Mar, Ciudad Universitaria, Mexioc D.F, Mexico
Mexico, D.F.
Mexico
04500
Tel.: 525 622-5786
Fax: 525 616-0748
robmen@servidor.unam.mx

E. John Simmonds
Fisheries Research Services
Marine Laboratory
P.O. Box 101
Victoria Road
Aberdeen AB11 9DB, United Kingdom
Tel.: +44 1224 295511
Fax: +44 1224 295511
simmondsej@marlab.ac.uk

Erik Stenersen
Simrad AS
P.O. Box 111
3191 Horten
Norway
Tel.: +47 33 03 42 12
Fax: +47 33 04 29 87
erik.stenersen@simrad.com

Ingvald K. Svellingen
Institute of Marine Research
P.O.Box 1870, Nordnes
Bergen
Norway
5817
Tel.: +47 55236930
Fax: +47 55236830
ingvald.svellingen@imr.no

Rick Towler
University of Washington
UW School of Aquatic and Fishery Sciences
Box 355020
Seattle, WA 98195-5020
USA
Tel.:206-221-6864
Fax:
rtowler@u.washington.edu

Paul Walline
Alaska Fisheries Science Center
7600 Sand Point Way NE
Seattle, WA 98115
USA
Tel.: 206-526-4681
Fax: 206-526-6723
paul.walline@noaa.gov

Neal Williamson
NOAA / NMFS
Alaska Fisheries Science Center
7600 Sand Point Way NE
Seattle, Washington 98115-6349
USA
Tel.: 206 526 6417
Fax: 206 526 6723
neal.williamson@noaa.gov

Chris Wilson
NOAA / NMFS
Alaska Fisheries Science Center
7600 Sand Point Way NE
Seattle, Washington 98115
USA
Tel.: 206 526 6435
Fax: 206 526 6723
chris.wilson@noaa.gov