

Training Course on principles and methods of broadband technologies: application to fisheries acoustics

ICES TRAINING COURSE REPORT



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1 Summary

The training course on “Principles and Methods of Broadband/Wideband Technologies: Application to fisheries acoustics” was held on board a Norwegian vessel, R/V G. O. Sars, from 10 to 17 December 2019. The participants were on board on 10 December in Bergen, Norway and got off the vessel on 17 December. The number of participants was 20 from 11 countries, representing 16 organizations. There were also 4 instructors and 2 technical and logistic assistants.

With the rapid advances in technologies, broadband acoustic systems such as Simrad EK80 echosounder and EdgeTech towed and vertically deployable systems have become commercially available. The potential advantages of these systems over the currently widely used narrow-band, multi-frequency systems in target detection, acoustic characterization and classification of marine targets such as fish and zooplankton have made them increasingly popular and accepted within the fisheries acoustic community at a pace much quicker than expected.

To help colleagues to conduct surveys and research efficiently and accurately in fisheries acoustics using these newly developed broadband acoustic systems, we proposed this training course to be held onboard a research vessel. The overall objective of this course was to provide participants the knowledge and skill of collecting, interpreting and processing acoustic broadband/wideband data with confidence, and to be well prepared for moving broadband/wideband technology forward into routine acoustic research and survey applications in fisheries science.

The course materials and data collected are shared on individual discs, while associated information on the training course can be found at the ICES website: https://i-marine.d4science.org/web/ices_fiaco/home?p_p_state=maximized&p_p_mode=view&saveLastPath=false&58_struts_action=%2Flogin%2Flogin&p_p_id=58&p_p_lifecycle=0&58_redirect=%2Fgroup%2Fices_fiaco%2Fices_fiaco.

(this VRE link is a place holder, where all the course materials and related information have been uploaded and needs to be modified so that it will be available for general public).

2 Course Descriptions



Course participants 2019

2.1 Contents

The course covered both the theoretical background and how to apply the theory to actual fisheries acoustics through case studies and exercises with synthetic, previously recorded, and real time data collected during the training course.

A number of Simrad EK80 echosounder systems, including systems mounted on the ship drop keel, on TSprobe (a vertically deployable system that can be deployed up to 1500-m depth), and WBAT (an autonomous EK80 recording system), were calibrated and operated during the class. Every participant had a chance to independently conduct the operation to gain hands-on knowledge and experiences.

2.2 Objectives

The overall objective of this course was to provide participants the knowledge and skill of interpreting and processing acoustic broadband/wideband data with confidence, and to be well prepared for moving broadband/wideband technology forward into routine acoustic research and survey applications in fisheries science.

By the end of the course, the participants could:

- Understand the fundamental differences between narrow-band and broadband acoustic systems;
- Interpret broadband/wideband echograms correctly;
- Understand the spatial and temporal characteristics of the broadband/wideband systems;
- Understand the techniques of spectral analysis such as pulse compression processing;
- Process broadband/wideband raw and pulse-compressed (complex) data.

2.3 Level

The training course was an advanced course in fisheries acoustics. The participants were assumed to have moderate (college level) knowledge in algebra, calculus, and experience with narrow band echosounders, such as Simrad EK60. In addition, programming ability (Matlab, R, etc.) was required.

3 Course program

Due to the room-space limitation on the vessel, the participants were divided into two groups. The two groups were taught essentially the same course contents but dealing with slightly different echosounder systems (different frequencies). Two groups had different course schedules as listed in the course Agenda (Annex 2).

Every evening, there was a two-hour discussion session. During this discussion session, some questions, problems, and suggestions for the next day(s) were raised, answered, solved, or recorded. Some of the questions did suggest future projects. All instructors were available during this time.

The host of the training course was Egil Ona (Institute of Marine Research - IMR, Bergen, Norway), who was the Chief Scientist or Project Leader on this G. O. Sars cruise. The IMR provided many necessary organizational and logistical supports. The funding to support this 5-day G.O. Sars operation was provided by IMR and University of Bergen.

4 Accomplishments

- a. Theory on broadband technologies (Dr. Korneliussen and Macaulay)
 - i. Background on narrow band and broadband signal
 - ii. Understanding the temporal, spatial, and spectral aspects of the complex broadband signal
- b. Overview of the specifications and data flow of commercially available and most commonly used broadband systems – Simrad EK80 (Drs. Korneliussen, and Macaulay)
- c. Knowledge on EK80 system operation and hands-on experiences (Drs. Ona and Macaulay)
 - i. System configurations
 - ii. Calibration procedures
 - iii. Data collection and preliminary processing
- d. Data collection (Drs Ona and Macaulay)
 - i. EK80 WBT data with transducers mounted on the ship drop keel
 - ii. EK80 WBT data with transducers mounted on the TSprobe, a vertically deployable system from the ship winch
 - iii. EK80 WBT-mini data from a WBAT.
- e. Data Processing (Drs Korneliussen, Macaulay, and Anderson)
 - i. Calibration quantities as a function of frequency
 - ii. $TS(f)$ of tracked individual targets
 - iii. $Sv(f)$ of a scattering layer

5 Recommendations

Some useful comments and recommendations from the course evaluation questionnaire (see Annex 3).

- a. Many course participants felt the need to have more time on EK80 data processing. If there are training courses on the broadband technology in the future, it is recommended to allocate more time to data processing.

6 Acknowledgements

We would like to thank the Institute of Marine Research and the University of Bergen for their generous support of the Training Course with 7 days of ship time onboard the R/V G. O. Sars. It allowed the course participants to have hands-on operation on the newly developed broadband echo sounders for real field applications. It is the only ICES training course that has been carried out onboard a ship in a calm and deep fjord system.

Annex 1: List of participants

Instructors:

Name	Email	Organization
Lars N. Andersen	lars.nonboe.andersen@simrad.com	Kongsberg Maritime, Norway
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Gavin J. Macaulay	gavin.macaulay@imr.no	Institute of Marine Research, Norway
Ronald Pedersen	Ronald.pedersen@imr.no	Institute of Marine Research, Norway
Martin Dahl	Martin.dahl@imr.no	Institute of Marine Research, Norway

Course participants:

count	Name	Gender	Institution	email	Nation
1	Allan Debertin	Male	Department of Fisheries and Oceans Canada St. Andrews Biological Station	allan.debertin@dfo-mpo.gc.ca	Canada
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4	Elor Sepp	Male	Estonian Marine Institute, Vanemuise 46a, Tartu, Estonia	elor.sepp@ut.ee	Estonia
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20	Geir Pedersen	Male	IMR, Bergen	Geir.Pedersen@imr.no	NORW

Annex 2: Agenda

Course Title: Principles and Methods of Broadband/Wideband Technologies: Application to fisheries acoustics

Time: 10 - 17 Dec 2019

Location: On Board R/V G.O. Sars;
Pier: Nykirkekaaien 1, Bergen, Norway

Course Organization:

G.O. Sars does not have a room capable of holding 20 participants who will take notes. We therefore divide the 20 participants in two groups. Both groups will have the same classes.

Question & Discussion Session:

This session is to help people understand class contents, to solve problems associated with the class and discuss broadband topic. There will be a Questions/Discussions session from 7 – 9 pm every evening. All instructors are available during this time.

Meals on G.O. Sars:

Meals are free and the meal times for breakfast, lunch, and dinner are:

Breakfast:	7:30 – 8:30 am
Lunch:	12:30 am – 1:00 pm
Dinner:	5:30 – 6:30 pm

In addition to the three meals, hot/cold drinks, snacks, and self-help food are provided 24 hours

Lecturing plan completed:

Installation and security									
	Finding your cabin, marking cabins								
	Finding lecturing spaces								
	Delivery of passport and seaman's certificates								
	Participate in the vessel security program, vessel familiarisation								
	Deliver security checklist to first mate								
	Course goodies								
Introduction	(Korneliusen, Macaulay)								
Theory	What is wideband/broadband								
	Chirps, upsweep, downsweep, hyperbolic, other bird chirps								
	Wideband history								
	Sonar equations, single targets, multiple targets								
	Important parameters and variation with frequency								
	Sphere response, different spheres, uncertainties								
	Time varied gain								
	Miscellaneous								
Hardware	EK60 w EK80 GPT, WBT								
	Other systems?								
	Transducers details, Tonpilz, ceramic, other materials?								
	Software filters								
	WBAT /TUBE/MINI								
Theory 1	(Korneliusen)								
	Brief introduction of fisheries acoustics								
	Fundamentals of broadband fisheries acoustics								
	Fast Fourier transform and Hilbert Transform								
	Convolution, cross correlation, and pulse compression								
	Temporal, spatial, and spectral characteristics of broadband signals								
	Calibration (partial wave)								
	Miscellaneous								
Calibration of ship	(Ona, Macaulay)								
	Calibrate ship transducers with different spheres								
	Single frequency and broadband pulses								
	Explore the differences								
	Hands on training of students								
	Repeat calibrations								
	Target strength and volume backscatter measurements, two ways, center and off center								
	Software demonstrations								
Theory 2	(Macaulay)							(Vessel collecting survey data)	
	Applications of broadband technology							(during lectures, survey coverage, sampling)	
	Issues associated with broadband systems							(ONA and CREW)	
	subsampling unwrap/shift in frequency domain								
	sidelobe influence								
	doppler effect on broadband								
	calibration: potential inconsistencies (EK80 & Echoview)								
	cross-channel talk								
Data Processing 1	(Korneliusen)								
	Single targets								
	Look at echoes from spheres (and surrounding targets)								
	Process data from spheres								
	Enter calibration data in post-processing systems								
	Use of post-processing systems: LSSS, Echoview								
Data processing 2	(Korneliusen, Macaulay)								
	Multiple targets								
	Process data from layers and schools								
	Test upsweep downsweep data								
Data collection	(Ona, Macaulay)								
	Set up a plan for data collection on survey								
	Grid								
	Single frequency and broadband								
	Limitations								
	Data storage								
	Sampling program								
Tsprobe /WBAT	(Ona, Macaulay)								
	Hands on training with probe echosounder and autonomous echosounder								
	Calibration at depth								
	Target strength measurements								
	Use for profiling								
Data Processing 3	(Korneliusen, Ona, Macaulay)								
	Processing data collected on survey								
Data Processing 4	(Korneliusen, Ona, Macaulay)								
	Processing data collected on survey								
Cruise report									
	Group 1 and group 2 presents their results								
Wrap up	Summary								
	Discs and data								
	Lecturing material								
	Final questionnaire from participants								