CRIMAC CRUISE REPORT 2024

Cruise report for 2024001019 RV G. O. Sars

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Summary (English):

This cruise report describes the objectives, methods, and preliminary results from the tasks carried out at the CRIMAC SFI 2024 survey. The first leg was conducted between November 8th (Bergen) and 11th (Bergen) in the Osterfjorden area north of Bergen. The objectives were to do a full broad band calibration of the echosounders on RV G. O. Sars, test the performance of the new 18 kHz BB transducer, and to observe mesopelagic fish using vessel based broadband acoustic combined with the Deep Vision trawl camera. The second leg was conducted between November 11th (Bergen) and 13th (Bergen) approximately 25 nautical miles west of Fitjar. The main objective was to test a suppression sheet to reduce the sediment plume and allow optical system to work in bottom trawl.

Summary (Norwegian):

Denne toktrapporten skildrar måla, metodane og førebelse resultat frå oppgåvene utførte under CRIMAC SFI 2024-toktet. Fyrste etappe vart gjennomført mellom 8. november (Bergen) og 11. november (Bergen) i Osterfjorden nord for Bergen. Måla var å gjennomføre ei full breibandkalibrering av ekkolodda på GO Sars, teste den nye 18 kHz BB-breidbandssvingaren til Kongberg Discovery, og observera mesopelagisk fisk ved hjelp av breibandsekkolodda til fartøyet, kombinert med Deep Vision-trålkamera. Den andre etappen vart gjennomført mellom 11. november (Bergen) og 13. november (Bergen), om lag 25 nautiske mil vest for Fitjar. Hovudmålet var å teste ein presenning for å redusera sedimentskya slik at optiske system fungerer i botntrål.

Content

1 - Introduction

CRIMAC is a centre of research-based innovation funded by the research council of Norway through their program for research-based innovation (SFI). Sustainable, healthy food production and clean energy production for a growing population are important global goals, and CRIMAC will contribute to these by obtaining accurate underwater observations of gas, fish, nekton and other targets. The data will be used in conjunction with CRIMAC data from other surveys to build a reference data set for optical and acoustic target classification. The classification libraries will be used for developing methods and products toward the fishing industry and marine science.

1.1 - Survey objectives

The first task was to mount, test and calibrate the new 18 kHz BB transducer on RV G. O. Sars in addition to the other echosounders frequencies. This task was conducted between November 6th – 7th .

The first leg was conducted between November 8th (Bergen) and 11th (Bergen) in the Osterfjorden area north of Bergen (Figure 1). The main objective was to test the performance of the new 18 kHz BB transducer on mesopelagic fish, with the objective to discriminate mesopelagic fish from other scatterers and to estimate the length using the resonance frequency. We also tested the Deep Vision system with the krill trawl and used that for validating the targets.

The second leg was conducted between November 11th (Bergen) and 13th (Bergen) approximately 25 nmi west of Fitjar (Figure 2). The main objective was to test a suppression sheet to reduce the sediment plume and allow optical system to work in bottom trawl.

1.2 - Timeline

Date	Task
08:00 06.11.2024	**Start preparations and calibration**
06.11.2024	Mounting 18kHz BB transducer
06.11.2024	Loaded equipment, prepared for departure, prepared sounder operation
07.11.2023	Echosounder calibration (and especially 18kHZ)
08:00 08.11.2024	**Start leg 1 – acoustics - Bergen-Bergen**
08-10.11.2023	Broadband, Probe, and Deep vision observations in Osterfjorden, krill trawl
08:00 11.11.2024	**Start leg 2 – bottom trawling – Bergen-Bergen**
11.-13.11.2023	Bottom trawling

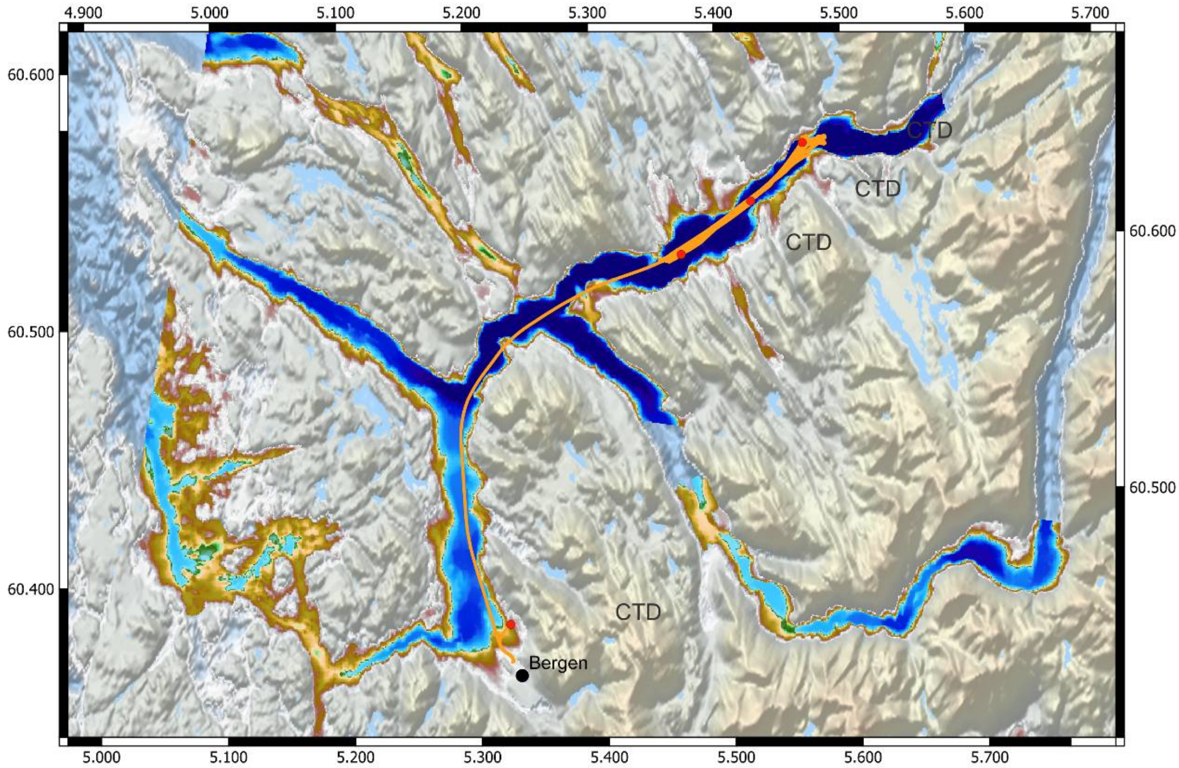


Figure 1 . CRIMAC 2024 Cruise – Leg I.

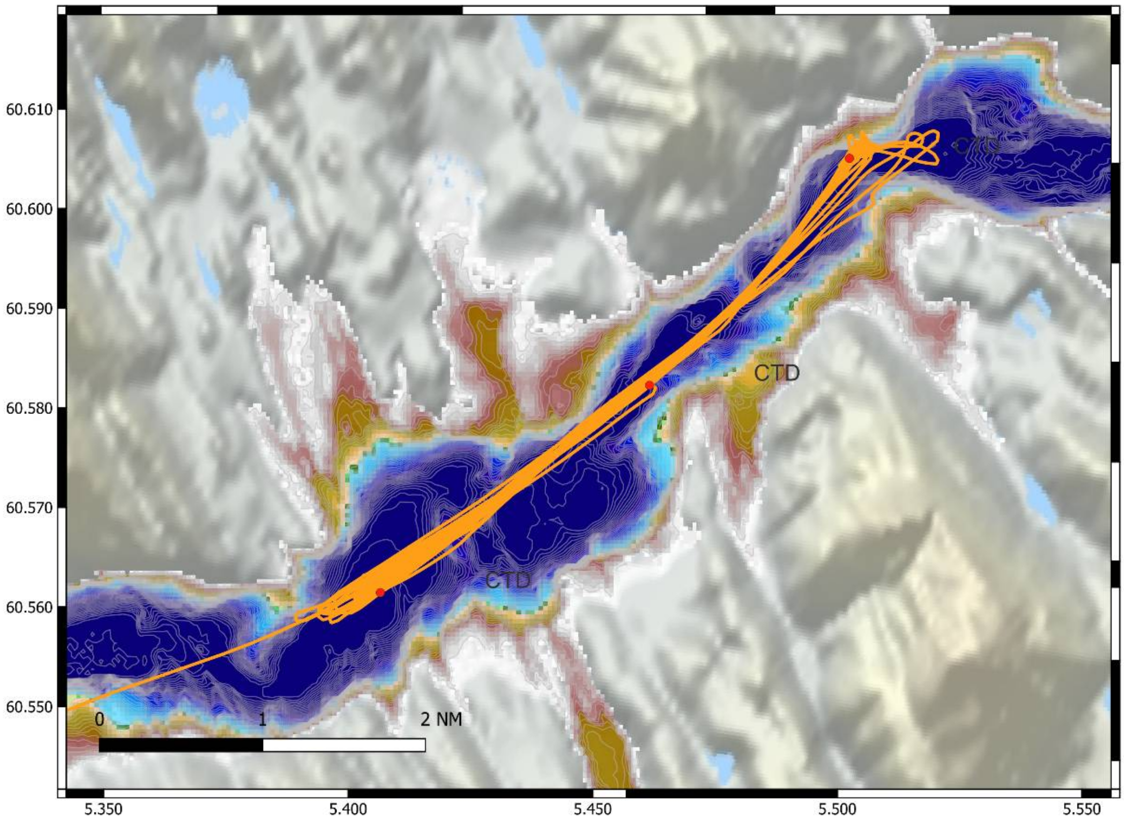


Figure 2 . CRIMAC 2024 cruise – Leg 1. Experimental area, tracks and CTD stations.

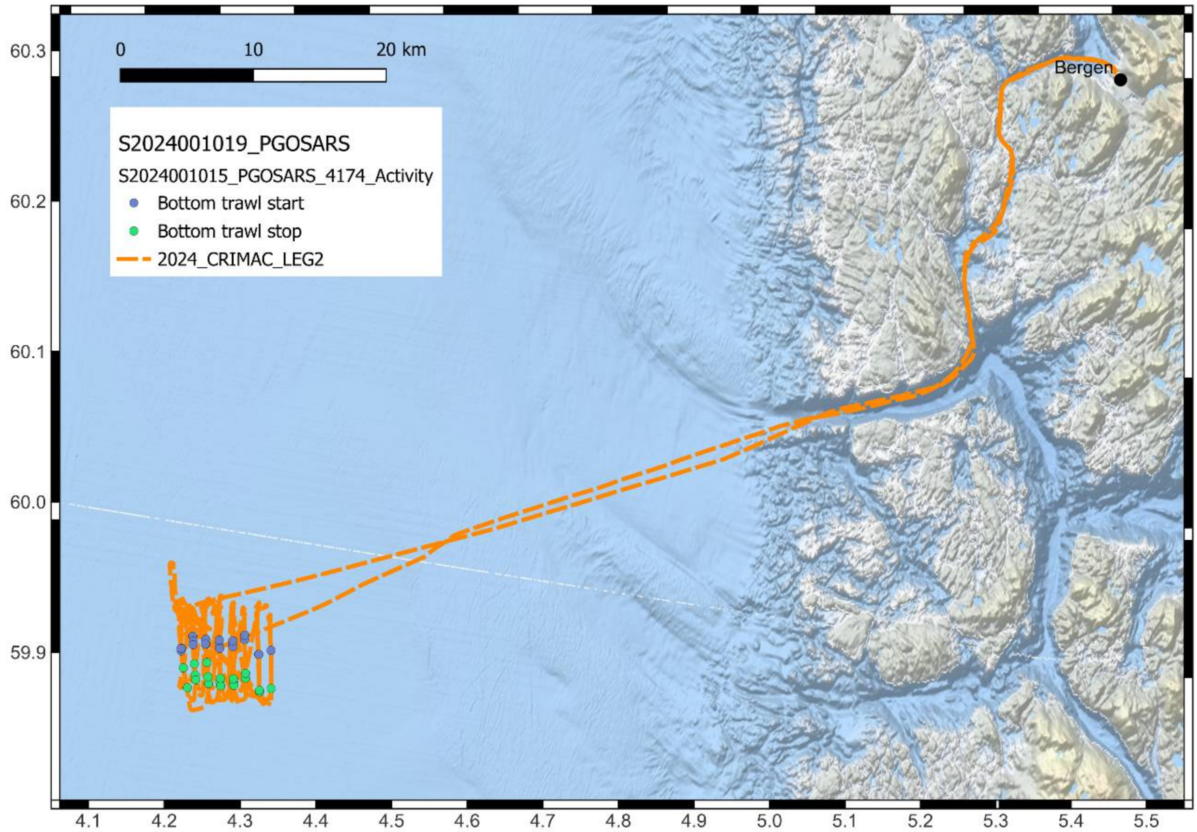


Figure 3 . CRIMAC 2024 cruise – Leg 2. Experimental area, tracks and trawl stations.

1.3 - Vessel details

The cruise was conducted with RV G. O. Sars (Figure 4) operated by the Institute of Marine Research.

RV G.O. Sars is 77.5 m length overall, has a m aximum speed of 17 knots and a c rew of 15 in addition to accommodation for 30 scientific crew members including instrument technicians. The vessel is equipped with Kongsberg Maritime EK80 scientific broadband echosounders (operating at 18, 38, 70, 120, 200, and 333 kHz centre frequency) and a range of other sensors (sonars, ADCPs). The vessel is equipped to deploy a wide range of additional equipment (e.g. probes, towed vehicles, pelagic and demersal trawls). More information about the vessel can be found online (https://www.hi.no/resources/brosjyre-g.o.sars.pdf).

Figure 4 . RV G. O. Sars (image credit: Institute of Marine Research).

1.4 - Cruise participants

Table 1. Scientific crew for the surveys, from the Institute of Marine Research, Norway (IMR), Woods Hole Oceanographic Institution (WHOI), Kongsberg Discovery (KD), University of Bergen (UoB), and DTU Aqua (DTU).

Scientific crew during calibration and EK installation (06.11 – 07.11)
Nils Olav Handegard (IMR) Martin Dahl (IMR) Åse Nina Sudman (IMR) Rolf Korneliussen (IMR) Ketil Malde (IMR) Andone Lavery (WHOI) Guosong Zhang (IMR) Geir Pedersen (IMR) Robert Sørhagen (KD) Rokas Kubilius (IMR) Babak Khodabandeloo (IMR) Max Christopher (WHOI)
Scientific crew 1 st leg (8.11 – 10.11)
Nils Olav Handegard (IMR) Martin Dahl (IMR) Åse Nina Sudman (IMR) Rolf Korneliussen (IMR) Ketil Malde (IMR) Andone Lavery (WHOI) Guosong Zhang (IMR) Geir Pedersen (IMR) Robert Sørhagen (KD) Rokas Kubilius (IMR) Babak Khodabandeloo (IMR) Max Christopher (WHOI) Maria Tenningen (IMR) Muhammad Sarmand (NR)
Scientific crew 2 nd leg (11.11 – 14.11)
Nils Olav Handegard (IMR) Martin Dahl (IMR) Shale Rosen (IMR) Jørgen Høyer (IMR) Jostein Saltskår (IMR) Georgina Vickery (DTU) Maria Tenningen (IMR) Adrian Røssland (UiB)

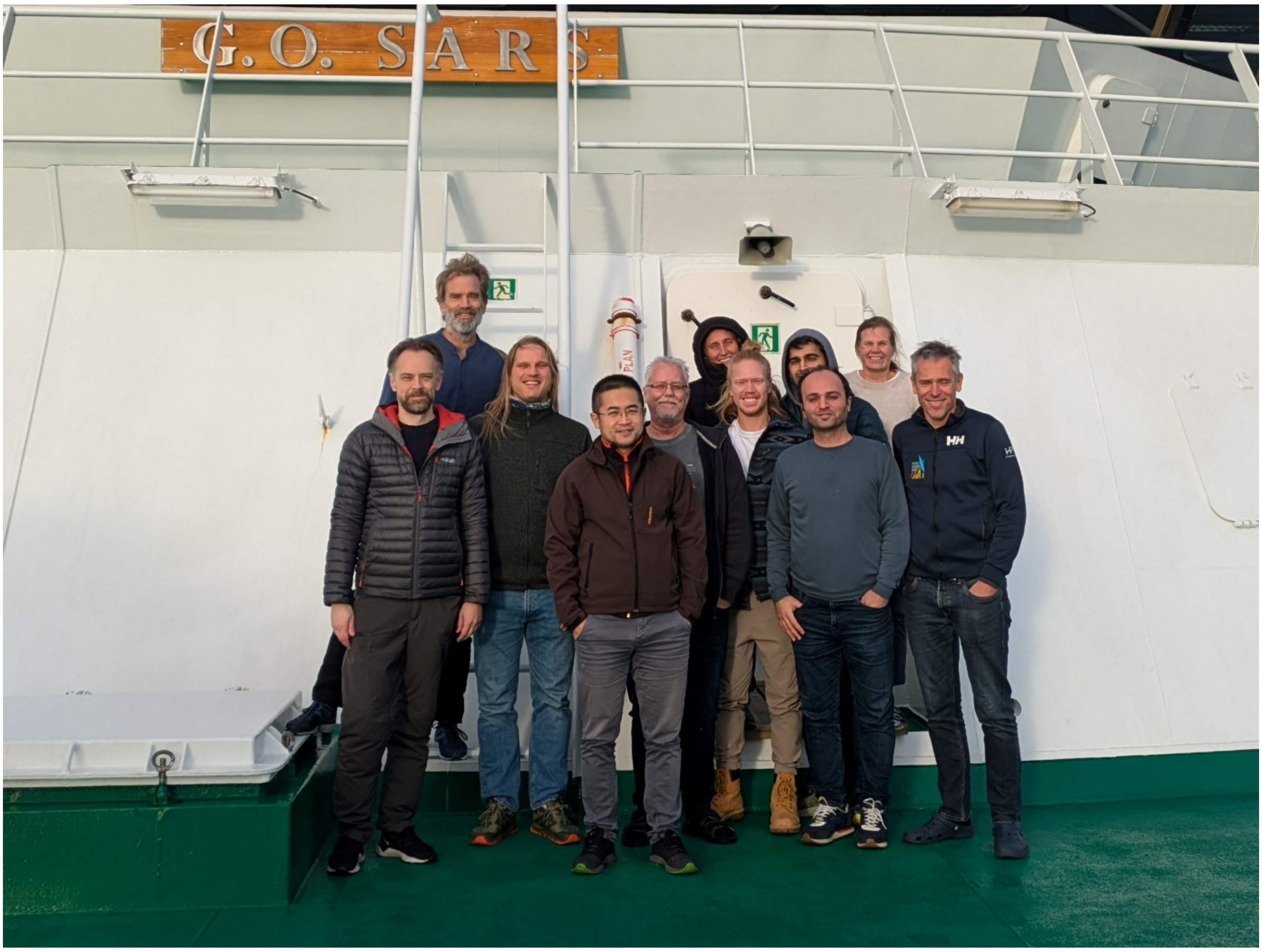


Figure 5. Scientific crew 1st leg.

2 - Calibration of acoustic instruments

Author(s): Rokas Kubilius and Babak Khodabandeloo (IMR)

RV G. O. Sars is equipped with six drop-keel mounted echosounders (Simrad EK80) capable of continuous wave (CW)/narrowband or frequency modulated (FM)/broadband pulse generation. These have nominal frequencies at 18, 38, 70, 120, 200, and 333 kHz. A new broadband-capable 18 kHz transducer (Simrad ES18-11 mk2) was installed on ship drop-keel at the beginning of the survey.

The Simrad EC150-3C ADCP / echosounder is also installed on the ship drop-keel and is capable of CW and FM pulse generation both when operated as an ADCP and as a scientific fisheries echosounder of rather narrow beamwidth (2.5 °).

TS-probe is a probe equipped with four echosounders (Simrad EK80) capable of continuous wave (CW)/narrowband or frequency modulated (FM)/broadband pulse generation (except 38 kHz). The four transducers are depth-compensated versions (ES-38D, ES70-7CD, ES120-7CD, ES200-7CD). Probe can be deployed to desired depth from the hangar of a stationary ship. Power and communication is achieved via combined fibre-optic and power cable.

2.1 - Echosounder calibration

Ship echosounders were operated with CW and FM acoustic pulses. Settings for these were chosen to fit survey objectives and to avoid undesirable effects such as acoustic “cross-talk” in broadband data. This influenced the choice of the acoustic bandwidth, power, and pulse duration settings (Table 1). Standard CW pulse settings (Korneliussen *et al.* , 2008) were used but with reduced power (this is to match power setting of alternating CW / FM pulses that were used during parts of this survey). The standard IMR FM pulse settings for broadband acoustic backscatter data collection were used.

Table 1 . The ship drop keel-mounted echo sounder (Simrad EK80) setting configurations. “CW” - continuous wave pulses (narrowband). “FM” – frequency modulated pulses (broadband). “FM-Up” – frequency modulated up-sweep pulse.

Chanel	Tr. type	Pulse shape	Bandwidth [kHz]	Taper	Pulse duration [ms]	Power [W]	
CW (Continuous Wave)							
18-CW	ES18-11mk2	CW	-	Fast	1.024	800	
38-CW	ES38-7	CW	-	Fast	1.024	400	
70-CW	ES70-7C	CW	-	Fast	1.024	225	
120-CW	ES120-7C	CW	-	Fast	1.024	100	
200-CW	ES200-7C	CW	-	Fast	1.024	105	
333-CW	ES333-7C	CW	-	Fast	1.024	40	
FM (Frequency Modulated)							
18-FM	ES18-11mk2	FM-Up	14-22	Fast	2.048	800	
38-FM	ES38-7	FM-Up	34-45	Fast	2.048	400	
70-FM	ES70-7C	FM-Up	50-85	Fast	2.048	225	
120-FM	ES120-7C	FM-Up	95-165	Fast	4.096	100	
200-FM	ES200-7C	FM-Up	170-260	Fast	4.096	105	

333-FM	ES333-7C	FM-Up	280-380	Fast	4.096	40	

Ship drop-keel mounted echosounders and TS-Probe echosounders (2024.11.06-07, Sandviksflaket) were calibrated using standard methods (Demer *et al.* , 2015) and metallic spheres of various sizes made of tungsten carbide with 6 percent cobalt binder. The calibration sphere diameter was chosen based on the best fit for the bandwidth in question in terms of the “null” positions in the frequency response of the sphere (Table 2 and Figure 6)

Example calibration results are shown in (Figure 7). CTD cast was performed immediately prior to the start of the calibration procedures and echosounder environment updated accordingly.

A second calibration target of a different size was used where needed to ensure calibration data across the entire bandwidth of the chosen acoustic pulse and the two calibration results merged as per EK80 software procedures for it.

Calibration target diameters used: 57.2 mm, 38.1 mm, 35 mm, 25 mm, 22 mm, and 20 mm (henceforth referred to in the format “WC57.2” indicating tungsten carbide sphere of 57.2 mm diameter). Calibration targets are traceable, and laser engraved with an ID number.

The EC150-3C ADCP is mounted on the drop keel along with fisheries echosounders and capable of operation as ADCP and as a split-beam echosounder of a rather narrow beamwidth (about 2.5 °) with both narrow- and broad-band acoustic pulses. It was calibrated with WC38.1.

An additional weight (400g shackle) was used to stabilize spheres of smaller size (WC38.1, WC35, WC22, and WC20) when calibrating ship echosounders. It was suspended 6 m below the calibration target by 0.30mm diameter nylon line. WC57.2 was used alone with no additional weights. No additional weights were used for TS-Probe calibration. All spheres had nylon line netting with 2 m long loop to ensure the calibration target is removed in range from the three winch-line suspension rig line and knot echoes that are present just above the calibration target.

Ship EK80 and EC150-3C echosounder calibration conditions and quality were good to excellent. Calibration results text files (*.xml) may benefit from check-up and calibration re-run from acoustic raw data files before these are used to scale fish acoustic frequency response data.

TS-Probe echosounders were calibrated at the same location and date as ship echosounders. Probe was deployed into water so that transducers were at 1.5m depth. Calibration target was suspended 6 m below the probe (Table 2 , Table 3). ES38D transducer was found to be defective as evident in the calibration data.

Table 2 . Calibration target choice for narrowband (CW) and broadband (FM) pulses of indicated nominal frequency echosounder (e.g., “70CW” - continuous wave pulses at 70 kHz nominal frequency). Yellow marked calibration are not used to update EK80 (additional experimentation data for CRIMAC WP2).

		18CW	**18FM**	**38CW**	**38FM**	**70CW**	**70FM**	**120CW**	**120FM**	**200CW**	**200FM**	**333CW**	**333FM**
G. O. Sars keel-mounted echosounders													
Sphere ID	BW (kHz)	**-**	**14-22**	**-**	**34-45**	**-**	**50-85**	**-**	**95-165**	**-**	**170-260**	**-**	**280-380**
IMR106	WC57.2	X	X	X	X								
IMR026	WC38.1					X	X	X	X	X	X		
IMR123	WC35								X		X		
IMR139	WC25										X	X	

IMR071	WC22											X	X
IMR008	WC20												X
TS-Probe mounted echosounders													
IMR026	WC38.1			X			X		X		X		
IMR123	WC35			X					X		X		

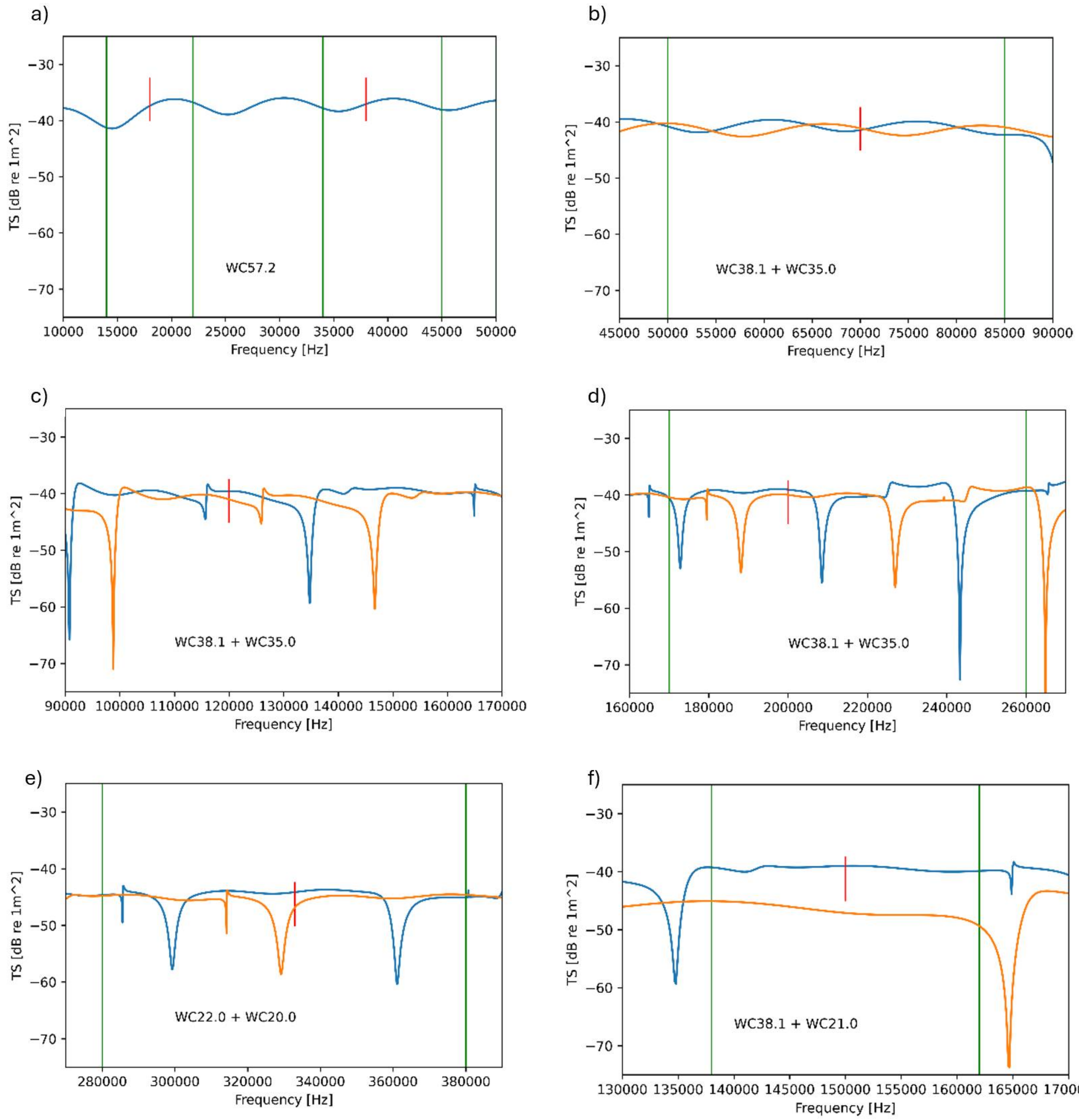


Figure 6 . The expected tungsten carbide calibration sphere acoustic target strength versus acoustic frequency. Calibration targets and target acoustic frequency response for the narrow- and broadband pulse calibration of nominal frequencies: (a) 18 and 38 kHz, (b) 70 kHz, (c) 120 kHz, (d) 200 kHz, (e) 333 kHz, and (f) 150 kHz of EC150-3C unit. Dual-sphere calibration was necessary for certain pulses of broad bandwidth. This is to bridge the gaps over "nulls" in the acoustic frequency response of one sphere with data from another sized sphere. "WC57.2" refers to sphere diameter (in mm) and material (tungsten carbide). Blue lines are for the larger of the two spheres in one graph. Vertical red lines indicate nominal "CW" frequencies. Vertical green lines indicate limits of broadband pulse bandwidth.

Table 3 . Ship EK80, EC150-3C, and TS-Probe calibration data collection log (2024.11.06-07) at the calibration site near Bergen (Sandviksflaket). The data collection sequence is based on calibration target deployment. The suffix "-T" indicates test datasets that were not used to update the echosounder calibration parameters.

Chanel	Frequency [kHz]	Pulse shape	Pulse duration [ms]	Power [W]	Power taper	Beam mapping	Calibration target	EK80 Updated	Data file start time stamp

G. O. Sars keel-mounted echosounders									
18-CW	18	CW	1.024	800	Fast	Full	WC57.2	Yes, replace	13:10:37
18-FM	**14-22**	FM-Up	**2.048**	800	Fast	Full	WC57.2	Yes, replace	13:26:30
18-FM-T	**14-22**	FM-Up	**2.048**	400	Fast	Centre	WC57.2	No	13:42:54
18-FM-T	**14-22**	FM-Up	**2.048**	2000	Fast	Centre	WC57.2	No	13:46:17
18-FM-T	**13-23**	FM-Up	**4.096**	400	Fast	Centre	WC57.2	No	13:50:24
38-CW	38	CW	1.024	400	Fast	Full	WC57.2	Yes, replace	13:54:35
38-FM	**34-45**	FM-Up	**2.048**	400	Fast	Full	WC57.2	Yes, replace	14:20:03
38-FM-T	**34-45**	FM-Up	**2.048**	200	Fast	Full	WC57.2	No	14:29:40
38-FM-T	**34-45**	FM-Up	**2.048**	400	Fast	Full	WC57.2	No	14:39:50
38-FM-T	**34-45**	FM-Up	**2.048**	400	**Slow**	Full	WC57.2	No	14:52:35
70-CW	70	CW	1.024	225	Fast	Full	WC38.1	Yes, replace	15:27:40
70-FM	**50-85**	FM-Up	**2.048**	225	Fast	Full	WC38.1	Yes, replace	15:49:30
120-CW	120	CW	1.024	100	Fast	Full	WC38.1	Yes, replace	16:02:45
120-FM	**95-165**	FM-Up	**4.096**	100	Fast	Full	WC38.1	Yes, replace	16:58:22
	All CW in PASSIVE	CW	PASSIVE record. 200pings. 700m record range. Ping rate 1/sec.						17:46:15
	All FM in PASSIVE	FM-Up	PASSIVE record. 200pings. 700m record range. Ping rate 1/sec.						17:58:20
200-CW	200	CW	1.024	105	Fast	Full	WC38.1	Yes, replace	07:46:00
200-FM	**170-260**	FM-Up	**4.096**	105	Fast	Full	WC38.1	Yes, replace	08:05:40
200-FM-T	**170-260**	FM-Up	**4.096**	45	Fast	Full	WC38.1	No	08:18:15
200-FM-T	**170-260**	FM-Up	**2.048**	105	Fast	Full	WC38.1	No	08:29:20
200-FM-T	**170-260**	FM-Up	**4.096**	105	**Slow**	Full	WC38.1	No	08:39:30
All channels active, simultaneous ping, low power setting					Fast	Full	WC38.1	No	09:04:20
All channels active, simultaneous ping, ‘standard’ power setting					Fast	Full	WC38.1	No	09:18:59
EC-150-3C	150	CW	1.024	90	Fast	Full	WC38.1	Yes, replace	09:41:40
EC-150-3C	**138-162**	FM-Up	**2.048**	90	Fast	Full	WC38.1	Yes, replace	09:49:00

18-FM-T	**14-22**	FM-Up	**2.048**	400	Fast	Centre	WC38.1	All channels active	10:02:00
18-FM-T	**14-22**	FM-Up	**2.048**	800	Fast	Centre	WC38.1	18-active, rest passive	10:05:40
18-FM-T	**14-22**	FM-Up	**2.048**	2000	Fast	Centre	WC38.1	18-active, rest passive	10:09:00
18-FM-T	**14-22**	FM-Up	**2.048**	400	Fast	Centre	WC38.1	18-active, rest passive	10:12:15
120-FM	**95-165**	FM-Up	**4.096**	100	Fast	Full	WC35	Yes, MERGE	10:53:45
200-FM	**170-260**	FM-Up	**4.096**	105	Fast	Full	WC35	Yes, MERGE	10:04:30
All channels active, simultaneous ping, low power setting					Fast	Full	WC35	No	11:14:00
All channels active, simultaneous ping, ‘standard’ power setting					Fast	Full	WC35	No	11:25:35
70-FM-T	**50-85**	FM-Up	**2.048**	225	Fast	Full	WC35	No	11:39:50
333-CW	333	CW	1.024	40	Fast	Full	WC22	Yes, replace	11:56:00
333-FM	**280-380**	FM-Up	**4.096**	40	Fast	Full	WC22	Yes, replace	12:05:00
333-FM	**280-380**	FM-Up	**4.096**	40	Fast	Full	WC20	Yes, MERGE	12:24:40
200-FM	**170-260**	FM-Up	**4.096**	105	Fast	Full	WC25	Yes, MERGE	12:41:40
333-CW-T	333	CW	1.024	40	Fast	Full	WC25	No	12:50:25
TS-Probe echosounders									
38-CW	38	CW	0.512	200	Fast	Full	WC38.1	Yes, replace	
70-FM	**55-85**	FM-Up	**2.048**	75	Fast	Full	WC38.1	Yes, replace	
120-FM	**95-165**	FM-Up	**2.048**	75	Fast	Full	WC38.1	Yes, replace	
200-FM	**170-260**	FM-Up	**2.048**	135	Fast	Full	WC38.1	Yes, replace	
38-CW-T	38	CW	0.512	200	Fast	Full	WC35	No	
70-FM	**55-85**	FM-Up	**2.048**	75	Fast	Full	WC35	Yes, MERGE	
120-FM	**95-165**	FM-Up	**2.048**	75	Fast	Full	WC35	Yes, MERGE	
200-FM	**170-260**	FM-Up	**2.048**	135	Fast	Full	WC35	Yes, MERGE	

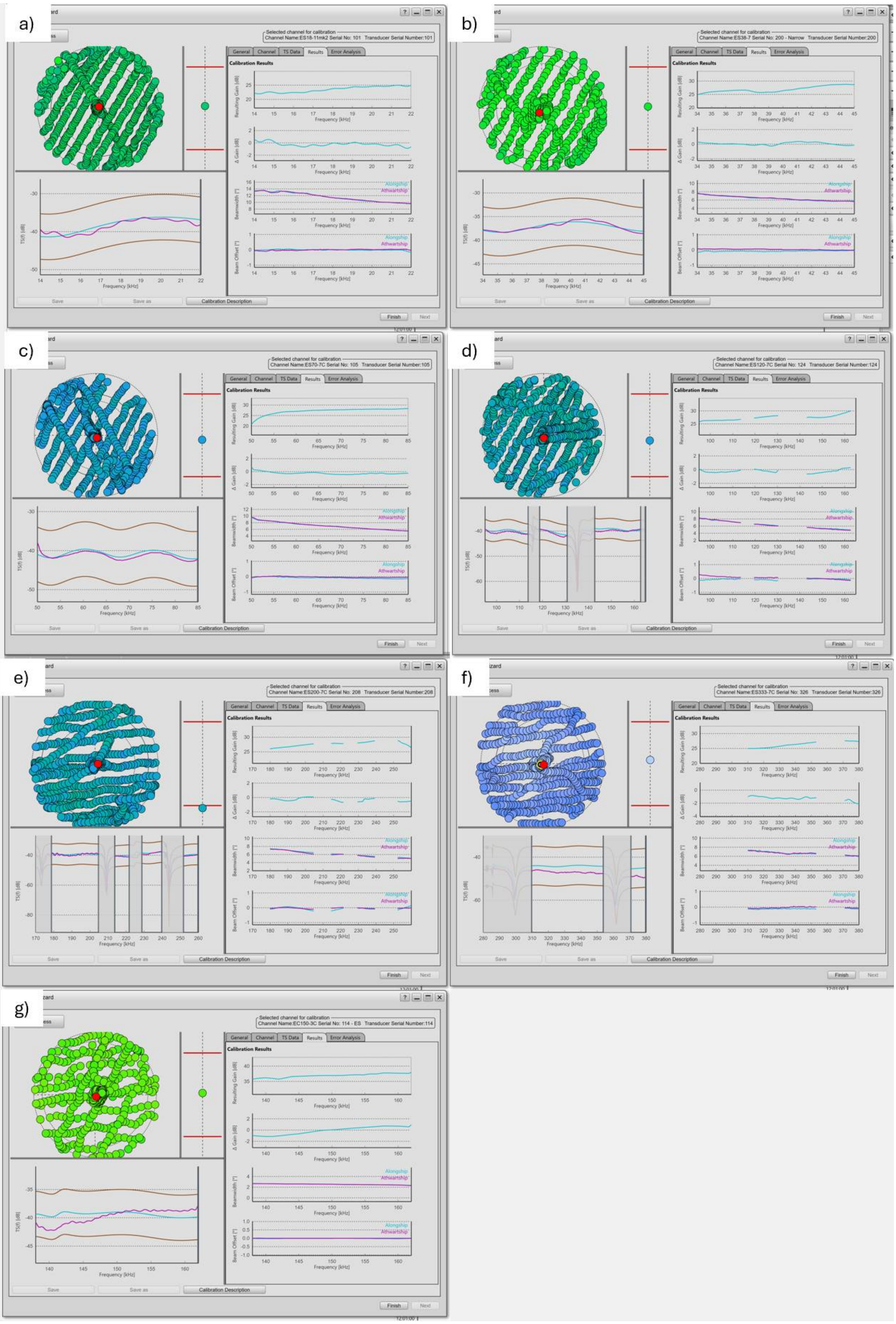

a)
b)
c)
d)
e)
f)
g)

Figure 7 . Representative ship EK80 echosounder calibration examples with full beam mapping exercise (left) and calibration results (right) displayed. Calibrations shown: (a) 12-22 kHz, (b) 34-45 kHz, (c) 50-85 kHz, (d) 95-165 kHz, (e) 170-260 kHz, (f) 280-380 kHz pulses. (g) show EC150-3C ADCP / echosounder system calibration. Operated as echosounder with 138-162 kHz broadband pulses. WC57.2 was used for (a) and (b), WC38.1 was used for (c), (d), (e), WC22 for (f), and WC25 for (g).

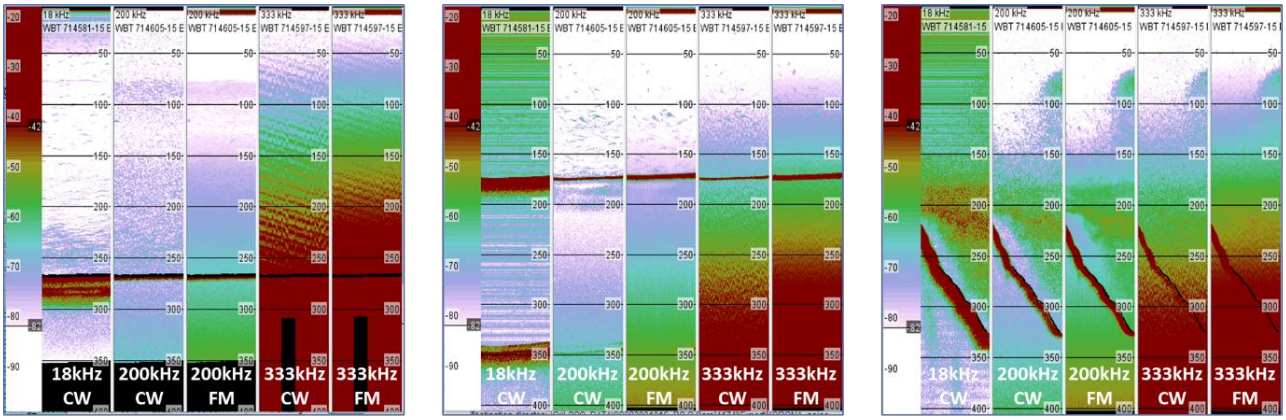
3 - Modified 18 kHz transducers

Author(s): Rolf Korneliussen (IMR)

3.1 - Objectives

The introduction of a broadband 18 kHz transducer is an important task in the CRIMAC project. The frequency band can be used for identifying the resonance frequency of mesopelagic fish.

A broadband 18 kHz transducer was mounted in the instrument keel of RV G. O. Sars and tested during the 2023001016 CRIMAC survey in November 2023, but the transducer was not accepted by IMR due to high noise levels. The objective here is accepting a new modified18-kHz broadband system. The 18 kHz system using the new ES18-11 Mk2 broadband transducer in 2023 performed worse than the original from the 2022 survey (Figure 8), and it was decided to switch back to the original narrowband 18 kHz transducer. Note also that the performance of the 333-kHz channel improved greatly when the original 333-kHz transducer was replaced by a 333-kHz transducer with different grounding (sea-water grounding).



(a) Survey 2022115 (b) Survey 2023001016 (c) Survey 2023001016

Figure 8 . Unfiltered calibrated EK80 data from two CRIMAC surveys with RV G. O. Sars in identical colour-scales (left column in figures a, b, c). Figure a (left) shows the original 18 kHz CW (survey 2022115), and figure b and c (left) the new 18 kHz Mk2 in two different situations in survey 2023001116. Noise at 18 kHz was weaker in the 2022115 survey than in 2023001016 survey.

3.2 - Methods

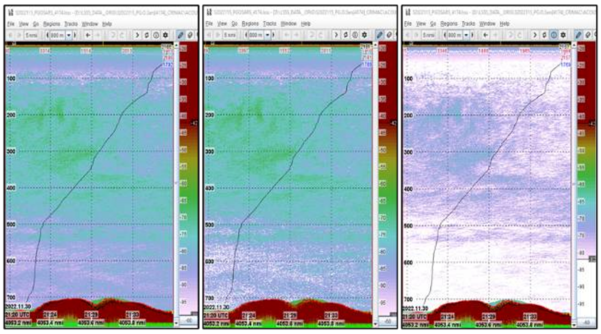
After a modification by Kongsberg a new ES18-11 Mk2 transducer was again mounted in the instrument keel of RV G. O. Sars and tested. The modification was to remove an unused connector (called “loddeører”). The comparison had to be done in narrowband mode (CW) since the old 18-kHz transducer was narrowband.

3.3 - Preliminary results

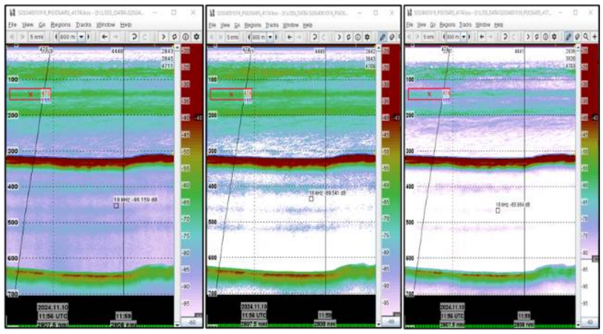
The echograms of the narrowband and broadband 18-kHz-channels from 2022 and 2024 shows quite similar noise estimates, although the noise from the pulse-compressed channel in this case is slightly lower (Figure 9 d vs Figure 9 h) . One advantage of broadband 18-kHz-channel (14 – 22 kHz) is the possibility to detect the resonance-peak (c.f. Figure 9 i) that may be used to estimate size of a gas-inclusion such as a swimbladder. Figure 10 shows a resonance peak together with a Deep Vision image. Figure 11 shows no noise-peaks in the

14 – 22 kHz band.

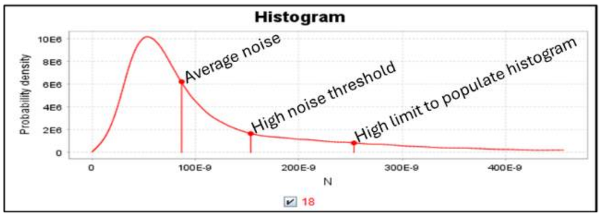
The extensive noise found in an 18-kHz-transducer in 2023 tests was not apparent in 2024. In conclusion the modification made by Kongsberg to the ES18-11 Mk2 transducer prior to the 2024001019 survey turned out to be successful.



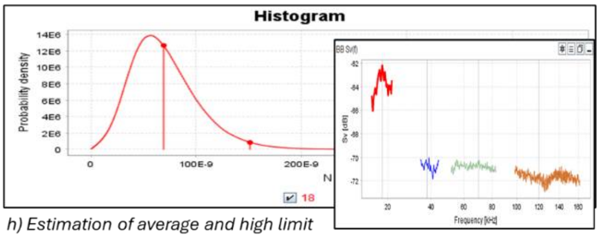
a) 18 kHz original, threshold –100 dB   *b) 18 kHz noise-corrected, threshold –100 dB*   *c) 18 kHz original, threshold –82 dB*



e) 18 kHz broadband, threshold –100 dB   *f) 18 kHz noise-corrected, threshold –100 dB*   *g) 18 kHz broadband, threshold –82 dB*



d) Estimation of average and high limit of noise, N_E and N_H, used to correct data collected with narrowband 18-kHz transducer



h) Estimation of average and high limit of noise , N_E and N_H, used to correct pulse-compressed data collected with broadband 18-kHz transducer

i) Resonance-peak in 18-kHz-channel (14 – 22 kHz) in marked red rectangle

Figure 9 . Noise in 18 kHz data collected from RV G. O. Sars with old 18-kHz narrowband transducer (a - d) in survey 2022115 compared against data collected from RV G. O. Sars new 18-kHz broadband transducer (e – h) in survey 2024001019. Figure (i) shows the resonance peak from the red rectangle in the broadband echograms.

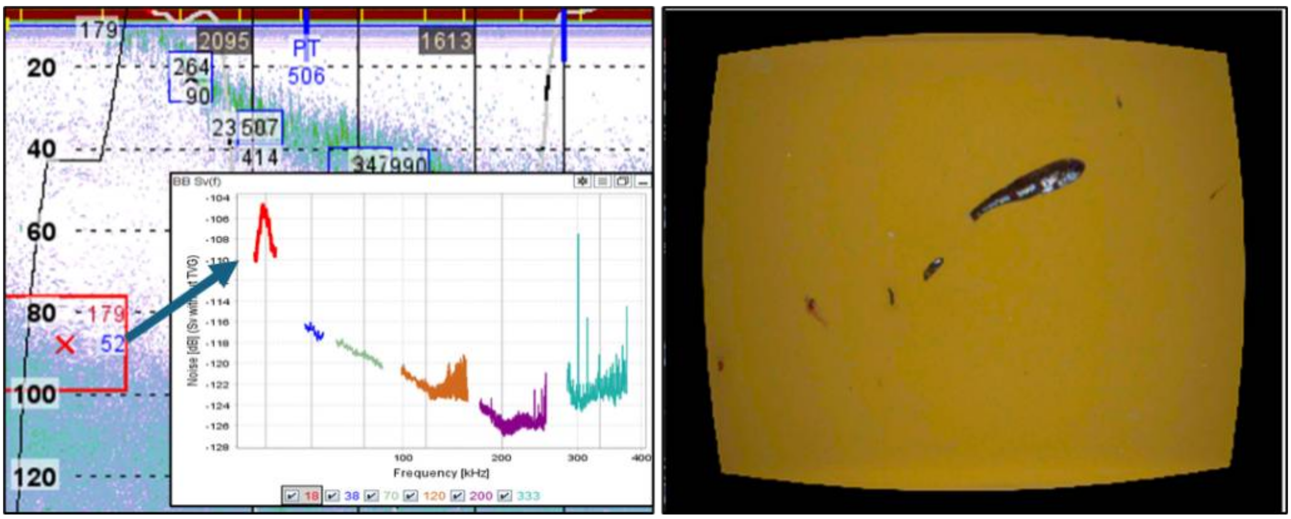


Figure 10 . Broadband backscatter of mesopelagic fish. Left panel shows the resonance-top of the 18-kHz channel from the red-marked region. Right panel shows Deep Vision image from the same layer.

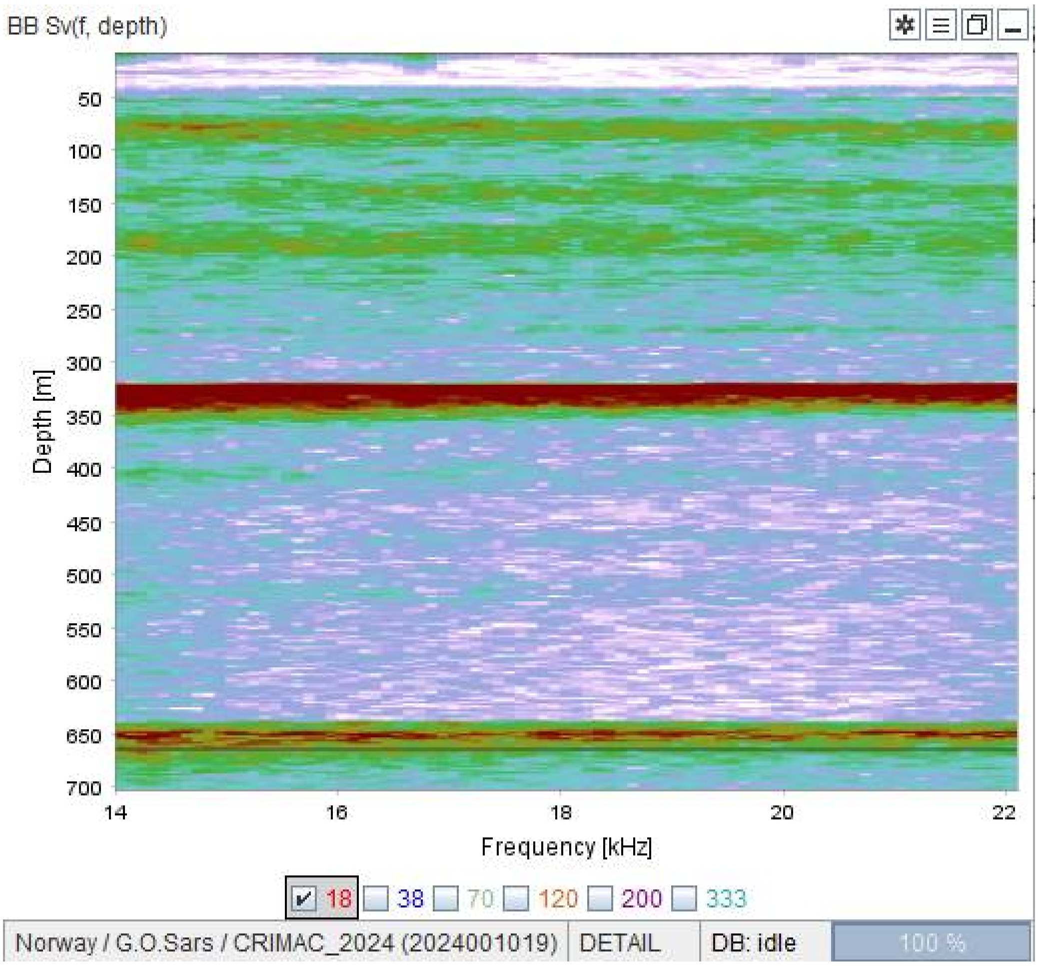


Figure 11 . Frequency-dependent backscatter if a single ping.

4 - Vessel based Broadband acoustic and Deep Vision trawl camera measurements of mesopelagic species

Author(s): Nils Olav Handegard, Ketil Malde, Vaneeda Shalini Devi Allken, Rolf Korneliussen and Geir Pedersen (IMR)

4.1 - Objective

The objective was to assess whether the new broad-banded 18 kHz transducer could be used to separate size groups of mesopelagic fish and test whether we could identify mesopelagic fish.

4.2 - Method

The Osterfjorden area was chosen for the experiment, were known distributions of mesopelagic fish are present.

For each replication of the experiment, we did one outward, and one inwards acoustic transect combined with a trawl haul from the inner part of the fjord and outwards. The trawl was kept at three or four depths, for approximately 10-15 minutes. The depth intervals were chosen based on the distribution in the echosounder. The trawl was equipped with the Deep Vision optical system. The images from the deep vision system were stored[1] in a separate folder for each trawl haul. A machine learning model trained to detect and enumerate mesopelagic fish was used (Westergerling et al., in prep), and the predictions were stored in an xml file for each trawl haul[2]. The LSSS system was used to annotate the layers from the echosounder that correspond to the trawling layers. The data was exported from the LSSS system for further analysis[3]. The TS probe stations that were originally planned were not performed due to a water leakage in the plug that connected the probe with the winch. Four CTD stations were conducted, one in the inner part, one in the outer part and two in the middle (Figure 2).

4.3 - Preliminary results

A total of 10 repetitions of the protocol were performed, with both an inbound and outbound acoustic transect (Table 4), an additional “detailed” transects with high ping rate covering the upper part of the water column, and a trawl hauls corresponding to the layers observed in the echosounder data (Table 5).

An example (ST5) of the DV image (Figure 12), and the distribution from the trawled layers combined with the frequency response from the acoustics (Figure 13 , Figure 14 , Figure 15) are provided for illustration. The CTD profiles show consistent hydrographic conditions throughout the experiment (Figure 16).

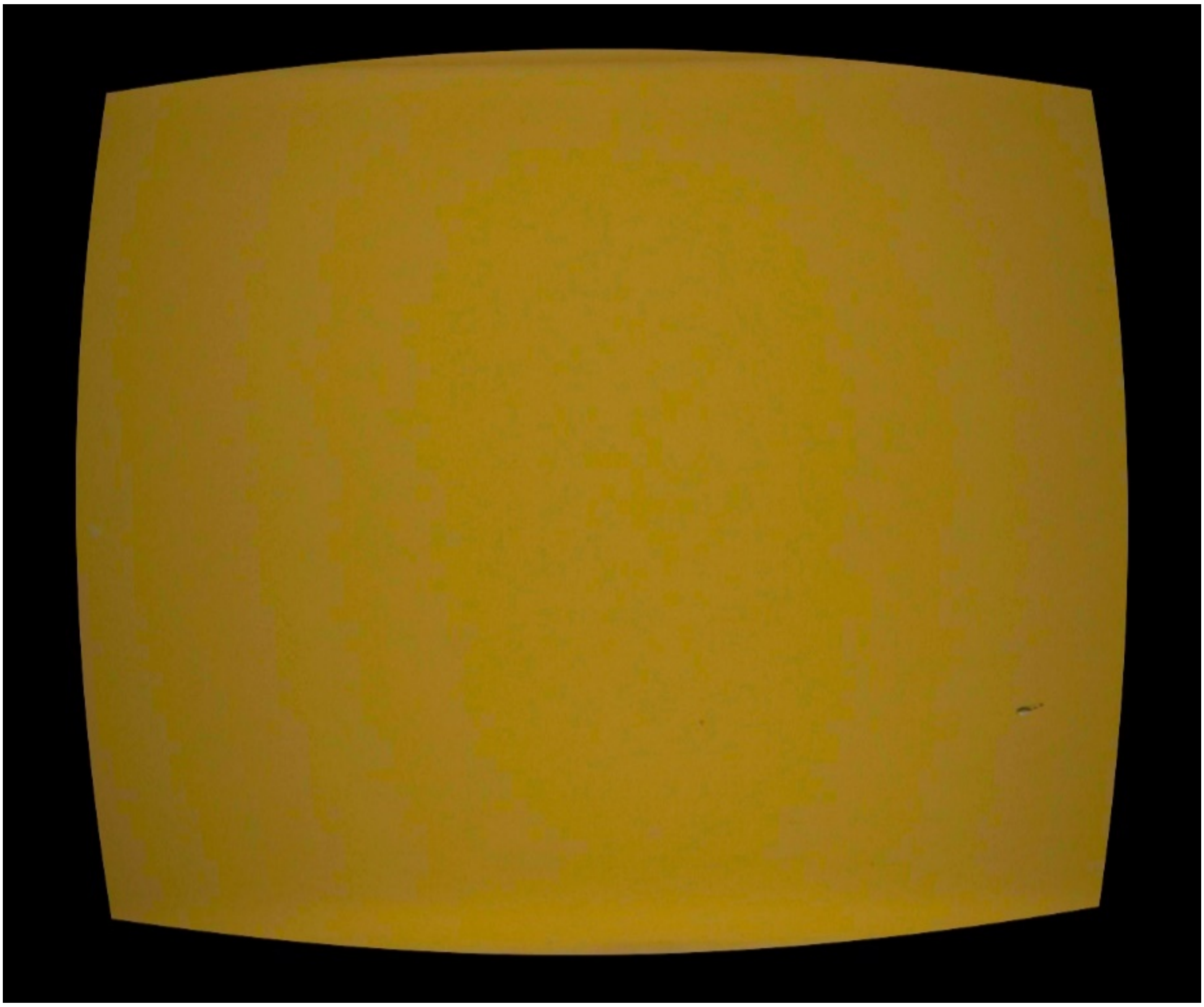


Figure 12 . Example of an individual Maurelicus from the DV images.

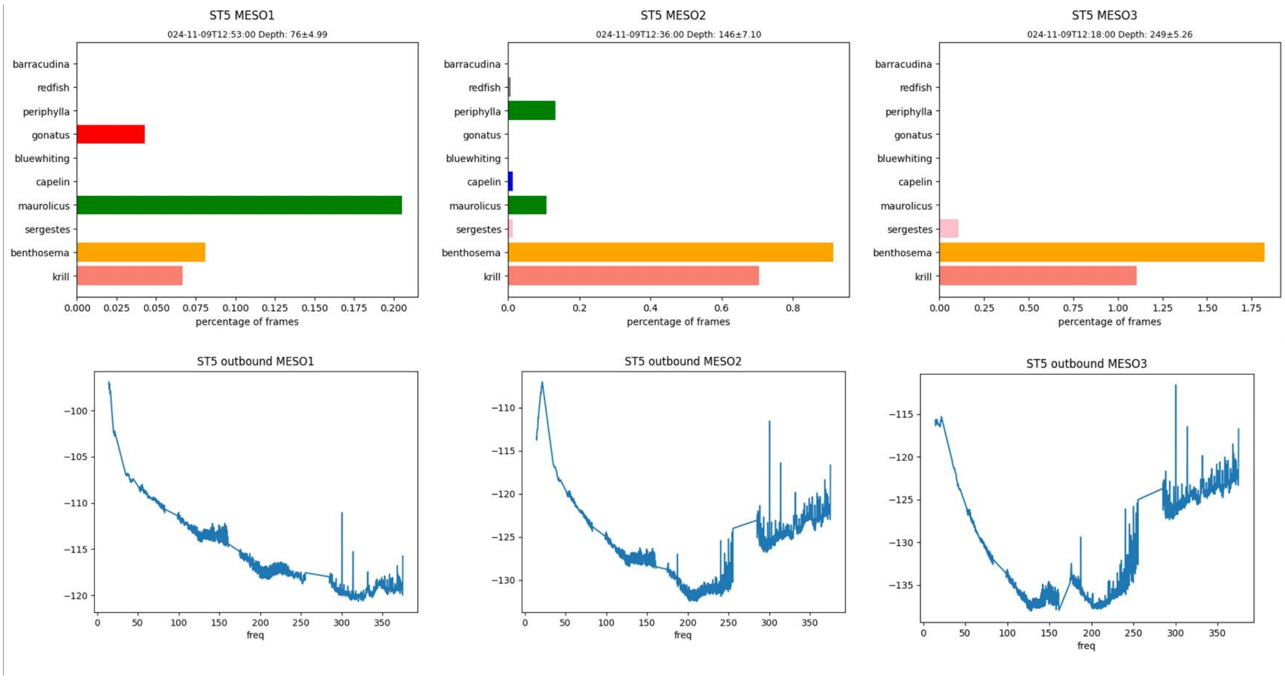


Figure 13 . The predictions from the DV (upper panels) and the frequency response for each layer on the three layers for station 5.

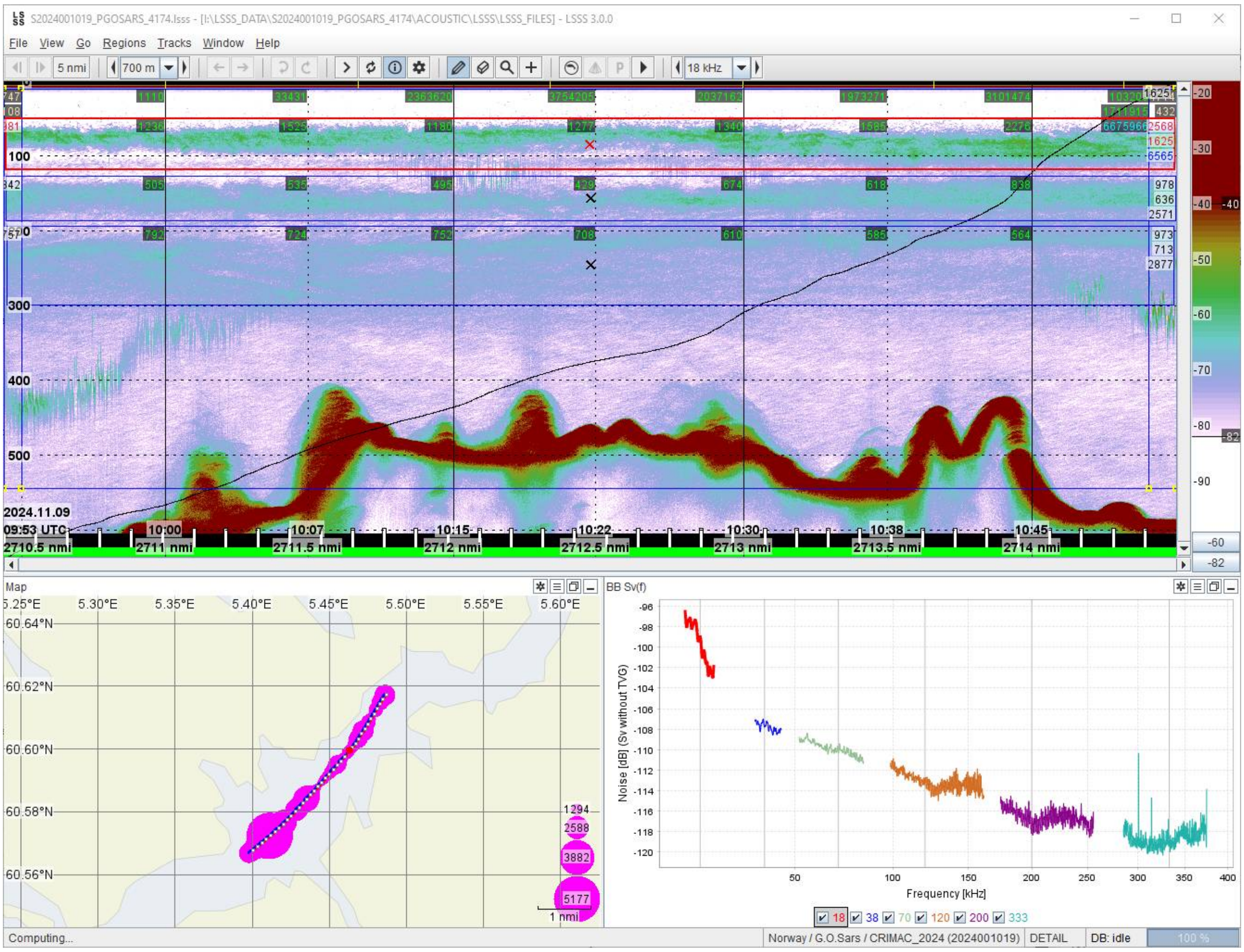


Figure 14 . Example echogram from ST5 – outbound. Broadband frequency-response of layer marked in red.

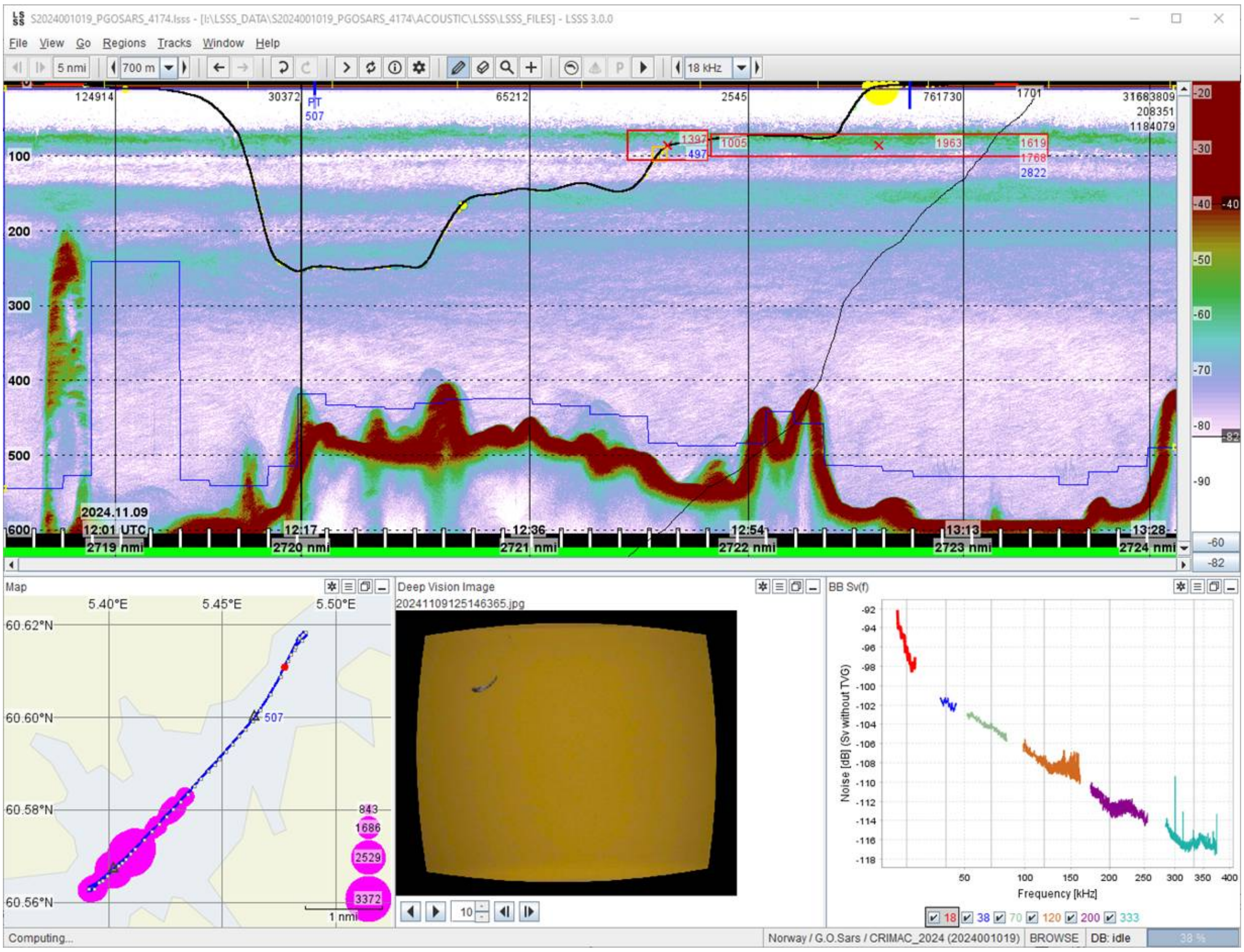


Figure 15 . Trawl station 507 with Deep Vision immediately after Station 5 – outbound.

Table 4 . Overview of acoustic transects.

Exp	Direction	AcousticCategories	StartTime	StopTime	DataFile
ST1	outbound	{MESO1, MESO2, MESO3, MESO4}	"2024-11-08T09:27:24Z"	"2024-11-08T10:54:19Z"	T1_Ut_AlleFBroadbandSv_T20241108_09272450-20241108_10542005.json
ST1	inbound	{MESO1, MESO2, MESO3, MESO4}	"2024-11-09T10:57:00Z"	"2024-11-08T11:17:00Z"	ST1_inbound_AlleF_BroadbandSv_T20241108_10570170-20241108_11172347.json
ST2	outbound	{MESO1, MESO2, MESO3, MESO4}	"2024-11-08T19:04:30Z"	"2024-11-08T20:04:00Z"	ST2_outbound_AlleF_BroadbandSv_T20241108_19064087 20241108_20053822.json
ST2	inbound	{MESO1, MESO2, MESO3, MESO4}	"2024-11-08T20:07:49Z"	2024-11-09T21:05:39Z	ST2_inbound_AlleF_BroadbandSv_T20241108_20074943-20241108_21053902.json
ST2	detailed[4]	{MESO1}	"2024-11-08T22:45:00Z"	"2024-11-08T23:49:39Z"	ST2_inbound_detailed_AlleF_BroadbandSv_T20241108_22 20241108_23493989.json
ST3	outbound	{MESO1}	"2024-11-08T23:54:12Z"	"2024-11-09T00:49:29Z"	ST3_outbound_detailed_AlleF_BroadbandSv_T20241108_2 20241109_00493178.json
ST3	inbound	{MESO1, MESO2, MESO3, MESO4}	"2024-11-09T00:53:30Z"	"2024-11-09T01:52:56Z"	ST3_inbound_AlleF_BroadbandSv_T20241109_00541207-20241109_01525656.json
ST4	outbound	{MESO1, MESO2, MESO3}	"2024-11-09T04:40:03Z"	"2024-11-09T05:36:15Z"	ST4_outbound_AlleF_BroadbandSv_T20241109_04404364 20241109_05361518.json

ST4[5]	inbound	{MESO1, MESO2, MESO3}	"2024-11-09T05:49:00Z"	"2024-11-09T06:38:00Z"	ST4_inbound_AlleF_BroadbandSv_T20241109_05492065-20241109_06380239.json
ST5	outbound	{MESO1, MESO2, MESO3}	"2024-11-09T09:51:42Z"	"2024-11-09T10:52:46Z"	ST5_outbound_AlleF_BroadbandSv_T20241109_09514270 20241109_10524603.json
ST5	inbound	{MESO1, MESO2, MESO3}	"2024-11-09T10:56:06Z"	"2024-11-09T11:53:13Z"	ST5_inbound_AlleF_BroadbandSv_T20241109_10560627-20241109_11531309.json
ST6[6]	outbound	{MESO1, MESO2, MESO3}	"2024-11-09T14:29:14Z"	"2024-11-09T15:27:30Z"	ST6_outbound_AlleF_BroadbandSv_T20241109_14291437 20241109_15273027.json
ST6	inbound	{MESO1, MESO2, MESO3}	"2024-11-09T15:33:00Z"	"2024-11-09T16:33:00Z"	ST6_inbound_AlleF_BroadbandSv_T20241109_15323099-20241109_16324971.json
ST7	outbound	{MESO1, MESO2, MESO3}	"2024-11-09T17:55:36Z"	"2024-11-09T18:53:40Z"	ST7_outbound_AlleF_BroadbandSv_T20241109_17553676 20241109_18534005.json
ST7	inbound	{MESO1, MESO2, MESO3}	"2024-11-09T18:59:00Z"	"2024-11-09T19:55:15Z"	ST7_inbound_AlleF_BroadbandSv_T20241109_18582566-20241109_19551585.json
ST8	outbound	{MESO1, MESO2, MESO3}	"2024-11-09T22:35:00Z"	"2024-11-09T23:38:00Z"	ST8_outbound_AlleF_BroadbandSv_T20241109_22380463 20241109_23381281.json
ST8	inbound	{MESO1, MESO2, MESO3}	"2024-11-09T23:43:40Z"	"2024-11-10T00:40:13Z"	ST8_inbound_AlleF_BroadbandSv_T20241109_23434083-20241110_00401325.json
ST9	outbound	{MESO1, MESO2, MESO3}	"2024-11-10T03:25:41Z"	"2024-11-10T04:25:44Z"	ST9_outbound_AlleF_BroadbandSv_T20241110_03254176 20241110_04254489.json
ST9	inbound	{MESO1, MESO2, MESO3}	"2024-11-10T04:35:00Z"	"2024-11-10T05:34:00Z"	ST9_inbound_AlleF_BroadbandSv_T20241110_04371111-20241110_05335111.json
ST10	outbound	{MESO1, MESO2, MESO3}	"2024-11-10T08:30:26Z"	"2024-11-10T08:59:06Z"	ST10_outbound_AlleF_BroadbandSv_T20241110_0830269 20241110_08590636.json
ST10	inbound	{MESO1, MESO2, MESO3}	"2024-11-10T09:02:00Z"	"2024-11-10T09:34:02Z"	ST10_inbound_AlleF_BroadbandSv_T20241110_09010821 20241110_09340285.json

Table 5 . Trawling layers.

Stasjon	Exp	Layer	Depth	StartTime	StopTime	DV_folder
STA503	ST1	MESO4	270	"2024-11-08T12:24:00Z"	"2024-11-08T12:34:00Z"	20241108T1011Z
STA503	ST1	MESO3	200	"2024-11-08T12:39:00Z"	"2024-11-08T12:47:00Z"	20241108T1011Z
STA503	ST1	MESO2	130	"2024-11-08T12:51:00Z"	"2024-11-08T12:59:00Z"	20241108T1011Z
STA503	ST1	MESO1	60	"2024-11-08T14:04:00Z"	"2024-11-08T14:14:00Z"	20241108T1011Z
STA504	ST2	MESO3	200	"2024-11-08T21:31:00Z"	"2024-11-08T21:46:00Z"	20241108T2110Z
STA504	ST2	MESO2	120	"2024-11-08T21:51:00Z"	"2024-11-08T22:06:00Z"	20241108T2110Z
STA504	ST2	MESO1	35	"2024-11-08T22:14:00Z"	"2024-11-08T22:29:00Z"	20241108T2110Z
STA505	ST3	MESO3	130	"2024-11-09T02:13:00Z"	"2024-11-09T02:28:00Z"	20241109T0155Z
STA505	ST3	MESO2	70	"2024-11-09T02:37:00Z"	"2024-11-09T02:52:00Z"	20241109T0155Z
STA505	ST3	MESO1	40	"2024-11-09T02:54:00Z"	"2024-11-09T03:09:00Z"	20241109T0155Z
STA506	ST4	MESO3	230	"2024-11-09T07:21:00Z"	"2024-11-09T07:31:00Z"	20241109T0658Z
STA506	ST4	MESO2	120	"2024-11-09T07:40:00Z"	"2024-11-09T07:50:00Z"	20241109T0658Z
STA506[7]	ST4	MESO1	50	"2024-11-09T07:56:00Z"	"2024-11-09T08:06:00Z"	20241109T0658Z
STA507	ST5	MESO3	250	"2024-11-09T12:18:00Z"	"2024-11-09T12:30:00Z"	20241109T1154Z

STA507	ST5	MESO2	150	"2024-11-09T12:36:00Z"	"2024-11-09T12:48:00Z"	20241109T1154Z
STA507	ST5	MESO1	70	"2024-11-09T12:53:00Z"	"2024-11-09T13:05:00Z"	20241109T1154Z
STA508	ST7	MESO3	250	"2024-11-09T20:22:00Z"	"2024-11-09T20:32:00Z"	20241109T1959Z
STA508	ST7	MESO2	135	"2024-11-09T20:42:00Z"	"2024-11-09T20:52:00Z"	20241109T1959Z
STA508	ST7	MESO1	35	"2024-11-09T21:07:00Z"	"2024-11-09T21:17:00Z"	20241109T1959Z
STA509	ST8	MESO3	150	"2024-11-10T01:08:00Z"	"2024-11-10T01:20:00Z"	20241110T0044Z
STA509	ST8	MESO2	150	"2024-11-10T01:28:00Z"	"2024-11-10T01:40:00Z"	20241110T0044Z
STA509	ST8	MESO1	35	"2024-11-10T01:46:00Z"	"2024-11-10T01:59:00Z"	20241110T0044Z
STA510	ST9	MESO3	265	"2024-11-10T06:05:00Z"	"2024-11-10T06:15:00Z"	20241110T0541Z
STA510	ST9	MESO2	100	"2024-11-10T06:26:00Z"	"2024-11-10T06:36:00Z"	20241110T0541Z
STA510[8]	ST9	MESO1	35	"2024-11-10T06:44:00Z"	"2024-11-10T06:54:00Z"	20241110T0541Z
STA511	ST10	MESO3	155	"2024-11-10T10:00:00Z"	"2024-11-10T10:15:00Z"	20241110T0940Z
STA511[9]	ST10	MESO2	95	"2024-11-10T10:21:30Z"	"2024-11-10T10:36:30Z"	20241110T0940Z
STA511	ST10	MESO1	75	"2024-11-10T10:39:00Z"	"2024-11-10T10:53:00Z"	20241110T0940Z

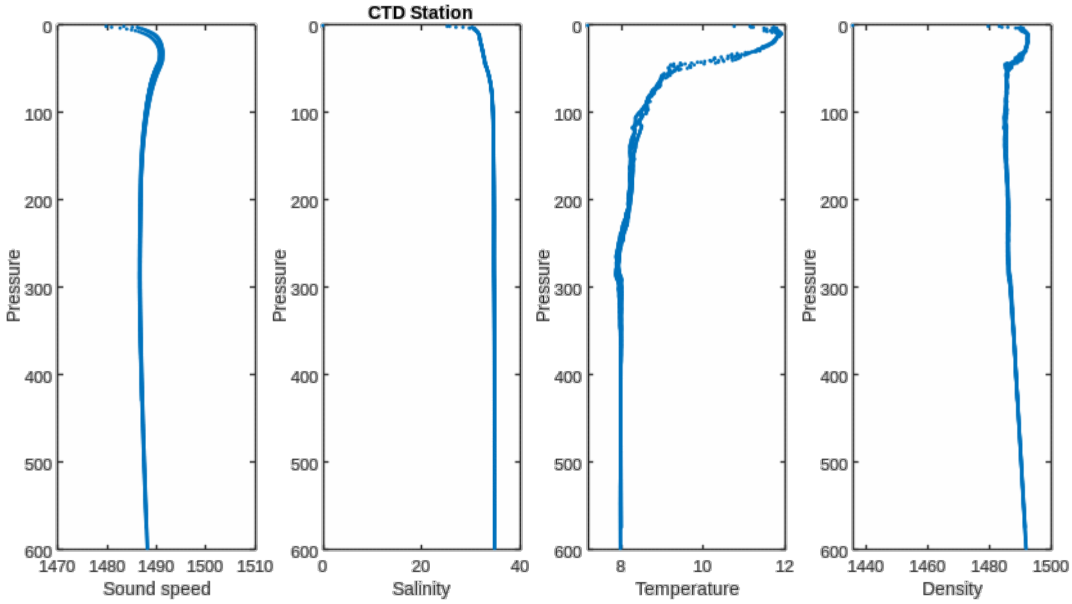


Figure 16 . CTD Stations in Osterfjord November 8 (Sta624-626).

5 - In-trawl camera systems in demersal trawls: sediment suppression testing

Author(s): Maria Tenningen, Shale Pettit Rosen and Georgina Vickery (IMR)

5.1 - Objective

A challenge with using cameras in demersal trawls is poor visibility due to sediment swirled up by the trawl ground gear. DTU Aqua in Denmark have developed a method where a sediment suppression sheet is attached behind the ground gear for improved image clarity (Sokolova *et al.* , 2022) . In this cruise we tested this method on the IMR Campelen 1800 demersal survey trawl. The main objective was to optimise a setup of Campelen trawl with camera and sediment suppression sheet.

Research Questions:

1. How does video quality change with the inclusion of the sediment suppression sheet (SSS)?
1. What is the impact of the SSS on trawl geometry and flow?
1. Does the SSS impact on trawl selectivity?
1. Where is the optimal position of in-trawl camera?

5.2 - Method

5.2.1 - Experimental design

The experiment was carried out about 25 nm west of Fitjar (Figure 17). Bottom depth along the transects was between 282m to 287m. Seabed substrate was mostly mud with a small area of sandy mud. Weather conditions were good with a light to moderate breeze from W - NW. The Campelen 1800 sampling trawl (Figure 18) was used in the experiment. A sediment suppression sheet was prepared by Seilmaker Hansen in Bergen before the cruise based on the Danish design and adapted to the Campelen trawl. Three different setups with an 8 m, 5 m and no sediment suppression sheet were carried out in a block design where the order of the setups within blocks were altered (Table 6). 30-minute-long trawl hauls were made in parallel lines with about 0.5 nm between the lines (Figure 17). Eight trawl lines were used. Survey design was a result of limitations by bottom type and effort required to map sea floor before trawling and reducing risk of damaging the trawl.

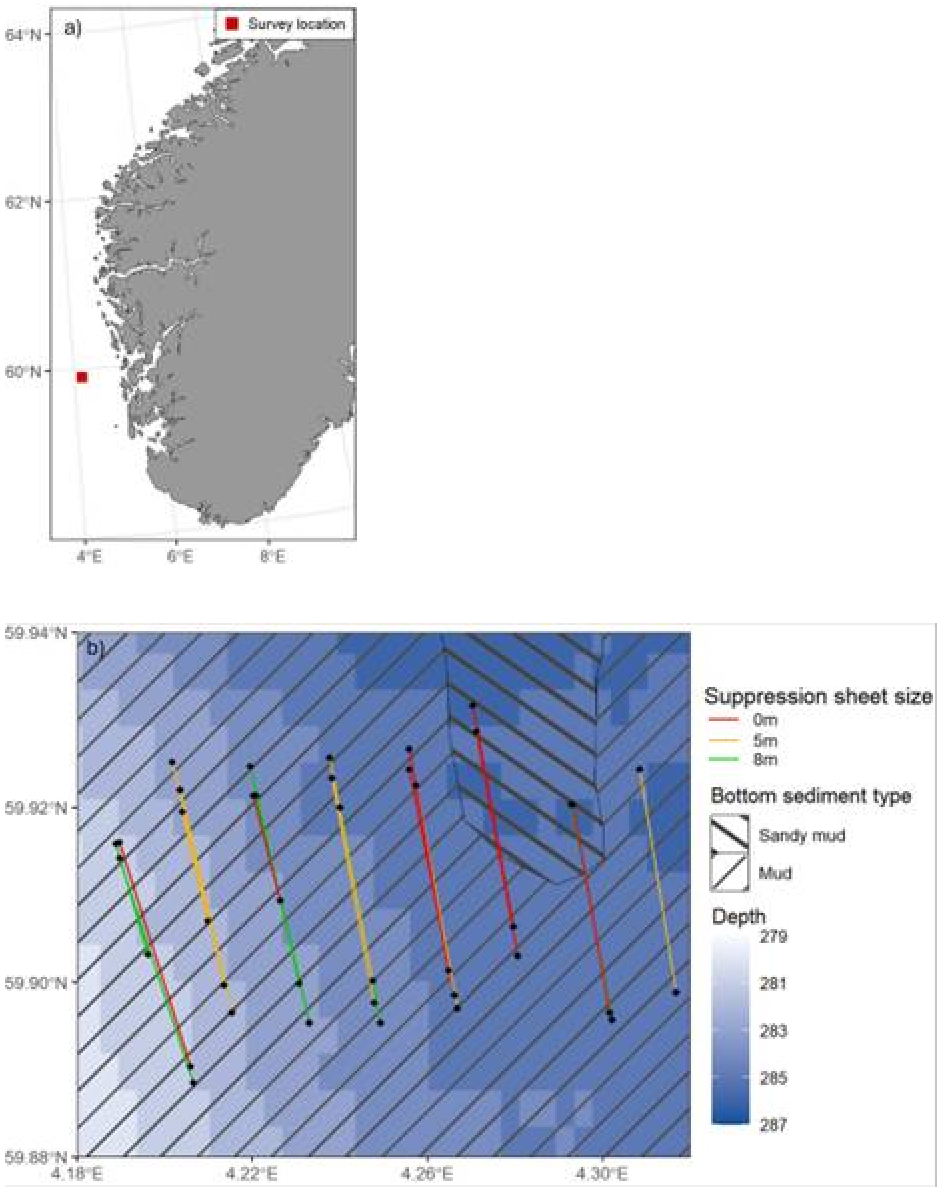


Figure 17 : survey location south-west of Bergen (a) and locations of trawl stations with depth and bottom type (b). Note all trawls were in the same direction, from north to south. Sediment data source: Geological Survey of Norway (NGU) (2022). Bathymetry data source: GEBCO Compilation Group (2024) GEBCO 2024 Grid doi:10.5285/1c44ce99-0a0d-5f4f-e063-7086abc0ea0f.

Table 6 : Overview of the trawl hauls. Block number, length in meters of the sediment suppression sheet (SSS), trawl path number (ref. Figure 1) and trawl start and stop times.

Station	Block	SSS (m)	Trawl_path	StartTime	StopTime
STA512	test	8	1	"2024-11-11T16:22:06Z"	"2024-11-11T16:52:12Z"
STA513	1	8	3	"2024-11-11T19:35:07Z"	"2024-11-11T20:05:09Z"
STA514	1	5	4	"2024-11-11T21:52:14Z"	"2024-11-11T22:22:15Z"
STA515	1	0	5	"2024-11-11T23:59:01Z"	"2024-11-12T00:29:08Z"
STA516	2	0	6	"2024-11-12T02:05:36Z"	"2024-11-12T02:35:45Z"

STA517	2	8	7	"2024-11-12T05:30:26Z"	"2024-11-12T06:00:33Z"
STA518	2	5	8	"2024-11-12T08:05:08Z"	"2024-11-12T08:35:11Z"
STA519	3	0	1	"2024-11-12T10:31:08Z"	"2024-11-12T11:01:07Z"
STA520	3	5	2	"2024-11-12T12:49:04Z"	"2024-11-12T13:19:15Z"
STA521	3	8	3	"2024-11-12T15:02:35Z"	"2024-11-12T15:32:38Z"
STA522	4	8	4	"2024-11-12T17:46:17Z"	"2024-11-12T18:16:21Z"
STA523	4	5	5	"2024-11-12T19:55:36Z"	"2024-11-12T20:25:37Z"
STA524	redo	5	2	"2024-11-12T21:34:24Z"	"2024-11-12T22:04:25Z"
STA525	redo	5	4	"2024-11-12T23:09:55Z"	"2024-11-12T23:40:05Z"
STA526	4	0	6	"2024-11-13T00:41:47Z"	"2024-11-13T01:11:56Z"
STA527	redo	0	5	"2024-11-13T02:22:55Z"	"2024-11-13T02:52:59Z"
STA528	redo	0	7	"2024-11-13T04:49:55Z"	"2024-11-13T05:20:02Z"
STA529	DV	8	1	"2024-11 13T11:42:11Z"	"2024-11-13T11:57:23Z"
STA530	DV	5	2	"2024-11 13T14:06:50Z"	"2024-11-13T14:21:58Z"
STA531	DV	0	3	"2024-11 13T15:52:34Z"	"2024-11-13T16:07:40Z"

5.2.2 - Rigging the sediment suppression sheet

The sediment suppression sheet (PVC) was attached in the trawl bottom panel (Figure 18). The front part of the SSS was attached to the ground gear and into the bottom panel netting using plastic rings and elastic rope (Figure 19). Two different sized SSS were used, 8m and 5m (Figure 20).

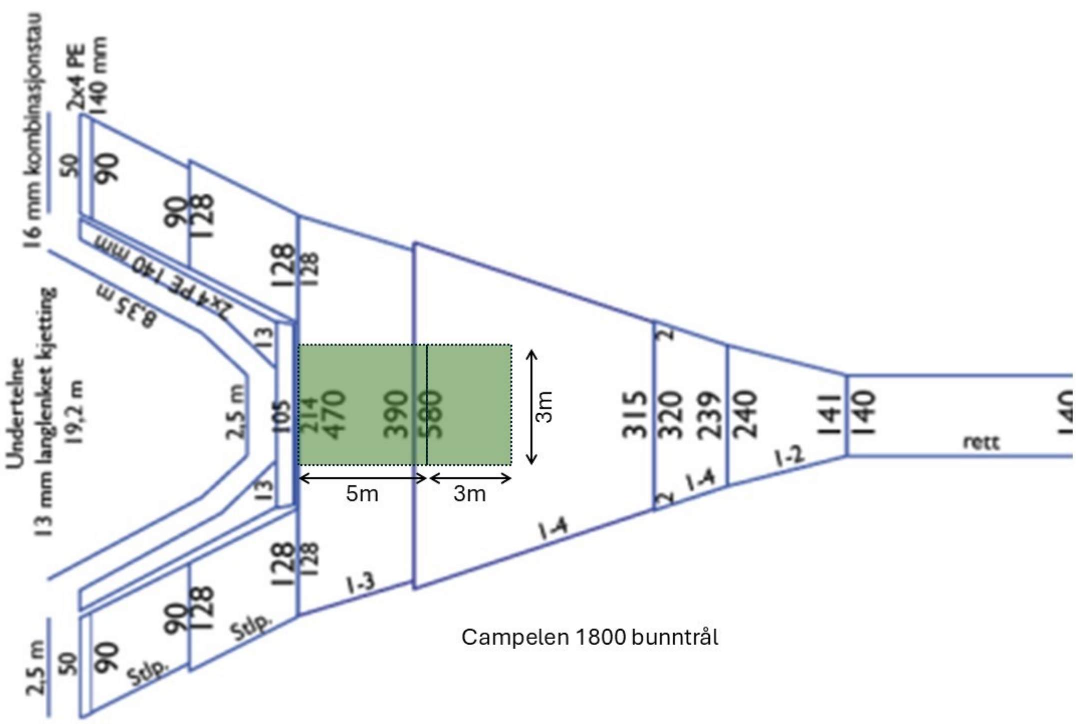


Figure 18 : The bottom panel of the Campelen 1800 trawl and the sediment suppression sheet is indicated by the green rectangle.

Figure 19 : The front part of the sediment sheet was attached into the ground gear and to the bottom panel with plastic rings and elastic rope.

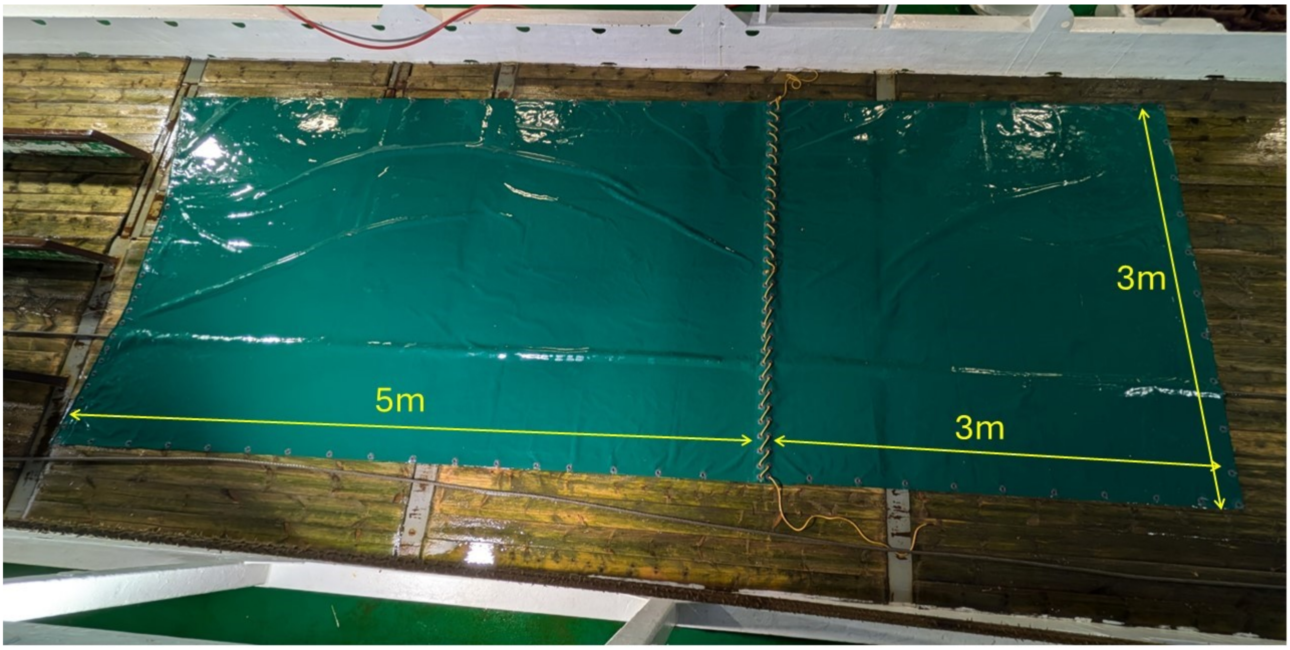


Figure 20 : Two different sized sediment suppression sheets were used a 5m and a 3m attached to the 5m sheet.

5.2.3 - Trawl and sediment plume monitoring

Trawl geometry was monitored with standard Scanmar trawl sensors including a trawl eye in the top panel above the ground gear and door sensors. The behaviour of the sediment suppression sheet was monitored with GoPro and Dark Vision cameras attached to various places, e.g. top panel looking down, side panel phasing the ground gear. The sediment plume and visibility were monitored with Dark Vison camera attached ahead of the tunnel and DV in the tunnel ahead of the codend.

Current in the water column was logged with the vessel ADCP.

The height and acoustic density of the sediment plume behind the ground gear was also measured with a Wideband Autonomous Transceiver (WBAT) with a 200 kHz split beam transducer (ES200-7C) (Kongsberg Discovery AS) (Table 7). The WBAT was mounted in the centre of the top panel, forwardmost in first 42 mm panel (3.9 m behind ground gear). Pointing directly down at the sediment suppression sheet.

Table 7 : Wbat transducer settings. Pulse interval was 1 s in hauls 512 – 521 and reduced to 0.250 s in hauls 522 – 529.

Transducer	Frequency (kHz)	Beam type	TX Power (W)	Pulse Type	Pulse Duration (us)	Ramping	Range (m)
ES200-7C	200	Split	75	CW	256	Fast	10

5.2.4 - Catch data

Catches were landed on deck and sorted by species. Total weight of each species was recorded and all individuals length measured. Where catches were large, random subsamples of rabbit fish (*Chimaera monstrosa* , havmus), greater argentine (*Argentina silus* , vassild) and blue whiting (*Micromesistius poutassou* , komule) were taken, weighed and scaled to total species weight. For station 521 the entire catch was subsampled on deck, with approximately 60% sorted, weighed and measured.

Catches were combined within experimental trawl designs and comparisons made of total catch weight, with significance assessed through one-way ANOVA. Relative frequency of species groups between trawl designs were also compared, with a focus on flatfish compared to roundfish and changes in length distribution of species. Significance assessed through inclusion of length and species terms in GAM.

5.3 - Preliminary results

5.3.1 - Acoustic density of sediment plume

There is no immediate clear signal on the WBAT data between the treatments, but when the sheet is mounted there are some strong scattering spikes and possibly a slightly lower band above the bottom data (Figure 21). The plume is believed to be approximately 0.5 m at the location of the transducer.

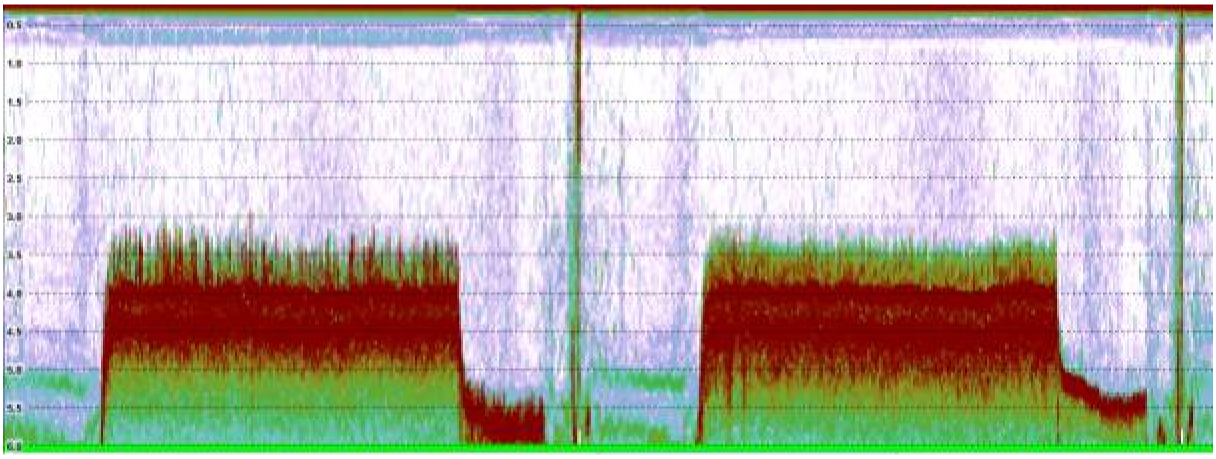


Figure 21 : Example of the WBAT data from the trawl. Left and right images are the cases with suppression sheet mounted and without suppression, respectively.

5.3.2 - Image clarity

Qualitatively, the average height of the sediment plume was lower with increasing SSS length (Figure 22 ; Figure 23), and also dissipates within the image frame in parts of tows using an 8m SSS, which is rarely observed in tows without the SSS.

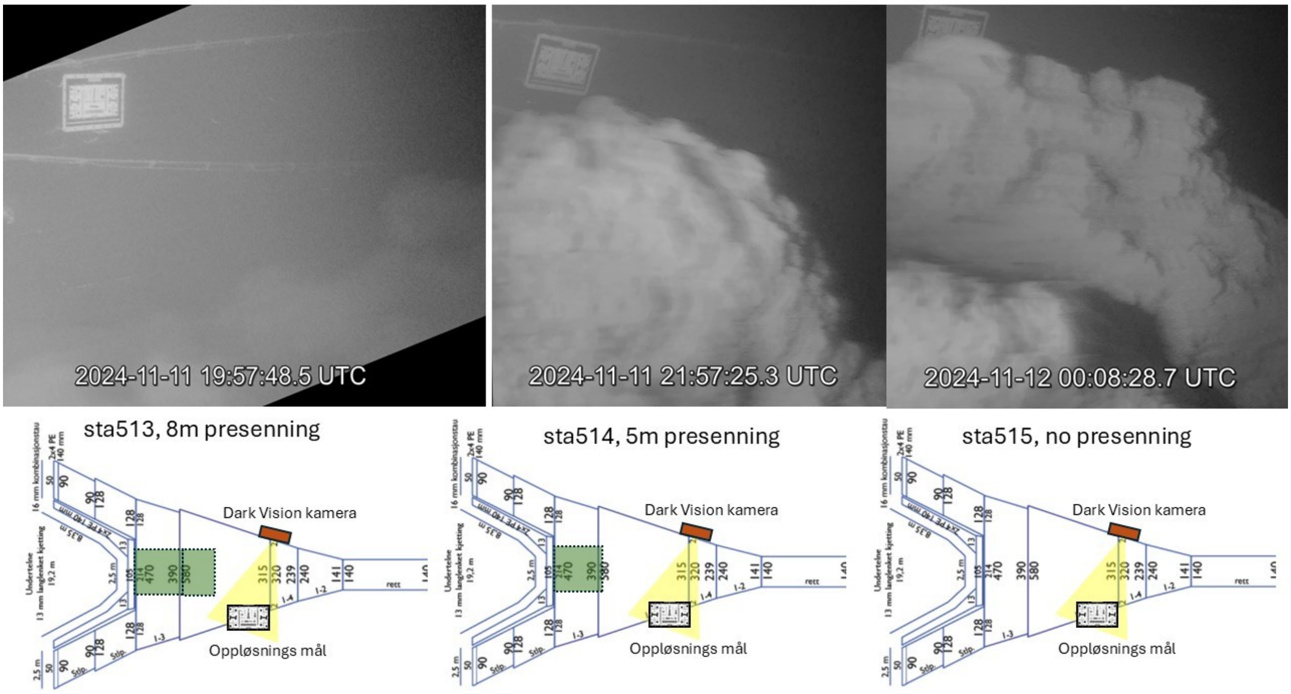


Figure 22 : Examples of image clarity with Dark Vision with the 8 m (left), 5 m (middle) and no suppression sheet (right).

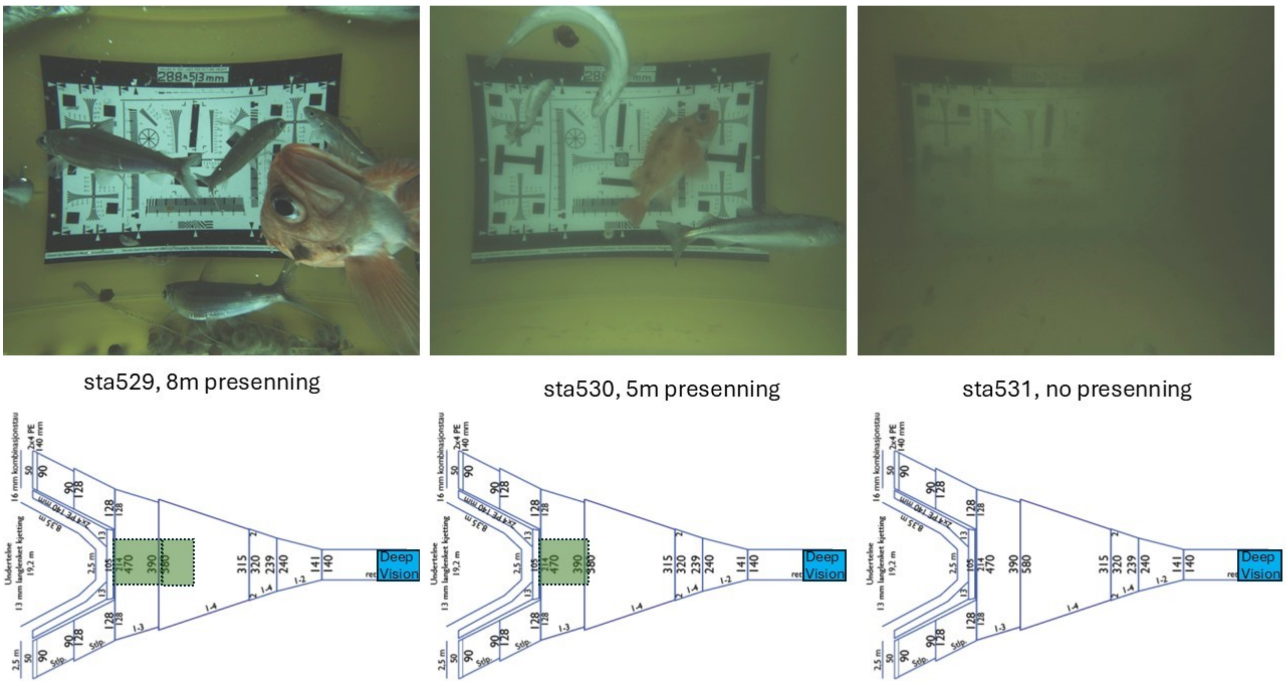


Figure 23 : Examples of image clarity with Deep Vision with the 8 m (left), 5 m(middle) and no suppression sheet (right).

5.3.3 - Catch composition

Mean catch weight was highest for 0m SSS at 118 kg, decreasing to 111 kg with the 5m and continuing to decline to 97 kg with the 8m SSS (Figure 24). ANOVA indicates non-significant difference $F(2, 10) = 0.36$, $p = 0.706$. No clear pattern in catch weights observed between transect groupings.

By weight, for all hauls blue whiting and rabbit fish were the largest proportion of the catch. Other species observed in high proportions by weight across all gear treatments were greater argentine, beaked redfish (*Sebastes mentella,* snabeluer) and European hake (*Merluccius merluccius* , lysing) (Figure 24). Similarly, in terms of numbers of individuals the catch predominantly consisted of blue whiting, Norway pout (*Trisopterus esmarkii* , øyepål), silvery pout (*Gadiculus argenteus* , sølvtorsk) and greater argentine (Figure 25). The length distribution of the catch was broadly consistent across each of the three gears (Figure 25), with mean lengths of 28 cm for both 0m and 5m groups, declining to 23 cm for the 8m SSS.

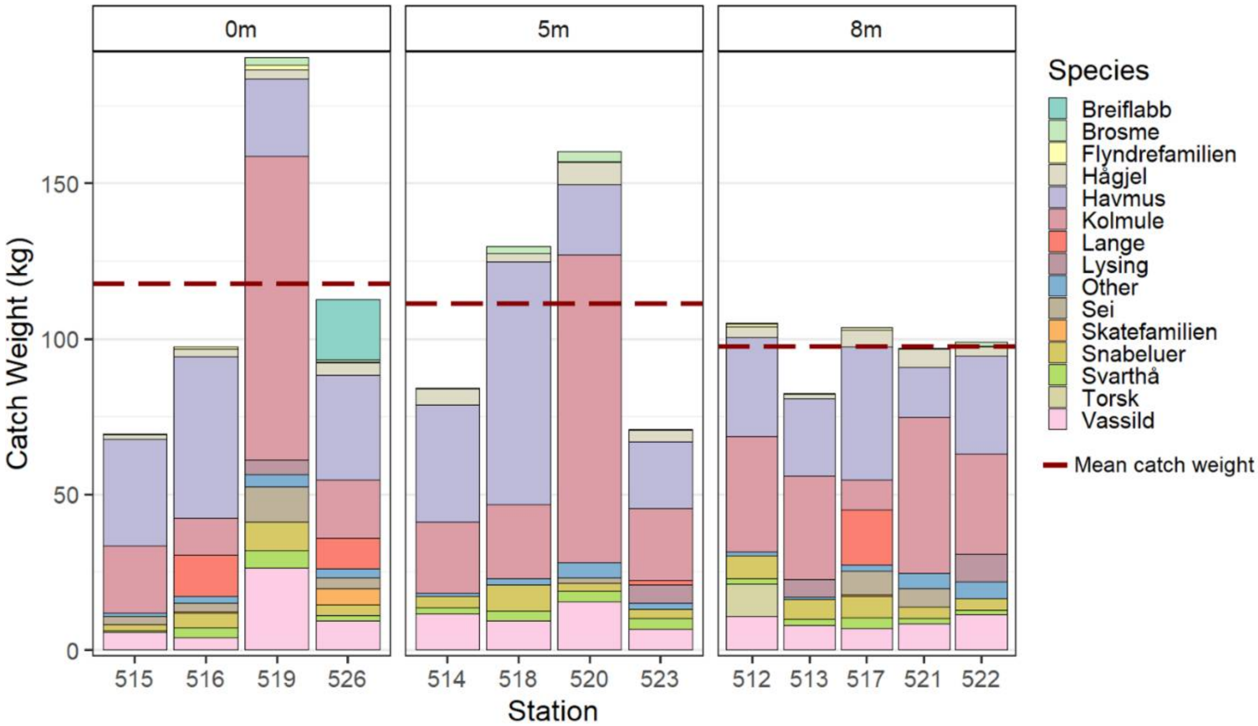


Figure 24 : Total catch weight for each haul, grouped by each size of sediment suppression sheet tested. Colours represent species or species-groups. 'Other' includes species with only a few individuals and with weights less than 1% of the total and were therefore grouped to aid visual clarity. Red dotted lines denote mean weight per treatment group.

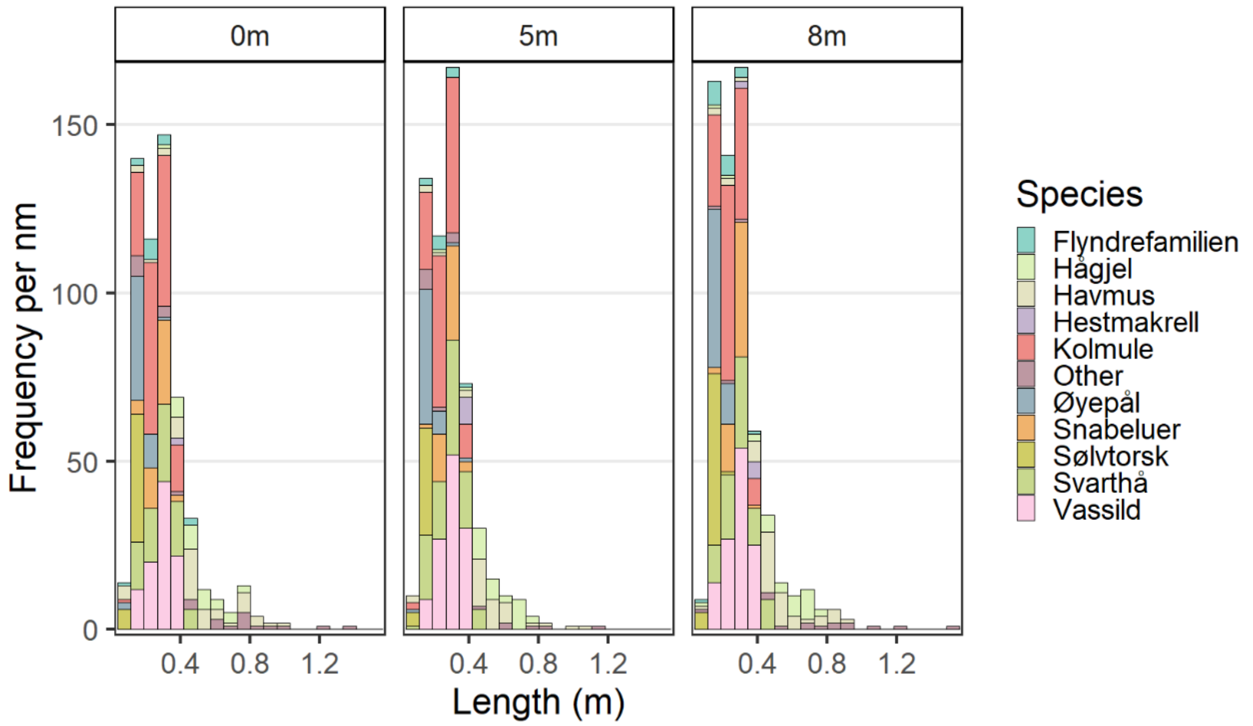


Figure 25 : Length distribution of catch, normalised per nautical mile (nm). Colours represent the dominant species, with the remainder grouped to 'other' to aid visual clarity. Plot faceted by size of sediment suppression sheet tested.

5.3.4 - Conclusion

The preliminary results indicate that the sediment suppression sheet effectively reduced the sediment plume and improved visibility in the trawl cameras. There were no clear indications of effects on trawl geometry or catch efficiency from the sediment suppression sheet. However, a more detailed data analyses is required before any conclusions can be made. Furthermore, the data set may be too limited to conclude on the catch comparisons.

6 - Data organization

The data is organized in accordance with the IMR data organization procedure. In this section the placement of each data set is described as well as a short description of each individual data set. The headings are equal to the folders in the data structure.

The data from RV G. O. Sars is safely stored at IMRs secure data storage system under \cruise_data\2024\S2024001019_PGOSARS_4174. All data placements below refers to this directory as the top level directory.

A git hub repository has been set up to store the code for analysing the data: https://github.com/CRIMAC-WP4-Machine-learning/CRIMAC-meso-18

A “readme” document containing information about positions of sensors and cameras in leg 2 is stored at: S2024001019_PGOSARS_4174\CRUISE_DOCUMENTS\OTHER_DOCUMENTS

6.1 - ACOUSTIC DATA

The shipboard EK80 echosounder channels were calibrated prior to data acquisition and the subsequent files contain the updated calibration settings. The calibration files are located under \ACOUSTIC\EK80\EK80_CALIBRATION and S2024001019_PGOSARS_4174\PHYSICS\ADCP\EC150_KHZ for the echosounders and the ADCP, respectively.

Ship-borne unprocessed EK80 data from FF G.O. was stored in accordance with the IMR data storage structure under \ACOUSTIC\EK80\EK80_RAWDATA. There were several different strategies for collecting data, so that the content of the EK80 data files are not all the same. During leg 1 the echo sounders operated using the IMR standard settings for BB, and for leg II they were operated using standard settings for CW.

The overall organizing of data from the survey is stored in the survey file localized at \ACOUSTIC\LSSS\LSSS_FILES. A survey-file keeps track of how the directories are organized, e.g. which Work-files to use, which KORONA-files to use and which preprocessing setup to use.

Sv(f) files are exported from LSSS and placed under \ACOUSTIC\LSSS\EXPORT\BroadbandSv. Each of the data-files represents an inbound or outbound transect according to the filename in Table 4 , where the different trawled layers are coded as {MESO1, MESO2, MESO3, MESO4} as an acoustic category within the files, c.f. the table.

6.2 - BIOLOGY

6.2.1 - Trawl sensors

S2024001019_PGOSARS_4174\BIOLOGY\TRAWL_SENSORS\SCANMAR

- RBR S2024001019_PGOSARS_4174\BIOLOGY\TRAWL_SENSORS\RBR
- StarOddi S2024001019_PGOSARS_4174\BIOLOGY\TRAWL_SENSORS\STAR_ODDI

6.2.2 - Deep Vision data

The deep vision data is stored under \BIOLOGY\CATCH_MEASUREMENTS\DEEP_VISION.

(leg 2: only raw images, not geometrically or colour corrected)

6.2.3 - DarkVision

S2024001019_PGOSARS_4174\BIOLOGY\CATCH_MEASUREMENTS\OTHER_MULTIMEDIA\DARK_VISION

6.2.4 - Catch data

(preliminary)
S2024001019_PGOSARS_4174\BIOLOGY\CATCH_MEASUREMENTS\OTHER_MULTIMEDIA\CATCH_PRELI

6.3 - OBSERVATON_PLATFORMS

6.3.1 - WBAT

S2024001019_PGOSARS_4174\OBSERVATION_PLATFORMS\WBAT

The data from the wbat is timestamped and the different treatments can be found by looking up the time interval in Table 6 . The files from the wbat have the file extension .ra_. These are converted to .raw files using the wbat mission planner. To be able to read the files into LSSS the files were reprocessed using the replay function in the EK80 software. The reprocessed files are denoted with a prefix “REPROCESSED-”. These can be imported into LSSS.

7 - References

Demer, D. A., Berger, L., Bernasconi, M., Bethke, E., Boswell, K., Chu, D., Domokos, R., *et al.* 2015. Calibration of acoustic instruments. ICES Cooperative Research Report No. 326: 133 pp. http://dx.doi.org/10.25607/OBP-185.

Korneliussen, R. J., Diner, N., Ona, E., Berger, L., and Fernandes, P. G. 2008. Proposals for the collection of multifrequency acoustic data. ICES Journal of Marine Science, 65: 982–994.

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1 \S2024001019_PGOSARS_4174\BIOLOGY\CATCH_MEASUREMENTS\DEEP_VISION

2 The model predictions are stored in the deepvision.xml file under each trawl haul in the deep vision folder.

3 \S2024001019_PGOSARS_4174\ACOUSTIC\LSSS\EXPORT\BroadbandSv

4 Shallow single targets/short rage.

5 Upper layer migrated to surface. Trawling when upper layer was moving down again. Not a good trawl match to the acoustic transects.

6 No trawl station for transect ST6. The layer migrated to surface and back during inbound transect with different distribution after migration.

7 The layer was migrating downwards.

8 The upper layer had migrated to the surface and was visible on the echosounder. We could not trawl at surface due to propeller water. This layer represents organisms that did not take part the diel vertical migration.

9 Thin middle layer before trawling, merged with upper layer and we tralwed in the lower edge of the merged layers.

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