

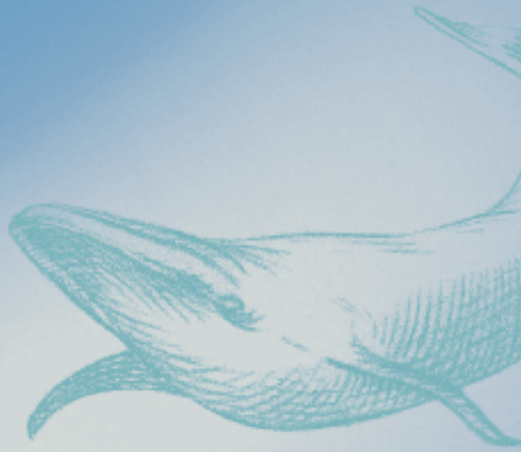

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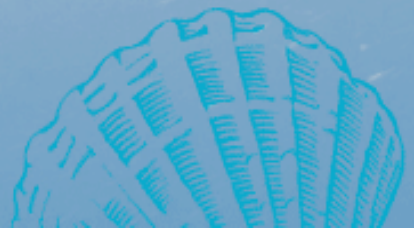

Is it possible to measure cod eggs & cod larvae with echo sounders instead of traditional net sampling?

Or: A new acoustic instrument for measuring vertical profiles of plankton

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Gavin Macaulay

Marine Ecosystem Acoustics Group

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Content

- History
- Egg surveys
- Acoustics and small targets
- Eggs and larvae
- Detection experiments
- Preliminary conclusions
- New observation tools

First published echogram of fish (Sund, 1935, Nature)

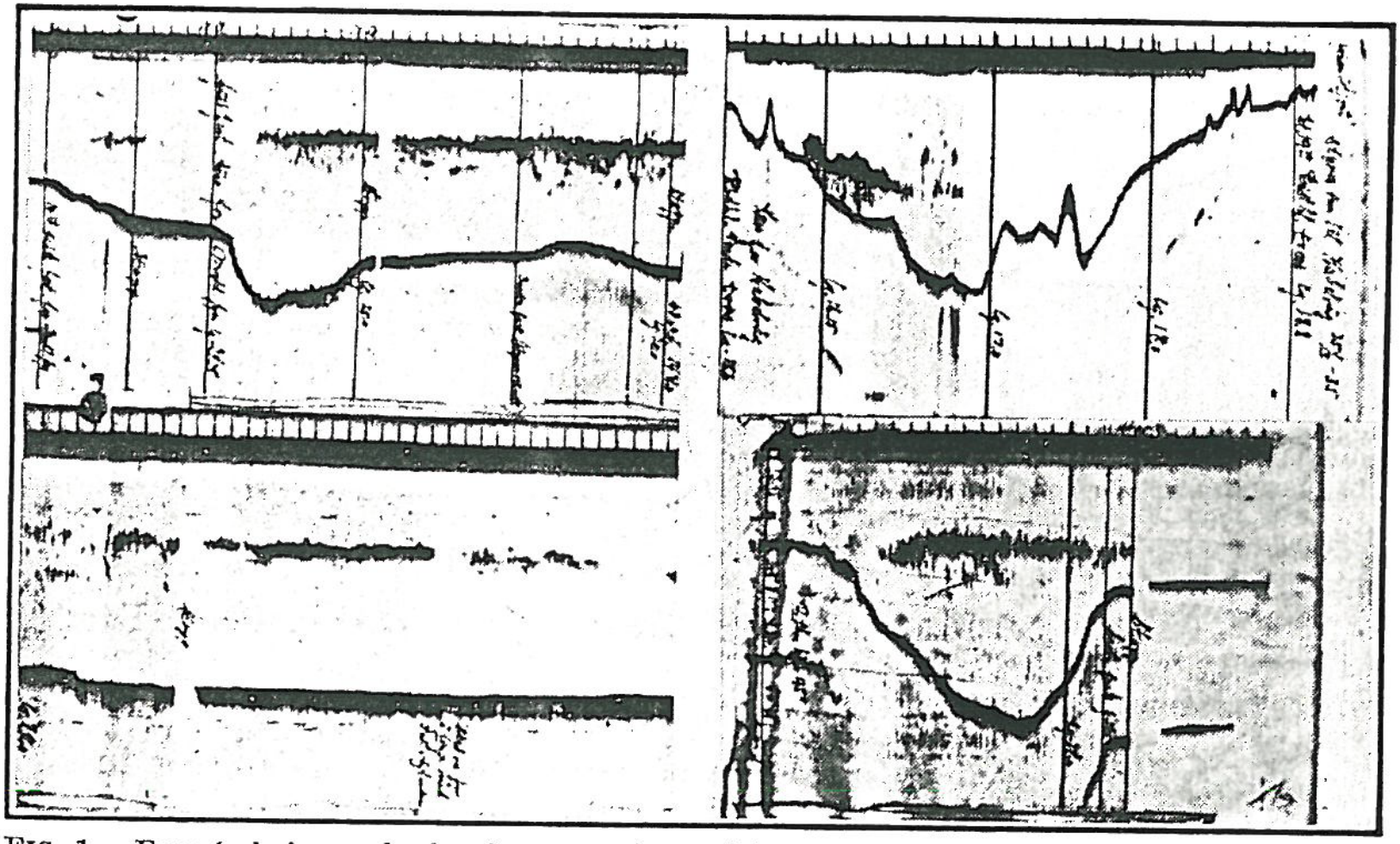
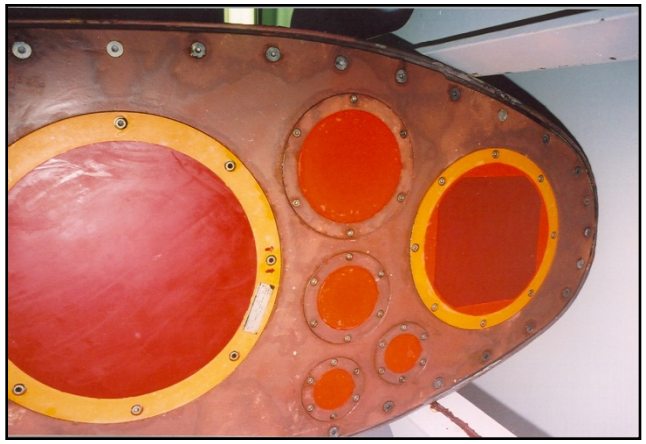


FIG. 1. Four 'echo'-records showing spawning cod in midwater at Lofoten. The left-hand diagrams partly with ship stopped. The bottom right-hand record is somewhat disfigured by oscillations set up by excessive shaking of ship's motor; but it shows also a second echo from the bottom, reflected from the surface. Marks on top of each diagram are produced every minute and are 6·7 mm. apart.

Standard 2003- methods
Echosounders:4-6 frequencies

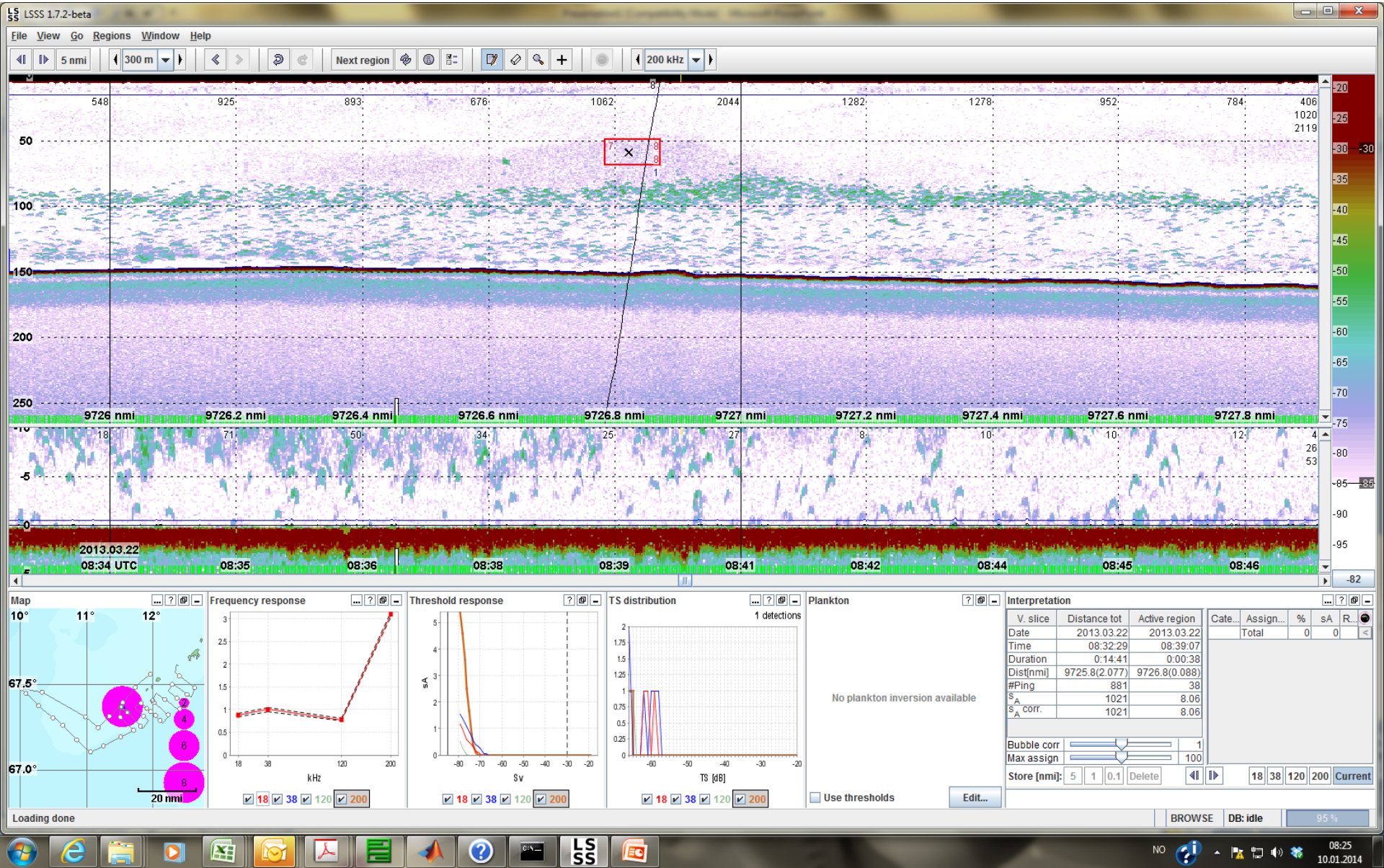


Ship-mounted

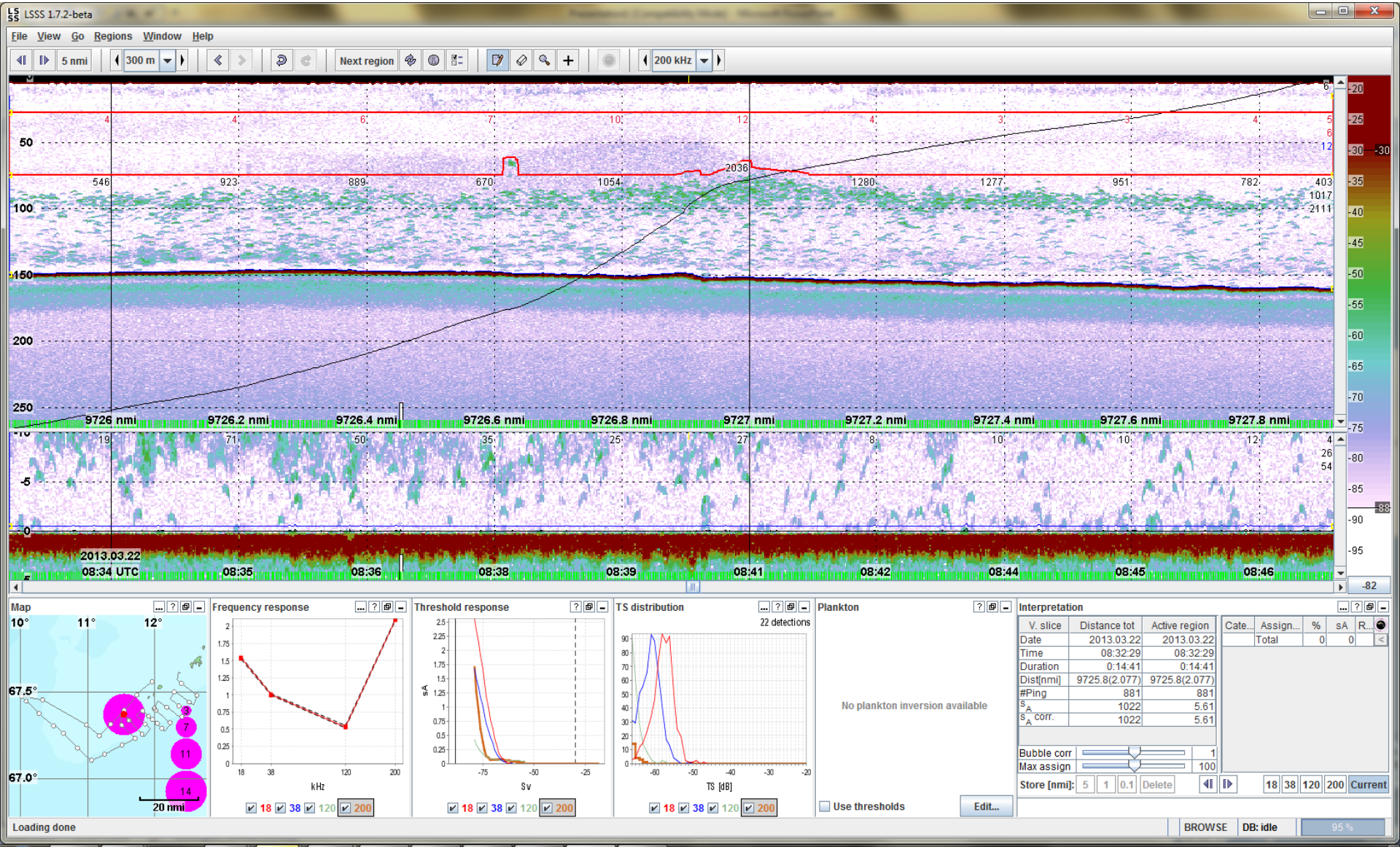
Vertically downwards

18, 38, 70, 120, 200, 333 kHz

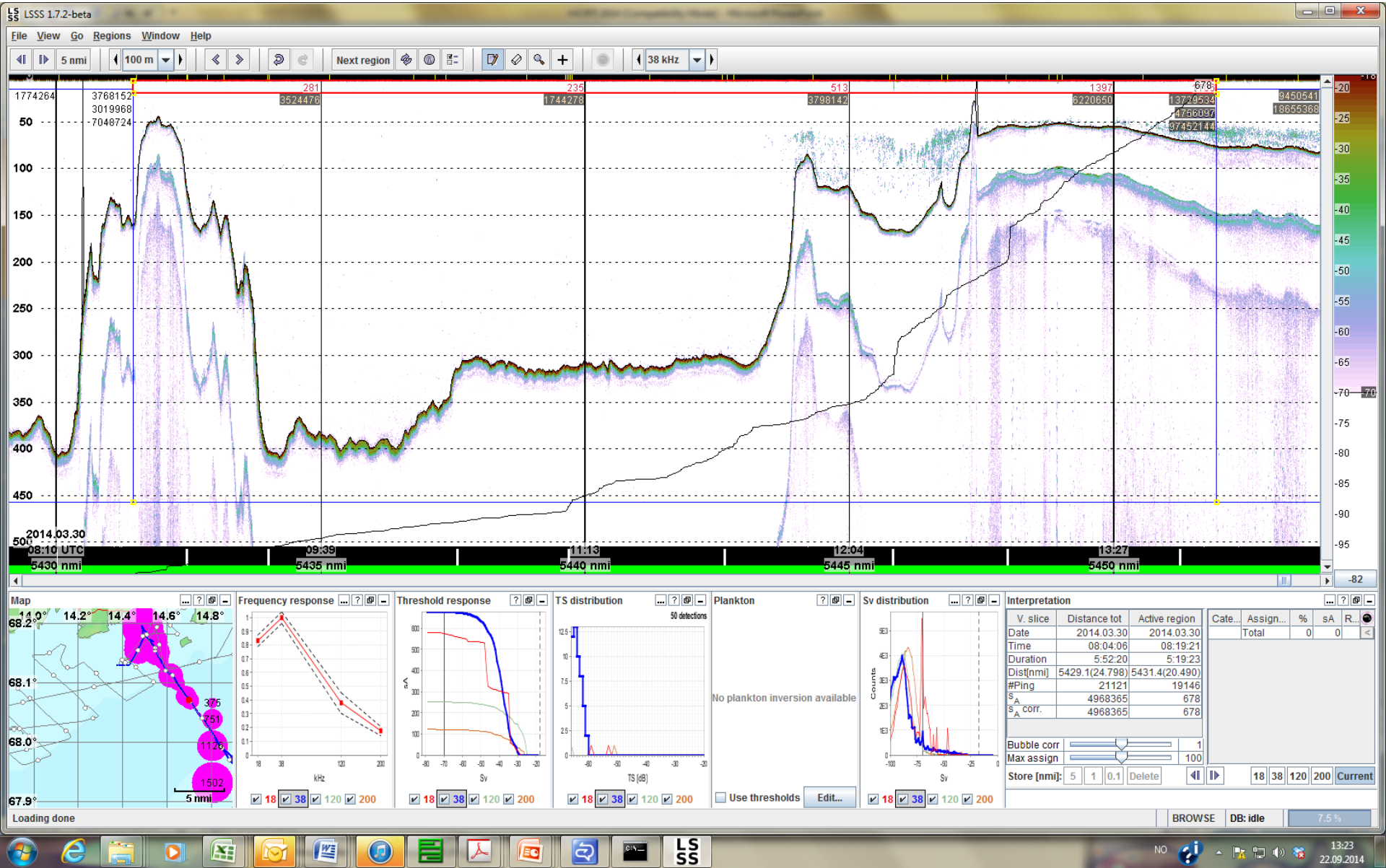
Observe weak echoes at 200 kHz above cod layer and r(f) = copepod or egg ?



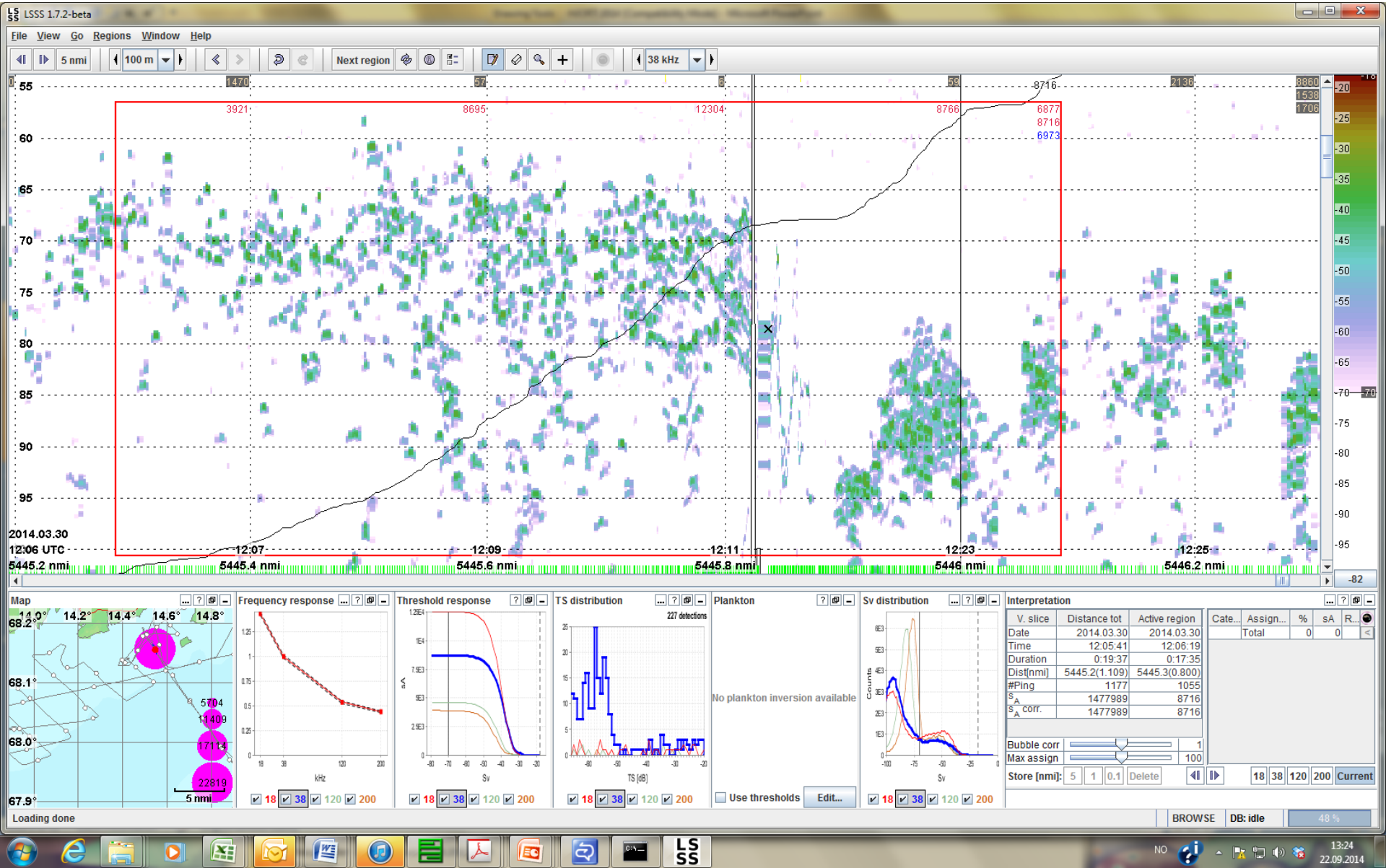
’Smoke’ layers follow fish density



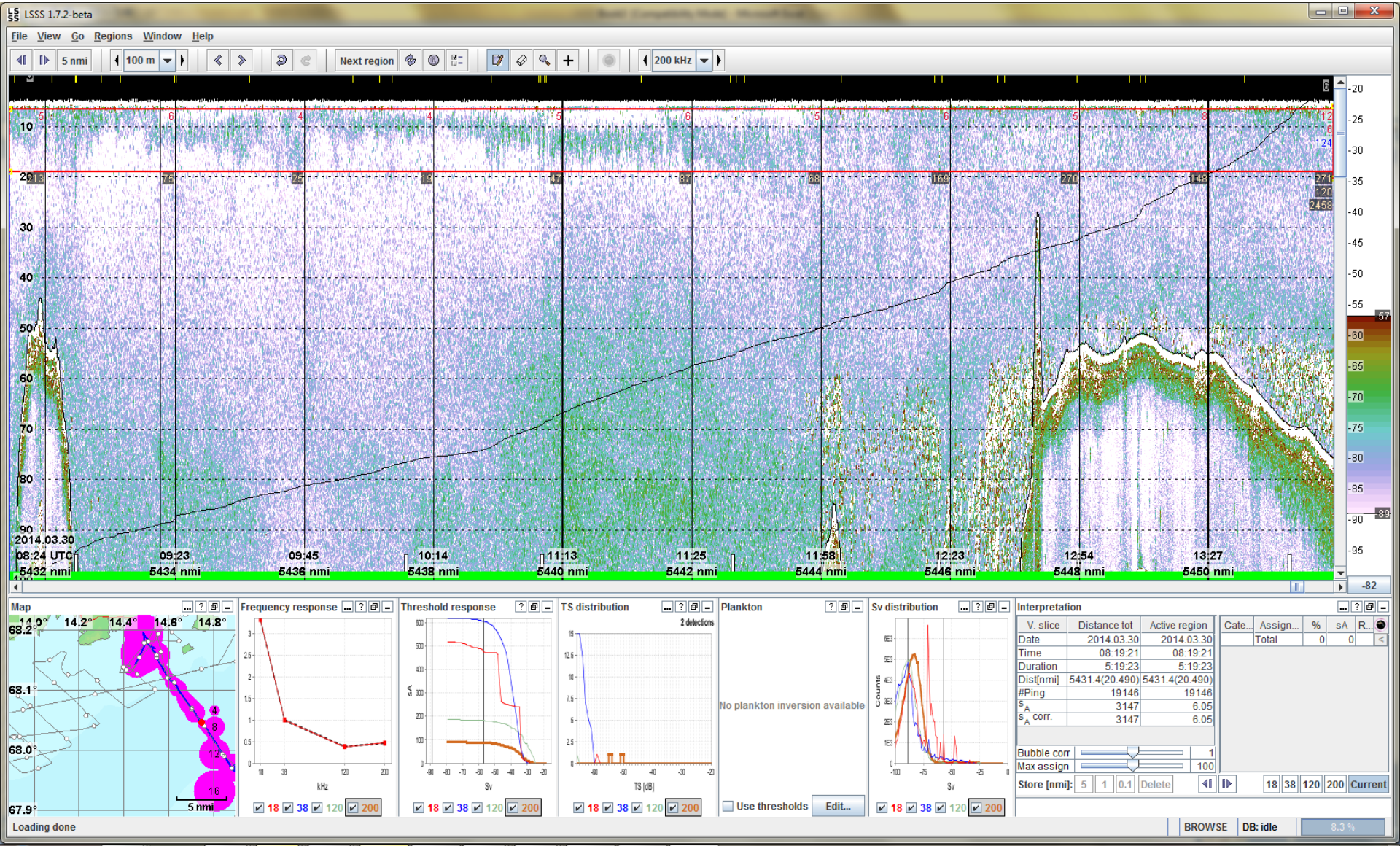
Cod at 38 kHz: Vestfjorden



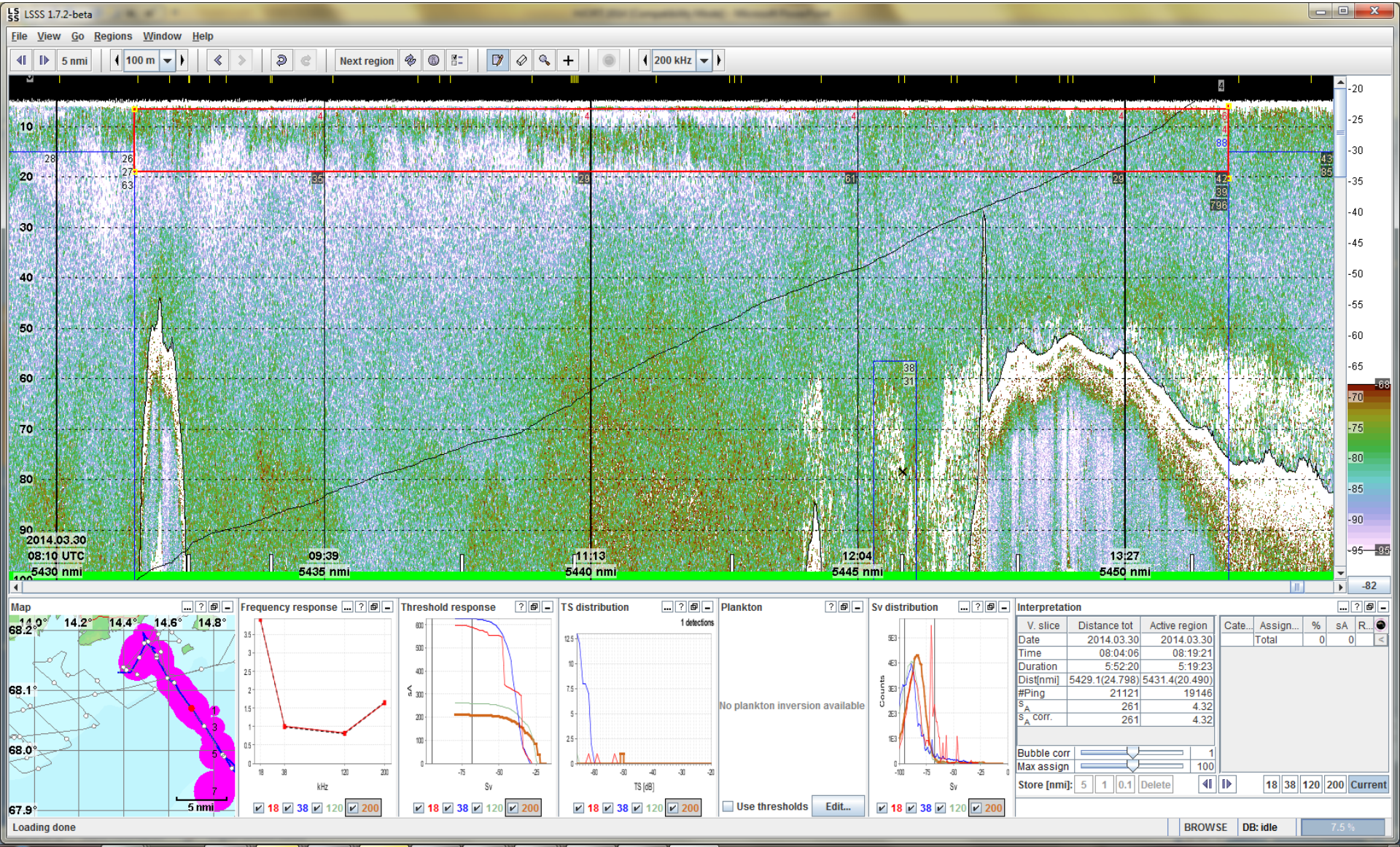
Zoomed view ≈ absolute fish density



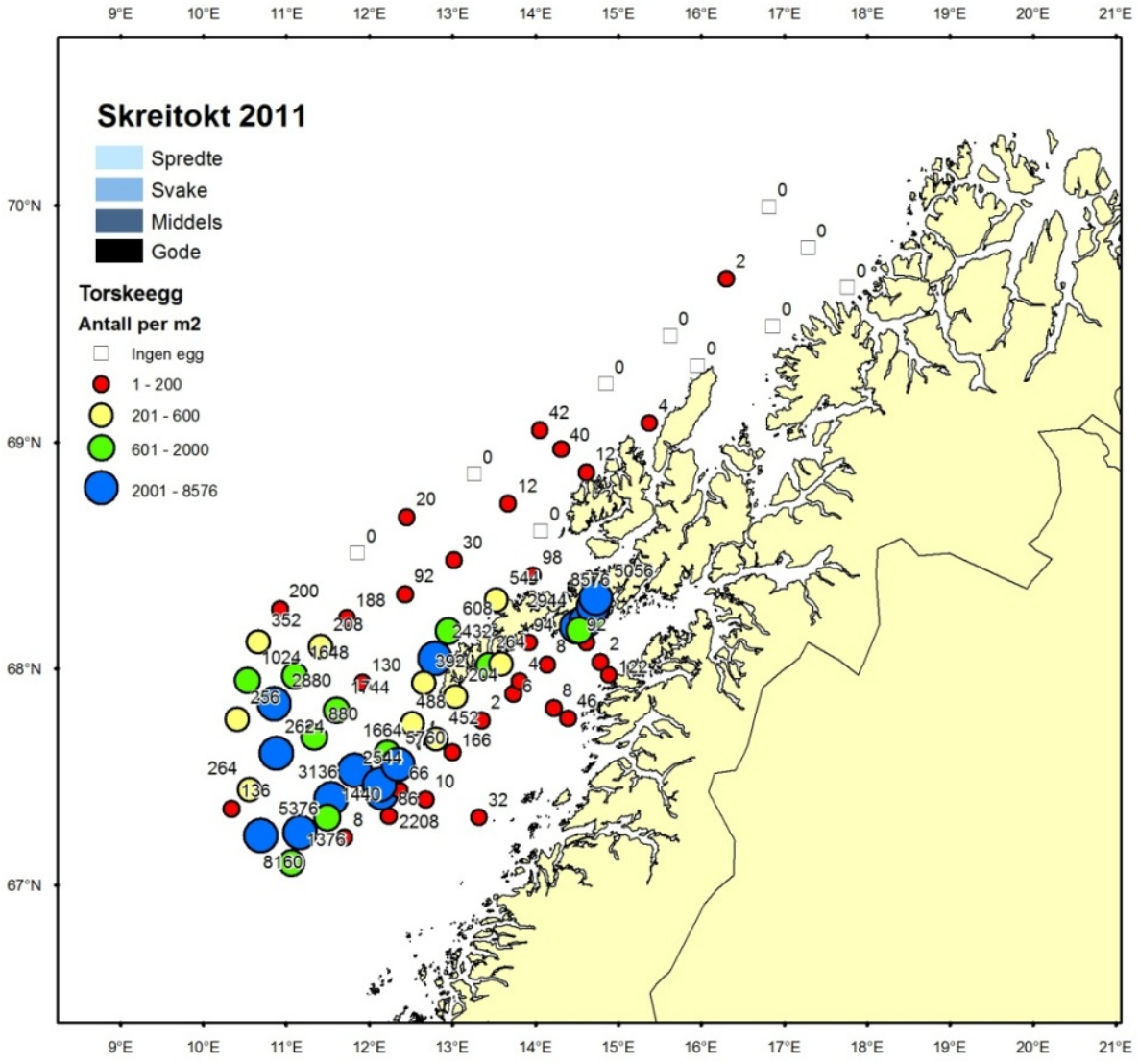
Egg layer at 200 kHz?
Vestfjorden 2014



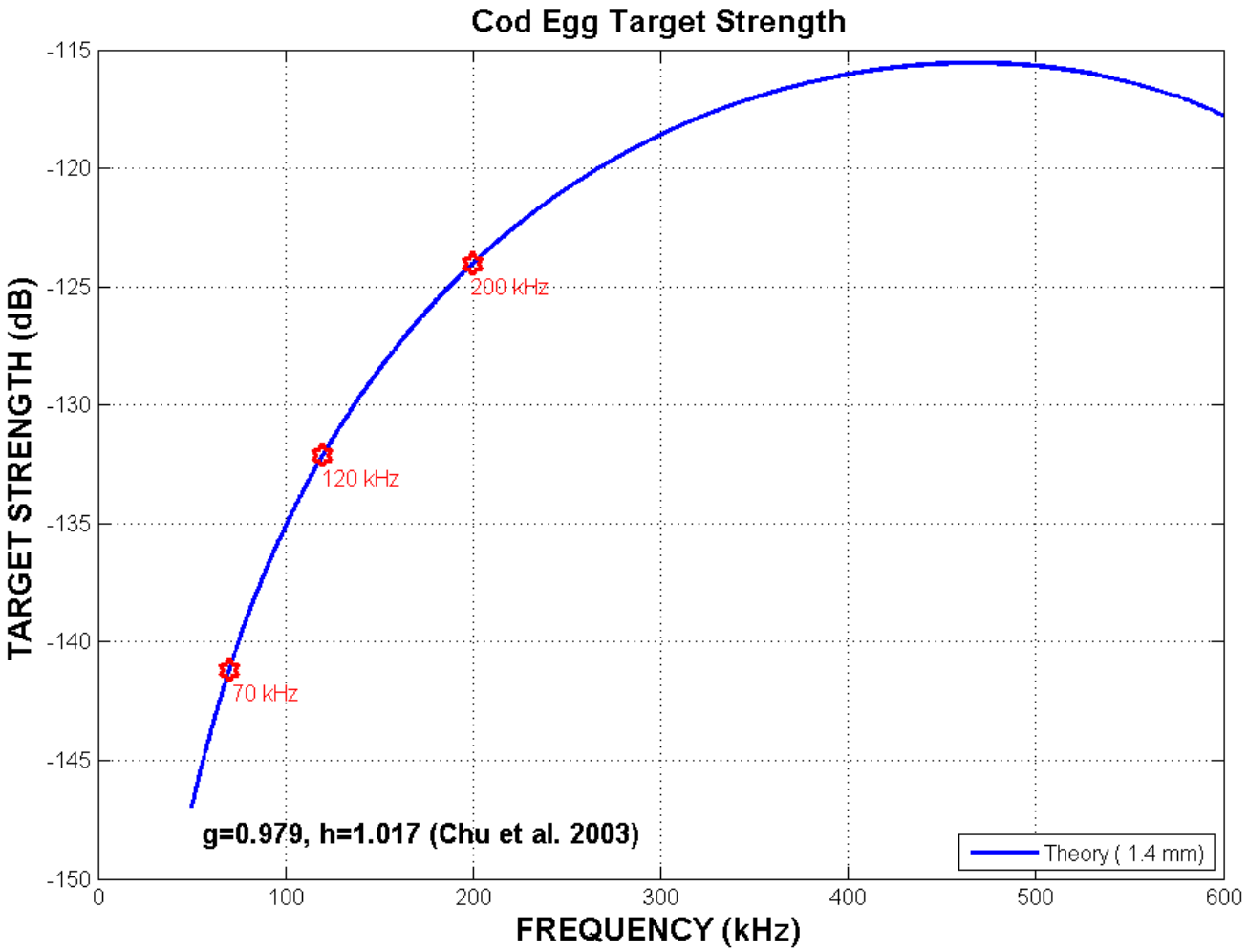
Egg layer, larger echoes removed
3000 – 6000 eggs/m²



Egg abundance from net tows



Modelled cod egg backscatter ø1.4 mm

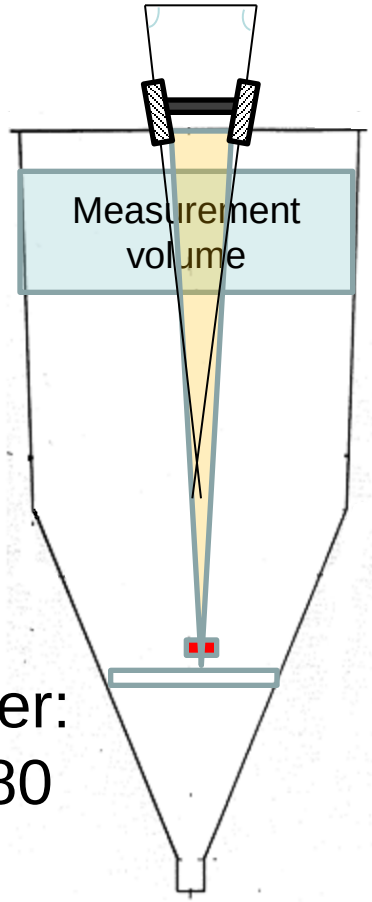


Can we measure these and larvae with adapted echo sounders?

- The 2014 Austevoll experiments
  - Conventional echosounders
    - Single frequencies
  - Broadband echosounders
    - Continuous frequency
    - Higher SNR, better detection range

Larvae silo

Stereo camera

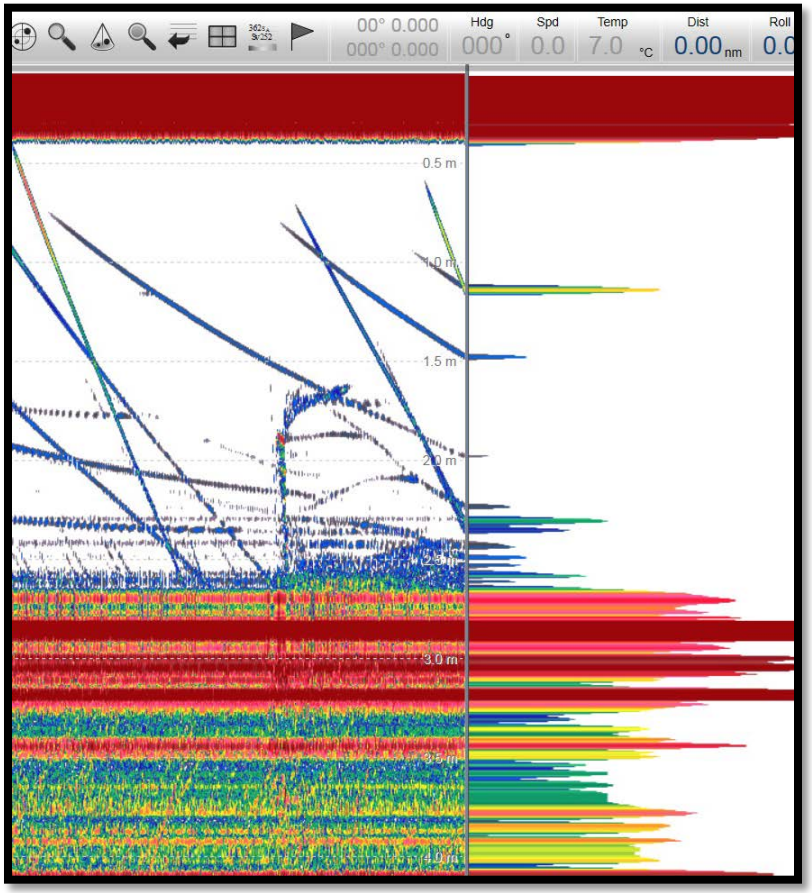


Filtered seawater
(34.5 PSU, 7^{o})

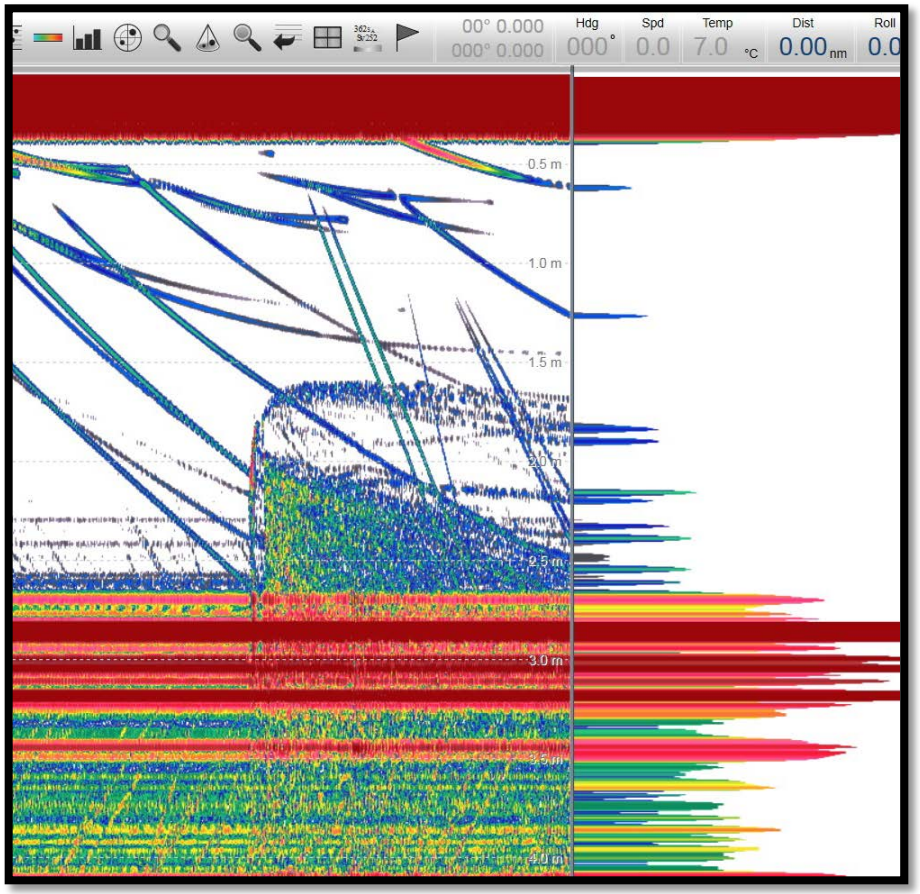
Echosounder:
Simrad EK80

- 200 and 333 kHz
- 170-260 kHz
- 300-360 kHz

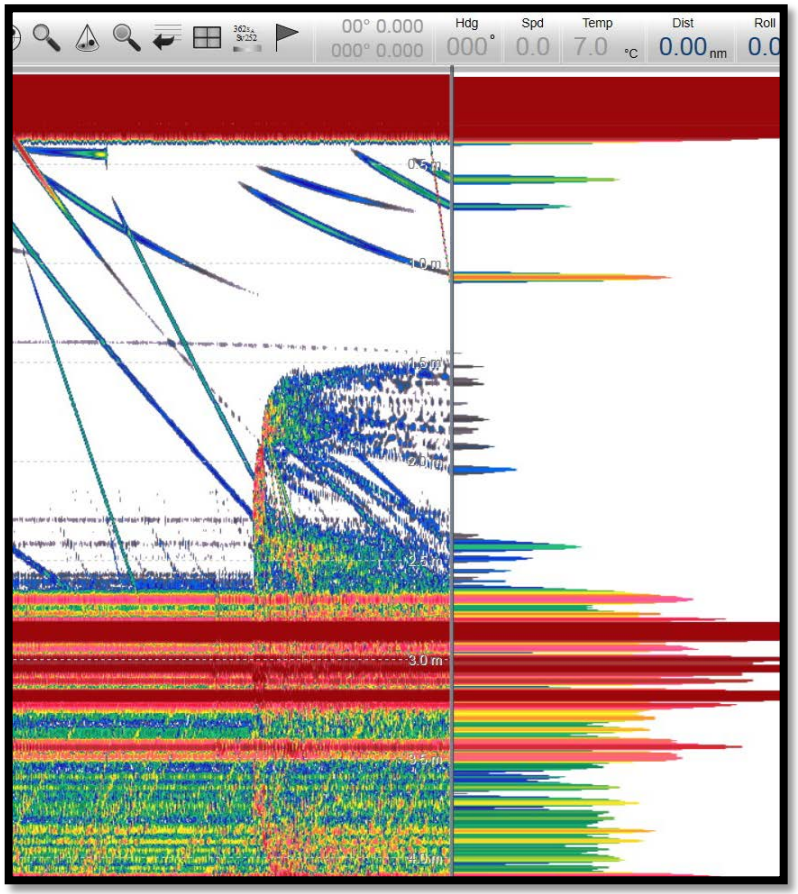
Sea water in sea water



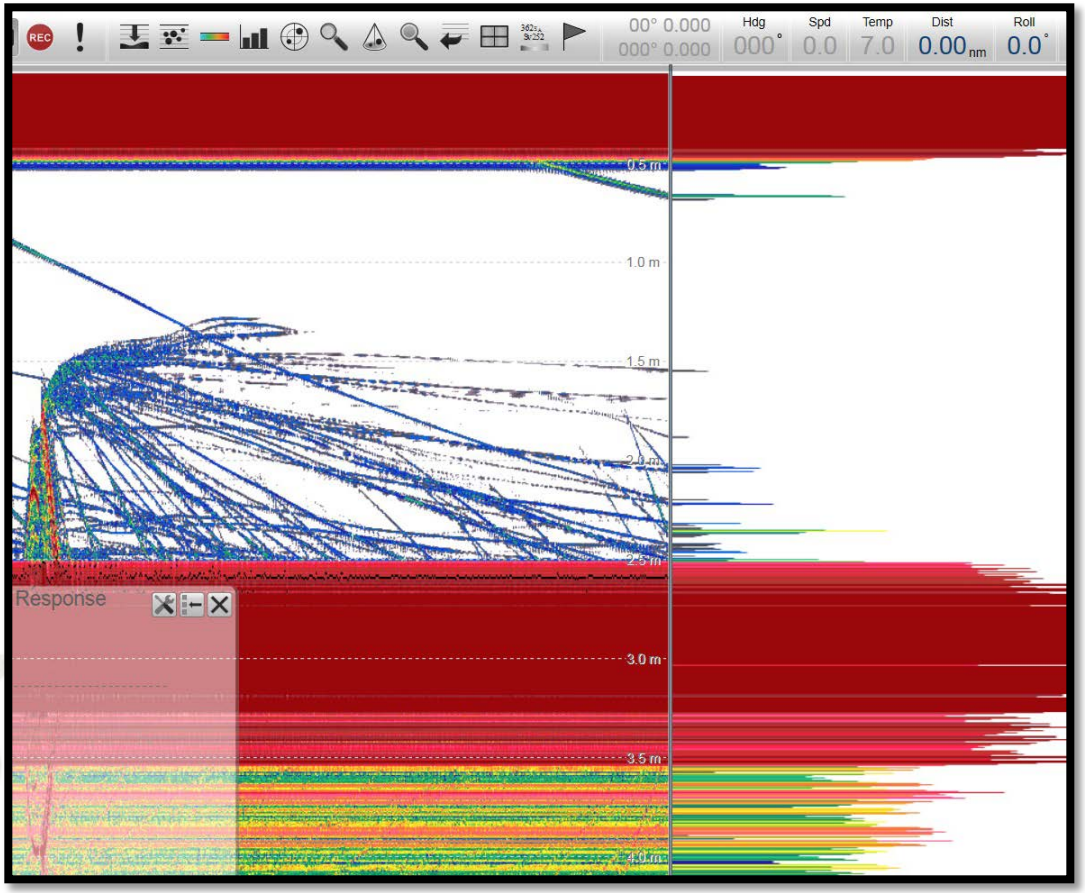
10 eggs, single tracks

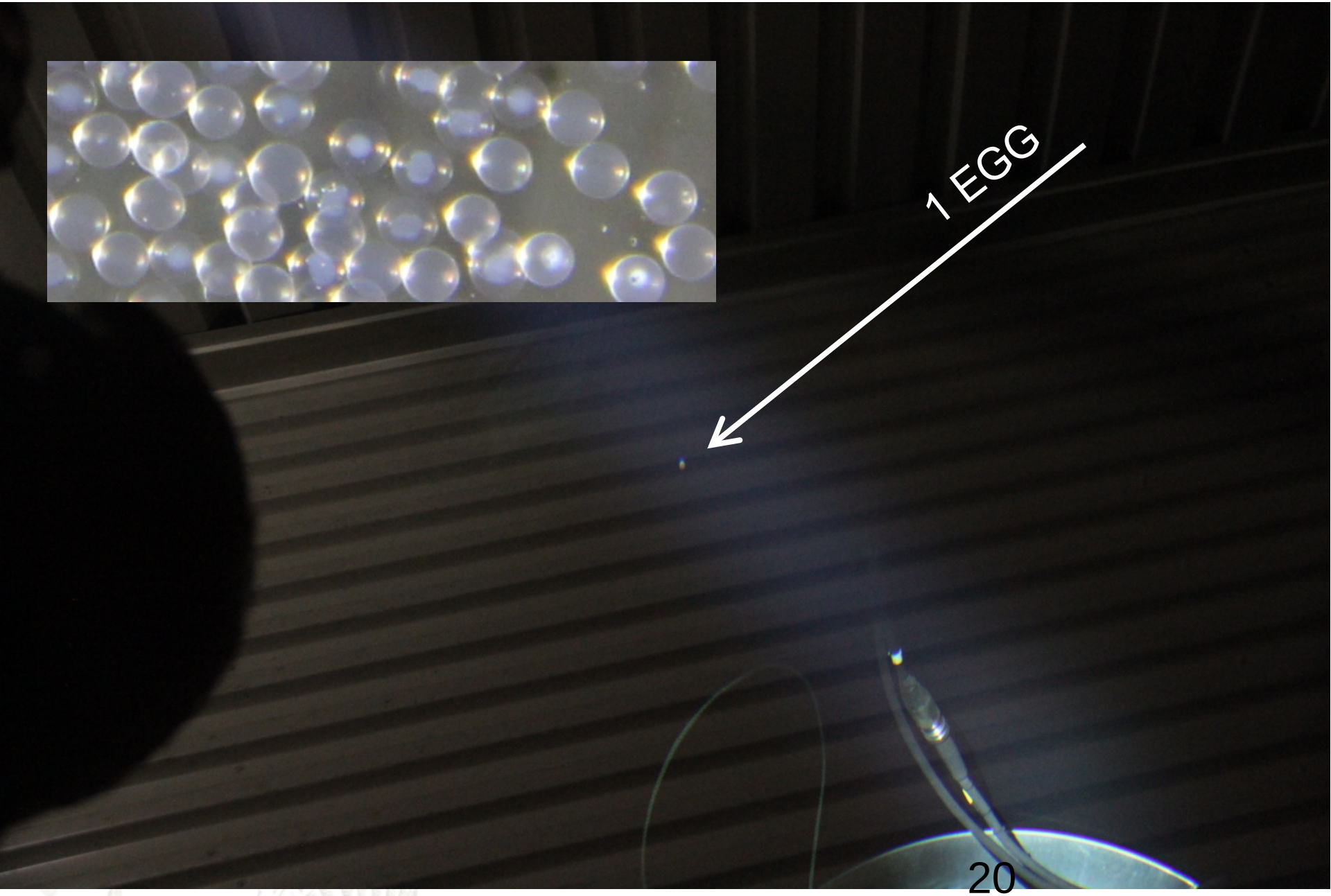


40 eggs

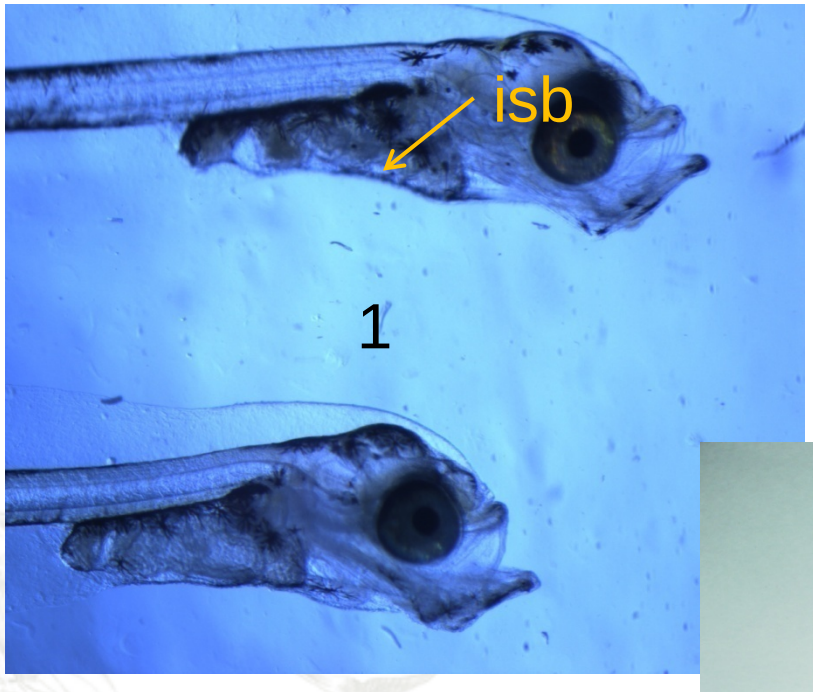

00° 0.000
000° 0.000
Hdg
000°
Spd
0.0
Temp
7.0 °C
Dist
0.00 nm
Roll
0.5 m
1.0 m
1.5 m
2.0 m
2.5 m
3.0 m
3.5 m
4.0 m

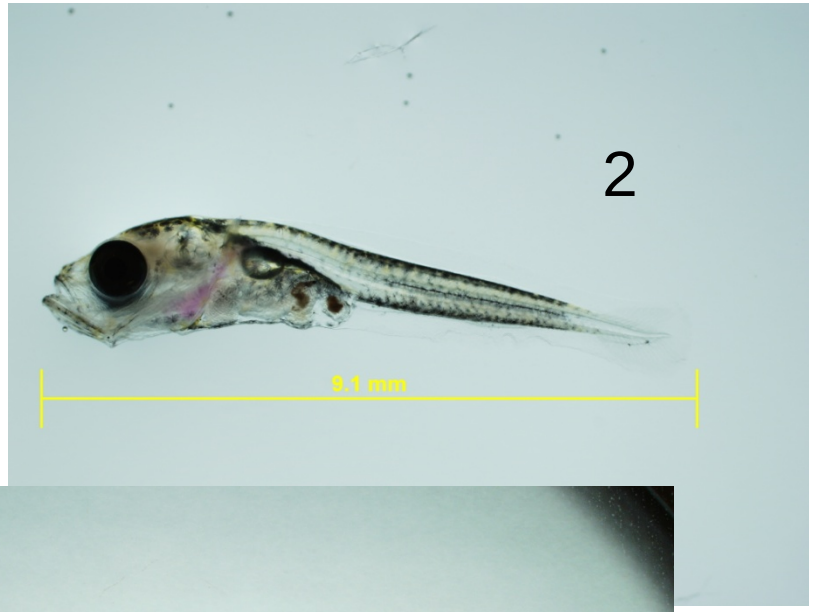
Many eggs

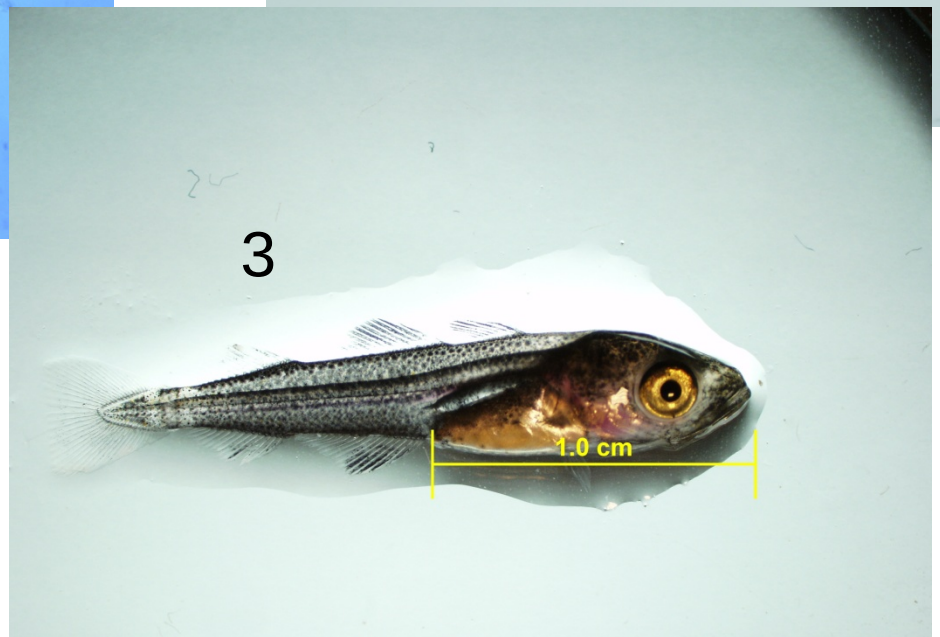

REC
00° 0.000
000° 0.000
Hdg
000°
Spd
0.0
Temp
7.0
Dist
0.00 nm
Roll
0.0°
0.5 m
1.0 m
1.5 m
2.0 m
2.5 m
Response
3.0 m
3.5 m
4.0 m


1 EGG

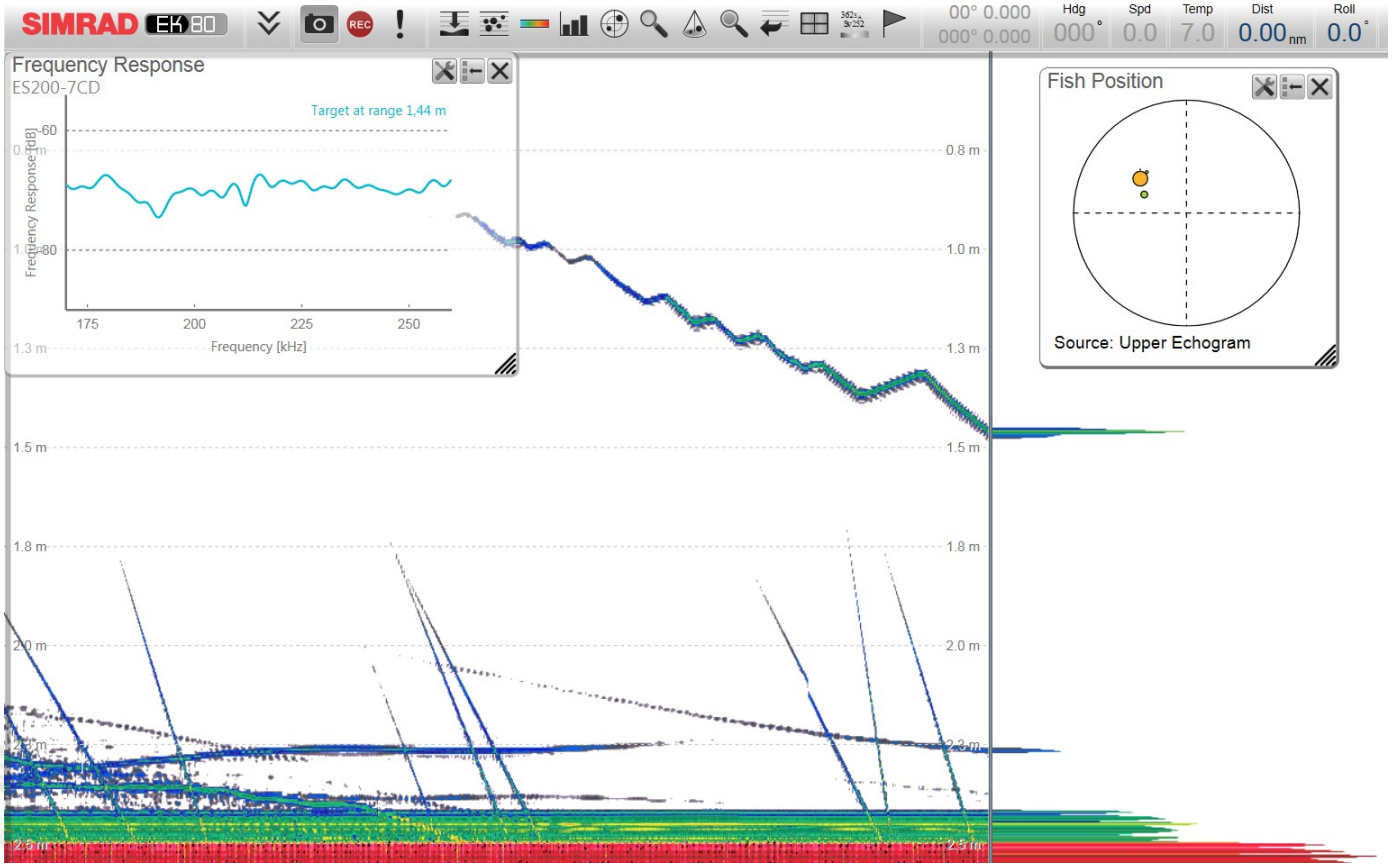
Larvae & juvenile cod



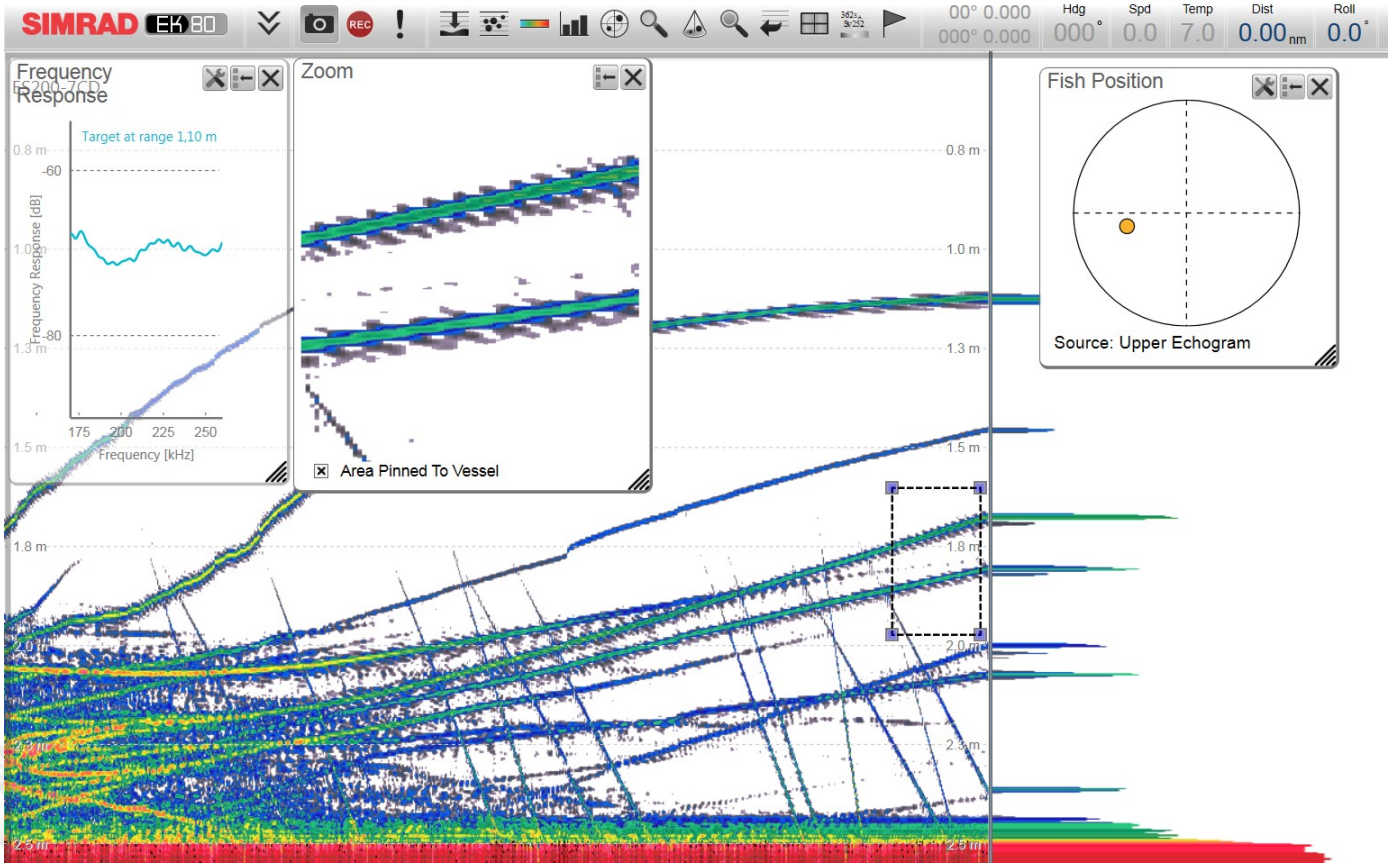




Larva 2


SIMRAD EK80
Hdg
Spd
Temp
Dist
Roll
Frequency Response
ES200-7CD
Target at range 1,44 m
Frequency Response [dB]
Frequency [kHz]
175
200
225
250
Fish Position
Source: Upper Echogram
0.8 m
1.0 m
1.3 m
1.5 m
1.8 m
2.0 m
2.3 m
2.5 m

Larva 2

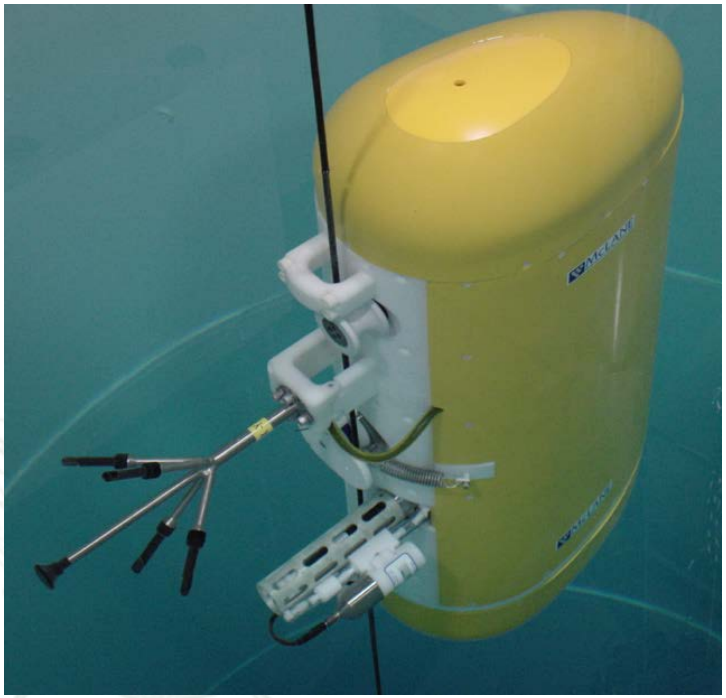

SIMRAD EK80
Hdg 000°
Spd 0.0
Temp 7.0
Dist 0.00 nm
Roll 0.0°
Frequency Response
Target at range 1,10 m
Frequency Response [dB]
Frequency [kHz]
Zoom
Area Pinned To Vessel
Fish Position
Source: Upper Echogram
0.8 m
1.0 m
1.3 m
1.5 m
1.8 m
2.0 m
2.3 m

Preliminary conclusions

- Can detect eggs at 5- 10 eggs/m^3
- Can measure egg volume density
- ID eggs and similar targets?
- Can detect larva without swimbladder
- Can easily measure larvae with initial swimbladder, standard methods
- Effective range: 0 – 50 m, (at 300-450 kHz)

HOW ?

CRAWLER



PROBE

Rearranged for profiling

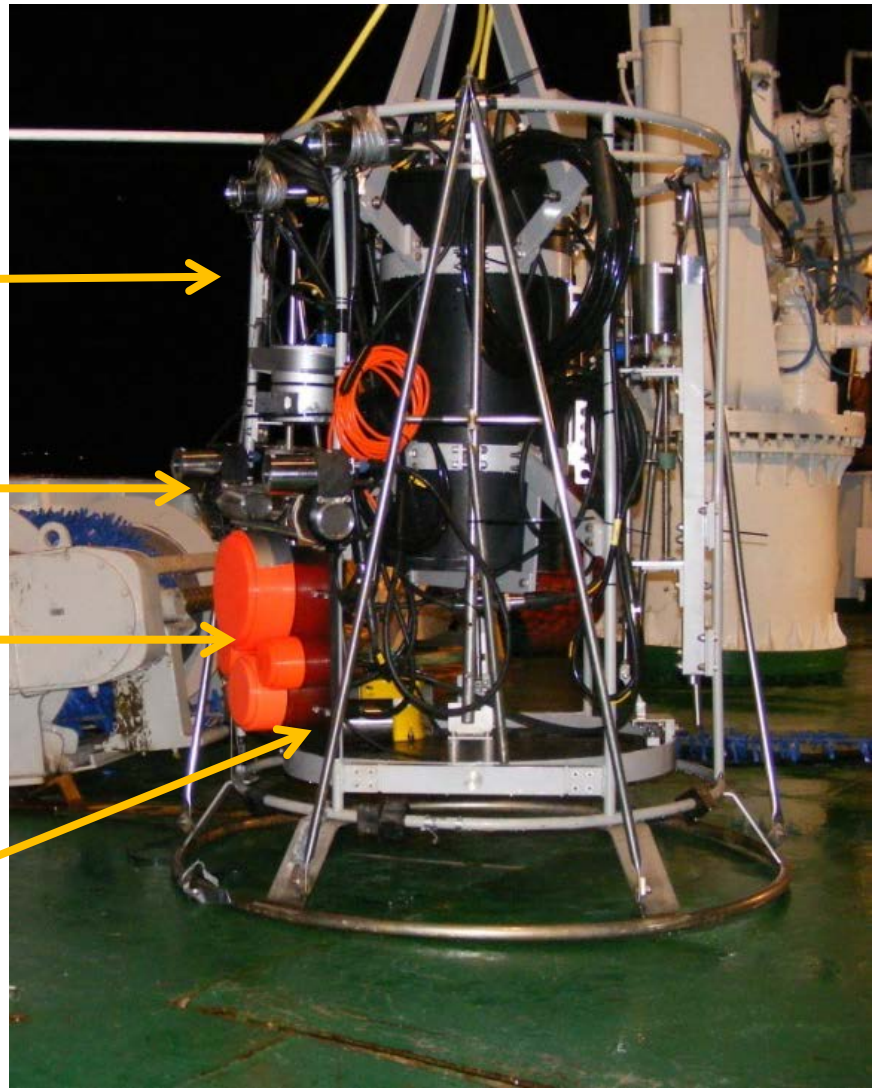
ROV (OE), 3 F, cable 3000m

CTD (Seabird microcat)

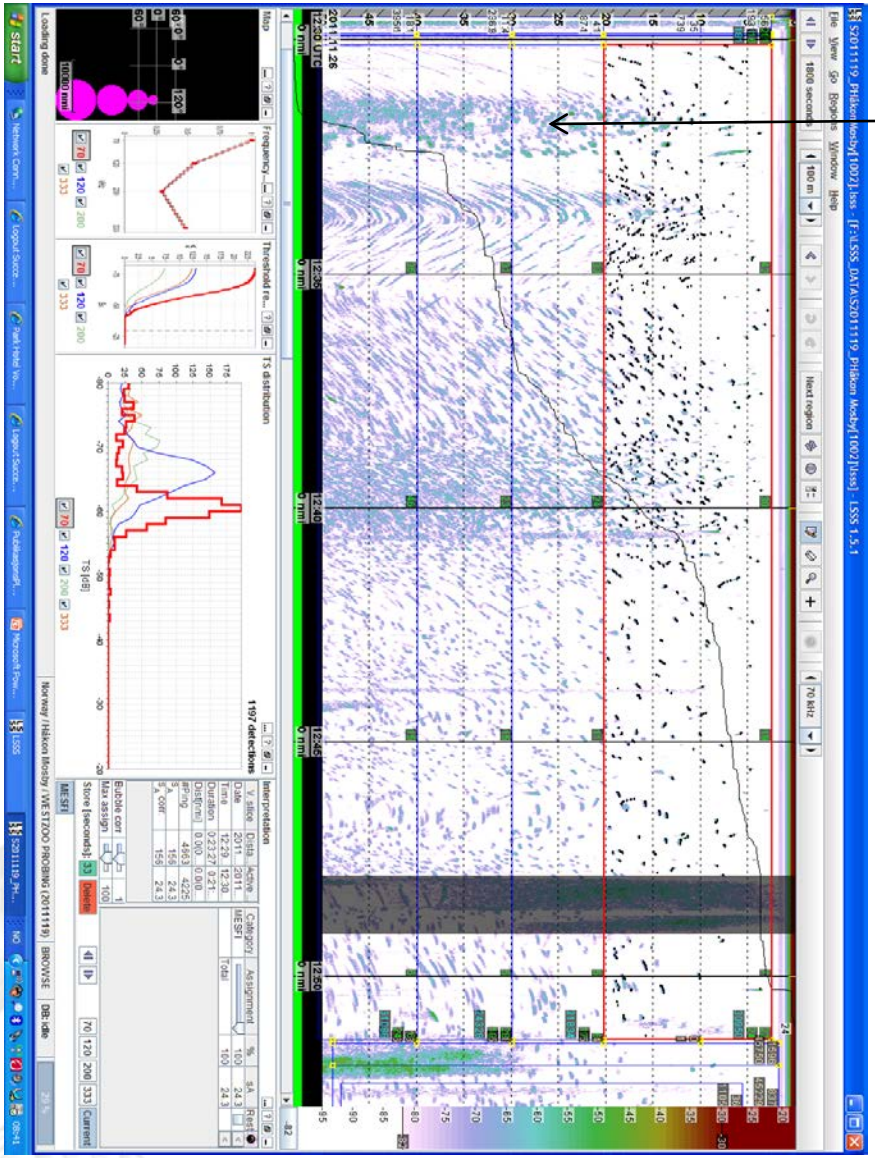
Stereo-camera

4 acoustic transducers
70, 120, 200, 333 kHz

ADCP (RDI-600 kHz)



Like this !

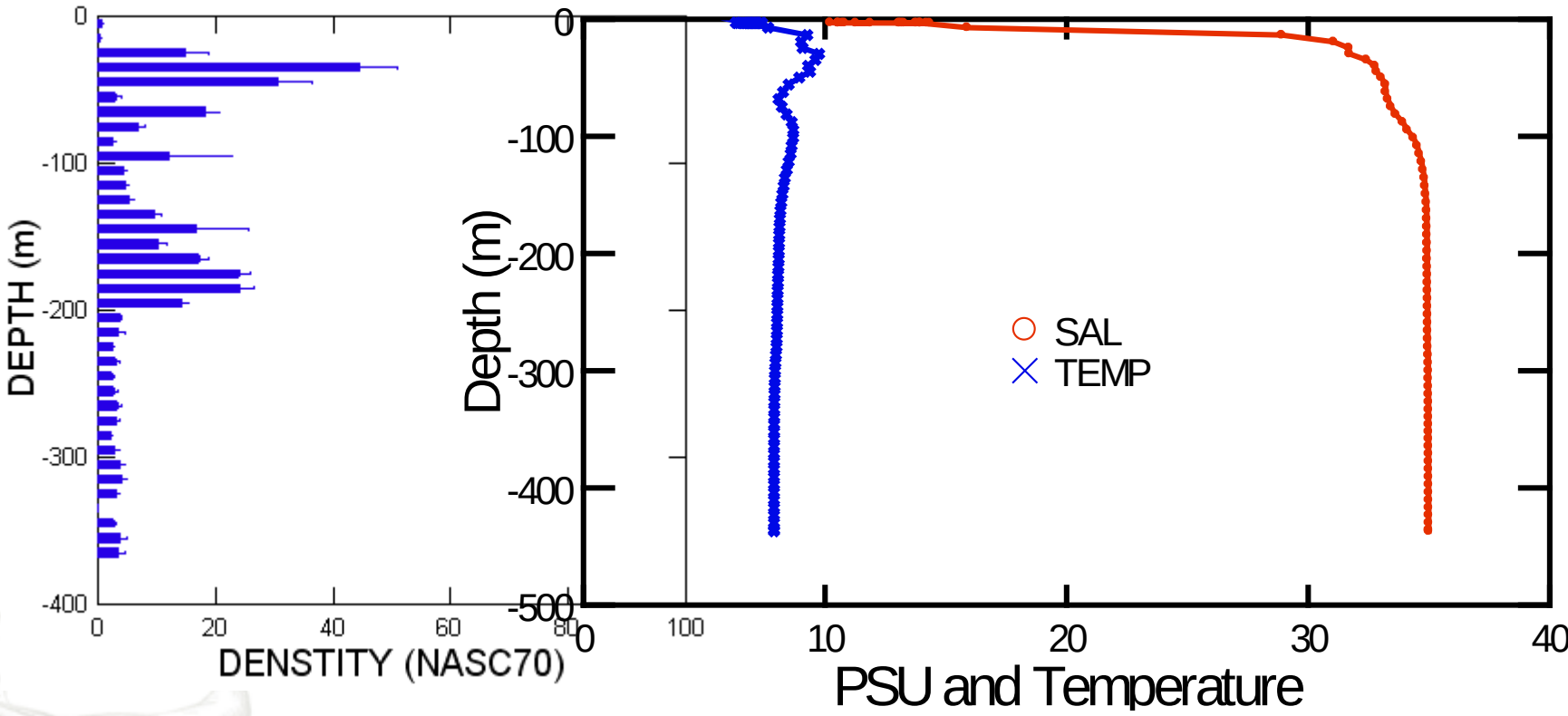


Layer 1

100 m

400 m

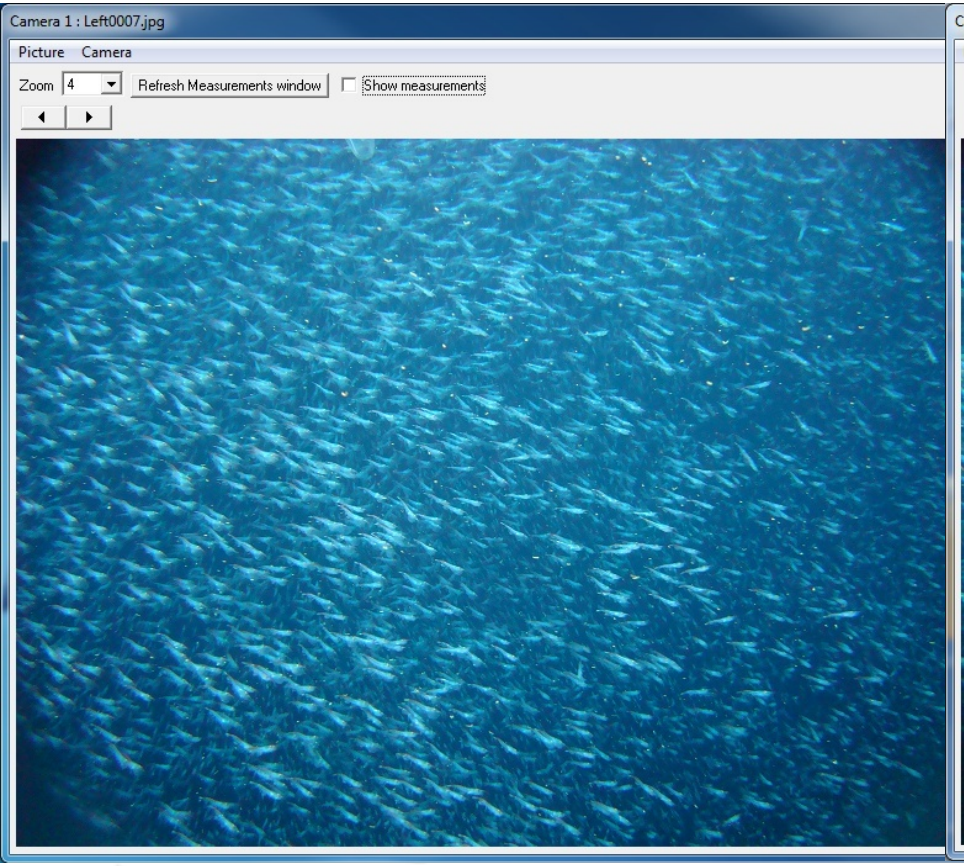
CTD


DEPTH (m)
0
-100
-200
-300
-400
0
20
40
60
80
DENSTITY (NASC70)
Depth (m)
0
-100
-200
-300
-400
-500
0
100
10
20
30
40
PSU and Temperature
SAL
TEMP

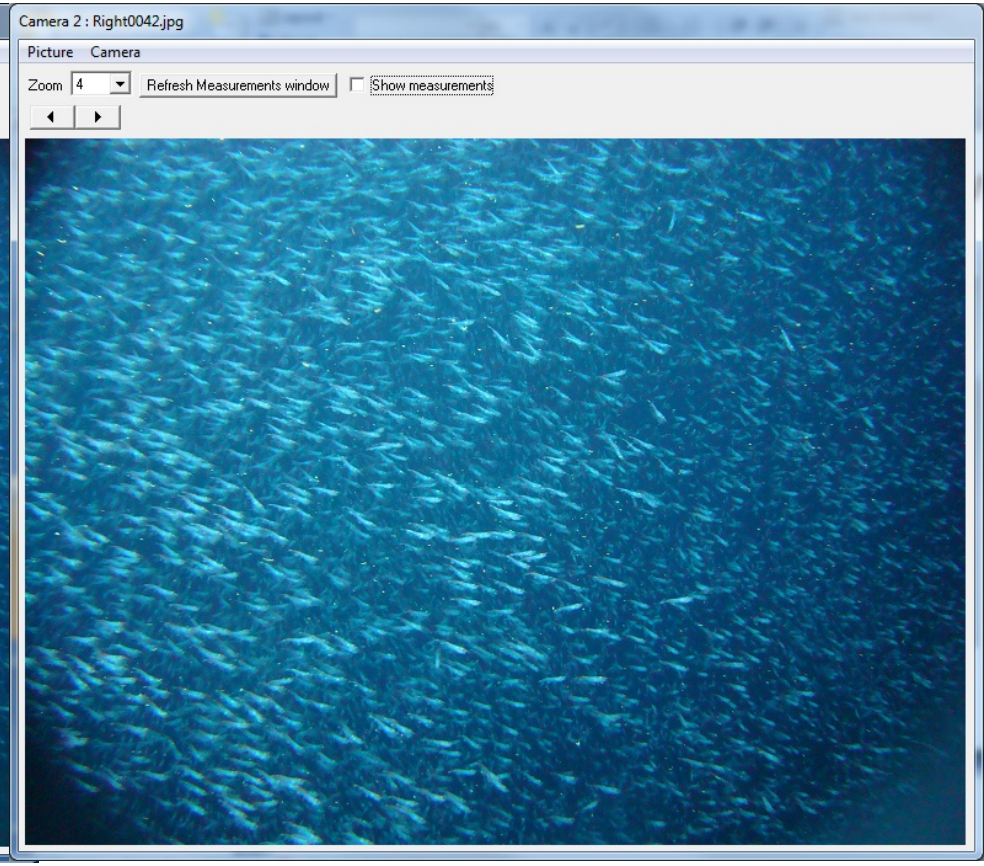
Volume density - Antarctic krill

(example)

Left Camera



Right Camera



R/V G.O.Sars (2008)

Antarctic ocean (~30m depth)

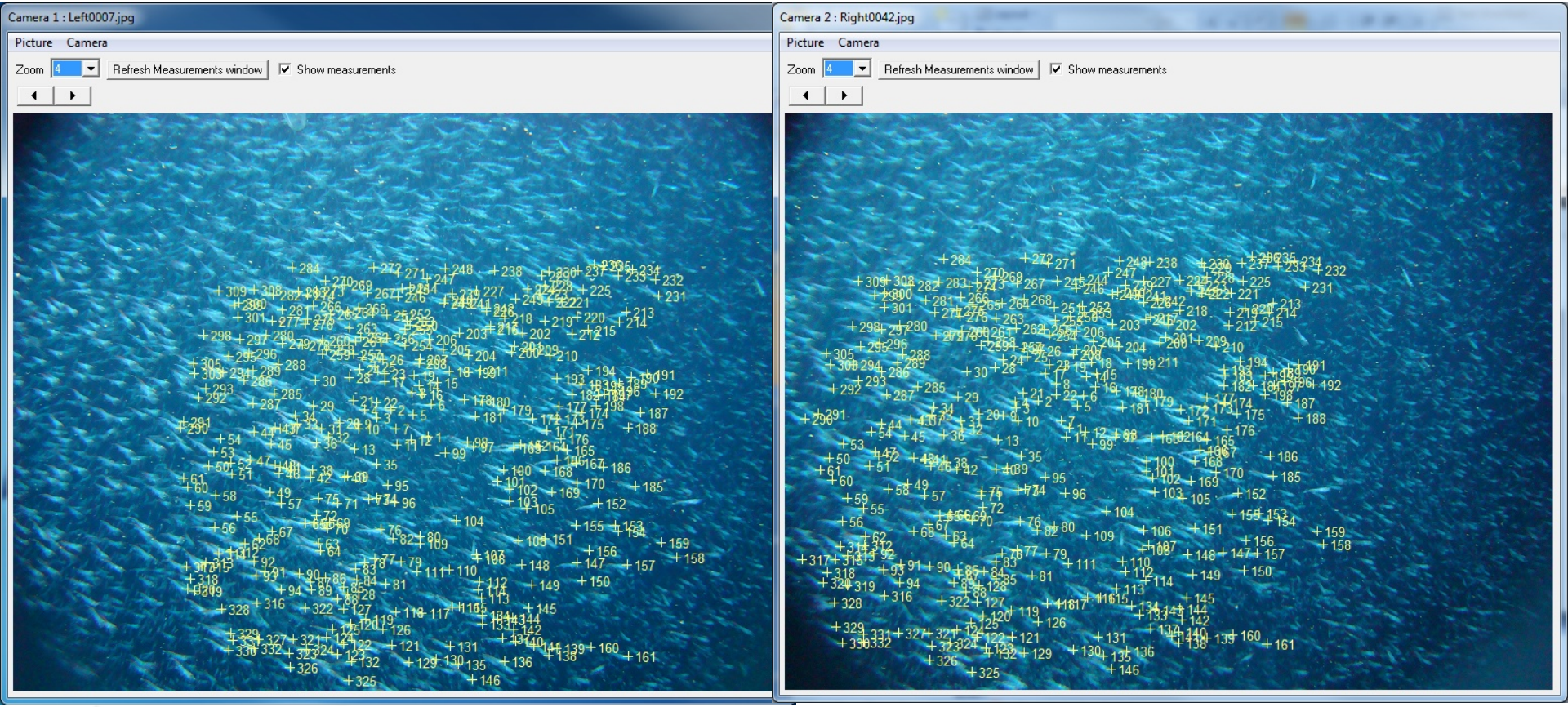
Volume density - Antarctic krill

(example)

Left Camera

1 m^3

Right Camera

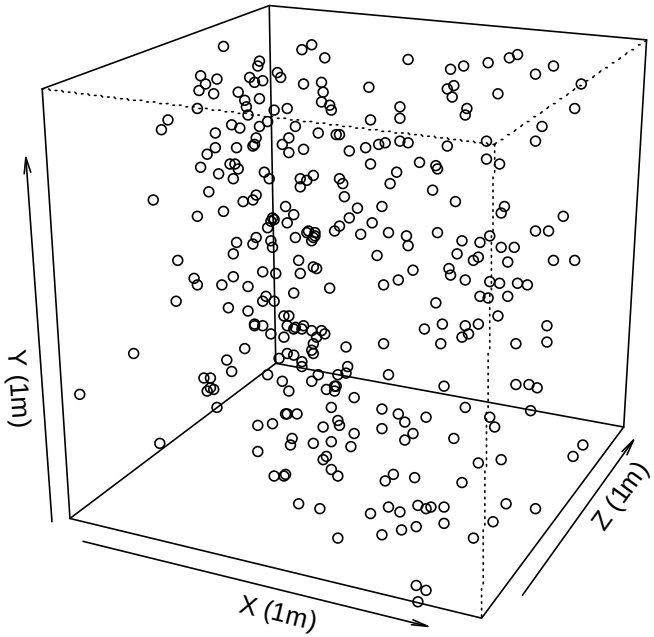


R/V G.O.Sars (2008)

Antarctic ocean (~30m depth)

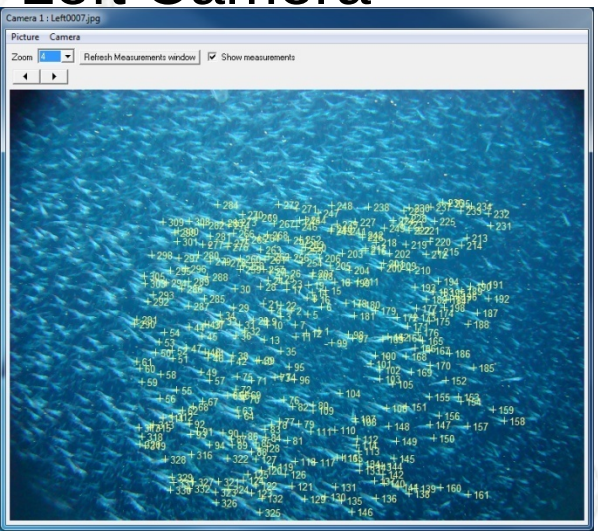
Volume density - Antarctic krill

(example)

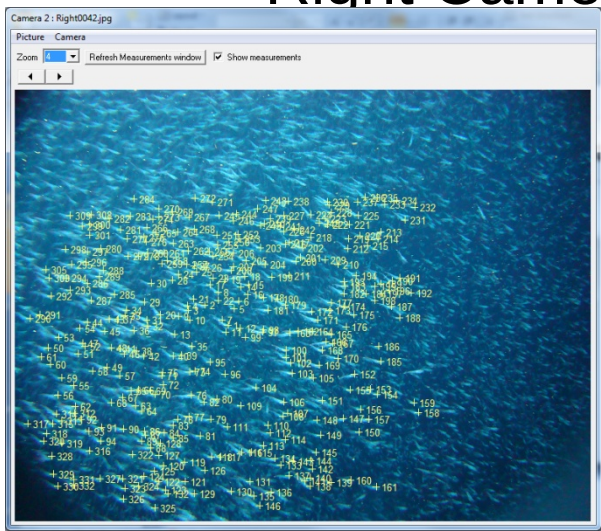


326/m³

Left Camera



Right Came



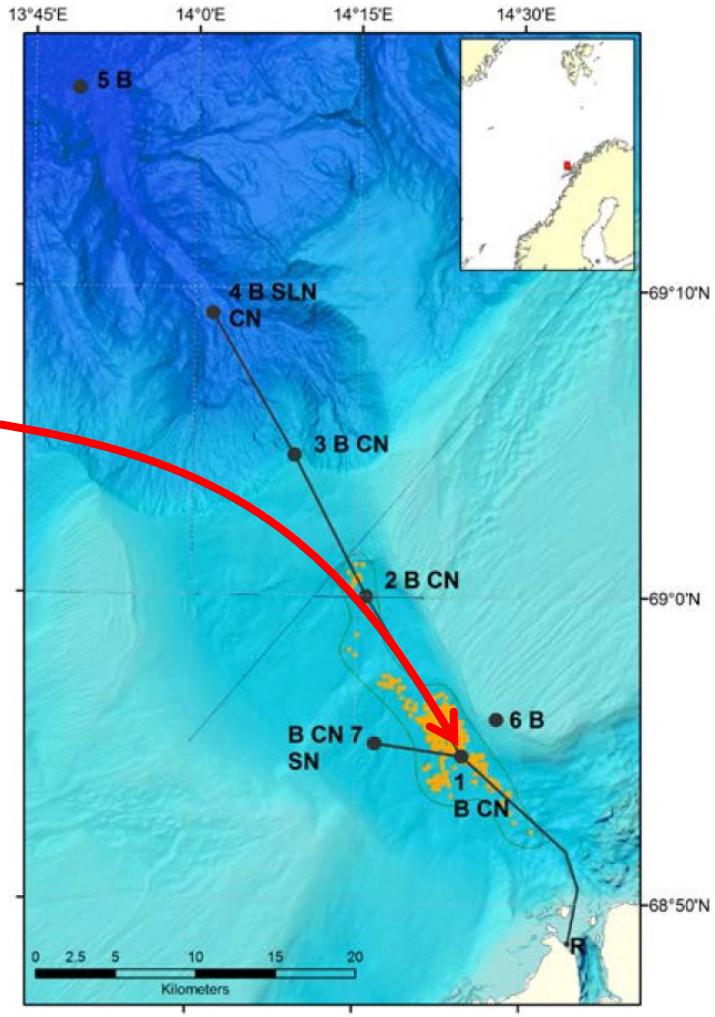
R/V G.O.Sars (2008)
Antarctic ocean (~30m depth)

Acknowledgements

- Margareth Møgster, IMR Austevoll, for arranging silo’s, filtered sea water, eggs and larvae.
- Atle Totland, Ronald Pedersen and Rokas Kubilius (IMR) for field work and initial analysis.
- Part financing from Statoil: Love-ECHOEGG project,
- Simrad, Kongsberg: EK80 broadband prototype.

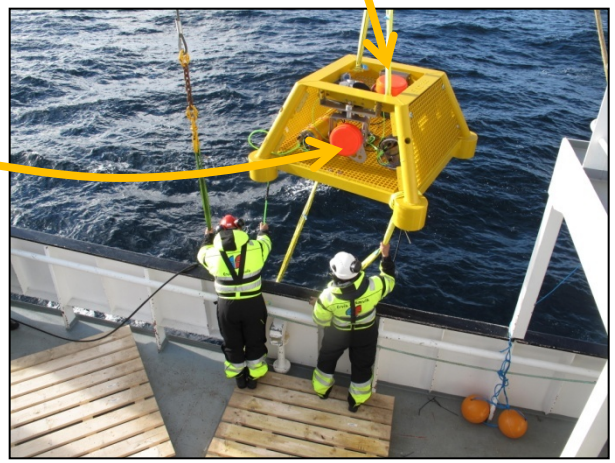
The LoVe observatory

- Cabled observatory
  - Based on conventional sub-sea technology
  - Power delivery
  - Ethernet communication
- One existing node
- Funded to add up to 6 more nodes
- All cabled nodes to have echosounders
- Existing node funded by Statoil



Node 1

- Vertical echosounder (70 kHz)
- Movable horizontal echosounder (70 kHz)
- Ping evey 4 seconds, range resolution 0.75m
- Long range ADCP (200 kHz)



Node 1: satellite

- Camera, video, flash
- Short range ADCP (600 kHz)
- Hydrophone
- Particle dynamics sensor
- Chlorophyll
- Turbidity
- Pressure
- Conductivity
- Temperature