Echosounders: Non-intrusive observations of the pelagic

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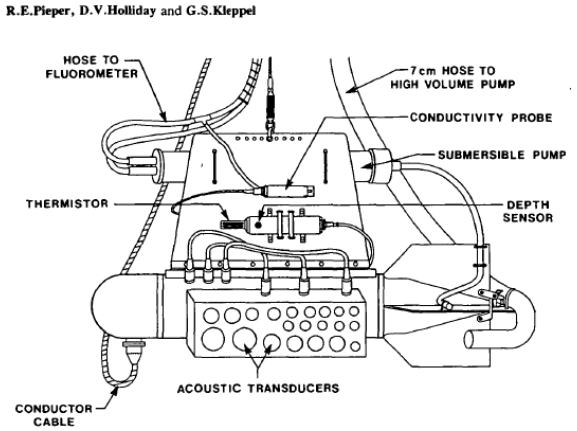
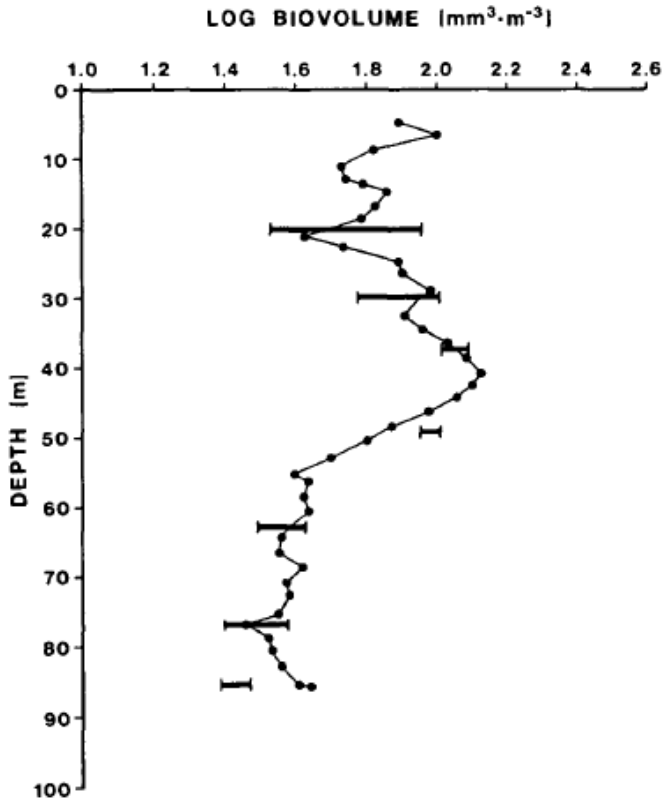
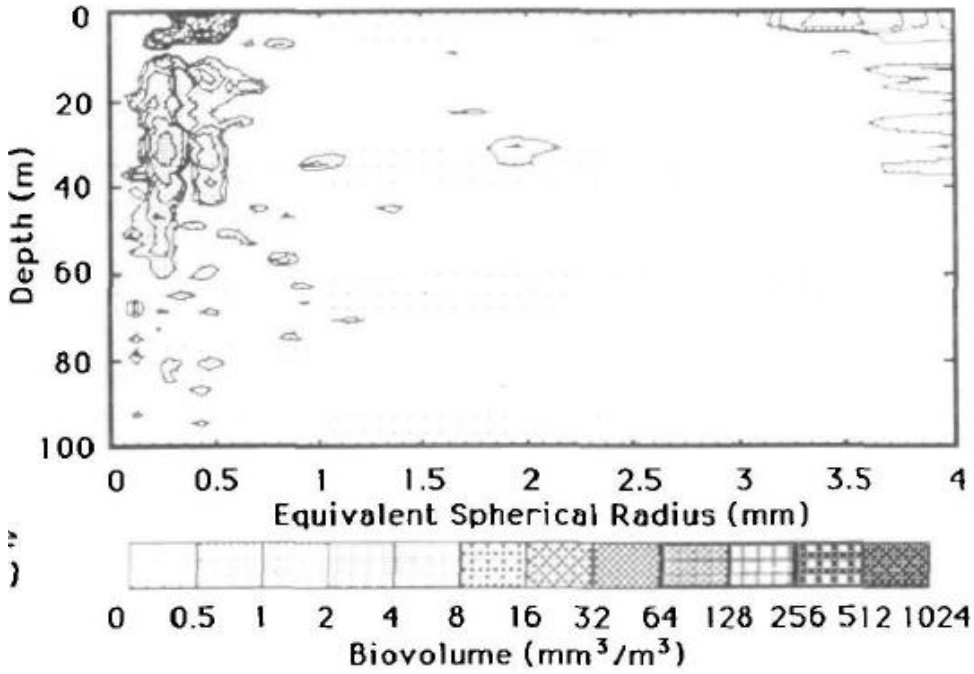


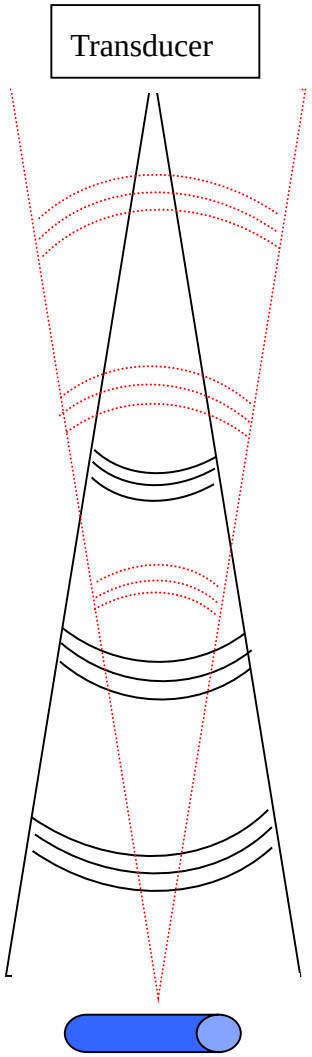


Pieper et al. (1990)
J Plankton Res



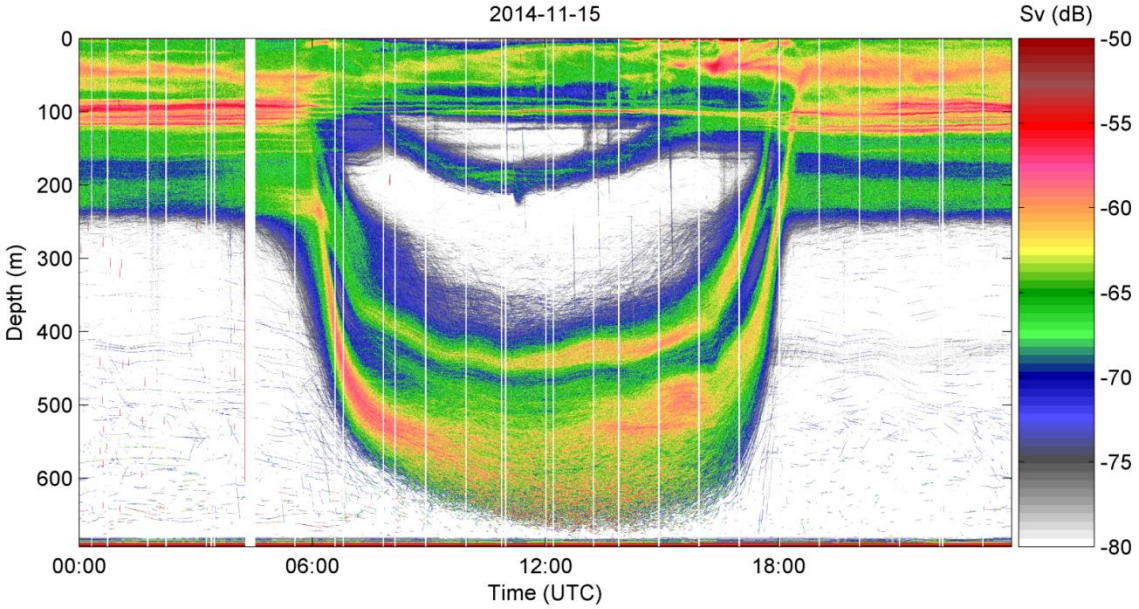
Holliday et al. (1989)
J Cons Int Explor Mer

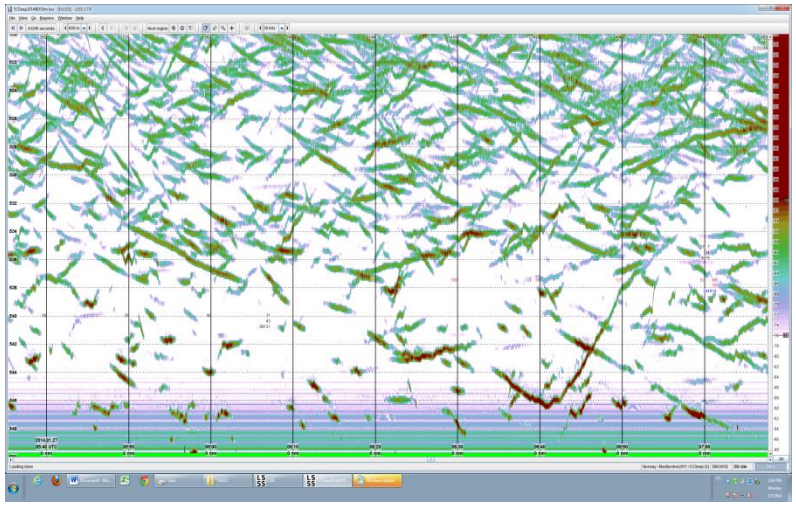
Functioning of an echo sounder

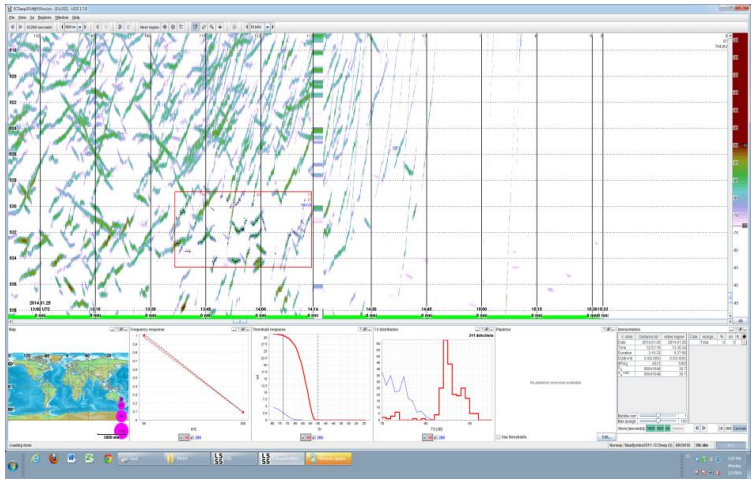


An echosounder transmits sound pulses and measures the time before an echo returns (gives range). The strenght of the echo is a proxy for biomass (volume backscatter) or size (target strength)

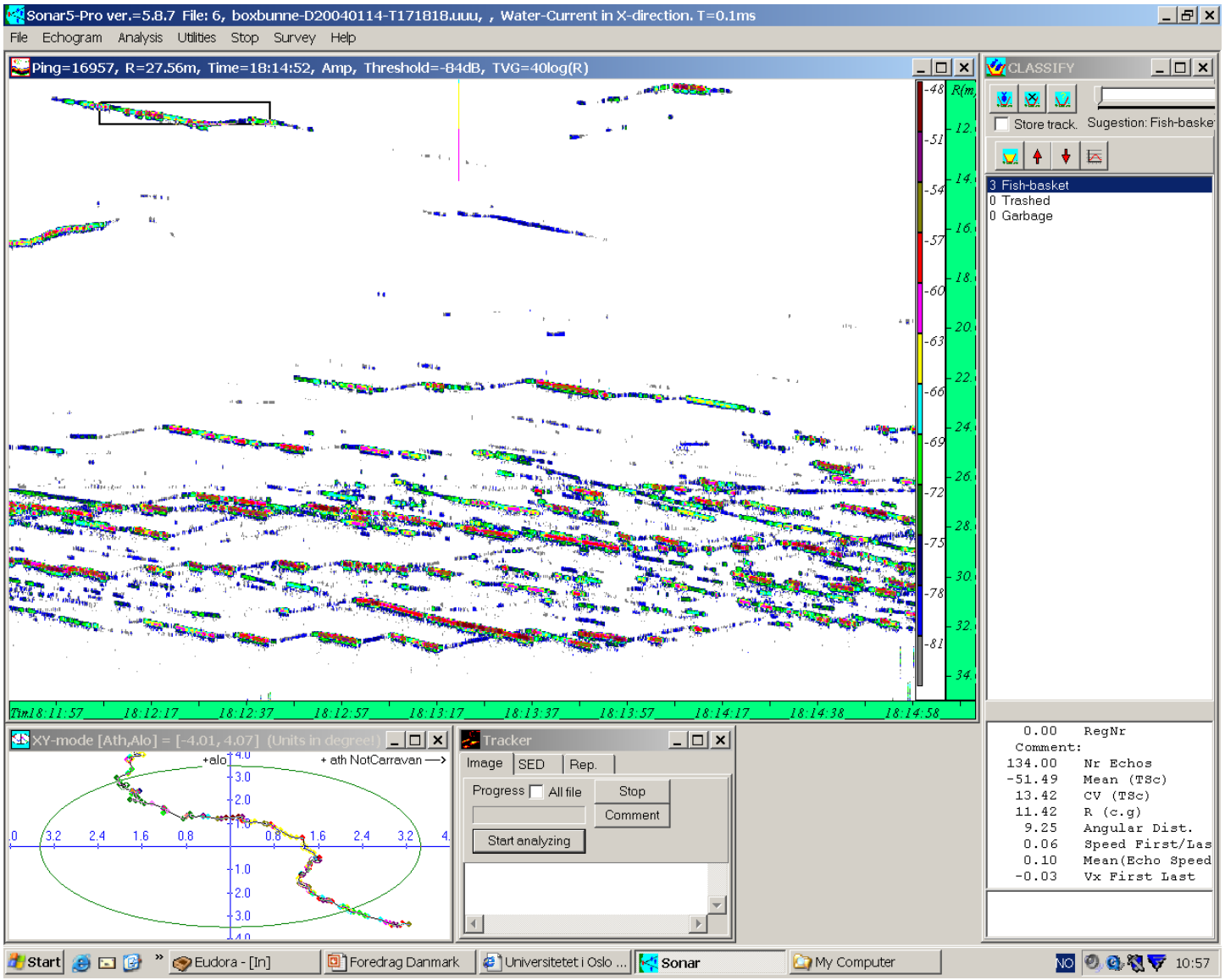
Echograms display range vs time, colors refer to strength of echoes (Red Sea)







Individuals can also be tracked accross the acoustic beam

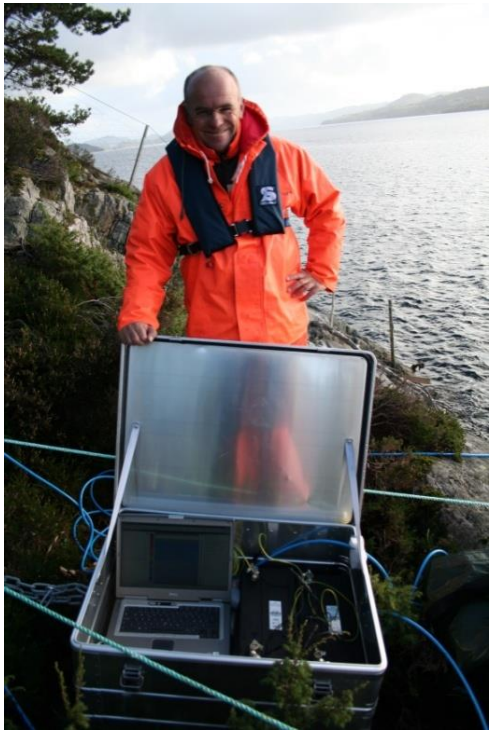


Use of stationary, submerged echosounders

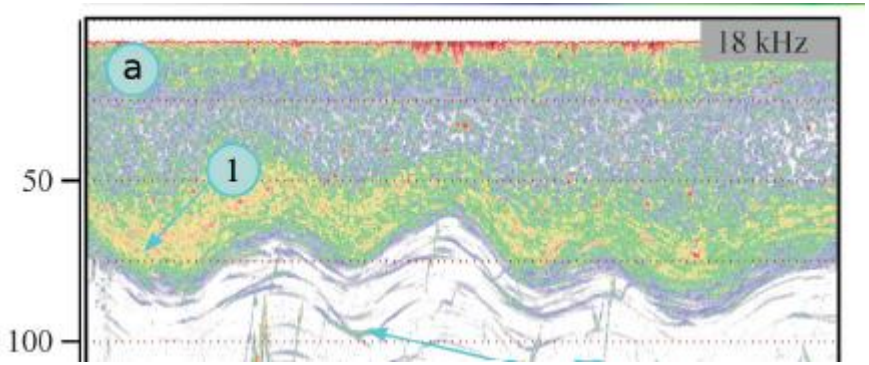
- Why echosounders?
  - “See” at long range, non-intrusive, provide information on abundance, distribution, size and behavior
- Why stationary?
  - Many successive echoes from same organism facilitates behavioral studies
- Why submerged?
  - High resolution in deep water

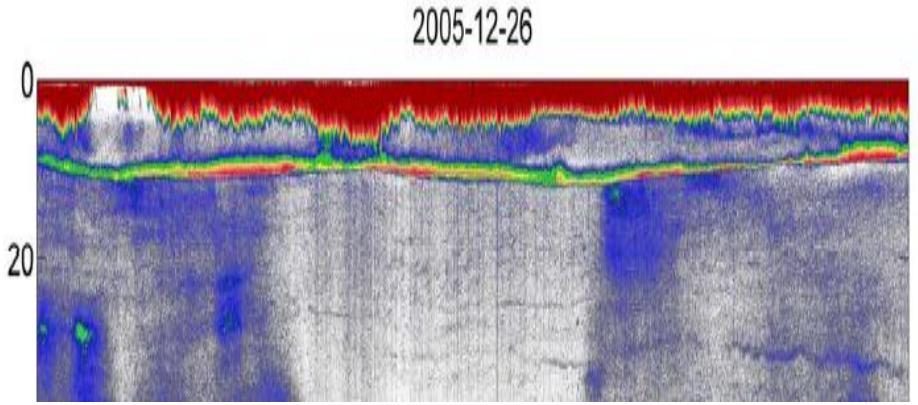
Methodological approach

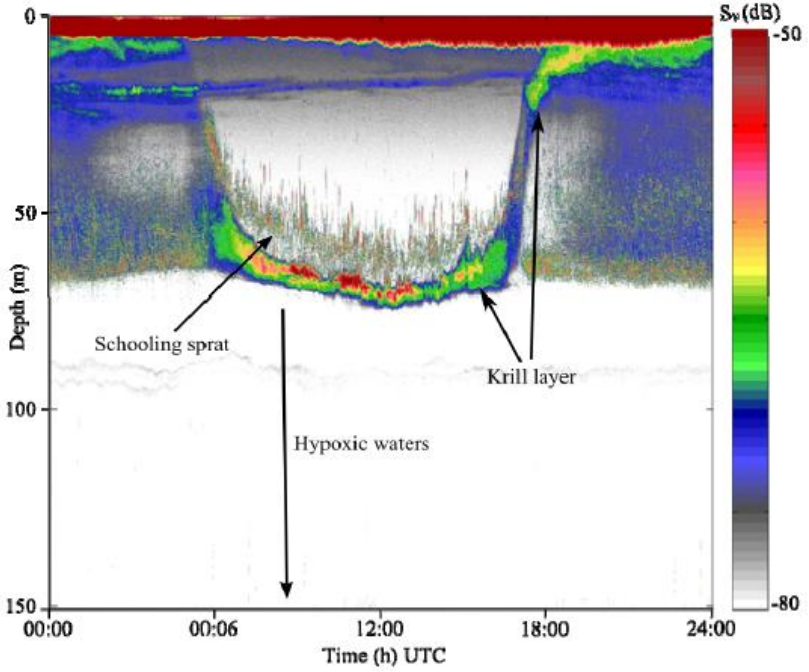
Acoustic laboratories

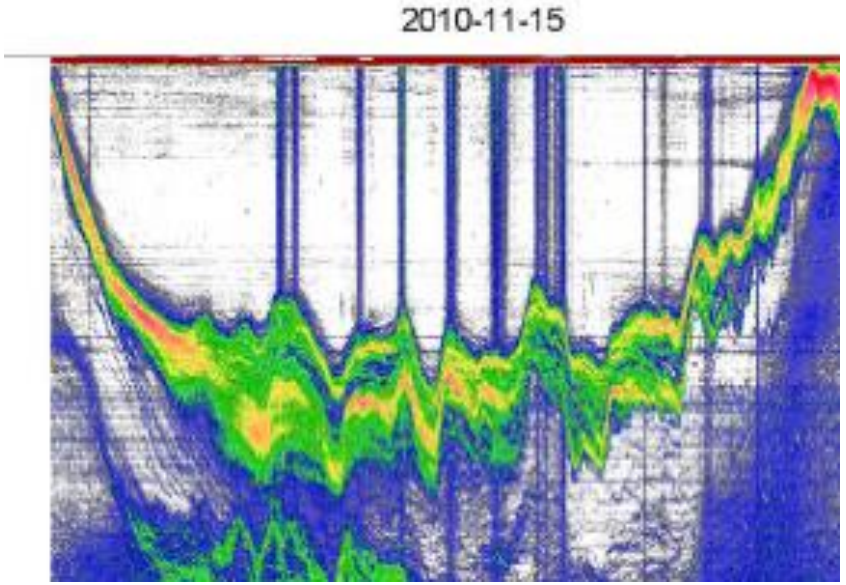


Information on environment









Zooplankton: ehosounders provide information on predators

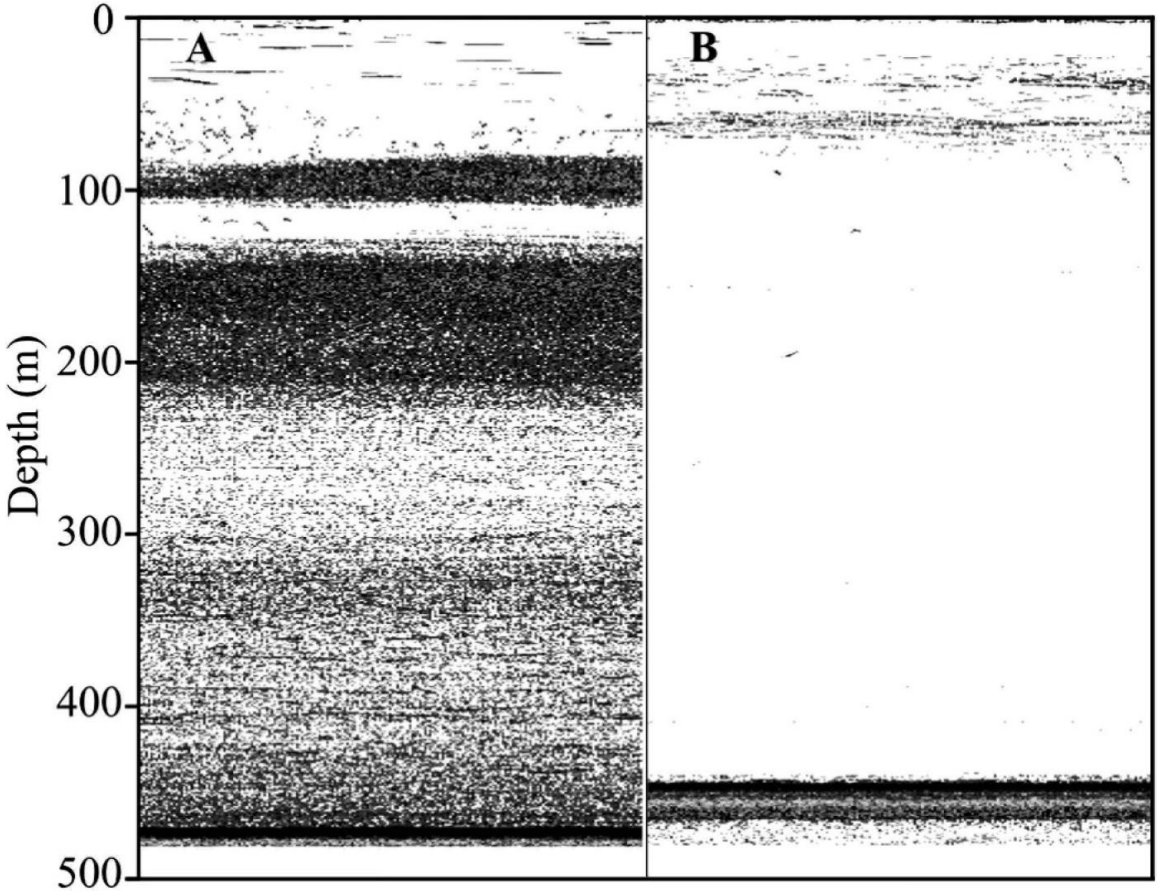
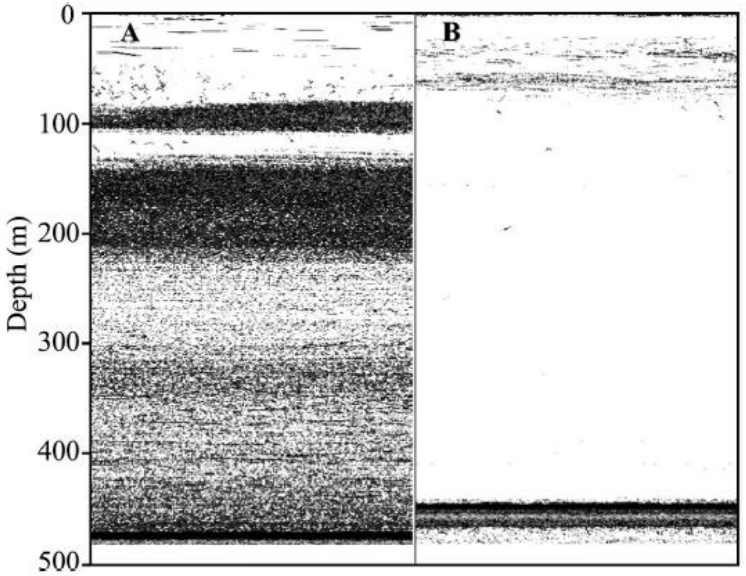


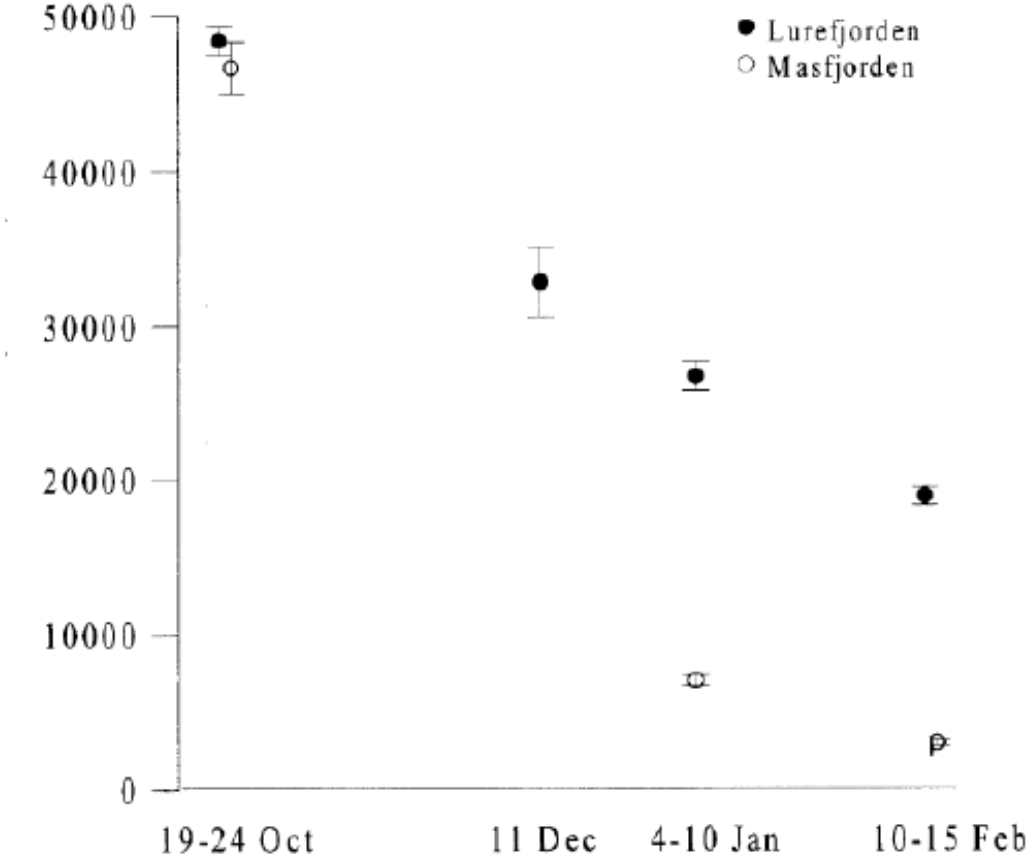
Fig. 1. Daytime echograms (38 kHz) from (A) Masfjorden and (B) Lurefjorden 06 and 07 November 2004, applying a Sv-threshold of −75 dB.

Mortality of overwintering *Calanus spp*

Masfjorden (A): mesopelagic fish

Lurefjorden (B):Jellyfish, abundant carnivorous invertebrates





Mortality rates counterintuitive to results from plankton nets with high abundance of invertebrate predators in Lurefjorden; make sence when including acoustics

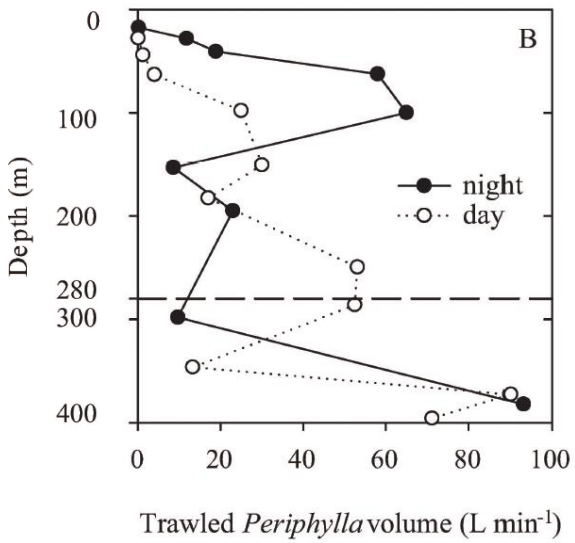
Bagøien et al. (2001) Limnol Oceanogr

Lurefjorden

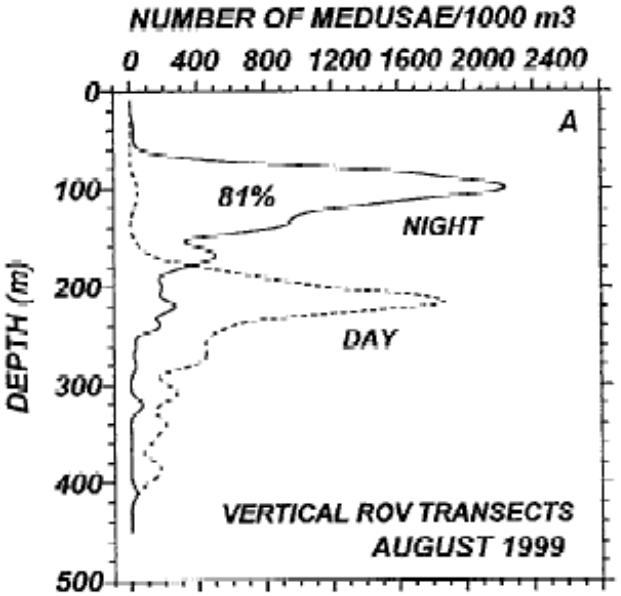
- 440 m deep, very enclosed
- The jellyfish *Periphylla periphylla* dominates the mesopelagic fauna (also other invertebrate predators very abundant)
- Mesopelagic fish are lacking

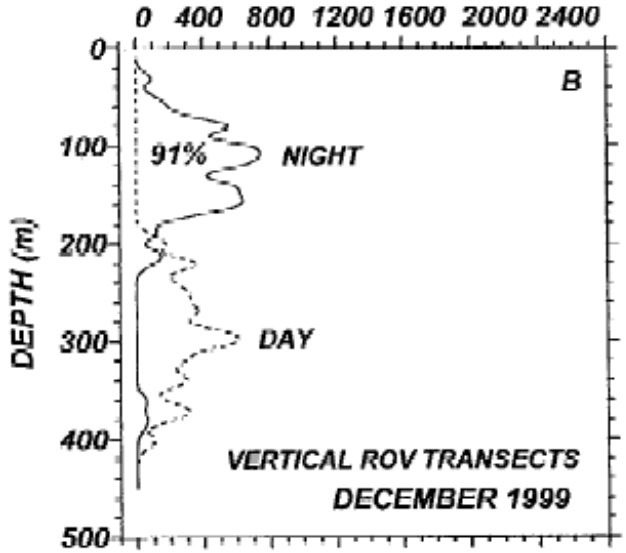

Trawling for 2 minutes

DVM of *Periphylla* revealed from trawling and ROV



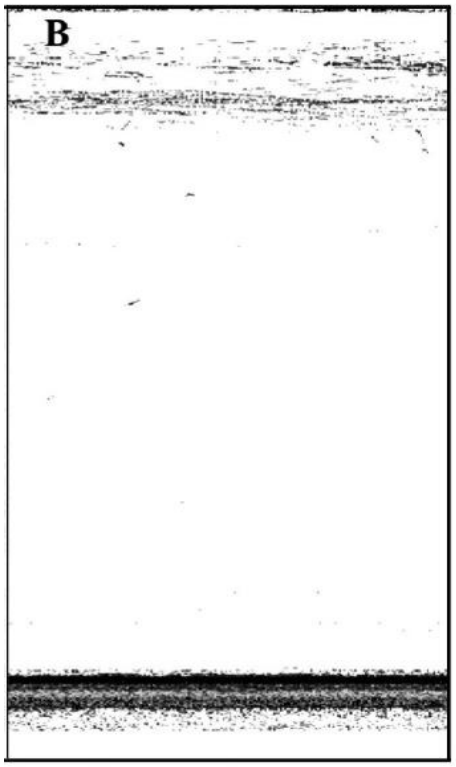
Kaartvedt et al. (2011) Limnol Oceanogr

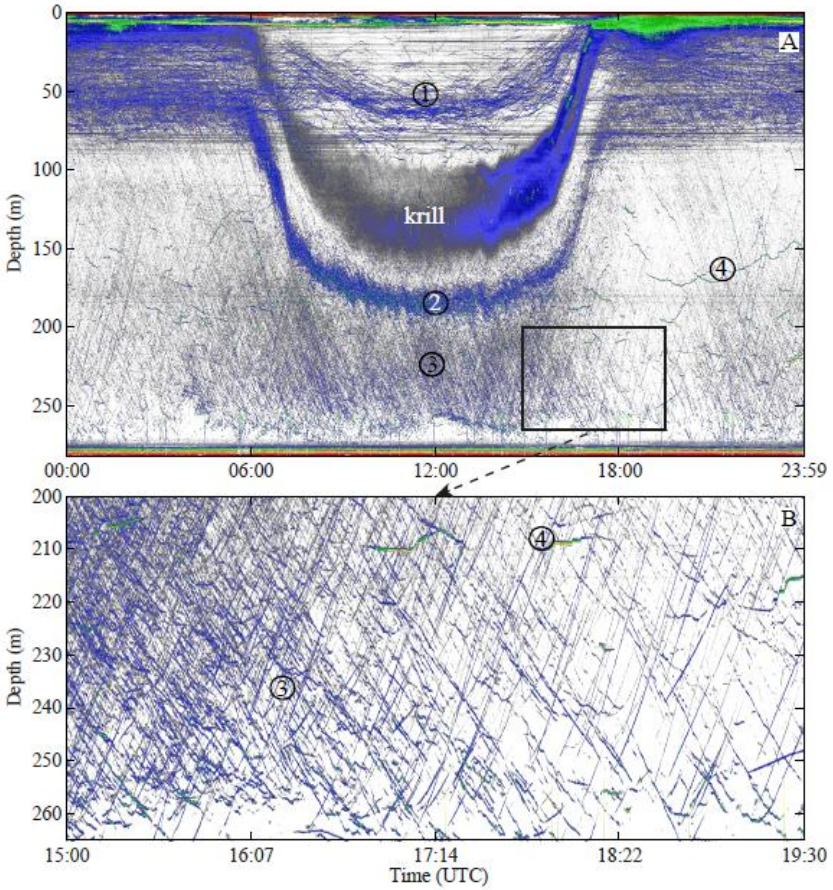




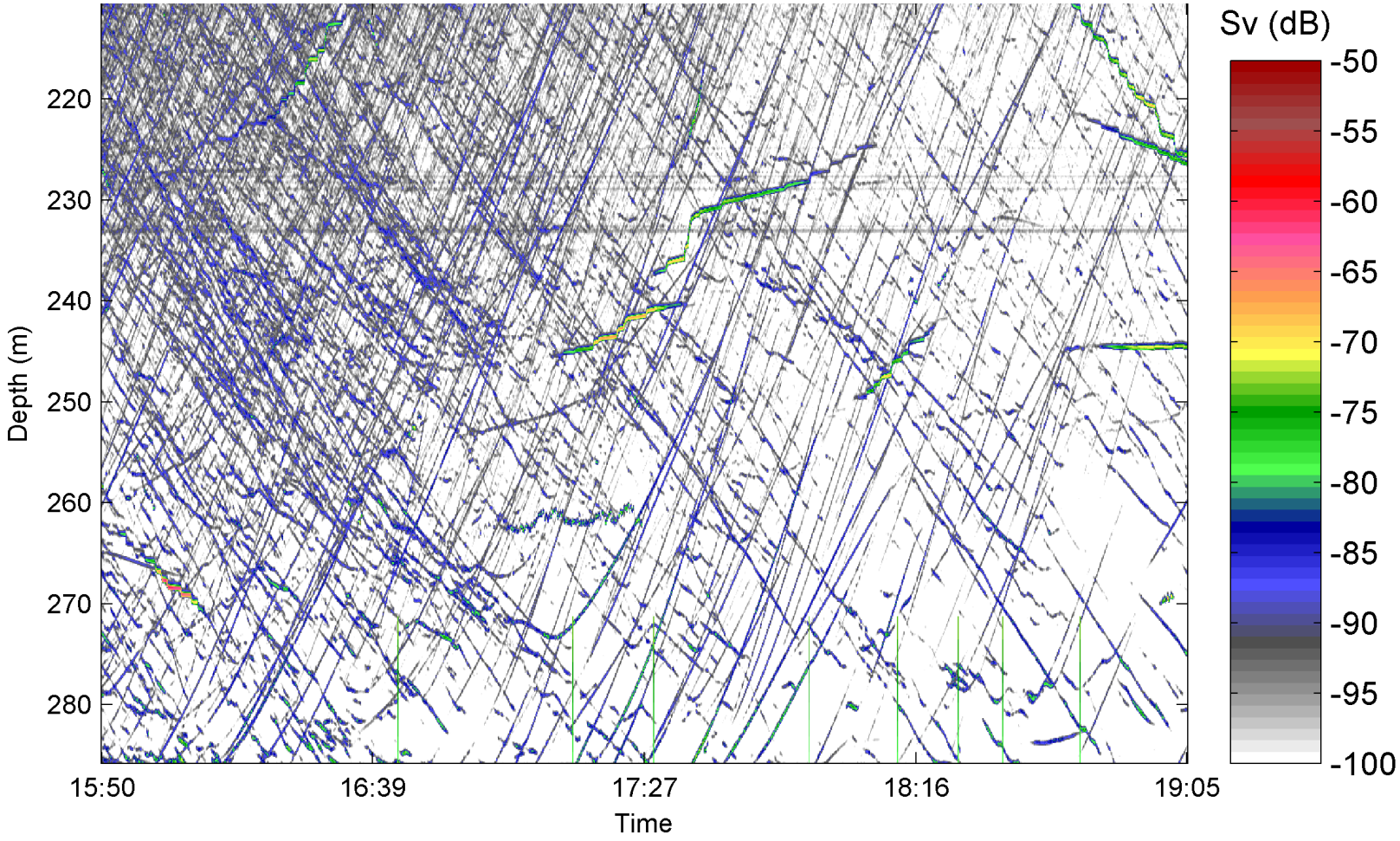
Yongbluth & Båmstedt (2001)
Hydrobiologia

Detection depends on settings (-75 dB vs -100 dB threshold at 38 kHz). Lower threshold reveals mixture of synchronous and asynchronous migration in jellyfish



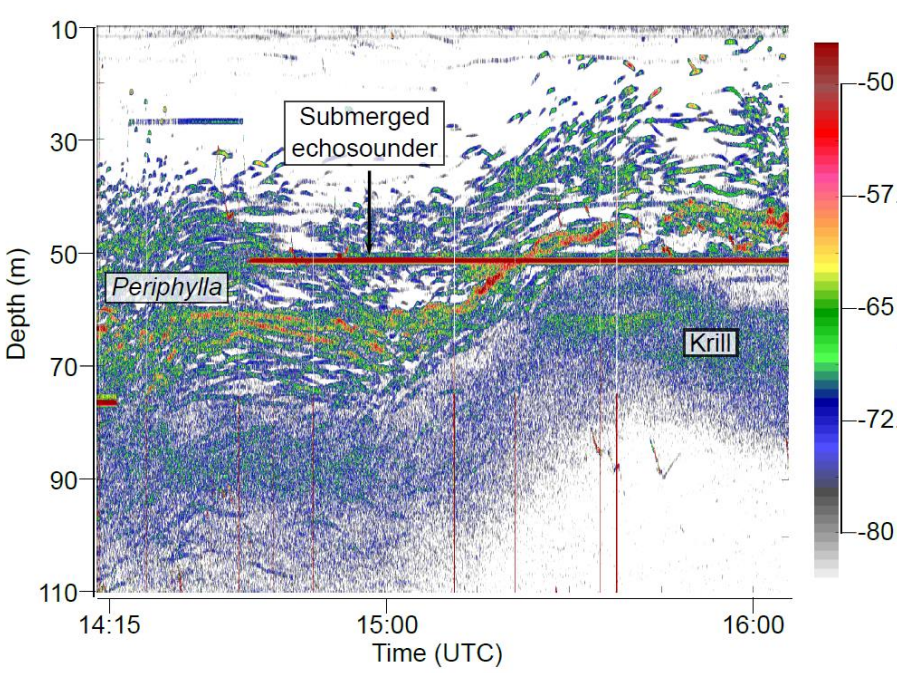


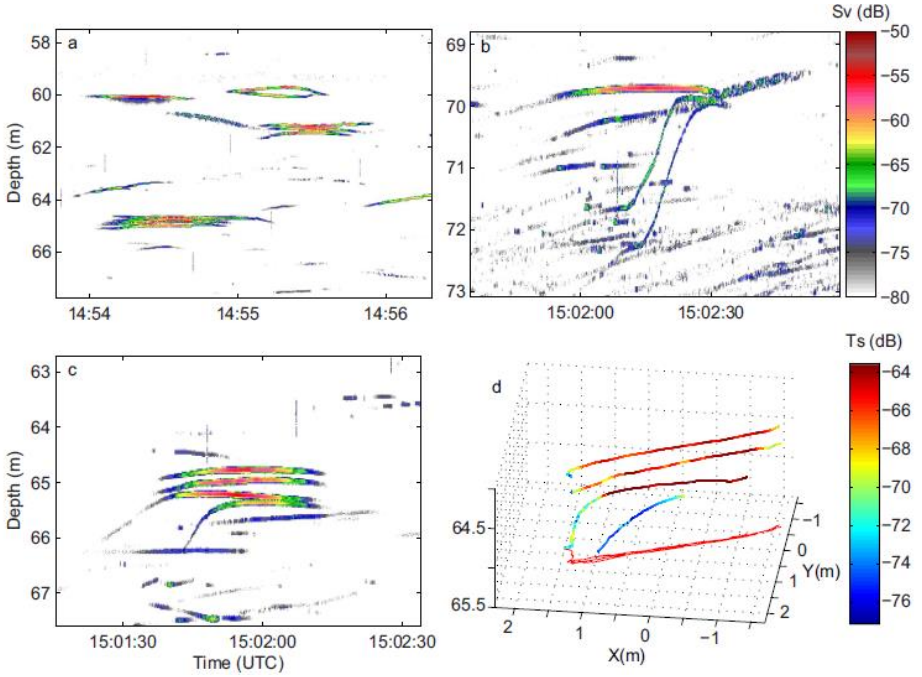
Kaartvedt et al. (2011)
Limnol Oceanogr



- The simplest organism in the animal kingdom displays diverse DVM-behavior (what about other plankton?)
- But there is more:

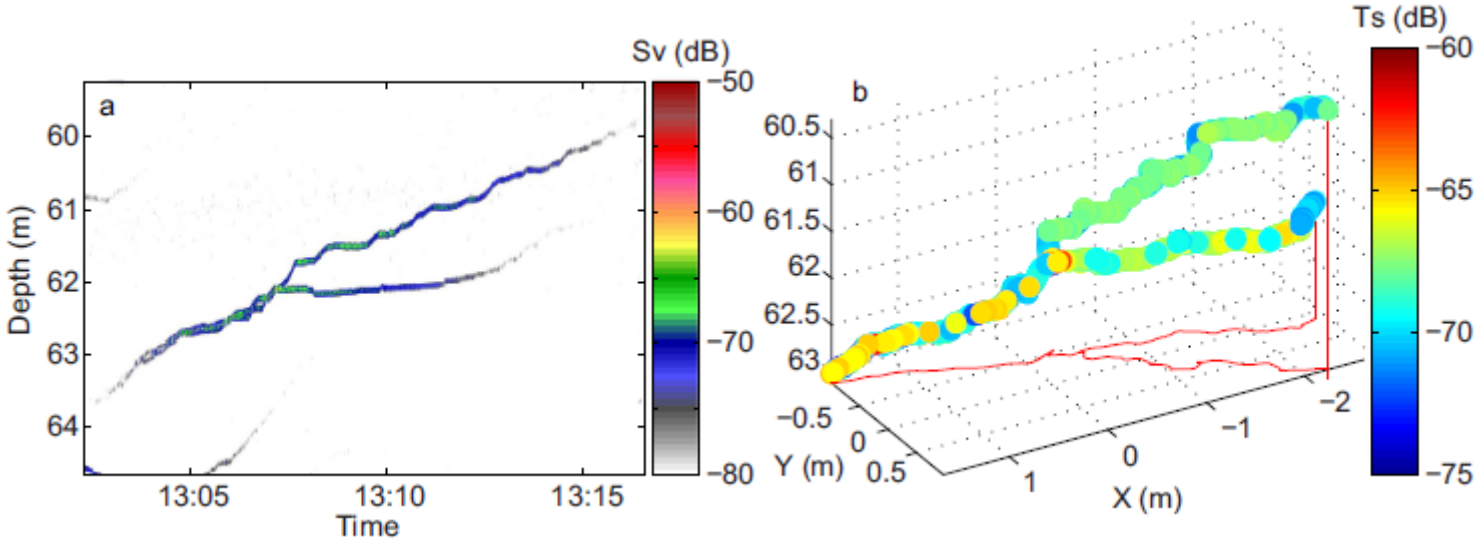
Echograms from hull mounted transducer left; submerged echosounder right

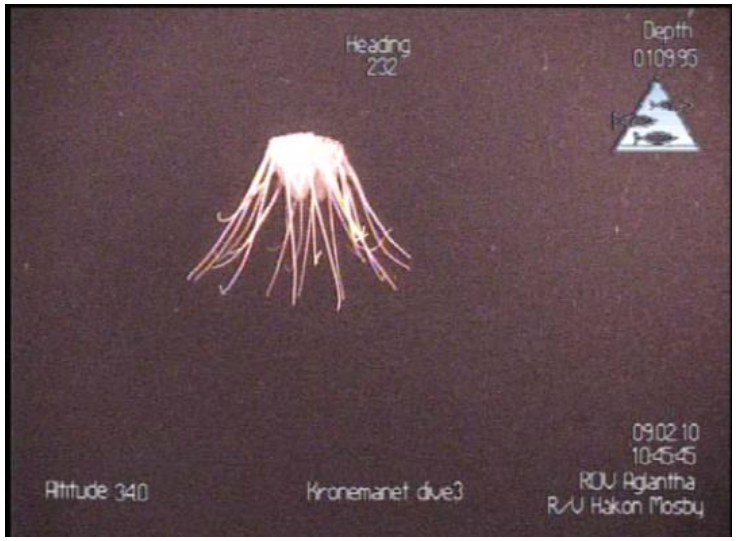


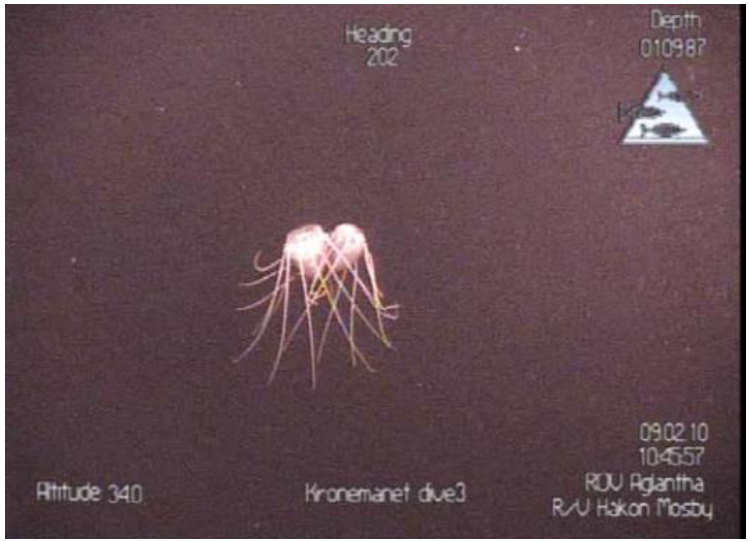


Kaartvedt et al. (2015) Sci Rep

Further documentation of group formation from deployed echosounder and ROV

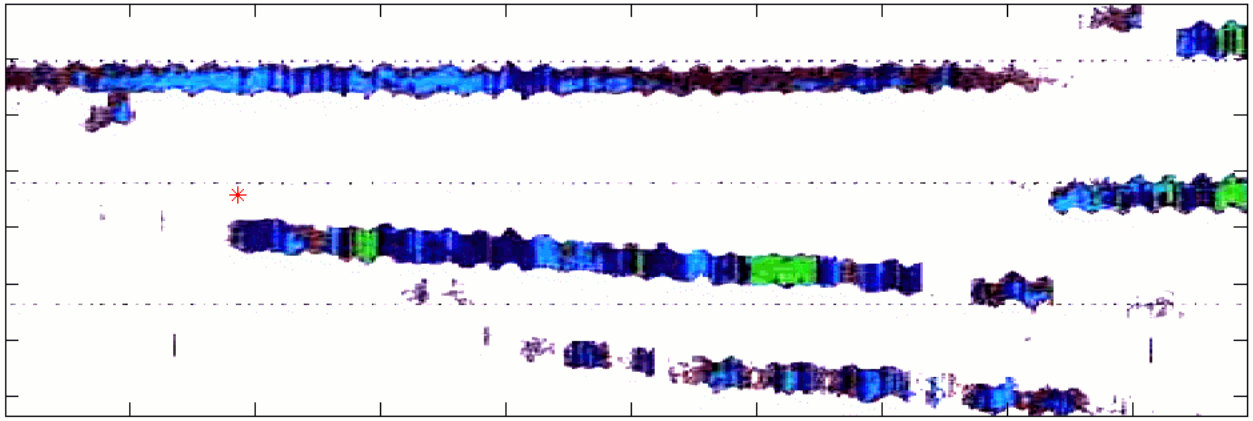


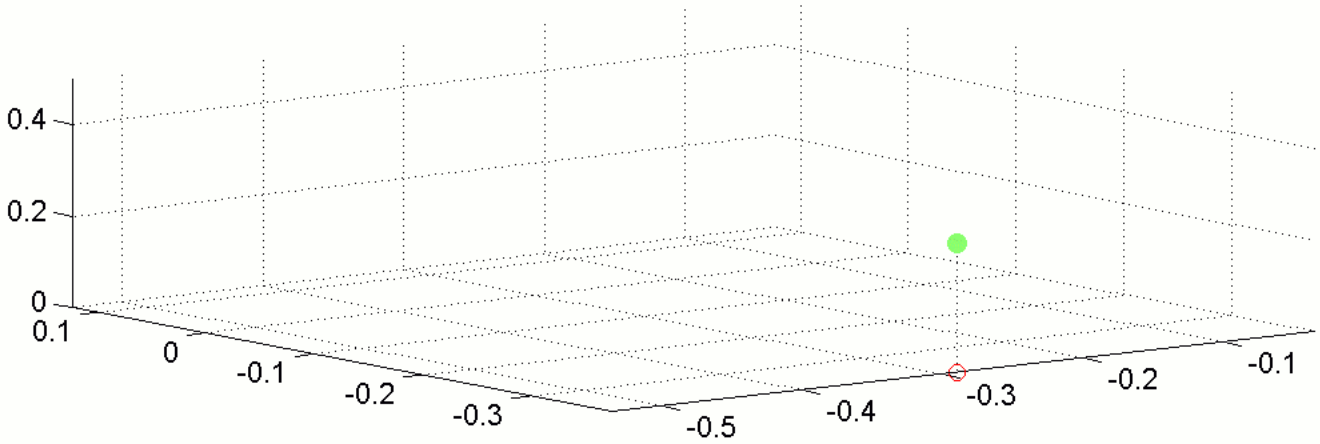




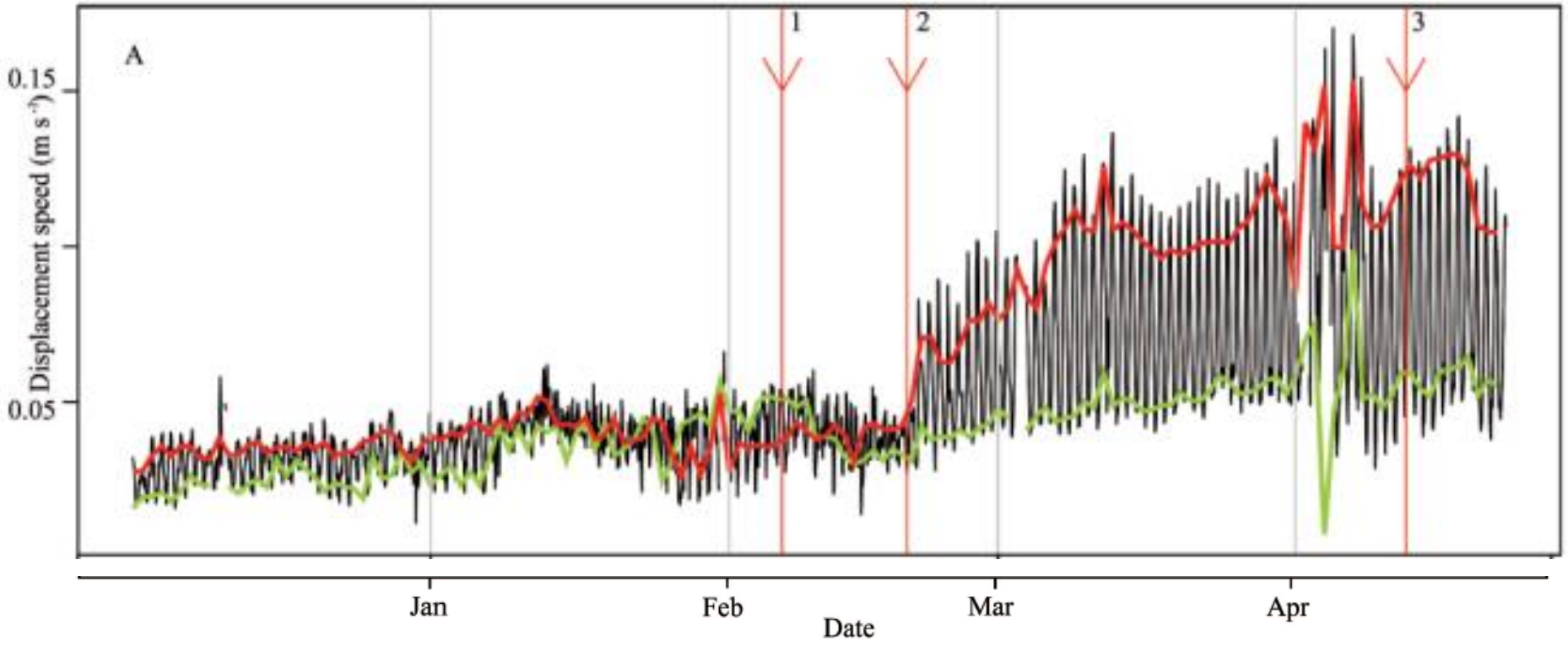
Krill swimming speed in deep water (> 100 m) day and night

In situ swimming path of krill



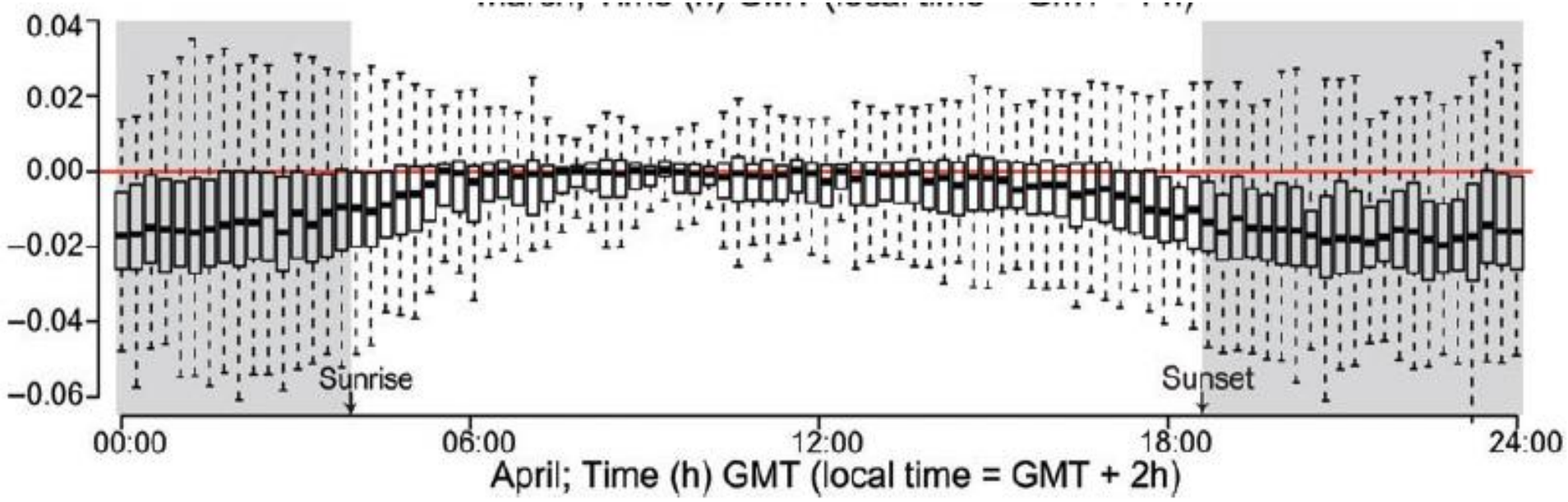


Horizontal swimming speed day (green) and night (red)
«2» water renewal = more oxygen (120 kHz)



Klevjer & Kaartvedt (2011) Limnol Oceanogr

Diel vertical swimming speed «What goes up, most come down» (Isaac Newton)

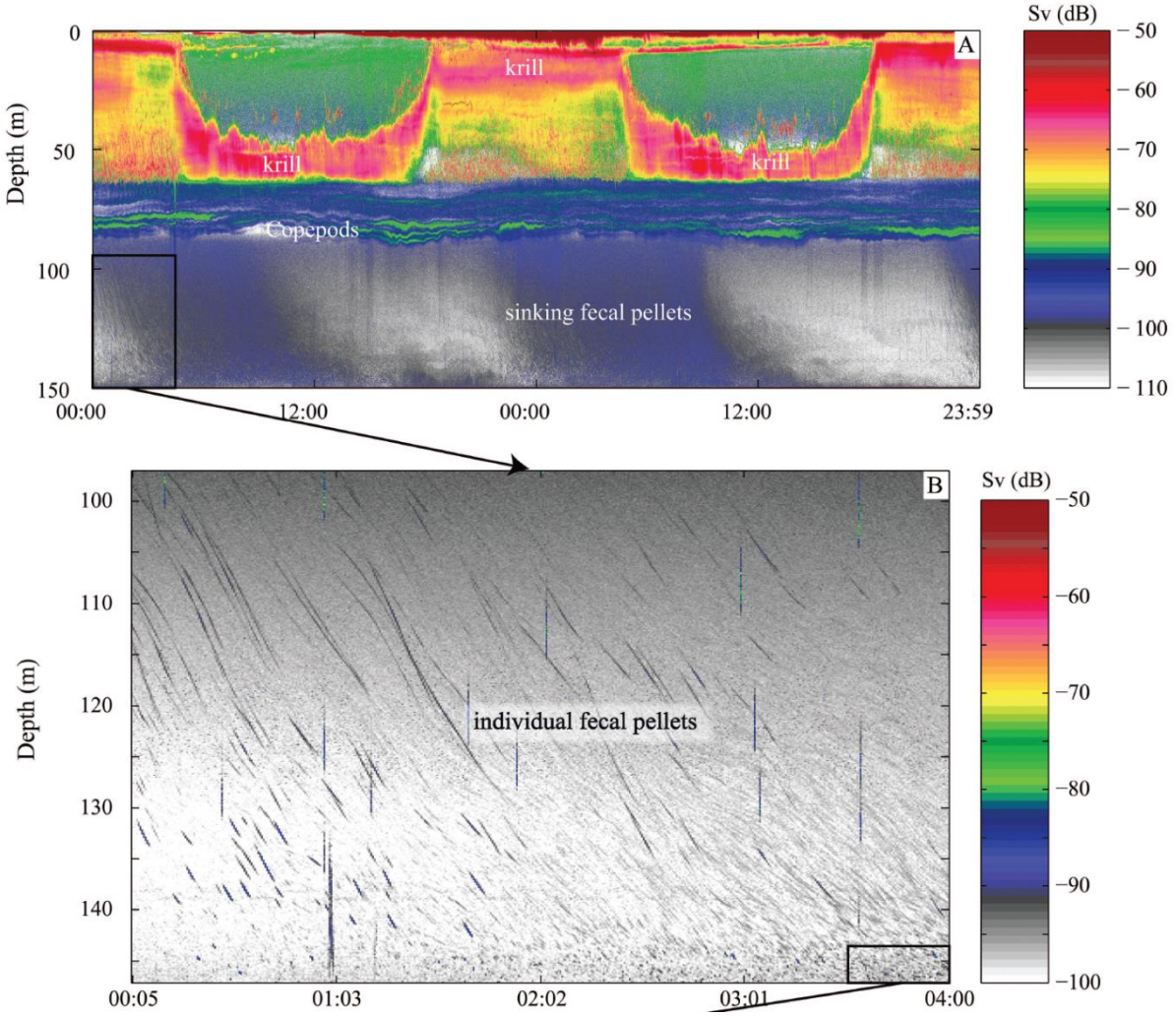


Average (n=18285) tracks at ~130-120 m for 6 days

Vestheim et al. (2014) J Plankton Res

Acoustic measurements of krill DVM and fecal pellet production (200 kHz)

- Krill DVM
- Avoidance hypoxy (ca 7% saturation)
- Krill feeding pattern
- Time to fill guts
- Gut evacuation
- Pellet sinking rate
- (copepods in hypoxic waters)



Røstad & Kaartvedt (2013) Limnol Oceanogr

Pellet sinking speed (400-800 m day^{-1})

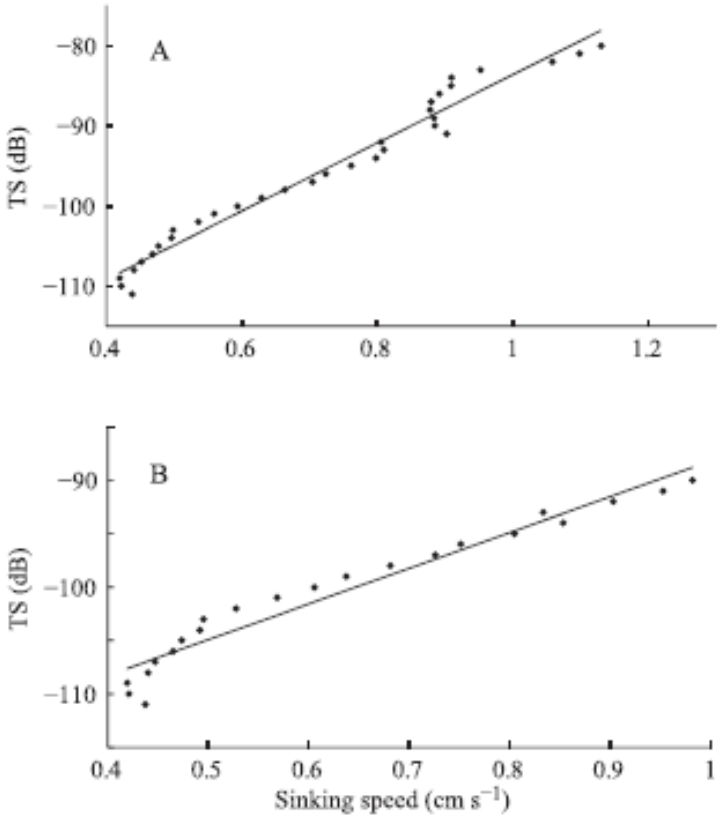


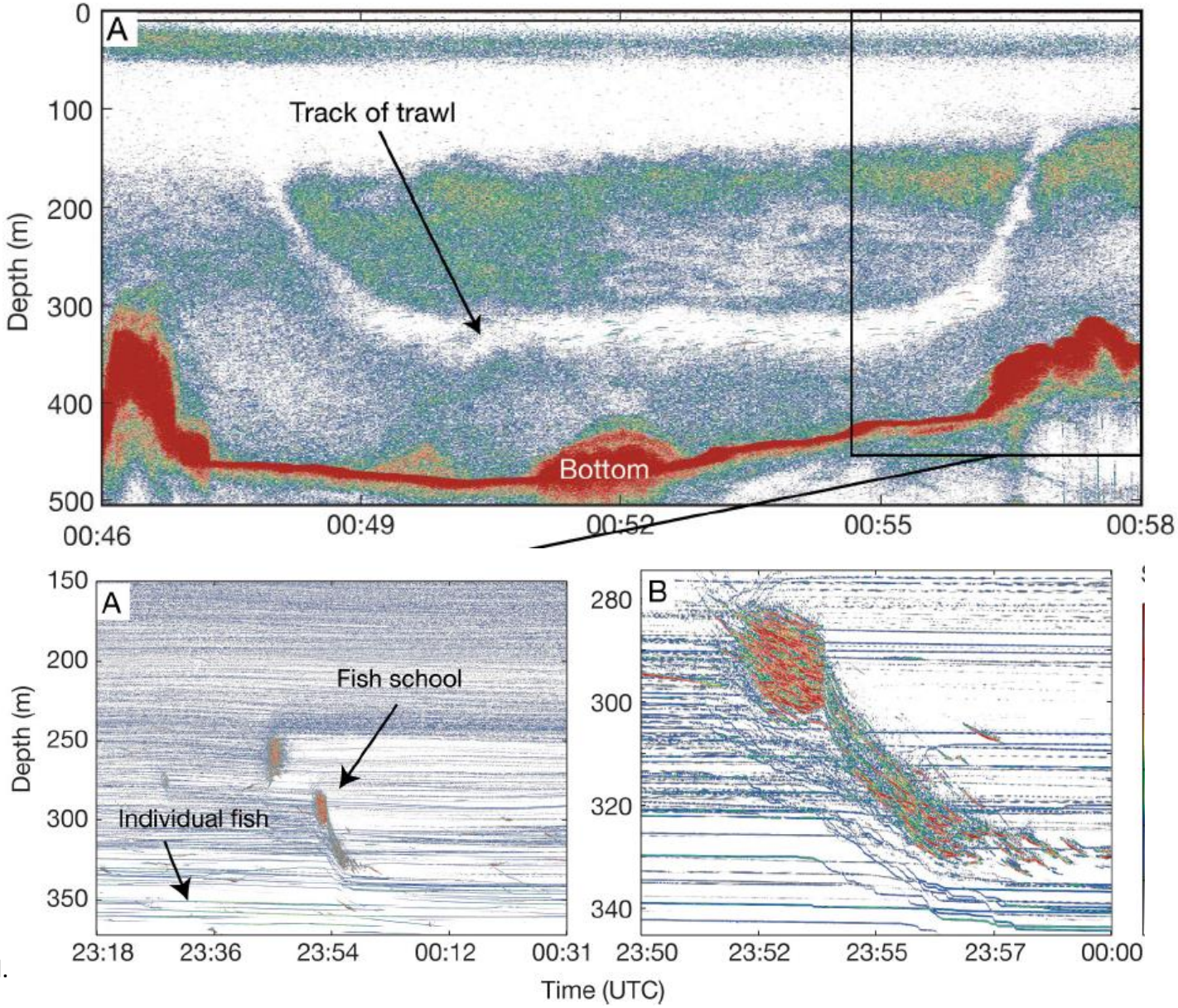
Fig. 13. Linear correlation between sinking speed and TS. Each point is average of all speeds for each dB of TS. (A) represents all particles tracked from 2 m to 40 m from the transducer and (B) particles tracked 2–5 m from the transducer.

Mesopelagic fish (200-1000 m)

Why focus on mesopelagic fish as plankton ecologist?

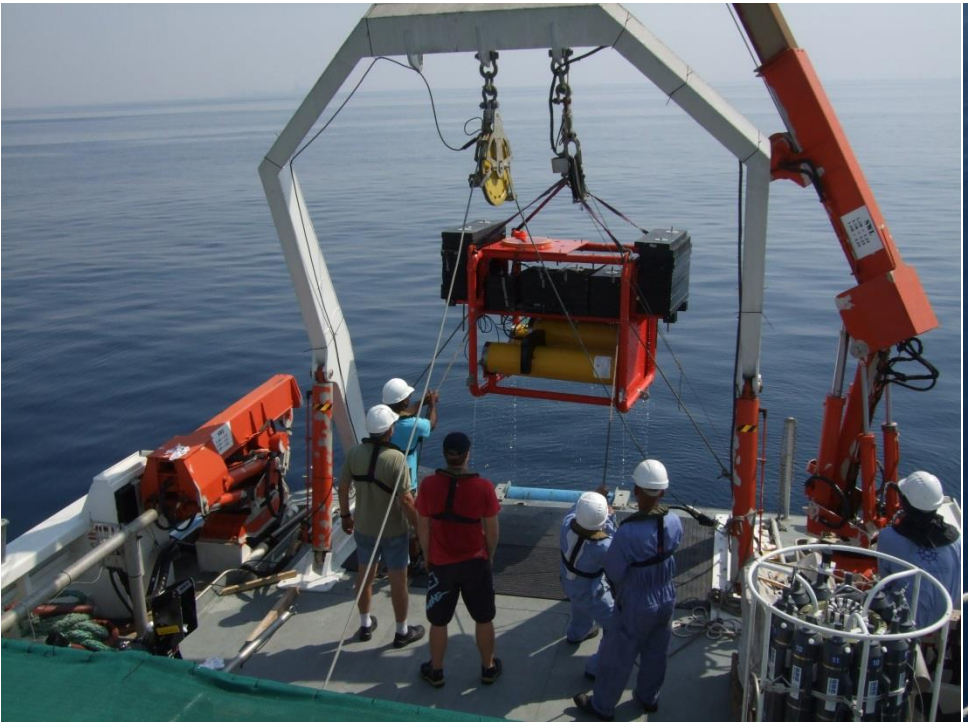
- Ref mortality overwintering *Calanus*
- Hernández-León et al. (2001, 2008, 2010): Mortality of zooplankton related to moon cycle, multiply at full moon
- Session on macroplankton
- Use of ADCPs – remember: high frequency echosounders still see fish
- Global abundance based on net tows 1 billion tonne
- Acoustics 10 billion tonne (for comparison global yearly fisheries 100 million tonne)
- How realistic are abundance estimates based on nets? (And acoustics?)

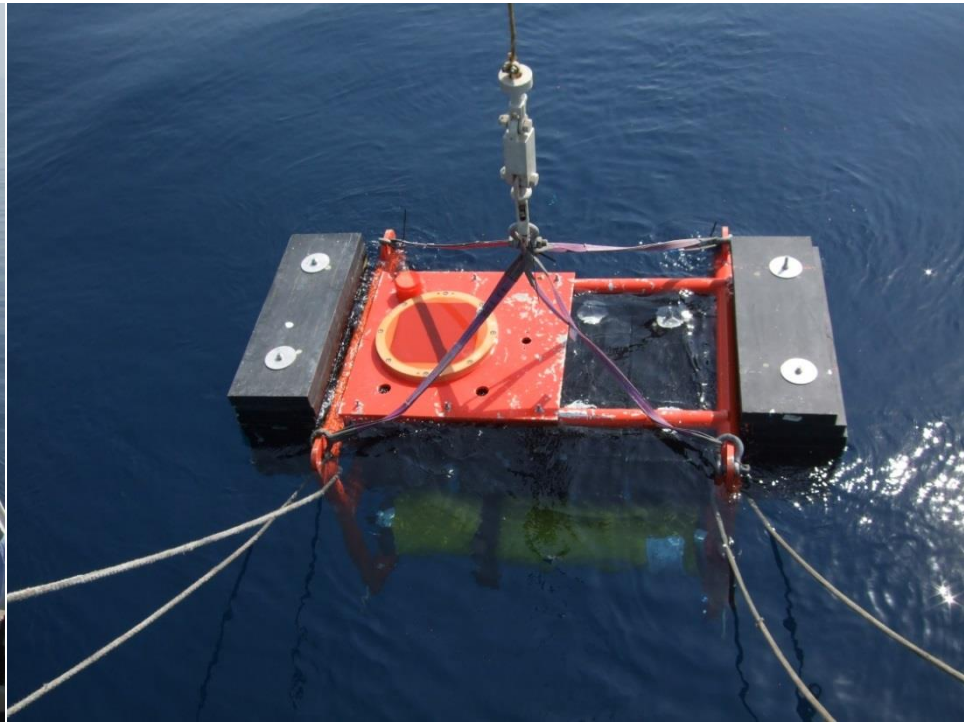
Avoidance of trawl and predators



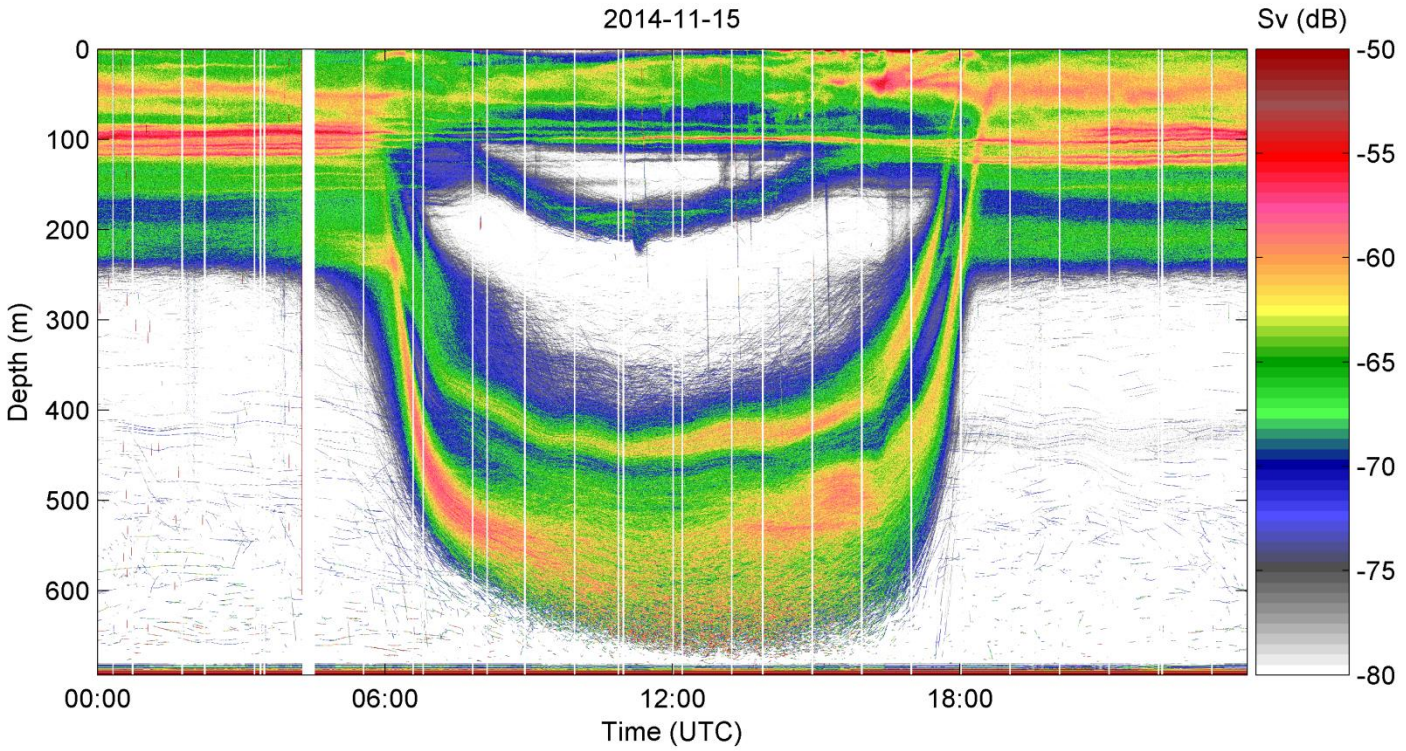
Kaartvedt et al. (2012) MEPS

Deployment of atonomous echosounder in the Red Sea

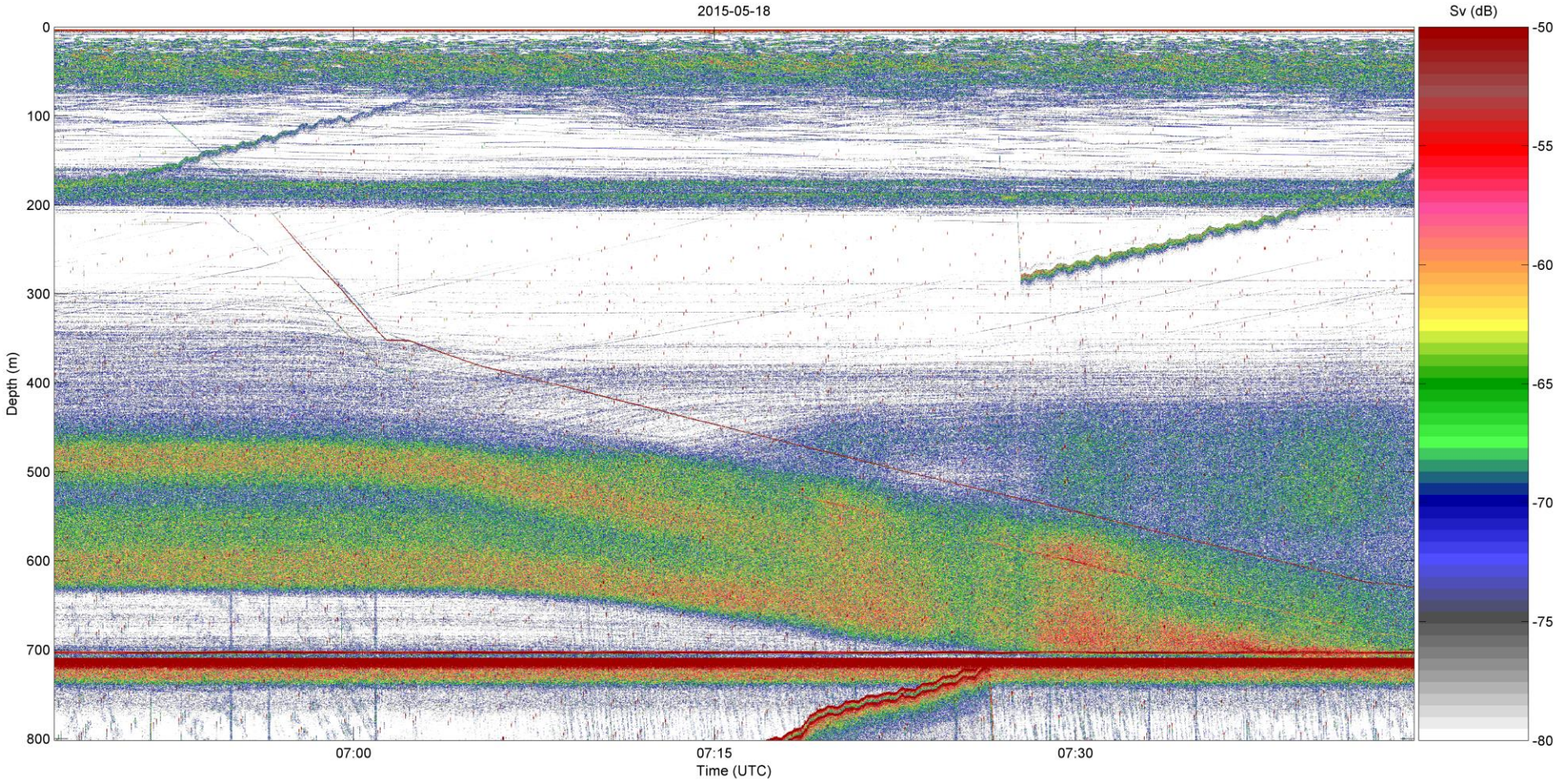




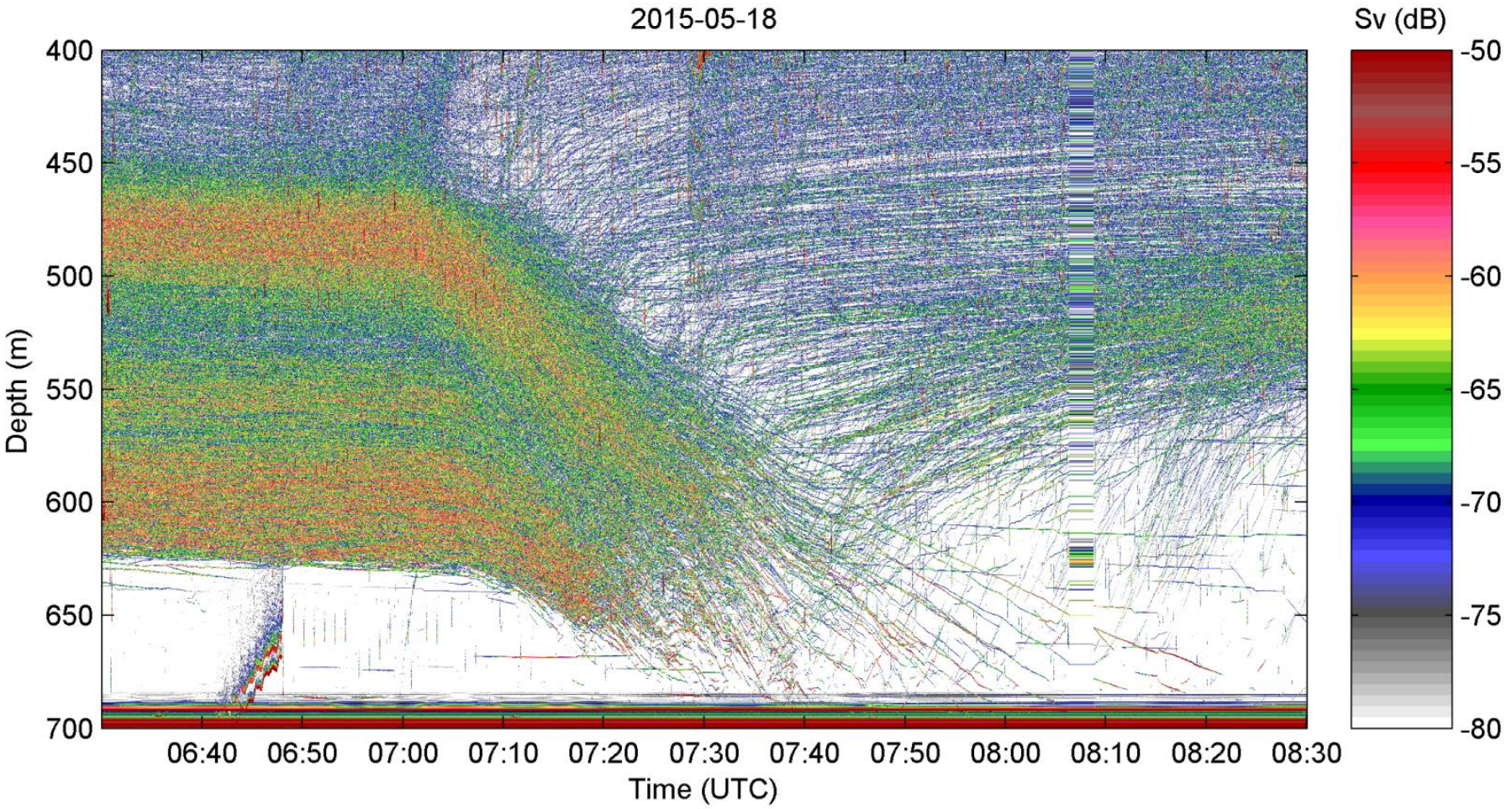
Example diel echogram Red Sea (38 kHz)

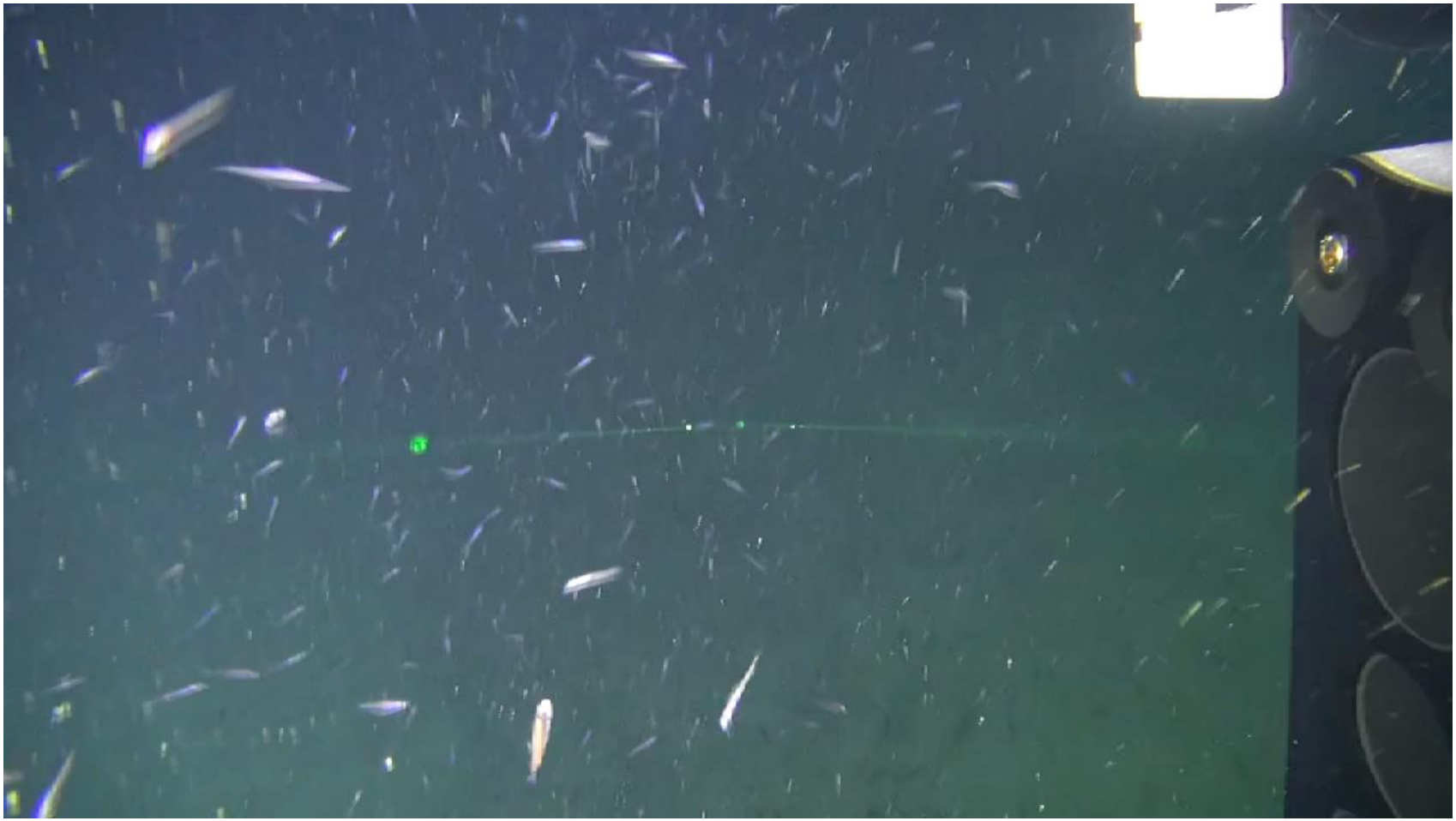


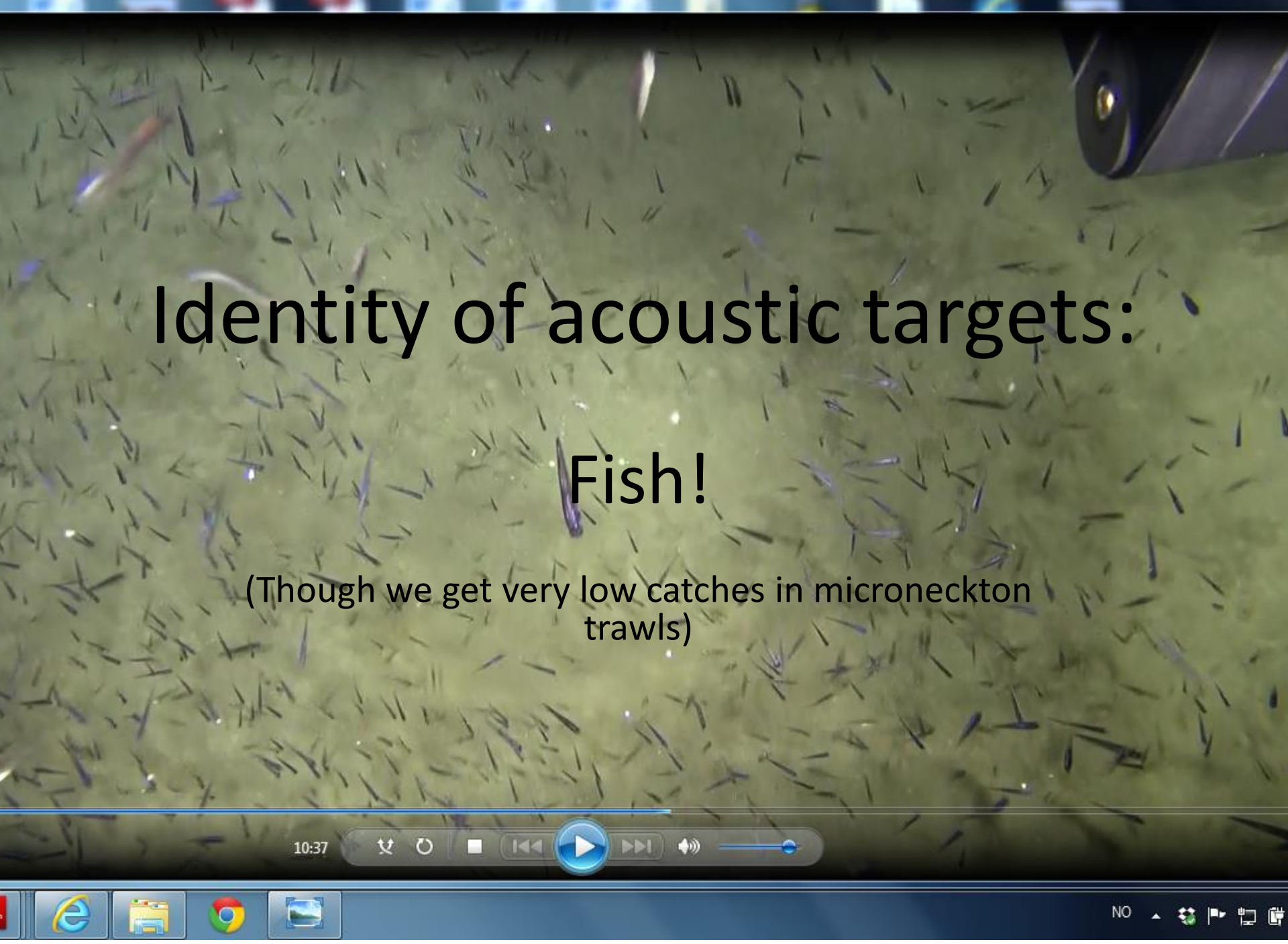
Both for abundance estimate and e.g. behavioral studies we want to know the identities of the acoustic targets (Echogram from hull-mounted 38 kHz)



Echogram from upwardlooking echsounder deployed on the bottom (38 kHz)






Identity of acoustic targets:
Fish!
(Though we get very low catches in microneckton trawls)
10:37
NO

Acknowledgement

Thor A. Klevjer

Anders Røstad