Mapping water column structures using single beam echosounder

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Seabed Acoustics Workshop 14.11.2013

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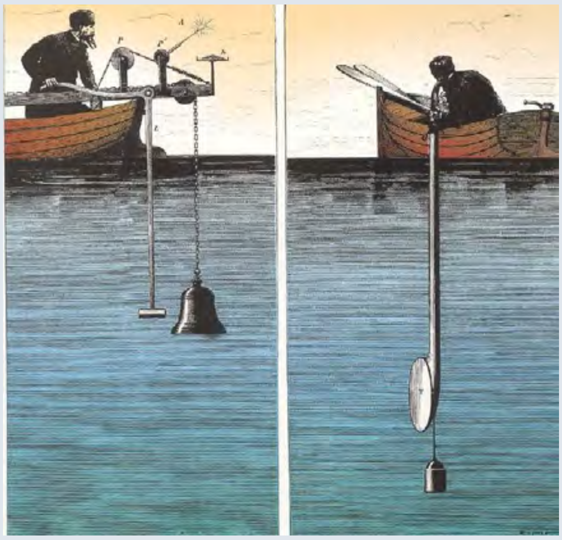

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6th Seabed Acoustics Innomar Workshop
14.11.2013
Rostock Warnemünde

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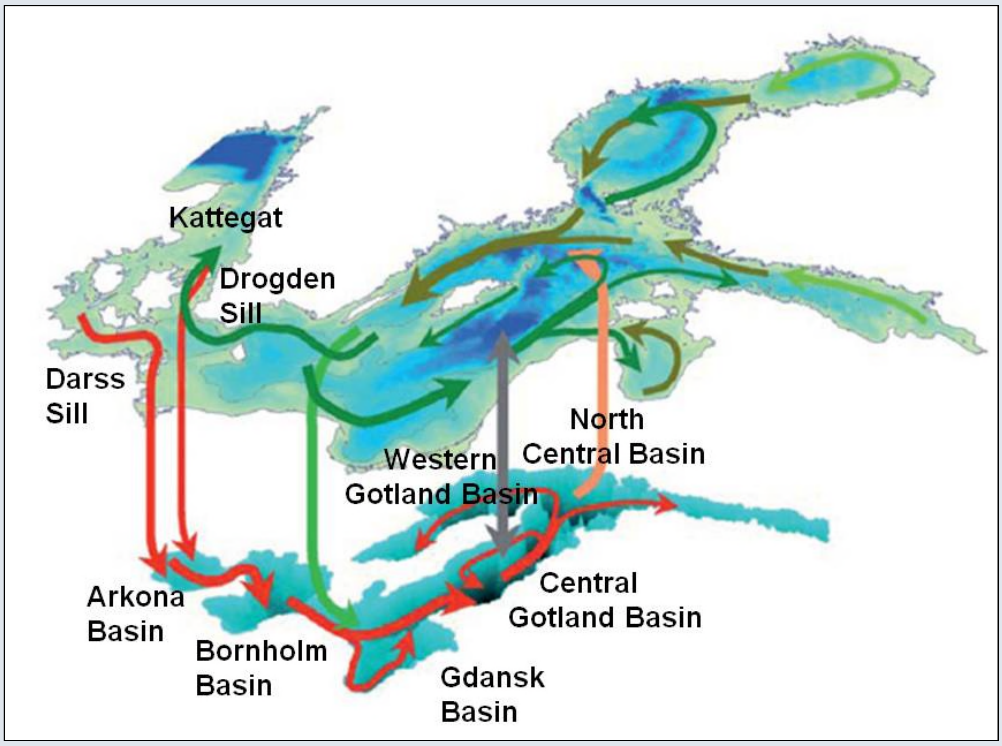
General Hydrography of the Baltic Sea



Matthäus et al. 2008, modified

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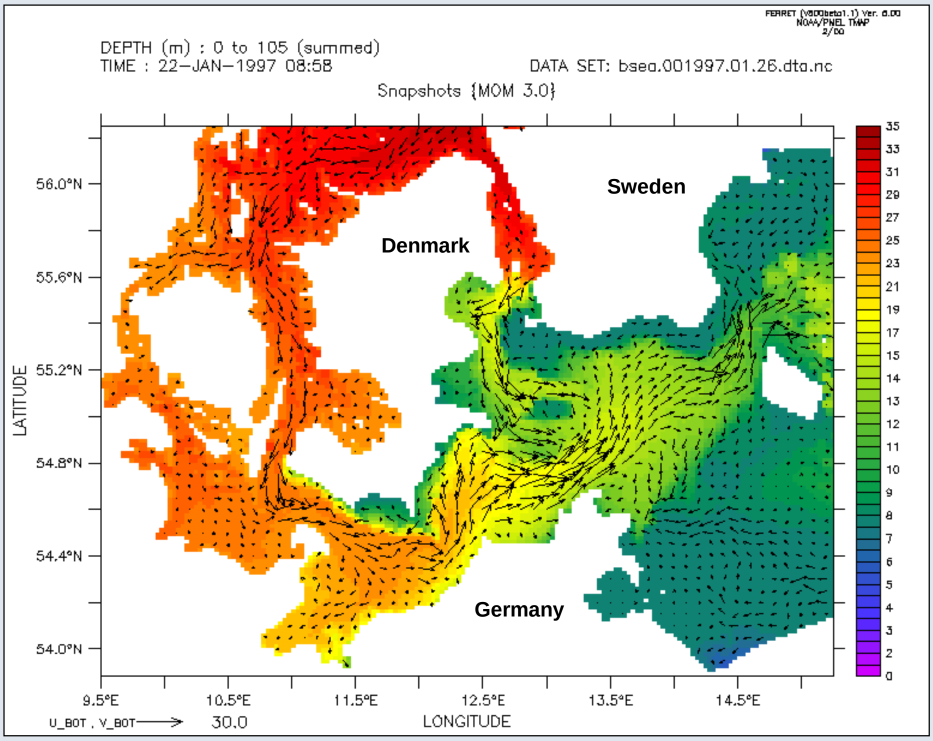
General Hydrography of the Baltic Sea



Current Velocity and Salt Content in Western Baltic, measured and modeled for 22.01.1997

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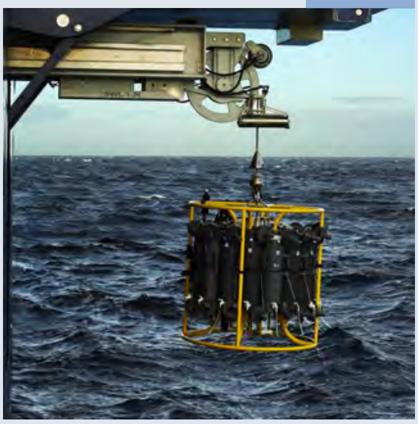
Devices for Hydrographic Investigations

Scanfish

MSS Profiler

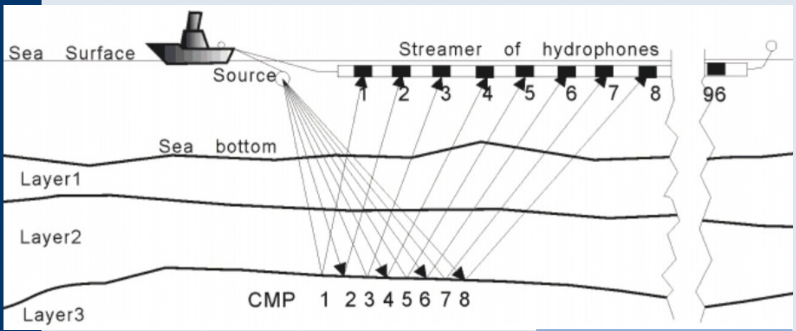
CTD



Water Sampler

Devices for Hydrographic Investigations

Acoustic Devices

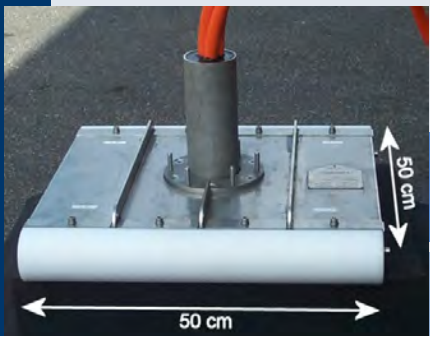


Haibin Song et al. 2012 in »Oceanography and Atmospheric Sciences » "Oceanography"

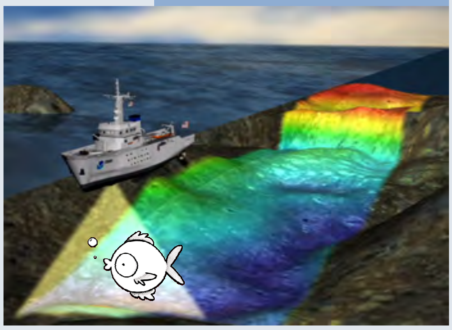
Seismic Oceanography

ADCP

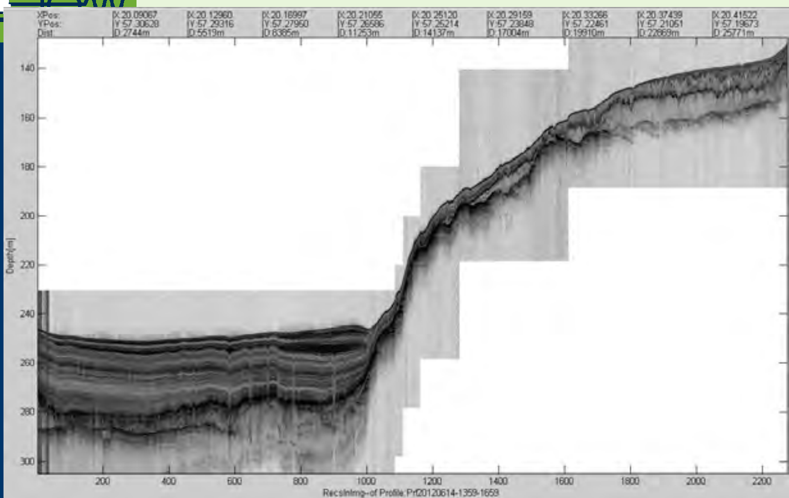
Multibeam Water Column Imaging



Single Beam Echosounder



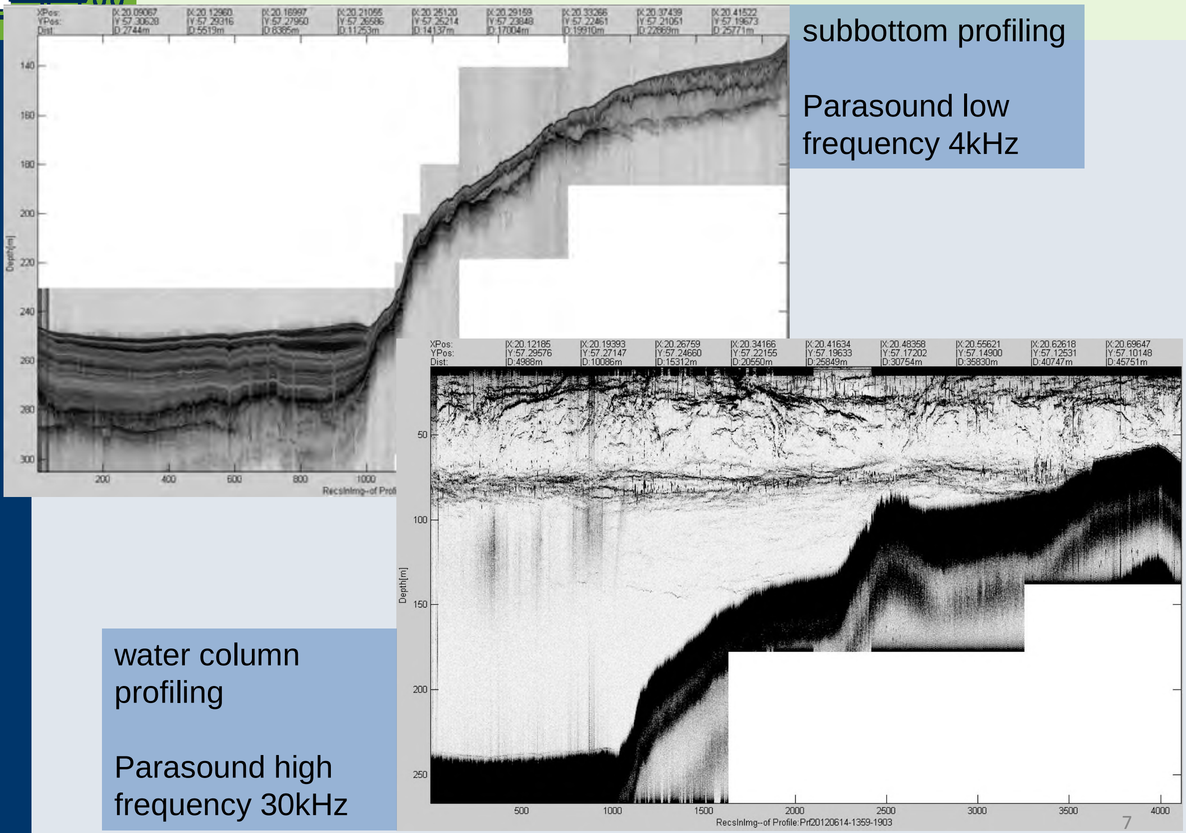
R/V Meteor Cruise M86



subbottom profiling

Parasound low frequency 4kHz

R/V Meteor Cruise M86 crossing Gotland Basin



subbottom profiling

Parasound low frequency 4kHz

water column profiling

Parasound high frequency 30kHz

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Processes Subject to Acoustical Investigation

- **Physical oceanography**
  Atmosphere-sea interactions, e.g. air bubbles
  Turbulence and mixing
  Internal waves
  Fronts
  Circulation, e.g., mesoscale, gyre, and basin-scale dynamics
  Salinity and temperature structures

- **Biological Oceanography**
  Detection, classification, and quantification of marine organisms
  Habitat characterization

- **Marine Geology**
  Investigation of benthic boundary layer, seafloor properties, sediment dynamics, gas bubbles

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Differences Water Column Profiling versus Subbottom Profiling

water column	vs.	**sediment**
easy calculation of in situ sound velocities		no direct in situ measurment of v_p, transformation of laboratory v_p data to in situ conditions with much effort
time variable layers, instable structures		time stable layers
influences by fish, plankton, seagrass		blanking by gas

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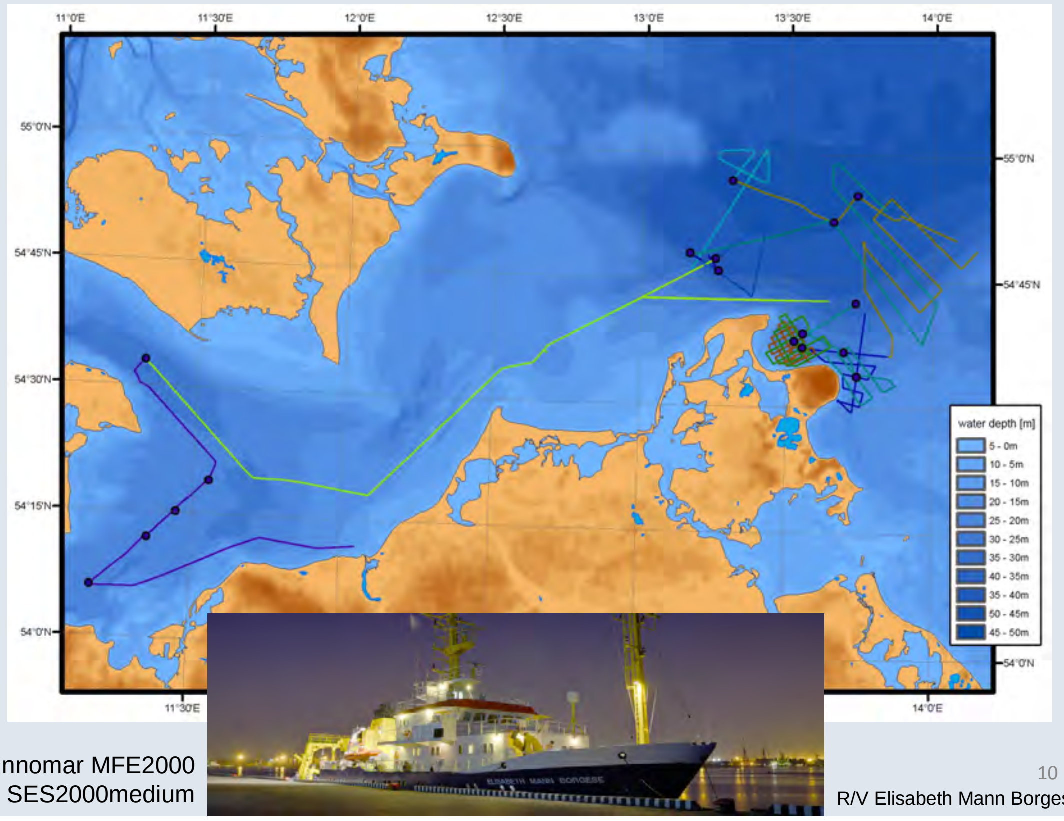
Cruise EMB058 - Oct2013



Innomar MFE2000
+ SES2000medium

R/V Elisabeth Mann Borgese

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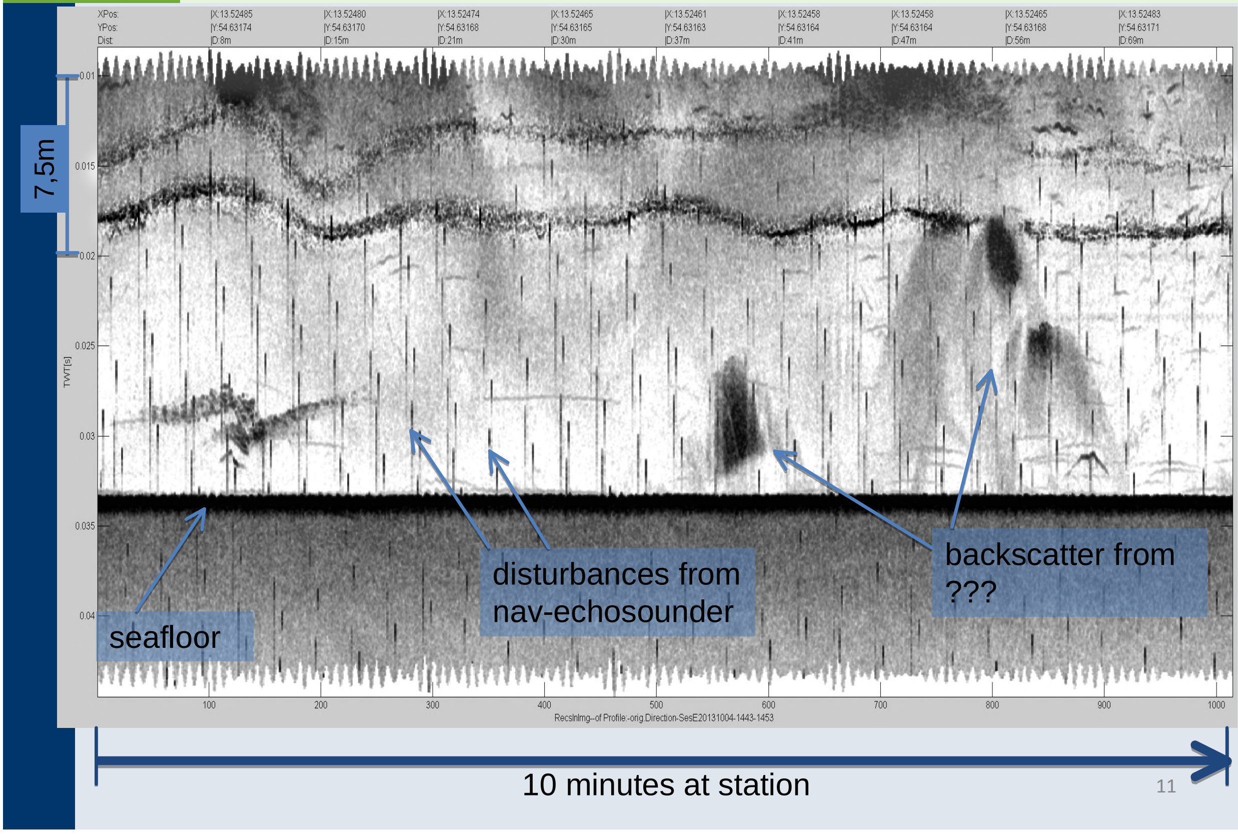
Ship Induced Internal Waves



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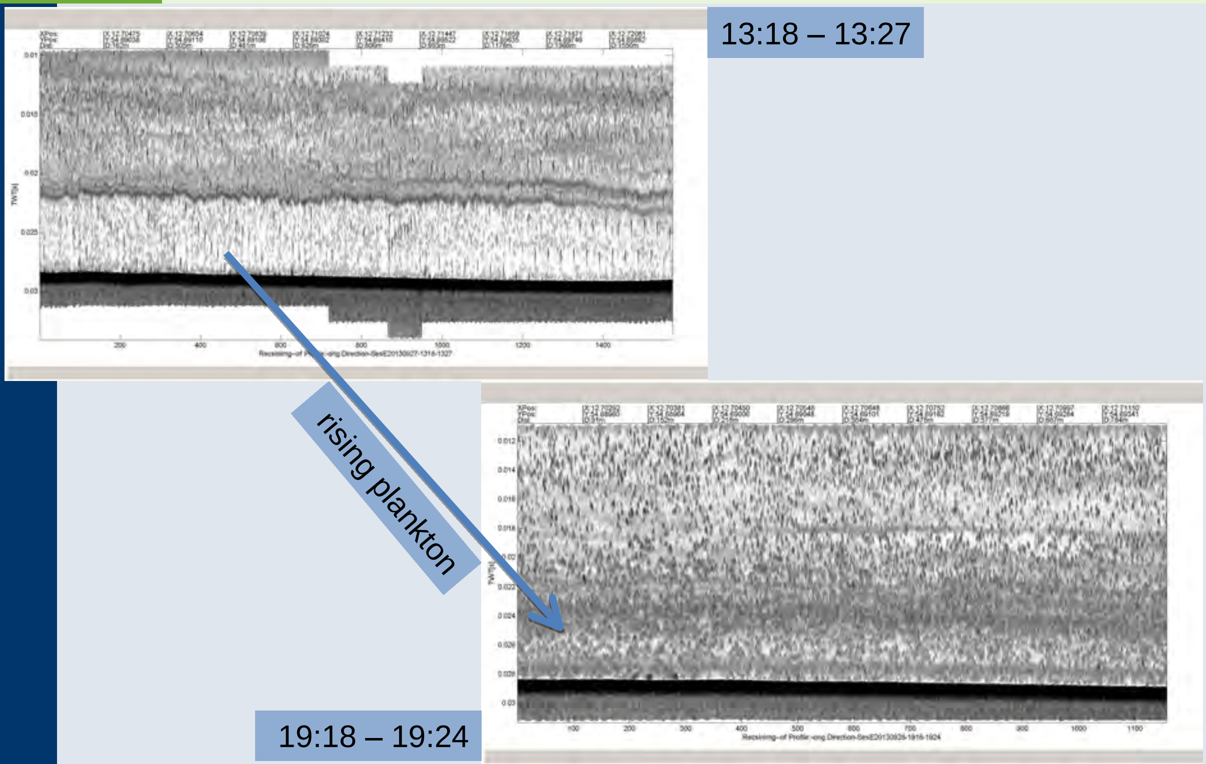
Plankton Rising Up At Night



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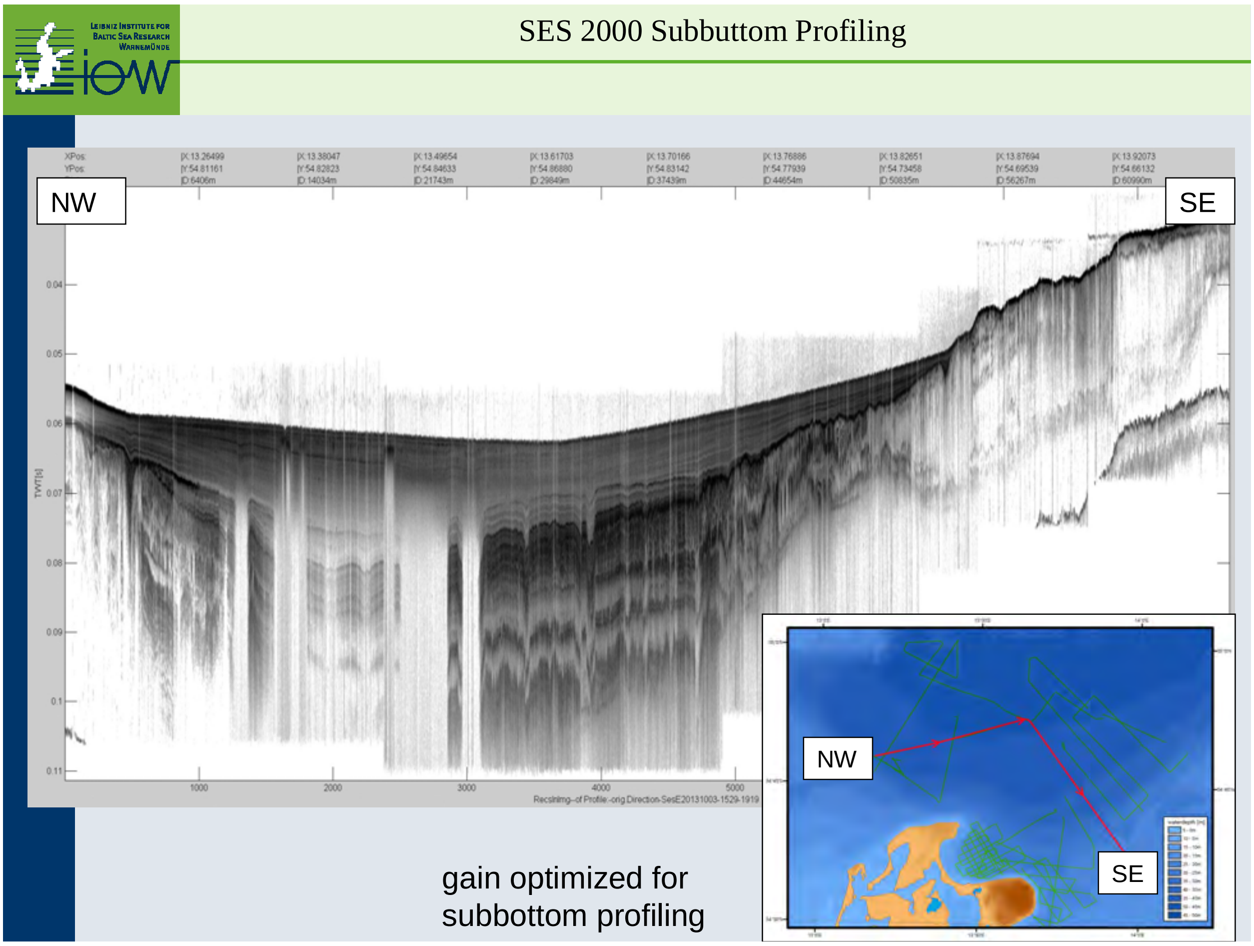
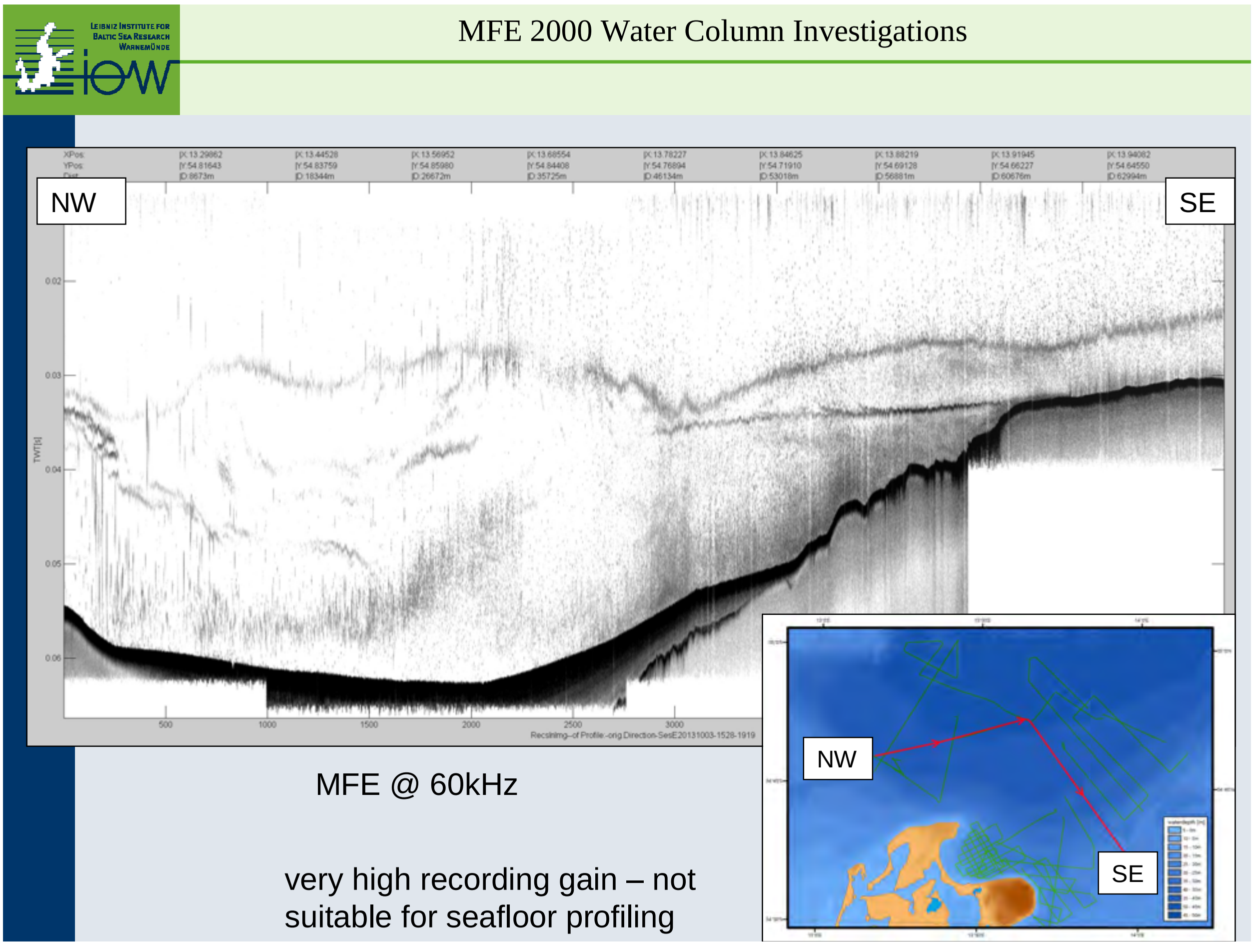

SES 2000 Subbuttom Profiling
NW
SE
NW
SE
gain optimized for
subbottom profiling


MFE 2000 Water Column Investigations
NW
SE
NW
SE
MFE @ 60kHz
very high recording gain – not
suitable for seafloor profiling

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Influencing Factors on Sound Velocity

Factor	Variation	Differences in Sound Velocity	Differences in Density	Differences in Acoustic Impedance
Temperature	1 K	4.5m/s	0.24kg/m³	4861 kg/s*m²
Salinity	1 (‰)	1.3m/s	0.76kg/m³	2440 kg/s*m²
Pressure	10 atm (i.e. ca. 100m)	1.6m/s	0.45kg/m³	2276 kg/s*m²

$$R_x = (Z_{ac}2 - Z_{ac}1)/(Z_{ac}2 + Z_{ac}1)$$

(normal incidence)

$$Z_{ac} = \rho * V_p$$

acoustic impedance = wet bulk density * sound velocity

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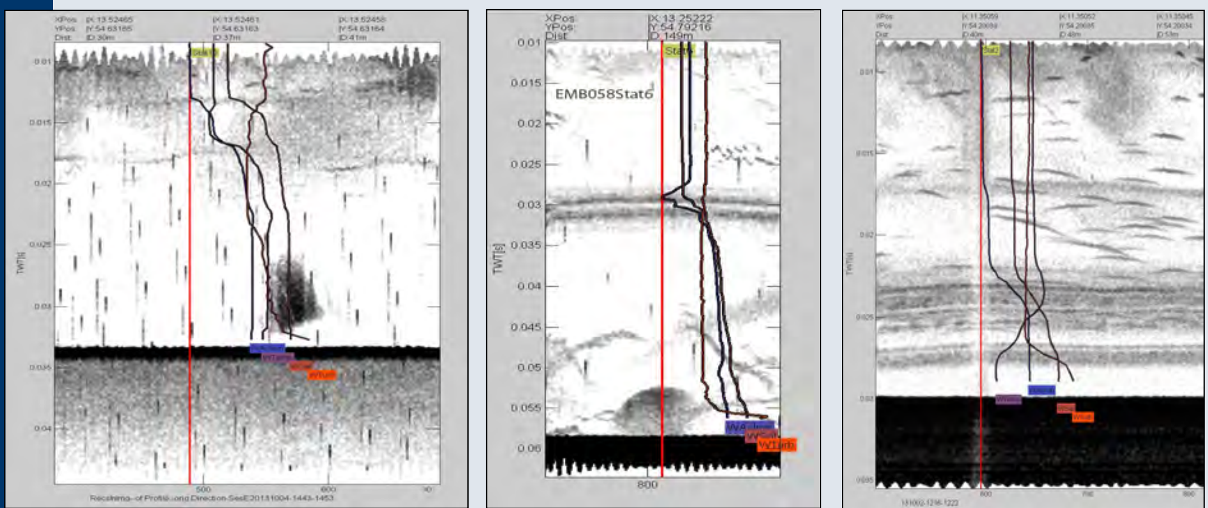
What causes Acoustic Boundaries ?

acoustic profiling simultaneously with CTD at stations



Graphs left to right: AcImp--Temp--Sal--Turb

AcImp = density * sound velocity

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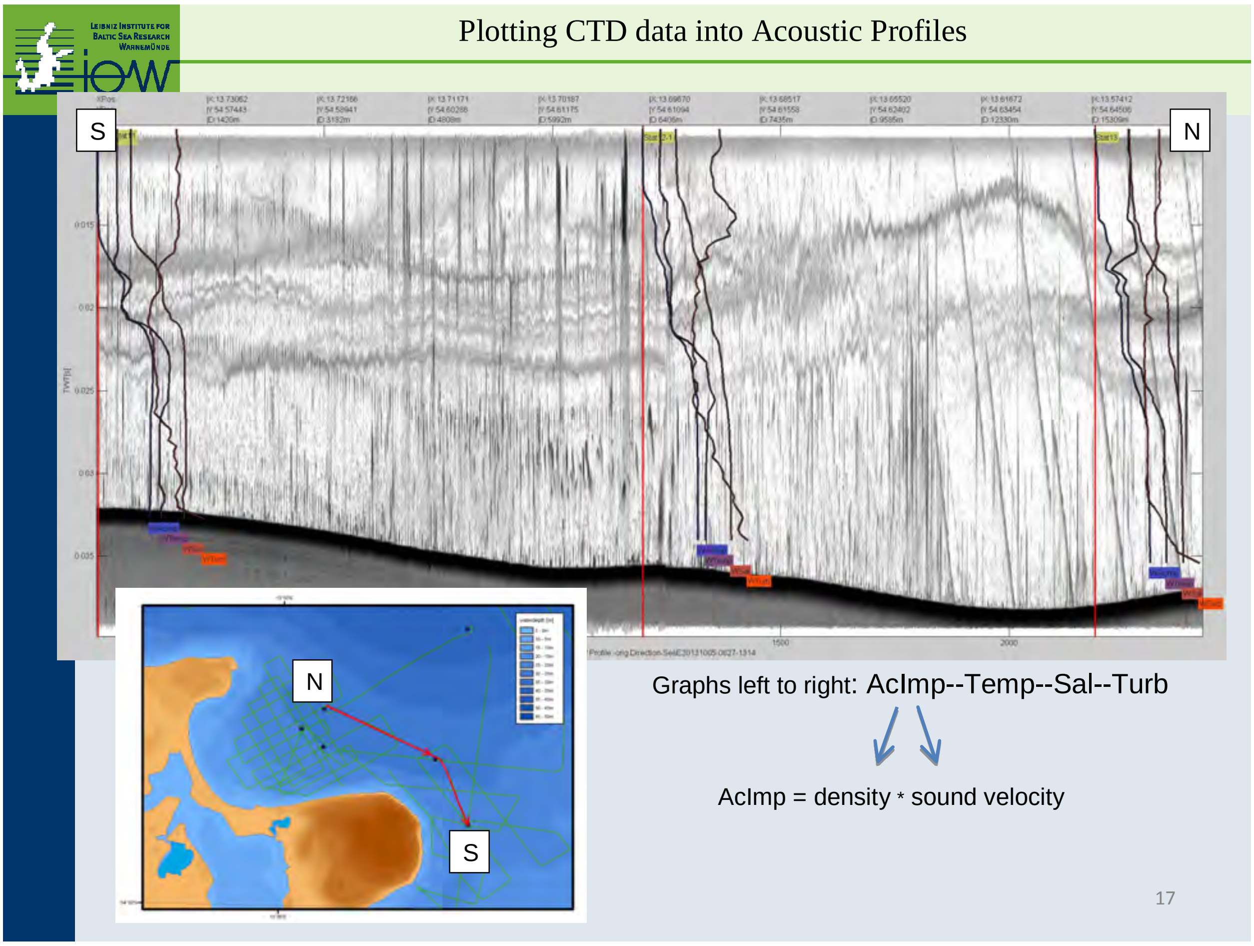
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IOW
Plotting CTD data into Acoustic Profiles
S
N
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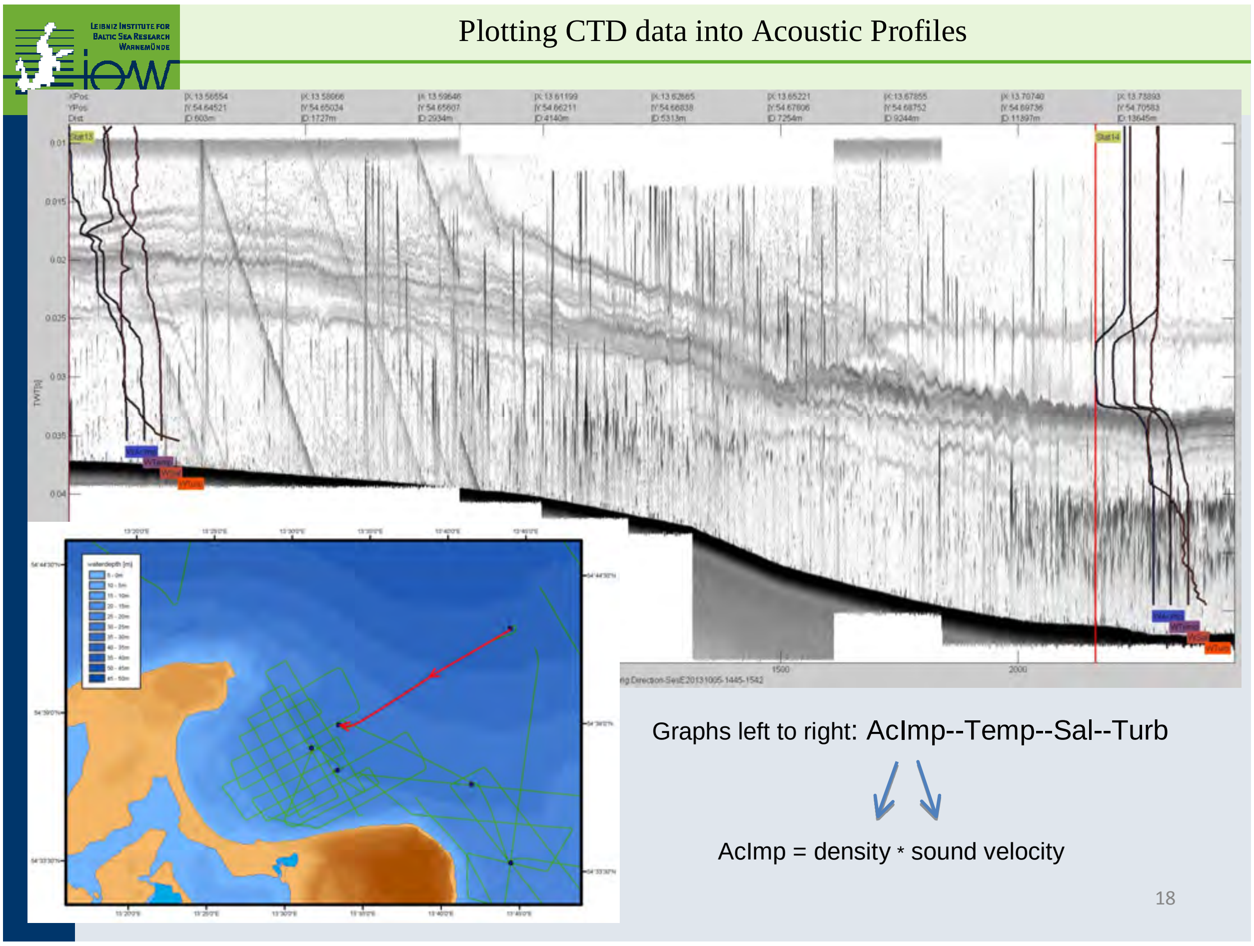
17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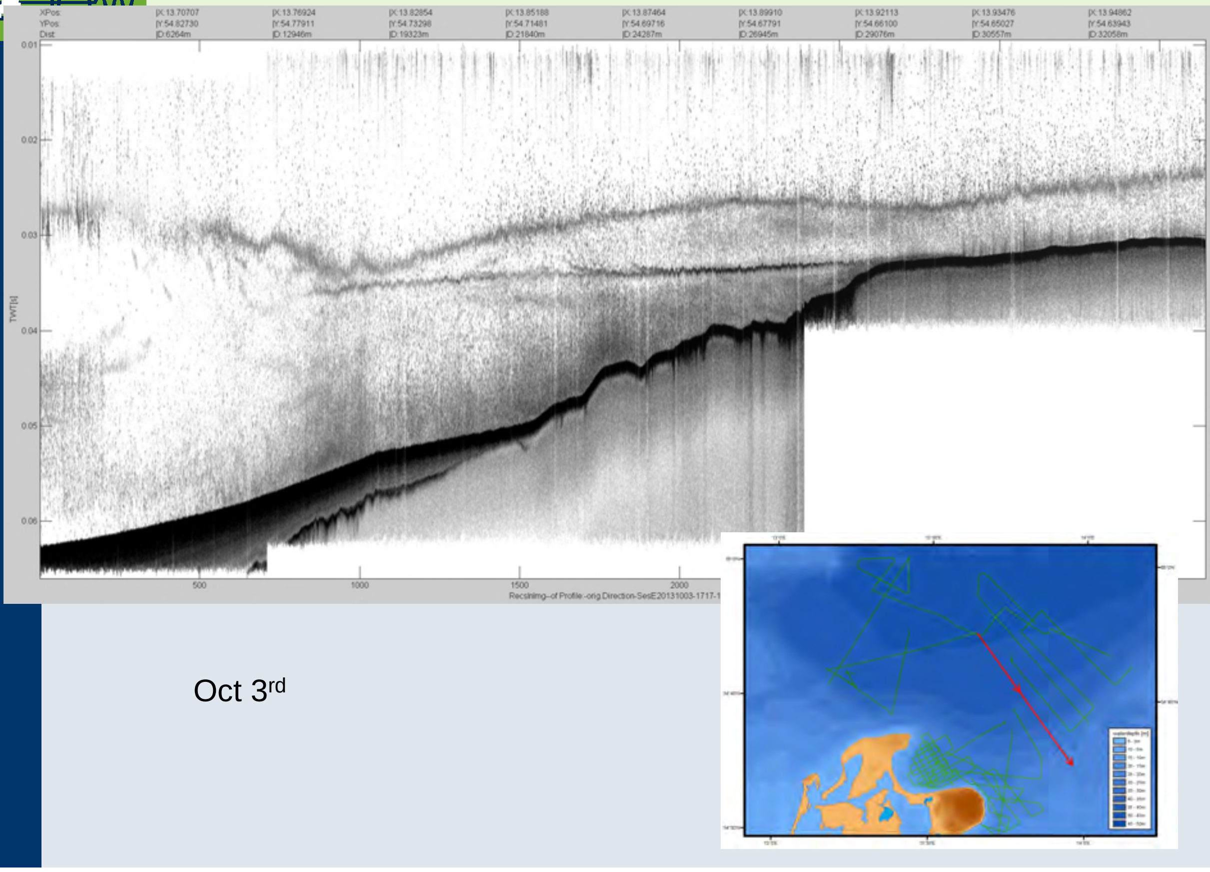
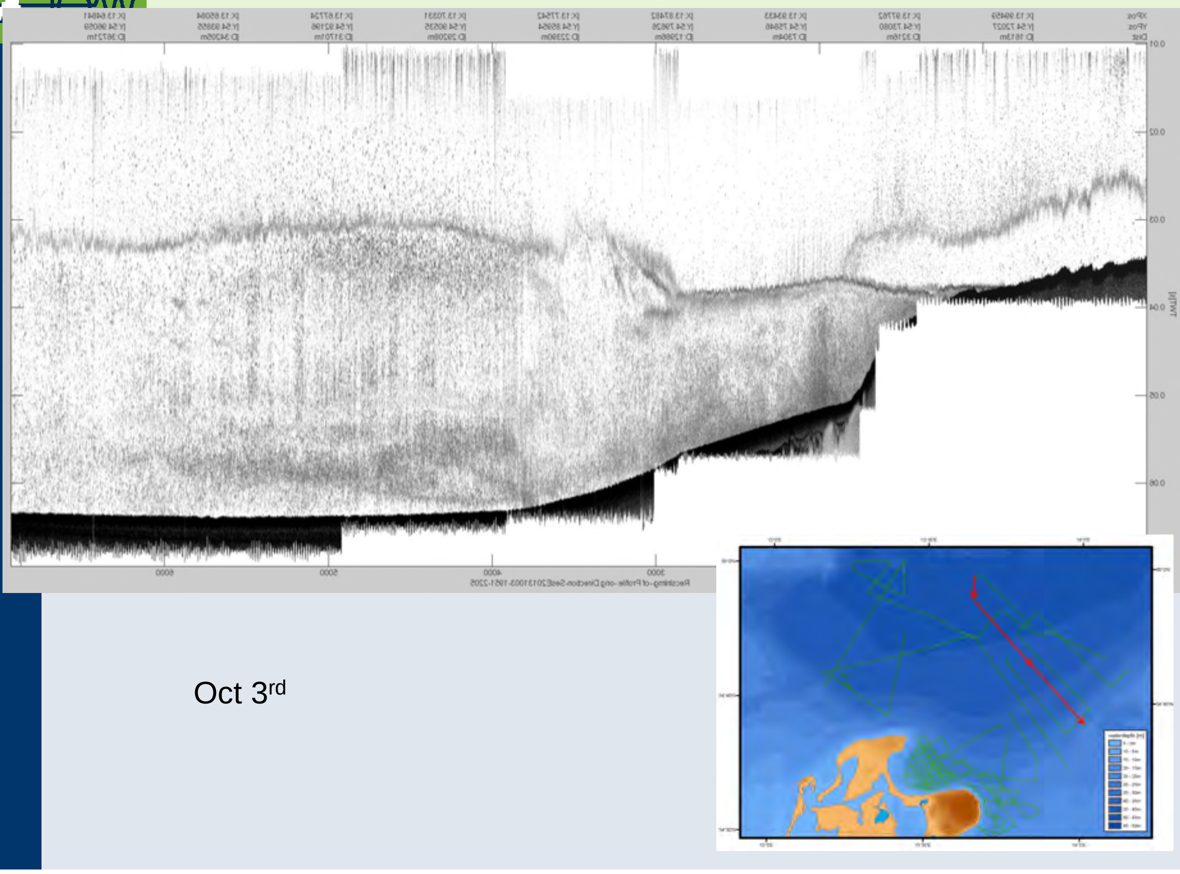
Time Variablity

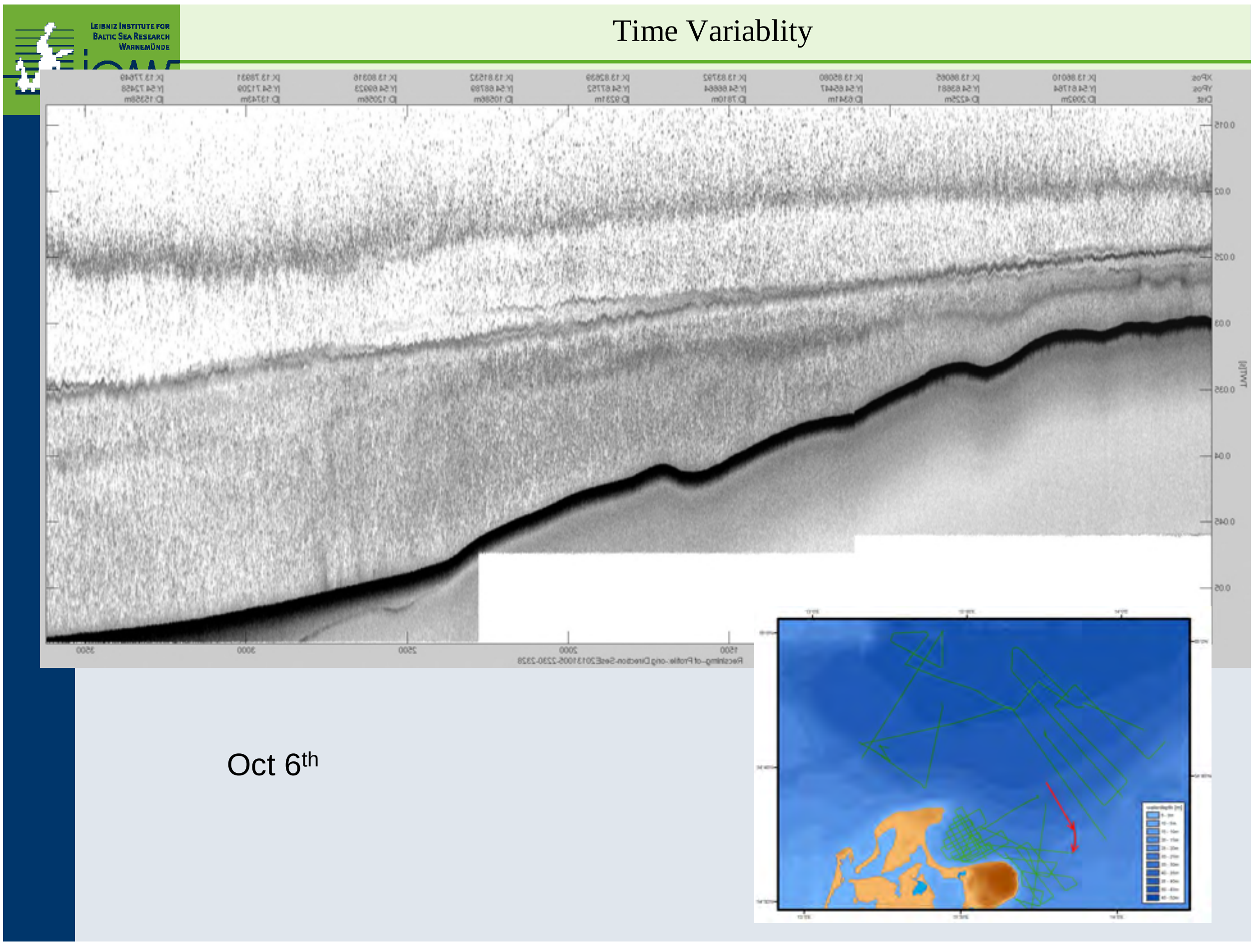


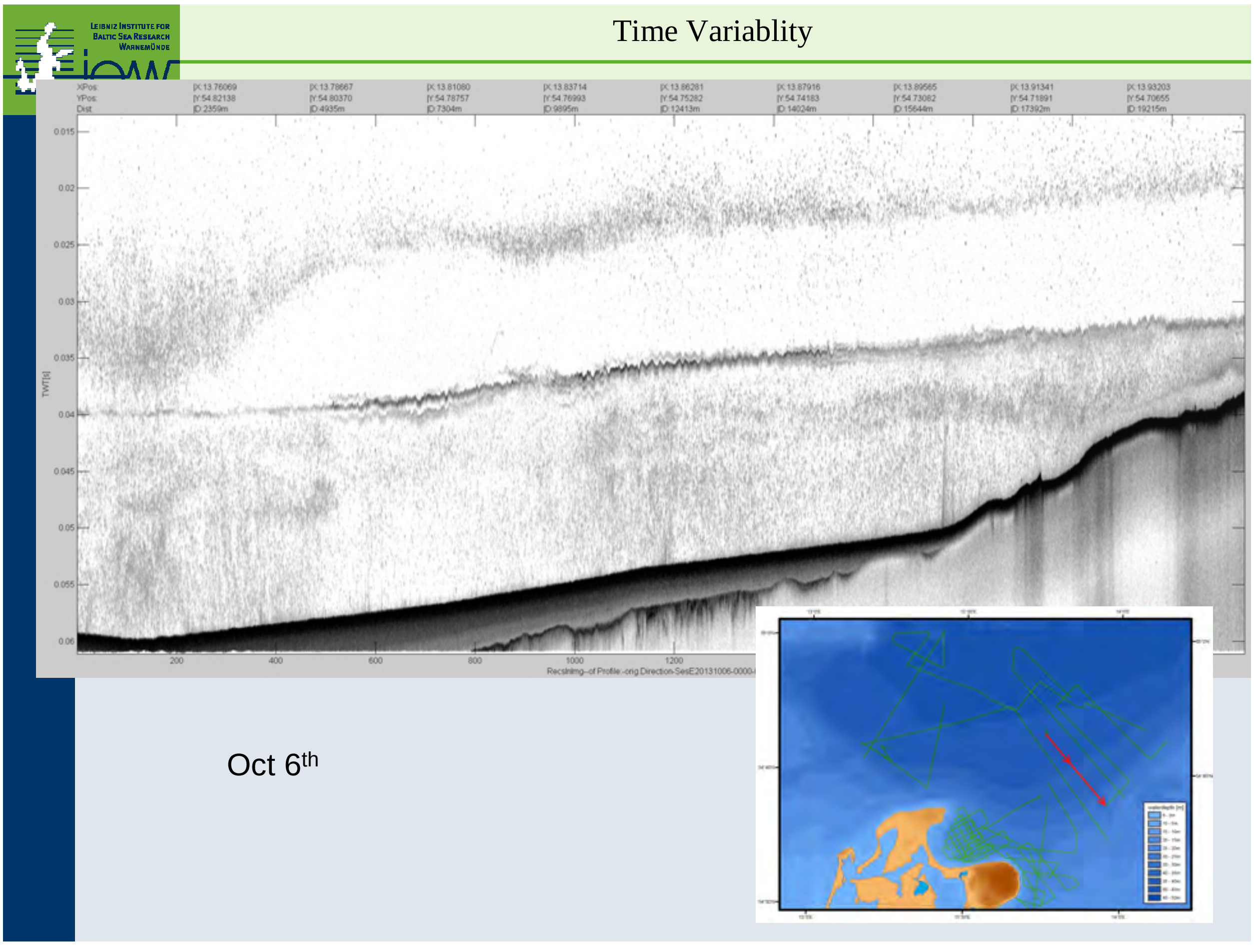
Oct 3rd

Time Variablity



Oct 3rd


Time Variablity
Oct 6th


Time Variablity
Oct 6th

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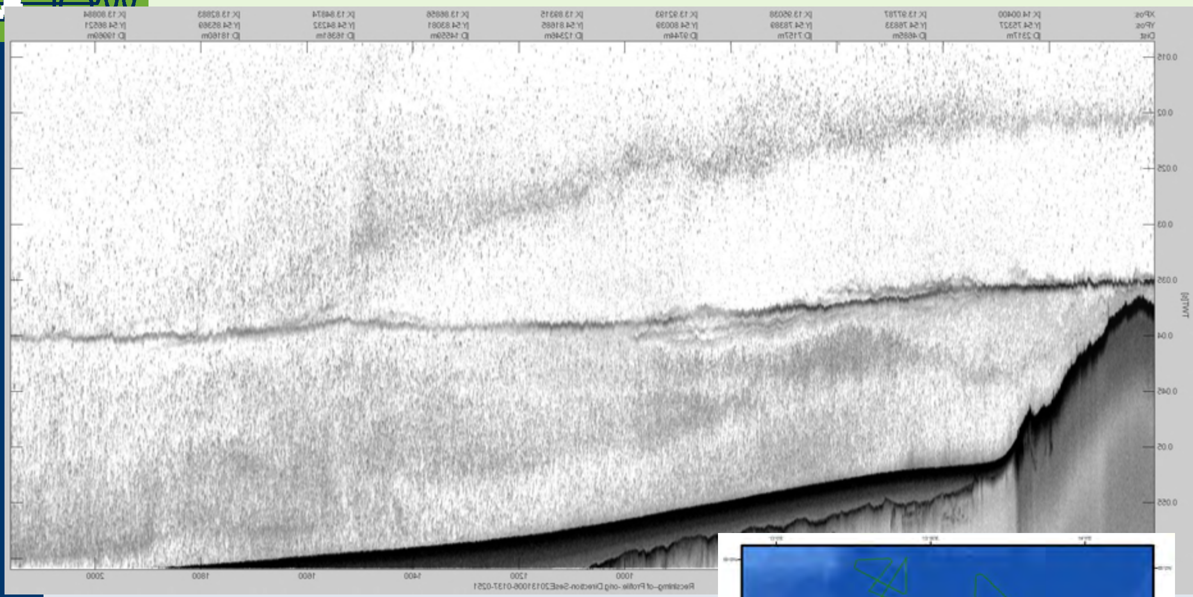

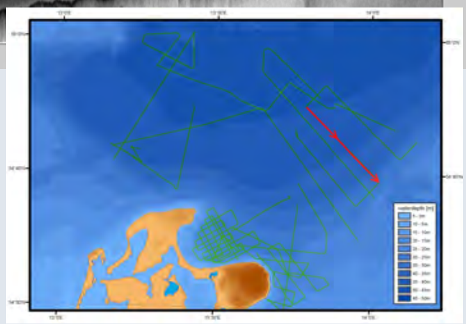

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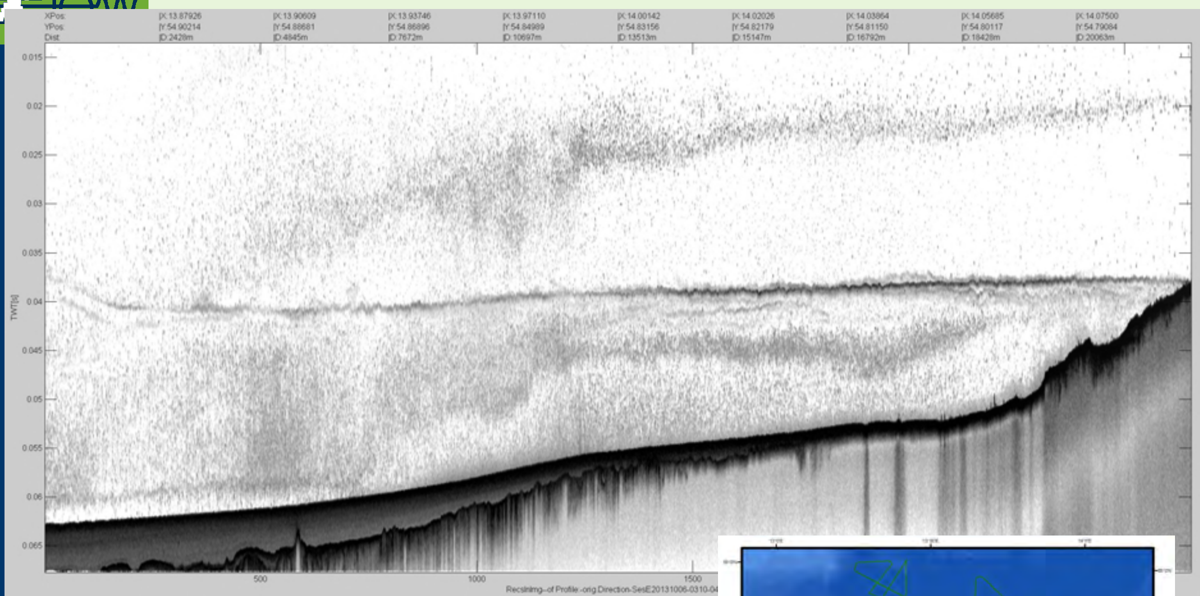
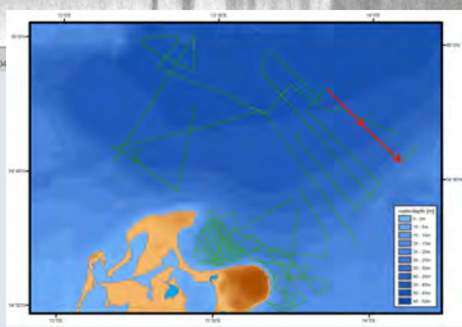
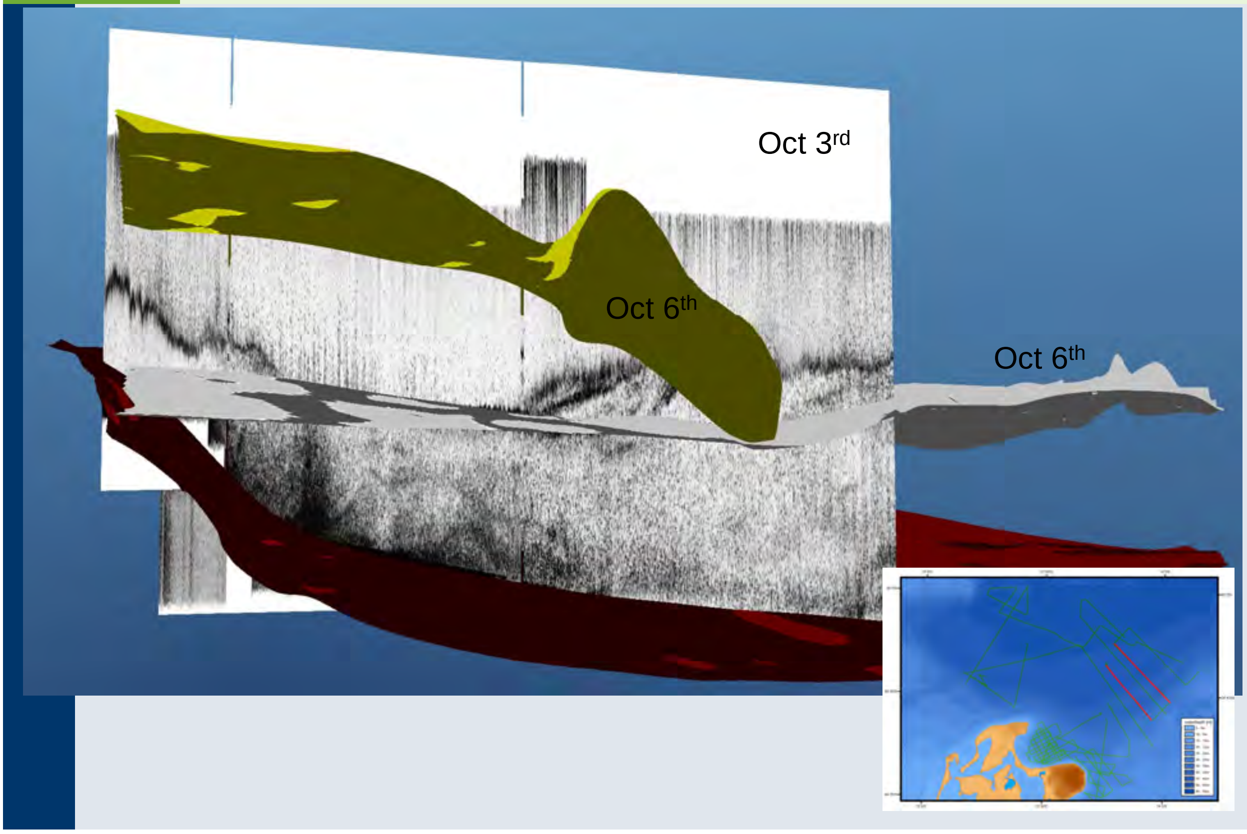




Oct 6th

Time Variablity 3D view



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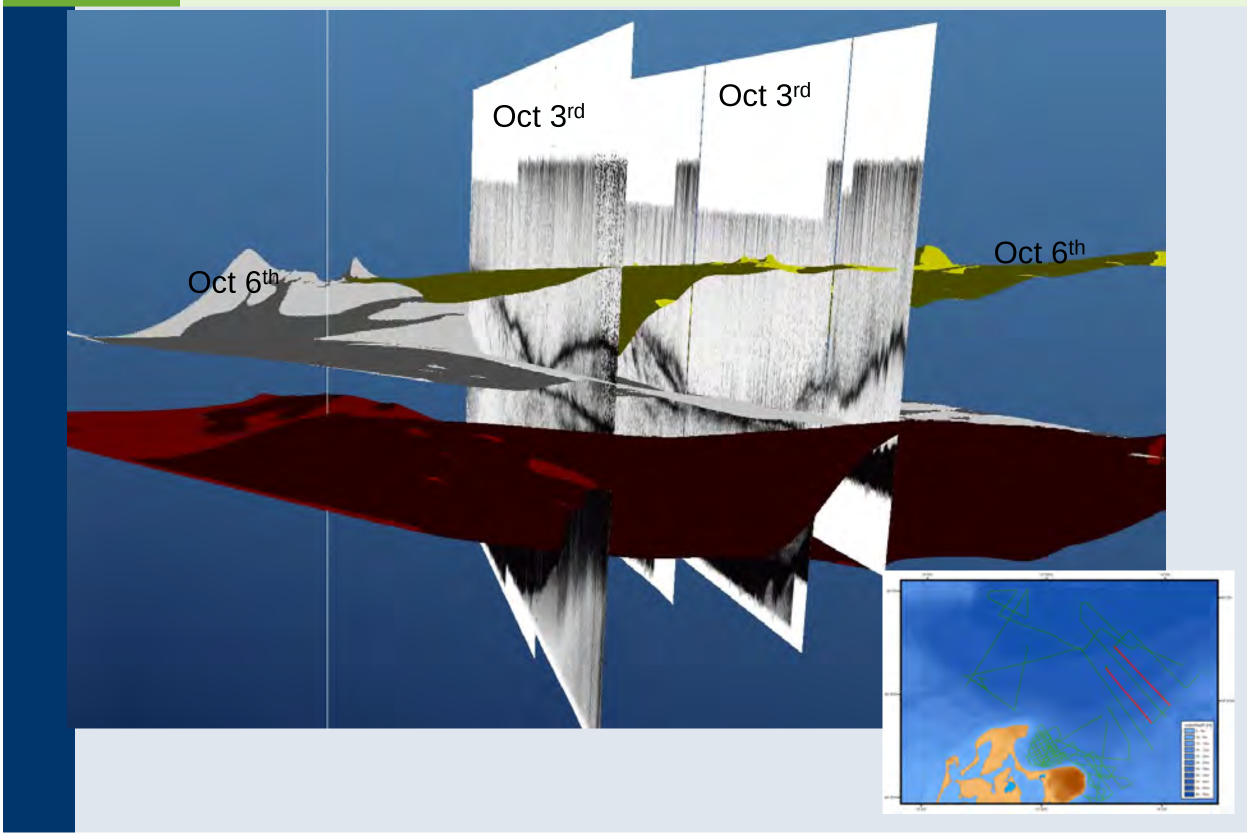

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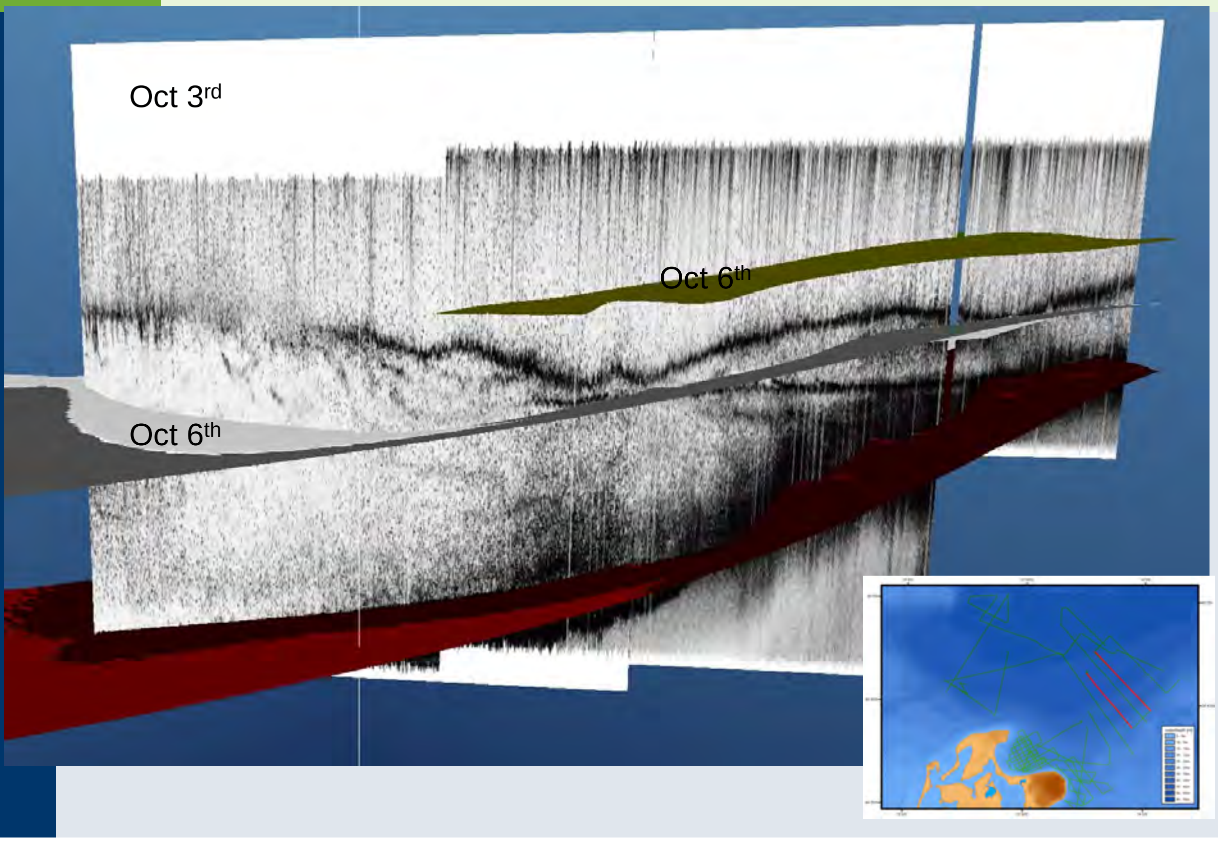

Summary

- provides **fast** 3D - **mapping** of water column structures with high resolution (10kn @ R/V EMB)
- high resolution monitoring of **time variability** during station work
- **CTD data needed** for interpretation of acoustic structures
- layers easily assigned since sound velocity calculated directly from CTD data (in contrast to problems known from sediment)
- widespread potential in use (Biological, Physical Oceanography, etc.)
    - echo signal strength can be used for **quantification** of suspended matter (e.g. **biomass**)
    - energy of **internal waves** can be derived from wave height
    - **volume calculation** of water masses
- **needs to be developed** and validated with CTD, MSS-profiler, etc.

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Thank you!

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