Impact of the Major Baltic Inflows to the Gulf of Finland

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Background, motivation

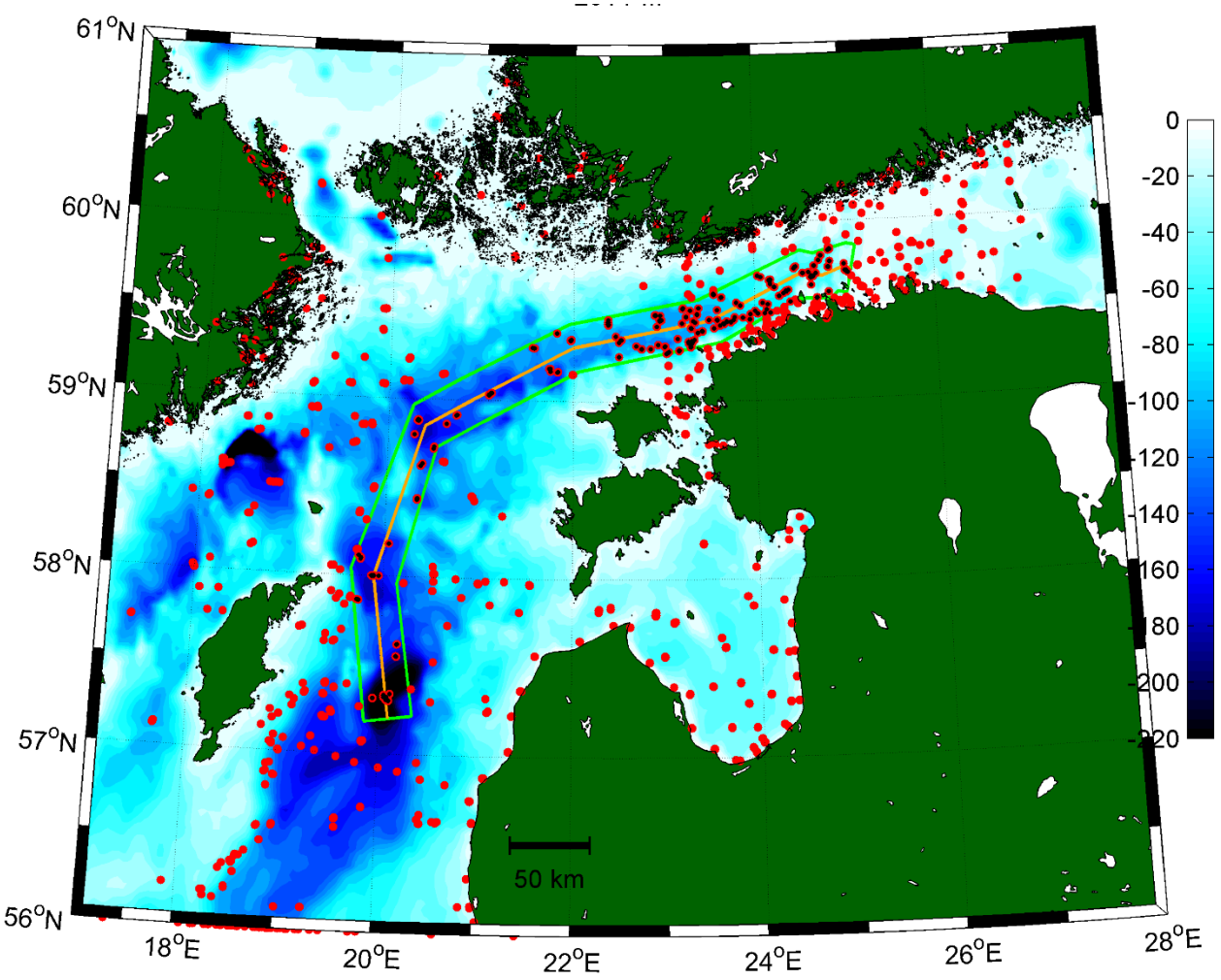
- Major Baltic Inflow (MBI) impact from Danish Straits to the Gotland Deep has been well investigated;
- Lack of dedicated measurement based MBI signal propagation study from the Gotland Deep towards GoF;
- Recent MBIs: Dec 2014 (strongest since 1951); two weaker events in Nov 2015 and Jan-Feb 2016

- If and how fast the effect of MBIs can be seen in the pathway from the Gotland Deep to the GoF?
- What is the impact on heat, salt and oxygen content; stratification?
- How and in which layers the signal propagates towards northeast?

Data 2014 - 2017 Mar

Estonian, Finland, German and Sweden data were merged: Temperature, salinity, oxygen.

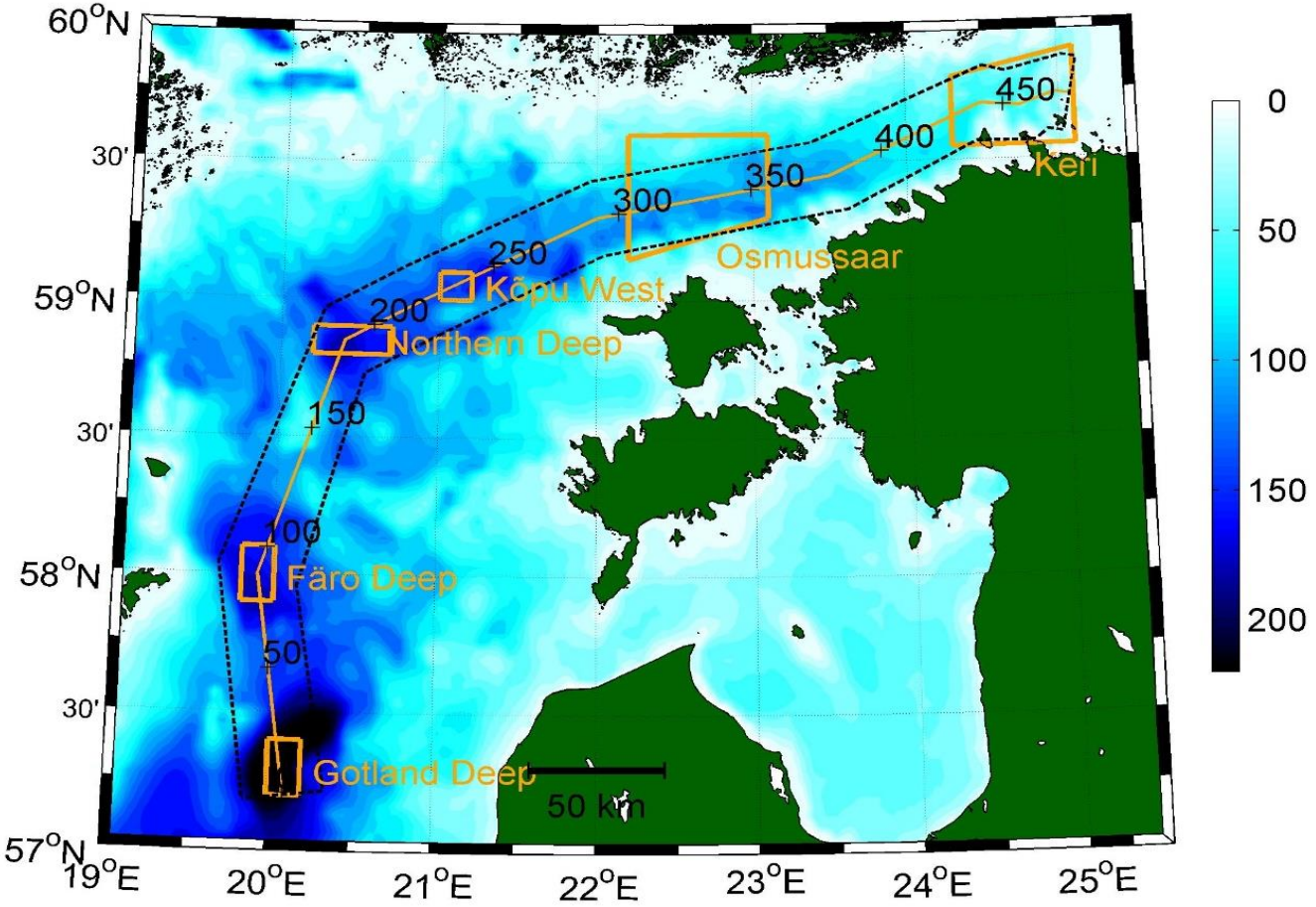
Ship measurements + vertical profilers and point recorders.



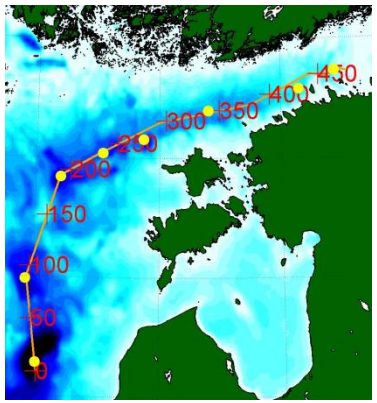
+ Historical time-series to validate our conclusions.

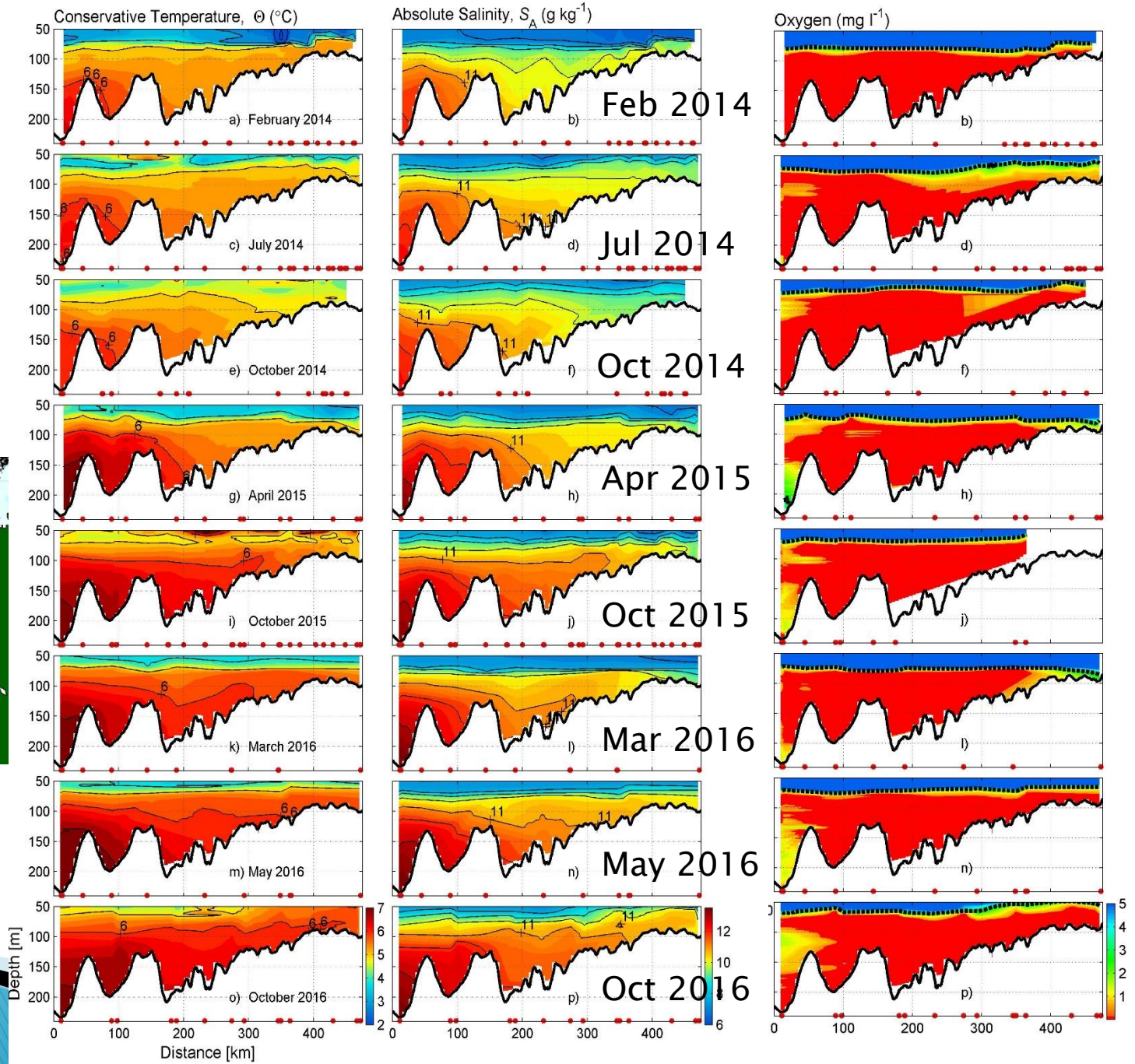
Data 2014 - 2017 Mar

470 km long section and 6 time-series stations



Temperature, salinity and oxygen along the section, 50-240 m



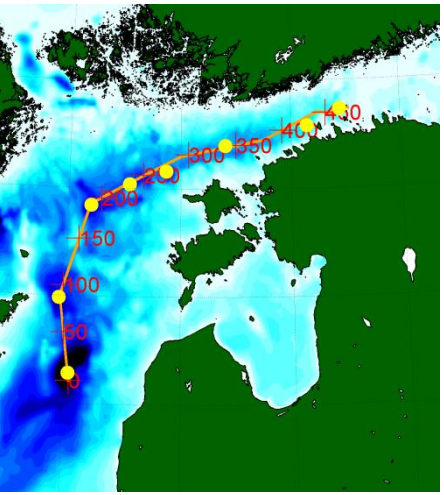


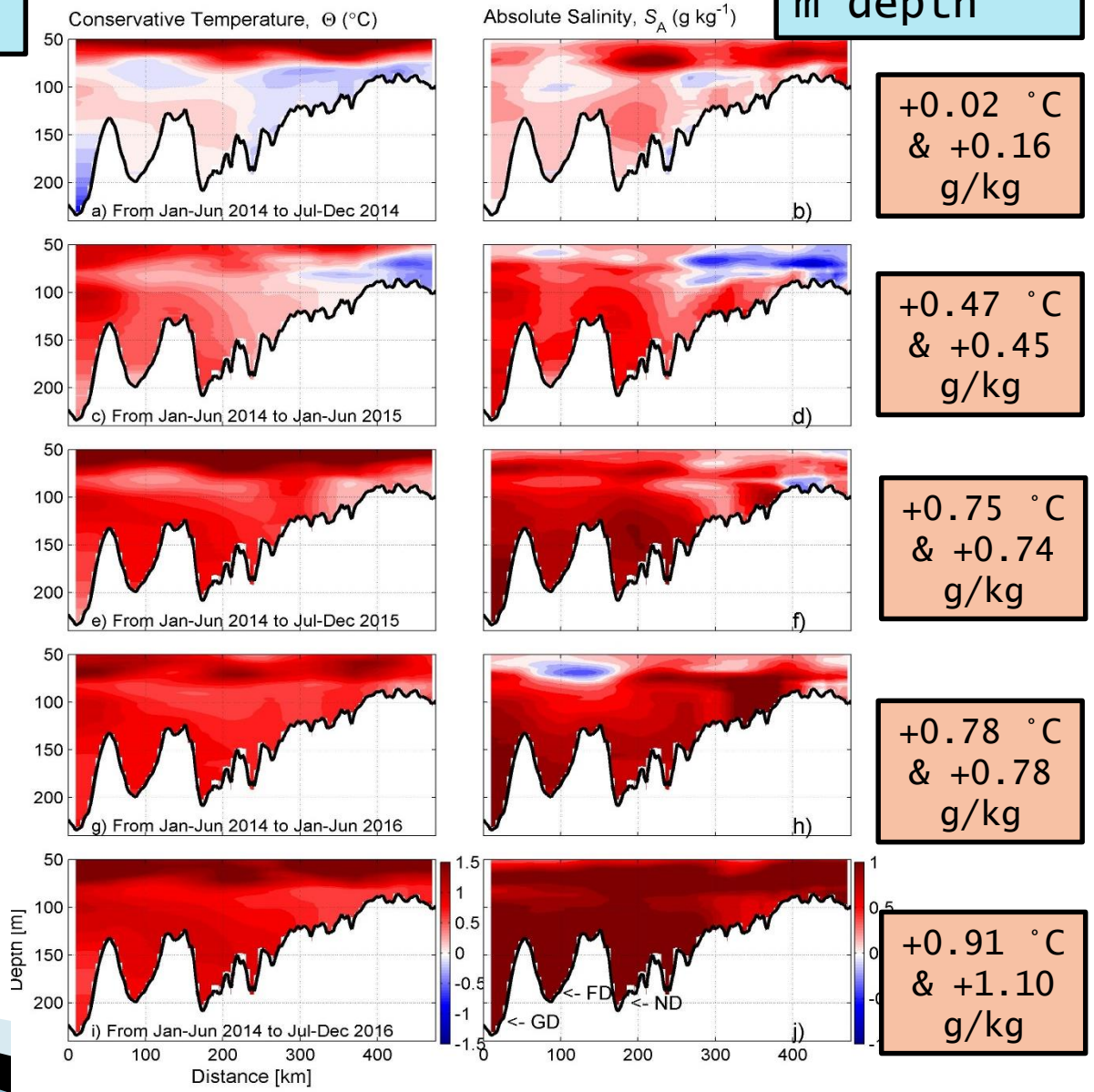
Changes in section

Change from Jan-Jun 2014 to:

Temperature and salinity change from 50 m depth to bottom

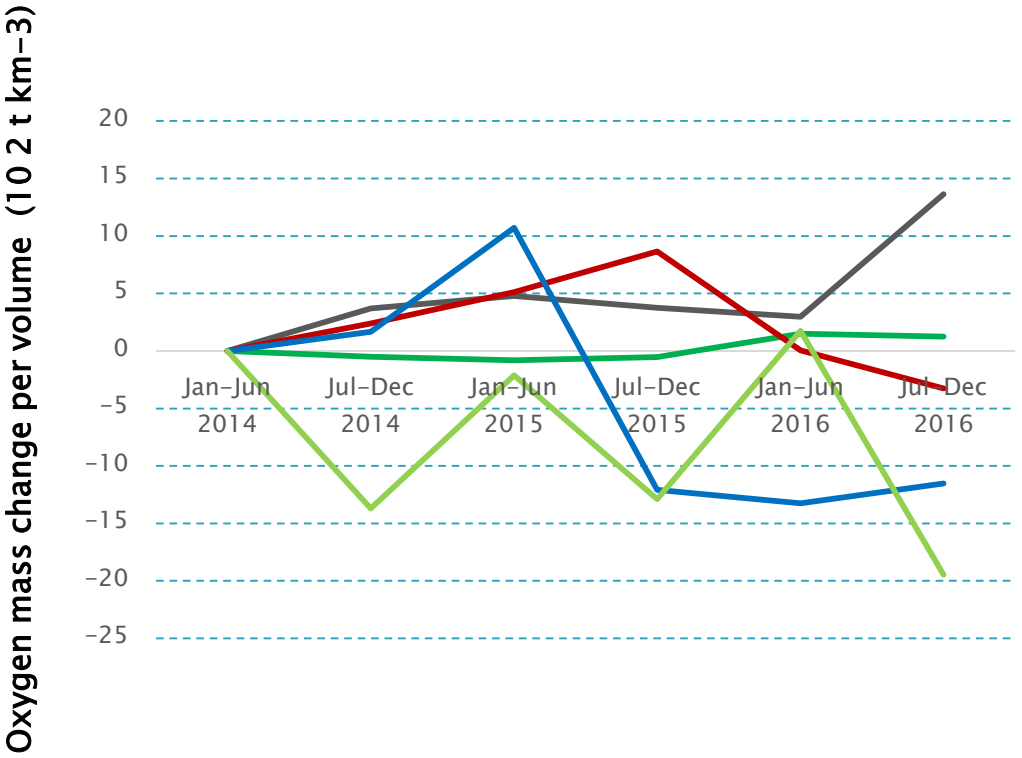
Section-averaged change >80 m depth

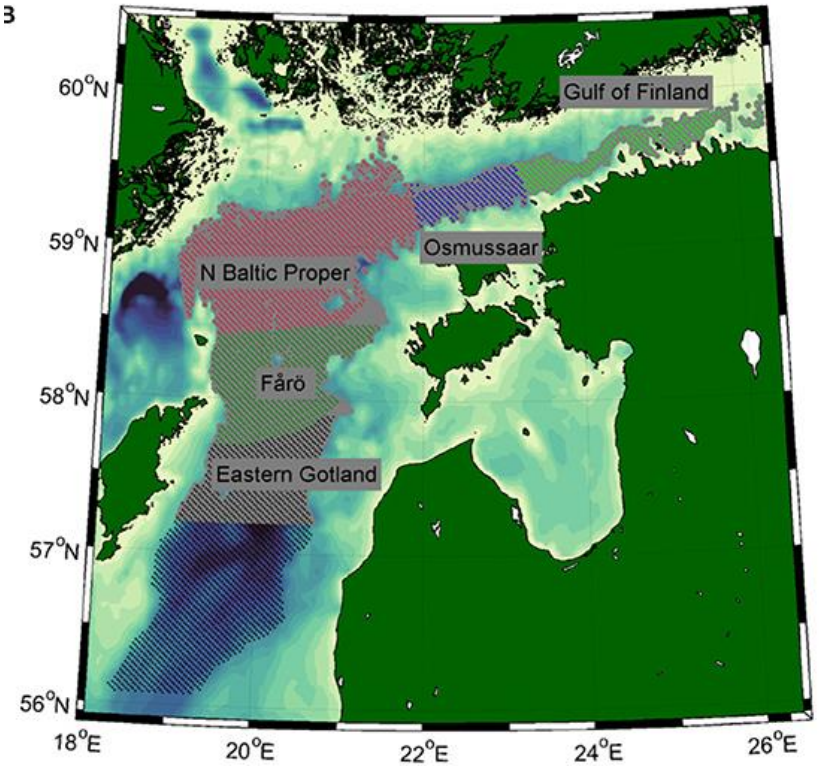




Jul-Dec 2014	a) From Jan-Jun 2014 to Jul-Dec 2014	+0.02 ˚C & +0.16 g/kg
Jan-Jun 2015	c) From Jan-Jun 2014 to Jan-Jun 2015	+0.47 ˚C & +0.45 g/kg
Jul-Dec 2015	e) From Jan-Jun 2014 to Jul-Dec 2015	+0.75 ˚C & +0.74 g/kg
Jan-Jun 2016	g) From Jan-Jun 2014 to Jan-Jun 2016	+0.78 ˚C & +0.78 g/kg
Jul-Dec 2016	i) From Jan-Jun 2014 to Jul-Dec 2016	+0.91 ˚C & +1.10 g/kg

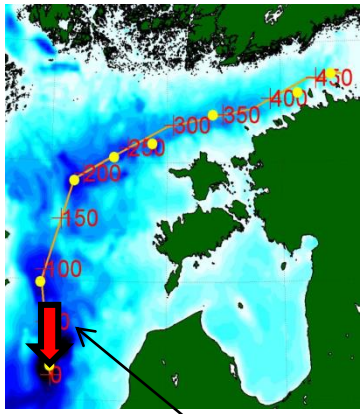
Changes in oxygen content >80 m depth



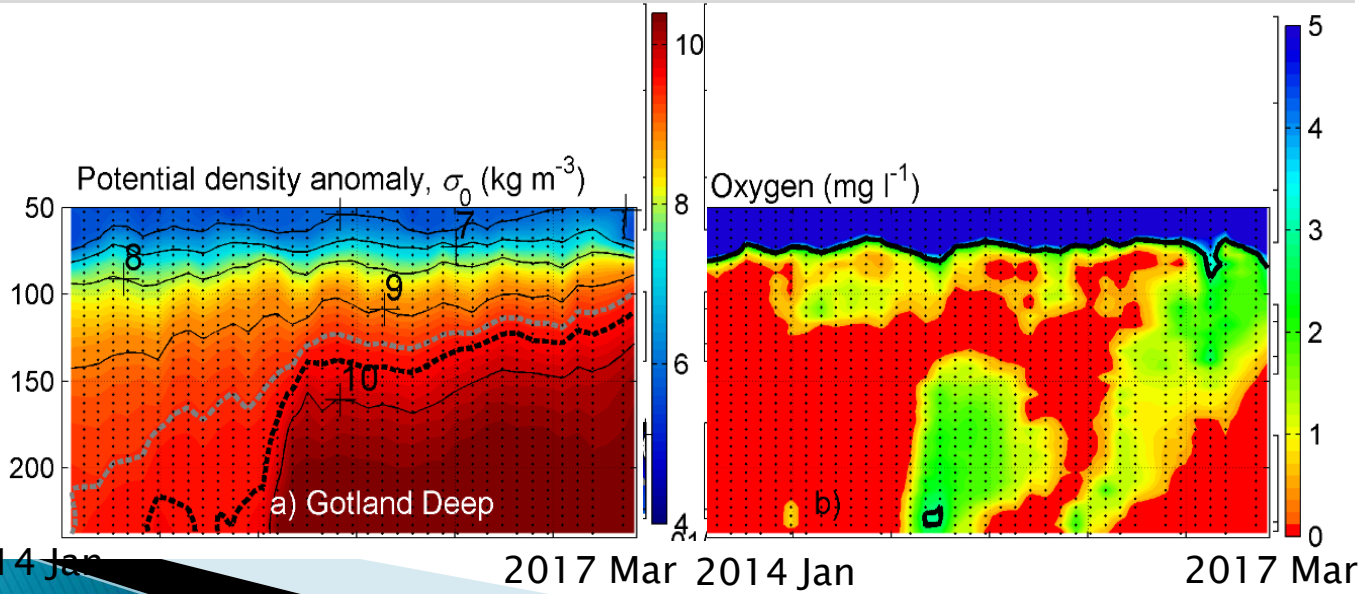


- Increase in oxygen content in the Eastern Gotland Basin, slight increase in the Farö Deep.
- Decrease in oxygen content in the NE part of the section (entrance of the GoF and Central GoF)

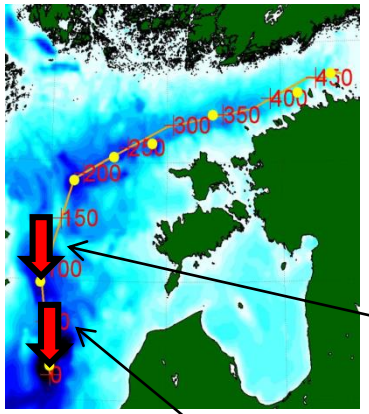
Time-series, 2014-2017 Mar, 50-240 m



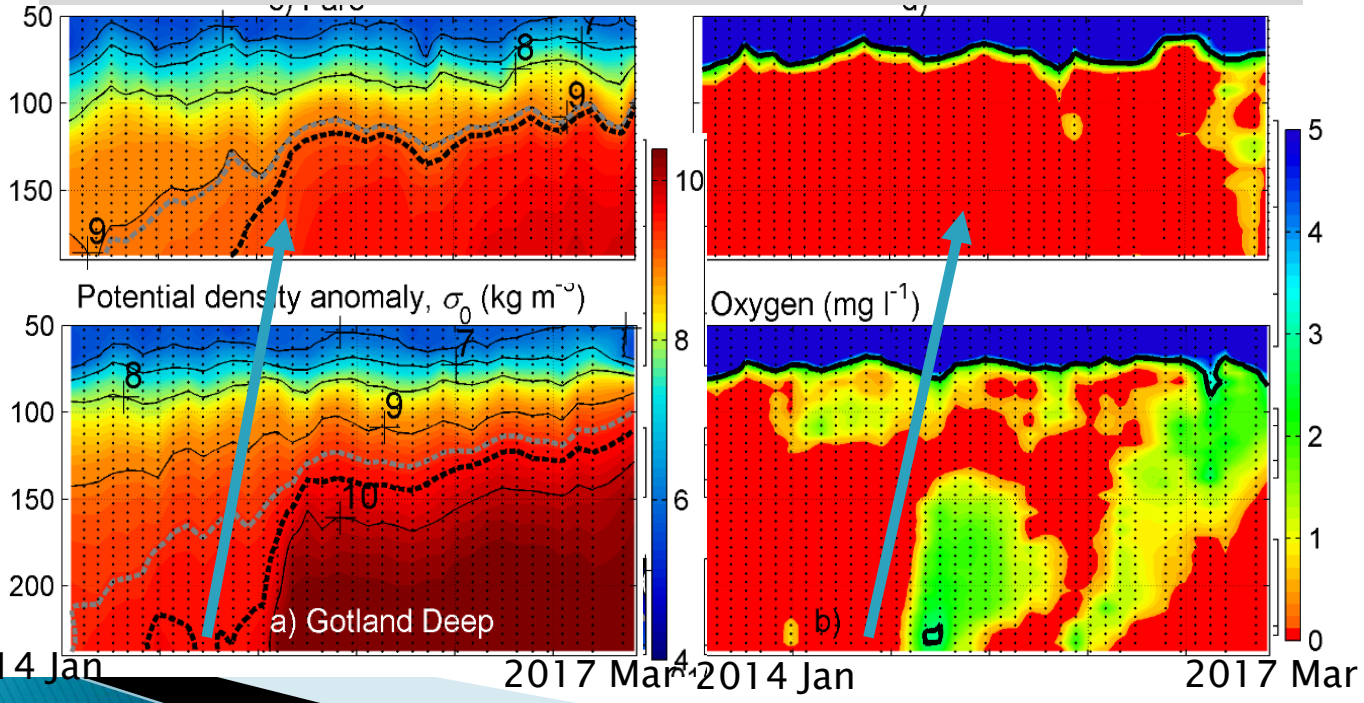
Arrived oxygen was consumed by 3-6 months in the near-bottom layer of the Gotland Deep



Time-series, 2014-2017 Mar, 50-240 m

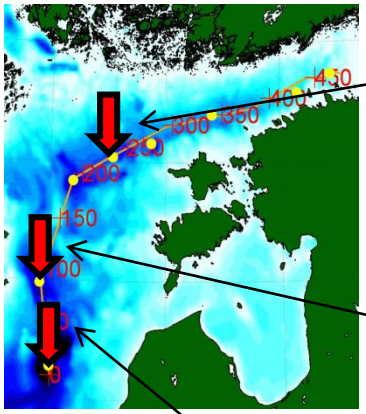


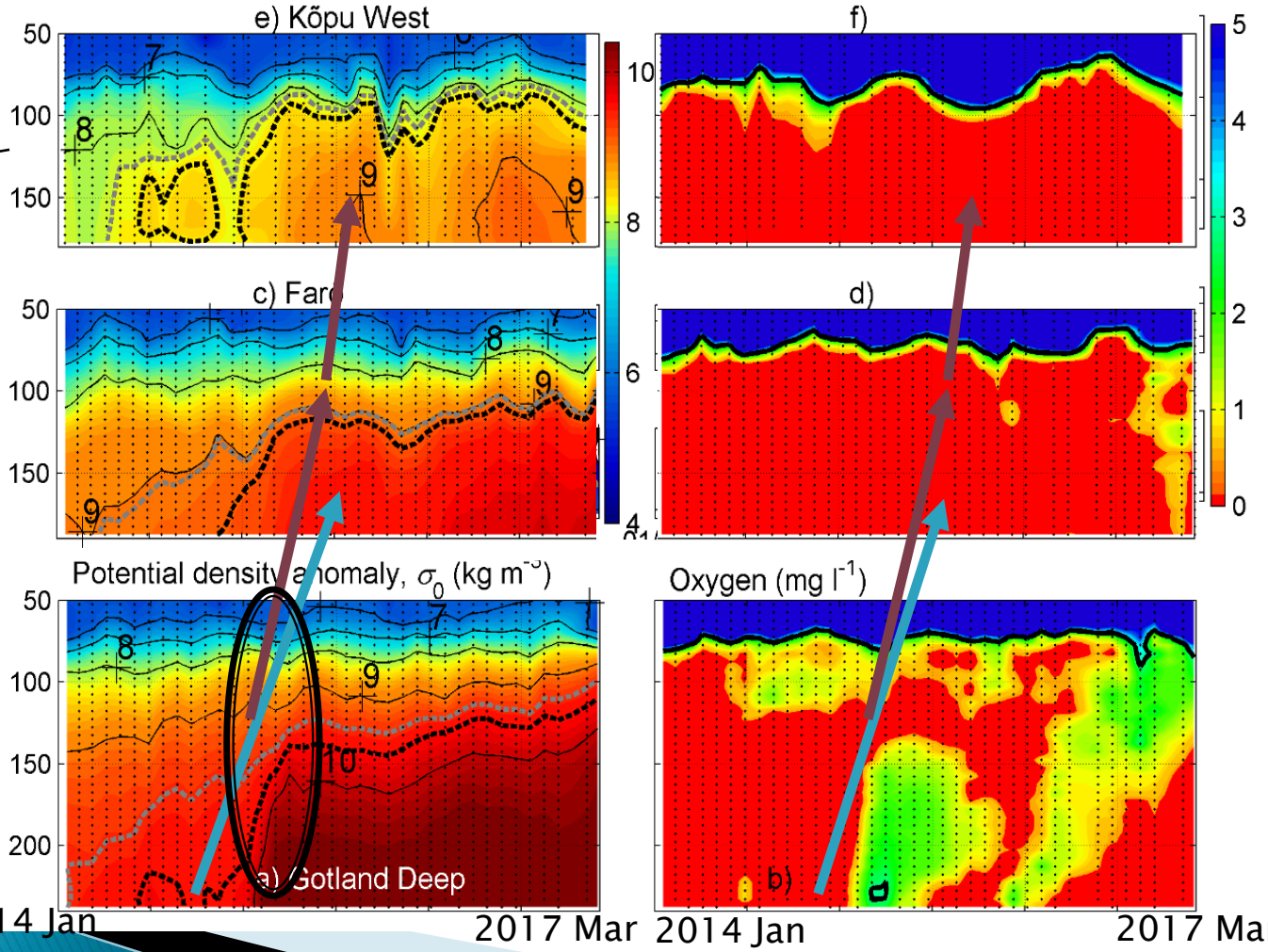
The old anoxic Gotland Deep water was pushed to Farö Deep. Also the first MBI water arrived there by push by later MBIs, but for that time oxygen was consumed already.



Time-series, 2014–2017 Mar, 50-240 m

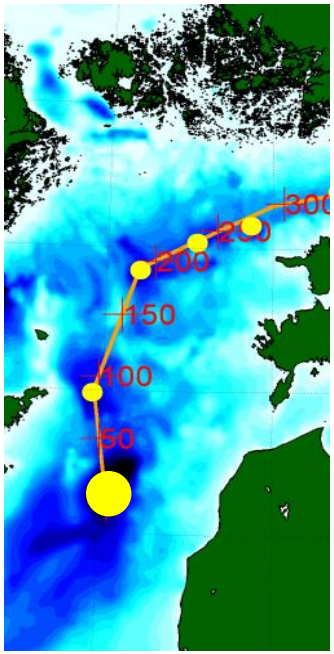
TS-diagrams does not suggest northward push of Farö Deep water. Sub-halocline mid-layer water from Eastern Gotland Basin occupied deep layer of the Northern Baltic Proper.

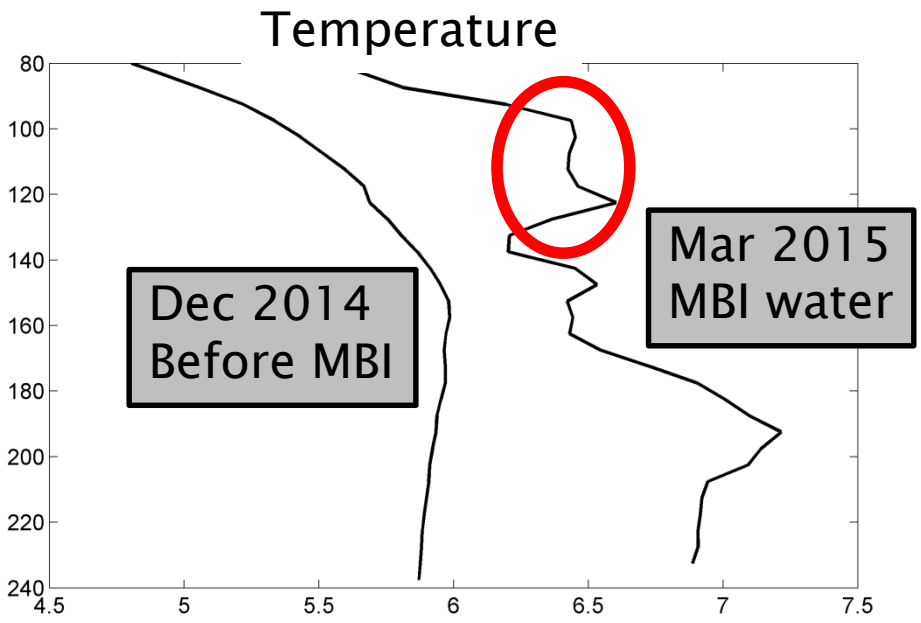


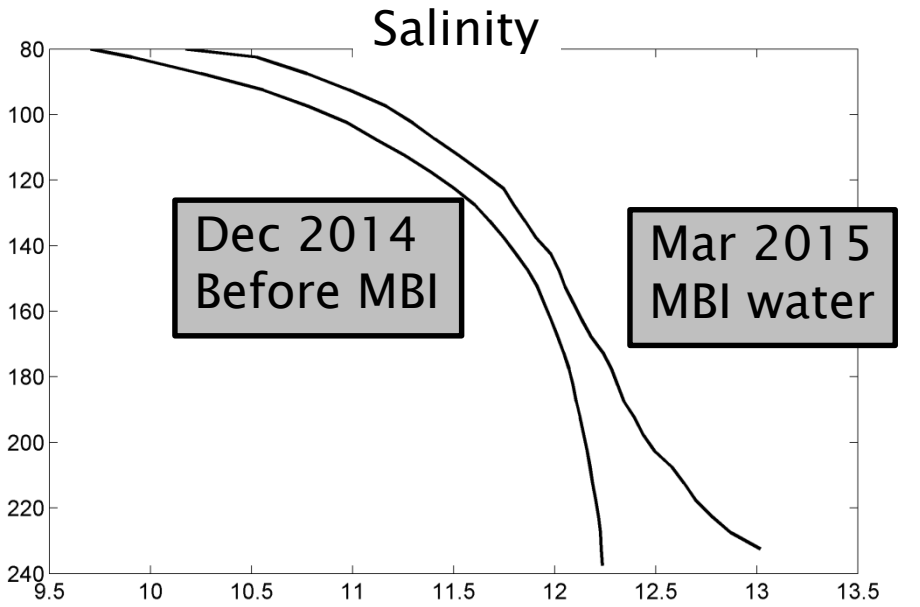


Gotland Deep profiles

- MBIs first fill the EGB and Farö Deep with dense water.
- This allows relatively dense water flow on the top of the MBI water and not to be trapped in those basins but penetrate northwards towards NBP.

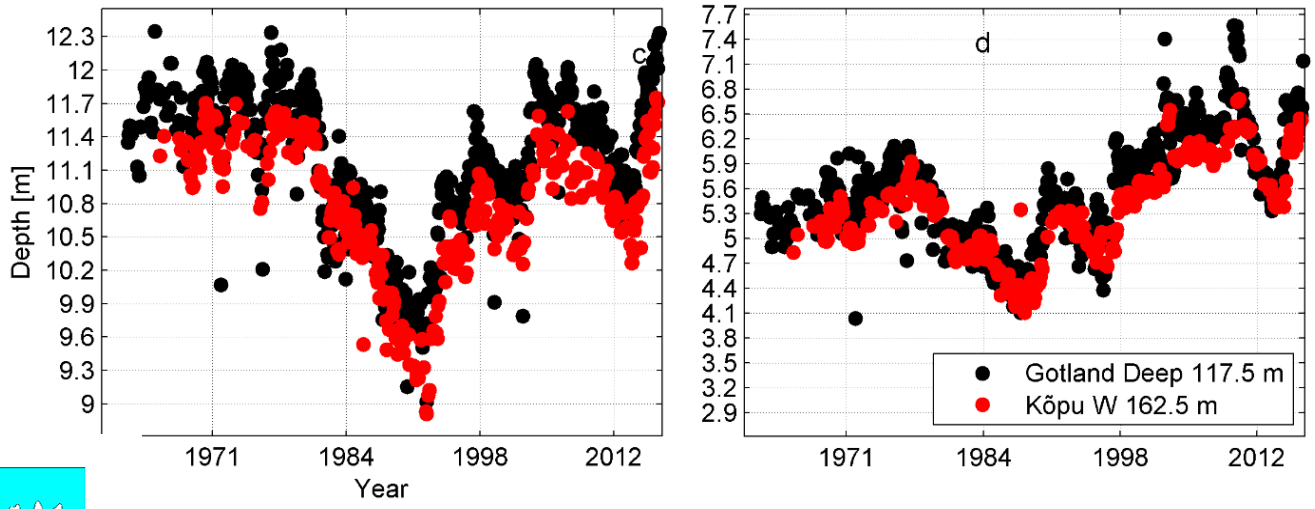


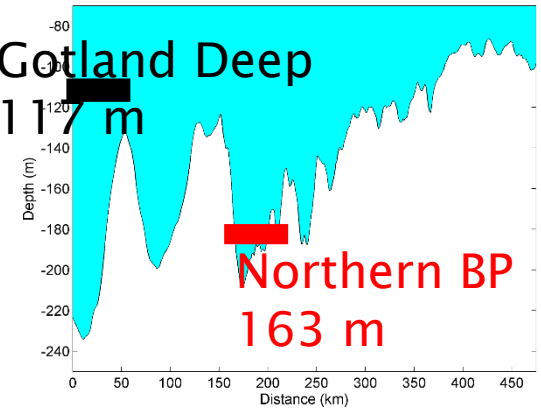




Historical time-series

Deep layer salinity and temperature since 1960



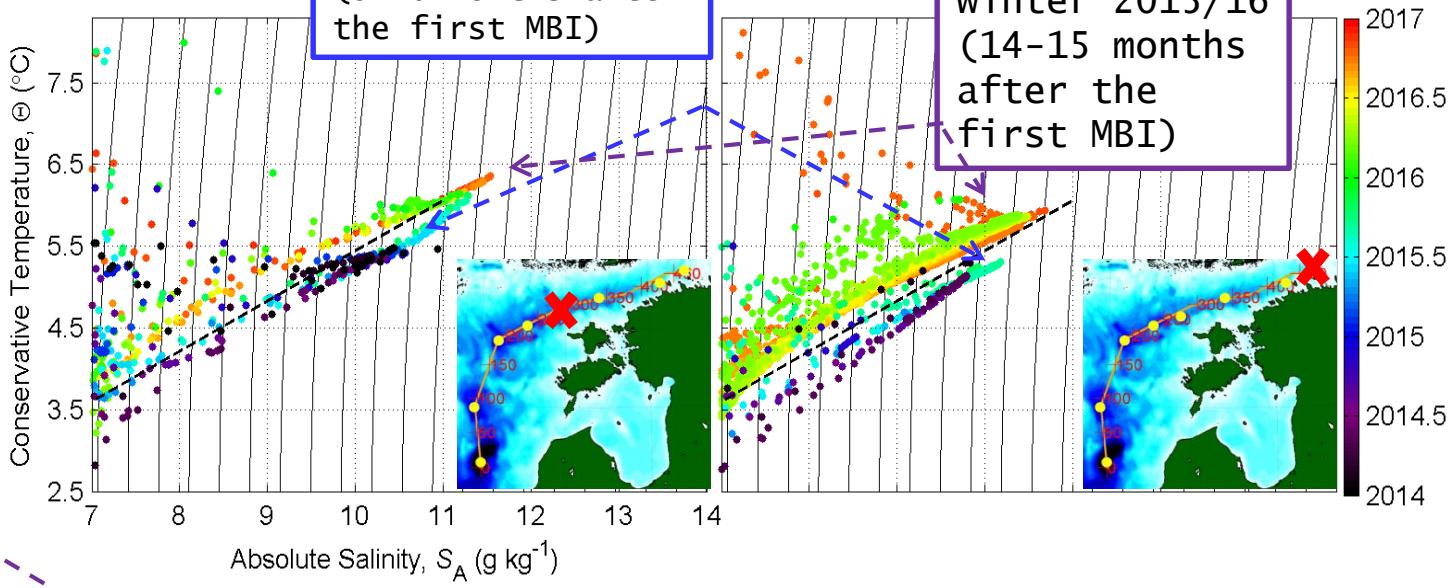


4-6 months delay between two time-series (propagation speed)

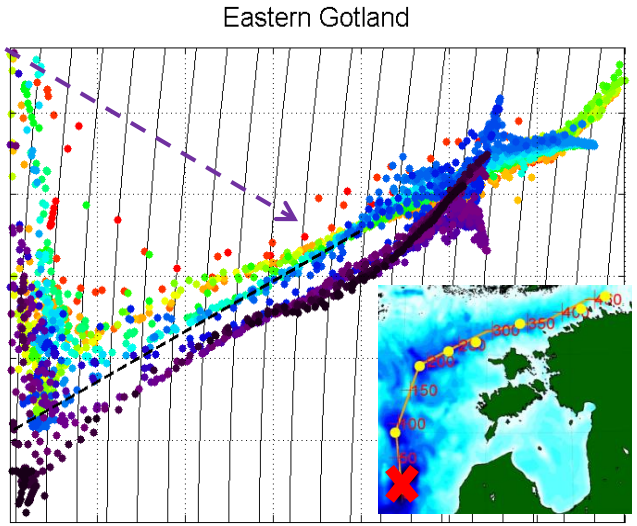
Shift in the Gulf of Finland

Former NBP water is pushed to the Gulf of Finland (9-10 months after the first MBI)

Shift to saltier/warmer halocline in winter 2015/16 (14-15 months after the first MBI)

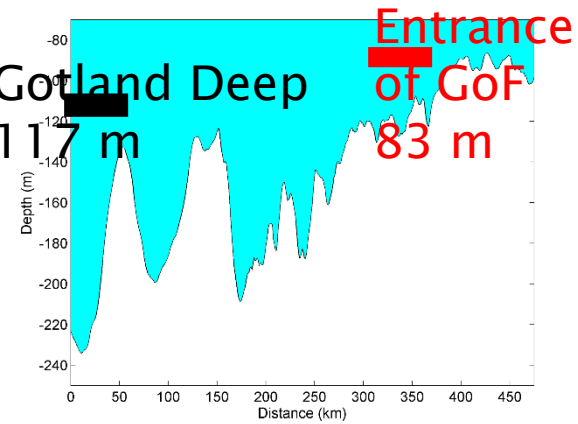


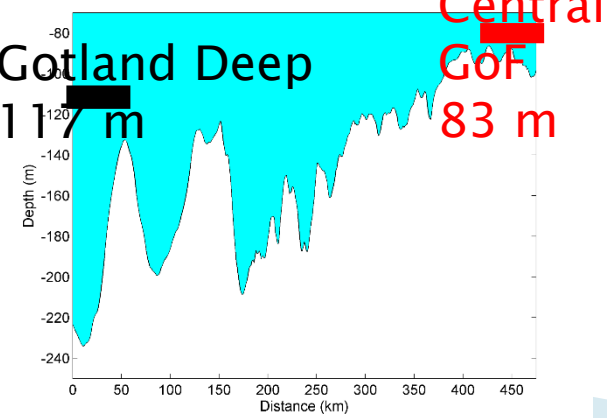
Shift in the Central Baltic occurred in early 2015

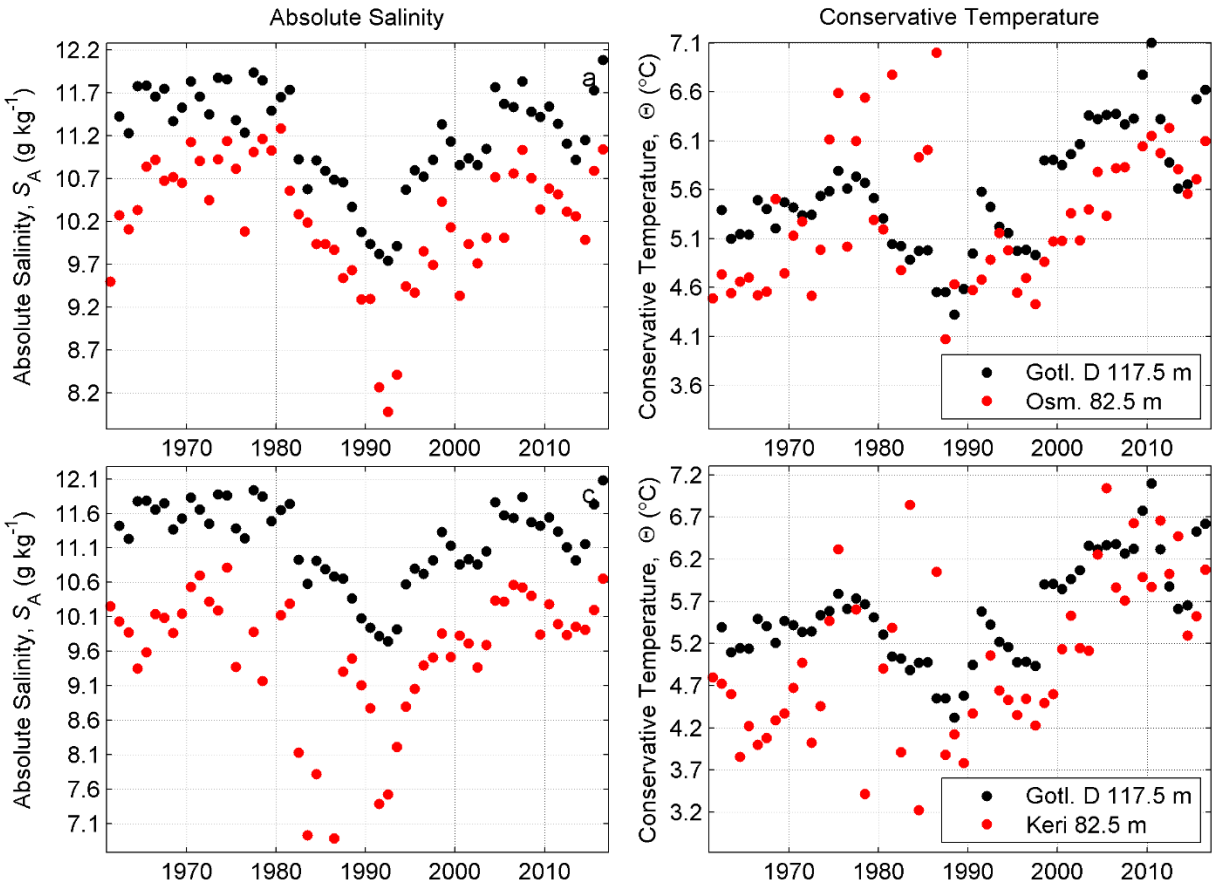


Changes in the near-bottom layer of the NE Baltic are dependent on the sub-halocline layer of the Central Baltic.

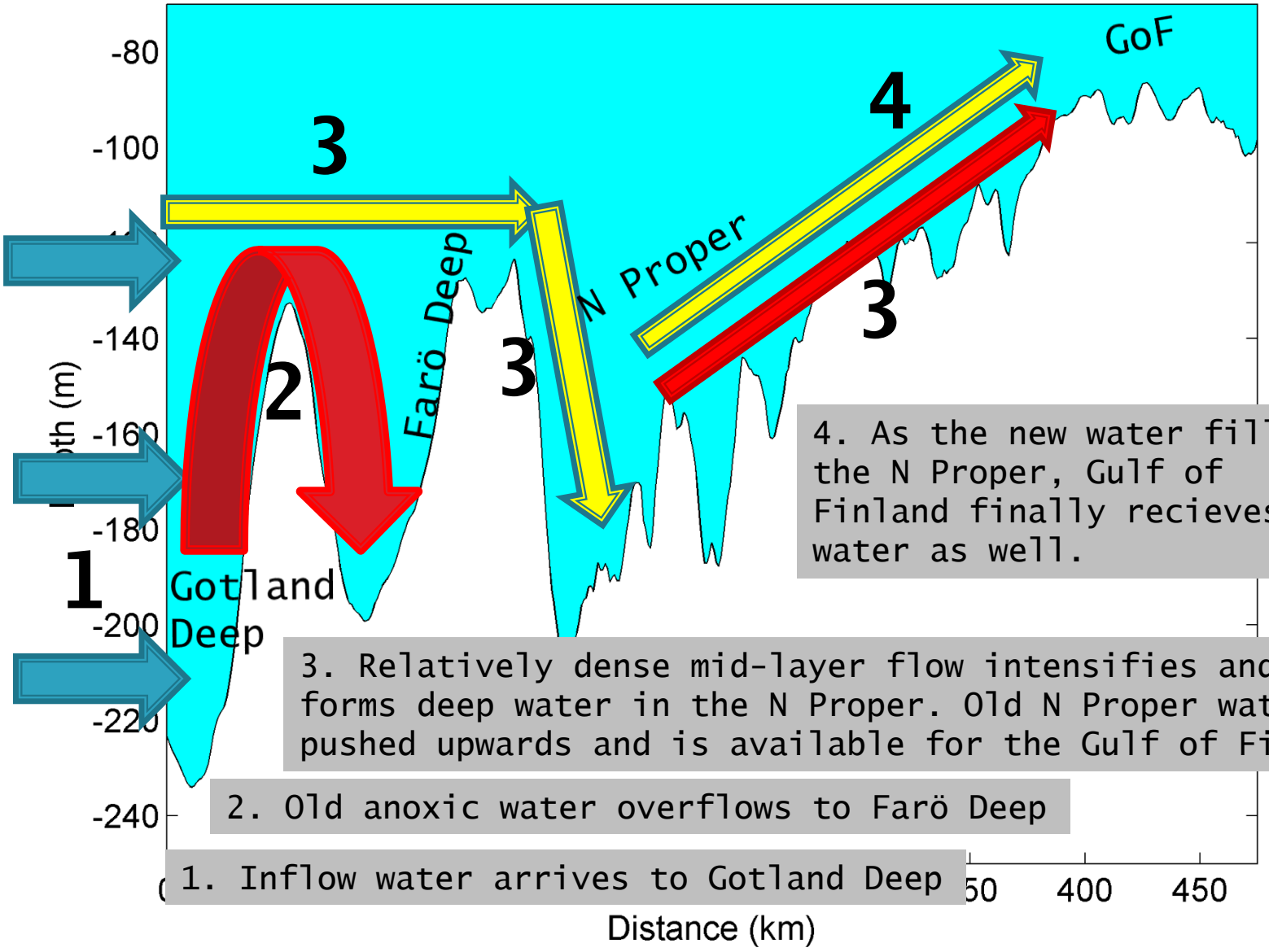
Annual mean T and S in the Gotland Deep vs. annual maximum T and S in the Osmussaar area and central GoF







Cascade of propagation to the GoF



4. As the new water fills the N Proper, Gulf of Finland finally recieves new water as well.

3. Relatively dense mid-layer flow intensifies and forms deep water in the N Proper. Old N Proper water is pushed upwards and is available for the Gulf of Finland

2. Old anoxic water overflows to Farö Deep

1. Inflow water arrives to Gotland Deep

Conclusions

Halocline and deep layer shift occurred in the GoF 14-15 months after the first MBI, first signs of MBI impact 9 months after the first MBI.

Stronger halocline after MBIs, vertical mixing is more prevented.

Highest salinities since last 40-60 years were observed in the whole study area. 10.77 g kg^{-1} in the central GoF in Oct 2016 (highest since 1974).

EGB and Farö Deep first fill with dense water. This allows relatively salty water flow on the top of this water and not to be trapped in those basins but penetrate northwards towards GoF.

New deep layer water in the Gulf of Finland originated from the Eastern Gotland Basin at the depth of 110-120 m.

Increase in oxygen content in the Eastern Gotland Basin has occurred, rather decrease in the NE Baltic (including GoF).

Ongoing studies and future plans

- Similar MBI propagation study for nutrients
- Assessing health of the GoF by high-resolution oxygen profiling (Stoicescu et al. submitted to Frontiers).
- Underwater glider experiment in winter 2018/19 in the Northern Baltic Proper
- MBI impact in the Eastern GoF...potential RUS-EST-FIN collaboration?

Collaboration proposals are welcome!

Thank you!

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