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Background

Baltic Sea

- Deep water renewal by inflow events
- "Natural laboratory" for ocean circulation

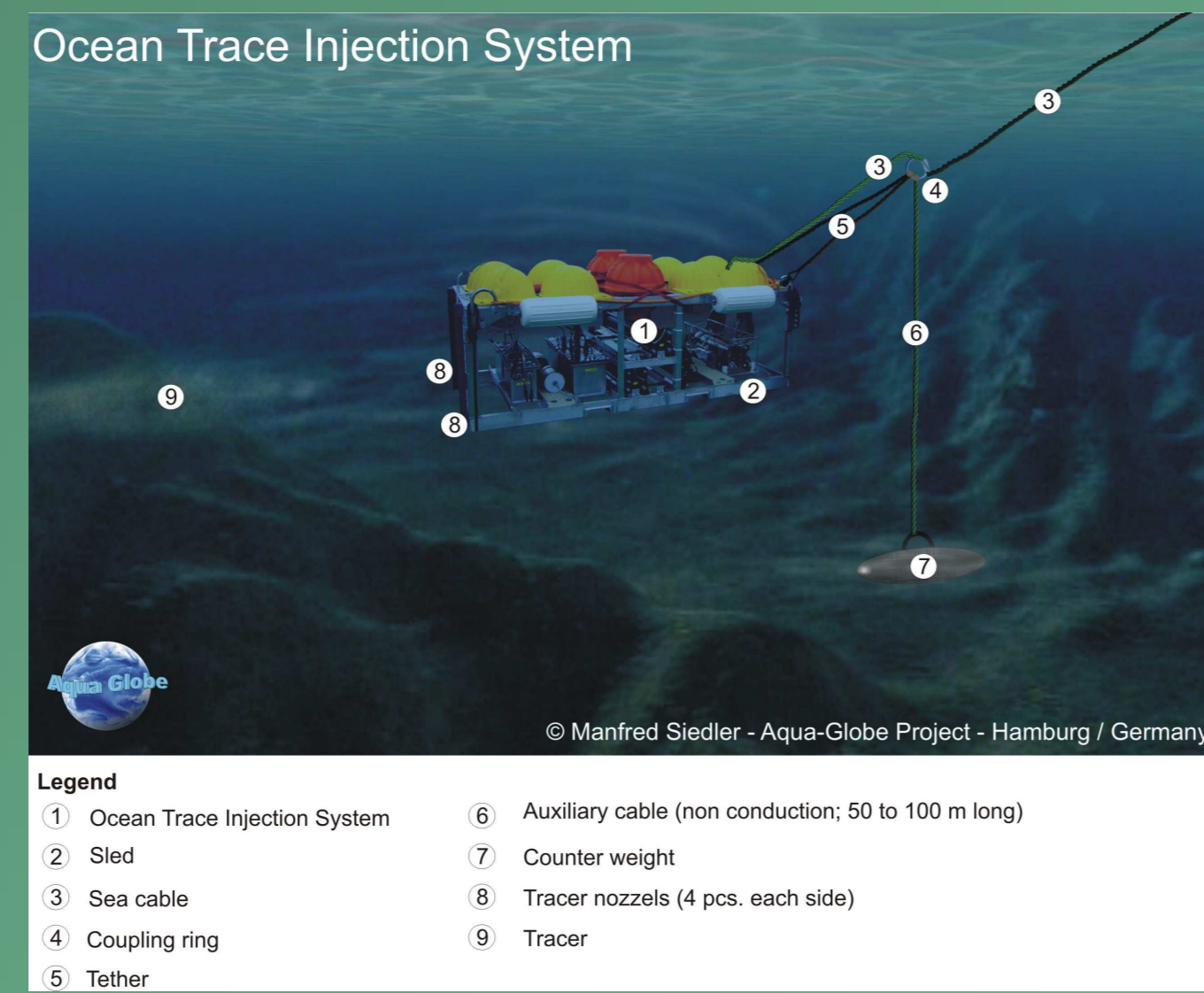
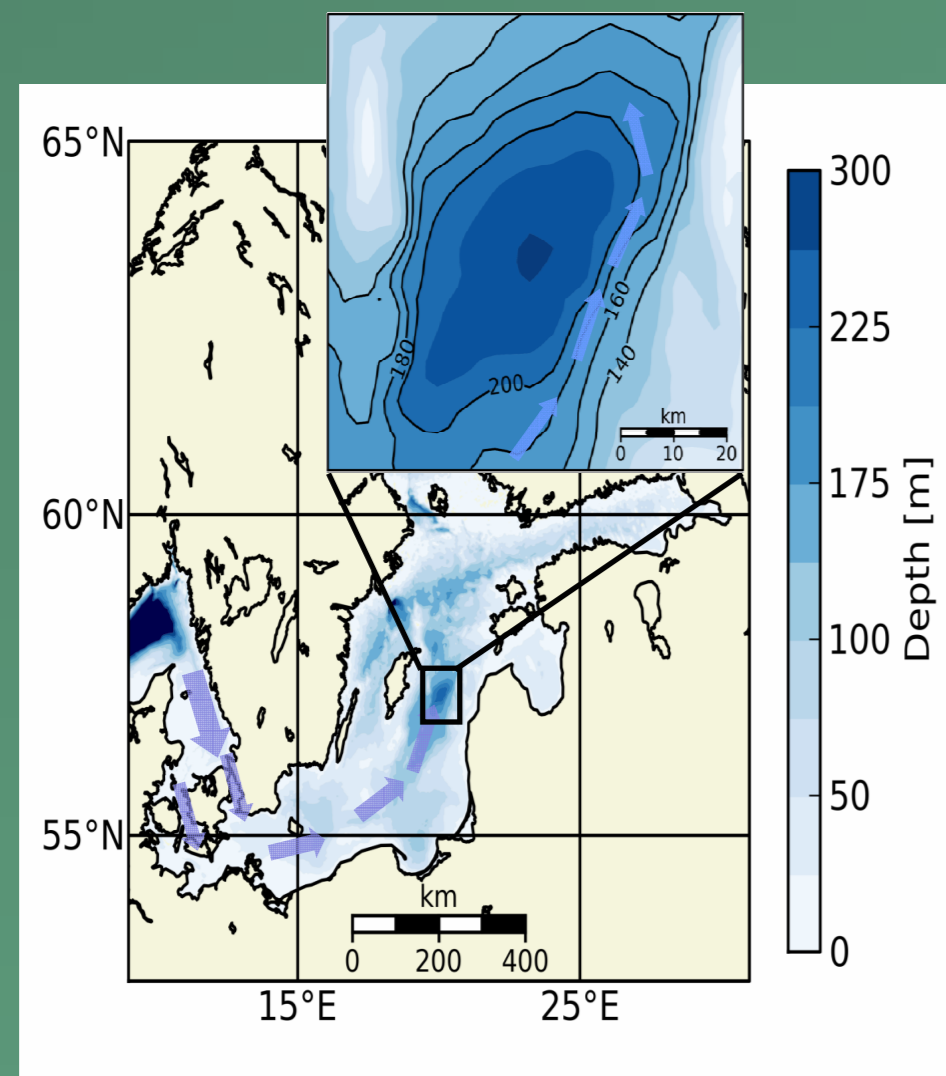
Gotland Basin

- No tides
- Seasonality of mixing

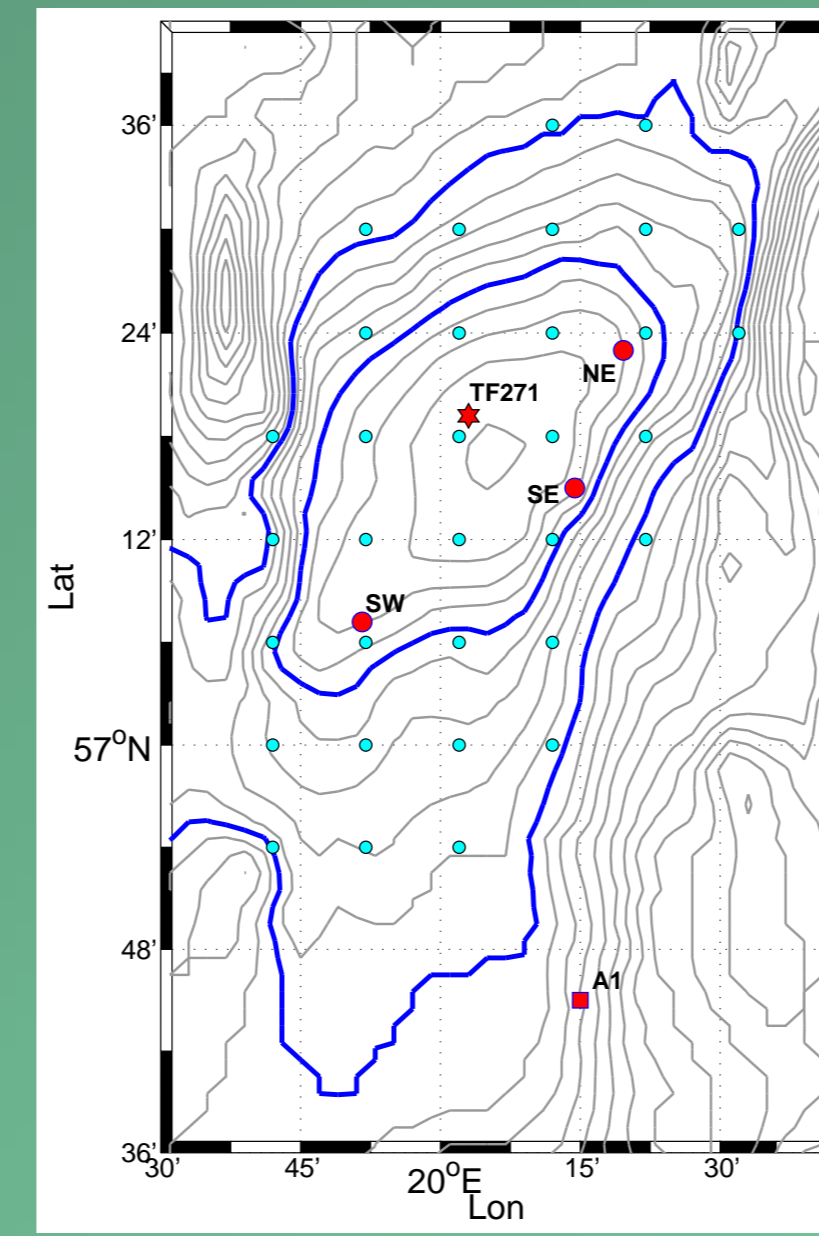
Key Questions:

Which processes cause deep water mixing during stagnation periods?

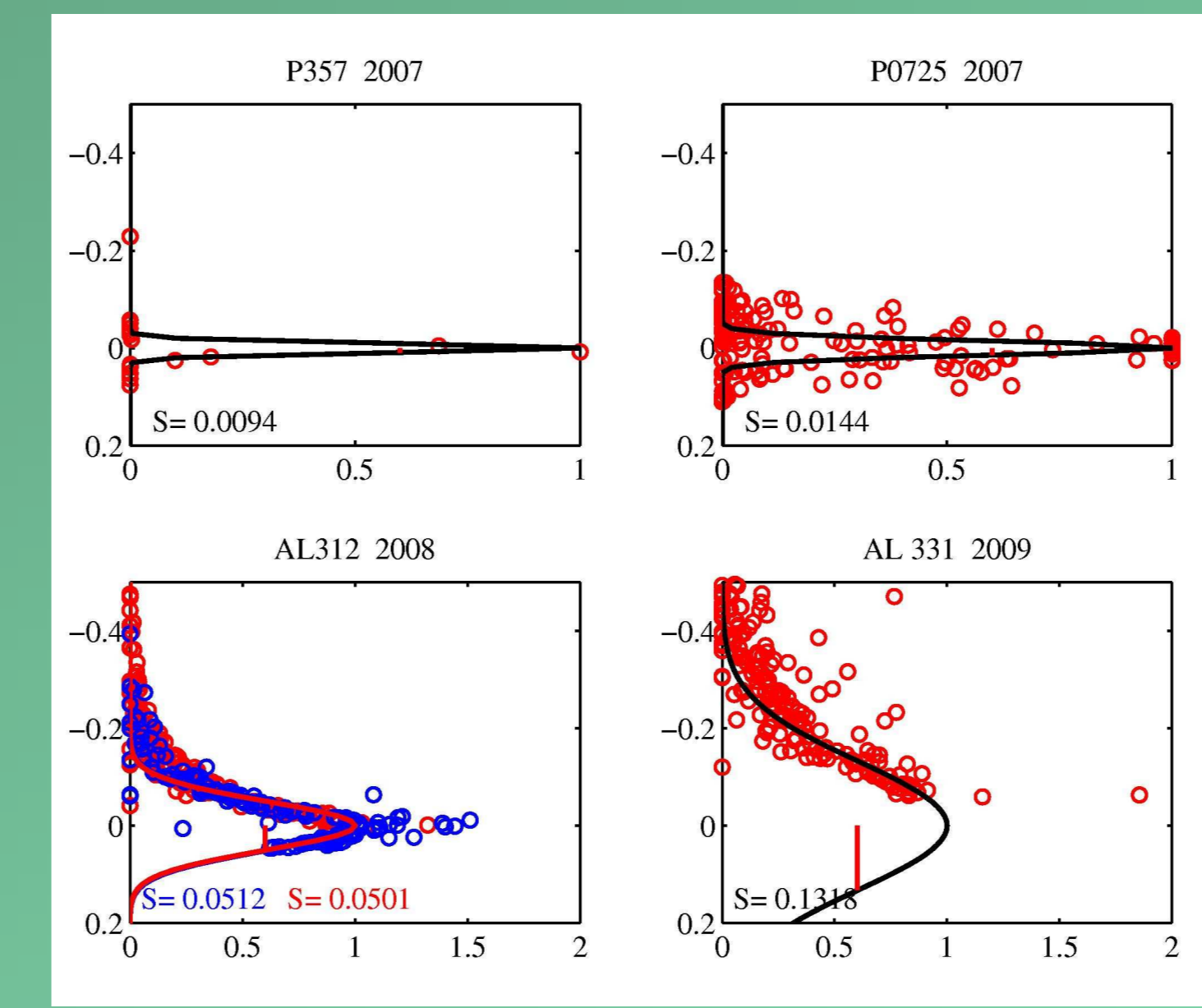
How are these processes linked to atmospheric forcing?



OTIS: Ocean Tracer Injection System
0.9 kg of SF₅CF₃ injected in September 2007



Five Moorings

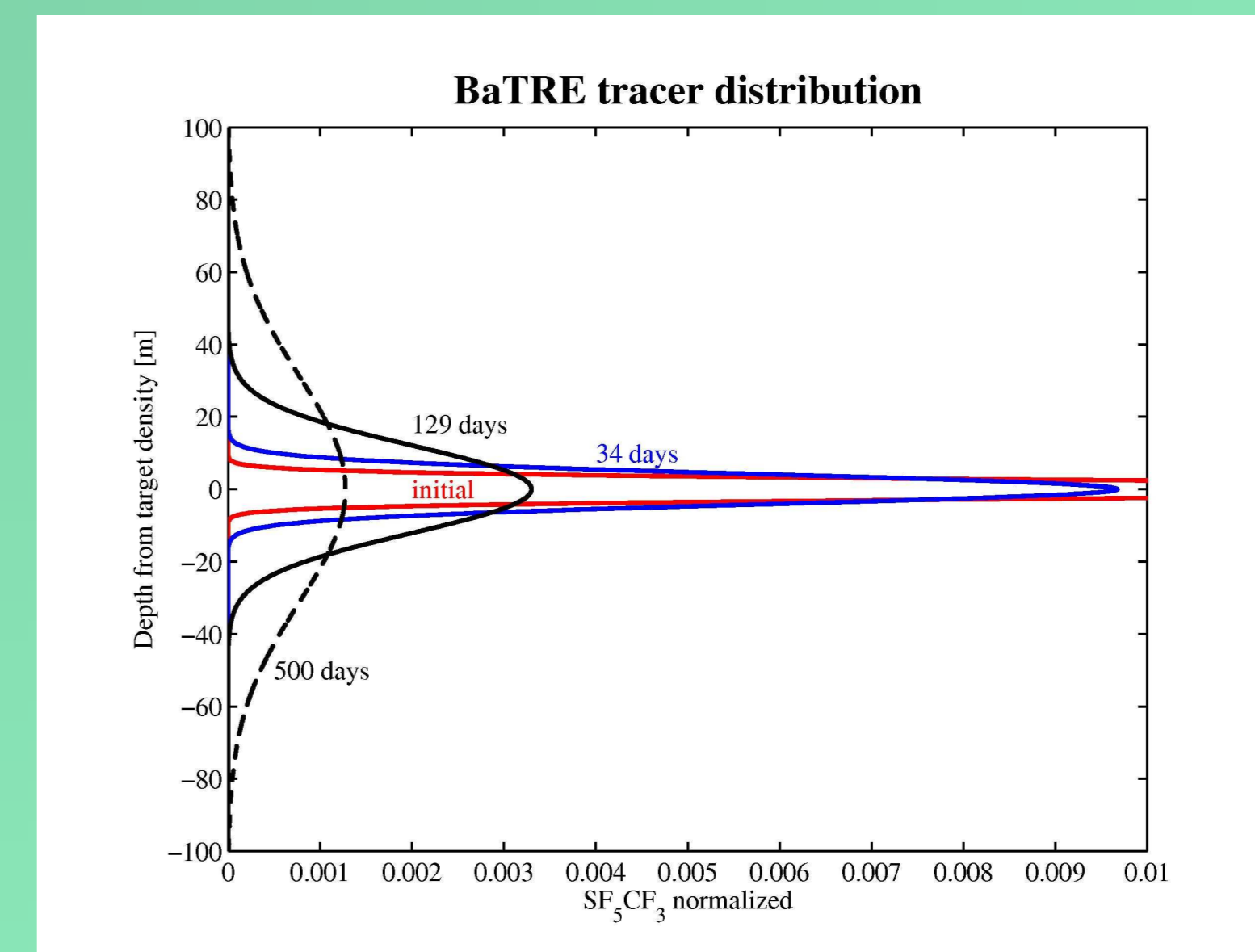


- Fit the data to Gaussian distributions
- Calculate the second moment of the fit, i.e. the width of the fit as a measure of the vertical mixing

Conclusions:

- One and a half year of stagnant conditions has been observed by moorings, CTD, MSS, and a deliberately released tracer.
- From salt and temperature budgets we find higher vertical mixing rates in the winter mixing period, and a stagnant period during the summer with lower mixing rates.
- The tracer reveal low vertical mixing in the interior of the basin, but significant higher rates close to the border/bottom of the basin.
- Possible signs of interleaving also during the „stagnant“ period

$$K_z = S2(T2) - S2(T1) / 2(T2 - T1)$$



Time	K _z (10 ⁻⁶ m ² /s)
T2 – T1	2.0
T3 – T1	6.3
T4 – T1	11.2
T3 – T2	7.9
T4 – T2	11.8
T4 – T3	12.9

T1 = September 2007
T2 = October 2007
T3 = January 2008
T4 = January 2009

Four Tracer surveys

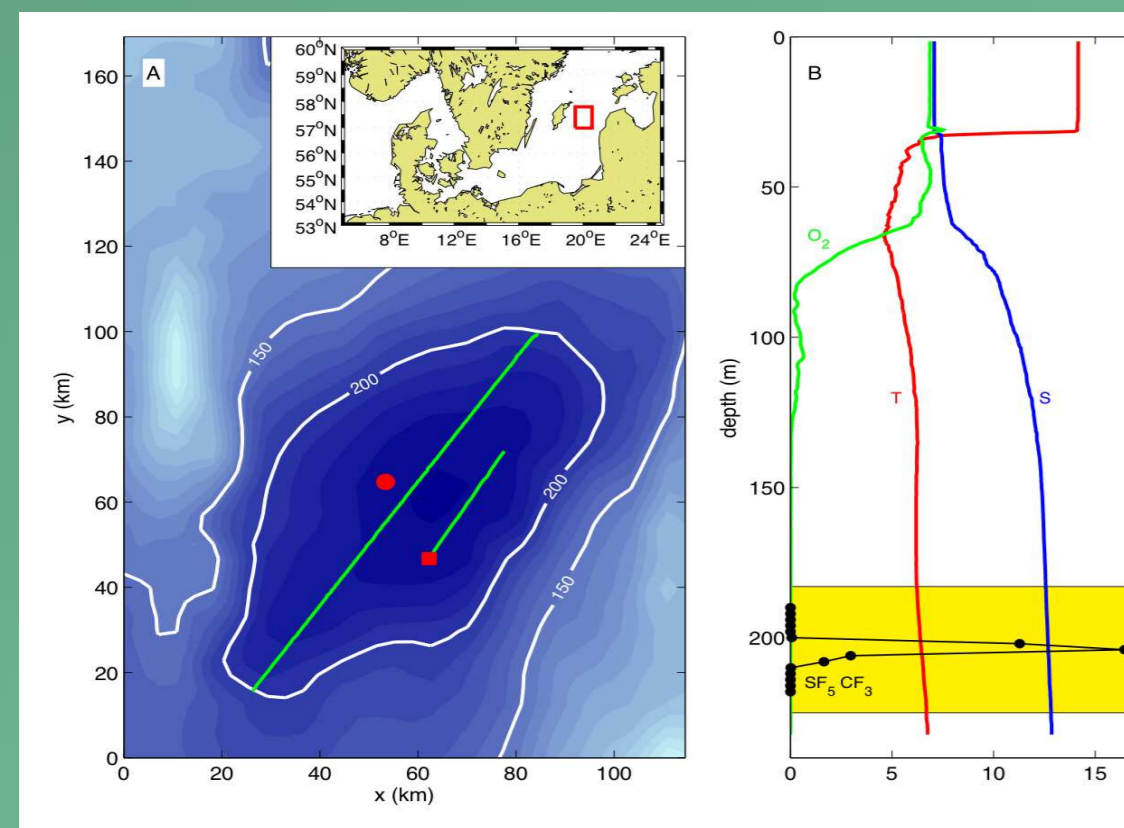
Initial survey (2 weeks)

1 Month later

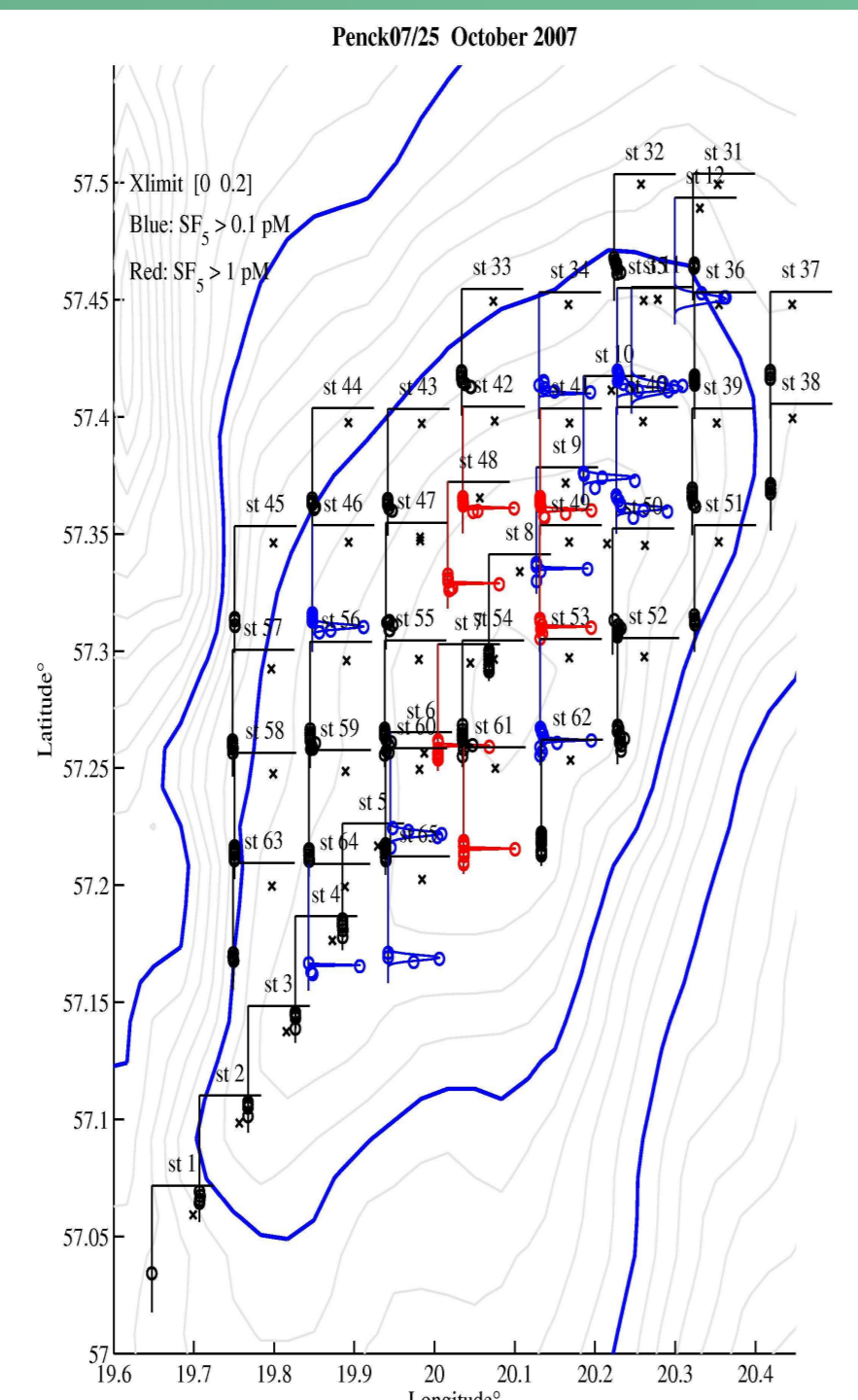
4 Months later

17 Months later

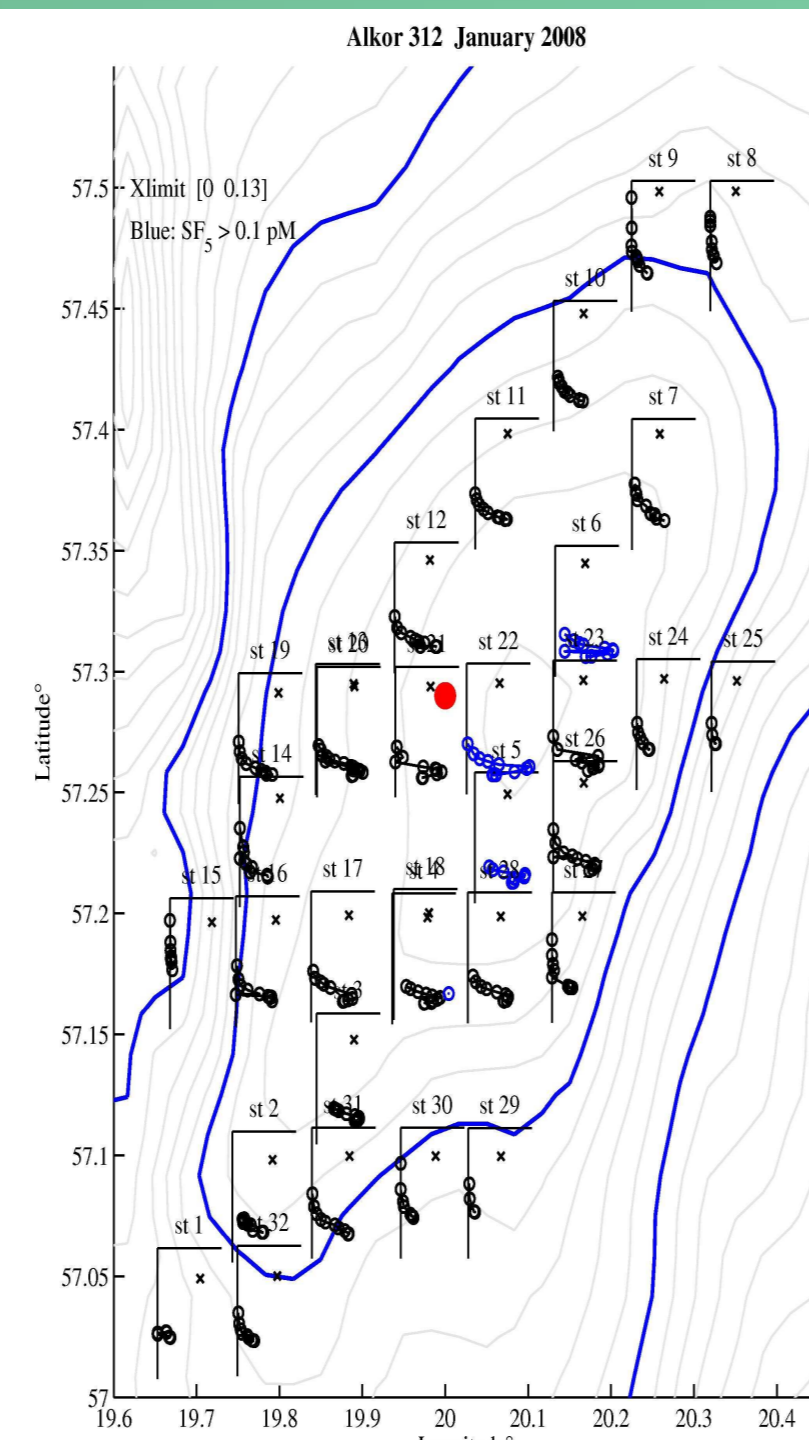
17 Months later



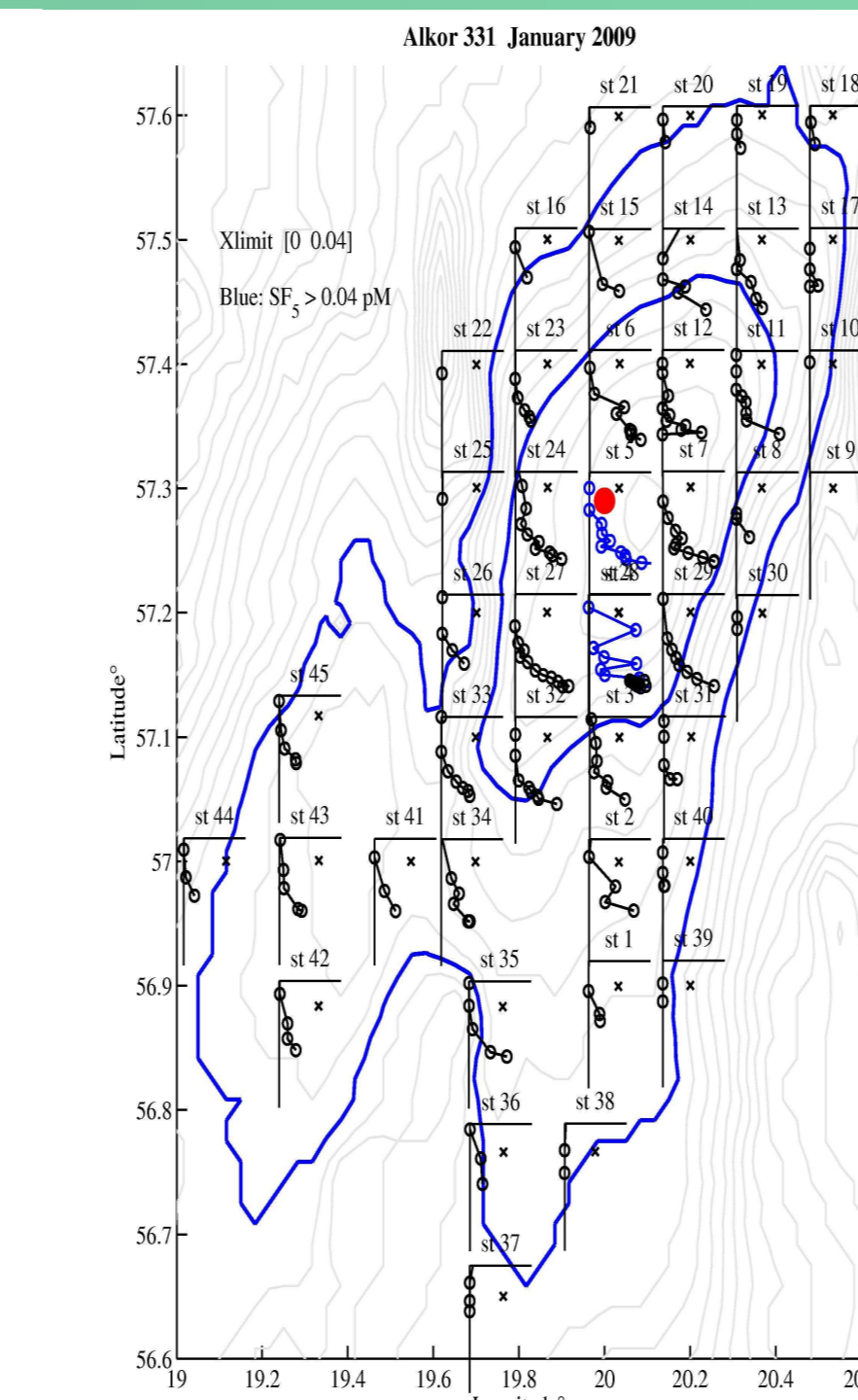
Umlauf et al., 2008 (EOS)



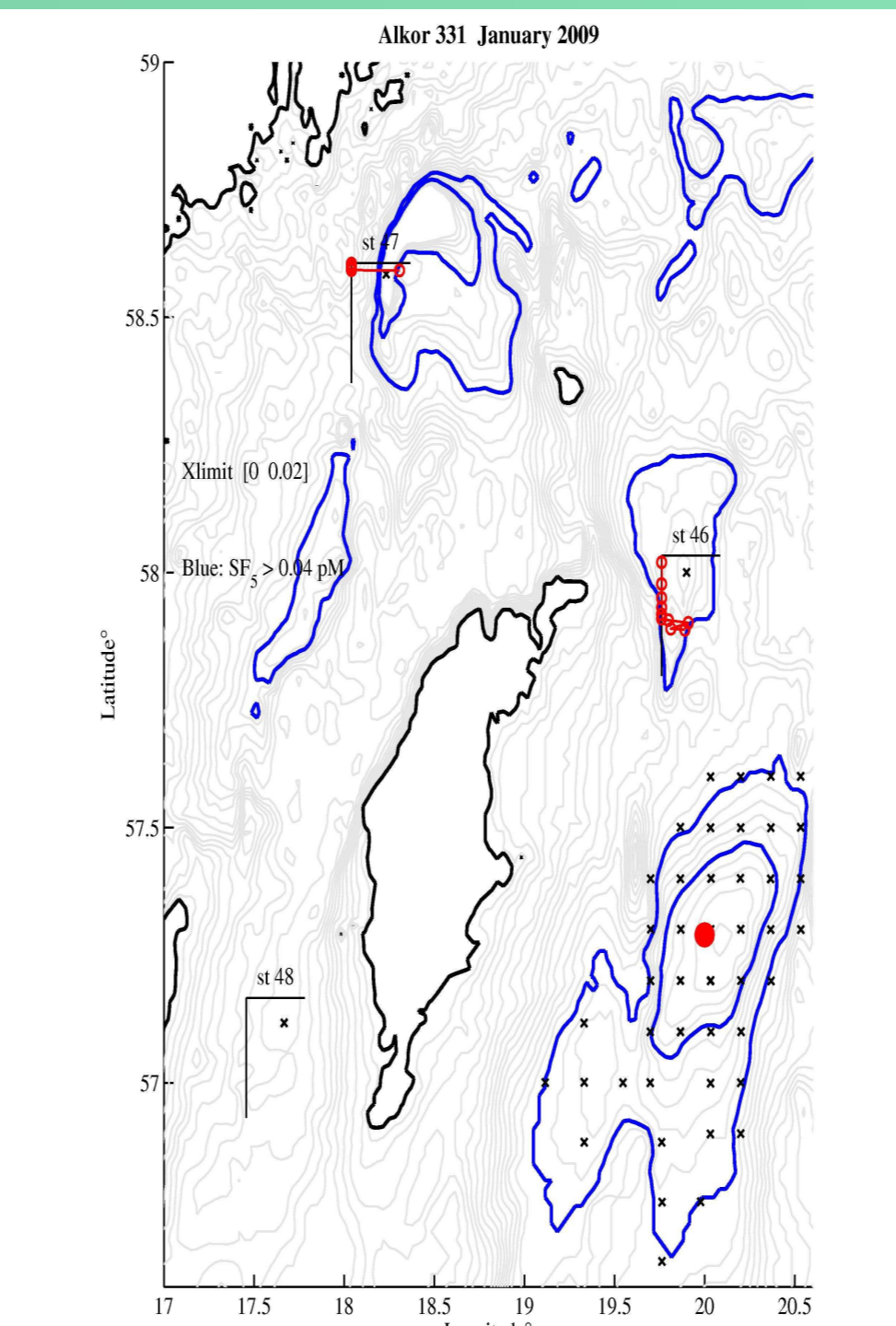
Tracer only in the interior basin



Tracer "hit" bottom



Tracer move outside of basin



..even far away

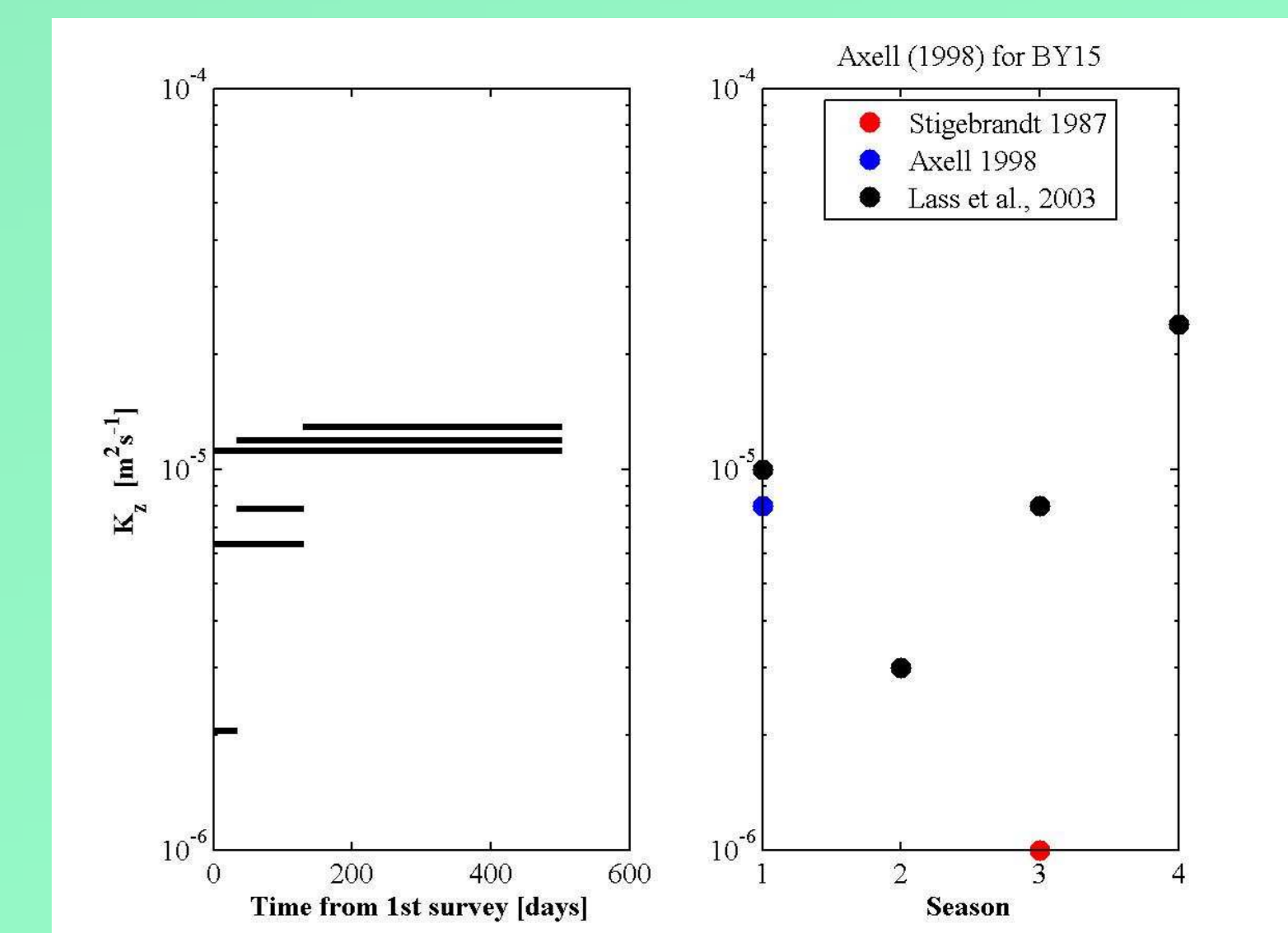
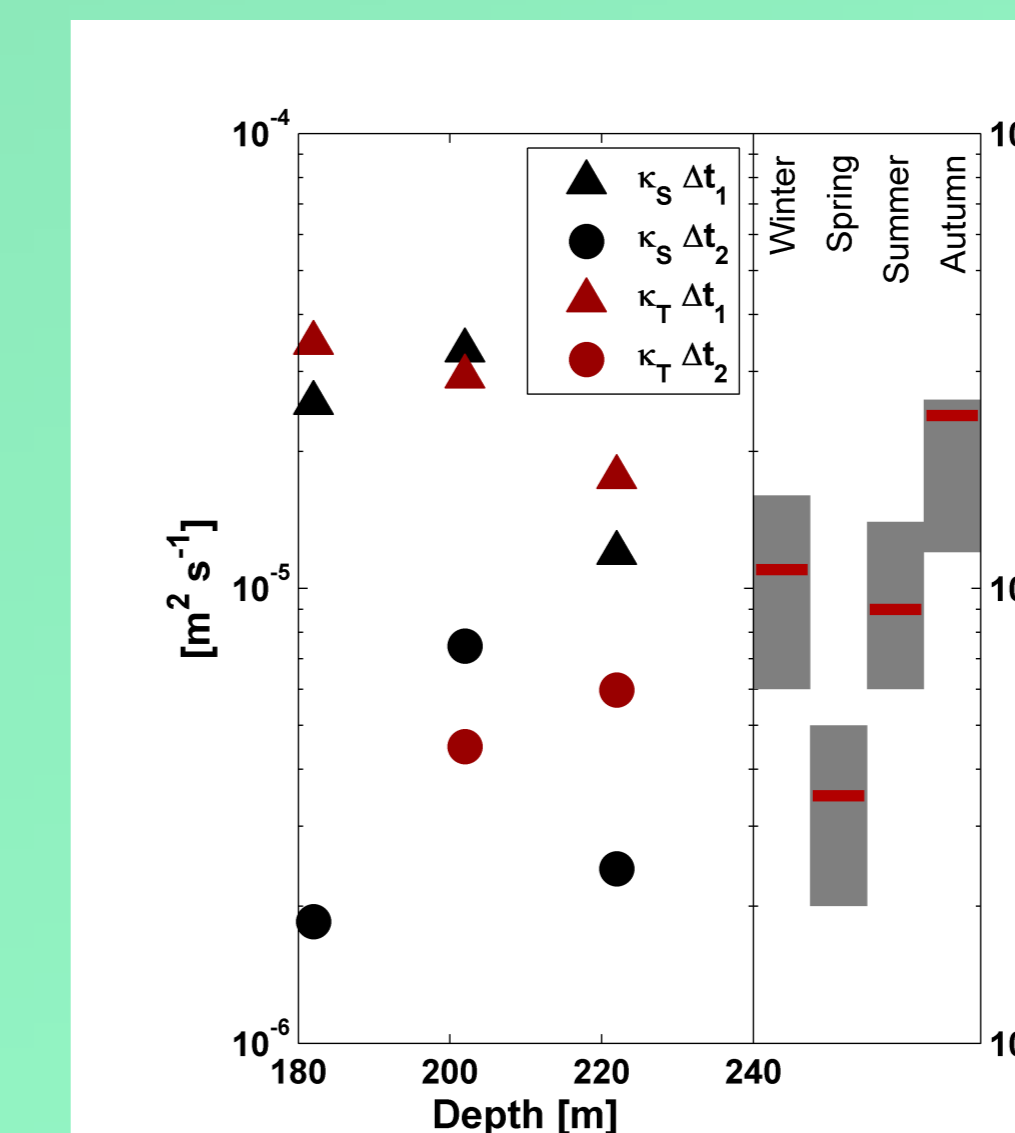
References

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- Lass, H. U., H. Prandke, and B. Liljebadh (2003), Dissipation in the Baltic proper during winter stratification, *J. Geophys. Res.*, 108, C6, 3187.
- Stigebrandt, A. (1987), A Model for the Vertical Circulation of the Baltic Deep-Water, *J. Phys. Oceanogr.*, 17, 1772–1785.
- Umlauf, L., T. Tanhua, J. Waniek, O. Schmale, P. Holtermann, and G. Rehder (2008), Hunting a New Oceanic Tracer, *EOS*, 89, 43, 419.

Photos: Mario Müller, IFM-GEOMAR

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Vertical diffusivity calculated from:



► S and T budgets

► Tracer dist.

► From Literature.

