Introduction to Loch Etive

Henrik Stahl (SAMS)

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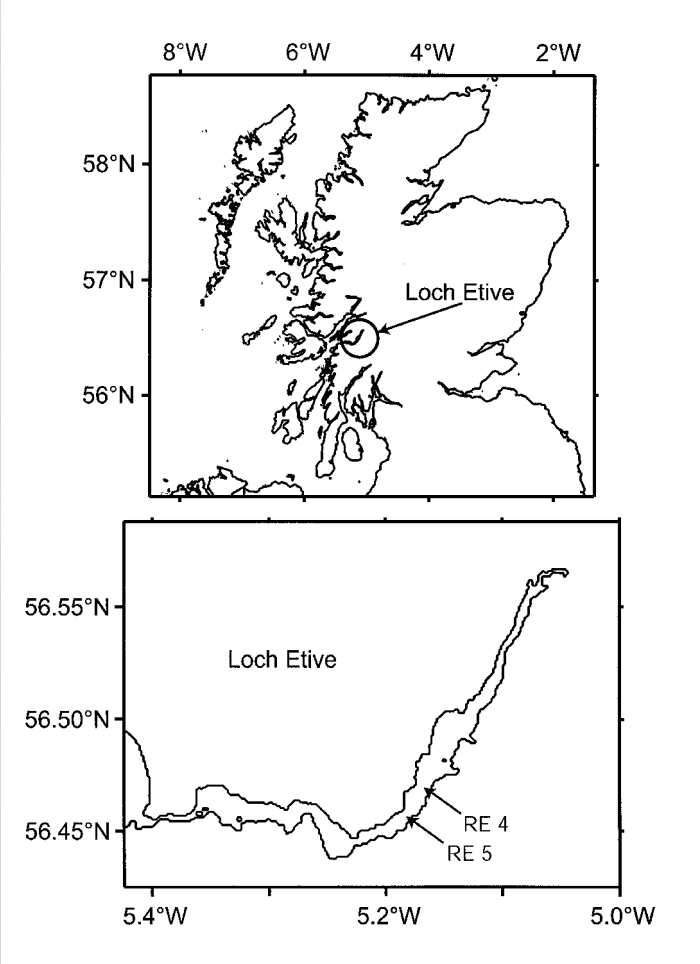
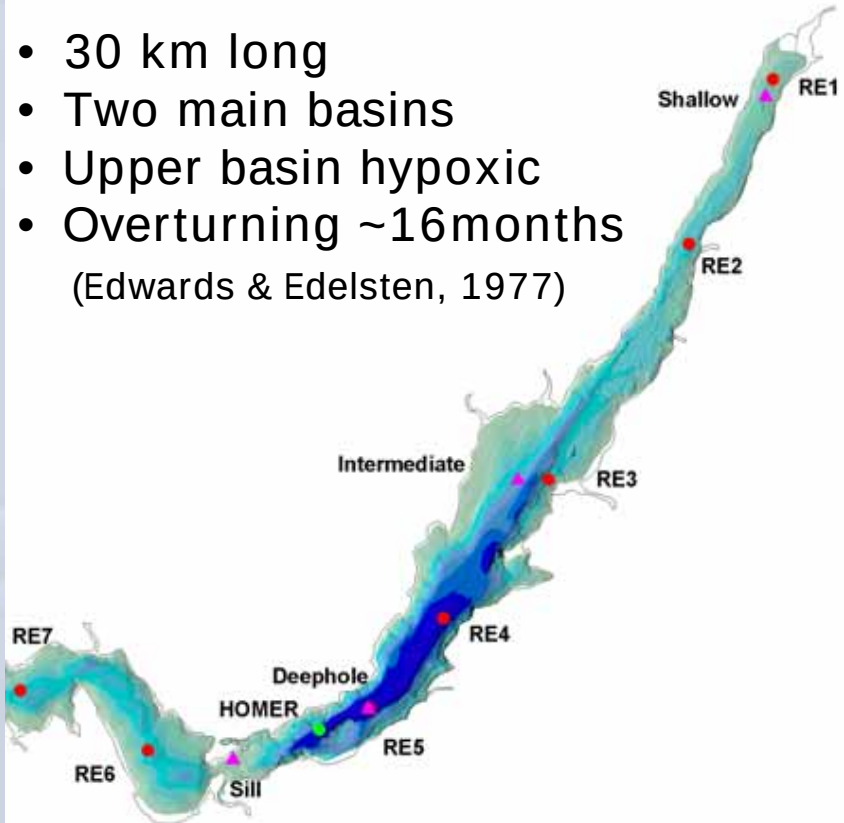


- 30 km long
- Two main basins
- Upper basin hypoxic
- Overturning ~16months

(Edwards & Edelsten, 1977)



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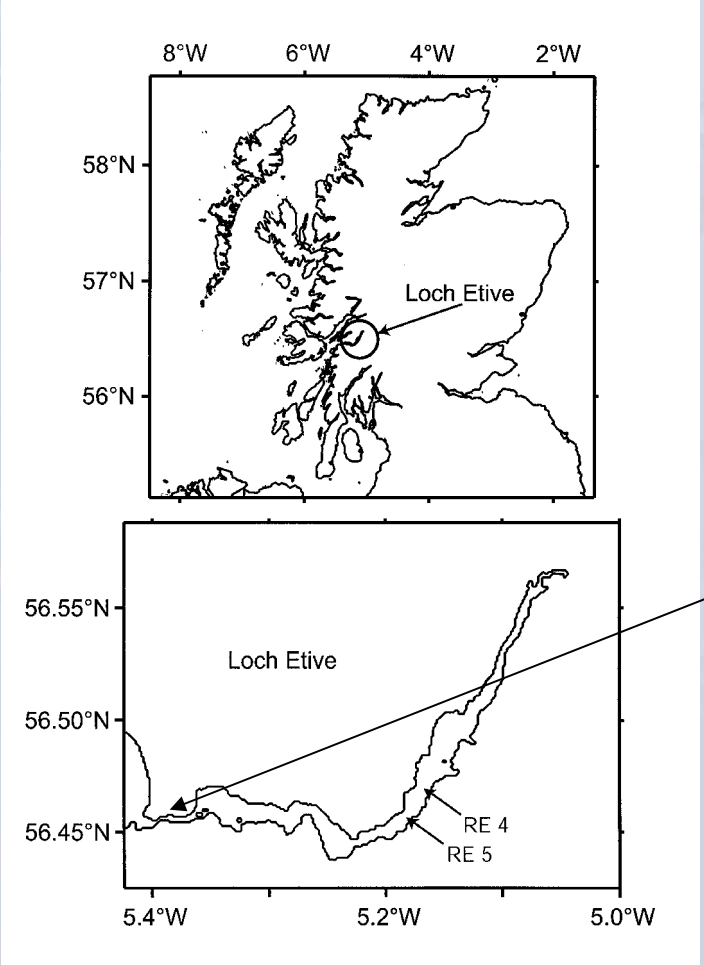

- 30 km long
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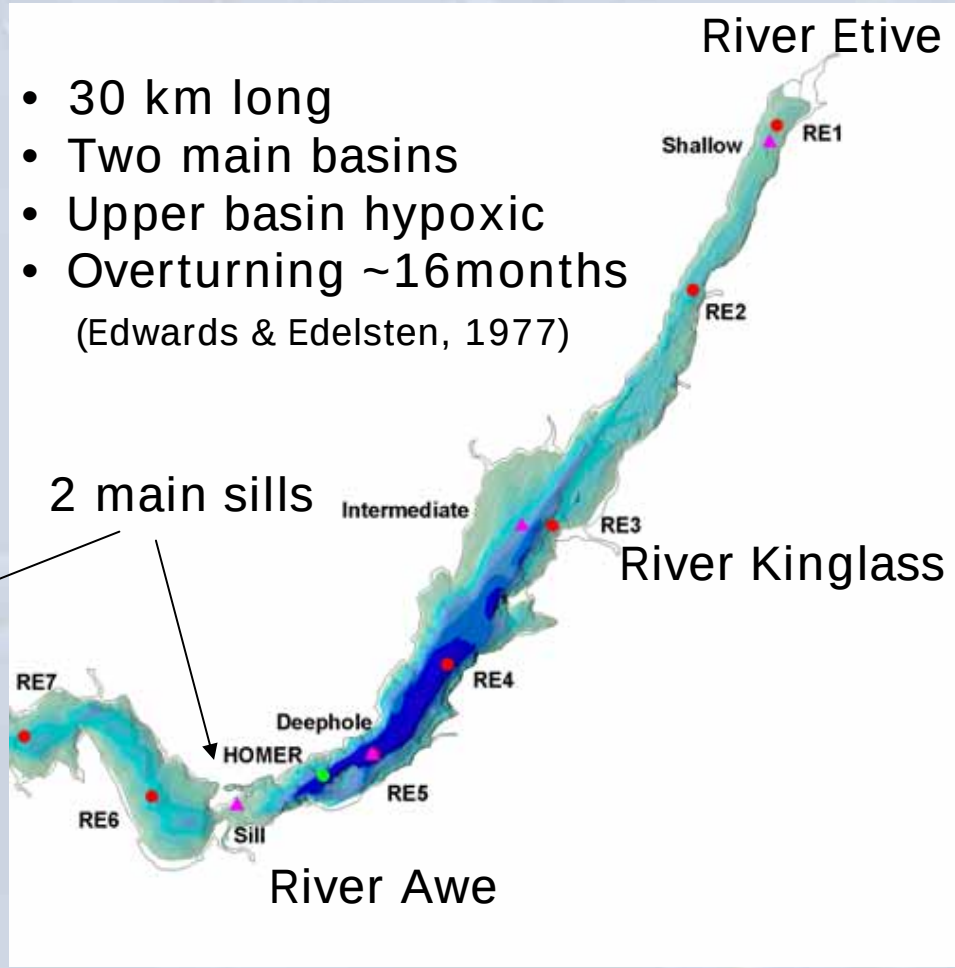
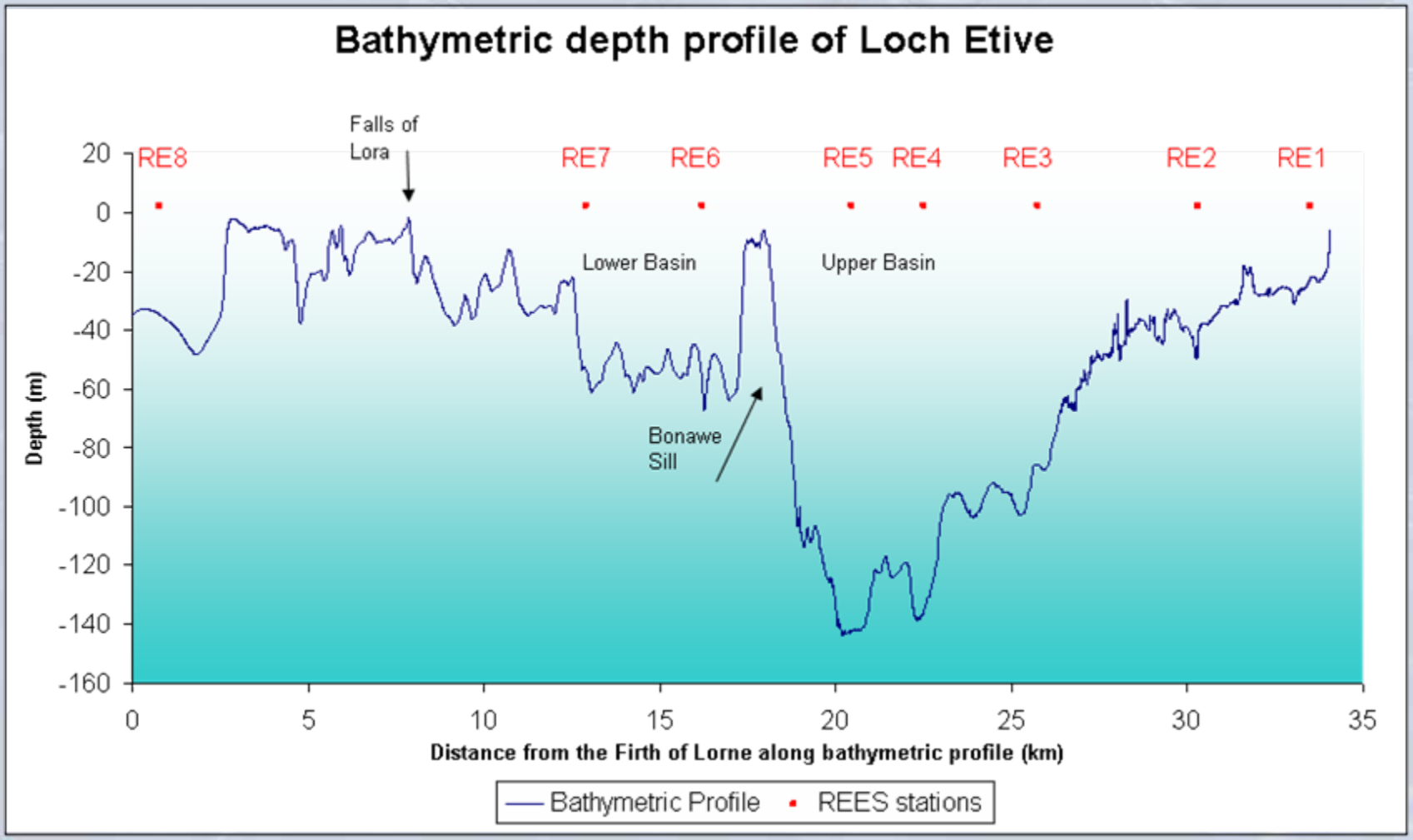
(Edwards & Edelsten, 1977)

2 main sills



Site bathymetry and hydrography



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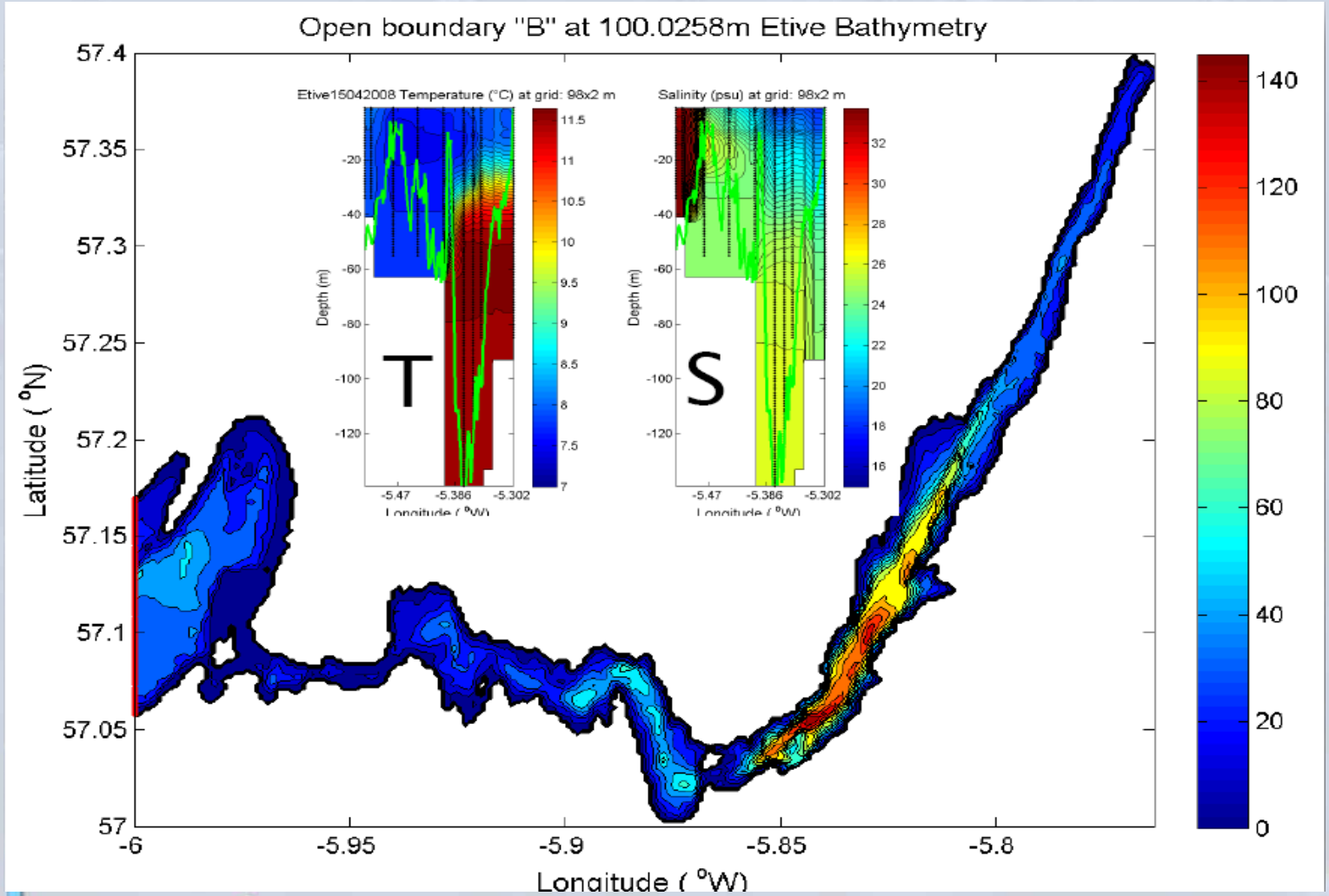
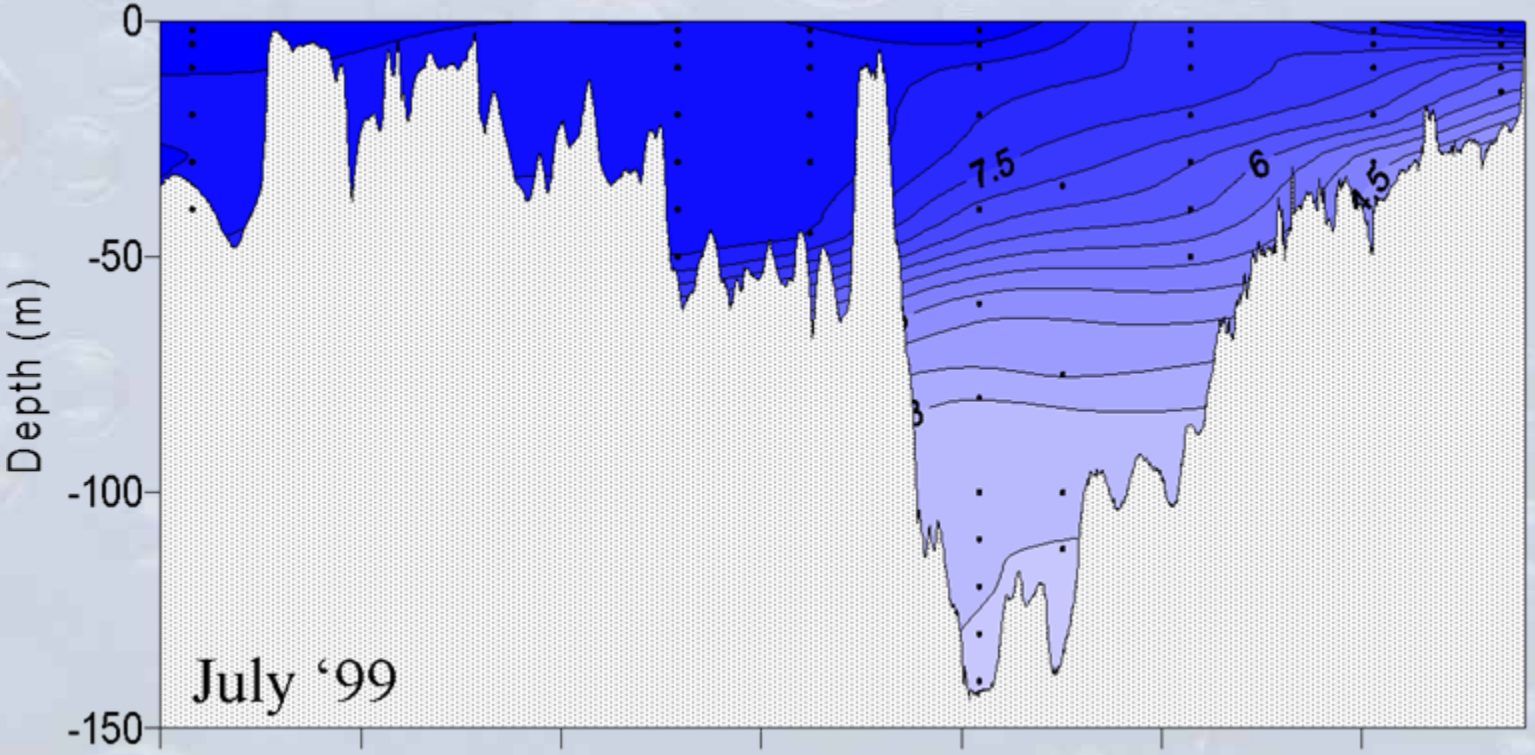


Distribution of oxygen (mg/l) in Loch Etive

time series plots

Distribution of oxygen (mg/l) in Loch Etive



REES programme 1999/2000 – monthly transects with CTD

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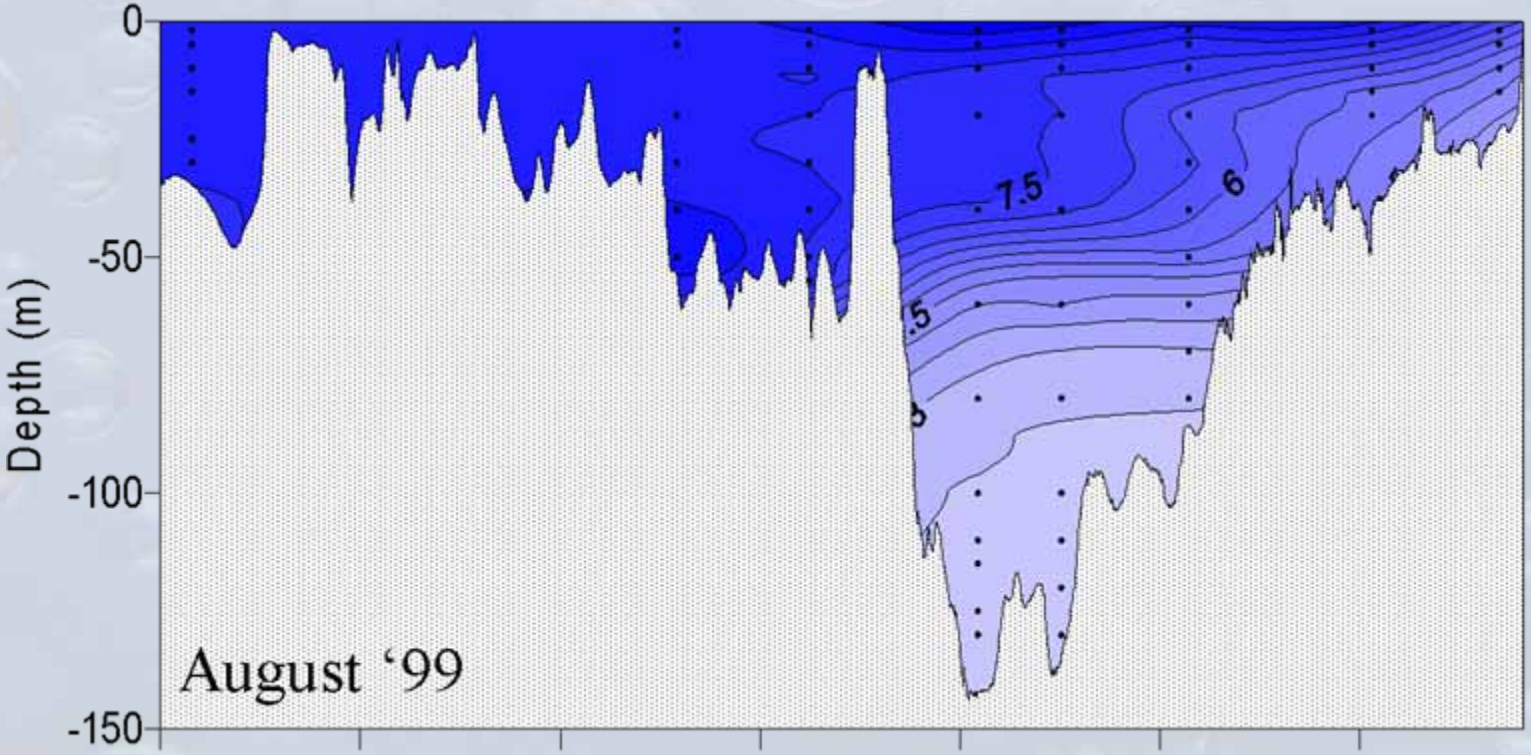

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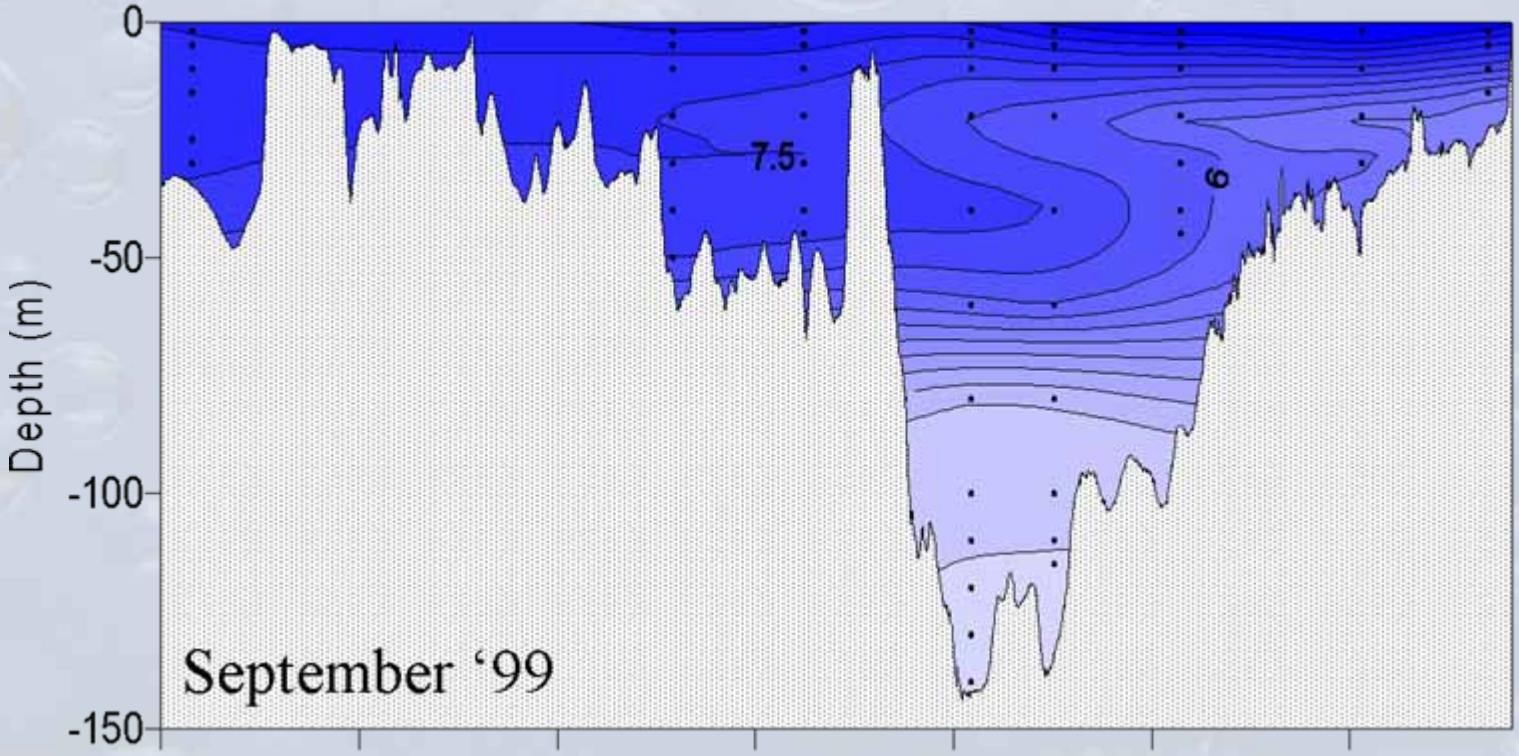

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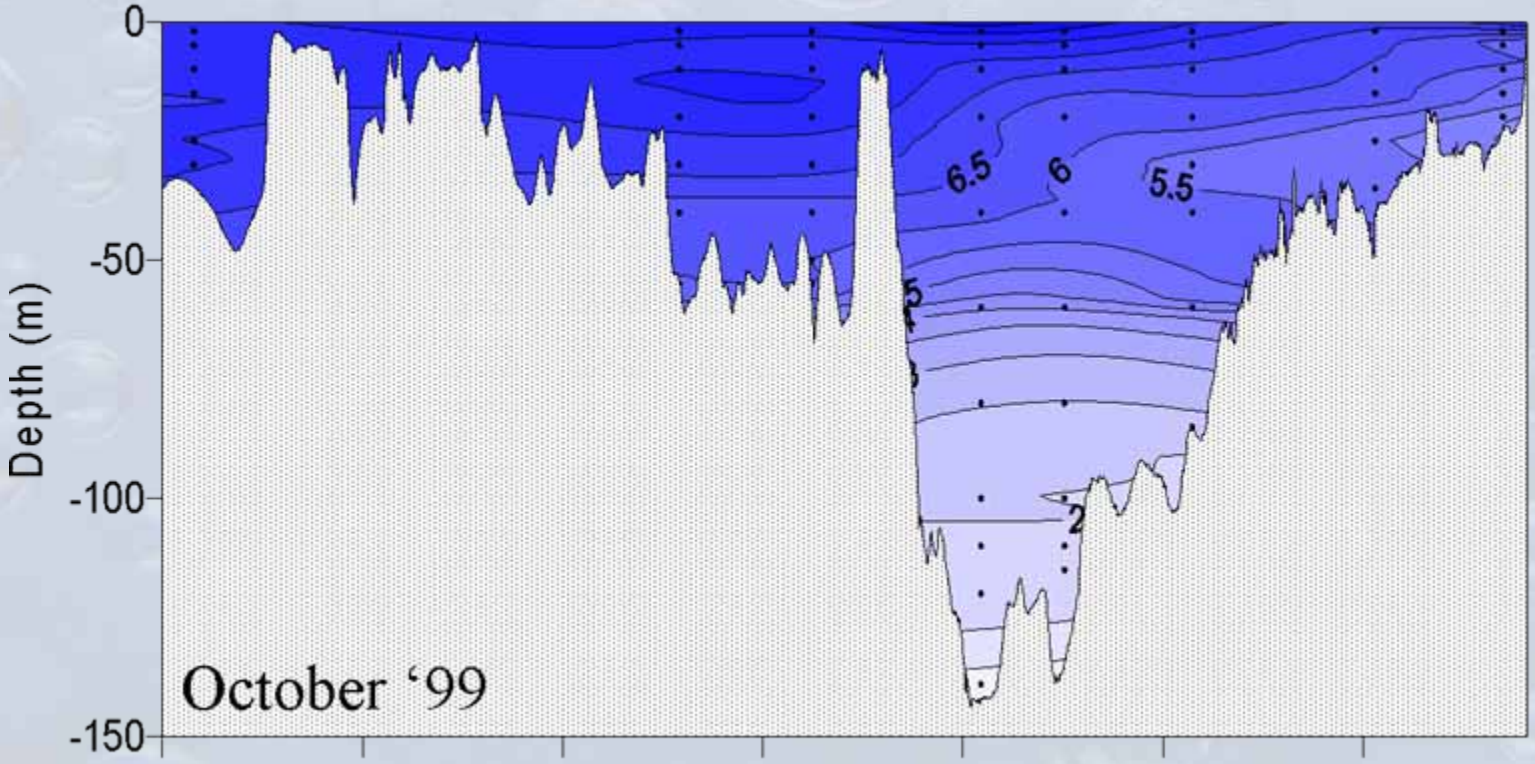

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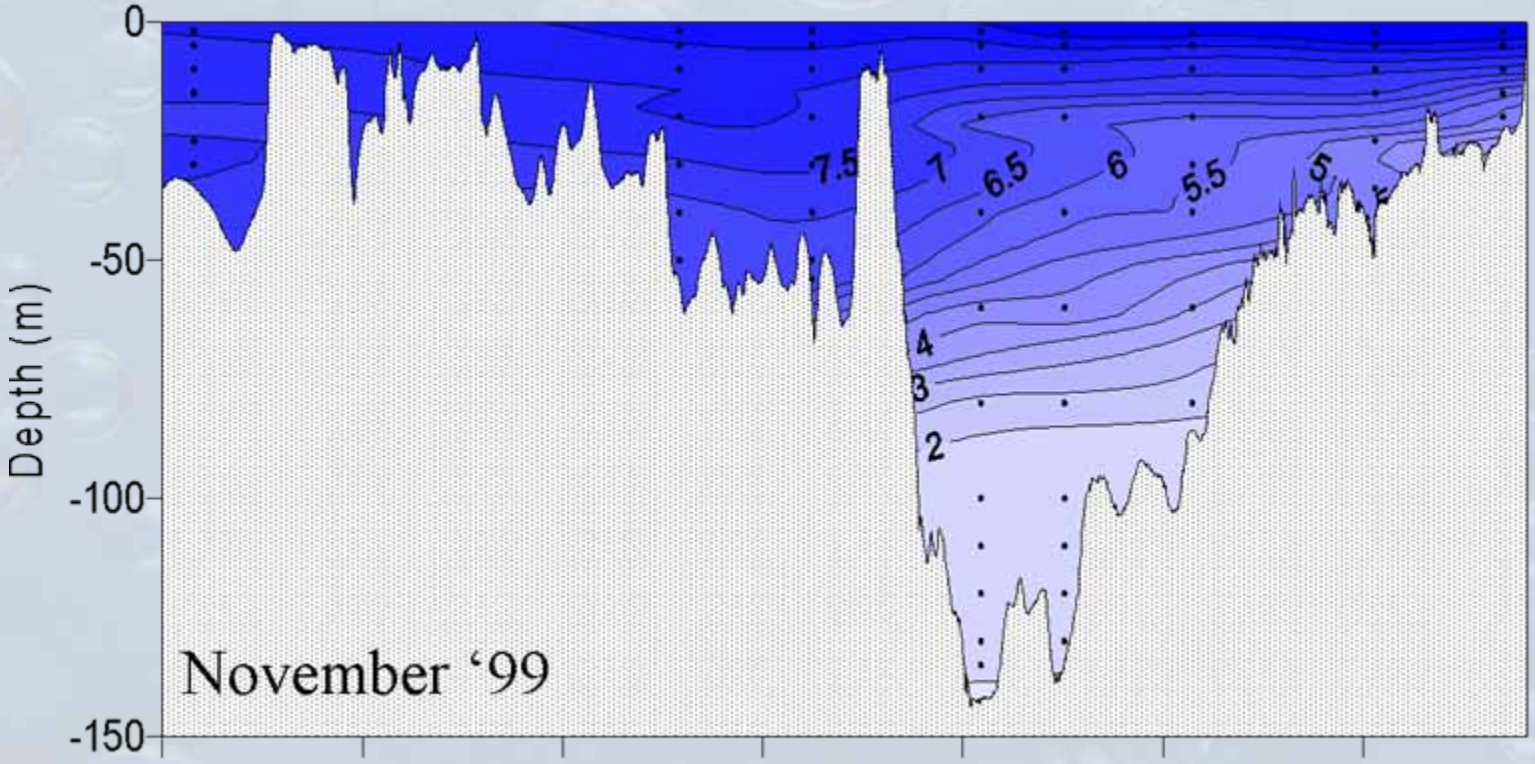

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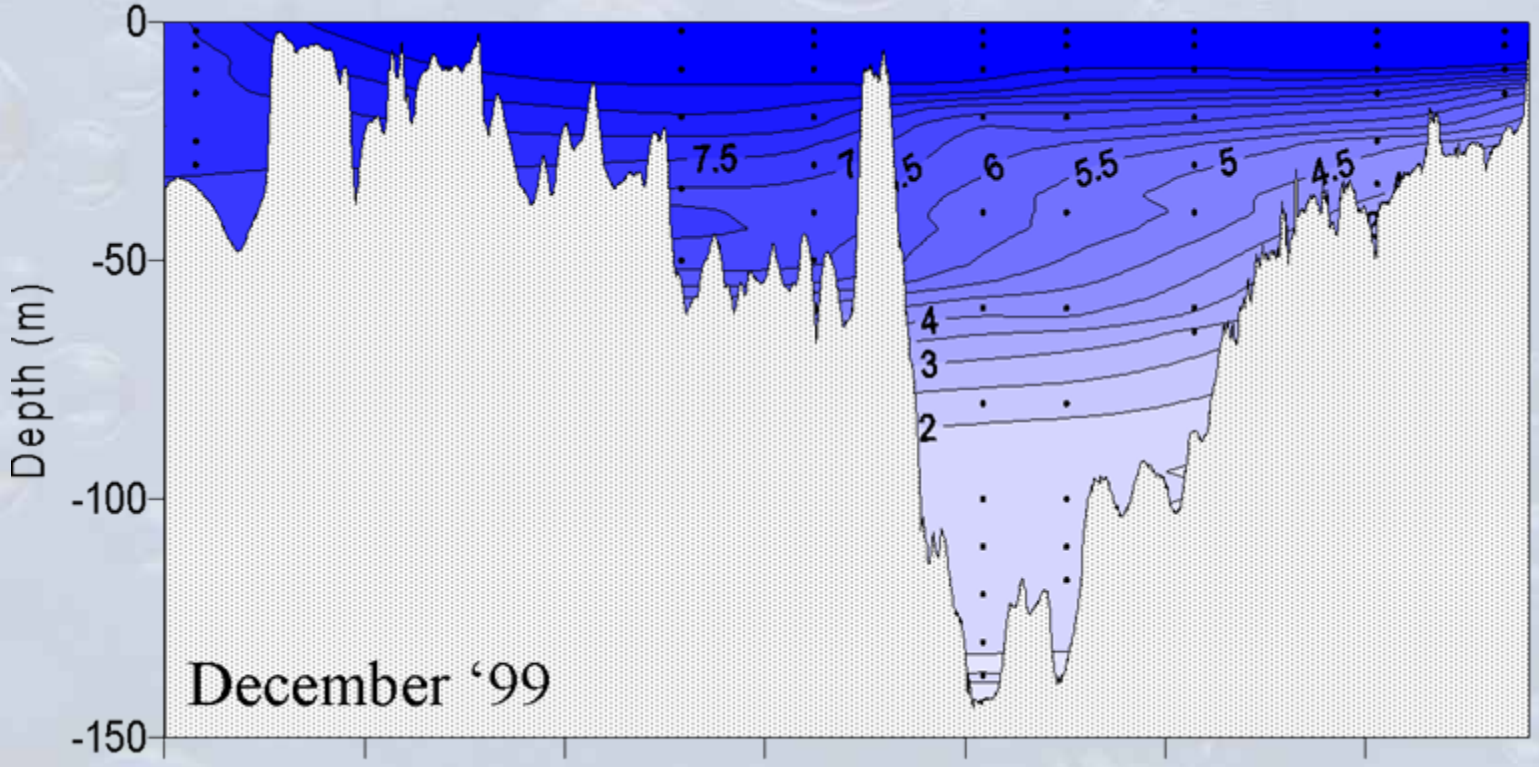

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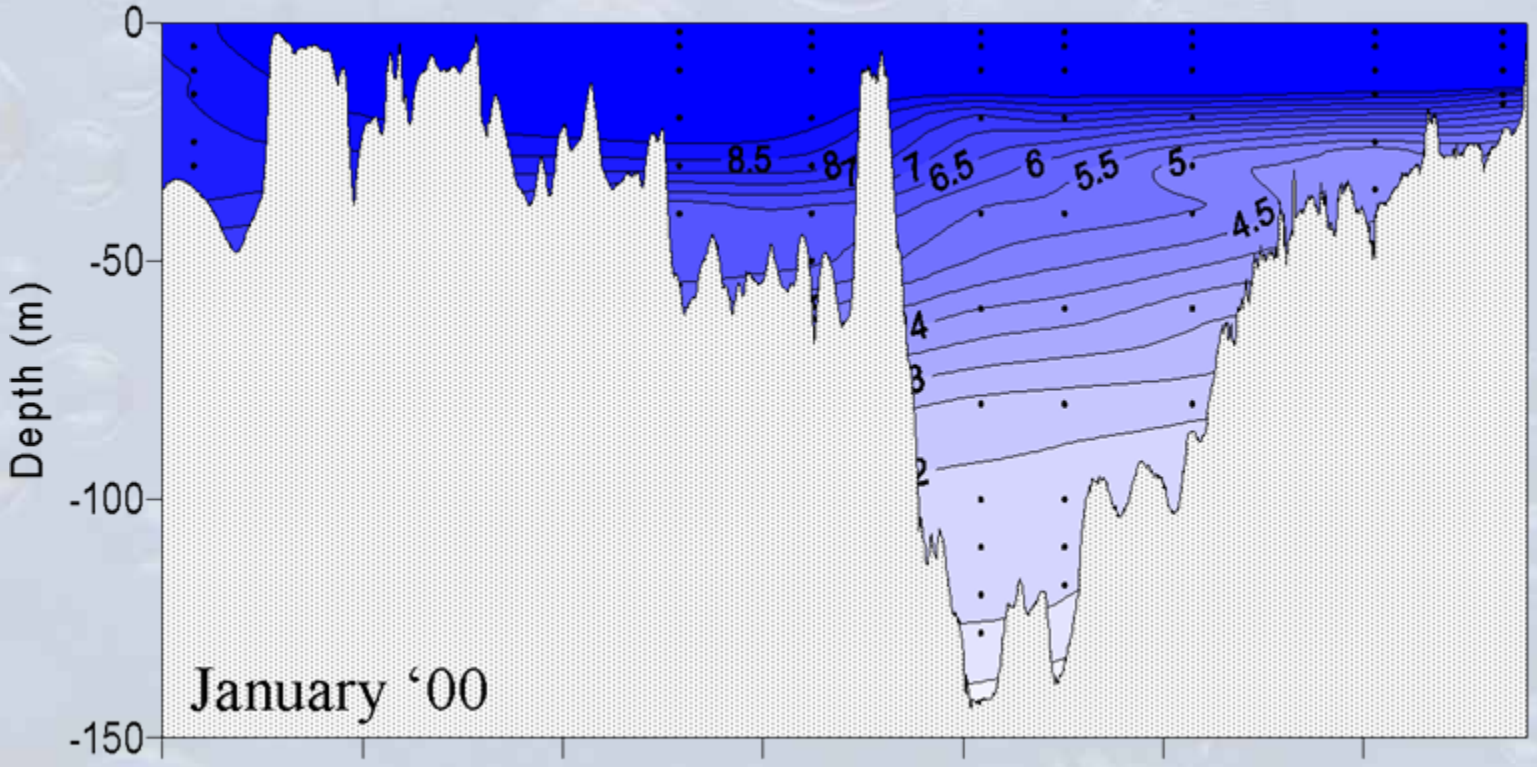

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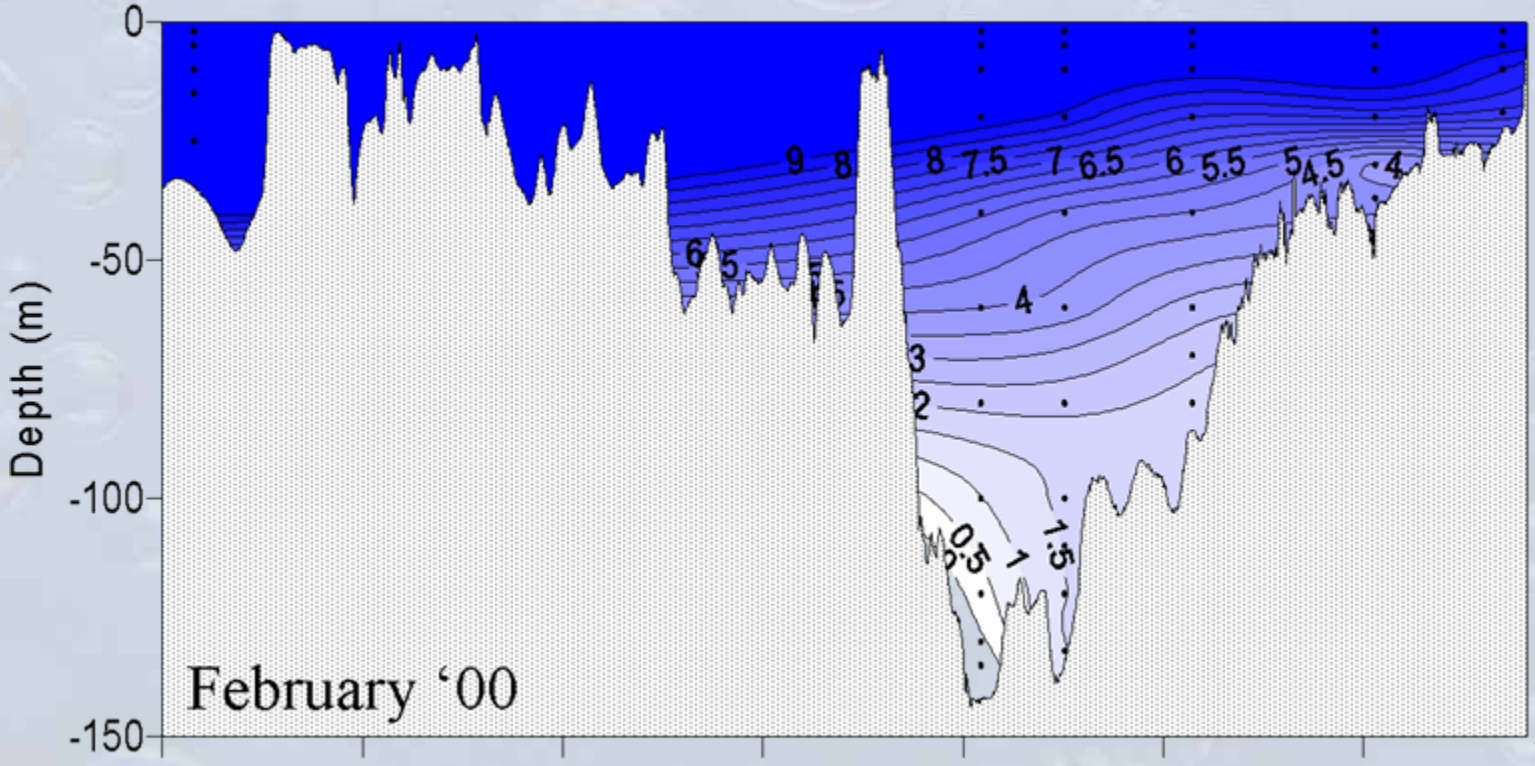

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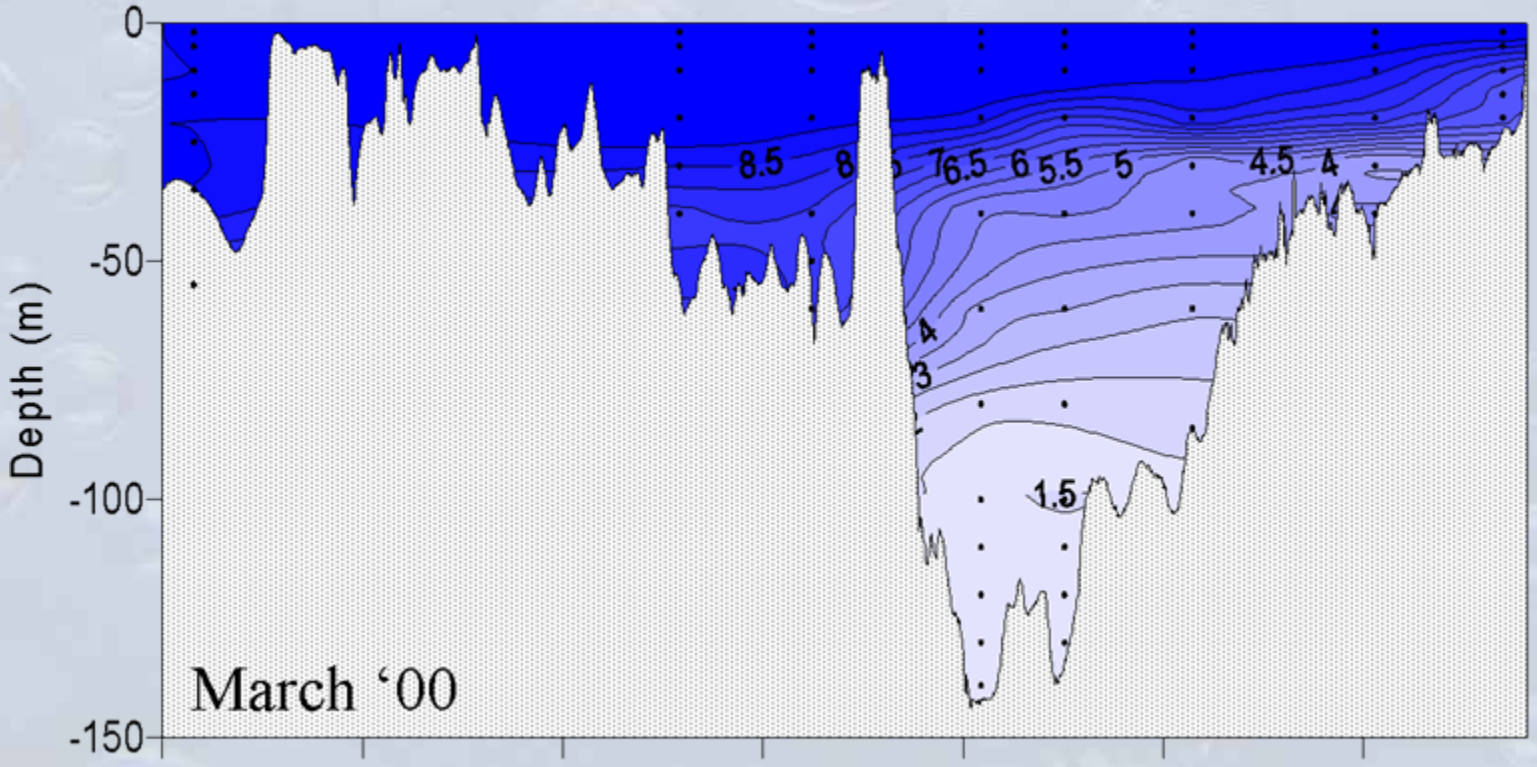

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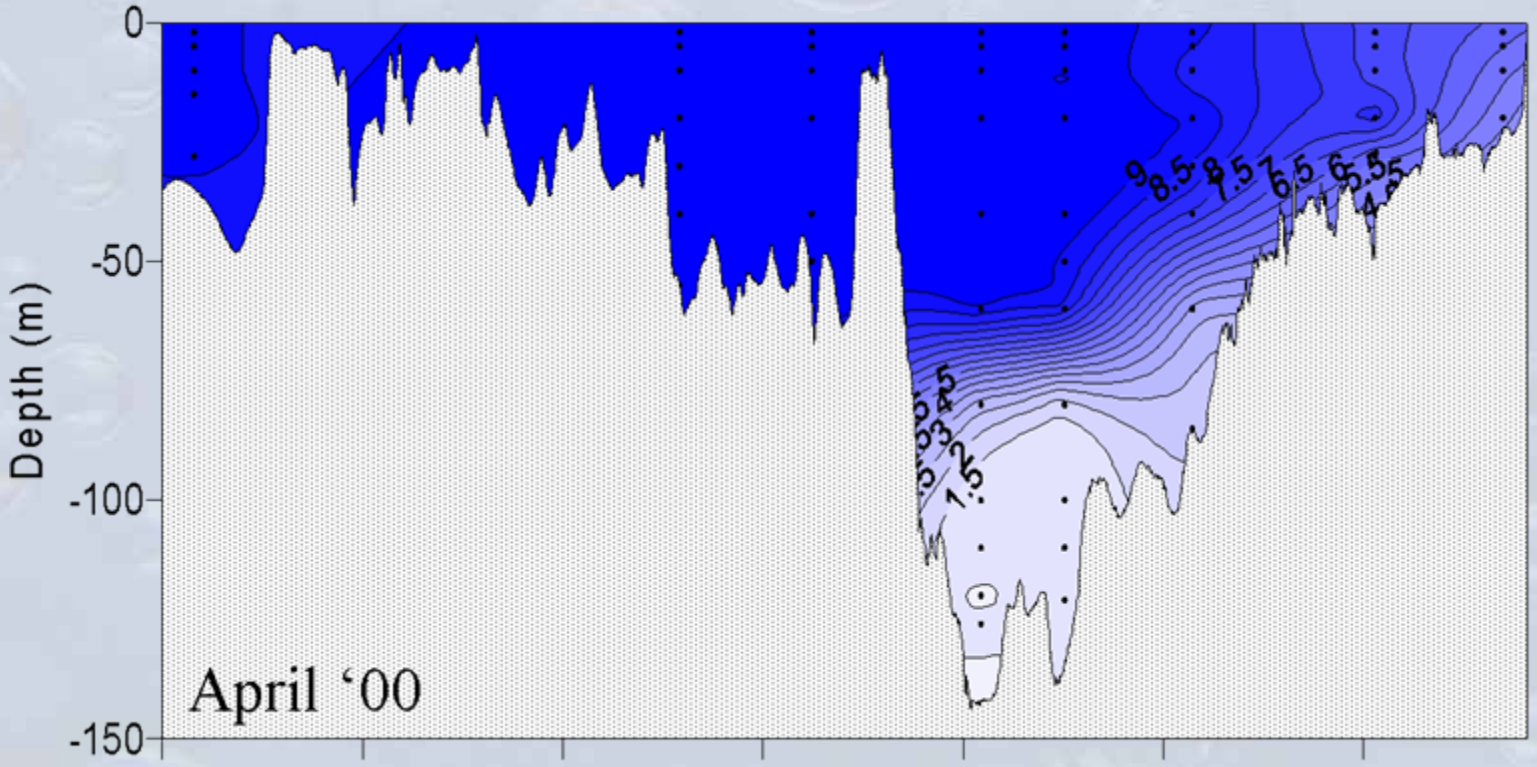

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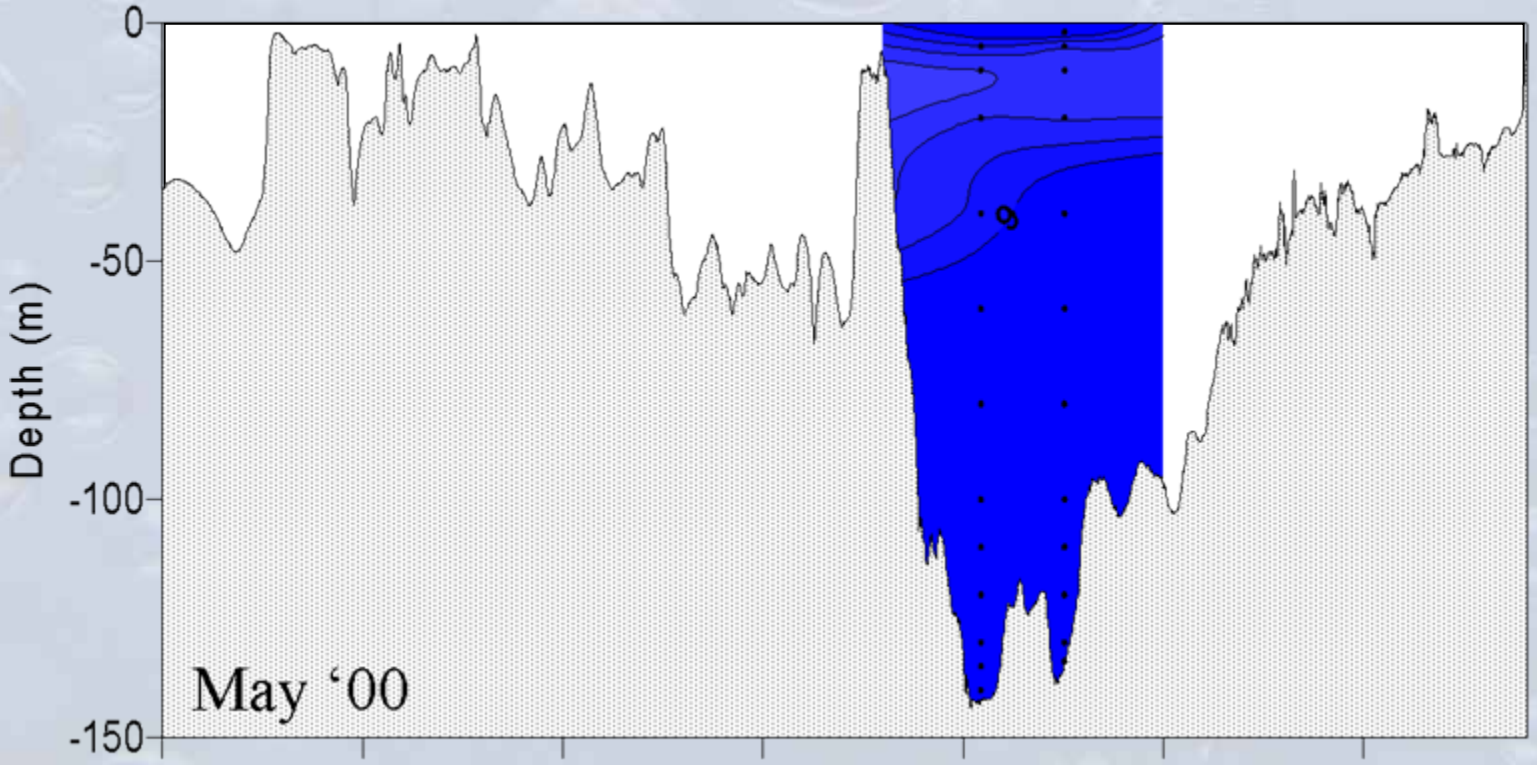

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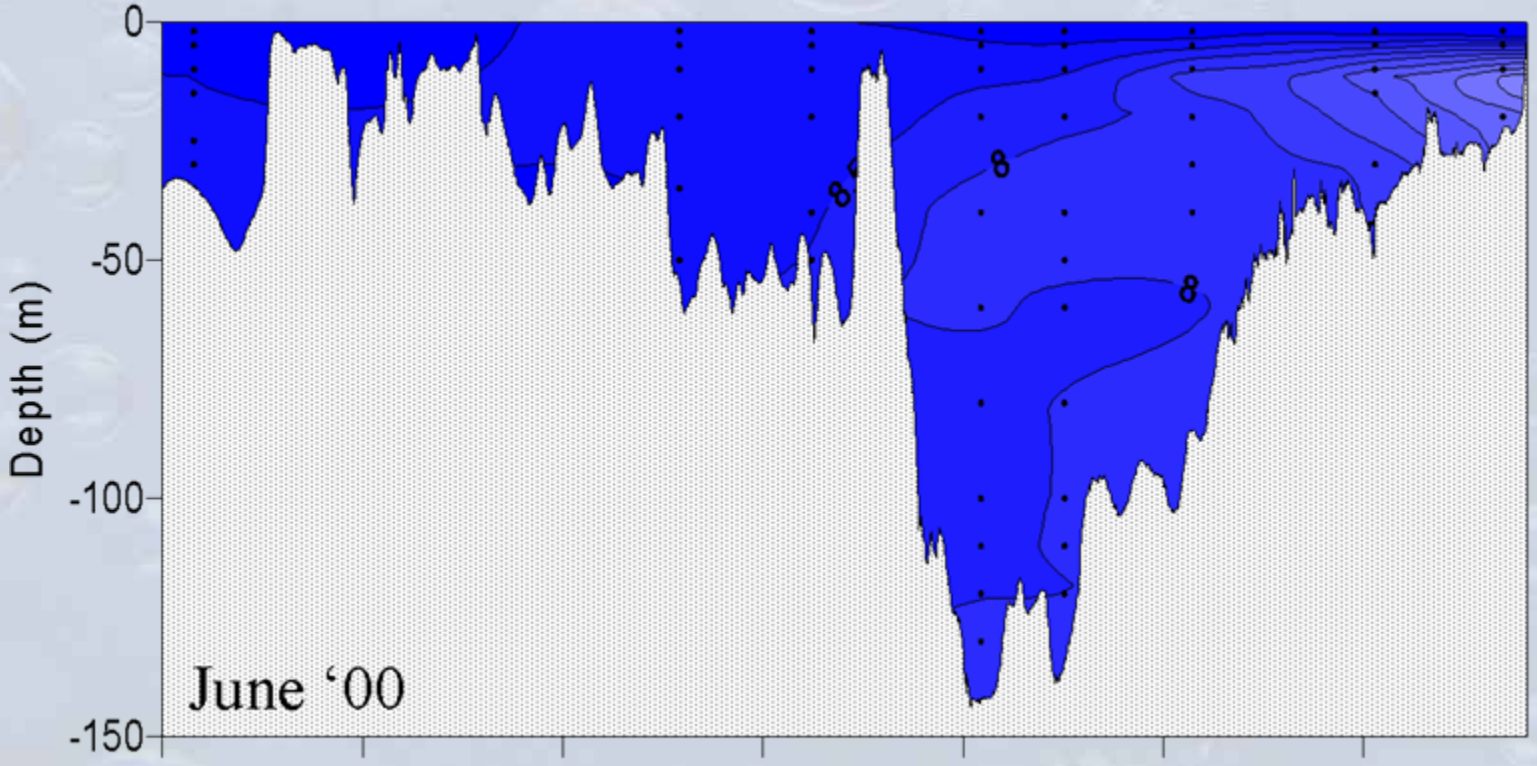

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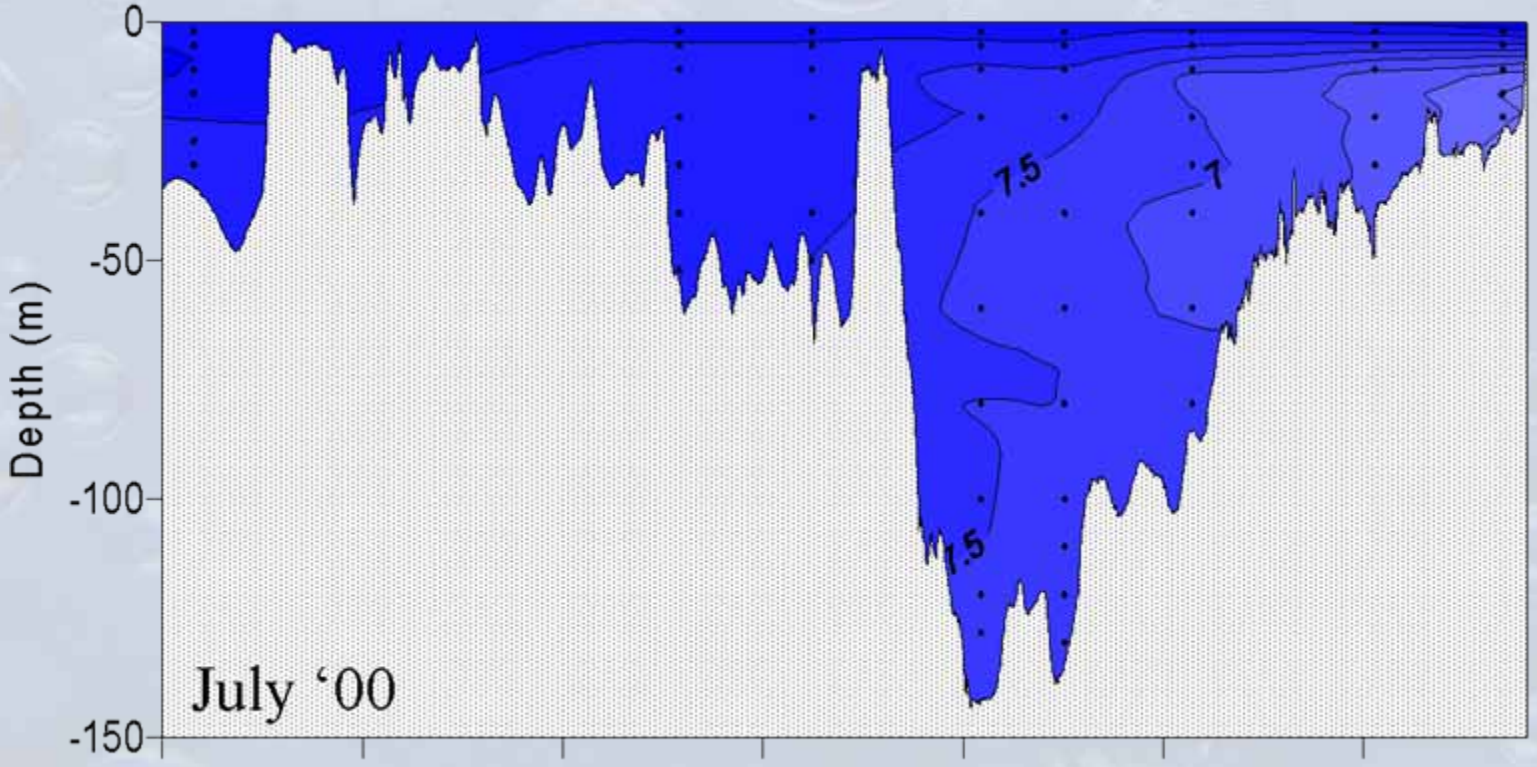

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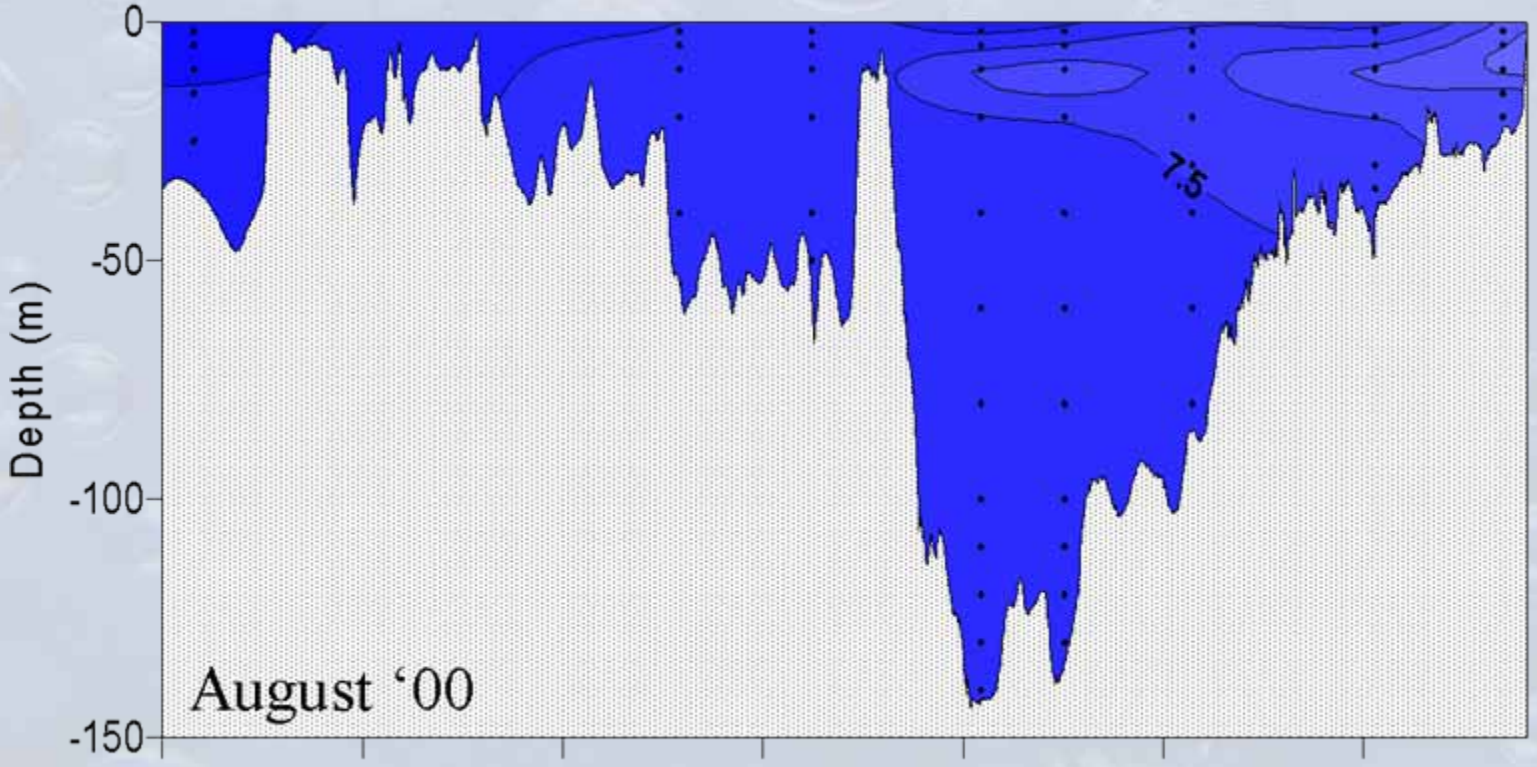
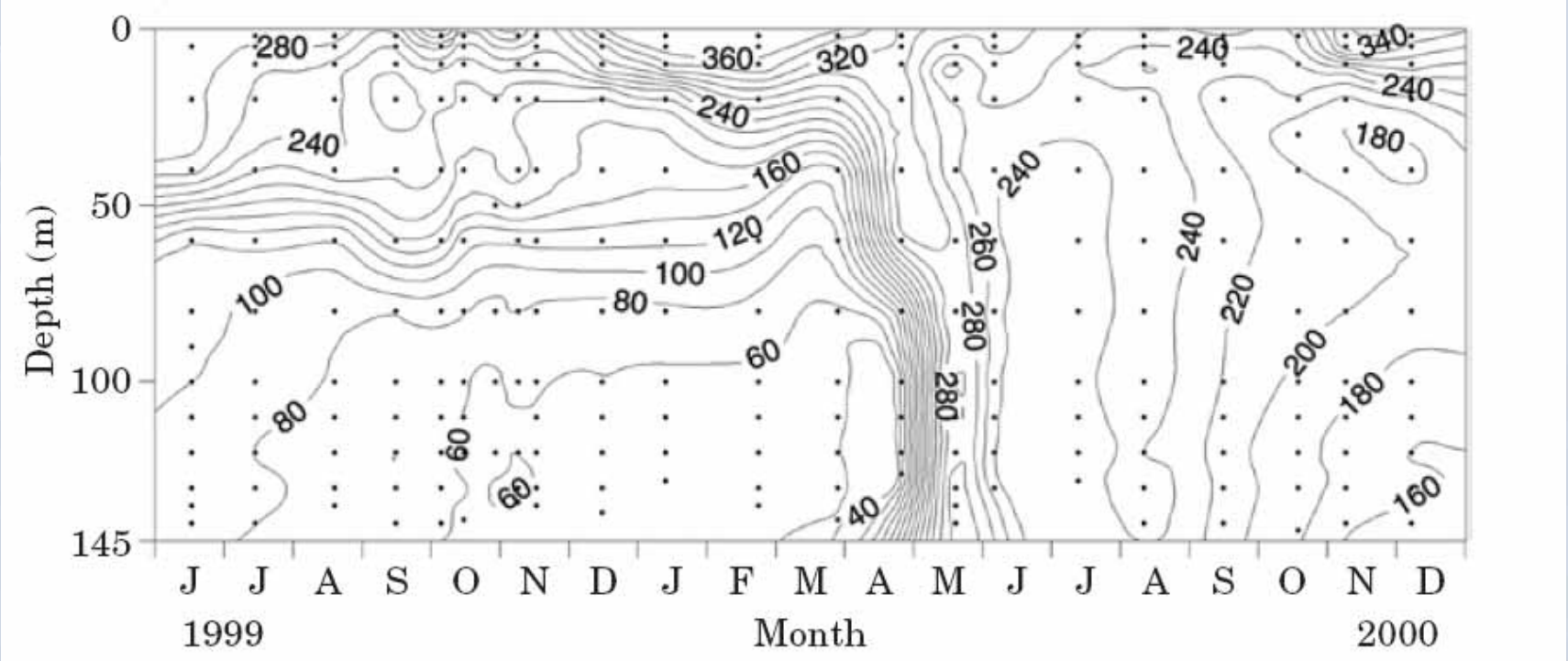


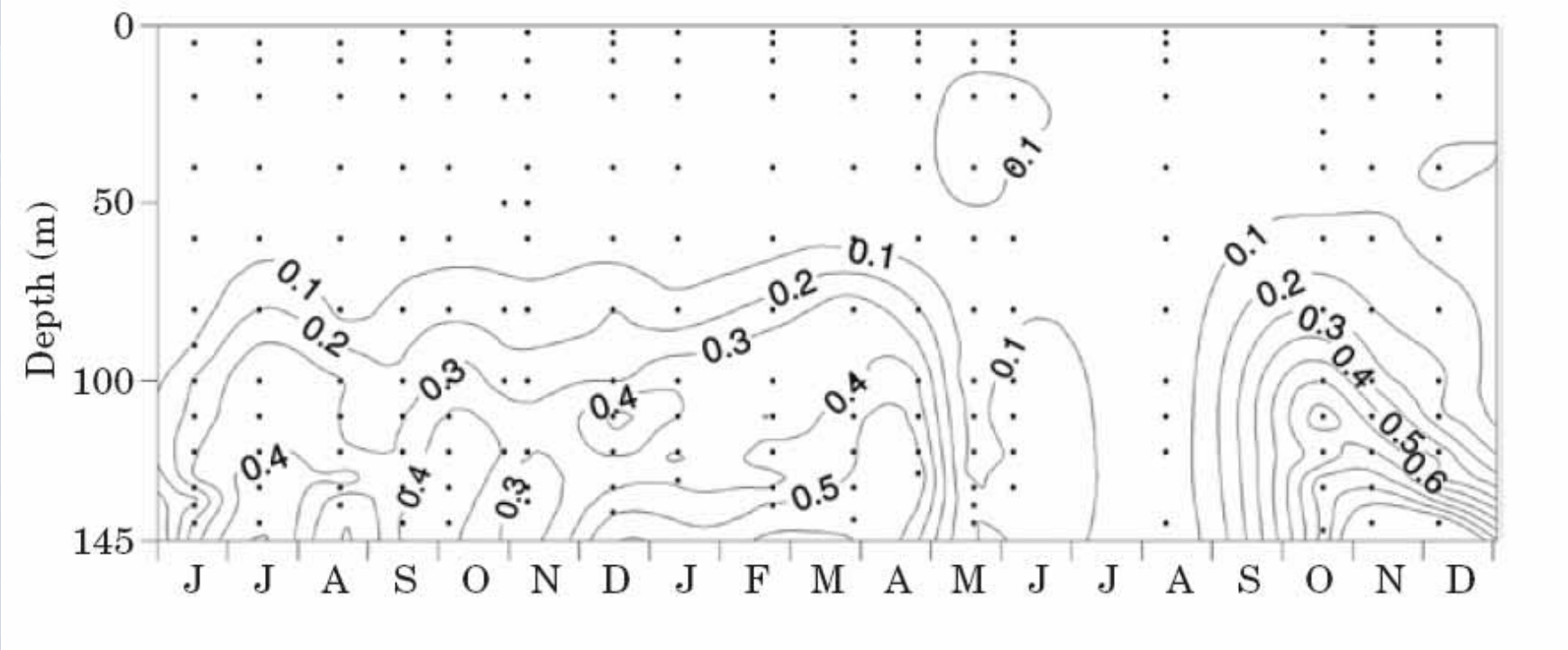
REES programme 1999/2000 – monthly transects with CTD

Distribution of oxygen and associated parameters



Dissolved O_2 (µM) at RE5 station (Overnell et al 2002)

Distribution of oxygen and associated parameters



Dissolved Mn^{2+} (µM) at RE5 station (Overnell et al 2002)

Reoxidation of Mn^{2+} >40% of benthic O_2 flux (Overnell 2002)

Rationale: Changes & problems connected to global change

Increasing surface temperatures and increased precipitation will potentially enhance water column stratification and reduce the exchange of deep isolated water bodies even further. Additional input of terrestrial organic matter due to an increased river runoff as well as higher surface water temperatures will increase the biological oxygen demand and decrease oxygen solubility.

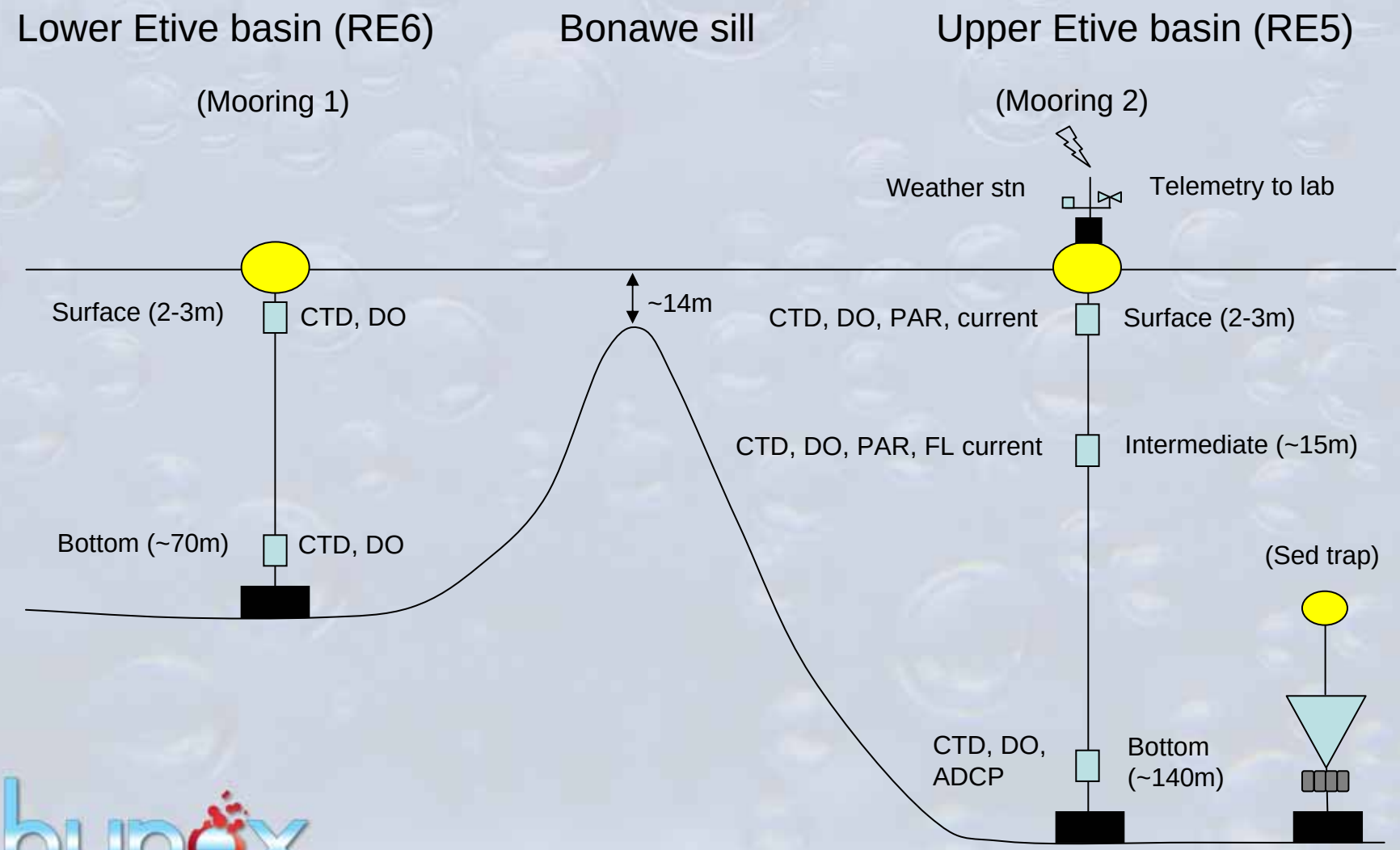
Thus, predicted climate changes may very well increase the duration and severity of hypoxia in Loch Etive, a fjord that already is classed as one of the most sensitive Loch's in Scotland in terms of oxygen depletion (Gilibrand et al. 2007).

Aim of the HYPOX work in Loch Etive suggested key parameters to measure:

1. Investigate physical processes which are key to accurately predicting renewal periodicity and deep water residence time and hence potential for oxygen depletion:

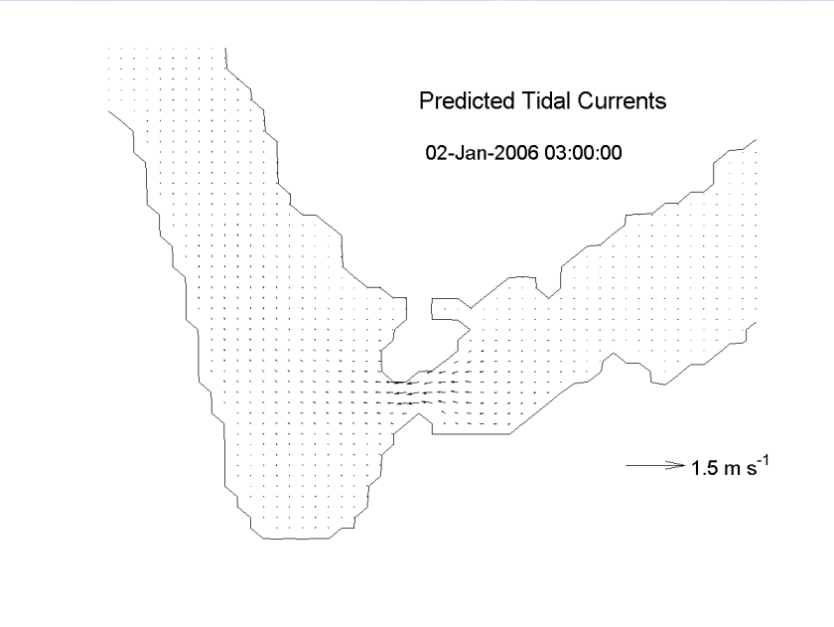
- Vertical mixing throughout the water column above the oxygen depletion zone
- Dynamics of deep water renewal; defining the pre-conditioning required for full or partial renewals; physics of gravity currents flushing the deep stratified basin
- Sensitivity of system to varying oceanographic and meteorological forcing and boundary conditions

Loch Etive observatory layout



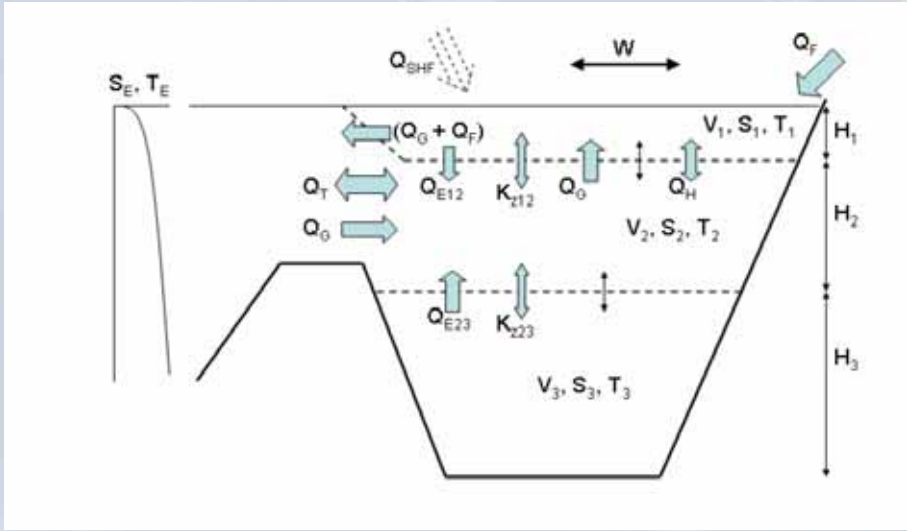
Loch Etive cabled observatory

Modelling Loch Etive

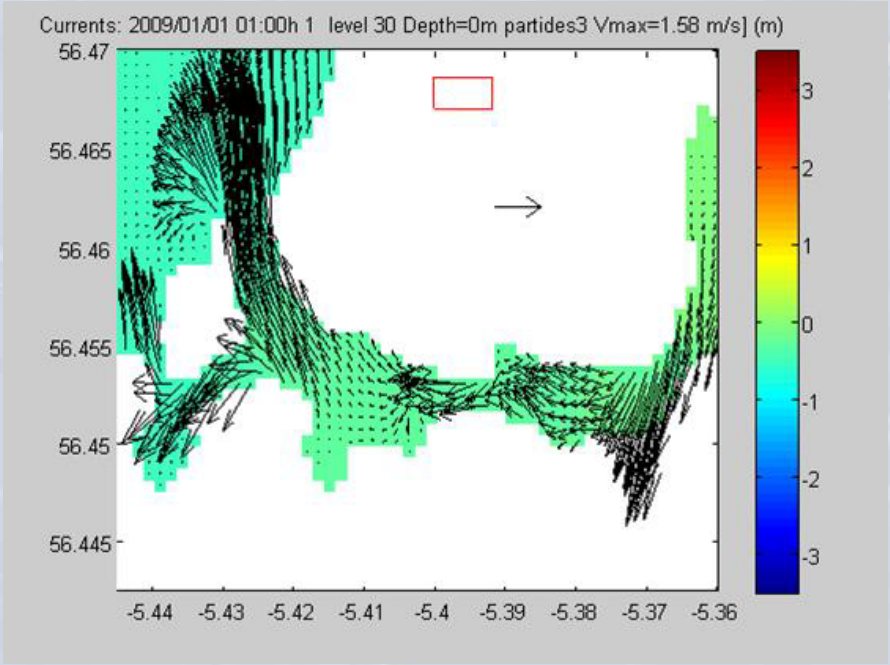


POLCOMs (3D, hydrostatic) – 50m horizontal resolution: resolves standing eddies and renewal inflow currents

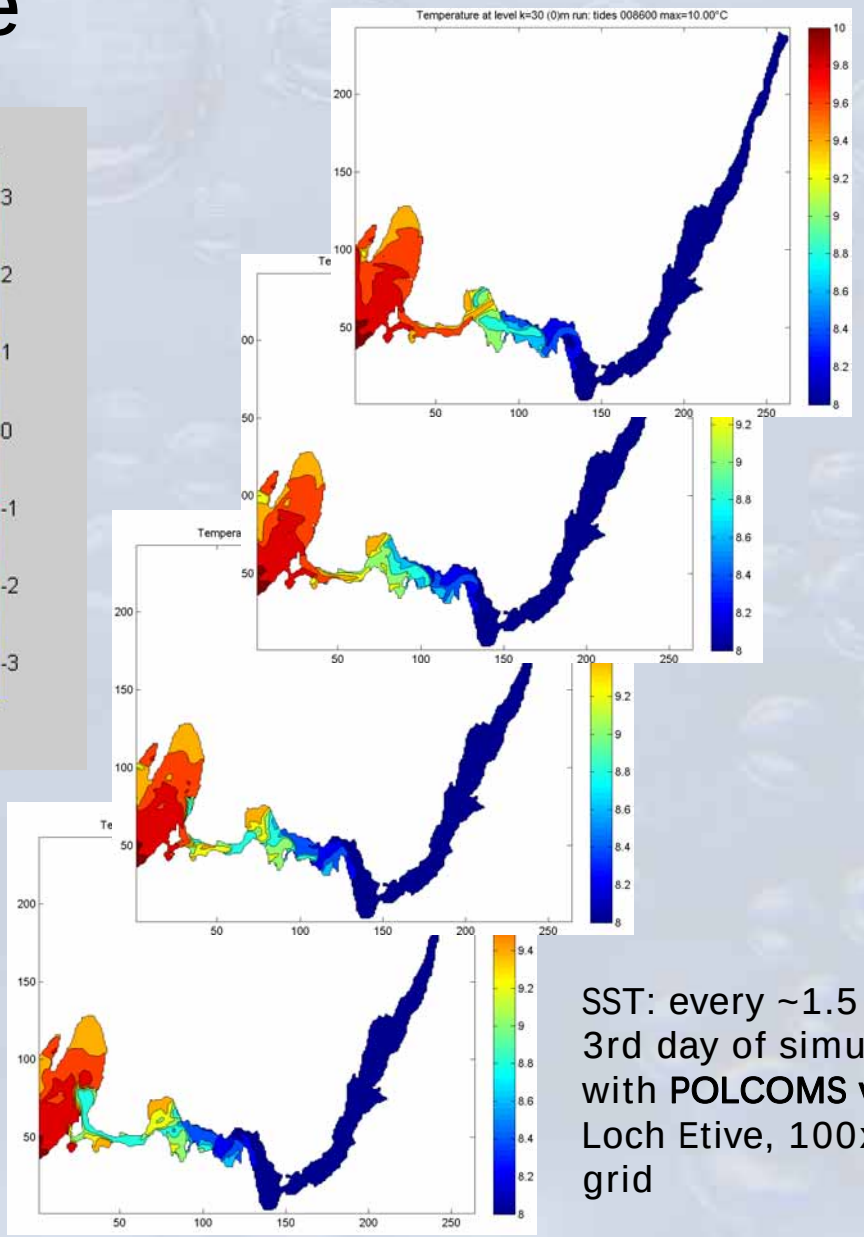
3-layer sub-box model, prognostic version of “Fjordenv” (Stigebrandt). Suitable for predicting renewals in shallow-silled macro-tidal fjords



Modeling Loch Etive



Surface velocity every ~1 h for 8 days of simulation with **POLCOMSv6.3**, 100x100m grid (264x243 nodes at 30 layers) with M2, S2 tidal constituencies; T,S fields - un-stratified



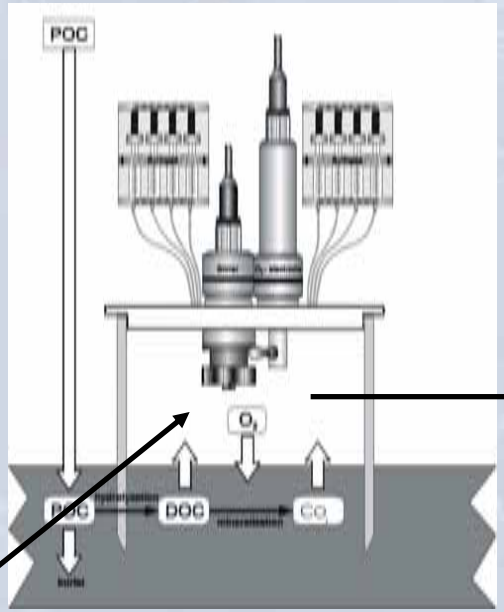
SST: every ~1.5 h on the 3rd day of simulation with **POLCOMS v6.3** Loch Etive, 100x100m grid

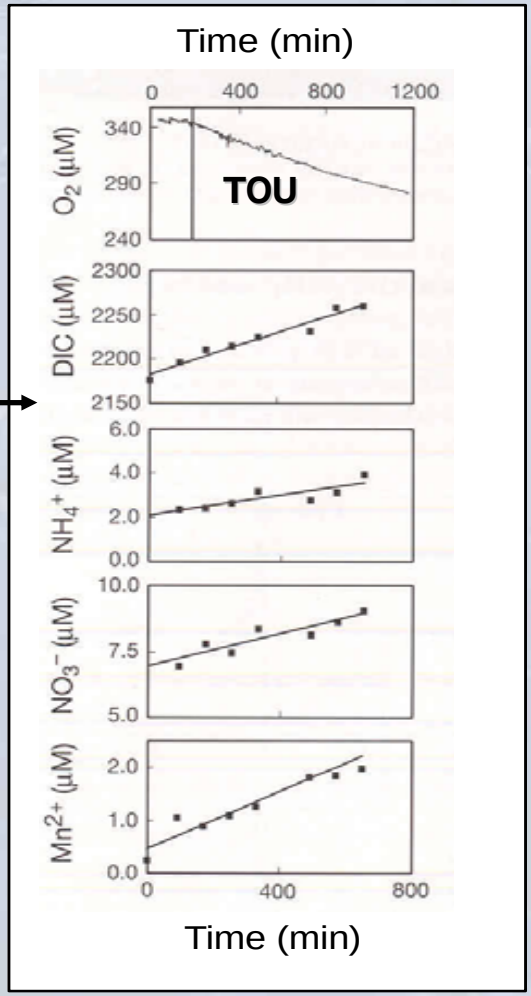
Aim of the HYPOX work in Loch Etive, suggested key parameters to measure

2. Investigate the effect of hypoxia on the benthic biogeochemistry in Loch Etive using short term in situ monitoring platforms (landers) on targeted field campaigns, before and after overturning events.

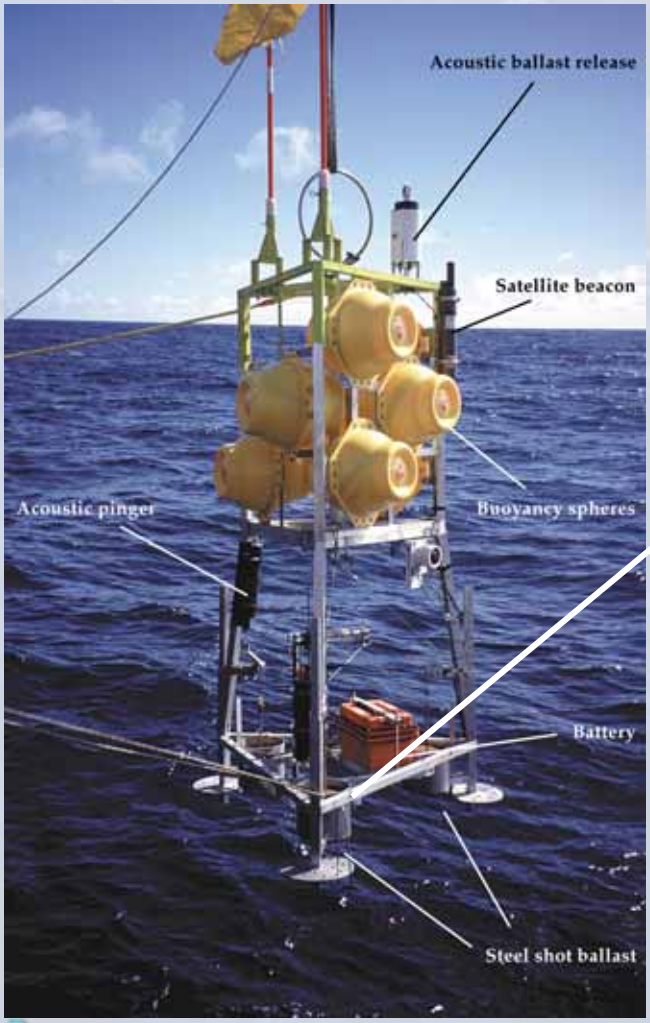
- Sediment fluxes (O_2, DIC, Nu) – Chamber lander, Eddy correlation
- Sediment profiling (O_2, H_2S, pH, NO_3) – Transecting profiler
- Sediment coring (PW parameters, Org C, porosity etc.)
- (Nitrogen Cycle – isotope pairing technique)
- (Relative importance of different respiratory pathways – bagincubations)
- (Fauna composition and diversity)
- (Gas formation)

SAMS chamber lander

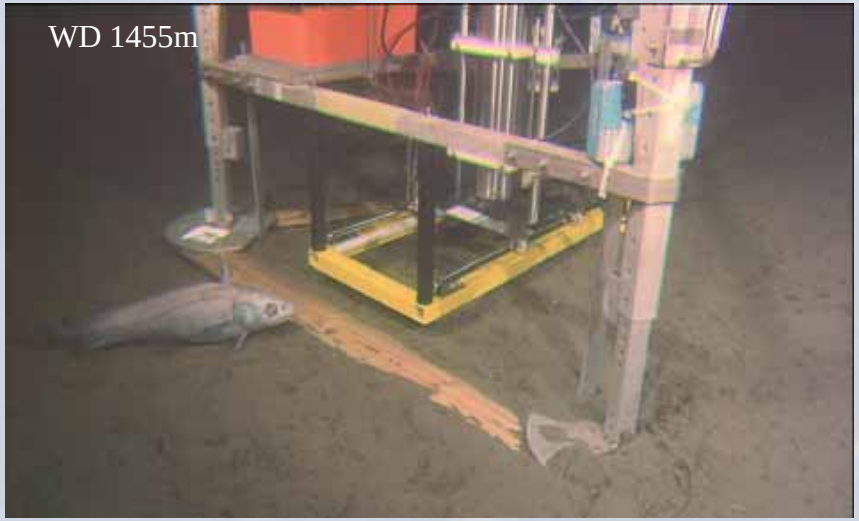




SAMS profiling lander



Microelectrodes:
O_2, pH, H_2S, NO_3^{2-}



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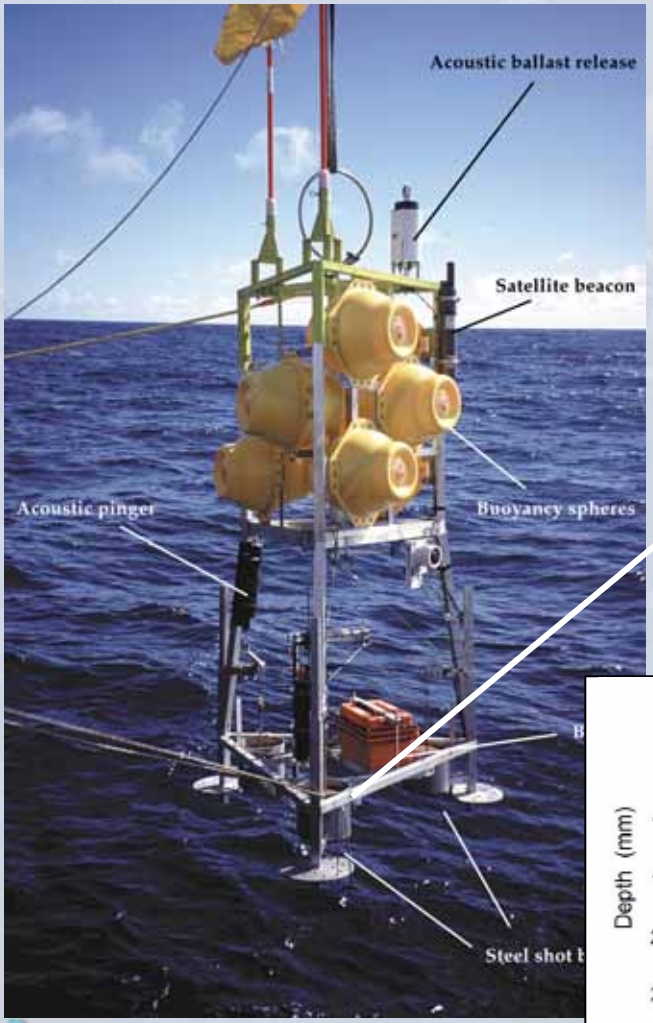

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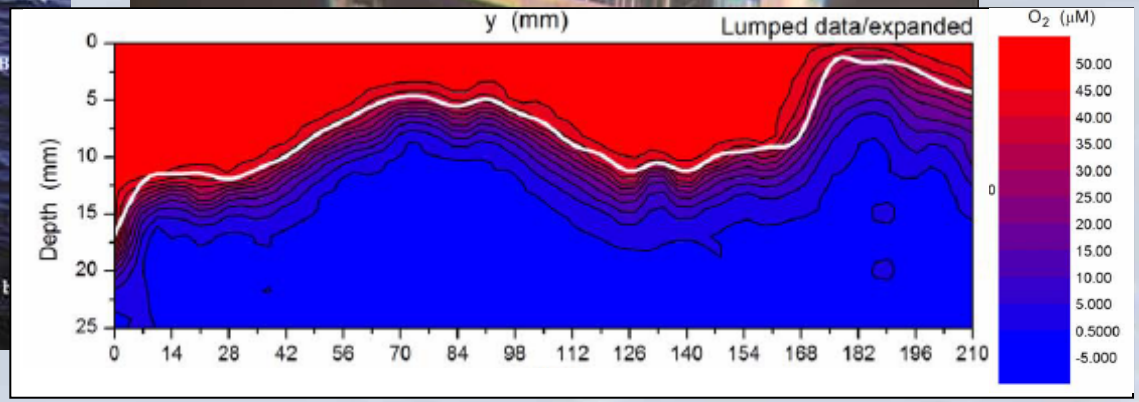
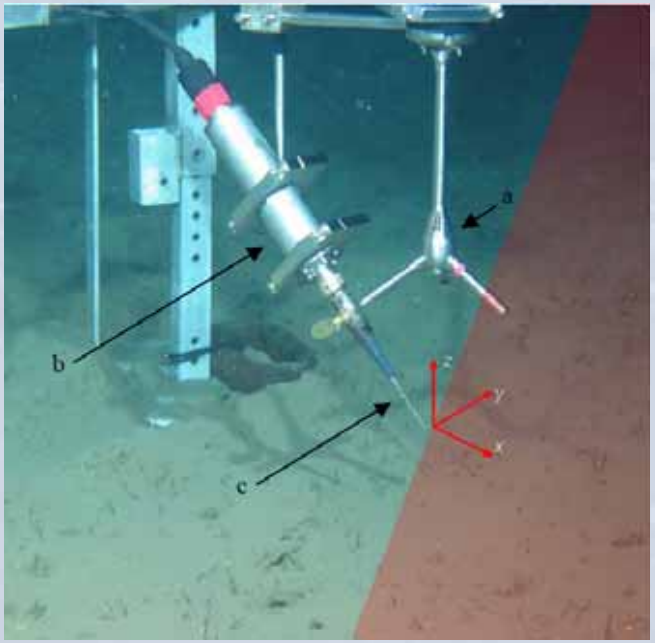


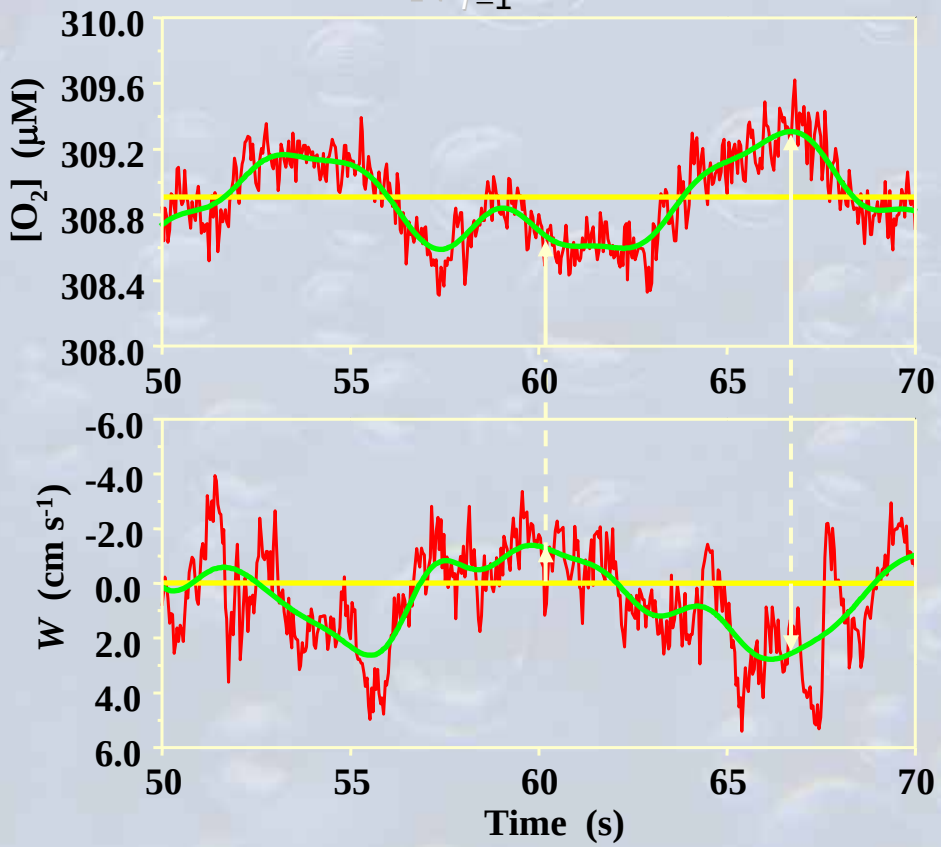
Glud et al (2009) L&O

SAMS Eddy correlation lander



Average flux

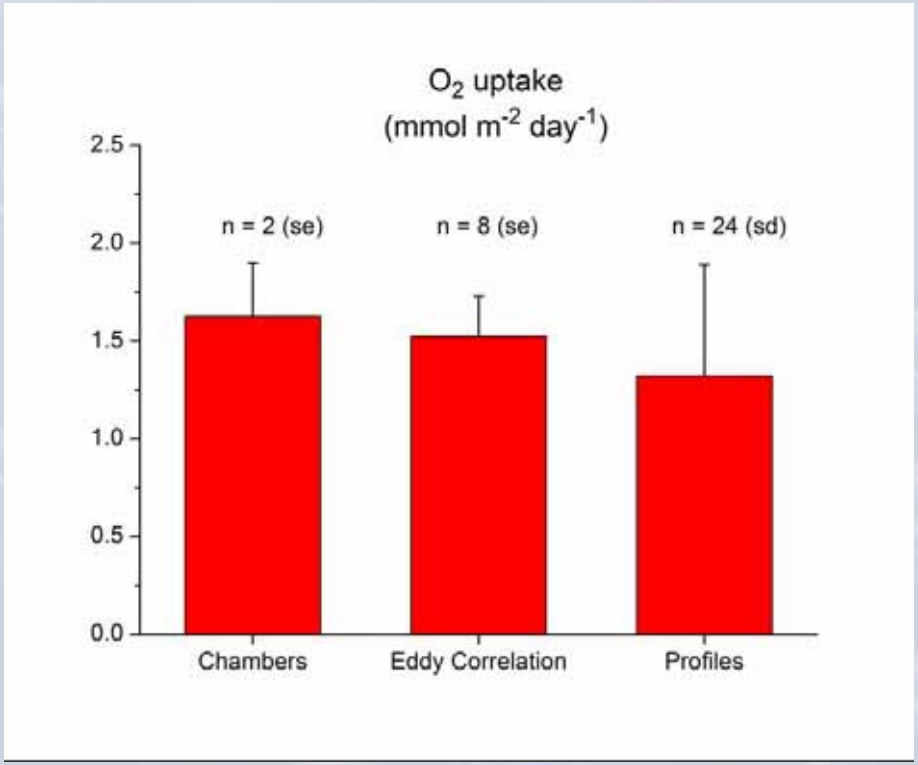
$$\frac{1}{N}\sum_{i=1}^{N} w_i' O_{2i}$$



Berg et al. 2003 Mar Ecol Prog Ser 261: 75-83
Berg et al 2007 Limnol Oceanogr 52:1672-1684

SAMS Eddy correlation lander

Sagami Bay, Japan 2008



Berg et al 2009 (submitted)