Low Winter $CaCO_3$ Saturation State in the Baltic Sea and Consequences for Calcifiers

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(acknowledgements to: Helen Findlay, Agostino Merico, Ingunn Skjelvan, Richard Bellerby, Anastasia Charalampopoulou, Ulf Riebesell, Mike Thorndyke and Andrew Yool)

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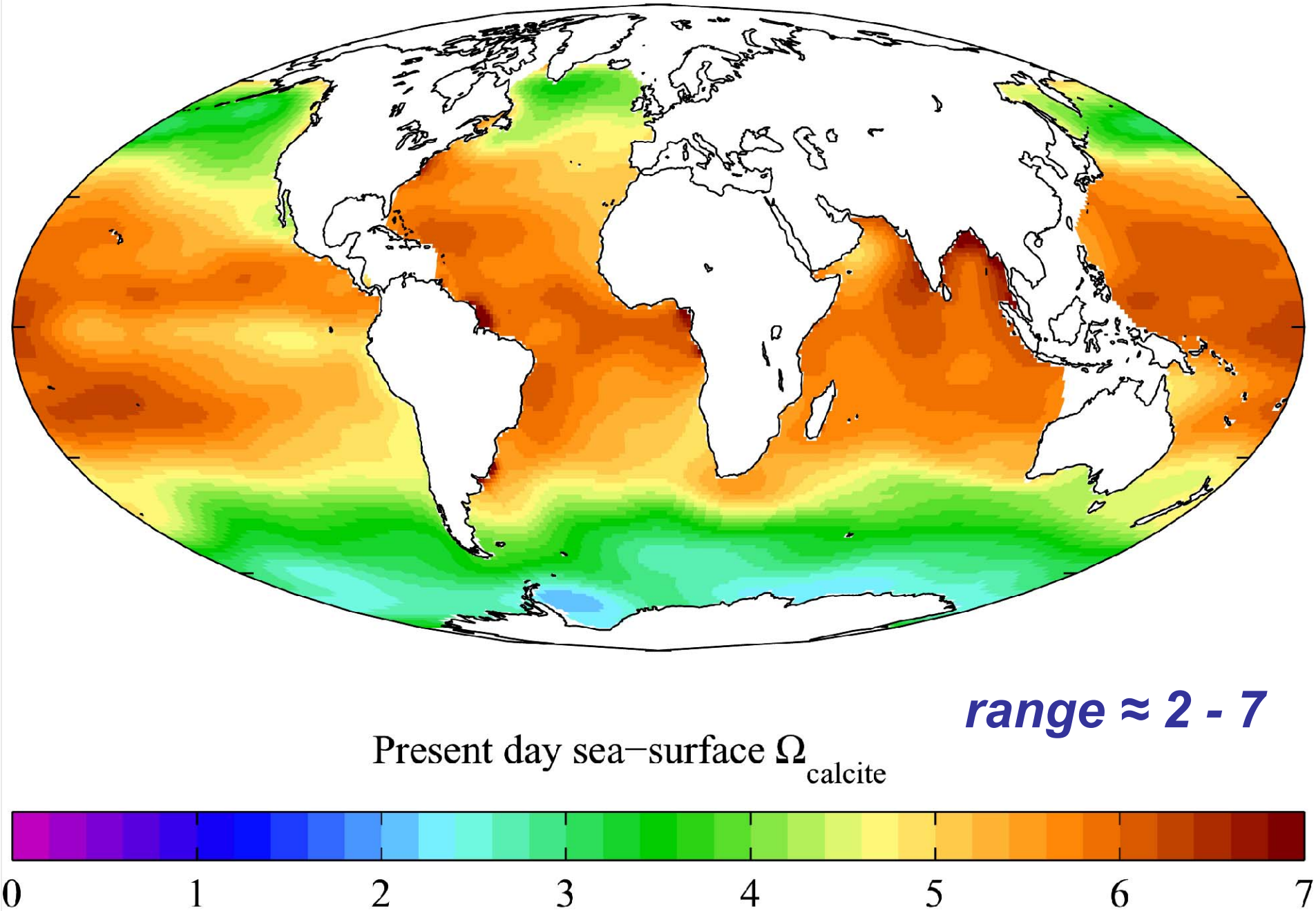
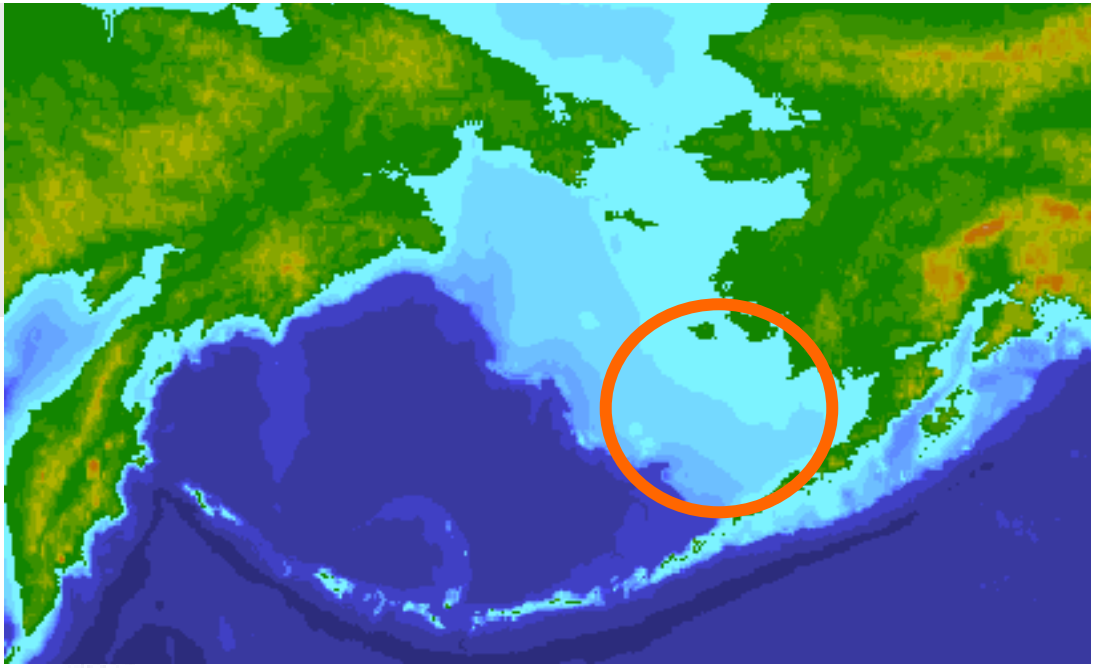
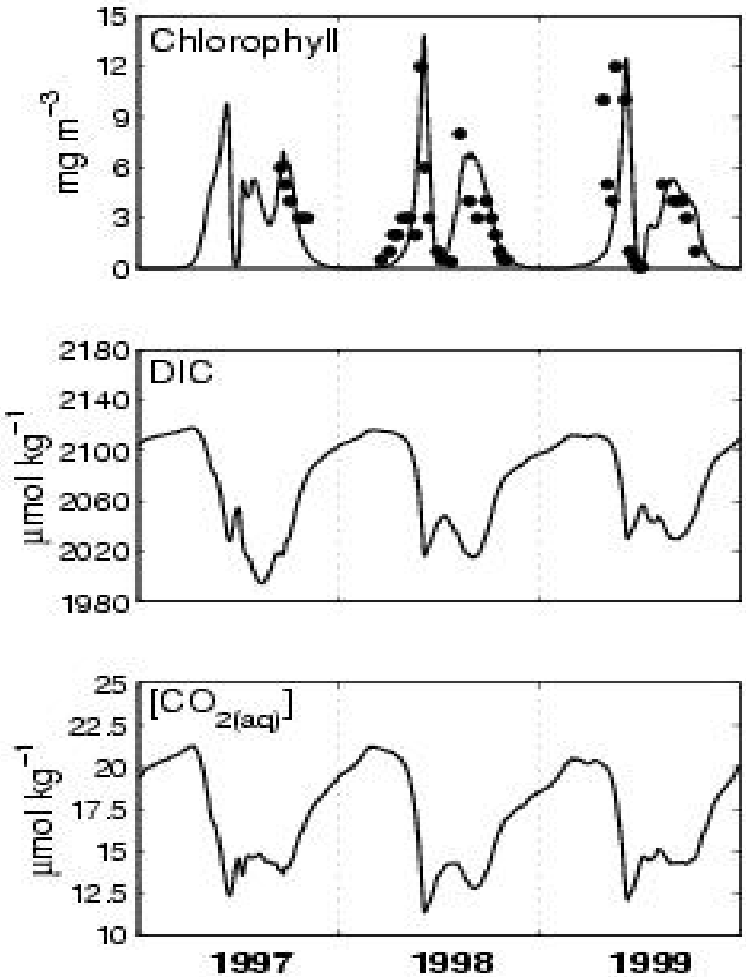
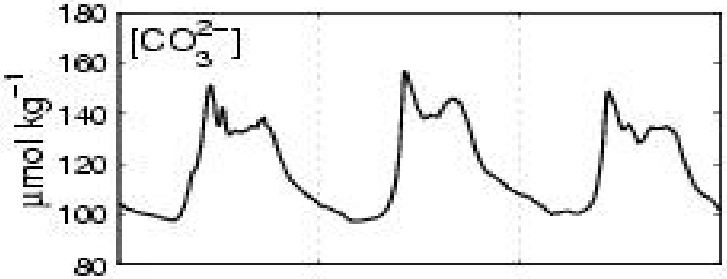


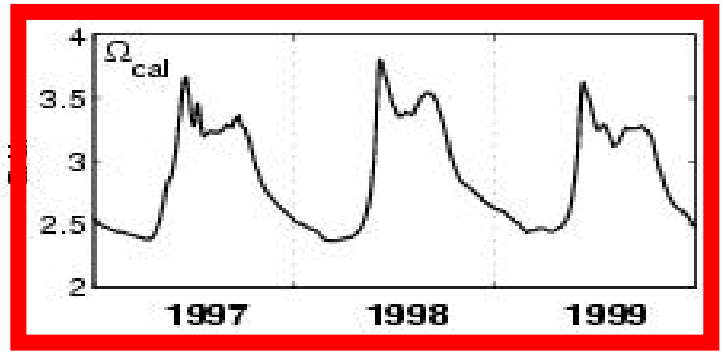
from GLODAP DATASET, plot by Andy Yool

Eastern Bering Sea





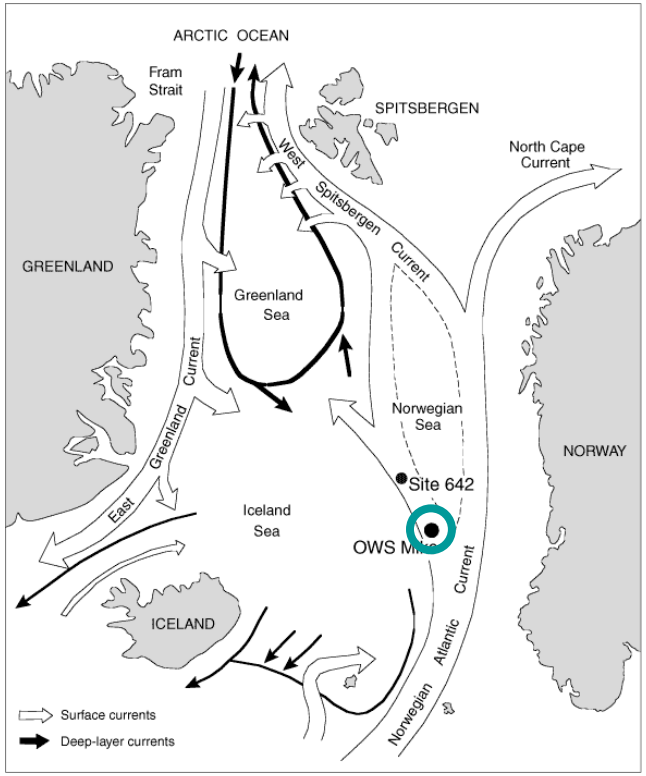


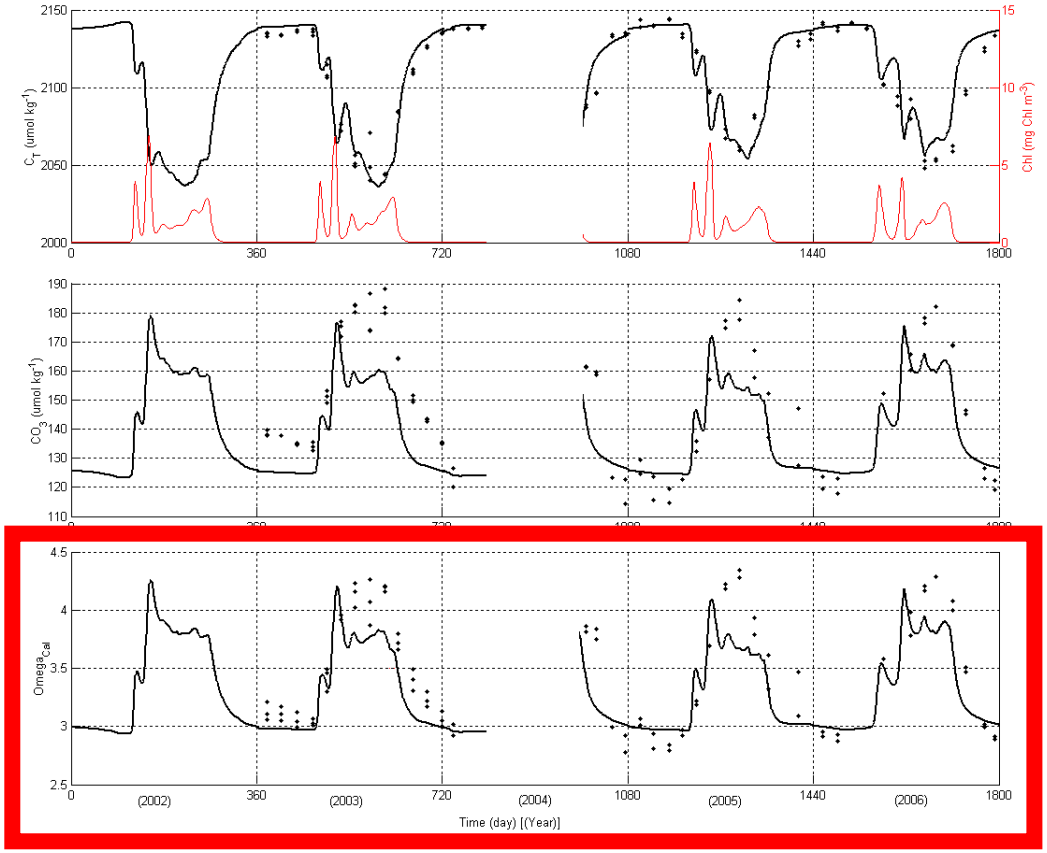


From model: range ≈ 2.5 – 3.5

from (Merico et al., 2006. *J. Mar. Syst.*)

OWS 'Mike' (Norwegian Sea)





From model and data: range ≈ 3 – 4

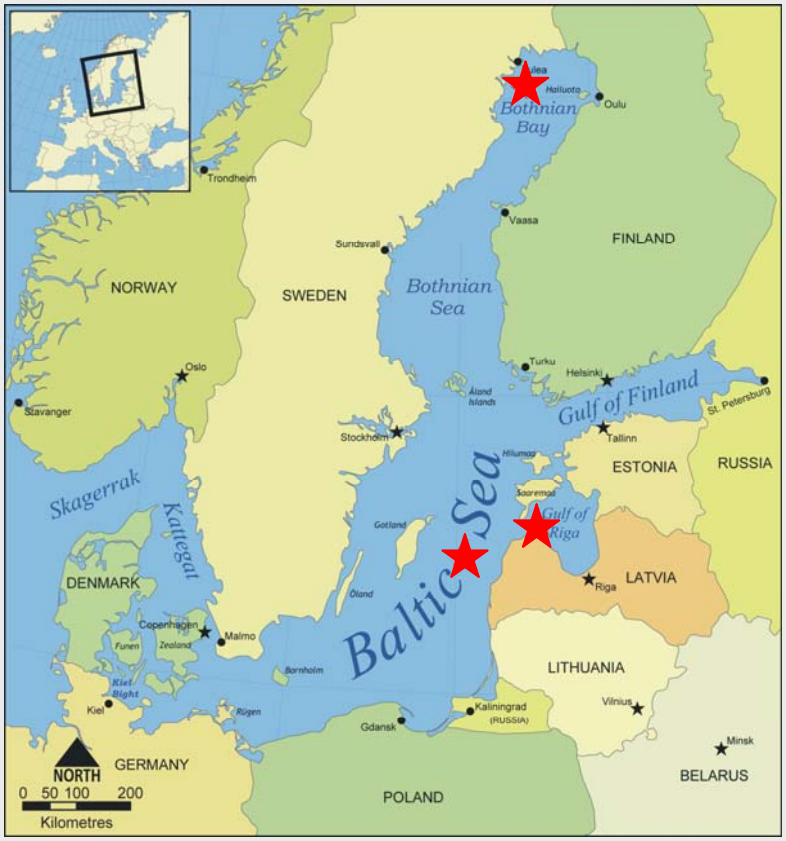
(Findlay et al. 2008. *Biogeosciences*, in press)

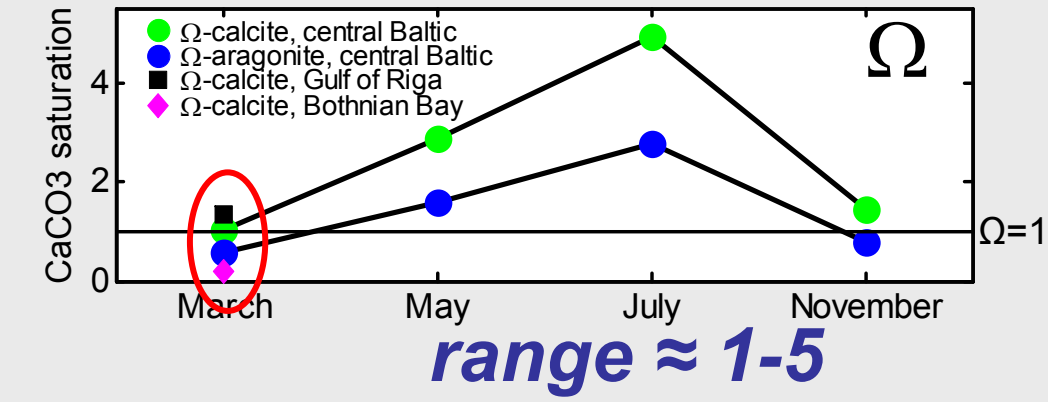
$CaCO_3$ UnderSaturation ($\Omega<1$)

1. No large areas of the ocean surface are undersaturated at present, even in winter
2. Some localised surface undersaturation in areas of upwelling (Feely talk; Gruber talk)
3. Very localised strong undersaturation near natural CO2 vents (Hall-Spencer talk)

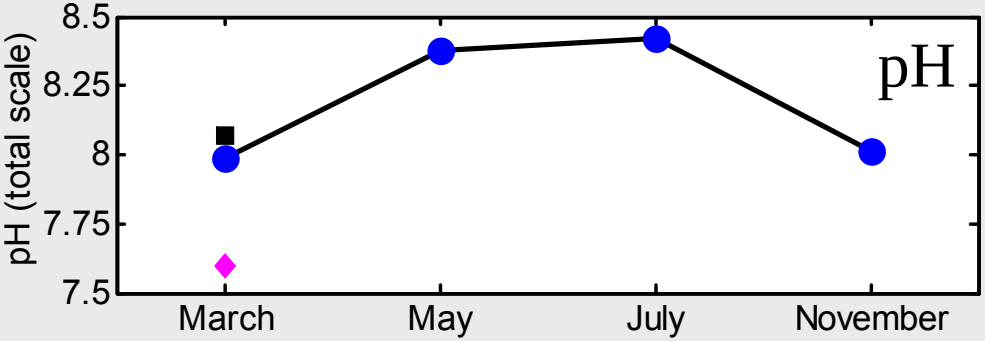
Scarcity of places which are naturally under-saturated, where biological consequences of $\Omega<1$ can be examined in-situ

Low Saturation States in Baltic Sea





range ≈ 1-5



From measurements of DIC and pCO2 by Bernd Schneider and group

(Tyrrell et al, 2008, *Biogeosciences*, 5: 485-494)

Central Baltic <u>undersaturated</u> in winter, even though pH not esp. low

Reasons for Low Wintertime Saturation States in Baltic Sea

$$\Omega = \frac{[CO_3^{2-}]*[Ca^{2+}]}{K^*_{sp}}$$

- ~5-fold lower $[CO_3^{2-}]$
- ~4-fold lower $[Ca^{2+}]$
- ~7-fold lower K^*_{sp}

} at Sal = 7, T = 0°C

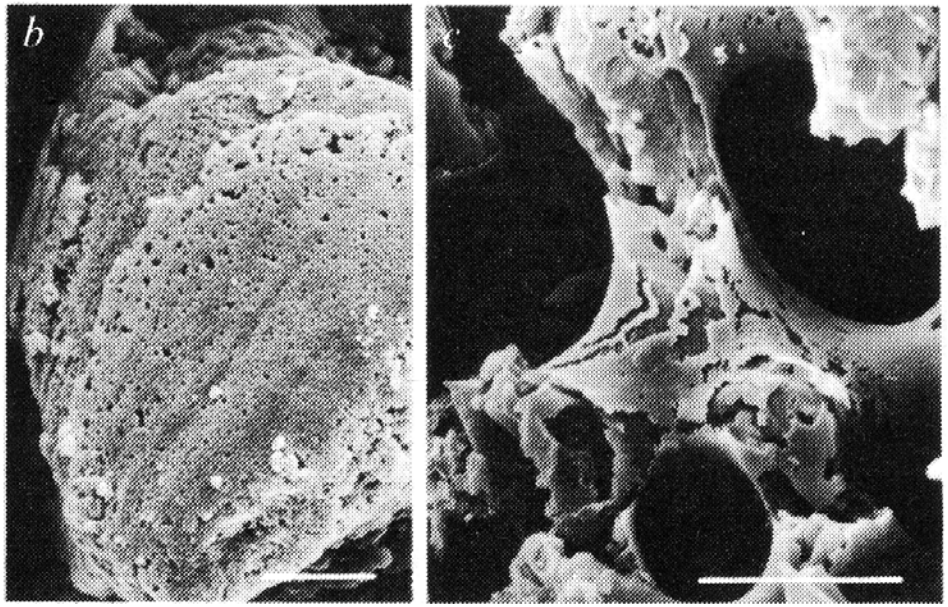
(5 * 4 / 7) ≈ 3-fold lower Ω in central Baltic Sea than in North Atlantic at same latitude

(Tyrrell et al, 2008, *Biogeosciences*, 5: 485-494)

Predicted 30 Years Ago

Torbjörn Alexandersson diagnosed carbonate undersaturation of the Skaggerak and Baltic Sea in the 1970's, through SEM analysis of $CaCO_3$ particles in sediments

corroded barnacle hinge tooth corroded echinoderm shell fragment



scale bars = 10 microns

'Petrographic saturometry'

"Contrary to common belief, areas with carbonate-undersaturated shallow marine waters actually exist at the present time, and they seem to be the result of natural – as opposed to man-made – environmental conditions."

(ET Alexandersson, 1976. *Nature*, 262: 653-657)

Conclusions

1. Undersaturation of the surface ocean will occur first in polar waters, in wintertime
2. Large parts of the Baltic (especially the northern parts) already experience undersaturation in winter
3. The Baltic Sea is a natural laboratory for examining consequences of seasonal undersaturation