Low Winter CaCO₃ Saturation State in the Baltic Sea and Consequences for Calcifiers

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Present day sea-surface $\Omega_{\text{calcite}}$

range $\approx 2 - 7$

from GLODAP DATASET, plot by Andy Yool
Eastern Bering Sea

From model: range $\approx 2.5 - 3.5$

from (Merico et al., 2006. J. Mar. Syst.)
From model and data: range ≈ 3 – 4

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 CO$_2$ vents (Hall-Spencer talk)

Scarcity of places which are naturally undersaturated, where biological consequences of $\Omega<1$ can be examined in-situ
Low Saturation States in Baltic Sea

Central Baltic undersaturated in winter, even though pH not esp. low

Reasons for Low Wintertime Saturation States in Baltic Sea

\[ \Omega = \frac{[\text{CO}_3^{2-}][\text{Ca}^{2+}]}{K^*_{sp}} \]

- ~5-fold lower $[\text{CO}_3^{2-}]$
- ~4-fold lower $[\text{Ca}^{2+}]$
- ~7-fold lower $K^*_{sp}$

\[(5 \times 4 / 7) \approx 3\text{-fold lower } \Omega \text{ in central Baltic Sea than in North Atlantic at same latitude}\]

Predicted 30 Years Ago

Torbjörn Alexandersson diagnosed carbonate undersaturation of the Skaggerak and Baltic Sea in the 1970’s, through SEM analysis of CaCO₃ particles in sediments.

“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.”

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.