

# **Low Winter $\text{CaCO}_3$ Saturation State in the Baltic Sea and Consequences for Calcifiers**

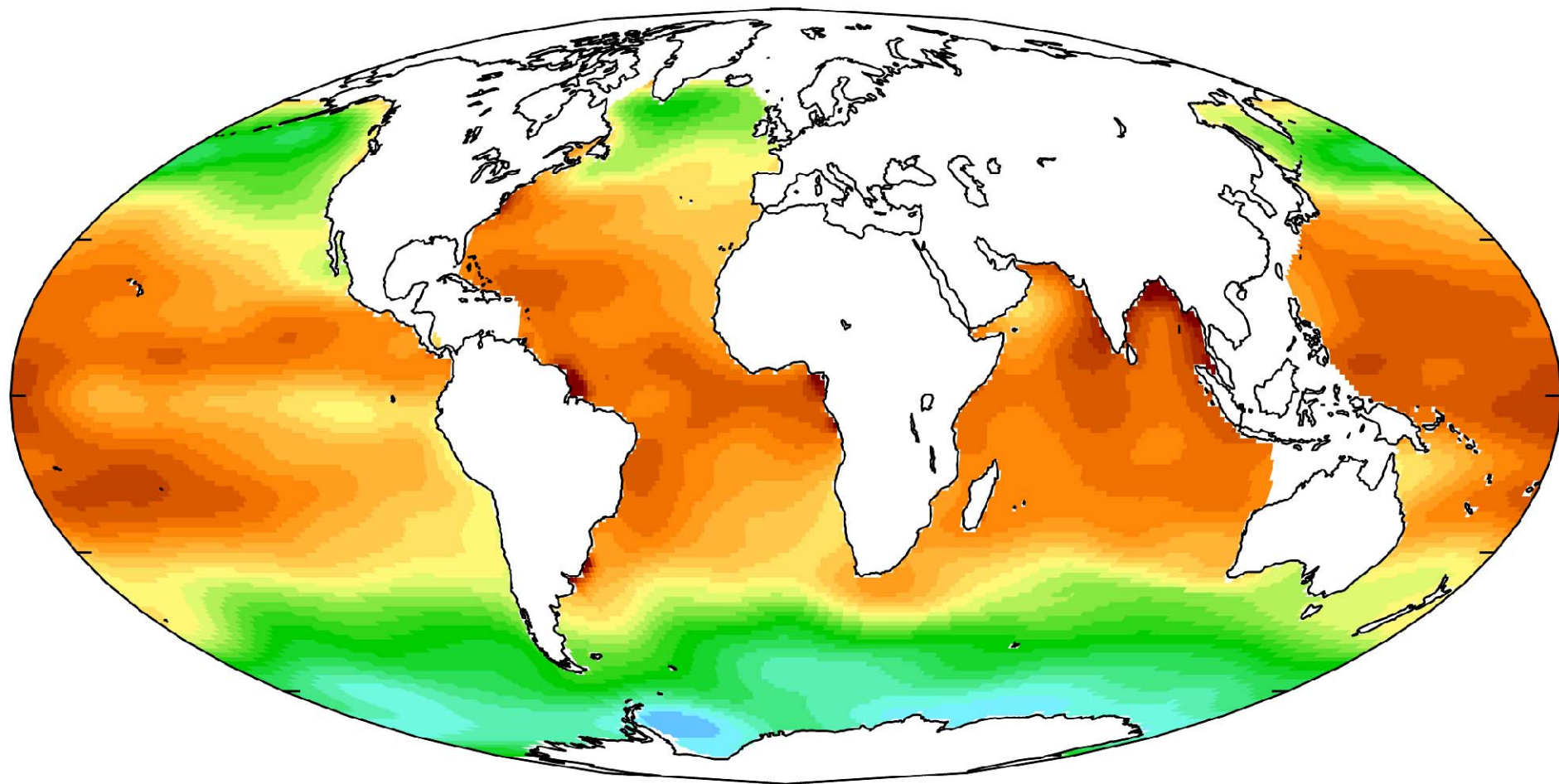
**Toby Tyrrell and Bernd Schneider**

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



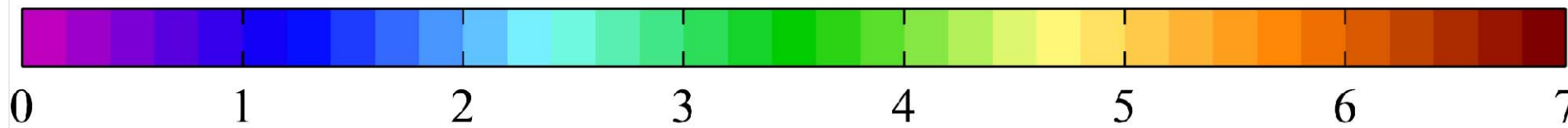
**National Oceanography  
Centre, Southampton**  
UNIVERSITY OF SOUTHAMPTON AND  
NATURAL ENVIRONMENT RESEARCH COUNCIL





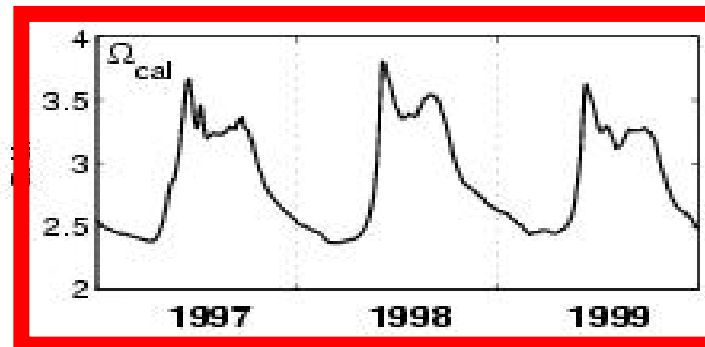
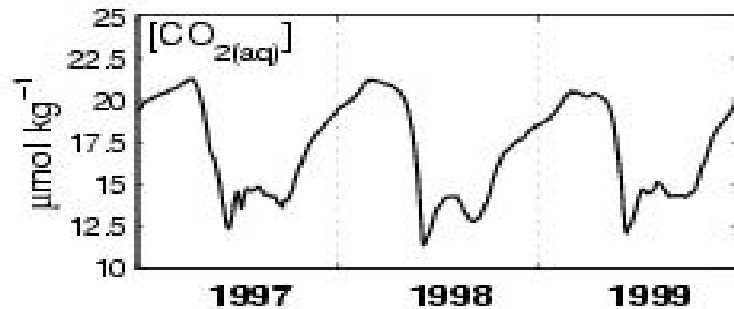
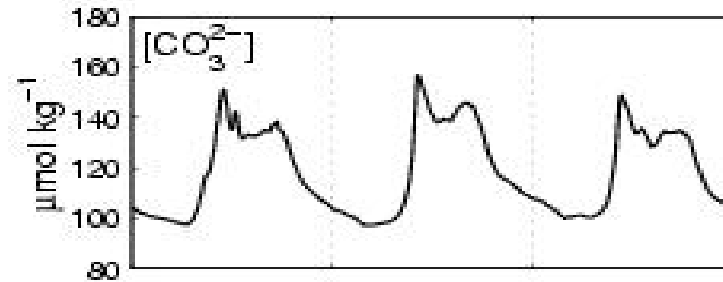
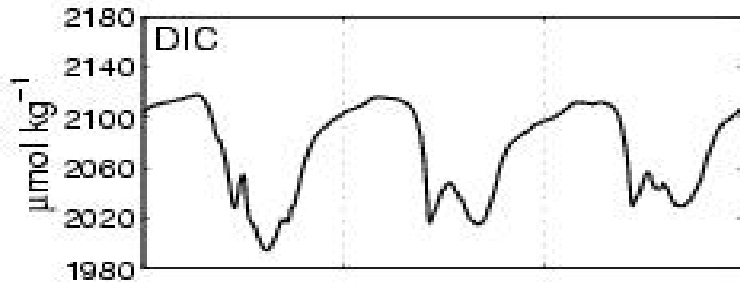
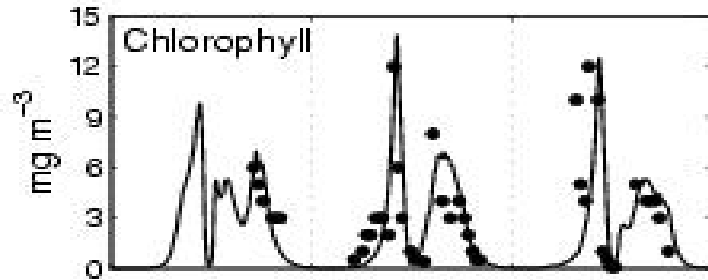
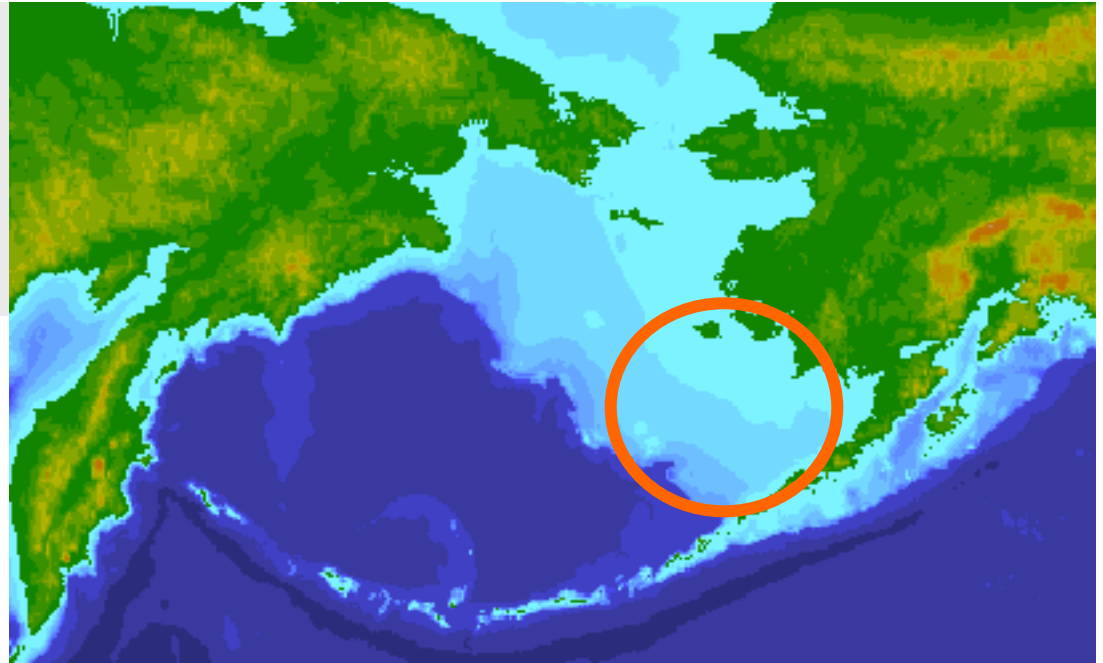
*range  $\approx 2 - 7$*

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



*from GLODAP DATASET, plot by Andy Yool*

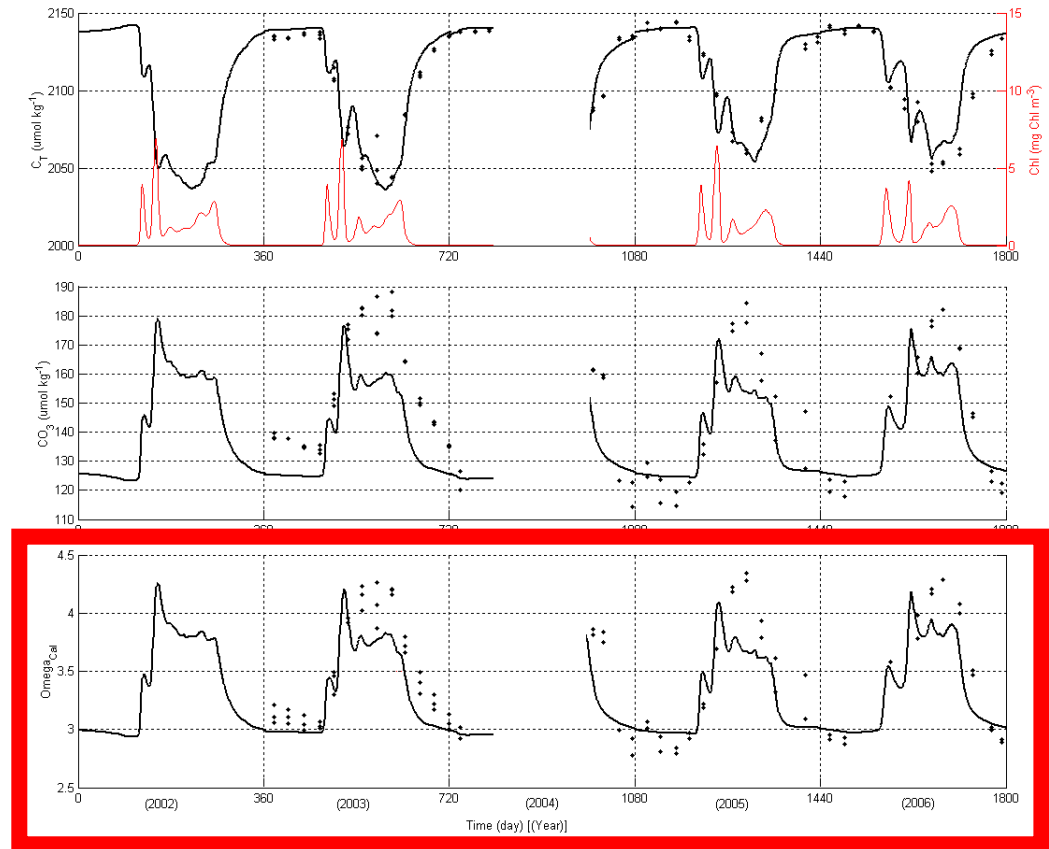
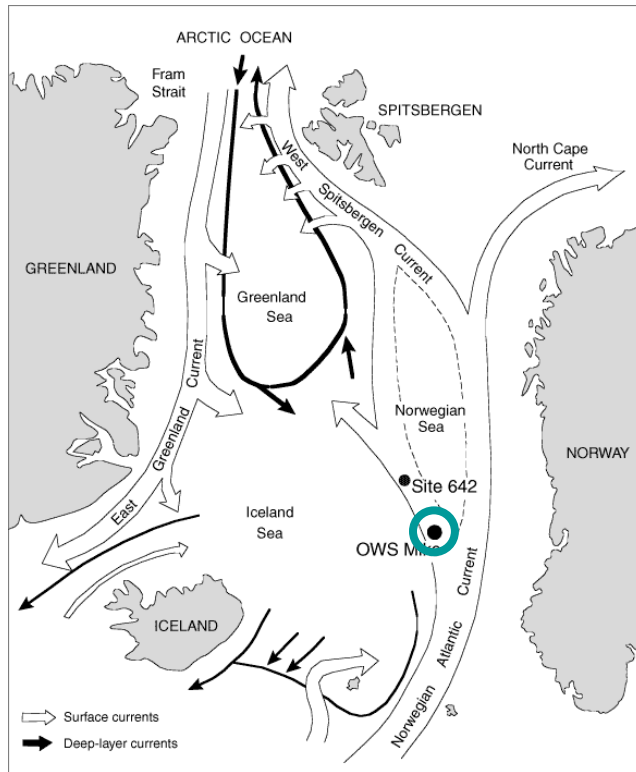
# Eastern Bering Sea



*From model:  
range  $\approx$   
2.5 – 3.5*

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

# OWS 'Mike' (Norwegian Sea)



**From model and data: range  $\approx 3 - 4$**

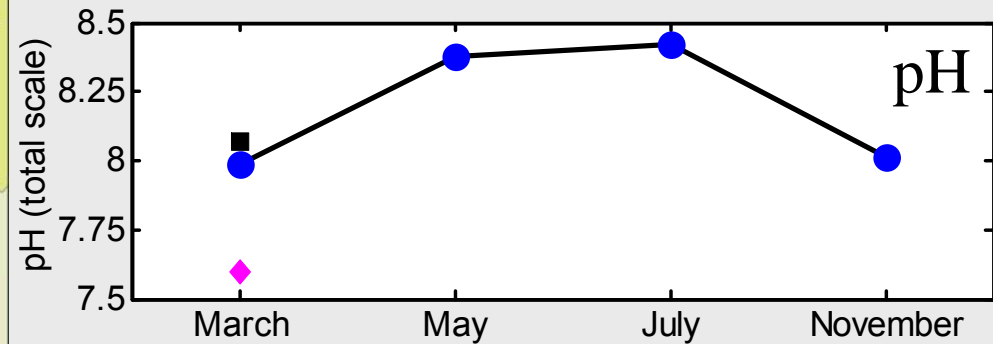
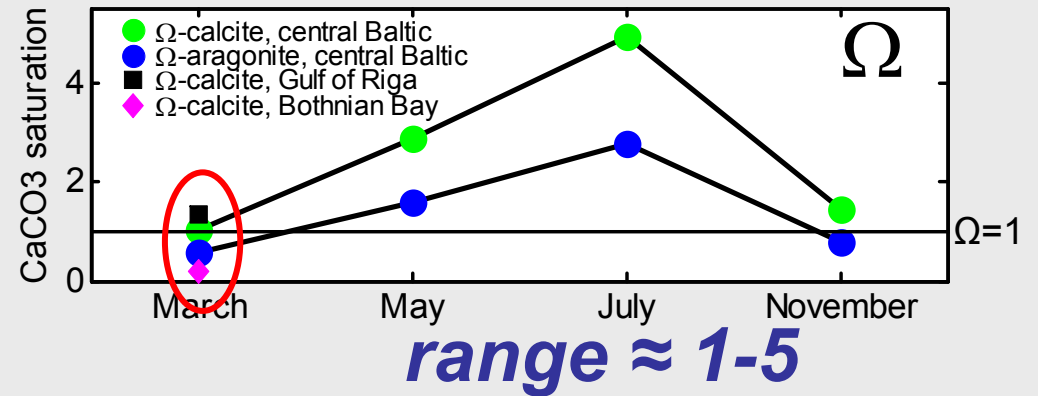
**(Findlay et al. 2008. *Biogeosciences*, in press)**

## **CaCO<sub>3</sub> 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<sub>2</sub> 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



From measurements of DIC and pCO<sub>2</sub> by Bernd Schneider and group

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

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

# Reasons for Low Wintertime Saturation States in Baltic Sea

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

- ~5-fold lower  $[\text{CO}_3^{2-}]$
  - ~4-fold lower  $[\text{Ca}^{2+}]$
  - ~7-fold lower  $K_{\text{sp}}^*$
- } at Sal = 7, T = 0°C

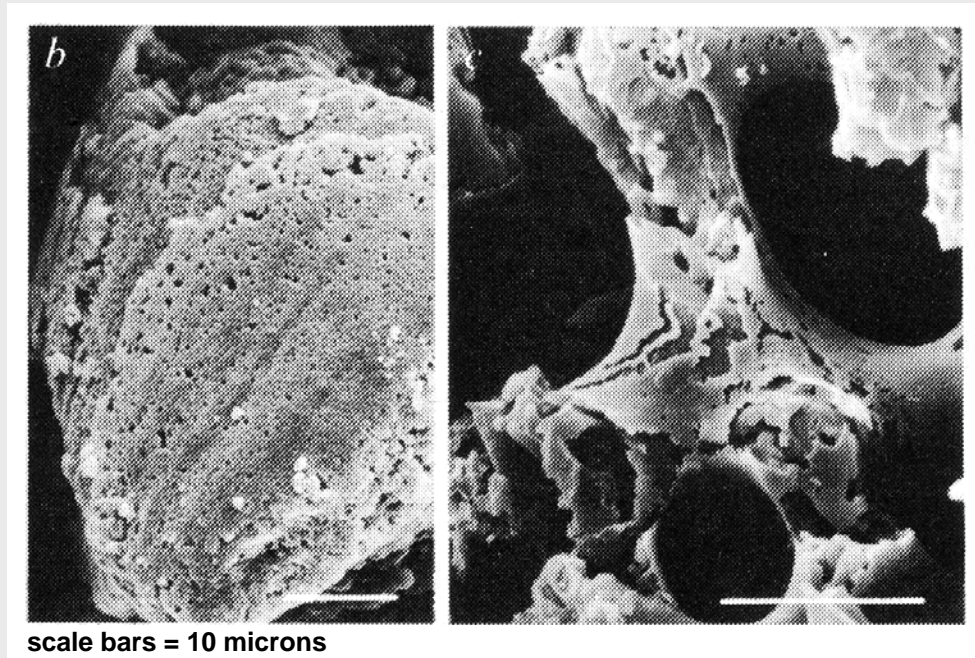
**(5 \* 4 / 7) ≈ 3-fold lower  $\Omega$  in central Baltic Sea than in North Atlantic at same latitude**

# Predicted 30 Years Ago

Torbjörn Alexandersson diagnosed carbonate undersaturation of the Skaggerak and Baltic Sea in the 1970's, through SEM analysis of  $\text{CaCO}_3$  particles in sediments

corroded barnacle hinge tooth

corroded echinoderm shell fragment



**‘Petrographic  
saturation’**

“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**