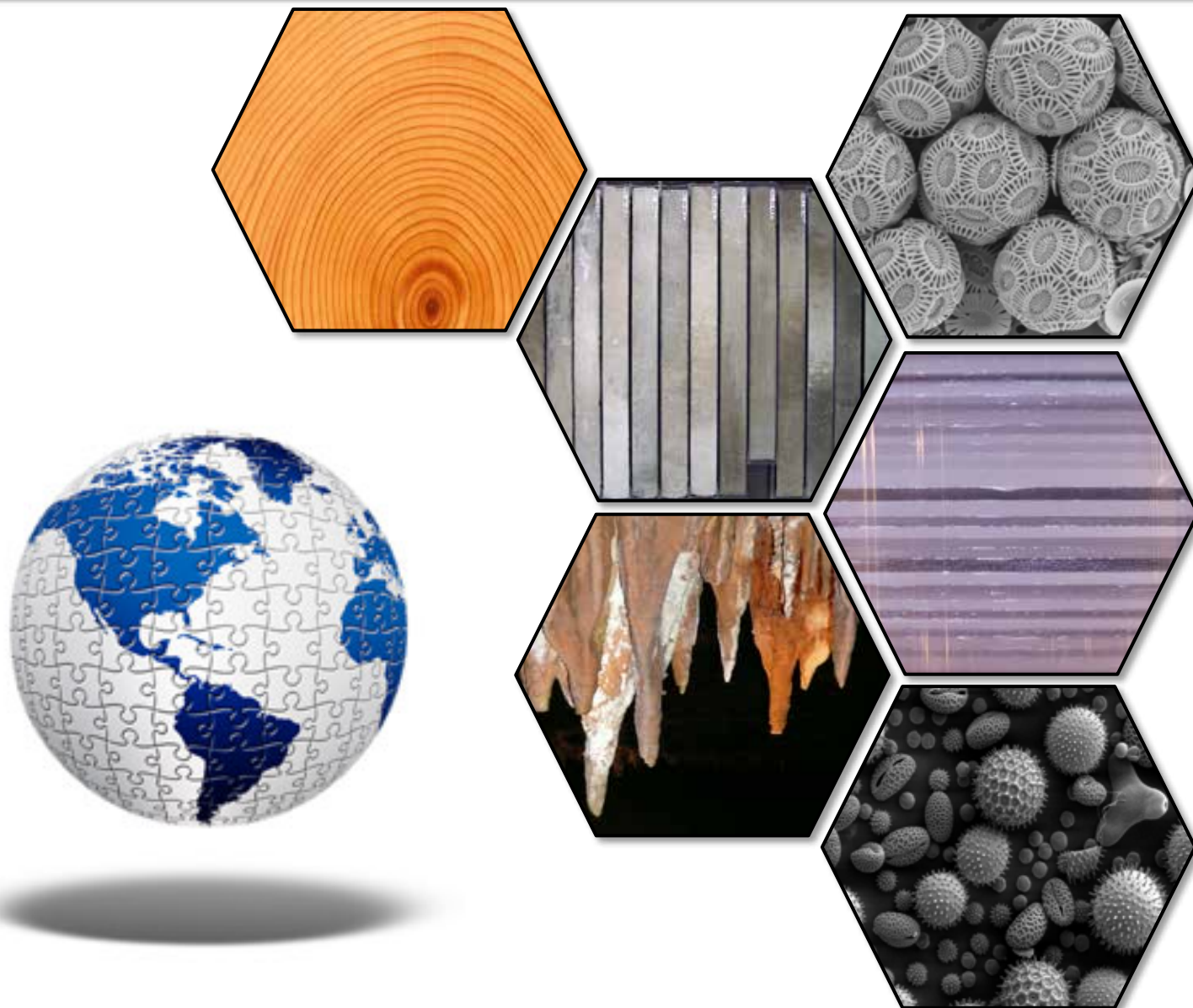


11-year variability in marine **bivalve** growth ...*Sun*-related?

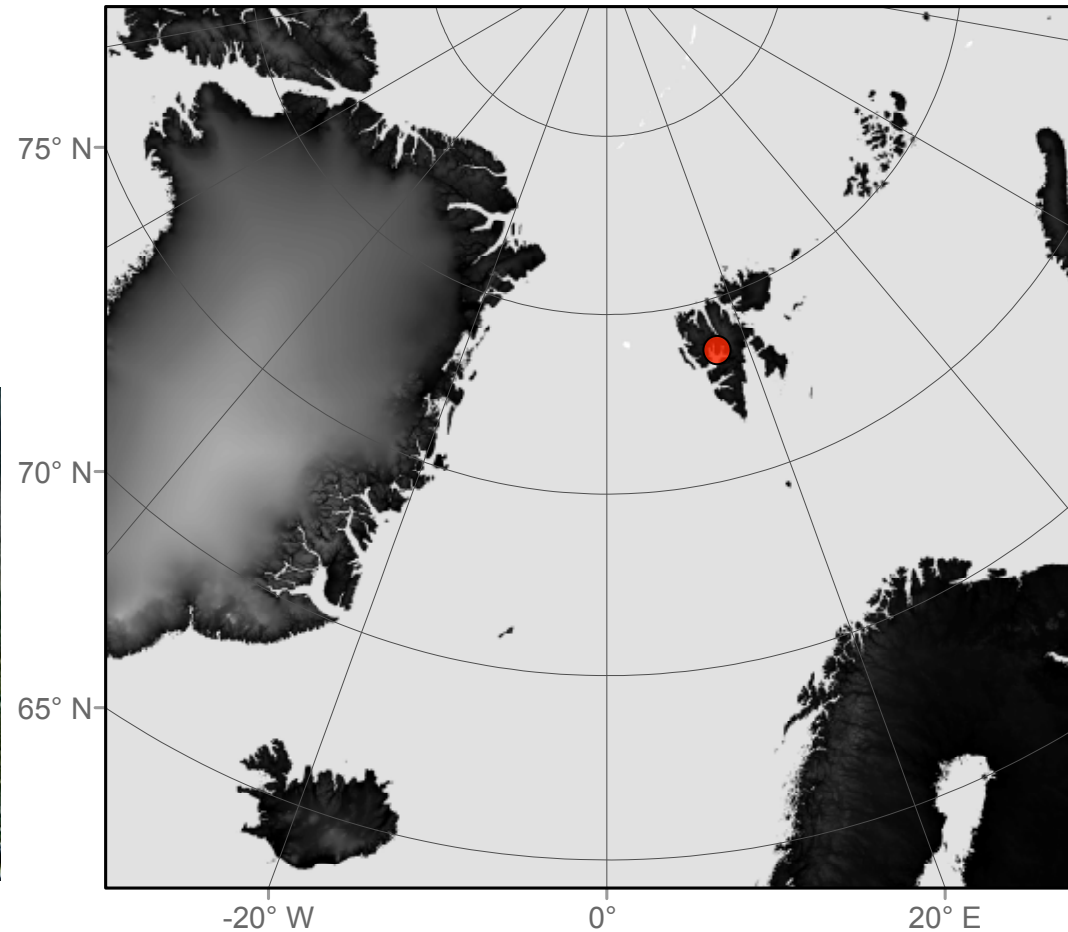
Lars Beierlein

Otto Salvigsen, Bernd R. Schöne, Mihai Dima, and Thomas Brey

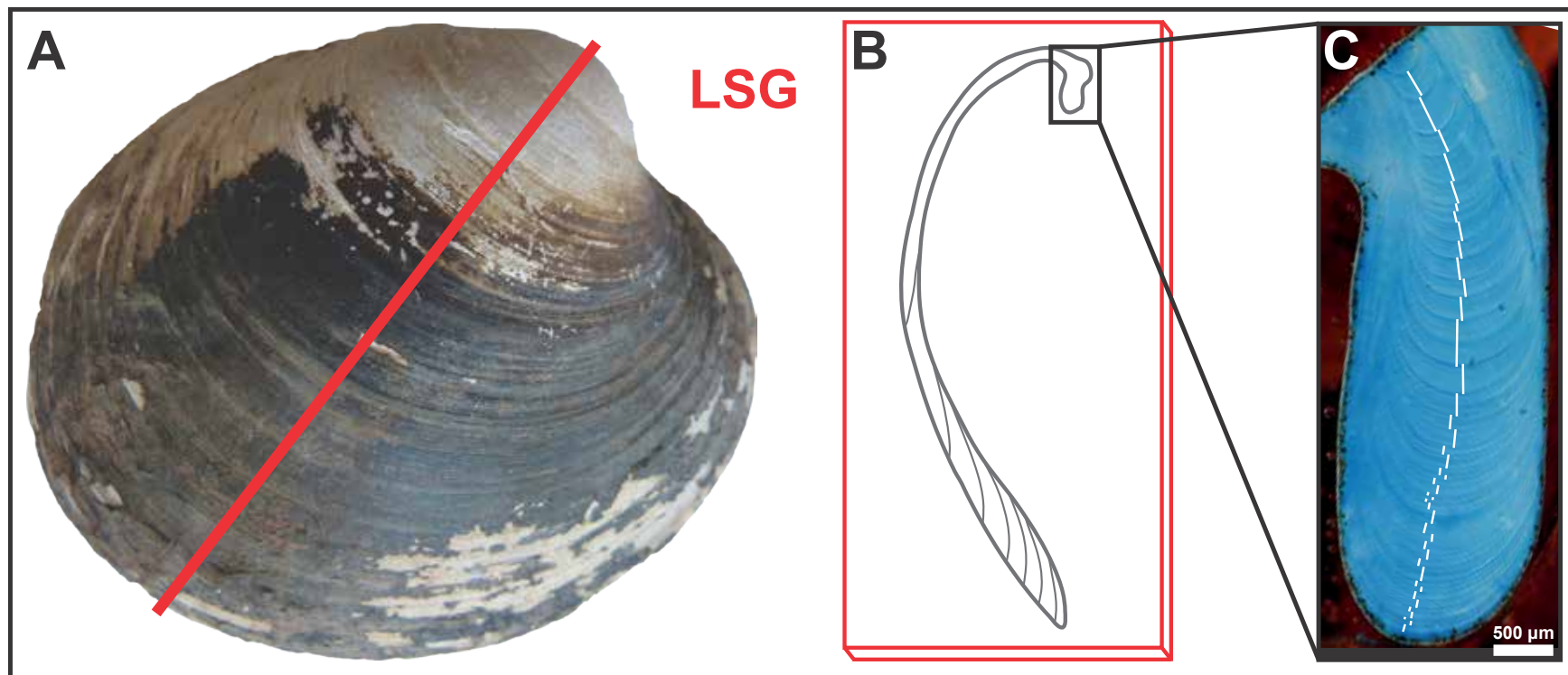
Archives of the past



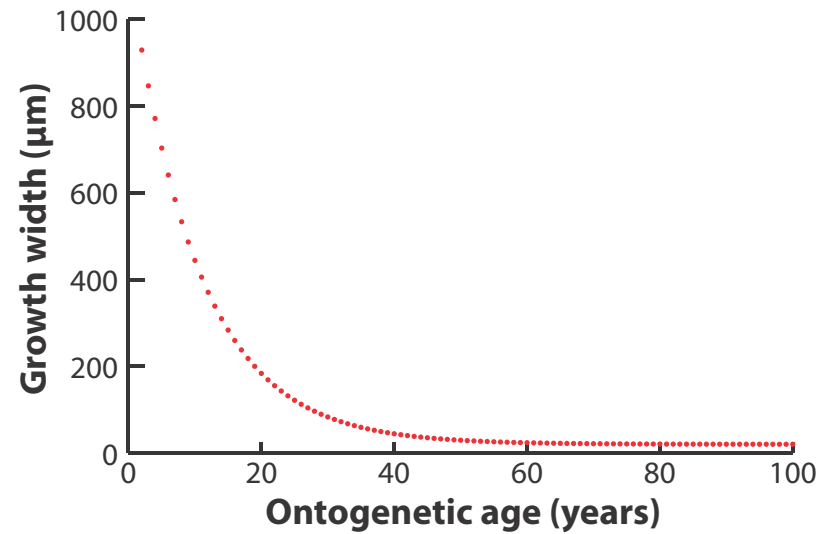
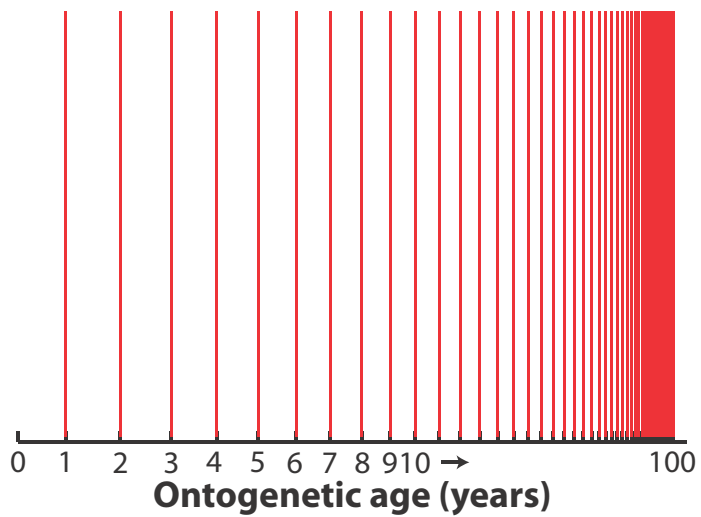
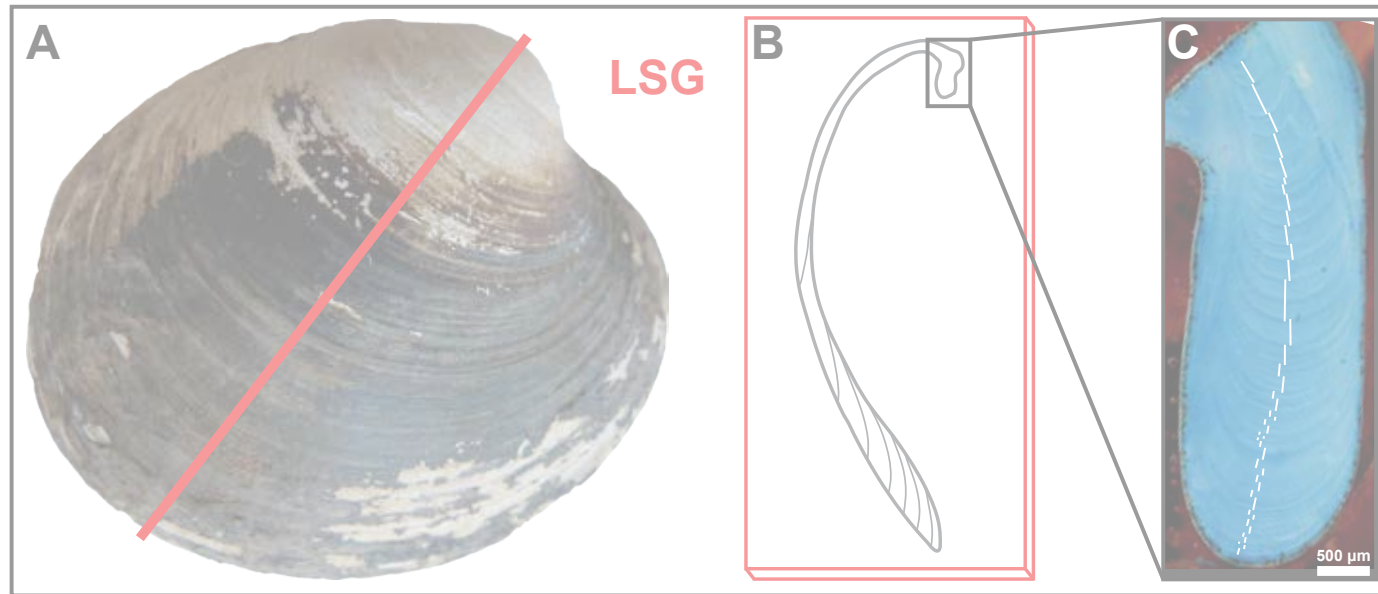
Svalbard: 6 sub-fossil *Arctica islandica*



Raised beach deposits
shells found ~5-10m a.s.l.



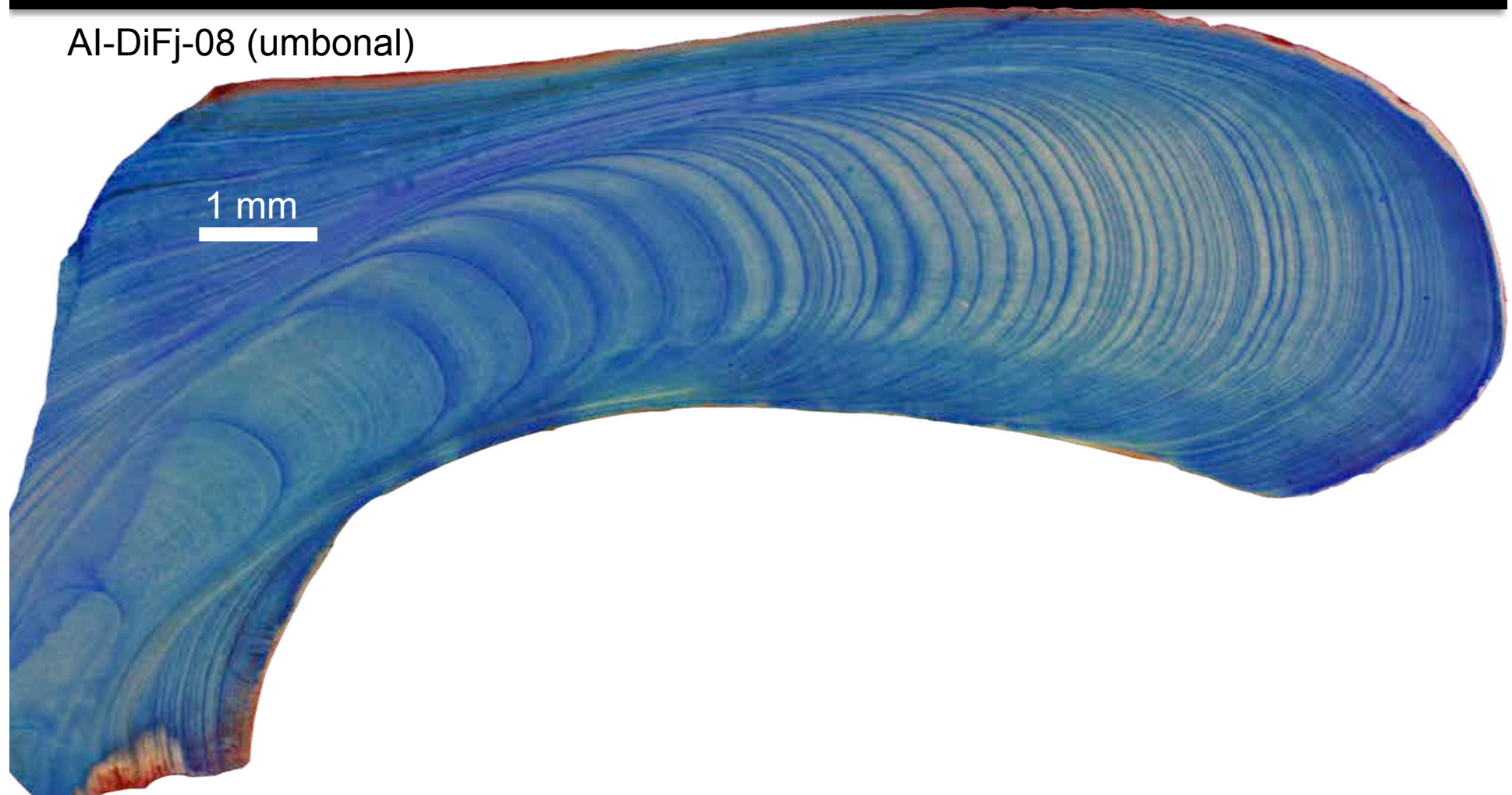
Methodology



Decadal time-scale



AI-DiFj-08 (umbonal)



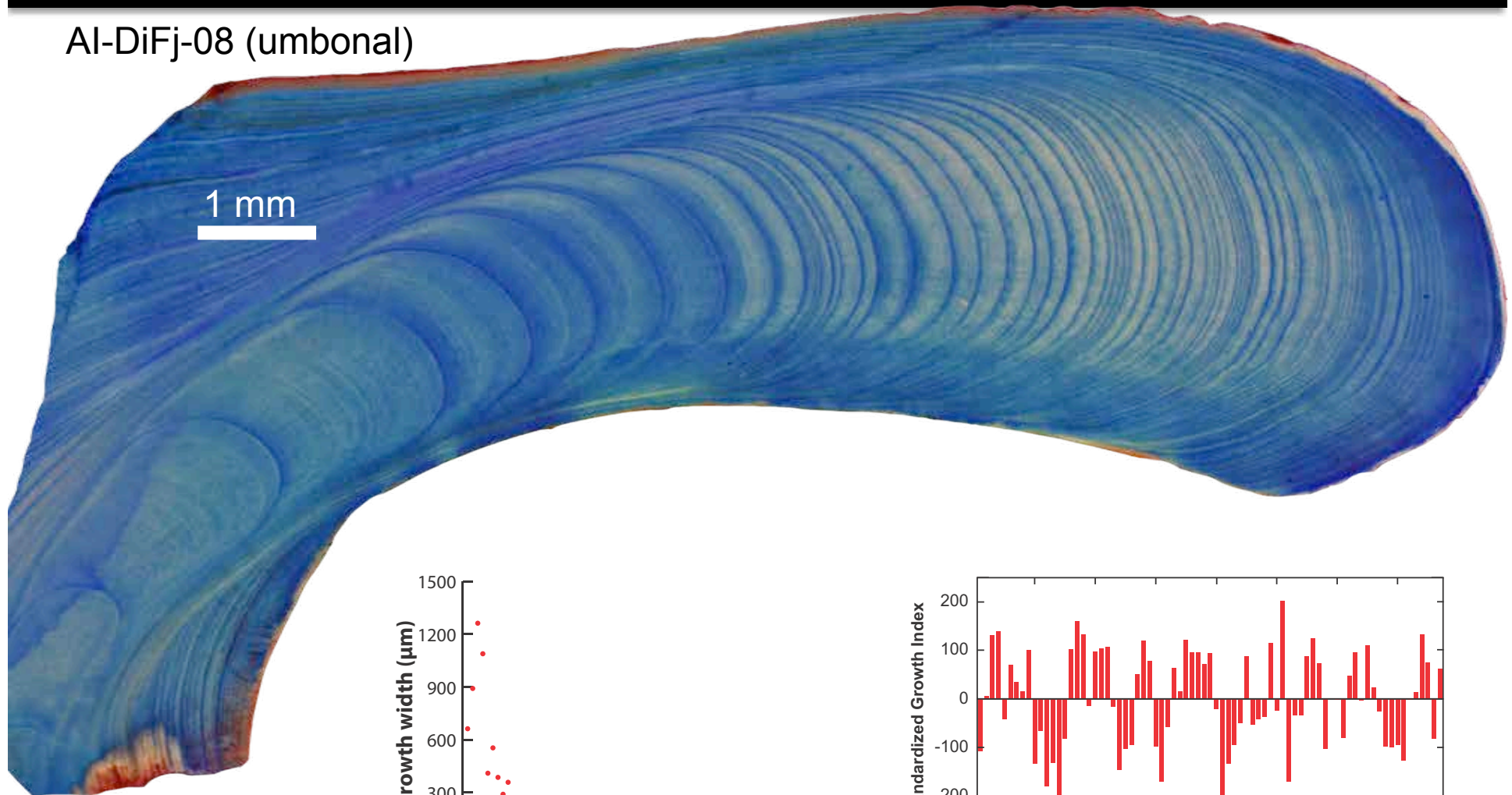
direction of growth



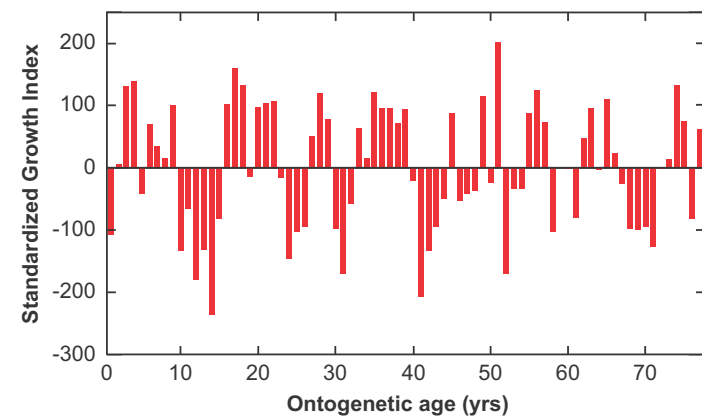
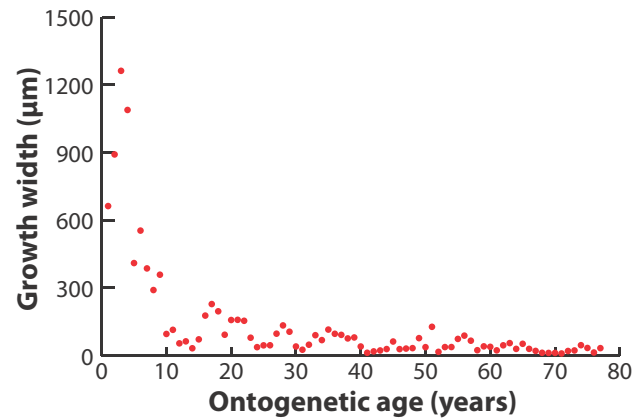
Decadal time-scale



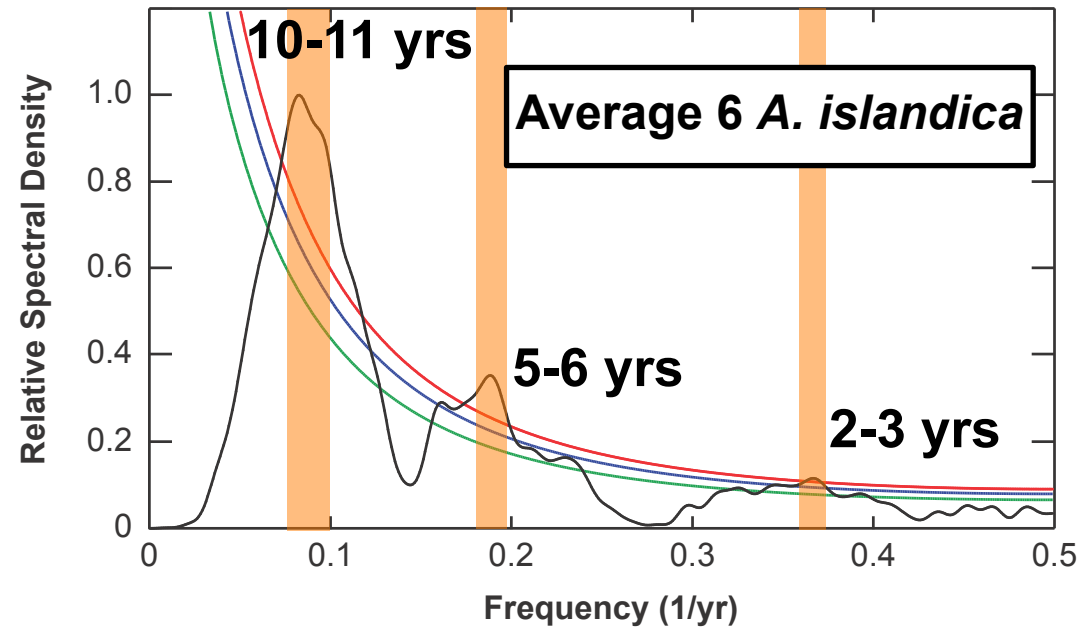
AI-DiFj-08 (umbonal)



direction of growth



Comparing spectral fingerprints



Significance levels:

99%

95%

90%

Comparing spectral fingerprints

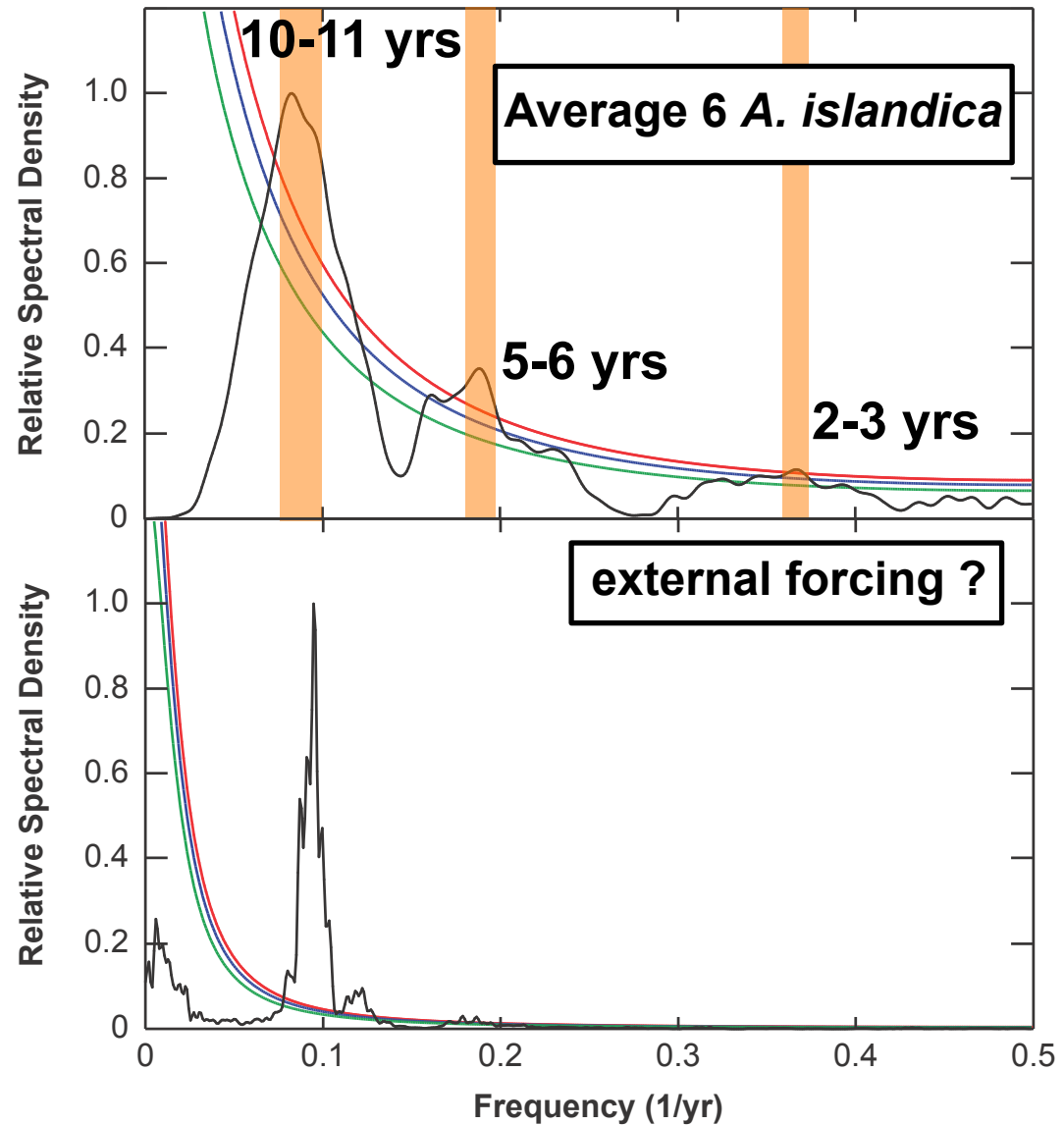


Significance levels:

99%

95%

90%



Comparing spectral fingerprints

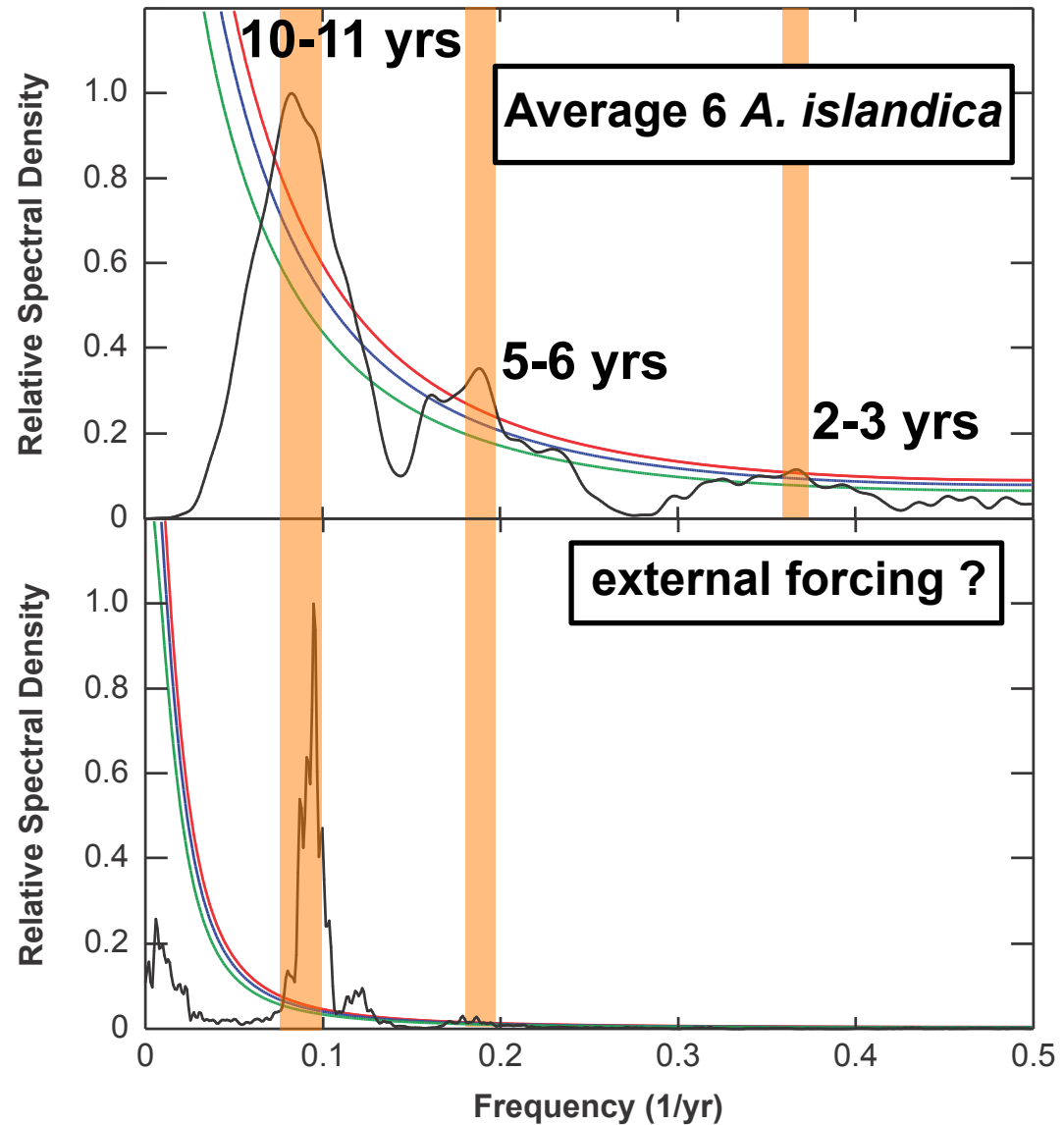


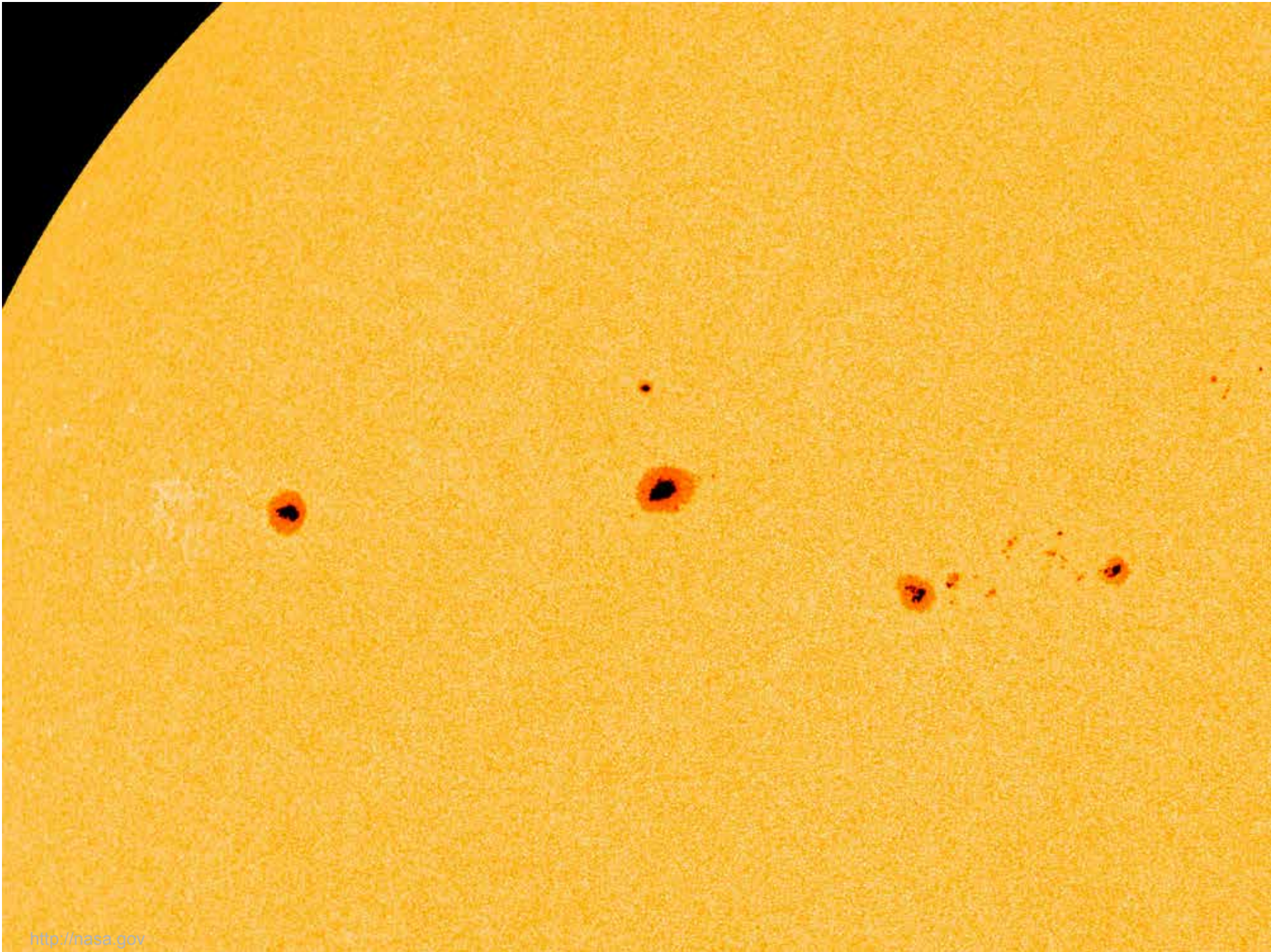
Significance levels:

99%

95%

90%





11 year sunspot **Schwabe cycle**

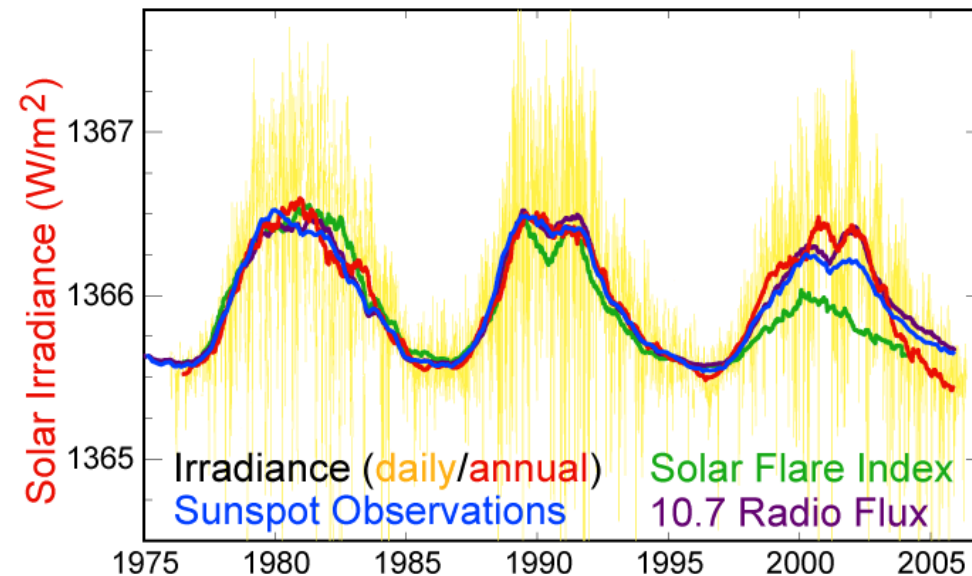
- Number of dark spots on the Sun's surface ranges from 0-200.
- Linked to Sun's magnetic activity (→ 22-year Hale cycle).
- Net increase in total solar irradiance of about **0.1%** ($\pm 0.06^\circ\text{C}$).

Indirect influence

Amplifying mechanism
needed.

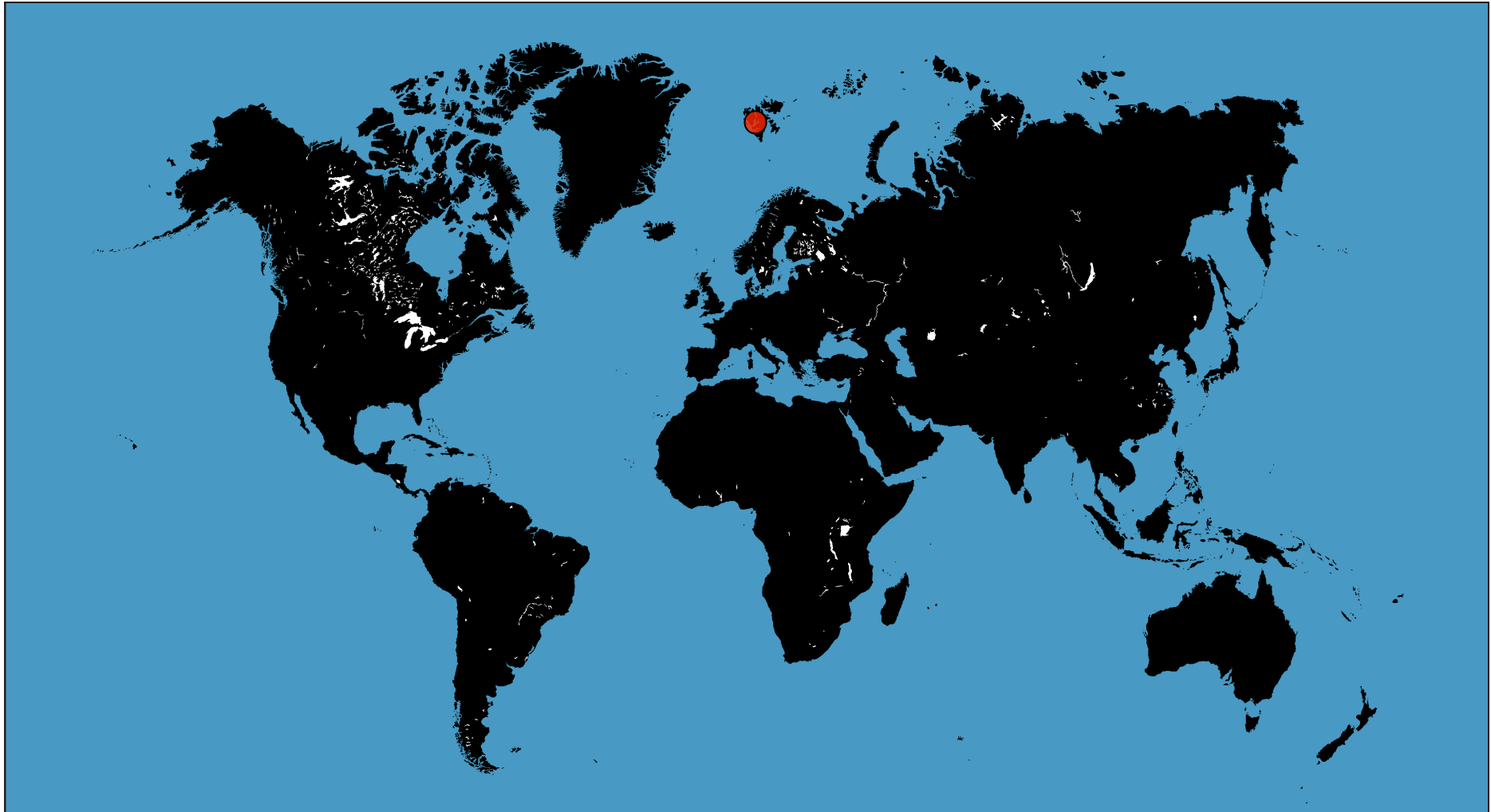
In bivalves via: **food** and/
or temperature.

Solar Cycle Variations

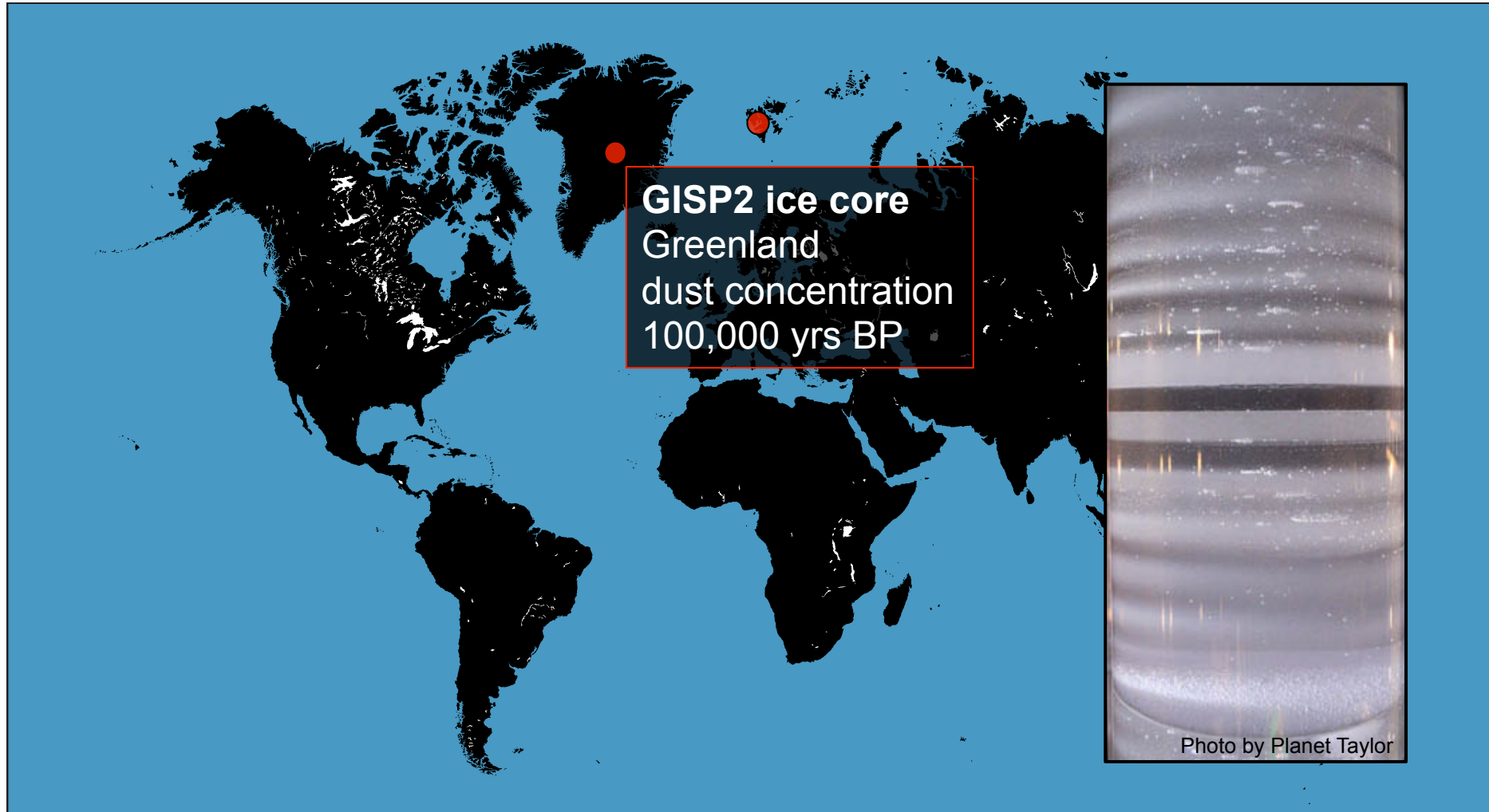


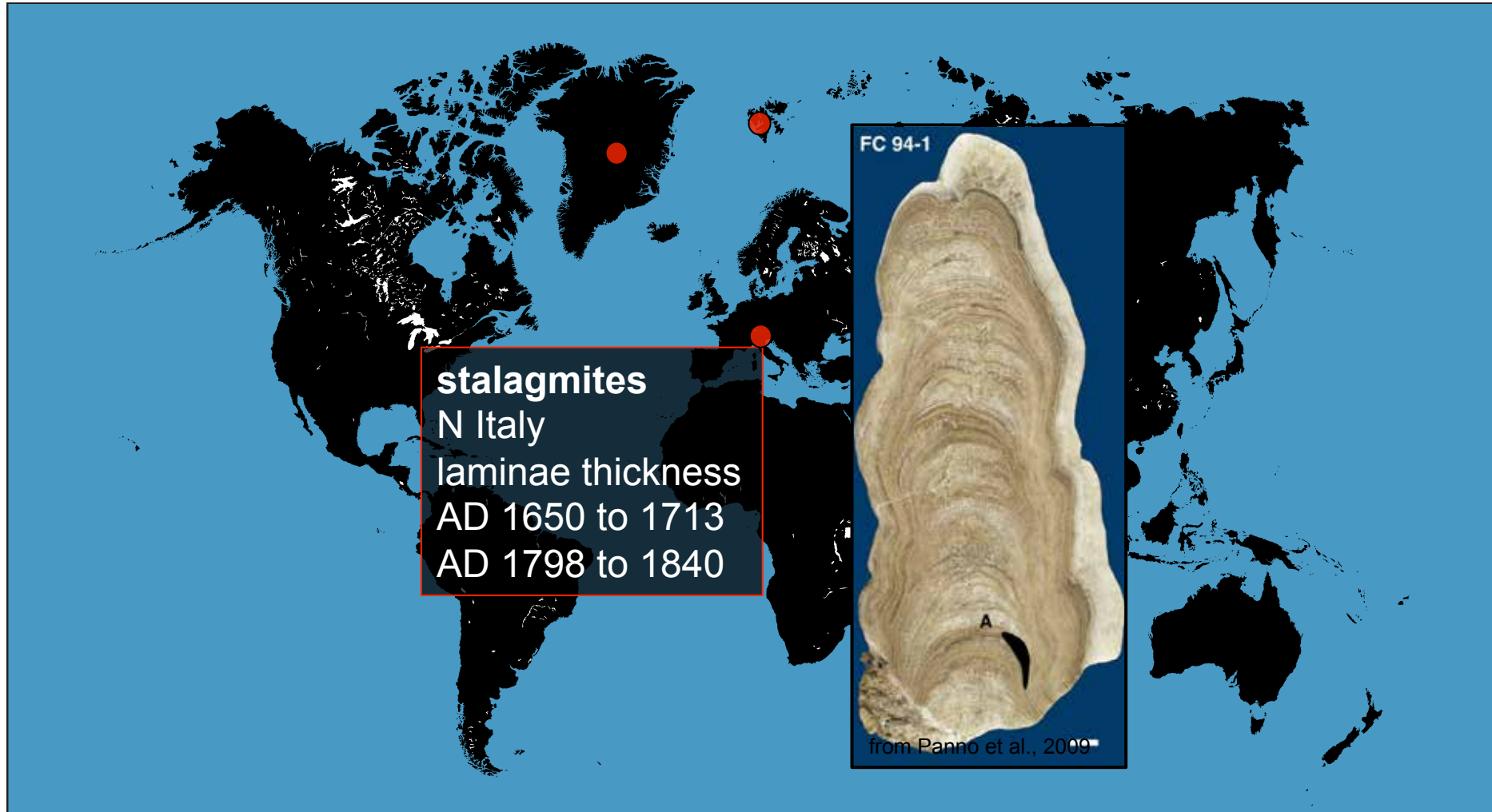
<http://en.wikipedia.org>

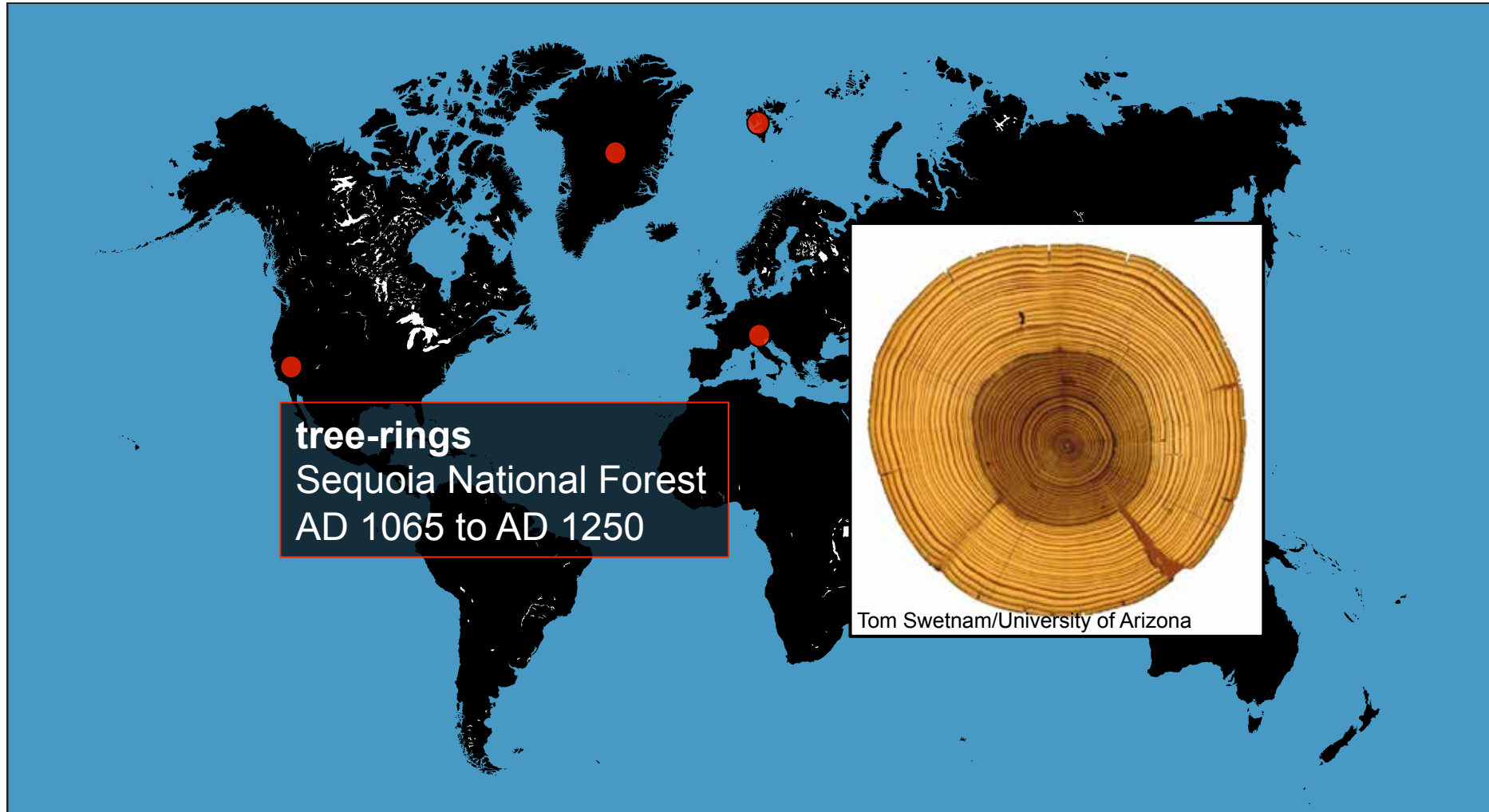
11-year signal

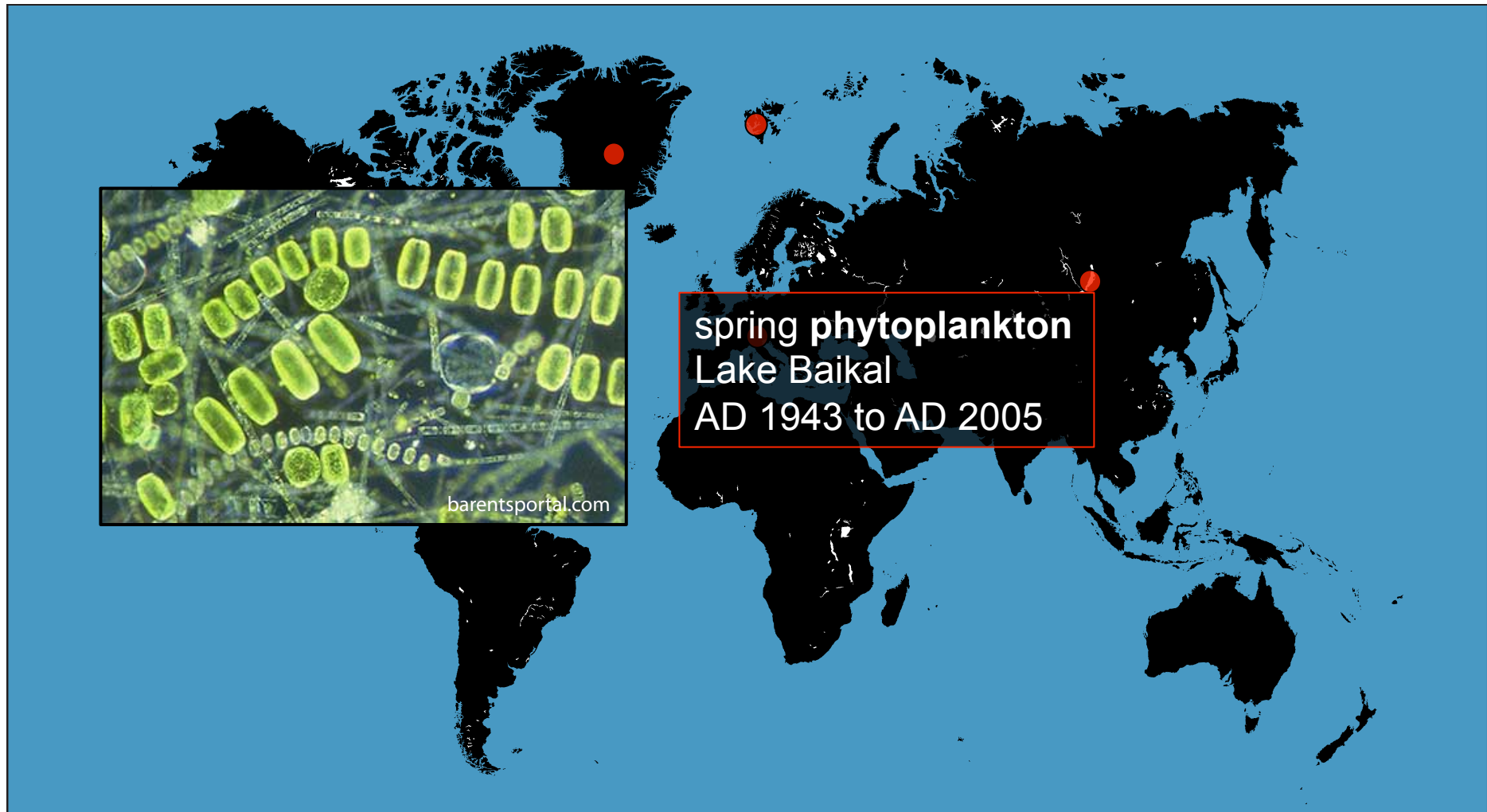


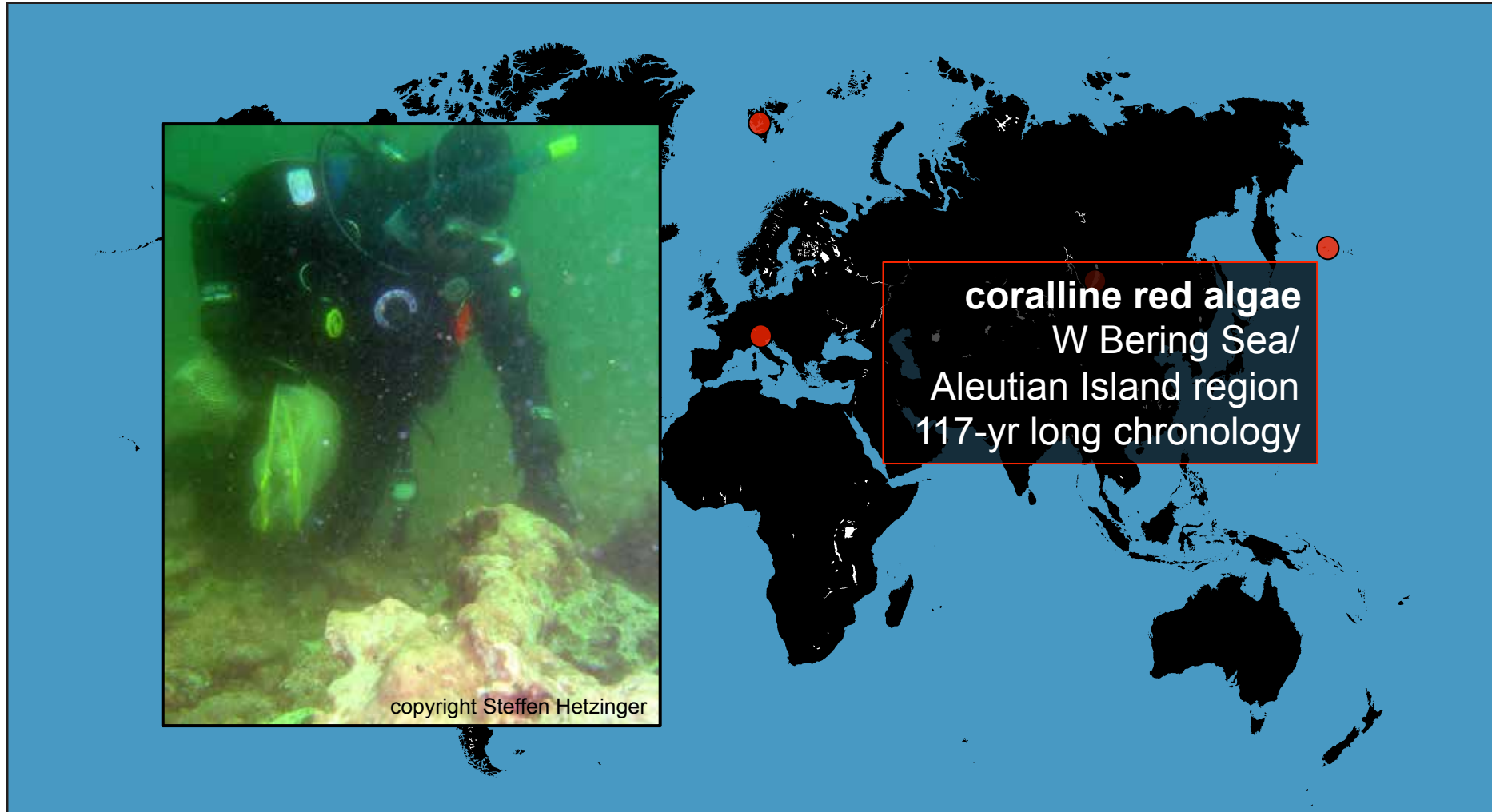
11-year signal: Ram et al., 1997

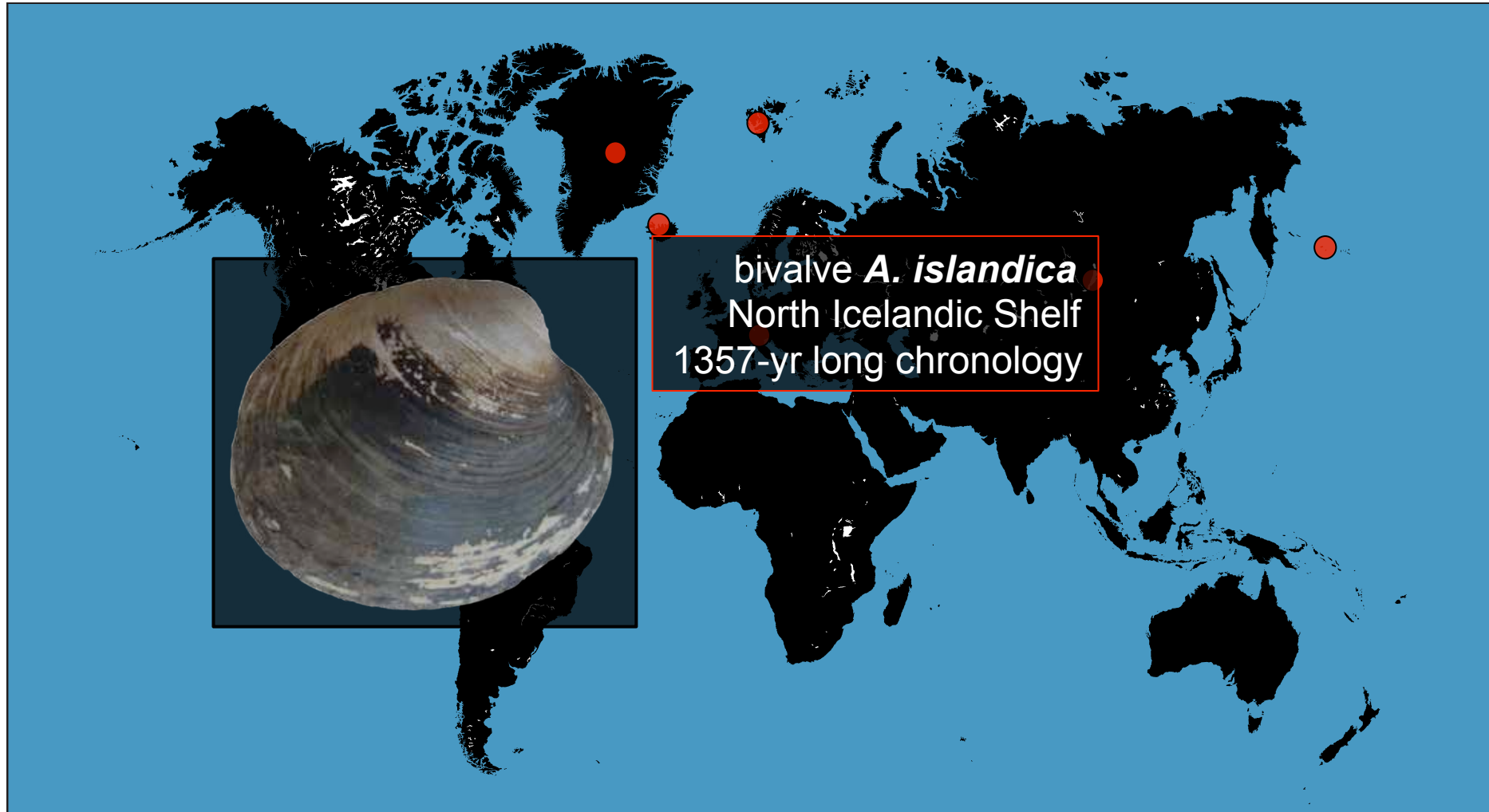




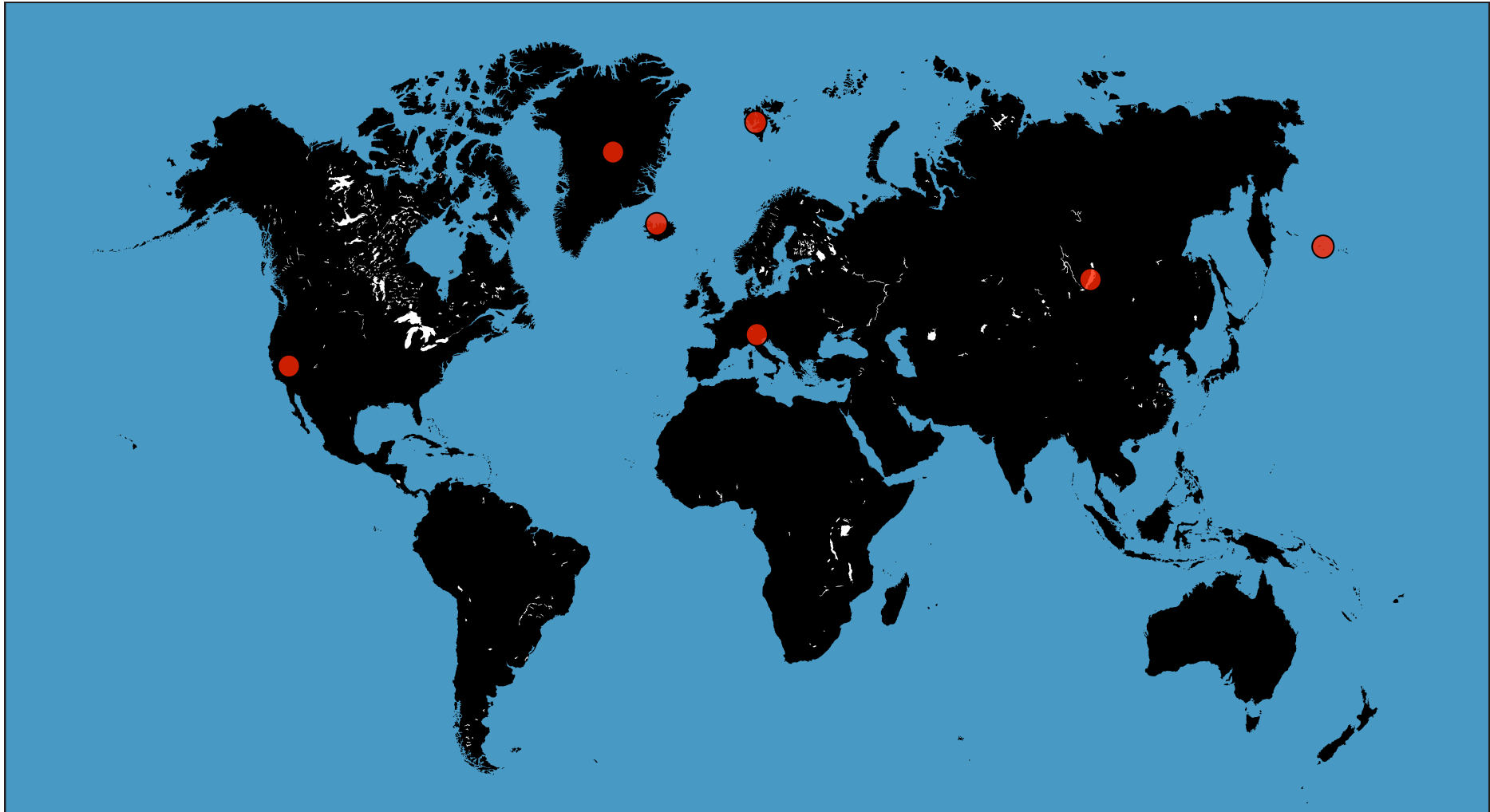




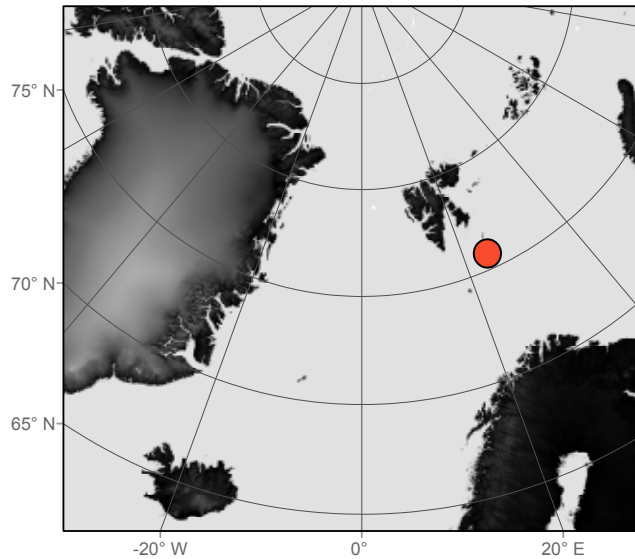




11-year signal



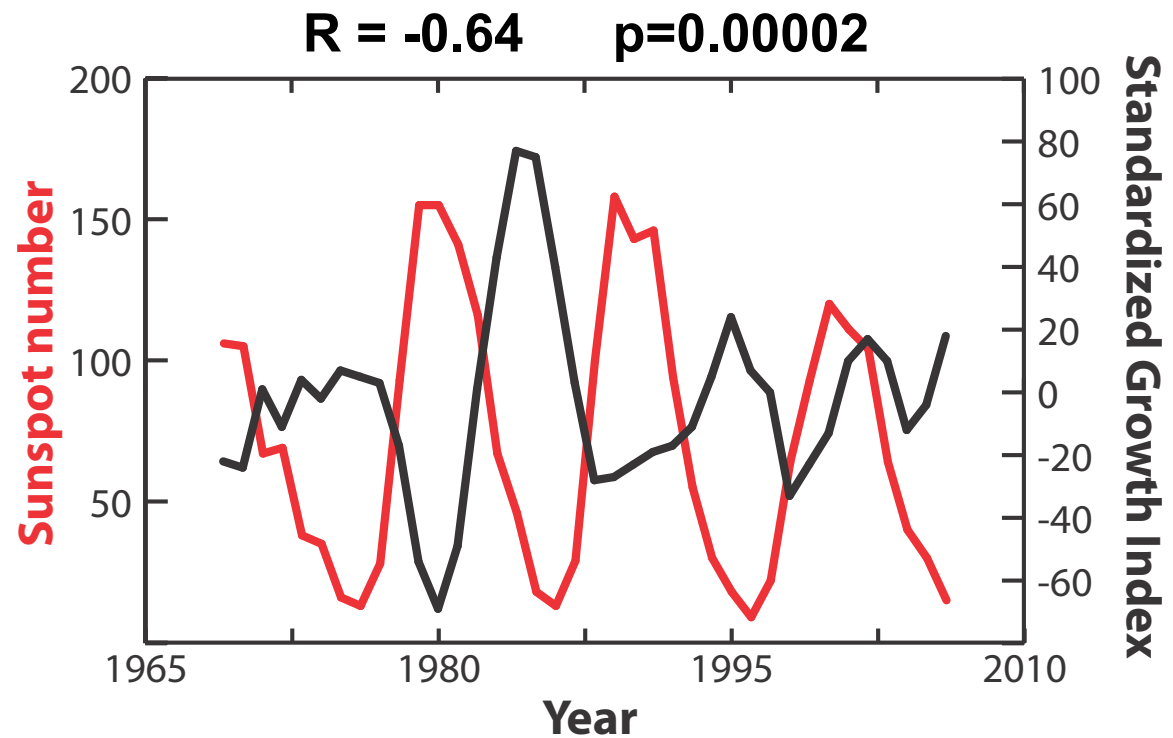
Correlation



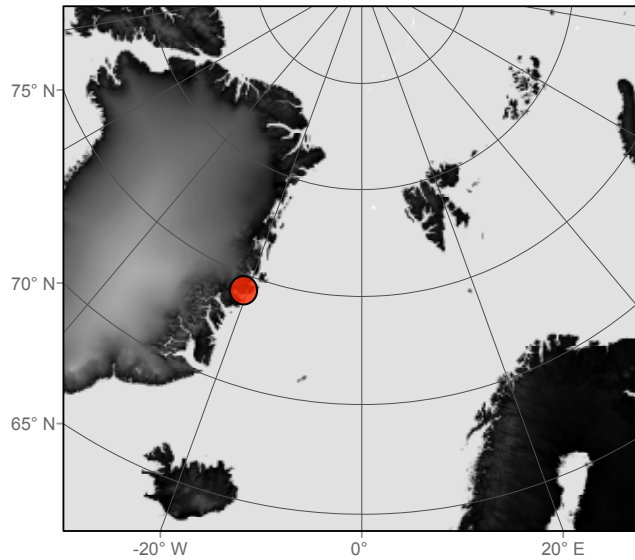
Ciliatocardium ciliatum

Barents Sea

SGL data by Michael Carroll
(from Carroll et al., 2014)



Correlation



***Mya* sp.**

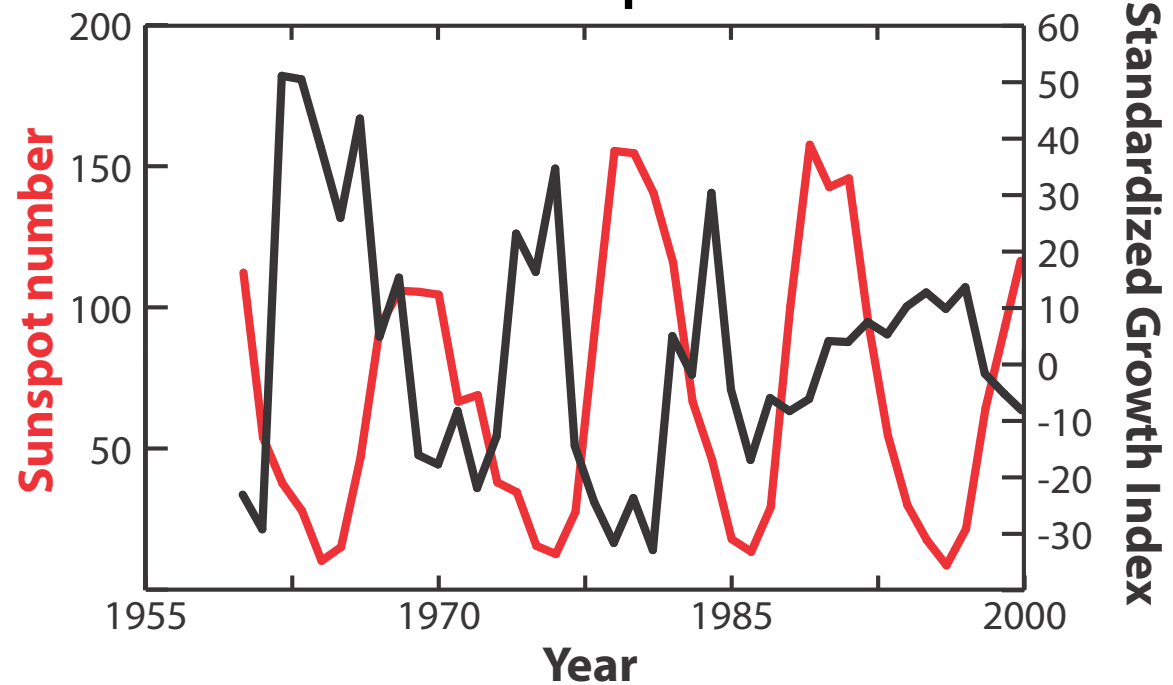
Young Sound
E Greenland

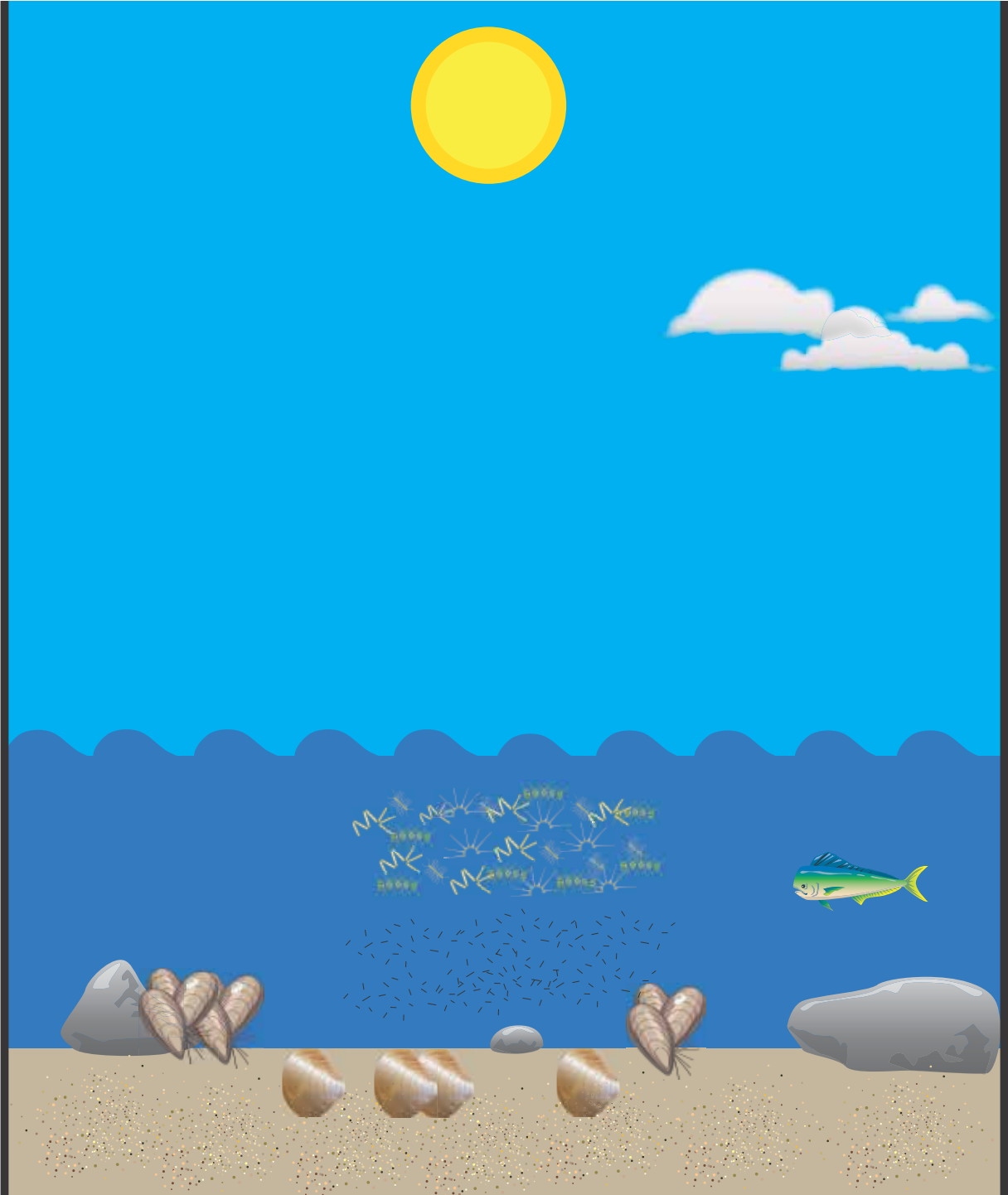
SGI data by Mikael Sejr

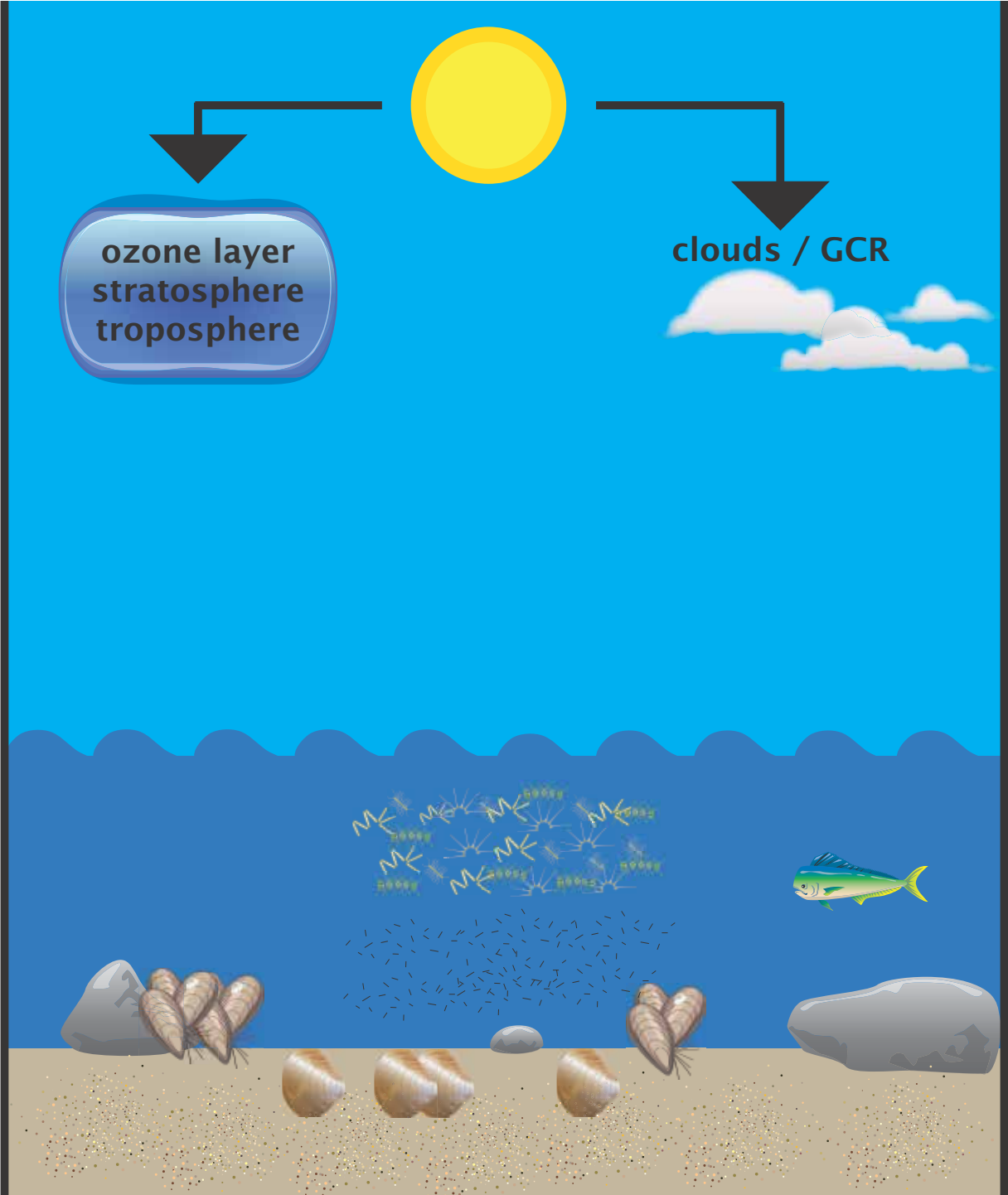


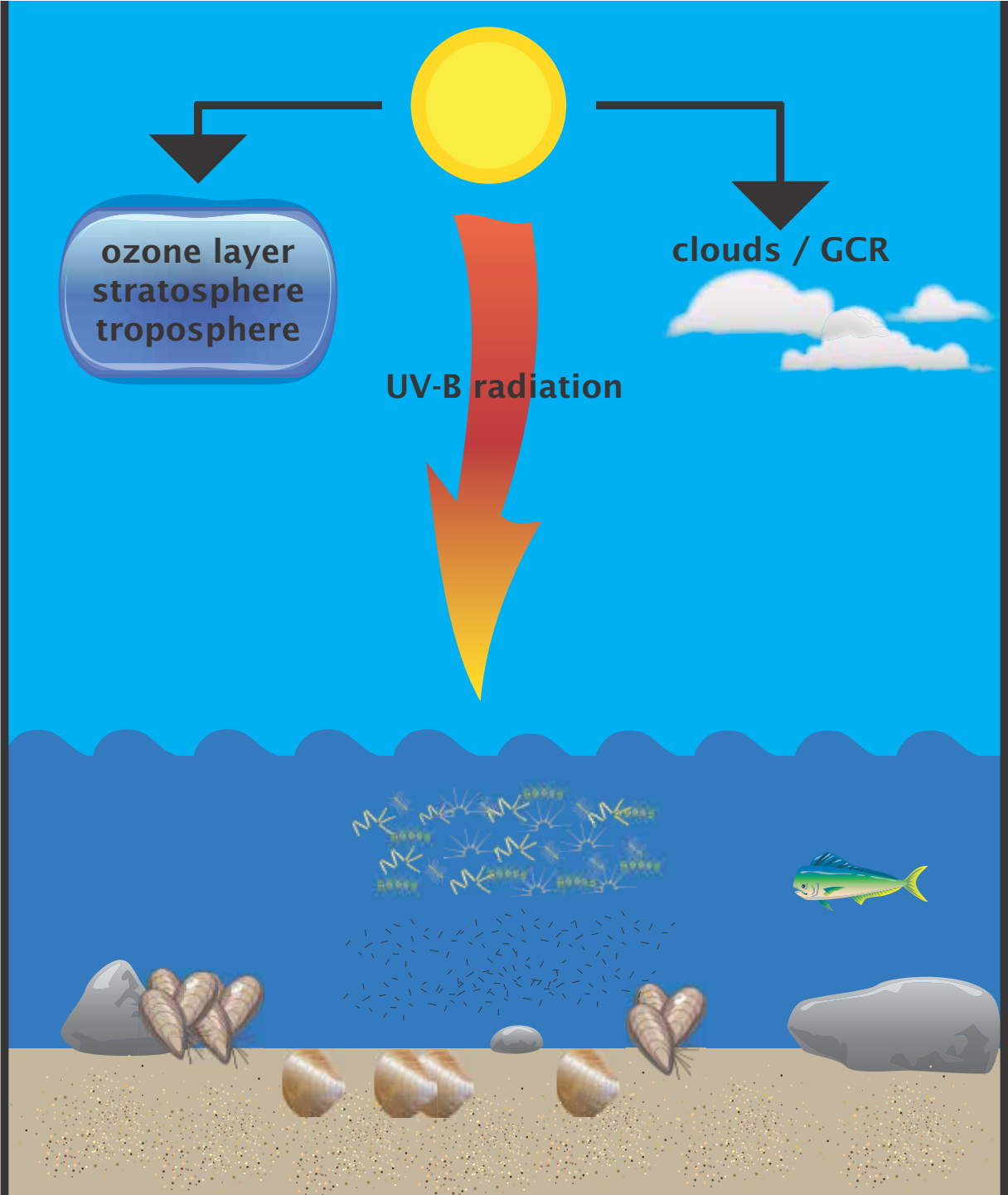
copyright National Museum Wales

R = -0.50 **p=0.00093**









Gray et al., 2005
Haigh, 1996



ozone layer
stratosphere
troposphere



Svensmark & Friis-Christensen, 1997
Pudovkin et al., 1995



positive correlation

Ineson et al., 2011
Haigh et al., 2010
Harder et al., 2009

clouds / GCR



UV-B radiation

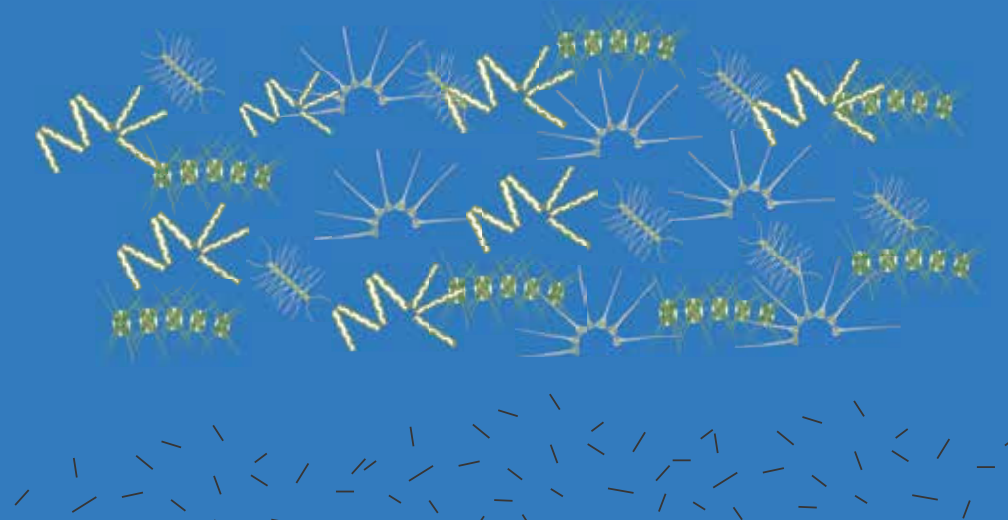


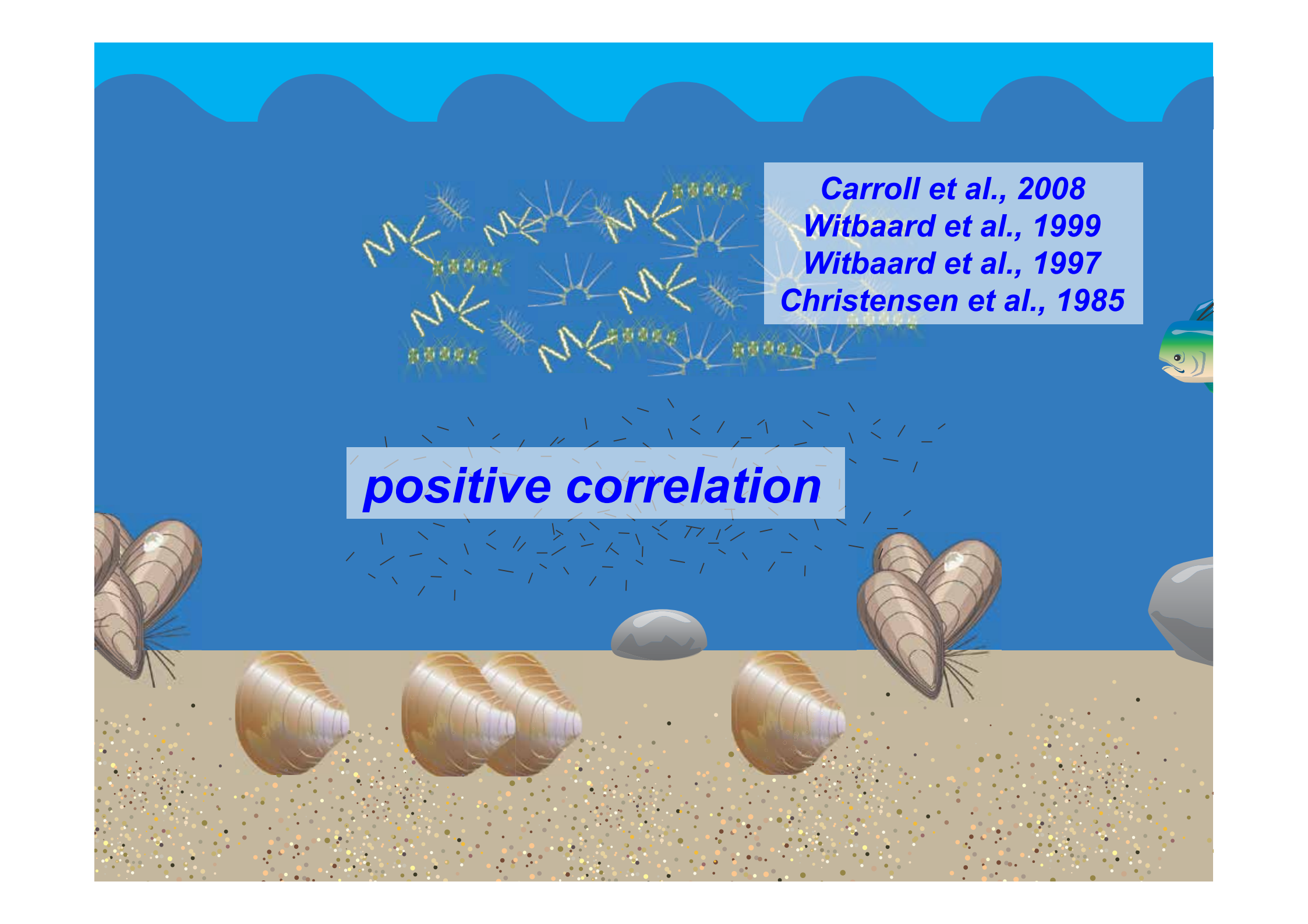


UV-B radiation

Häder et al., 2007
Häder et al., 2003
Hessen, 2002
Aas et al., 2002
Estevez et al., 2001
Sinha et al., 2001
Ghetti et al., 1999
Klisch & Häder, 1999
Wängberg et al., 1998
Vincent & Roy, 1993

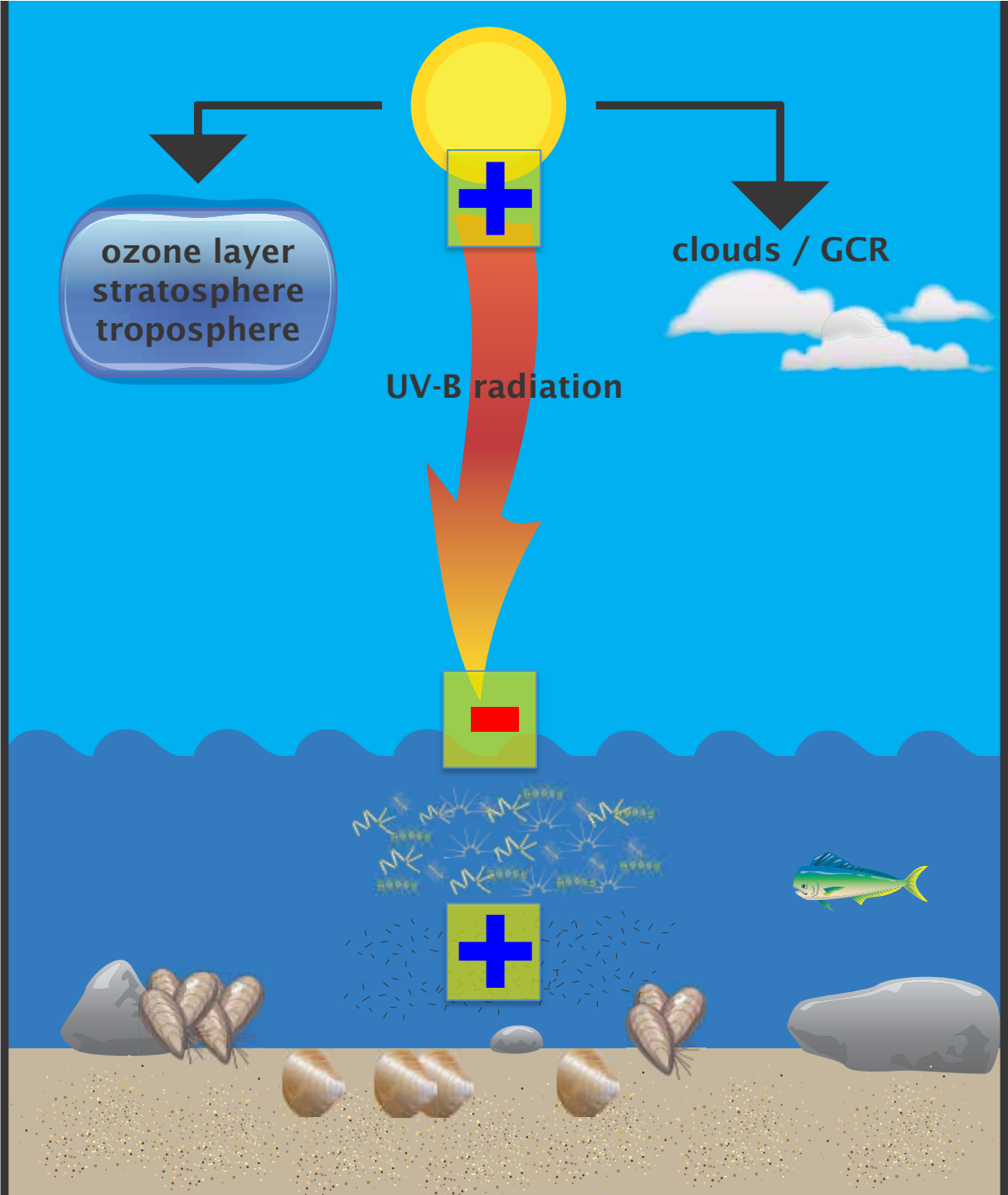
negative correlation





Carroll et al., 2008
Witbaard et al., 1999
Witbaard et al., 1997
Christensen et al., 1985

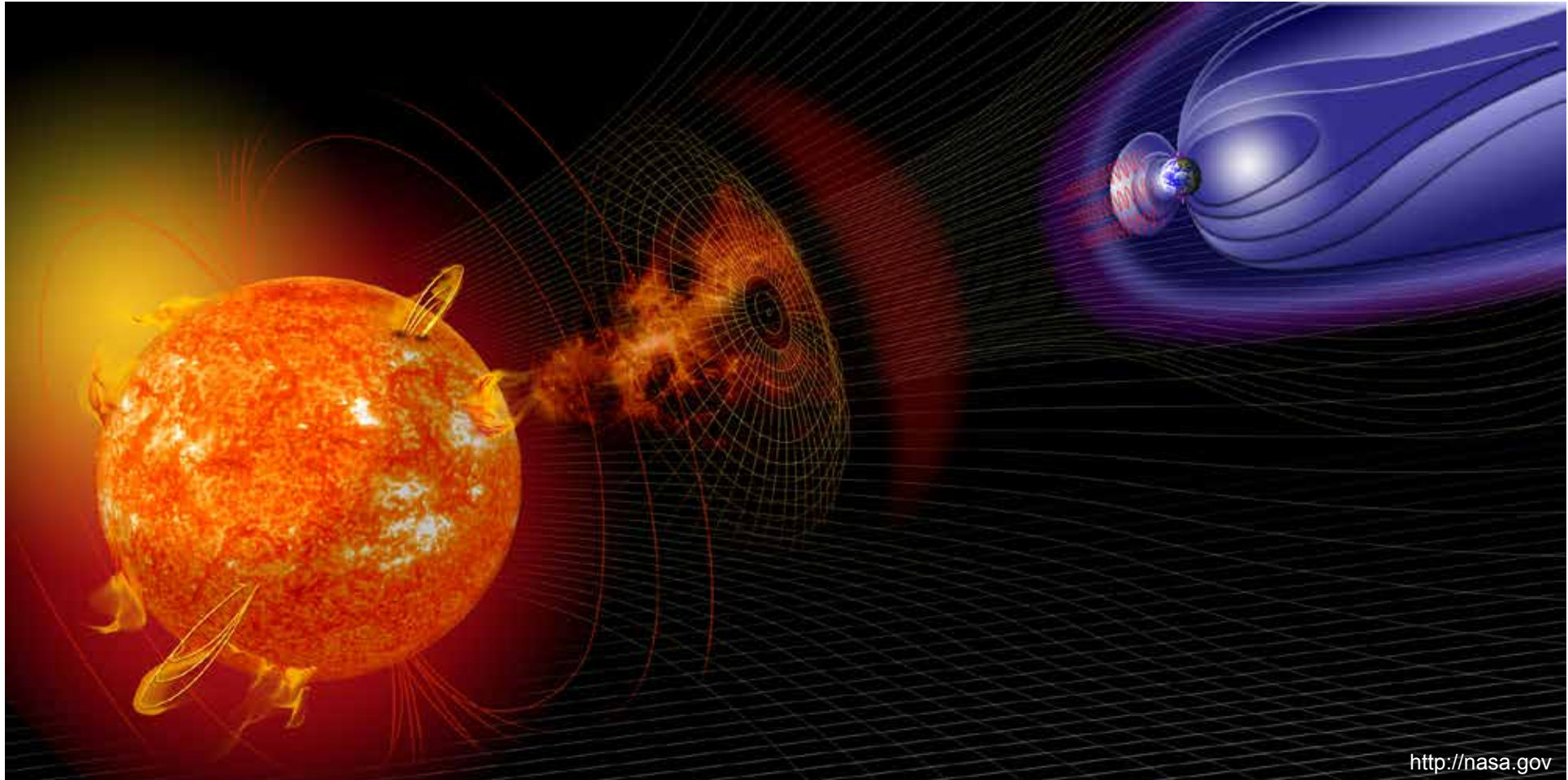
positive correlation



Latitude dependence



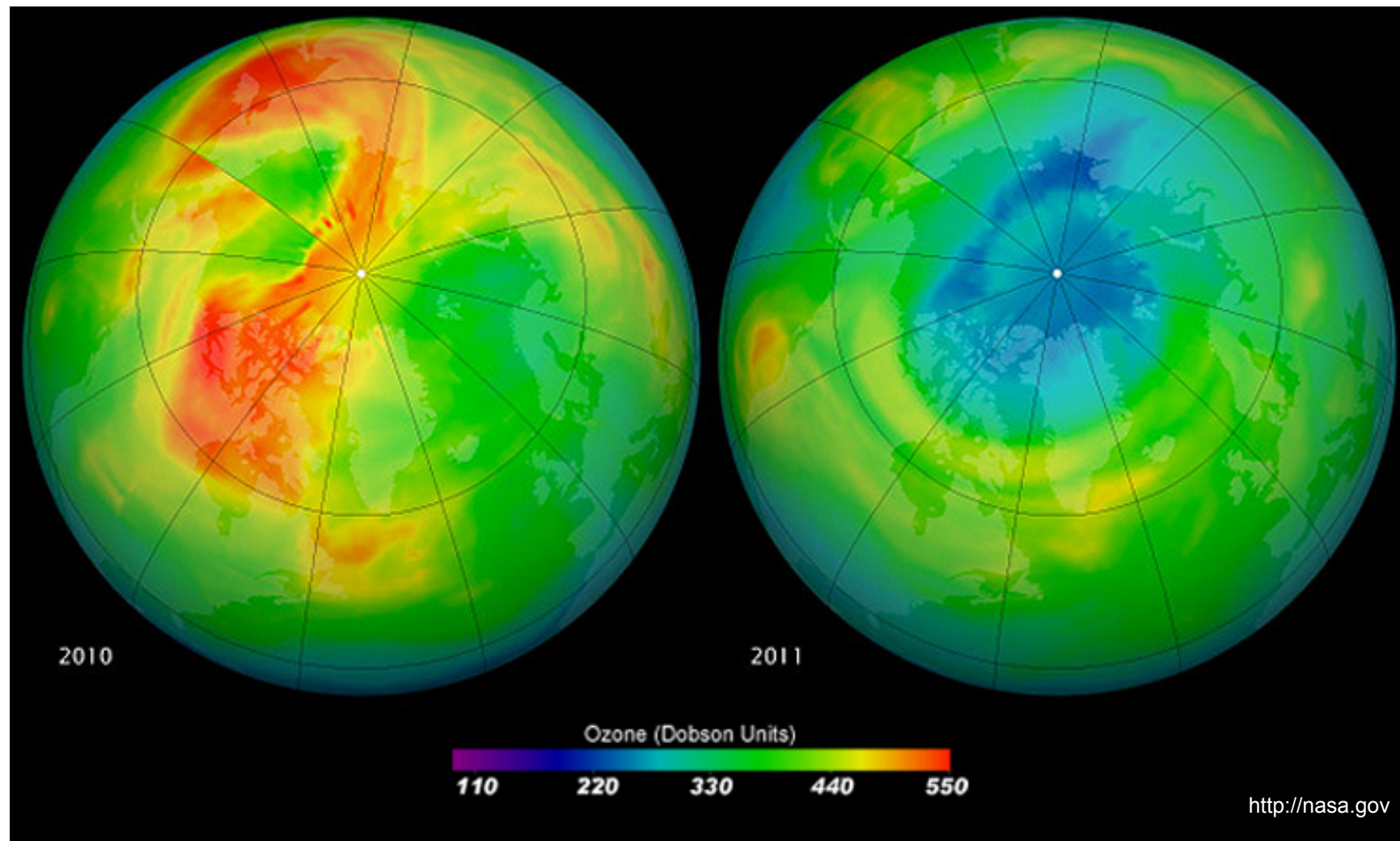
Earth's magnetic field



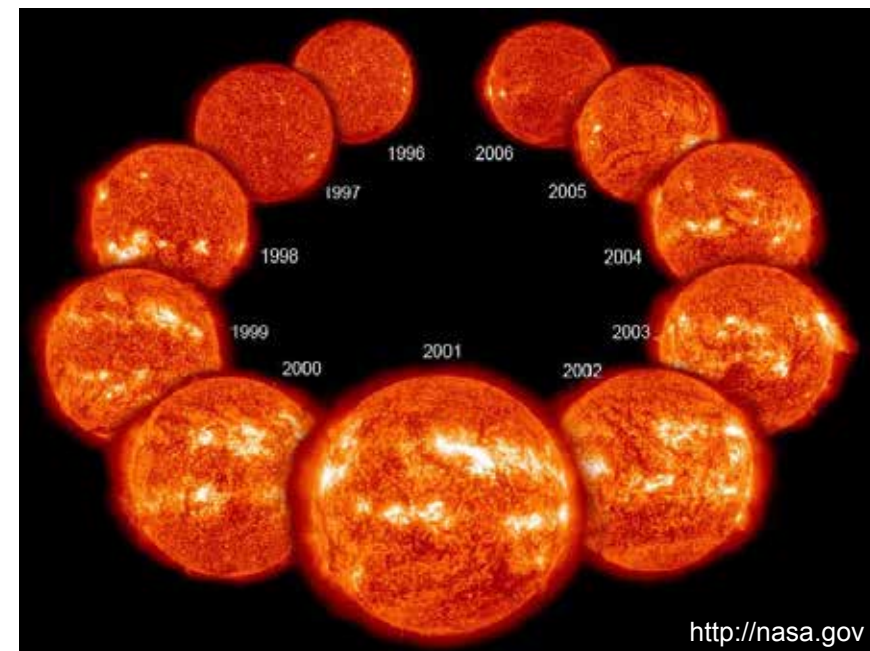
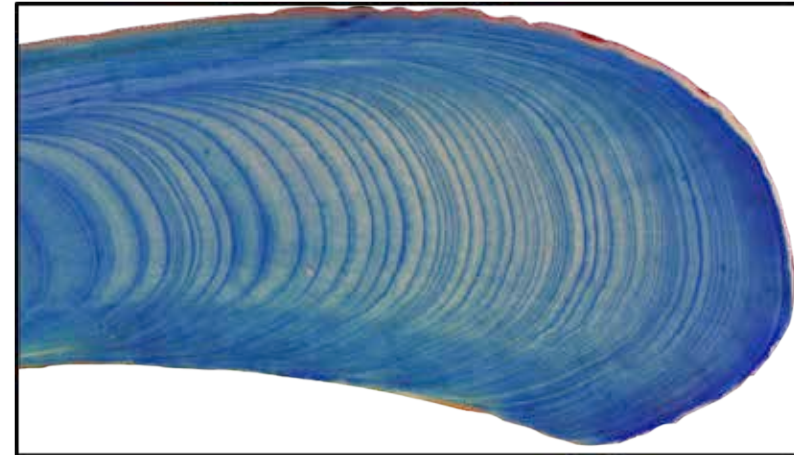
Latitude dependence



ozone depletion

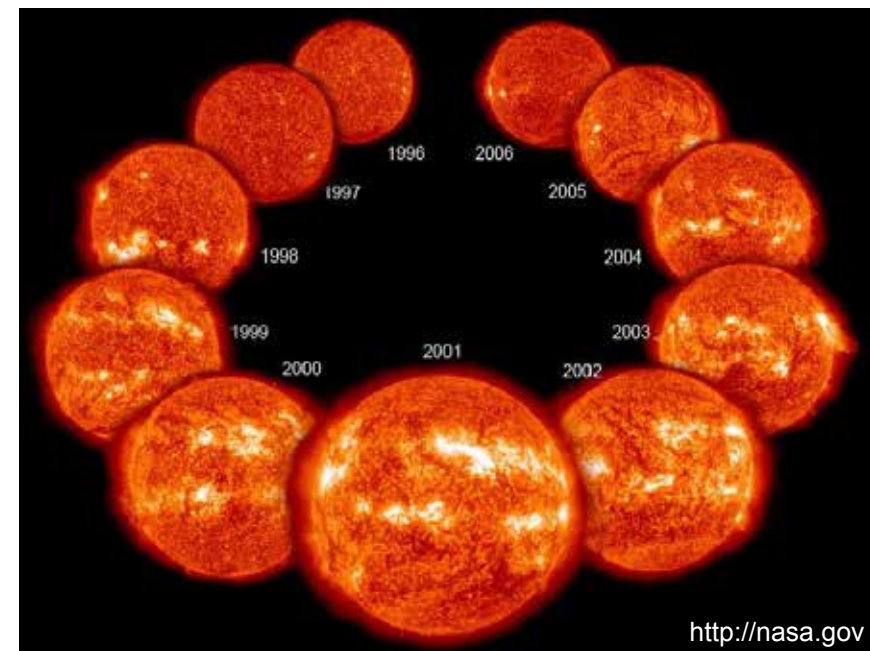
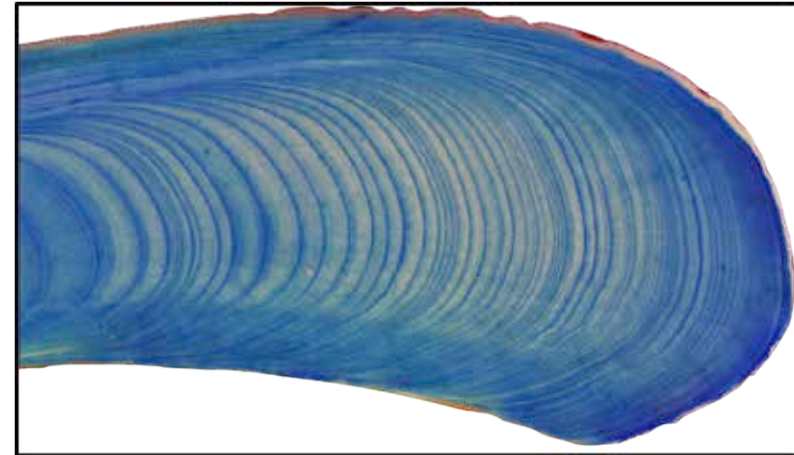


- **11-year signal** in sub-fossil *A. islandica* from the high Arctic
- marine, freshwater and terrestrial archives show **11-year signal**
 - Sun as common (**external**) driver accepted
- *IF* 11-year signal is related to the Sun, what is the **amplifying mechanism** for marine bivalves?
 - **UV-B radiation** inhibits photosynthesis in phytoplankton
 - affects **food quantity/quality** at benthos

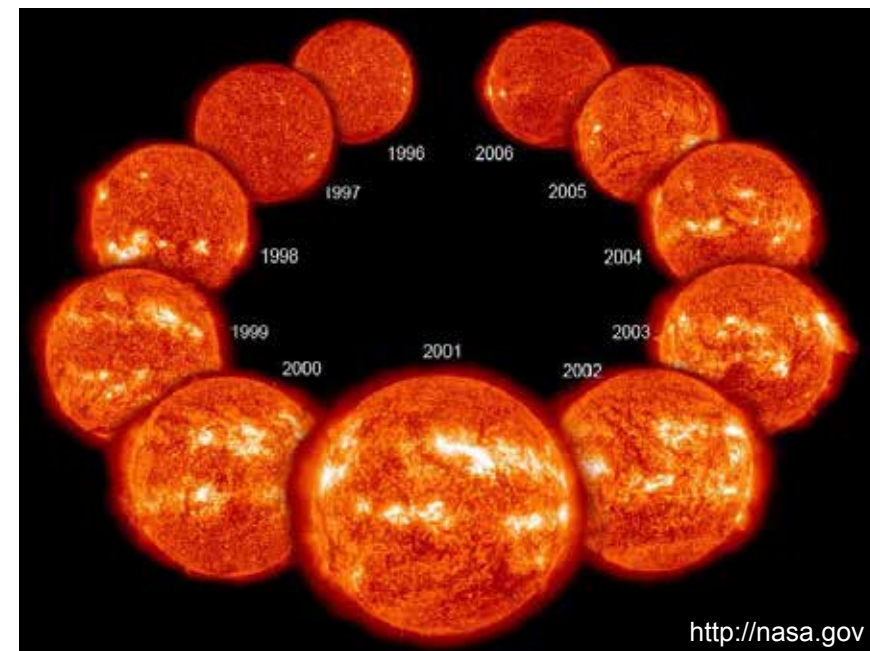
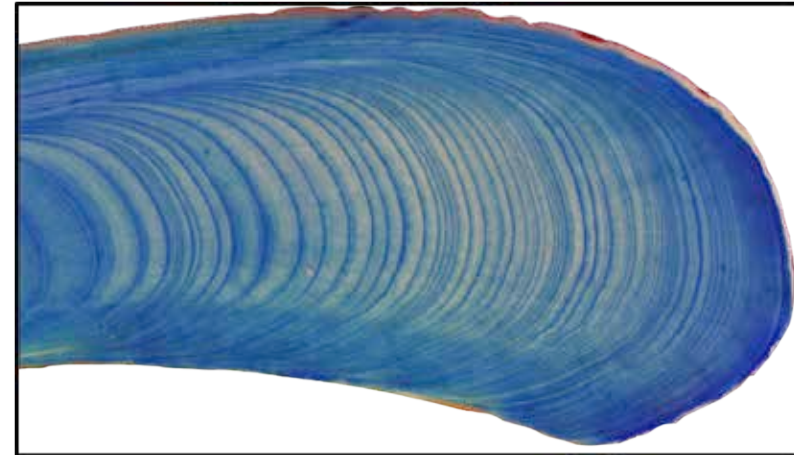


Conclusions

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