



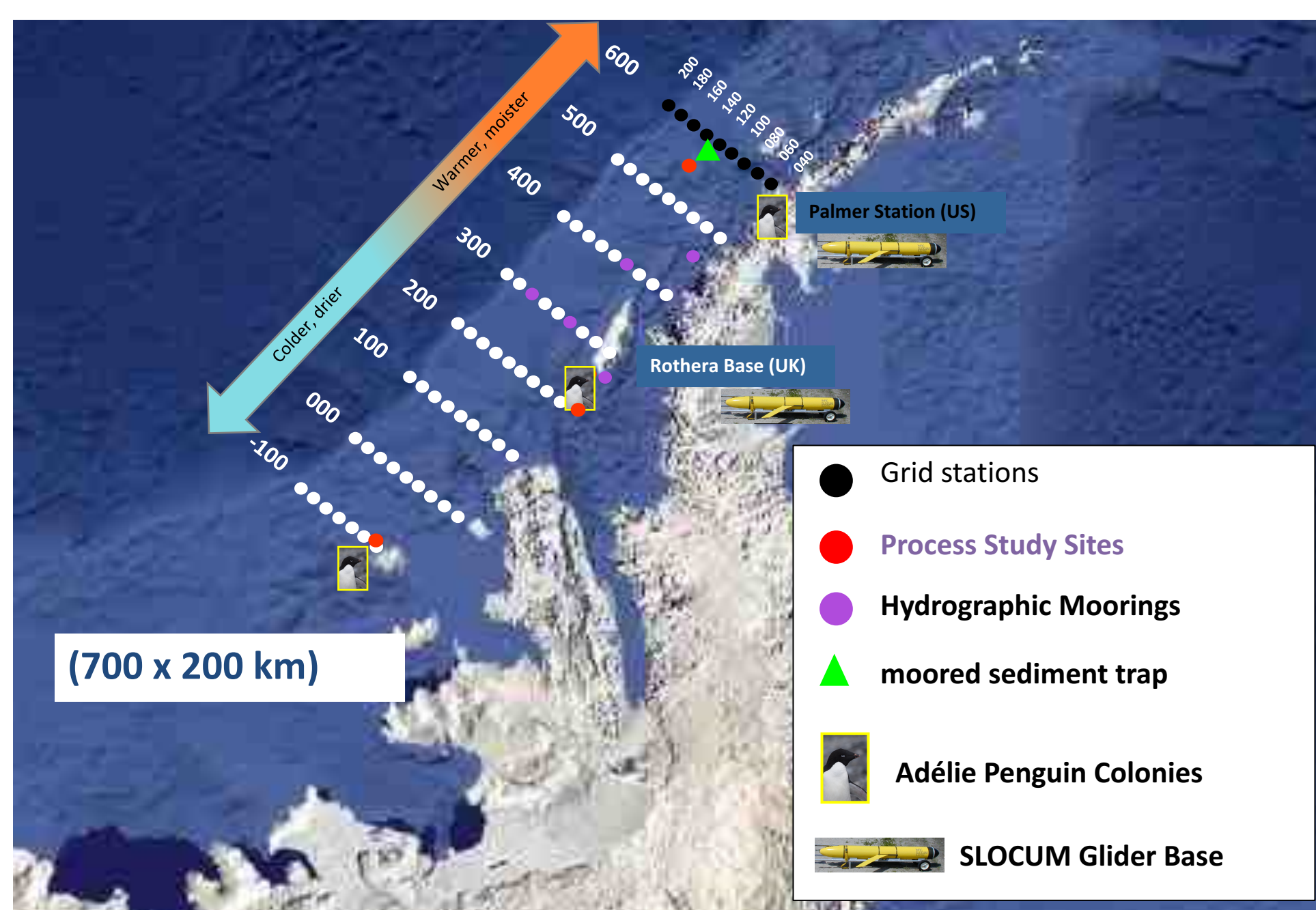
# How does shrinking sea-ice affect ecosystems along the Western Antarctic Peninsula?

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& Palmer Station Antarctica LTER Team (<http://pal.lter.edu>)



## Palmer, Antarctica LTER Program

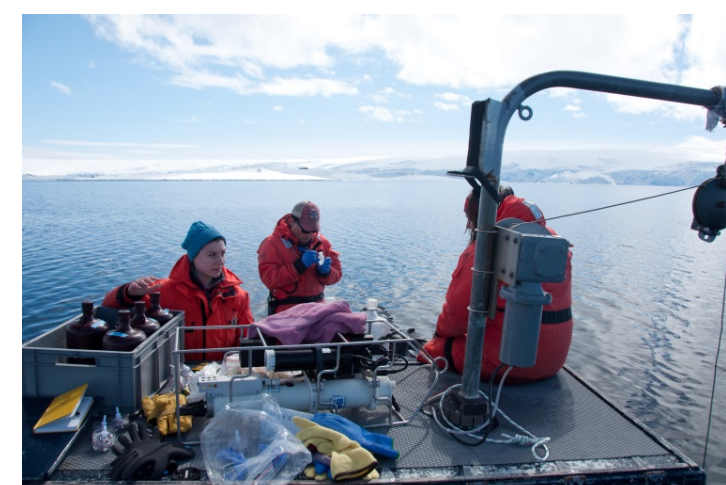
The western continental shelf of the Antarctic Peninsula is experiencing some of the most dramatic climate change on the planet, with rapid ocean-atmosphere warming, melting of coastal glaciers, reductions in seasonal ice cover, and shifts in phytoplankton distributions. The Palmer LTER program has collected more than two decades of physical, chemical & biological data on this critical and sensitive polar ecosystem.



Annual ship-based survey of regional grid along Peninsula



Weekly time series at coastal sites near Palmer Station of water column...



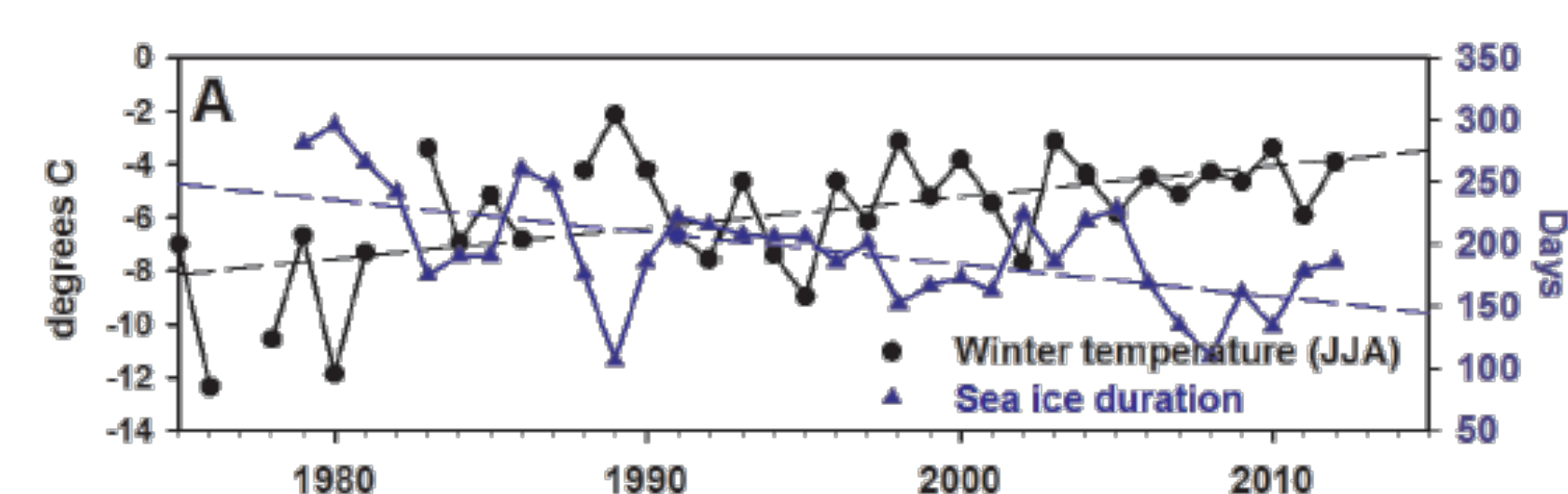
...& seabird colonies



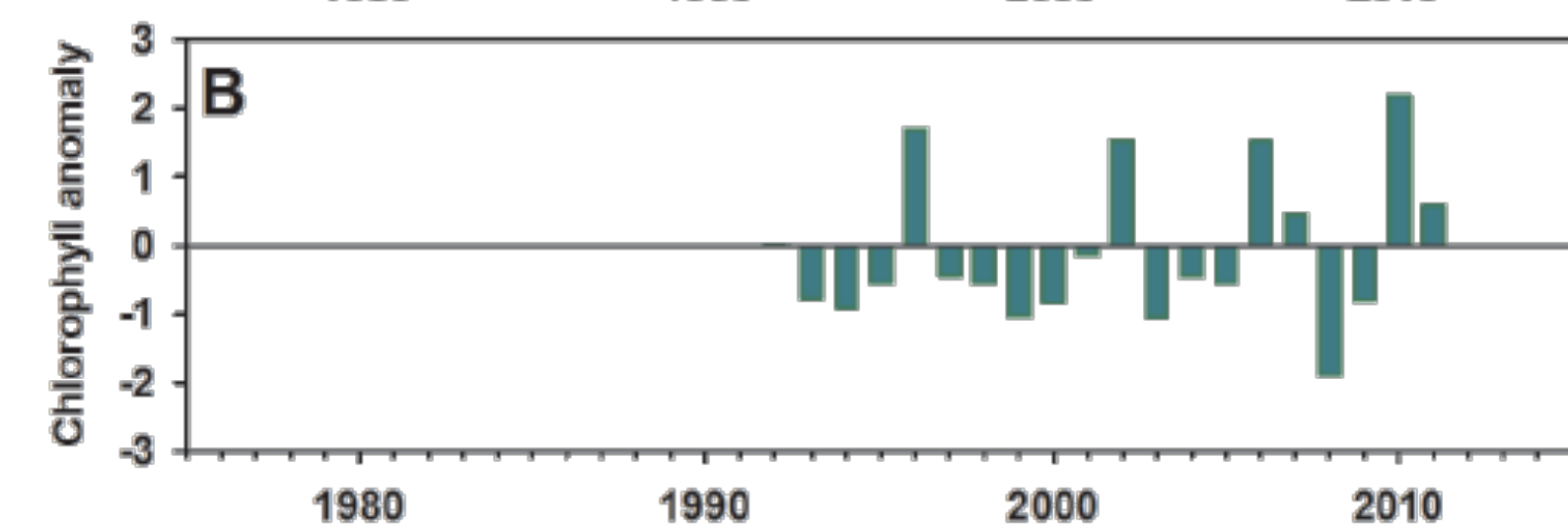
## Trends in Climate & Ecological Indicators

Two decades of data (2001–2015) show strong trends in some indicators and large interannual variability in sea-ice and plankton dynamics.

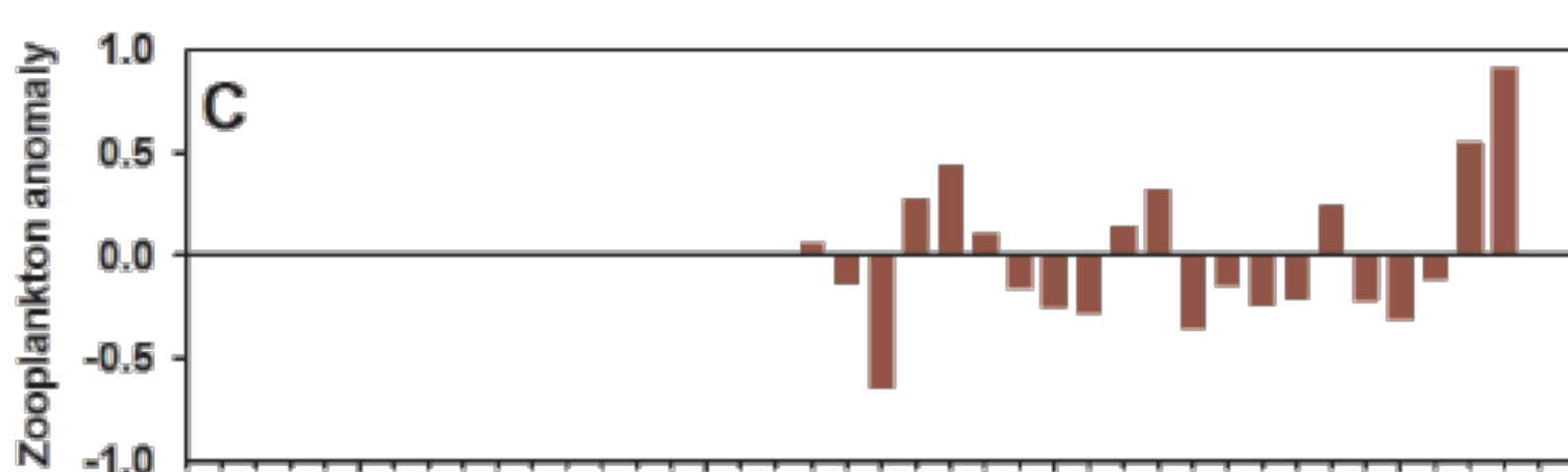
- Winter surface warming
- Shorter sea-ice duration



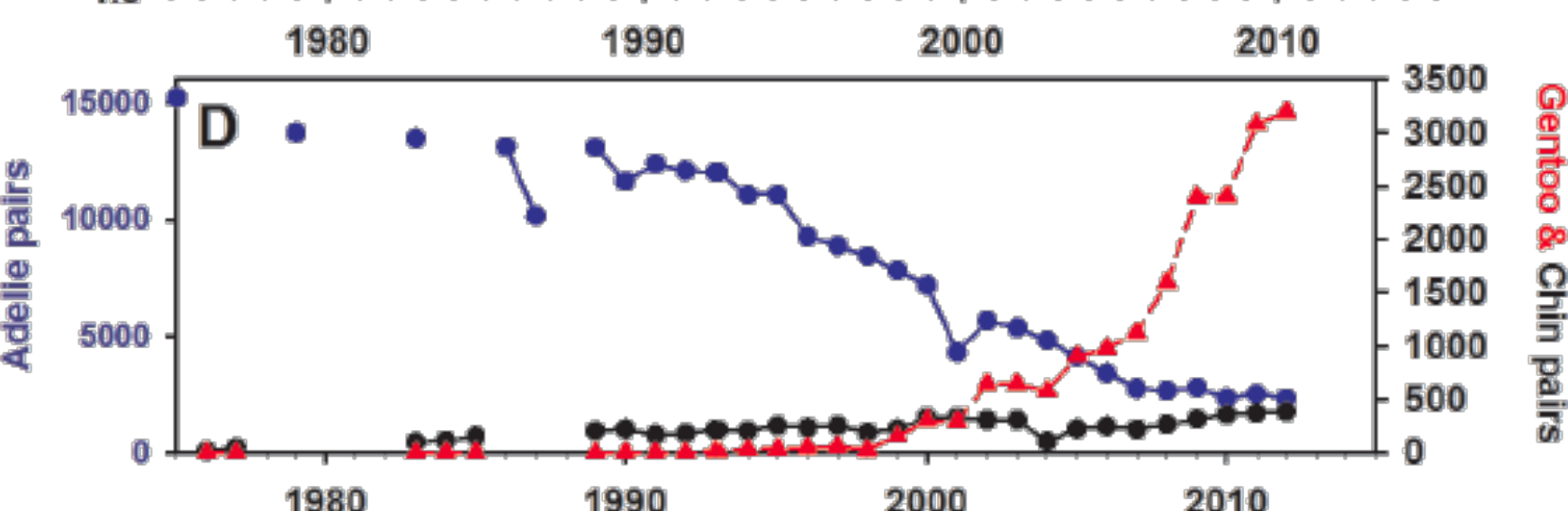
- Phytoplankton blooms every 3-5 years



- Zooplankton lag phytoplankton blooms

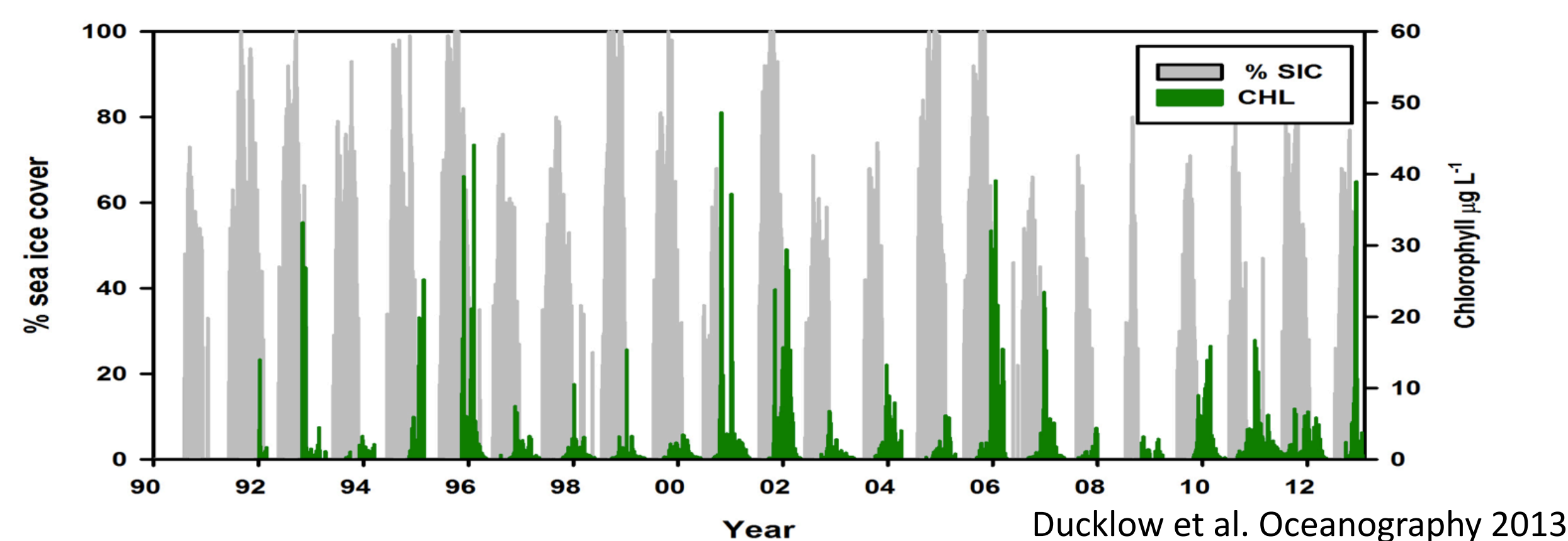


- Reduced penguin abundance & shift in species



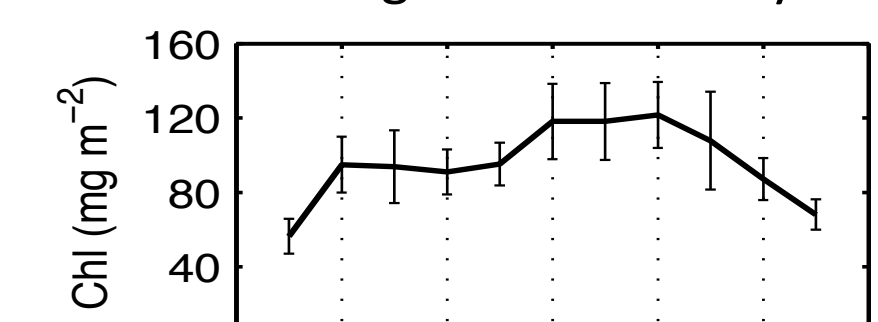
## Sea-Ice Modulates Phytoplankton Blooms & Biogeochemistry

Seasonally ice-covered coastal waters are highly productive, exhibit large spring and summer drawdowns of nutrients and carbon dioxide, and support high densities of upper trophic level organisms.

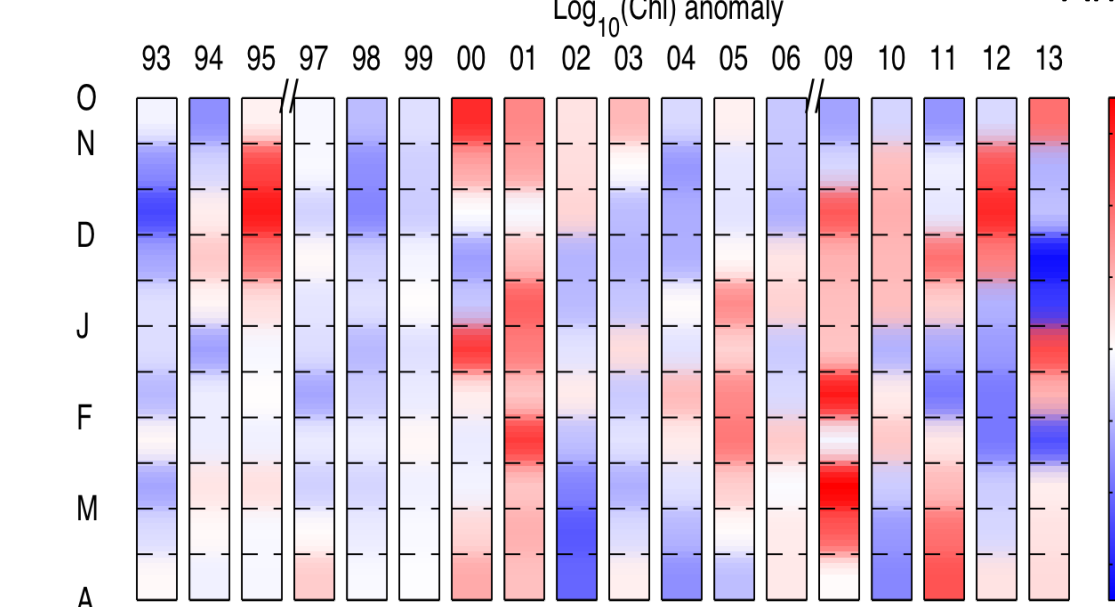


Interannual variations in seasonal bloom phenology & magnitude linked to sea-ice cover & climate modes including Southern Annual Mode (SAM) and El Niño/La Niña. At Palmer station, spring sea-ice melt stabilizes the upper ocean and fosters phyto-plankton growth resulting in spring (1995 & 2012) or summer (2001 & 2009) blooms.

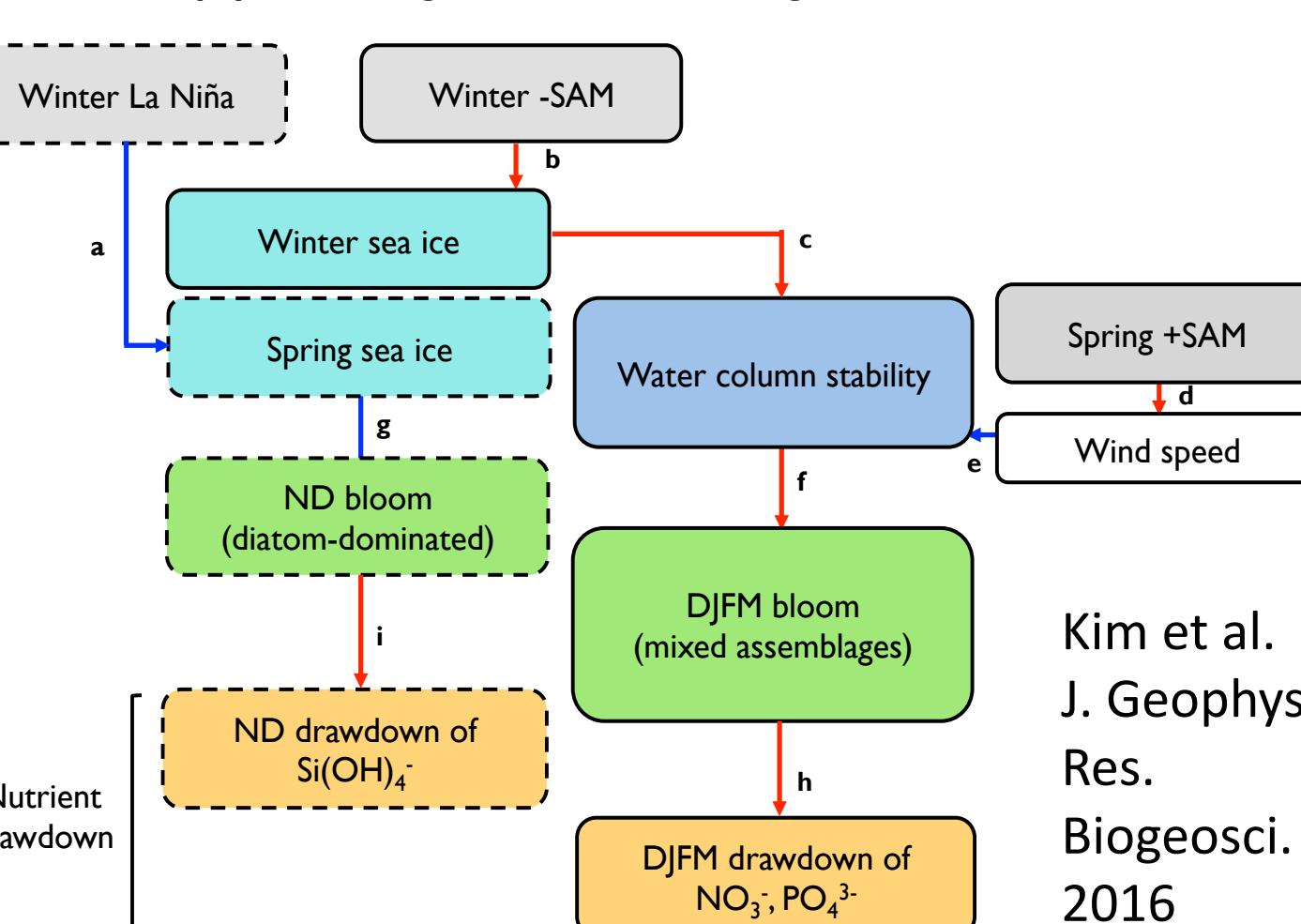
Climatological Seasonal Cycle



Interannual Chlorophyll Anomalies

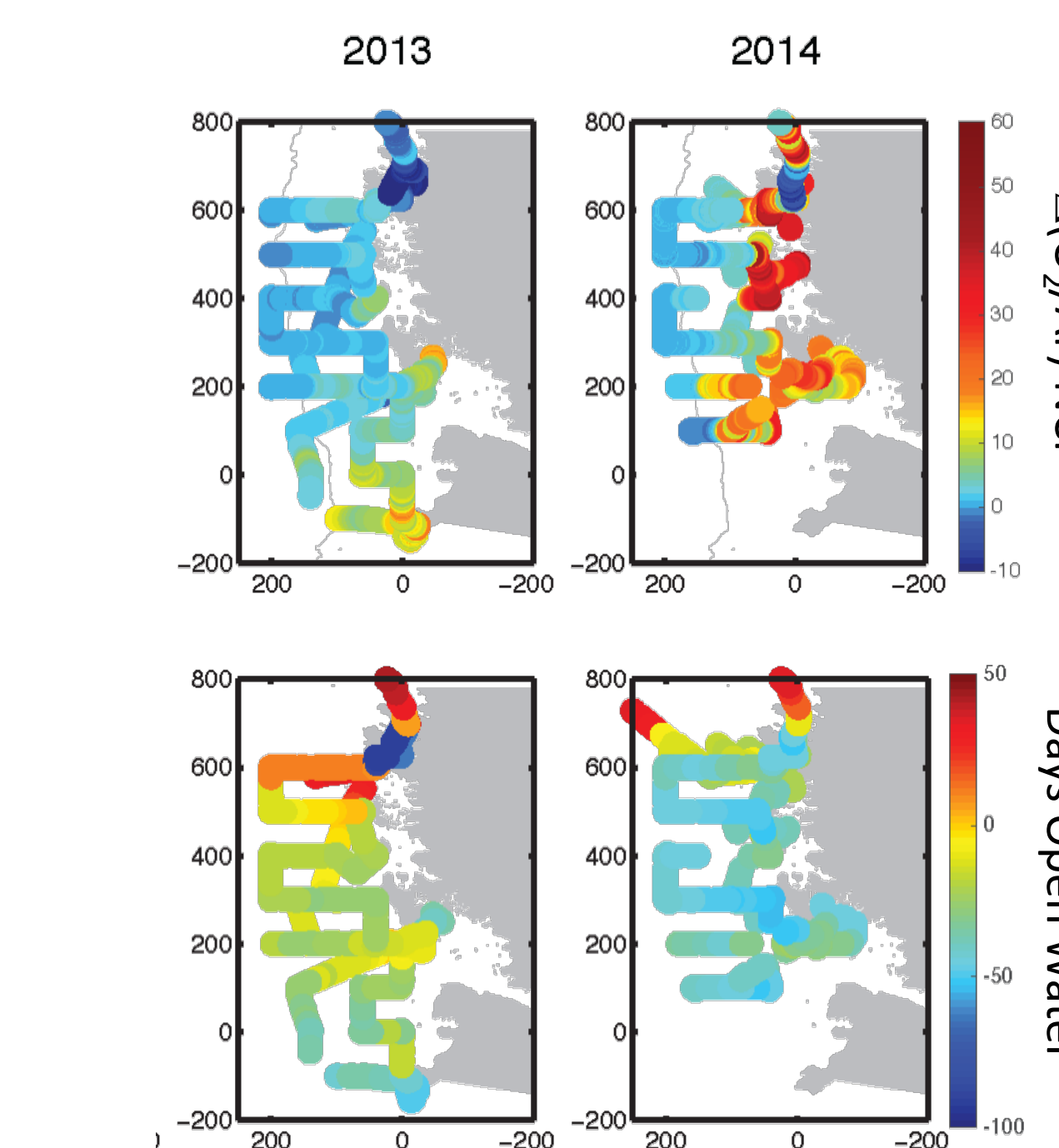
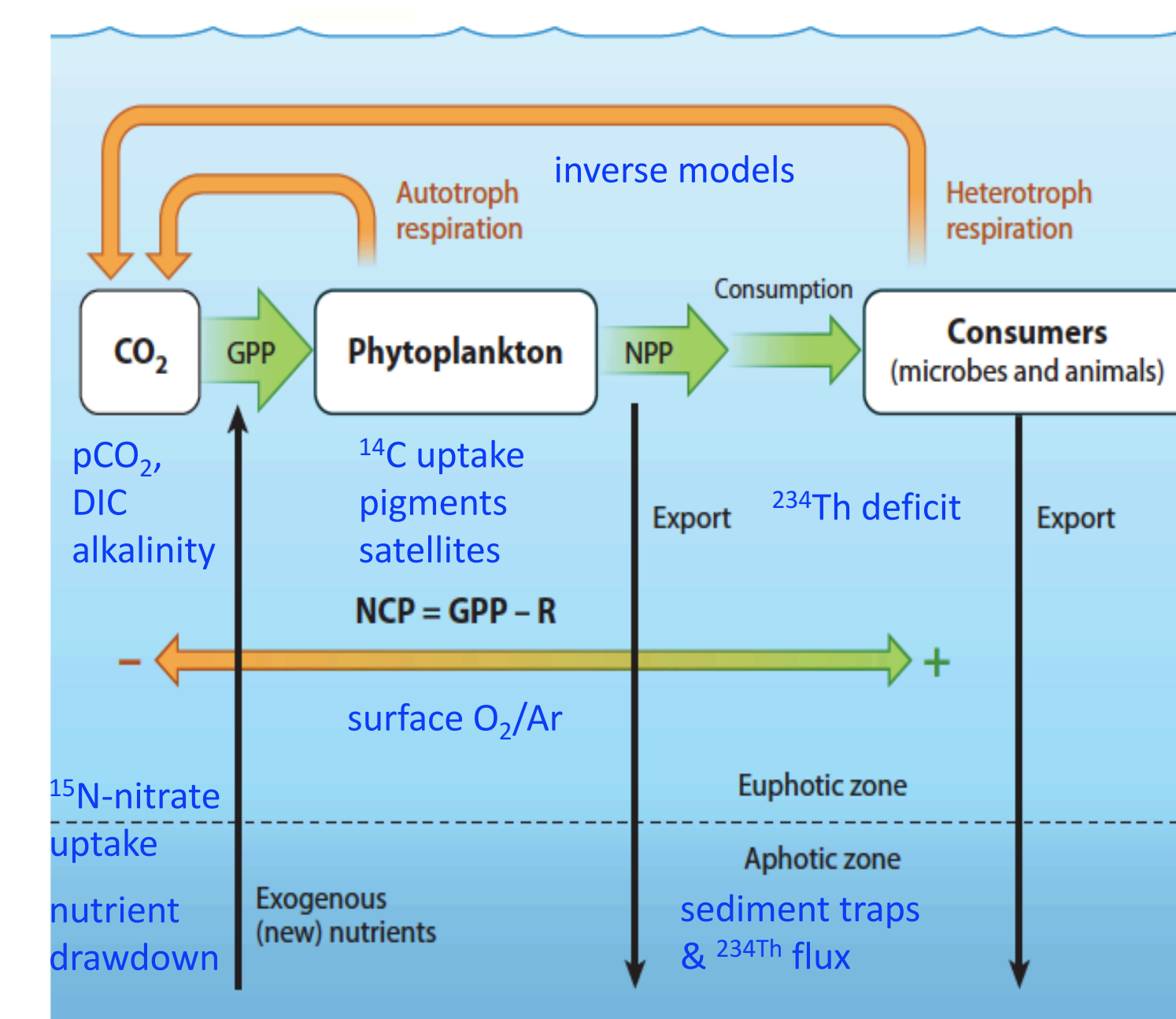


Climate/physical forcing mechanisms for biological nutrient drawdown



Kim et al. J. Geophys. Res. Biogeosci. 2016

Biogeochemical tracers provide valuable constraints on spatial patterns and year to year variations of different metrics of biological productivity. Strong net community production (NCP) and nutrient & carbon drawdown occur near the coast where micronutrients like iron are elevated.

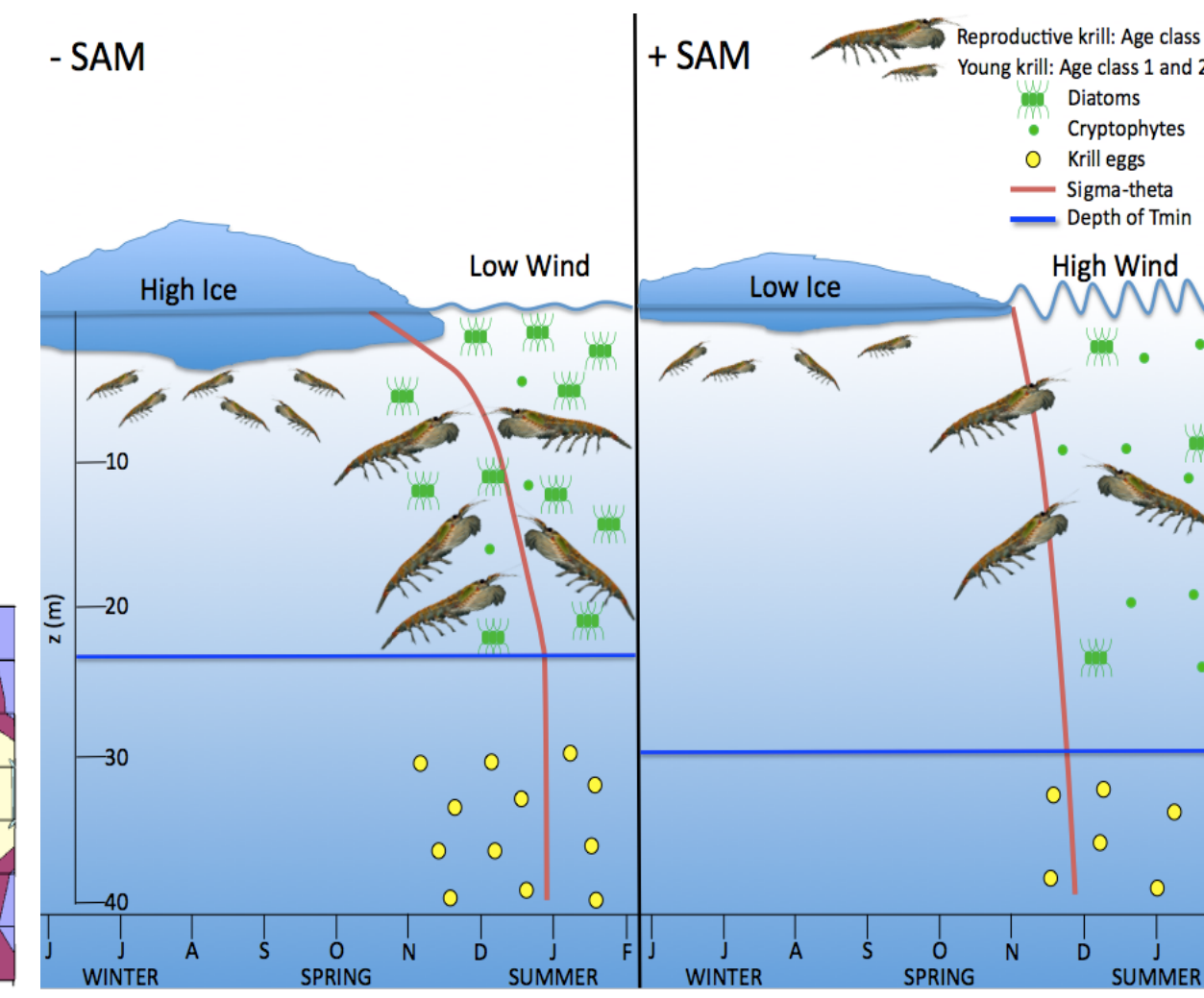
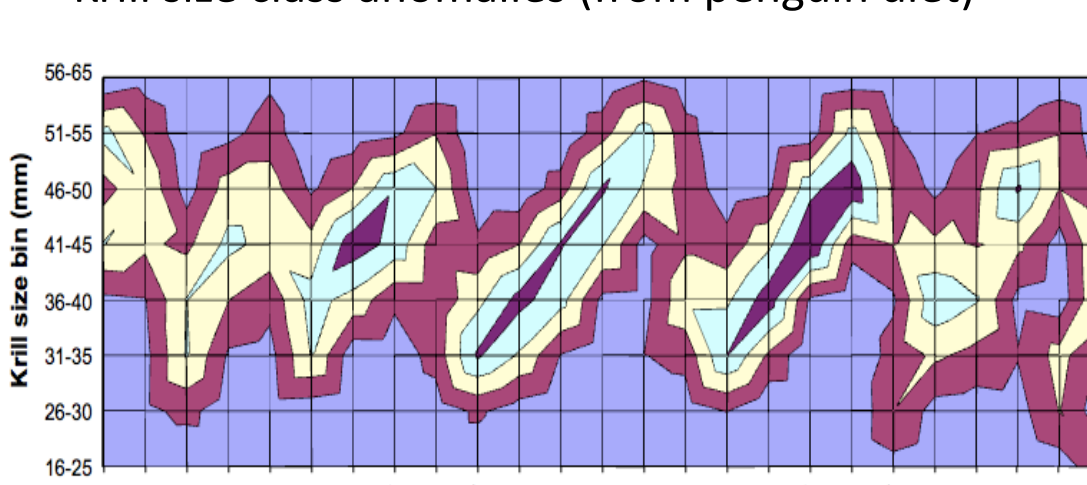


R. Eveleth, N. Cassar et al., Deep-Sea Res. II 2017

## Higher Trophic Levels & Ecosystem

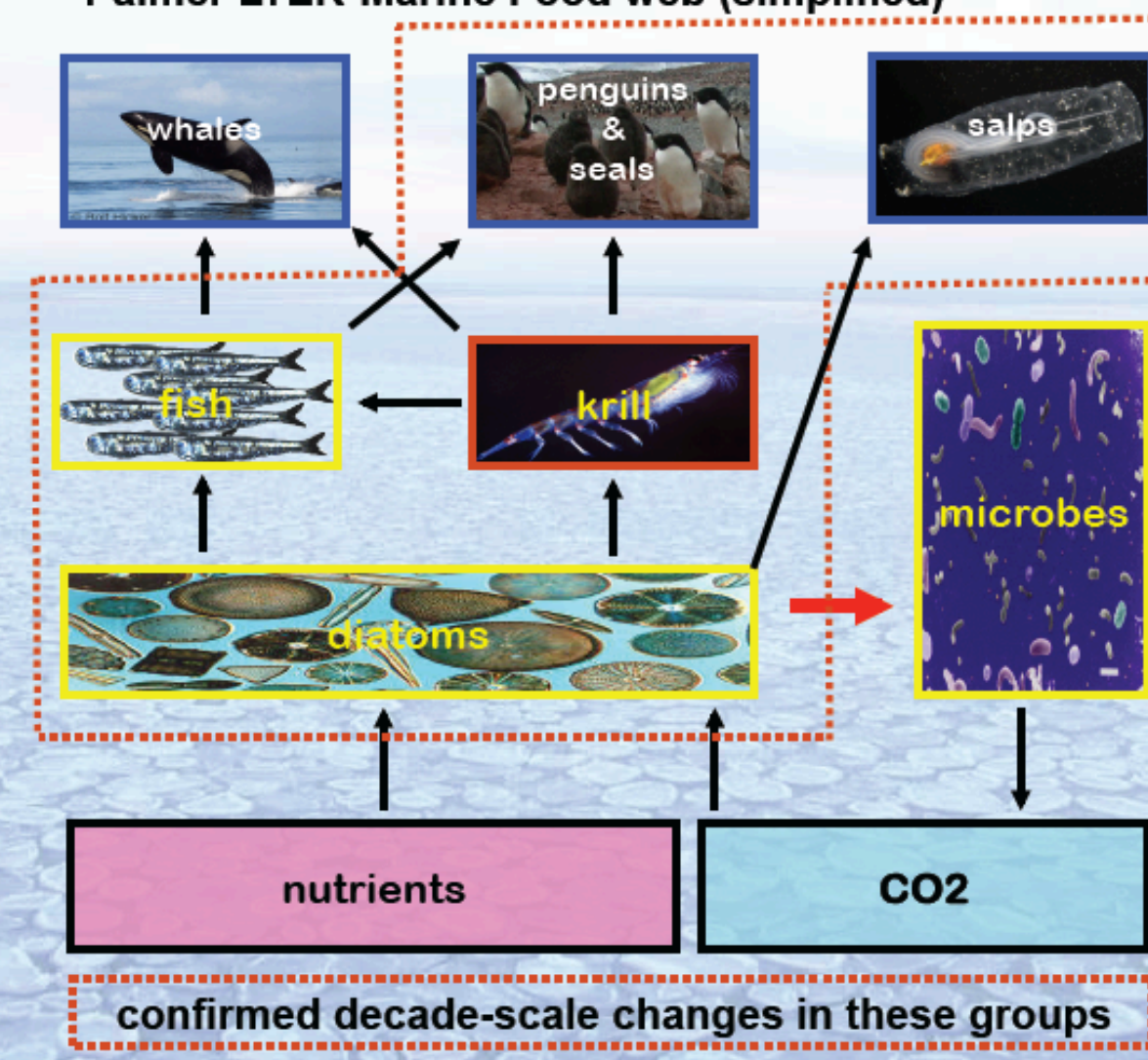
Strong krill recruitment occurs after high-ice years with large bloom events associated with negative Southern Annular Mode (SAM) conditions.

Krill size class anomalies (from penguin diet)



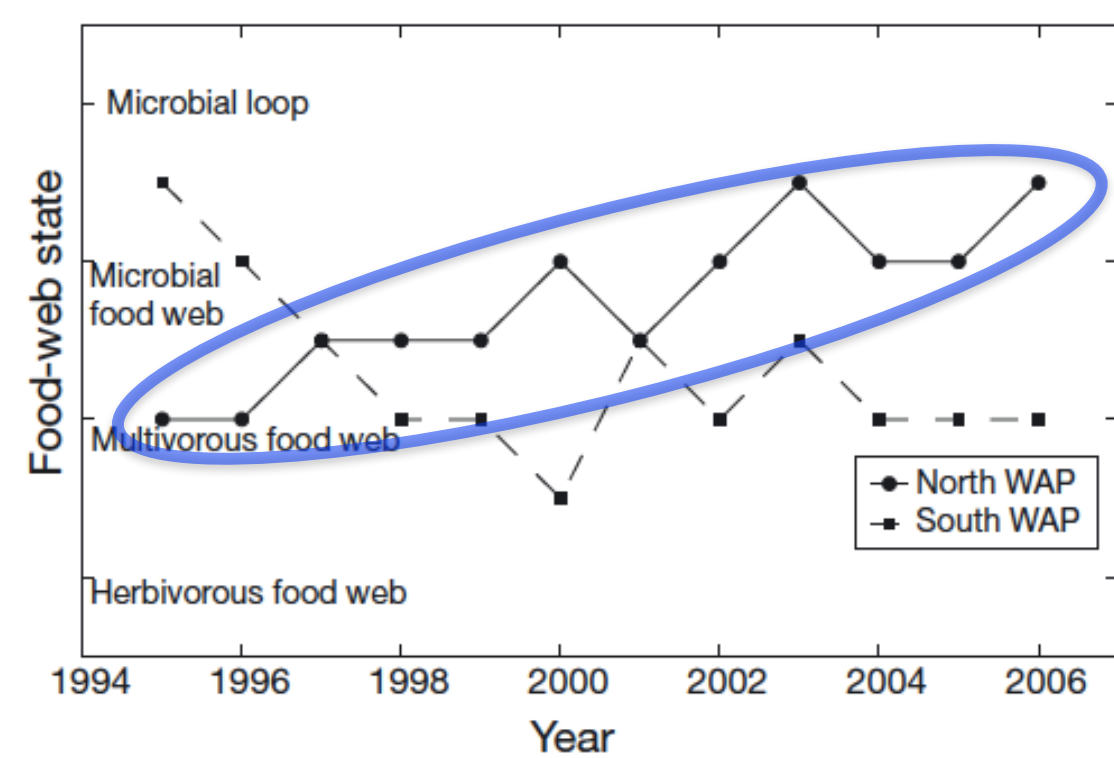
Saba et al. Nature Communications 2014

Palmer LTER Marine Food web (simplified)



Ducklow et al. Adv. Polar Sci. 2015  
Sailley et al. Mar. Ecol. Prog. Ser. 2013

Food-web changing with time away from a simple system of large diatoms & krill towards a more complex microbial food-web.



## Conceptual model of poleward climate shift

As the peninsula warms, the northern region becomes more subpolar with time while polar conditions remain, for now, in the south.

