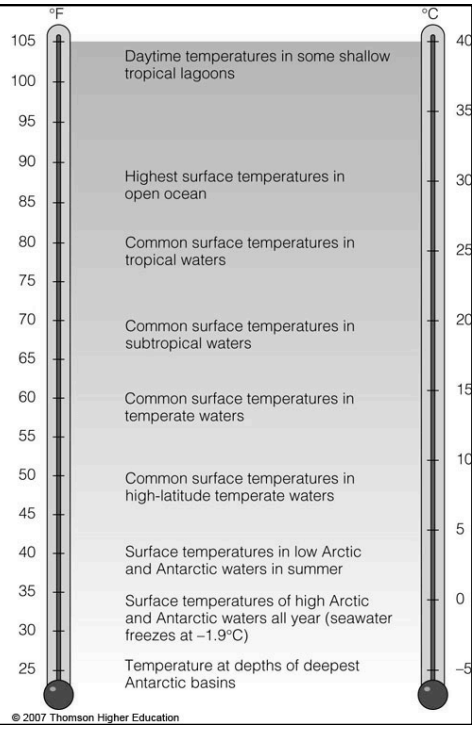
9. Habitats: High Latitude Ecosystems

- High Latitude Environments
- Seasonal Processes
  - Sea ice
  - Food Fall
  - Reproduction
- Bentho-pelagic coupling
- Food Weds
- Climate Change Effects

Dr Rhian G. Waller
26th April 2010
Reading:

High Latitude Environment

- Arctic
  - Shelf ~ 200m deep
  - Completely ice-covered in winter
- Antarctic
  - Shelf ~500m deep
  - Localized areas sea ice-covered
  - Contains 70% of worlds fresh water
- Colder Water
  - ~7°C – -1°C
  - Nutrient rich



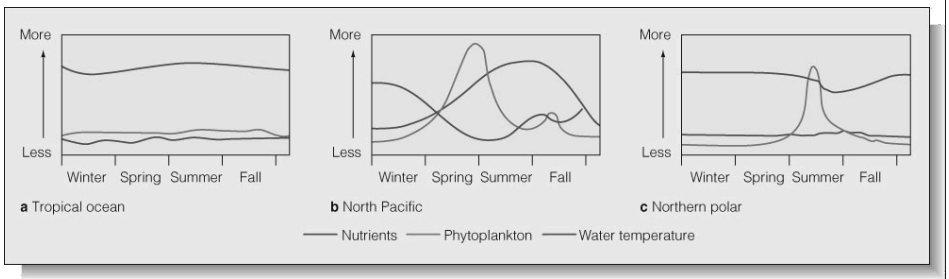
Cooler water = Higher Gases

Table 13.3 The Solubility of Gases in Seawater Decreases as Temperature Rises

	Solubility (ml/l at atmospheric pressure and salinity of 33‰)[a]		
Temperature	N_2	O_2	CO_2
0°C (32°F)	14.47	8.14	8,700.0
10°C (50°F)	11.59	6.42	8,030.0
20°C (68°F)	9.65	5.26	7,350.0
30°C (86°F)	8.26	4.41	6,600.0

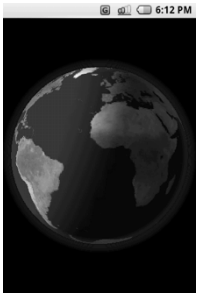
High Latitude Environment

- Seasonal processes more pronounced at poles
- Nutrients, Phytoplankton, Temperature
- Why?



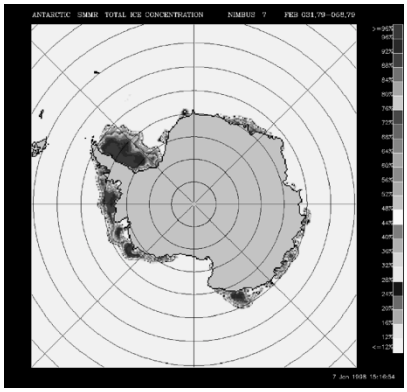
High Latitude Environment

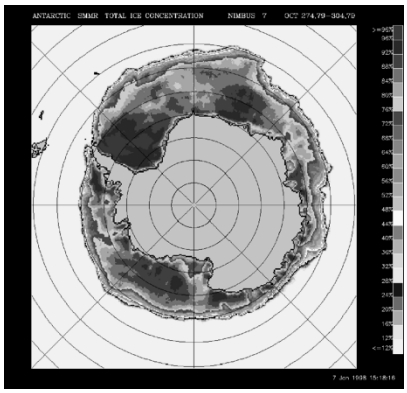
- Time of Day
  - Daily solar cycle leaves ½ earth in darkness at all times
- Season
  - Earths rotation around the sun (at a tilt) changes light availability on a yearly basis



High Latitude Environment

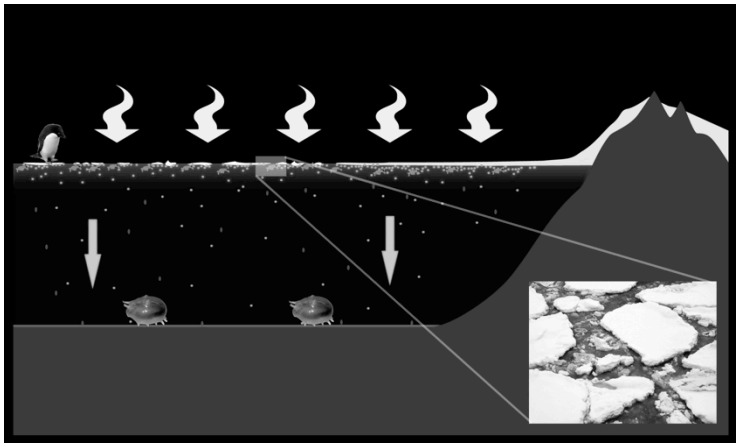
- What does this mean for the benthos?
- Highly seasonal food supply





Oct-Nov (Late Spring)

- Sea-ice cover breaking up; nearing 24 hr daylight
- Ice-algae released by melting ice
- Melt water-induced stratification of the water column begins

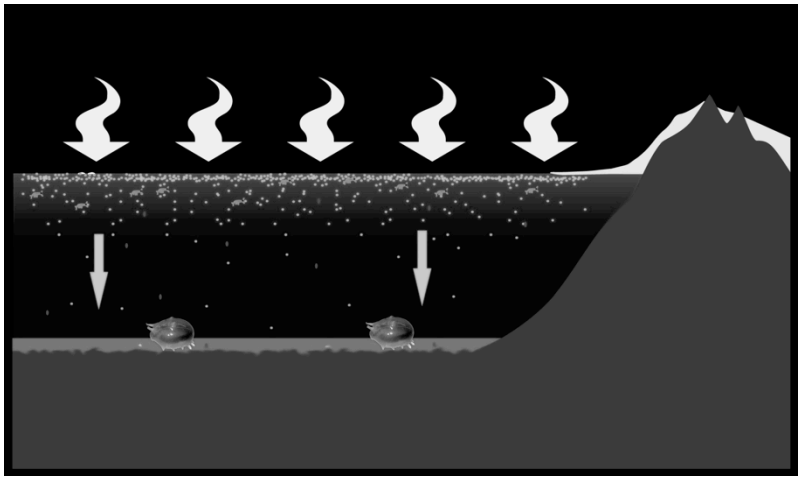


Jan-March (Austral Summer)

Antarctica

-Sea-ice cover receded

-Phytoplankton bloom fully developed; sedimentation of organic material can produce thick phytodetrital carpet

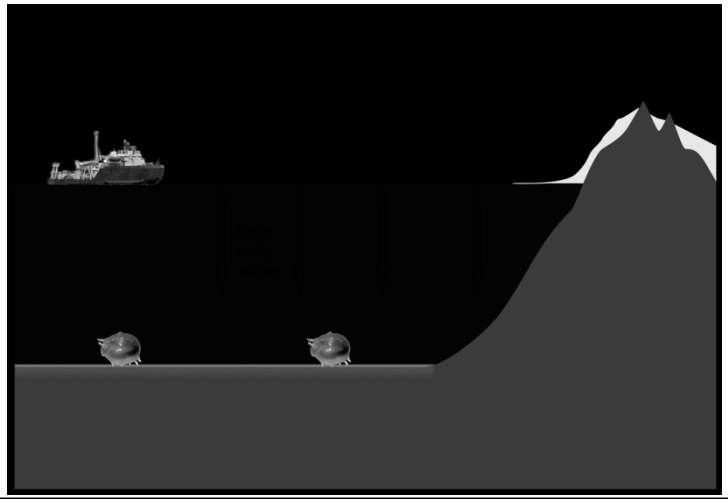


Antarctica

May-July (Late Fall-Winter)

-Nearly 24 hr darkness, sea-ice forms

-Very low phytoplankton biomass

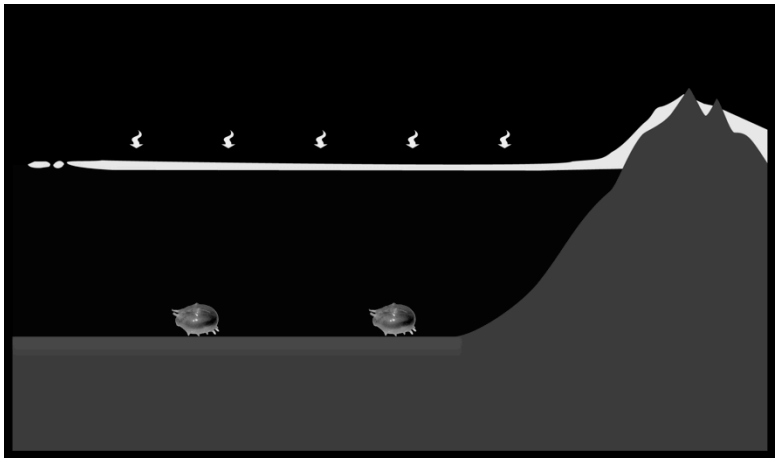


Antarctica

Aug-Sept (Late Winter - Early Spring)

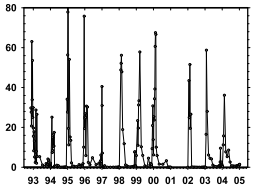
-Period of maximum sea-ice coverage, short but lengthening daylight hours

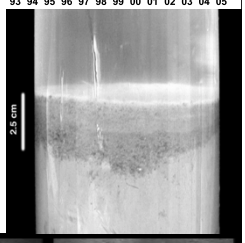
-Relatively austere water column



Highly Seasonal Food Fall

- Palmer LTER region (150m)
  - Ducklow et al., 2006
- Intense summer pulses of POC to shelf floor
- Feeds the benthos
  - Ecological processes center around this energy pulse





Highly Seasonal Food Fall

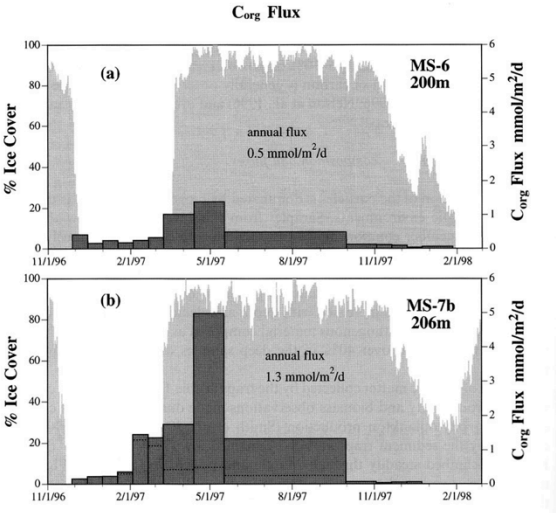


Fig. 3. Time series of organic carbon fluxes (C_{org}, mmol m^{-2} d^{-1}) to the upper traps at MS-6 (a) and MS-7 (b). Ice coverages from Fig. 2 are shown for reference. The annual fluxes were averaged over a single "season", not the full deployment, beginning with the first cup (November 28, 1996) through cup 11 (November 20, 1997). The dotted lines on the fluxes for MS-7b (b) represent the estimated organic carbon flux after removing a component potentially associated with pteropods (see discussion in text).

- Flux not always tightly coupled
- Time Lags
  - Complex bloom/ current structure
  - Wind vs melting induced sea-ice removal
  - Development times of grazers

Collier et al., 2000

Highly Seasonal Food Fall

- Would expect feeding to stop during winter ice
  - Many species do stop for <2-3 months
  - Not always true!
- **Suspension Feeders**
  - If feed on large phytoplankton – seasonal
  - Most feed on regenerated or resuspended material
- **Deposit Feeders**
  - Few studies
  - Most highly seasonal feeders
    - Brockington et al., 2001 – *Sterechinus*

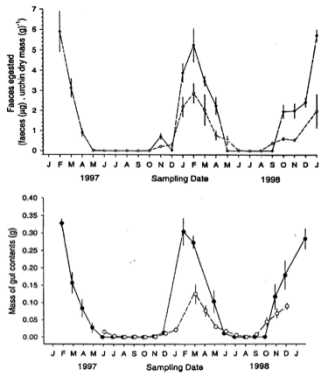


Fig. 4A, B *Sterechinus neumayeri*. A Seasonal variation in feeding (as measured by faecal egestion) from both North (●) and South Cove (○) at Rothera Point. Each point represents a mean of four

Highly Seasonal Food Fall

- **Reproduction and Development**
  - (Usually) closely tied to energy availability
- Most polar macrofauna have brooded or lecithotrophic development
- Spawning and recruitment often occur in winter months!
- Life histories often surprisingly weakly coupled to summer blooms

TABLE 2. Mode of larval development in echinoderms from two polar and one temperate location. Table compiled from data in *Pearse* [1994], incorporating original data from *Thorson* [1936]. Data are number of species at that location utilizing a given mode of larval development, with percentage of total species in parentheses.

	Number of species reproducing by		
Site	Pelagic feeding larva	Pelagic non-feeding larva	Protected development
TEMPERATE			
Monterey Bay, CA	18 (50%)	8 (22%)	10 (28%)
POLAR			
N.E. Greenland	4 (17%)	16 (70%)	3 (13%)
McMurdo Sound	5 (23%)	11 (50%)	6 (27%)

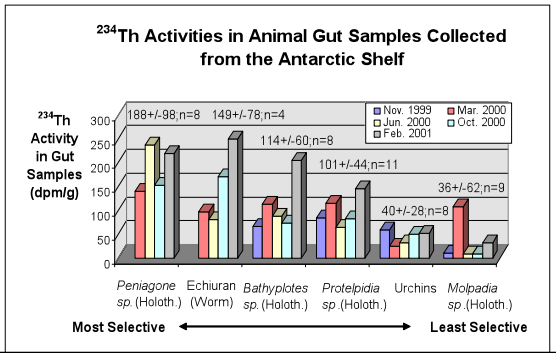
Clark, 1996

Highly Seasonal Food Fall

- **So…..**
  - In winter there is little food
  - In summer there are intense food blooms
- **Yet……**
  - Feeding occurs year-round
  - Reproduction occurs year-round
  - Recruitment occurs year-round
- **How??**

"Food Bank" Hypothesis

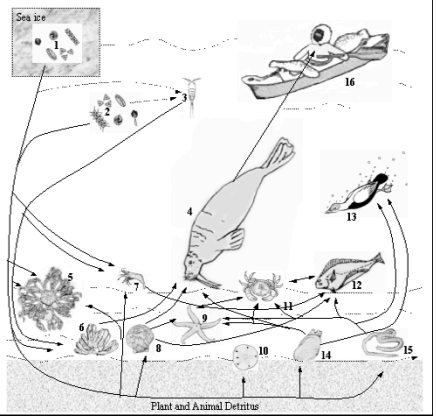
- Large amounts of summer bloom detritus rapidly deposited on WAP shelf
- Slow decomposition (cold temperatures!)
- The detritus forms a "food bank" for benthic detritivores during lean winter months



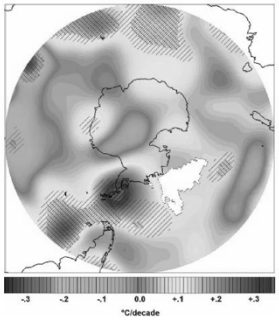
Smith & DeMaster, 2008

Food Webs

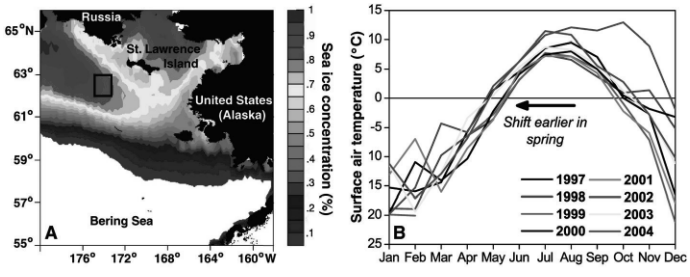
- Short food chains
  - Based around seasonal food fluxes
- Benthic ecosystem important for higher organisms
  - Arctic
    - Walrus
  - Antarctic
    - Seals



Climate Change Effects



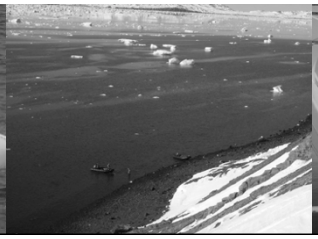
- High Latitudes
- Warming faster than many areas in globe
  - The WAP in particular!



Grebmeier et al., 2006

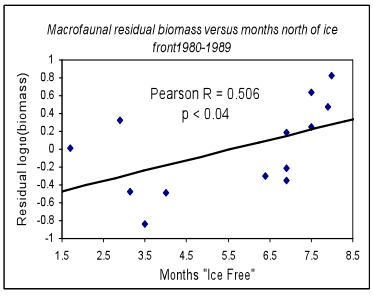
Climate Change Effects

- Climate Changes
  - Faster/larger at the poles than anywhere else
  - Will it effect the benthos?
- Warming
  - Reduce annual sea ice accumulation & duration
  - Alter quantity and quality of food flux to seafloor
  - Likely to fundamentally change seafloor ecosystem structure and function


Climate Change Effects

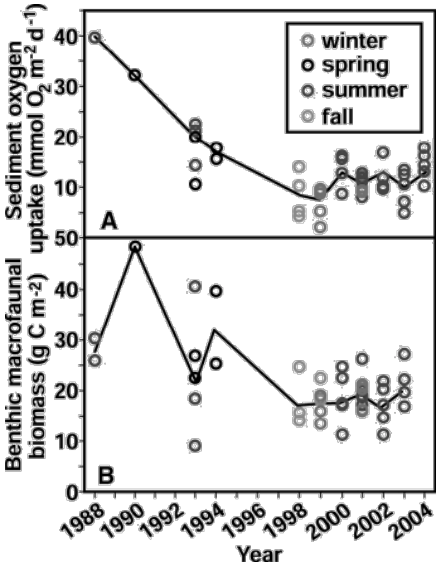
- Duration of sea ice is correlated with shelf macrofaunal biomass
- Shift to more seasonal suspension feeders (?)
- Stronger summer peaks in recruitment (?)
- Decrease in importance of benthic prey to larger predators
  - Pelagic seas remain highly productive year-round



Smith et al., 2006

Climate Change Effects

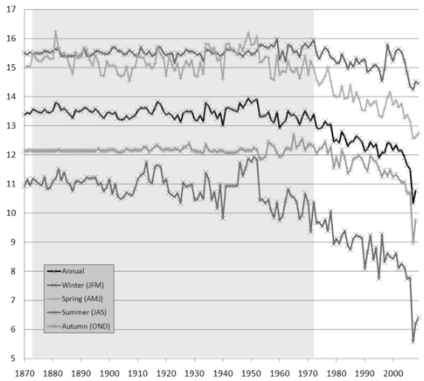
- **Arctic**
- Sediment O_2 uptake
  - Indicator of C supply to benthos
- Macrofaunal Biomass
- Both are rapidly decreasing



Grebmeier et al., 2006

Climate Change Effects

- Arctic
  - Shrinking (35 miles in last 30 years)
  - 2100 no sea ice
- Antarctic
  - Is primarily cooling!
  - Western Antarctic Peninsula
    - Temperature risen 2.5C in last 50 years



Conclusions

- High latitude ecosystems are highly seasonal
- Many of the organisms in these ecosystems are highly adapted to use seasonal resources year-round
- Food webs are short, benthic biomass is important to larger marine predators
- Global warming effects more than just sea ice, polar bears and penguins, it will change the whole ecosystem from the bottom up