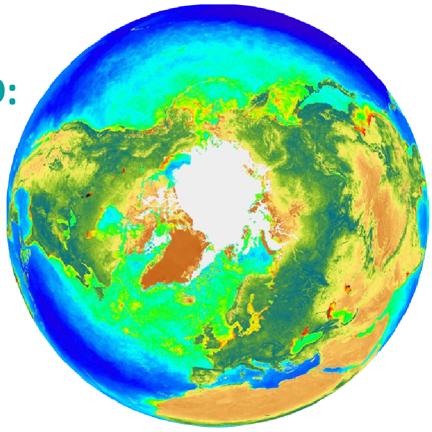
Providing spatial and temporal context to DIAPOD: What can we learn from satellites?



Dr Anna Belcher

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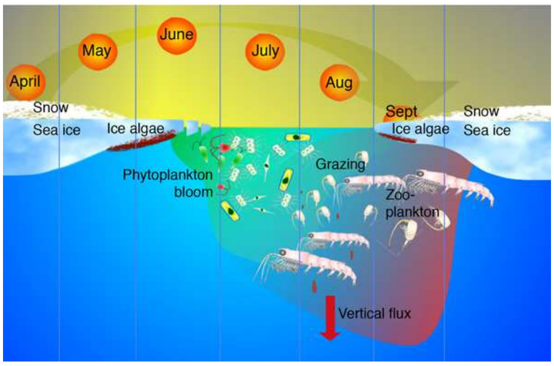
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
NERC DIAPOD
Changing Arctic Ocean NERC

Arctic Phytoplankton

- Phytoplankton fuel Arctic ecosystems
  - Fix inorganic carbon to organic carbon via photosynthesis



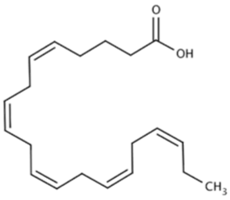
From: http://www.arcticsystem.no/

British Antarctic Survey NERC DIAPOD

Arctic Phytoplankton

- Phytoplankton are also key for the synthesis of fatty acids (FA)
  - Required by all organisms –synthesised by phytoplankton
- *Calanus* convert into storage lipids
  - Support diapause in zooplankton
- Not all phytoplankton created equal
  - Different FA structures
  - Different levels of saturation
  - Used as biomarkers for classes

Calanus lipid stores. From Pond & Tarling (2011)

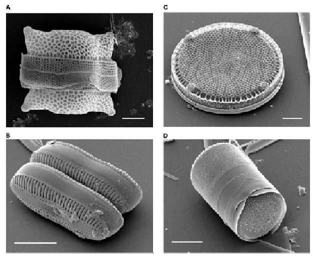


Diatoms: 16:1(n-7), 16:4(n-1), 16:4(n-3), 20:5(n-3)

Flagellates: 18:0, 18:1(n-9), 18:2(n-6), 22:6(n-3)

Arctic Phytoplankton

- Use fatty acids to identify food source and assess food availability
- Diatoms major source of long-chained energy rich fatty acids
  - Dominate *Calanus* lipid stores
    - EPA: 20:5 (n-3), and 16:1 (n-7)
- Flagellates such as *Phaeocystis* can also be important

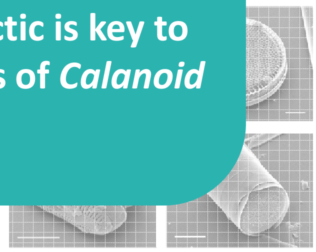


Scanning electron micrographs of diatoms.
Scale bar = 10 µm. From Bradbury (2004)

Arctic Phytoplankton

- Use fatty acids to identify food source and assess food availability
- Diatoms r
  - Do
- Flagell

Knowledge of phytoplankton community structure and biogeography of the Arctic is key to understanding of success of *Calanoid* copepods

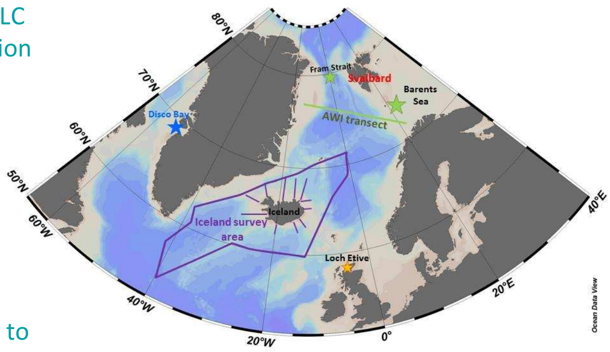


Scanning electron micrographs of diatoms. Scale bar = 10 µm. From Bradbury (2004)

INTRODUCTION Slide 4 of 17 British Antarctic Survey NERC DIAPOD

DIAPOD

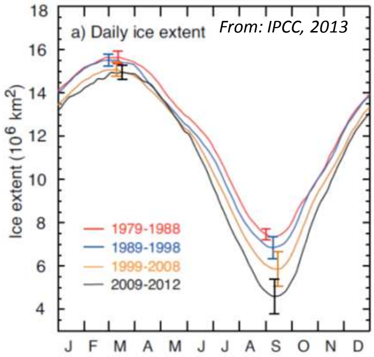
- DIAPOD – cruises in Artic spring and summer/autumn
  - Additional data from other CAO cruises
- Information on the phytoplankton community
  - Total chlorophyll – HPLC
  - Community composition
    - Lugol's
    - Pigments
  - Fatty acid content
- Identify regions high in diatoms, rich in fatty acids to support copepod community



DIAPOD Slide 5 of 17 British Antarctic Survey NERC DIAPOD

Changing Arctic

- But the Arctic is changing…
  - Possible increased production due to longer growing season (Arrigo et al. 2008)
  - But, also increased riverine input – increased stratification – depletion of surface nutrients (Tremblay & Gagnon 2009)
  - Changes in both community structure and timing of bloom



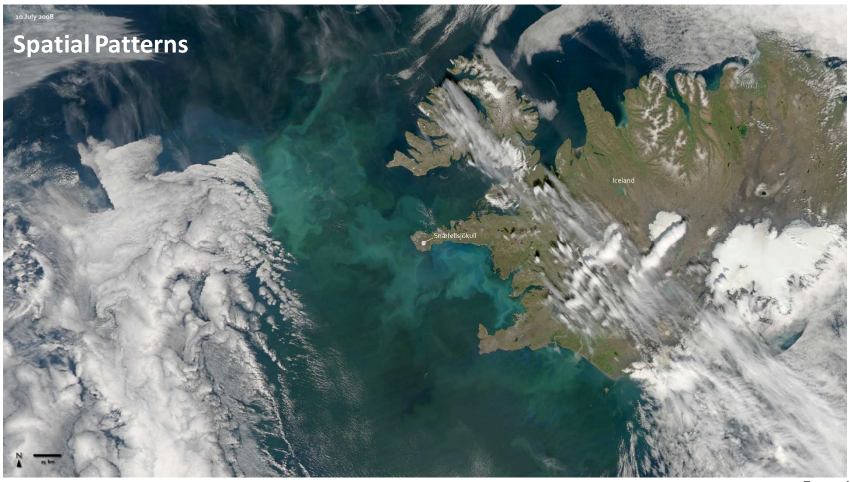
- Useful to understand phytoplankton composition and fatty acid supply on a more Arctic basin scale
- Do we see regional/temporal differences in quality of food supply – driven by phytoplankton community composition?

Remote Sensing

From NASA

Remote Sensing

- Ocean colour satellites such as SEAWIFS, MODIS and SENTINEL



From NASA

Remote Sensing

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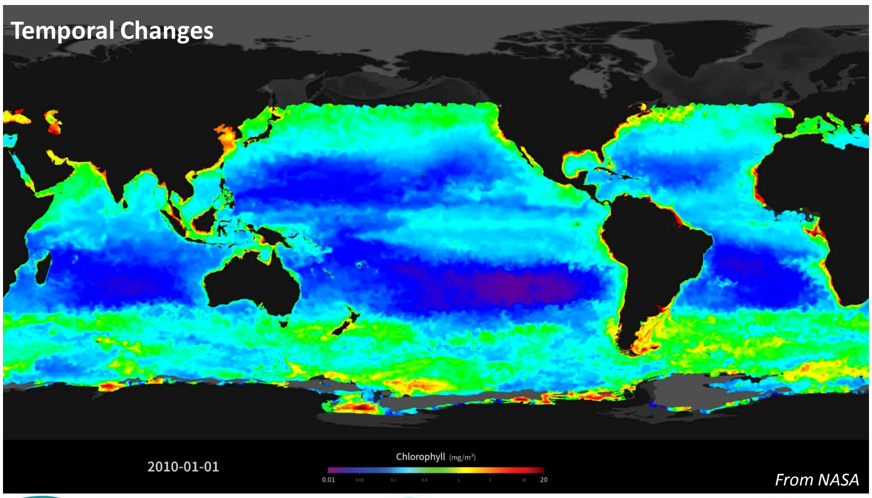
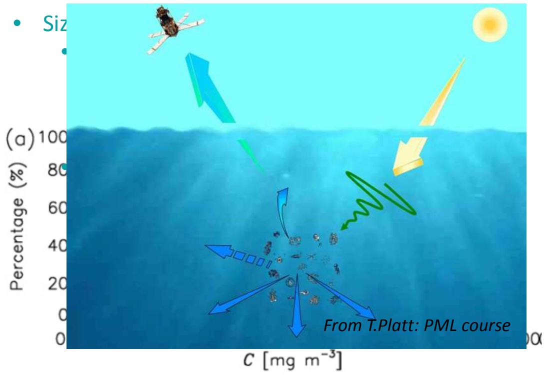


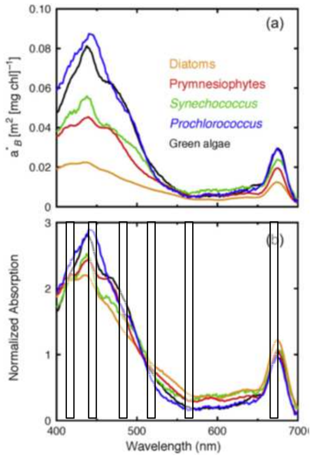
From NASA

Remote Sensing

- Ocean colour satellites look at reflectance
  - A lot of information in the spectra if we are intelligent enough to decipher it
- Siz



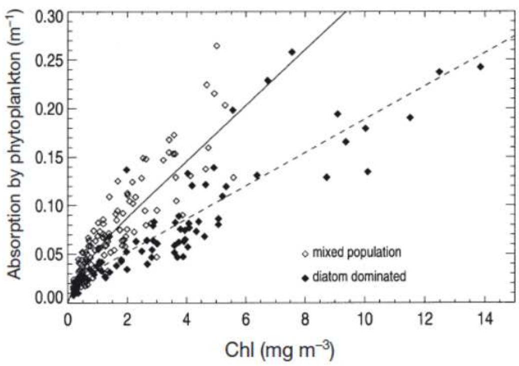
From Brewin et al. 2010



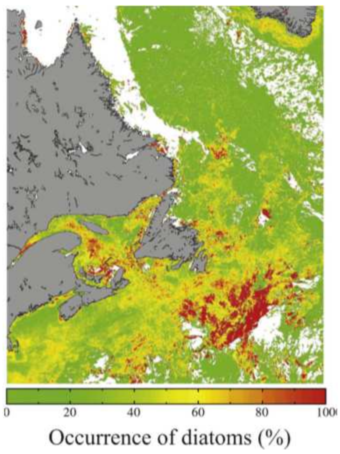
From Sathyendranath and Platt (2007)

Diatom chlorophyll

- Despite some uncertainties/limitations satellites have been used to estimate the chlorophyll associated with diatoms (Sathyendranath et al 2004)



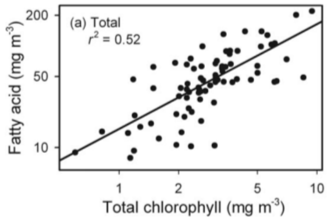
Absorption at 443nm. From Sathyendranath et al 2004



From Nair et al 2008

Chl:Fatty Acids

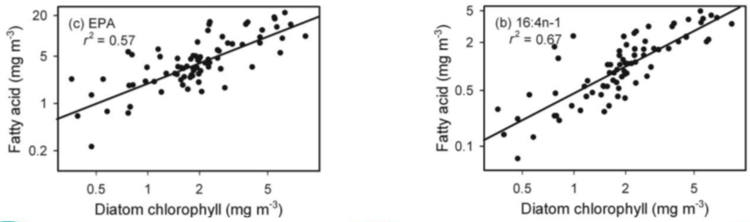
- Work by Budge et al. 2014 took this one stage further
  - Total chlorophyll to total fatty acids



Linear relationships on log transformed data - still quite a lot of variability

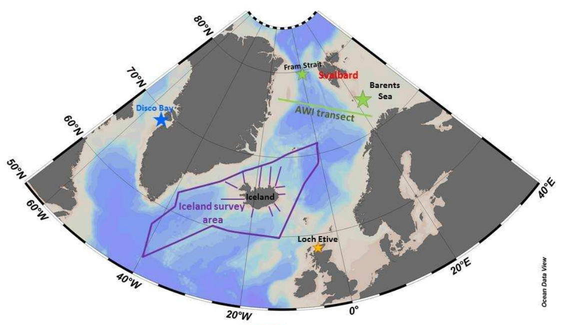
From Budge et al. 2014

- Diatom chlorophyll to specific fatty acids, e.g. EPA



Application to DIAPOD

- Derive relationships between *in situ* data – HPLC chlorophyll and fatty acids
  - Specific to different phytoplankton classes
- Map phytoplankton distribution- satellite based?, or create bioregions from *in situ* data → Fatty acid distribution/quality
- Highlight areas high in energy rich fatty acids such as EPA (diatom marker)

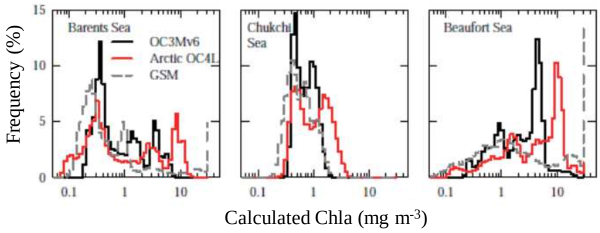


Challenges

- Applicability of relationships (Chl a: fatty acids) to seasons outside field sampling
  - Ratio between fatty acids and phytoplankton carbon/chlorophyll vary
    - Nutrient regime
    - Growth phase
    - Light
- Mismatch between sample size for ground truthing
  - *In situ* samples ~ 0.5 L vs satellite footprint of km^2
- Satellite data availability/accuracy in the Arctic
  - Low sun angles – limits of atmospheric corrections
  - Deep chlorophyll maximums
  - Under ice blooms
  - Cloud/Ice cover
  - Riverine inputs of CDOM – affects reflectances

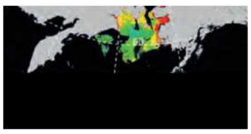
Challenges: Arctic algorithm

- Choice of algorithm for surface chlorophyll can make a difference

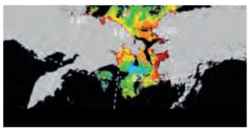


From IOCCG report 2015

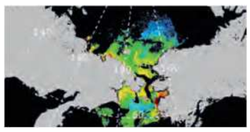
Frequency distribution of surface chl a calculated from standard MODIS OC3Mv6 algorithm, a regional model for the Arctic OC4L, and a semi-analytical model (GSM)



OC3mv6



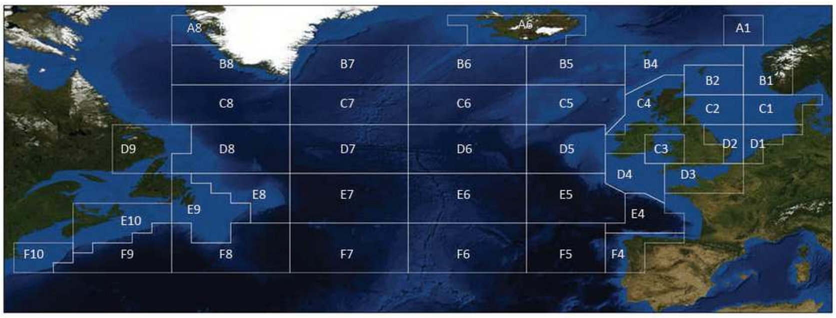
Arctic OC4L



GSM

Validation

- Hopefully *in situ* data validation (CAO cruises) will help increase robustness of relationships and products derived from satellite data
- Continuous plankton recorder (CPR) data
- *In situ* samples from the literature



SAFHOS Standard CPR areas

Summary

- Phytoplankton blooms key to success of *Calanus* in the Arctic
- Quality of fatty acid supply depends on phytoplankton community composition
- Remotely sensed data can help provide spatial and temporal context to DIAPOD
  - When combined with *in situ* measurements
- Lots to learn, lots to do – suggestions welcome :)

THANK YOU!

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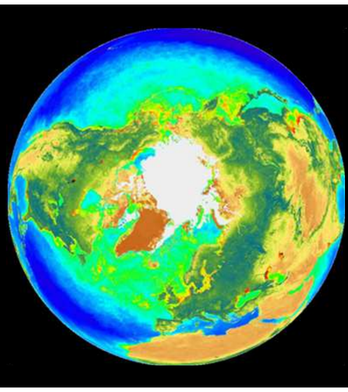
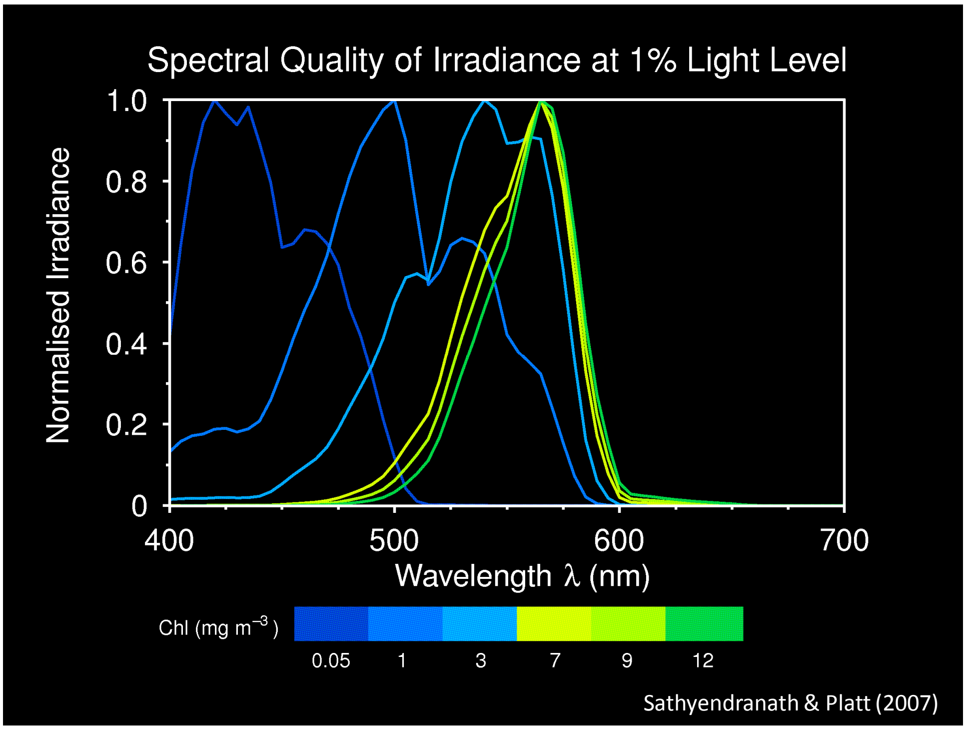
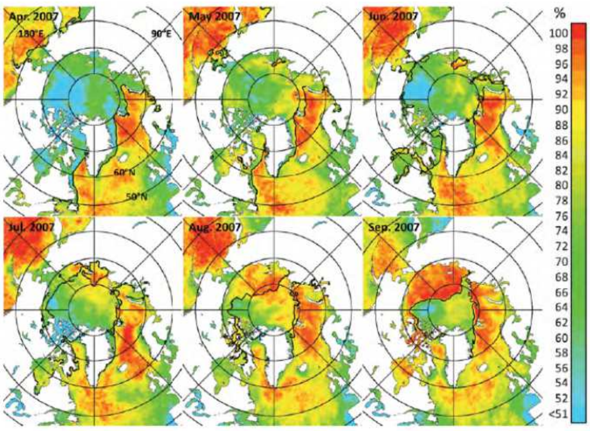




Challenges: cloud cover



Cloud cover April- September 2007

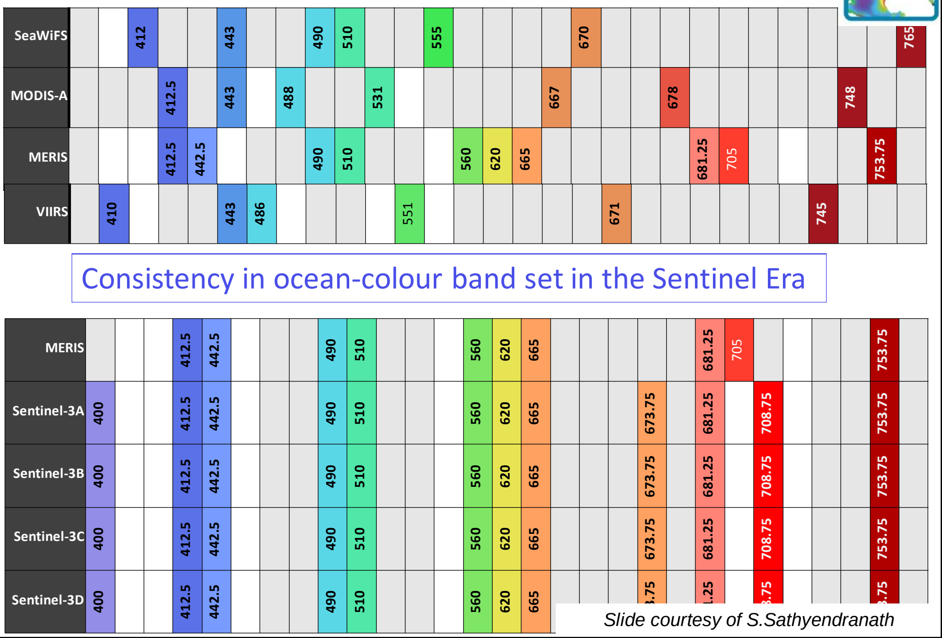
Red = high cloud cover   Black line = ice extent

From IOCCG report 2015

EXTRA SLIDES

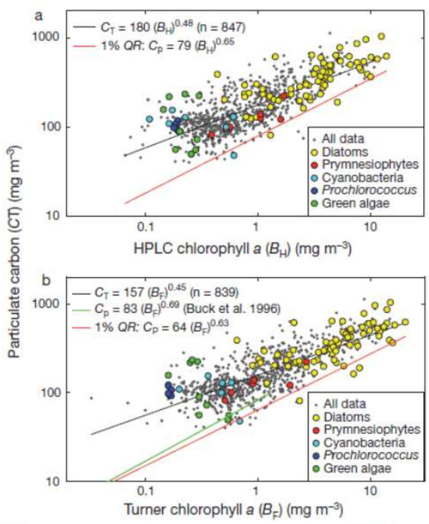
British Antarctic Survey NERC DIAPOD

Sensors currently contributing to OC-CCI merged product



Slide courtesy of S.Sathyendranath

Chl to Phytoplankton C



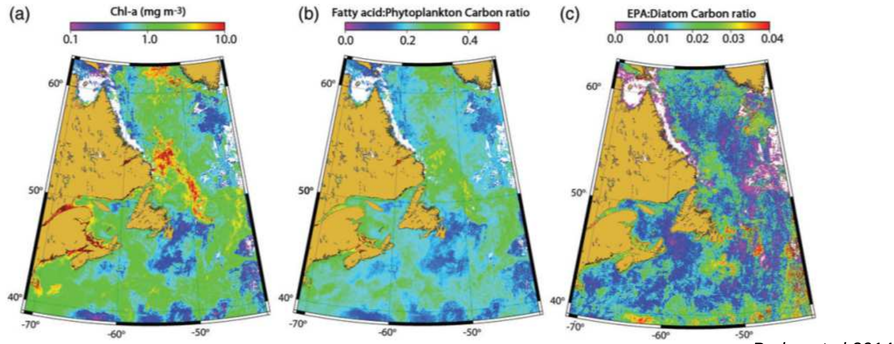
- In situ data from mostly Labrador Sea and Scotian Shelf
- Least squares fit to log-transformed data
- Assumes that at any given [chl], the lowest particulate carbon observed represents the phytoplankton carbon associated with that [chl]
- Used the first quartile percentile (q =0.01)

From Sathyendranath et al. 2009

EXTRA SLIDES

British Antarctic Survey NERC DIAPOD

Chl to Fatty acids



Budge et al 2014

- Total Fatty acid: phytoplankton carbon – same patterns as Chl a, but reduced variation
- EPA: Diatom carbon – high ratios in regions of lowest chlorophyll, such as those in nutrient poor oligotrophic Gulf stream

EXTRA SLIDES

British Antarctic Survey NERC DIAPOD

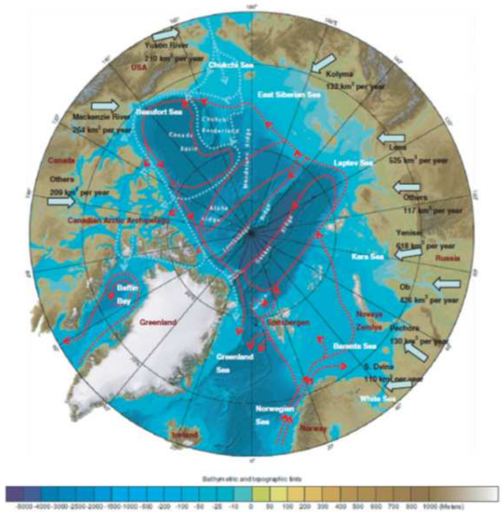


Figure 1. Bathymetric map of the Arctic Ocean showing general circulation and the importance of riverine inflow. Adapted from Carmack (2000) and Jakobsson et al. (2004, 2008).