Fate of the key Arctic copepod *Calanus glacialis* in a changing environment

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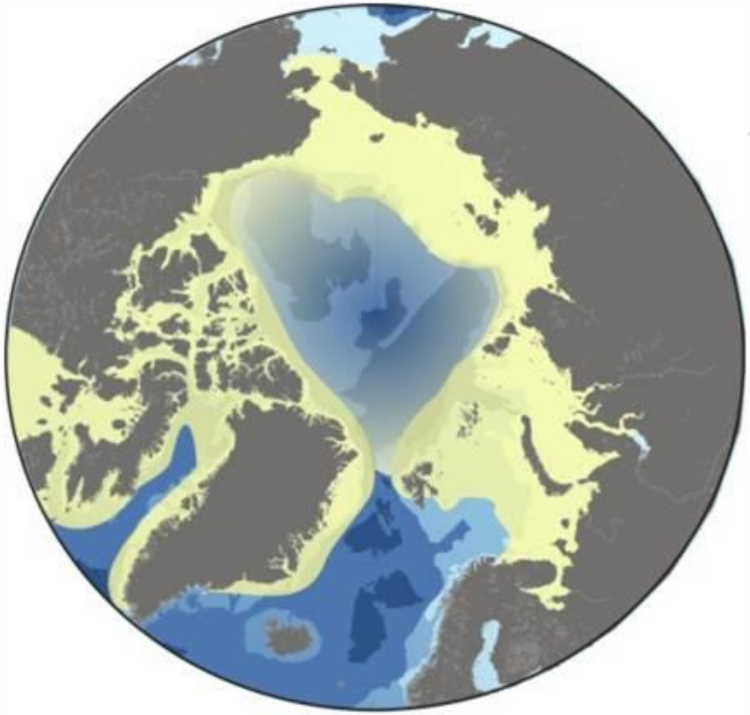
Calanus glacialis

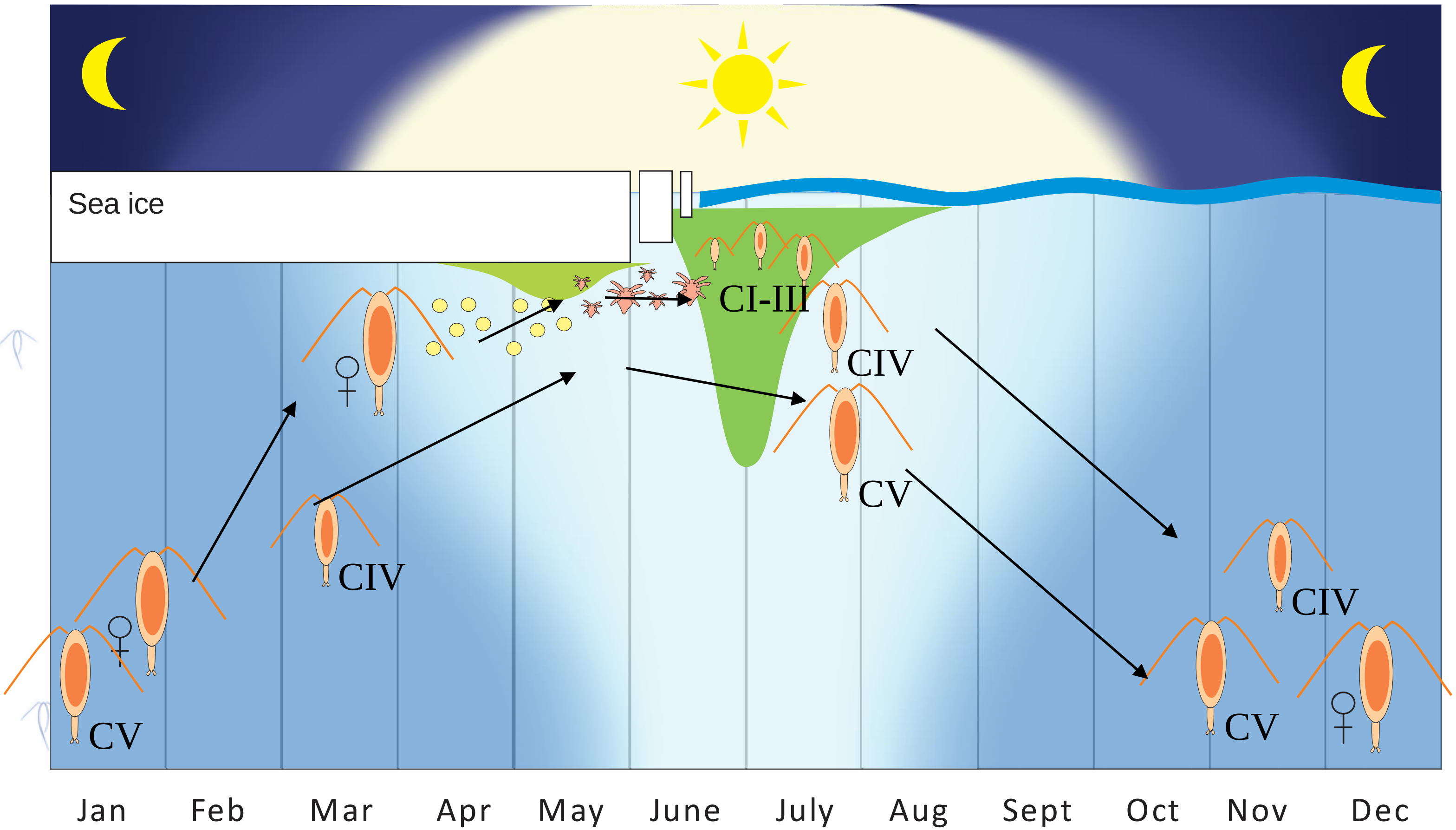
3-4.6 mm
0.4-0.45 mg lipids



- Herbivorous
- Shelf seas
- High biomass (up to 90%)
- Large lipid stores

Key species in pelagic ecosystem of Arctic shelves

Calanus glacialis life cycle



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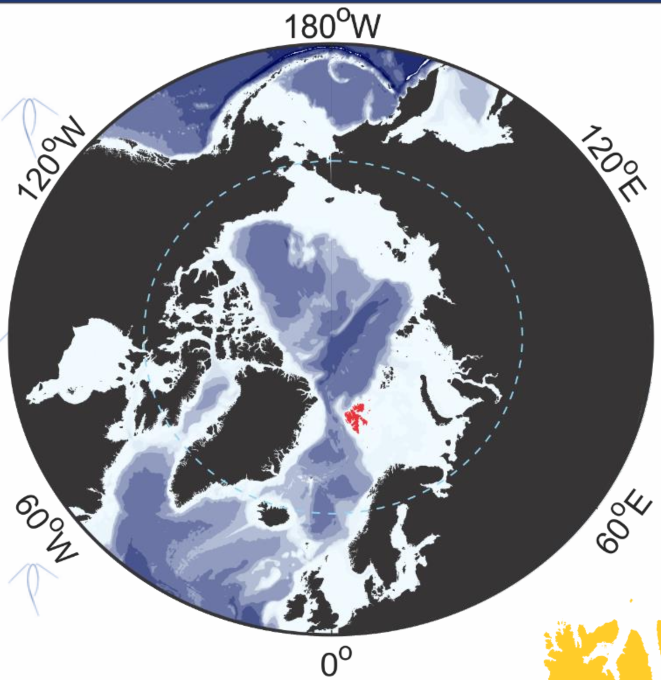
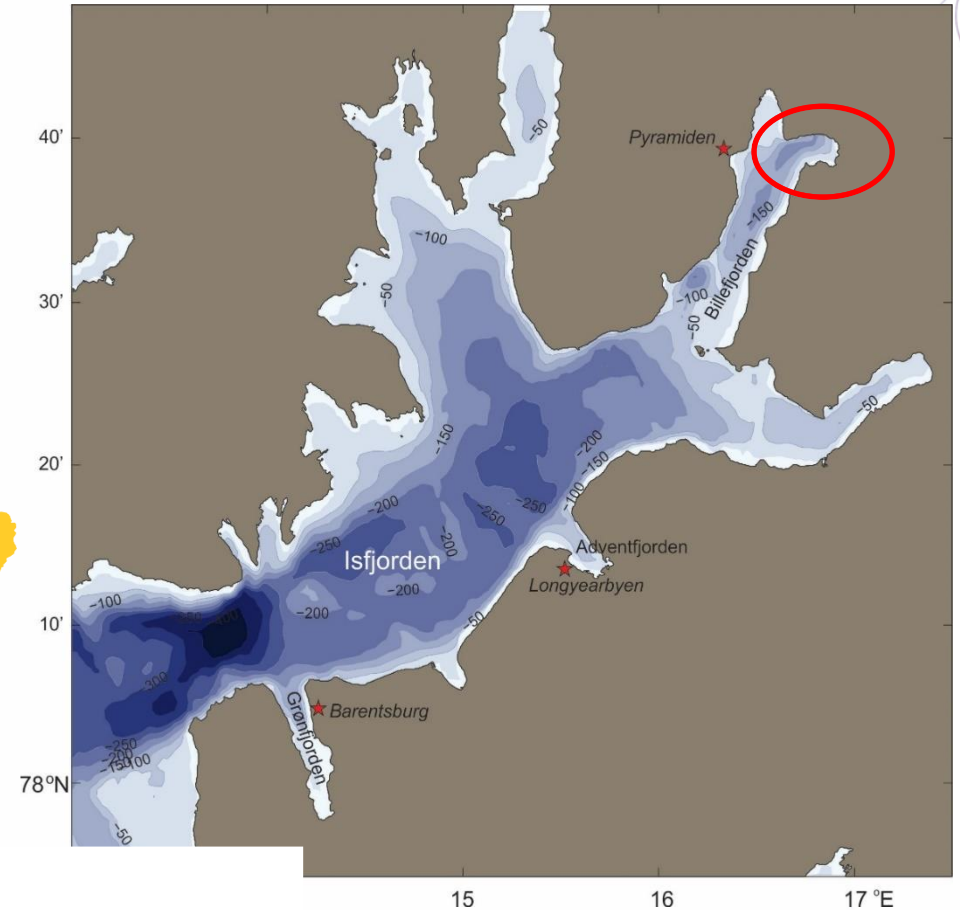
Year-round study of *C. glacialis*

How is *C. glacialis* adapted to the high variability of environmental conditions in seasonally ice covered seas?

What do these traits tell us about the possible fate of *C. glacialis* in a changing Arctic?

Study area – Billefjorden 78°N

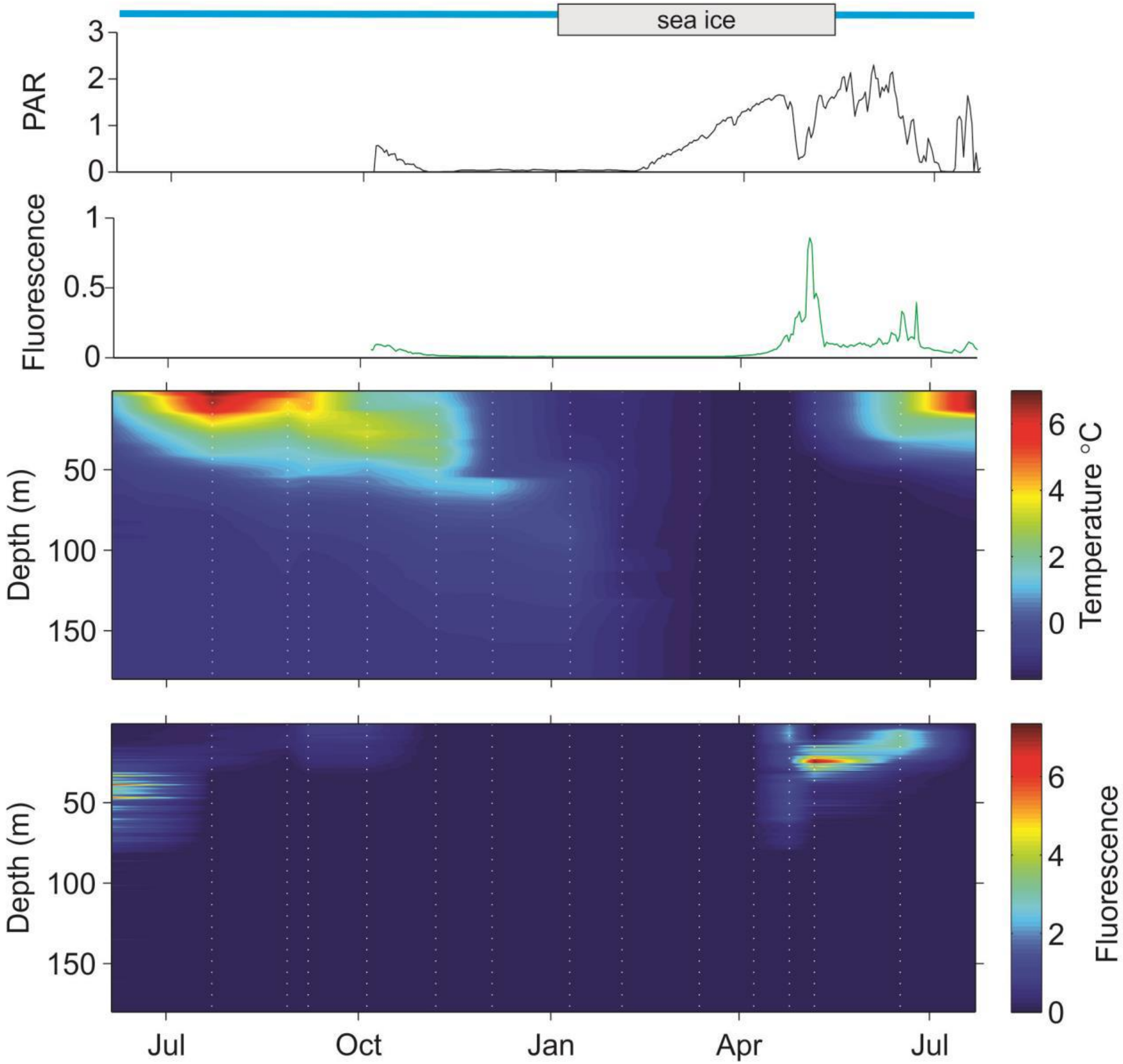




Sill fjord

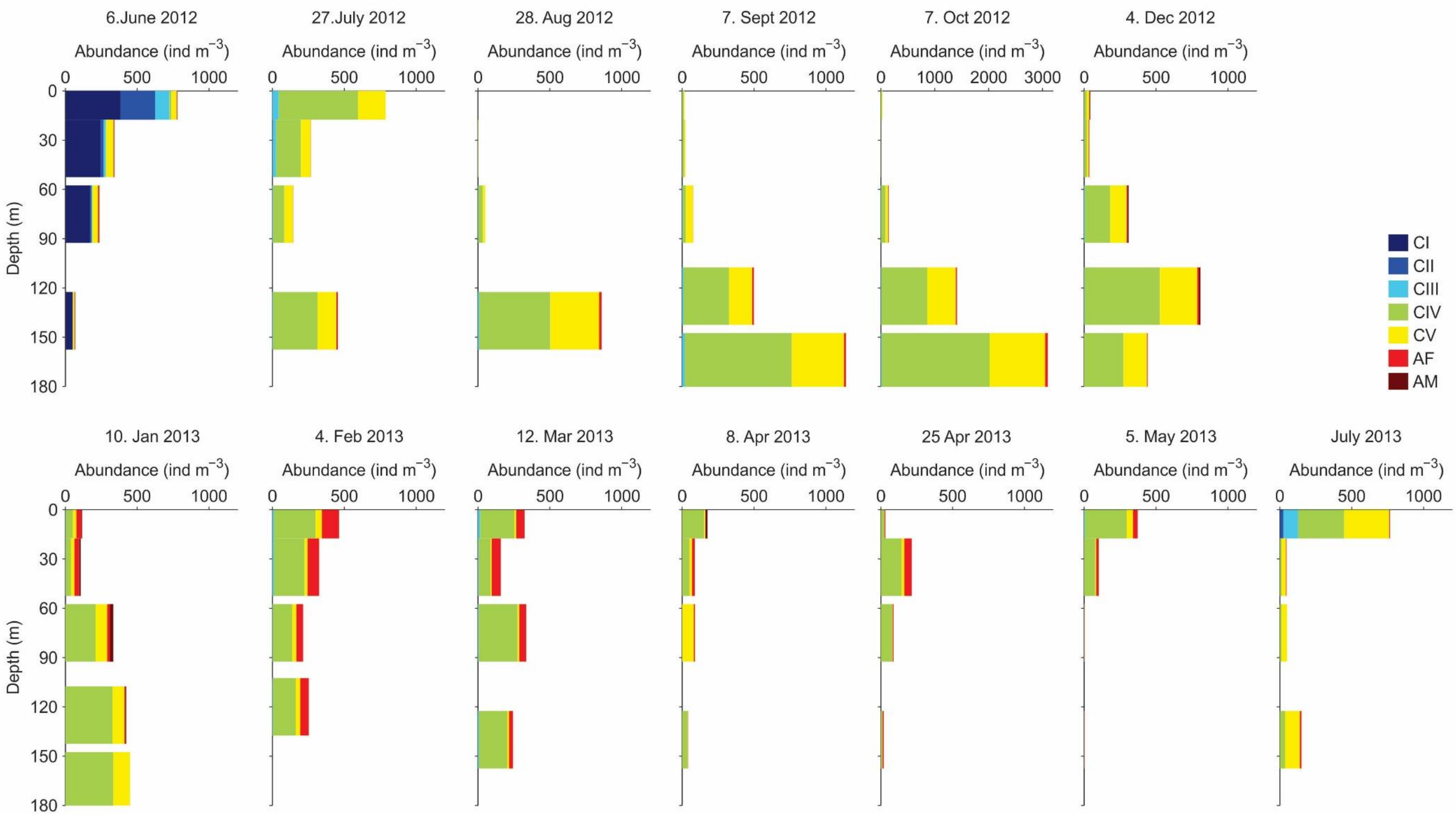
Outer basin: max depth 230m; sill 80m

Inner basin: max depth 190 m; sill 45m



sea ice
PAR
3
2
1
0
Fluorescence
1
0.5
0
Depth (m)
50
100
150
Temperature °C
6
4
2
0
Depth (m)
50
100
150
Fluorescence
6
4
2
0
Jul
Oct
Jan
Apr
Jul

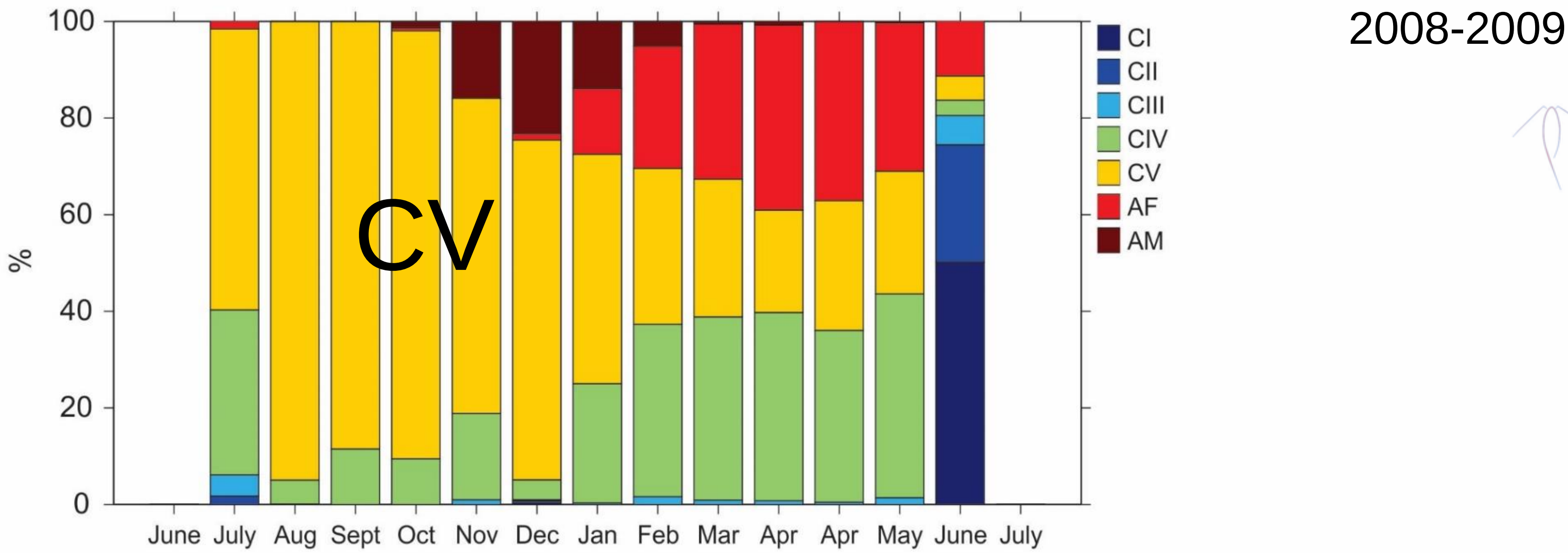
Seasonal vertical distribution of *C. glacialis*

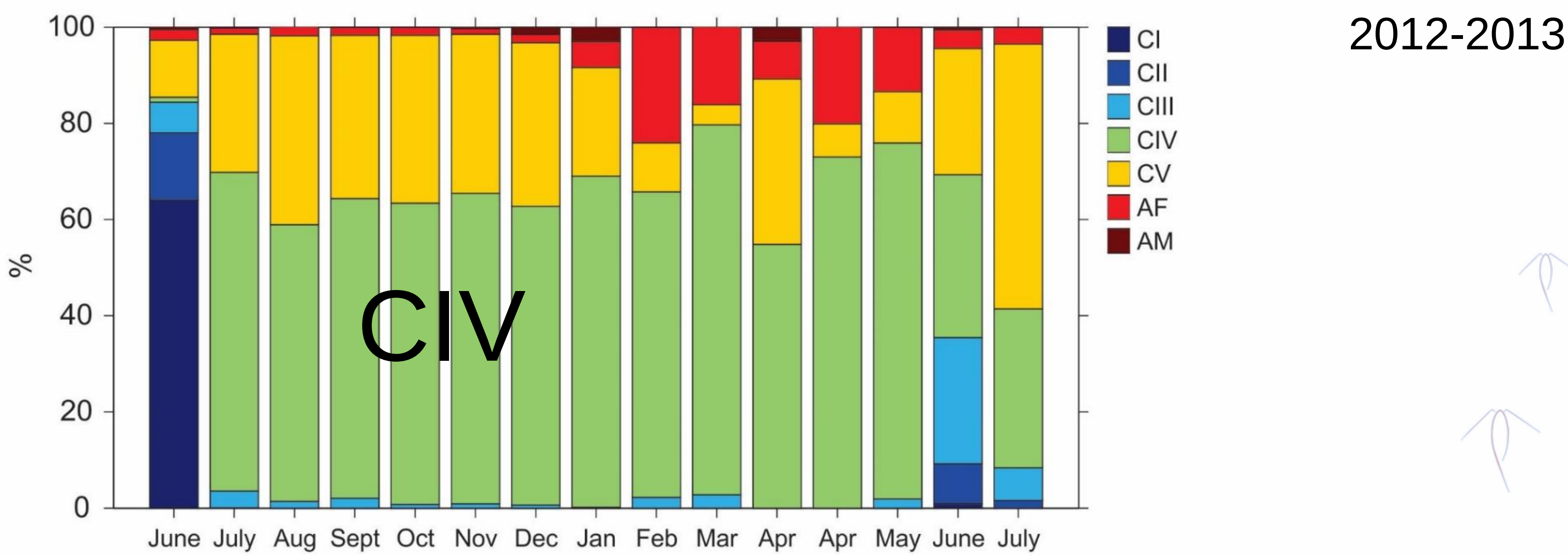


Ice algae

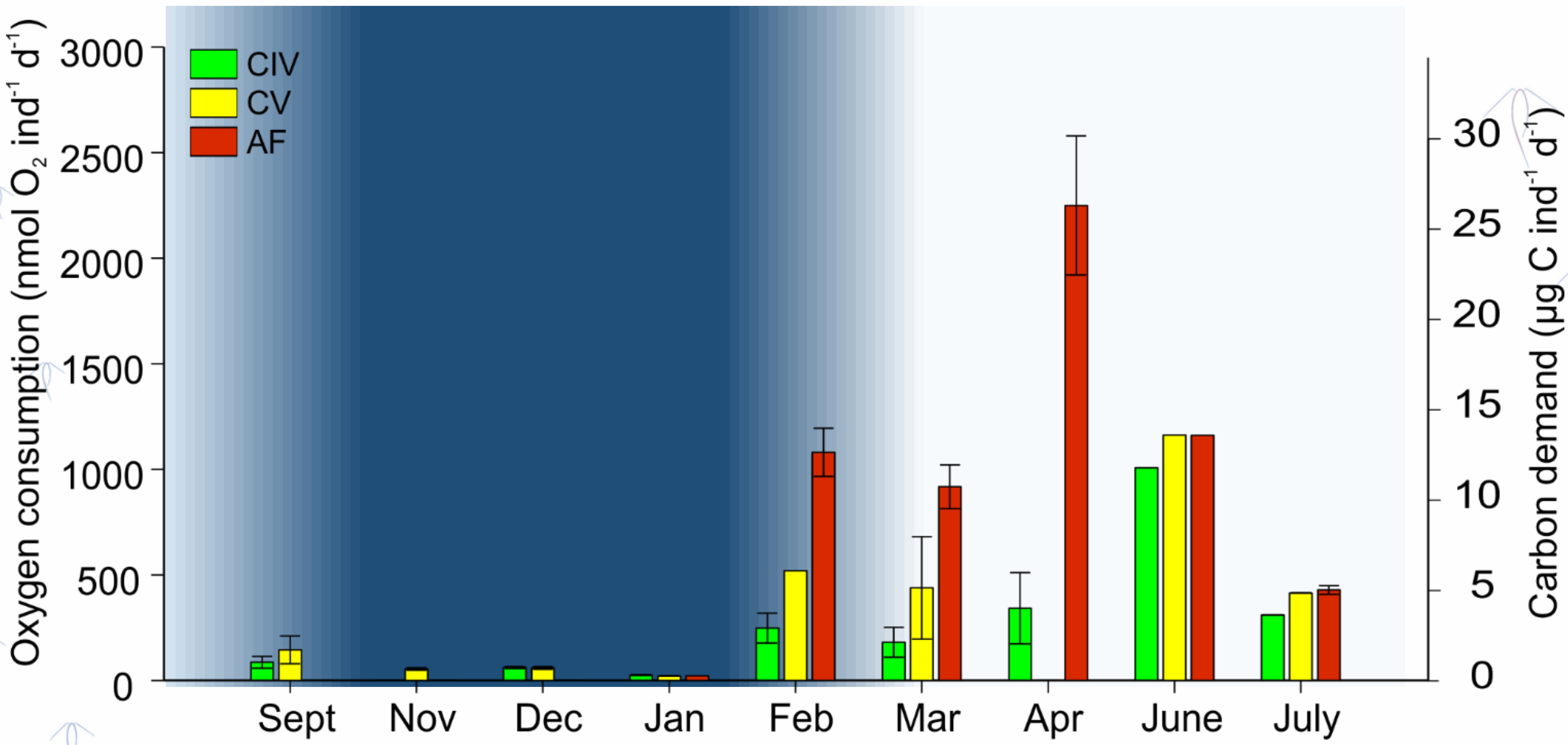
Phytoplankton

C. glacialis stage composition



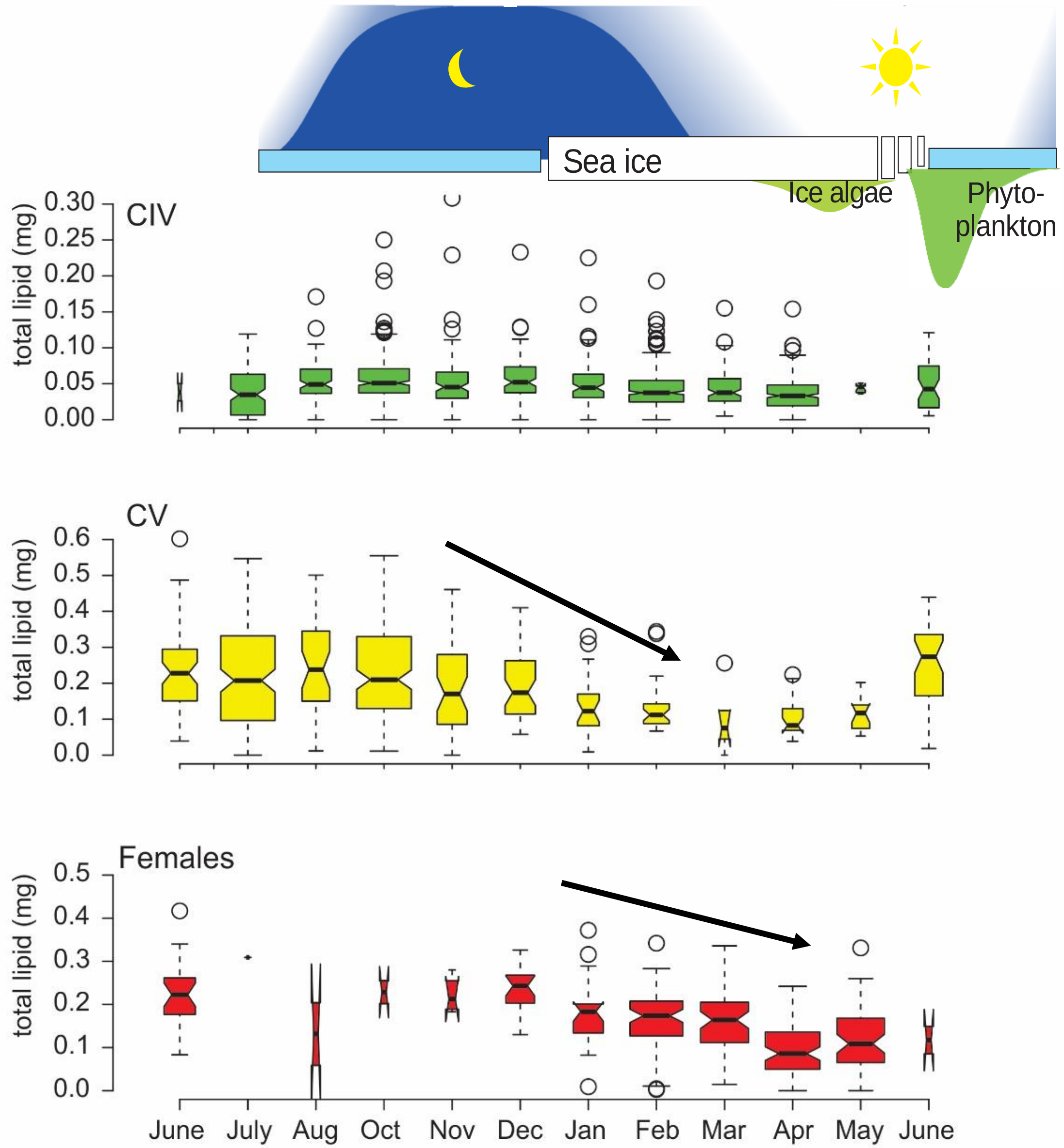


Seasonal oxygen consumption / carbon demand

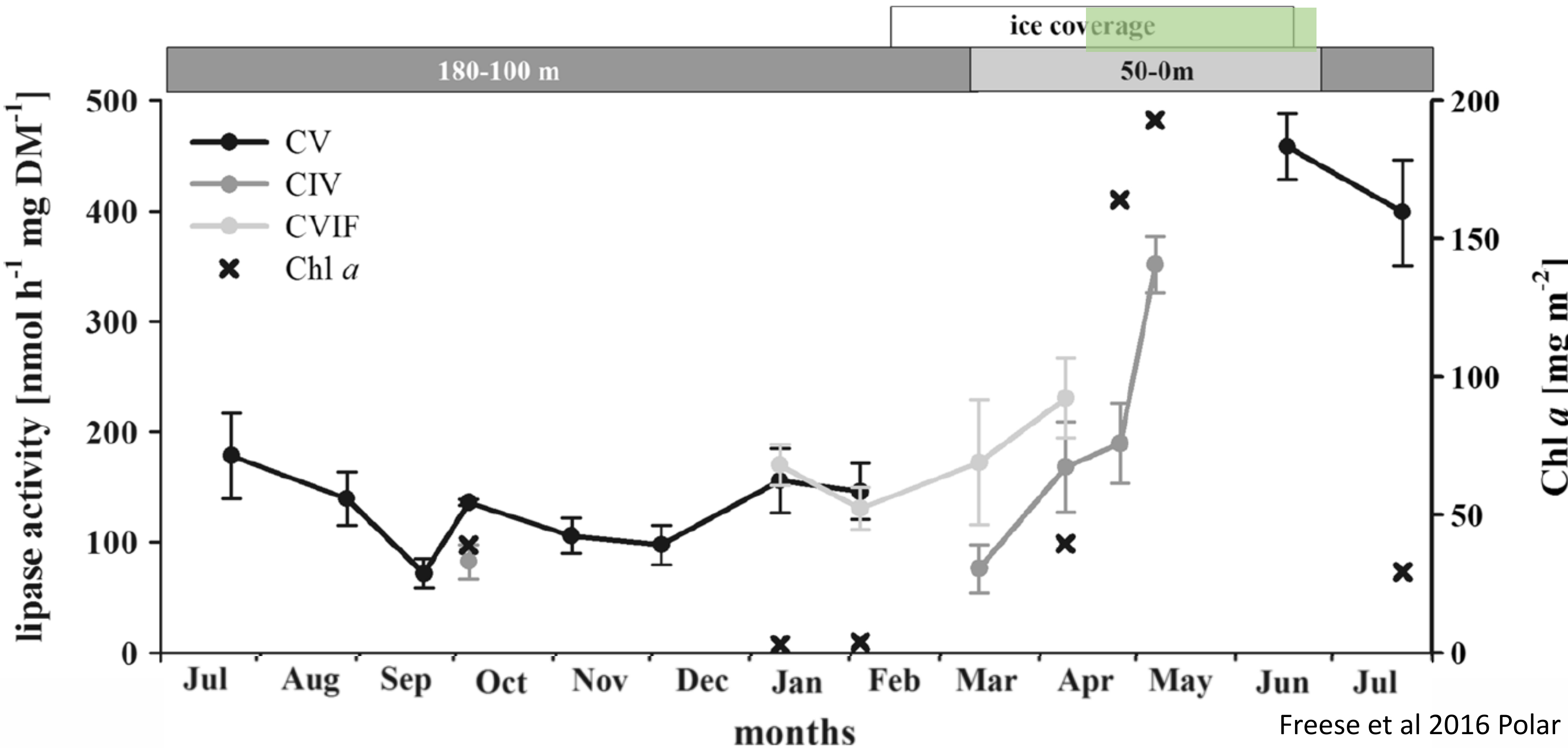


- Low carbon demand in autumn and «dark winter»
- Increase in carbon demand when light returns in February
- Particularly high carbon demand for females during final maturation

Seasonal variability in lipid & carbon content



Seasonal variability in digestive enzyme activity

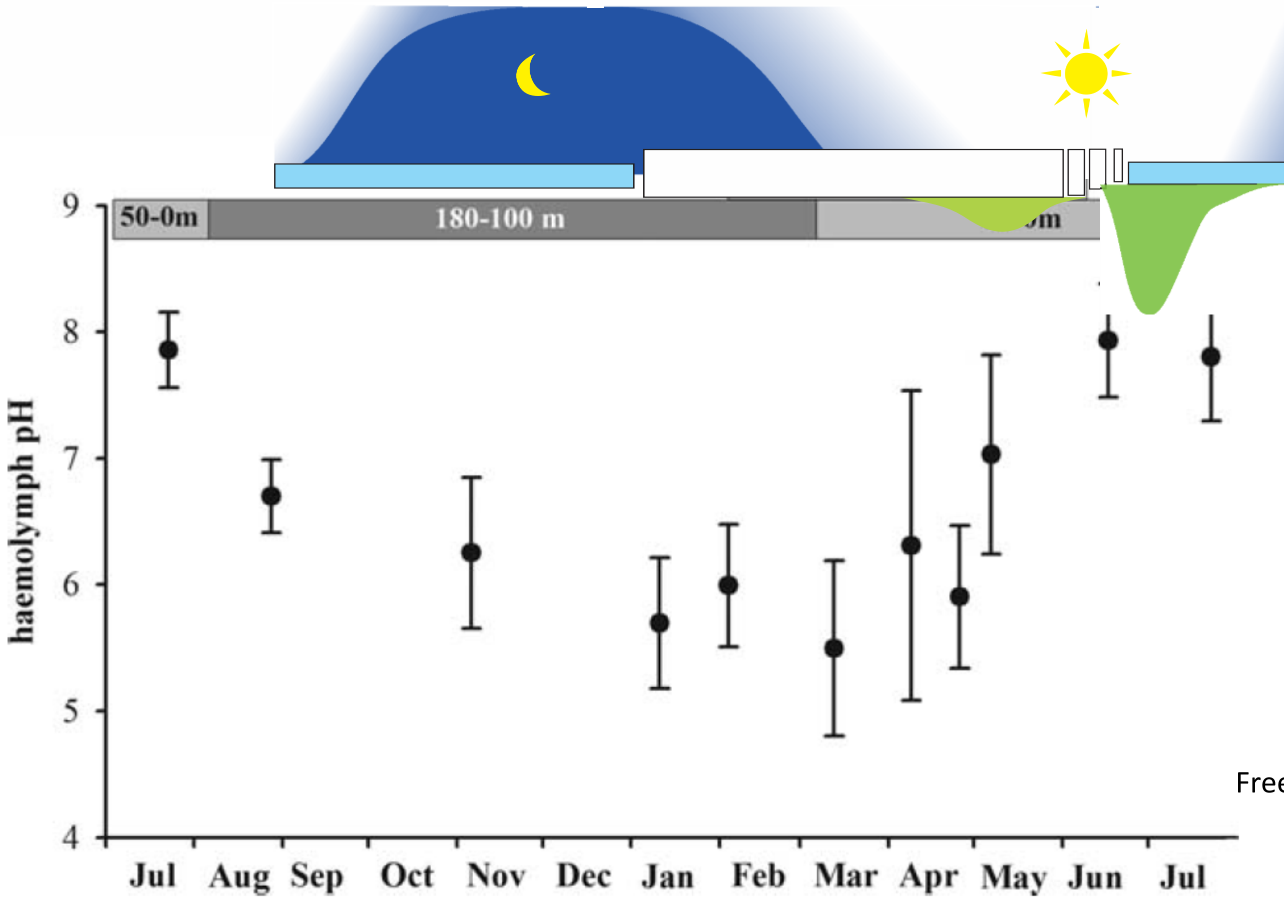


Freese et al 2016 Polar Biology

- Activities in winter reduced by 75% as compared to spring
- High enzyme activities related to spring bloom
- Copepods descend in summer when food is still available

C. glacialis benefits from early spring blooms
but not from prolonged phytoplankton availability

Seasonal patterns in extracellular pH in the haemolymph of CV of *C. glacialis*



Freese et al 2015 L&O

Low haemolymph pH could be related to depression of the metabolism

What will be the fate of *C. glacialis* in a changing Arctic?

Which environmental changes does *C. glacialis* have to cope with?

Changes in sea ice:

- Thickness
- Snow cover
- Timing of freeze-up and break-up

→ Affects phenology and productivity of ice algae and phytoplankton blooms

What will be the fate of *C. glacialis* in a changing Arctic?

Adapations to deal with changes in bloom phenology and productivity:

- Light rather than food triggers transition from dormancy to activity:
  -> Acscent before algal bloom, ready to feed and reproduce as soon as food becomes available
- Lipid reserves fuel early gonad development at the end of winter
- Capital and income breeding
  -> (some) eggs will be produced, even if blooms are delayed
- 1-2 year life cycle
  -> *C. glacialis* may respond flexible to bloom conditions
- CIV: dormant for a longer period and develop when food is available
  -> Reduces risk of population failure

The life history traits of *C. glacialis* will allow for coping with changes in timing and magnitude of bloom

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Changes in sea ice:
- Thickness
- Snow cover
- Timing of freeze-up and break-up

Affects phenology and productivity of ice algae and phytoplankton blooms

Increased water temperatures
Increased inflow of Atlantic water

Affects physiology, growth, energy demand and interspecific competition

What will be the fate of *C. glacialis* in a changing Arctic?

Can *C. glacialis* cope with increasing water temperatures?

High winter temperatures are worrying for their energy budget

- Lipid reserves are depleted by the time the spring bloom starts
- Reserves cannot compensate for carbon demand when light returns
- High mortality during winter – due to energetic constraints?

More studies needed
- to estimate energy demand during winter and
- to identify potential «population bottlenecks»

Forskningsrådet

Fram Centre

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Cleopatra II

Climate effects on planktonic food quality and trophic transfer in the Arctic marginal ice zone

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Sum up
C. glacialis life history and physiological traits:

- Seasonal vertical migration
  - Descend startes end July
  - Ascend when light returns (beginning of February), before food is available
- pH varies seasonally – possibly related to changes in metabolic activity
- Lipid reserves decrease in winter in CV and females
- Lipids reserves decrease less in CIV
- Respiration and carbon demand increase with ascent
- Females produce eggs as soon as food is available
- High mortality during winter
- High abundance in autumn
- CV overwinter in domancy not diapause