How much for the night?
Energetic costs of overwintering for the Arctic copepod *Calanus glacialis*

CLEOPATRA II

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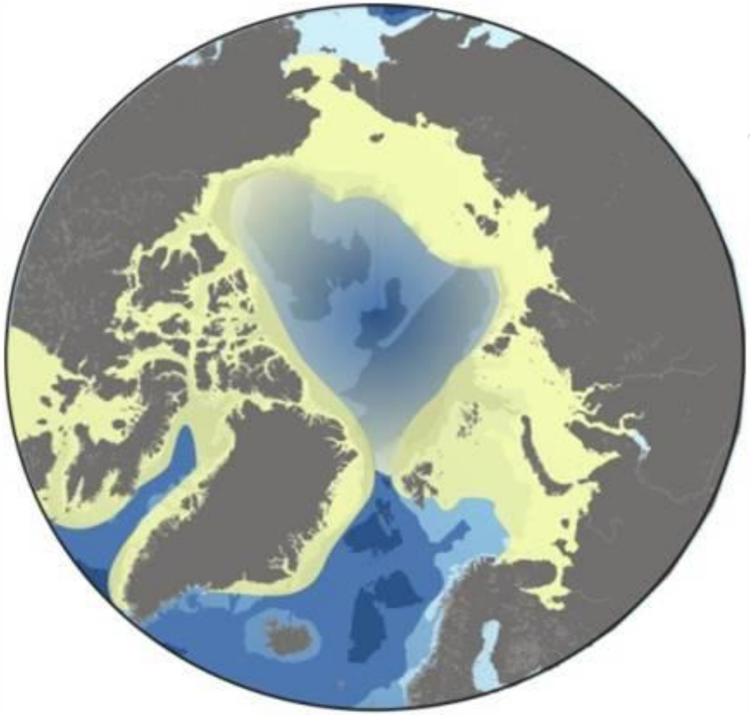
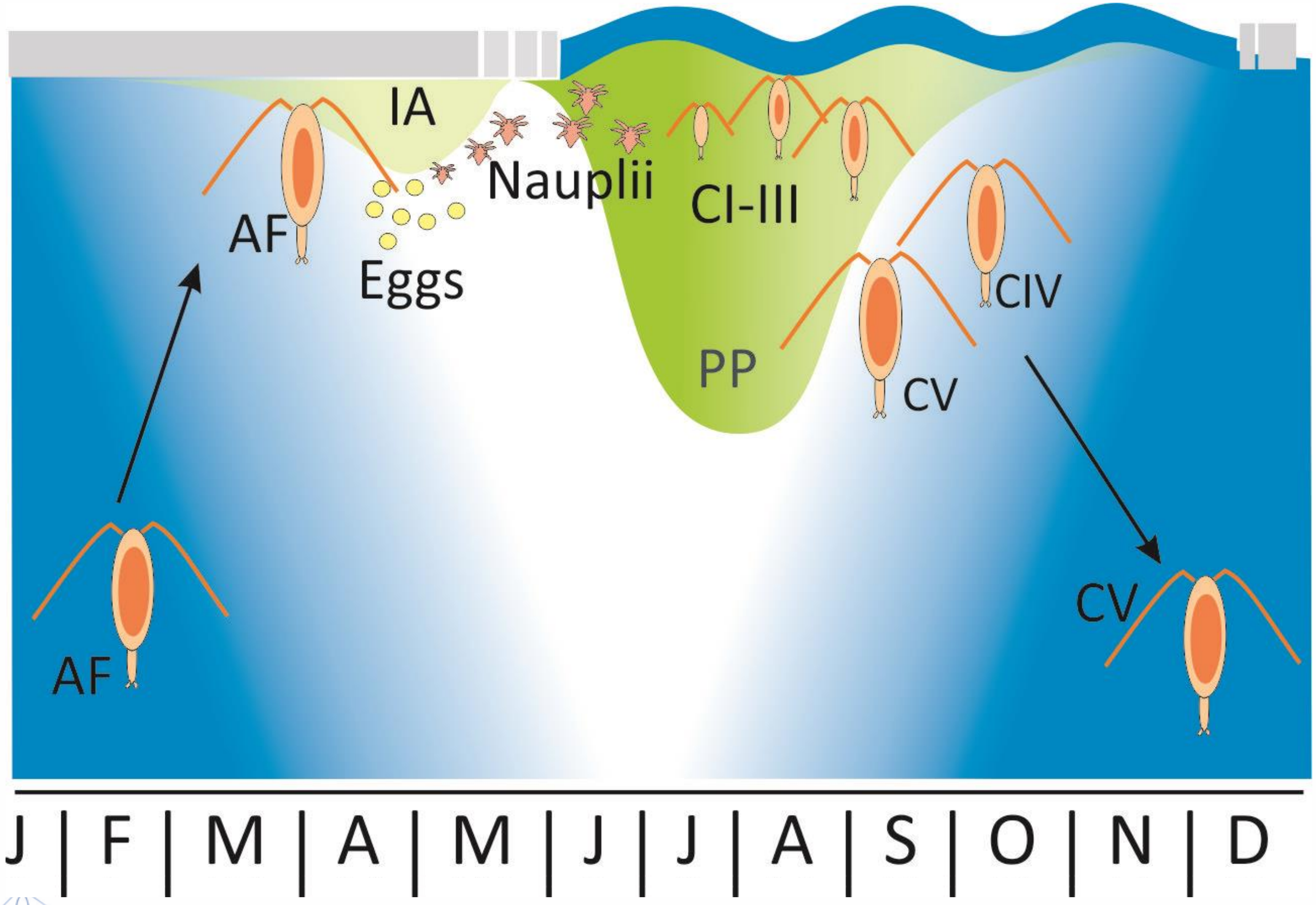
Calanus glacialis



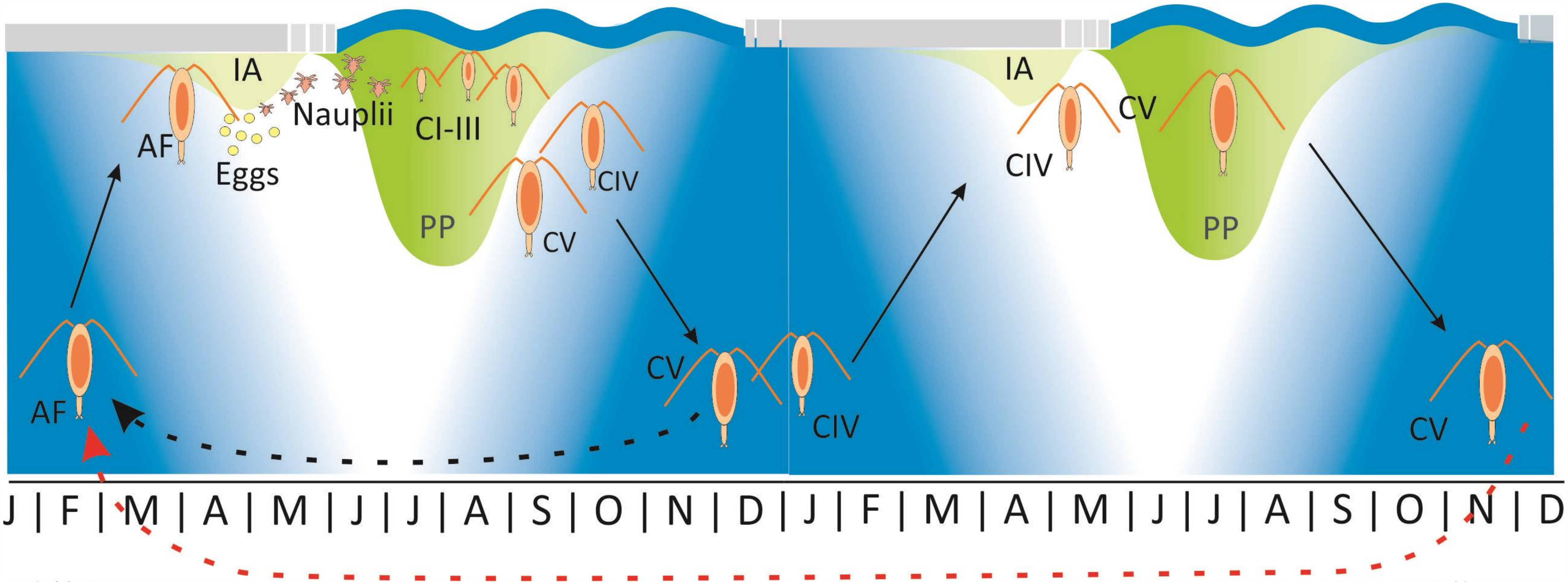
- Herbivorous
- Wide distribution
- High biomass
- Large lipid stores

Key species in pelagic ecosystem of Arctic shelves

Calanus glacialis life cycle



Calanus glacialis life cycle



Objectives

Field study:

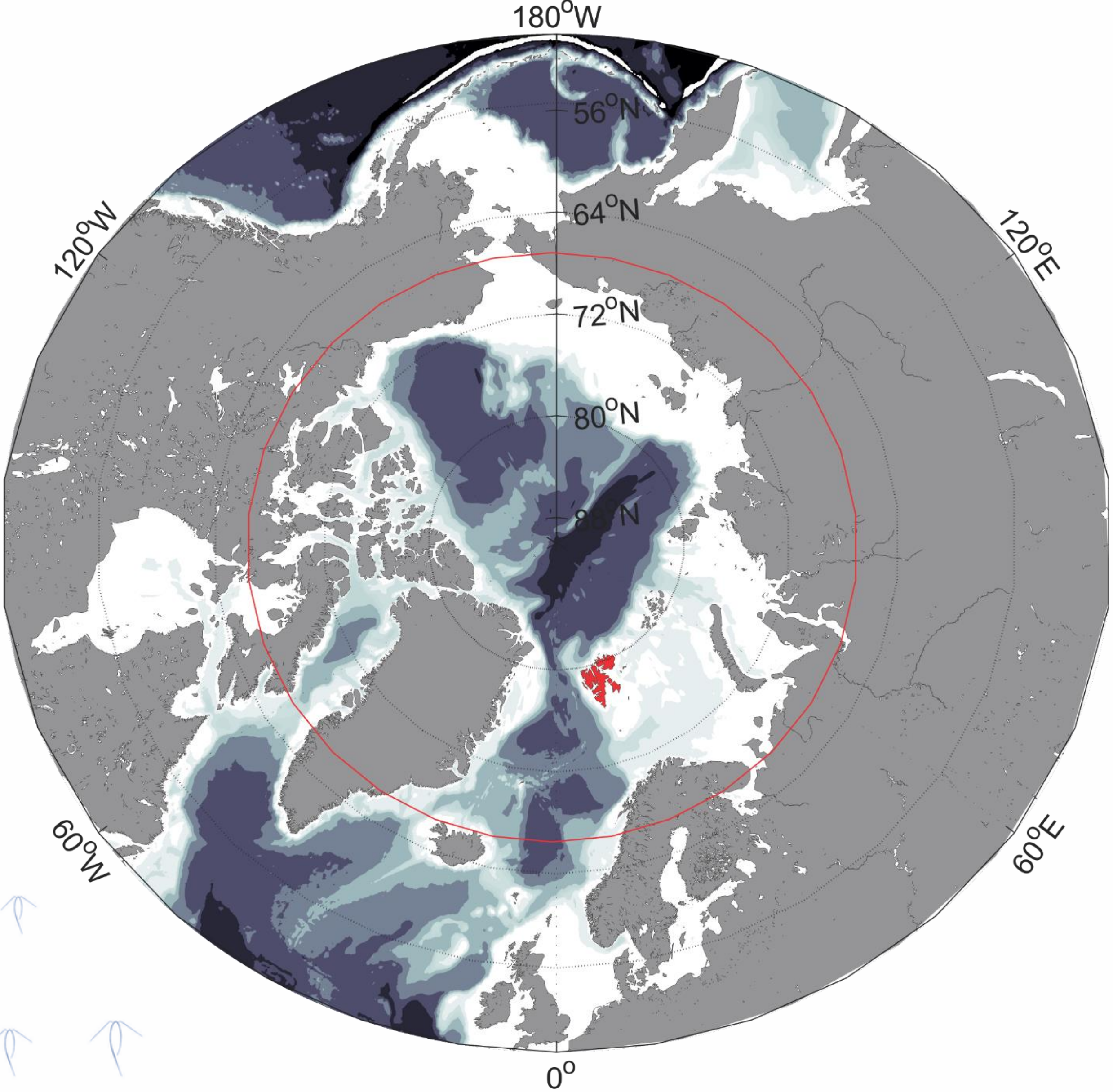
to document the **full annual cycle** of *Calanus glacialis* to obtain data on diapause duration, critical size of lipid storage, and reproductive success and population abundance

Laboratory studies:

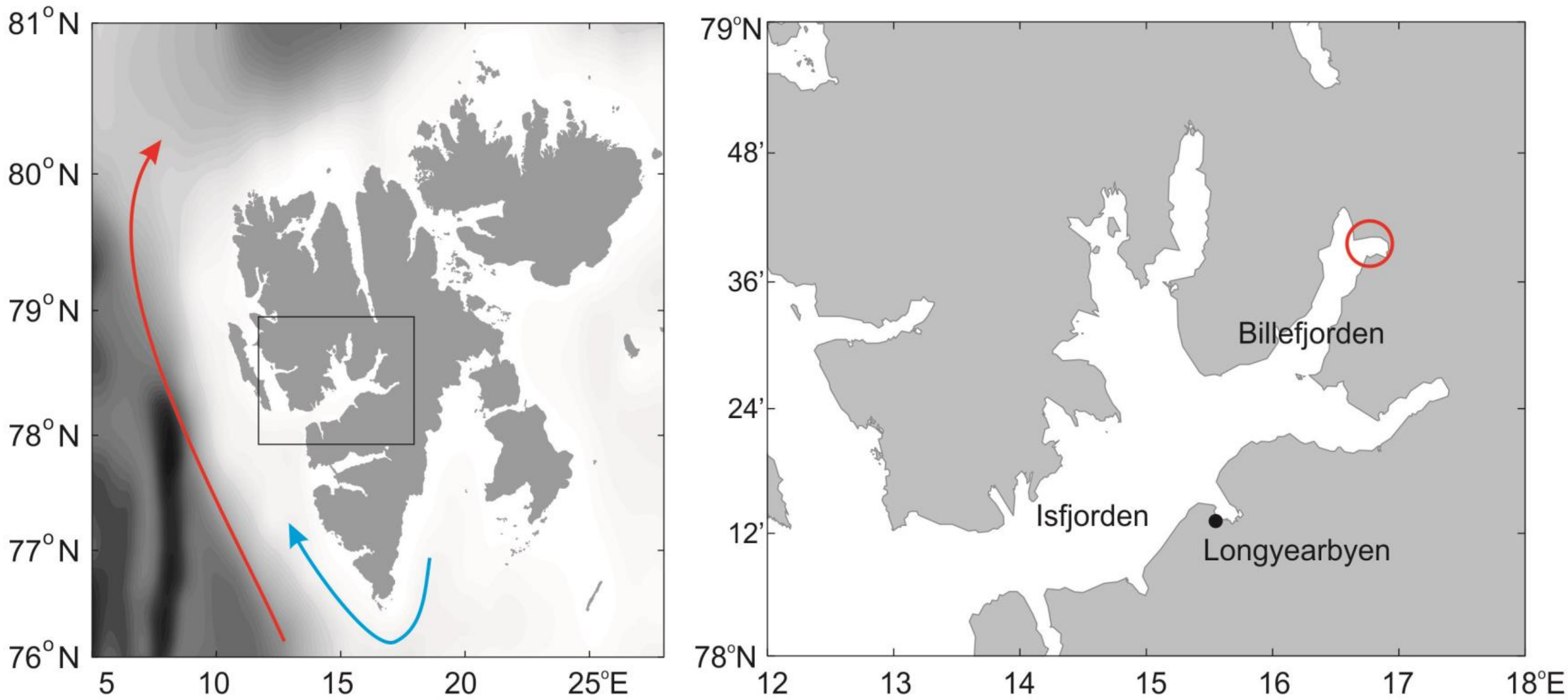
to obtain fundamental measurements of metabolism and diapause-flexibility of C. glacialis, incl. temperature- and food-dependence of these traits

- When does *C. glacialis* ascent from overwintering depth?
- How high is the energy demand during overwintering? Are there stage specific differences?
- Are lipid stores large enough to fill the energy demand during overwintering?
- Is *C. glacialis* actually in diapause?

Study area



Study area



Polar night: 26 October- 16 February
Midnight sun: 17 April – 25 August

Methods

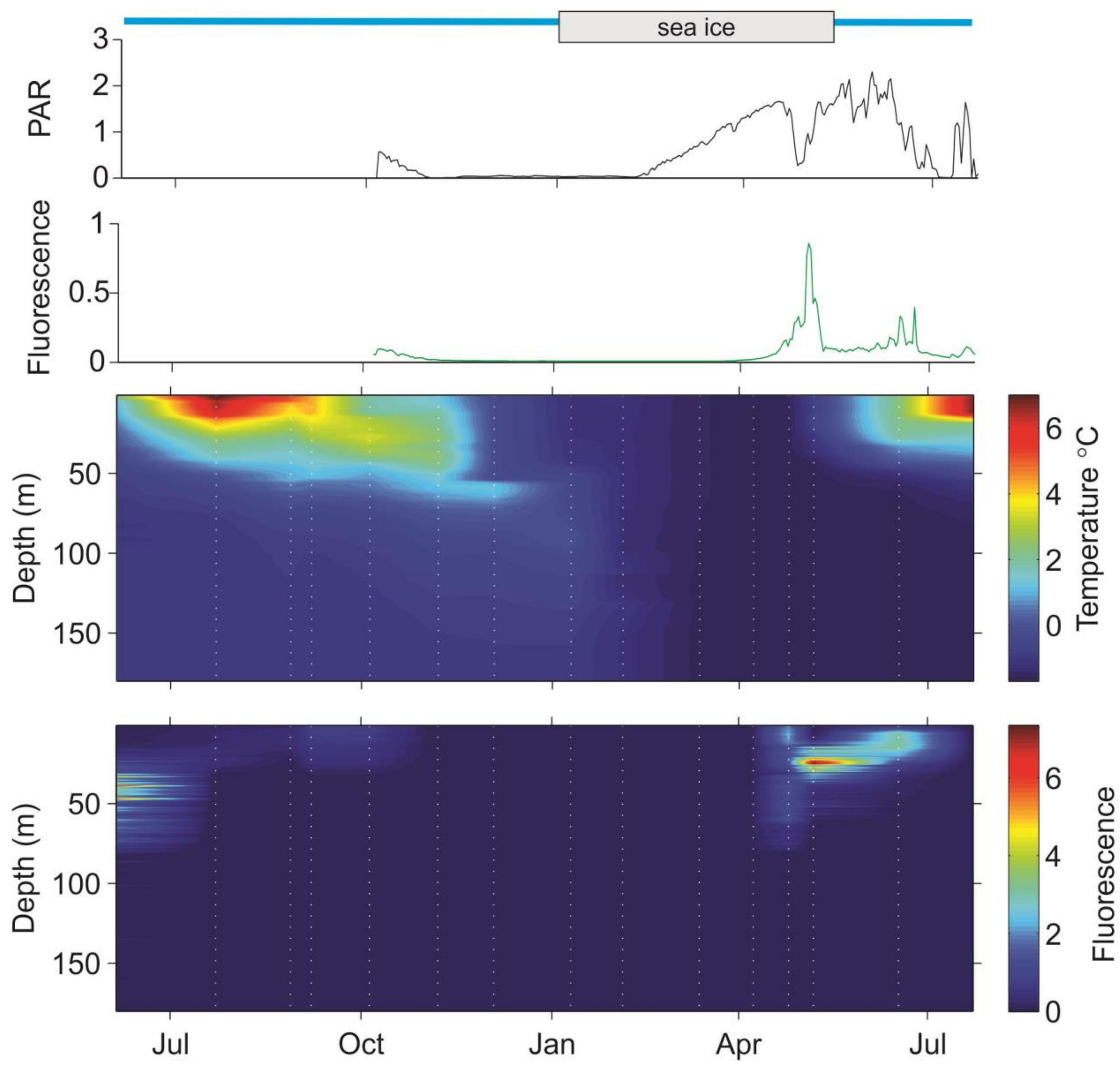
Monthly sampling June 2012-july 2013

⇒Vertical net hauls

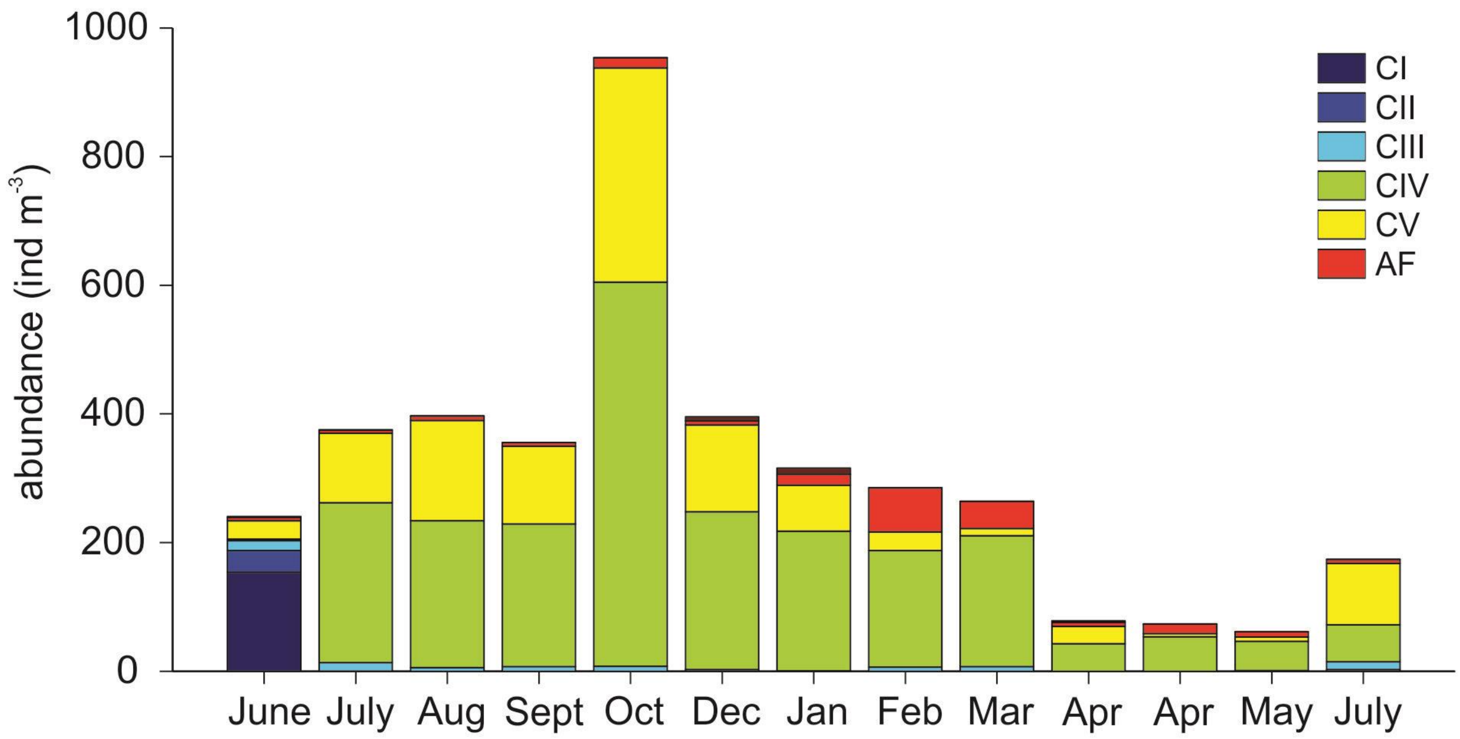
- abundance
- stage composition
- vertical distribution
- individual lipid content
- Respiration measurements to estimate carbon demand

- Lab experiments to study effects of food, light and temperature

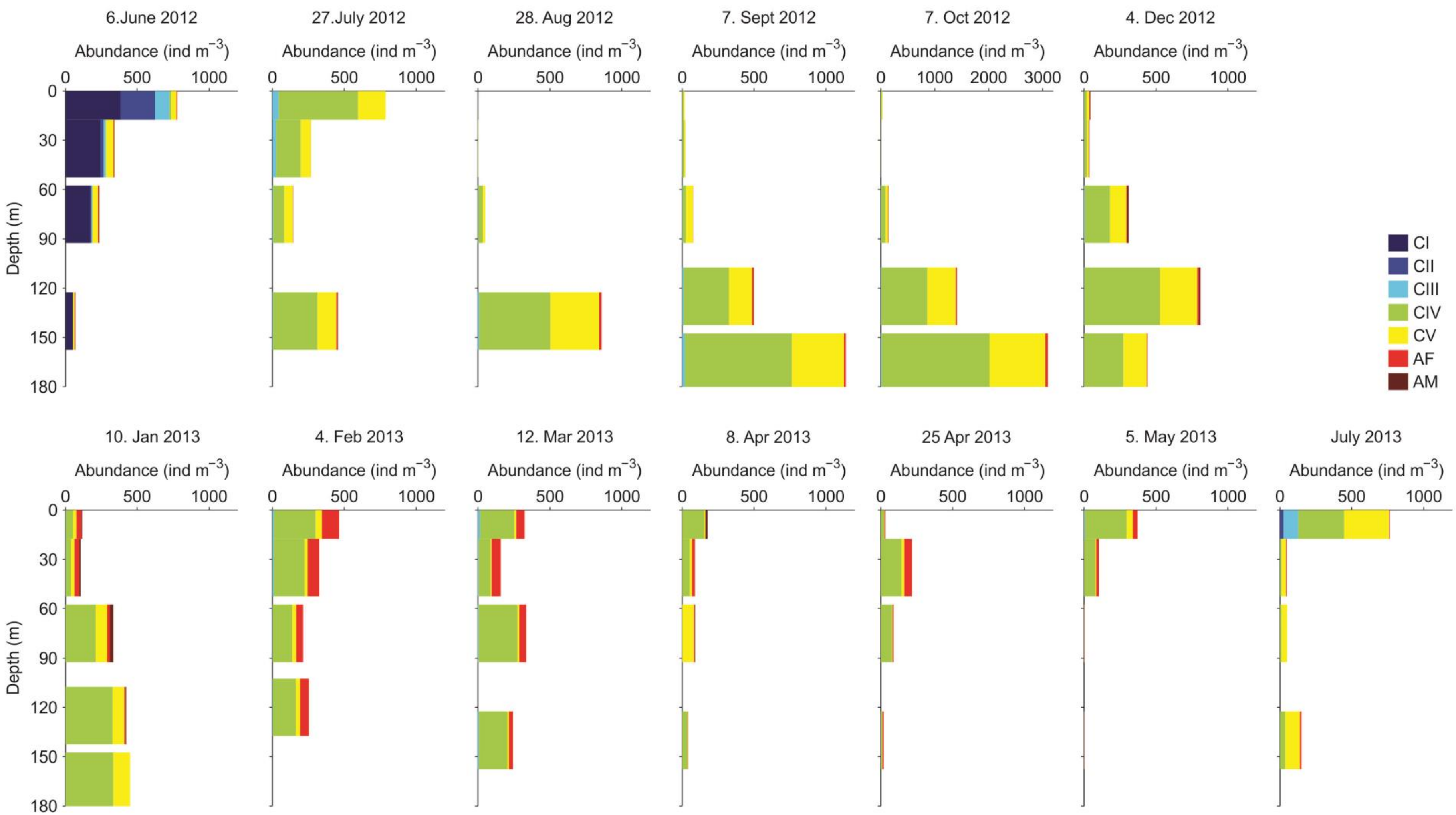
The season in Billefjorden: physical parameters



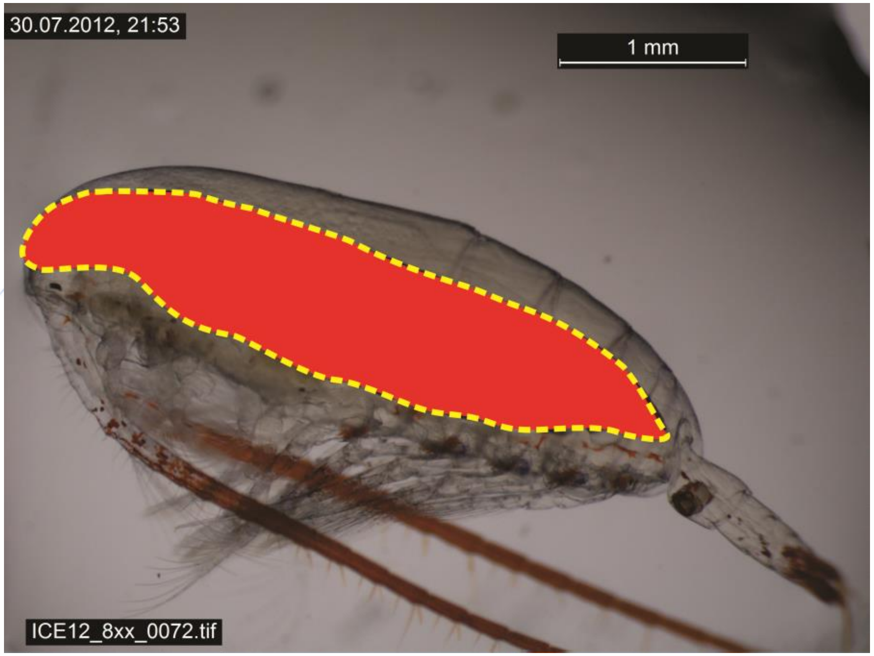
The season in Billefjorden: *C. glacialis* abundance

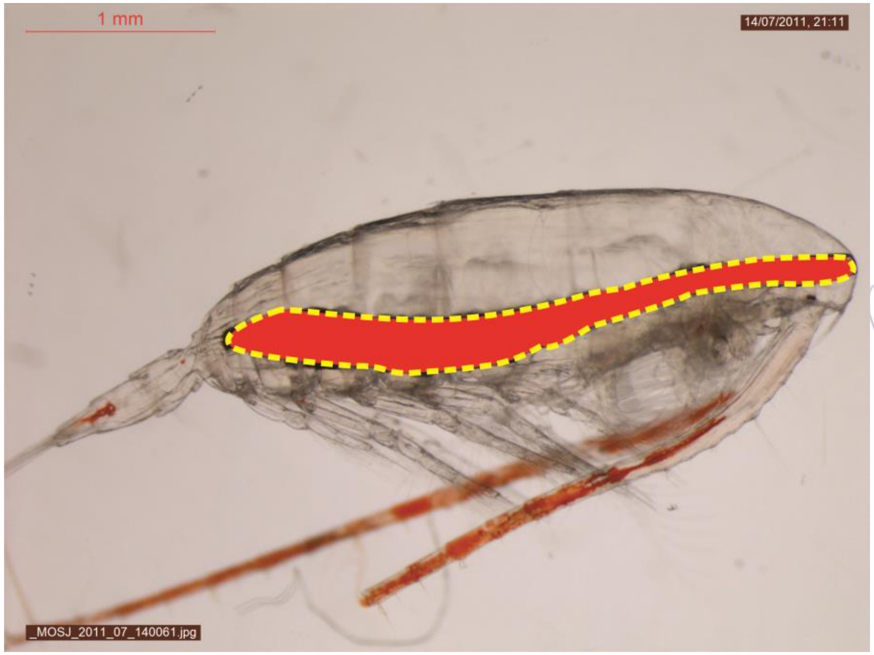


The season in Billefjorden: vertical distribution of *C. glacialis*



Estimating individual lipid content



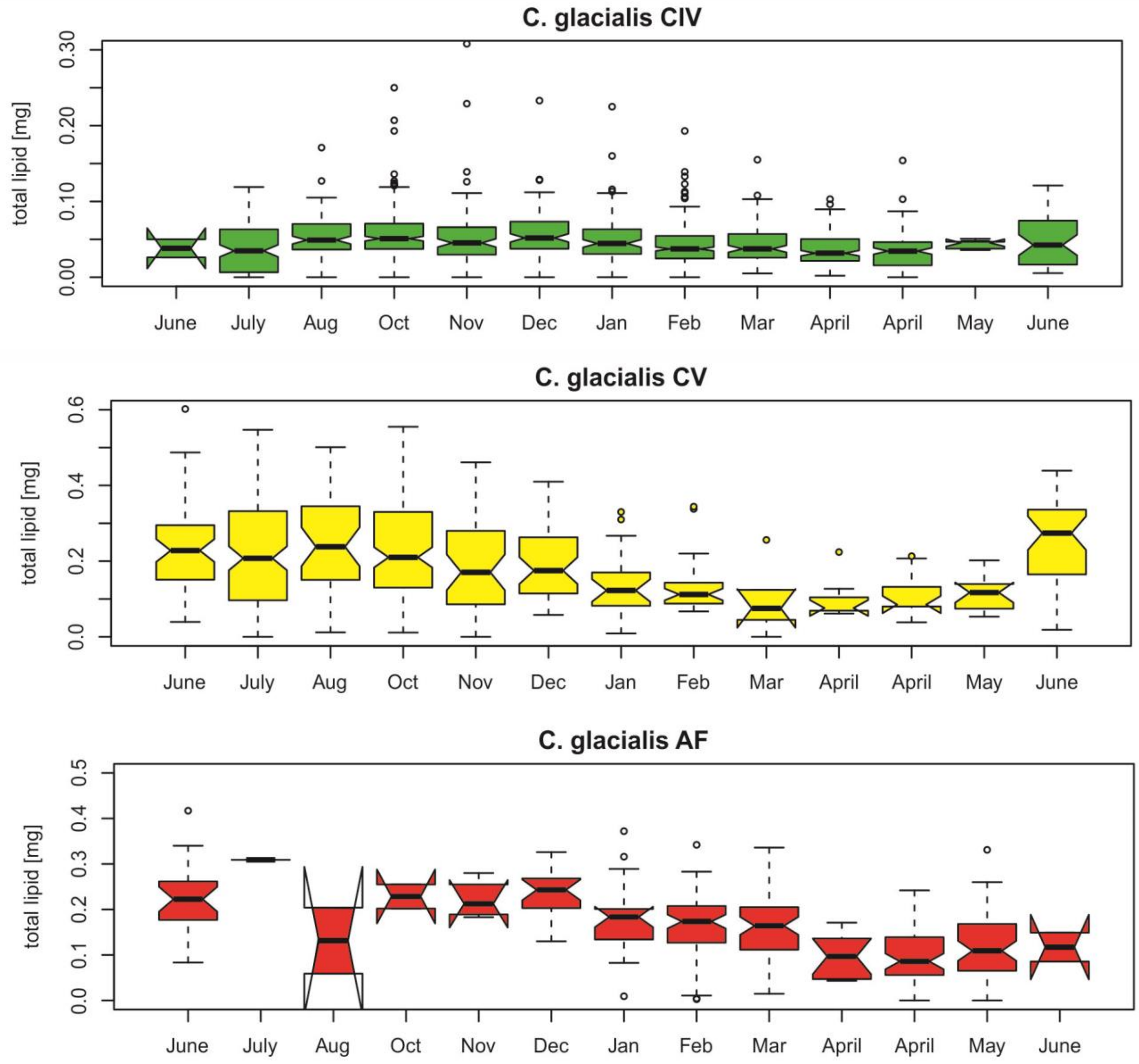


Wax ester $WE = 0.167\ A^{1.42}$

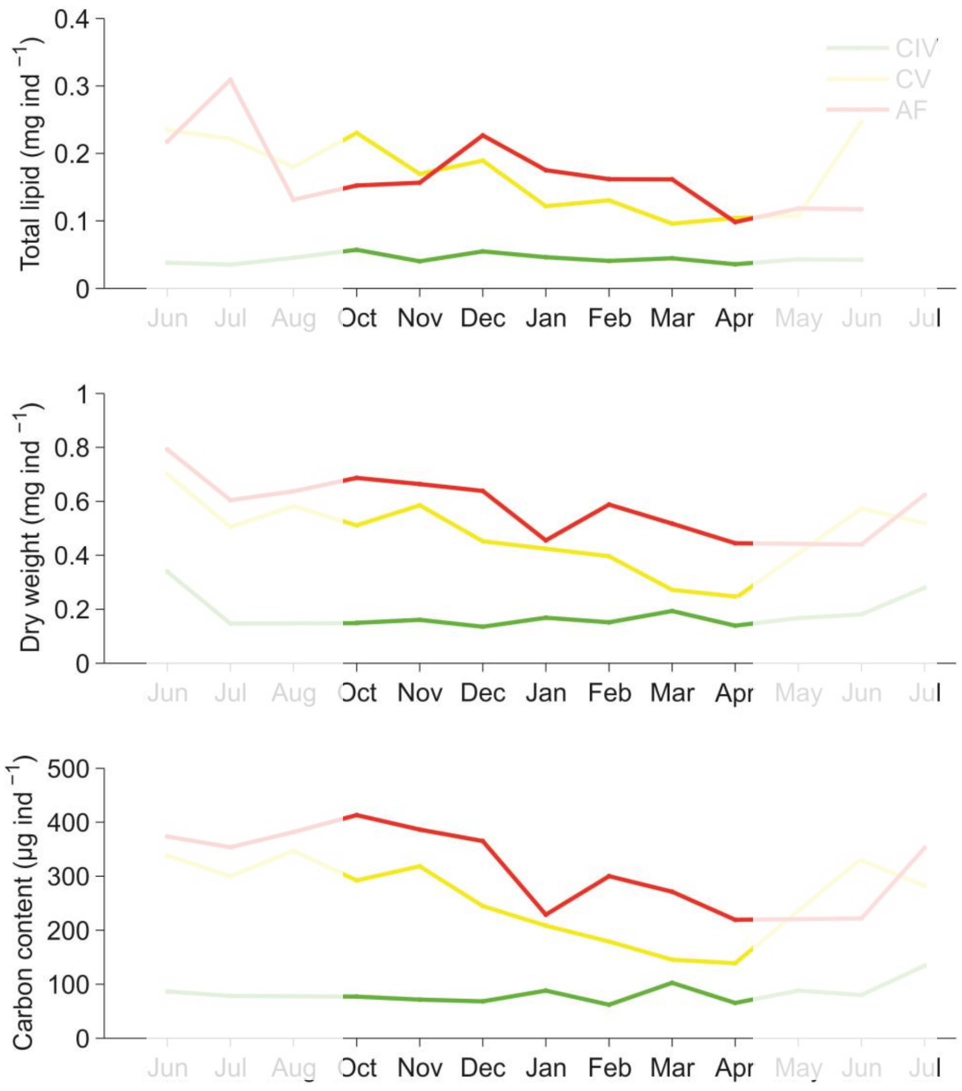
Total lipid $TL = 0.197\ A^{1.38}$

Vogedes et al 2010, JPR

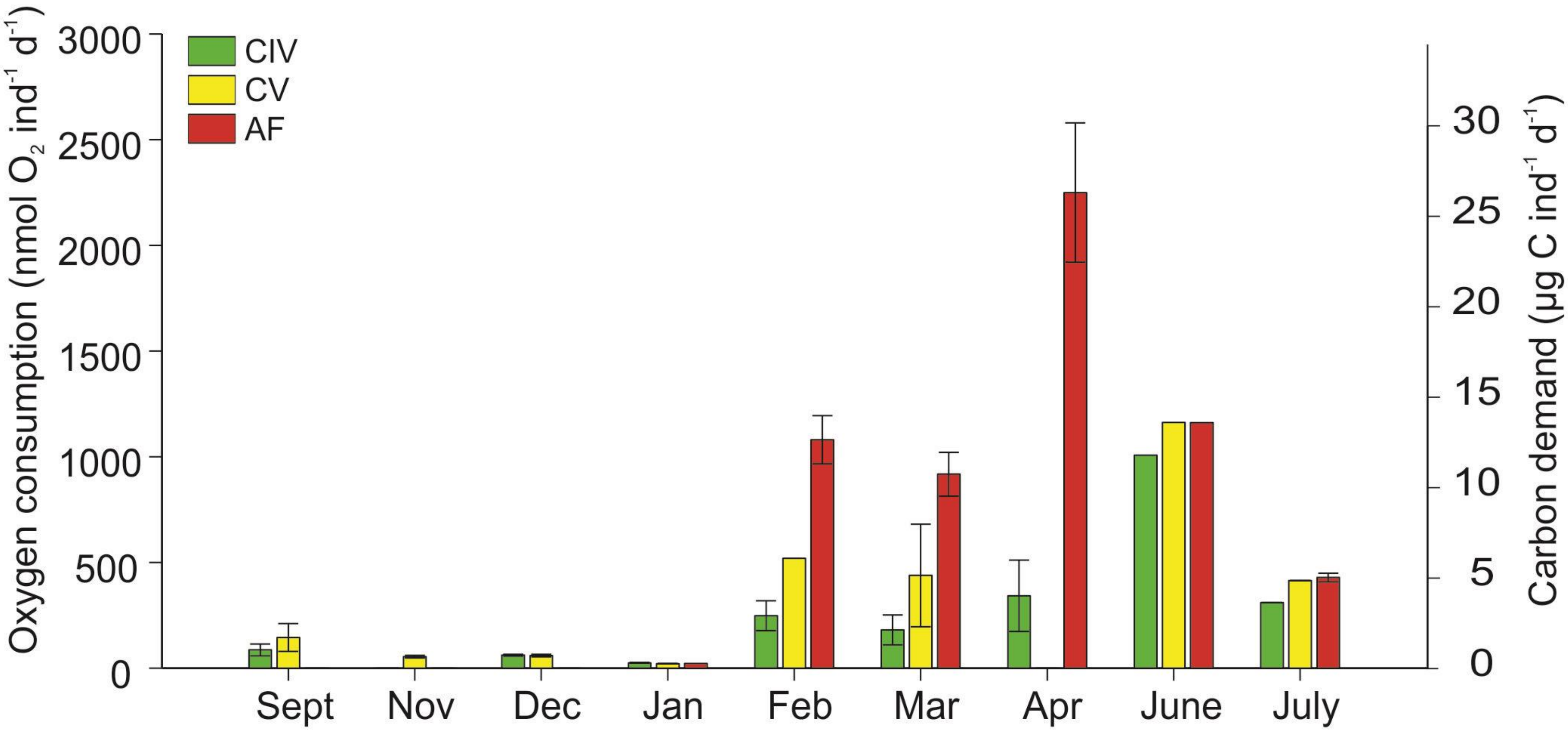
The season in Billefjorden: variability in lipid content



The season in Billefjorden: mean lipid, dry weight and C content



Seasonal oxygen consumption



Carbon demand: does it add up?

Carbon demand during overwintering (Sept-April)

			average	average
μg C ind^{-1} d^{-1}	min	max	Sept-Jan	Feb-April
AF	0.25	26.18		16.48
CV	0.25	6.05	0.81	5.58
CIV	0.29	3.98	0.5	2.99

Southeastern Beaufort Sea
Females:
March: 4.8 to 7.2 μg C ind^{-1} day^{-1}
May: 14.4–21.6 μg C ind^{-1} day^{-1}

(Seuthe et al. 2007)

Carbon demand: does it add up?

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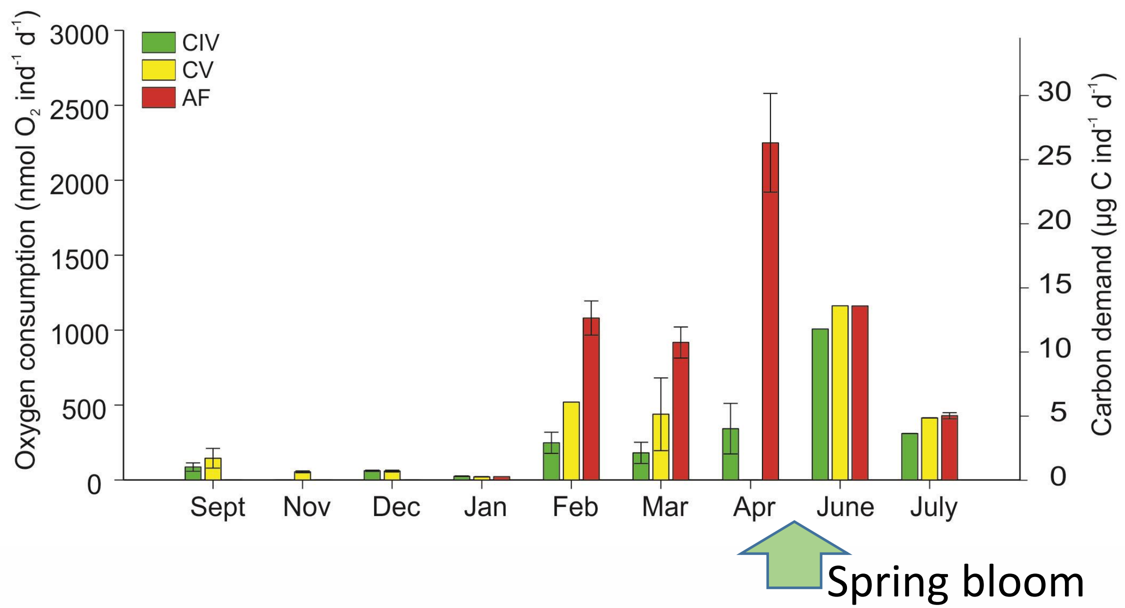
How long will carbon last?

		# of days that Carbon may last			
	μg C lipid ind^{-1} (Autumn max.)				
AF	210				
CV	190				
CIV	45				

Carbon demand: does it add up?



Adult female and CV:
⇒ enough lipid stores to survive winter as long as respiration remains low
⇒ Lipid stores may not be sufficient enough to deal with increase carbon demand when the light returns
⇒ especially **females** will need external energy sources to fuel maturation, egg production

CIV: does not deplete lipid stores throughout winter, metabolism remains low

Food-Light experiment

Set up:

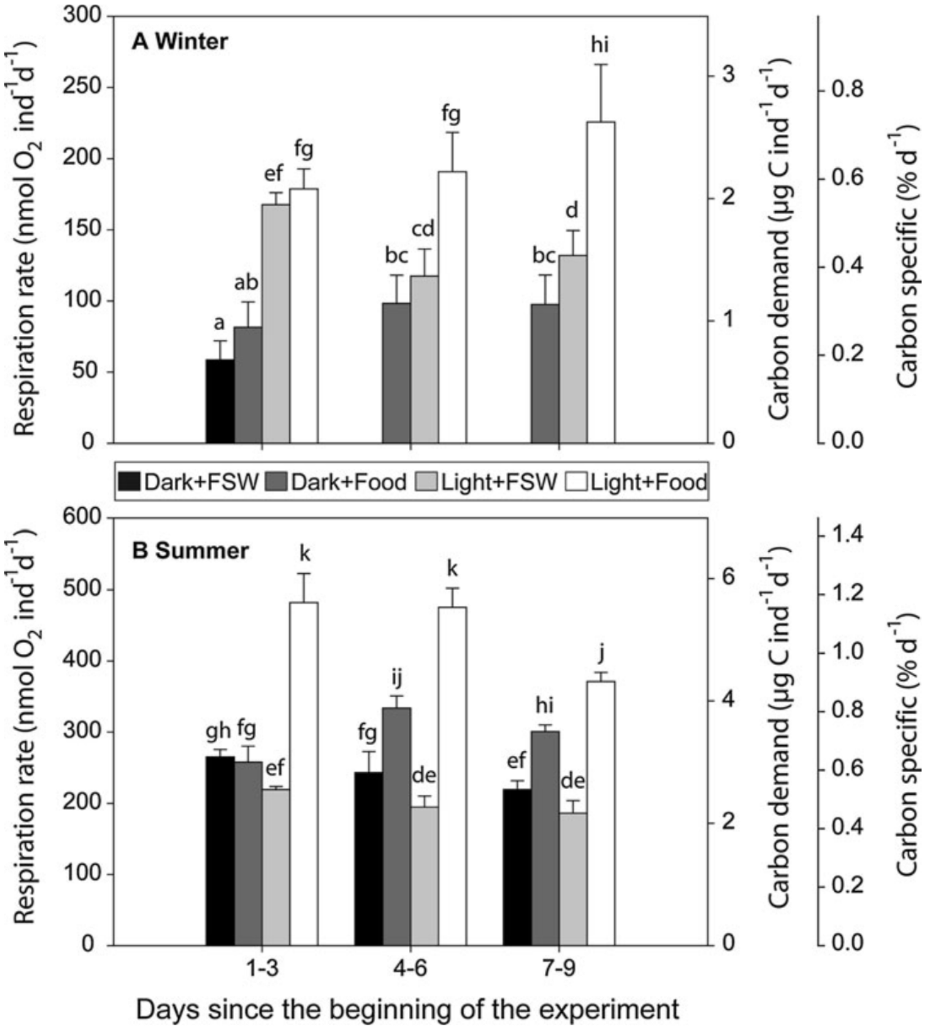
- CV in dormancy (November) vs active (July)
- Metabolic response to presence and absence of food under different light regimes (light vs dark)

Winter:

- In situ respiration 3x lower
- **light was main factor to increase metabolism**
- **metabolism remained only high if food was present**

Summer:

- combined effect of light and food increased respiration
- Food seemed more important
- Metabolism decreased with time if food was absence



Morata and Søreide 2013 Polar Biology

Summary

- Population size decreases sharply during winter
  - Predation?
  - Not enough energy stores?

- Overwintering population emerges from depth already in February (light, but no food)
- Low oxygen demand in autumn
- Increase oxygen demand for CV and AF in Feburay when light returns
- Decrease in lipid, dry weight and carbon during winter for CV & AF - but not CIV

⇒ **CV and AF** have large enough lipid stores to survive winter, but not fuel increased carbon demand at end of overwintering

⇒ external energy supply needed for maturation and egg production

⇒ **CIV** does not deplete lipids and metabolism remains low throughout winter

=> only stage in real diapause?

Acknowledgements

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