


Image: Callum Whyte (SAMS)

# Chronobiology of changing Arctic Sea Ecosystems (CHASE) 2018-2021

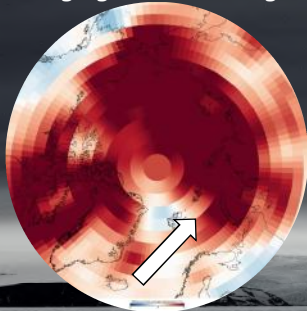
NERC CAO Annual Science Meeting, Birmingham  
15<sup>th</sup> - 17<sup>th</sup> Jan. 2019

Kim S. Last (SAMS)  
Bettina Meyer (Oldenburg/AWI)



The slide features a dark background with a landscape image of a snowy, mountainous Arctic region. The text is centered and white. At the bottom, there are two logos: 'Changing Arctic Ocean NERC' and 'NERC SCIENCE OF THE ENVIRONMENT'.


### Changing thermal ranges



NOAA Climate.gov  
Temperature anomalies, 2010-11.

But...

### Constant day-lengths



Berge, J *et al.* 2015. *Prog. Ocean*,  
Photoperiodic regime during mid-winter.

... so we have a thermal / photoperiodic mismatch.

The slide contains two circular maps of the Arctic region. The left map shows temperature anomalies with a color scale from blue (cooler) to red (warmer), with a white arrow pointing to a red area. The right map shows photoperiodic regime with a color scale from blue (shorter days) to yellow (longer days), with a white arrow pointing to a blue area. The text 'But...' is placed between the two maps. The background is a dark landscape image.

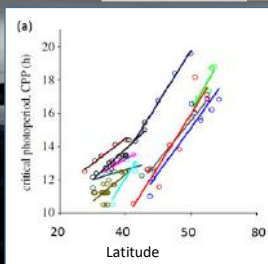
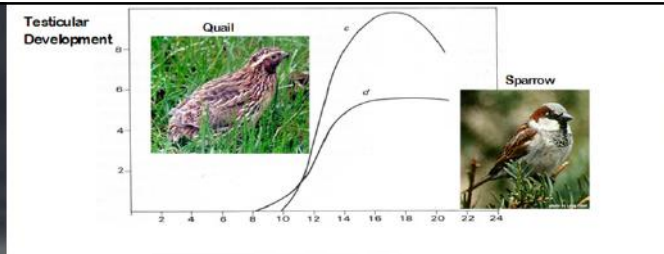
So what?



"As marine organisms track isotherms there will be trade-offs between latitudes of favourable temperature and potentially unfavourable day-length (photoperiod)"

Image: <http://maricult.com>

So what?

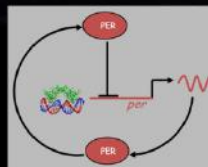


Hut et al., 2013 Proc. Roy. Soc. B

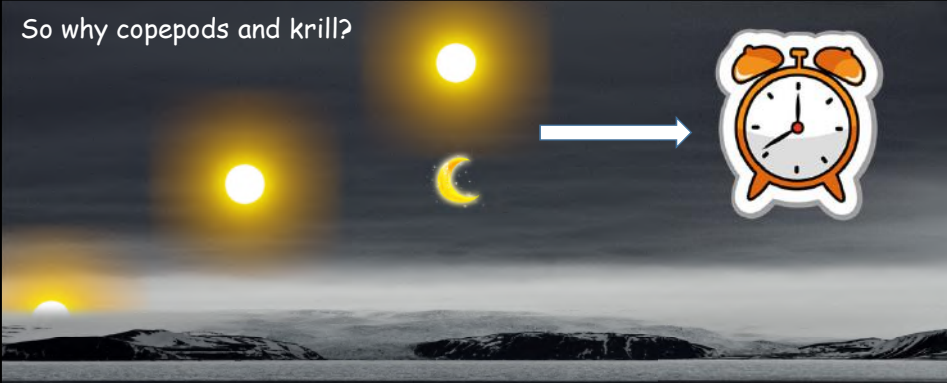


Thermal year	Photic year	Fitness of northern populations ( $R_y$ )
North	North	+47%
South	North	
South	South	-88%

Bradshaw and Holzapfel 2017 Adv. Gen.



So why copepods and krill?

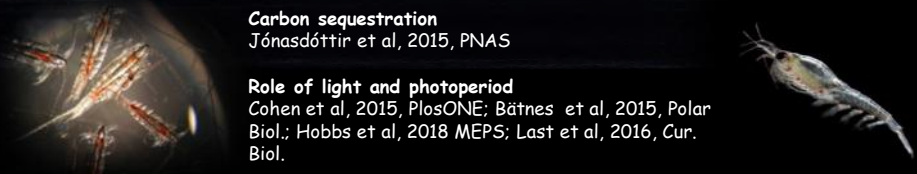


**Base of food chain - fish + seals + polar bears**

**Carbon sequestration**  
Jónasdóttir et al, 2015, PNAS


**Role of light and photoperiod**  
Cohen et al, 2015, PlosONE; Bättnes et al, 2015, Polar Biol.; Hobbs et al, 2018 MEPS; Last et al, 2016, Cur. Biol.

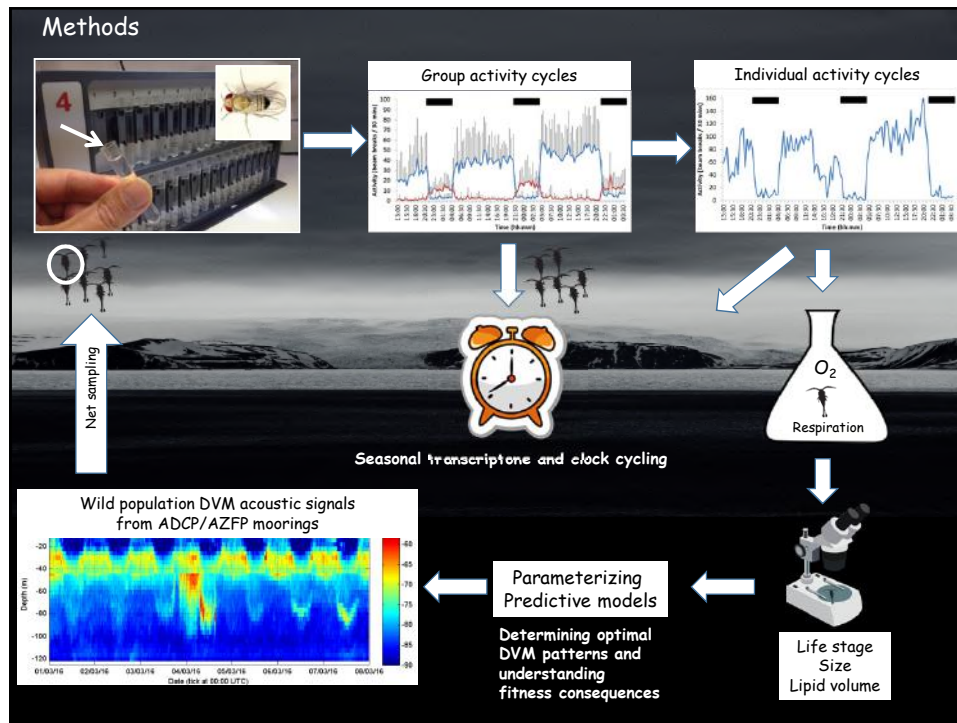
**Role of circadian clock and entrainment**  
Häfker et al. 2017 Curr. Biol.; Häfker et al. 2018 L&O; Teschke et al, 2011. PlosONE.



## Overarching hypothesis

"Circadian clock rhythmicity, which determines behavioural and physiological responses in copepods and krill, will be disrupted by a changing environment, altering Arctic ecosystem function."





Three NERC CAO cruises with Arctic PRIZE have resulted in:

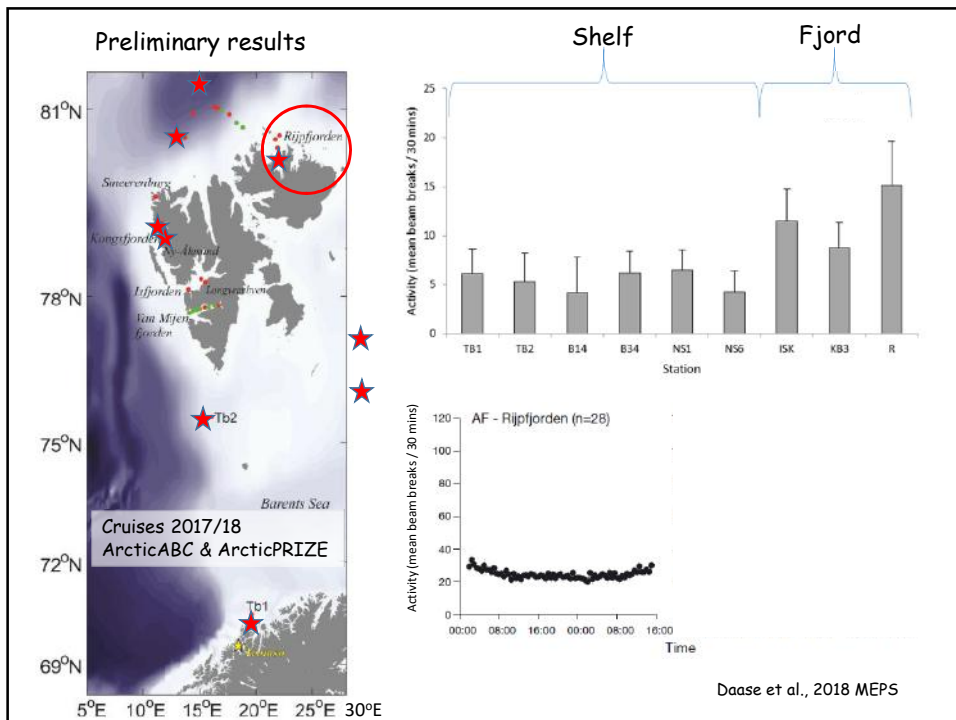
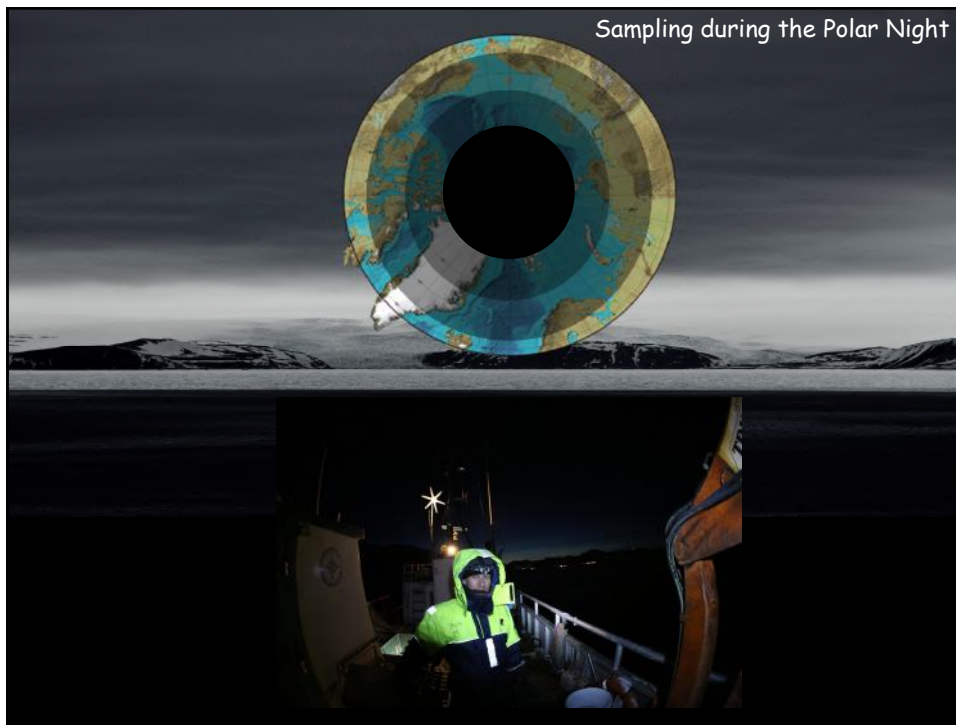
Behavioural / respiration experiments (*Calanus* spp.)

- Measured individual swimming behaviour and respiration under ambient photoperiod / temp conditions in Jan, April and June.
- Photoperiod manipulation experiments in April and June to light/dark (LD) treatments: DD, LD6:18, LD12:12, LD18:6, LL.

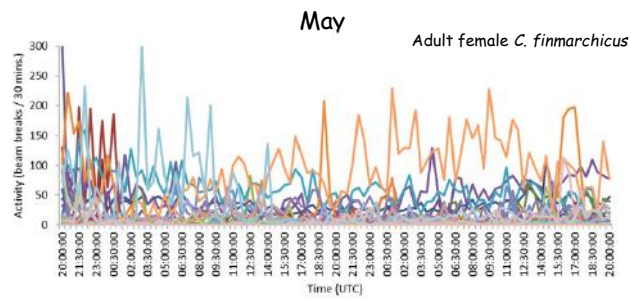
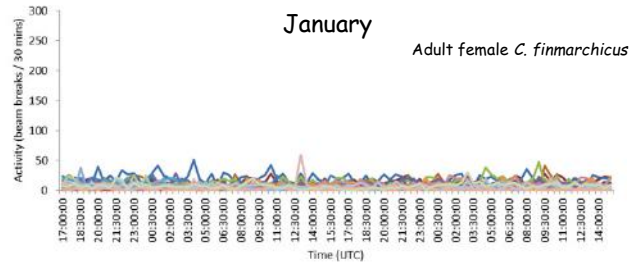
Over the three cruises 3161 animals were behaviourally screened with 960 individual respiration incubations.

Gene expression analysis (*Calanus* spp. and *T. inermis*)

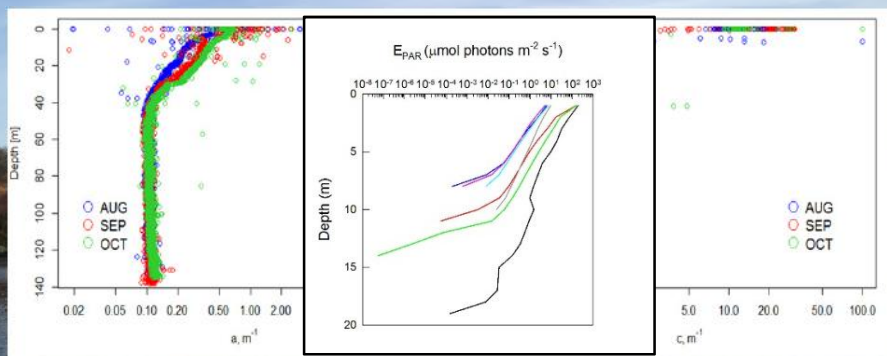
- Sampled animals over multiple 24 hour time courses (every 4 hours) for clock gene expression in April and June (*Calanus* spp.) and day/night (*T. inermis*).
- Sampled animals in April and June for seasonal transcriptome analysis.



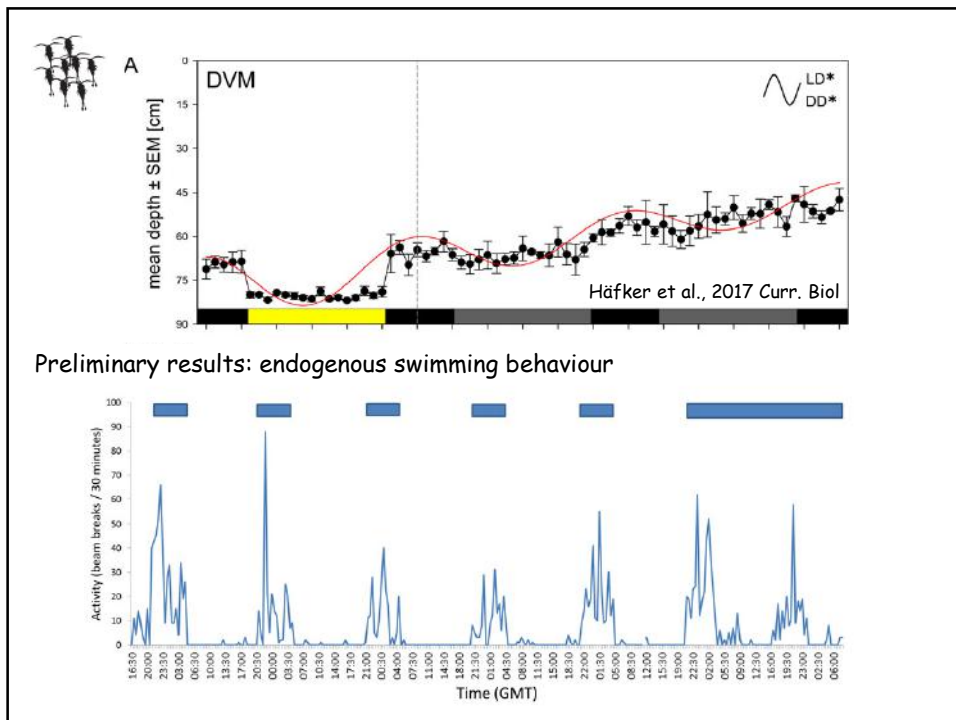
Preliminary results: swimming activity in constant darkness

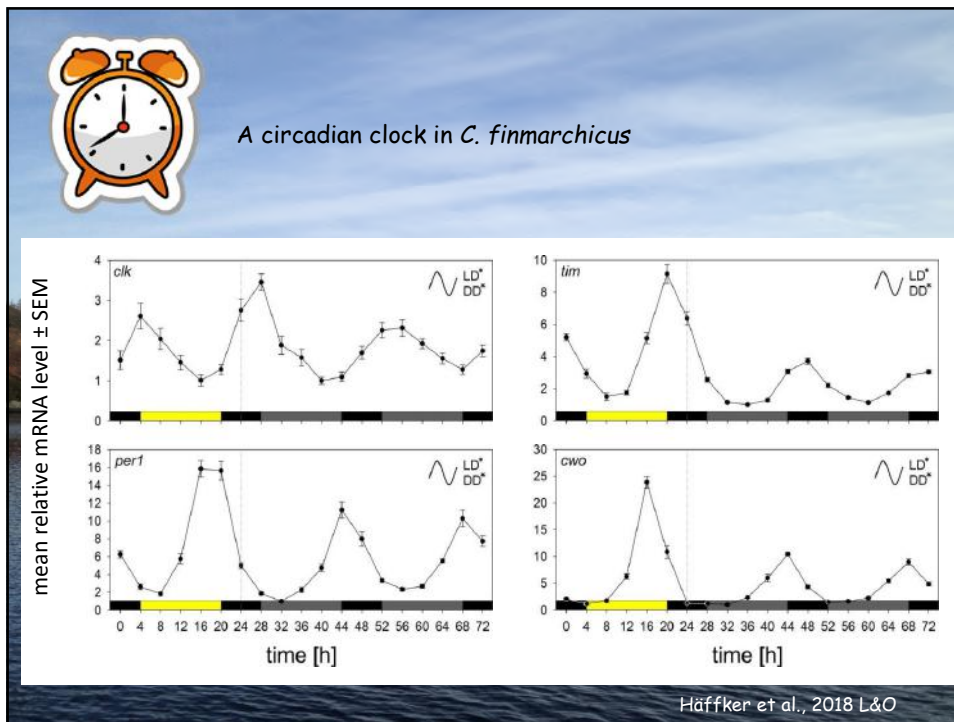
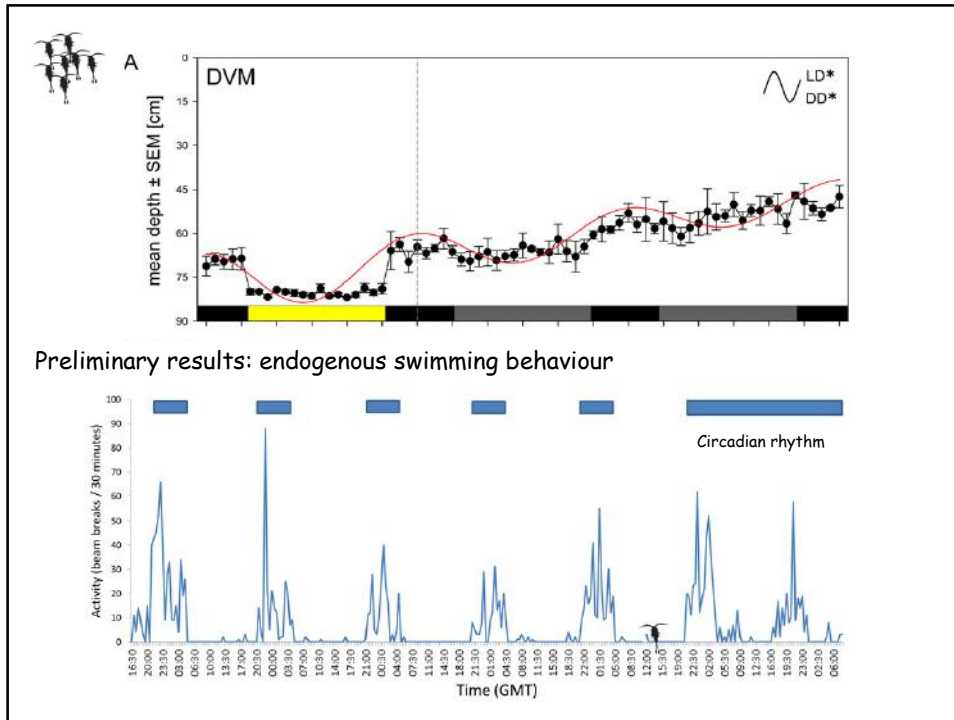


Loch Etive

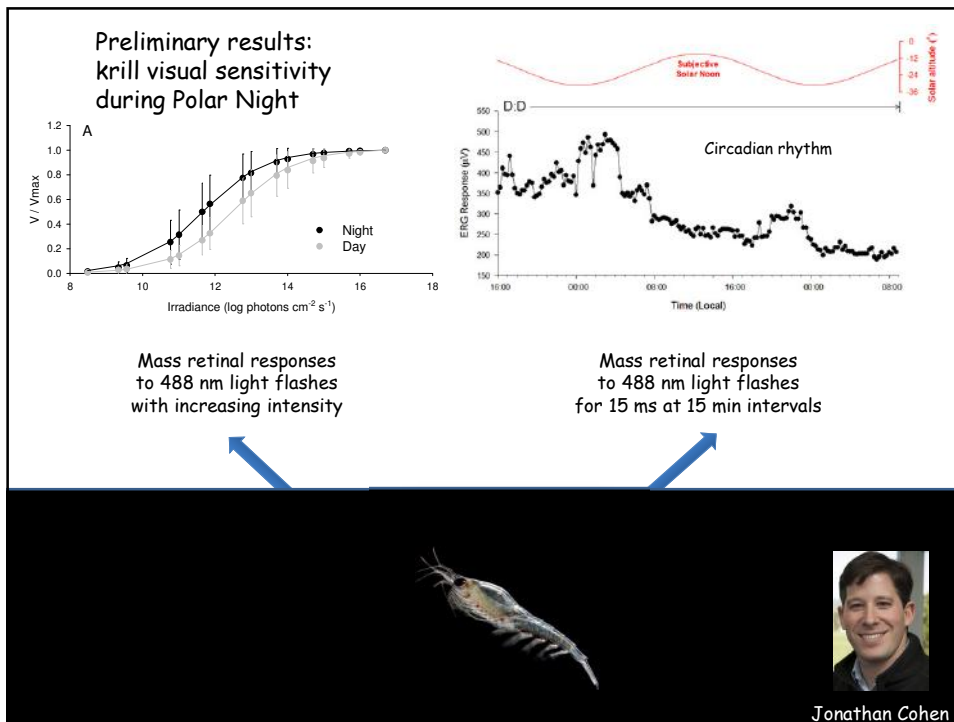
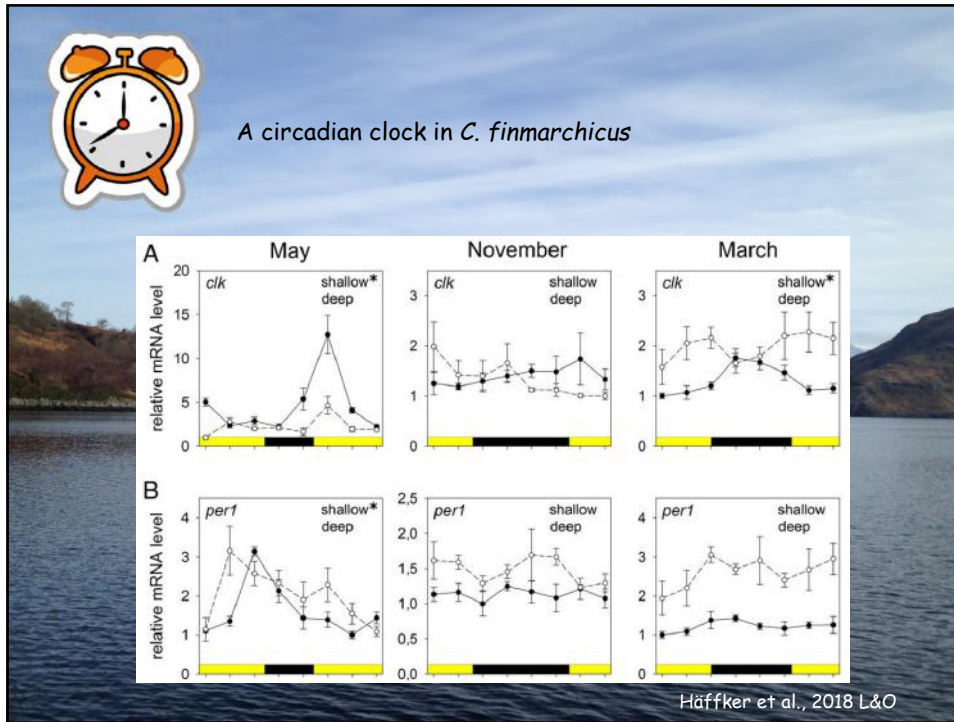


Seasonal optics profiles with an AC-S *in situ* spectrophotometer. Absorption (*a*) and beam attenuation (*c*) profiles are consistent with a stratified water column over the study period.











## The CHASE Team

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**Biophysical coupling**  
 Finlo Cottier (SAMS) - PI PRIZE  
 Chelsey McGowen-Yallop (PhD SAMS)

**Light and biology**  
 Jonathan Cohen (Delaware)

**Behaviour and physiology**  
 Kim Last (SAMS)  
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**Clock genes / biology**  
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