The unique life cycle of Antarctic krill: Adaptations to a high latitude environment

Bettina Meyer[1], Mathias Teschke[1], Alberto Biskontin[2], Cristiano Depitta[2], Rodolfo Costa[2,], So Kawaguchi[3]

[1]Alfred Wegener Institute, Bremerhaven, Germany
[2]University of Padua, Padua, Italy
[3]Australian Antarctic Division, Kingston, Tasmania, Australia

Content

Introduction

- Synchronisation of physiological function of krill to the seasonal environment.
- A Molecular clock as driver for important life cycle functions in organisms.

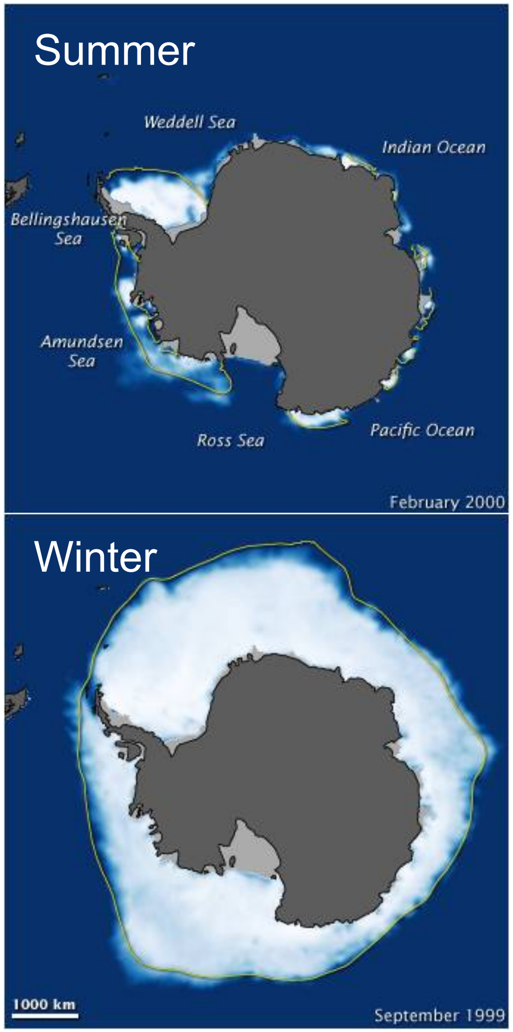
Results

- The importance of photoperiod vs. food as "Zeitgeber" to adjust an endogenous clock in krill.
- The molecular clock machinery in krill.

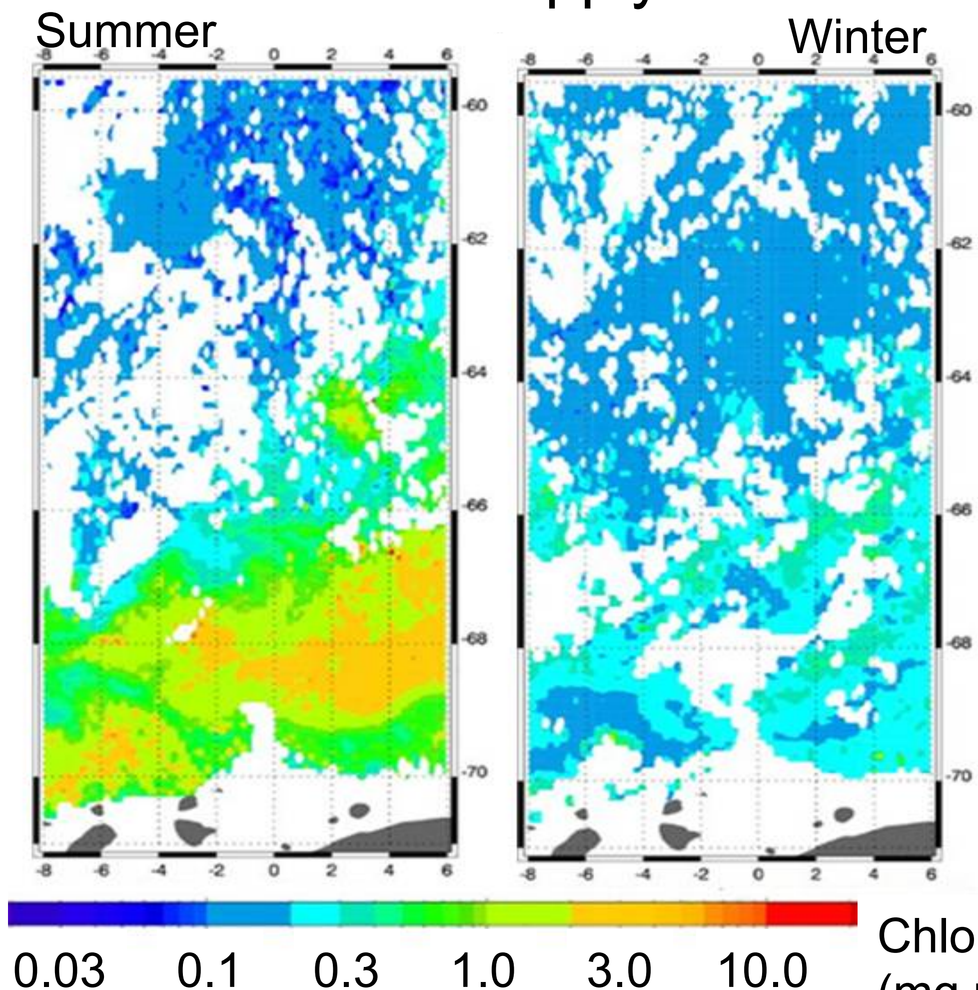
Summary

INTRODUCTION: Synchronisation of krill to the seasonal environment

Sea ice extent

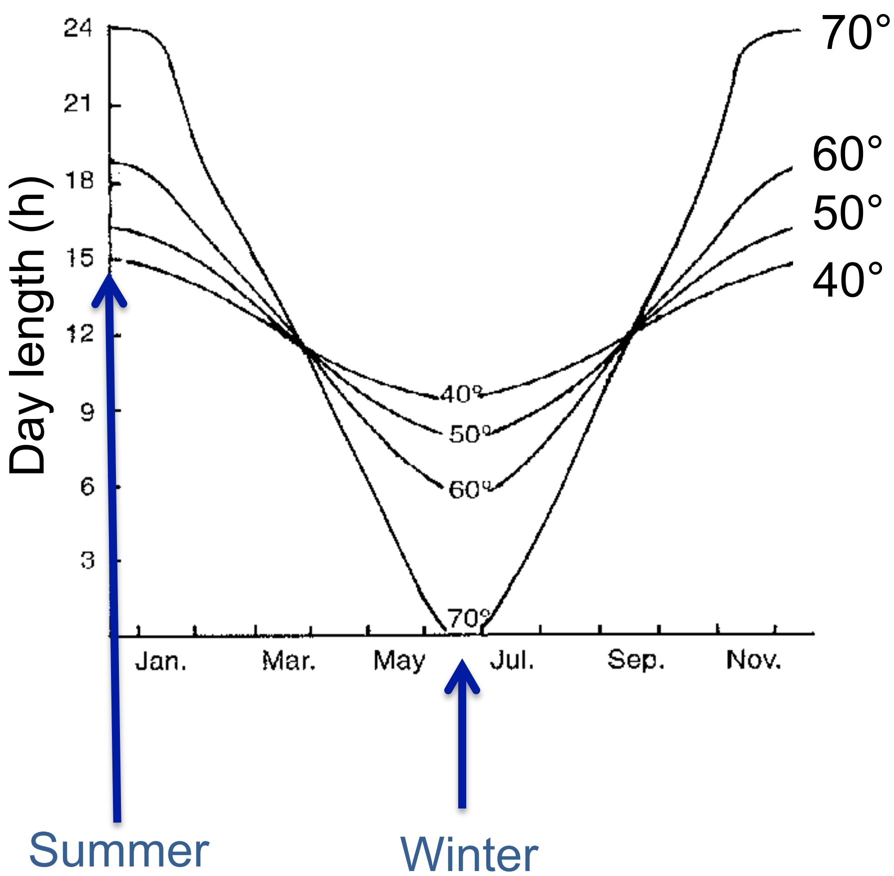


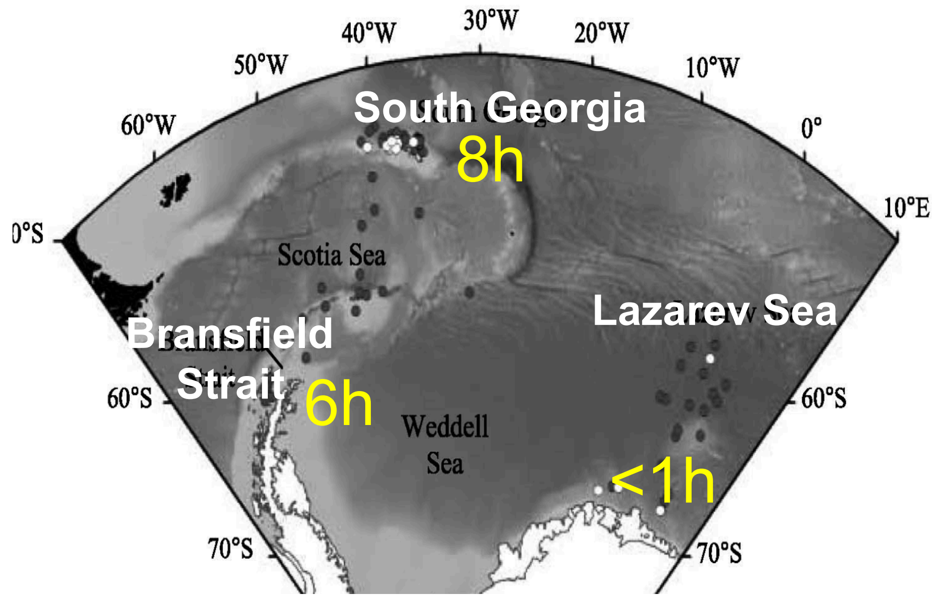
Food supply



Chlorophyll a ($mg\ m^{-3}$)

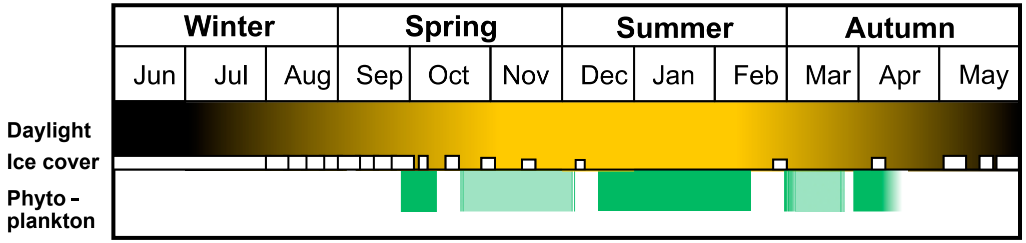
Seasonal photoperiod at different latitudes



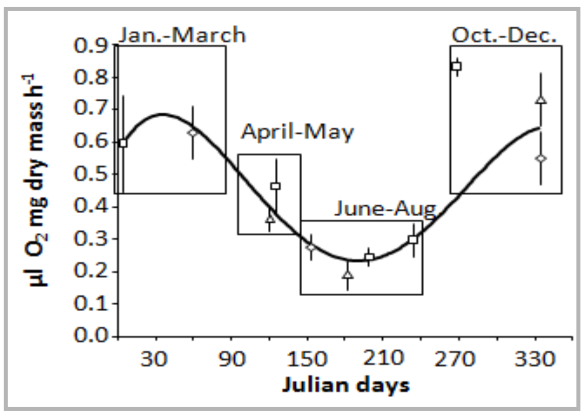


Map from Schmidt et al. 2014

Seasonal physiological functions in krill

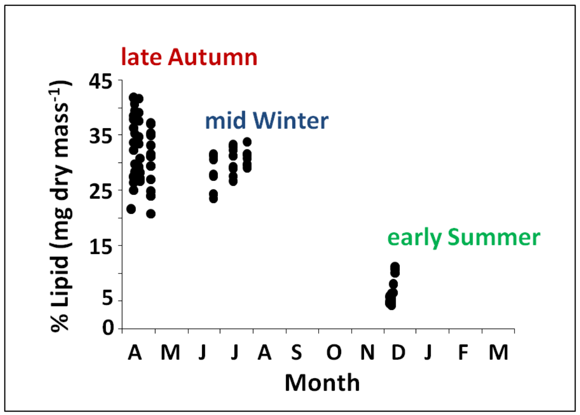


Metabolic activity



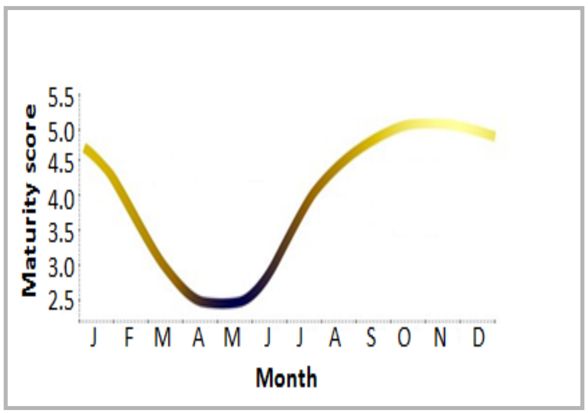
Meyer et al. 2012

Lipid dynamic



Meyer et al. 2010

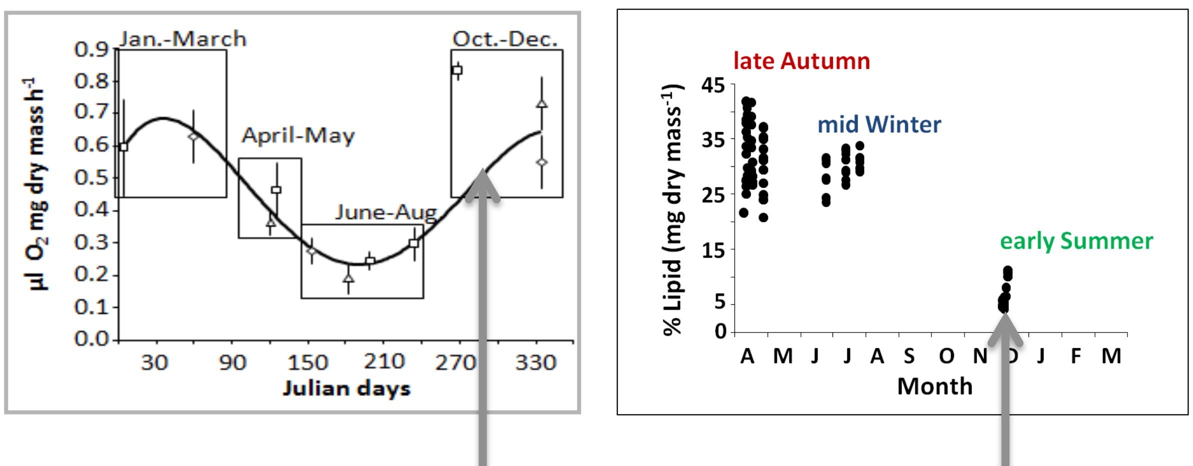
Maturity



Brown et al. 2010

- What governs the seasonal rhythmicity in krill's physiological function?
- Does an environmental cue act as stimulus for an endogenous clock machinery in krill?

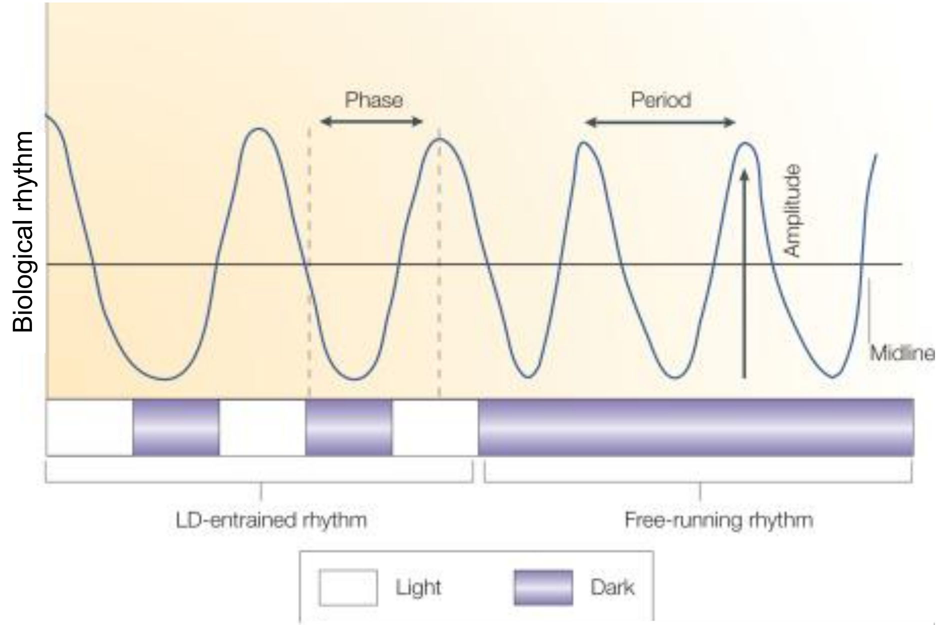
Metabolic activity



Lipid dynamic

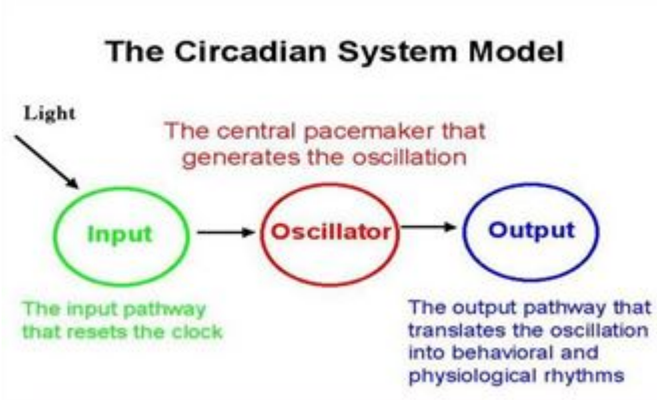
A Molecular clock

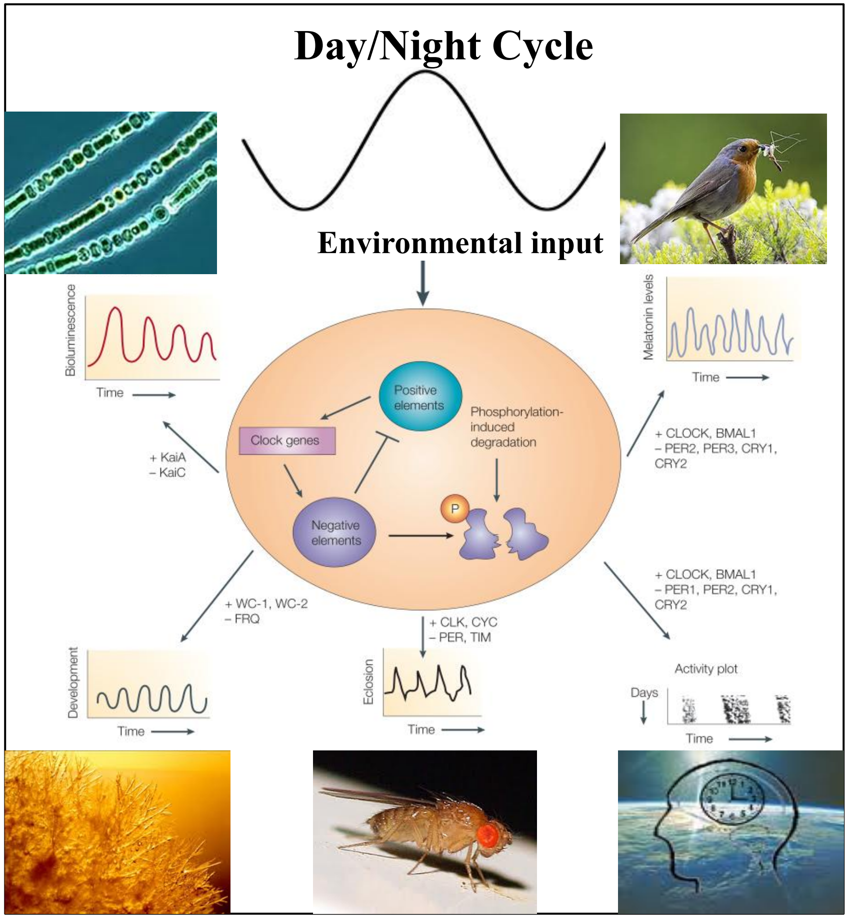
- Self-sustaining – maintain a rhythmic in absence of cues
- Occur with approximately the same frequency such as some environmental features
- Can be entrained by environmental cues



INTRODUCTION: A Molecular clock as driver for important life cycle functions in organisms

Endogenous rhythms an the Circadian clock

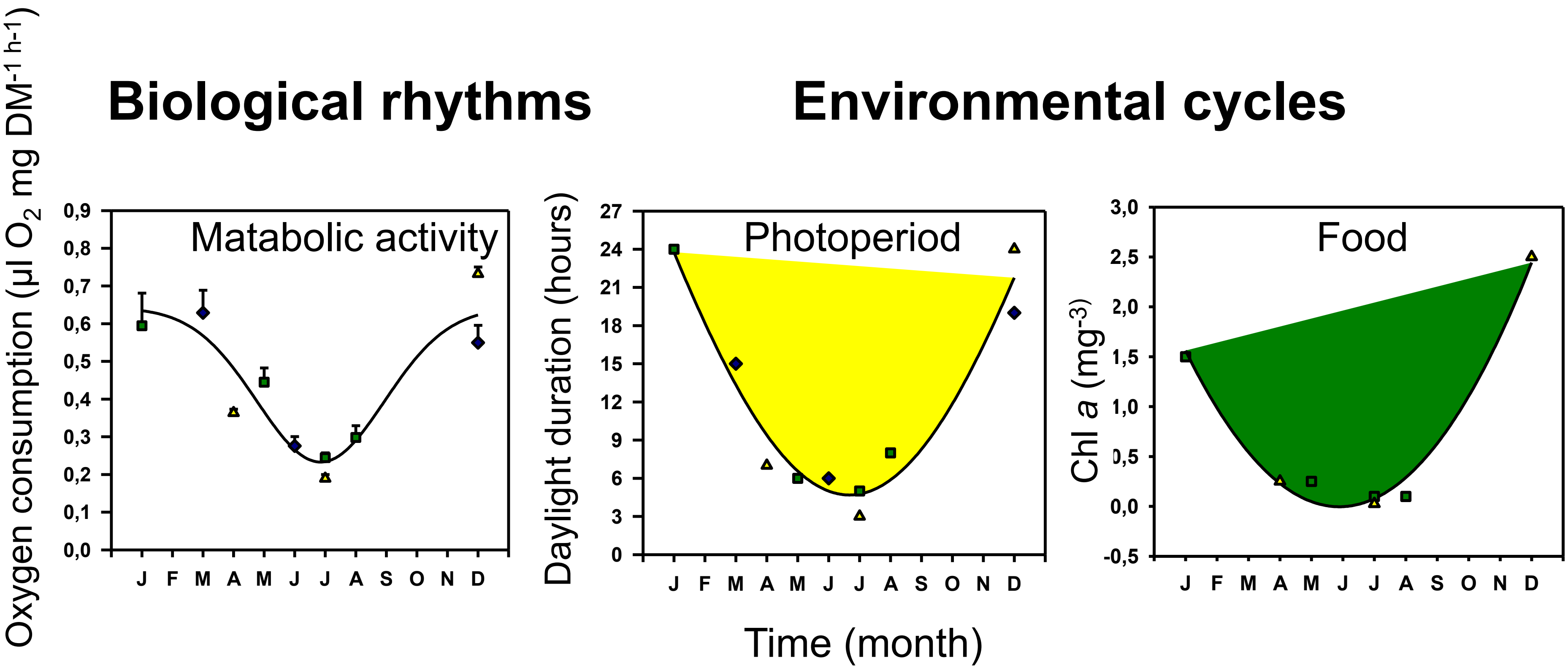




RESULTS: The importance of photoperiod vs. food as "Zeitgeber" to adjust an endogenous clock in krill

Biological rhythms

Environmental cycles



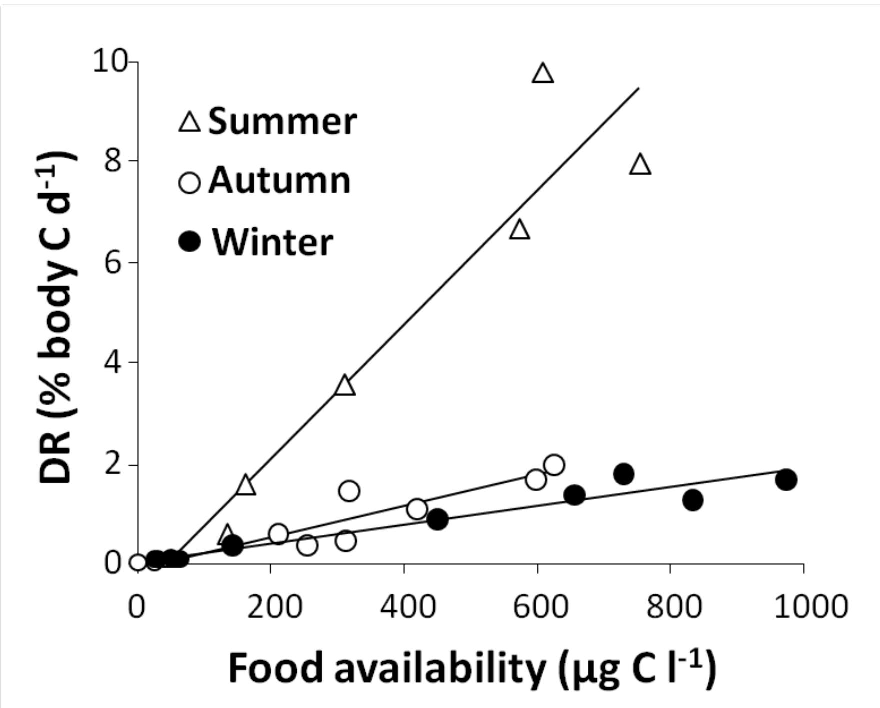
△ Lazarev Sea (Atkinson et al. 2002, Meyer et al. 2010)

■ Lütz-Holm Bay (Kawaguchi et al. 1996)

◆ Southern Scotia-Northern Weddell Sea (Torres et al. 1994)

RESULTS: The importance of photoperiod vs. food as “Zeitgeber” to adjust an endogenous clock in krill

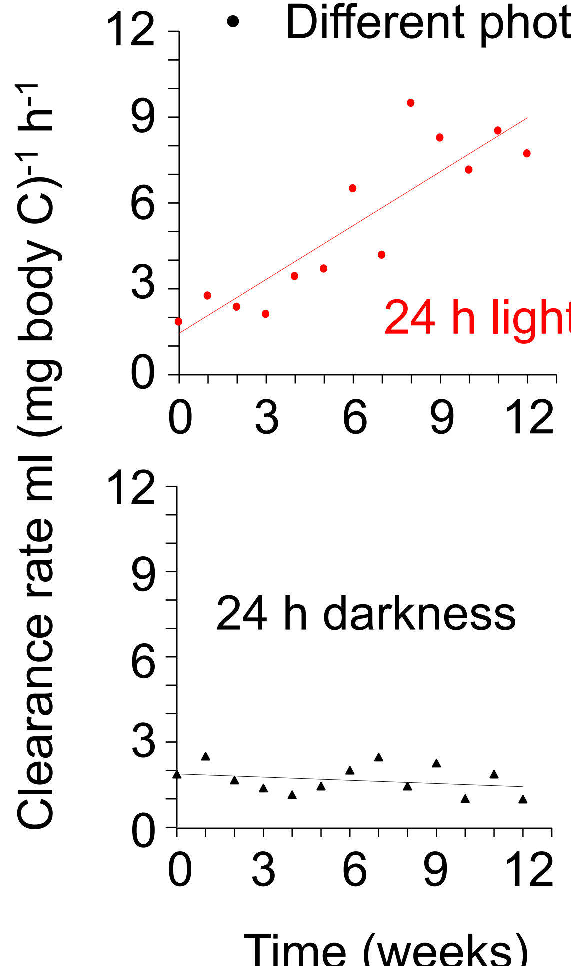
Seasonal feeding activity on board experiments at 65°S



Meyer et al. 2010

Feeding activity in lab experiments

- Constant high food
- Different photoperiod

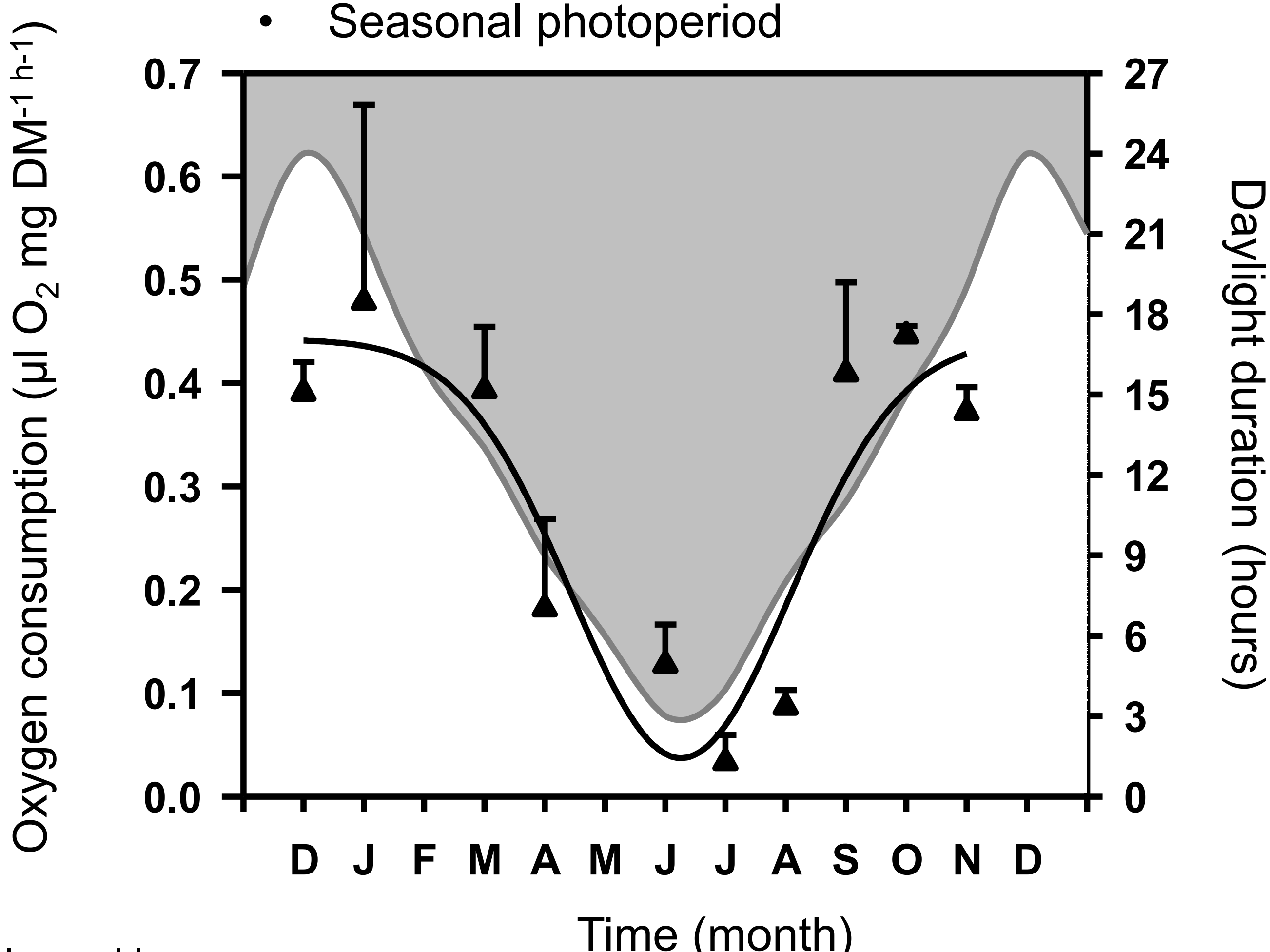


Teschke et al. 2007

RESULTS: The importance of photoperiod vs. food as "Zeitgeber" to adjust an endogenous clock in krill

Metabolic activity in lab experiments

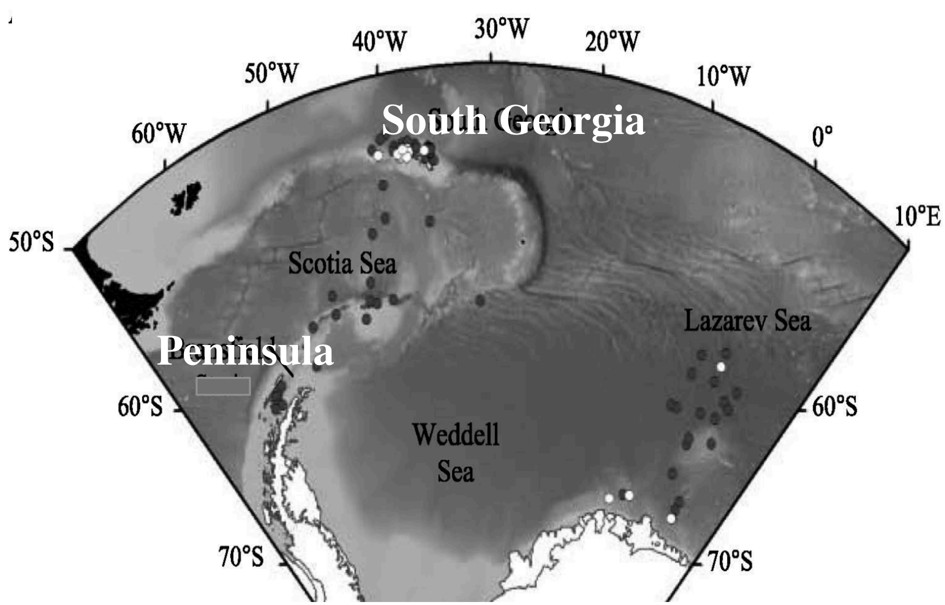
- Constant high food
- Seasonal photoperiod



Teschke et al. unpubl.

RESULTS: The importance of photoperiod vs. food as "Zeitgeber" to adjust an endogenous clock in krill

Seasonal gene expression at different latitudes (feeding, digestion, respiration, motor activity, vitellogenesis)



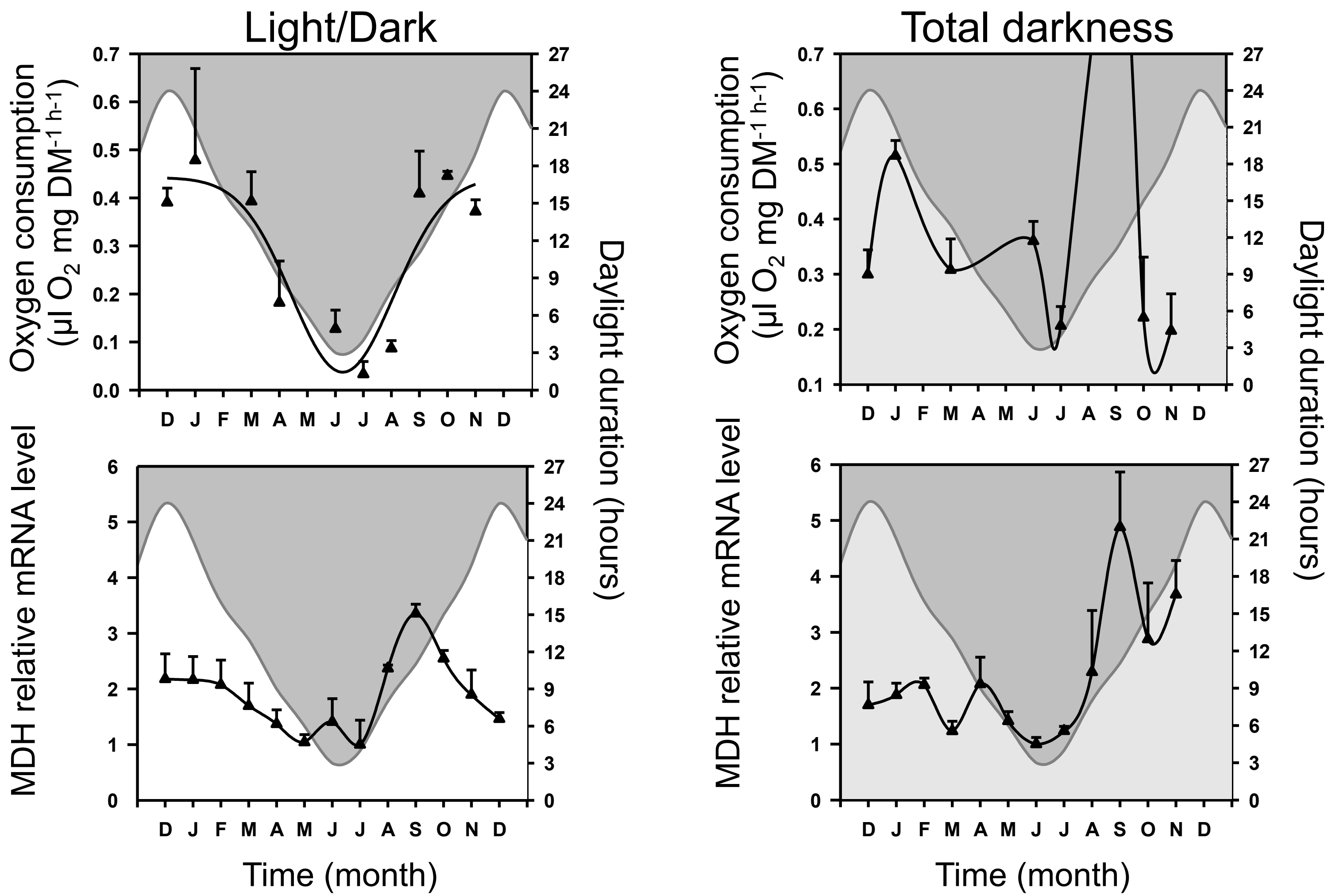
Summer and winter Chl *a* levels at both locations similar

Seear et al. 2012

Peninsula:	**Summer**	**Winter**
Feeding, Digestion, Respiration, Motor activity, Vitellogenesis	↑	↓

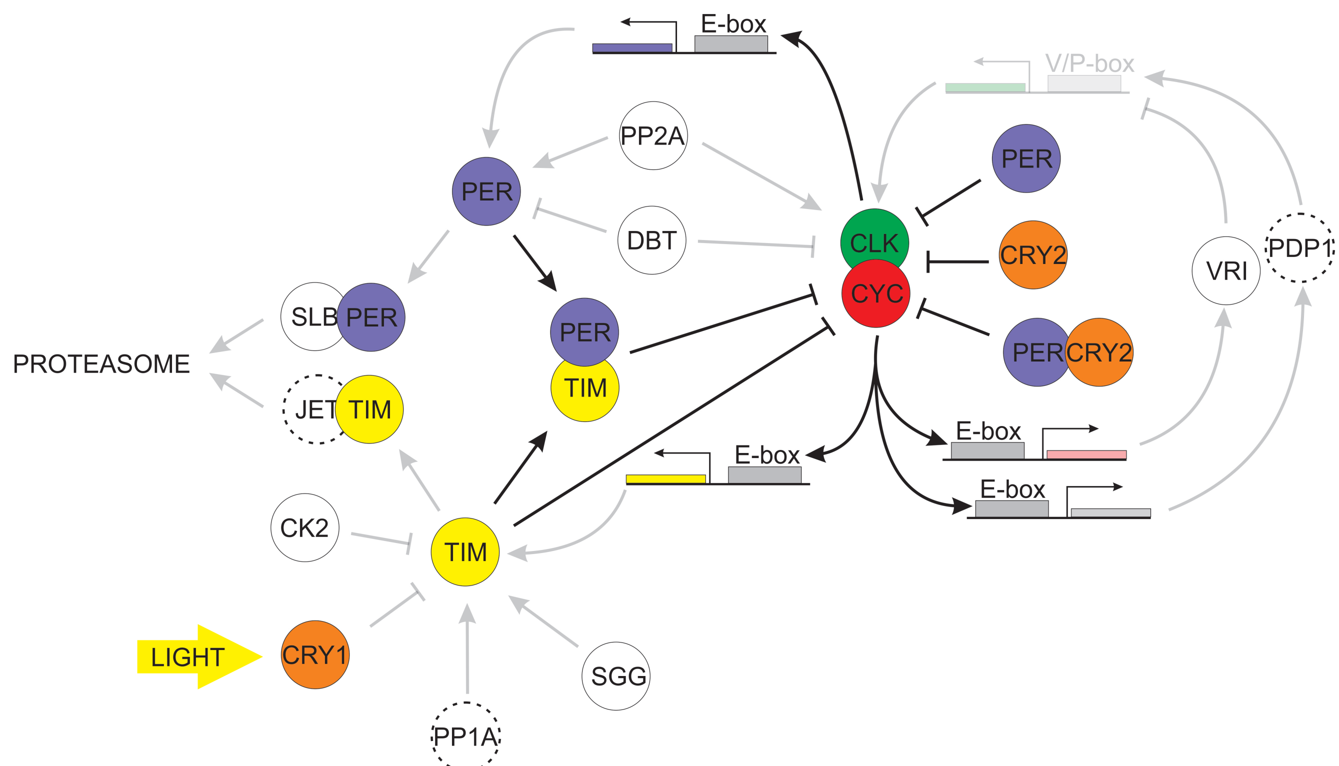
South: Georgia	**Summer**	**Winter**
Feeding, Digestion, Respiration, Motor activity, Vitellogenesis	↑	↑ ↓

Seasonal rhythms at constant high food levels but different light conditions



Teschke et al. unpubl.

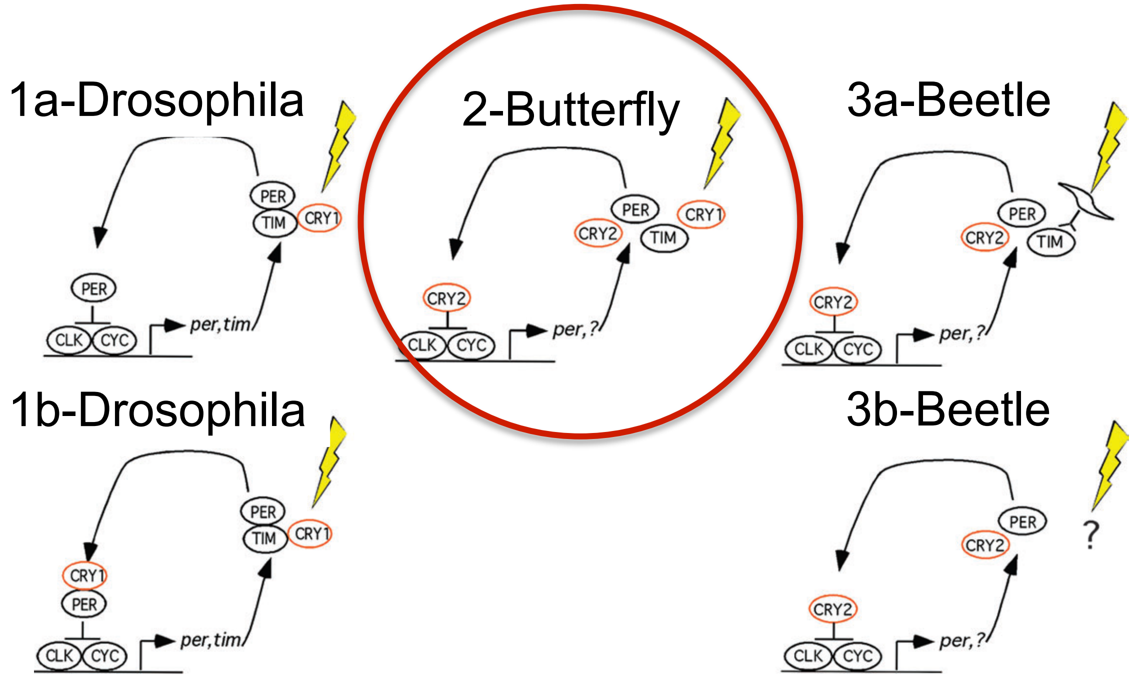
The complete coding sequence of 18 transcripts involved In the krill clock machinery were identified



Components for which a functional characterization has been performed are indicated in color (= not found yet = activation = inhibition).

Biskontin et al. unpubl.

Clockwork machinery reference models



Krill circadian oscillator seems to be a 2 cryptocromes-based system (butterfly model);

where CRY1 is involved in the synchronization of the clock through the light-mediated degradation of TIM, while CRY2 inhibits CLOCK:CYCLE-mediated transcription.

SUMMARY

- Photoperiod seem to act as important Zeitgeber for the rhythmicity of seasonal physiological functions.

- Seasonal physiological changes occur on a molecular level.

- During winter krill is in a kind of quiescent stage

- The activity of specific genes are partly flexible according to latitude.

- A molecular clock in krill is identified

- The clock machinery of krill is similar to the monarch butterfly model

- Marine chronobiology in times of climate change gets more and more attention.
- Marine chronobiology research has to be an essential part to understand and predict population shifts of pelagic key invertebrates

Current Biology

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Last et al. 2016

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Cell Rep. 2013 Oct 17; 5(1): 99–113.
doi: 10.1016/j.celrep.2013.08.031
PMCID: PMC3913041

Zantke et al. 2013

Circadian and Circalunar Clock Interactions in a Marine Annelid

Juliane Zantke,[1,2] Tomoko Ishikawa-Fujiwara,[3] Enrique Arboleda,[1,5] Claudia Lohs,[1,6] Katharina Schipany,[1,7] Natalia Hallay,[1,2] Andrew D. Straw,[4] Takeshi Todo,[3] and Kristin Tessmar-Raible[1,2,*]

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