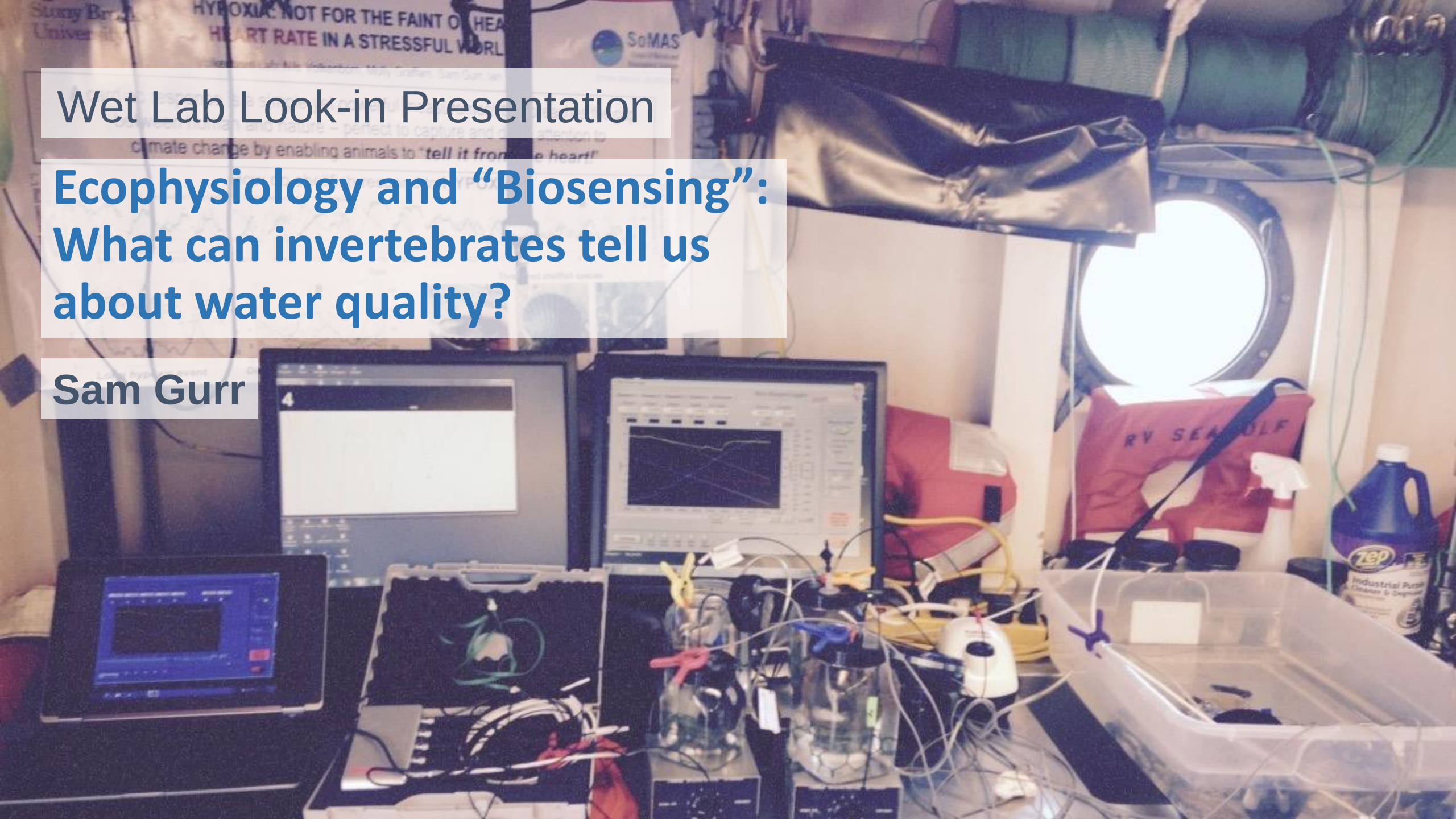


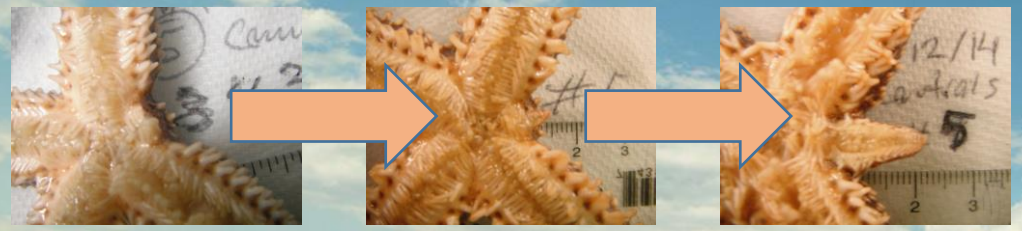
Wet Lab Look-in Presentation

Ecophysiology and “Biosensing”: What can invertebrates tell us about water quality?

Sam Gurr

Lighthouse Point
New Haven, CT

UNIVERSITY OF NEW HAVEN



Ecophysiology

Stony Brook University

AUTODESK

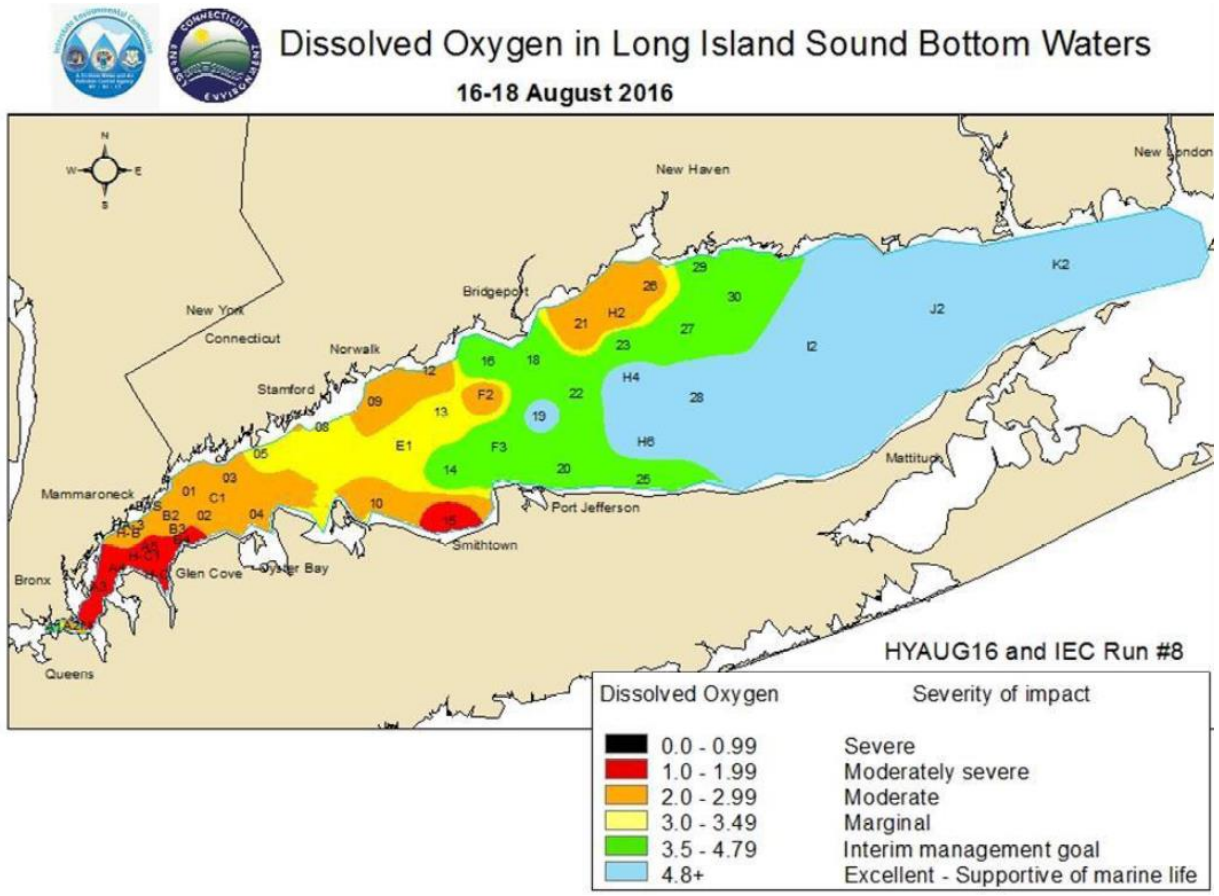
http://wshu.org/topic/connecticut-news#stream/0

The stressor: Hypoxia

Hypoxia

- Low dissolved oxygen (DO)

  <u>demand > supply</u>



The stressor: Hypoxia

Hypoxia

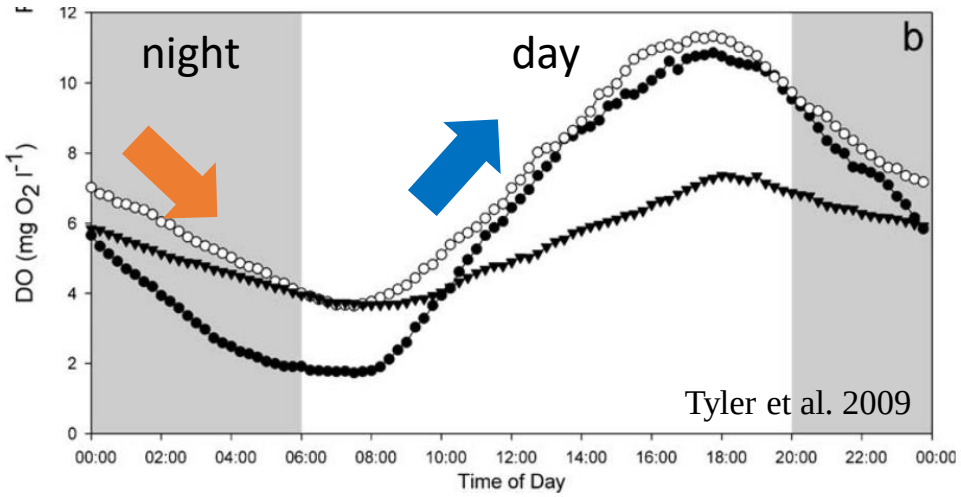
- Periods of low dissolved oxygen (DO)

demand > supply

Diel-cycling hypoxia

- Varies on a seasonal and **daily** time scale

Respiration Photosynthesis



Common effects of diel-cycling hypoxia

- mass mortality
- growth, calcification
- behavior
- early life stage development
- calcification
- immunoregulatory response

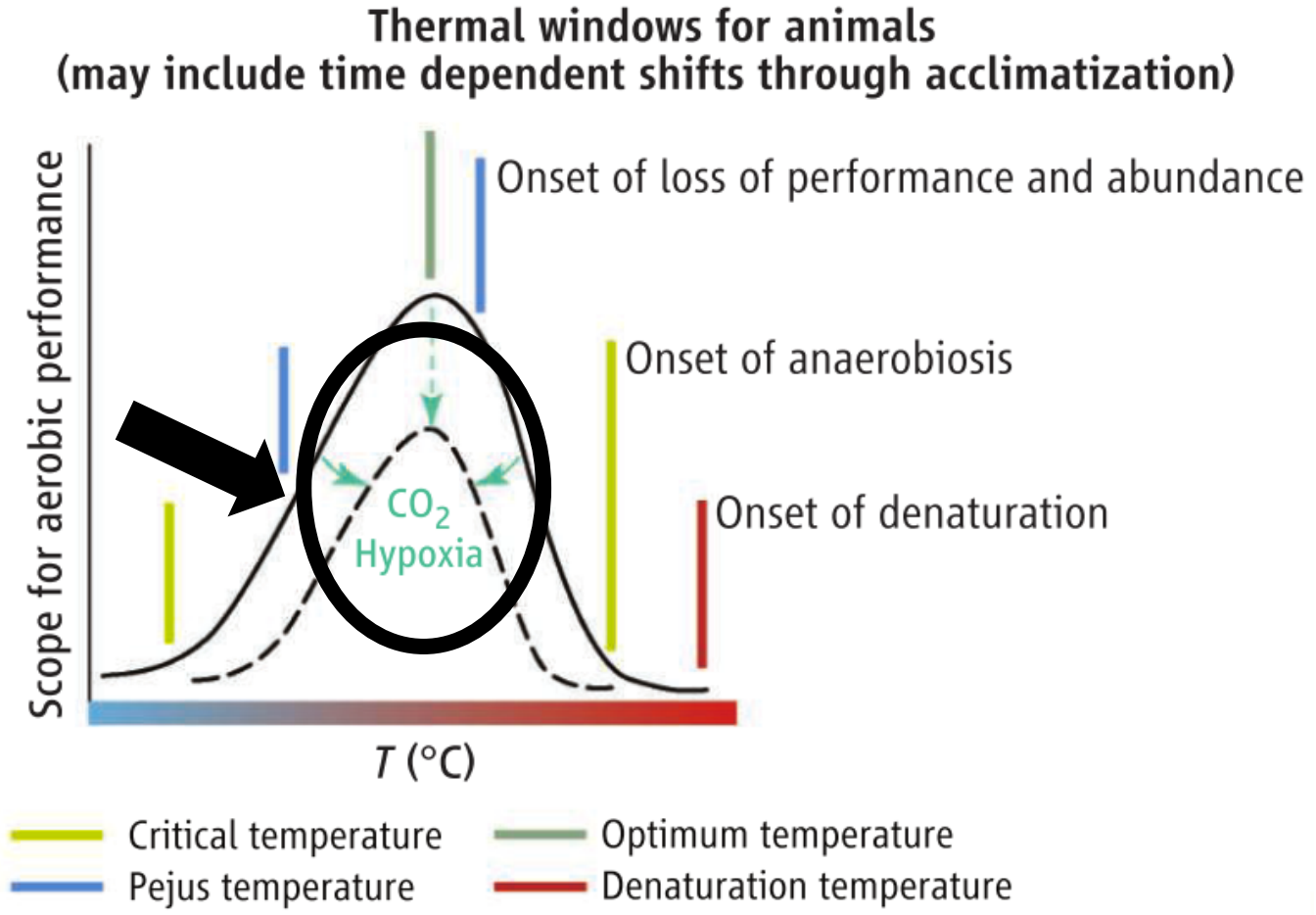
LIMITATION!
Integrate over relatively
long time scales

Physiological “windows” of optimal aerobic performance

Aerobic performance

- Respiration rate
- Cardiac activity

This window can be **narrowed** by environmental stressors



Pörtner and Farrell, 2008

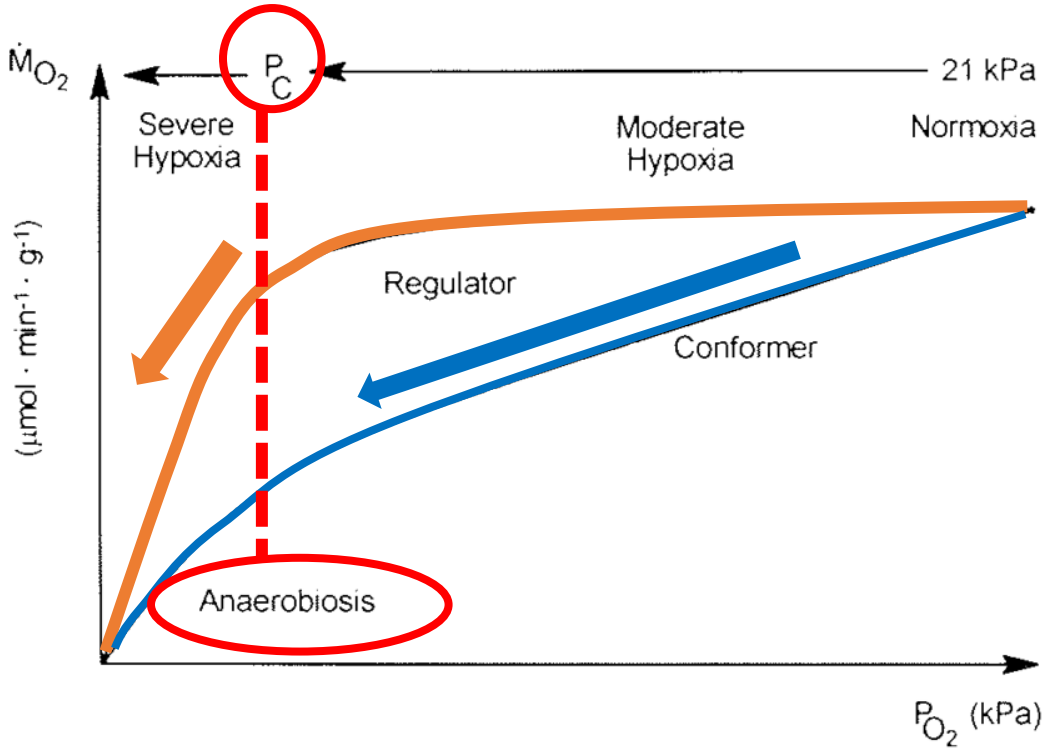
Respiration rate of marine invertebrates:
Responses to **oxygen decline and hypoxia**

Conformer VS **Regulator**

(oxyconformity) (oxyregulatory)

- Linear dependence on ambient oxygen availability
- Non-linear response
- Hits a clear transitional breakpoint at P_c

Critical P_{O_2} or P_c
onset of anaerobic metabolism

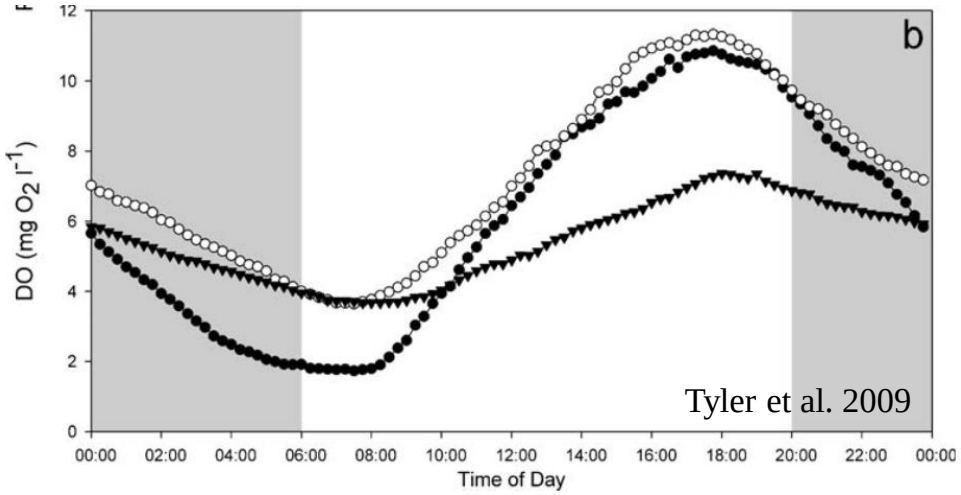


Greishaber et al. 1994

Rational

To understand and identify effects of ***dynamic environmental stressors***…

Need a dynamic response!!!



Heartbeat rate

Non-invasive Infrared sensors

Important **sub-lethal** physiological implications for whole animal metabolism

Rational

To understand and identify effects of ***dynamic environmental stressors***…

Need a dynamic response!!!

Common effects of diel-cycling hypoxia

- mass mortality
- growth, calcification
- behavior
- early life stage development
- calcification
- immunoregulatory response

Heartbeat rate

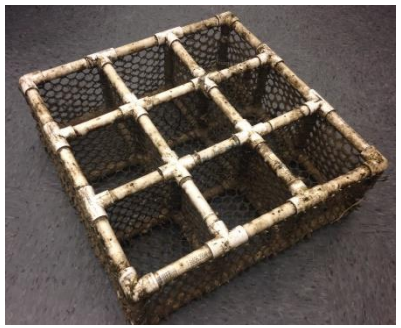
Non-invasive Infrared sensors

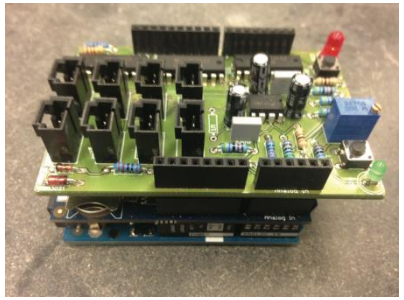
Important **sub-lethal** physiological implications for whole animal metabolism

Methods

?

1. *A. irradians* alters cardiac activity under exposure to *in-situ* diel-cycling dissolved oxygen

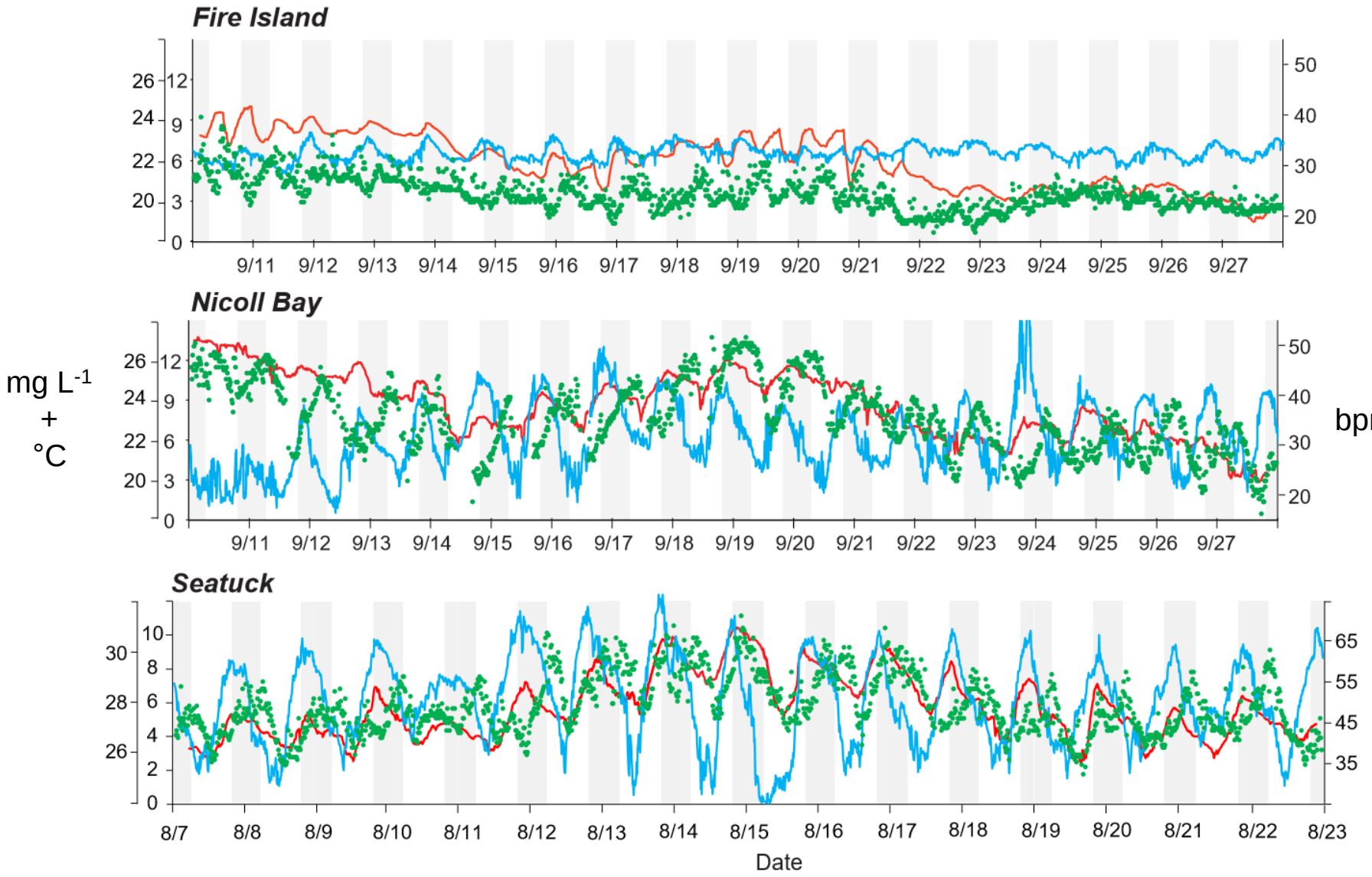




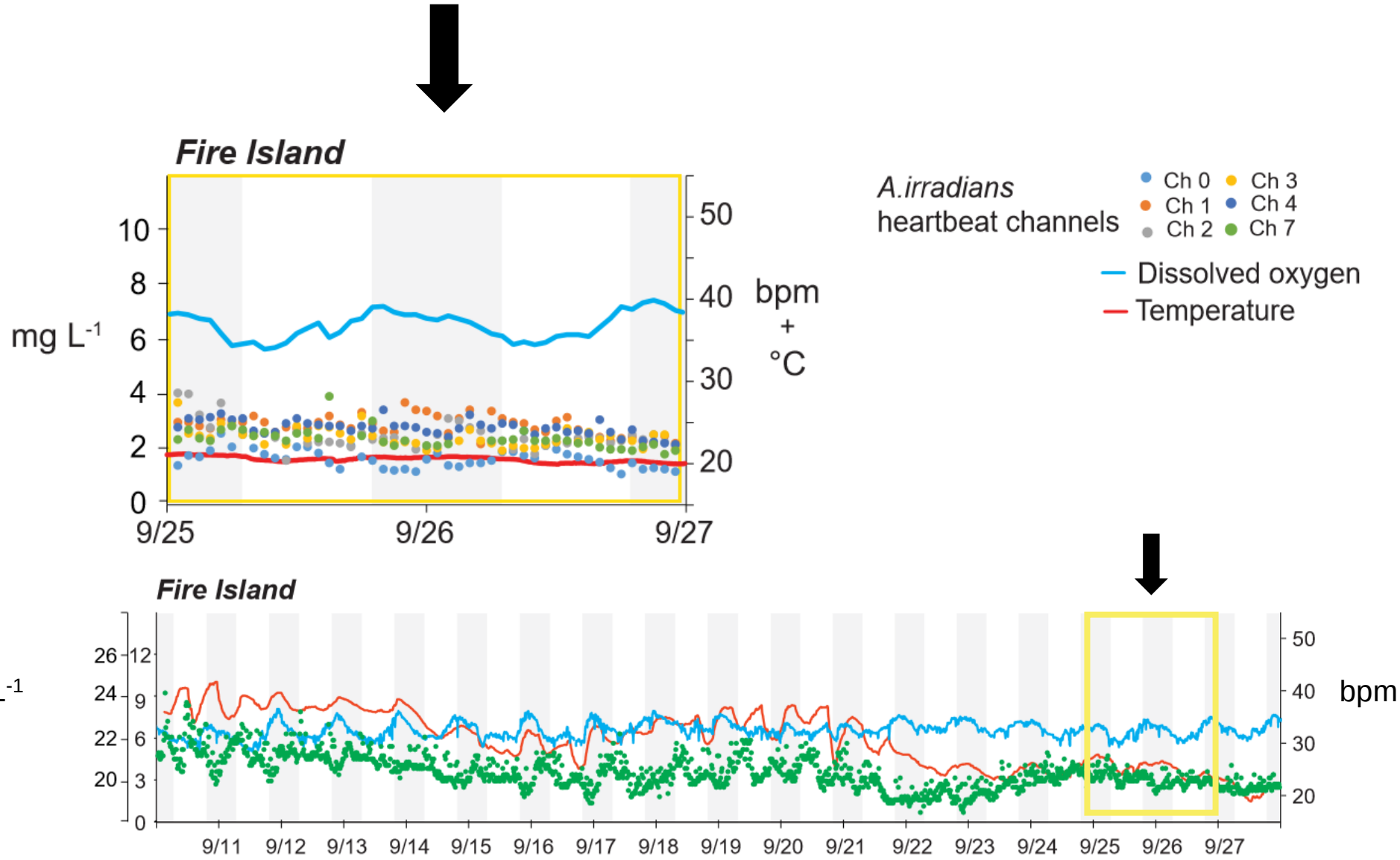
- 8 *A. irradians* per site
- 60 seconds of heartbeat data for each individual, cycle **repeated every 10 minutes**
- DO and temperature recorded every 15 minutes, Long Island Water Quality Index program

In-situ Heartbeat Deployments

- *A.irradians* heartbeat (bpm)
- Dissolved oxygen (mg L^{-1})
- Temperature (°C)



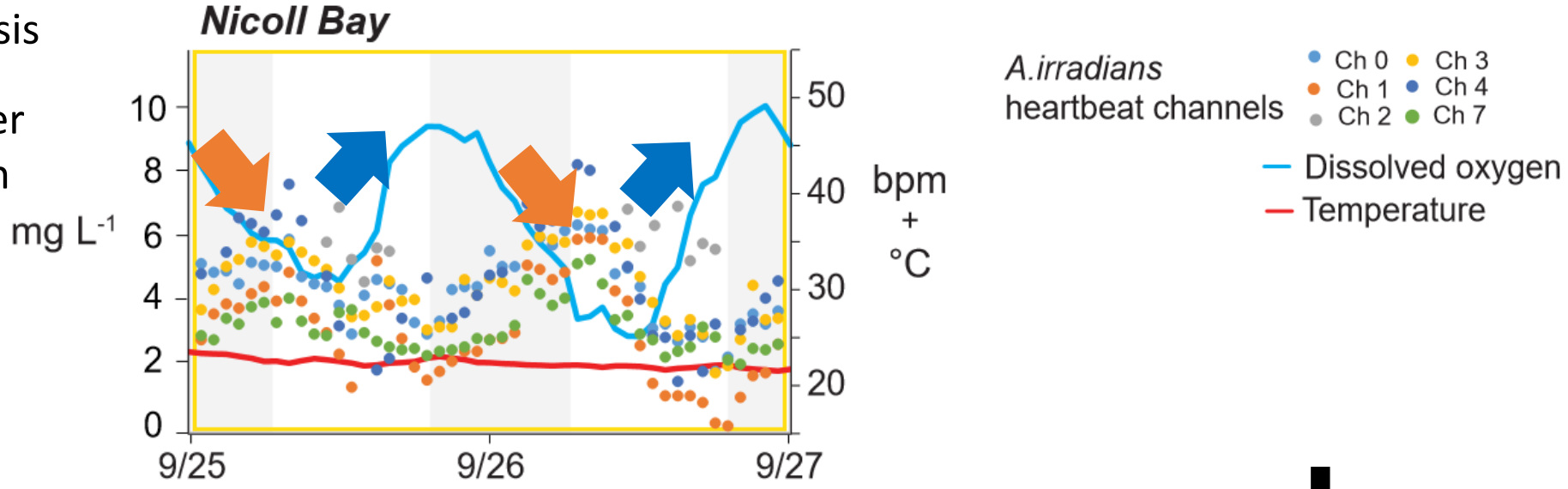
In-situ Cardiac Activity: **Normoxic VS. Hypoxic conditions**



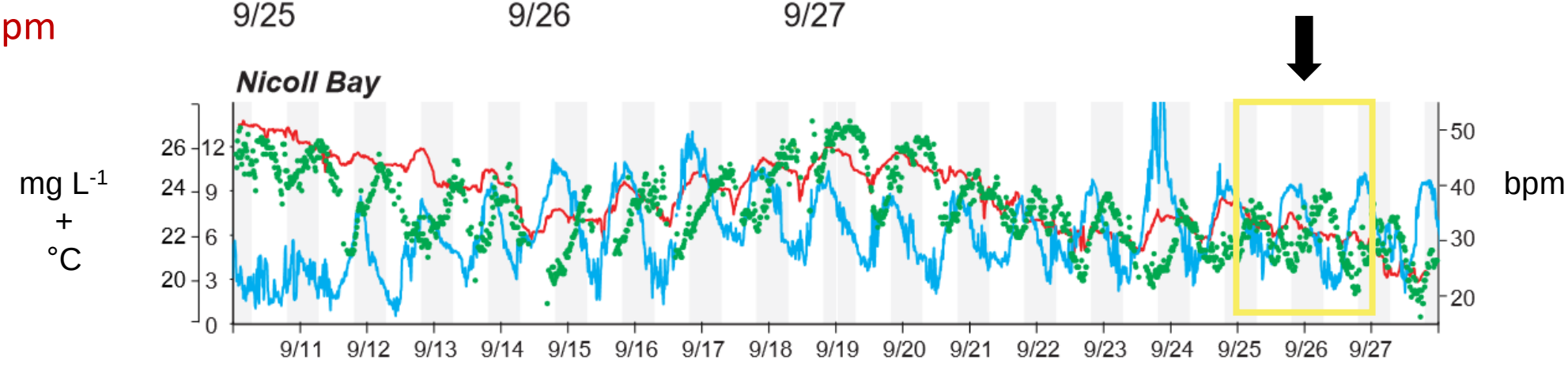
In-situ Cardiac Activity: **Normoxic VS. Hypoxic conditions**

Photosynthesis

Organic matter mineralization

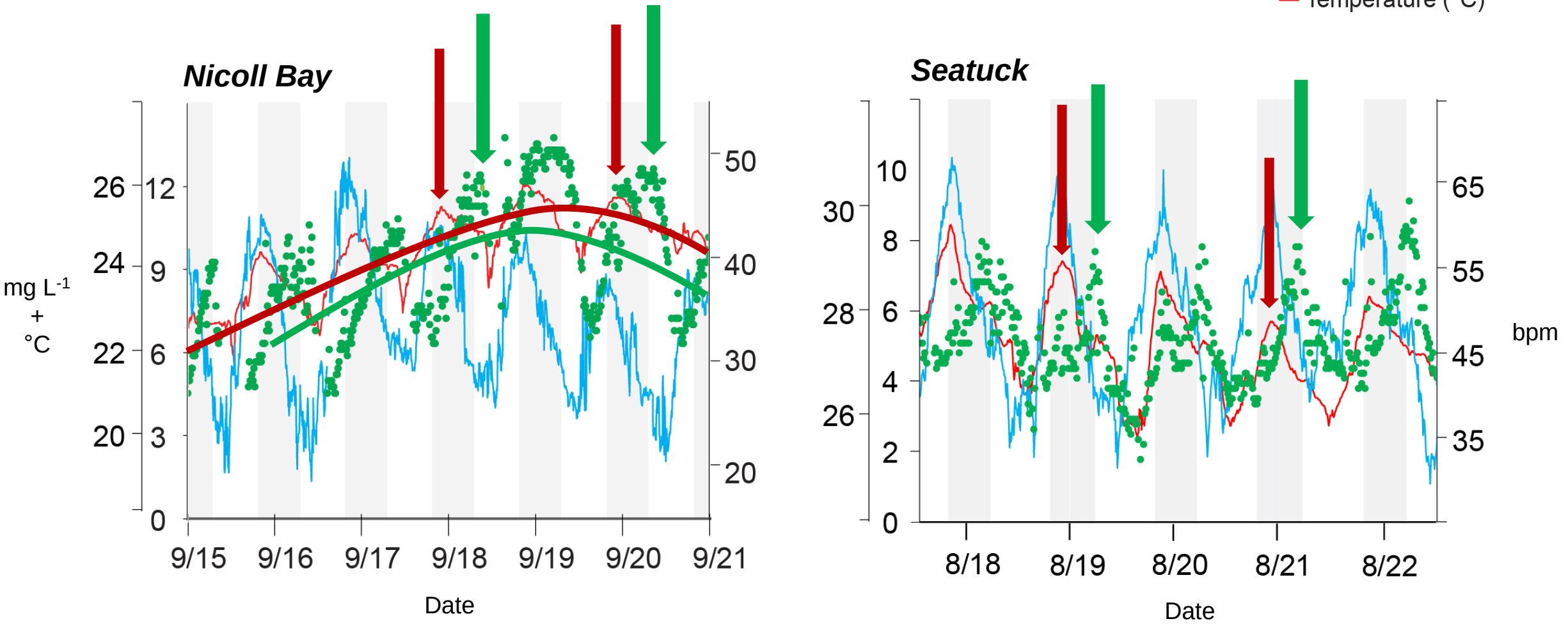


- **Heartbeat rate**: dynamic daily range of 20 bpm



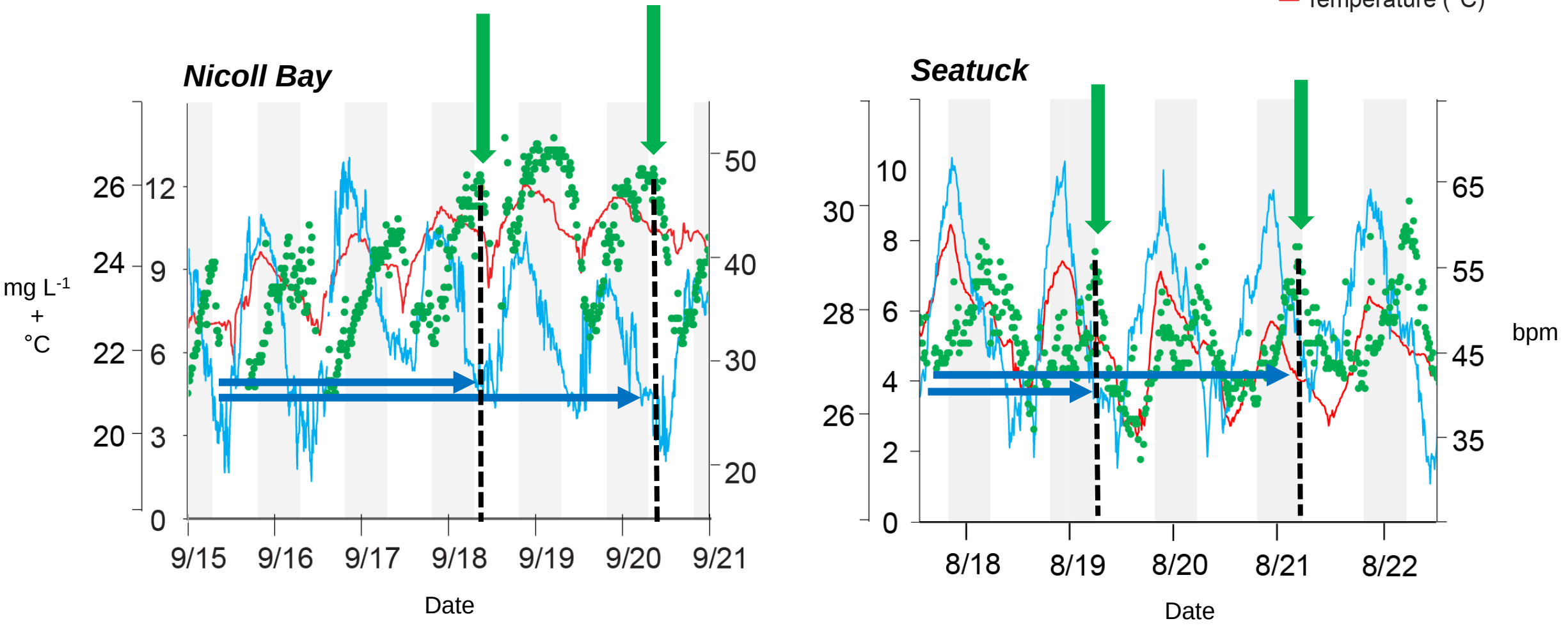
In-situ Cardiac Activity: **Diel-cycling hypoxia**

- Daily oscillations of activity are **not temperature driven**



In-situ Cardiac Activity: **Diel-cycling hypoxia**

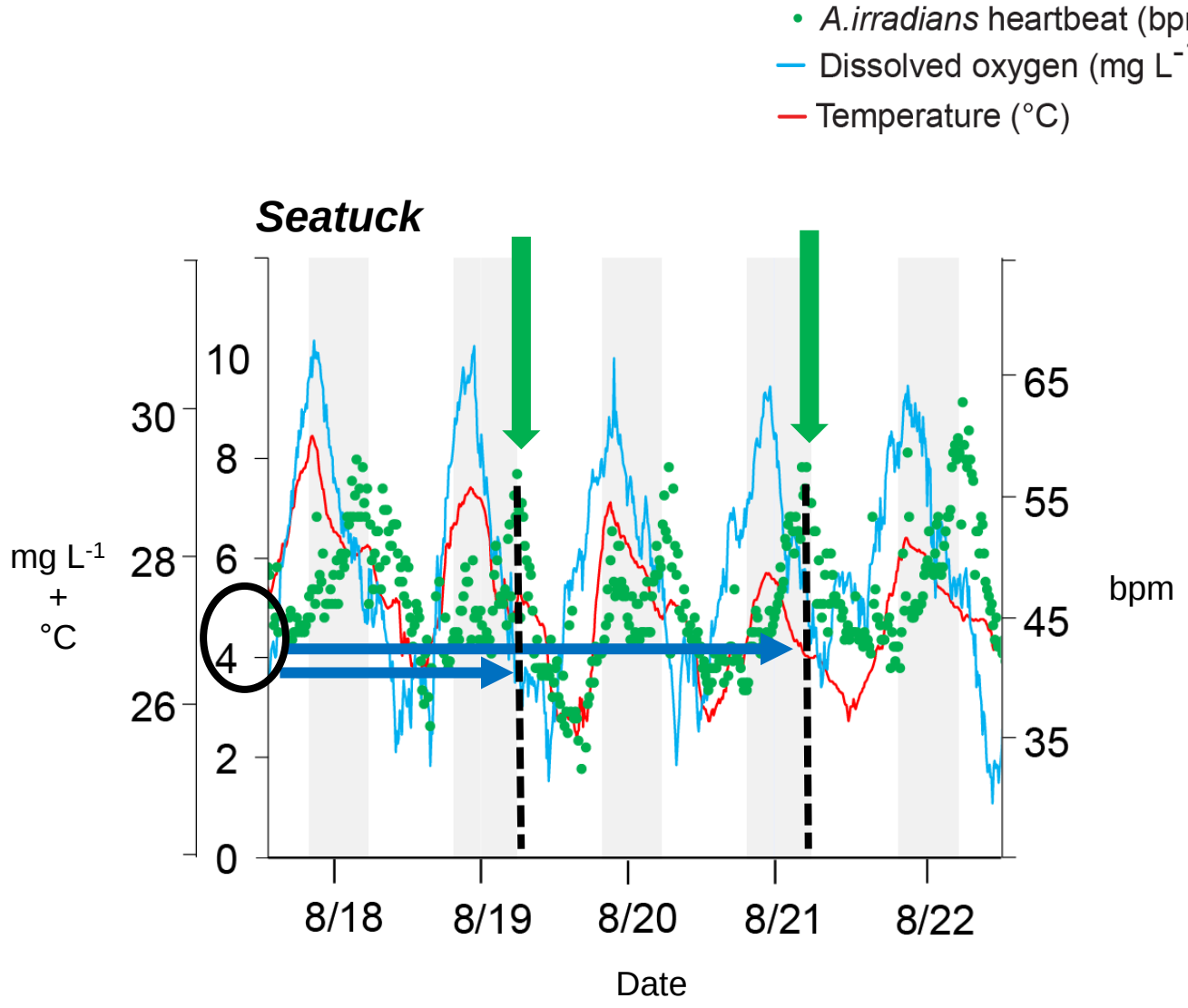
- Cardiac oscillations are **driven by DO decline**



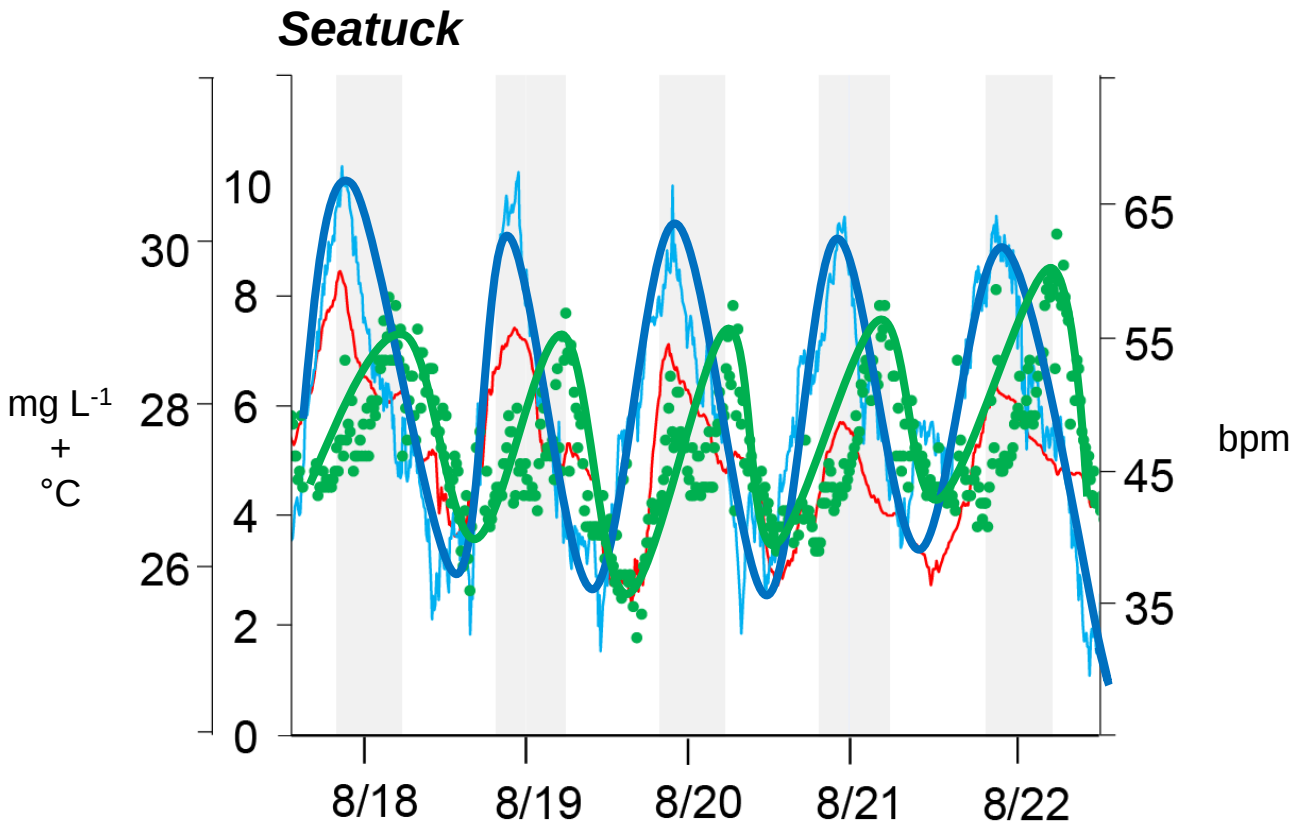
In-situ Cardiac Activity: **Diel-cycling hypoxia**

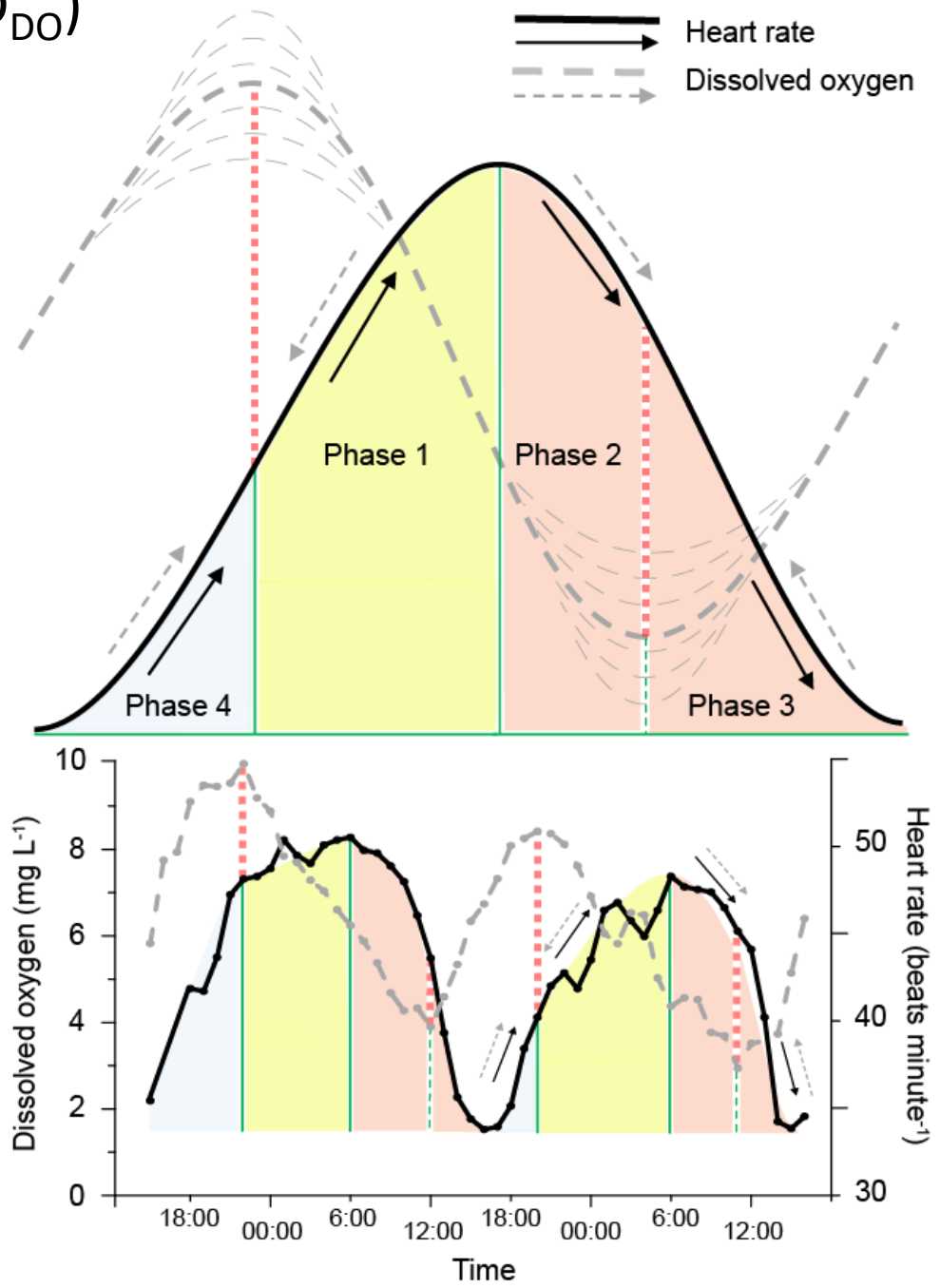
- Cardiac activity always peaked when DO decline to **5 mg L^{-1}** during early to late mornings

- Evidence of a potential onset of:
  - decline of aerobic function
  - transition to anaerobic respiration

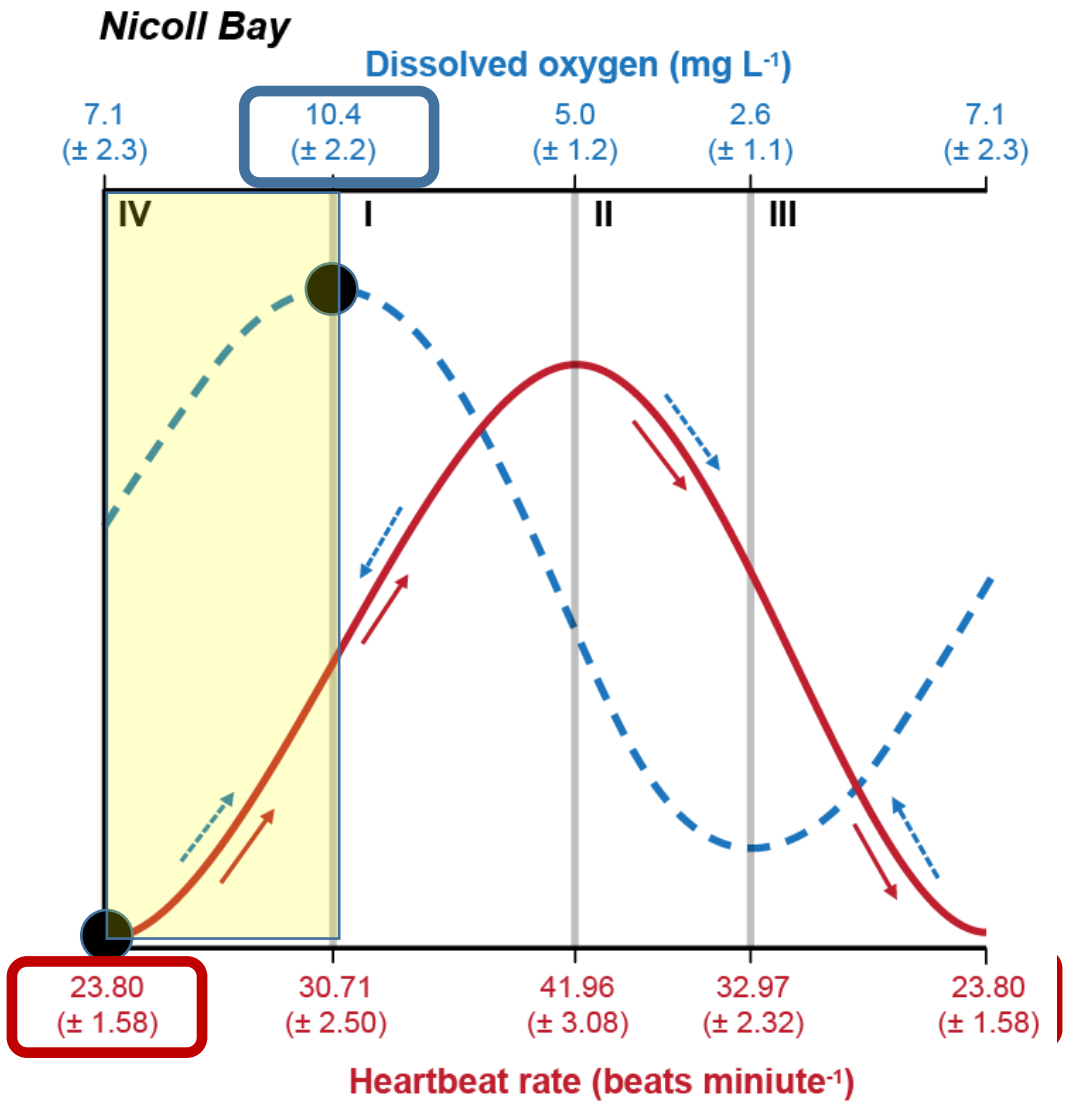


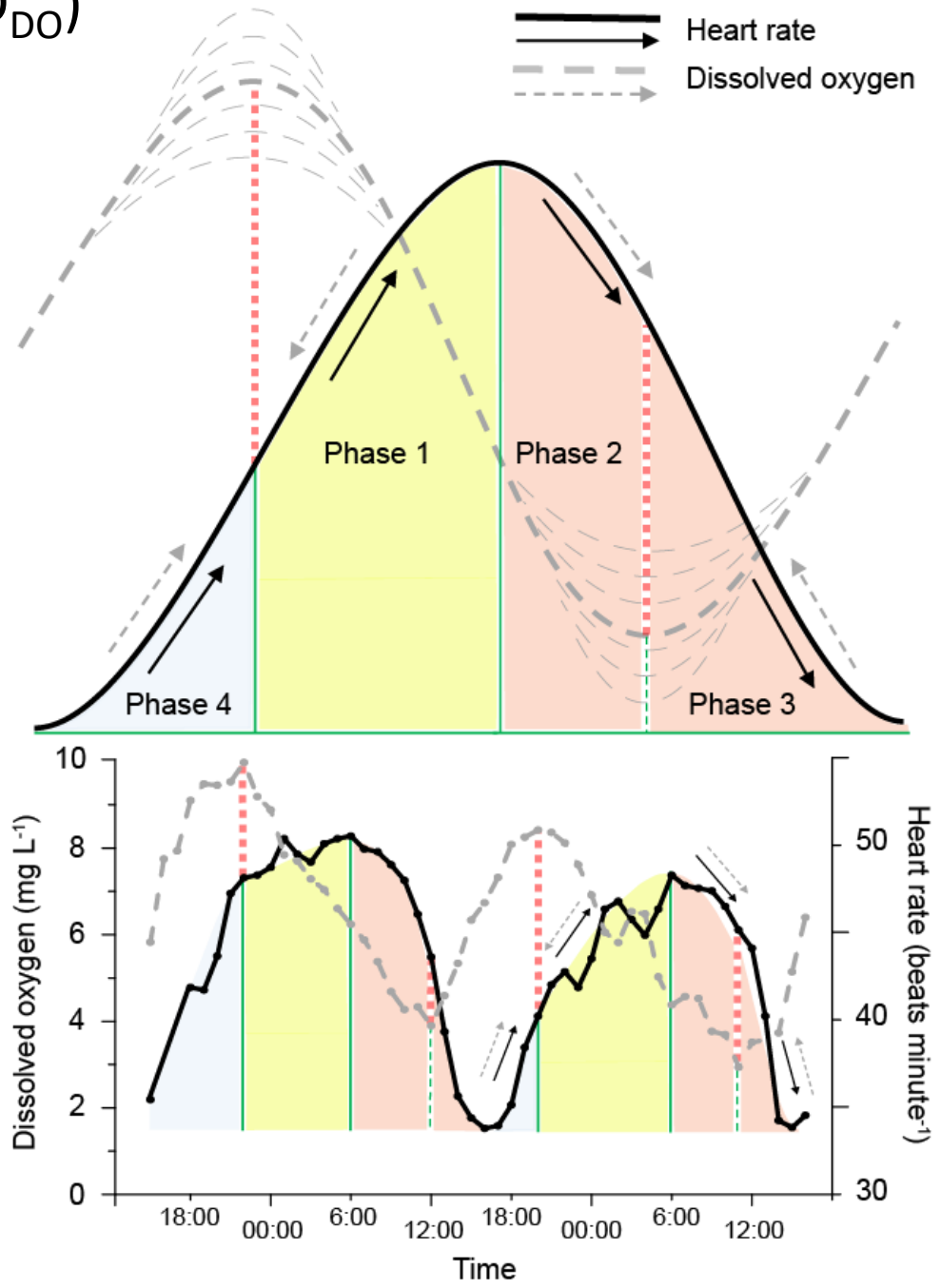
Cardiac response of diel-cycling dissolved oxygen (CRD_{DO})





Cardiac response of diel-cycling dissolved oxygen (CRD_{DO})





Cardiac response of diel-cycling dissolved oxygen (CRD_{DO})

Phase 1

Heartbeat rate

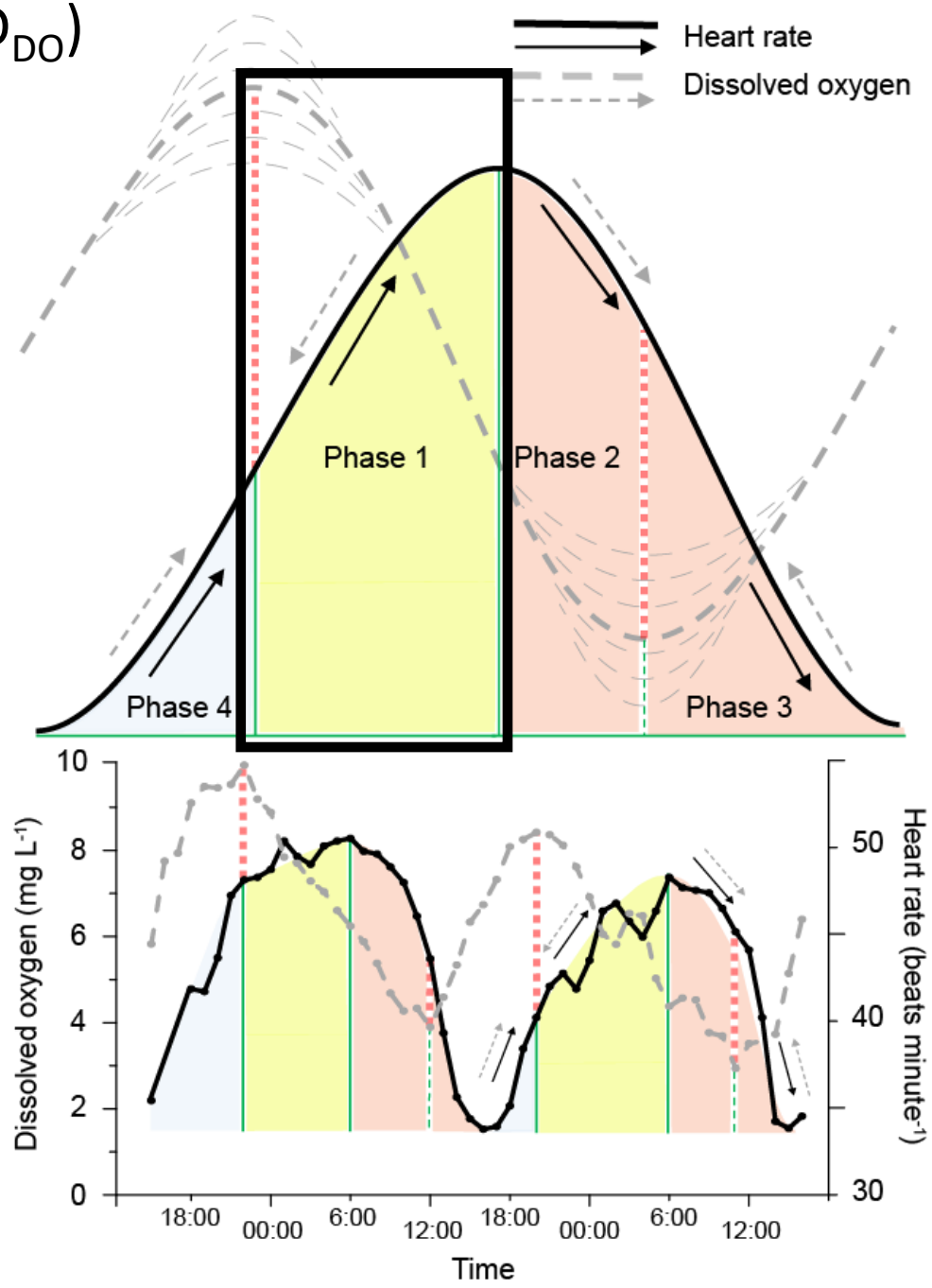
Dissolved oxygen

Oxy<u>regulatory</u> response

- maintain oxygen uptake and aerobic metabolism as DO becomes less available

Heartbeat rate change: +10 bpm

Duration: 8 – 10 hours (longest phase)



Cardiac response of diel-cycling dissolved oxygen (CRD_{DO})

Phase 2

Heartbeat rate ↓

Dissolved oxygen ↓

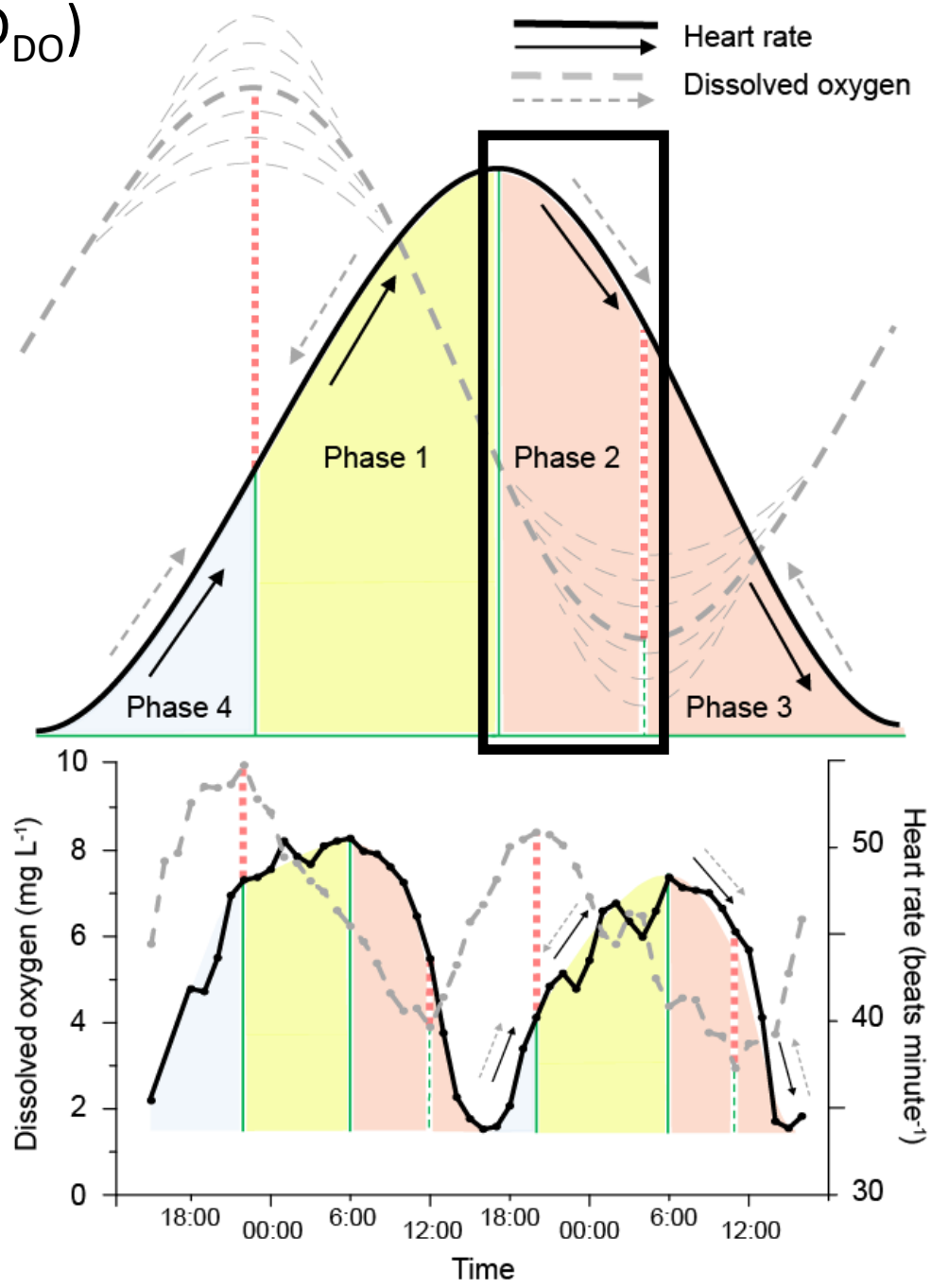
Transition to oxyconformity

- **Peak heartbeat rate at 5 mg L^{-1}**
- May indicate an initiation of anaerobic pathways

Remember: Pc, TcII, and ABT

Heartbeat rate change: -10 bpm

Duration: 4 – 4.5 hours (shortest phase)



Cardiac response of diel-cycling dissolved oxygen (CRD_{DO})

Phase 3

Heartbeat rate

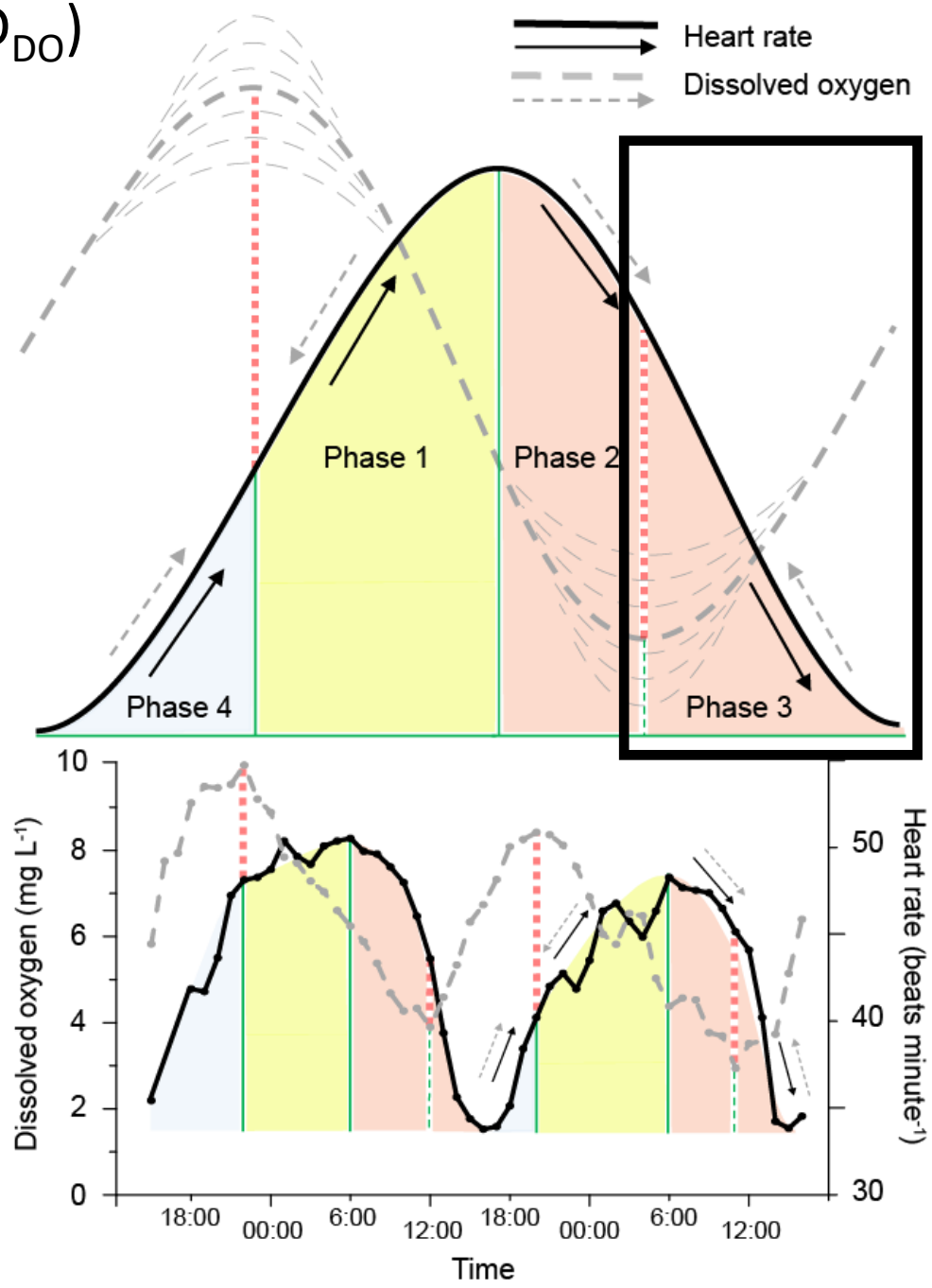
Dissolved oxygen

"Stress and rest"

- Cardiac activity continues to decline to a minimum rate although DO increases
- **Minimum heartbeat rate at 5 – 7 mg L^{-1}**

Heartbeat rate change: -10 bpm

Duration: 5 – 6 hours



Cardiac response of diel-cycling dissolved oxygen (CRD_{DO})

Phase 4

Heartbeat rate

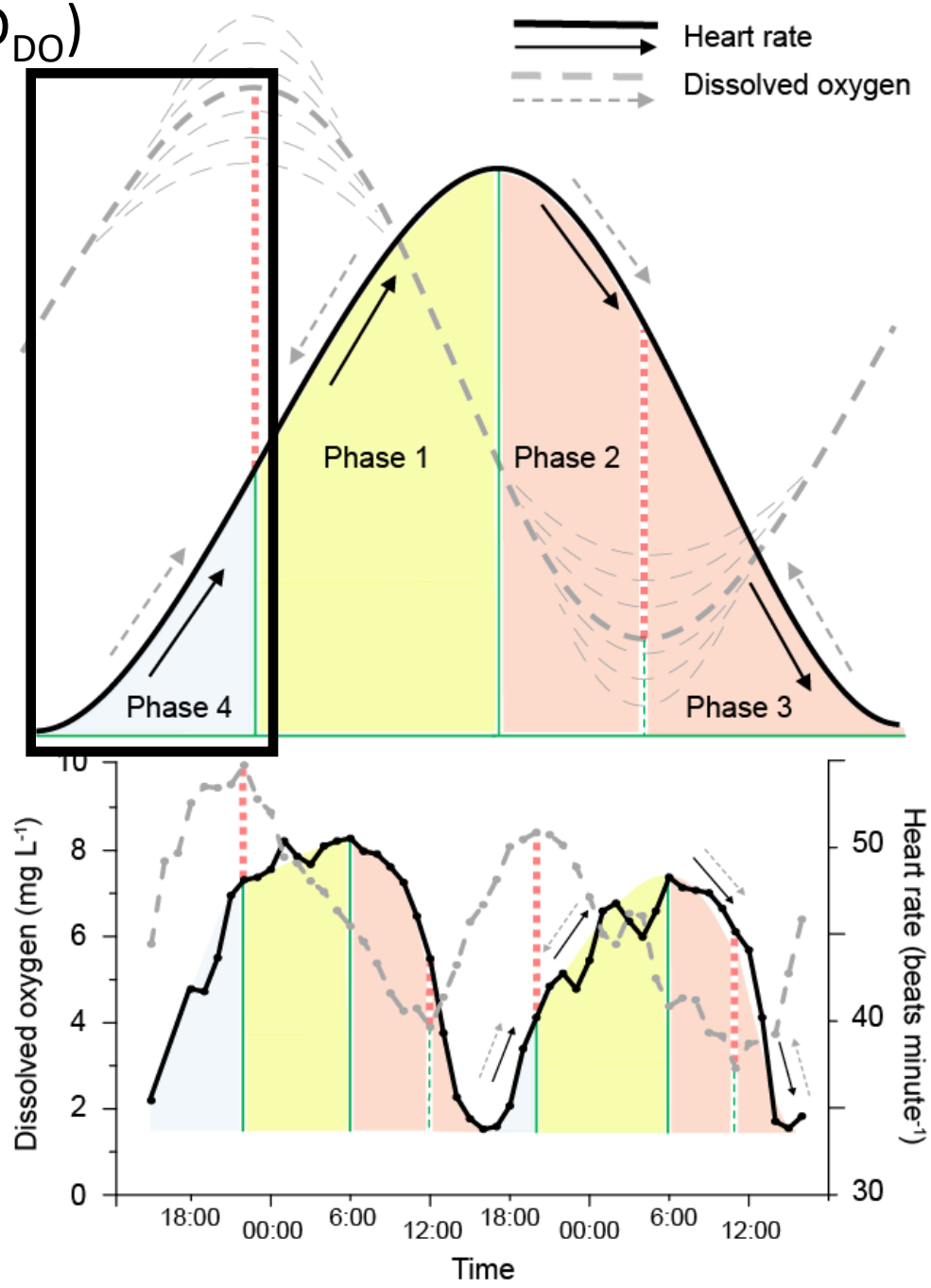
Dissolved oxygen

Cardiac and aerobic recovery

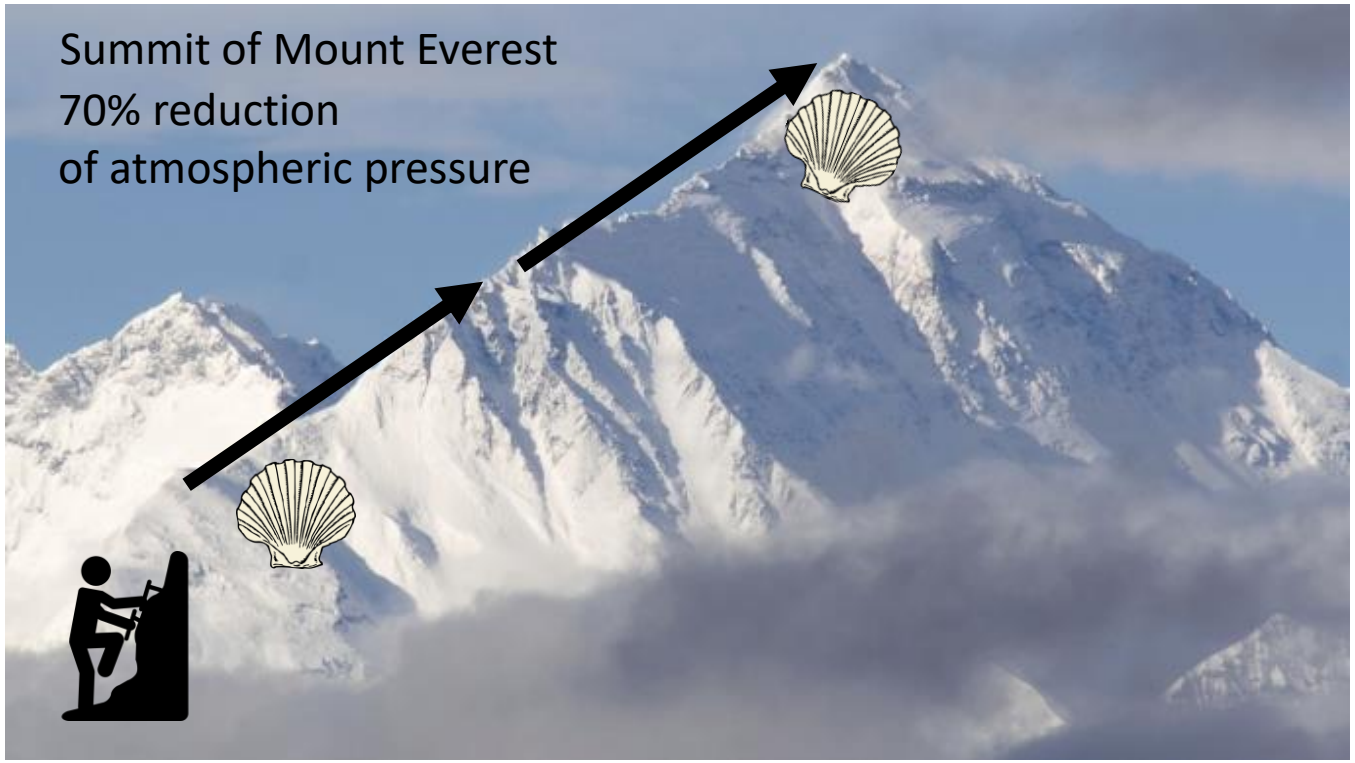
- Only phase when both heartbeat rate and DO **increase**
- Suggests an initial effort to restore aerobic function to basal heartbeat rates

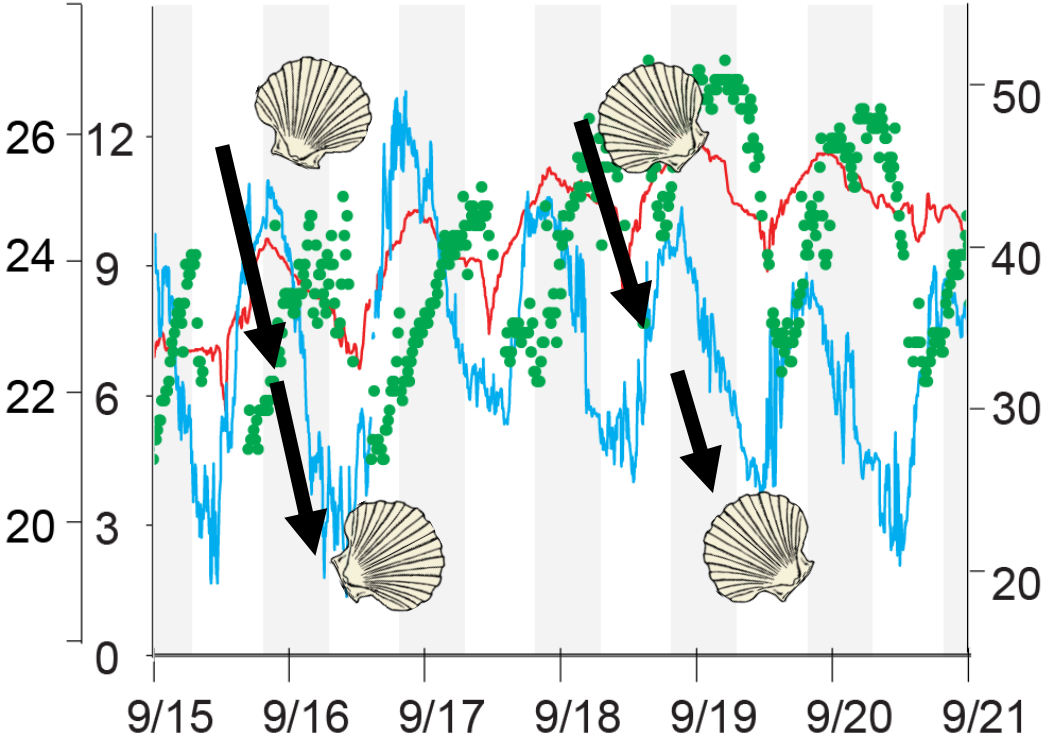
Heartbeat rate change: +10 bpm

Duration: 4 – 6 hours

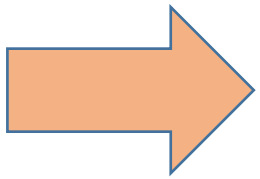


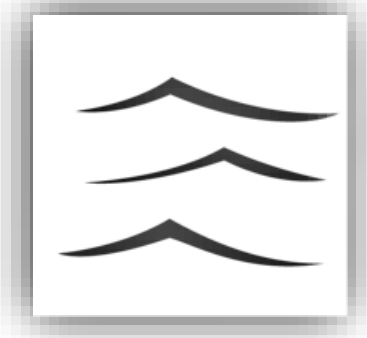
In a metaphorical sense…





As if these scallops reached the summit of Mt. Everest
<u>every morning</u>

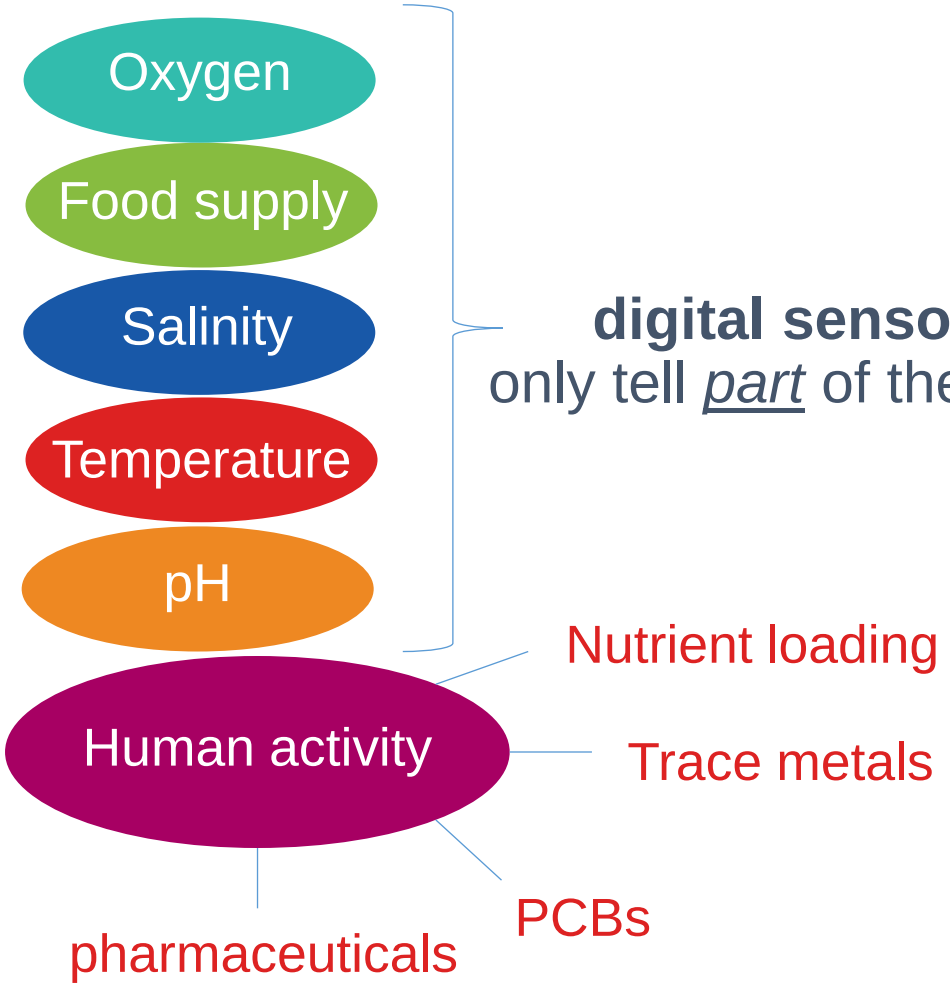




THE RIVER PROJECT

Project Goals

- Coastal water quality determined by...



Bio-sensors
organisms used to detect complex conditions

- ***Goal*: use biosensors as an augmentation of traditional digital sensor data to better understand ecosystem health**

How? *Cardiac activity* and *valve gape behavior*

- **Blue mussel**

- Atlantic coast native

- filters water to feed and respire

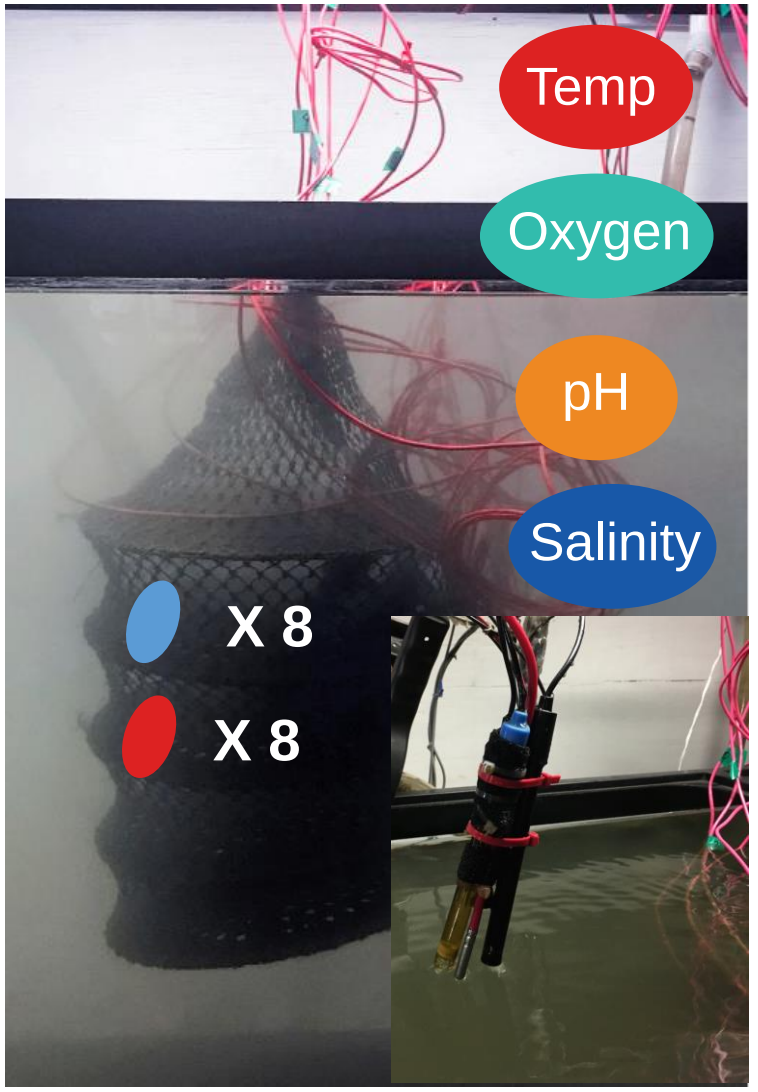
- semi-sessile (sedentary)

Process and Methods

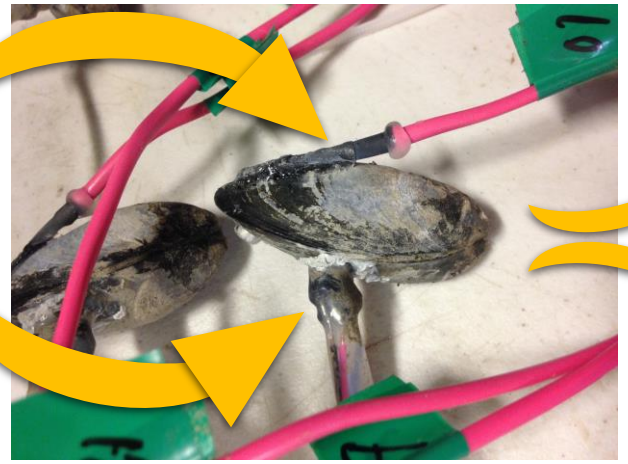
Site collection

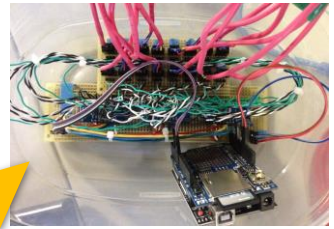
= New York City

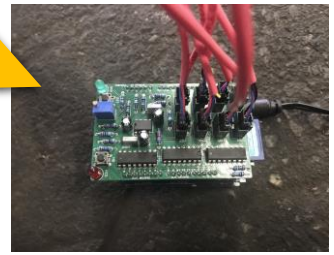
= Stony Brook



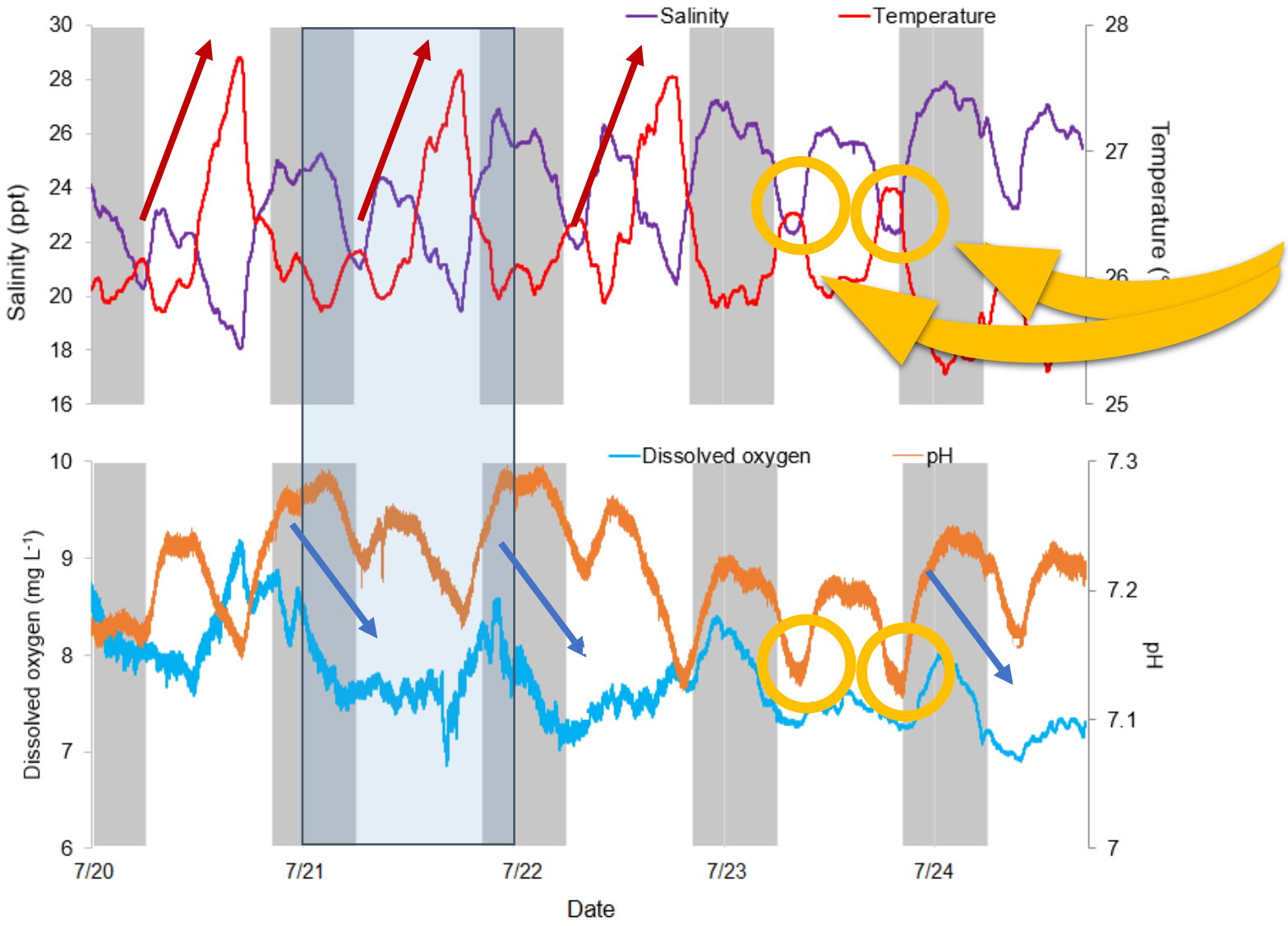
- **Valve gape**
  Hall effect sensor
- **Heartbeat rate**
  Infrared sensor







Results



- Complex coupled dynamics from digital sensors
- Obvious influence of semidiurnal tides
- Interplay between

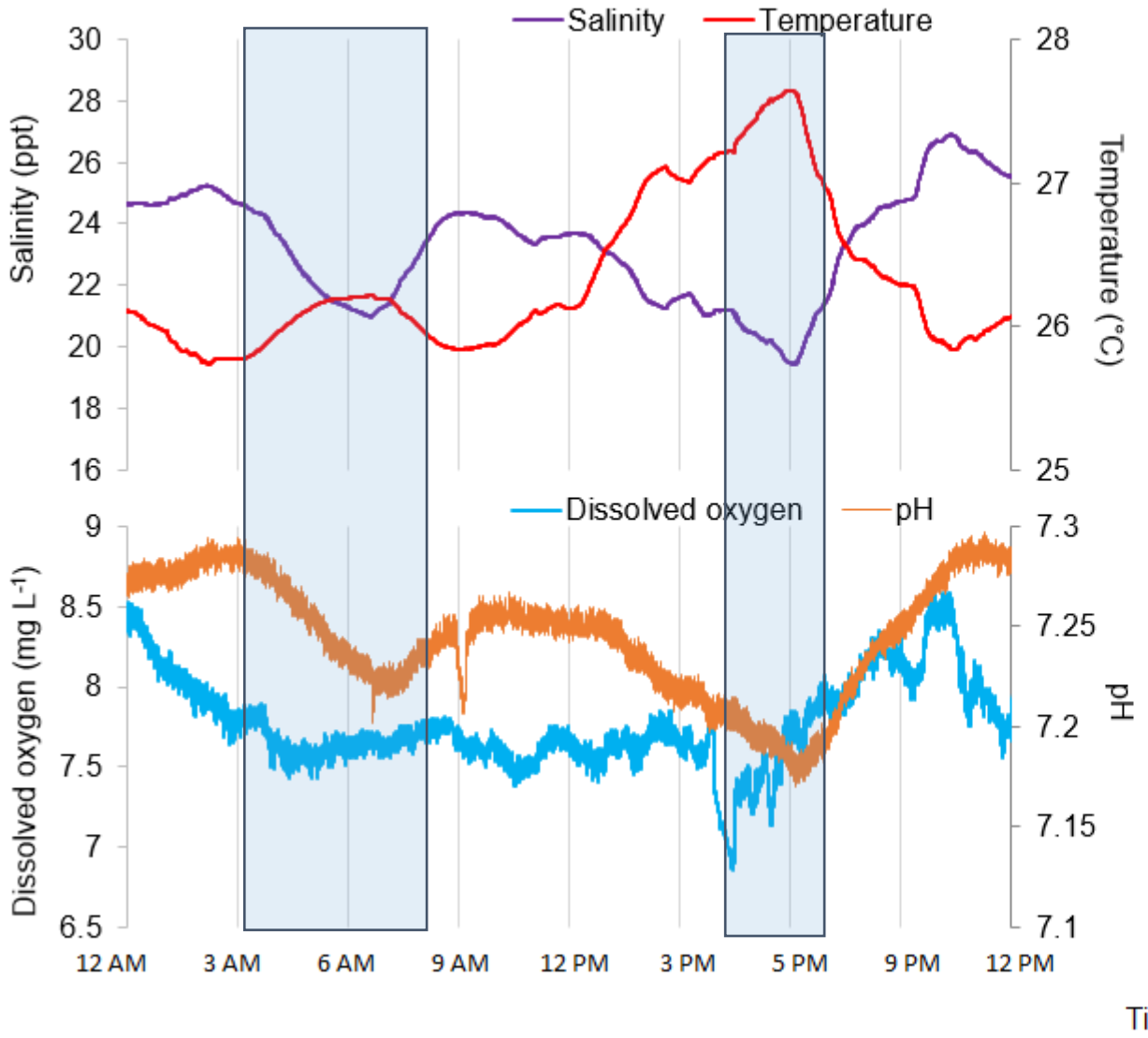
  fresh water (Hudson River)

  +

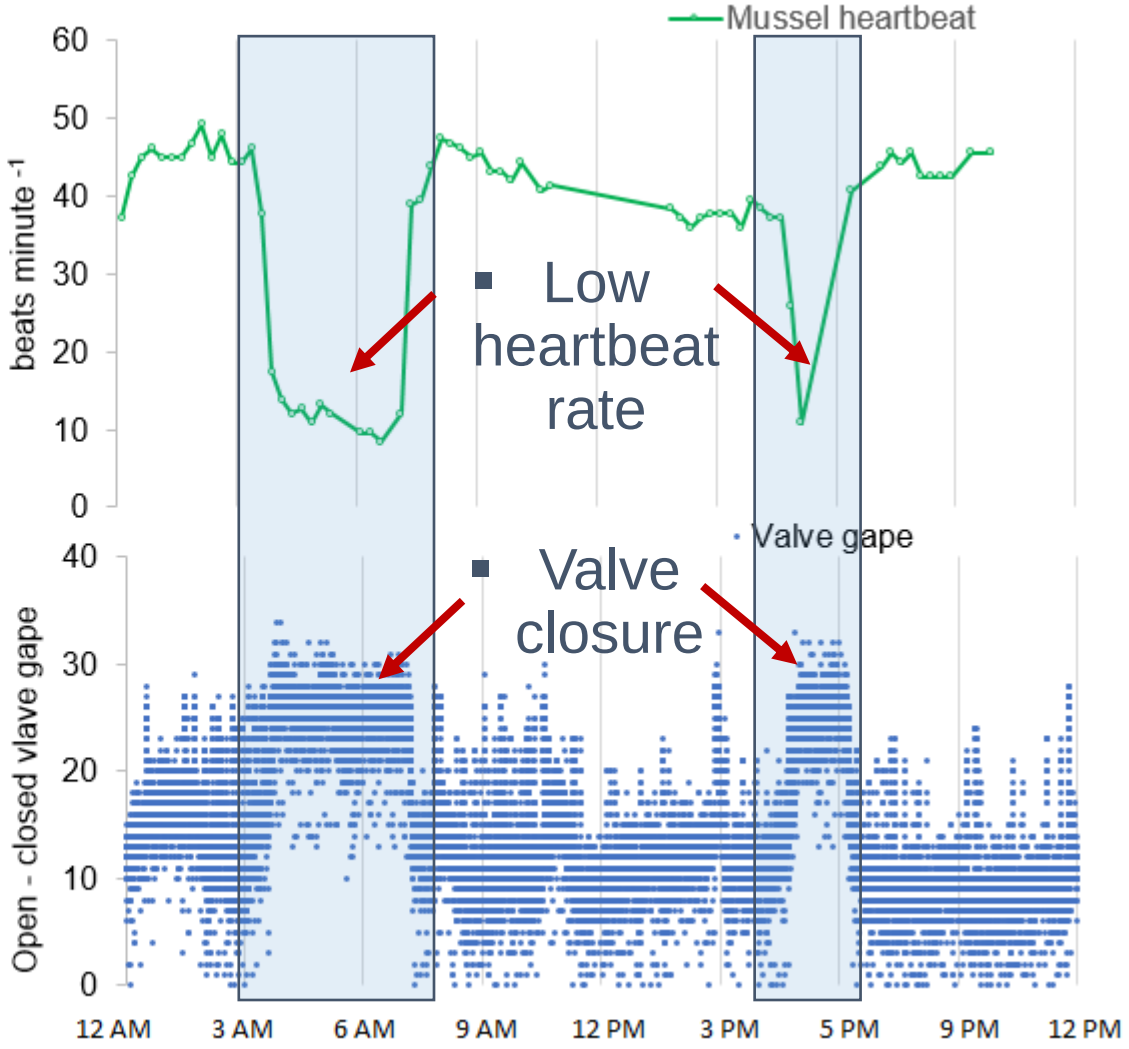
  salt water (Atlantic Ocean)

Results

- Digital sensors

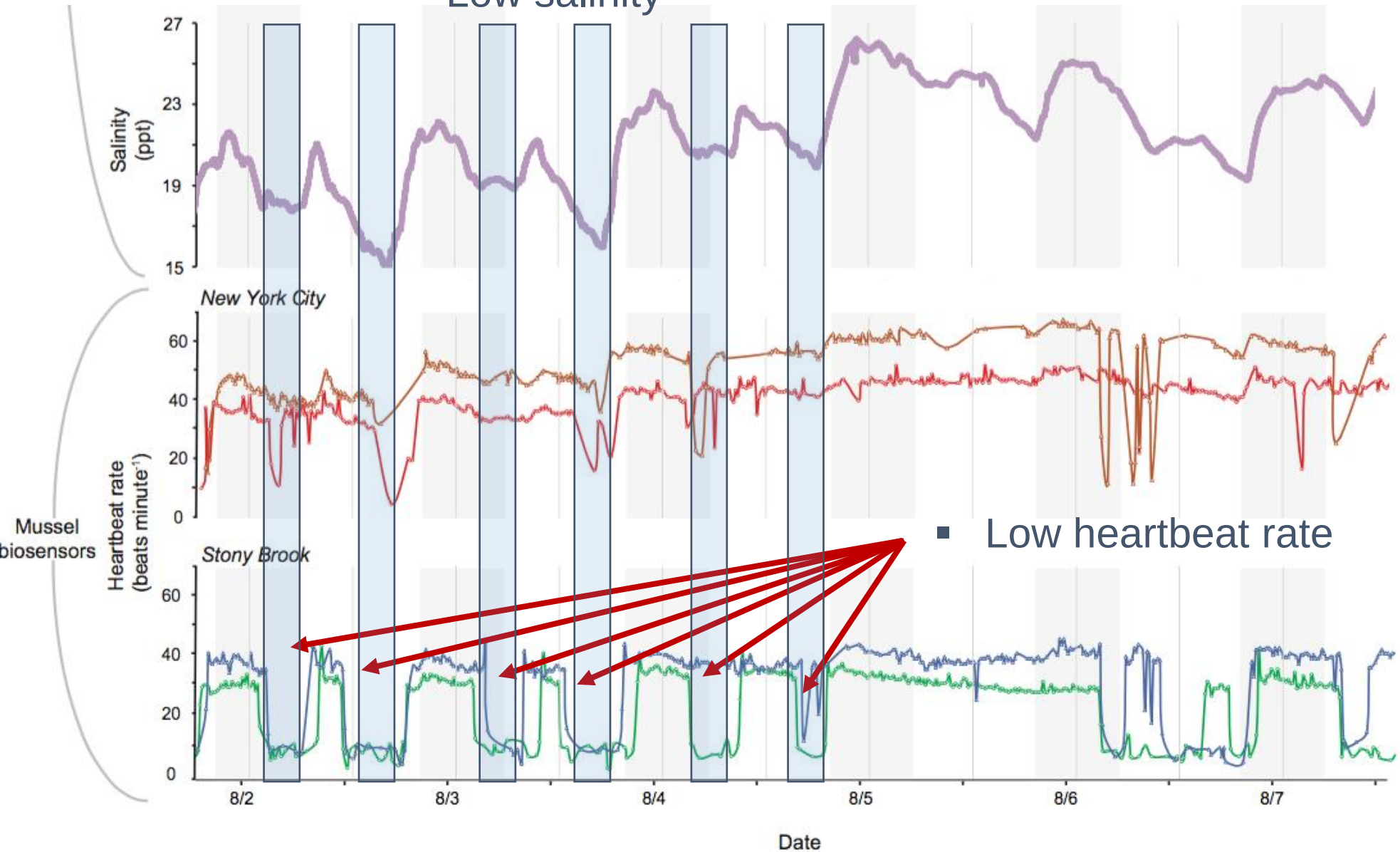


- Biosensors



Results

- Low salinity



- Low heartbeat rate

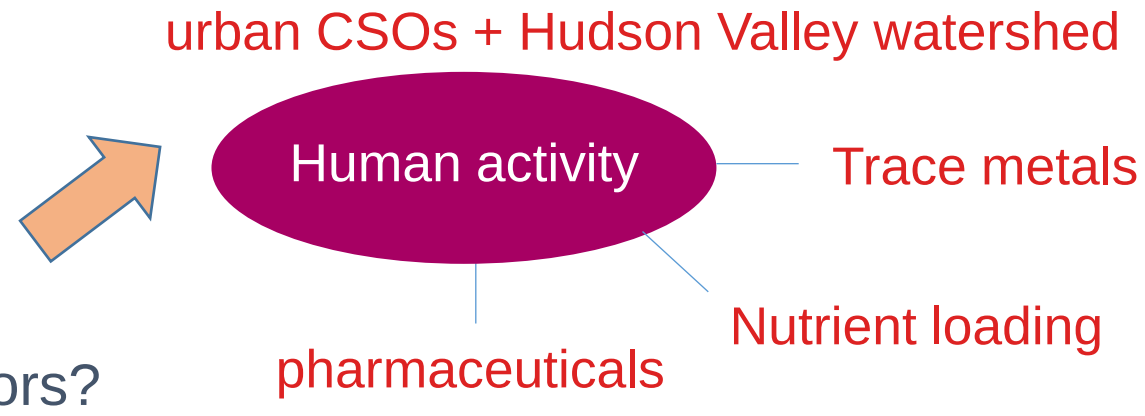
Local

Tranlocated (naïve)

Results

What does this mean?

- Local mussels are tolerant of a stressor
  - Salinity alone
  - Response to attributing factors?



In Summary

- Bio-sensors give a **unique view** of ecosystem status unachievable by digital sensors alone

Questions?


GAPE! QUICK!!!
That way he can't apply a heartbeat sensor and deploy us to our doom!
ERRRGH! Yup.
…he glued me shut.