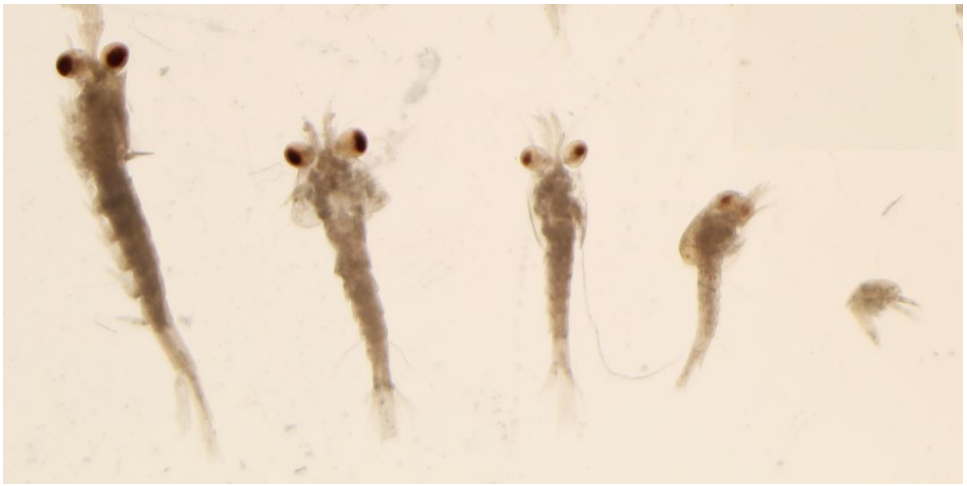
Fighting a hard battle: effects of hypoxia and temperature on euphausiids in the North Pacific



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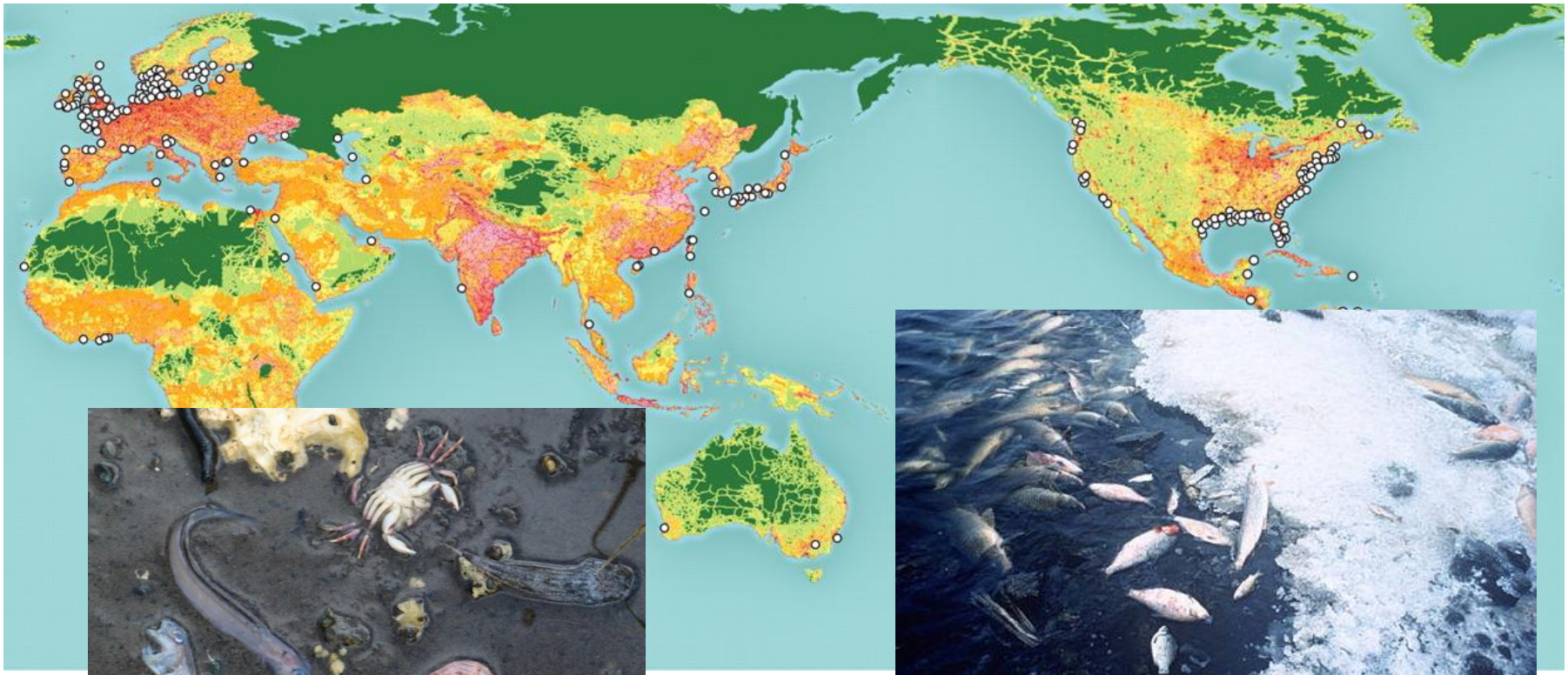
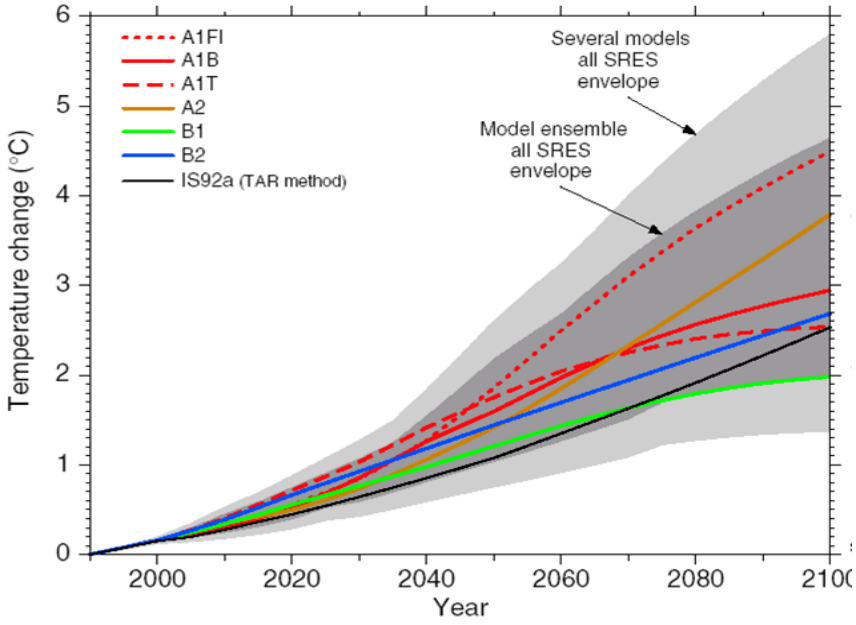
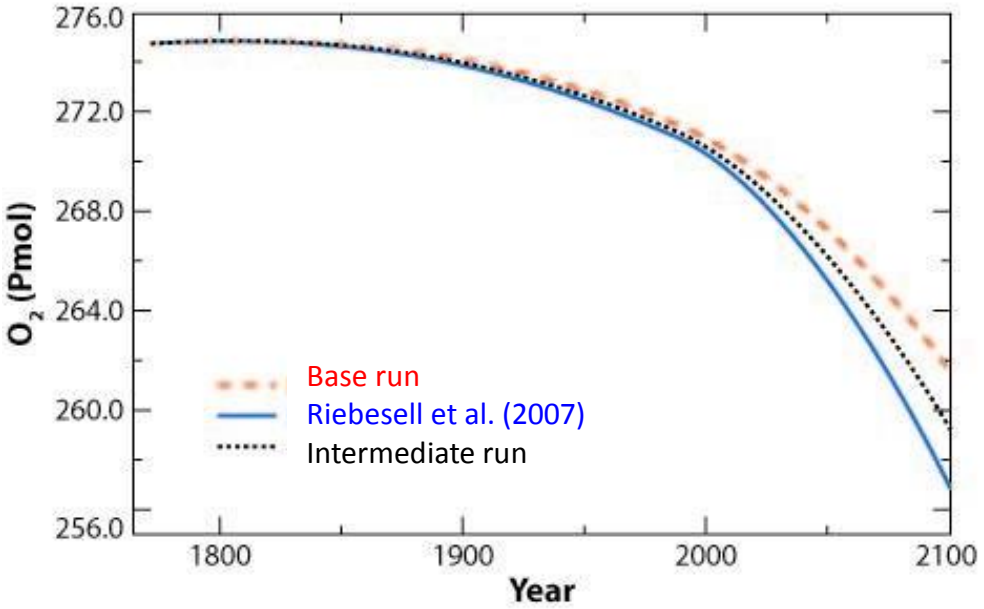
Coastal hypoxic systems



Diaz, and Rosenberg Science 2008

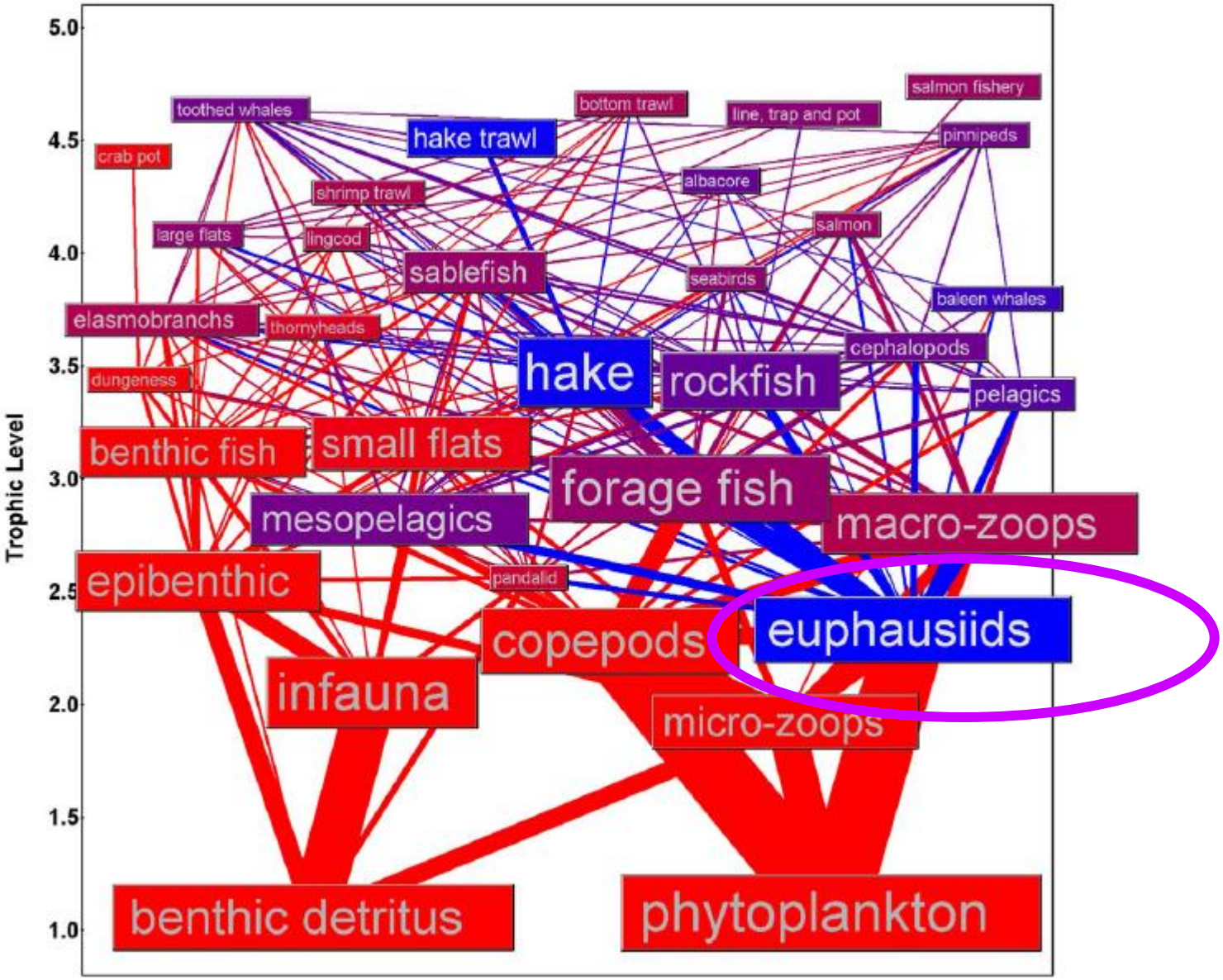
Projected future ocean: Increasing temperature and decreasing O_2





IPCC 2013; Keeling et al. 2010

Importance of euphausiids in the North Pacific



Field &Francis (2006)

Oxygen and temperature effects on *Euphausia pacifica*

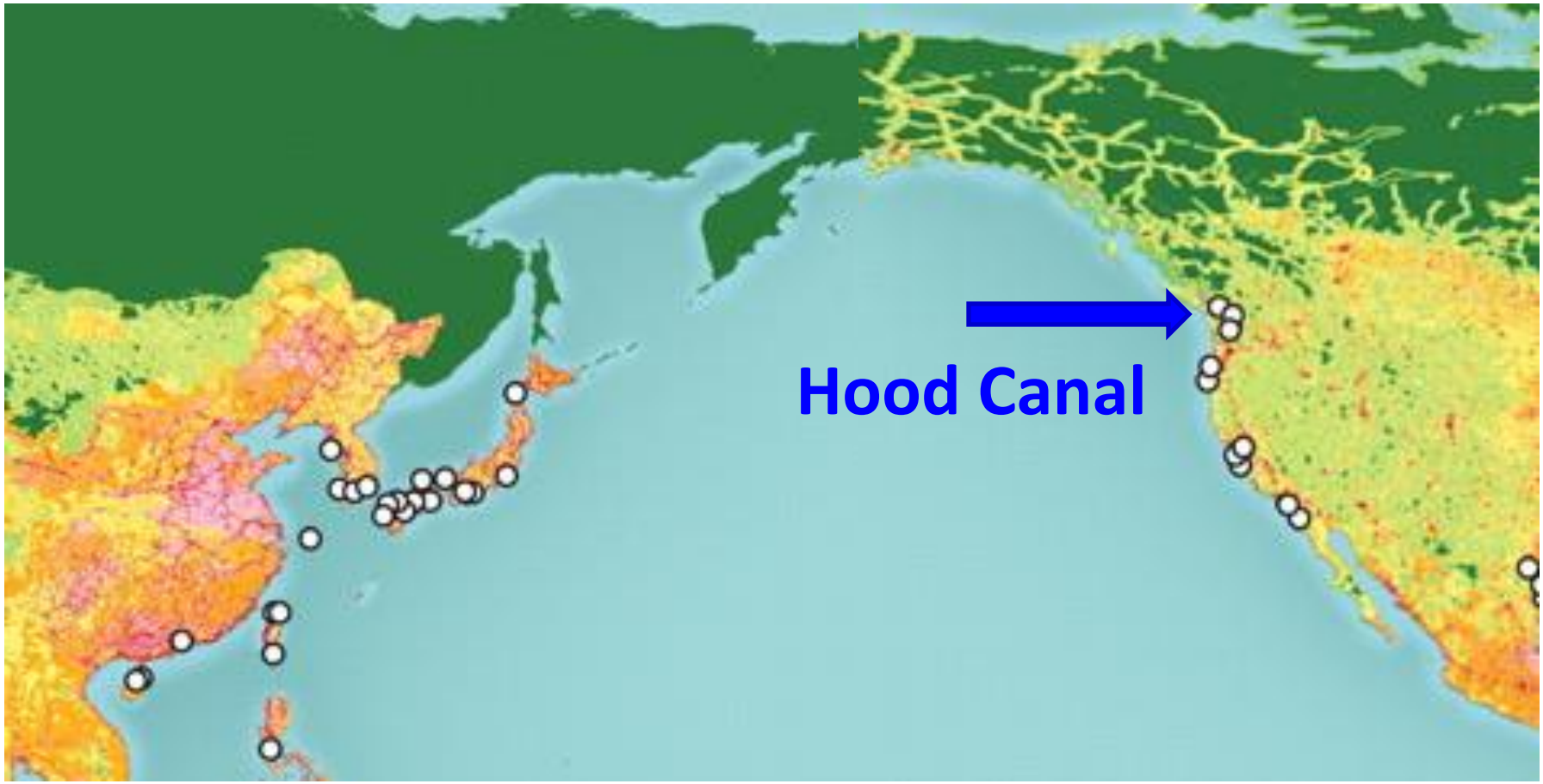
- Field: avoidance of high temperature (> 15°C)
  - Taki 2008
- Field: avoidance of low oxygen
  - Jaffe et al. 1999; Mackie & Mills 1983
- Lab: 1.5 mg O_2/l + 10°C
  Adult mortality: Low
  - Tremblay & Abele 2015

Goals of this study

#1.Do *E. pacifica* show threshold responses to oxygen and temperature?

#2. How does their distribution covary with environmental conditions?

Coastal hypoxic systems in the North Pacific



Diaz, and Rosenberg Science 2008

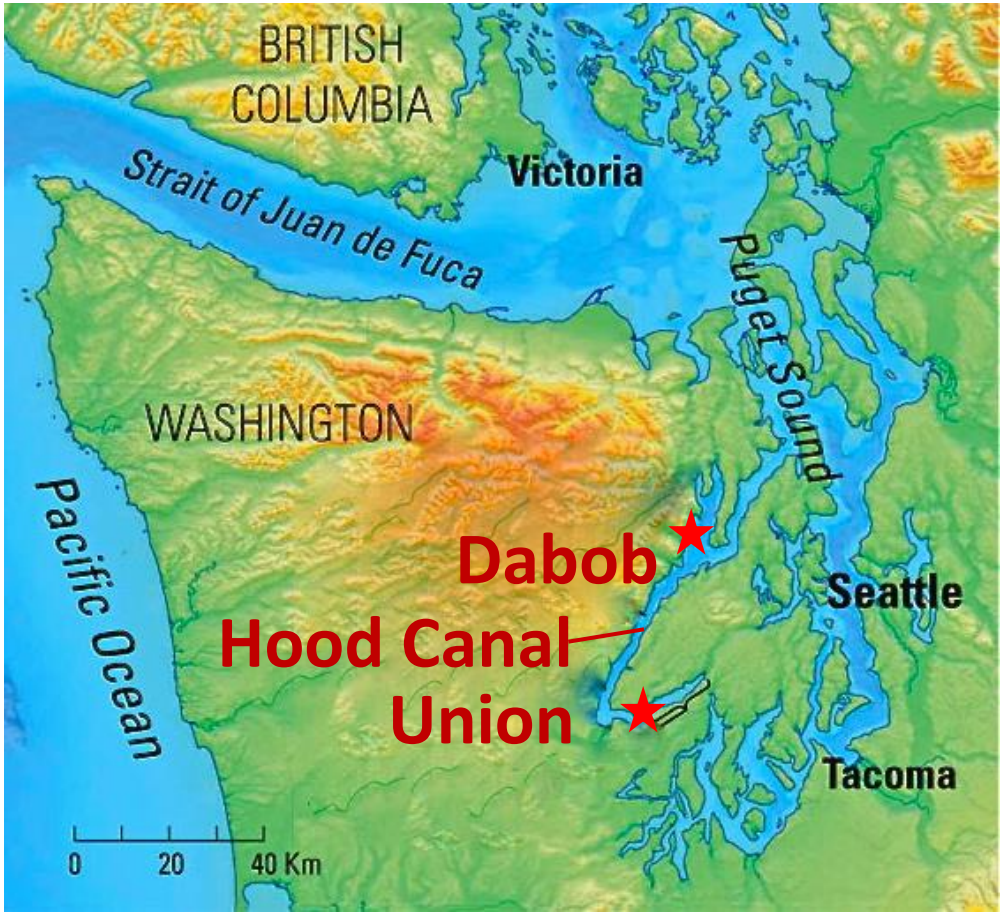
Hood Canal, Puget Sound, WA

Seasonal hypoxia

Long history of fish kills

Two stations:

Dabob and Union



Field collections at Union & Dabob

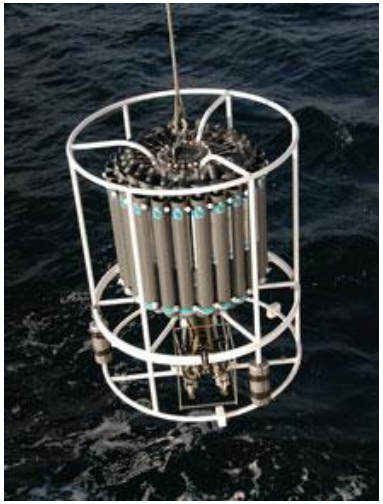
2012 & 2013, monthly June-Oct cruises

Depth-stratified MultiNet® plankton net

- Day & night oblique tows
- 200 & 335 µm mesh

CTD: SeaBird Electronics SBE911 plus

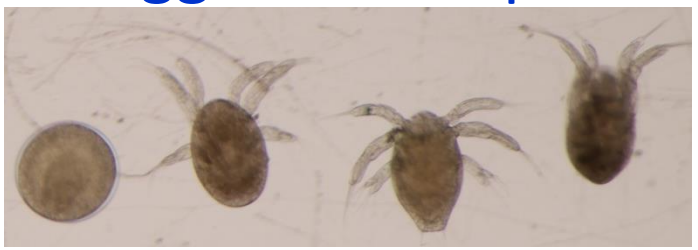
- Temperature
- Dissolved oxygen
  (calibrated with Winkler titration)
- Salinity
- Fluorescence
- PAR (Photosynthetically Active Radiation)



Life stages of *Euphausia pacifica*

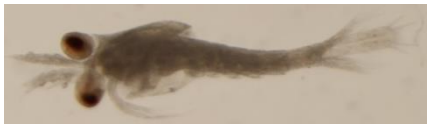
Juveniles and adults

Eggs and nauplii



Calyptopes I-III

Furcilia I-III



Furcilia IV-VII

Images by Amanda Winans

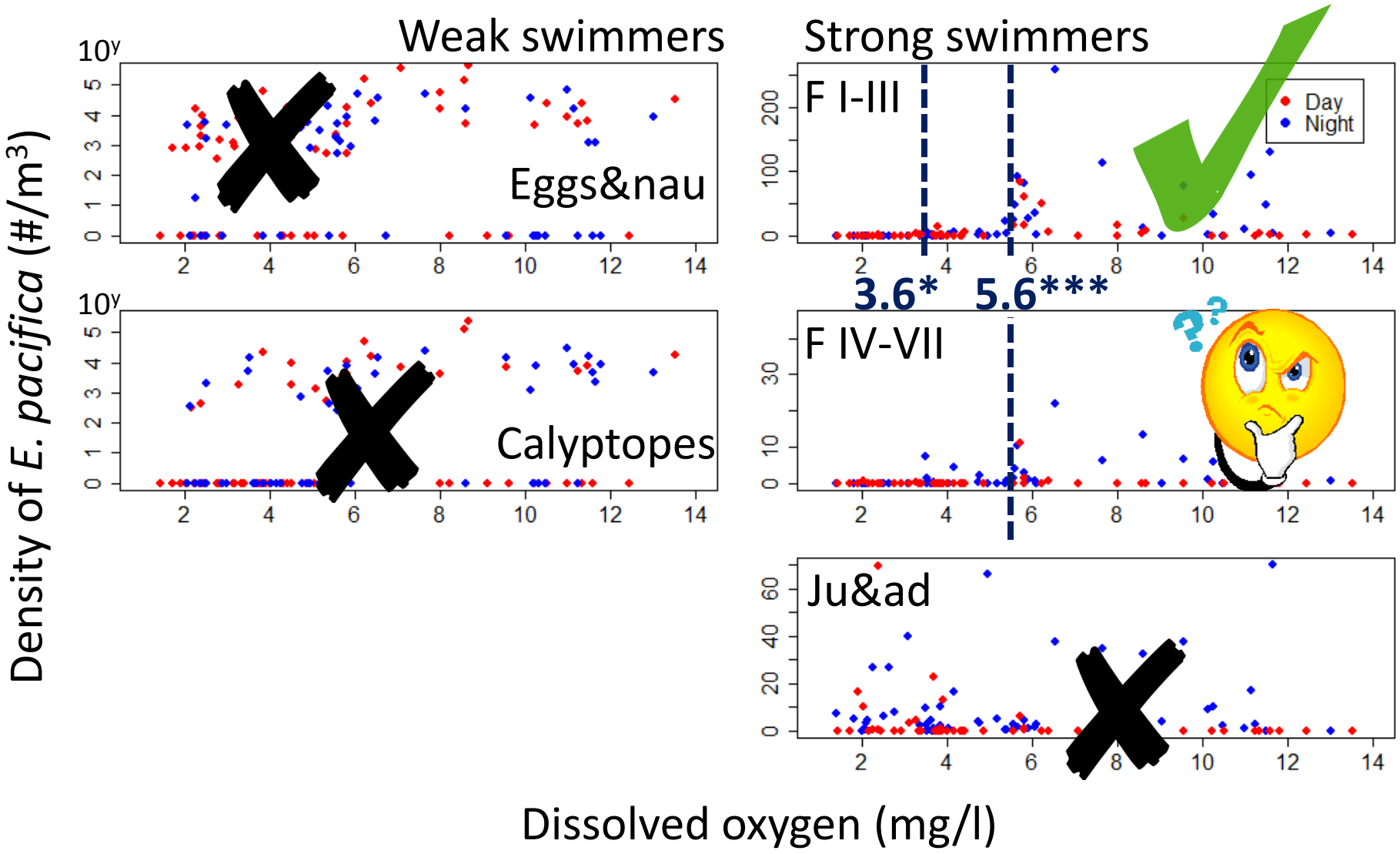
Goals of this study

1.Do *E. pacific* show threshold responses to oxygen and temperature?

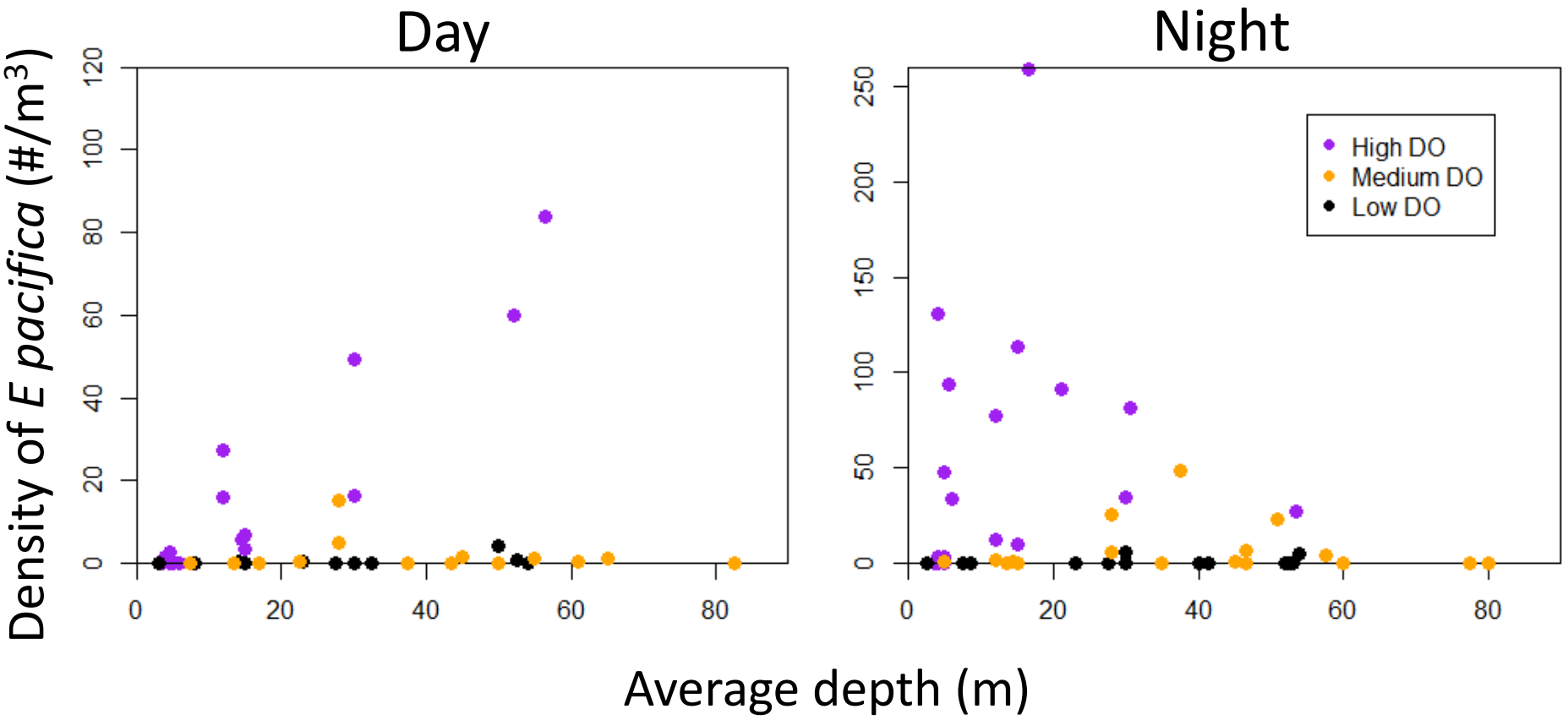
- Piecewise regressions

2. How does their distribution covary with environmental conditions?

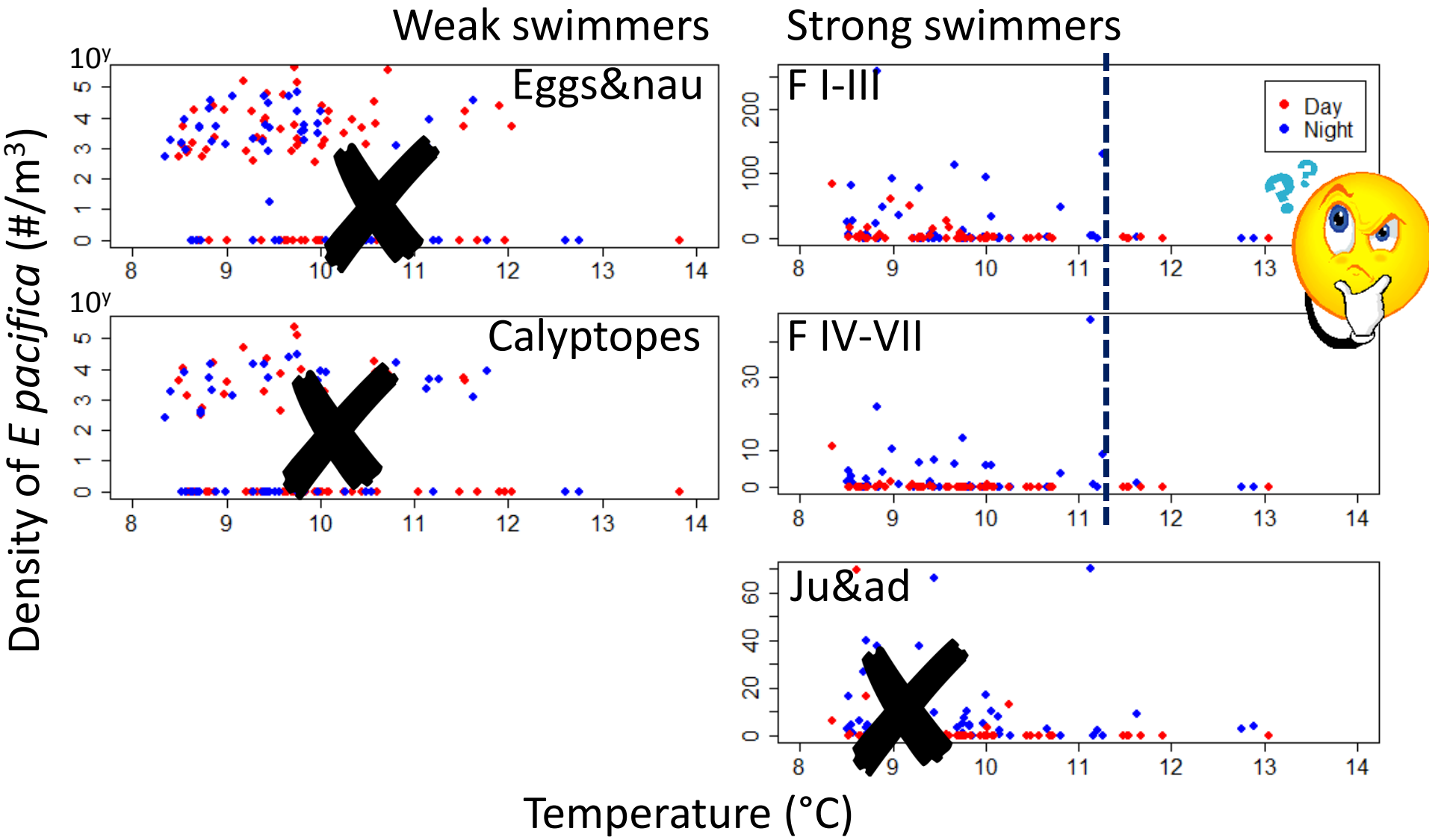
Threshold searching: dissolved oxygen



Furcilia I – III density



Threshold searching: temperature



Goals of this study

1.Do *E. pacific* show threshold responses to oxygen and temperature?

2. How does their distribution covary with environmental conditions?

- GLMM (Generalized Linear Mixed Models)
  - Random effects: tow
  - Fixed effects: depth, temperature, and dissolved oxygen
- Corrected AIC as a model selecting criterion

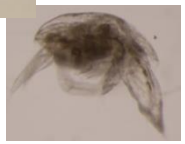
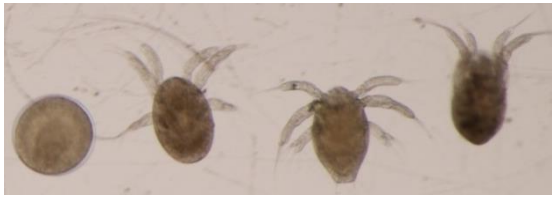
Binomial candidate models for each stage

- Presence/Absence — The best model for each stage
  - Depth — Juveniles & adults
  - Oxygen
  - Temperature — Eggs & nauplii
  - Depth + Temperature
  - Depth + Oxygen
  - Temperature + Oxygen — Calyptopes; Furcilia I-III
  - Depth + Temperature+ Oxygen
  - With/without confounding effects (Year, Month & Station)
- Strong random effects***
- Oxygen and temperature interactions excluded

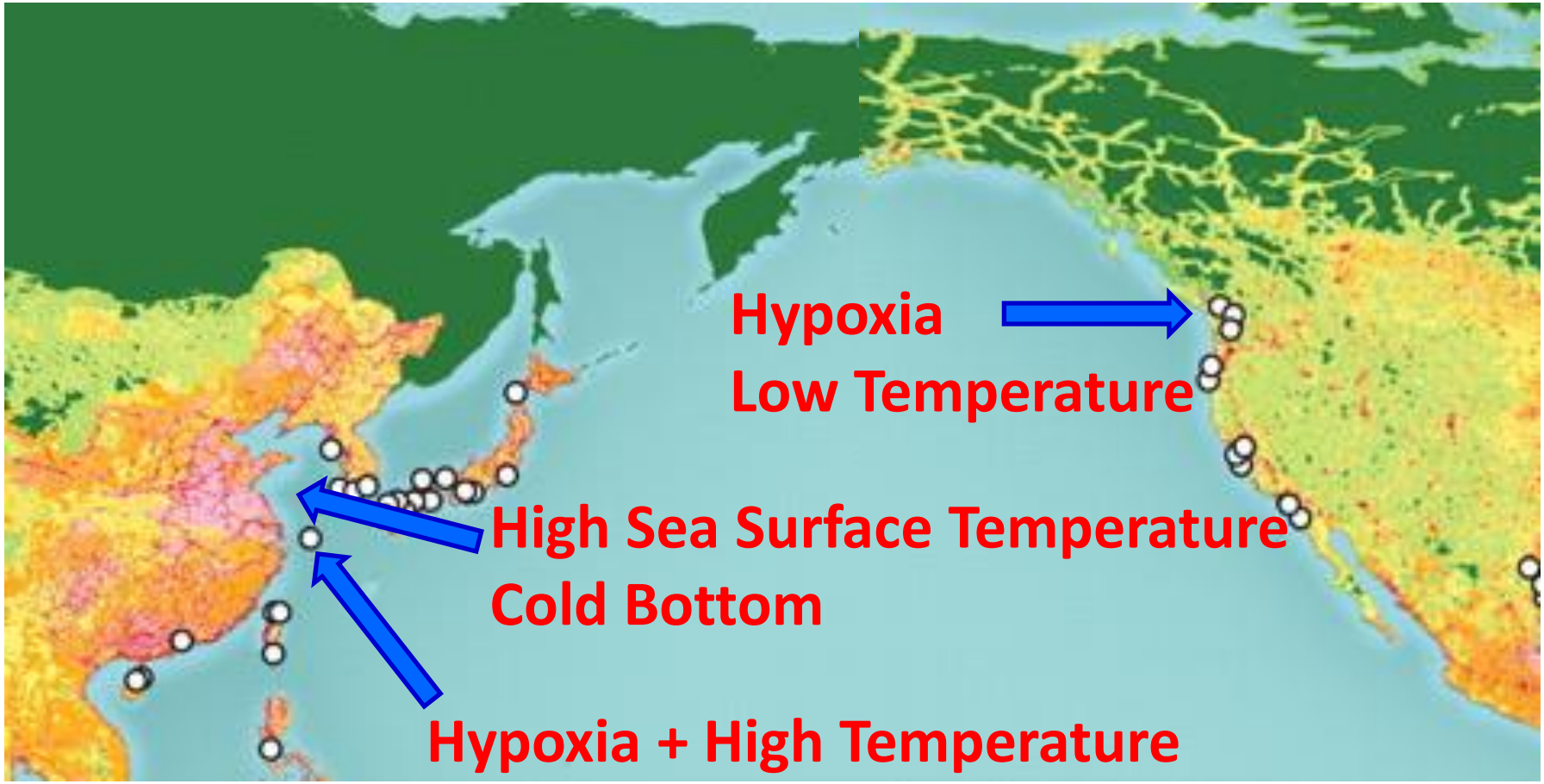
Conclusions

- Within our oxygen range, furcilia I-III is the only stage that demonstrated clear avoidance of low oxygen (<3.6mg/l)
- We need more high temperature observations to study the thermal limit of *E. pacifica*
- Furcilia I-III distribution is most related to both temperature and oxygen



Next steps: *E. pacifica* habitat and stress comparison in the North Pacific



Diaz, and Rosenberg Science 2008

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- The Essington lab
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