Oxygen and pH conditions experienced by zooplankton in a NE Pacific fjord: effects on ~~taxonomic composition,~~ distributions, and growth

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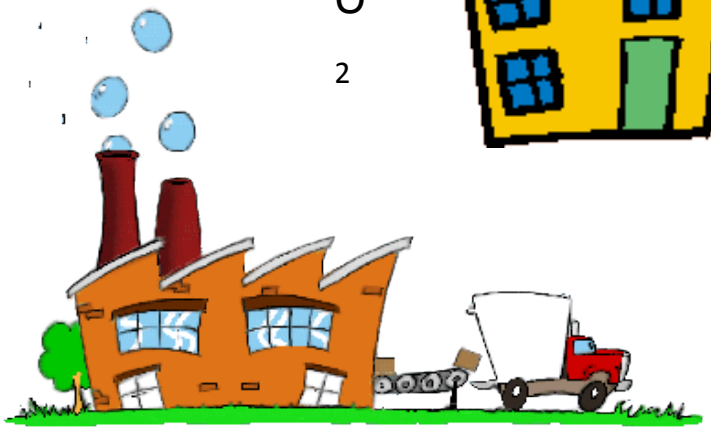
Ocean Acidification

CO_2 CO_2 CO_2 CO_2 CO_2 CO_2 CO_2

C O 2



http://psp.88000.org/wallpapers/75/Pacific_Ocean_Emerald_Wave.jpg

Causes and potential effects of coastal hypoxia

Direct effects:

•Mortality

•Stressed physiology

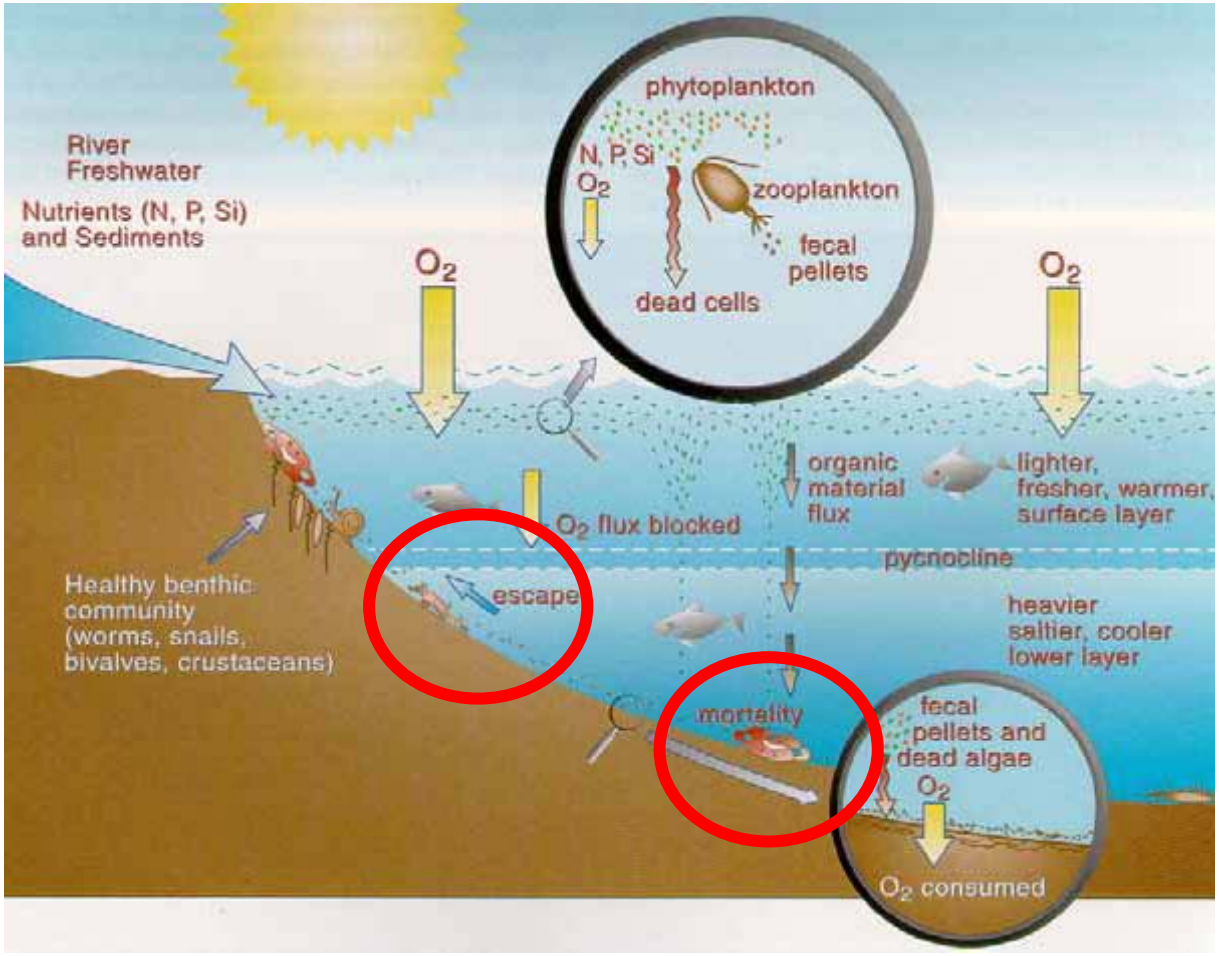
Indirect effects:

•Avoidance

•Changes in community structure

•Changes in trophic interactions

•Altered biogeochemistry



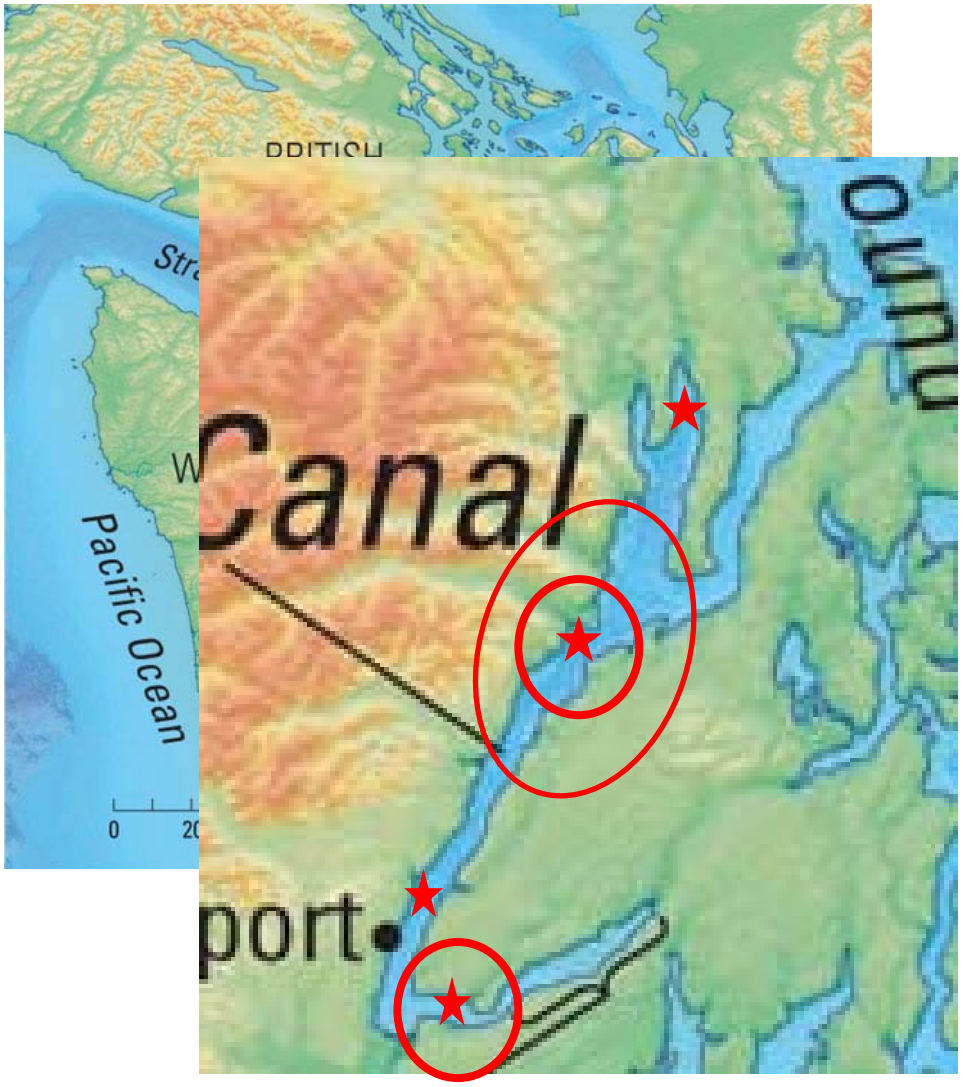
From Downing et al. 1999

Study location: Puget Sound, WA

North-South gradient in hypoxia and pH

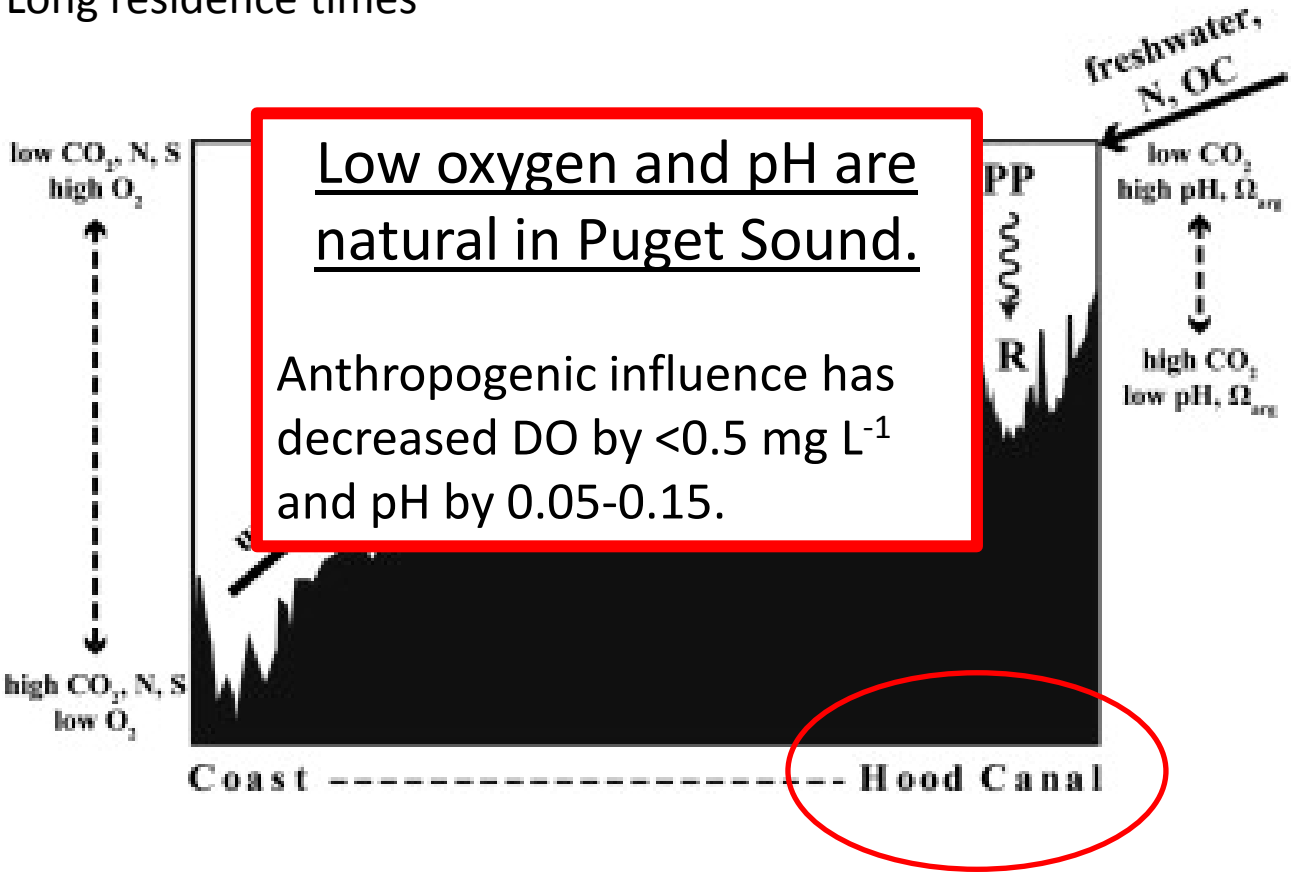
Diverse, oceanic zooplankton assemblage

Easily accessible



Processes contributing to low oxygen and pH levels in Puget Sound

- Influx of upwelled water (low DO, high CO_2, high NO_3)
- High productivity (>2 g C m^{-2} d^{-1})
- Long residence times

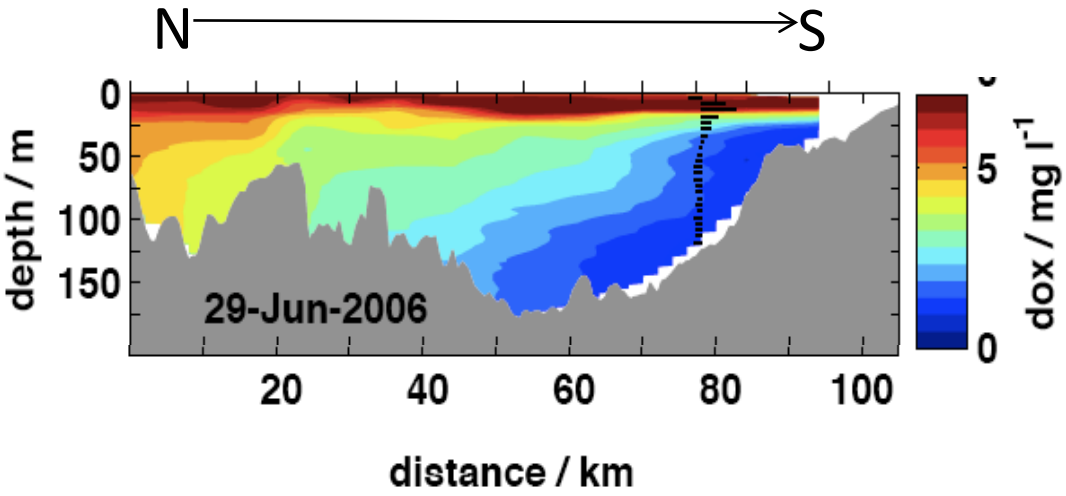


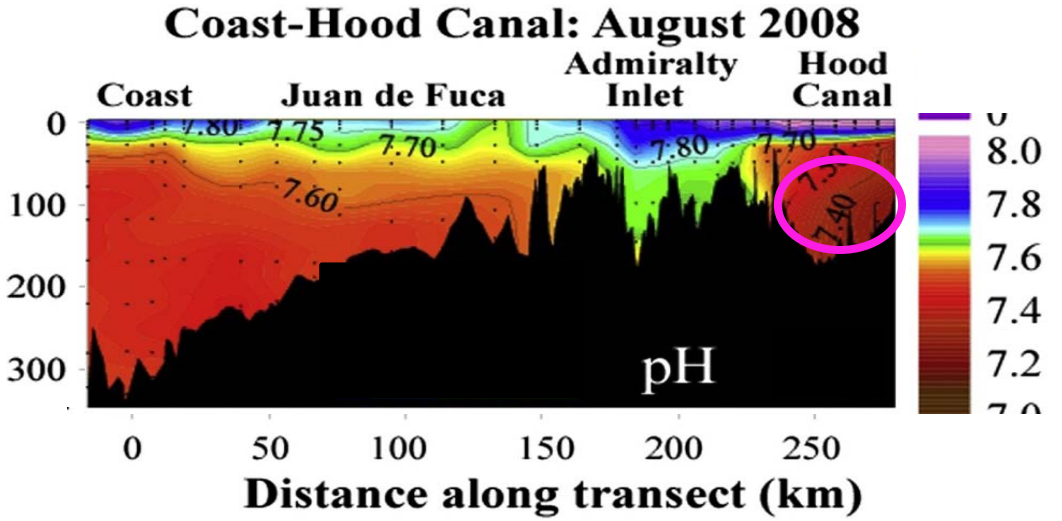
Low oxygen and pH are natural in Puget Sound.

Anthropogenic influence has decreased DO by <0.5 mg L^{-1} and pH by 0.05-0.15.

Feely et al. 2010

Hood Canal oxygen and pH patterns:





Feely et al. 2010

Research questions:

Are Puget Sound zooplankton adapted to the hypoxic and acidified conditions?

- Behavioral adaptations
- Physiological adaptations

1) How are the organisms distributed in the water column with respect to the chemistry? (field observations)

2) Do their vertical distributions change with conditions?

3) Are their growth, development, or survival affected?

→focusing on early life stages (lab studies)

4) Are there implications for energy transfer to upper trophic levels? (future modeling study)

Field methods:

SeaBird Electronics SBE911 plus CTD:

- T, S, DO, pH probe

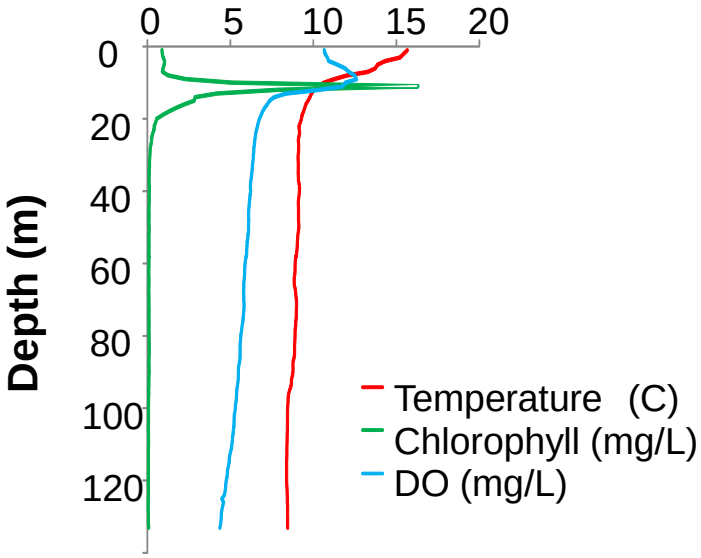
Niskin bottle sampling:

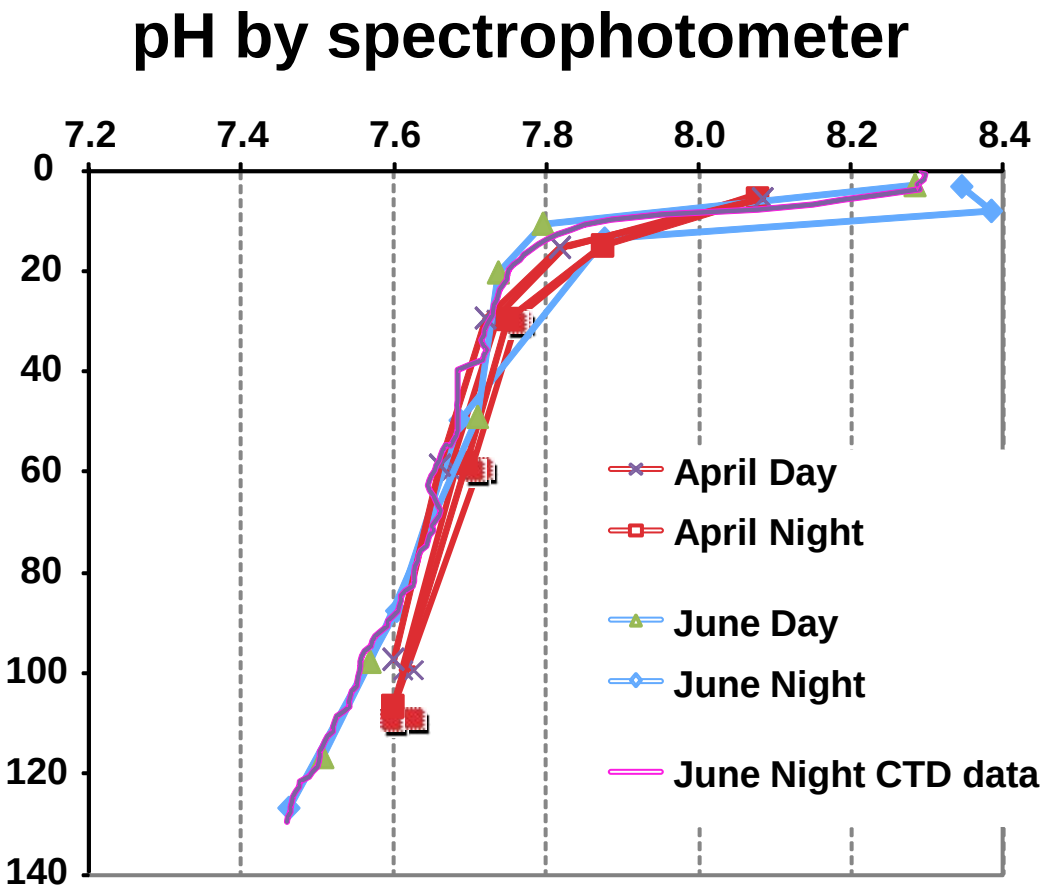
- DIC, TA
- Spectrophotometer pH
- Winkler titrations
- Phytoplankton and microzoop spp.

Depth-stratified net tows

- MultiNet® - 5 depths
- 200 um mesh

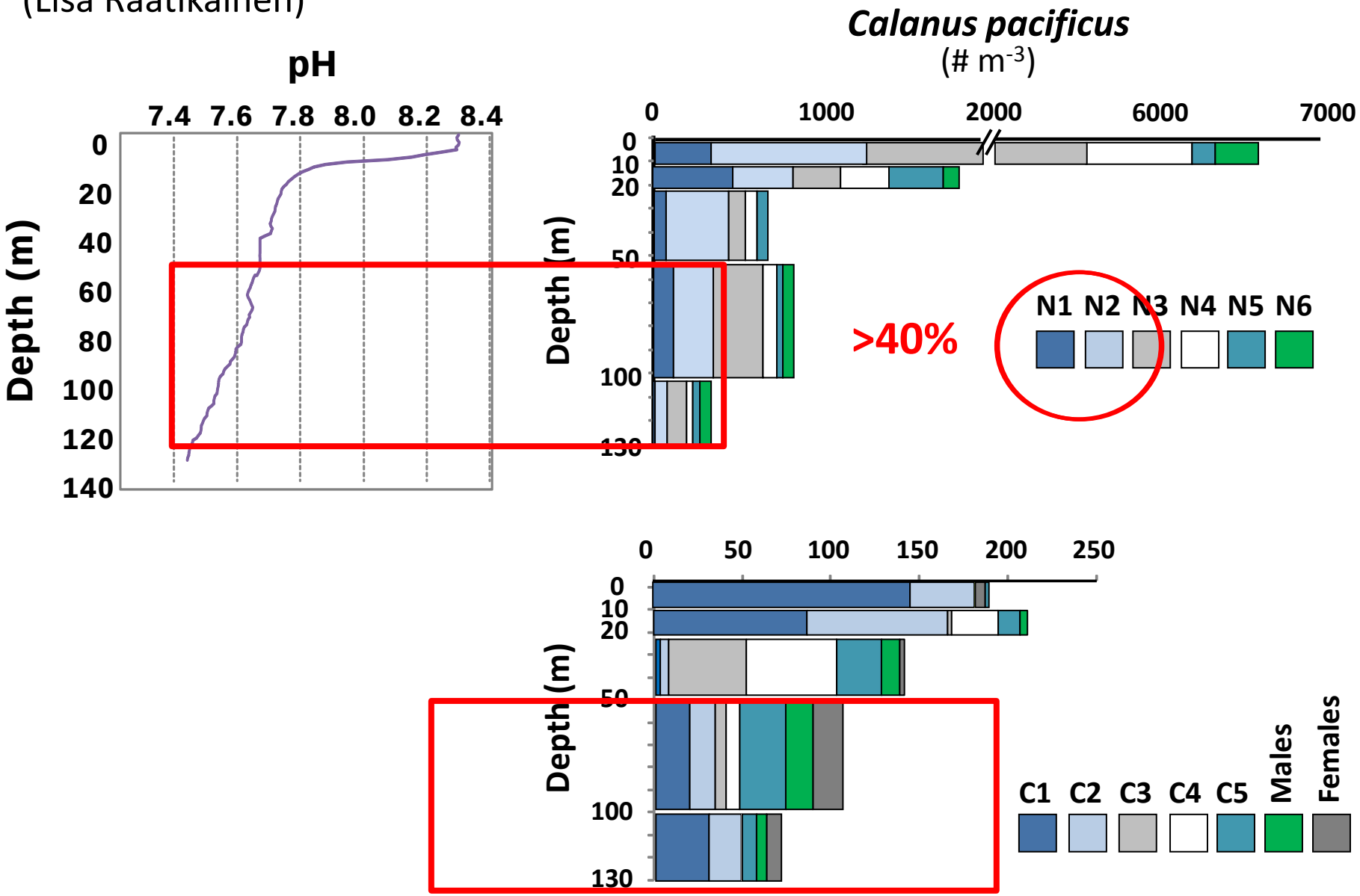
Northern Hood Canal station:





Daytime field distributions: *Calanus pacificus*

(Lisa Raatikainen)



The OA lab at the Seattle NOAA facility

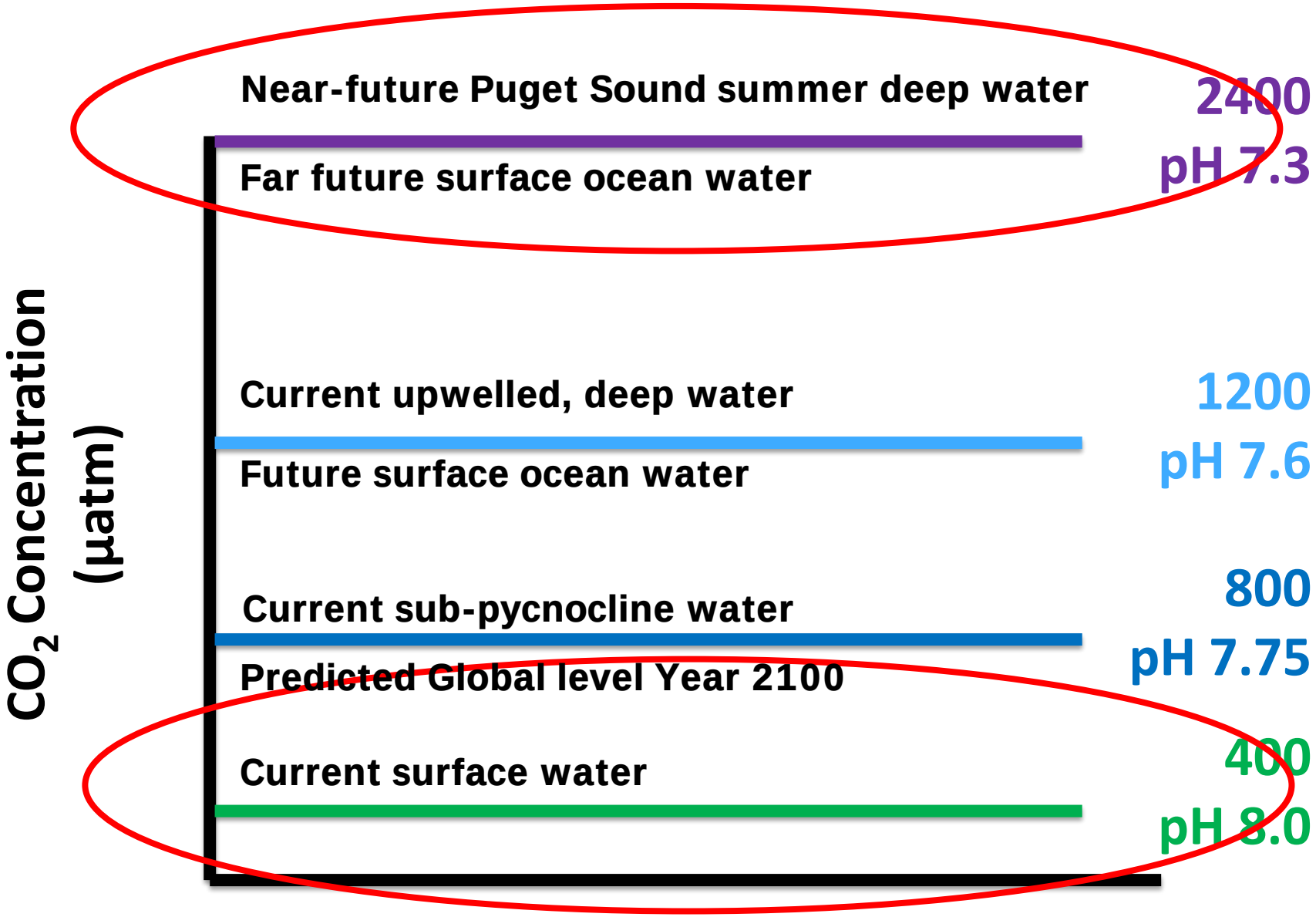
- 7 independently-controlled treatment tanks
- pH and temperature are controlled – bubbled with CO_2, O_2, N to control pH and DO
- pH (Durafet® probe), pCO_2 (Licor®), Temp, Salinity, and oxygen are continuously measured
- DIC, TA, and spectrophotometer pH are periodically measured.
- Capable of producing time cycles that mimic natural daily fluctuations in CO_2

Experimental methods:

- Copepods collected from Puget Sound
- Females place into individual 125 mL jars and spawned overnight under treatment conditions (pH, 12C).
- Next day – females removed, broods counted and used to create mixed broods or left intact
- Left undisturbed for 4 days ~until 50% reach 1st feeding stage (N3).
- On Day 4 after spawning, dead nauplii removed and jars preserved for counts of unhatched eggs and stages of live nauplii.

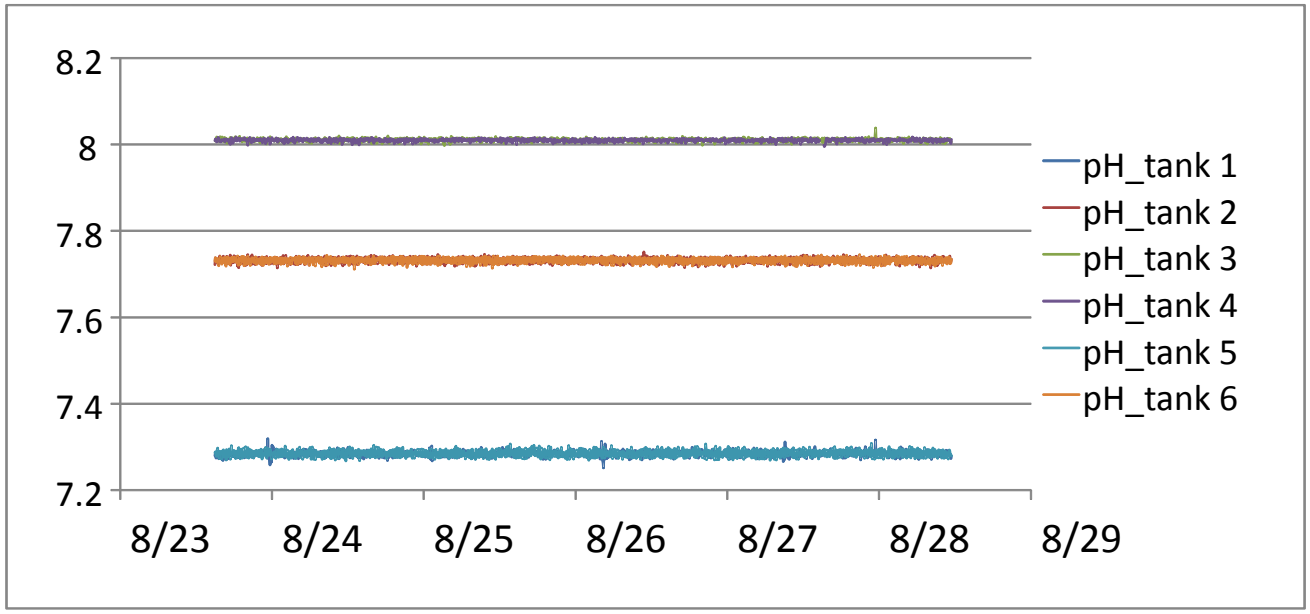
CO_2 treatment levels used?

*All at 12°C

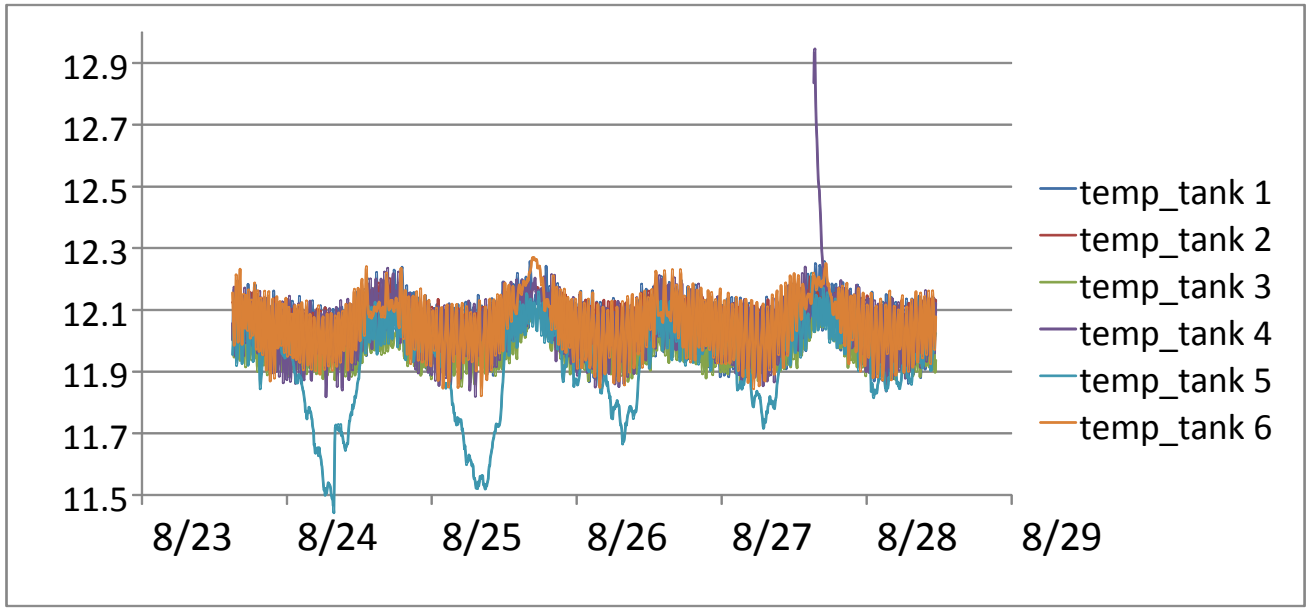


Probe data during experiment (example):

pH

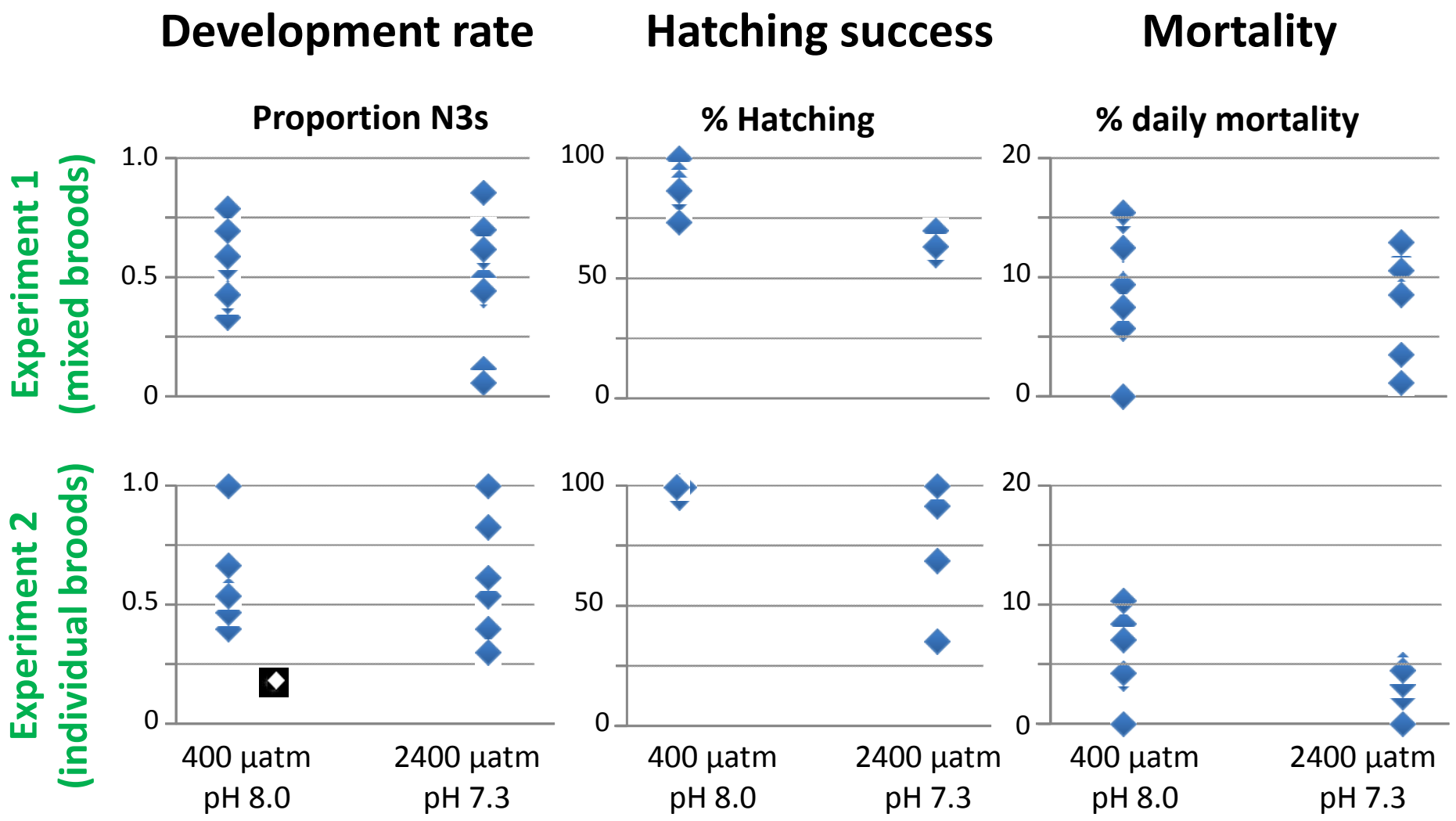


Temperature

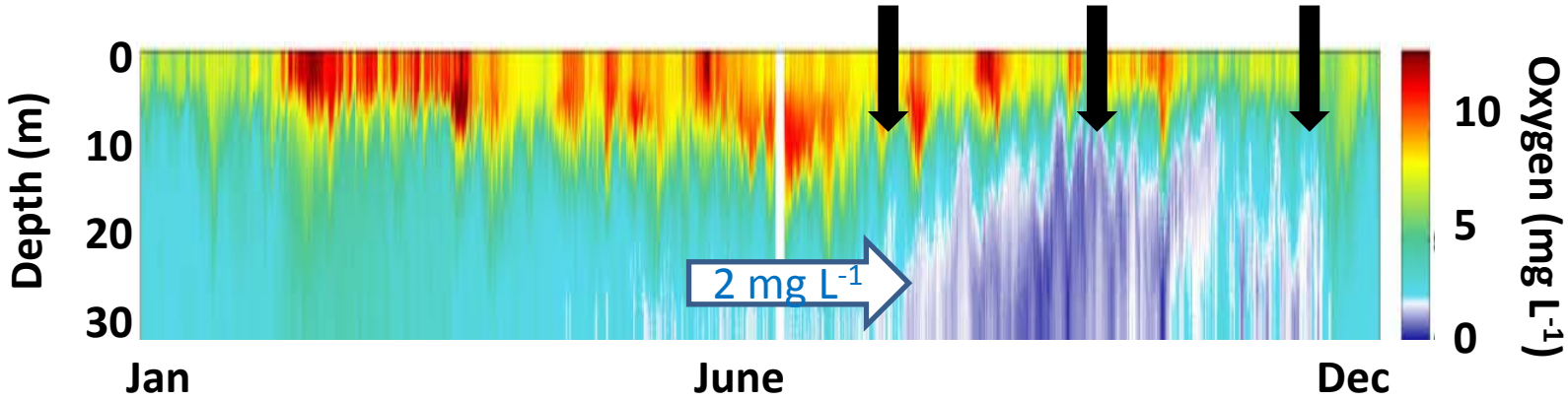


Experimental Results (preliminary)

(Anna McLaskey)



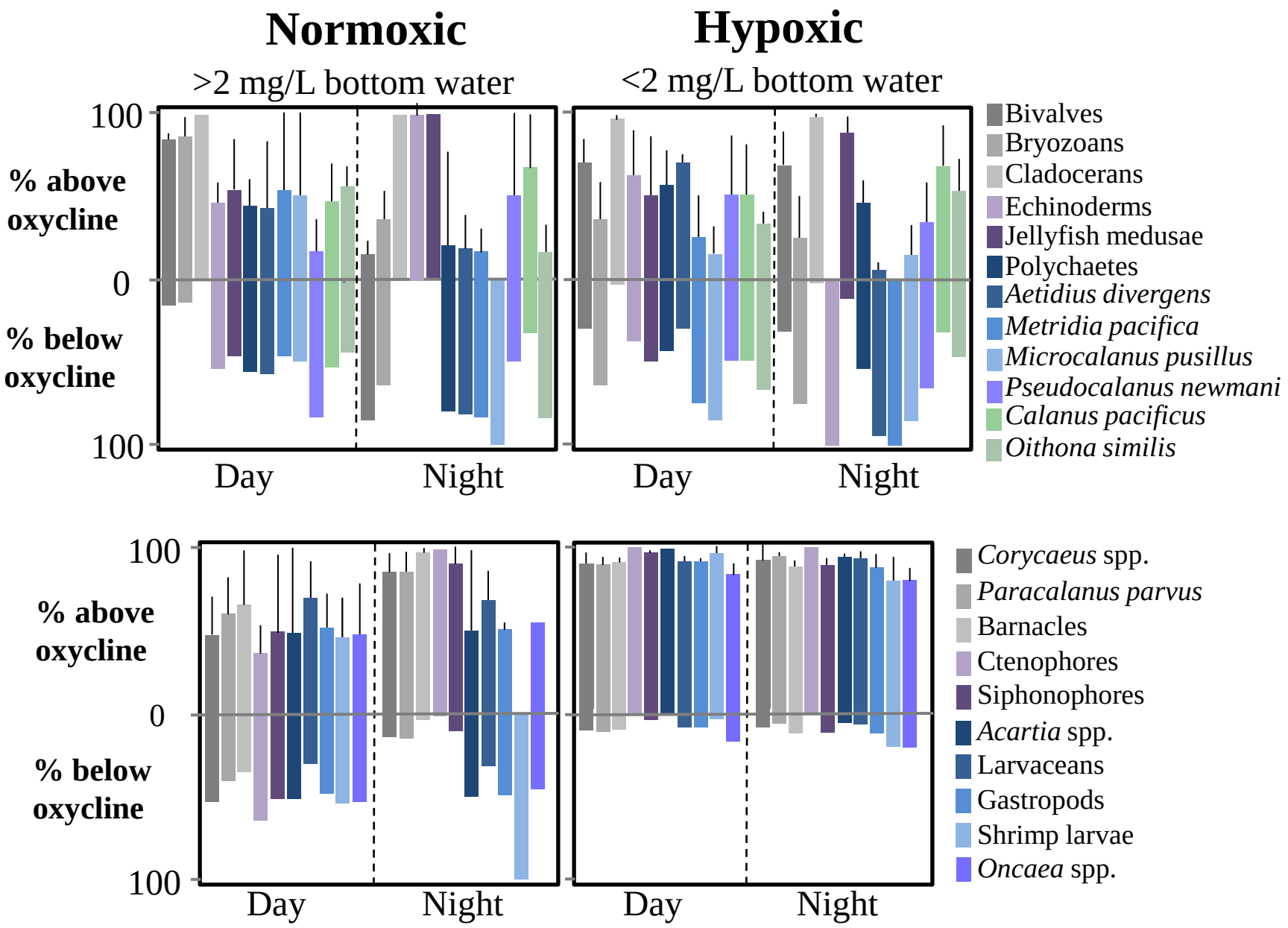
Seasonal hypoxia



ORCA buoy data, 2008, courtesy of Devol and Ruef

Avoidance of hypoxic bottom water? Effects on DVM

Keister and Tuttle (2012?)In revision at L&O



Conclusions

- A significant fraction of the early life stages of zooplankton inhabit very low-pH waters (example: *Calanus pacificus*). Population implications?

- Lab experiments hint that hatching success is affected by low pH, but not development after successful hatching.
  -supports results of Zhang et al. 2011 and others on effects on copepods.

- Hypoxia causes species-specific modification of behavior with some taxa showing distribution changes.

- Effects are species specific, and will not be simple to generalize to ecosystems without measuring critical ecosystem components.

Funding acknowledgments:

Field surveys

Laboratory experiments