Diversity in zooplankton responses to hypoxia and elevated pCO_2

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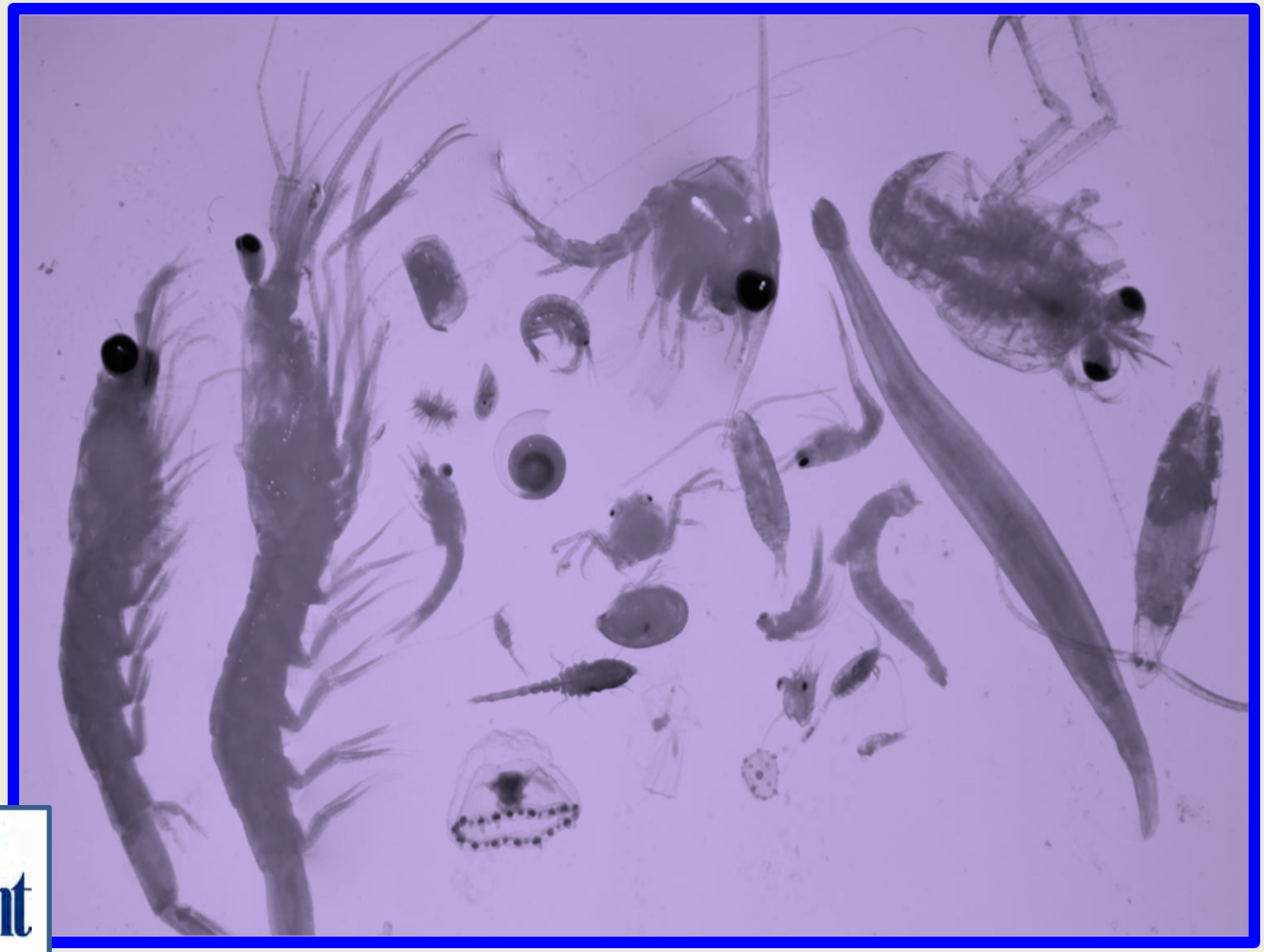


Global Climate Change

Expanding regions of hypoxia and low pH

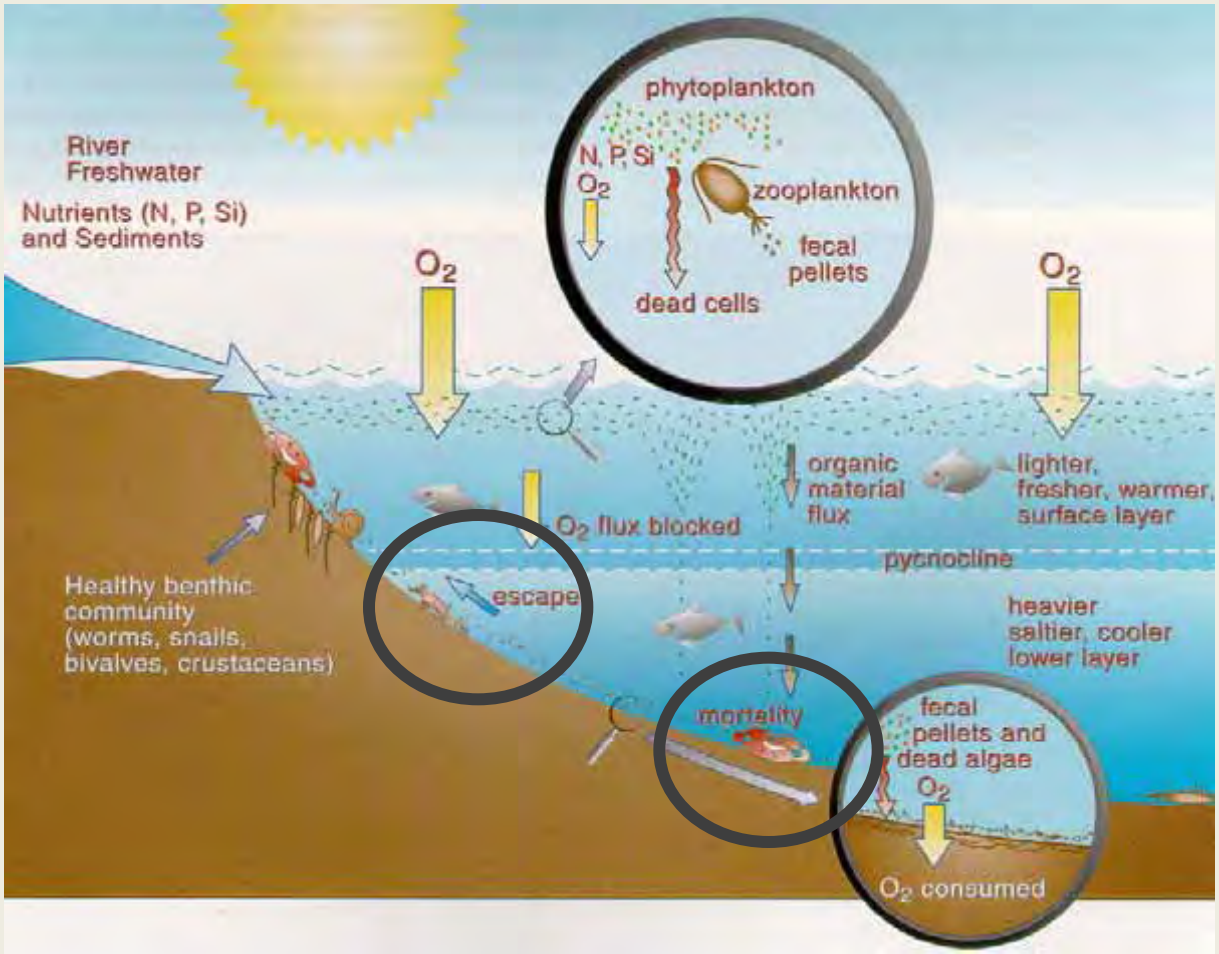
Direct effects:

- Mortality
- Stressed physiology

Indirect effects:

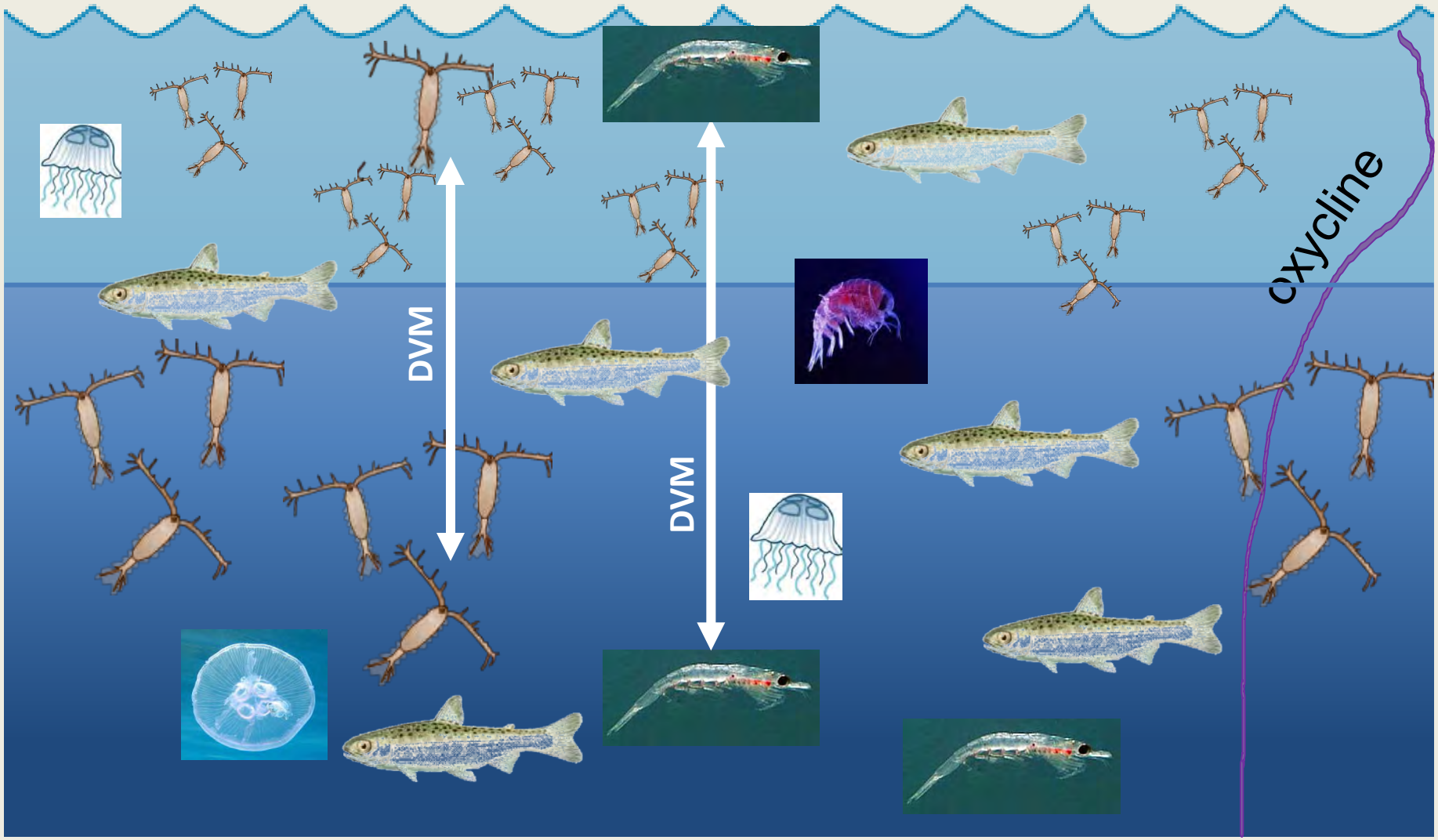
- Avoidance
- Changes in community structure
- Changes in trophic interactions
- Altered biogeochemistry

Ecosystem change



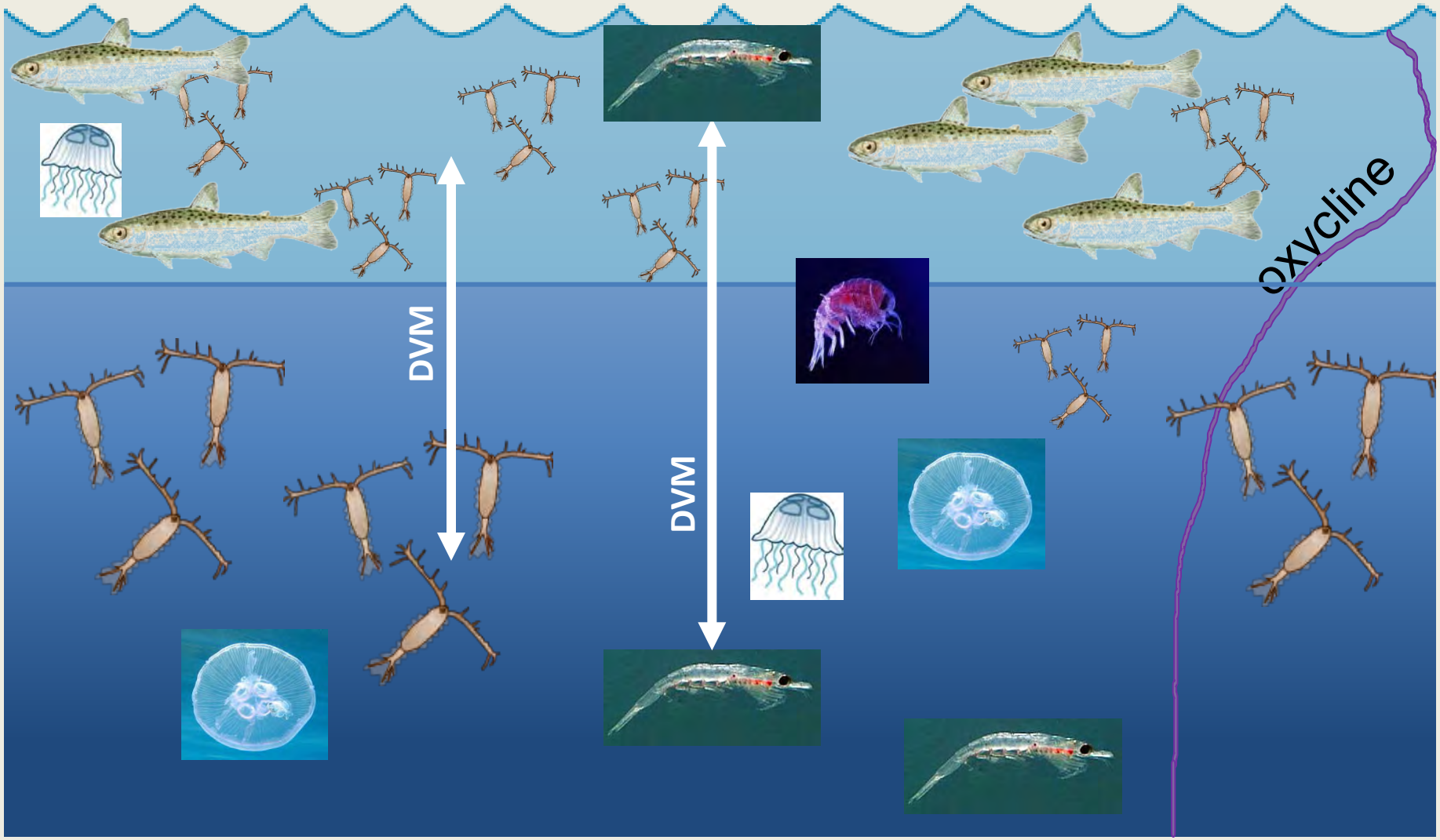
From Downing et al. 1999

In an undisturbed water column:
How do fish and zooplankton interact?



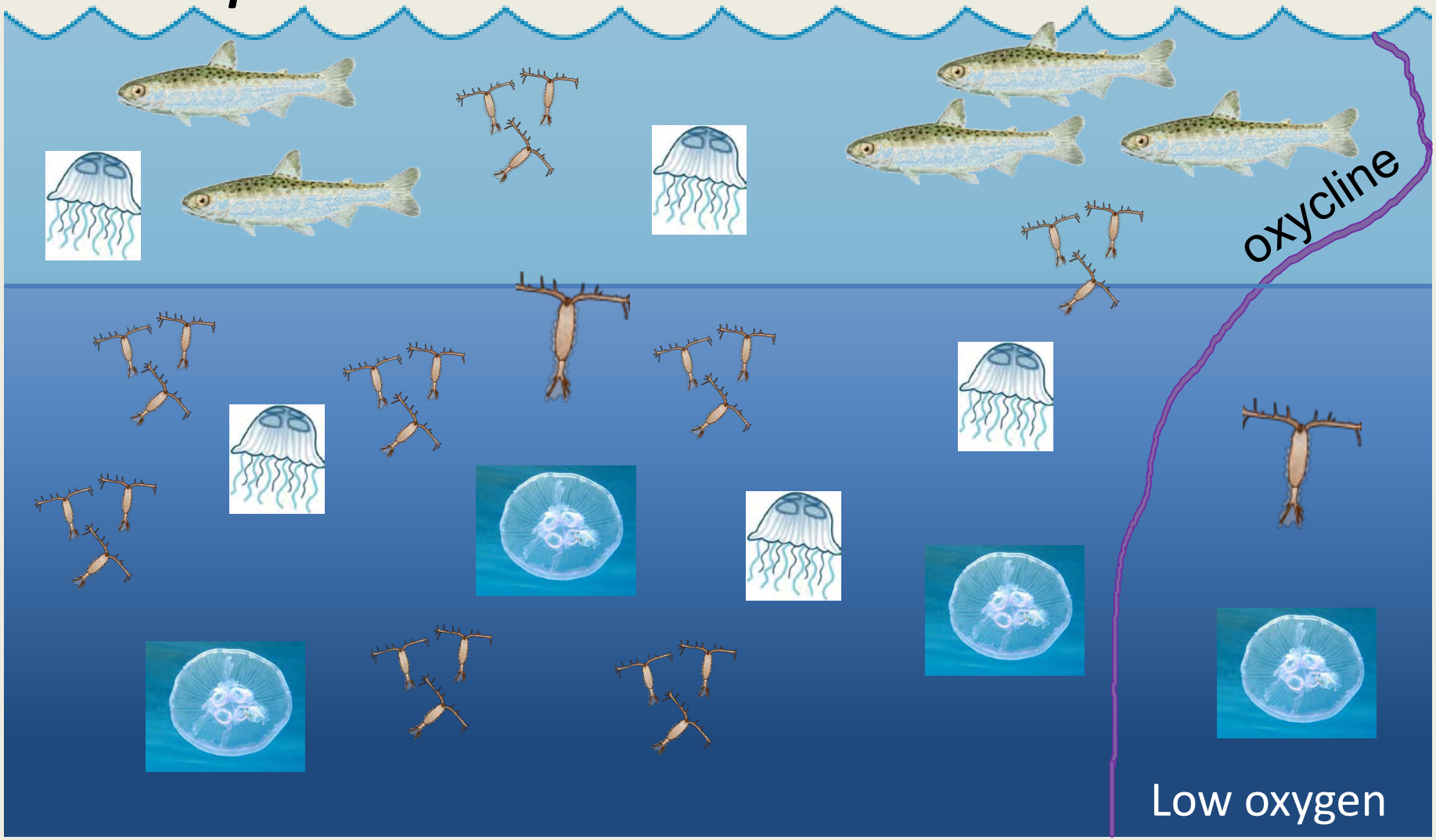
Under moderate oxygen depletion (2-4 mg DO l^{-1}):

Hypothesize shifts in fish; subtle changes in zooplankton.



Under hypoxic conditions (<2 mg DO l^{-1}):

Hypothesize changes in zooplankton abuandance, location, and composition.



Research questions:

How do changes in water chemistry affect trophic energy transfer between zooplankton and fish?
(my focus = on the zooplankton)

1) Do whole water column abundances change with conditions?
2) How are the organisms distributed in the water column with respect to the chemistry?
3) Is zooplankton community composition affected?
   (= talk at Ocean Sciences)
4) Are predatory-prey overlap and feeding altered?
   (fish observations → future modeling study)

How does zooplankton species diversity affect our ability to address these questions?

Study location: Puget Sound, WA

Seasonal hypoxia

Strong gradient in oxygen and pH with distance from the ocean

Diverse species assemblage

Species composition (dominant taxa):

Copepods (>30 spp.):

Acartia clausi
Acartia longiremis
Aetideus divergens
Calanus pacificus
Centropages abdominalis
Corycaeus spp.
Euchaeta elongata
Harpacticoida
Metridia pacifica
Microcalanus pusillus
Oithona atlantica
Oithona similis
Oithona spinirostris
Oncaea borealis
Oncaea subtilis
Paracalanus parvus
Pseudocalanus newmani
Pseudocalanus mimus
Pseudocalanus minutus

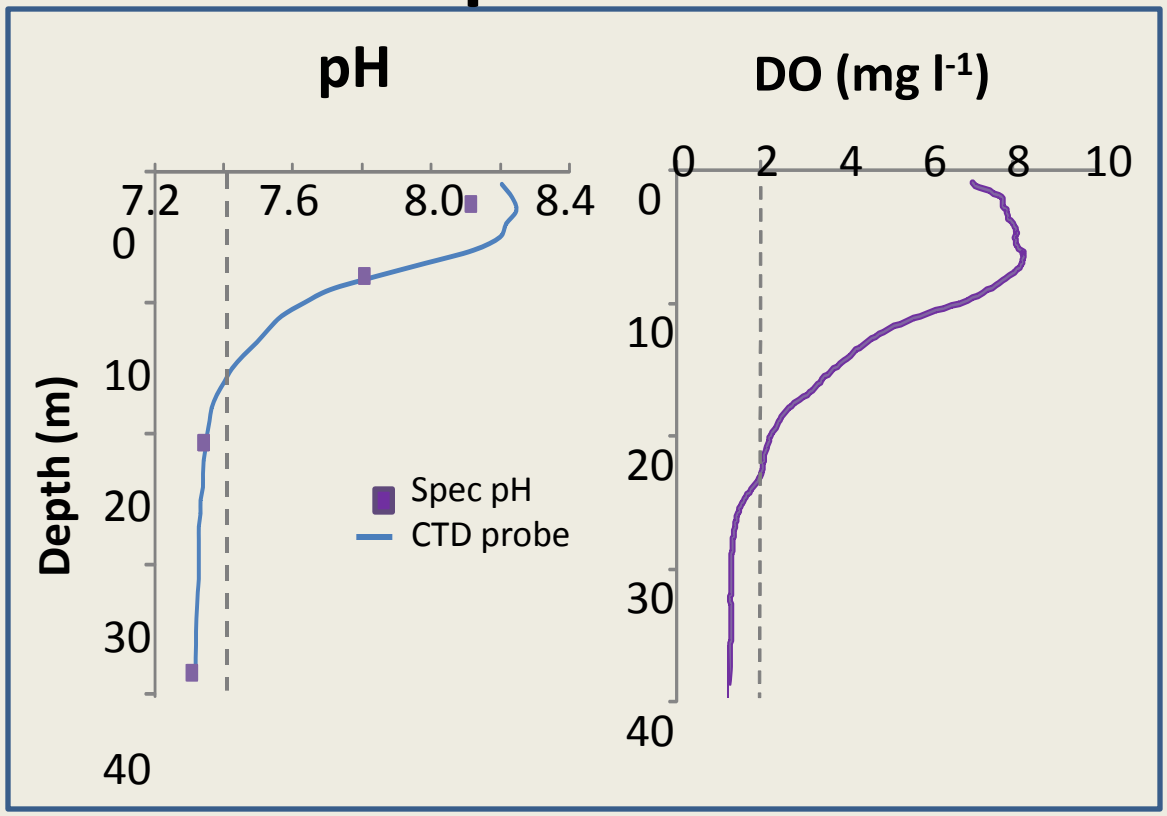
Other Crustaceans:

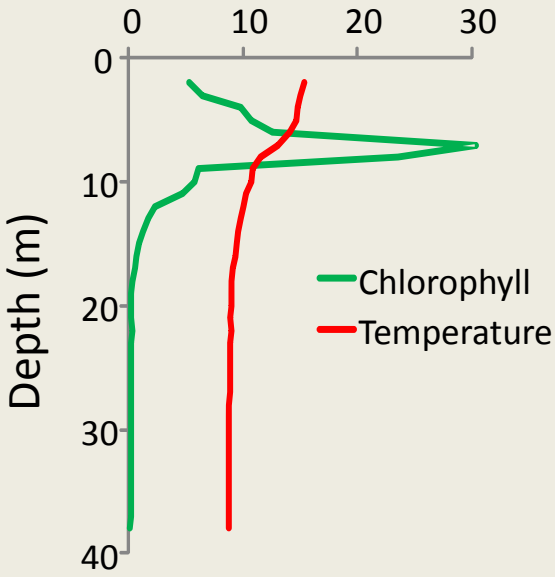
Amphipods - *Hyperoche, Primno, Parathemisto, Cyphocaris*
Barnacles
Crab larvae - *Fabia, Cancer, Lophopanopeus, Pugettia*
Euphausiids – *E. pacifica, T. raschii, T. spinifera, T. longipes*
Cladocerans - *Evadne* sp.
Ostracods
Cumaceans
Shrimp

Others:

Medusae - *Aurelia, Aequorea, Cyanea*
Siphonophores
Ctenophores
Bivalves
Bryozoans
Chaetognaths
Pteropods (*Limacina, Clione, Clio*)
Echinoderms
Gastropods
Larvaceans
Polychaetes

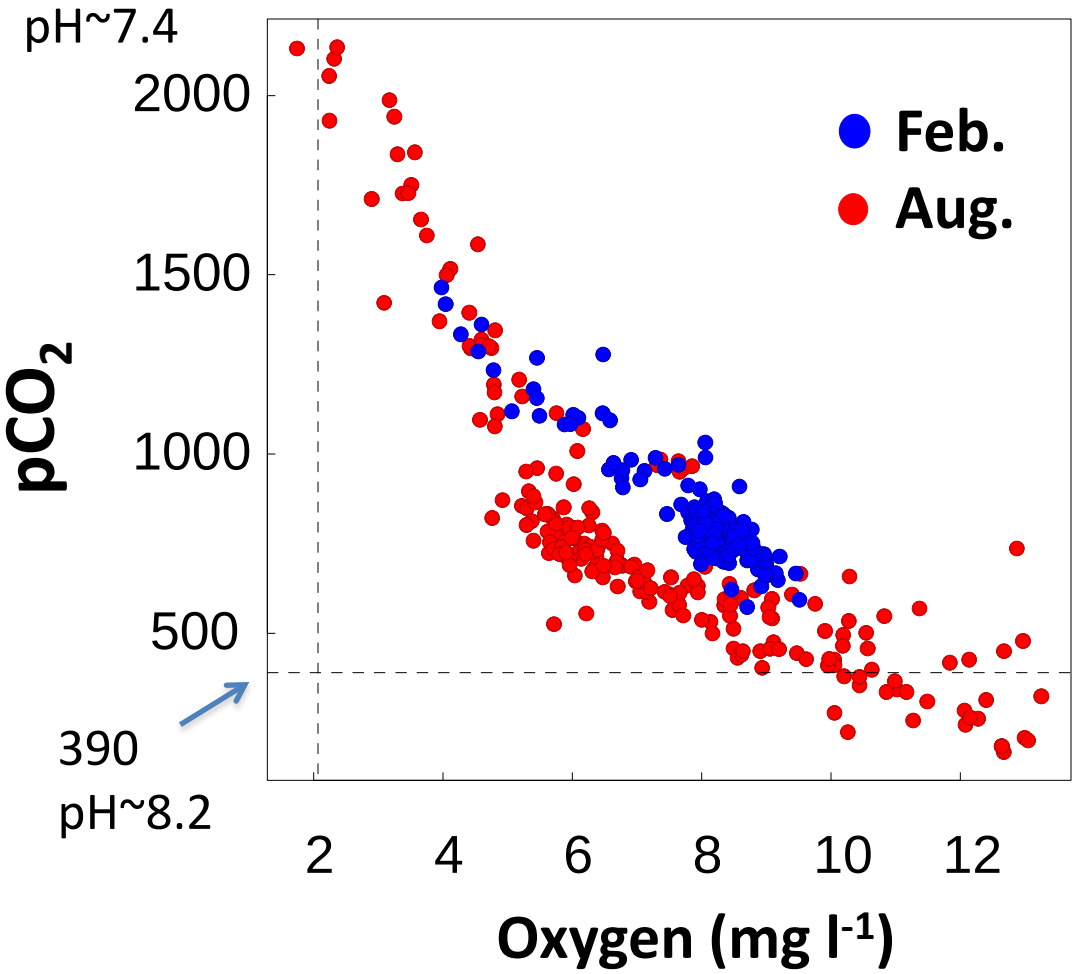
September





Bottom water:

pH < 7.4 **DO < 2.0 mg l^{-1}**

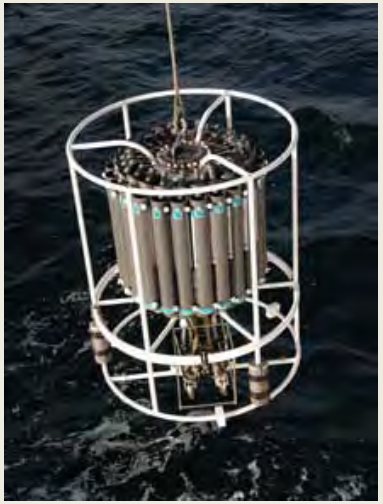


Data courtesy R. Feely, NOAA
Plot courtesy J. Reum, NOAA

Field collections:

SeaBird Electronics SBE911 plus CTD:

- T, S, DO, pH probe



Niskin bottle sampling:

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

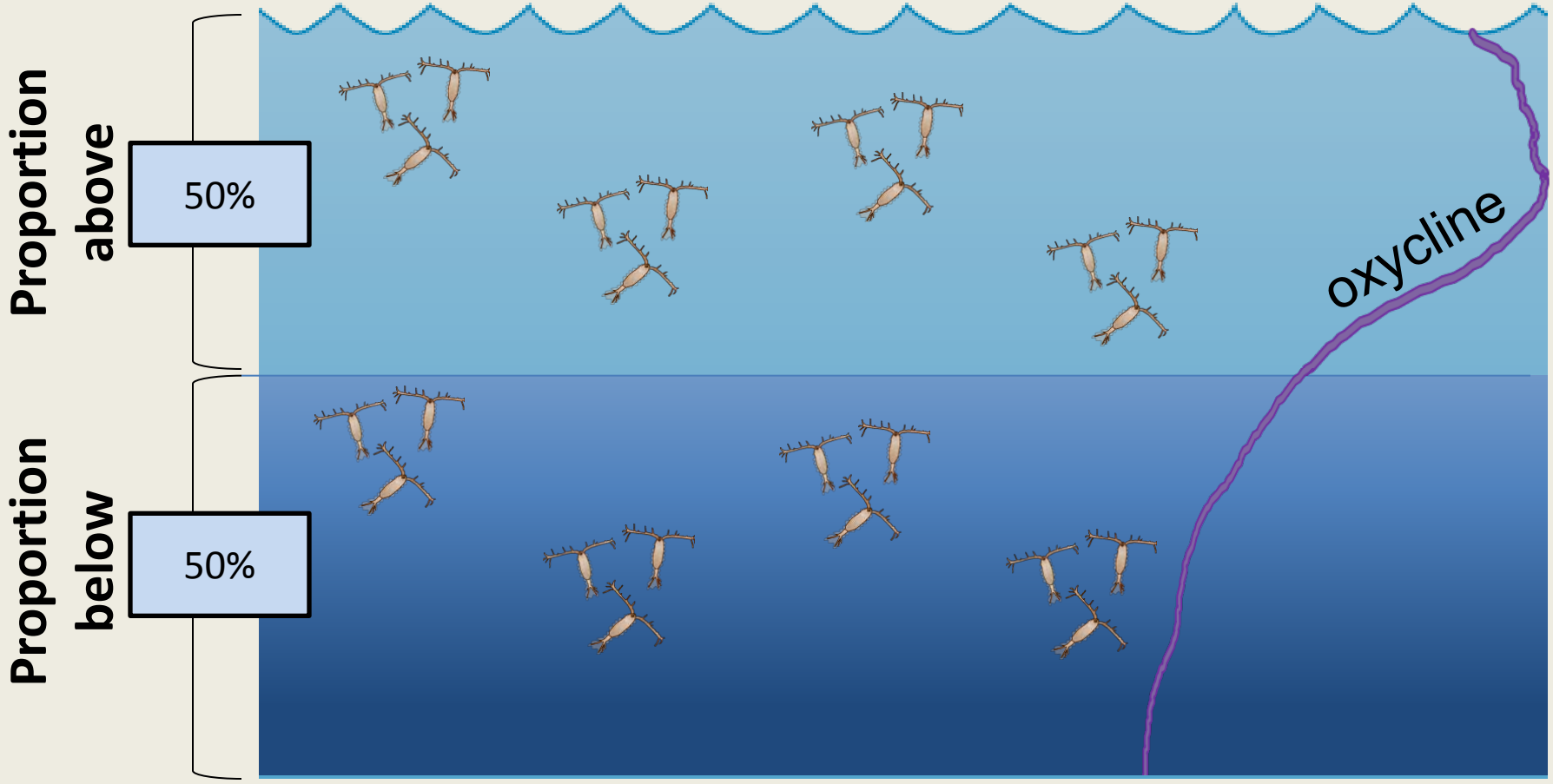
Depth-stratified plankton net tows

- Closing vertical nets – 75 and 200 µm mesh
- Closing oblique nets - 335 µm mesh

(Acoustics)

(Mid-water trawls)

Measuring vertical distributions:
Metric = proportion above the oxycline



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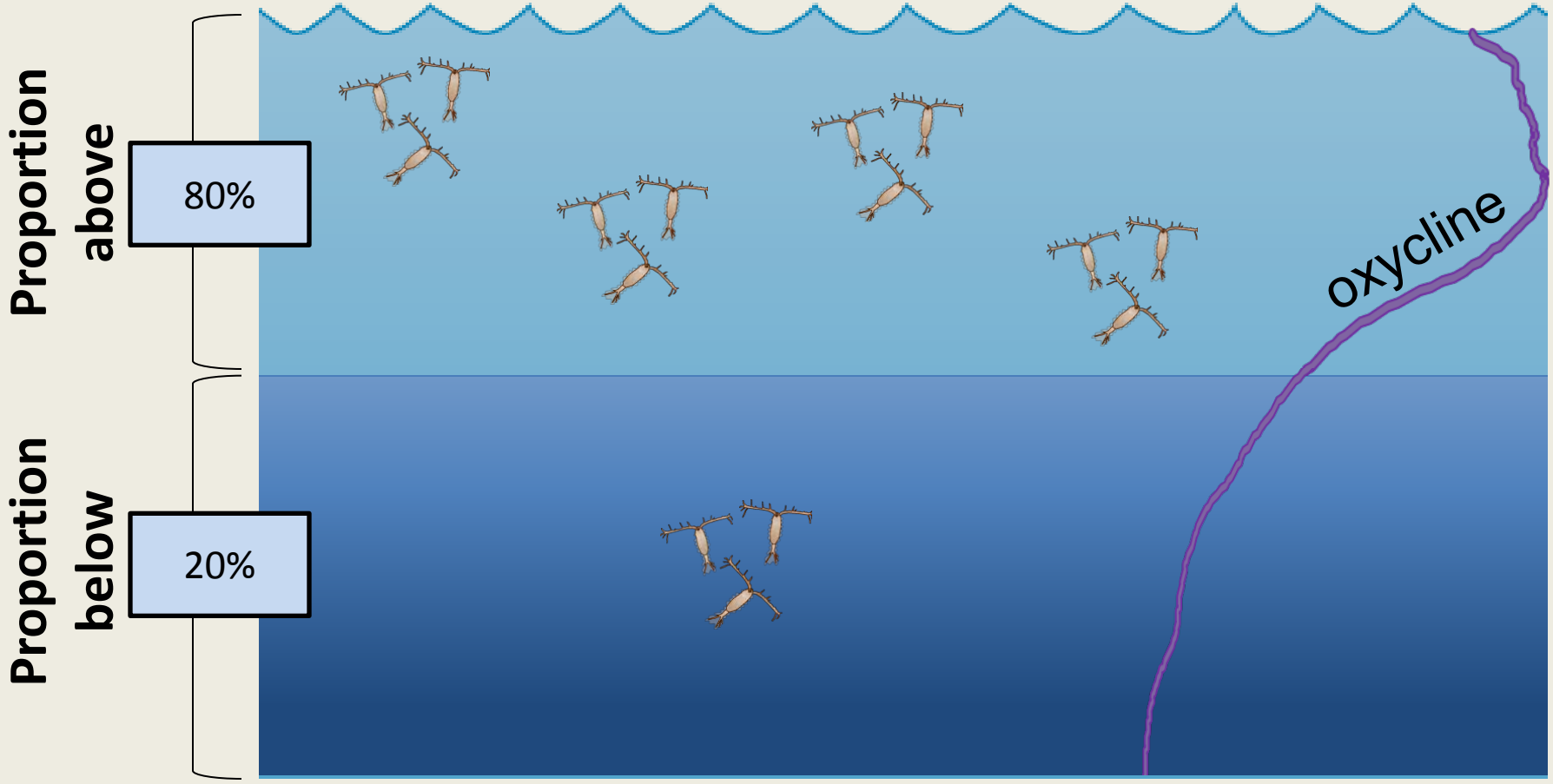
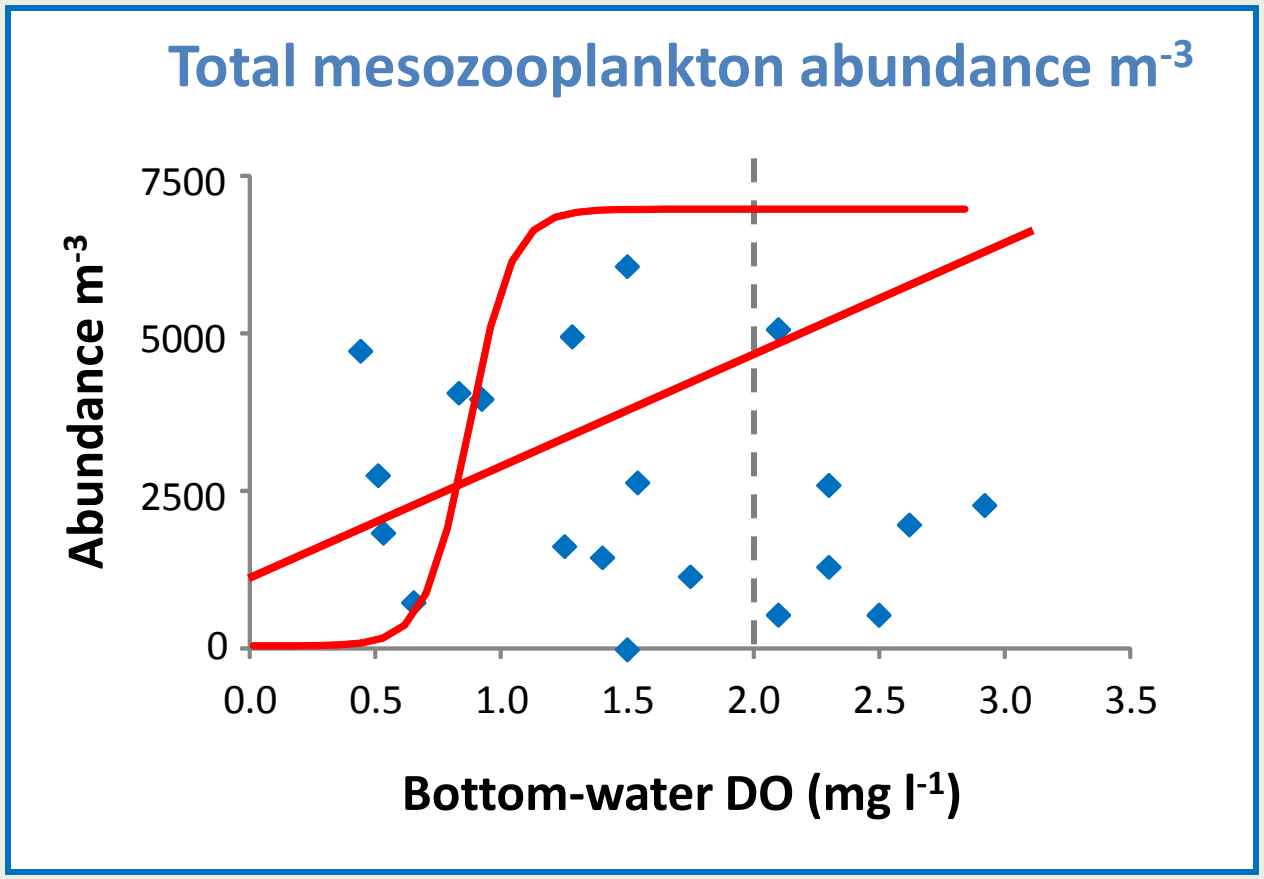
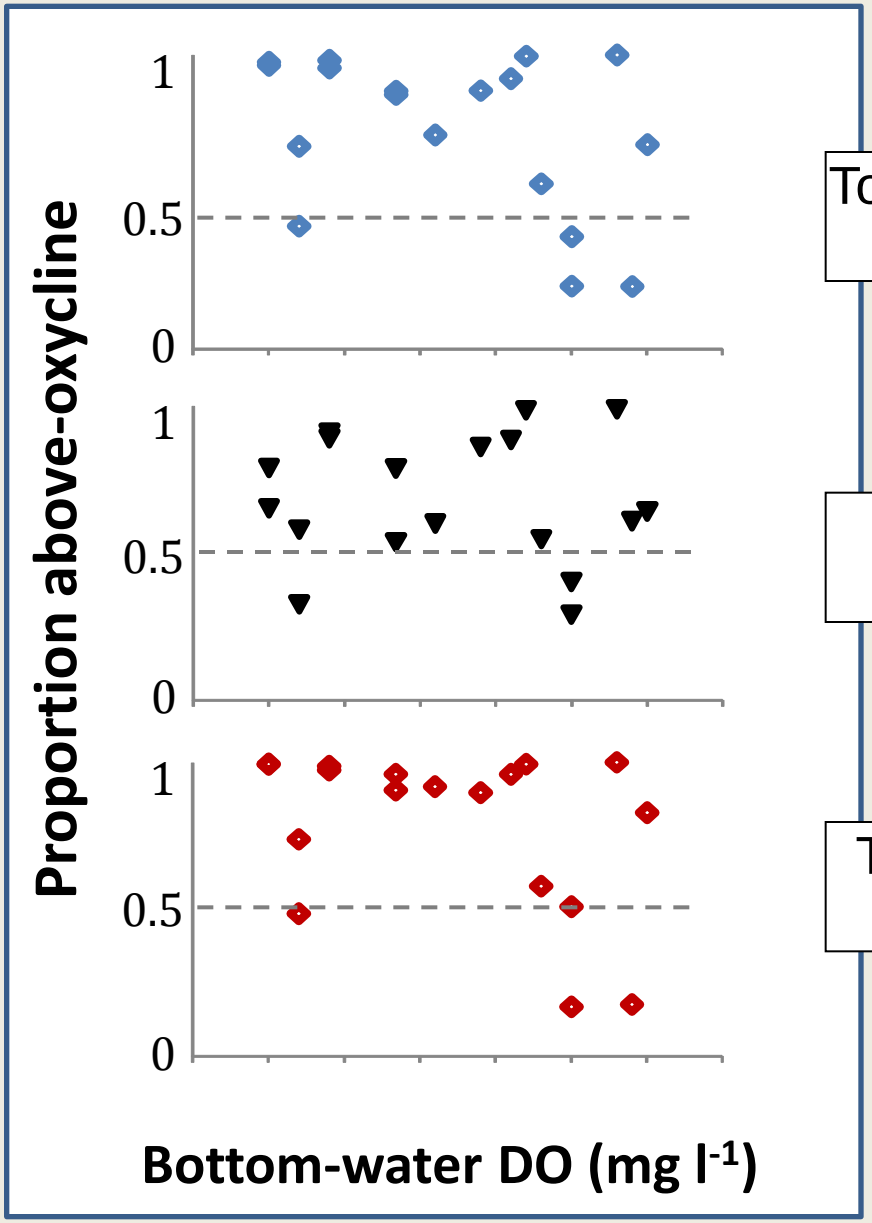


Results:

No pattern in total abundances with bottom oxygen:



No pattern in proportion of organisms above the oxycline with bottom oxygen:

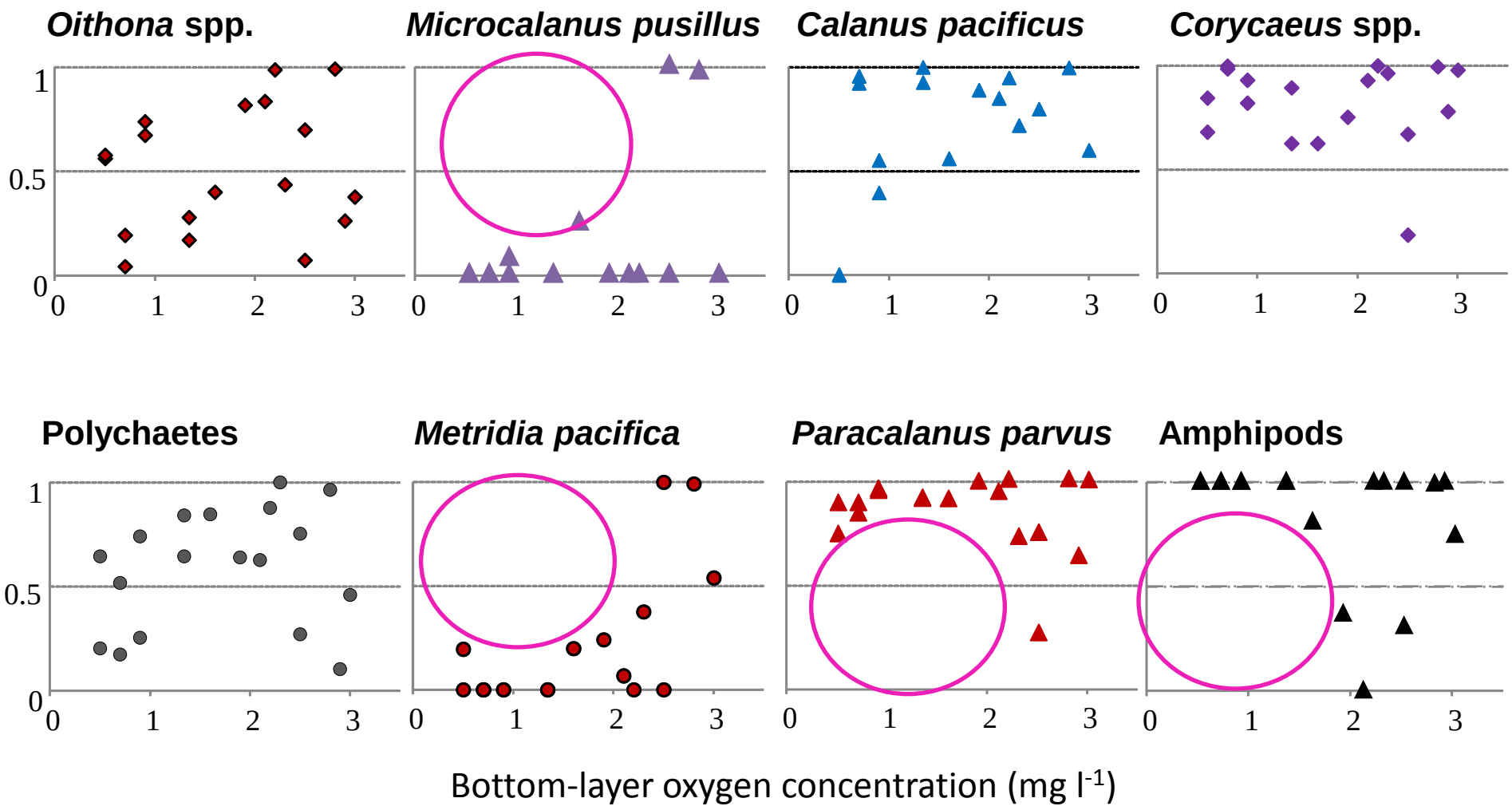


Total mesozooplankton abundance

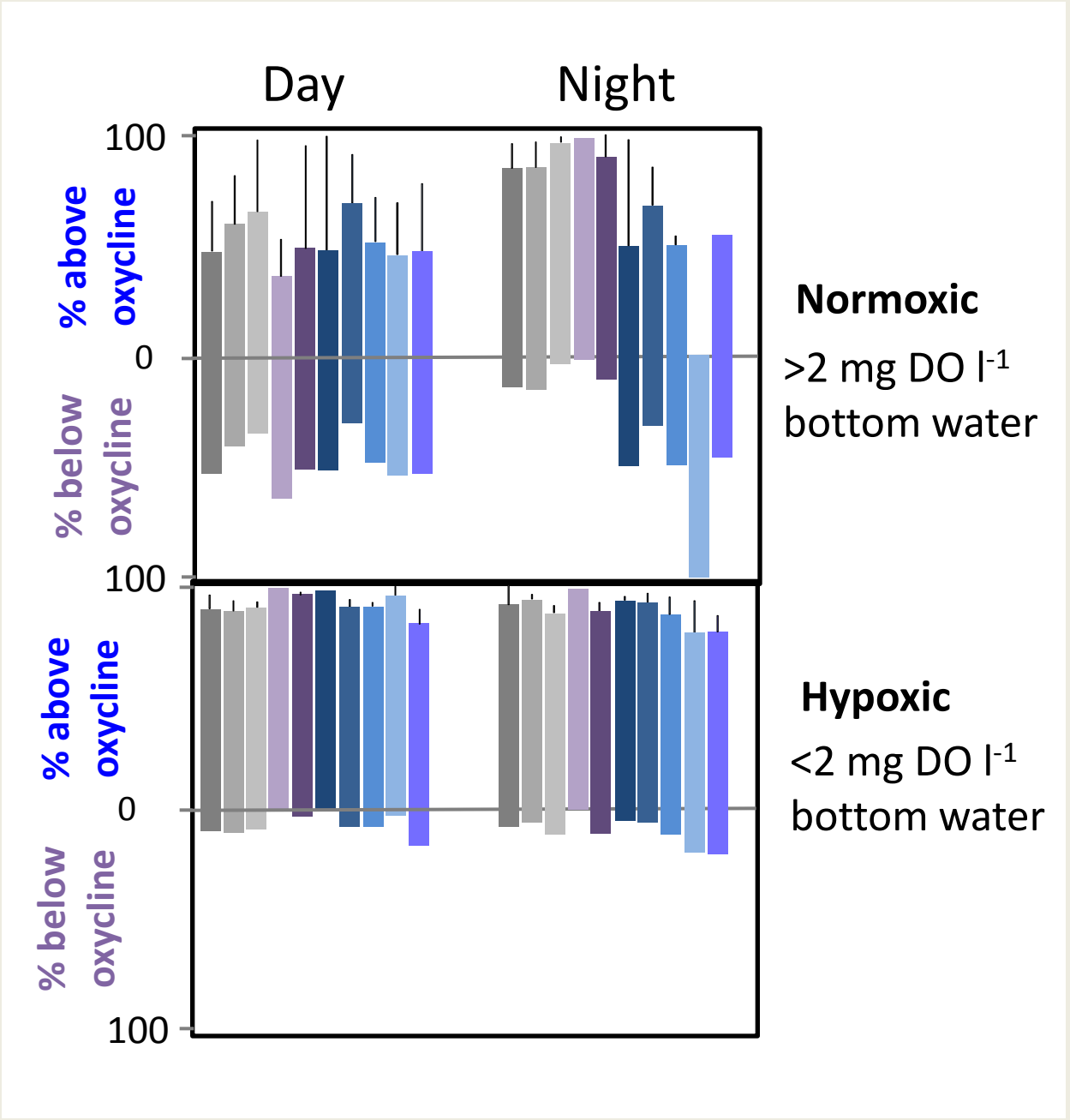
Total copepod abundances

Total non-copepod abundances

Proportion of population above the oxycline:



Avoidance of bottom water? Effects on Diel Migration



Keister and Tuttle (2013)

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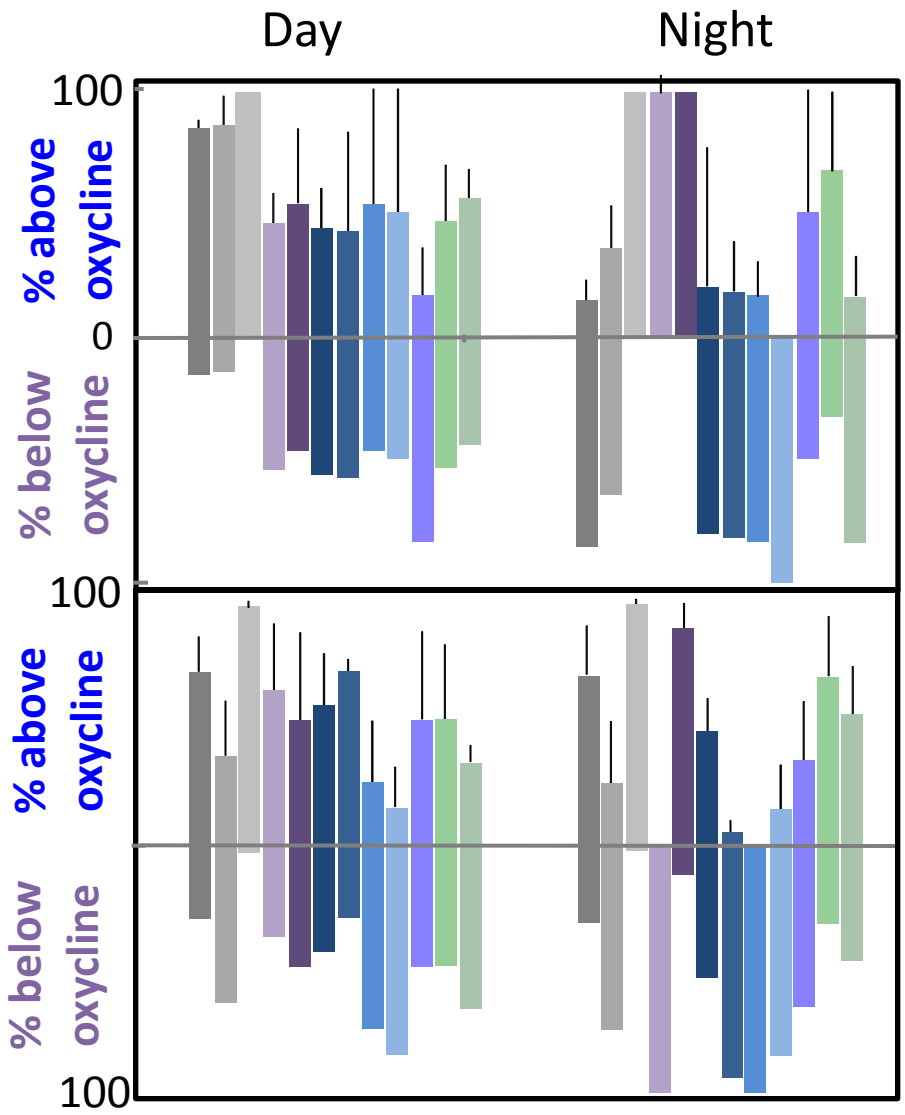

Normoxic
>2 mg DO l^{-1}
bottom water

Hypoxic
<2 mg DO l^{-1}
bottom water

- Bivalves
- Bryozoans
- Cladocerans
- Echinoderms
- Jellyfish medusae
- Polychaetes
- *Aetidius divergens*
- *Metridia pacifica*
- *Microcalanus pusillus*
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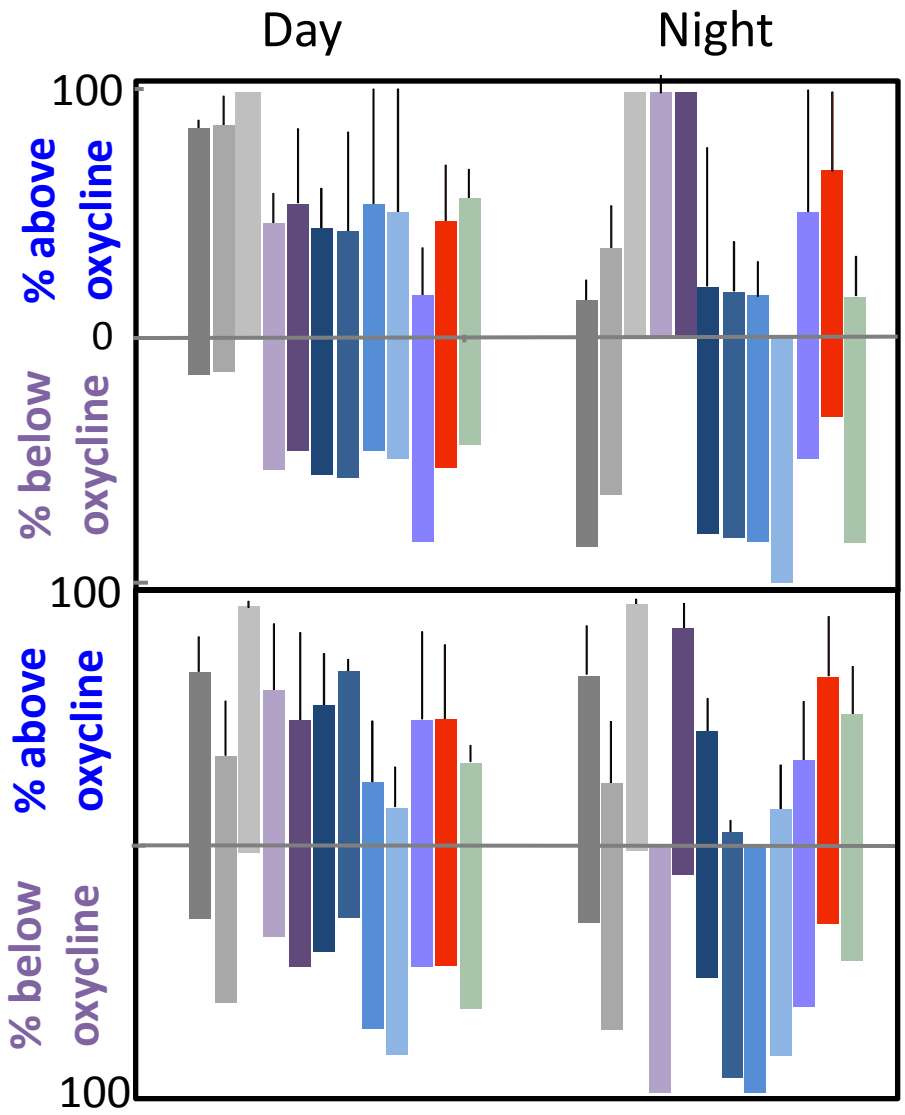

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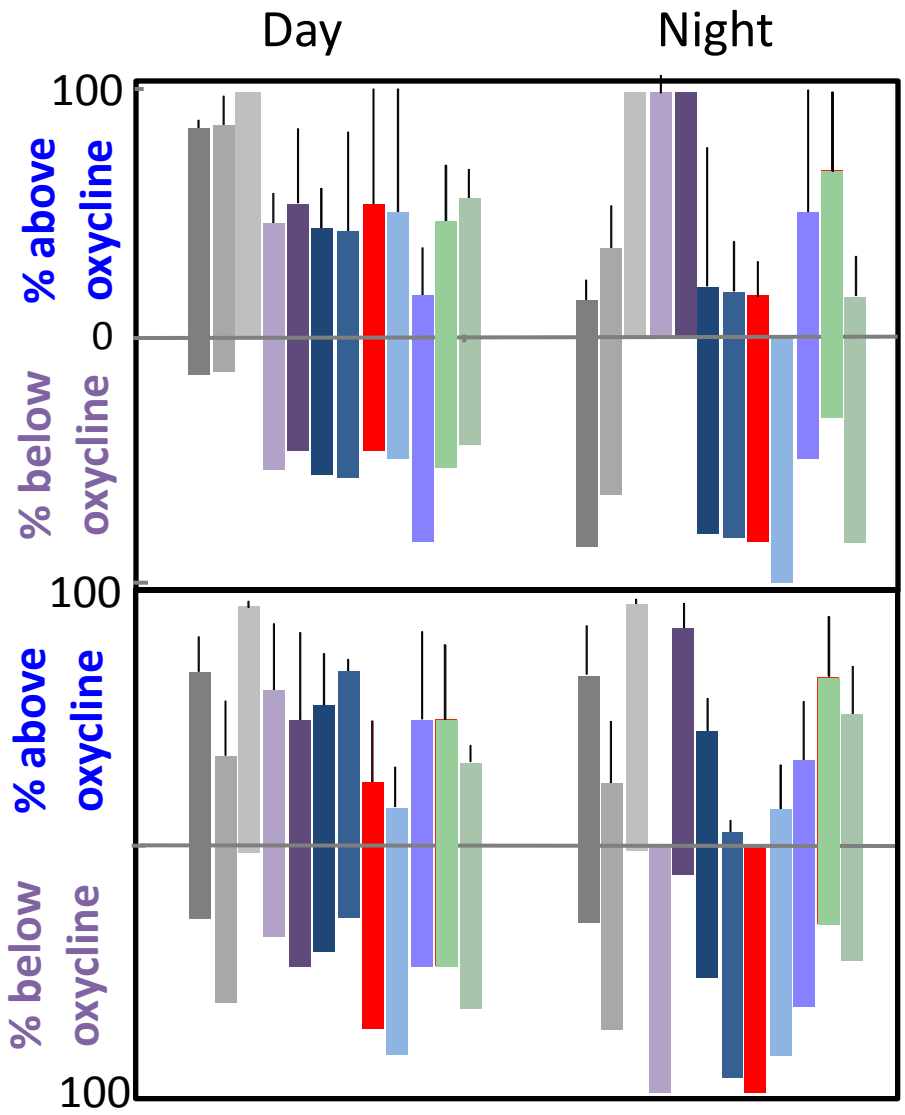

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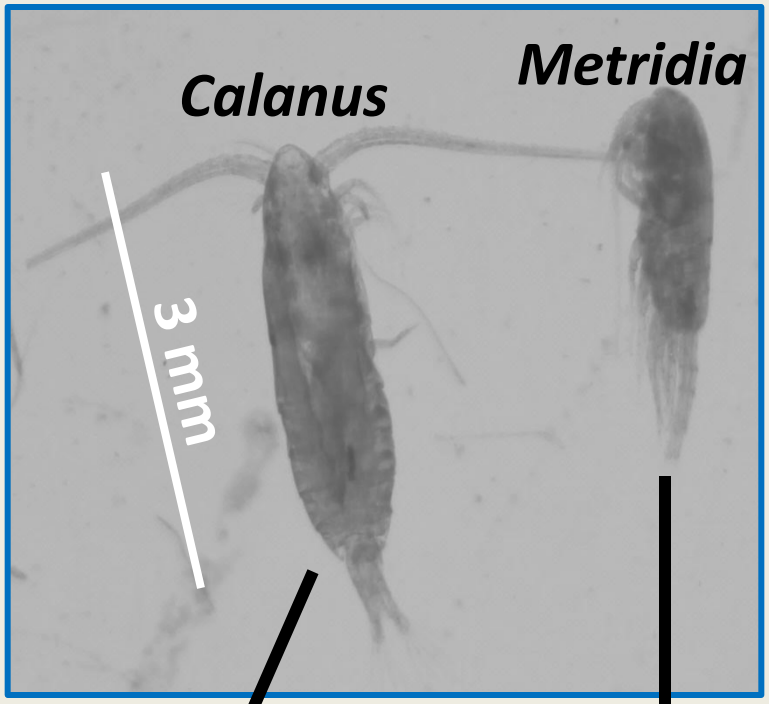
Keister and Tuttle (2013)

Not all copepods are created equal!
And not all behave the same way.

Showed no change



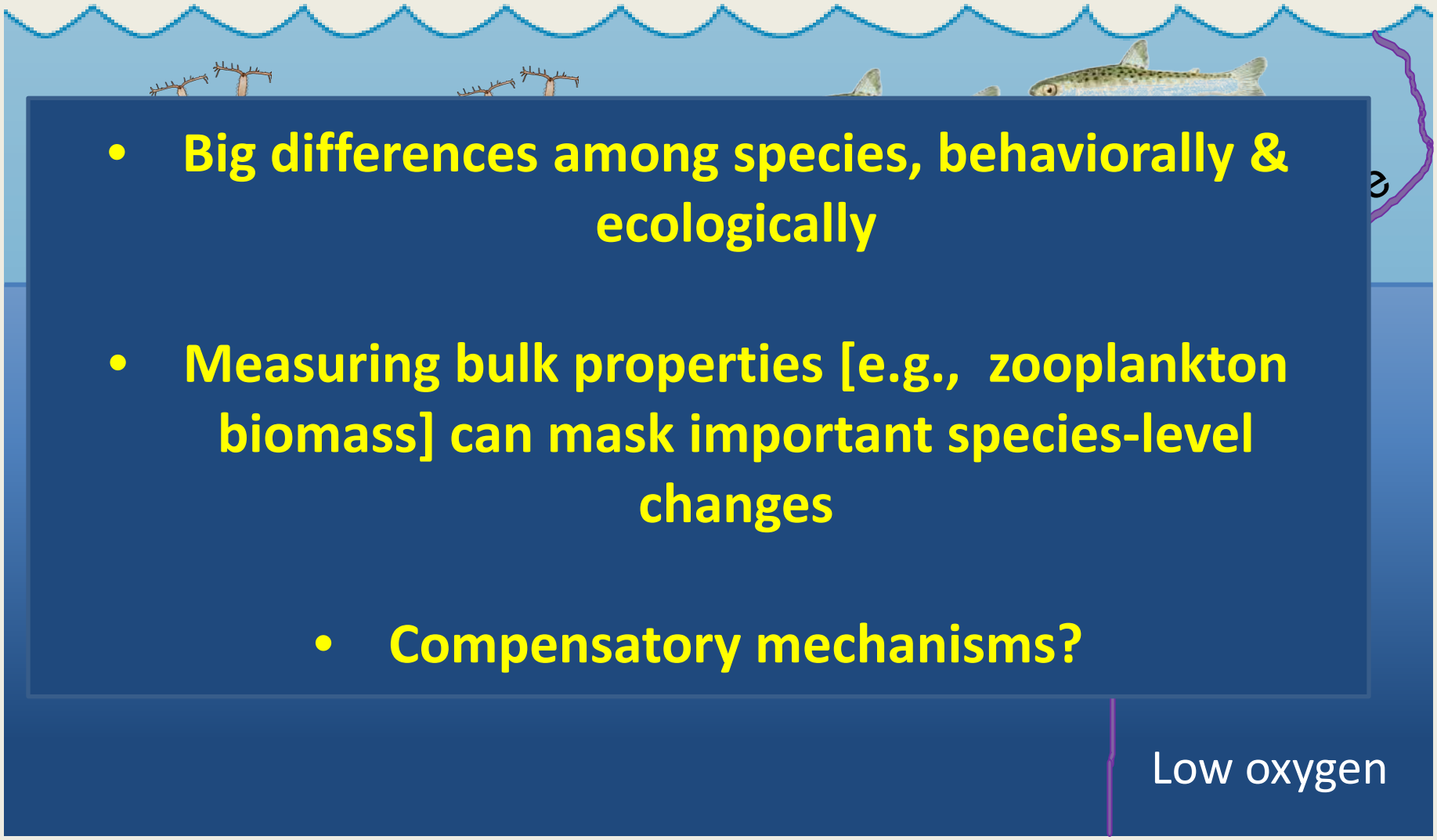
Showed change

Moved towards surface

Remained mainly below oxycline

Maintained normal DVM for the region (but most above oxycline D&N)

Trophic consequences of differential tolerances:



- **Big differences among species, behaviorally & ecologically**
- **Measuring bulk properties [e.g., zooplankton biomass] can mask important species-level changes**
- **Compensatory mechanisms?**

Funding:

Acknowledgments:

Crew of the R/V Barnes
Crew of the F/V Memories
Naomi Yoder
Olga Kalata
Tim Essington
Sandy Parker-Stetter
John Horne
Shallin Busch
Ray McQuin