Too Hot to Breathe:

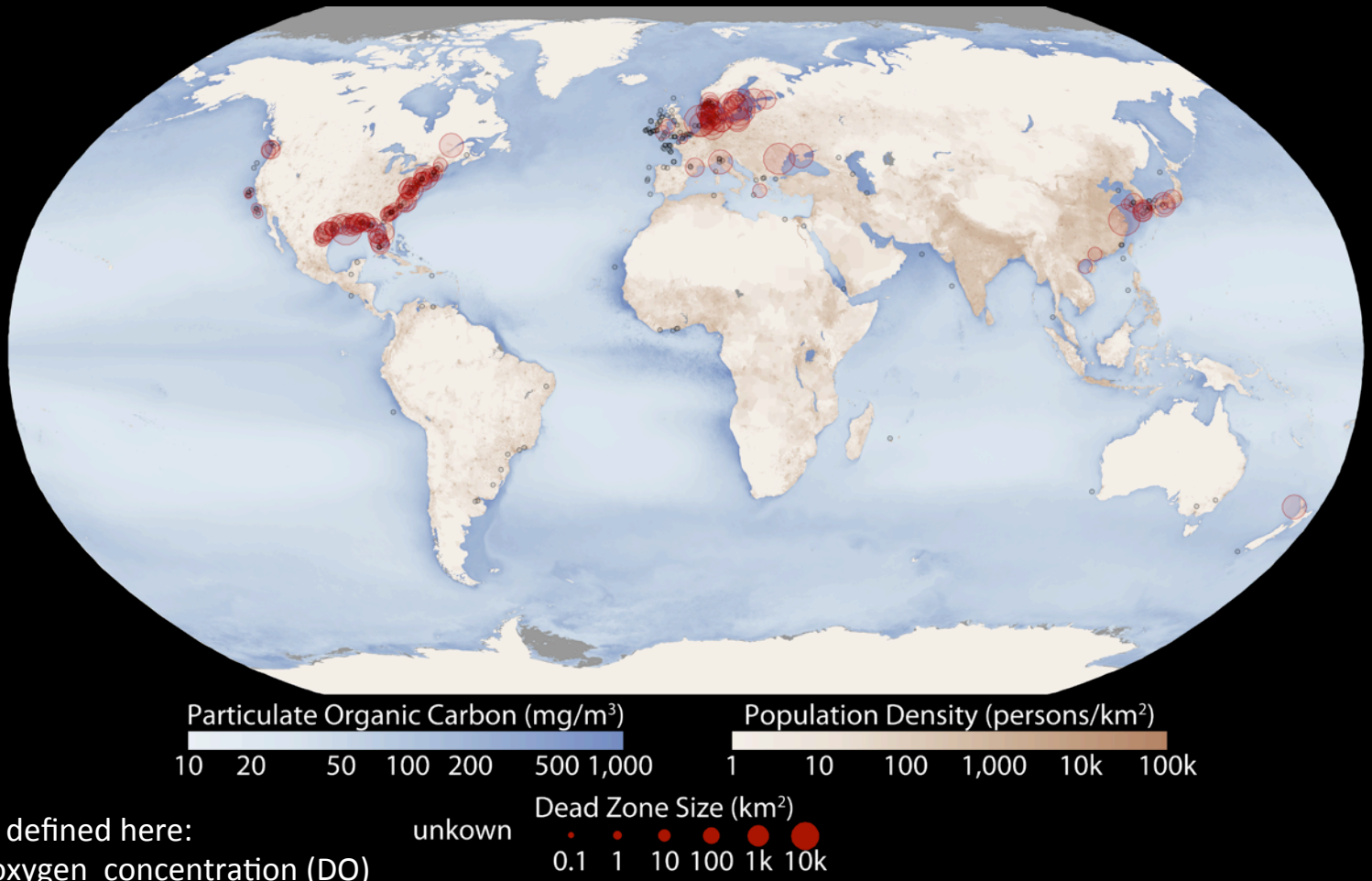
The impact of rising temperature and decreased oxygen on zooplankton individuals and populations

Jamie Pierson
Michael Roman
Jeremy Testa
David Elliott

ICES/PICES Zooplankton Production Symposium
Bergen, Norway
11 May 2016

University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE
HORN POINT LABORATORY

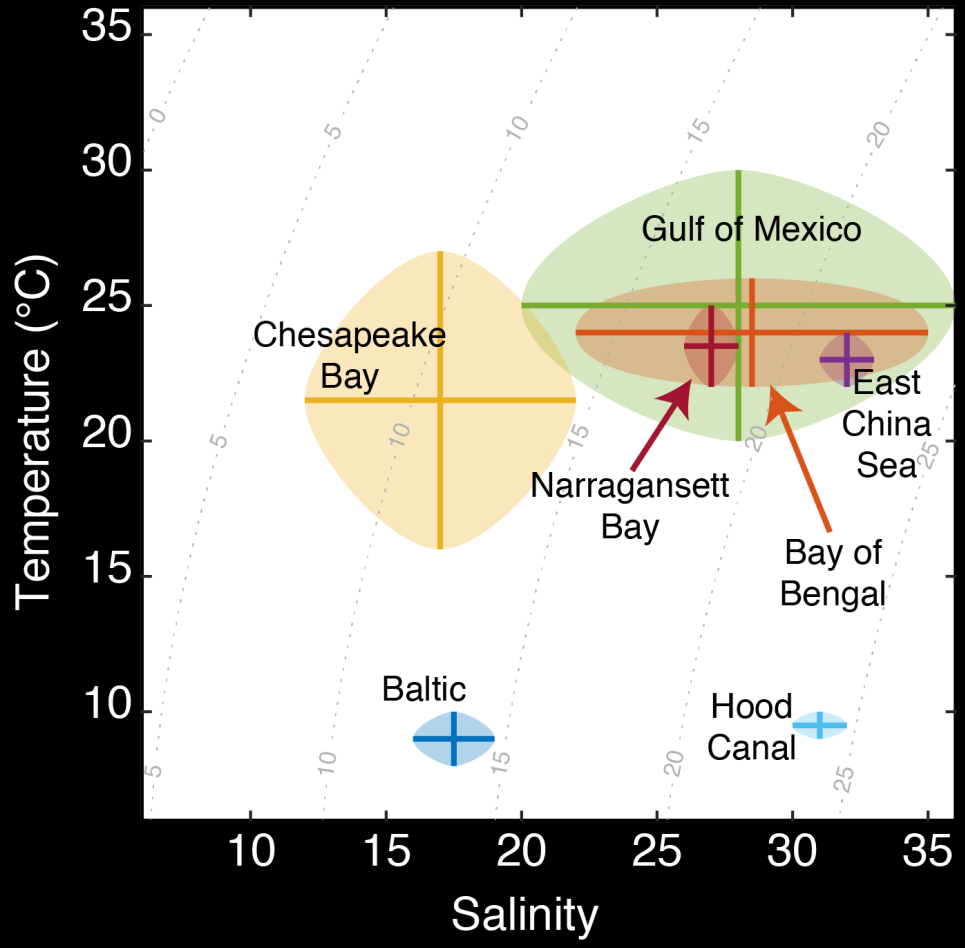
Prevalence of hypoxia is increasing worldwide



Hypoxia as defined here:
Dissolved oxygen concentration (DO)
< 2 mg L^{-1} <1.42 ml L^{-1} <62.5 µmol L^{-1}

Diaz and Rosenberg 2008,
http://earthobservatory.nasa.gov/IOTD/view.php?id=44677&src=iotdrss

World wide variation in Temperature (°C) and Salinity in hypoxic systems



Data compiled by M. Roman

Hypoxia means low dissolved oxygen, *but how low is low?*

As defined by US agencies

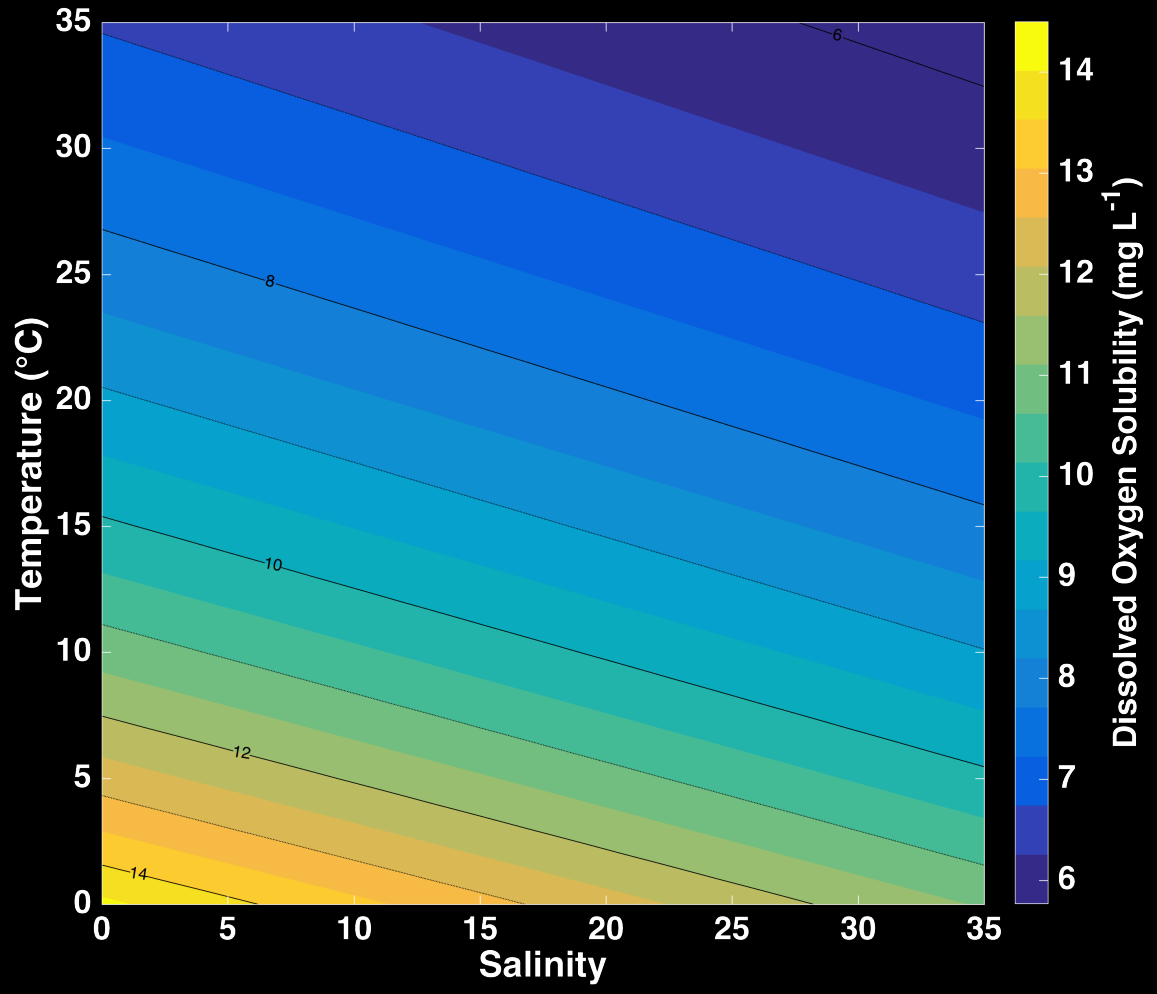
(EPA, NOAA, etc.):

Hypoxia is the [dissolved O_2] in water:

2 mg L^{-1} ≅

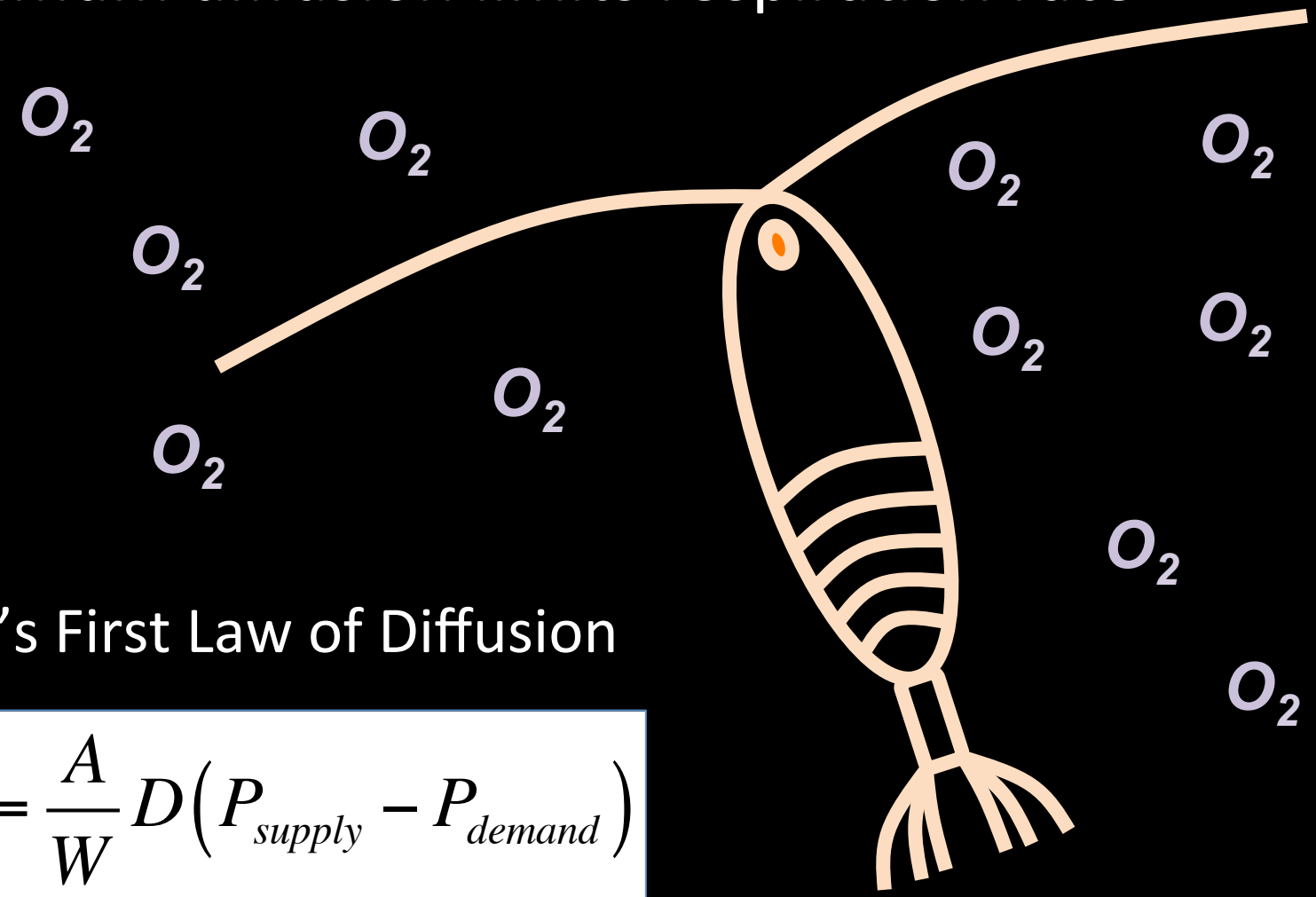
1.42 ml L^{-1} ≅

62.5 µmol



Formulation from: Benson and Krause (1980, 1984) oxygen-solubility formulations (now adopted by USGS)

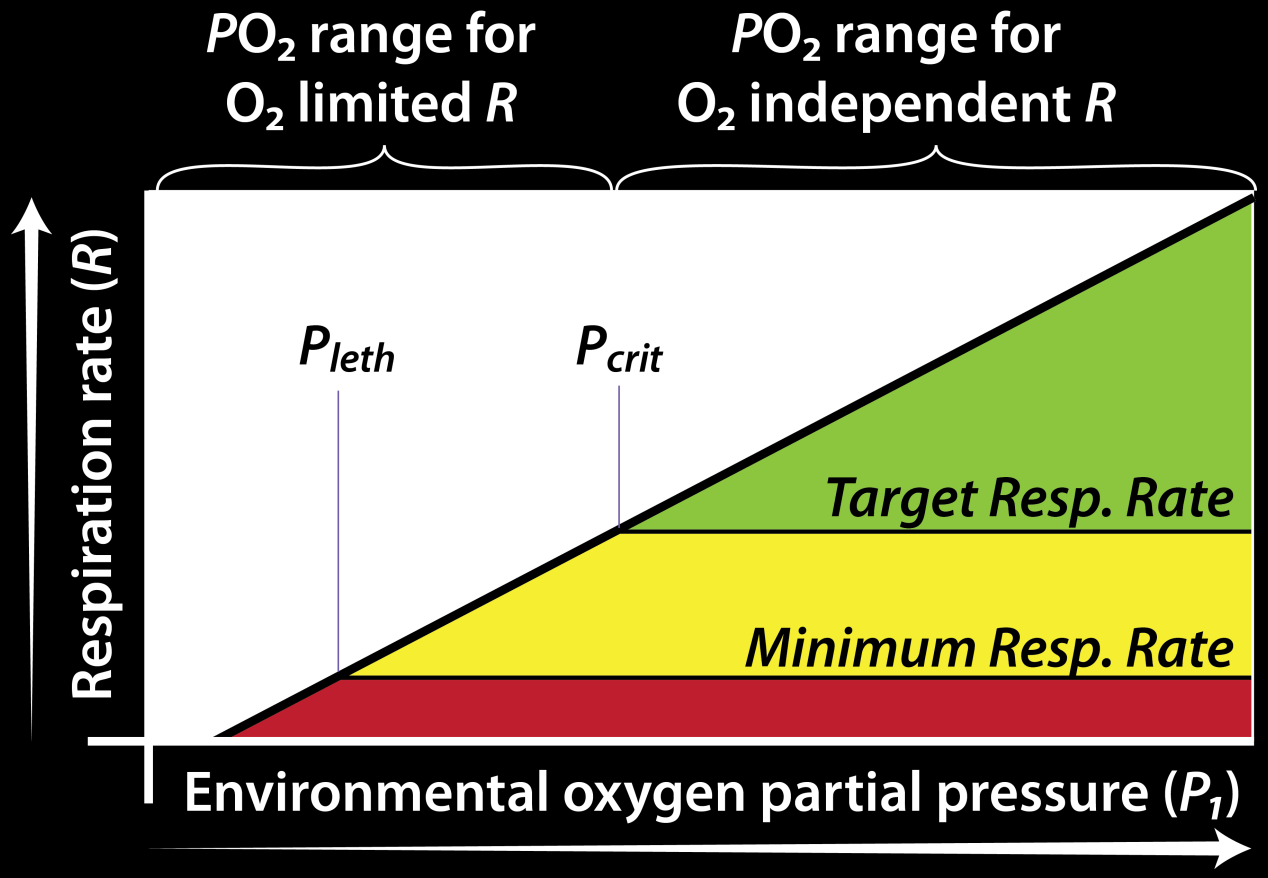
Partial Pressure, pO_2 is a more relevant metric.
Maximum diffusion limits respiration rate



Fick's First Law of Diffusion

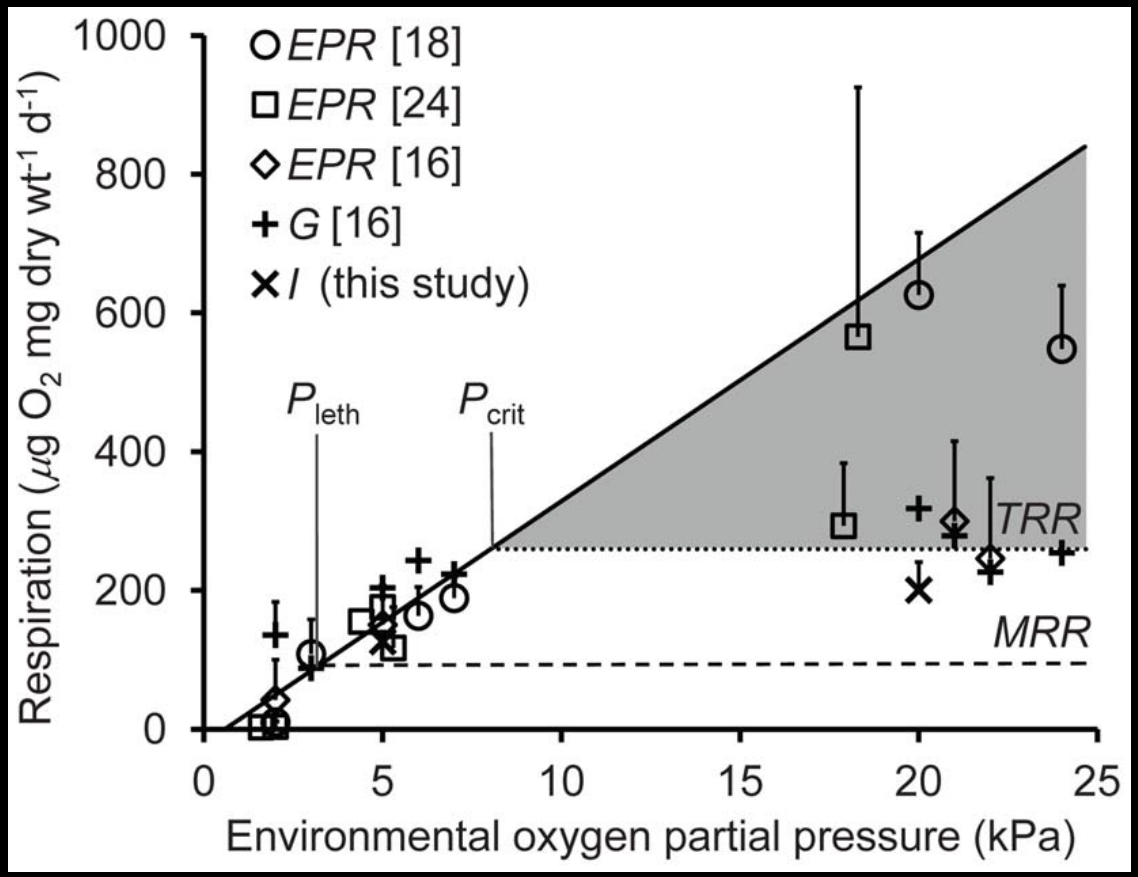
$$\frac{dV}{dt} = \frac{A}{W} D\left(P_{supply} - P_{demand}\right)$$

Determining an ecologically relevant measure of DO_2



Adapted from Elliott et al. 2013 *PLoS One*

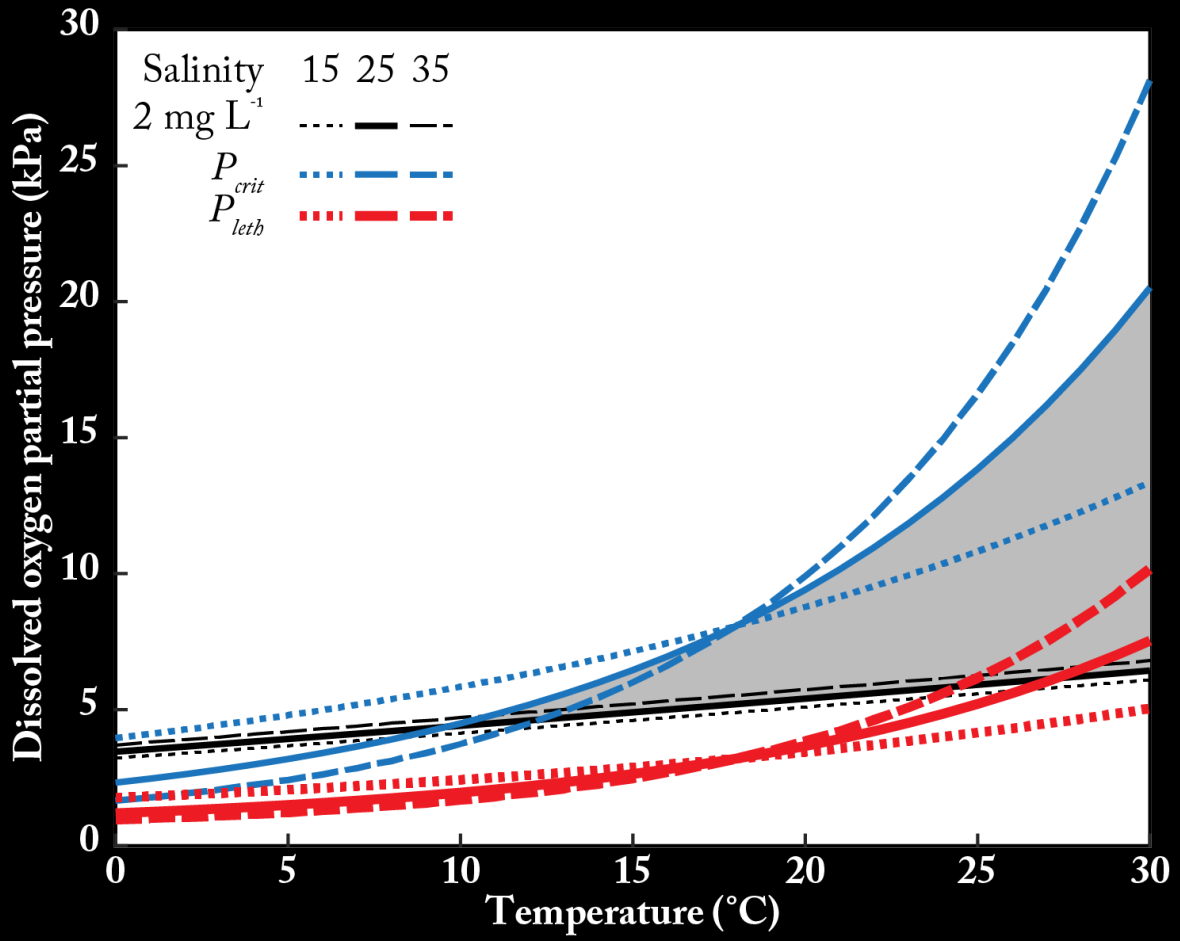
Determining an ecologically relevant measure of DO_2



Acartia tonsa

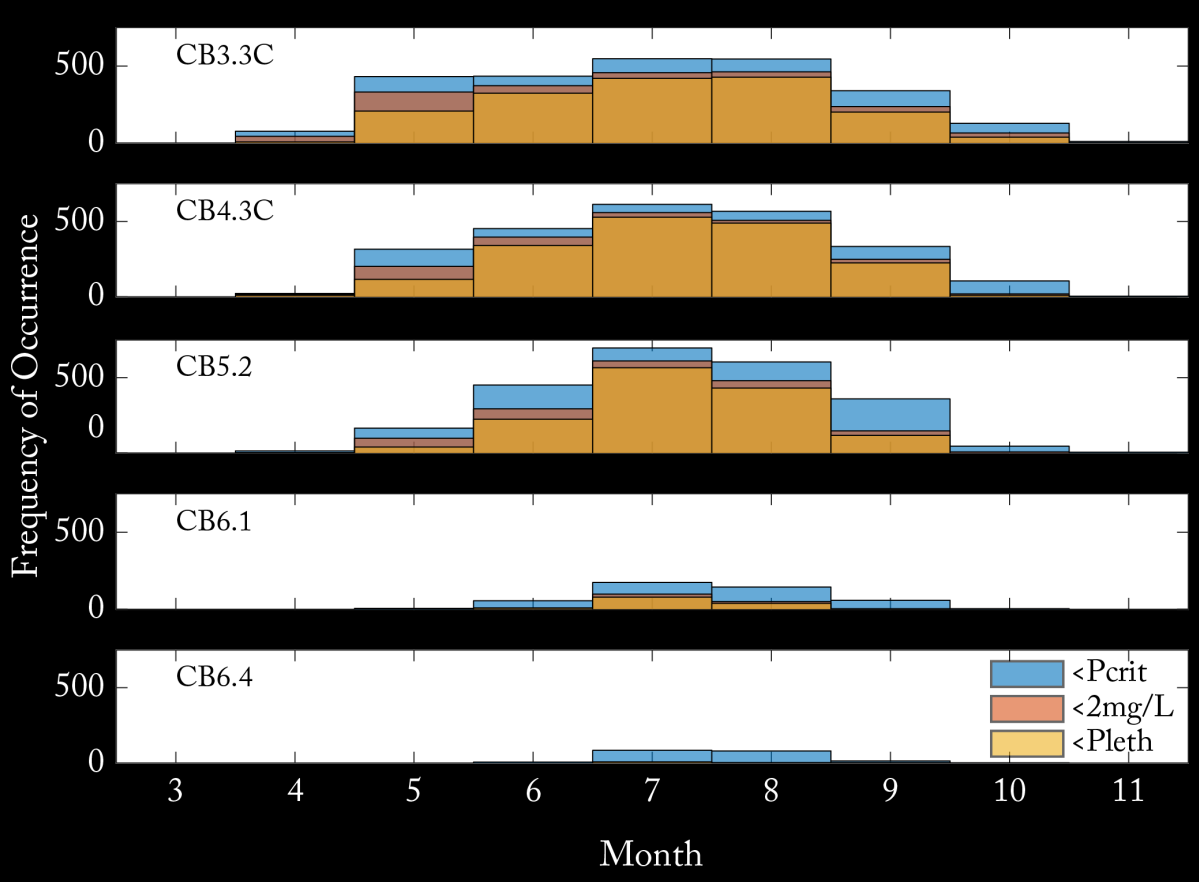
Elliott et al. 2013 *PLoS One*

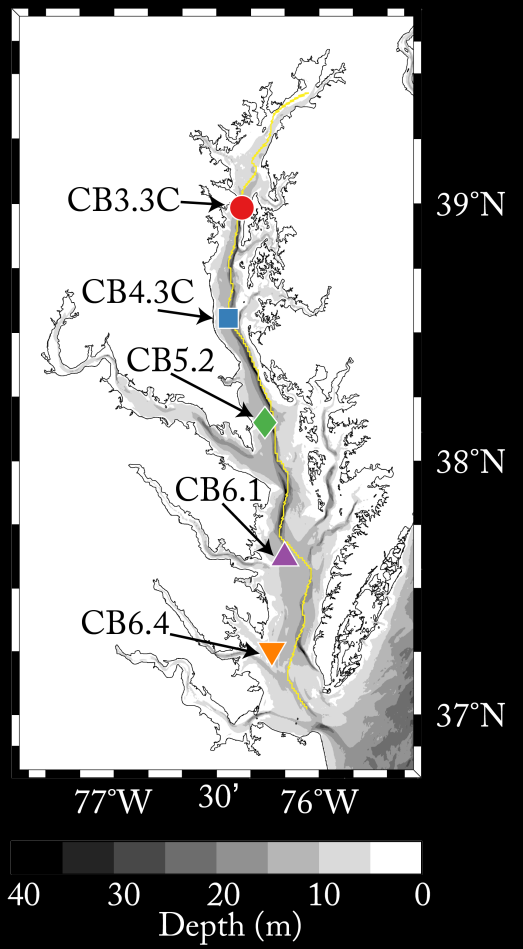
Determining an ecologically relevant measure of temperature – dependent DO_2



Elliott et al. 2013 *PLoS One*

Hypoxia metrics can make a difference defining habitat



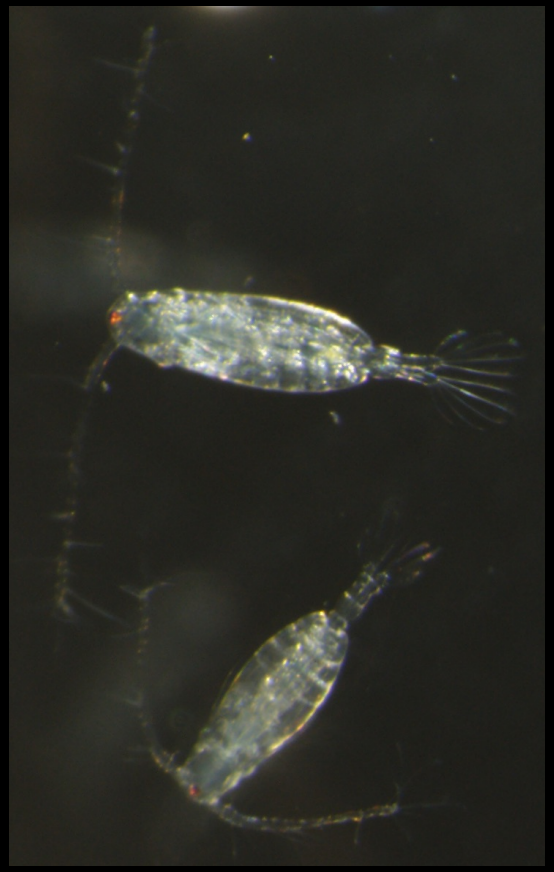


Conclusions

- Species-specific responses to multi-stressors may require more nuanced indicators

  (e.g. Temperature-dependent)

- Indices could be based on ***multiple species & stressors***

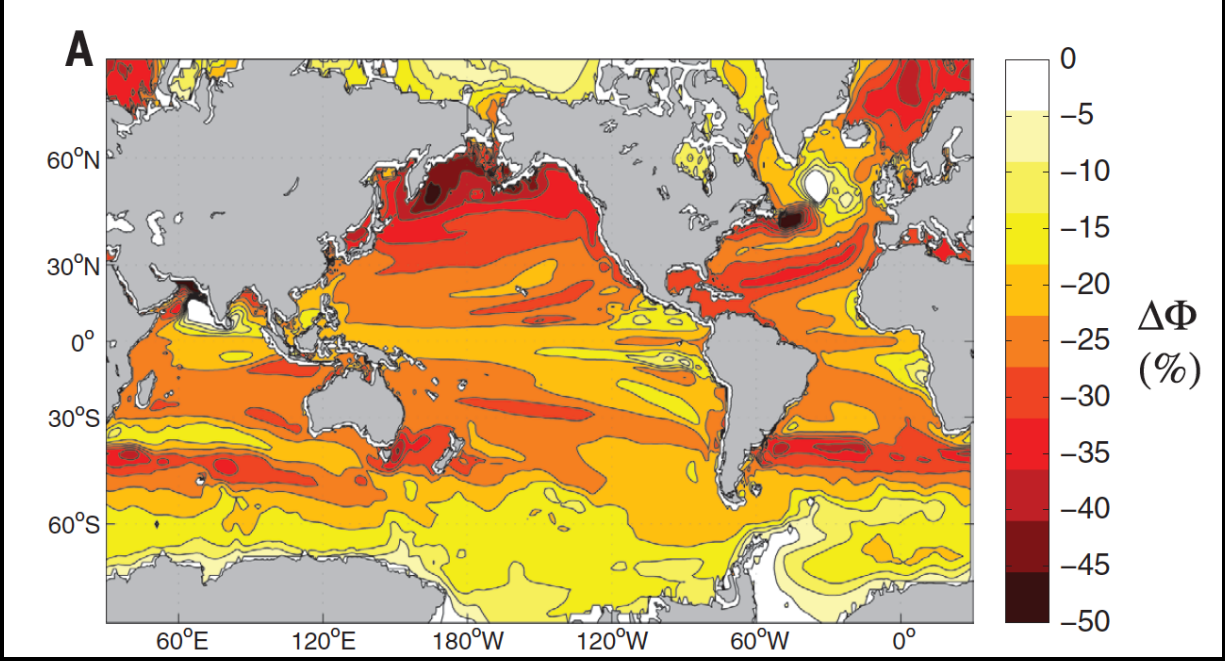


Thank You

Metabolic Index
Reduced Globally by the end of the Century

$\underline{O_2 \text{ supply}}$

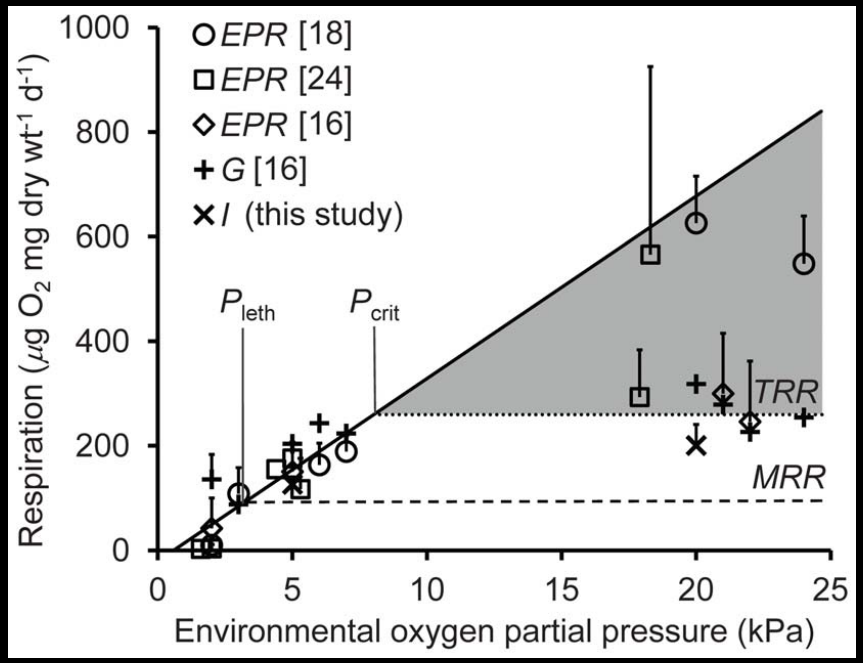
O_2 demand

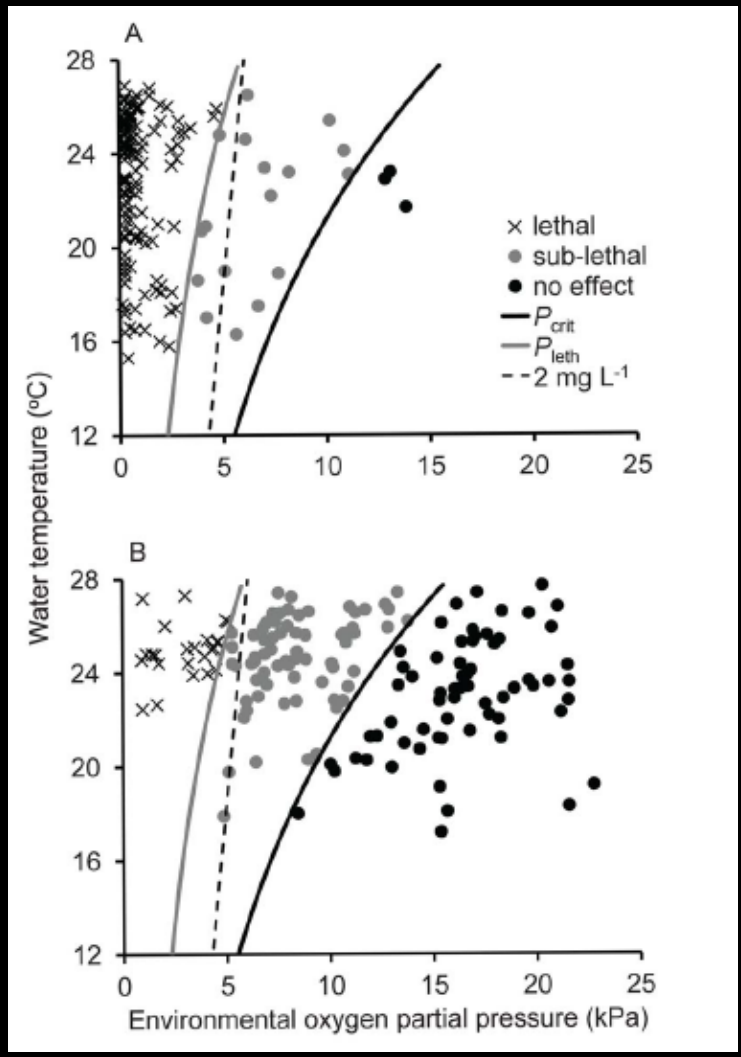


$$\Phi = A_o B^n \frac{PO_2}{\exp(-E_o / k_B T)}$$

Deutsch et al. 2015 Science

Model predicting the influence of hypoxia on *Acartia tonsa applied to data from Chesapeake*





Elliott et al. 2013 *PLoS One*