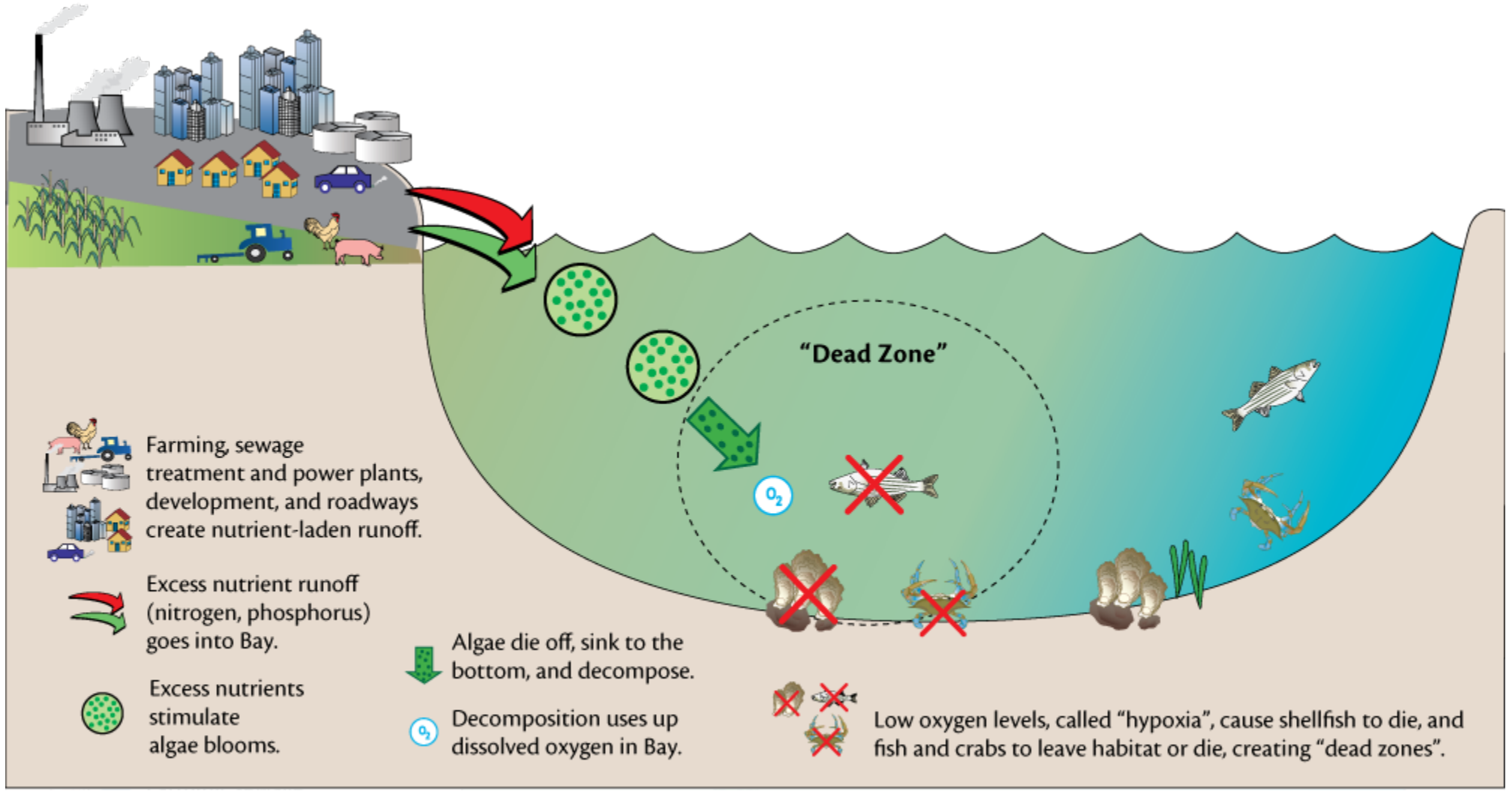
Plankton and hypoxia: complex feedbacks on physiology and community structure.

Beth Stauffer, Ph.D.
Assistant Professor
Department of Biology
University of Louisiana at Lafayette
stauffer@louisiana.edu

How we think of hypoxia



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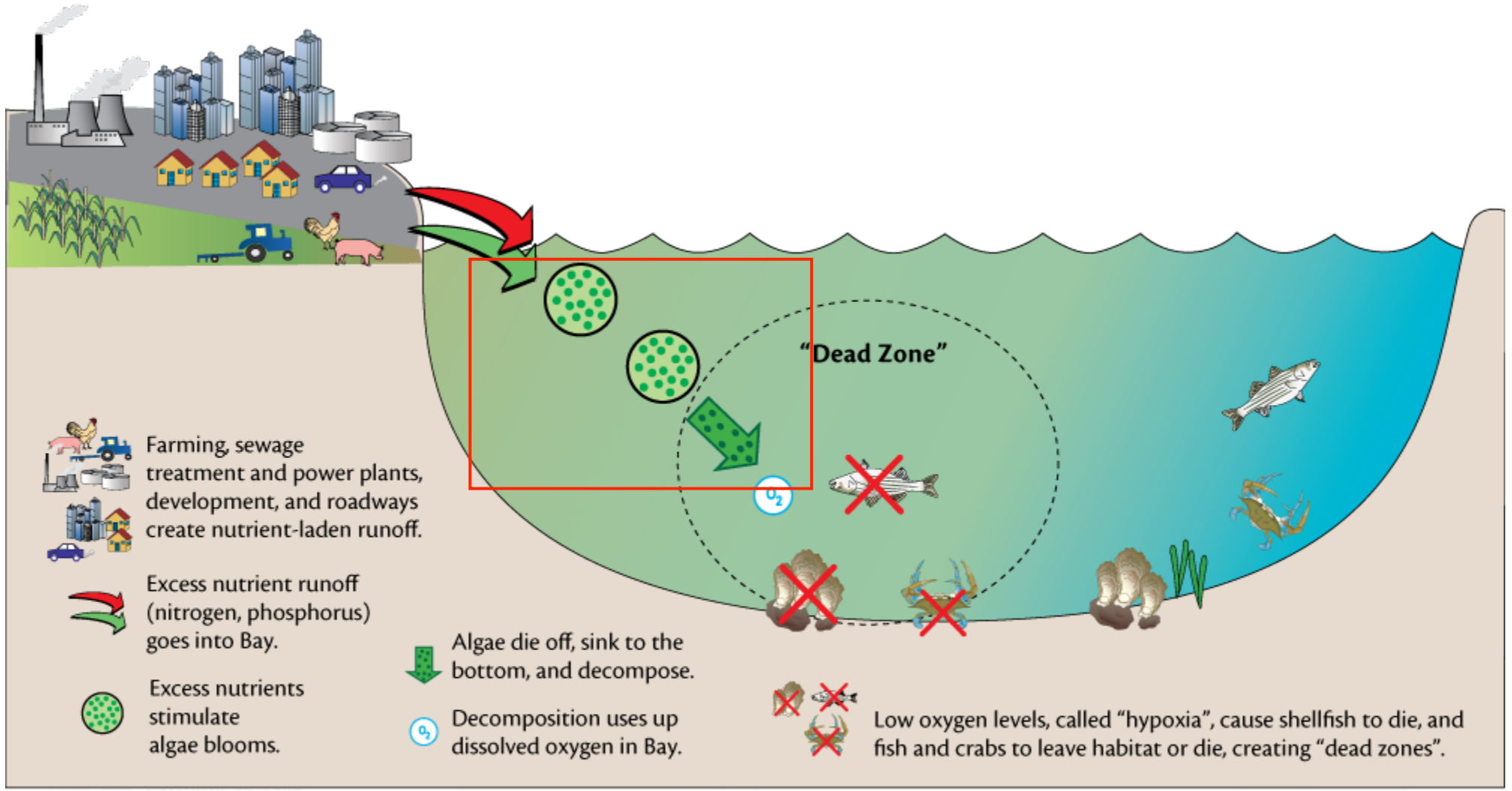
How we think of hypoxia



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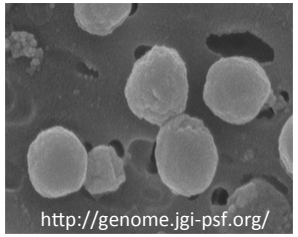
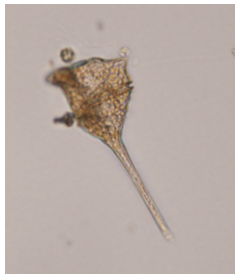
Plankton: a lifestyle

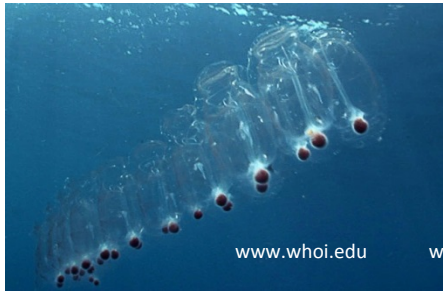
- *Planktos* – Greek for “errant” or “wanderer”



Bacteria and Archaea

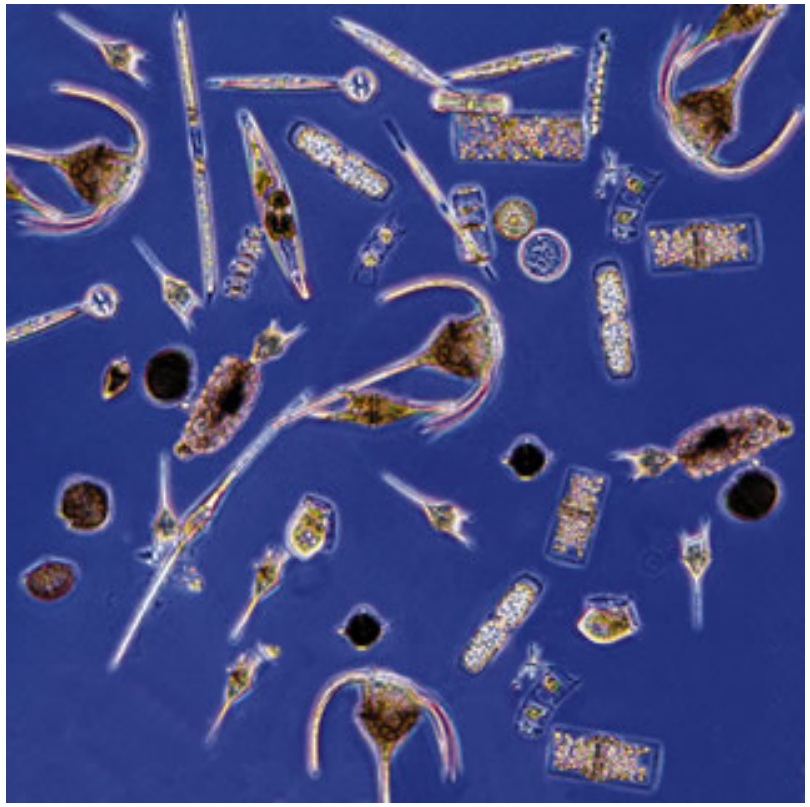


Protists

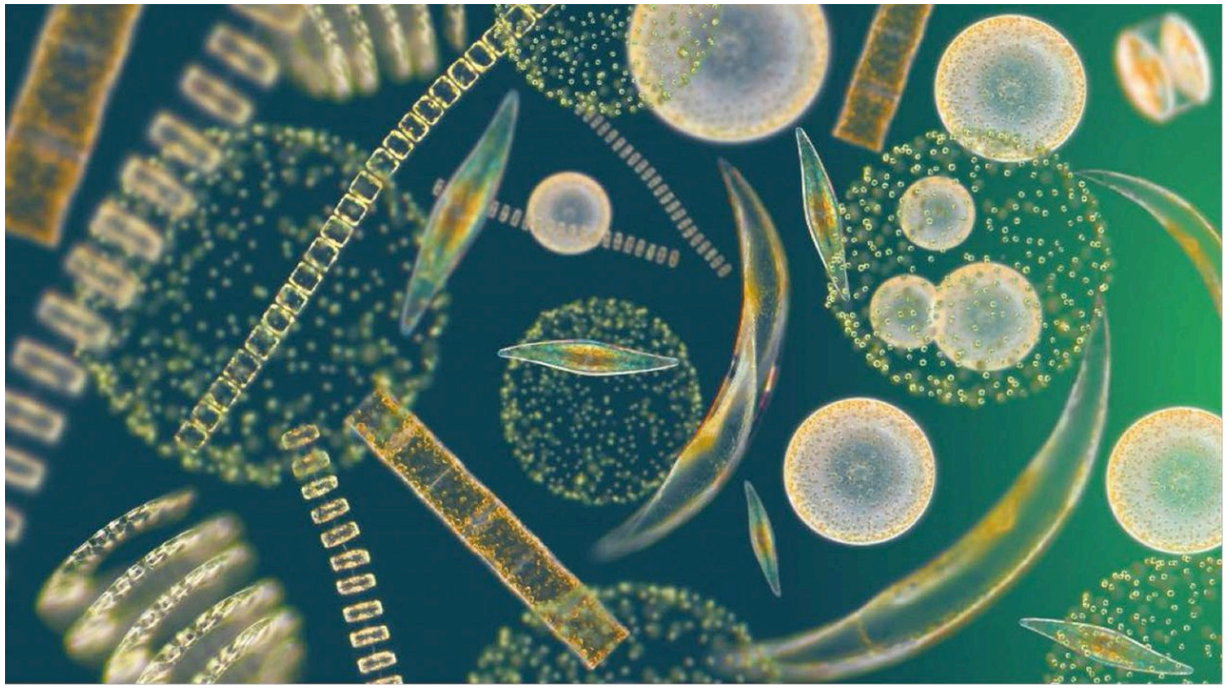


Animals

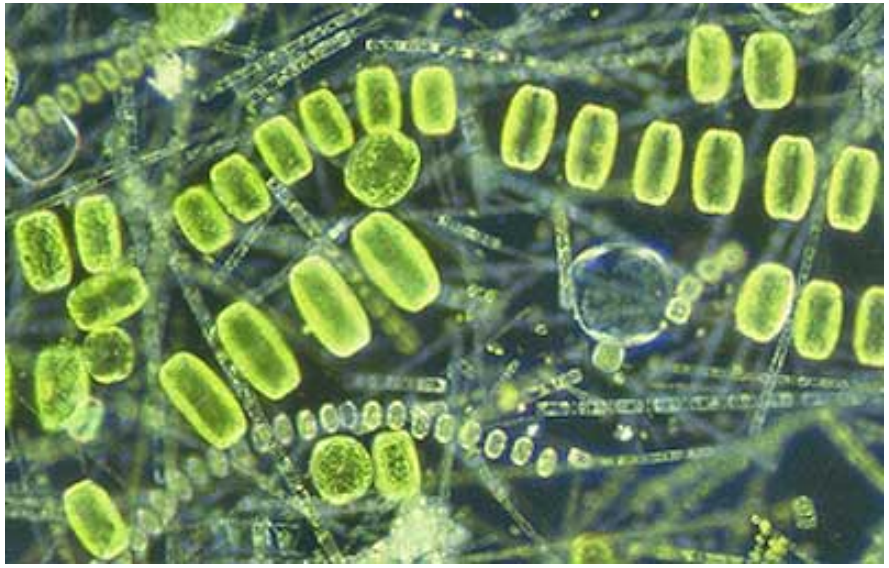
Phytoplankton



www.edc.uri.edu



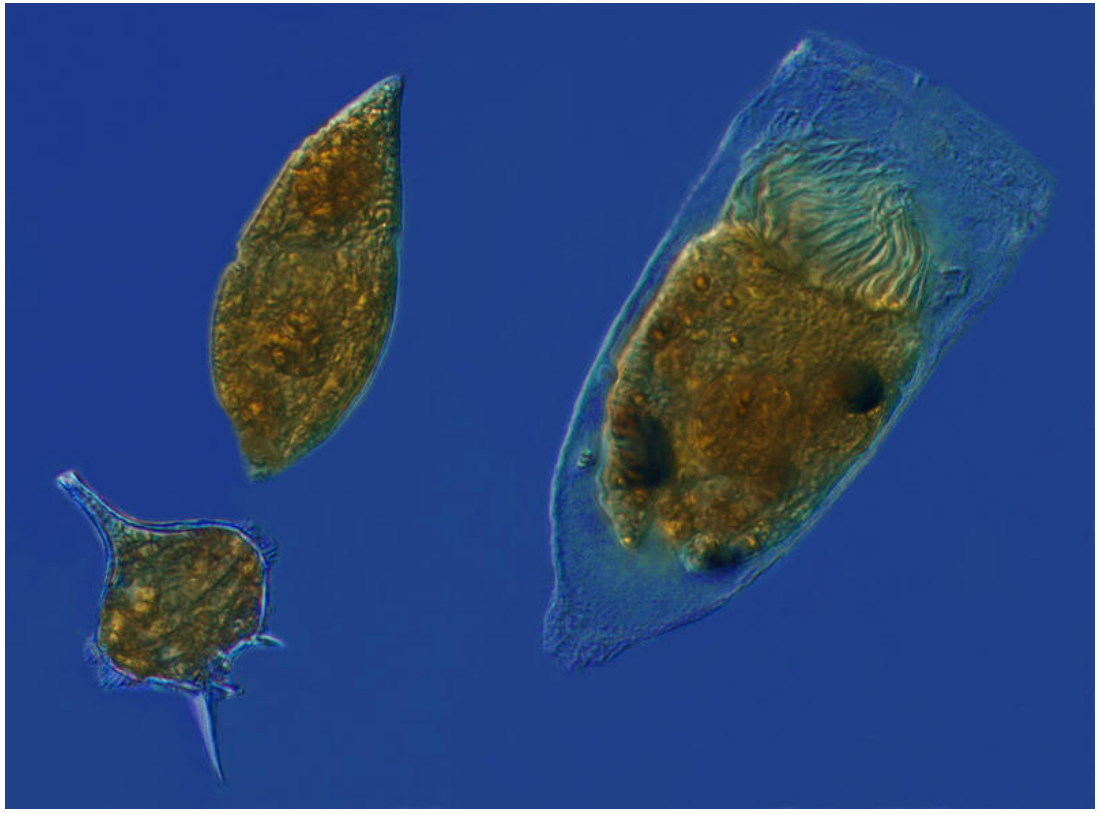
pnas.org



barentsportal.com

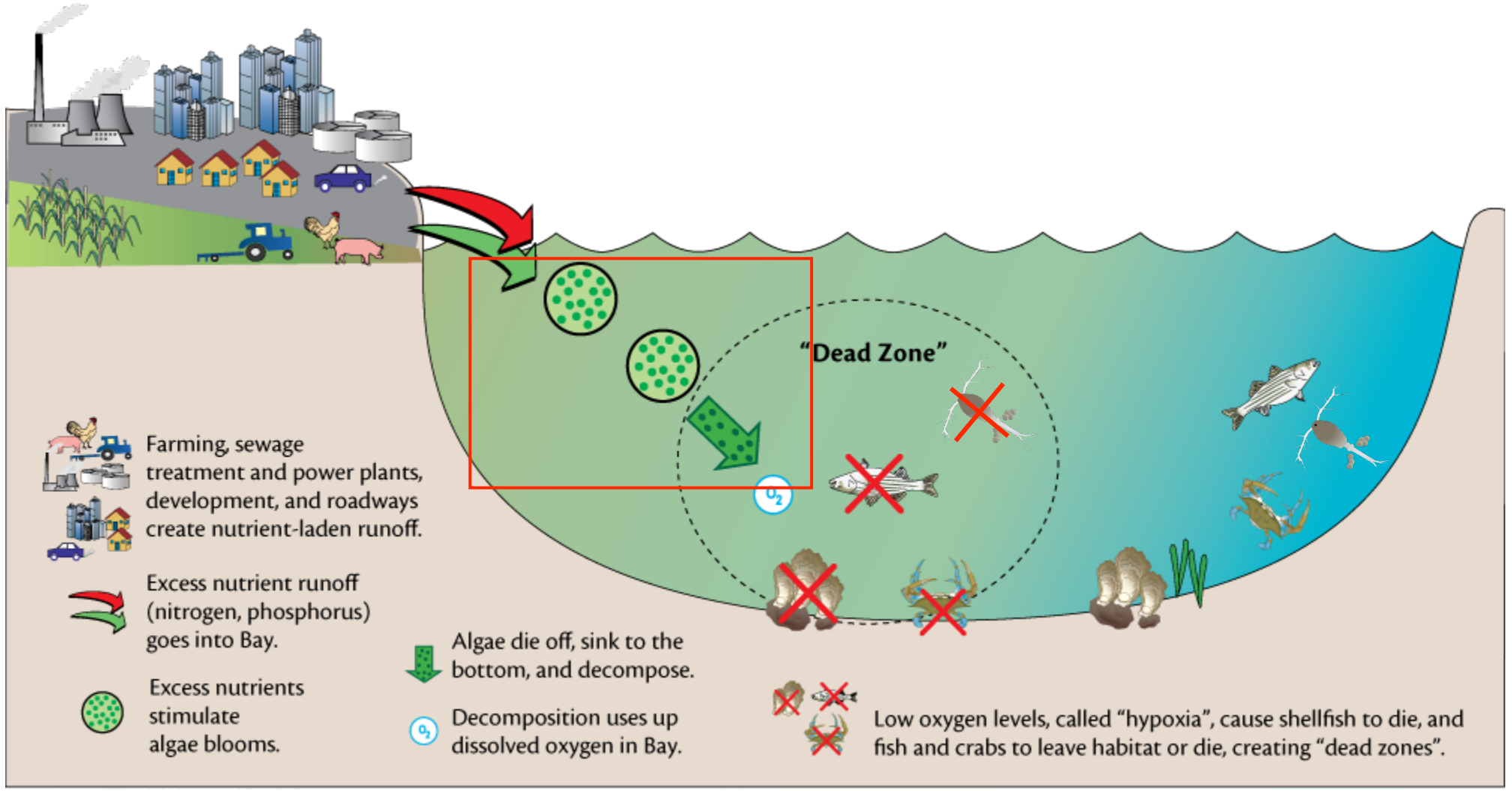
Zooplankton

vims.edu



http://gallery.obs-vlfr.fr/

How we typically think of hypoxia



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A fish kill and hypoxic event in Southern California

"Millions of dead fish at King Harbor in Redondo Beach" - LA Times

8 March 2011

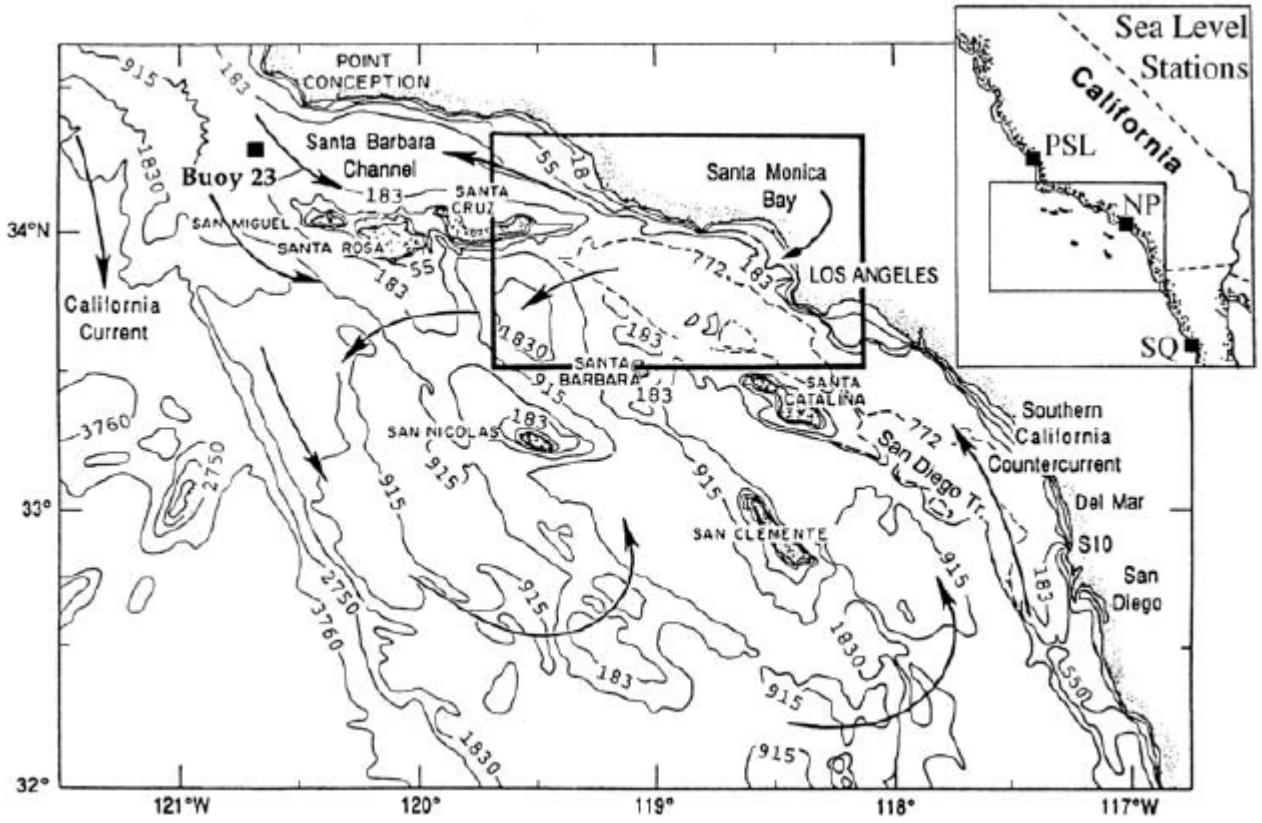
"Millions of dead anchovies float to surface in Redondo Beach" – CNN.com

"'One million' dead sardines clog Redondo Beach marina" – BBC News

"Millions of dead fish turn up in southern California marina in third bizarre mass animal death in the U.S. in past few months" – Daily Mail UK

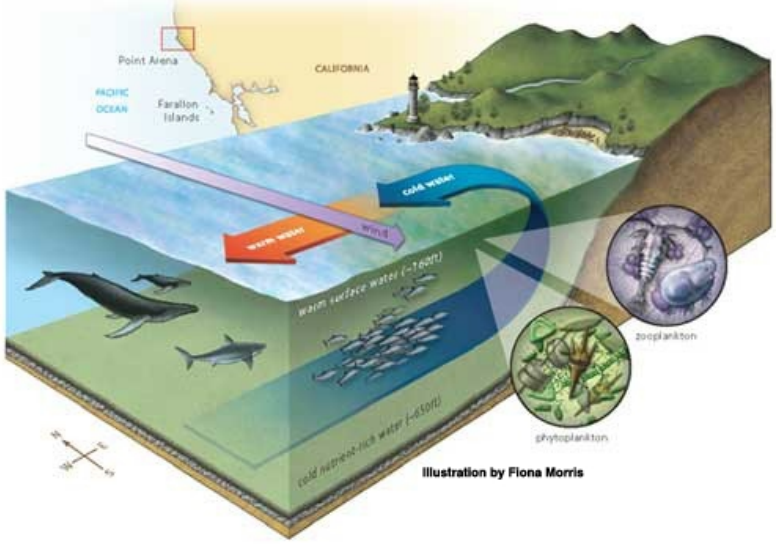
"Mystery over dead fish in California harbour" – Vancouver Sun

Southern California Bight



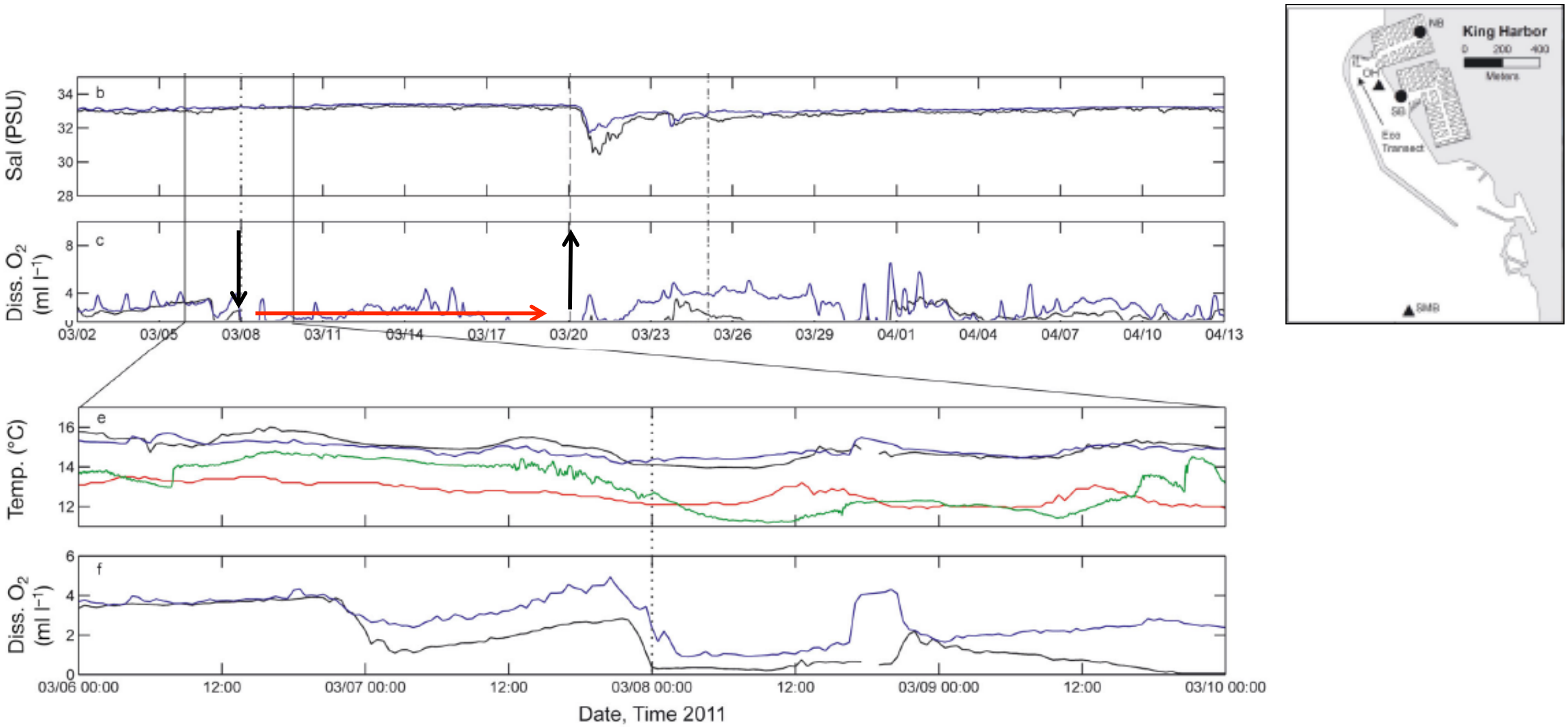
Hickey et al. 2003, Journal Geophysical Research

Upwelling System



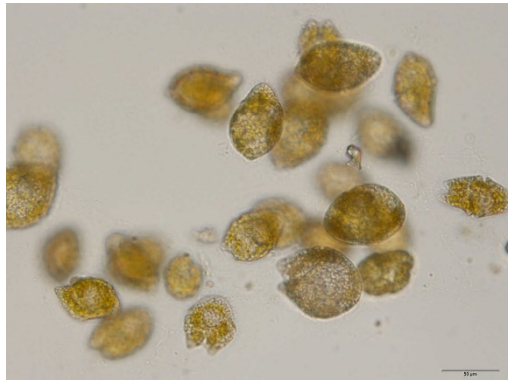
www.cce.lternet.edu

- Transport of deep, cold, nutrient-rich waters into shallow coastal waters



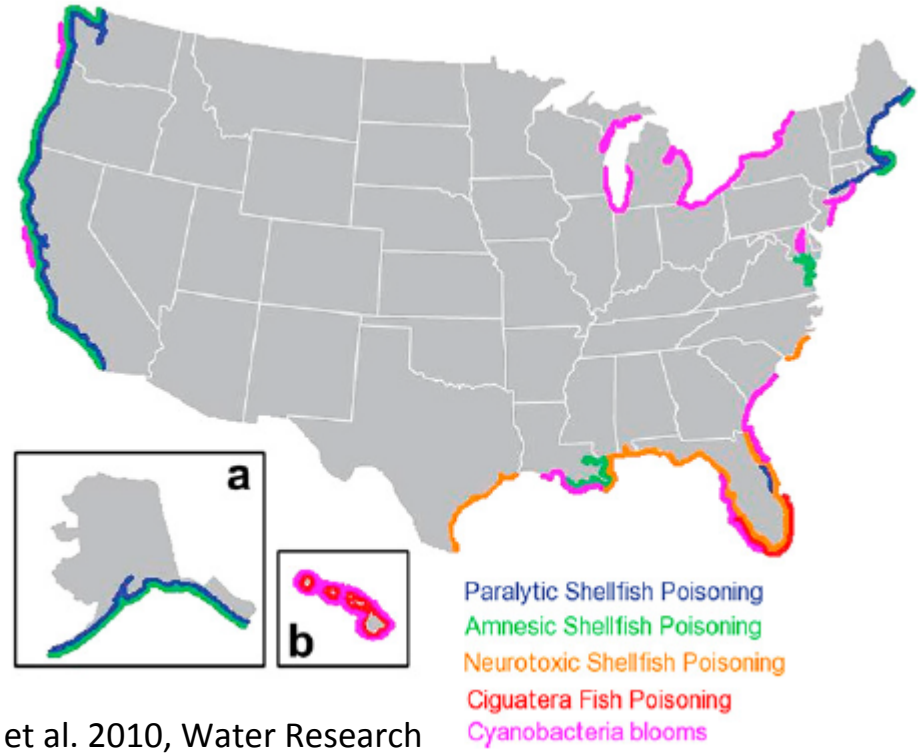
Stauffer et al. 2012 Marine Ecology Progress Series

Phytoplankton role in King Harbor hypoxia, fish kill?



Akashiwo sanguinea bloom in King Harbor

Prorocentrum micans bloom in King Harbor



Caron et al. 2010, Water Research
(adapted from ww.whoi.edu/redtide)

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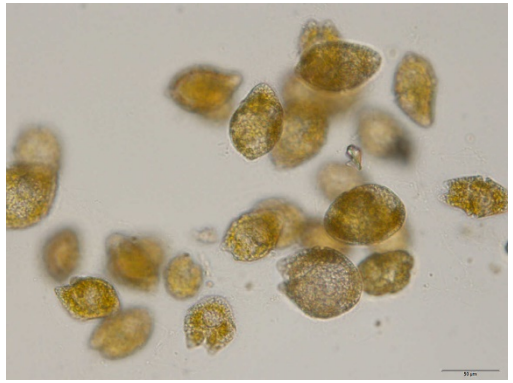

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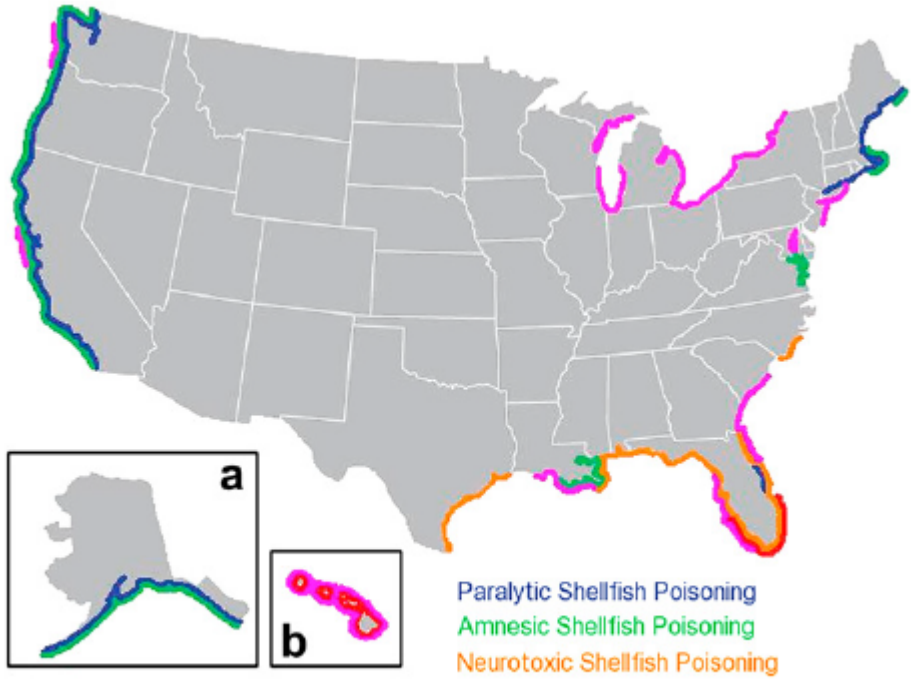

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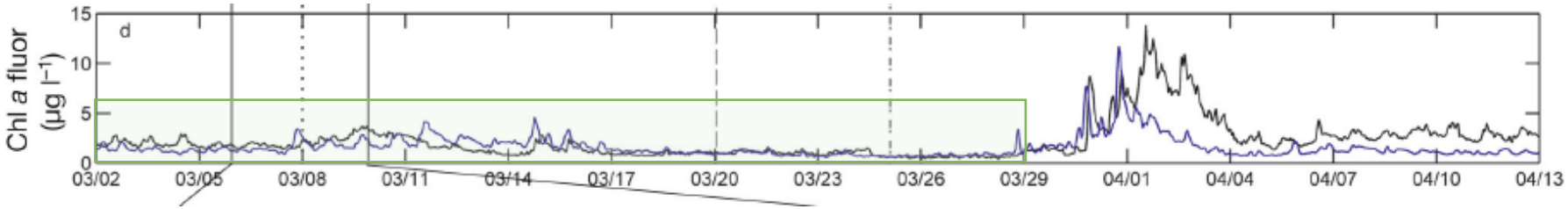
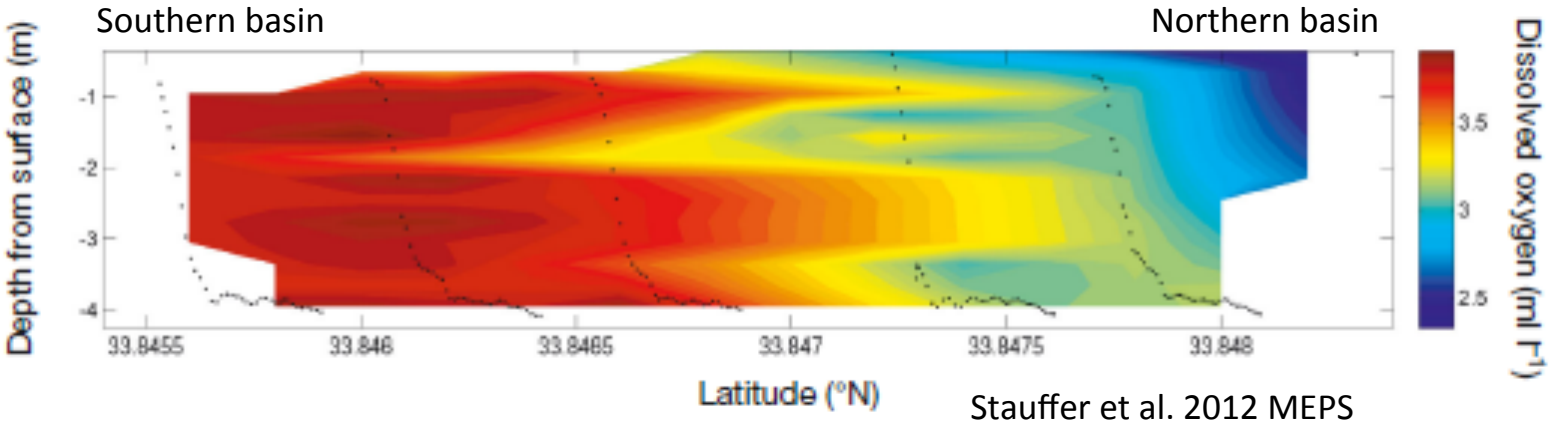


Stauffer et al. 2012 MEPS

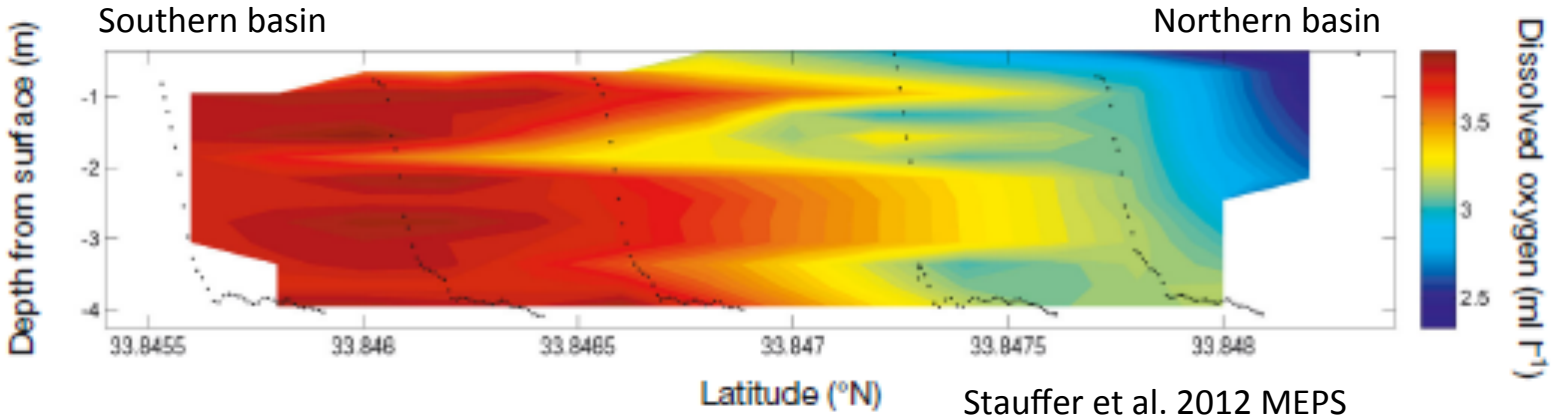
Physiological Effects



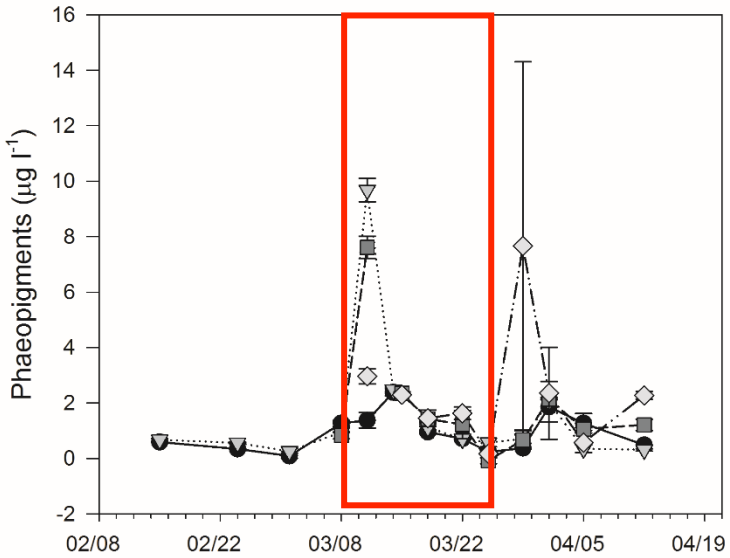
Stauffer et al. 2012 MEPS

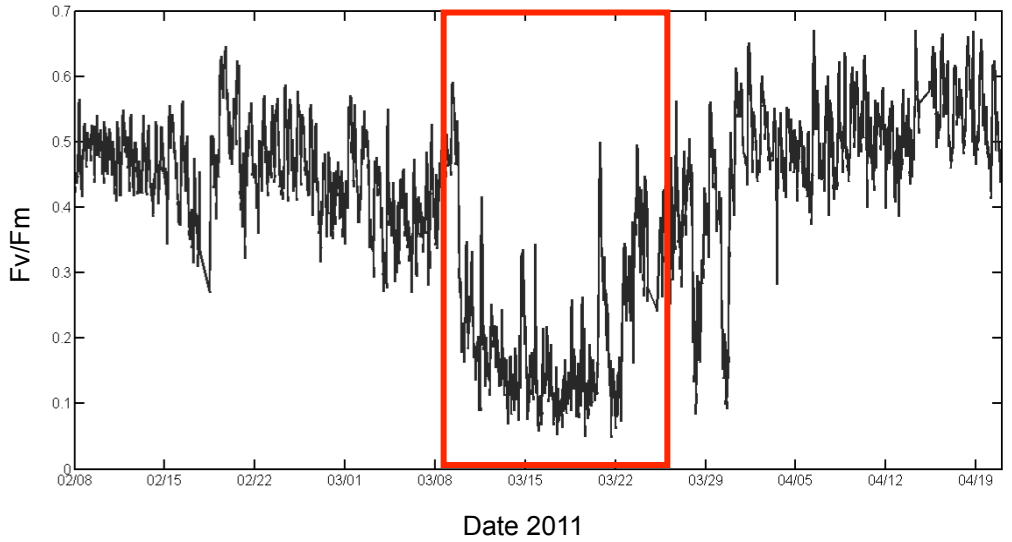
- Hypoxia spanned the entire water column in northern basin of King Harbor

Physiological Effects



Stauffer et al. 2012 MEPS

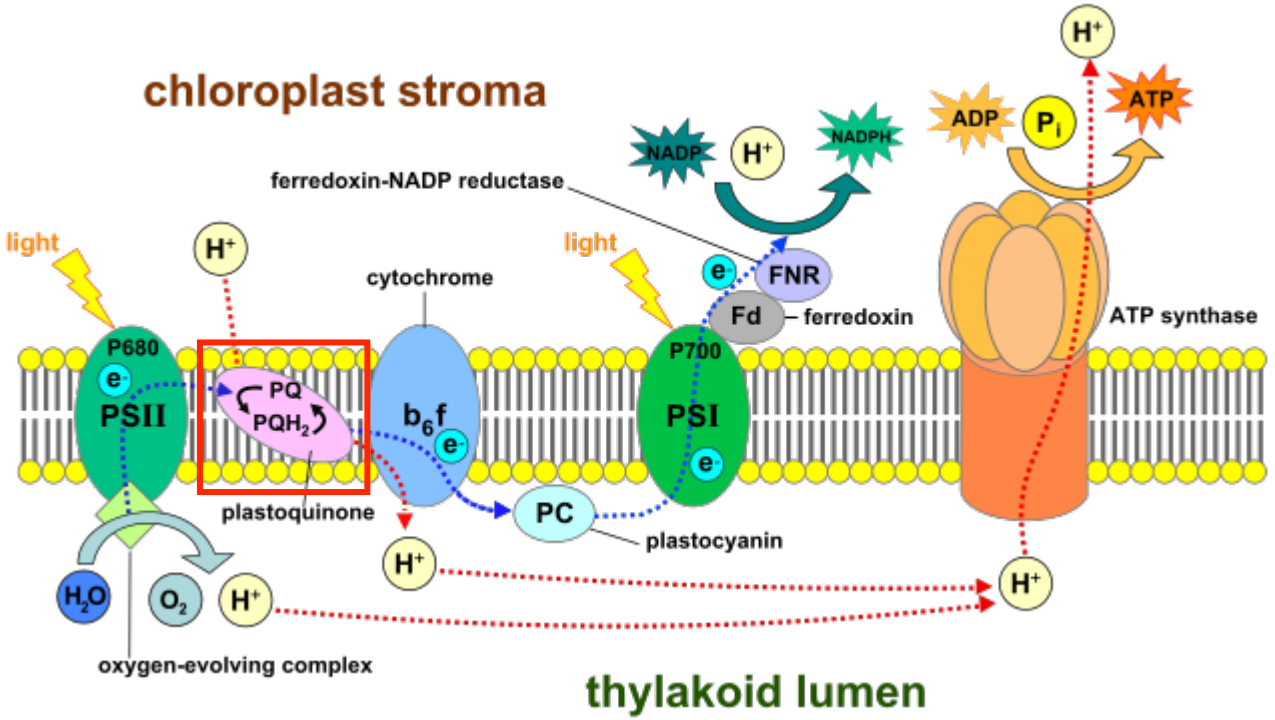




Stauffer et al. 2013, Estuaries and Coasts

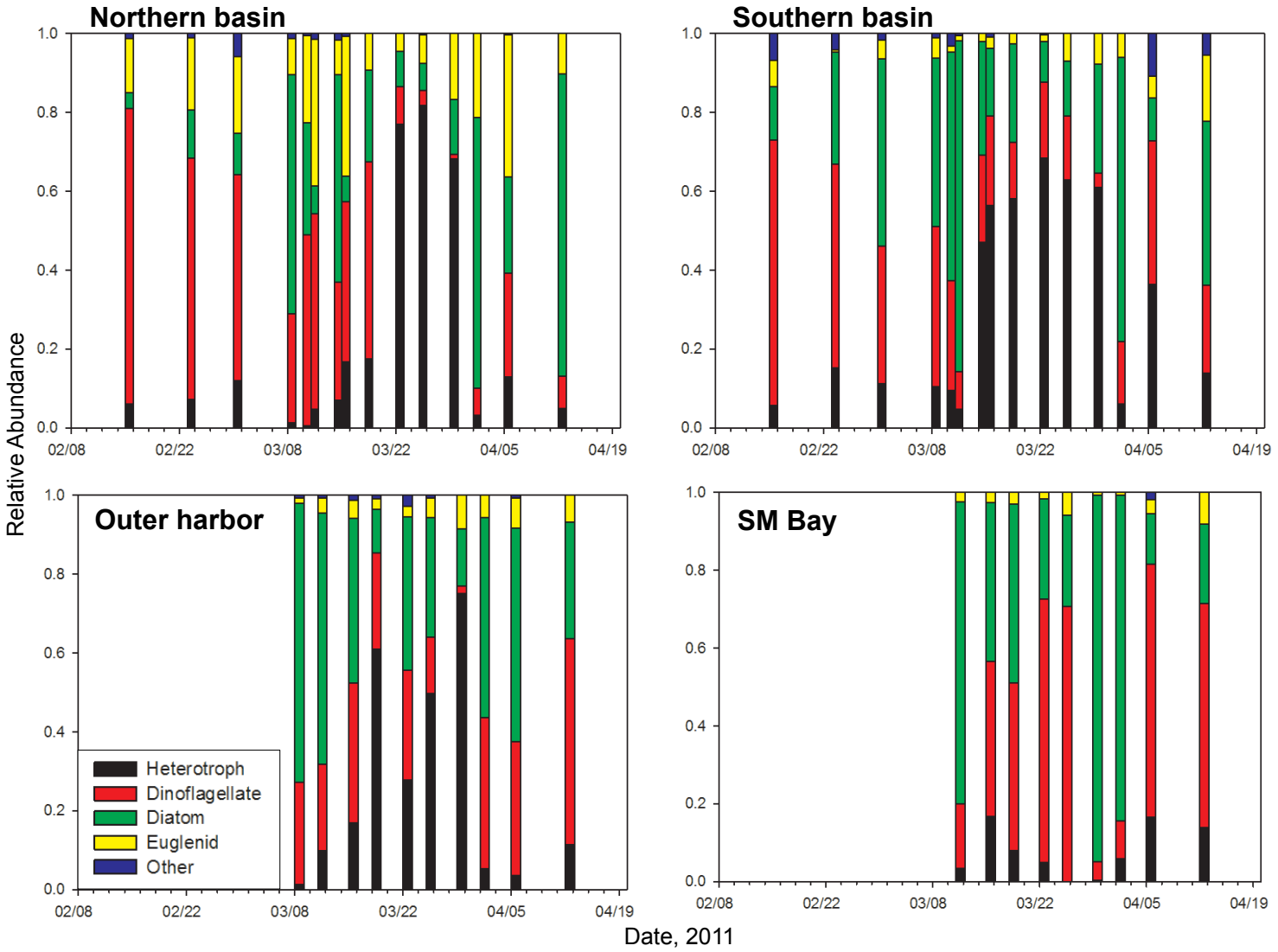
Physiological Effects

- Photosynthesis PSII
  - Highly reduced plastoquinone pool → state transitions, inactive reaction centers (Falkowski & Raven 2007)
- Toxicity?
  - NH_4
  - H_2S



"Thylakoid membrane 3" by Somepics - Own work. Licensed under CC BY-SA 4.0 via Commons https://commons.wikimedia.org/wiki/File:Thylakoid_membrane_3.svg#/media/File:Thylakoid_membrane_3.svg

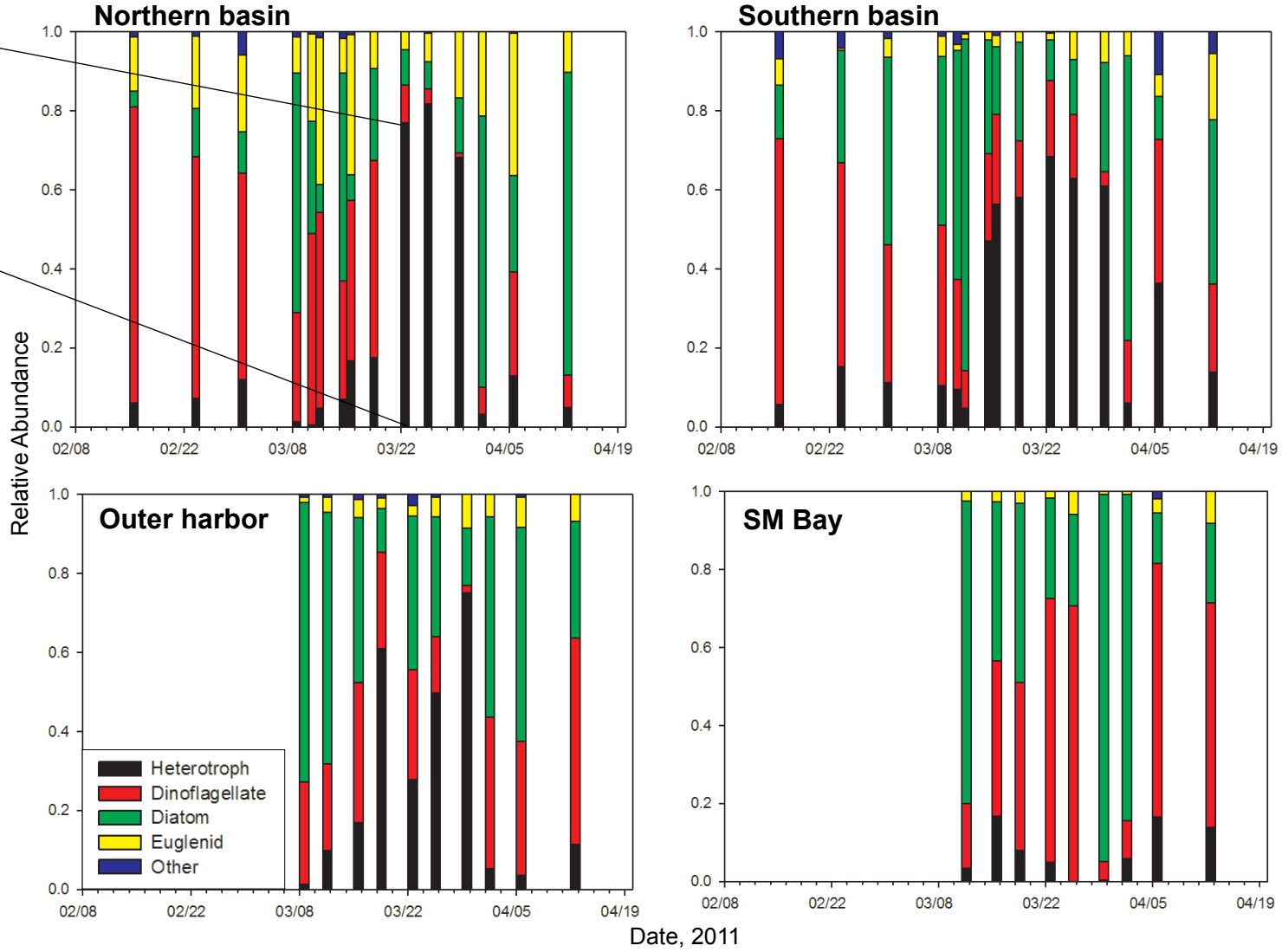
Community composition effects



Stauffer et al. 2013, Estuaries and Coasts

Community composition effects

Uronema marinum
Photo: Micro*scope



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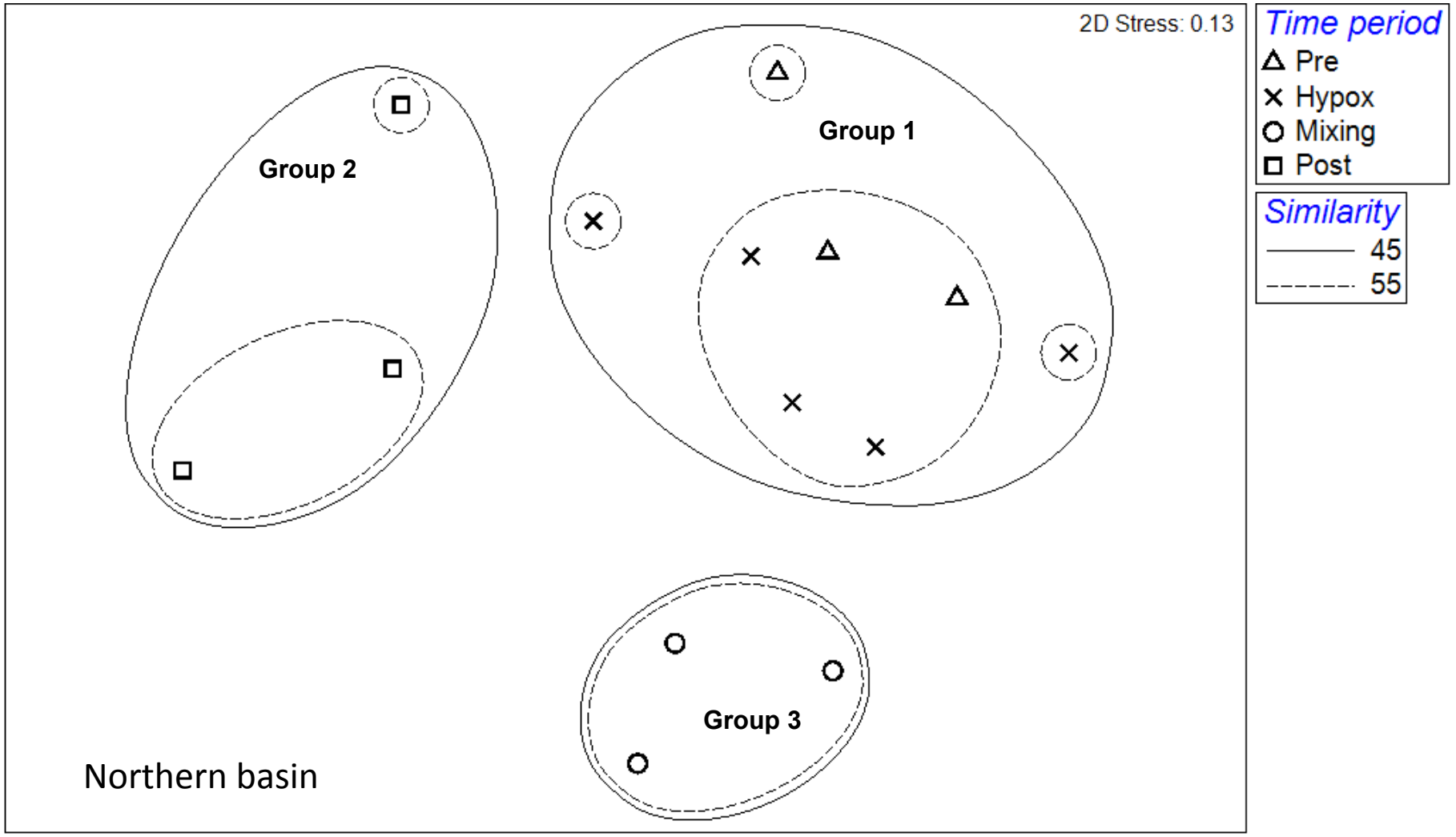
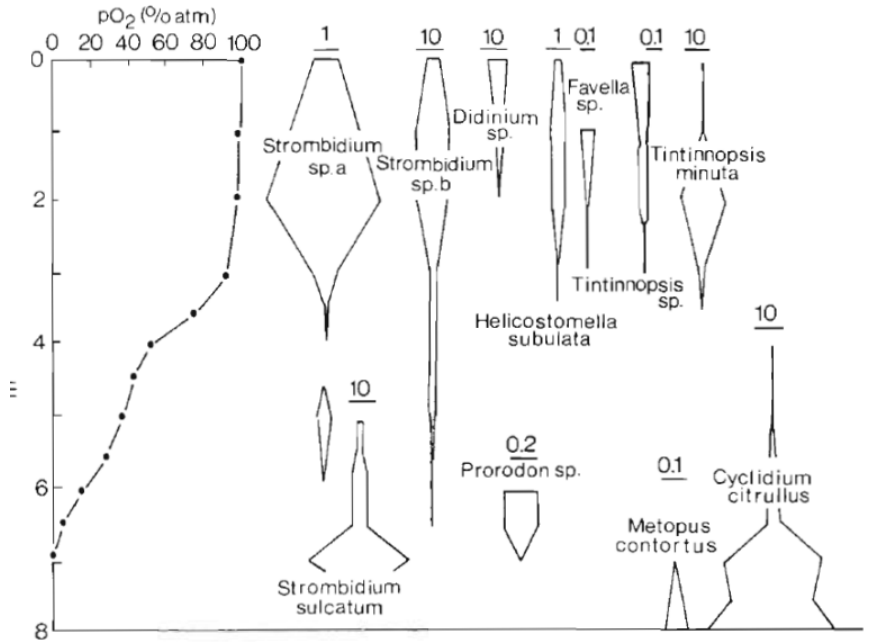
Community composition effects

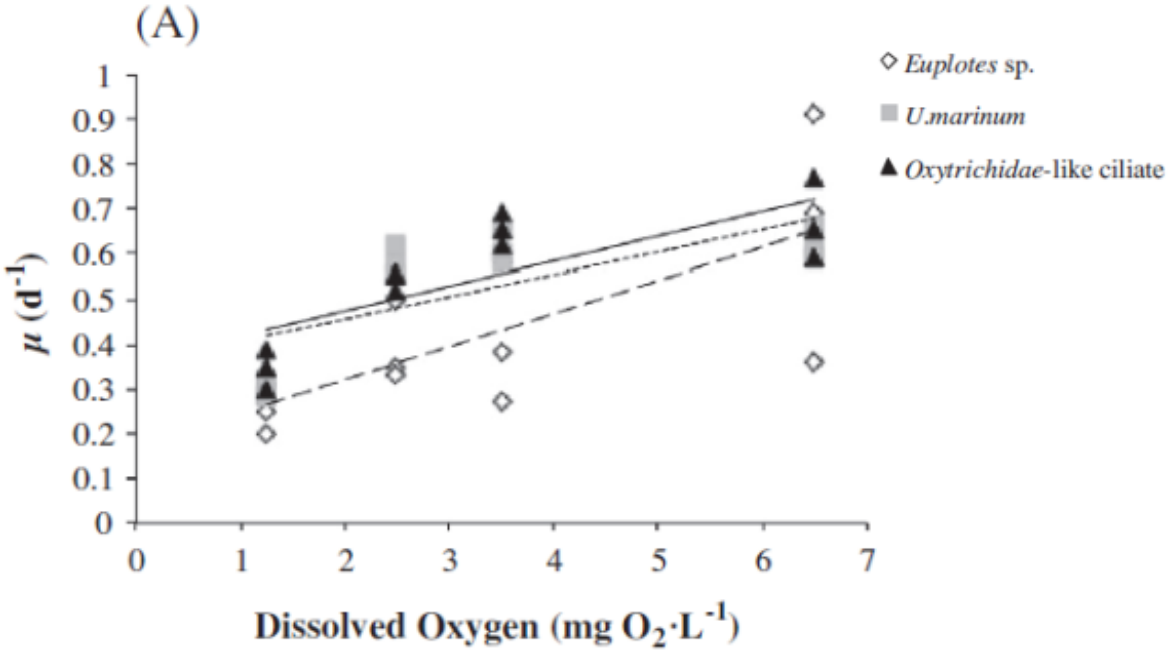


Stauffer et al. 2013, Estuaries and Coasts

Unique ciliate assemblages associated with hypoxia

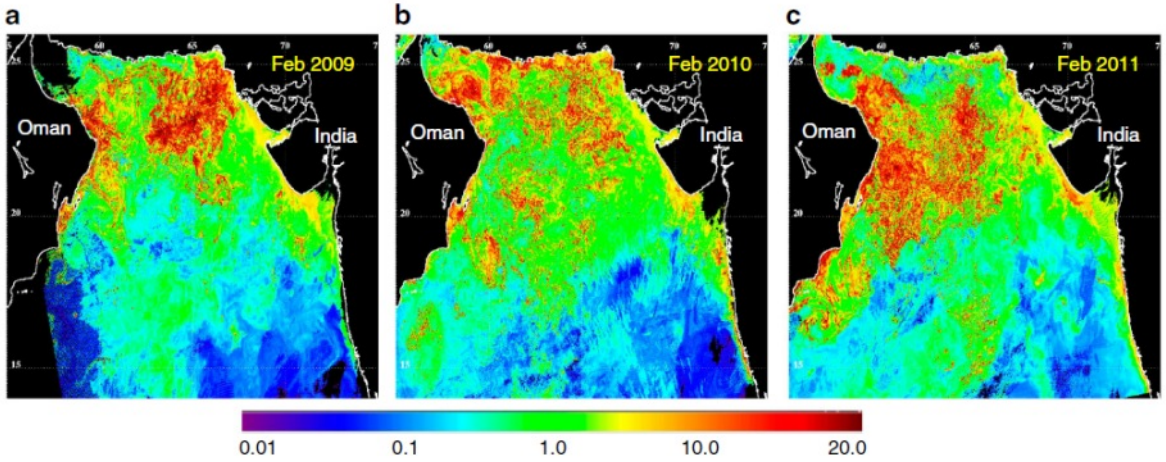


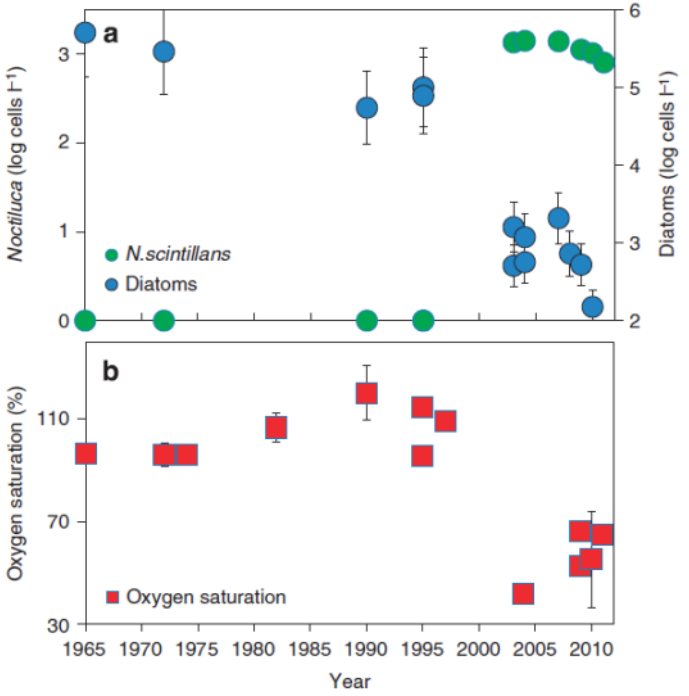
- Fenchel et al. 1990 MEPS
- Unique protozoan assemblages along oxycline in Danish eutrophic fjords
- Distinct scuticociliate species at low oxygen levels

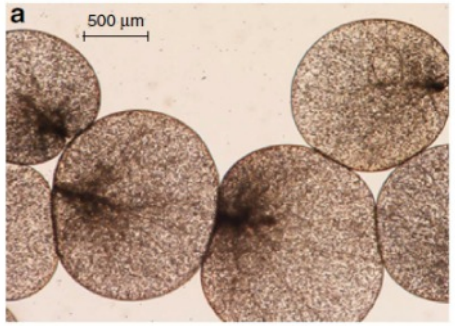


- Rocke & Liu. 2014 Marine Pollution Bulletin
- Continued *Uronema marinum* growth and ingestion to < 1.5 mg O_2 L^1.

Other feedbacks between oxygen and plankton





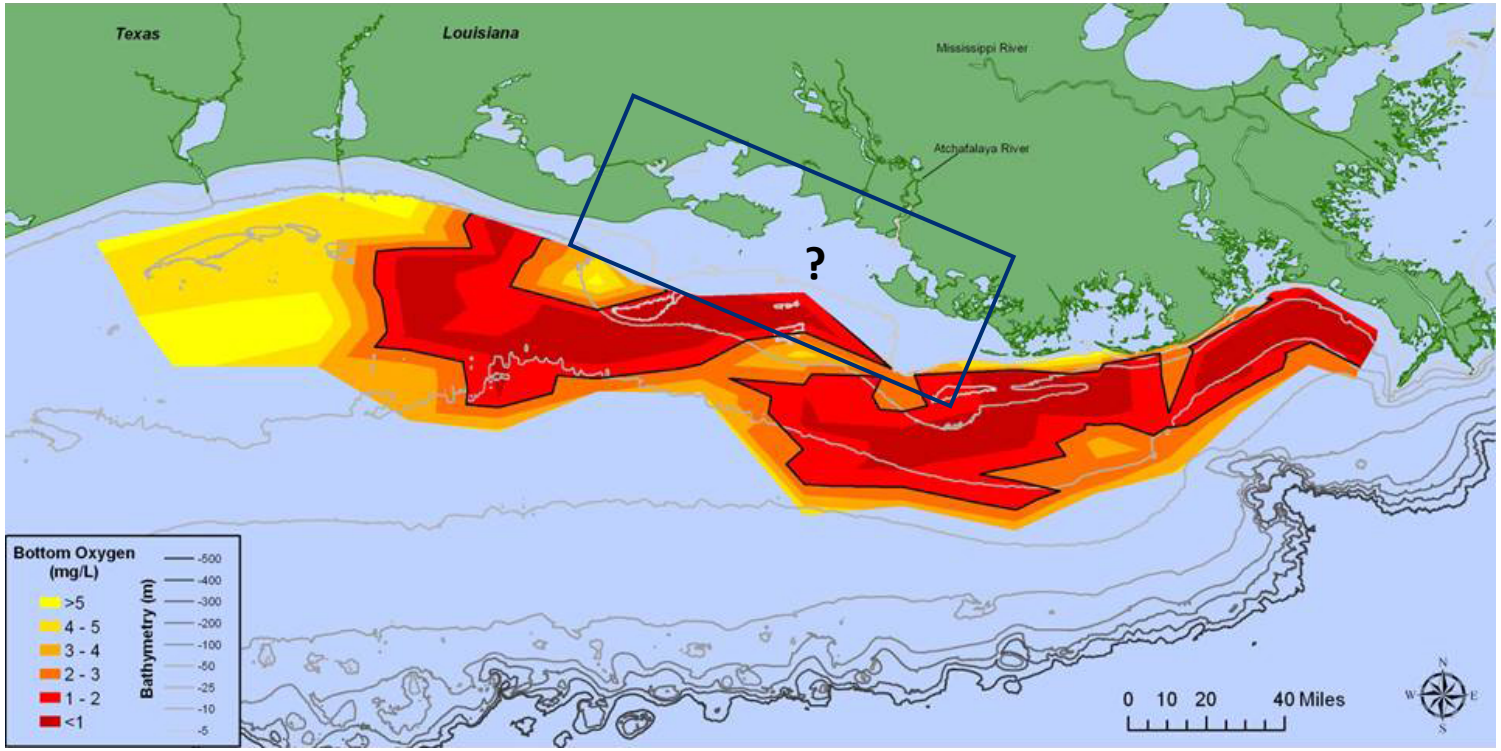


- Arabian Sea: Expansion of endosymbiont- containing *Noctiluca scintillans* blooms since 2000
- Correlated with waters undersaturated in DO

Gomes et al. 2014. Nature Communications

Implications

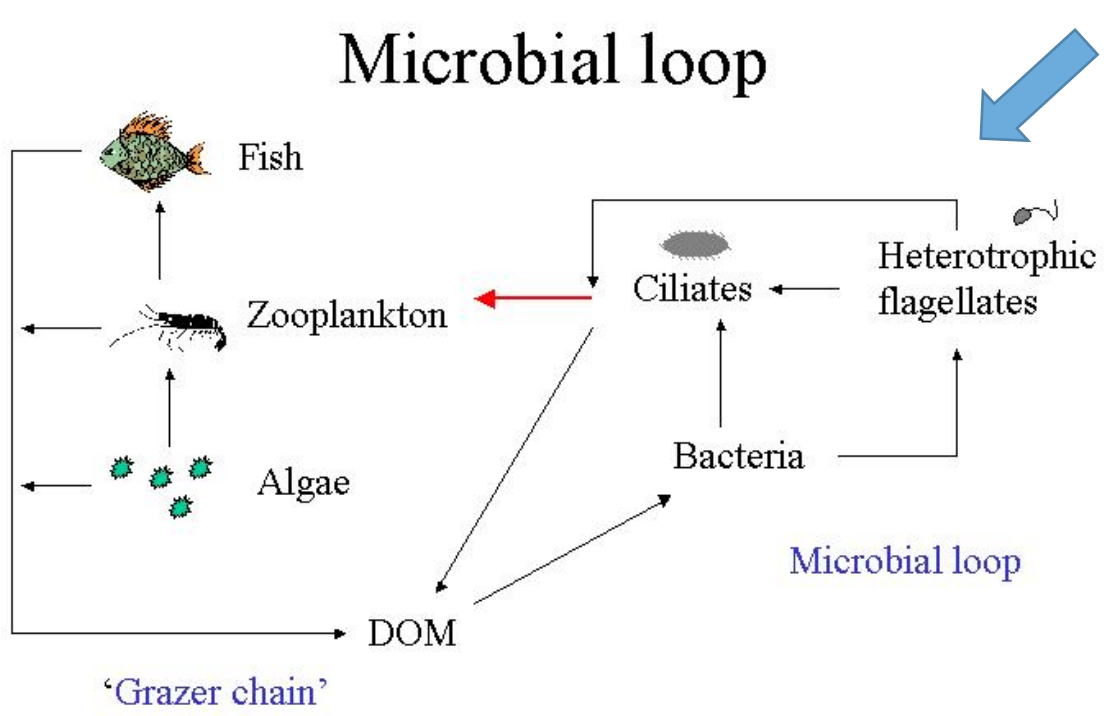
- Potential for significant effect especially where hypoxic waters extend into the euphotic zone



Data: Nancy Rabalais, LUMCON; R Eugene Turner, LSU. Credit: NOAA

Implications

- Potential for added stressor on higher organisms in hypoxic regions with shifting plankton community composition.

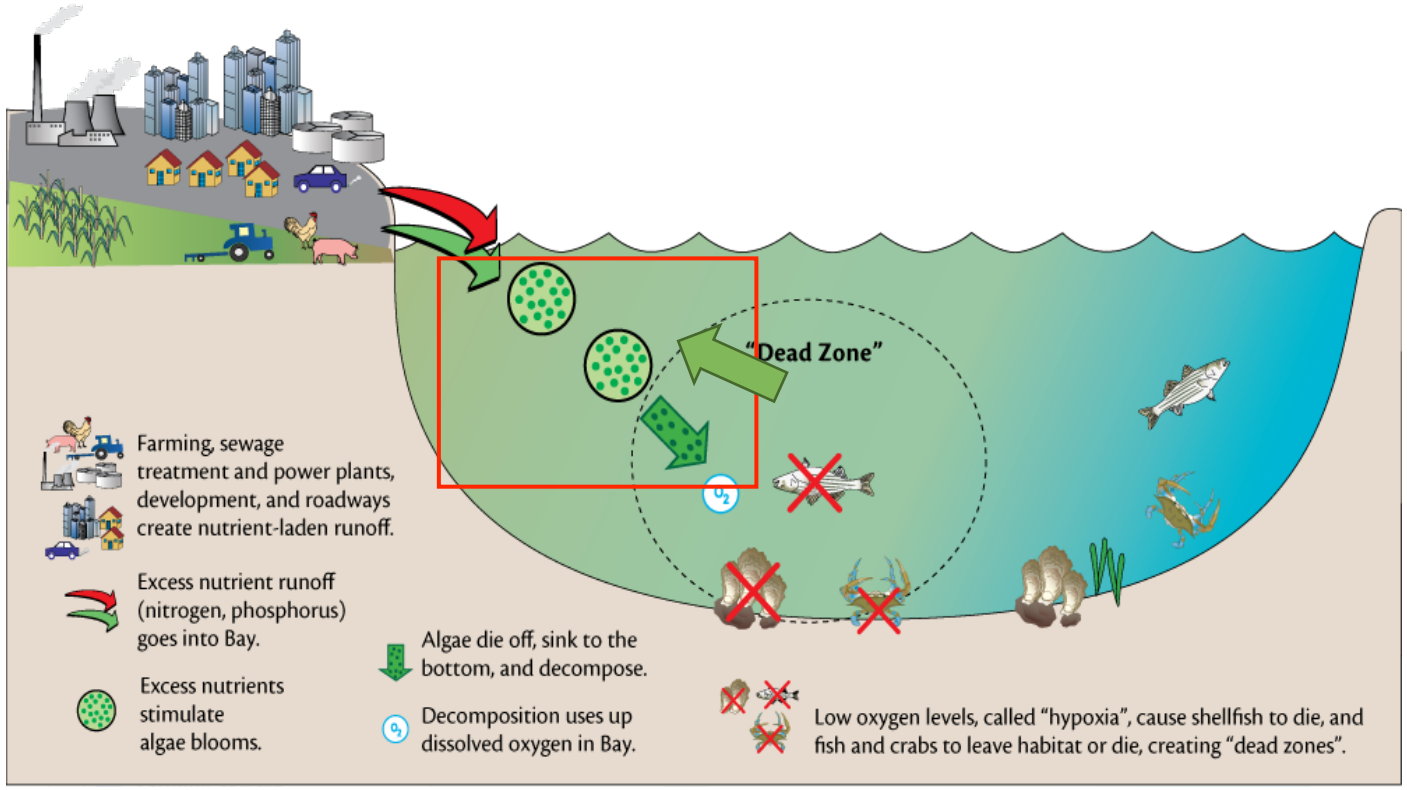


Reduced C flux to deep waters

http://www.esf.edu/efb/schulz/

Conclusions

- Phytoplankton both drive and are affected by hypoxia in coastal ocean systems



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Conclusions

- Phytoplankton both drive and are affected by hypoxia in coastal ocean systems
  - Effects include physiological and shifts in community structure

- Relationships between hypoxia and plankton dynamics have been observed in several coastal ocean systems
  - e.g. emergence of *N. scintillans* in Arabian Sea in just the last 2 decades.

- The relationships between hypoxia and plankton dynamics are complex but may have significant implications for coastal ocean food webs.

Thank you!

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