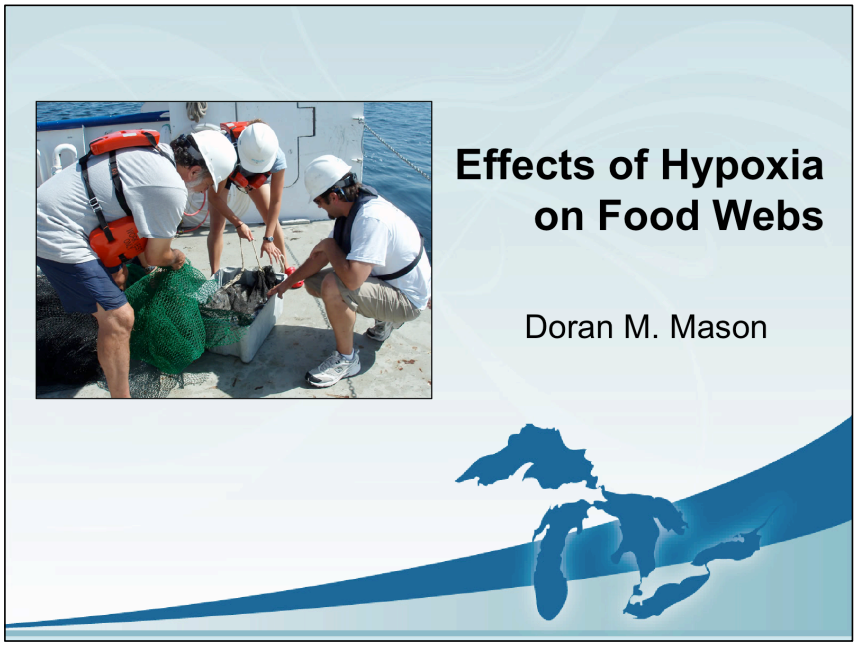

Key Points:
Hypoxia research comprises many different scientists from technology to field operations and also modeling.
Scientists:
Joann Cavaletto (GLERL), Steve Constant (GLERL), David Fanslow (GLERL), Nathan Hawley (GLERL)
John Lane (GLERL), Jim Liebig (GLERL), Dr. Steve Lozano (GLERL), Nancy Morehead (GLERL)
Ron Muzzi (GLERL), Thomas Nalepa (GLERL), Steve Pothoven (GLERL), Steve Ruberg (GLERL)
Edward Rutherford (GLERL), Craig A. Stow (GLERL), Henry Vanderploeg (GLERL), Aaron Adamack (CILER)
Tom Johengen (CILER), Hongyan Zhang (CILER)

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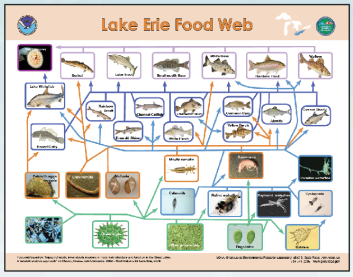
Guiding Scientific Questions

- How does the spatial extent and seasonal timing of hypoxia affect:
  - Fish growth and production?
  - Food web interactions?
  - Habitat quality and suitability for important fishes?
- How does the combined effects of hypoxia and other stressors affect fish abundance and community composition?
- What are the most effective tools to forecast food web interactions, habitat suitability and fish production in relation to hypoxia?

Key Scientific Questions

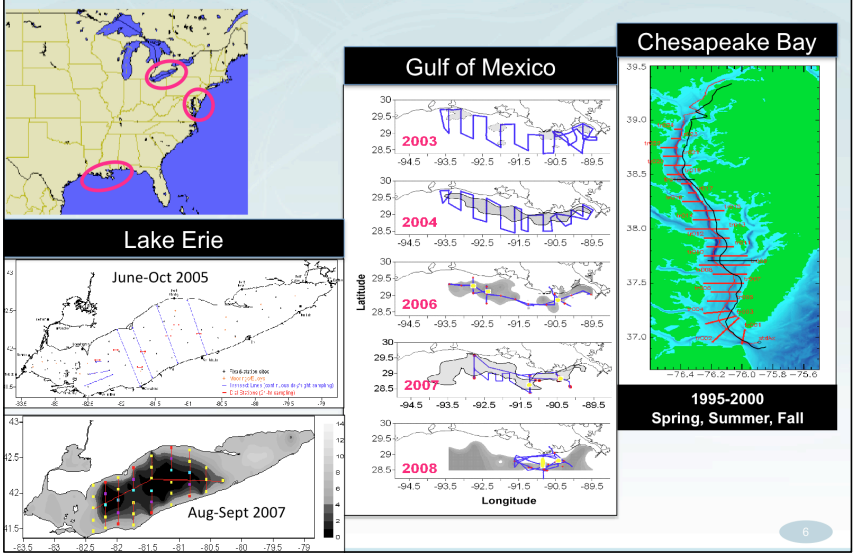
- Modifies food web interactions?
  - Food availability
  - Foraging efficiency
- Increases fisheries harvest?
- Disrupts diel vertical migration?
  - Maintenance costs



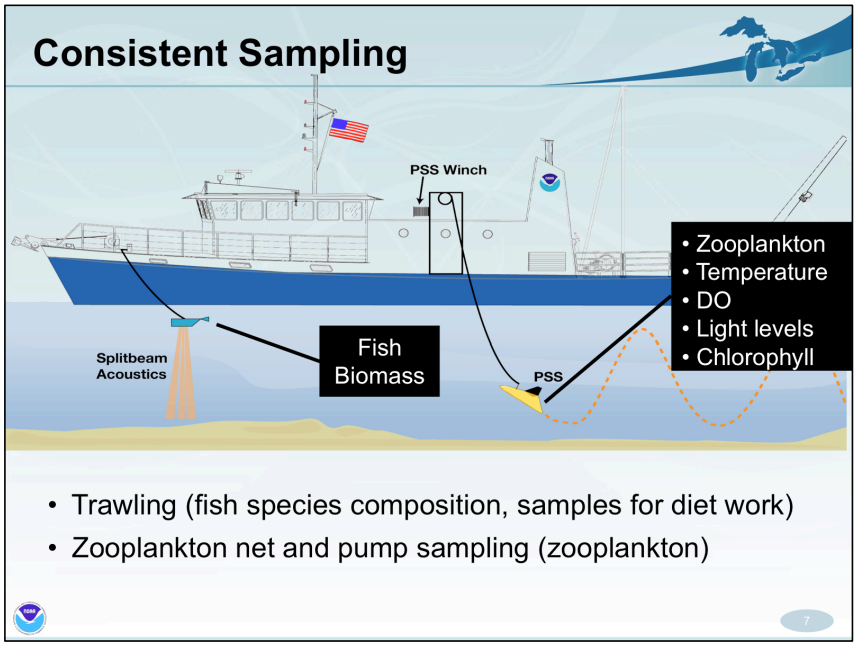
Approach

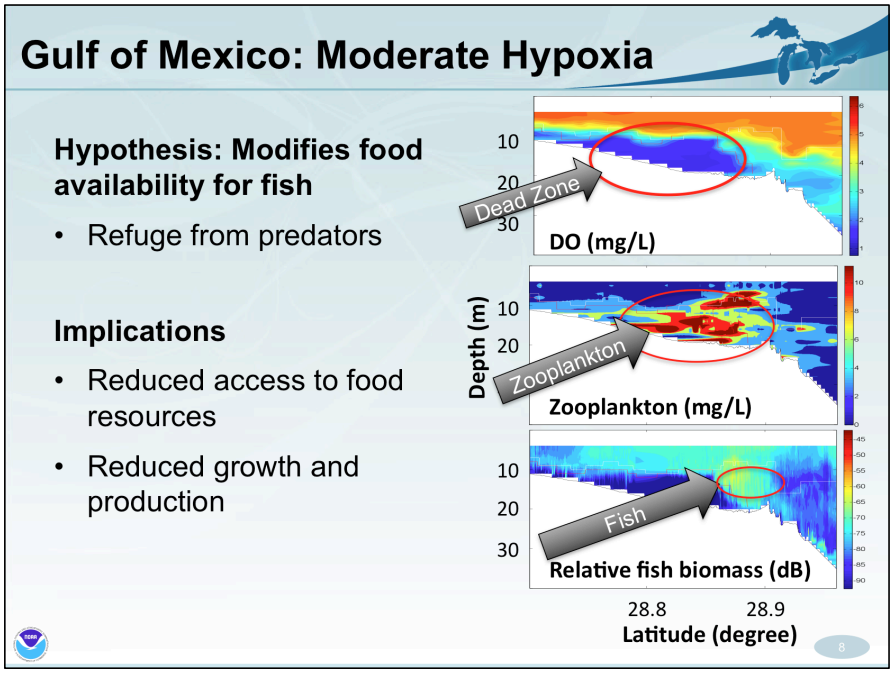
- Comparative across ecosystems
- High-resolution mapping of the pelagic food web in relation to hypoxia
- Data analyses and model development to assess the effects of hypoxia on food webs and production
- Ultimately will provide tools to forecast food-web interactions, habitat suitability and fish production in relation to hypoxia

Comparative Approach



The hypoxia research are large intensive field efforts in three freshwater estuarine coastal areas.





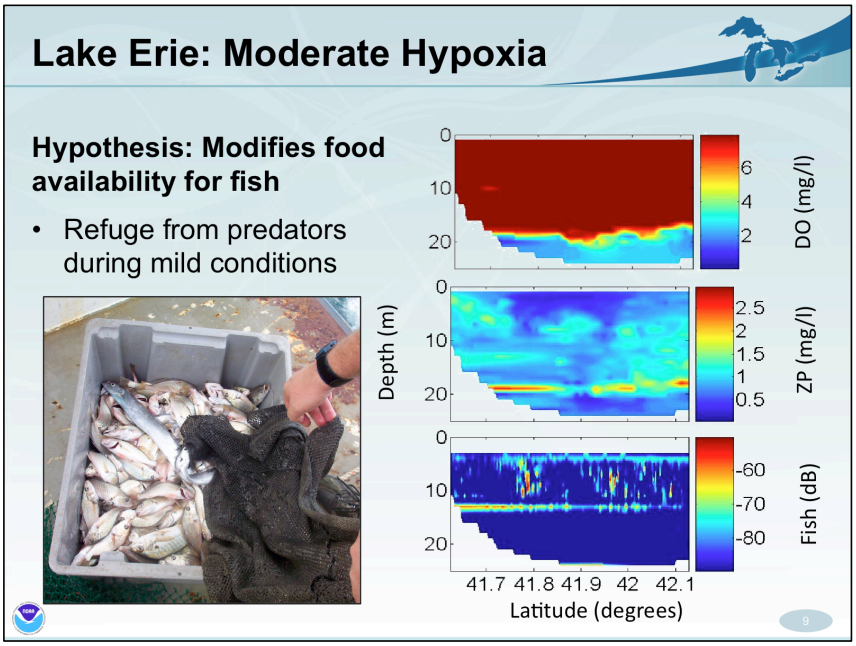
Hypoxic conditions provide a refuge for zooplankton from predators.

Zhang, H., S.A. Ludsin, M.R. Roman, W.C. Boicourt, X. Zhang, D.G. Kimmel, A.T. Adamack, D.M. Mason, and S.B. Brandt. 2009. Hypoxia driven changes in the behavior and spatial distribution of pelagic fish and zooplankton in the northern Gulf of Mexico. Journal of Experimental Marine Biology and Ecology 381: S80-S91. *

References for slide #10 (Lake Erie: Severe Hypoxia)*

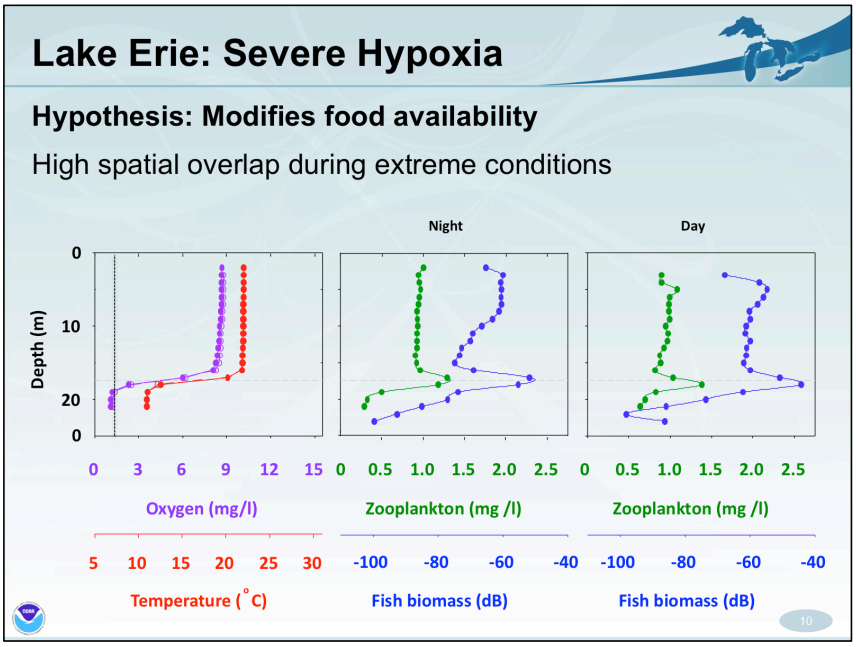
Vanderploeg, H.A., S.A. Ludsin, S.A. Ruberg, T.O. Hook, S.A. Pothoven, S.B. Brandt, G.A. Lang, J.R. Liebig, and J.F. Cavaletto. 2009. Hypoxia affects spatial distributions and overlap of pelagic fish, zooplankton and phytoplankton in Lake Erie. Journal of Experimental Marine Biology and Ecology 381: S92-S107.

Vanderploeg, H.A., S.A. Ludsin, J.F. Cavaletto, T.O. Hook, S.A. Pothoven, S.B. Brandt, J.R. Liebig, and G.A. Lang. 2009. Hypoxia zones as habitat for zooplankton in Lake Erie: Refuges from predation or exclusion zones? Journal of Experimental Marine Biology and Ecology 381: S108-120.



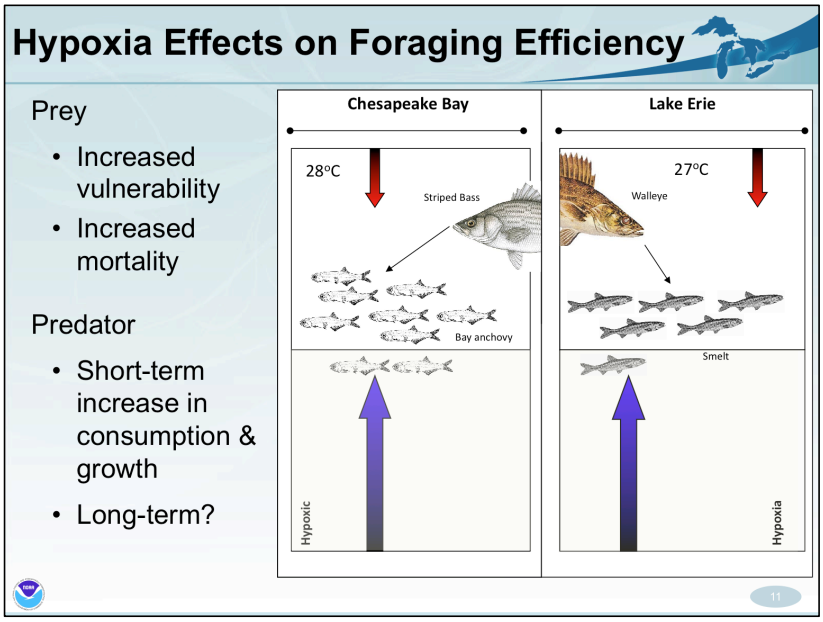
Observe same process we saw in the Gulf of Mexico in Lake Erie under moderate hypoxia conditions.

Concentrates predator and prey in different areas, zooplankton move into low dissolved oxygen area.



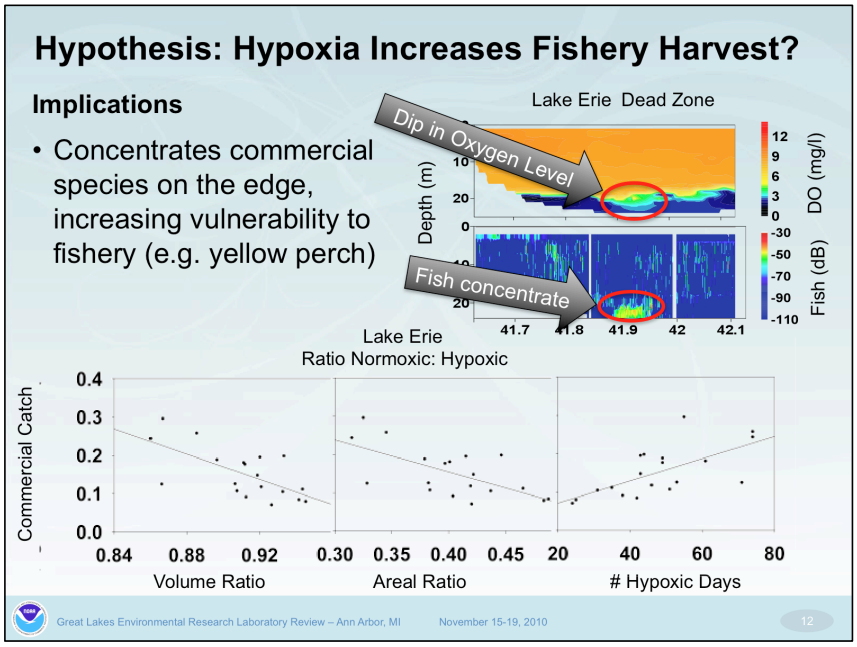
In contrast, under severe hypoxia conditions, we don't see zooplankton move into low dissolved oxygen areas.

Implications: increases vulnerability of prey; compression of prey into a smaller volume may increase foraging efficiency and encounter rates for predators.



Concentrates predator and prey into a smaller volume of water.
Implications: increases vulnerability of prey, compression of prey into a smaller volume may increase foraging efficiency and encounter rates for predators.
Studies were done on commercially and recreationally important fishes
GOM: Striped Bass -> anchovies
Lake Erie: Walleye -> smelt

Ludsin, S.A., X. Zhang, S.B. Brandt, M.R. Roman, W.C. Boicourt, D.M. Mason, and M. Costantini. 2009. Hypoxia-avoidance by planktivorous fish Chesapeake Bay: Implications for food web interactions and fish recruitment. Journal of Experimental Marine Biology and Ecology 381: S121-S131.
Costantini, M., S.A. Ludsin, D.M. Mason, X. Zhang, W. Boicourt, and S.B. Brandt. 2008. Effect of hypoxia on habitat quality of striped bass Morone saxatilis (Walbaum) in Chesapeake Bay. Canadian Journal of Fisheries and Aquatic Science 65:989-1002.
Brandt, S.B., M. Costantini, S. Kolesar, S.A. Ludsin, D.M. Mason, C.M. Rae, and H. Zhang. In Press. Does hypoxia reduce habitat quality for Lake Erie Walleye? A bioenergetics perspective. Canadian Journal of Fisheries and Aquatic Sciences.



Hypoxia can concentrate fish on edges of the hypoxia zone.

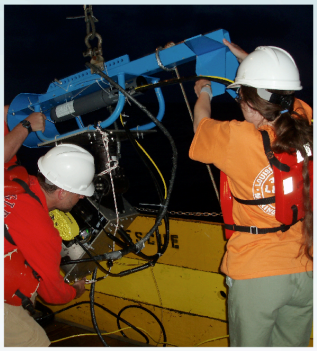
As the severity of hypoxia increases, so does the catch rate, evidence to support this in the commercial catch rates in Lake Erie.

Impact of Hypoxia on Food Webs

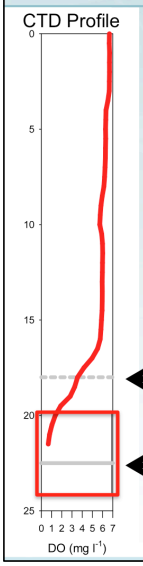
Disrupts diel vertical migration: maintenance costs

Implications

- Increased maintenance costs
- Decreased growth and production
- Increased mortality
  - Directly: thermal stress
  - Indirectly: increased predation



Impact of Hypoxia on Food Webs

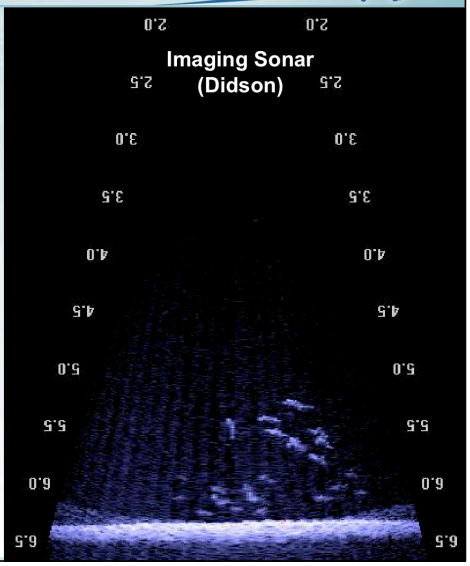


Role of Behavior?

Implications:
- Prey vulnerability
- Predator growth & production

Approximate depth of DIDSON

Water column bottom at site of CTD cast



Red box indicates where sonar image was taken from.

In low dissolved oxygen, we see fish enter area presumably to forage.
** Not consistent with fisheries acoustic data we saw earlier. Adaptable behavioral modification s may provide access to food in low dissolved oxygen areas.

Partners

Gulf of Mexico

- Florida Int'l University
- Louisiana Dept. of Fisheries and Wildlife
- Louisiana State University
- NMFS SE Regional Office
- Oregon State University

Chesapeake Bay

- University of Maryland

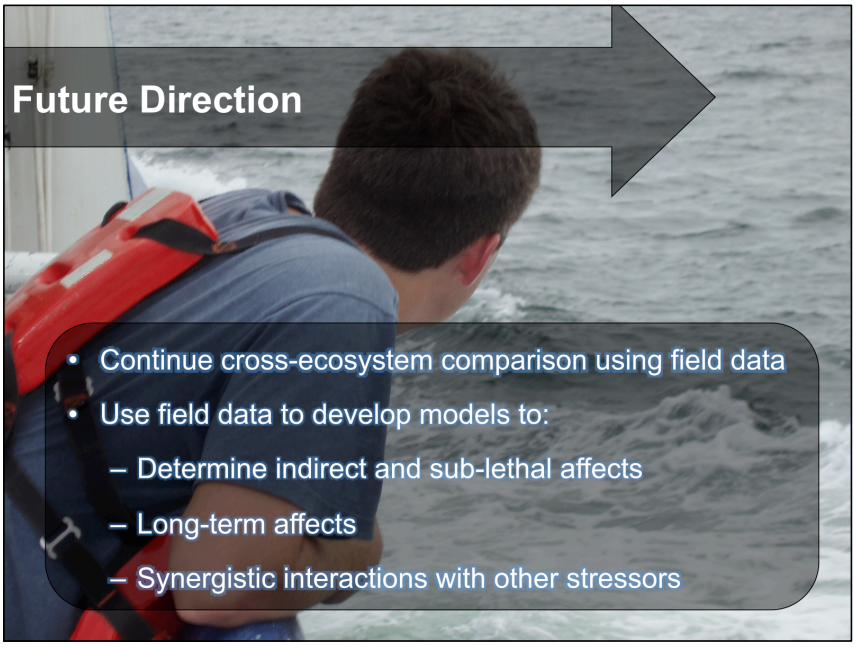
Lake Erie

- Ohio State University
- Purdue University
- University of Akron

Products

- **Large database across three ecosystems**
  - Diet
  - Spatial Distribution and abundance across trophic levels
  - Environmental variables (salinity, DO, temperature)
- GLERL Co-Guest Editor in a **Special Supplement of the *Journal of Experimental Marine Biology and Ecology*** on "Ecological Impacts of Hypoxia on Living Resources"

GLERL contributed 8 of 20 manuscripts


Future Direction
• Continue cross-ecosystem comparison using field data
• Use field data to develop models to:
– Determine indirect and sub-lethal affects
– Long-term affects
– Synergistic interactions with other stressors


Thank you!
Questions?