Fish and Zooplankton Distributions in a Seasonally Hypoxic Fjord

Mei Sato  
University of Washington, meisato@uw.edu

John K. Horne  
University of Washington

Sandra L. Parker-Stetter  
University of Washington

Follow this and additional works at: https://cedar.wwu.edu/ssec

Part of the Terrestrial and Aquatic Ecology Commons

Sato, Mei; Horne, John K.; and Parker-Stetter, Sandra L., "Fish and Zooplankton Distributions in a Seasonally Hypoxic Fjord" (2014). Salish Sea Ecosystem Conference. 46.  

This Event is brought to you for free and open access by the Conferences and Events at Western CEDAR. It has been accepted for inclusion in Salish Sea Ecosystem Conference by an authorized administrator of Western CEDAR. For more information, please contact westerncedar@wwu.edu.
Fish and Zooplankton Distributions in a Seasonally Hypoxic Fjord

April 30 2014

Mei Sato, John Horne, Sandra Parker-Stetter

School of Aquatic and Fishery Sciences
University of Washington
Hypoxia Impacts on Ecosystems

• Compress favorable habitat for predators and prey
• Shift in community composition
• Alter energy flow in food webs

(Newton & Devol 2012)
Hypoxia Impacts on Ecosystems

- Compress favorable habitat for predators and prey
- Shift in community composition
- Alter energy flow in food webs

(Newton & Devol 2012)
Limitations in previous studies

Lack of direct observation of how responses to hypoxia alter food-web coupling

Goal

To understand how hypoxia affects

• distribution: predator/prey overlap,
• zooplankton community composition, and
• physiological/behavioral responses of fish.

If so, does hypoxia affect energy flow from zooplankton to fish?
Limitations in previous studies

Lack of direct observation of how responses to hypoxia alter food-web coupling

Goal

To understand how hypoxia affects

• **distribution**: predators/prey overlap,
• zooplankton community composition, and
• physiological/behavioral responses of fish.

If so, does hypoxia affect energy flow from zooplankton to fish?
Does hypoxia affect vertical distributions of predators and prey?
Does hypoxia affect vertical distributions of predators and prey?
Does hypoxia affect vertical distributions of predators and prey?
Study site

Survey period
Jun – Oct in 2012 & 2013
Multi-frequency Echosounder

- 38 kHz
- 70 kHz
- 120 kHz
- 200 kHz

University of Washington Marine Research
Transect lines

$S_v = \text{proxy for density}$

Depth (m)

Latitude (°N)

Longitude (°W)

$S_v (\text{dB re } 1 \text{ m}^{-1})$
Separation of fish vs. zooplankton
Separation of fish vs. zooplankton
Separation of fish vs. zooplankton

Sv$_{38}$ kHz

Sv$_{120}$ kHz

Sv$_{38}$ kHz (fish)

Sv$_{120}$ kHz (zooplankton)

Sv$_{120}$ kHz – Sv$_{38}$ kHz

ΔSv (dB re 1 m$^{-1}$)

Depth (m)

Distance

500 m

Separation of fish vs. zooplankton
Net Samplings

Pacific herring

Pacific hake

Euphausiids

Amphipods

Copepods

Chaetognaths

Jellyfish
Hypoxia: $O_2 < 2 \text{ mg/L}$
Hypoxia: $O_2 < 2 \text{ mg/L}$
Do zooplankton avoid hypoxic water?

$Sv_{120\ kHz}$ (zooplankton) : 2012 Aug

- Depth (m)
- Distance 1.6 km
- $Sv$ (dB re 1 m$^{-1}$)
- $Sv$ (dB re 1 m$^{-1}$) vs Depth (m)
Do zooplankton avoid hypoxic water?

$S_{\nu_{120\ kHz}}$ (zooplankton) : 2013 Aug
Do zooplankton avoid hypoxic water?
Do zooplankton avoid hypoxic water?
Do zooplankton avoid hypoxic water?

No upward movement of daytime scattering layer due to hypoxia
Do fish avoid hypoxic water?

Pre-hypoxia  Hypoxia  Post-hypoxia  Oxygen

Depth (m)

Sv (dB re 1 m⁻¹)

O₂ (mg/L)

2013 Jun  2013 Sep  2013 Oct  2013 Oct
Do fish avoid hypoxic water?

![Map showing locations: Union, Hoodsport, Duckabush, Dabob]

![Graph showing Median $S_v$ (dB re 1 m$^{-1}$) vs Near-bottom $O_2$ (mg/L)]

- High density
- Low density

Legend:
- Black: Union
- Blue: Hoodsport
- Red: Duckabush
- Gray: Dabob
Do fish avoid hypoxic water?

No avoidance of near-bottom hypoxic waters

High density

Low density

Median $S_v$ (dB re 1 m$^{-1}$)

Near-bottom $O_2$ (mg/L)
Conclusions

- Hypoxia does not affect vertical distribution of fish and zooplankton

- Survey period in 2012-2013 is moderately hypoxic ($O_2 = \sim 2 \text{ mg/L}$)

- Possibility of horizontal and vertical movements in distributions

(ORCA buoy data provided by Newton, Devol & Ruef)

(ORCA buoy data provided by Newton & Devol 2012)
Acknowledgements

Tim Essington, Julie Keister, Jen Nomura, Pamela Moriarty
Amanda Winans, Shannon Hennessey, Hannah Linder,
Halley Froehlich, Lillia Bannister, Sarra Tekola
Capt. David Duggins, Scott Lindgren
Behavior and physiology responses

- Impact on growth/abundance in cod
- Impact on squid spawning
- Distribution limit sardine larvae
- Impact on hatching length in herring
- Decrease of squid catches
- Active selection of normoxic areas
- Drastically lowered catches demersals
- Distribution limit in sprat/horse mackerel
- Reduced growth/gonad size flatfish
- Disruption of schooling in herring
- Distribution limit jellyfish
- Impact on squid occurrence
- Impact on copepod swimming/filtering/abundance
- Impact on copepod egg development and hatching

~ 2 mg O₂ L⁻¹

(Ekau et al. 2010)
Benthic macrofauna

(Vaquer-Sunyer & Duarte 2011)
$Sv_{120 \text{ kHz}}$
Vertical Distributions

Fish Zooplankton

Jun 2012 Oct

Jun 2013 Oct

Depth (m)

Sv (dB)