Trends in mycobacteriosis and associated relative mortality in striped bass in Maryland waters of the Chesapeake Bay

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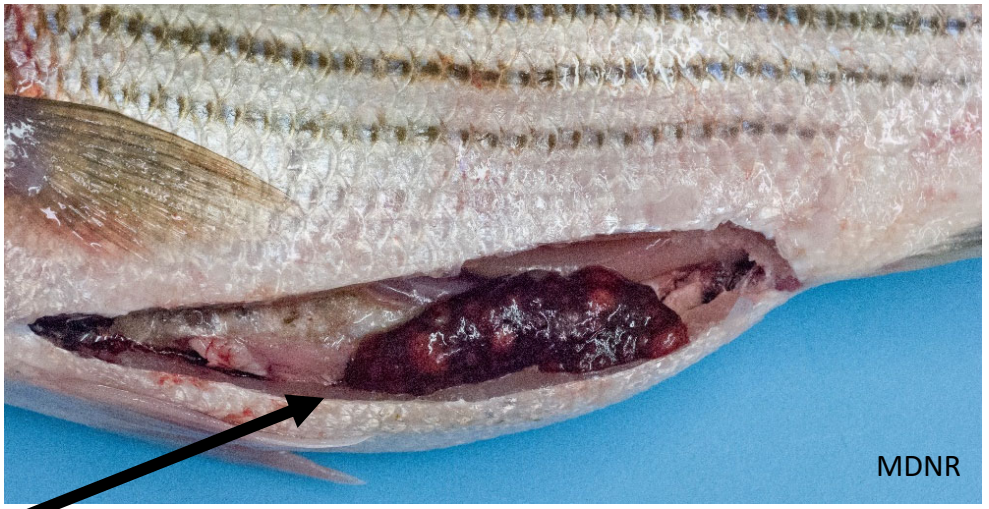
Mycobacteriosis

- Chronic disease from bacteria of the genus *Mycobacterium*
- Identified in several fish species
- Symptoms include
  - Nodules on internal organs
  - Scale loss, pigment changes, external lesions



Mycobacteriosis in Chesapeake Bay striped bass

- Disease first described in 1997, archived samples as far back as 1984 have tested positive (Jacobs et al. 2009)
- Disease prevalence high in Chesapeake Bay, low in coastal ocean (Matsche et al. 2010)

Photo: Anthony Burrows, MDNR

Mycobacteriosis affects striped bass population dynamics

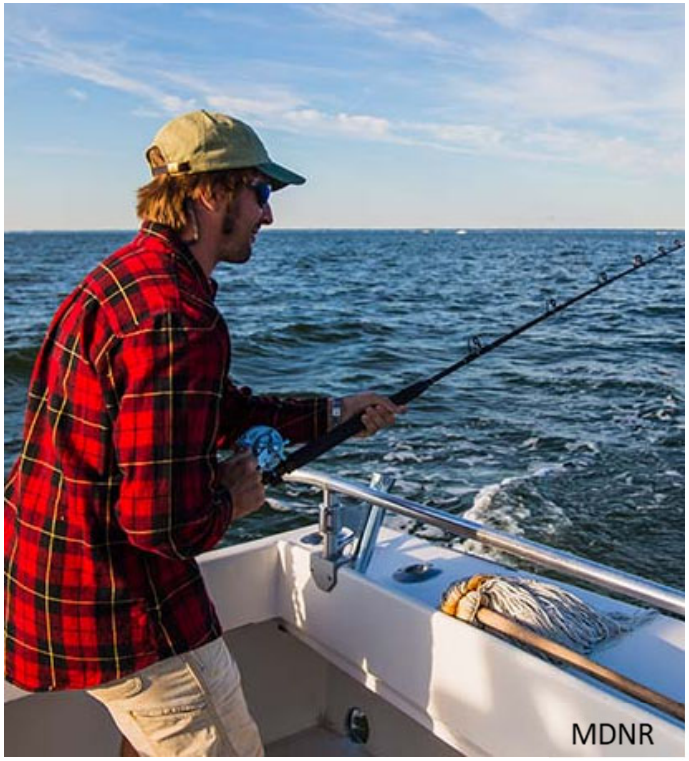
- Decreased growth and earlier/smaller size at maturity (Latour et al. 2010, Gervasi et al. 2019)
- Relative survival of diseased fish lower (Gauthier et al. 2008, Groner et al. 2018)
- Relative survival of severely diseased fish half that of healthy fish (Hoenig 2017)

Maryland Department of Natural Resources Fish Health Program

1998 - present
Opportunistic and directed sampling with various gears

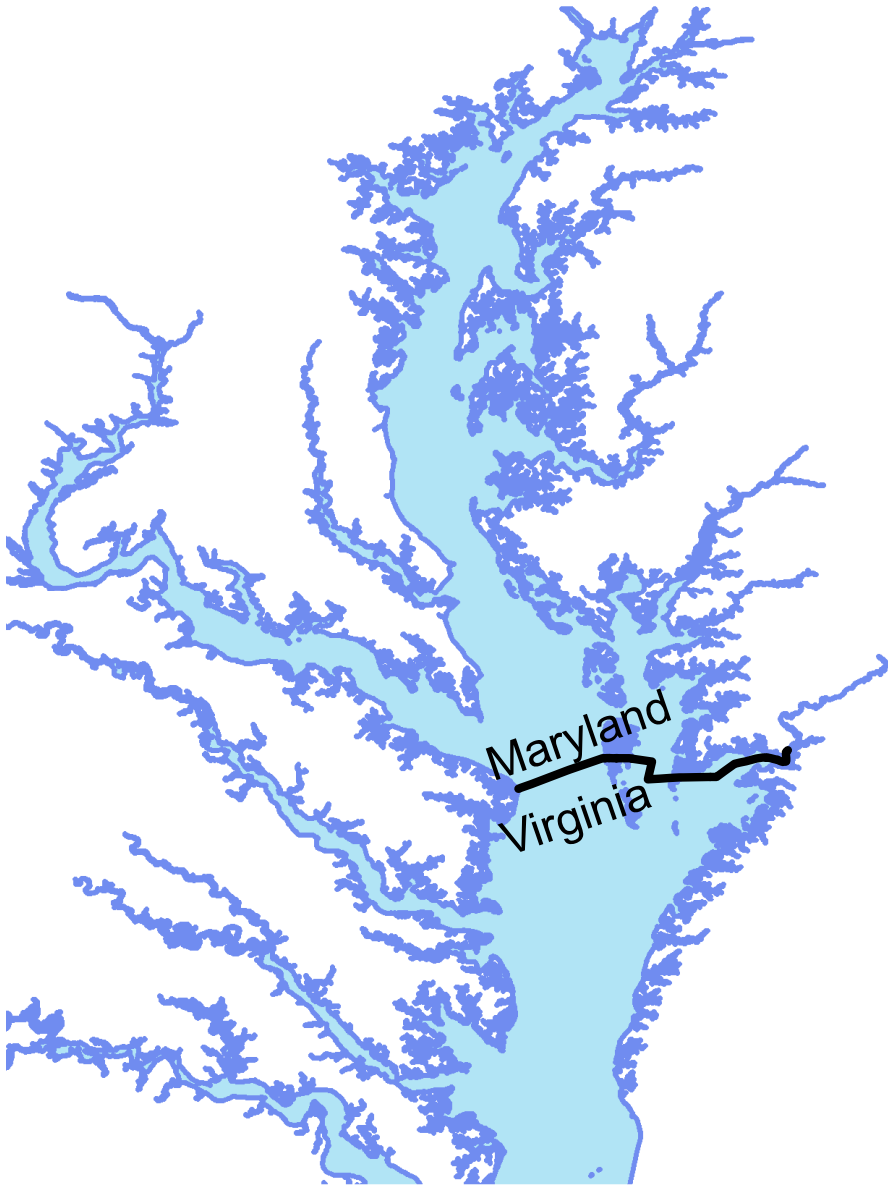
Sex, weight, condition, length/age

Disease presence and severity



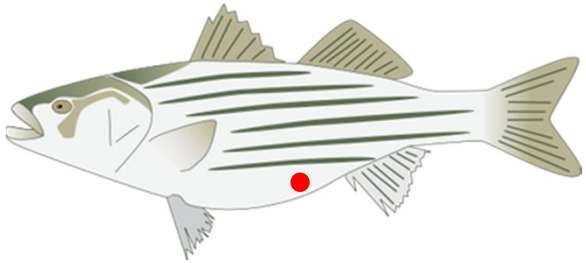
Objectives

1. Quantify trends in mycobacteriosis in striped bass in Maryland waters of the Chesapeake Bay

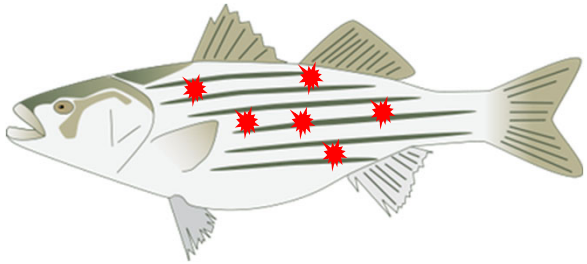


Objectives

2. Model relationship between disease apparent prevalence and potential disease drivers

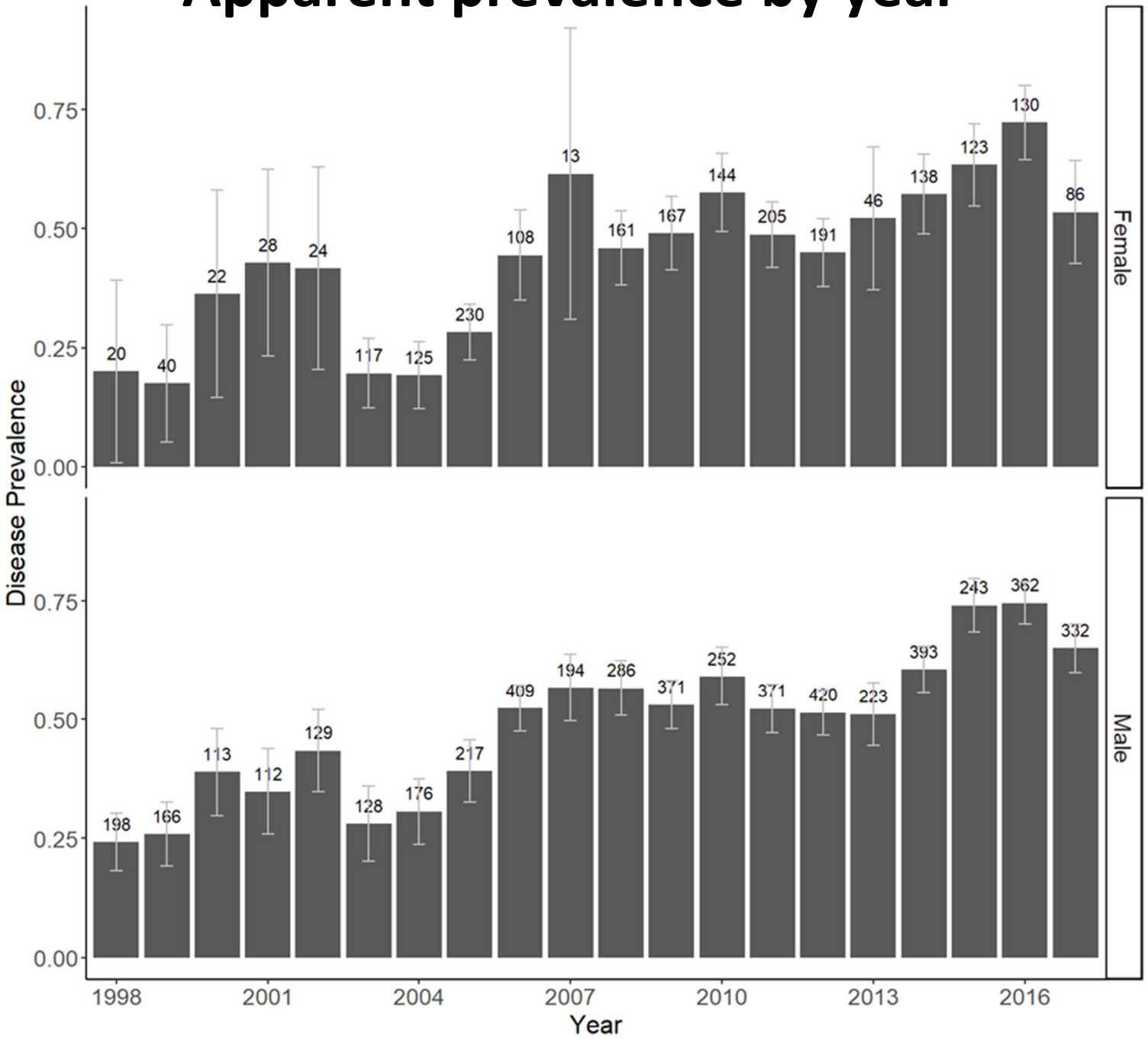


3. Model relationship between disease severity and potential disease drivers

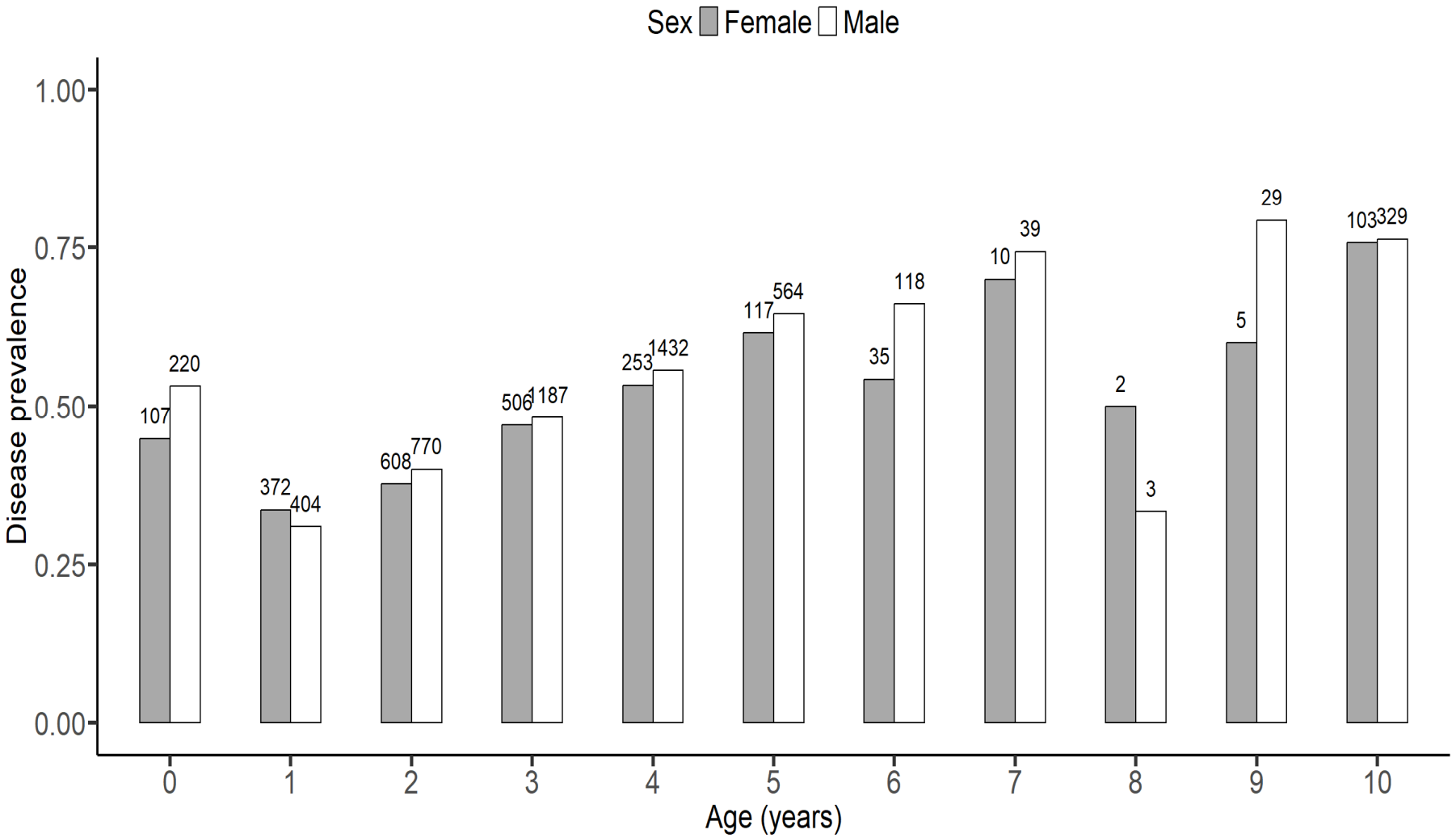


Objective 1 : Quantify trends

Apparent prevalence by year



Apparent prevalence by age



Objectives 2-3: Identify potential drivers of disease

Potential drivers

- **Fish condition**: if fish in poor condition due to malnutrition, fish more susceptible to disease

- **Environmenta**l: if water conditions (e.g., temperature & dissolved oxygen) are poor, fish may be stressed or change feeding behavior

Potential drivers

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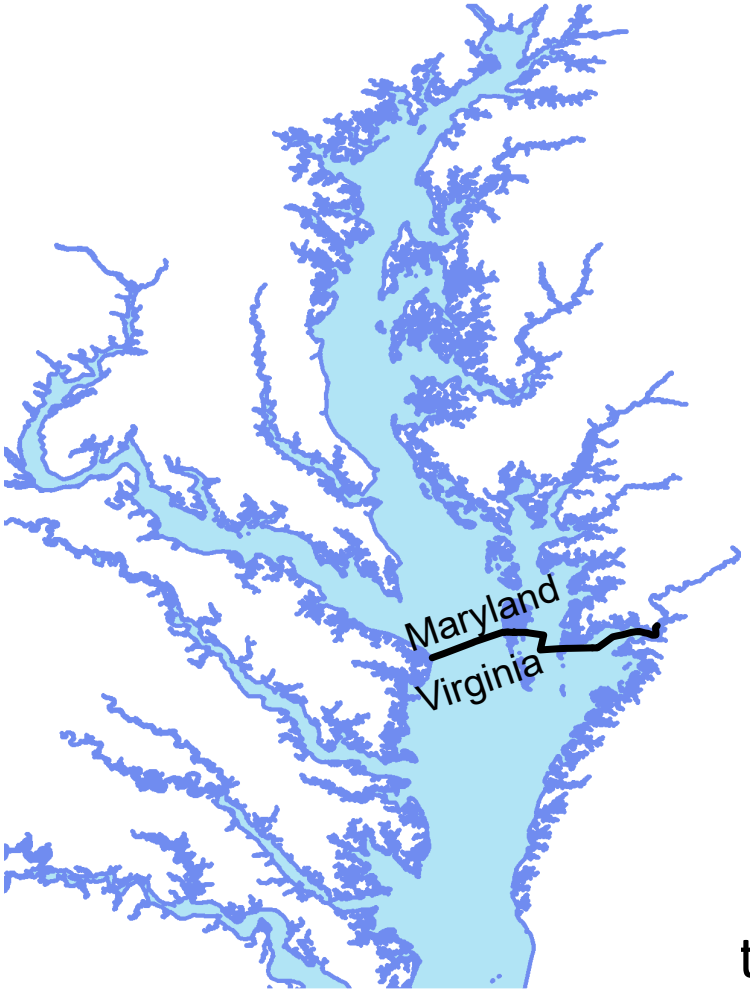
Fulton's K – condition metric (total weight/length^3)

- **Environmenta**l: if water conditions (e.g., temperature & dissolved oxygen) are poor, fish may be stressed or change feeding behavior

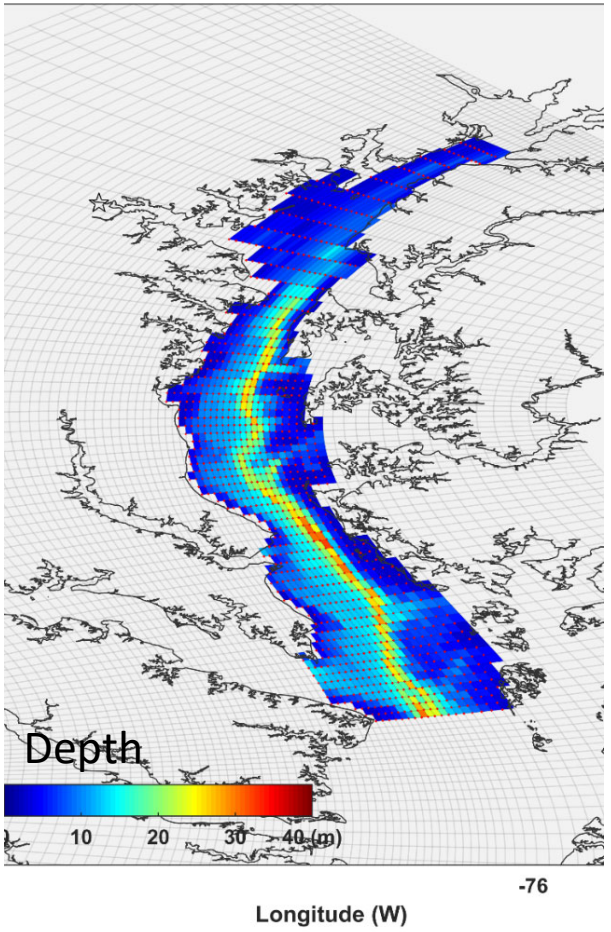
Coupled hydrodynamic-biogeochemical model (ROMS-RCA) – 1998-2015



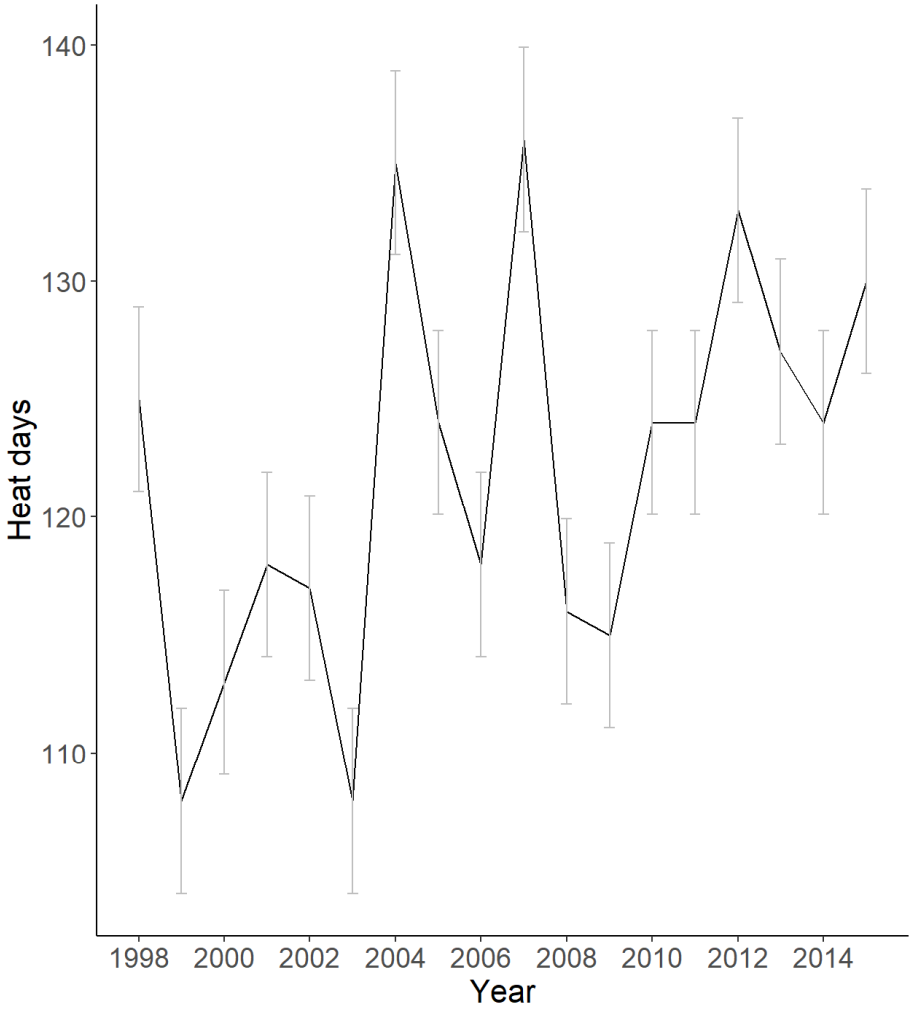
Annual summer average:

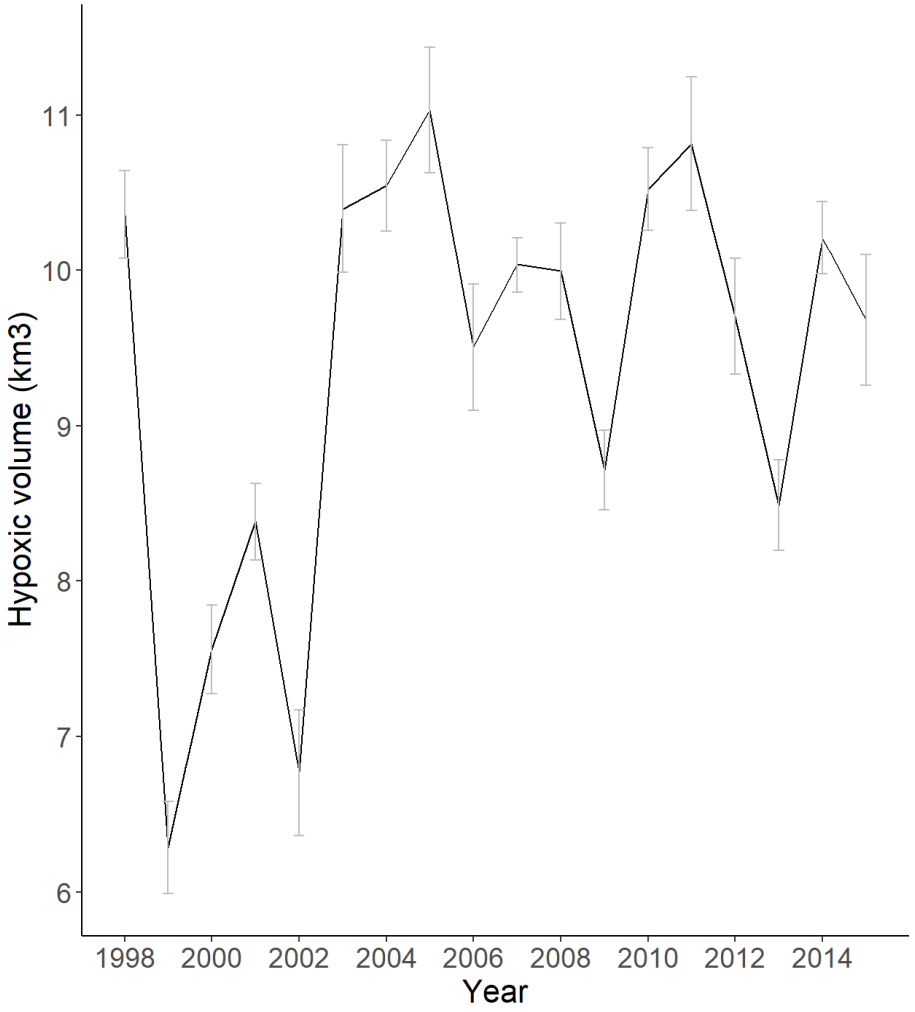
Hypoxic Volume:
Volume of bottom water with DO < 3 mg/L

Heat Days:
Number of days surface water temperature > 25 C

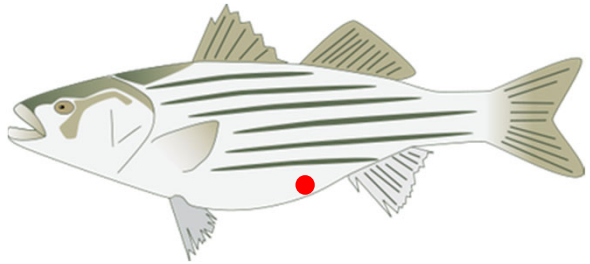


ROMS-RCA estimates





Apparent prevalence model



Binomial GLM

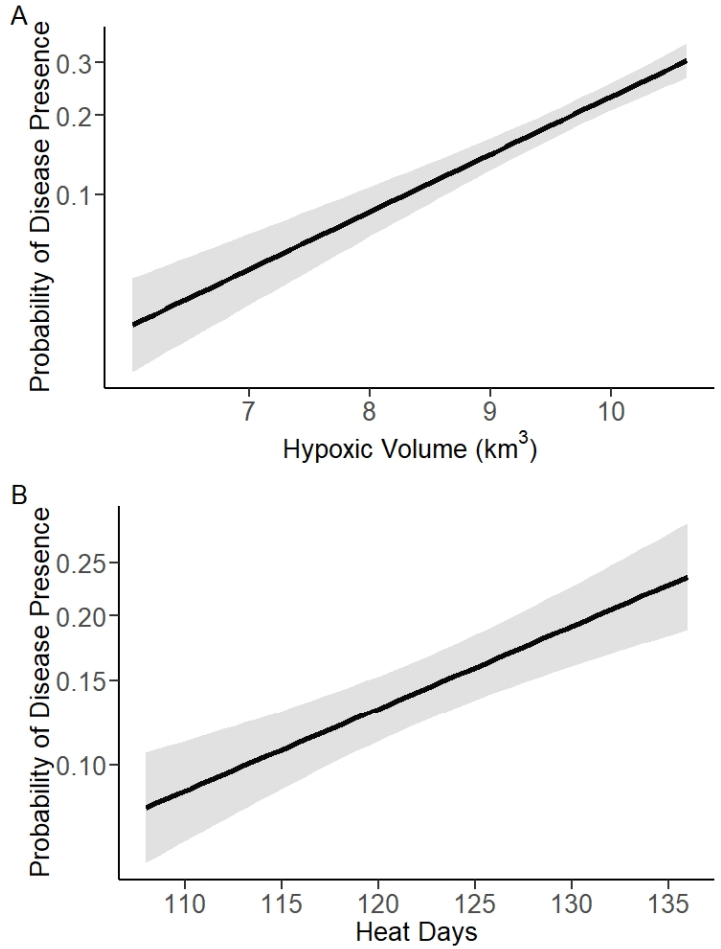
-Diseased (+ mycobacteria in spleen samples) or not

-age 0-1 pre-migratory fish (known residents)

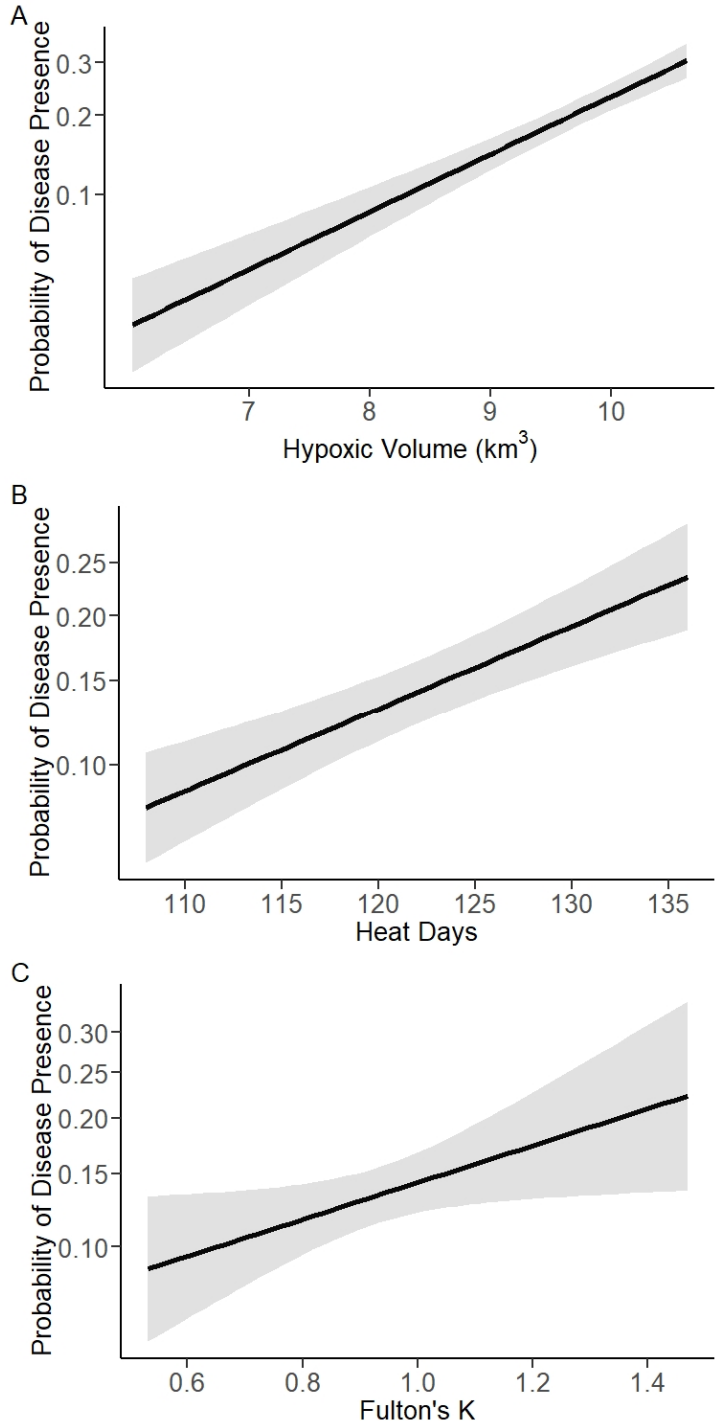
-1998-2015

$$\hat{Y} = \beta_0 + \beta_1 Hypoxic\ Volume + \beta_2 Heat\ Days + \beta_3 Fulton's\ K$$

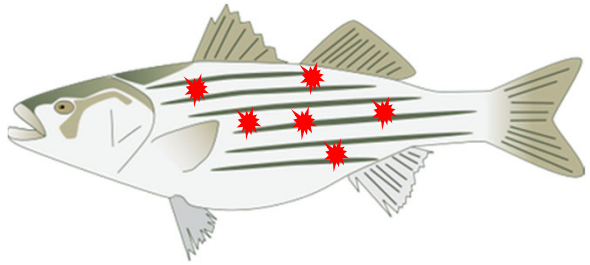
- Disease presence in pre-migratory fish increased with increasing hypoxic volume and heat days



- Disease presence in pre-migratory fish increased with increasing hypoxic volume and heat days
- Disease presence for pre-migratory fish increased with increasing fish condition



Disease severity model



Binomial GLM

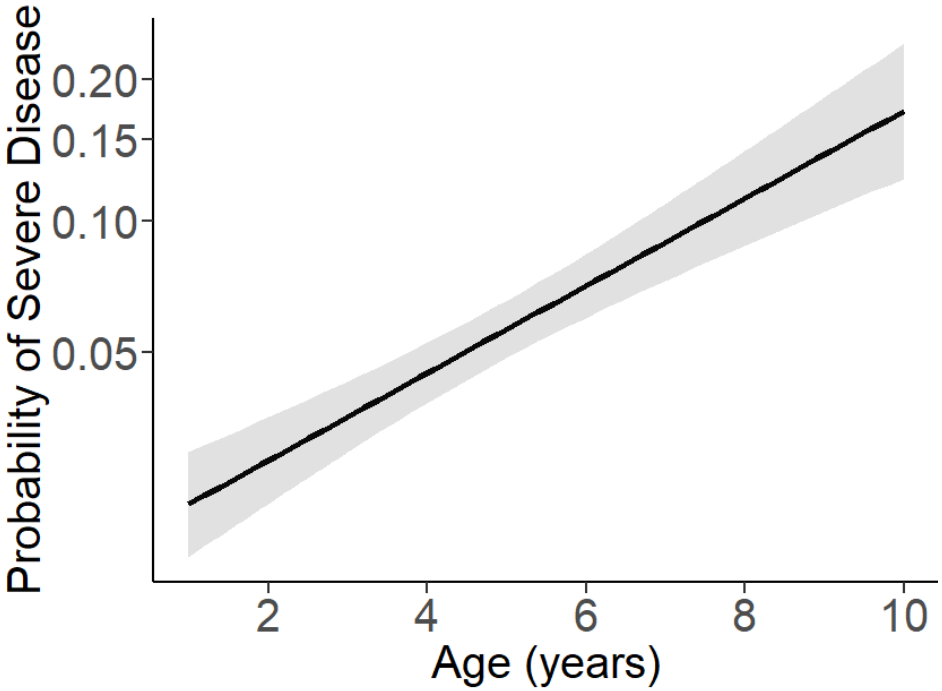
-Severe external lesion severity score (yes/no)

-age 1+ fish

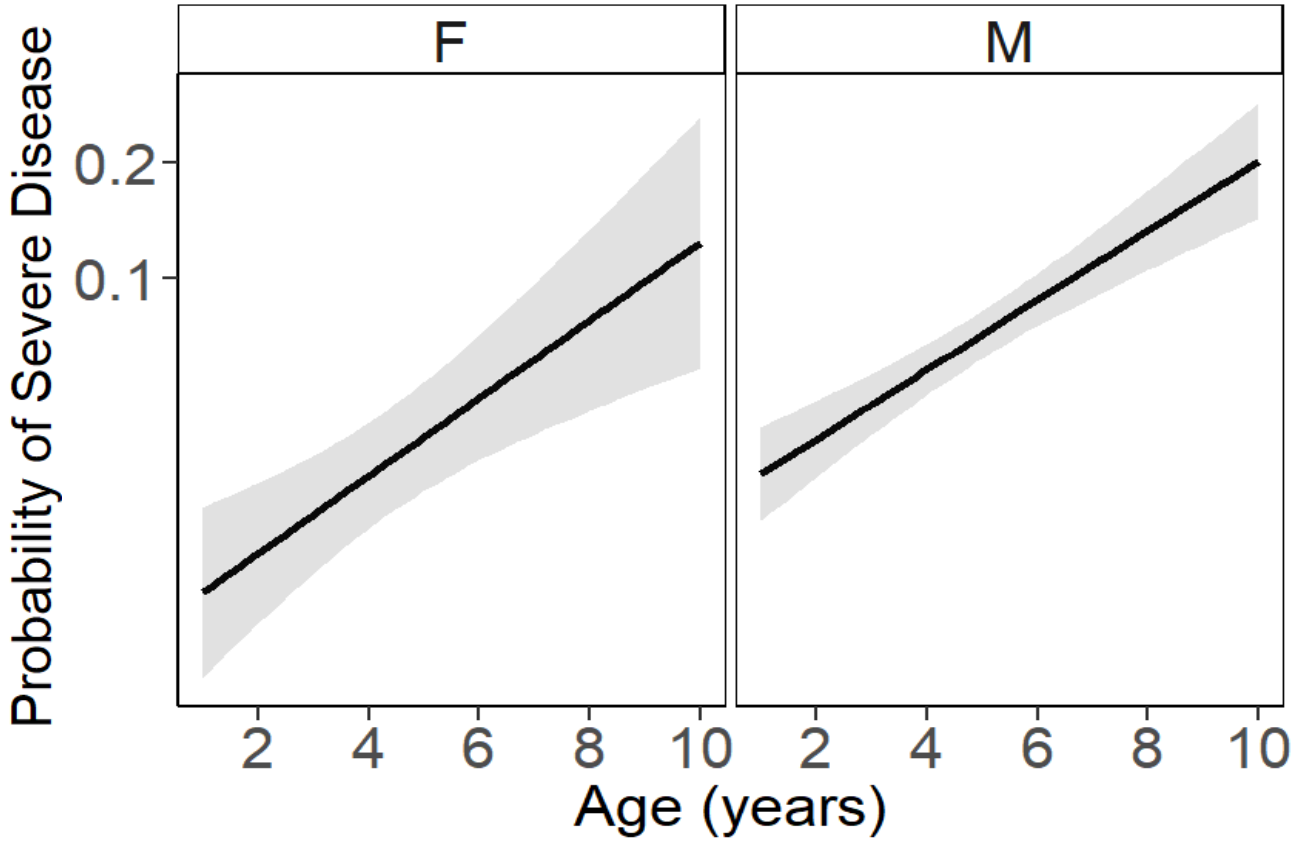
-2007-2017

$$\hat{Y} = \beta_0 + \beta_1 Hypoxic\ Volume + \beta_2 Heat\ Days + \beta_3 Fulton's\ K + \beta_4 Age + \beta_5 Sex + \beta_6 Age * Sex,$$

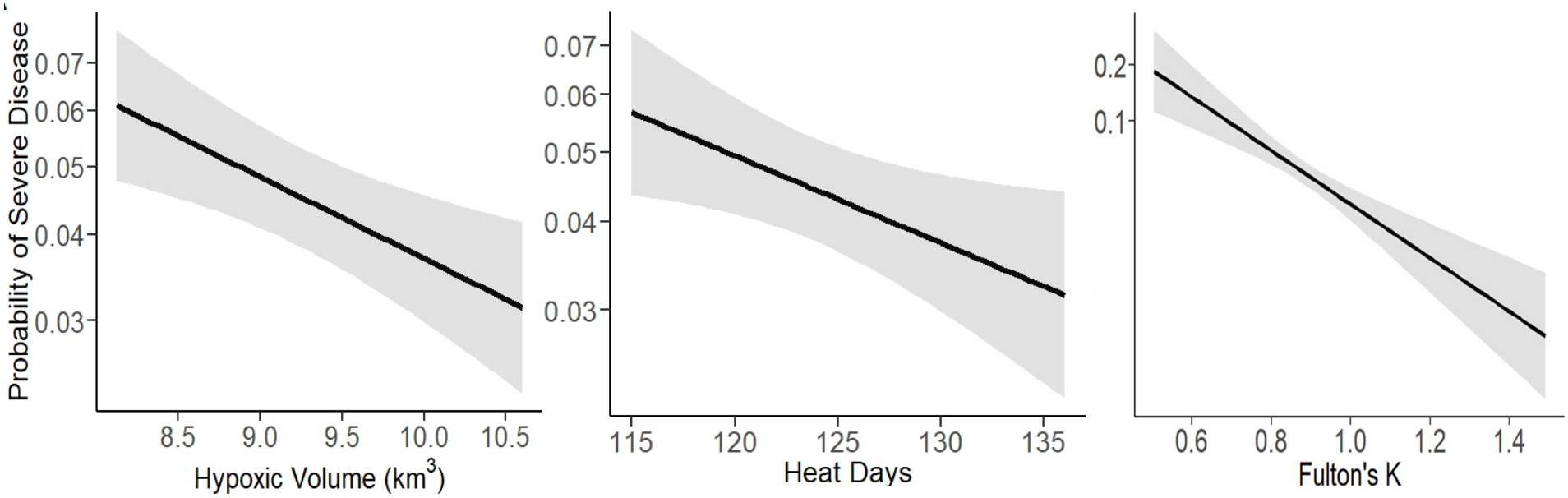
$$Probability = \frac{e^{\beta_0 + \beta_1 Hypoxic\ Volume + \beta_2 Heat\ Days + \beta_3 Fulton's\ K + \beta_4 Age + \beta_5 Sex + \beta_6 Age * Sex}}{1 + e^{\beta_0 + \beta_1 Hypoxic\ Volume + \beta_2 Heat\ Days + \beta_3 Fulton's\ K + \beta_4 Age + \beta_5 Sex + \beta_6 Age * Sex}}$$



- Occurrence of severe disease increased with age
- Males more likely to be severely diseased, but…

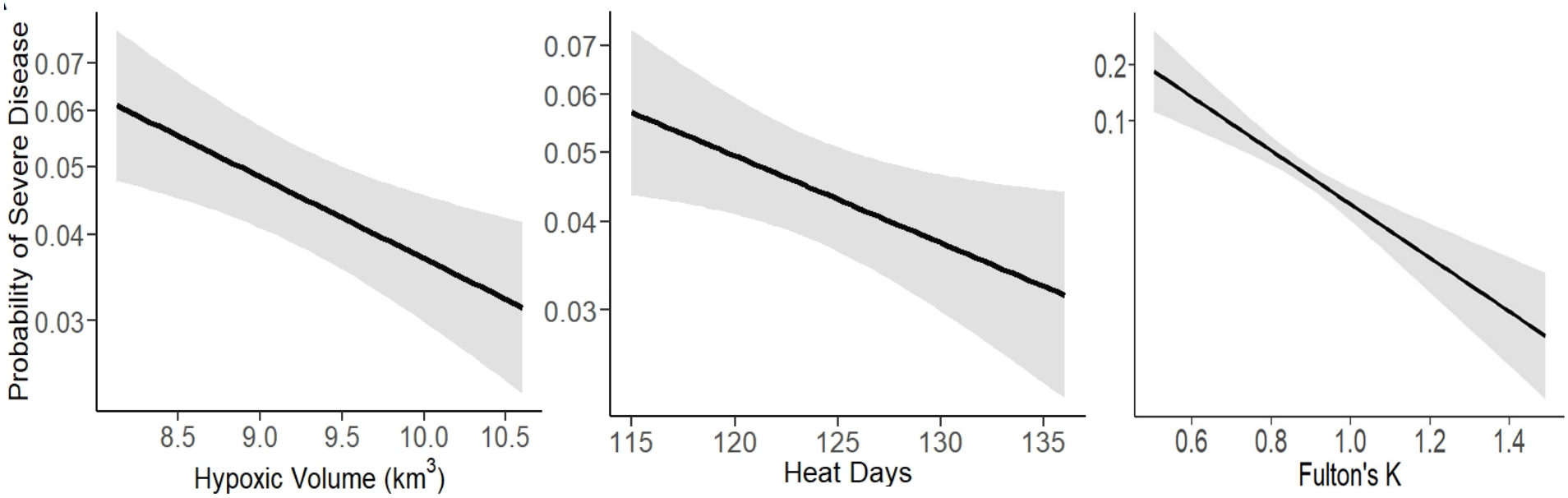


- Similar progression of disease with age for both sexes

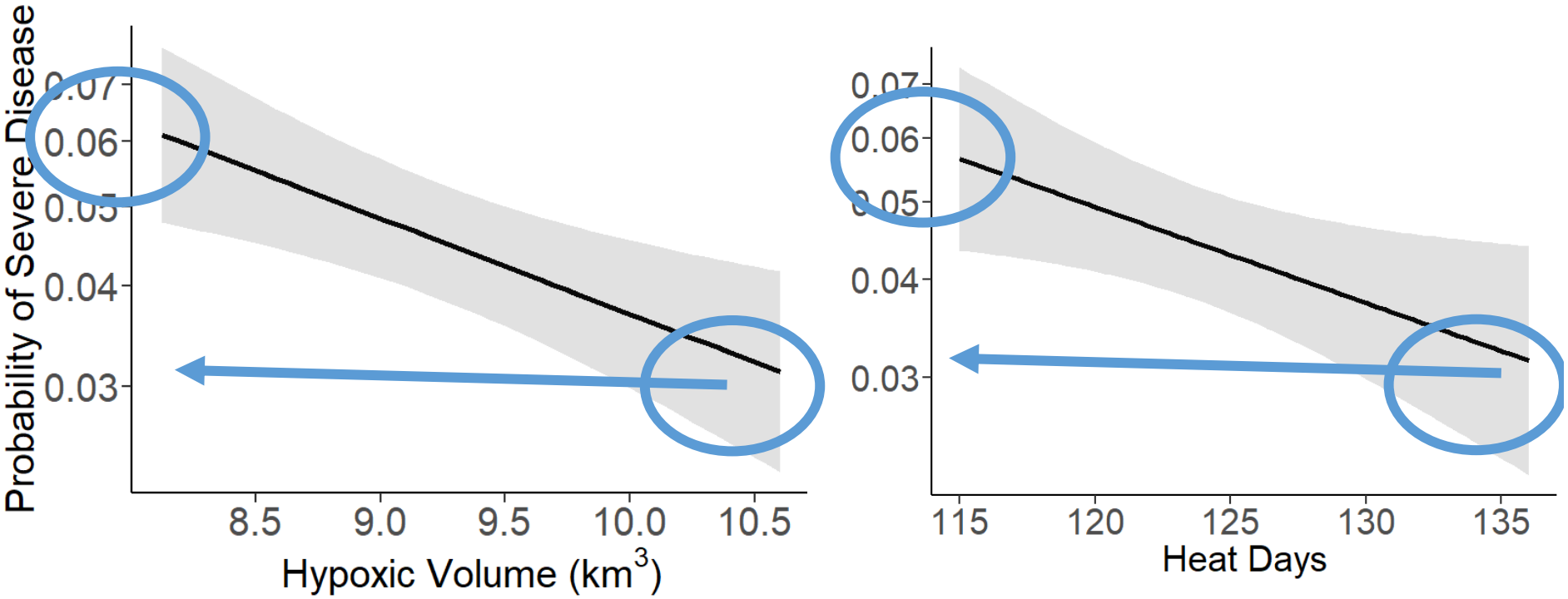


Counterintuitive results:

- Occurrence of severe disease decreased with increasing hypoxic volume and heat days
- Occurrence of severe disease decreased with increasing fish condition



- Evidence of mortality among severely diseased fish?
- If dead, can't be caught in survey!



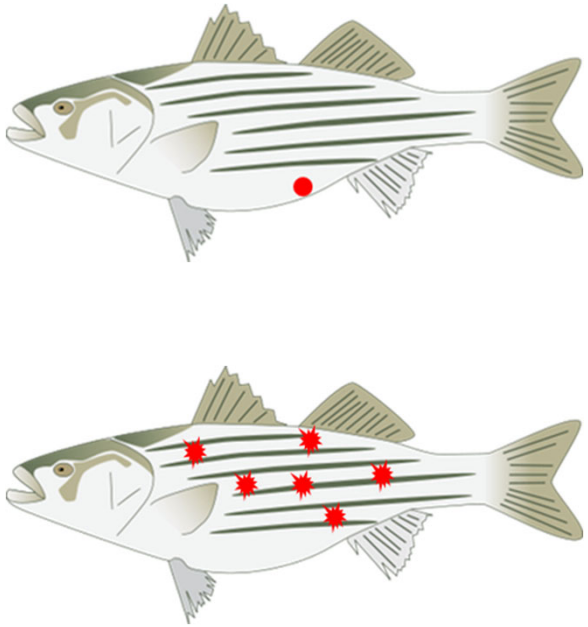
- If severely diseased fish are dying at a higher rate, we can estimate their mortality relative to other fish
- Implies approx. doubling of natural mortality for severely diseased fish
- Similar to other published studies (Gauthier et al. 2008, Hoenig et al. 2017, Groner et al. 2018)

Deeper dive into fish condition

- Modeled prevalence using only fish with no disease vs mild disease, and found fish condition (Fulton's K) no longer a significant covariate but hypoxic volume and heat days remained significant covariates
- Modeled fish condition as a function of severity (all ages), but disease severity alone could not predict fish condition
- Poor condition may contribute to disease contraction and progression in some fish
- However, Maryland data suggest fish condition is more likely a symptom of disease than a cause

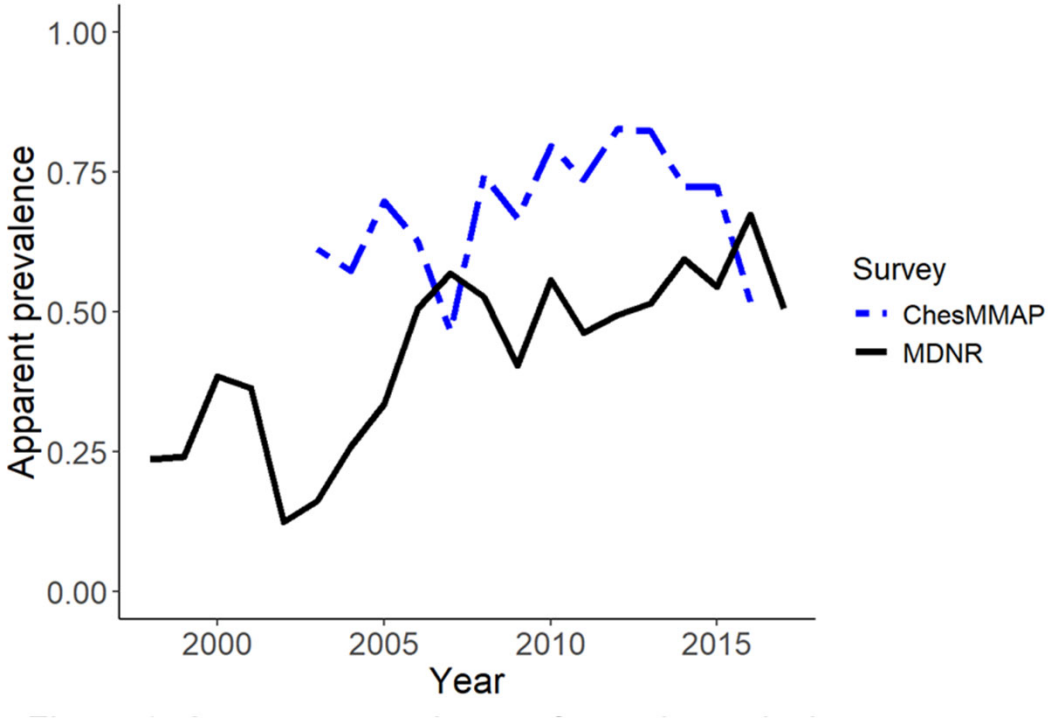
Conclusions

- Mycobacteriosis is widespread in the Maryland portion of the Chesapeake Bay
- Disease prevalence and severity in Maryland striped bass is related to poor water quality and fish condition
- Relative mortality for severely diseased fish implied by our models doubled across the range of low oxygen and water temperature conditions examined in this study



Next steps

- Team formed: CBL, VIMS, Maryland DNR, NOAA, URI/RIDEM, ASMFC
- Pursuing funding to:
  - Comprehensively examine all myco data across Chesapeake Bay
  - Develop age-specific mycobacteriosis trends
  - Estimate age-specific trends in natural mortality (Schonfeld 2023)



Jesse et al. 2024 (in proofs). Quantifying trends in and potential drivers of mycobacteriosis in Atlantic Striped Bass in Maryland waters of the Chesapeake Bay. Transaction of the American Fisheries Society.

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