The competing impacts of climate change and nutrient reduction on dissolved oxygen in Chesapeake Bay

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Biogeosciences, 15, 2649–2668, 2018
https://doi.org/10.5194/bg-15-2649-2018
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Biogeosciences

The competing impacts of climate change and nutrient reductions on dissolved oxygen in Chesapeake Bay

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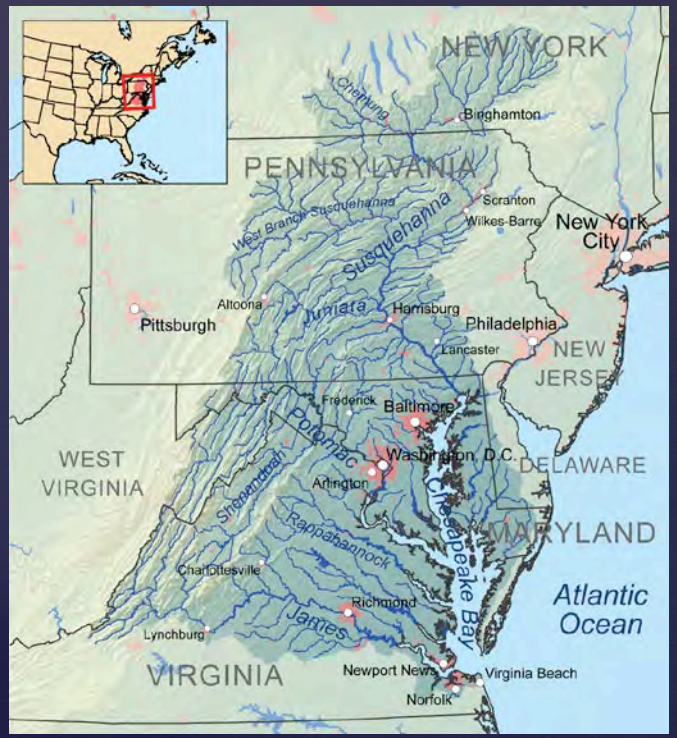
Chesapeake Bay Total Maximum Daily Load (TMDL)



Pollutants

- Nitrogen
- Phosphorus
- Sediment

Goals

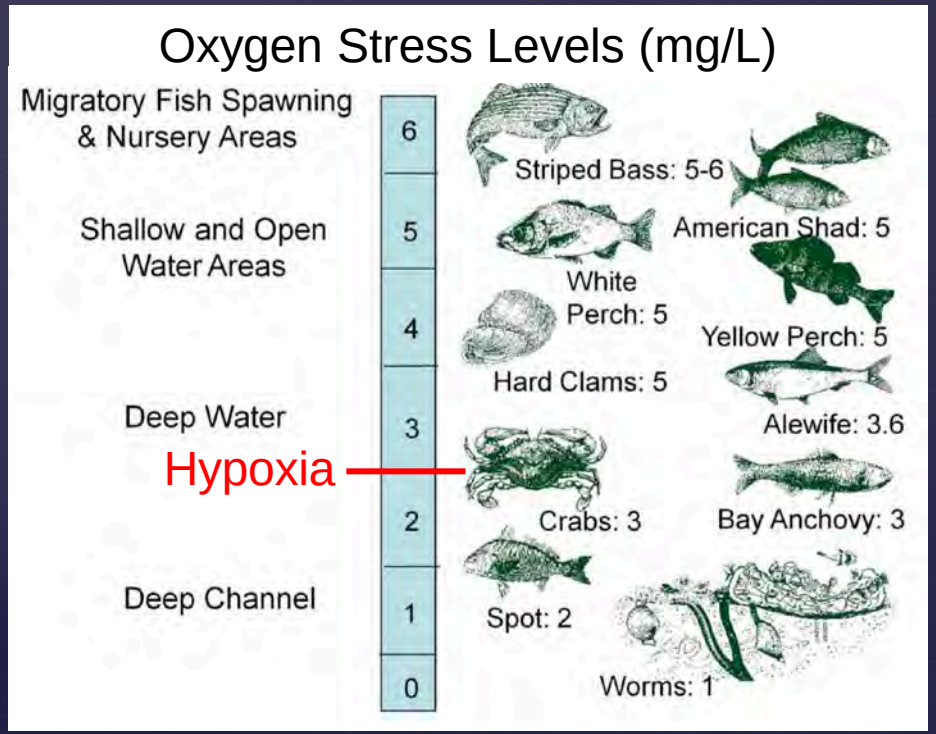
- **Increase dissolved oxygen (DO)**
- Increase water clarity
- Decrease chlorophyll

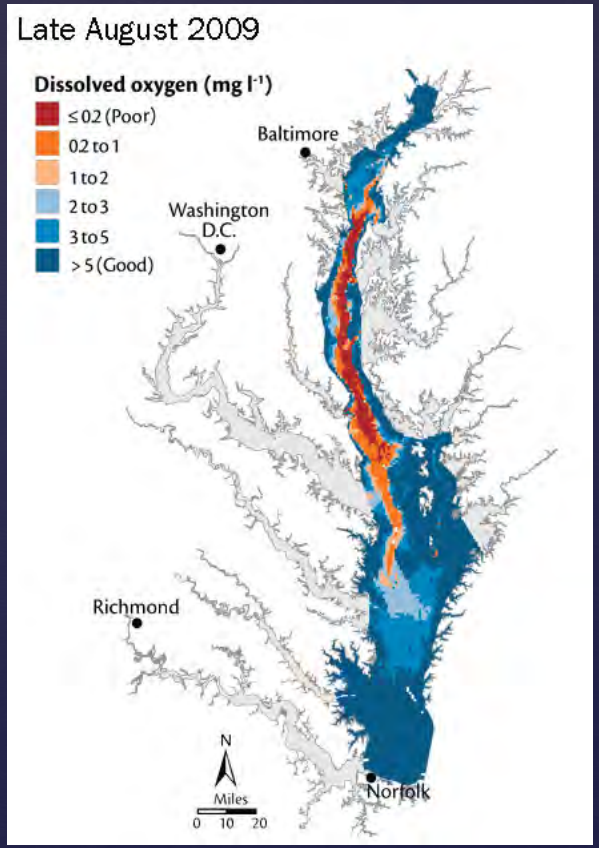
↓ Pollutants = ↑ DO

https://goo.gl/images/VTu5Hf

Chesapeake Bay Total Maximum Daily Load (TMDL)

Why is dissolved oxygen so important?





USEPA TMDL, 2010; www.cbf.org

Chesapeake Bay TMDL Water Quality Standards

Habitat	Dissolved Oxygen Rules	Rationale	Timeframe
Open Water	30-day mean ≥ 5.0 mg/L (tidal habitats with salinity ≥ 0.5 PSU)	Protects growth of larval, juvenile, and adult fish and shellfish as well as threatened/endangered species	All year round
	Instantaneous minimum ≥ 3.2 mg/L	Protects survival of threatened/endangered sturgeon species	
Deep Water	30-day mean ≥ 3.0 mg/L	Protects survival and recruitment of Bay anchovy eggs and larvae	June 1 – September 30
	Instantaneous minimum ≥ 1.7 mg/L	Protects survival of Bay anchovy eggs and larvae	
Deep Channel	Instantaneous minimum ≥ 1.0 mg/L	Protects survival of bottom-dwelling worms and clams	June 1 – September 30

Multiple Models Available

Biogeosciences, 13, 2011–2028, 2016
www.biogeosciences.net/13/2011/2016/
doi:10.5194/bg-13-2011-2016
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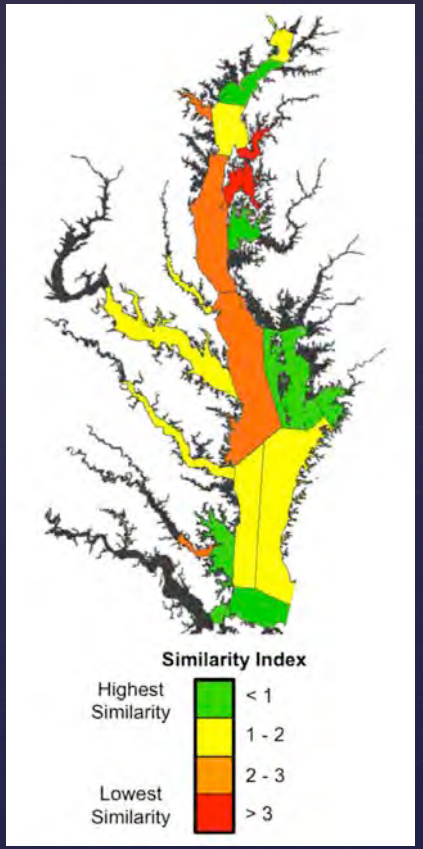
Challenges associated with modeling low-oxygen waters in Chesapeake Bay: a multiple model comparison

Isaac D. Irby[1], Marjorie A. M. Friedrichs[1], Carl T. Friedrichs[1], Aaron J. Bever[2], Raleigh R. Hood[3], Lyon W. J. Lanerolle[4,5], Ming Li[6], Lewis Linker[7], Malcolm E. Scully[8], Kevin Sellner[9], Jian Shen[1], Jeremy Testa[6], Hao Wang[3], Ping Wang[10], and Meng Xia[11]



Potential Success of Nutrient Reduction

Will climate change impact the ability of mandated nutrient reductions to achieve desired water quality outcomes?

Evaluation of Climate Change Impacts

2050 Relative to 1993-1995

Temperature

1.75°C

- Oxygen Solubility
- Biologic Rates

Sea Level Rise

0.5m

- Seawater intrusion
- Stratification & Circulation

Precipitation

~15% winter

- River flow
- Nutrient load

Evaluation of Climate Change Impacts

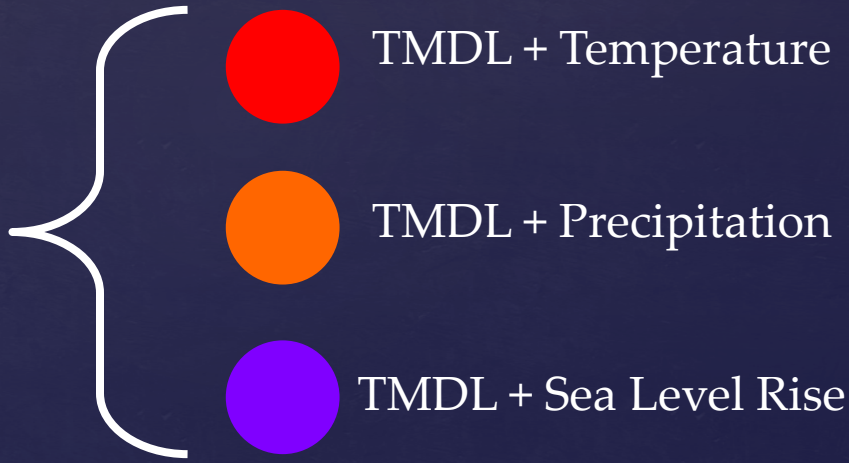
Climate Change Scenarios

Anoxia < 0.2 mg L^{-1}
Hypoxia < 2 mg L^{-1}
Low-DO < 5 mg L^{-1}

Current

TMDL

TMDL + Climate Change

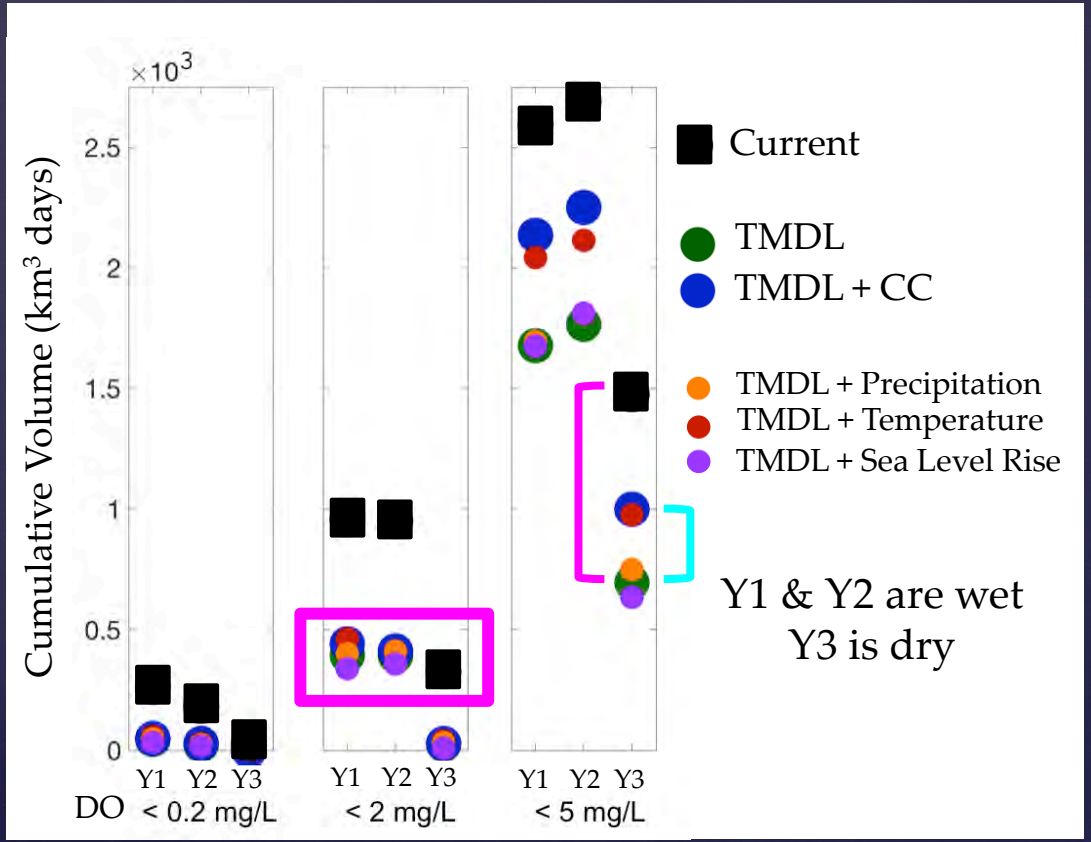


TMDL + Temperature

TMDL + Precipitation

TMDL + Sea Level Rise

Evaluation of Climate Change Impacts

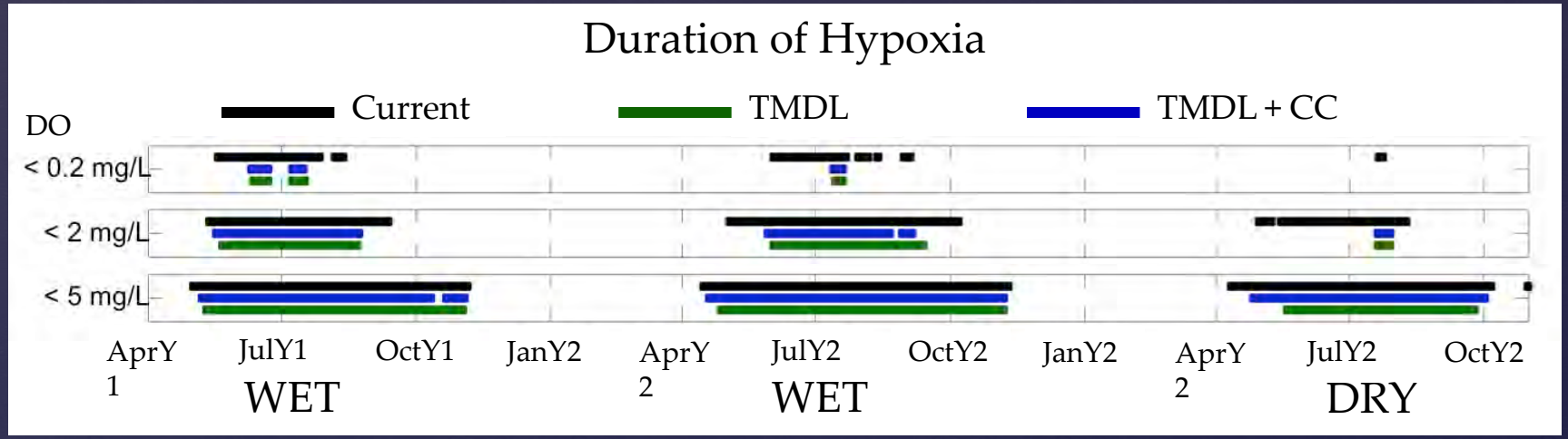


Impact of TMDL is greater than impact of climate change

Temperature is the biggest driver of climate change impact

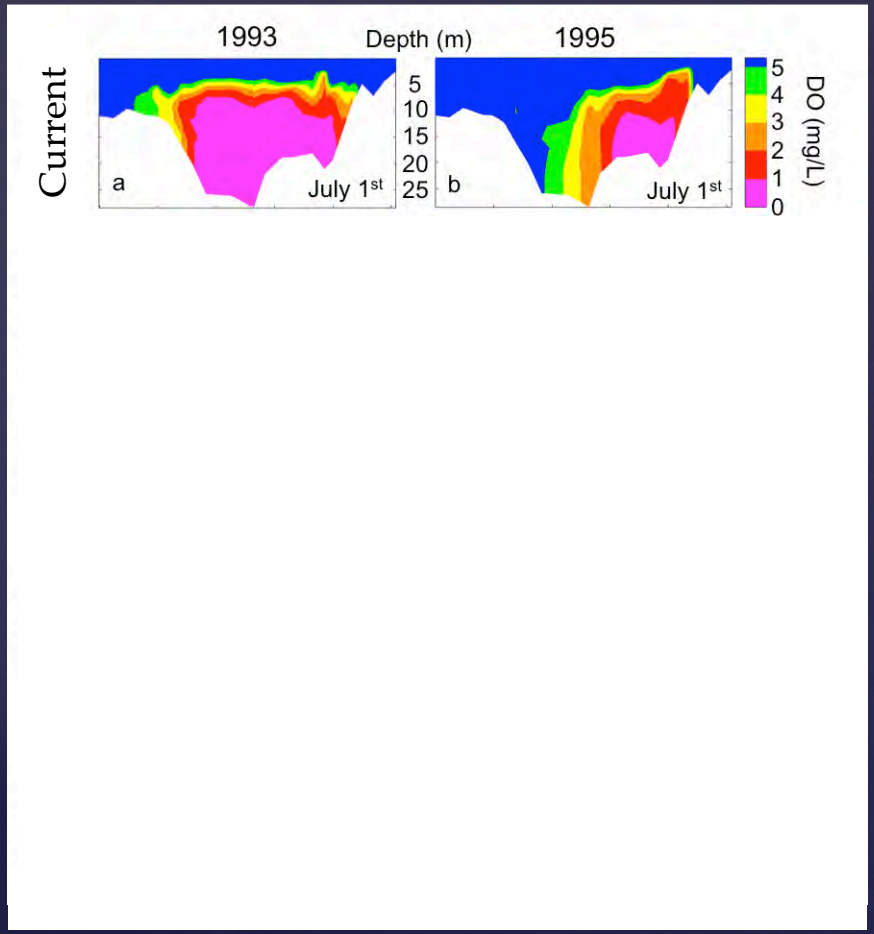
A TMDL wet year looks like a current dry year

Evaluation of Climate Change Impacts



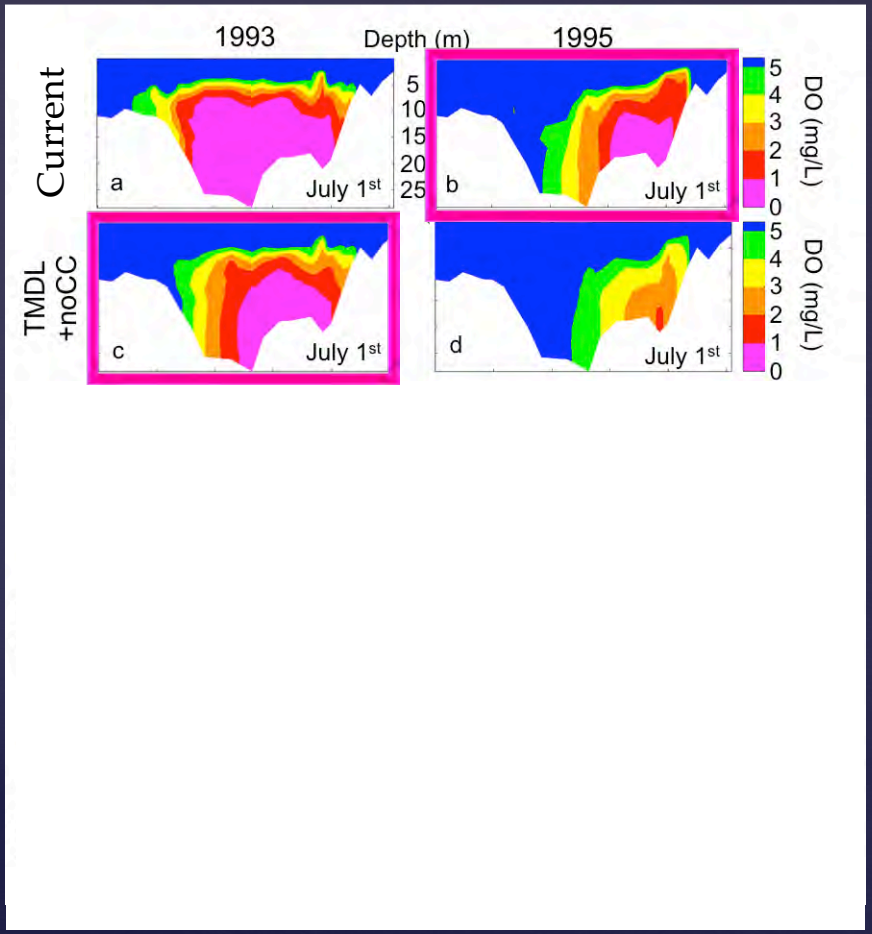
With impacts of climate change,
hypoxic conditions will start ~7 days earlier

Evaluation of Climate Change Impacts



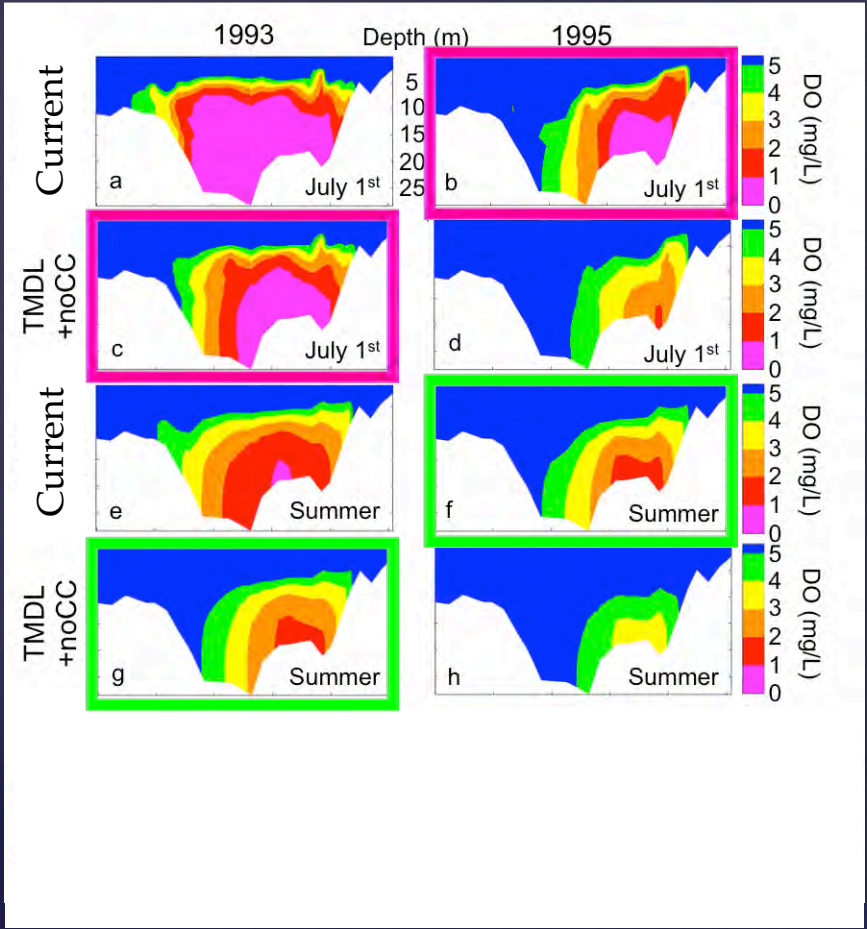
- Large interannual variability

Evaluation of Climate Change Impacts



- Large interannual variability
- TMDL wet looks like Current dry

Evaluation of Climate Change Impacts



- Large interannual variability
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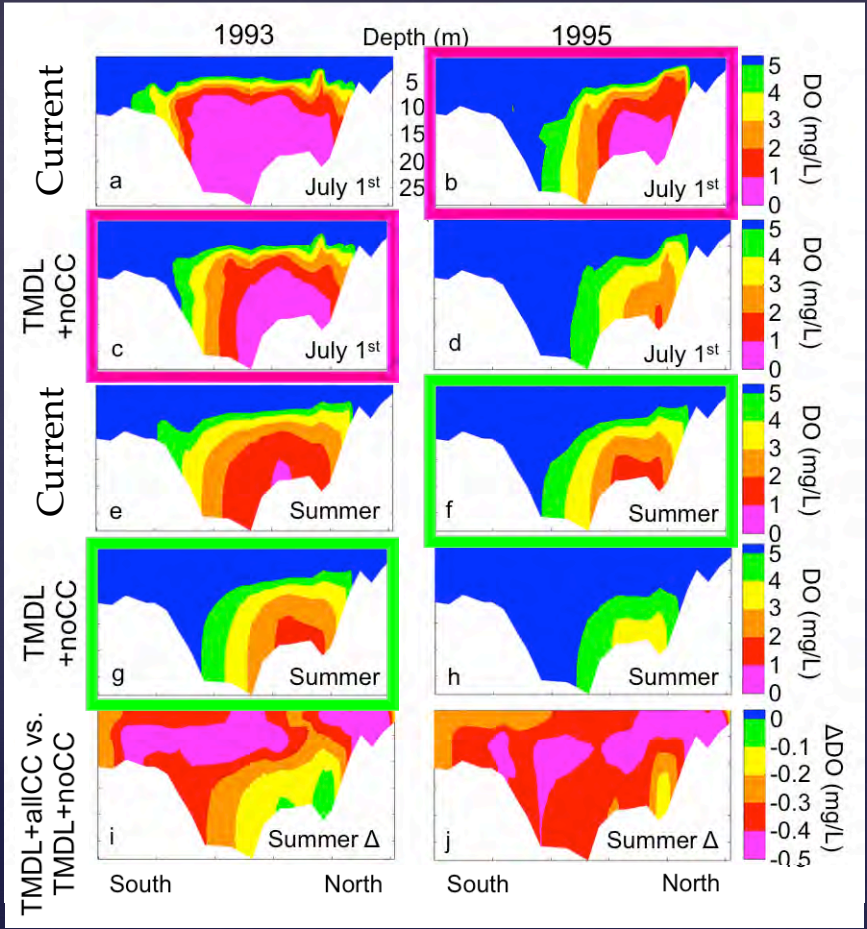
Evaluation of Climate Change Impacts



- Large interannual variability
- TMDL wet looks like Current dry
- Biggest impact due to climate change is at the periphery of low-DO waters

Results

Nutrient Reduction > Climate Change

Temp > Sea Level Rise & Precipitation

+ 7 Days Longer

Impact at periphery and higher DO

Wet vs Dry

Conclusions

Will climate change impact the ability of mandated nutrient reductions to achieve desired water quality outcomes?

Conclusions

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- Increasing sea level will *increase** oxygen via:
  - → **increased estuarine circulation**

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- Warming bay waters will *decrease* oxygen via:
  - → **decreased solubility year-round, throughout Bay**
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- Warming bay waters will *decrease* oxygen via:
  - → **decreased solubility year-round, throughout Bay**
  - → **increased respiration/remineralization rates in spring**
- OVERALL, oxygen will *decrease* primarily due to temperature increases

Conclusions

Will climate change impact the ability of mandated nutrient reductions to achieve desired water quality outcomes?

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YES, but…

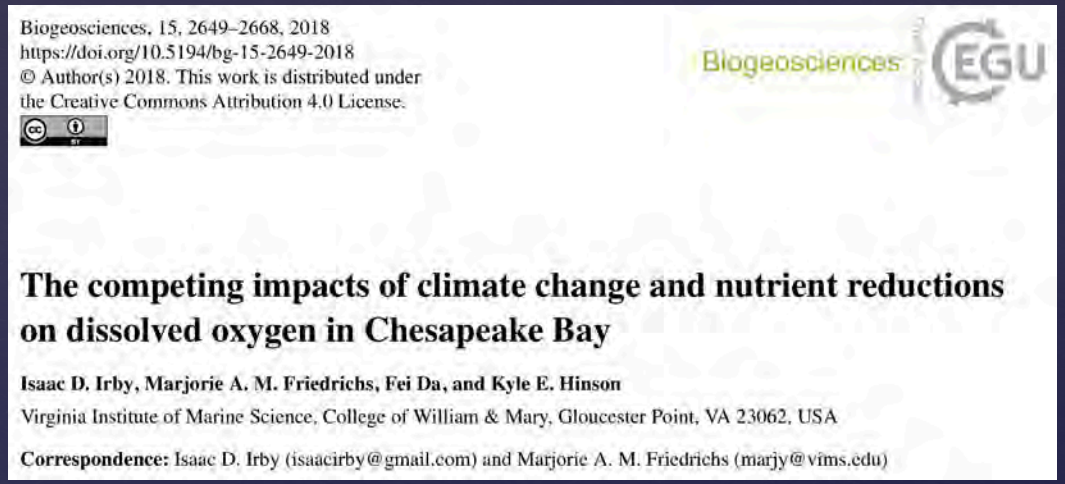
Conclusions

Will climate change impact the ability of mandated nutrient reductions to achieve desired water quality outcomes?

YES, but…

- Closer look at temperature
- Wind?
- Continuous time?
- Comprehensive multiple model approach

Questions?



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