From headwaters to coast: Influence of human activities on water quality of the Potomac River Estuary

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Inspiring Action, Creating Resilience
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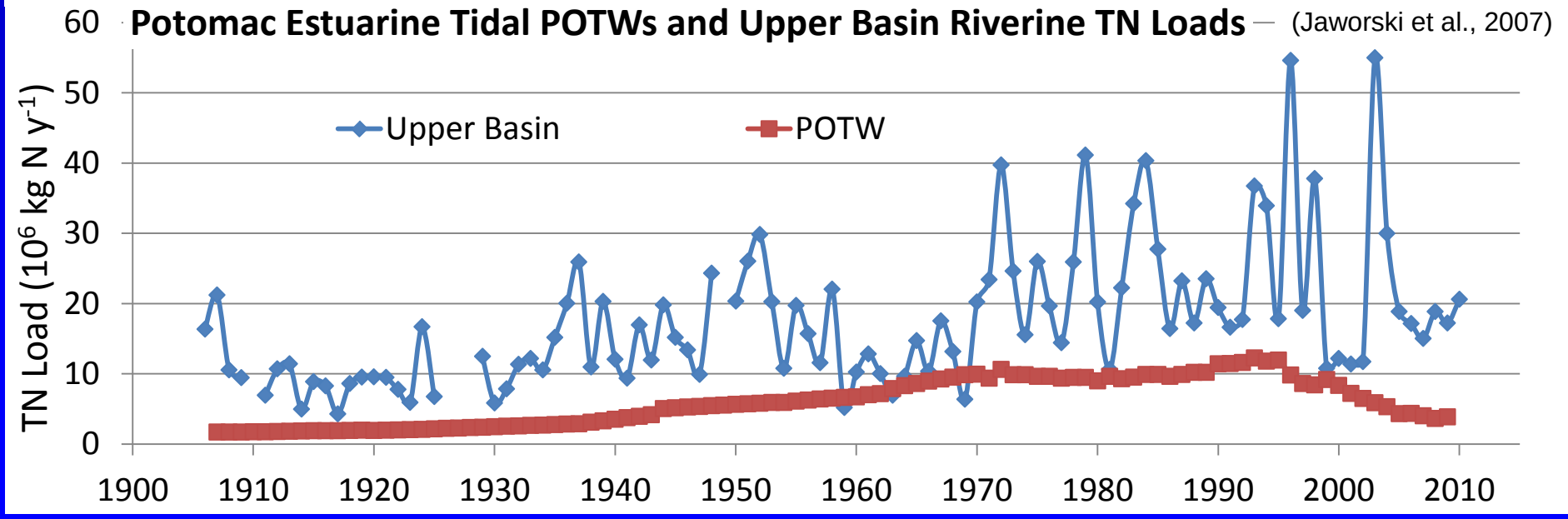
USGS science for a changing world

Acts, policies, and partnerships to prevent pollution impacts in Chesapeake Bay

Year(s)	Act, Policy, or Partnership
1940	Interstate Commission on the Potomac River Basin
1963	Clean Air Act (amendments 1970, 1977, 1990)
1969	National Environmental Policy Act
1972	Clean Water Act (amendments 1977, 1983, 1985, 1987)
1983, 1987, 2000	Chesapeake Bay Agreements developed Chesapeake Bay Program partnership
2008	Bay Action Plan
2009	Executive Order 13508 Chesapeake Bay Protection and Restoration



Project objectives:

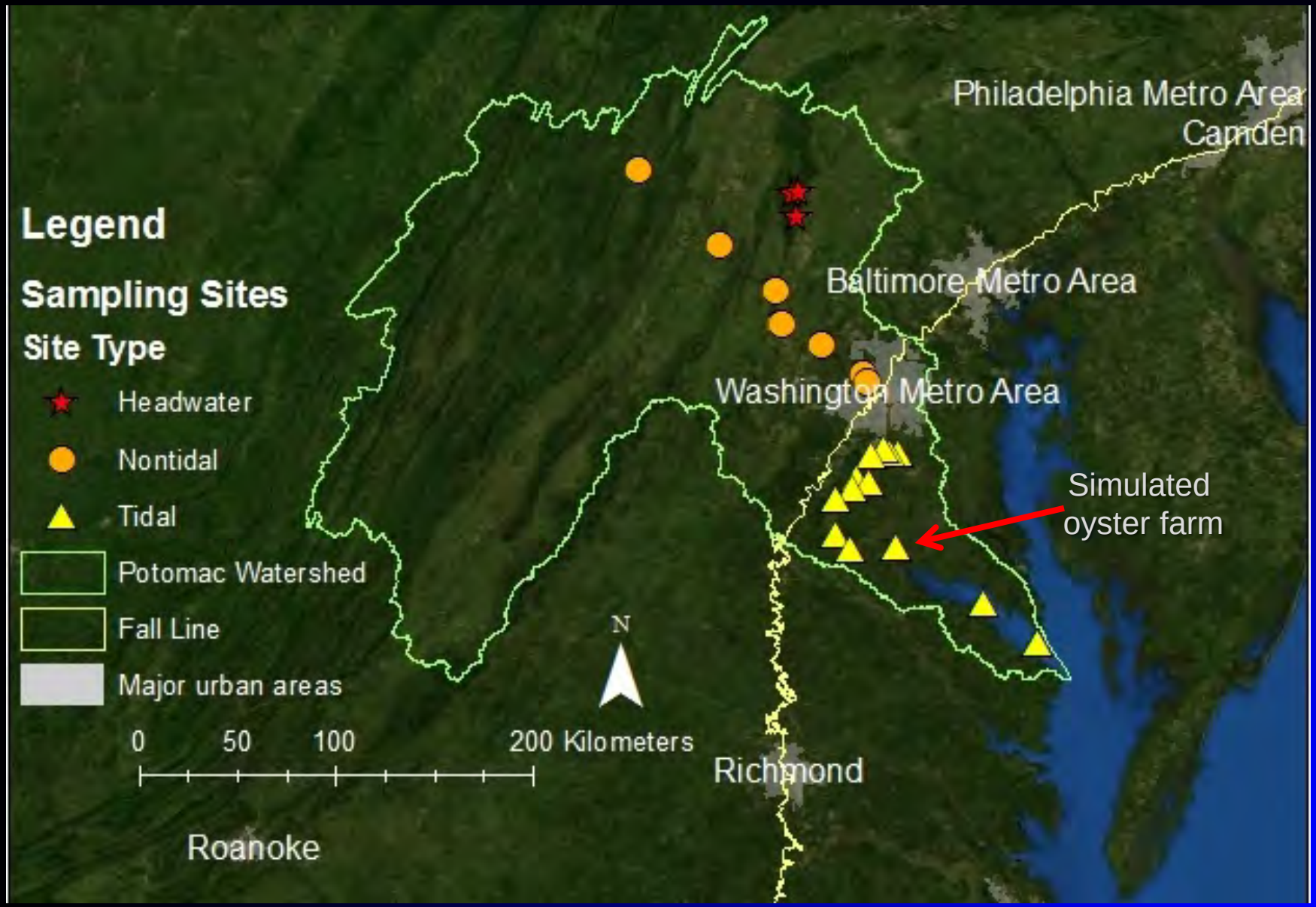
1. Evaluate contribution of headwater streams to total nitrogen load to Potomac River Estuary: how much is from headwaters?

2. Update the eutrophication assessment from the early 2000s: have there been changes?

3. Evaluate efficacy of shellfish aquaculture: could oyster cultivation and restoration improve water quality?

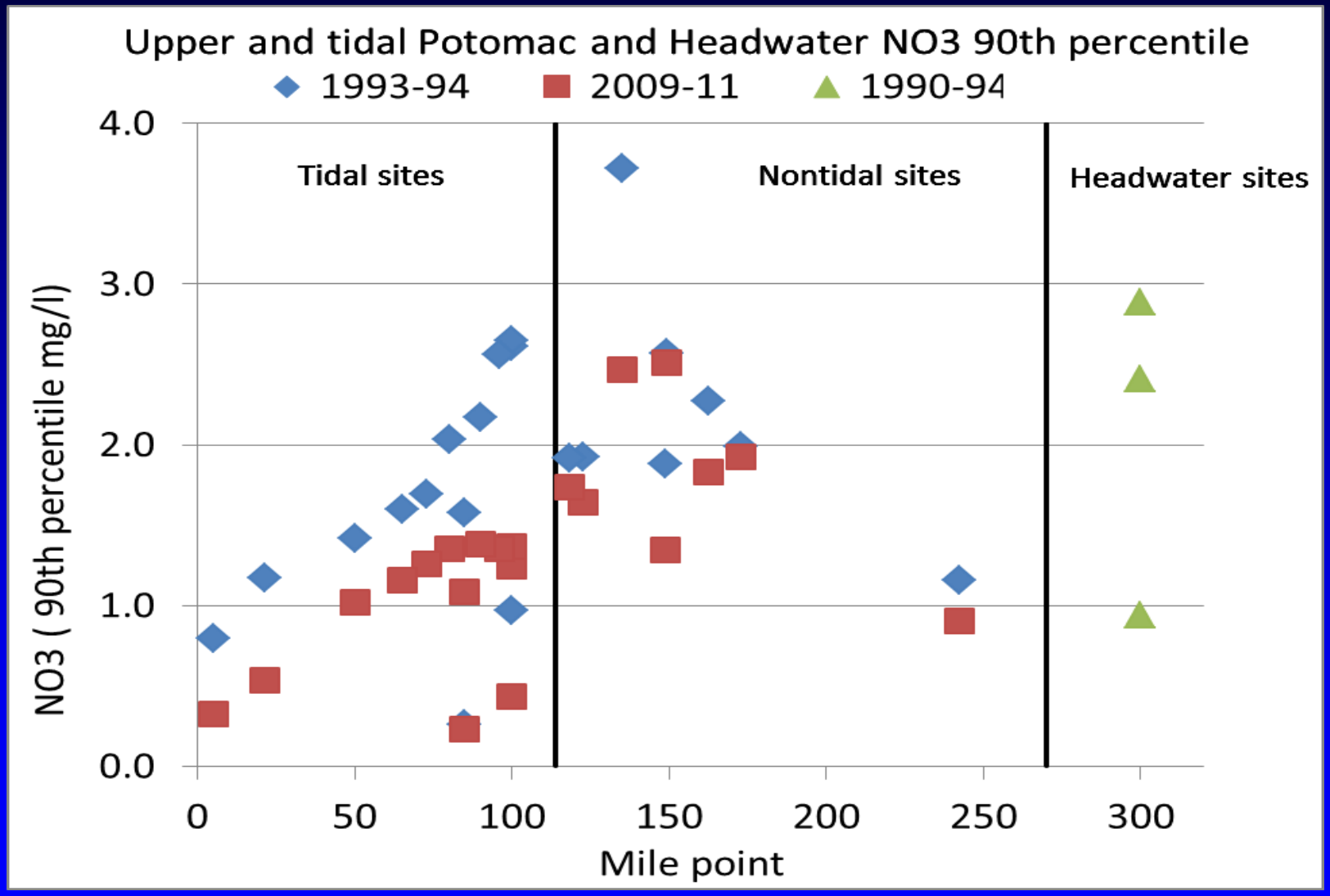
Potomac River Estuary: Sampling locations

(MD DNR - tidal, nontidal, USGS – headwater)



1. How much do headwaters contribute to N load?

(Stream data for 1990-1994 only)

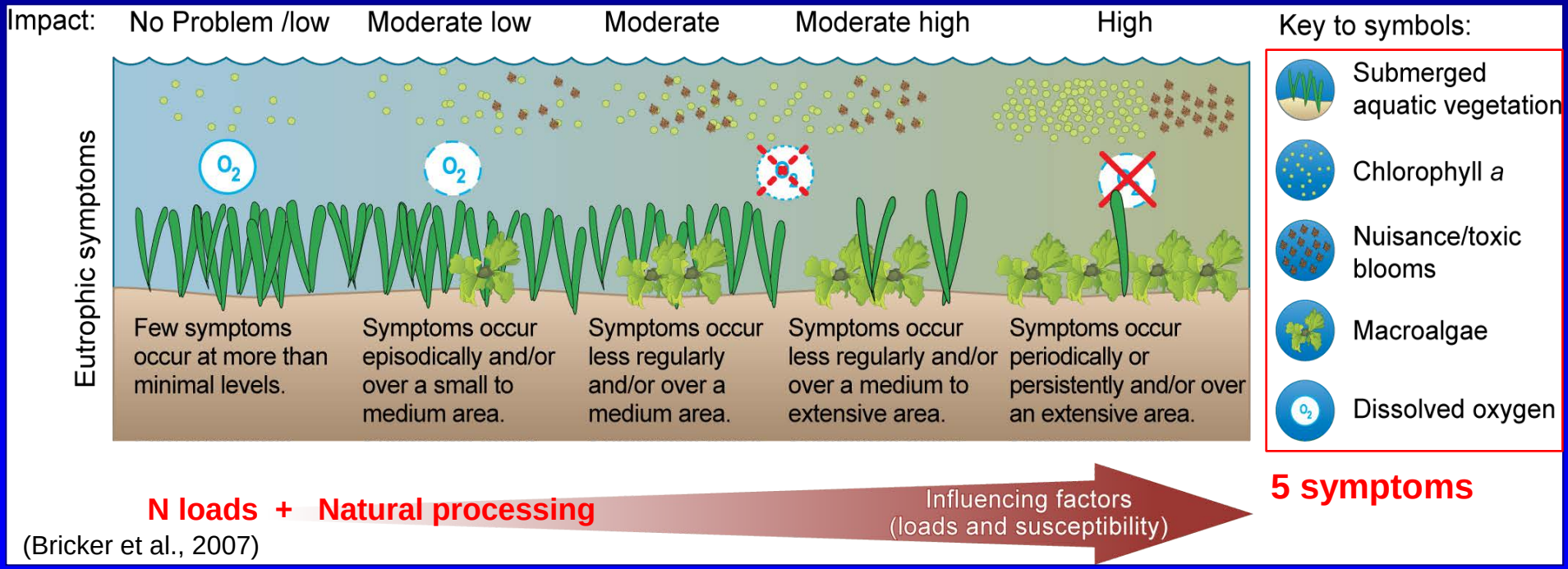


- Combined TN load from the three headwater <0.02 % of the total load 1990-1994; upscaled to all forested headwaters is ~2%

2. What is eutrophication status of Potomac River Estuary? How has it changed since early 1990s?

Assessment of Estuarine Trophic Status (ASSETS) model

Pressure - State – Response approach



(Bricker et al., 2007)

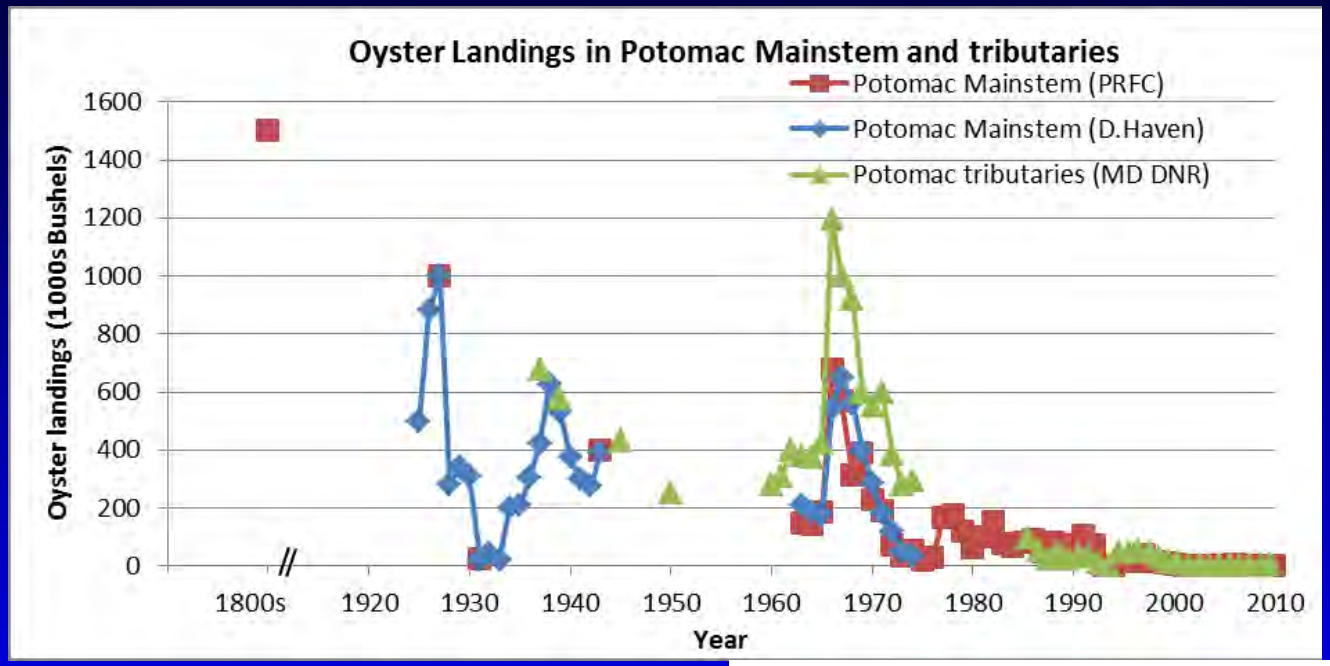
http://www.eutro.us http://www.eutro.org/register

Eutrophication Assessment results and changes

Assessment Component	Early 1990s (Bricker et al., 1999)	Early 2000s (Bricker et al., 2007)	2009-2011
N Load	High	High	High
Eutrophic Condition	High	High	High
Chlorophyll	High	High	High
Macroalgae	Low	No Data	Low
**Dissolved oxygen	High	Moderate	Moderate
**Seagrasses	Moderate	Low	Low
*Nuisance/toxic blooms	Moderate	High	High
Future outlook	Worsen	Worsen	Improve
Future N loads	Increase	Increase	Decrease

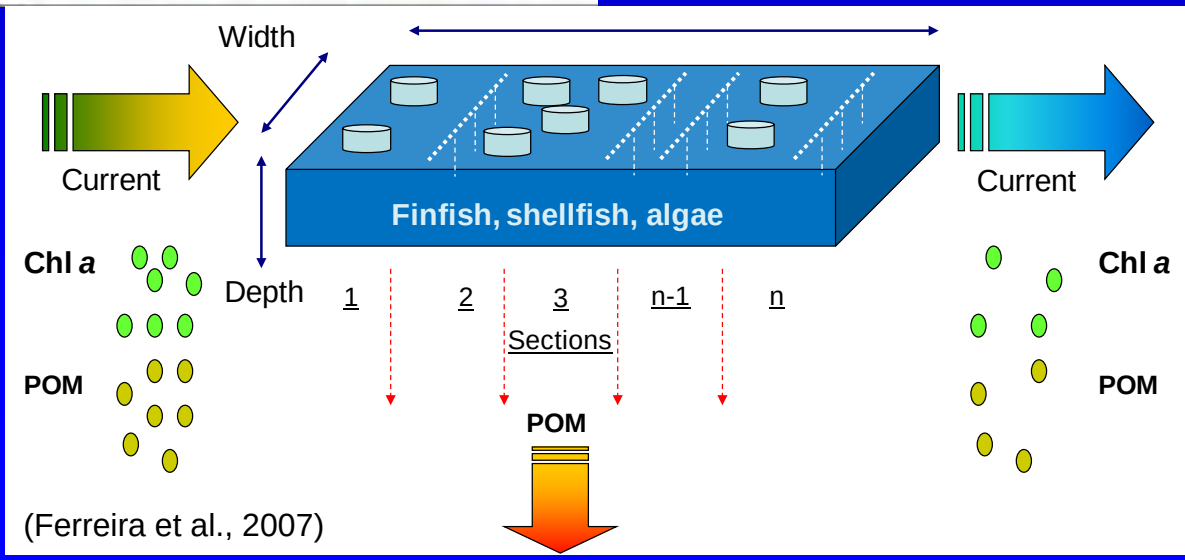
- Overall conditions remained the same; noted improvements for dissolved oxygen and seagrass coverage, worsening for nuisance/toxic blooms
- Upper estuary has greater improvements
- Future outlook more optimistic

3. Can oyster aquaculture and restoration improve Potomac River Estuary water quality?

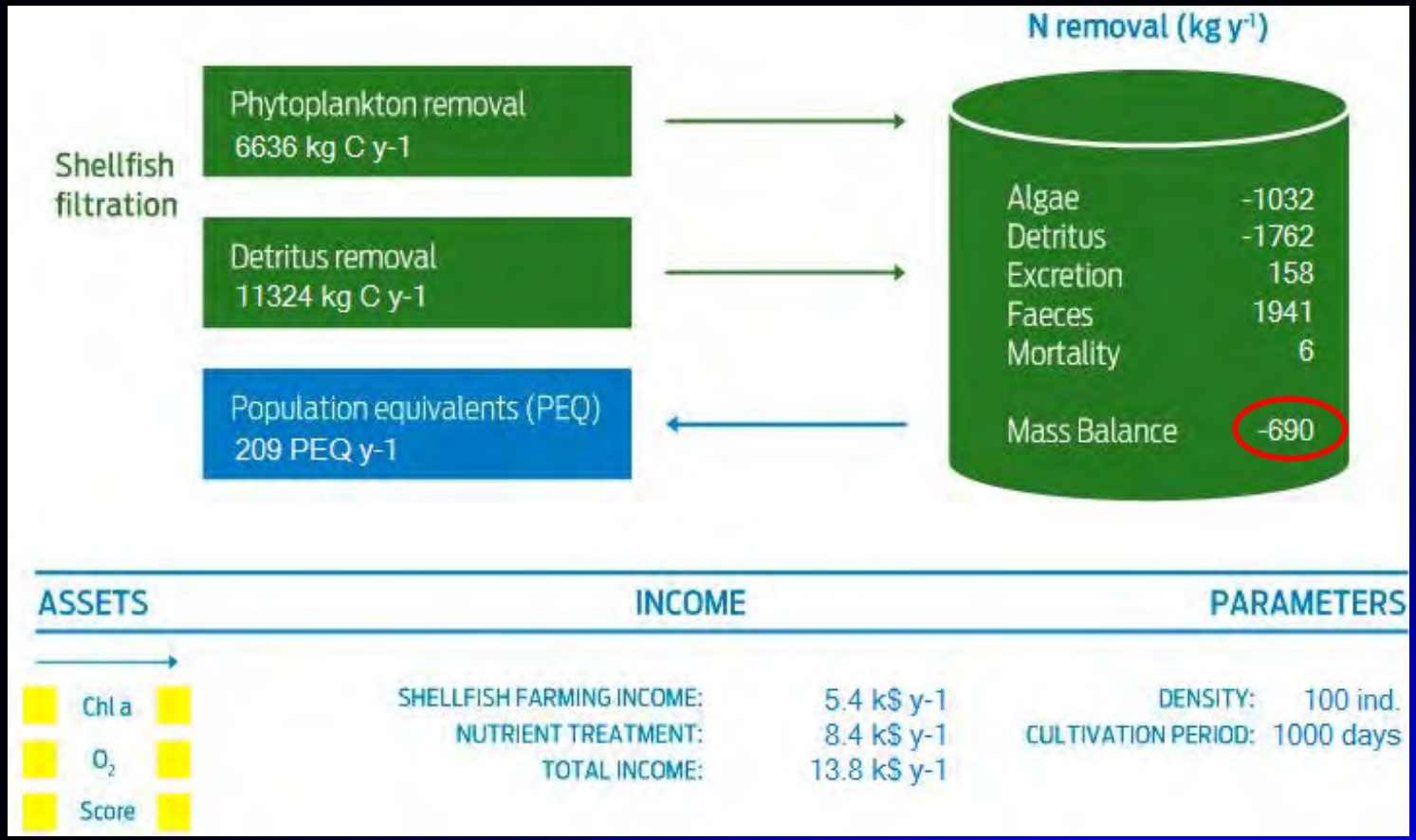


Eastern oyster populations are 1% of historic populations

Farm Aquaculture Resource Management Model (FARM) (www.farmscale.org)



FARM model results – simulated 4 acre farm



- One farm could remove <2% of total present N load, upscaled (with caveats) to ½ of all suitable areas would remove ~50% of present load
- Removal per acre = removal by denitrification in reefs (Kellogg et al. 2013)
- To remove an equivalent of total load would require 40% of bottom area in combined cultivation and/or reef

Conclusions

- Headwater streams: contributed~2% N load in early 1990s; unknown present contribution due to lack of data
- Eutrophic condition: has remained the same overall with noted improvements in dissolved oxygen, seagrass, mostly in upper estuary concurrent with decreased loads
- Shellfish aquaculture:
  - One 4 acre farm could remove <2% of N input, upscaled (with caveats) to ½ of all suitable areas would remove ~50% of present load
  - Removal per farm acre equal to removal by denitrification in reefs (0.23×10^3 kg $acre^{-1}$ yr^{-1}; Kellogg et al. 2013)
  - To remove an equivalent of total load would require 40% of bottom area in cultivation or reef

Thank you!!

Try the models yourself at:

ASSETS www.eutro.org/register

FARM www.farmscale.org

The paper:

Bricker, Rice, Bricker. 2014. Aq. Geochem. 20: 291-323

Thanks for making this analysis possible:

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