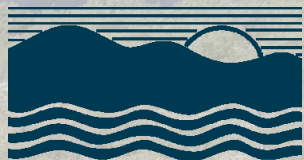


Barriers and Bridges in Abating Coastal Eutrophication

Donald Friedrich Boesch



Øresund Bridge



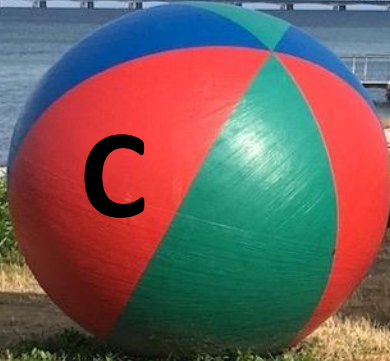
University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

Scientific & Technical Advisory Committee
September 10, 2019



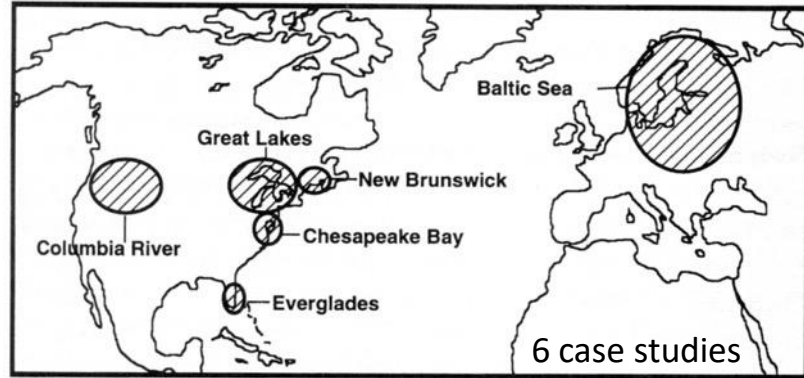
4th International Symposium on Research and Management
of Eutrophication in Coastal Ecosystems (EUTRO 2018)
18-20 June 2018, Nyborg, Denmark

Great Belt Bridge



Boesch, D.F. 2019 Barriers and bridges in abating coastal eutrophication.
Frontiers in Marine Science. Vol 6, Article 123

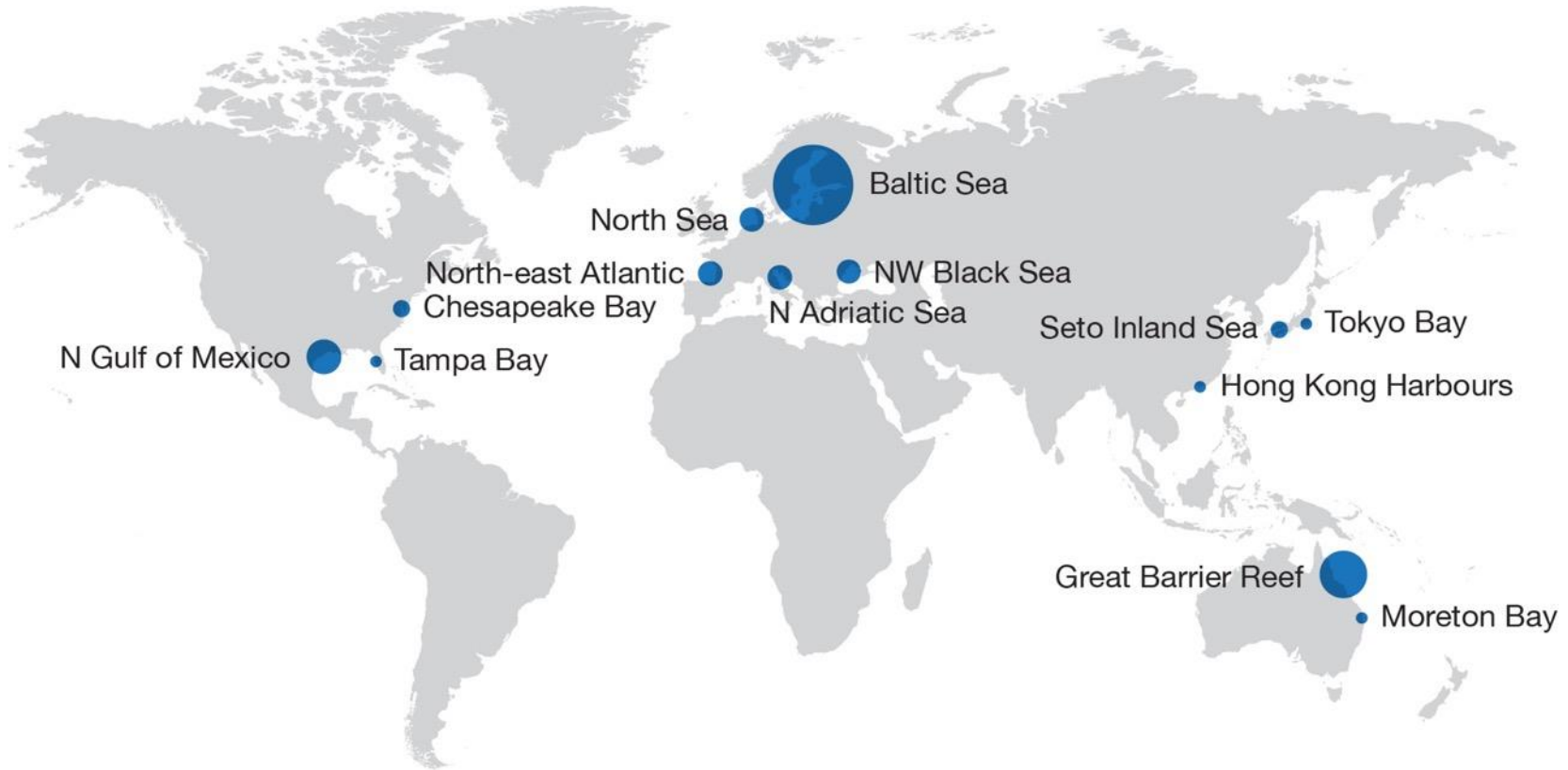
Barriers and Bridges



Bengt-Owe Jansson & Harold Velner:

- The Øresund bridge project . . . by some called a bridge, and by others a barrier
- Following the June 1994 decision to build the bridge, the Minister of Environment in Sweden and the Minister of Finance in Denmark resigned.

Eutrophication Abatement Campaigns



Greenland (U.S.)

European Campaigns Considered

North Sea

OSPAR



Baltic Sea

HELCOM

EU Directives

- Urban Waste Water Treatment
- Nitrates
- Water Framework
- Marine Strategy Framework



North-East Atlantic

OSPAR

Black Sea

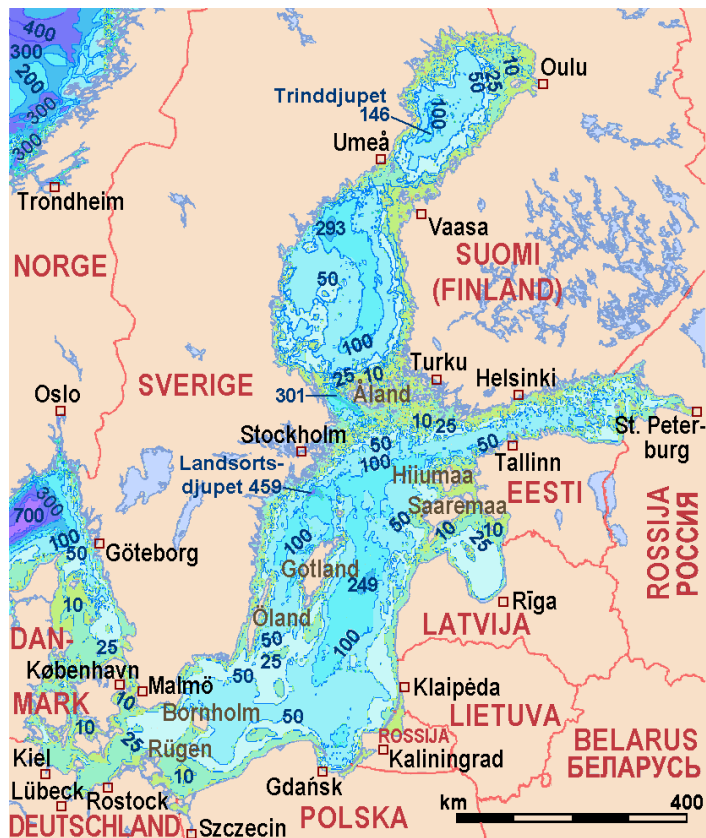
Budapest Commission

Adriatic Sea

Mediterranean Sea

Barcelona Convention

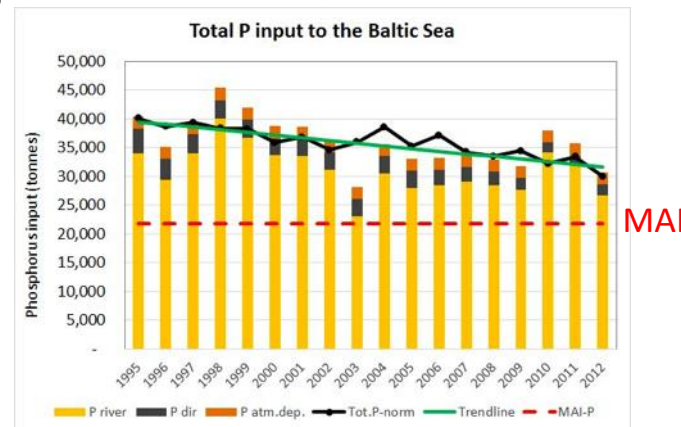
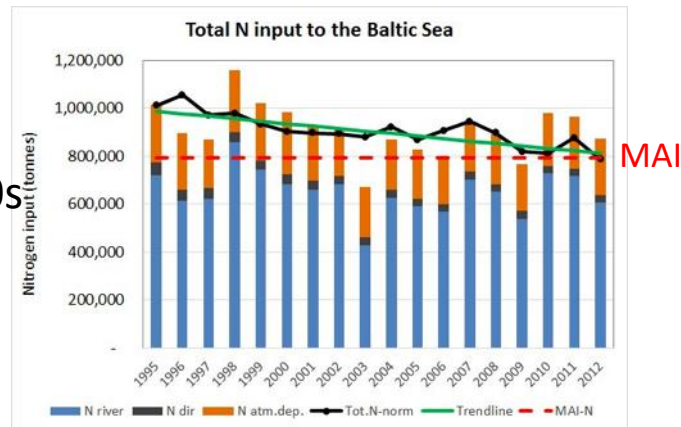
Baltic Sea – the World Class Campaign



HELCOM 1988
 -50% N&P by 1995
 ✓-24% N & -50% P >80s

Baltic Sea Action Plan
 2013

Max. Allowable Inputs
 -16% N & -70 % P by
 2015 based on 1997-
 2003 loads



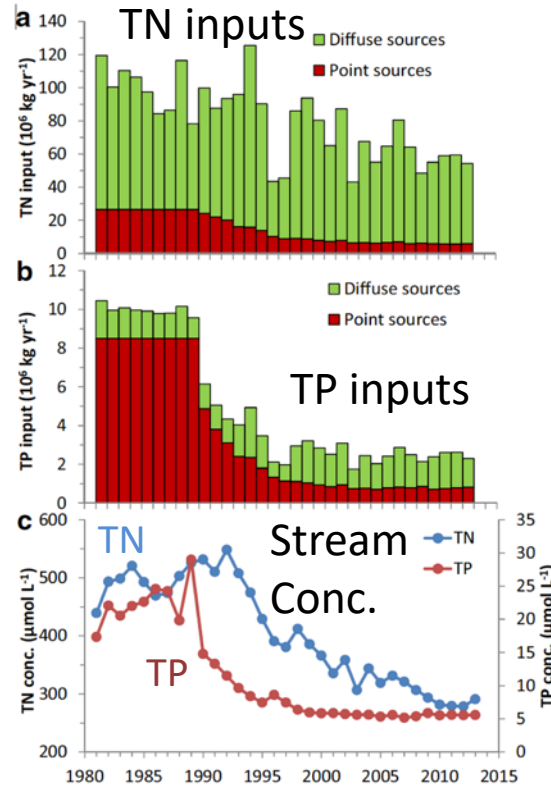


The Danish Experience



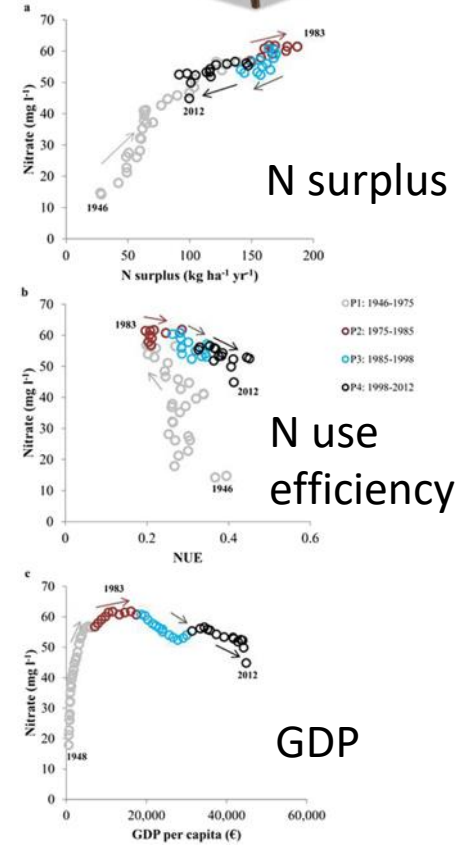
- 1987 National Action Plan on Aquatic Environment: -50% N & -80% P
- Additional agricultural measures, including N application 85-90% of economic optimum & mandatory cover crops
- >1988 sustained & coupled monitoring & assessment
- Inputs to coastal systems -50% N & -70% P

Riemann et al. 2016. *Estuaries & Coasts*



Hansen et al. 2017. *Scientific Reports*

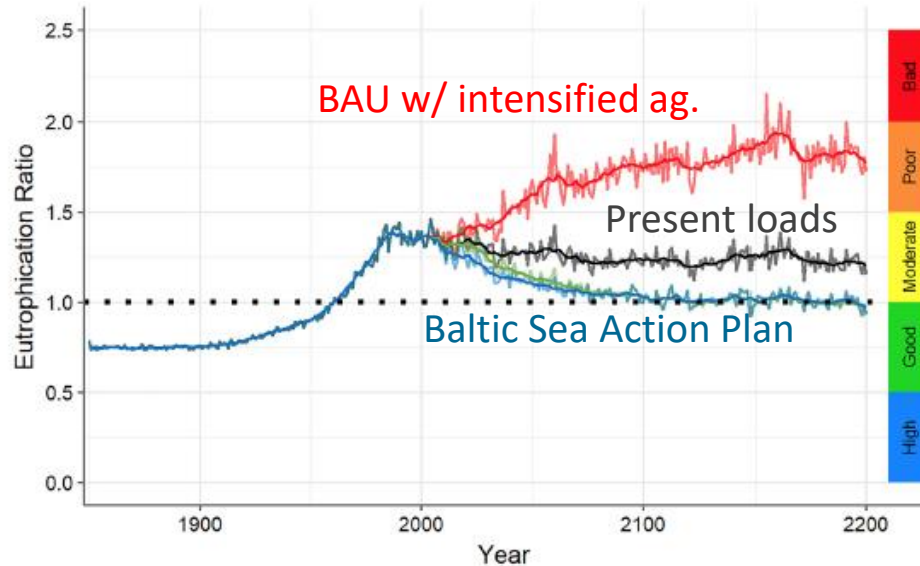
Average nitrate concentration in groundwater



Modeling Future of Baltic

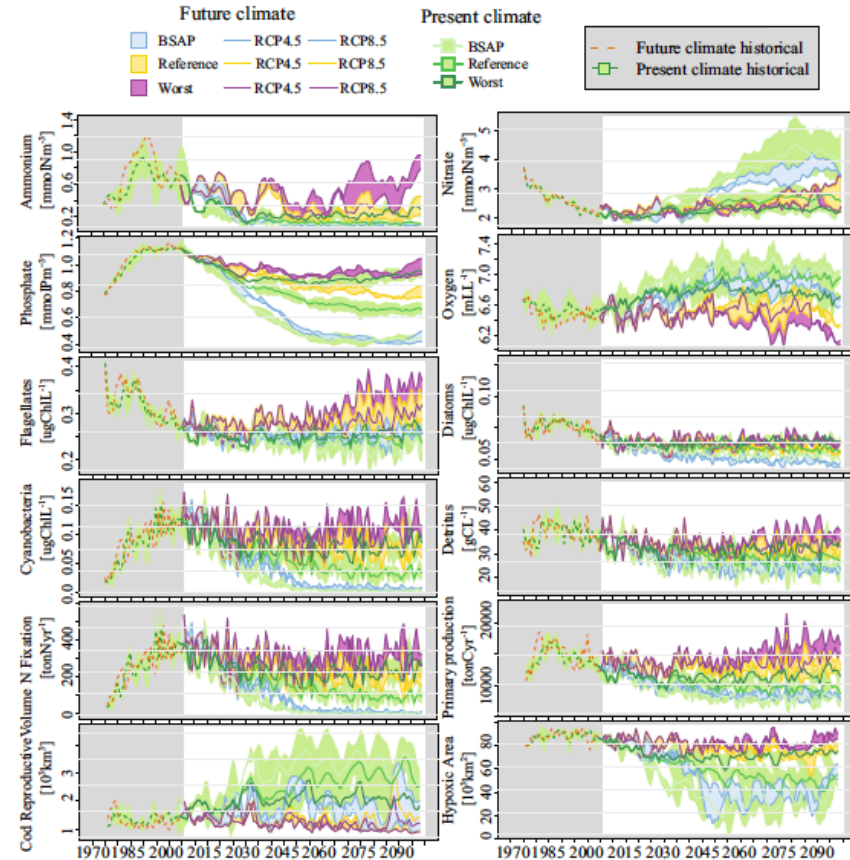
Compounding effects of climate change

Recovery of eutrophication health index



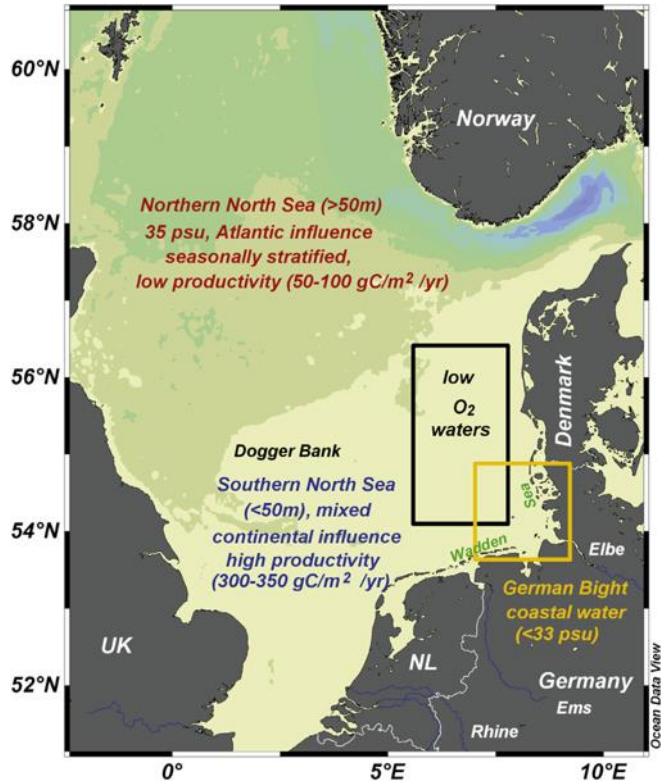
Murray et al. 2019. *Frontiers in Marine Science*

Saraiva et al. 2018. *Climate Dynamics*

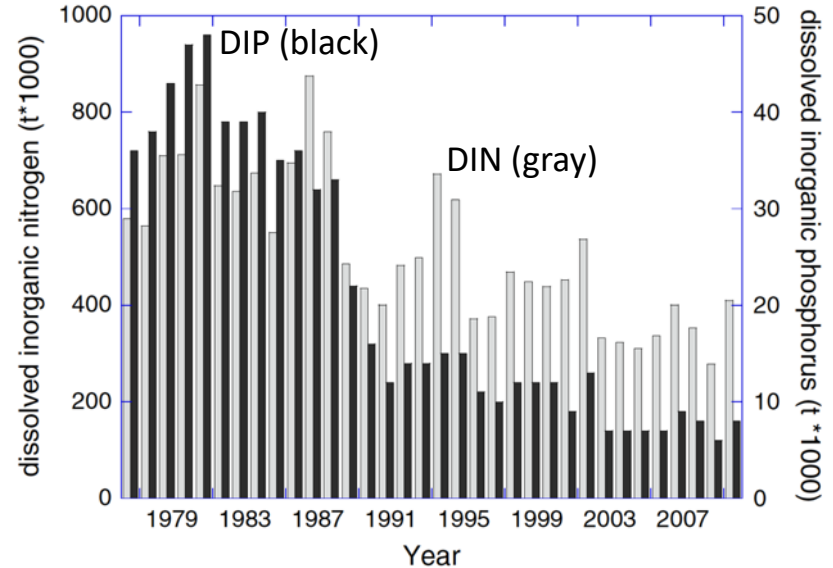


Southern North Sea

OSPAR 1987: reduce river loads of N and P by 50%
between 1985 and 1995, P goal exceeded, N ~20%
By 2010 -81% P, -45% N

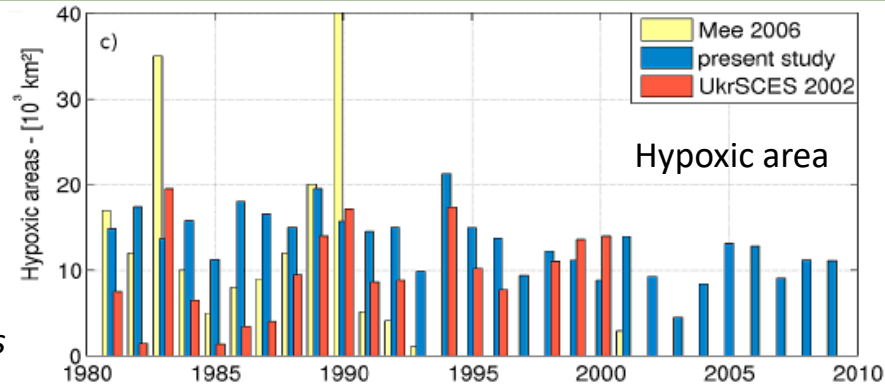
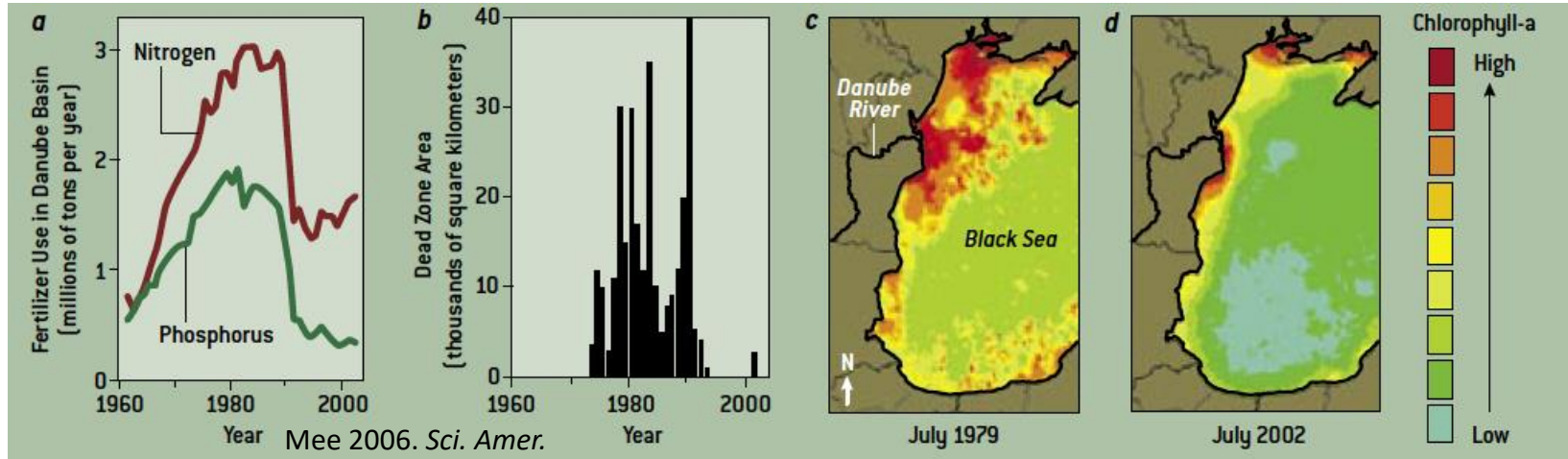


Emeis et al. 2015. *Journal of Marine Systems*

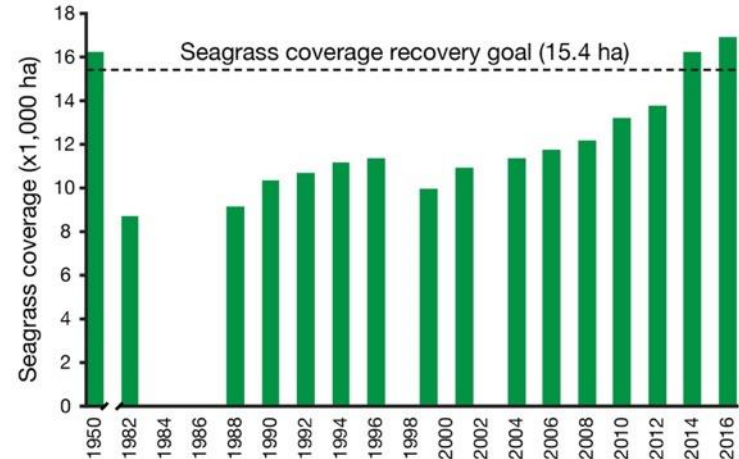
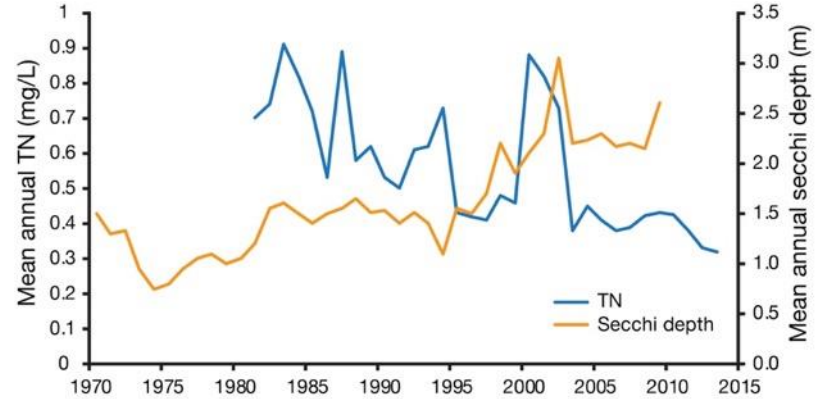
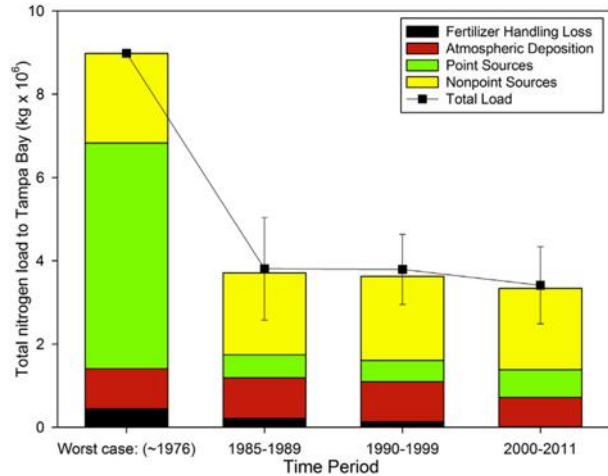


Annual loads from Elbe, Weser, Ems, Ijssel, Rhine, Scheldt & Meuse rivers

Black Sea: A Textbook Story Retold



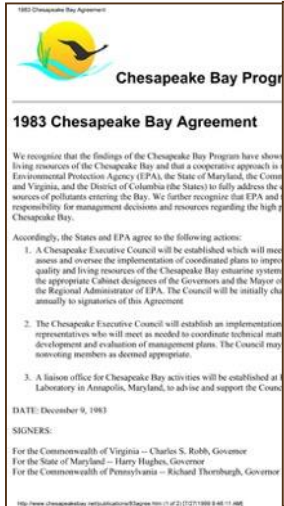
Tampa Bay: Impressive Reversal



Chesapeake Bay Agreements

Nutrient Source Reduction Goals

1983



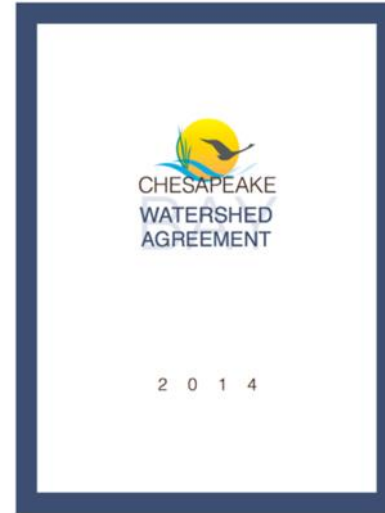
1987



2000



2014



2025?

1987

40% reduction in N & P loads

2000

Voluntary reductions determined by science

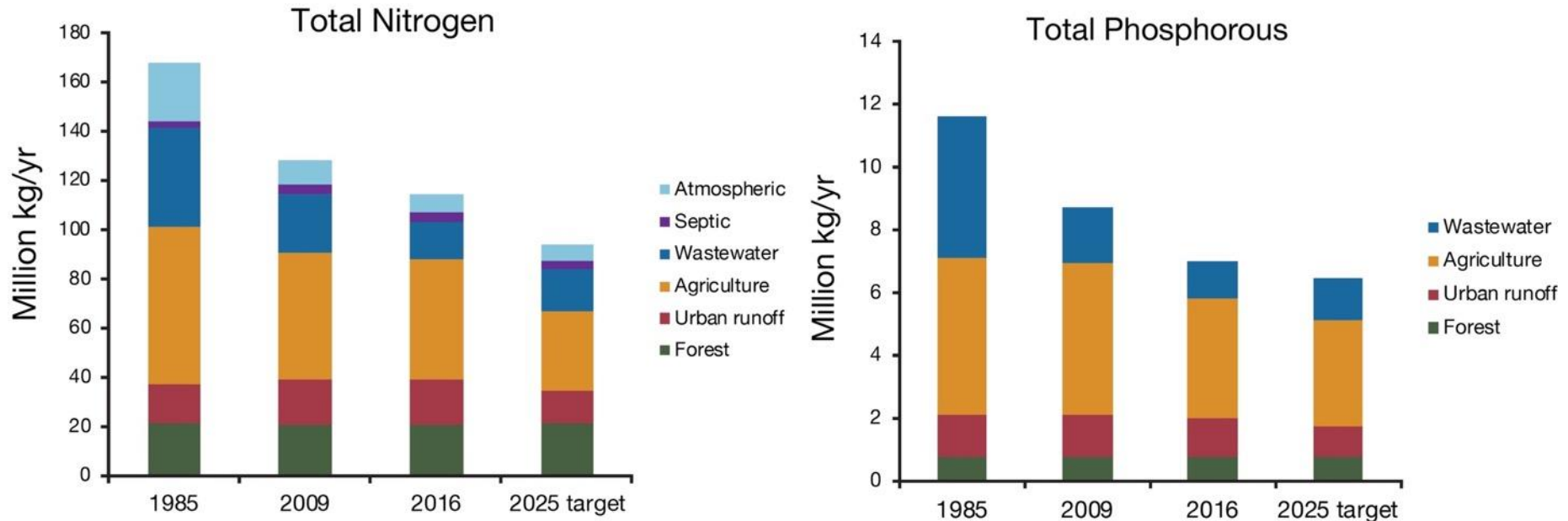
2010

Mandatory Total Maximum Daily Load

2025

Estimated Nutrient Load Reductions Achieved

Except for Direct Wastewater Discharges, Estimated by Models

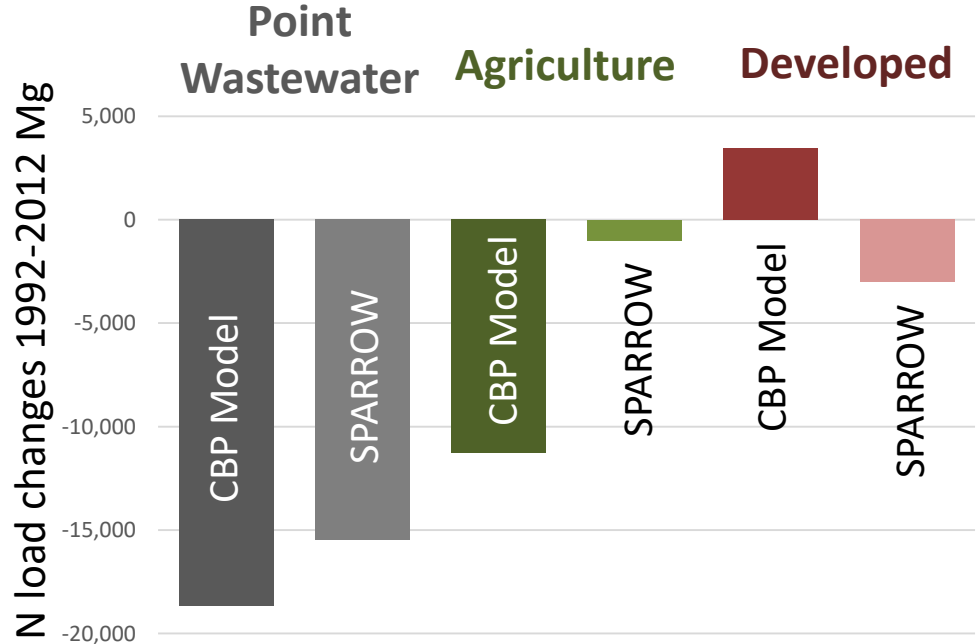
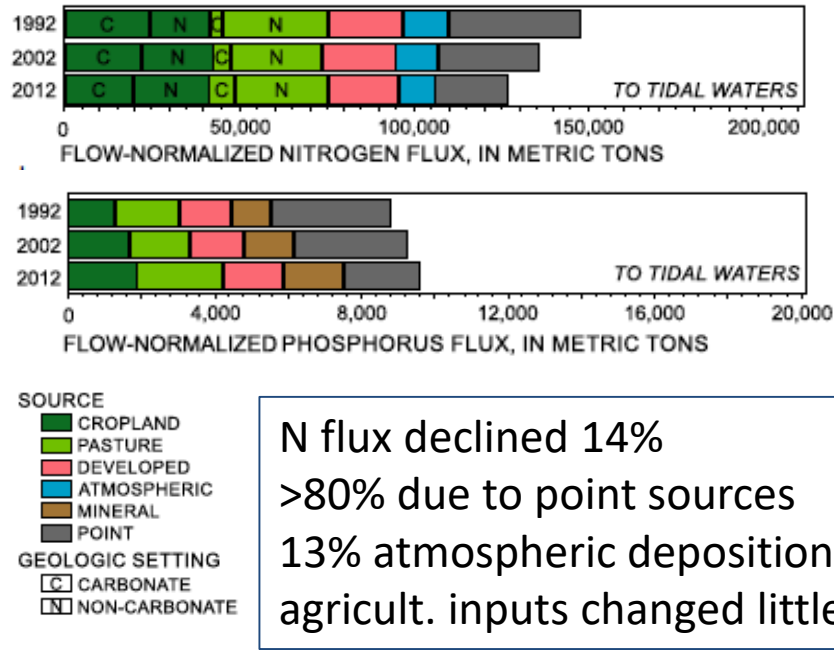


Boesch 2019. *Frontiers in Marine Science*

Based on www.chesapeakeprogress.com; more recent model estimates differ in categories and amounts

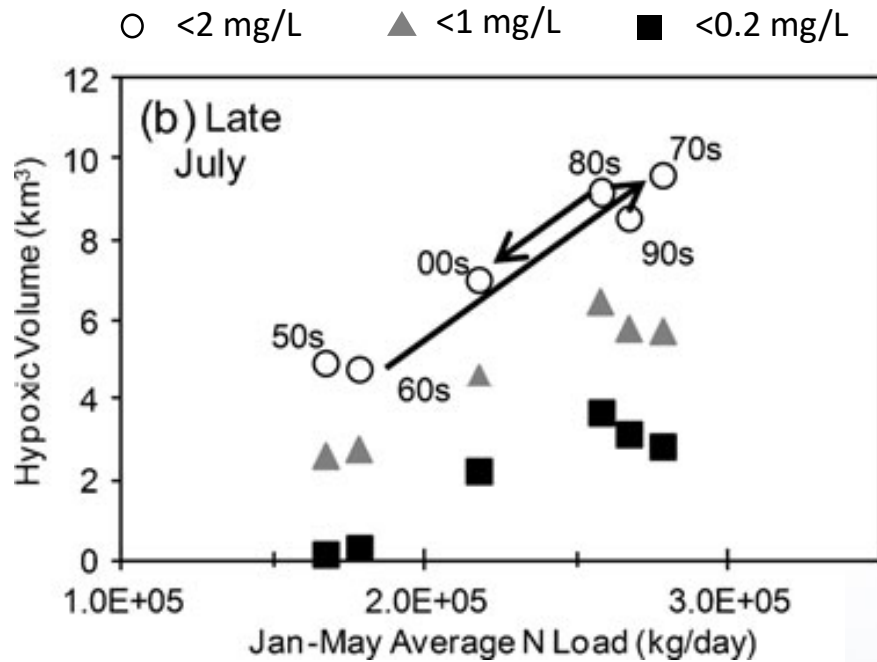
A Tale of Two Models

CBP Watershed & SPARROW



Chesapeake Bay Indicators of Recovery

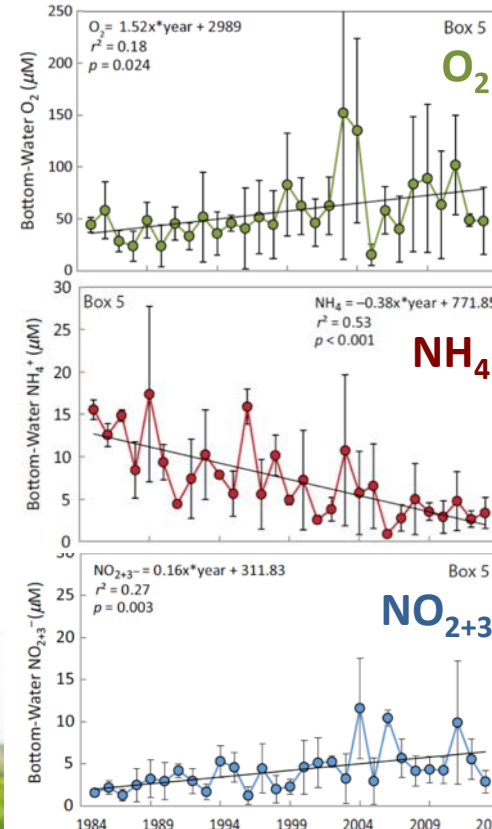
Hypoxia



Murphy et al. 2011 *Estuaries & Coasts* 34:1293



Nutrient cycling



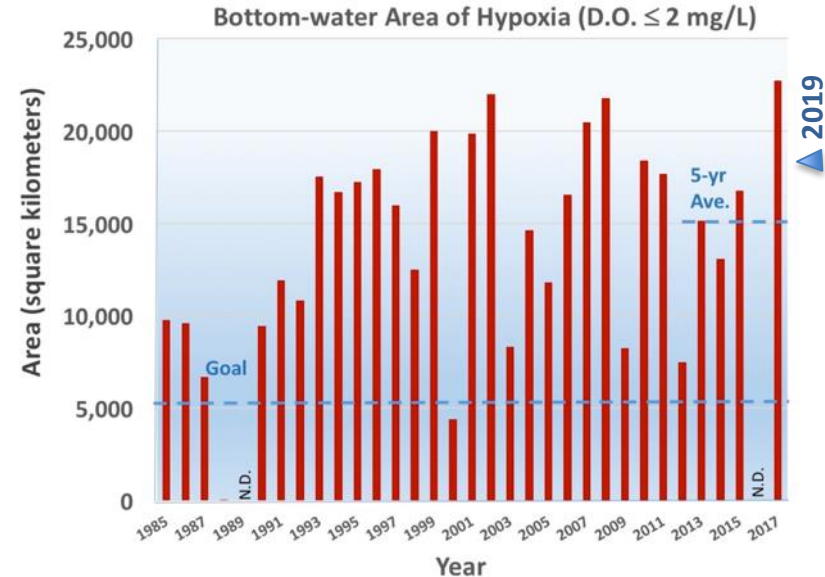
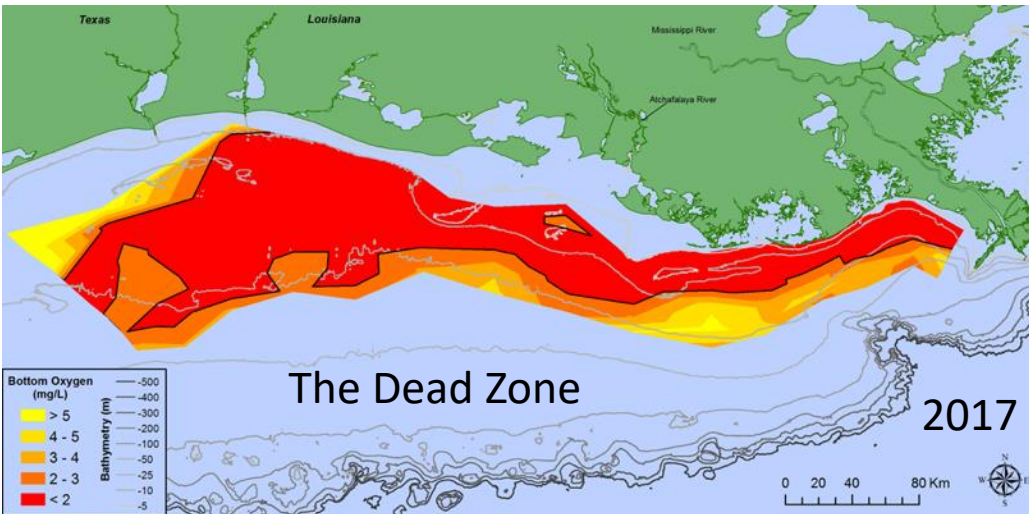
Testa et al.
2018 *L&O*

Northern Gulf of Mexico Hypoxia



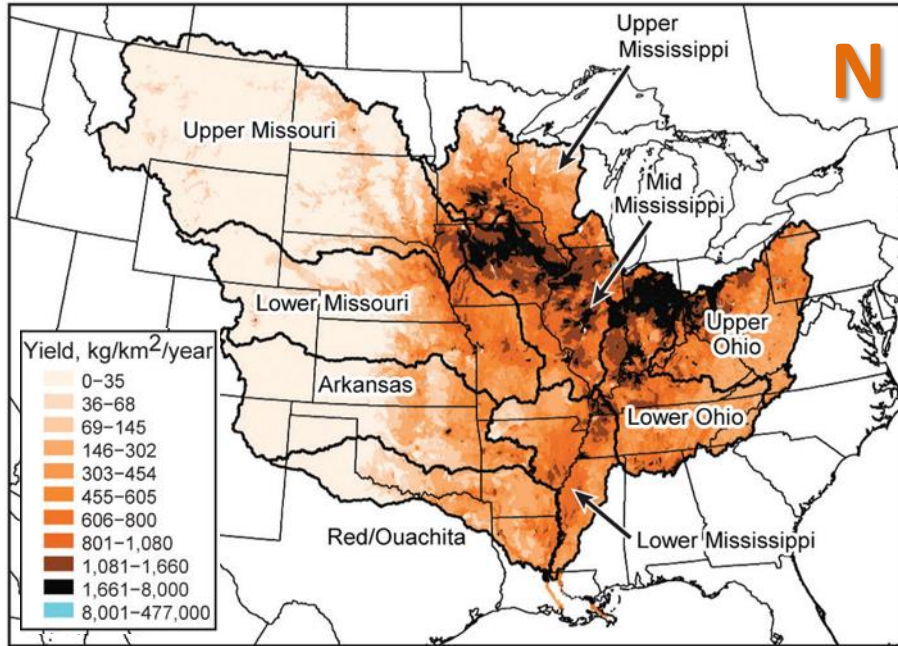
2000 Integrated Assessment
2001 Action Plan
2007 EPA SAB Report
2008 Action Plan

<5,000 km² by 2015 → 2035
~45% N & P, interim goal -20% by 2025
Voluntary Action (no TMDL)
Task Force – 12 states & Federal agencies

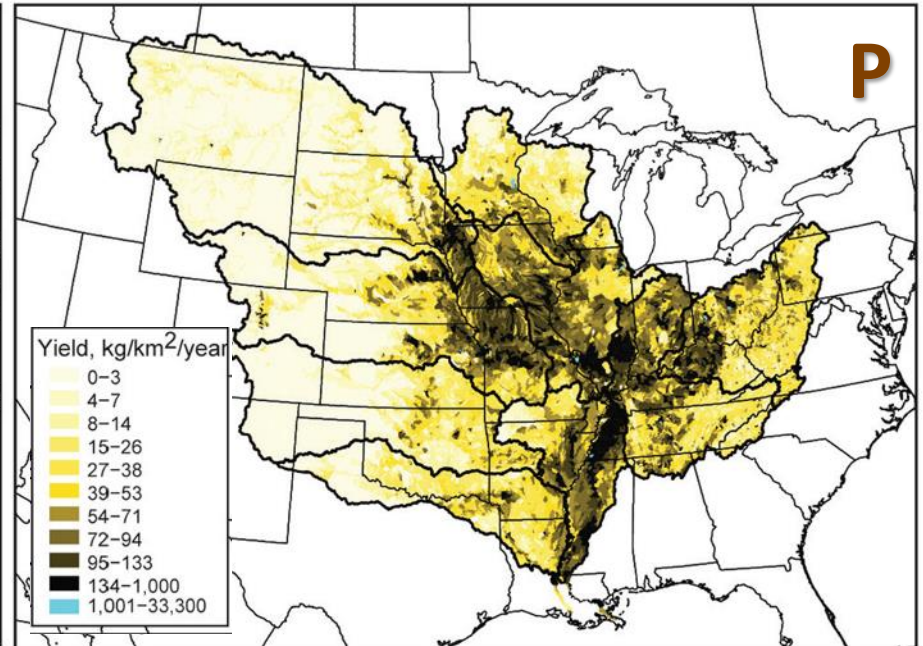


Mississippi River Basin Delivered Yields

Delivered Incremental N Yield



Delivered Incremental P Yield

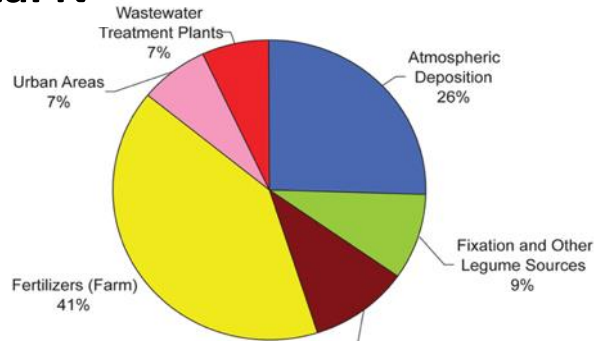


Spatially Referenced Regression on Watershed Attributes (SPARROW) Model

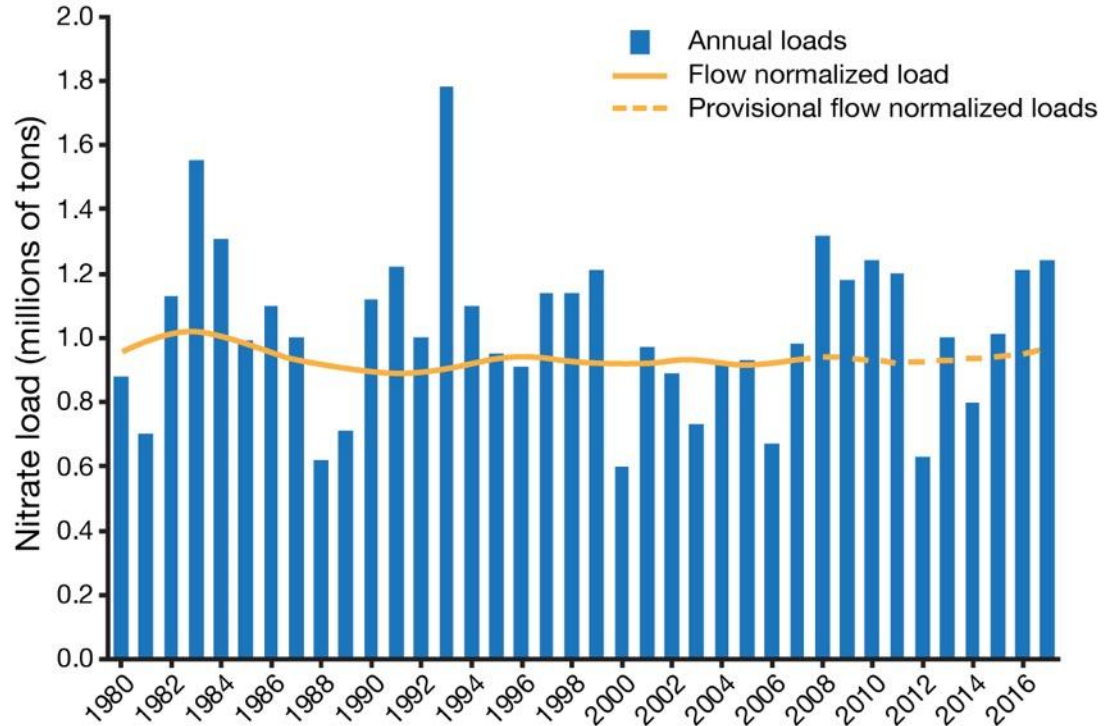
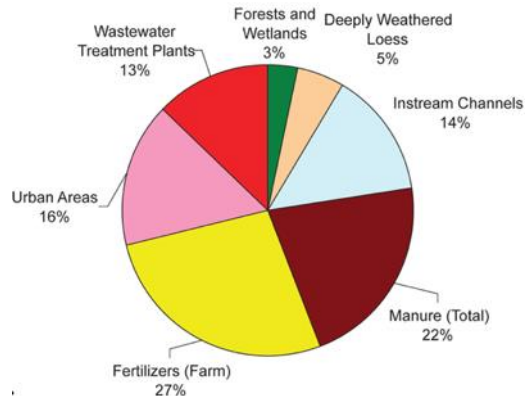
Robertson & Saad 2014 *Journal of Environmental Quality* 42:1422

Mississippi River Basin Sources & Trends

Total N



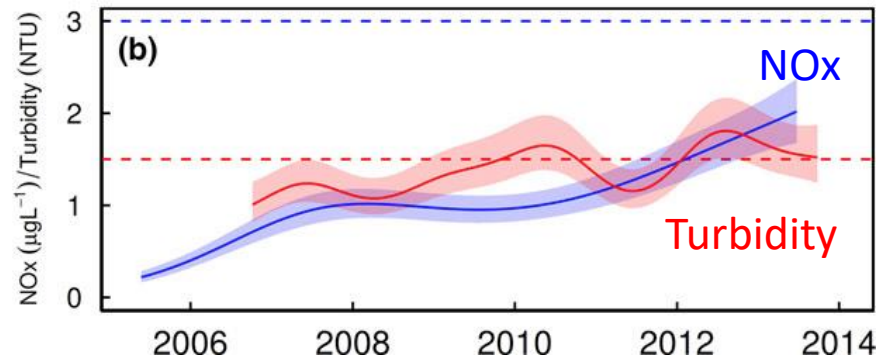
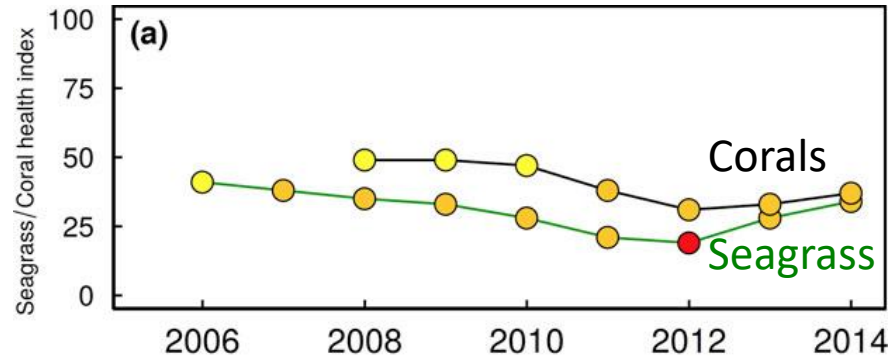
Total P



Great Barrier Reef: No Sanctuary



Inshore Areas



Agriculture
Reef Plans
2013 & 2050
Efforts
insufficient
Hydrological
restoration
Changes in
production

Kroon et al. 2016 *Global Change Biology* 22: 1985



Barriers and Bridges 1



Themes	Barriers	Bridges
Advancing actionable science	Limited knowledge of causes	Apply knowledge/approaches
	Fragmentary understanding	Client-responsive strategic research
	Paralyzing controversies	Responsive, conclusive adjudication
Providing accountable governance	Managers lack authority & responsibility	Enduring engagement of high-level parties
	Limited stakeholder engagement	Effective communication
	Overgeneralized commitments	Allocation & accountability
	Non-binding commitments	Statutory requirements

Client-Responsive Strategic Research





Barriers and Bridges 1



Themes	Barriers	Bridges
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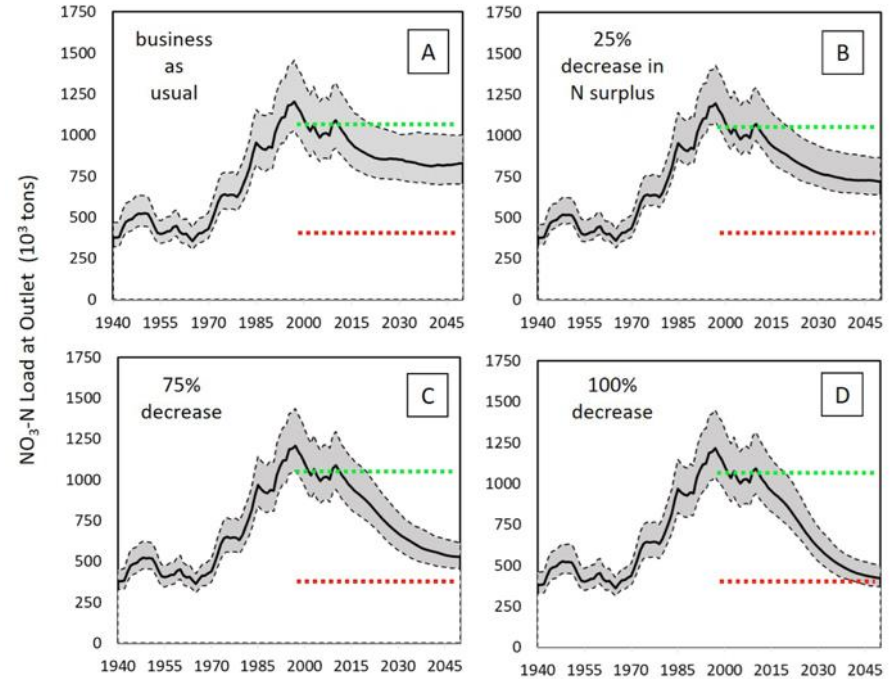
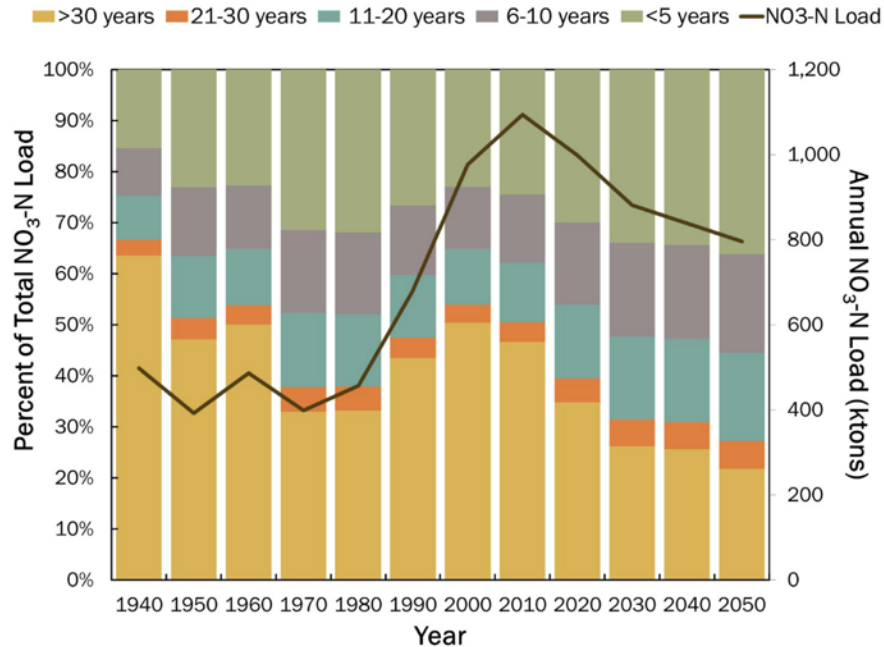
Barriers & Bridges 2



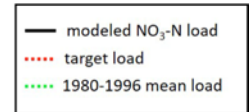
Theme	Barriers	Bridges
Reducing nutrient loads	Debates over limiting nutrients	Holistic N & P strategies
	Atmospheric sources out of control of water mgrs.	Air quality regulations reduce N loads
	Voluntary implementation	Performance compliance
	Expansion of biofuels	Transition to cellulosic biofuels
	Legacies and lags	Focus on sources with more immediate pathways

Legacies in Mississippi River Basin

Van Meter et al. 2018 *Science* eaar4462



But see comment by Ballard et al. and response by Van Meter et al. in *Science*!





Barriers and Bridges 3



Theme	Barriers	Bridges
Assessing outcomes & adapting strategies	Inadequate/underused monitoring	Sustained monitoring of key indicators, processes
	Inadequate/over-prescribed modeling	Multiple models guide management
	Models not reconciled	Truly adaptive management
	Rehabilitation recalcitrant	Intervention in coastal ecosystem
Addressing climate change	Goals practically unachievable	Reassess to inform climate-smart strategies
	Decoupled water-quality & climate strategies	Alternatives that address climate change & loads

Break barriers, build bridges.



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@DonBoesch 

Chesapeake Bay Bridge

Photo: Ben Schumin