COLLABORATIVE SCIENCE FOR ESTUARIES
WEBINAR SERIES

Brian Yellen
University of Massachusetts Amherst

Sarah Fernald
Hudson River NERR, NY

Dams and Sediment in the Hudson

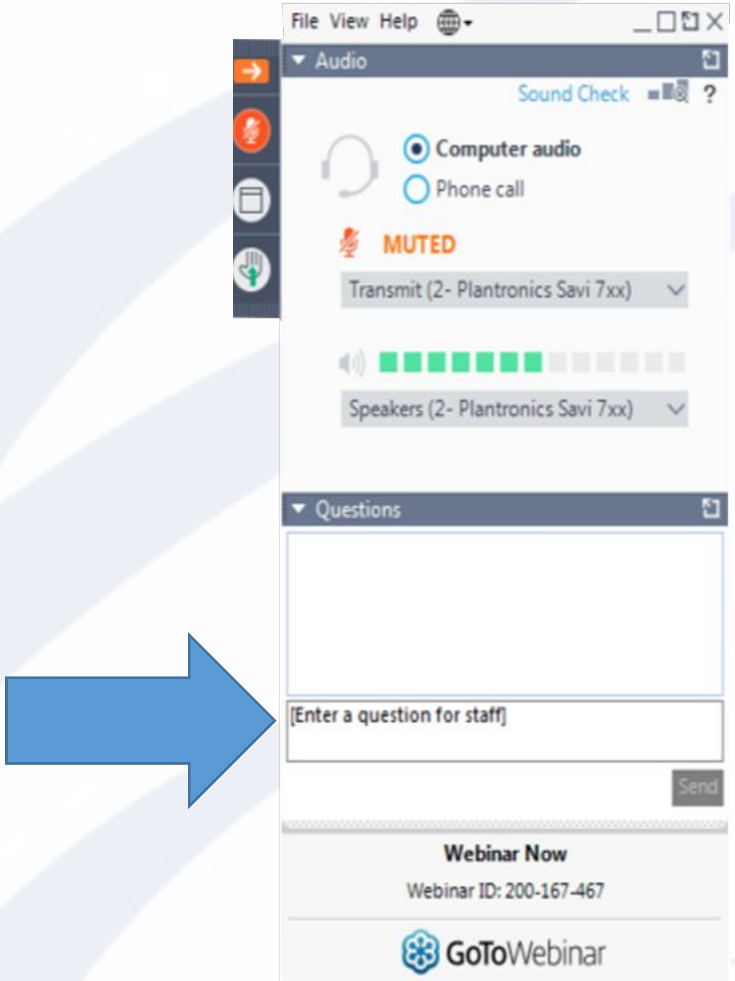
National Estuarine
Research Reserve System
Science Collaborative

Date: Thursday, September 24, 2020
Time: 3.30PM ET - 4.30PM ET

National Estuarine Research Reserve System

Have a question?

Use the "Questions" function to pose questions throughout the webinar.



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NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

Hudson River National Estuarine Research Reserve

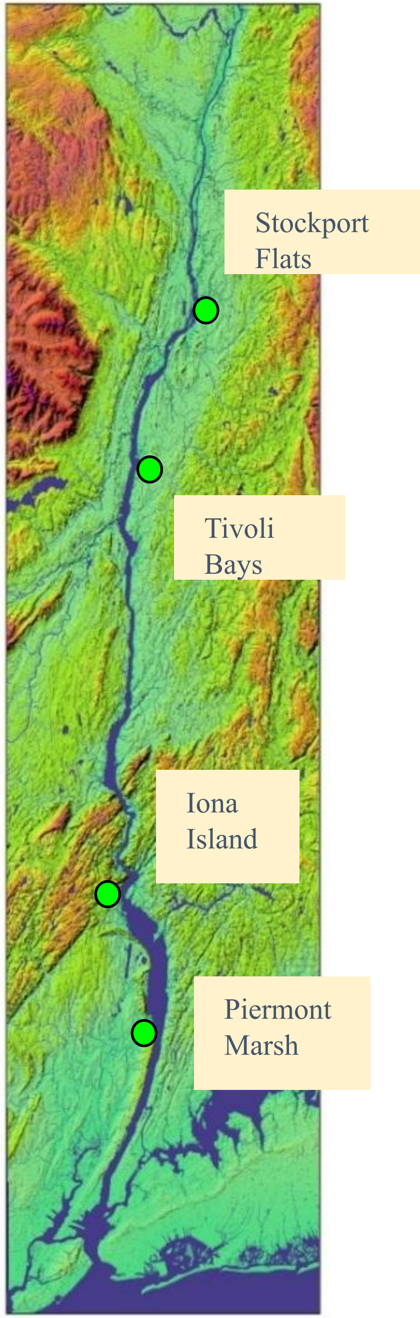
HRNERR Mission

- Federal Program with NOAA
- Partnership with NYS DEC
- Designated in 1982
- 5,000 protected acres at 4 sites

Dams and Sediment on the Hudson (DaSH)

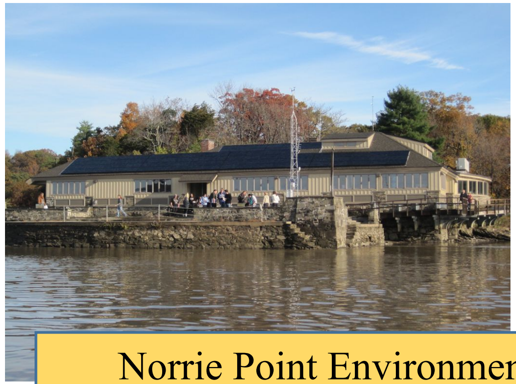
a NERRS Science Collaborative project

Hudson River National Estuarine Research Reserve




Stockport Flats


Tivoli Bays


Norrie Point Environmental Center
HRNERR Headquarters


Iona Island


Piermont Marsh

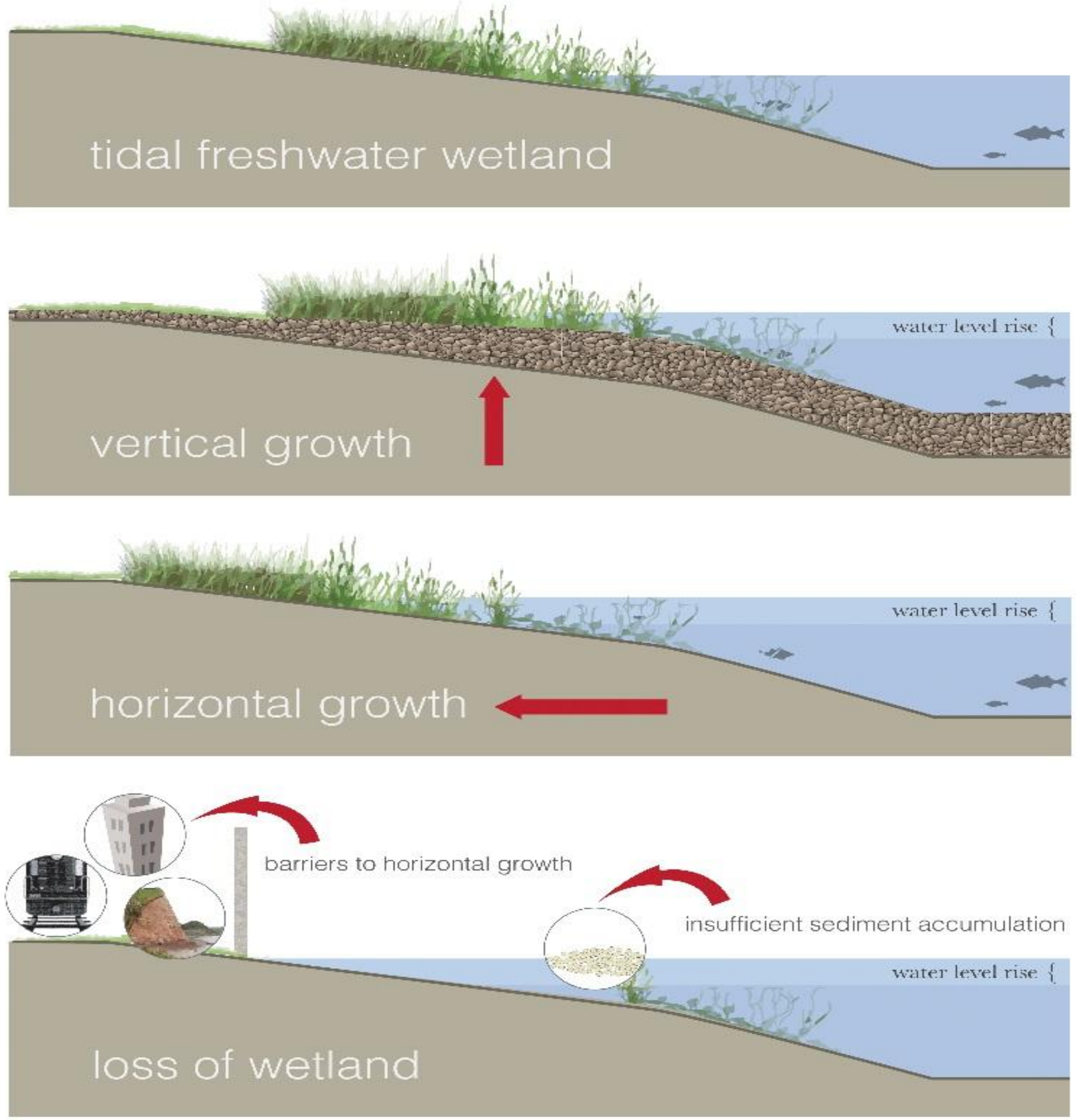
A Network of 29 Research Reserves

MISSION:

To promote stewardship of the Nation's estuaries through science and education using a system of protected areas

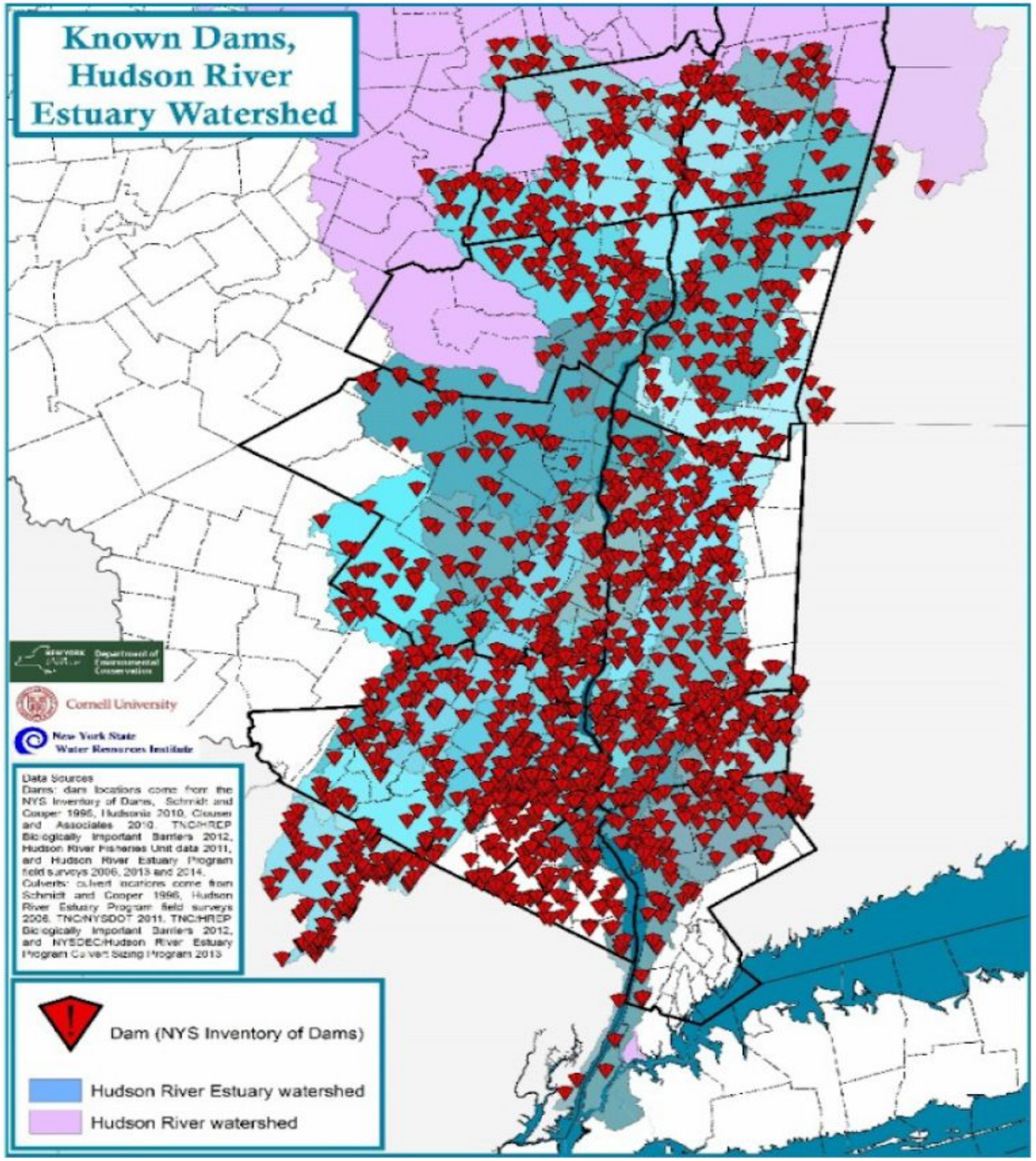
Tidal Wetlands and Rising Waters

- Vegetation in the intertidal zone
- Tides deposit sediment (vertical growth)
- Pathways for inland marsh migration (horizontal growth)
- Barriers to horizontal growth and insufficient vertical growth lead to loss of wetlands with sea level rise



Graphic: Cary Institute of Ecosystem Studies. L. Tumblety

Dams and sediment supply



Hudson River NERR Research Priority

To improve the scientific understanding of the impacts that dam removals have on sediment transport and downstream tidal wetlands, including how this might change under future climate conditions.

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National Estuarine
Research Reserve System
Science Collaborative

Facilitator

Research
Reserve

Researcher

End Users

Coastal
Issues
in the
NERRS

End Product
Final Report

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

The DaSH Team

Major end user groups in collaborative process.

NYS Department of Environmental Conservation

Hudson River NERR
Hudson River Estuary Program
Division of Water
Dam Safety Office

Other Government Agencies

NOAA Office of Response and Restoration
US Geological Survey
NYC Department of Environmental Protection

Engineering consultants

The Chazen Companies
Fuss and O'Neill Engineering

Wetland managers and environmental non-profits

Scenic Hudson
Hudson River Foundation

Academic Institutions

University of Massachusetts Amherst
Woods Hole Oceanographic Institution
Cary Institute of Ecosystem Studies

Poll:
What is your interest in DaSH?

South Lattintown Creek Dam, Photo Credit Andrew Meyer

Poll Questions:

How are you connected to today's webinar?

Which topic is most of interest to you for today's webinar?

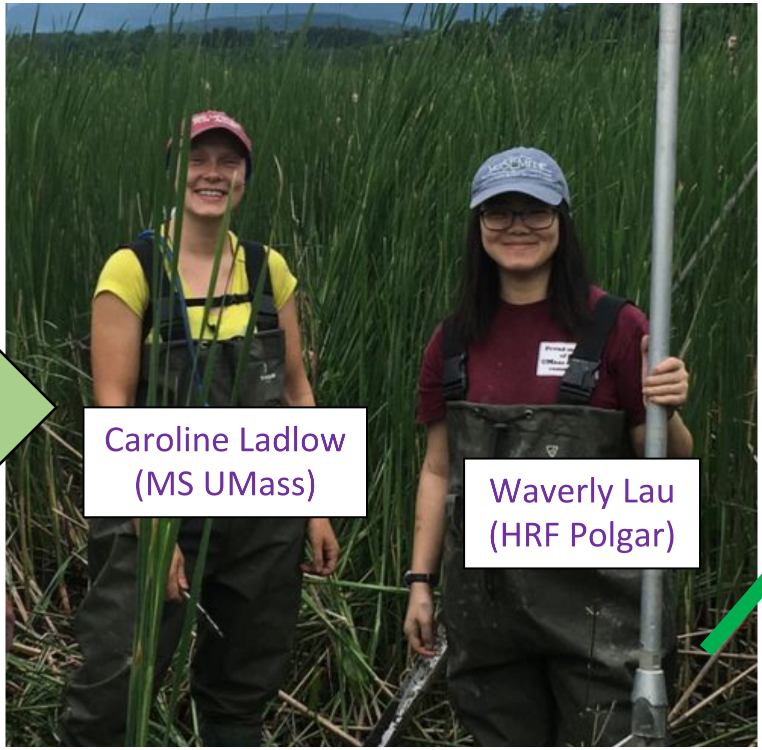
Dams and Sediment in the Hudson

DASH
Dams and Sediment in the Hudson

Brian Yellen
UMass Amherst, Dept of Geosciences

Open water ~1900

?



NERRS Science Collaborative Webinar – September 24, 2020

National Estuarine Research Reserve System Science Collaborative
NECASC Northeast Climate Adaptation Science Center
NOAA
HRF HUDSON RIVER FOUNDATION
UMASS geosciences

Dams and Sediment in the Hudson (DaSH) – Our Team

What effects will dam removal have on sediment dynamics in the Hudson Estuary?

Modeling studies
David Ralston, Associate Scientist
Woods Hole Oceanographic Institution

Field studies
Brian Yellen, Research Professor
University of Massachusetts

Jon Woodruff, Associate Professor
University of Massachusetts

End user coordination
Sarah Fernald, Research Coordinator
Hudson River National Estuarine Research Reserve

Collaborative engagement
Ona Ferguson, Senior Mediator
Consensus Building Institute, Inc.

Advisory Committee
Elias Dueker
Jennifer Cavanaugh
Phil Moreschi
Scott Cuppett
Fran Dunwell
Dan Miller
Jim Lodge
Betsy Blair
Carl Alderson
Lisa Rosman
Megan Lung
Maria Tupper-Goebel
Alon Dominitz
Jennifer Ross
Karen Woodfield
Nava Tabak
Stuart Findlay
Barbara Beall
Russell Urban-Mead
Andy Peck

Woods Hole Oceanographic Institution 1930
UMASS AMHERST
cbi Consensus Building Institute
NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

DaSH - Who are the stakeholders?

DaSH
Dams and Sediment in the Hudson

Dam Owners

NYC Environmental Protection

Dam Regulators

US Army Corps of Engineers®

Environmental Regulators

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Fisheries

NOAA

American Rivers
Rivers Connect Us

TROUT UNLIMITED

Tidal wetlands

HRF HUDSON RIVER FOUNDATION

SCENIC HUDSON

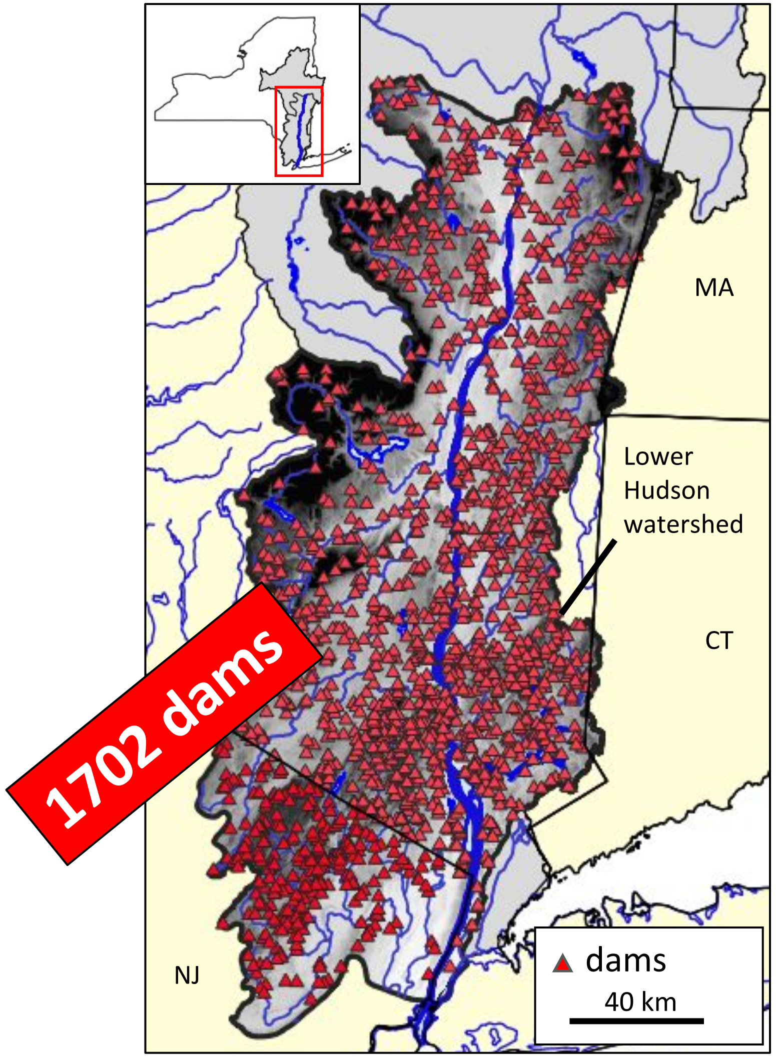
Practitioners

FUSS & O'NEILL
Disciplines to Deliver

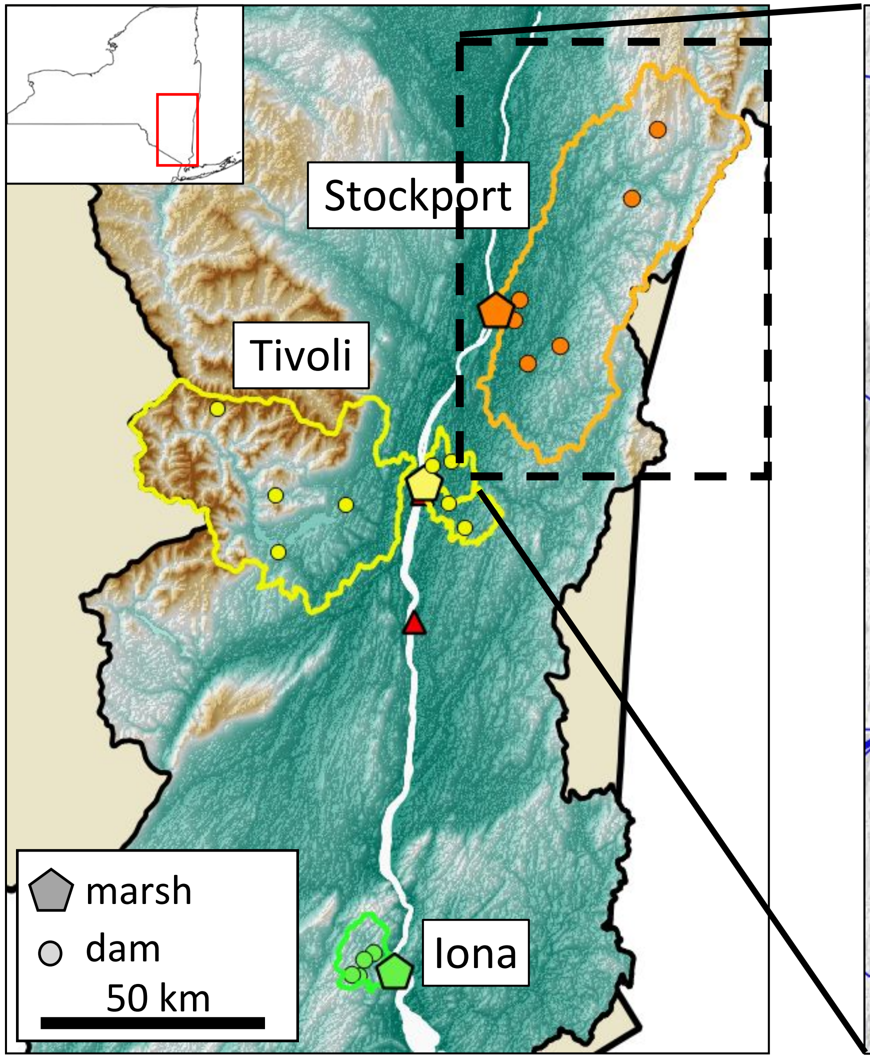
Chazen
ENGINEERING CONSULTANTS
A Chazen Company

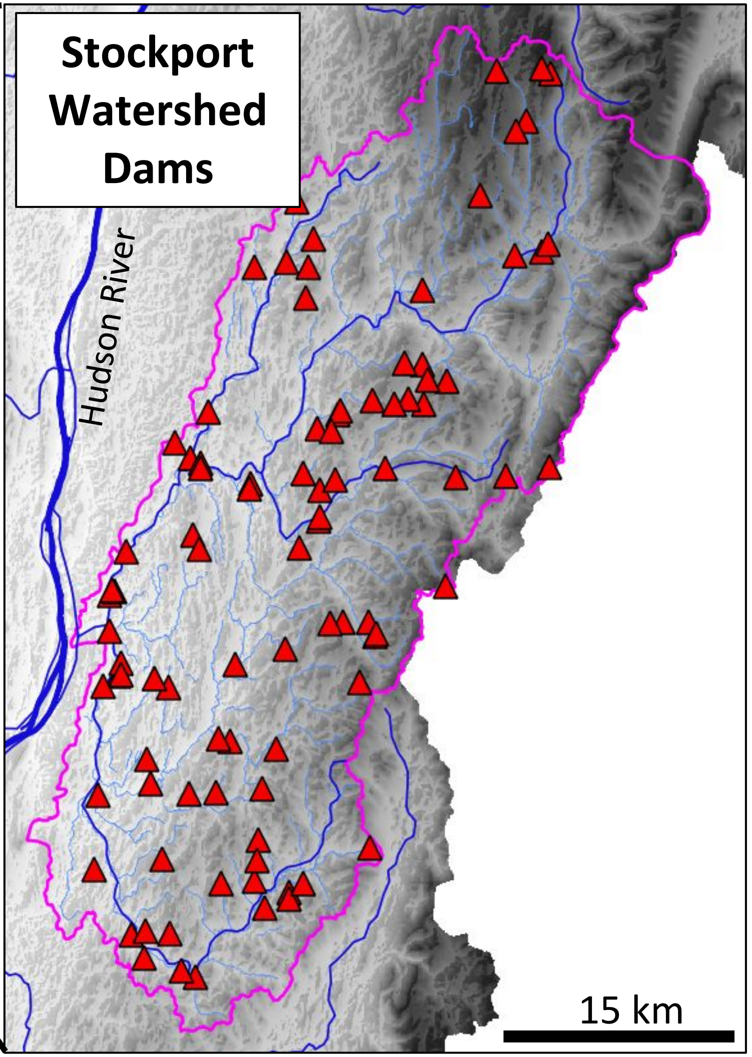
Project Background

Dams and Sediment in the Hudson



- Registered dams in Lower Hudson
- ~half watershed drains to estuary





- Three tidal marshes, catchments
- Varying geology, land use, relief

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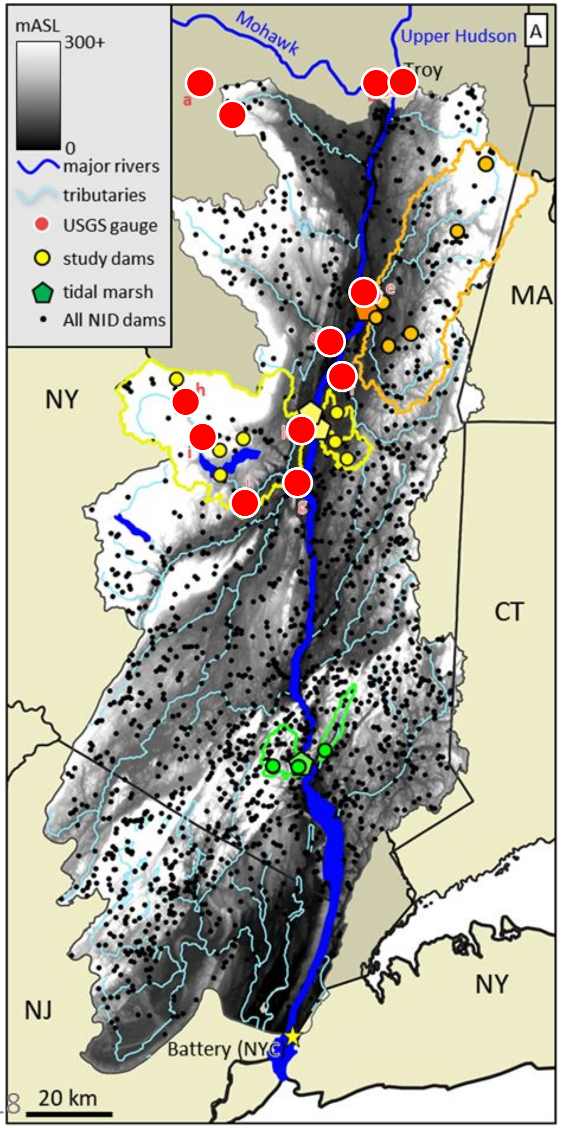
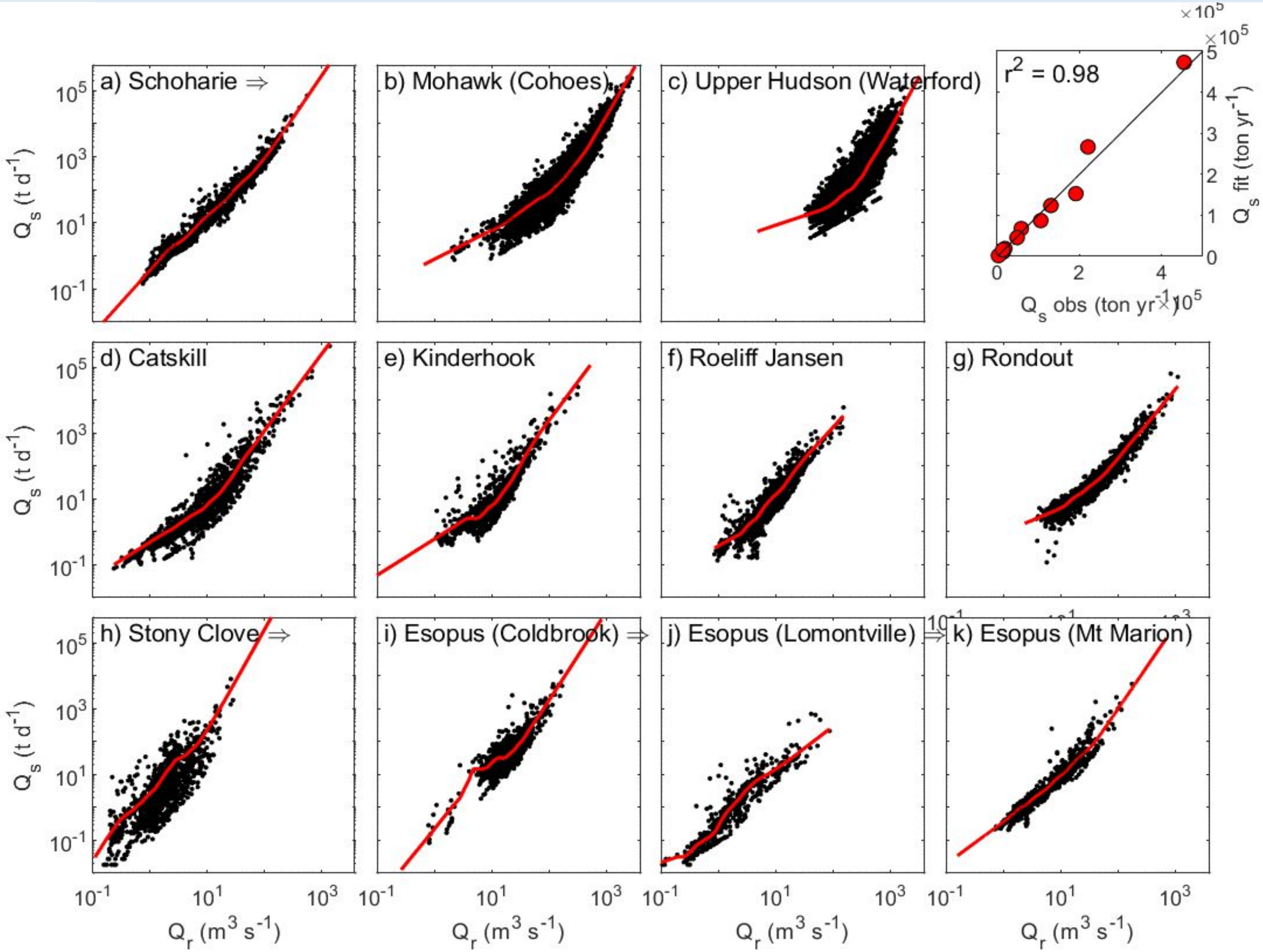
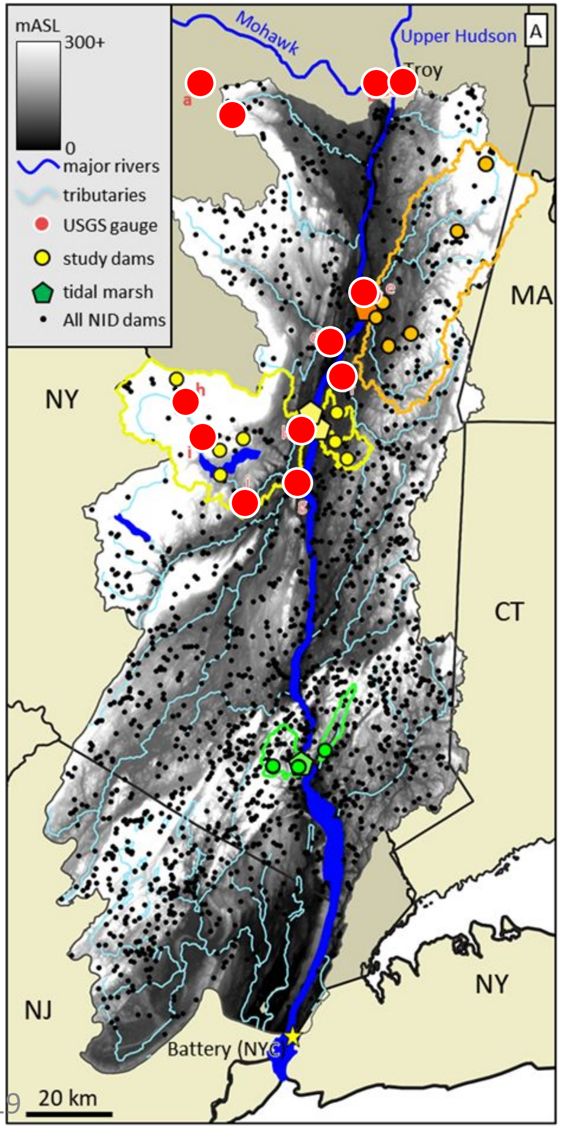
Background sediment loading

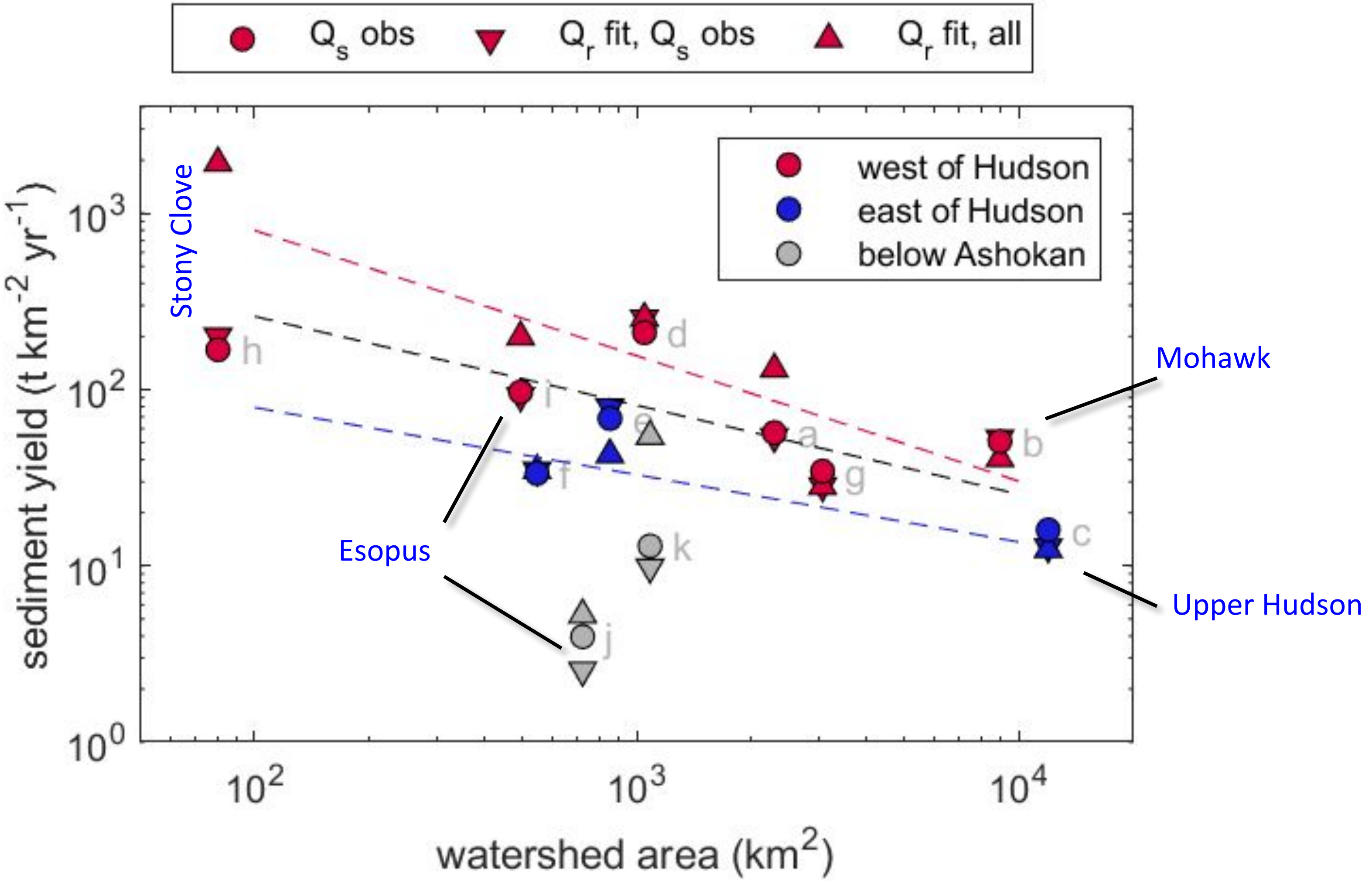
Dams and Sediment in the Hudson





Sediment yields are 60 / 100 T km^{-2} yr^{-1}





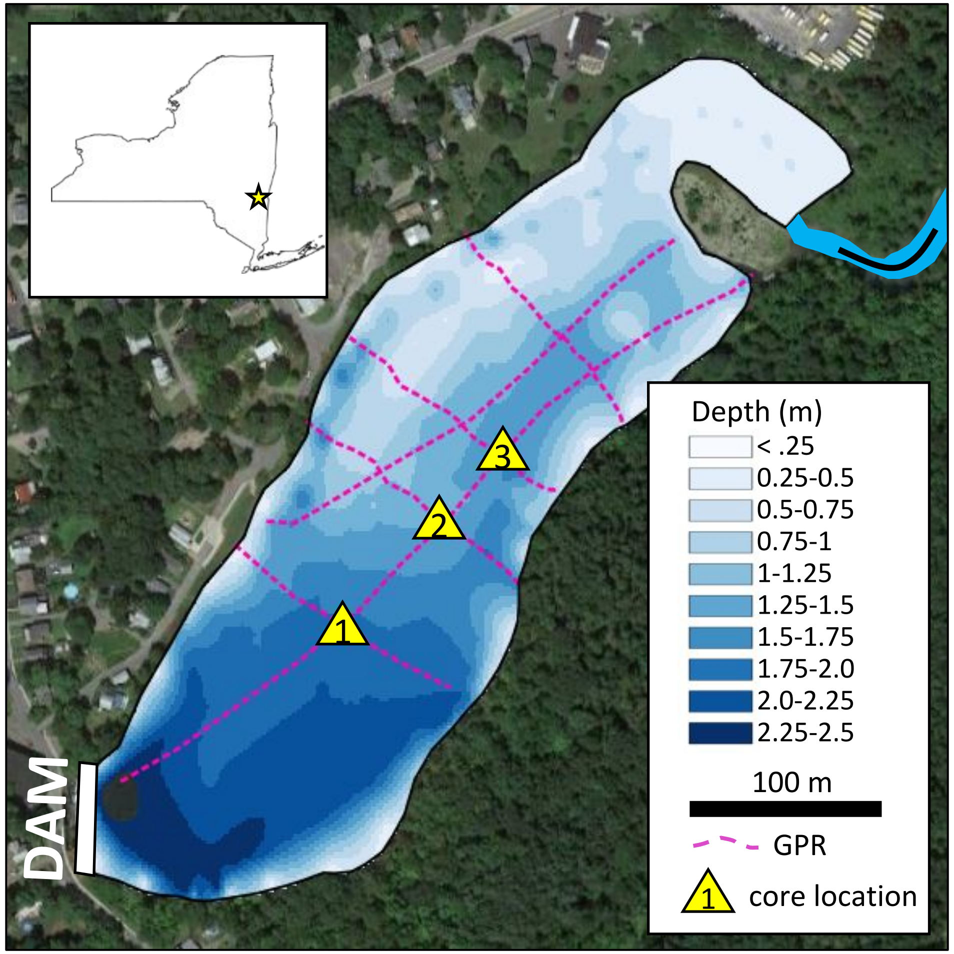
Annual Sediment Load = 1.2 MT

Can we use dams to refine these curves?

Dams and Sediment in the Hudson

What we wanted…

Summit Lake - Philmont, NY



What we found…

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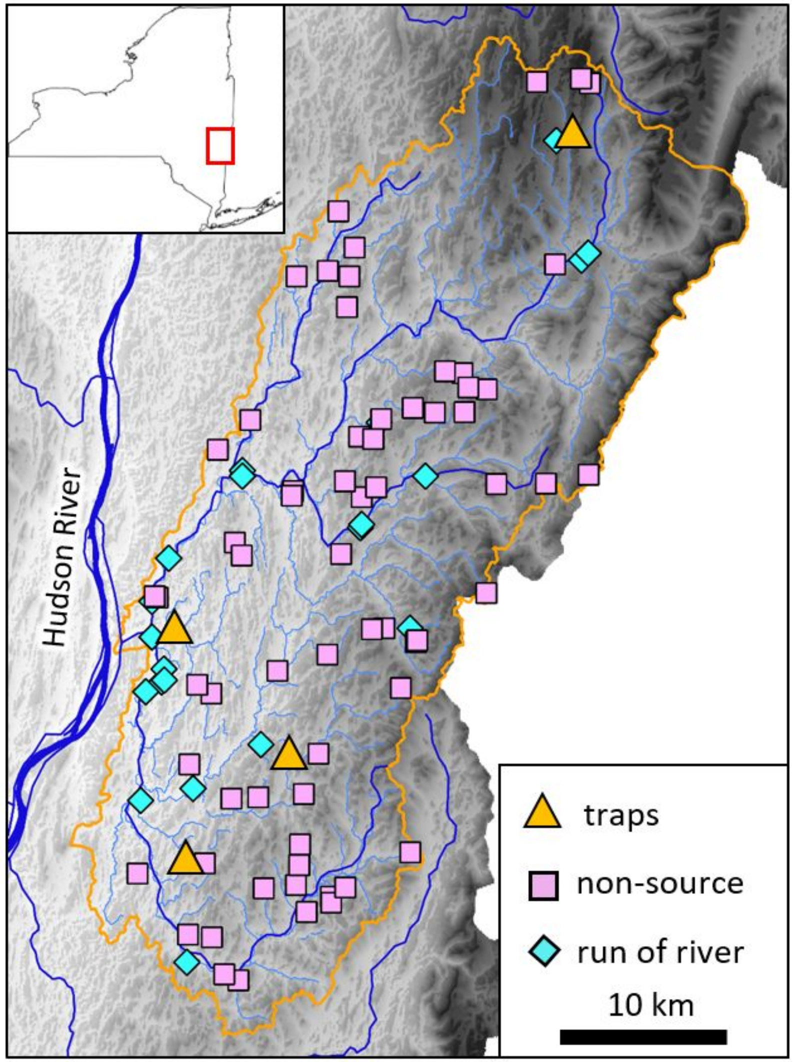
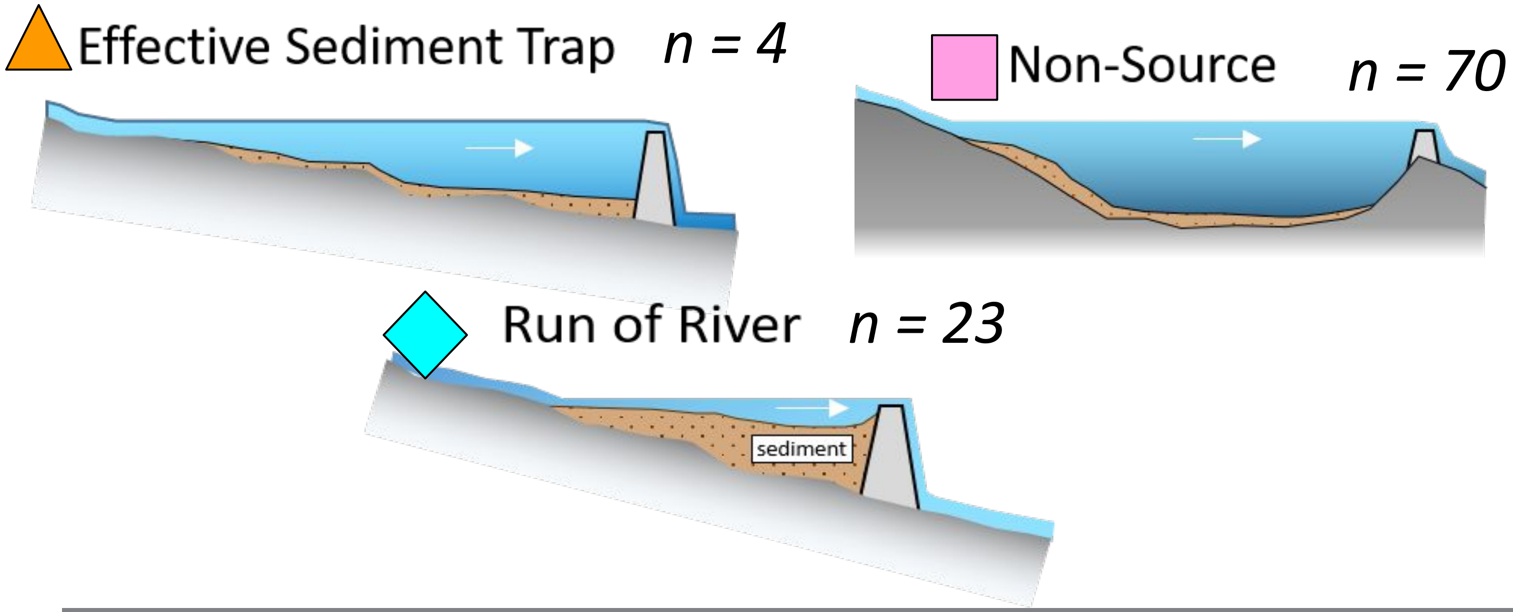
Most dams don't trap sediment (only 4 of 97 do)

Dams and Sediment in the Hudson

Stockport Creek Watershed





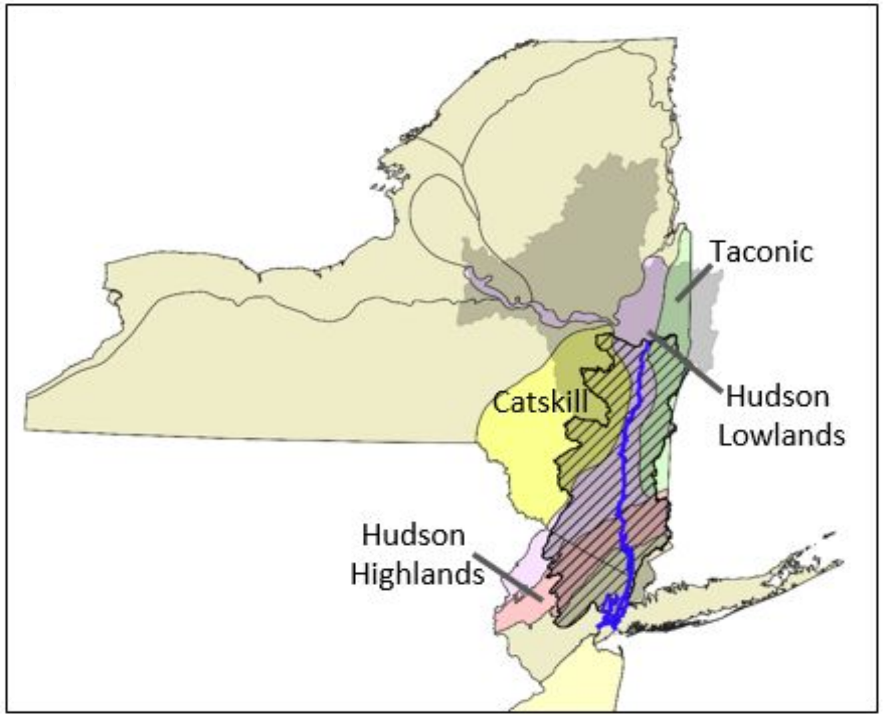
IMPOUNDMENT SEDIMENT ESTIMATION TOOL FOR THE LOWER HUDSON RIVER VALLEY

Methods for assessing dam sediment inventories and a blue print for extension beyond the Hudson to the greater Northeast Region

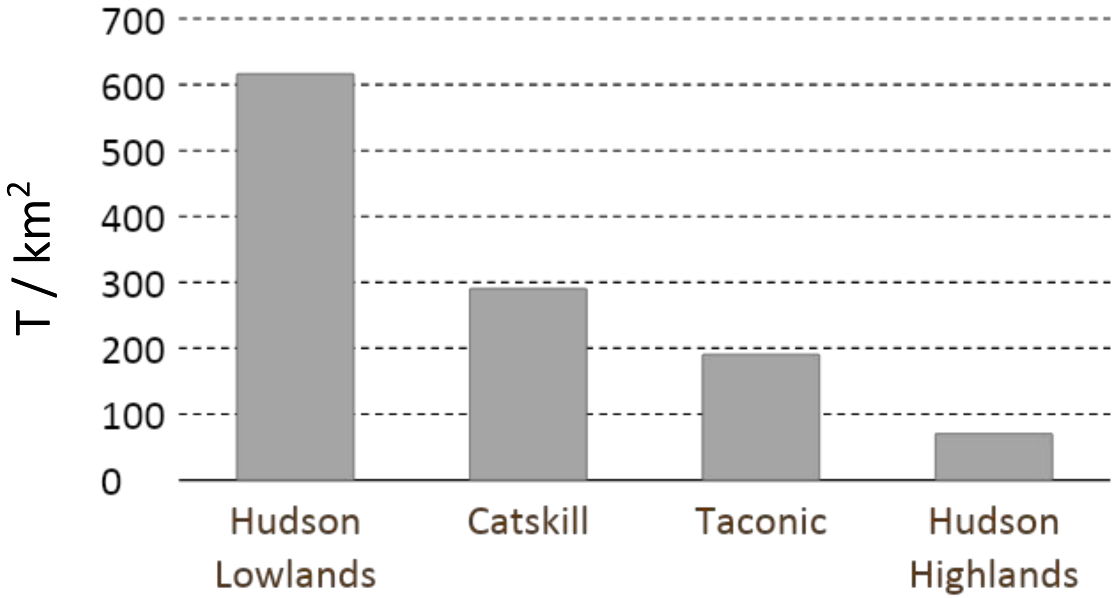
https://www.hrnerr.org/hrnerr-research/dams-and-sediment-in-the-hudson

Scaling up the estimate

Physiographic Provinces



Impoundment sediment by Province



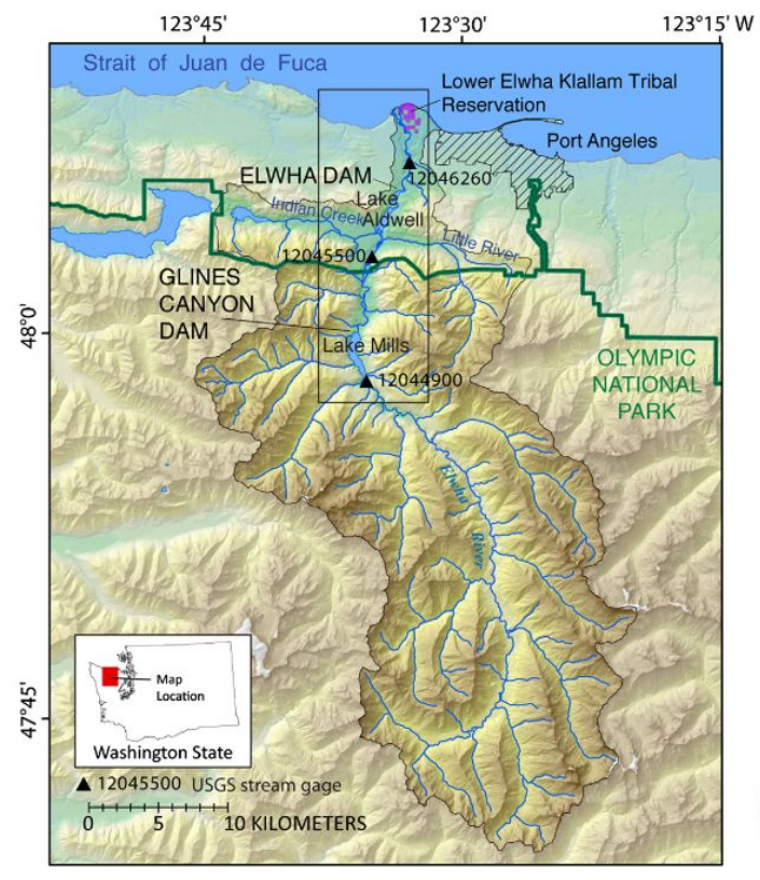
∴ Scaled estimate = 4.9 Mt in ~100 years
~ 4 years equiv sediment load

Importance of regional studies: East vs West coast

Dams and Sediment in the Hudson

Elwha River

2 dams

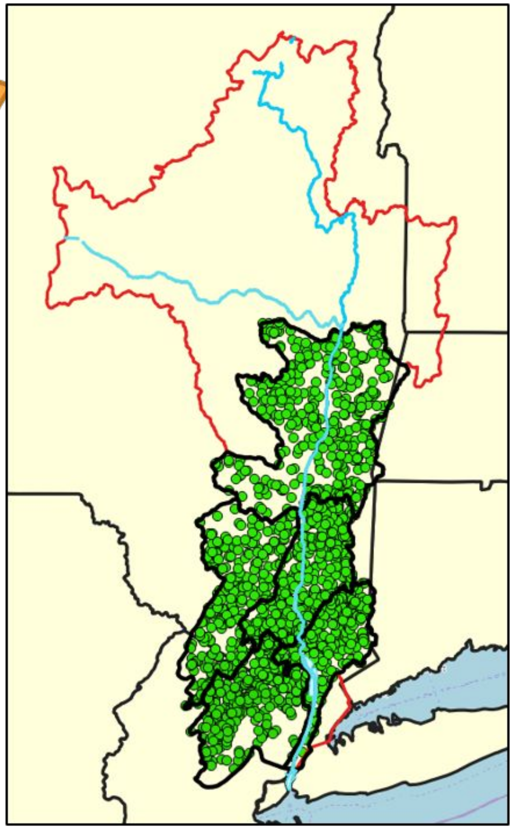


10.5 Million T

832 km^2

Hudson River

1700 dams



~4 yrs equiv.

4.9 Mill. T*

13000 km^2

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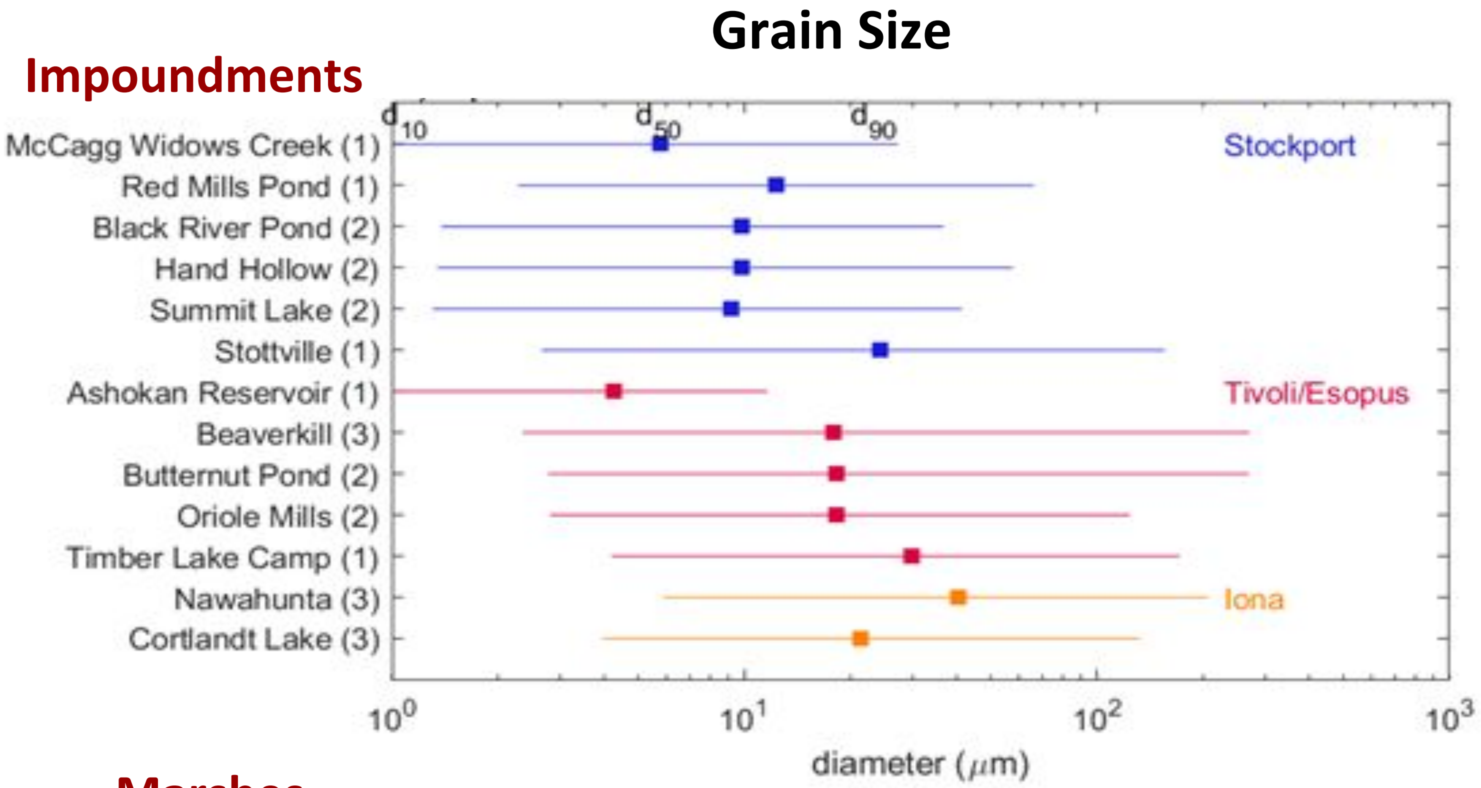
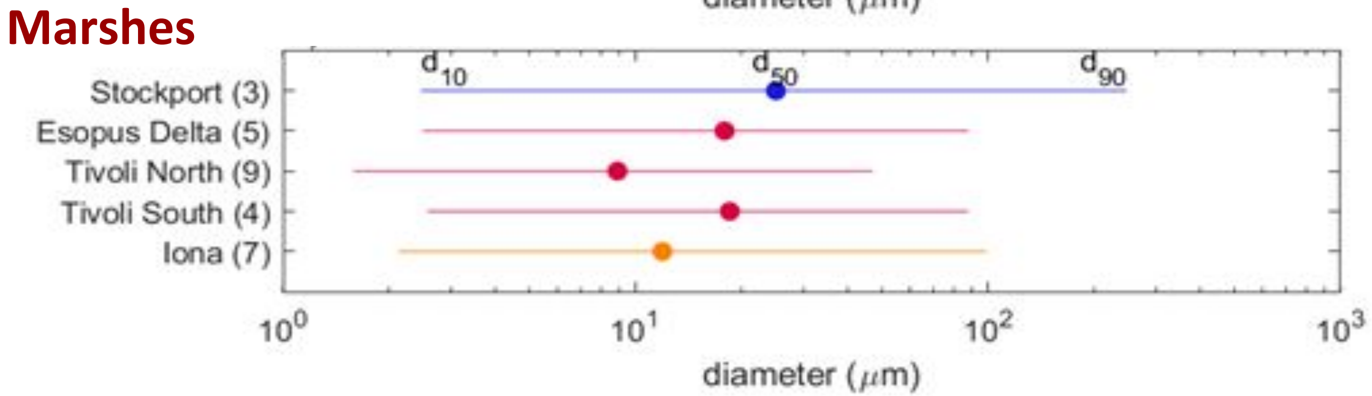
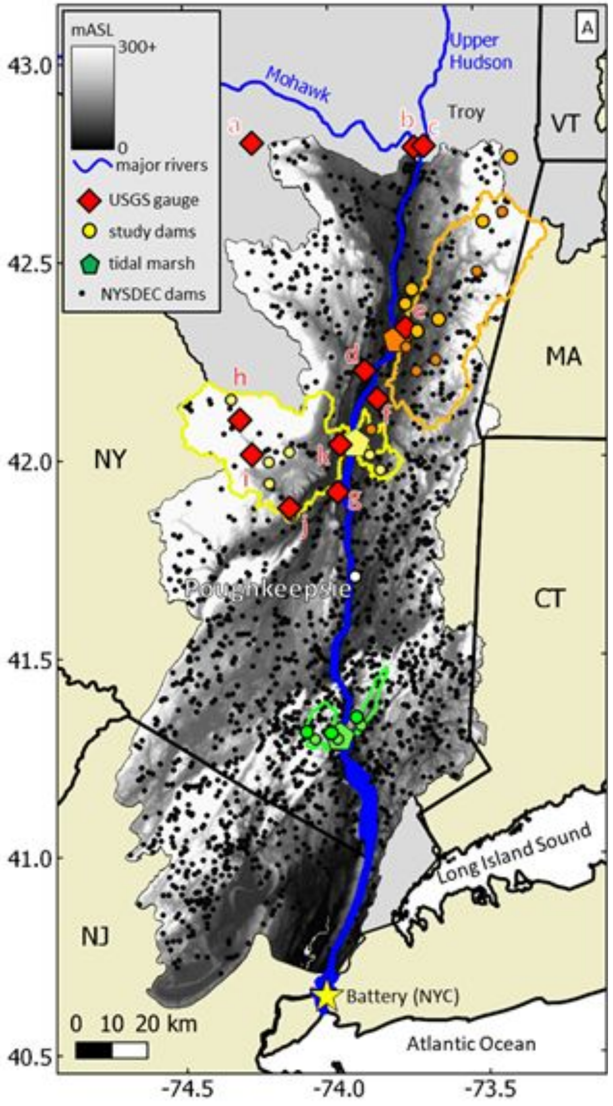
Modeling sediment release to the estuary

Dams and Sediment in the Hudson



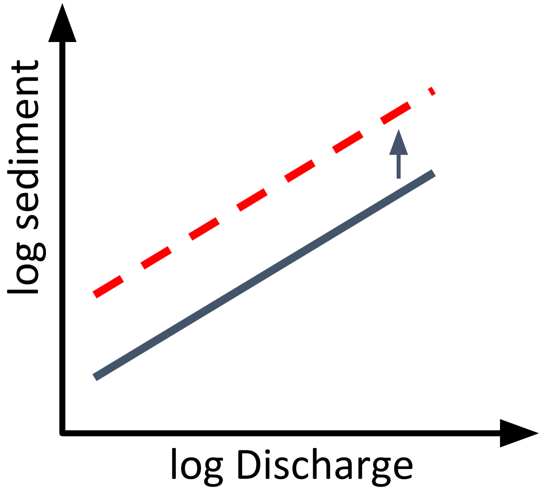


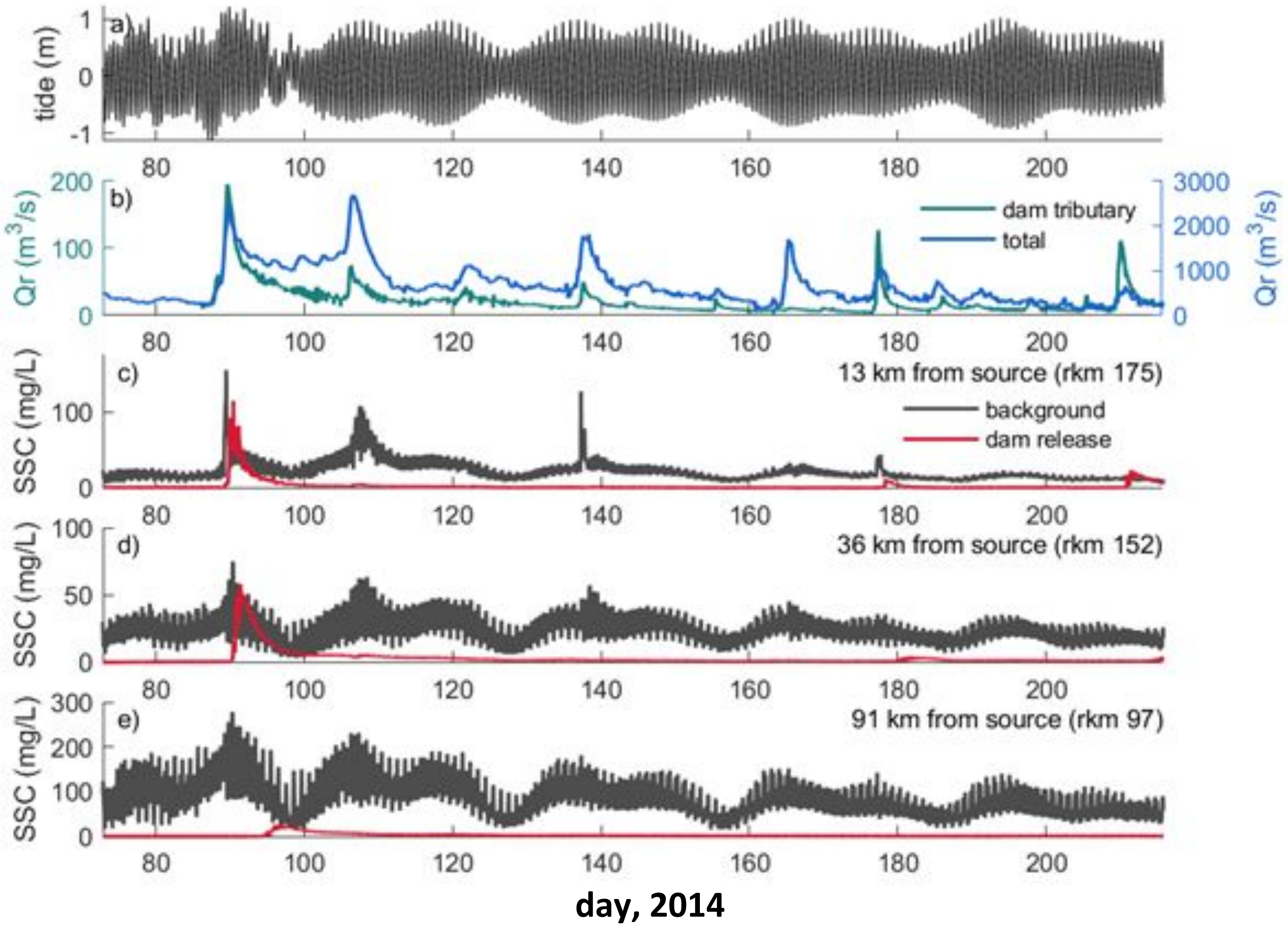


Modeling sediment release to the estuary

Dams and Sediment in the Hudson

Assume 3x sediment relative to discharge





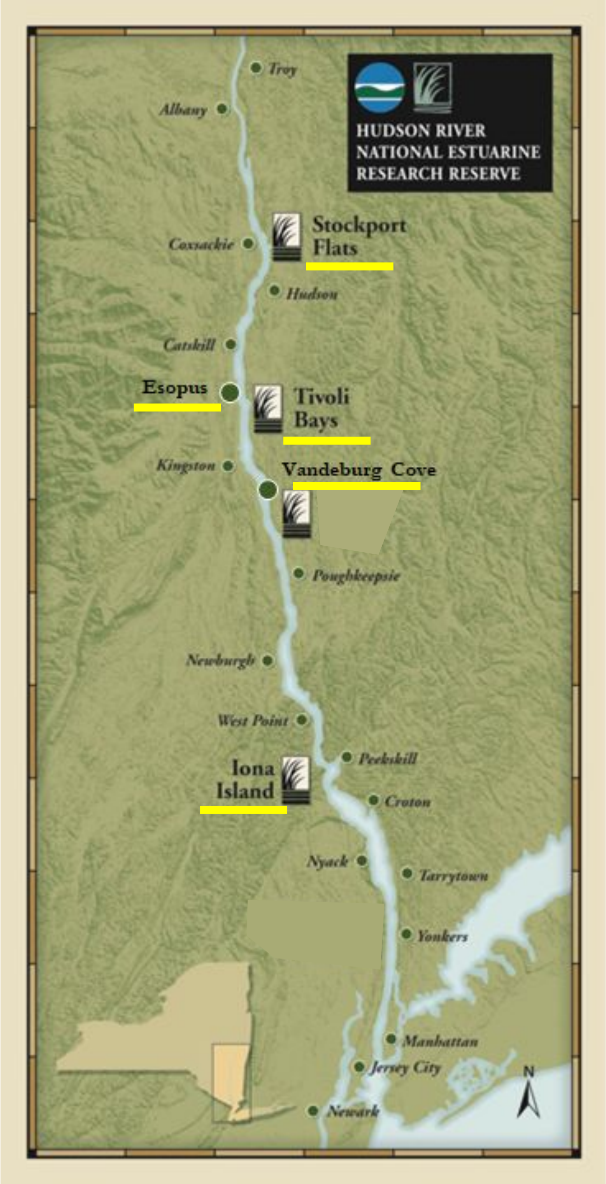
Summary of Dam Findings

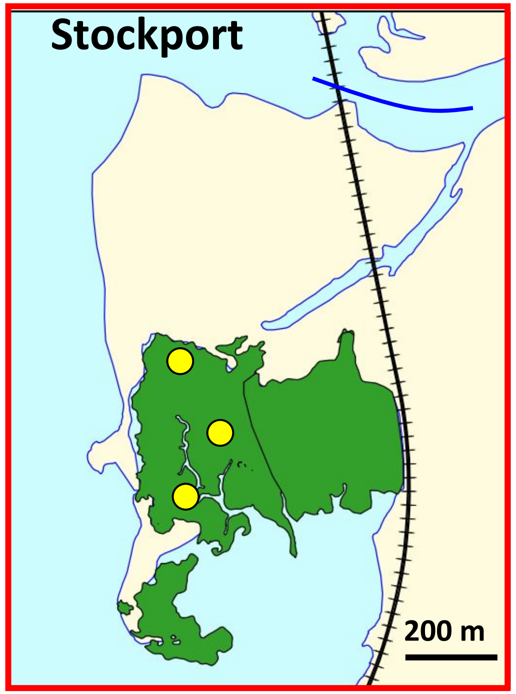
DaSH
Dams and Sediment in the Hudson

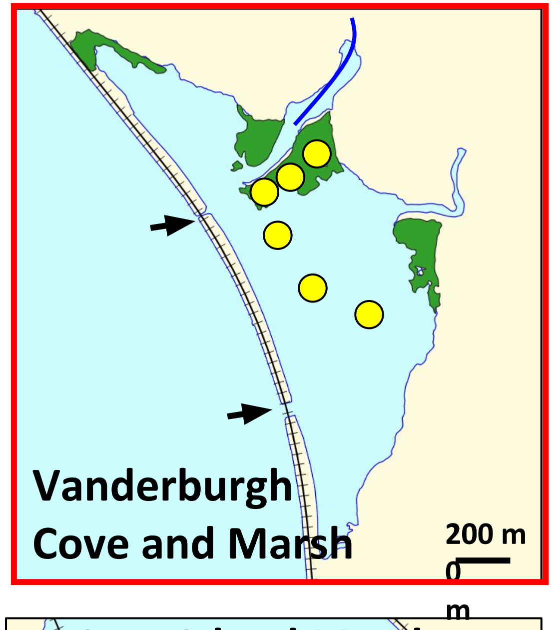
- Annual sediment delivery to estuary = 1.2 Mt
- Sediment trapped in impoundments = 5 Mt
- Effects of dam removal are local and short lived

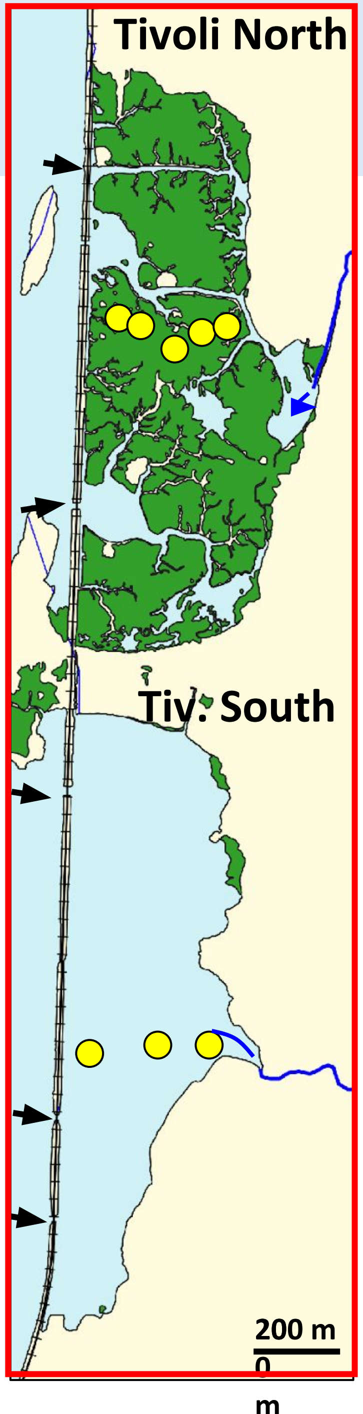
What about the marshes?

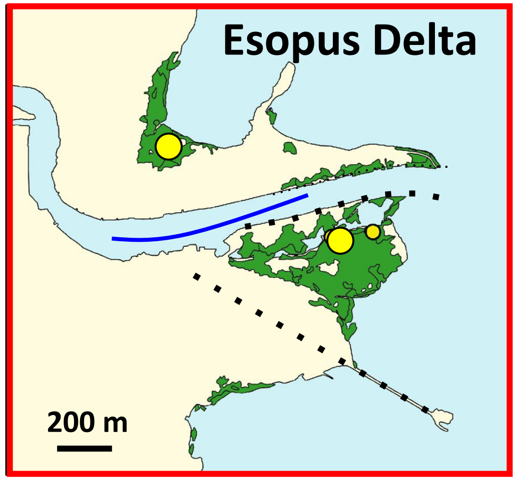
anthropogenic marshes

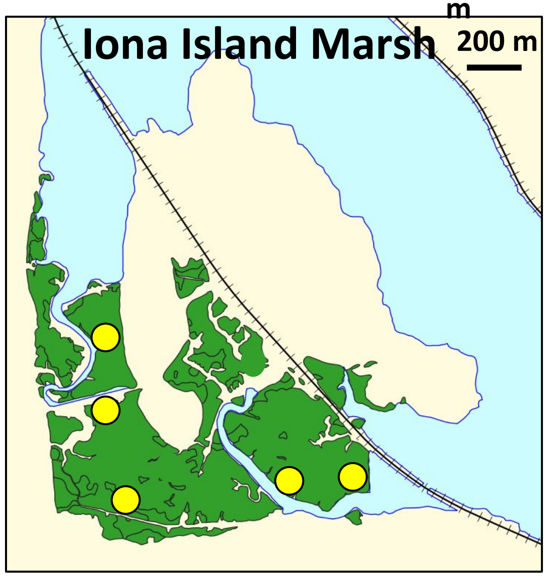












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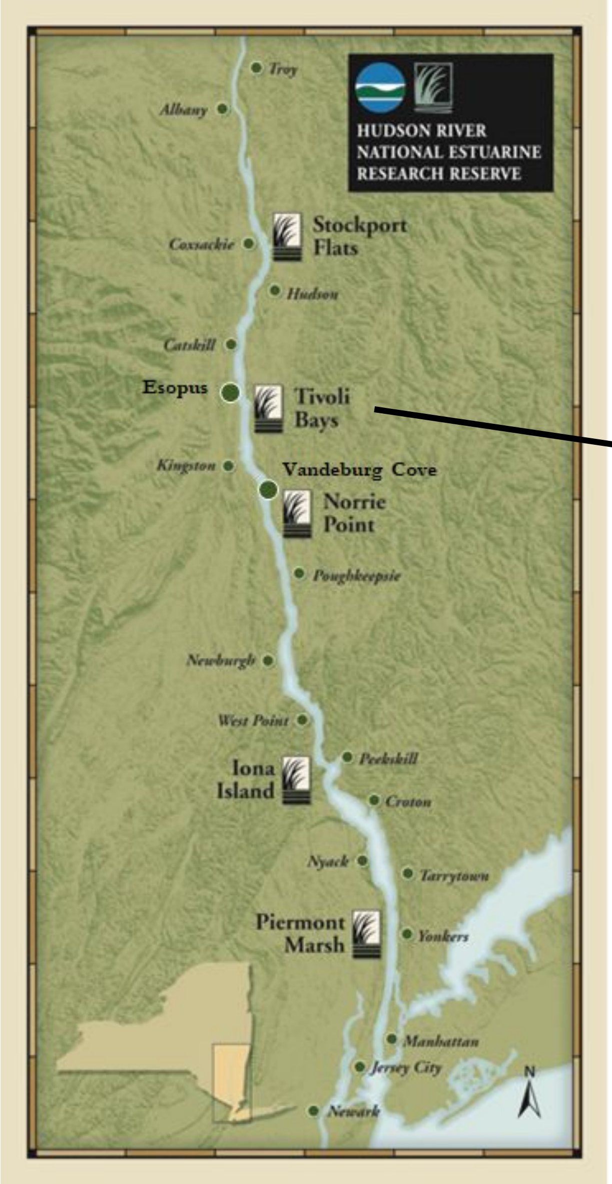
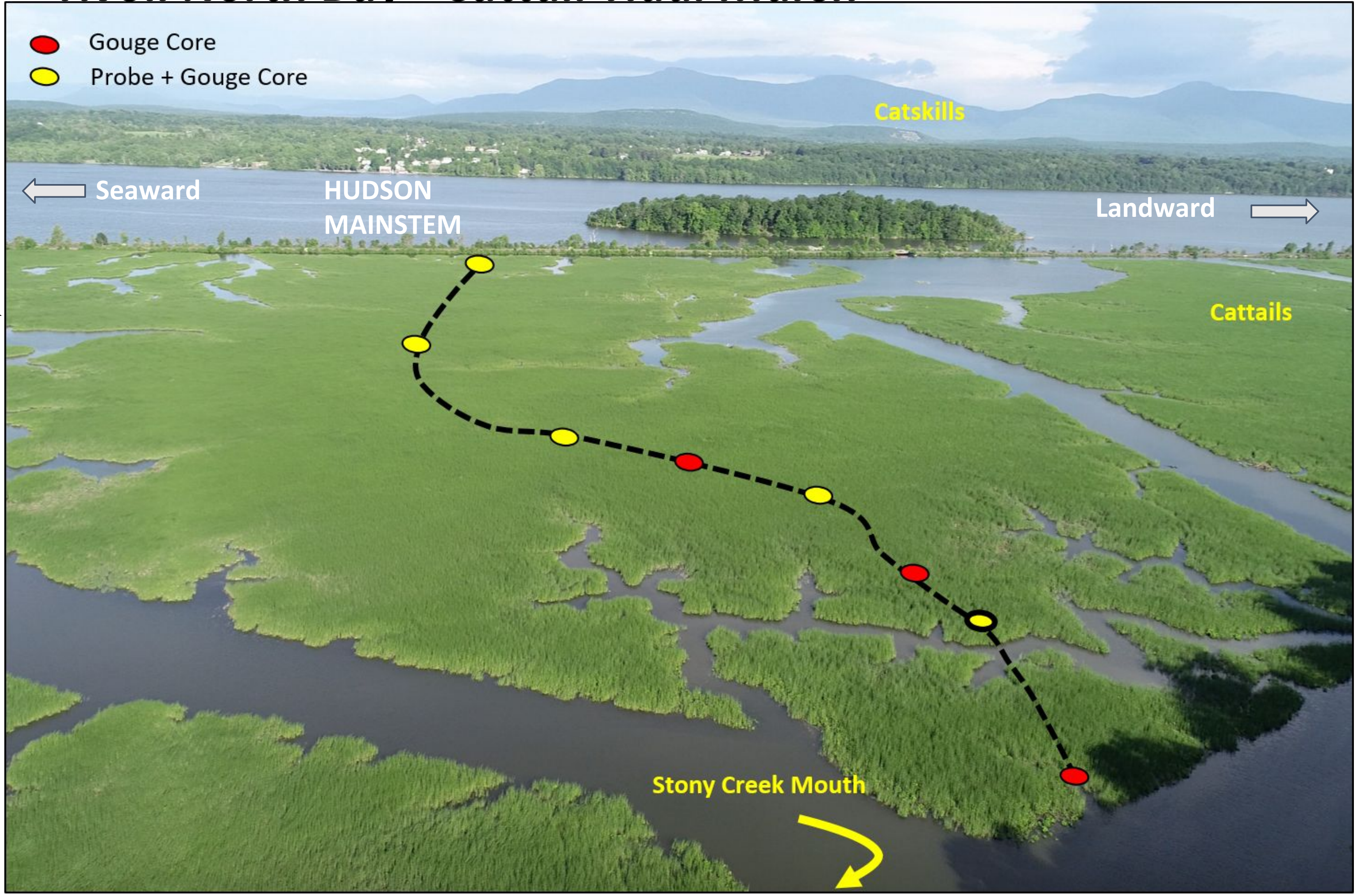
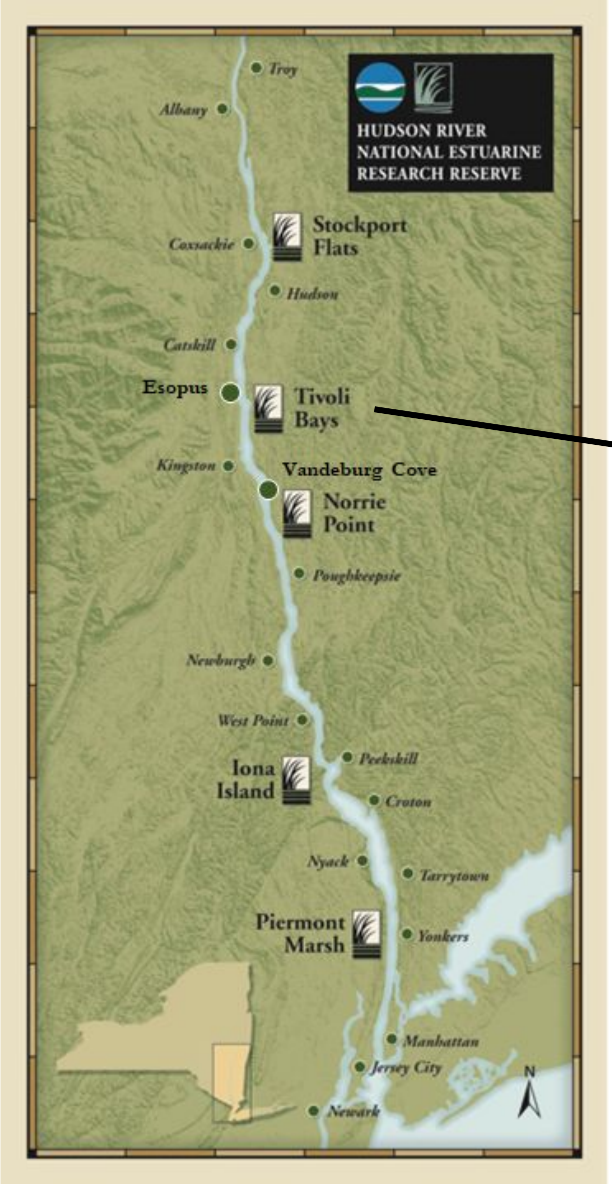
What about the marshes?

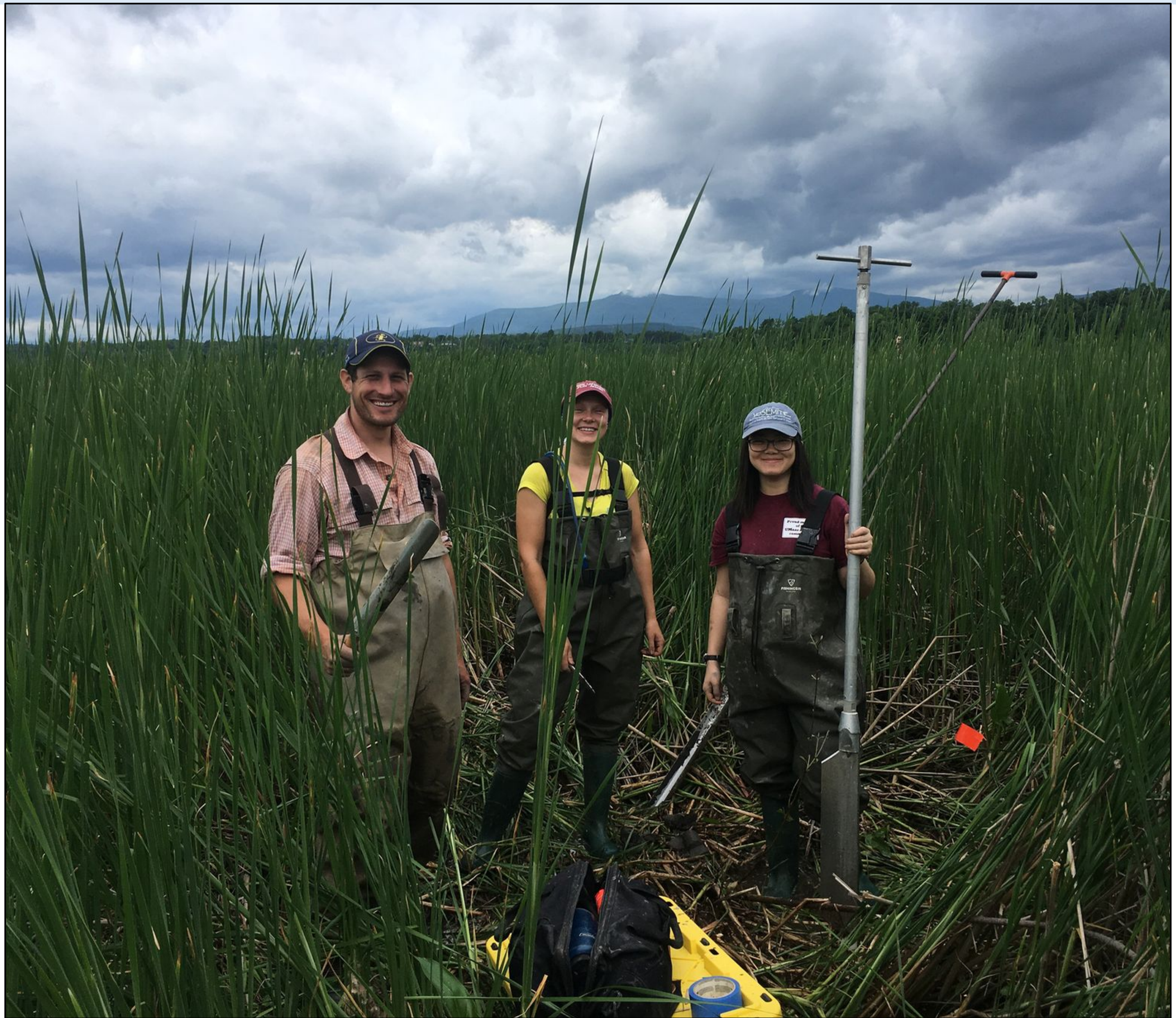


Tivoli North Bay - Cattail Tidal Marsh



What about the marshes?

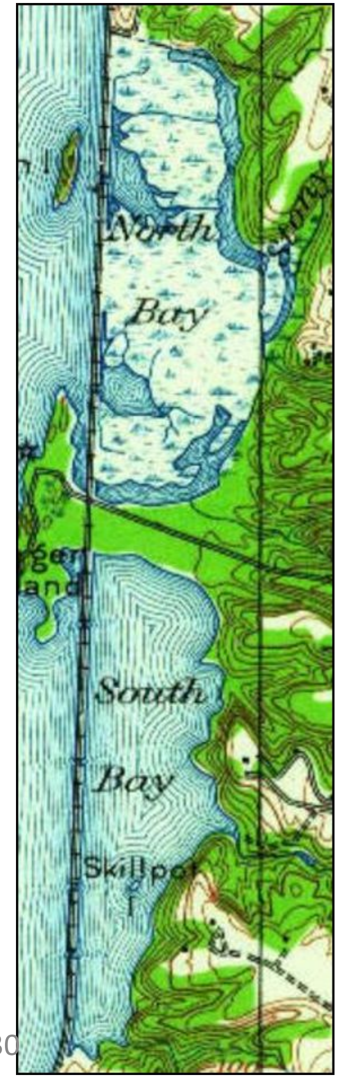




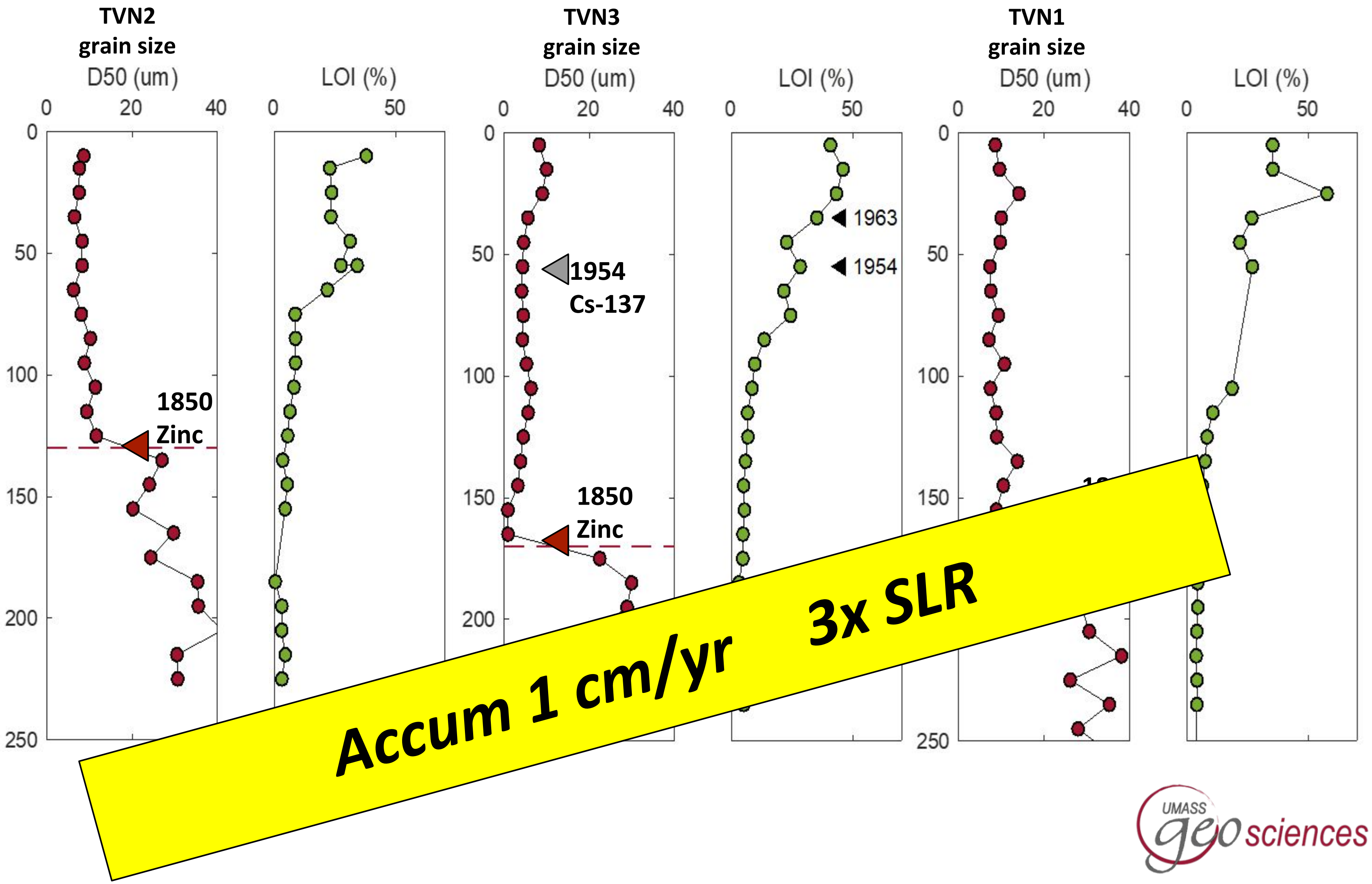
Tivoli Marsh developmental history

DASH
Dams and Sediment in the Hudson

Catskill, 1934



Google Earth, 2017



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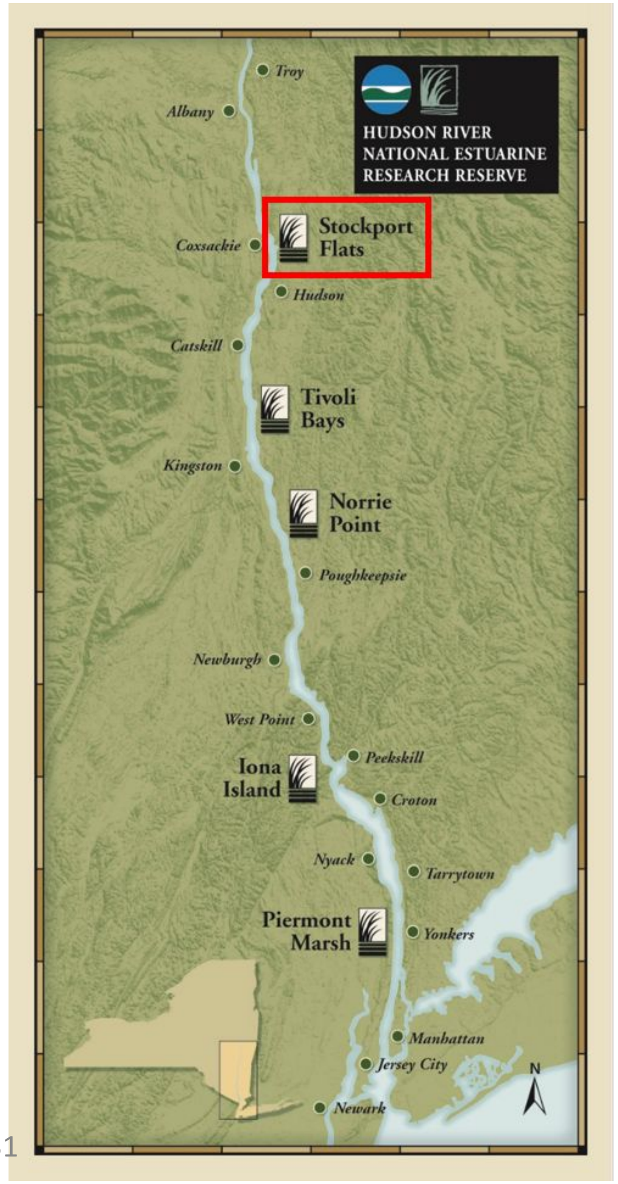
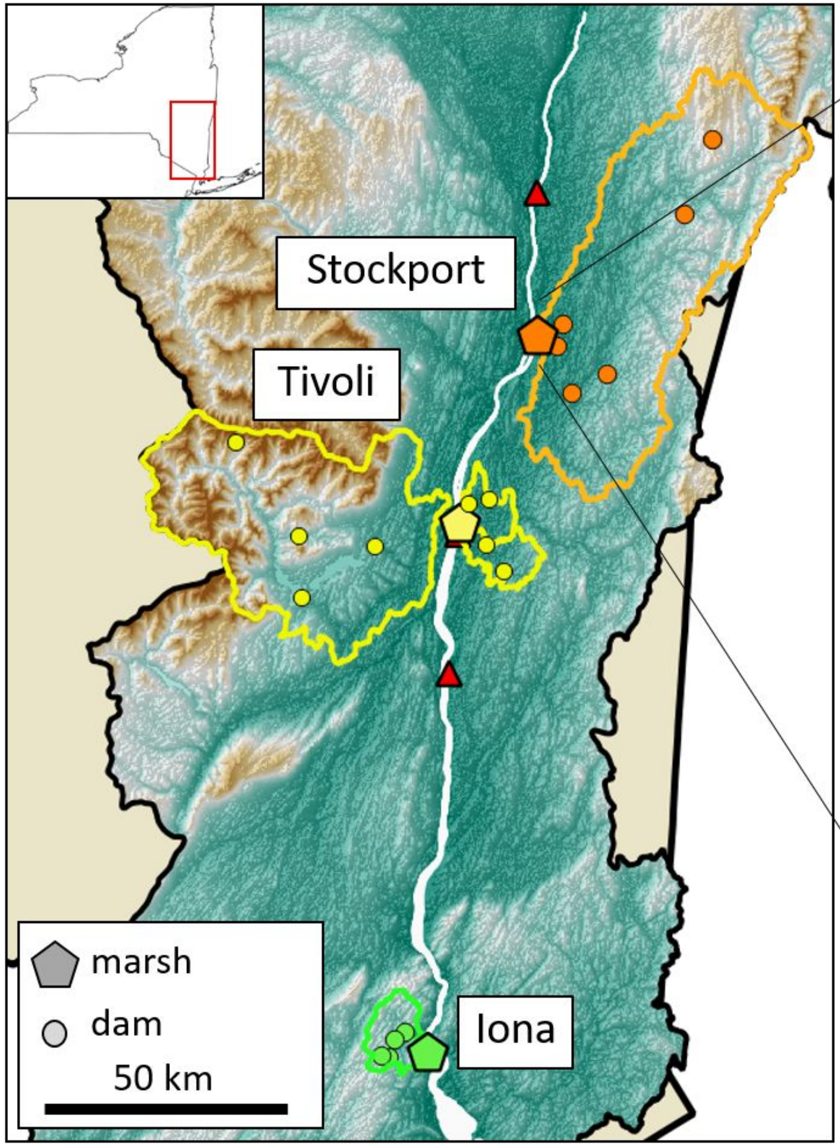
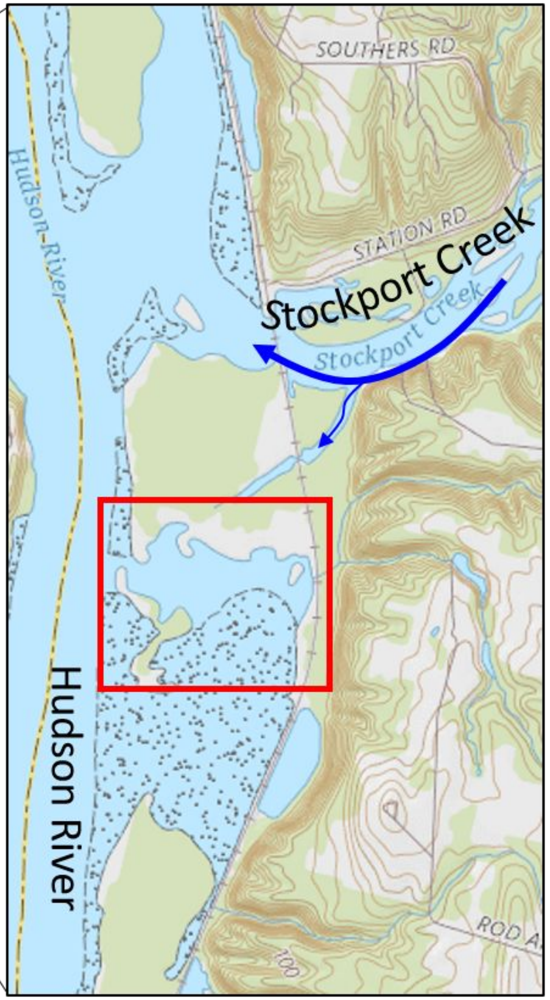
Stockport Marsh developmental history

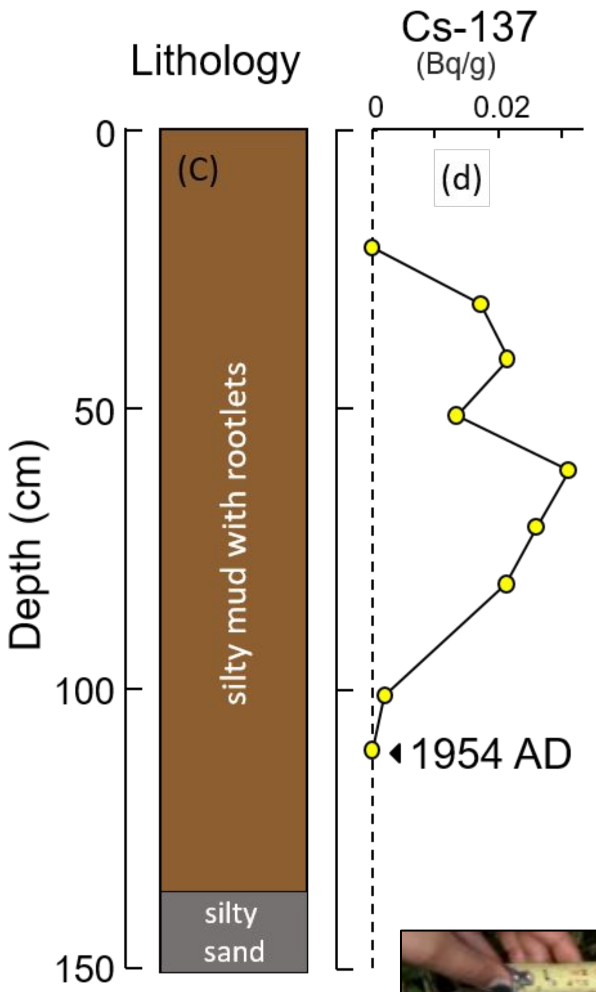


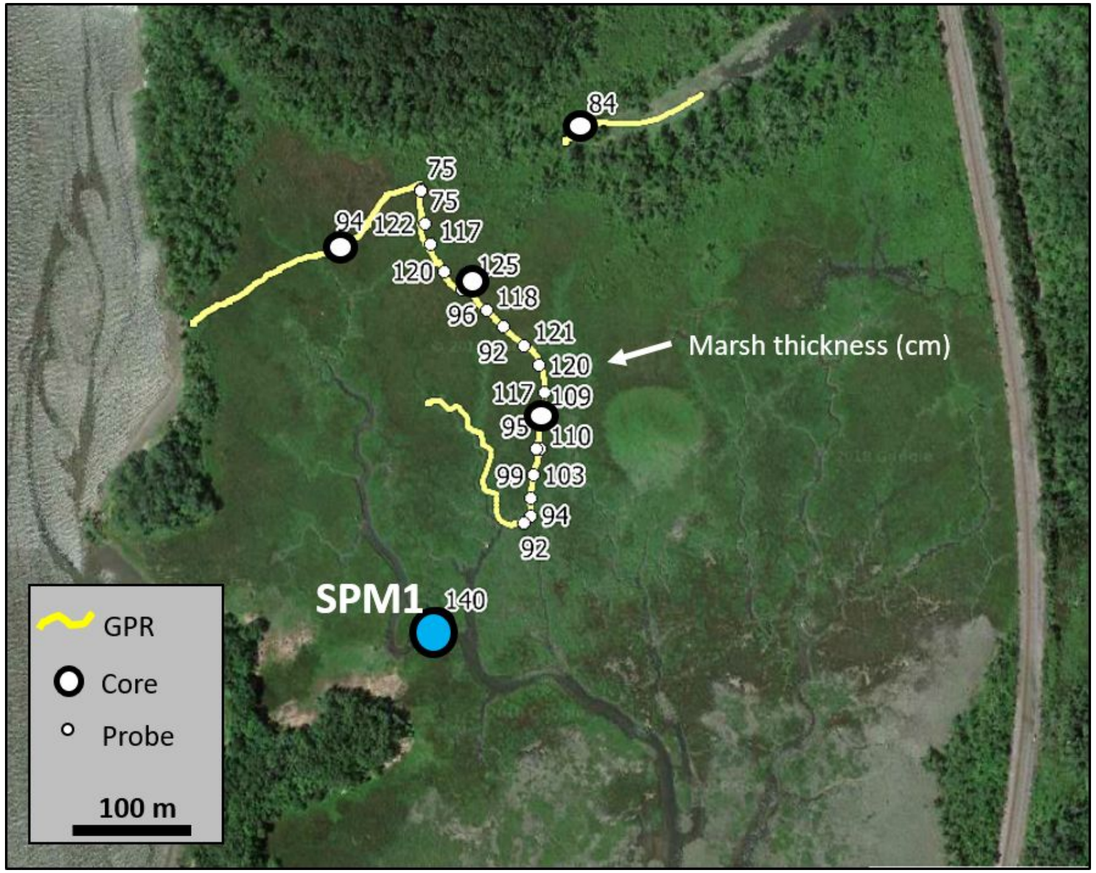


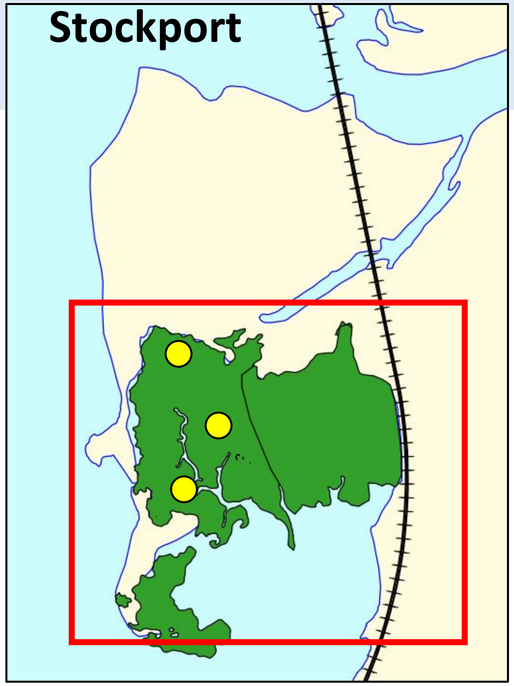


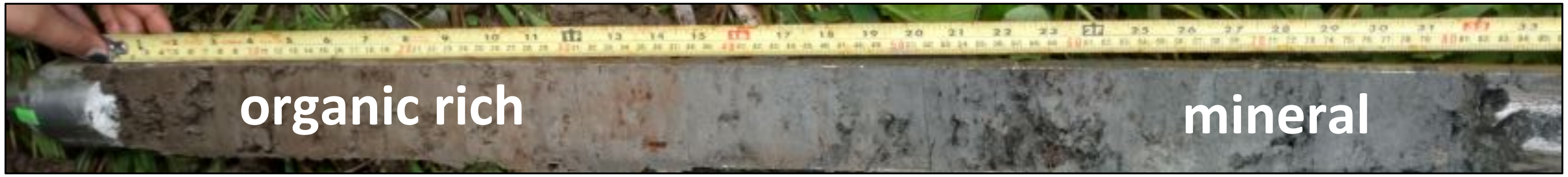
Stockport Marsh developmental history

Accumulating 10+ mm/yr!





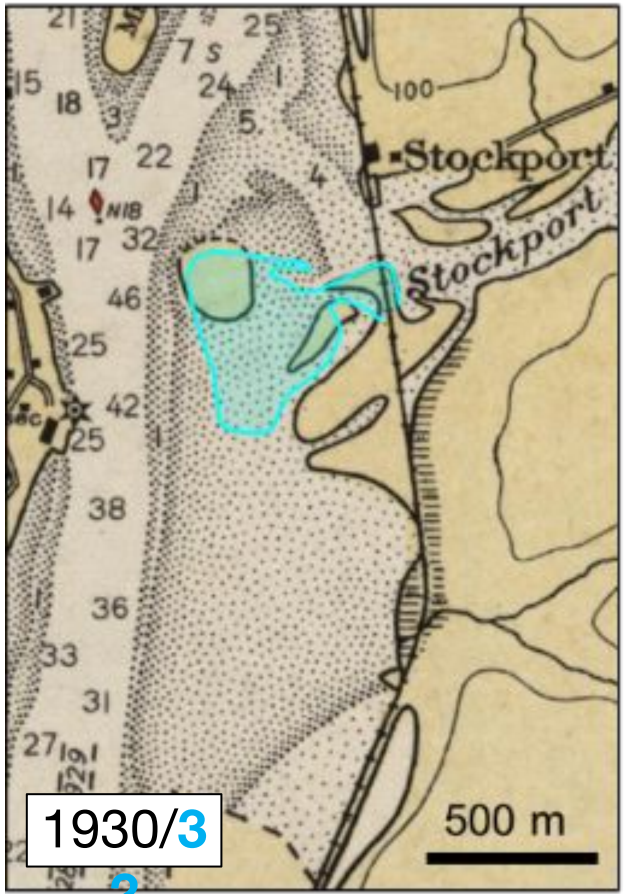


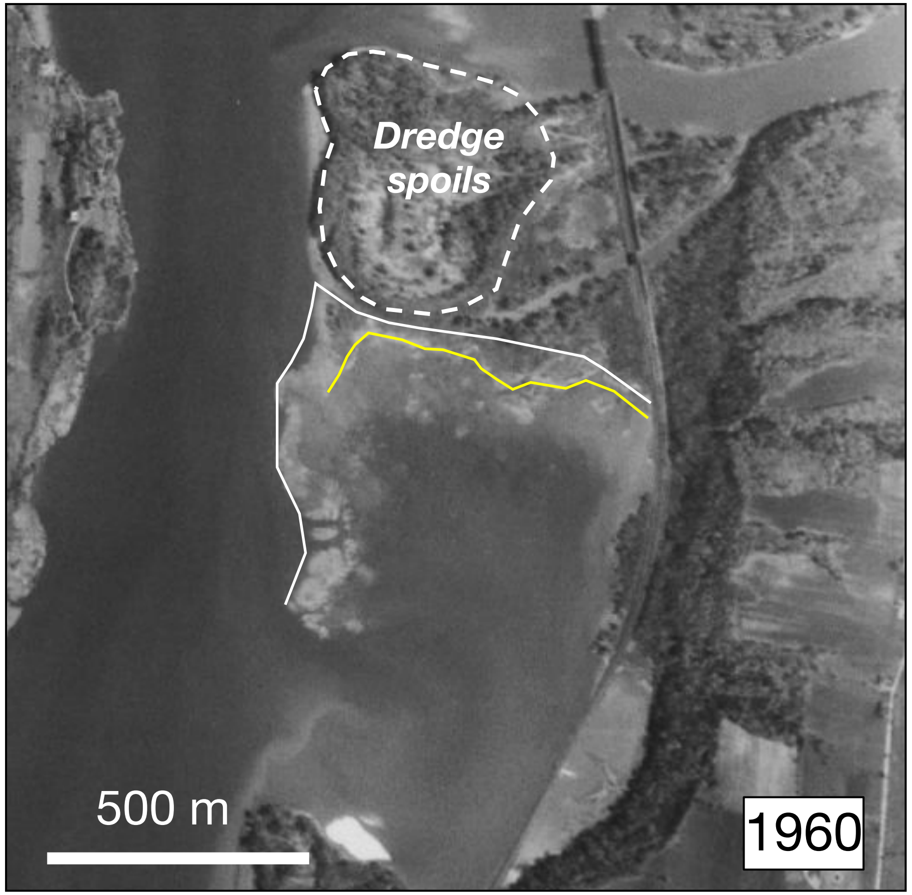


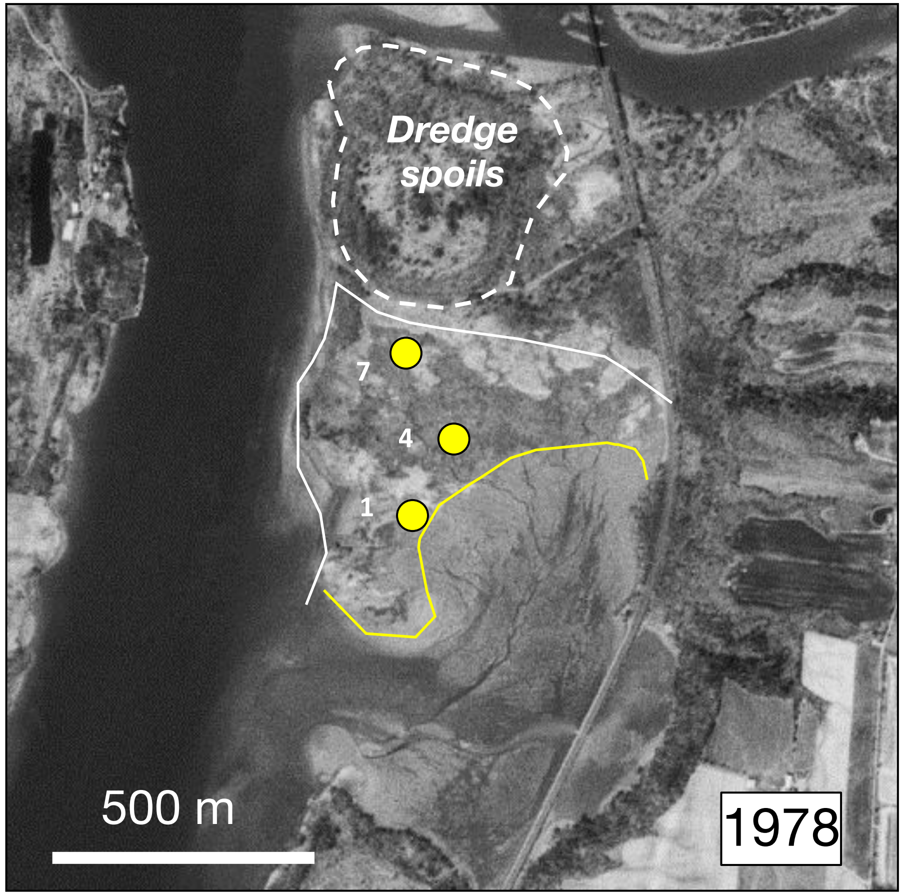
Stockport Marsh developmental history

Dams and Sediment in the Hudson

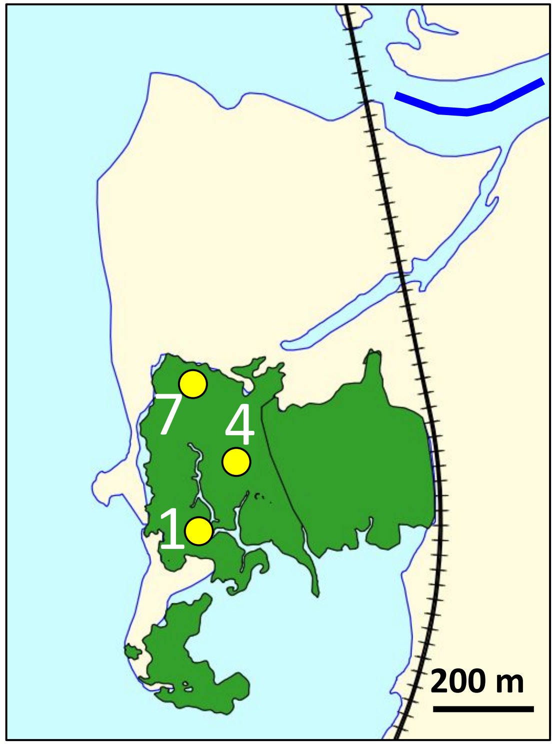
An inadvertent experiment in marsh seeding *...success!*

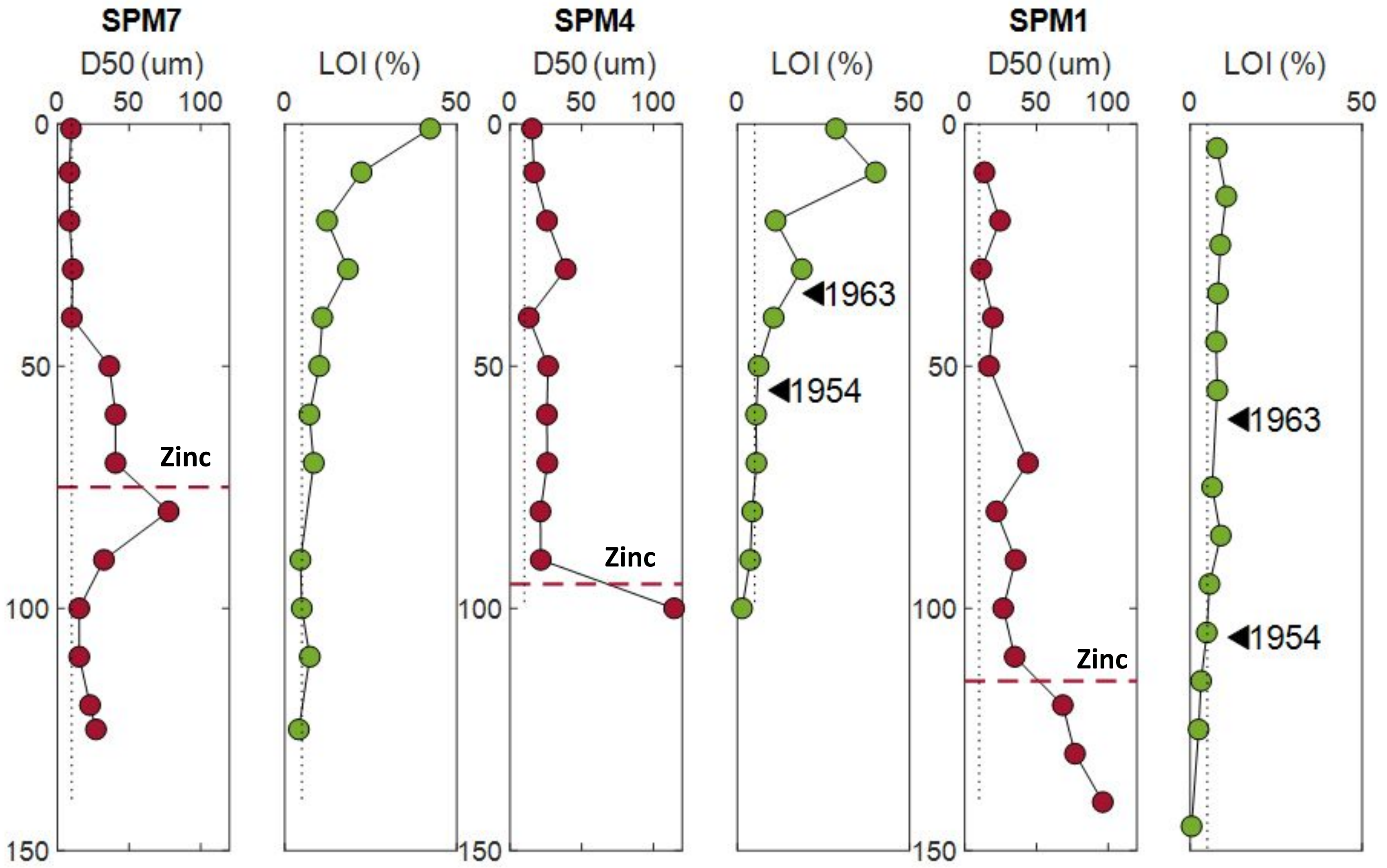






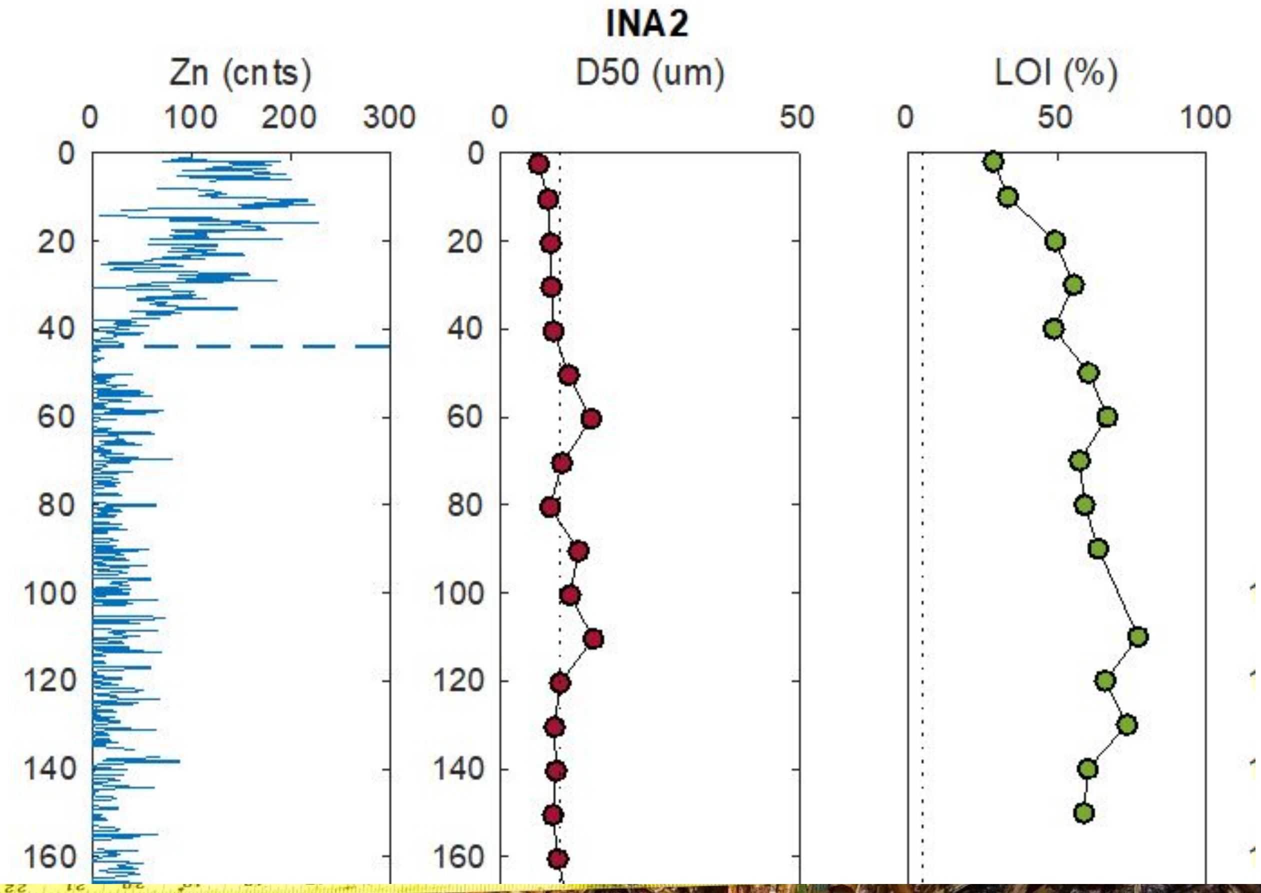
Stockport Marsh developmental history

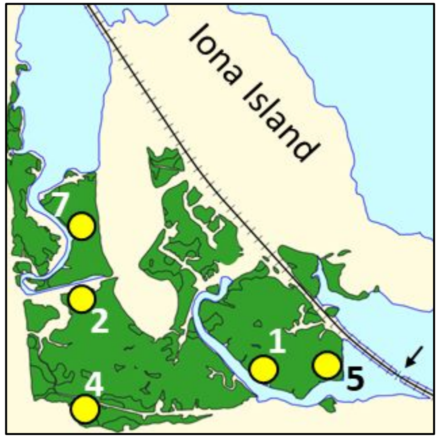




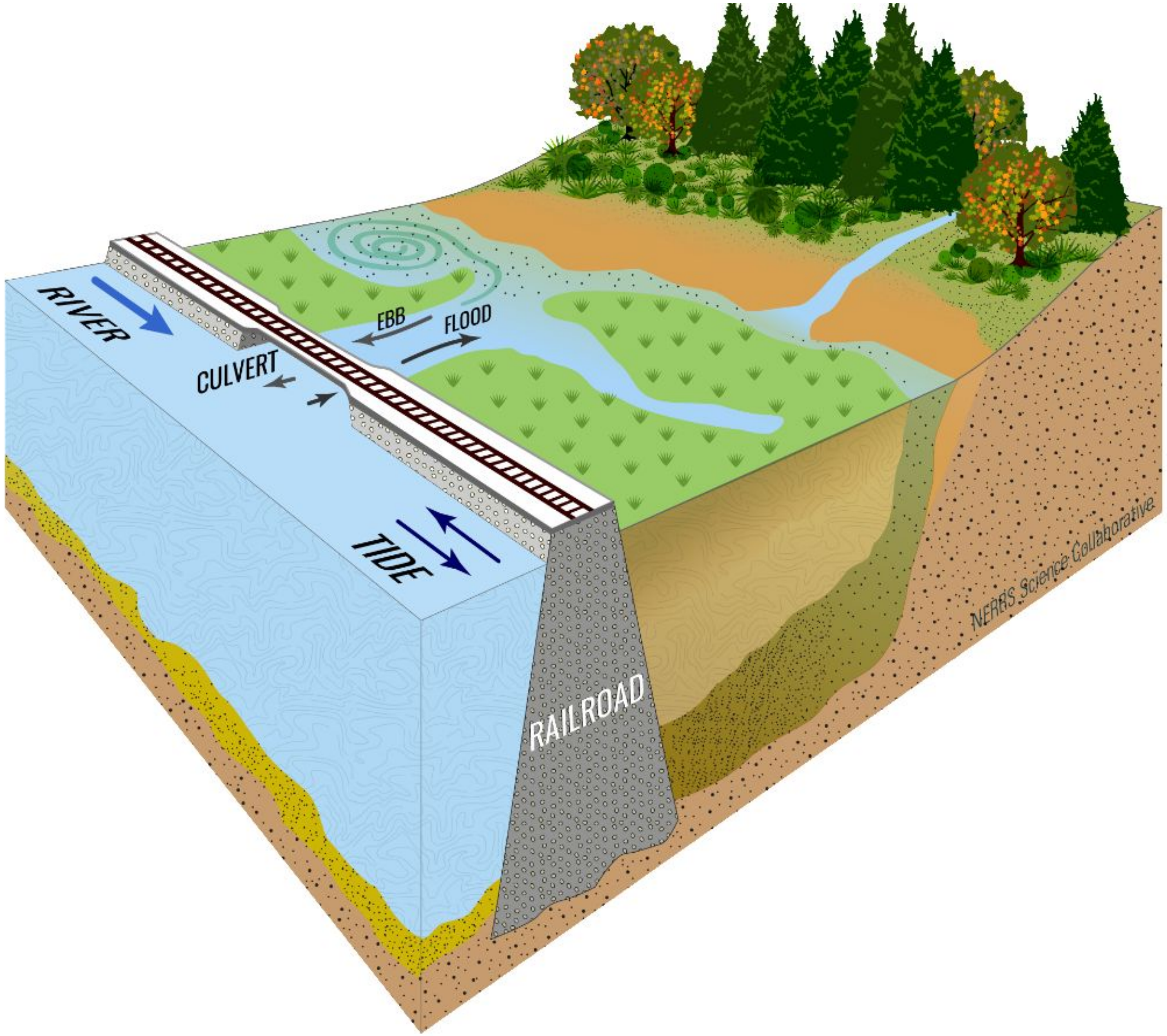
Iona Island Marsh

Iona Island Marsh





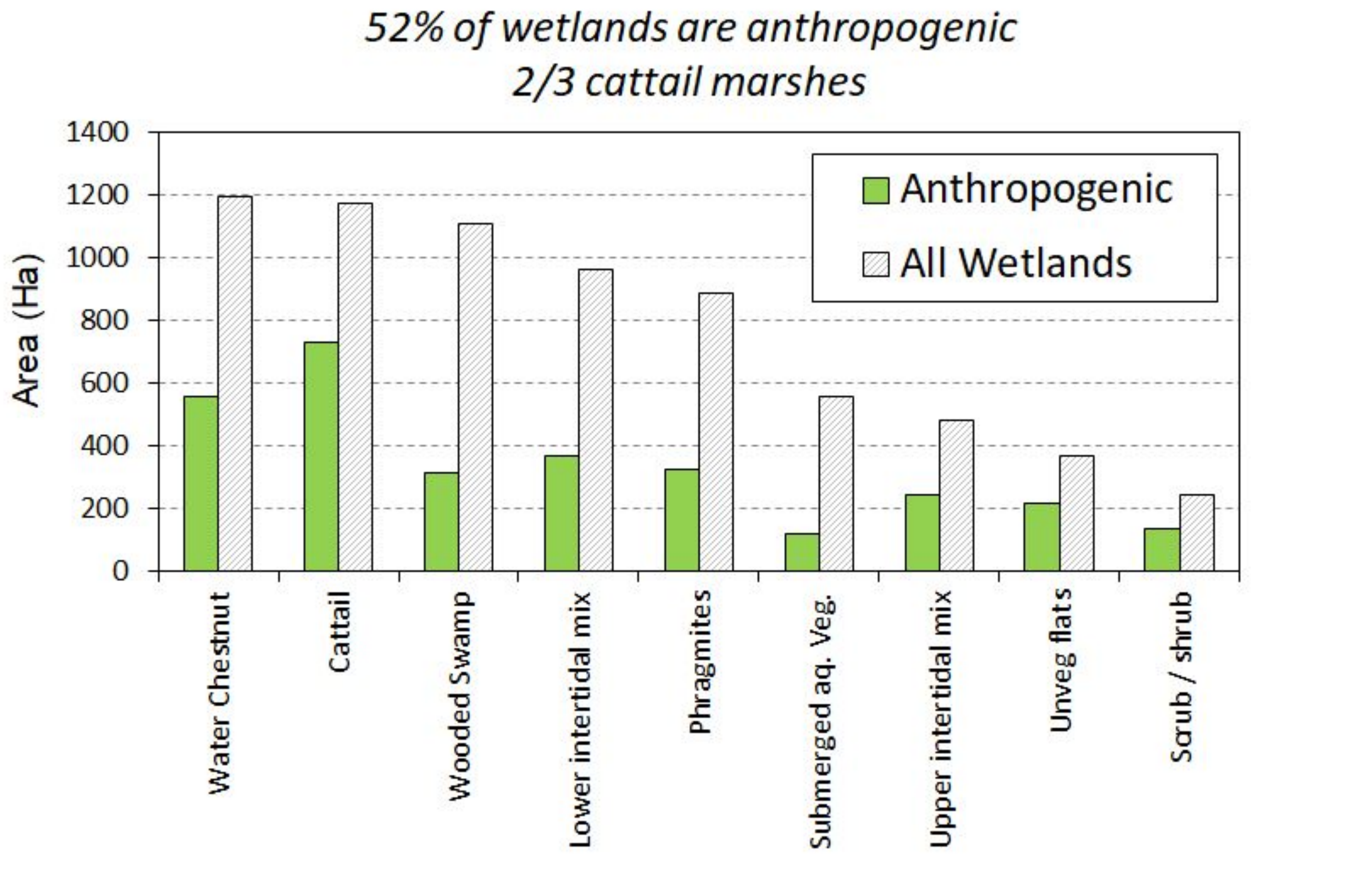
Net result of channel modifications



More than half of Hudson marshes are anthropogenic

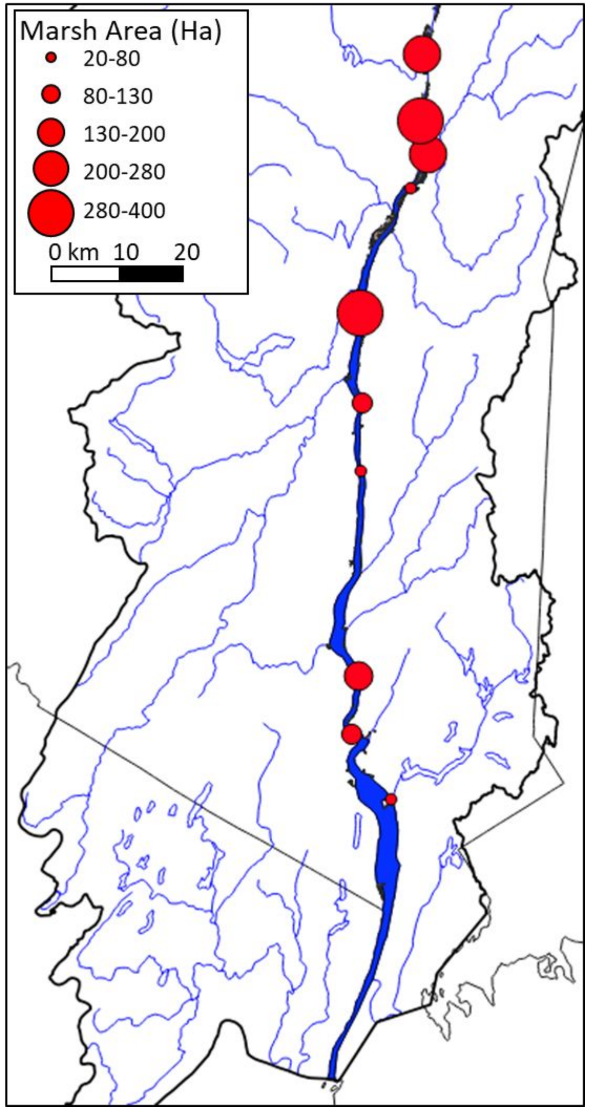
Trap ~ 7% of annual sediment load

Anthropogenic Marsh characteristics

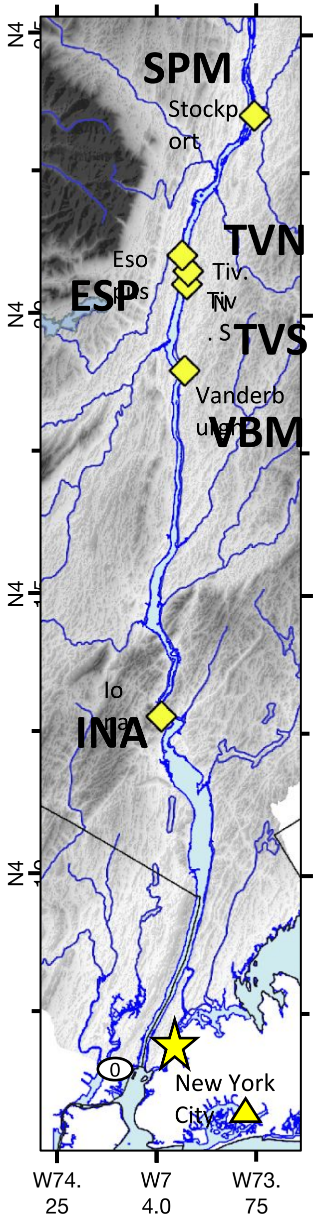


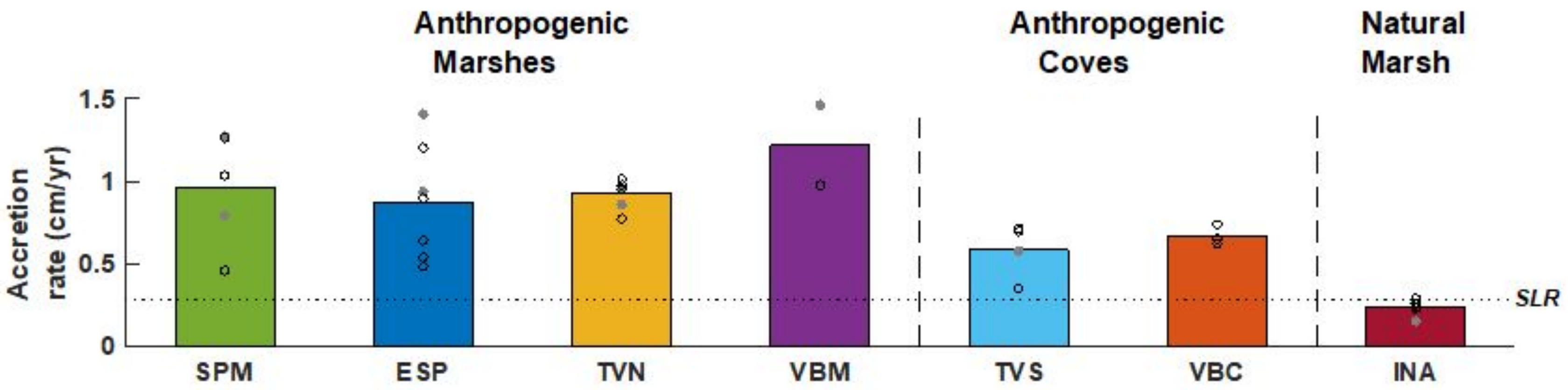
Data: Cornell Institute for Resource Information Sciences, 2011

Anthropogenic Marshes

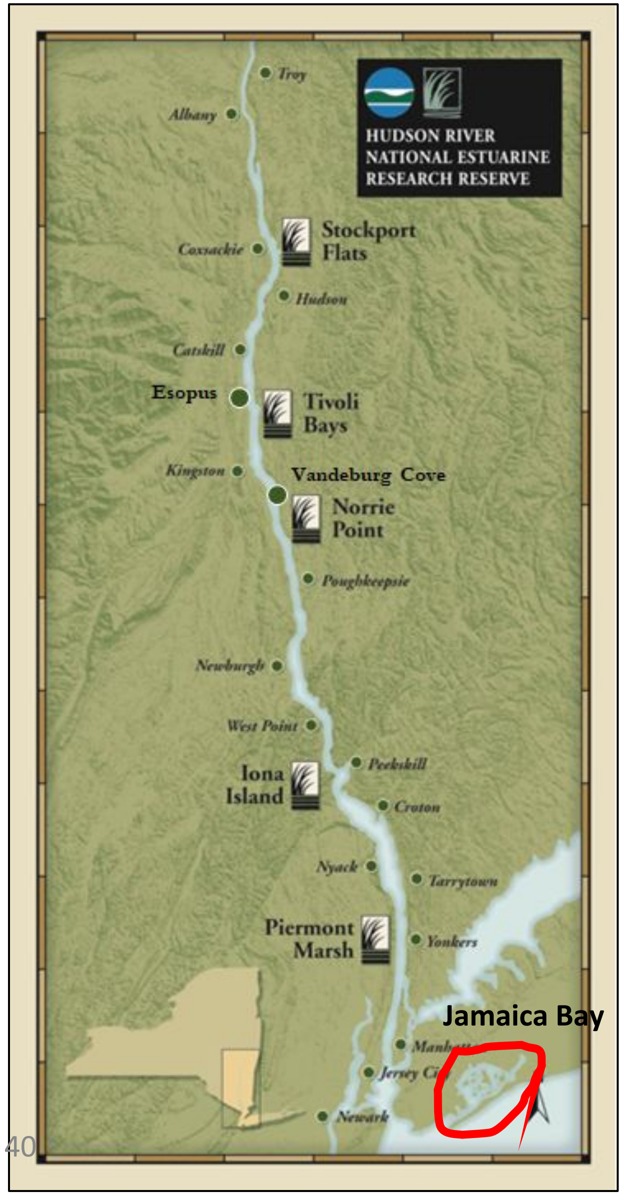


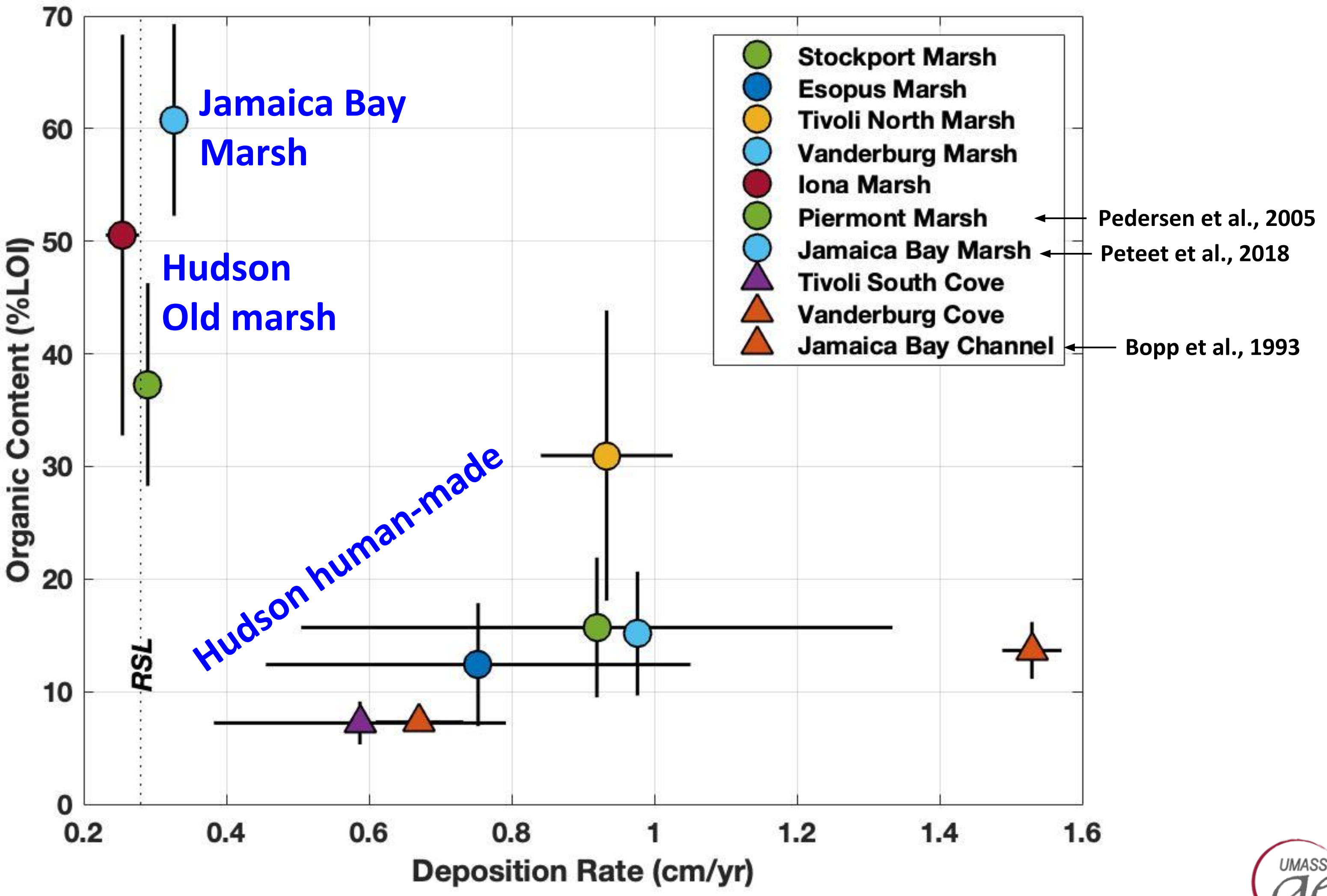
Contrasting new and old marshes (and coves)





Regional sediment comparison

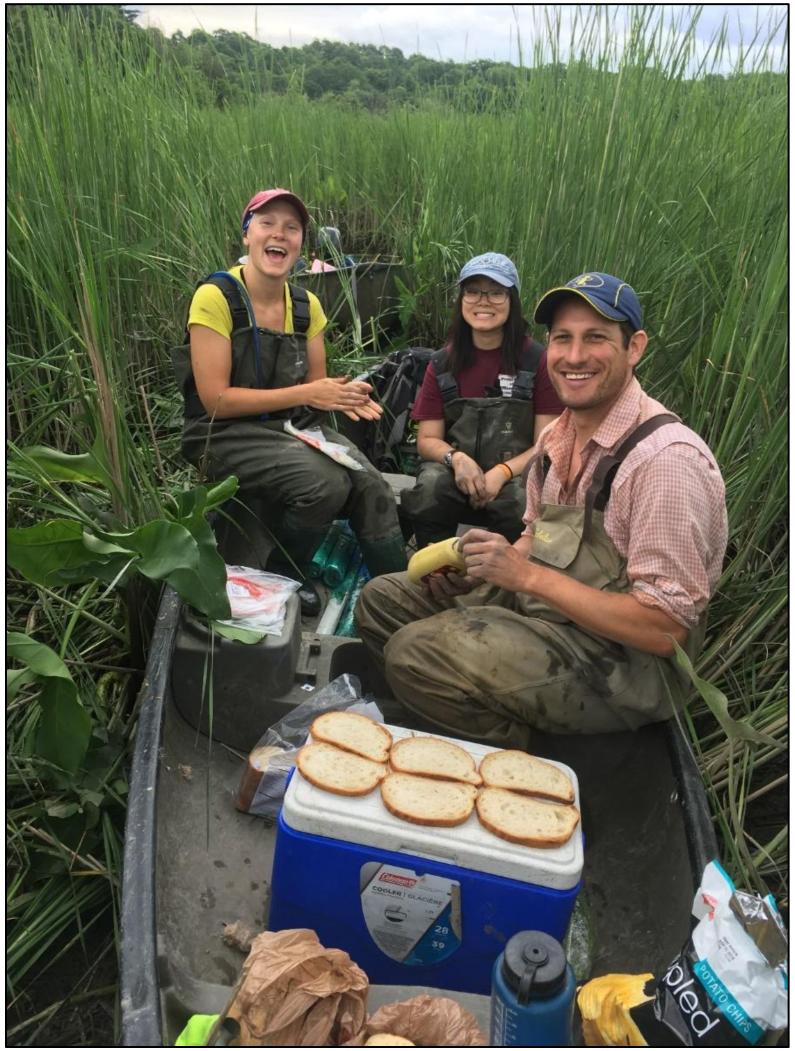




What's next for marsh studies?

Dams and Sediment in the Hudson

1. Quantify modern sediment trapping across seasons, tidal cycles.
2. Identify locations where marsh is likely to develop
3. Examine potential impacts to marshes of a surge barrier



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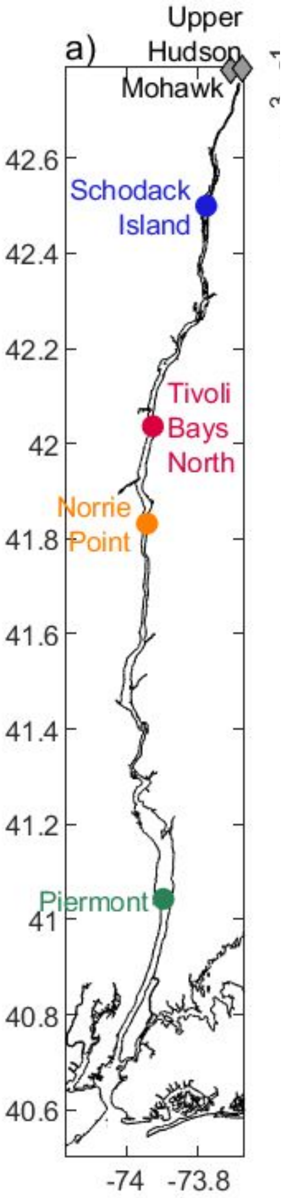
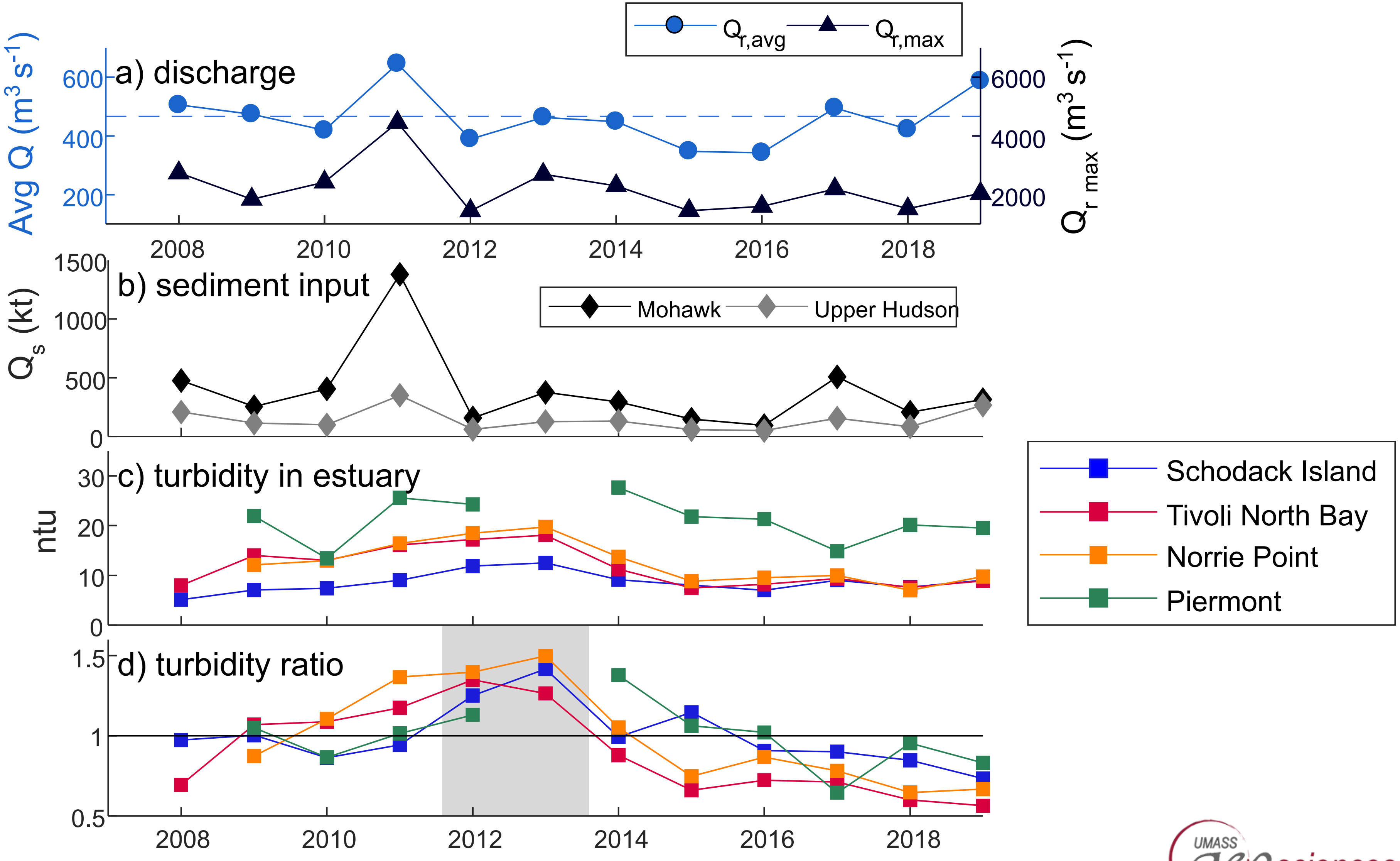
Hurr. Irene turbidity lasted 2 years after 2011



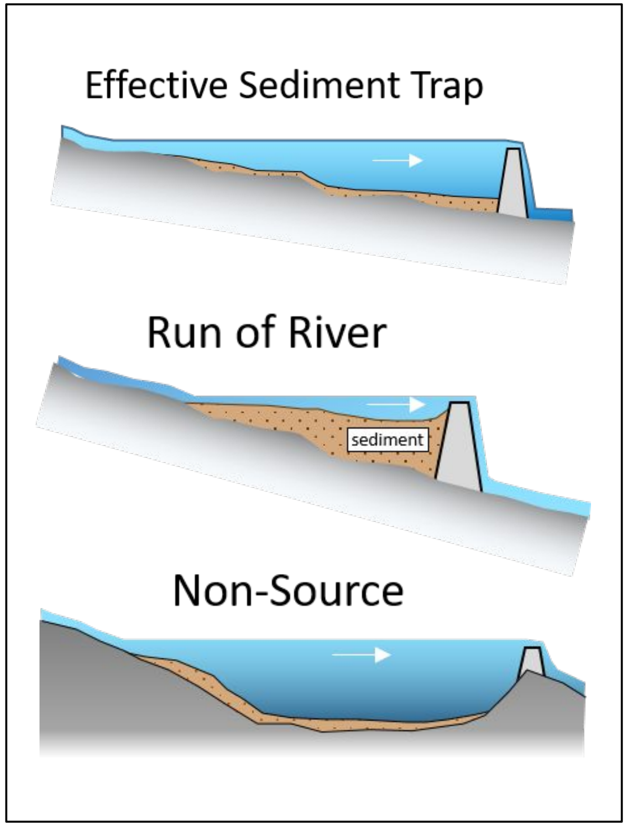


Ralston et al., 2020

Conclusions (paper summaries)

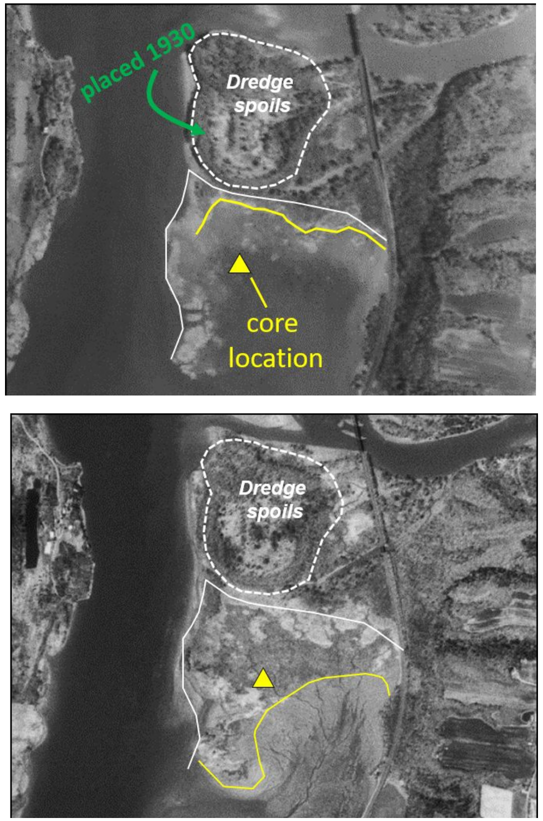
DaSH
Dams and Sediment in the Hudson

1. Watershed sediment supply and potential impacts of dam removals for an estuary



Small role of dams

2 . Rapid Tidal Marsh Development in Anthropogenic Backwaters



50% marshes are human-made

3. Turbidity hysteresis in an estuary and tidal river following an extreme discharge event

Turbidity lingered for ~2 yr after Irene

Geophysical Research Letters

RESEARCH LETTER
10.1029/2020GL088005

Turbidity Hysteresis in an Estuary and Tidal River Following an Extreme Discharge Event

Citations

Bopp, R.F., Simpson, H.J., Chillrud, S.N., Robinson, D.W., 1993. Sediment-derived chronologies of persistent contaminants in Jamaica Bay, New York. Estuaries 16, 608–616.

Pederson, D.C., Peteet, D.M., Kurdyla, D., Guilderson, T., 2005. Medieval Warming, Little Ice Age, and European impact on the environment during the last millennium in the lower Hudson Valley, New York, USA. Quaternary Research 63, 238–249. https://doi.org/10.1016/j.yqres.2005.01.001

Peteet, D.M., Nichols, J., Kenna, T., Chang, C., Browne, J., Reza, M., Kovari, S., Liberman, L., Stern-Protz, S., 2018. Sediment starvation destroys New York City marshes' resistance to sea level rise. PNAS 115, 10281–10286. https://doi.org/10.1073/pnas.1715392115

Ralston, D.K., Yellen, B., Woodruff, J.D. and Fernald, S., 2020. Turbidity hysteresis in an estuary and tidal river following an extreme discharge event. Geophysical Research Letters, 47(15), doi.org/10.1029/2020GL088005.

Preprint Manuscripts

Ralston, D., Yellen, B., Woodruff, J., 2020. Watershed sediment supply and potential impacts of dam removals for an estuary (preprint). Earth and Space Science Open Archive. https://doi.org/10.1002/essoar.10502519.1

Yellen, B., Woodruff, J., Ralston, D., Ladlow, C., Fernald, S., Lau, W., 2020. Rapid Tidal Marsh Development in Anthropogenic Backwaters (preprint). EarthArXiv. https://doi.org/10.31223/osf.io/ga5pm

Q&A

Use the "Questions" function in the GoToWebinar console

Sarah Fernald
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Woods Hole
Oceanographic Institution

National Estuarine
Research Reserve System
Science Collaborative

Q&A

Q: Some of your site photos (e.g. Iona) seem to show a lot of invasive *Phragmites* vegetation. How have identified vegetation species affected marsh sediment dynamics? Does *Phragmites* (or other vegetation changes) explain the increase in organic content shown in sediment cores?

- **A:** There is a massive *Phragmites* infestation at Iona, and there are ongoing mitigation efforts underway. We don't see big changes in the lithology going downcore; if anything there's a slight decrease in the organic content of the sediment at the surface, and we actually hadn't considered that that could have been explained by the introduction of *Phragmites*. We can't say for sure at the moment - it's definitely a question we have at other locations like Piermont, which is irregularly flooded and sits at a higher elevation. This has led to concerns that the Piermont could see decreased sediment input.

Q: It looks promising that marshes can be formed - 50% of current marshes seems high. Do you have context for marsh area gained and lost over time (e.g., NYC)?

- **A:** While some locations such as Piermont and Jamaica Bay seem to be seeing some erosion, overall marsh loss has not been significant. We are currently in the process of conducting a study to remap all of the tidal wetland areas within the Hudson to analyze the extent of these changes since 2007.

Q: Are the big dams used for hydropower or used to store water, and how does the different usage of the dams influence the sediment retention?

- **A:** The two biggest impoundments (Ashokan and Rondout) are for water supply. Some of the biggest individual sediment stores that can potentially be mobilized are in run of river dams on large rivers, such as the Esopus, Claverack, Catskill Creek, Fishkill Creek etc. However, the high flow velocities of these large rivers and low water residence times prevent further sediment trapping at these sites. Rather, many of these sites likely filled up within a very short period of time, reflecting the high sediment loads of these larger rivers relative to impoundment volumes.

Q: How influential is the Mohawk River to the sediment dynamics of the Hudson?

- **A:** The Mohawk is the single biggest source of sediment to the tidal Hudson, with about 0.5 Mt annual input compared to the total of about 1.2 Mt.

Q: Can you place the sediment load from Irene in context of the annual sediment load?

- **A:** The sediment input from Irene and Lee was about 2.7 Mt, compared with the annual sediment load of about 1.2 Mt.

Q: How did your advisory group react to these findings, and do you see them incorporating the ideas and tools into their work?

- **A:** A couple consultants were really excited by the prospect of getting the results to impact regulations. As far as reaction to the tidal wetland results, it was fairly impactful to hear that our tidal wetlands have been accreting at a rapid pace, and that sediment supply is rich in the Hudson looking ahead at sea level rise. We were also pleased and surprised by the diversity and level of engagement of end users who attended meetings and expressed interest.

Webinar Announcements

Upcoming Schedule

- **Decision Support for Siting of Shellfish Aquaculture**
  3.00 - 4.00 PM Eastern Time, October 20, 2020
  Speakers: Beth Darrow, Martin Posey, and Doug Bell
- **Measuring Climate Adaptation Success and Progress: System-wide Introduction to the Resilience Metrics Toolkit**
  3.00 - 4.00 PM Eastern Time, November 18, 2020
  Speakers: Kristen Goodrich and Susi Moser

Thank you for joining us

Please complete the short survey at the end of the webinar, and be on the lookout for the webinar recording!

Sarah Fernald
Research Coordinator
Hudson River NERR, NY

Brian Yellen
Research Assistant Professor
UMass Amherst

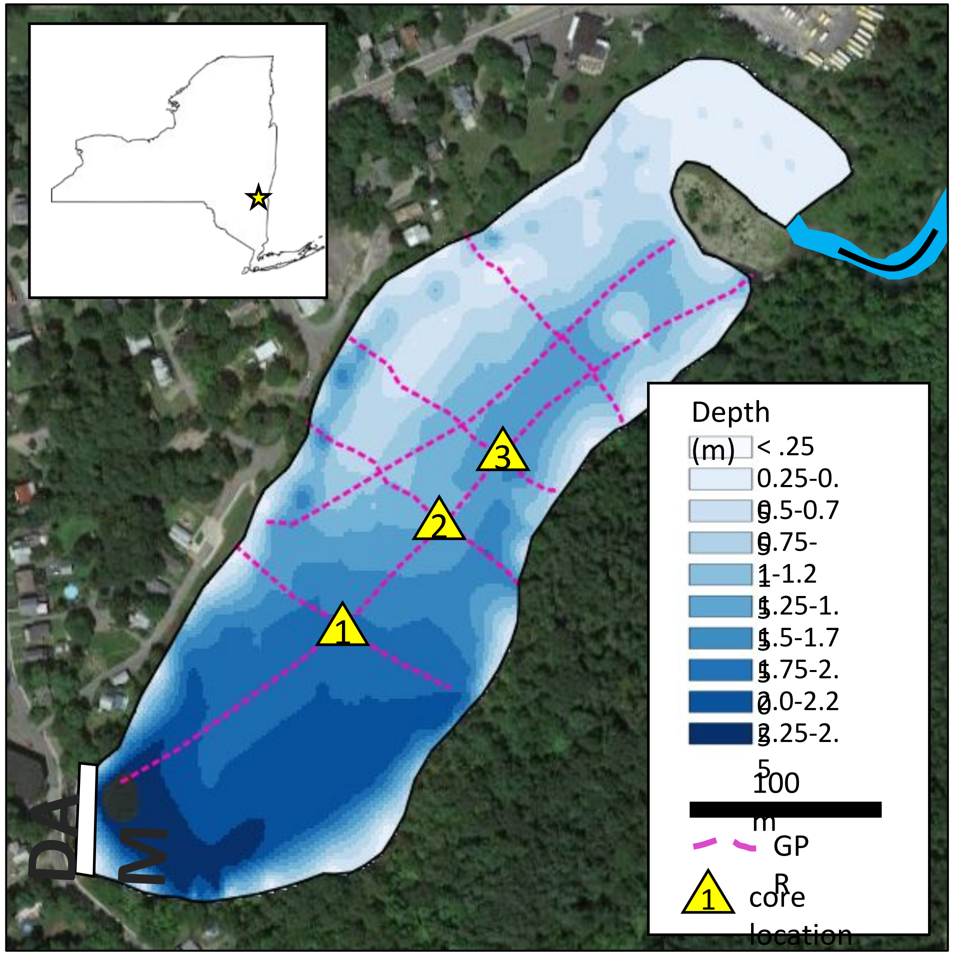
David Ralston
Associate Scientist
Woods Hole Oceanographic Institution

EXTRA SLIDES

Impoundment Flavors: (1) Effective Sediment Trap

Summit Lake - Philmont, NY

Watershed = 56 km^2

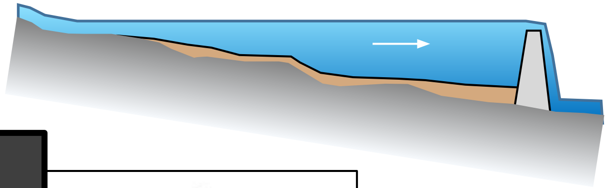


total sediment **mass**

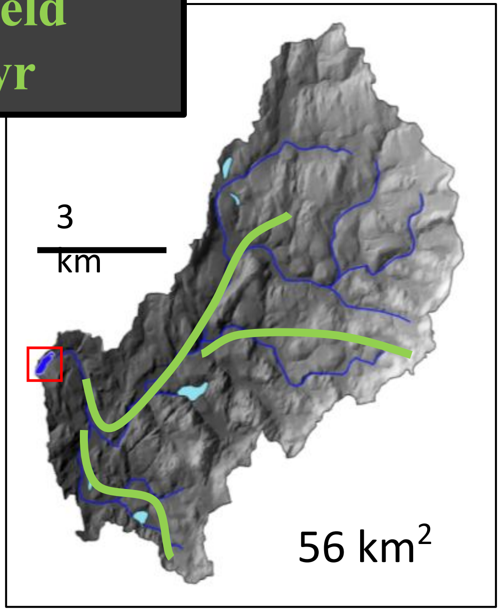
$$\mathbf{110{,}000}\ \boldsymbol{Tons}\ (\mathbf{1}\boldsymbol{T} = \mathbf{1000}\ \boldsymbol{kg})$$

Trapping Efficiency (Brune, 1953)

$$\mathbf{28\%}$$



Sediment yield
46 T/km^2/yr



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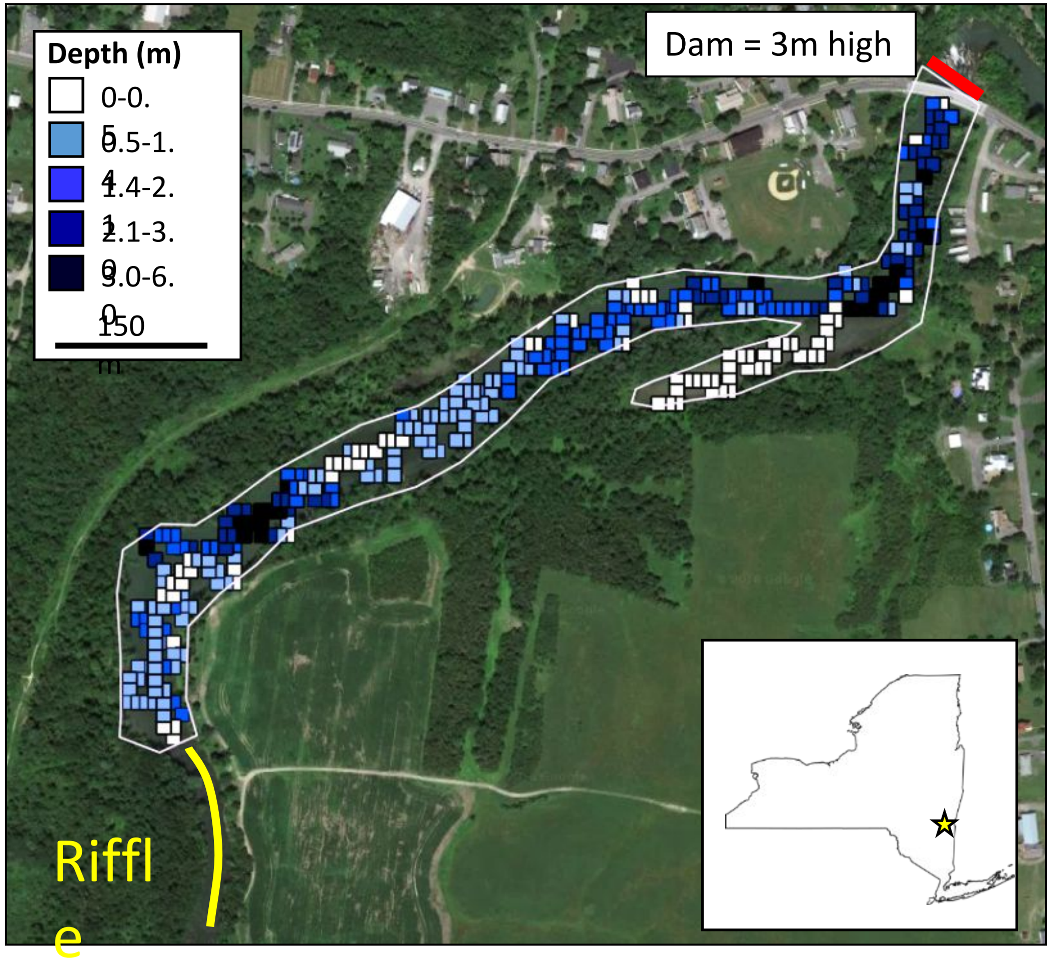
Impoundment Flavors: (2) Run of River

Stottville Dam

Watershed = 438 km^2



total sediment mass

$\mathbf{45,000\ \mathit{Tons}}$

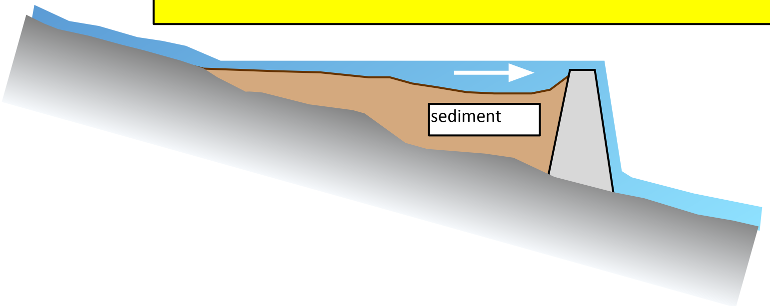
high flow residence time

$\mathbf{4\ \mathit{min}}$

time to settle silt

$\mathbf{1.2\ \mathit{hours}}$

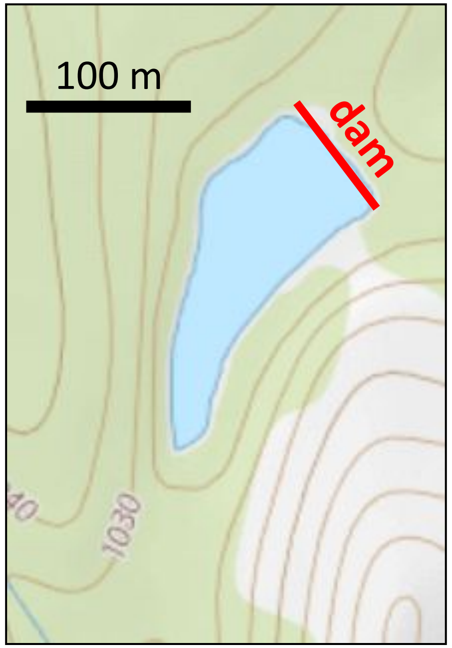
Trap < 1 T/km^2/yr
Trapping efficiency = 3%



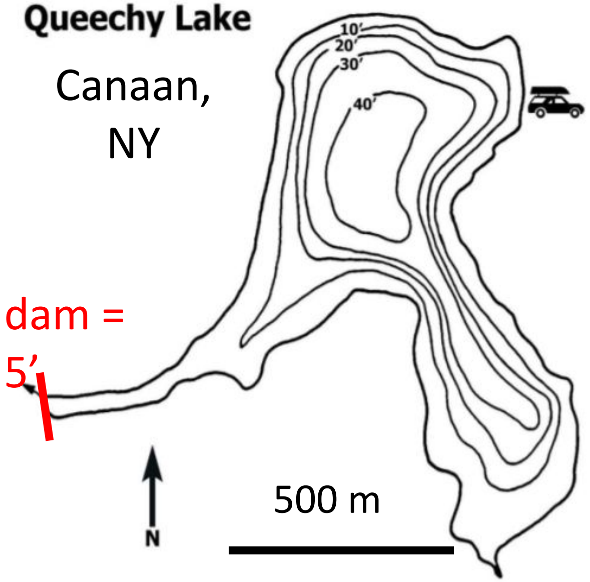
Impoundment Flavors: (3) Non-source

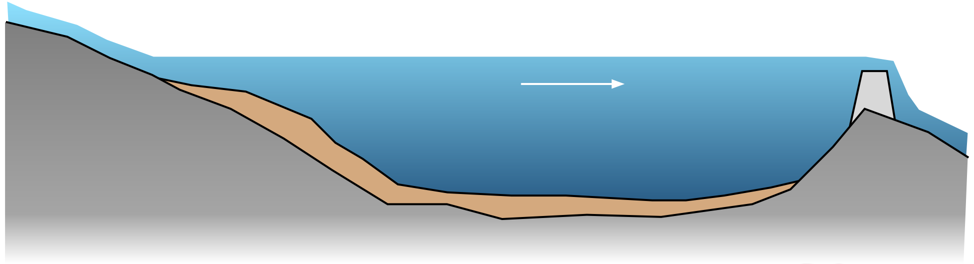
headwater ponds

Scafford Wildlife Marsh Dam
Chatham, NY

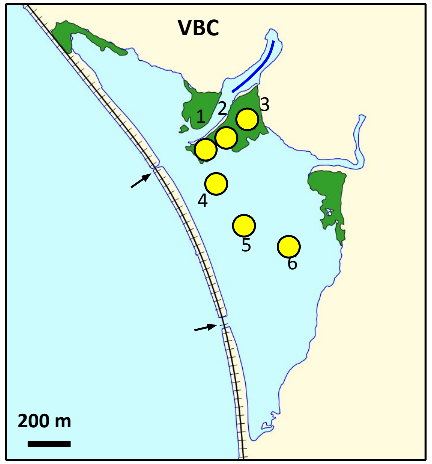


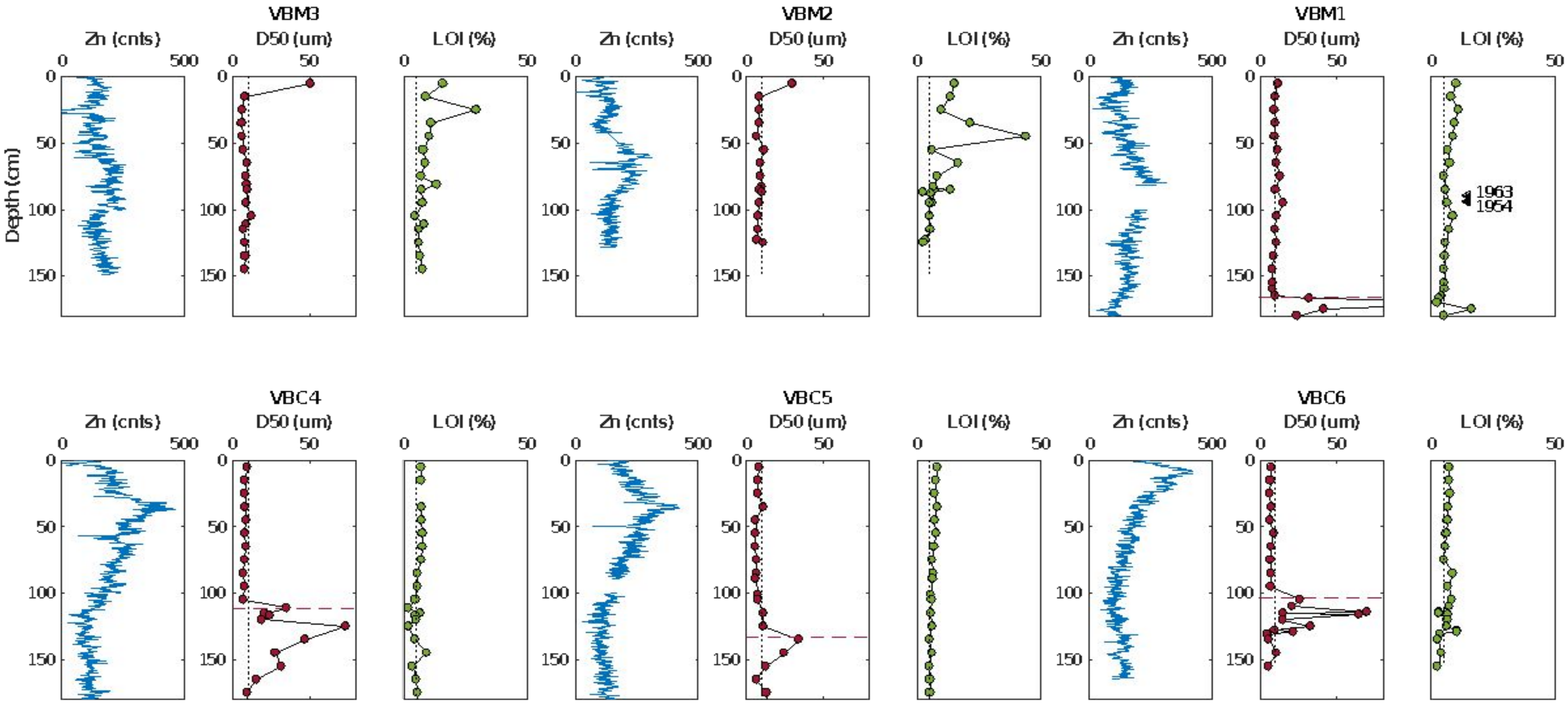
natural lakes



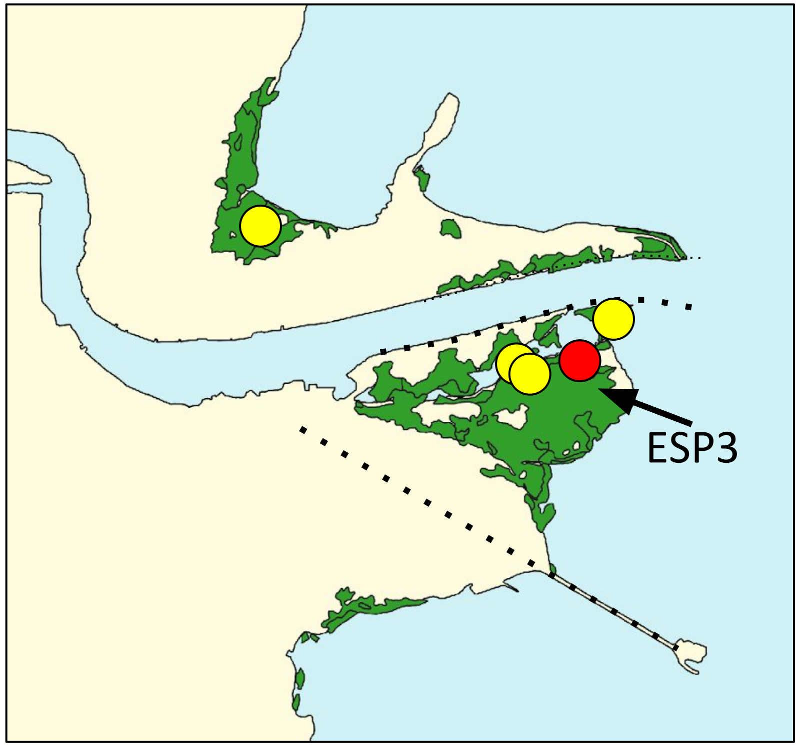


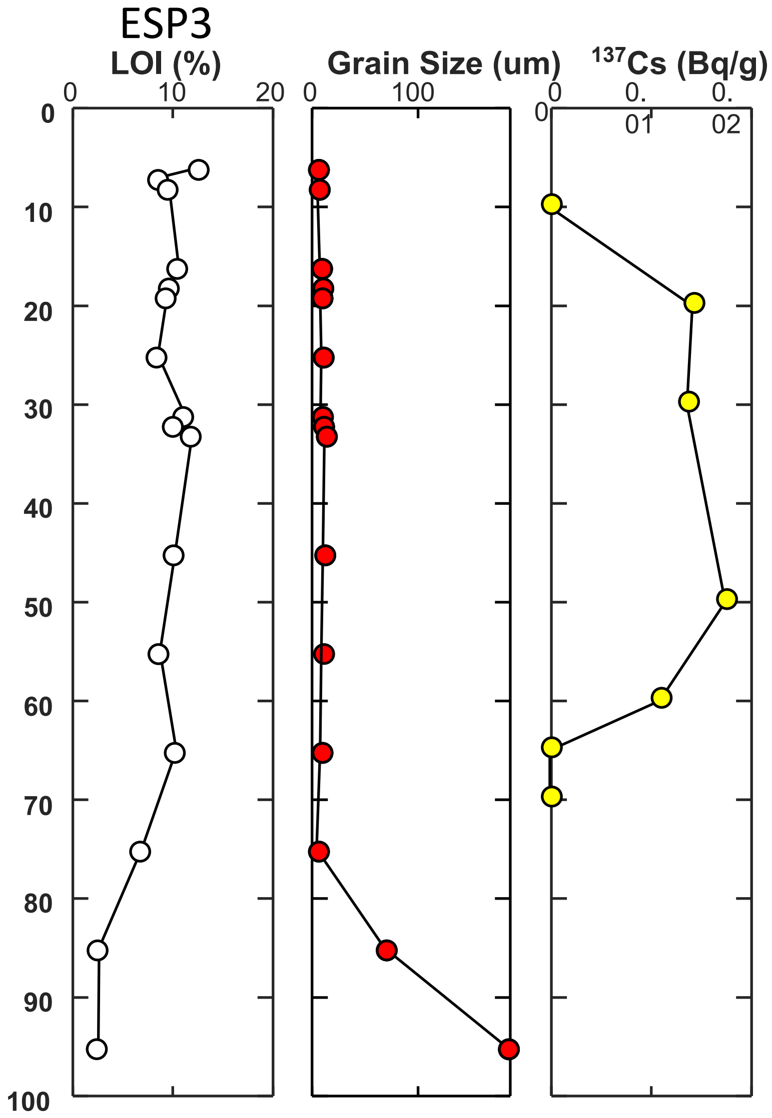
Vanderburgh Marsh

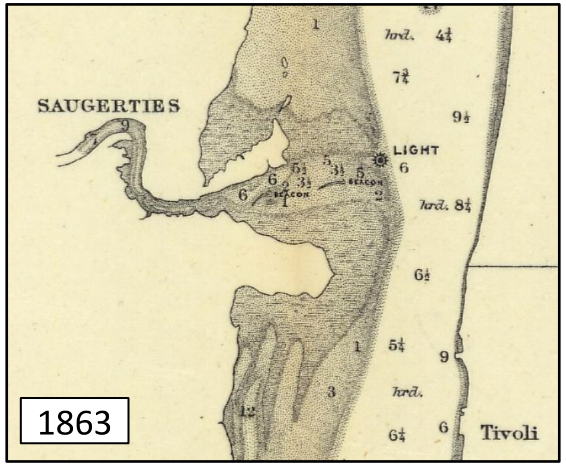


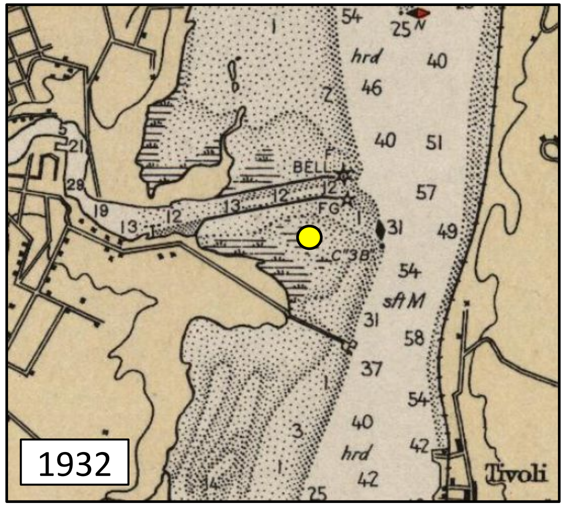


Esopus Delta





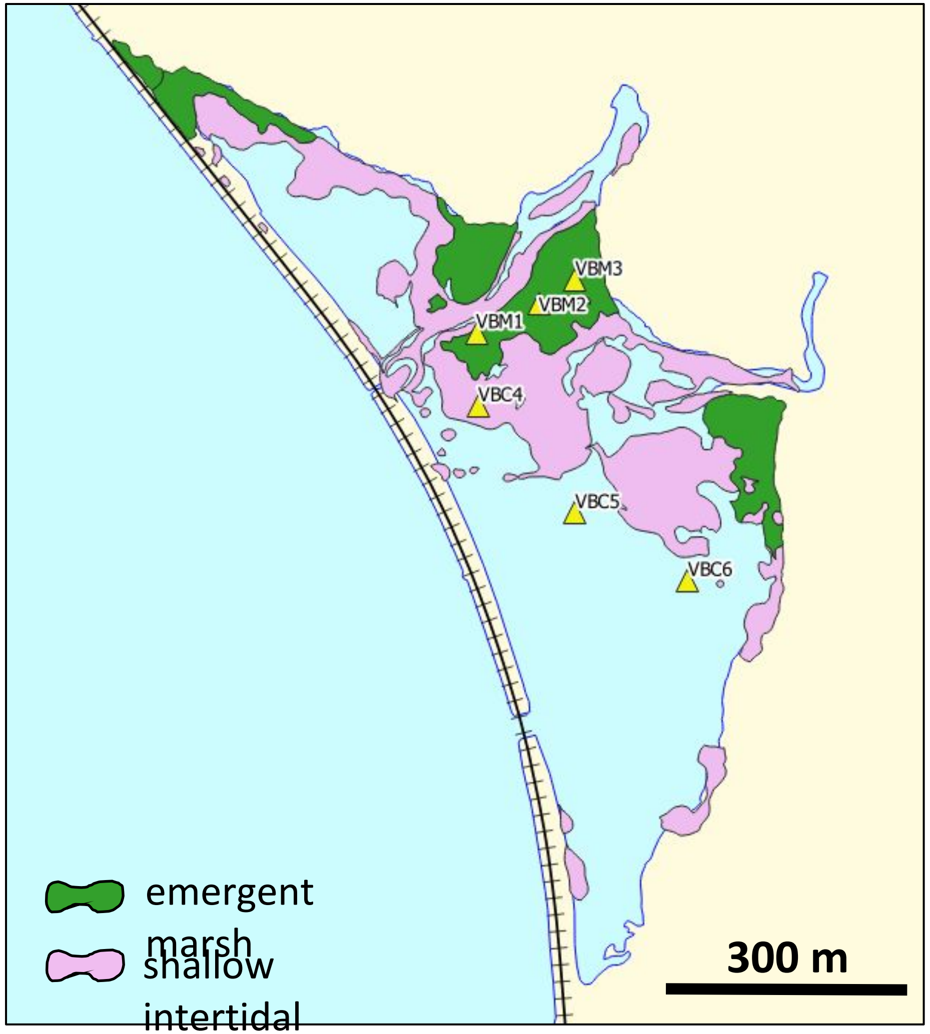


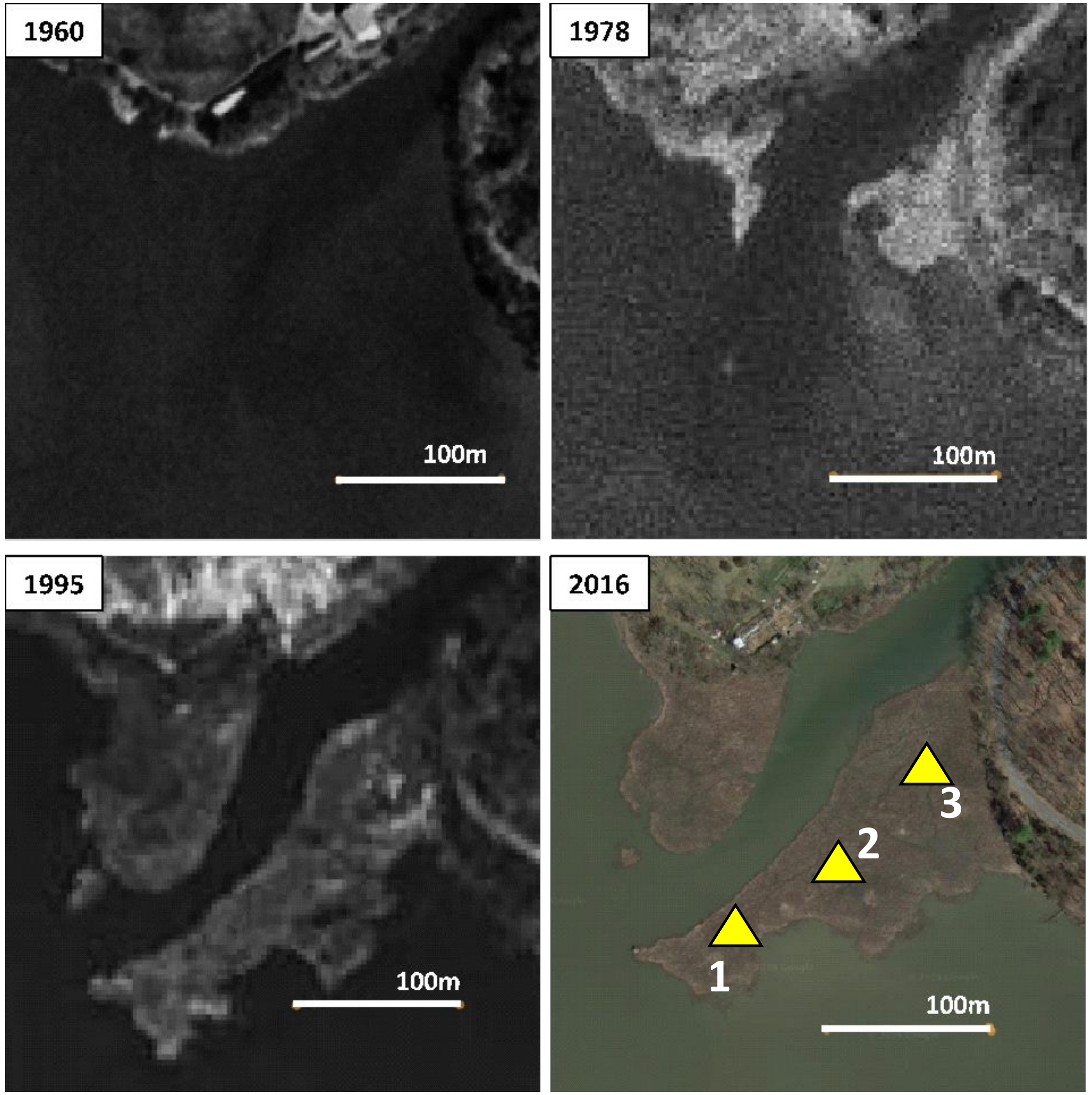


At what elevation does marsh emerge?

Dams and Sediment in the Hudson

Vanderburgh Cove, river km 140





At what elevation does marsh emerge?

DASH
Dams and Sediment in the Hudson

Vanderburgh Cove