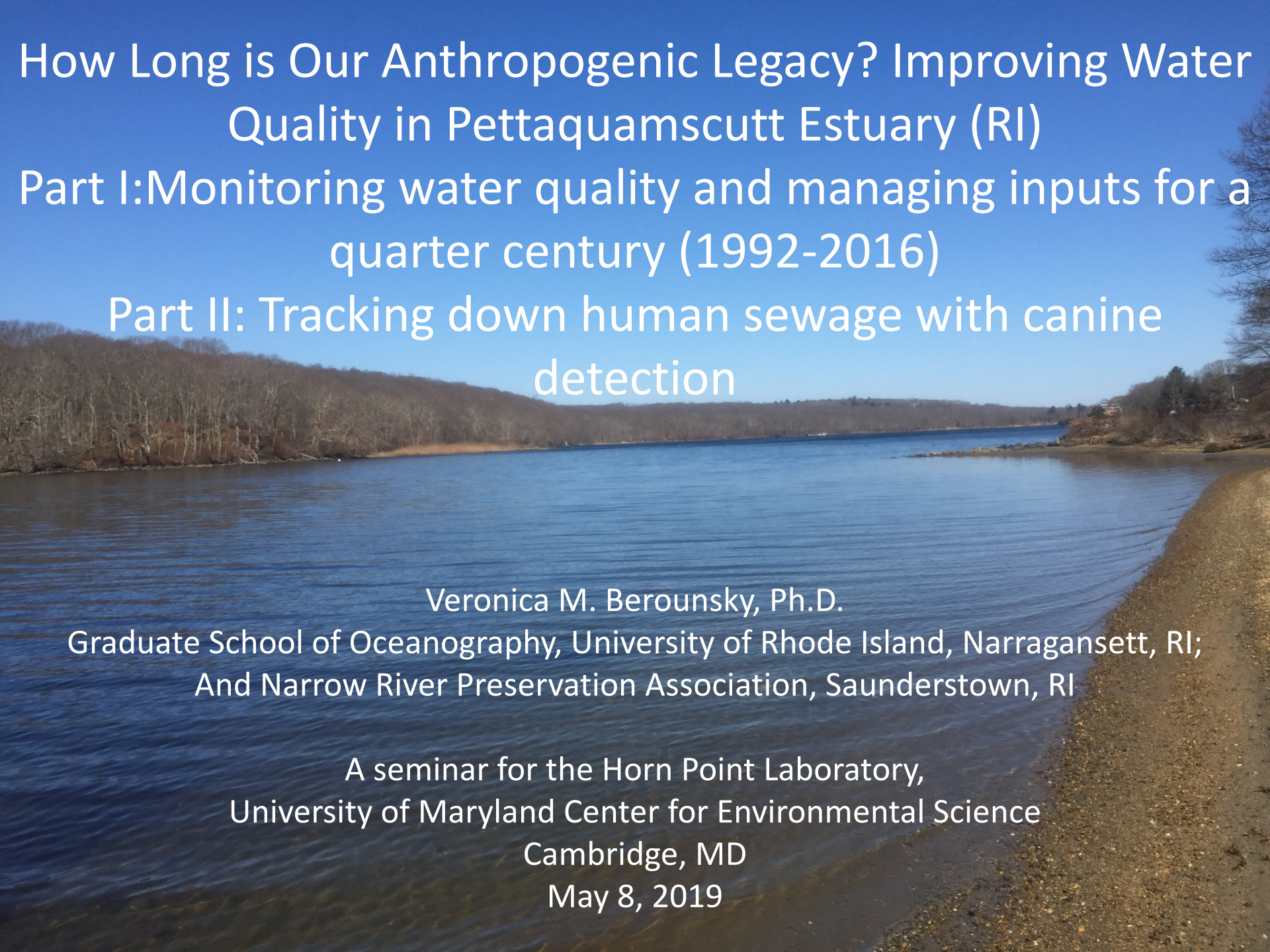
How Long is Our Anthropogenic Legacy? Improving Water Quality in Pettaquamscutt Estuary (RI)

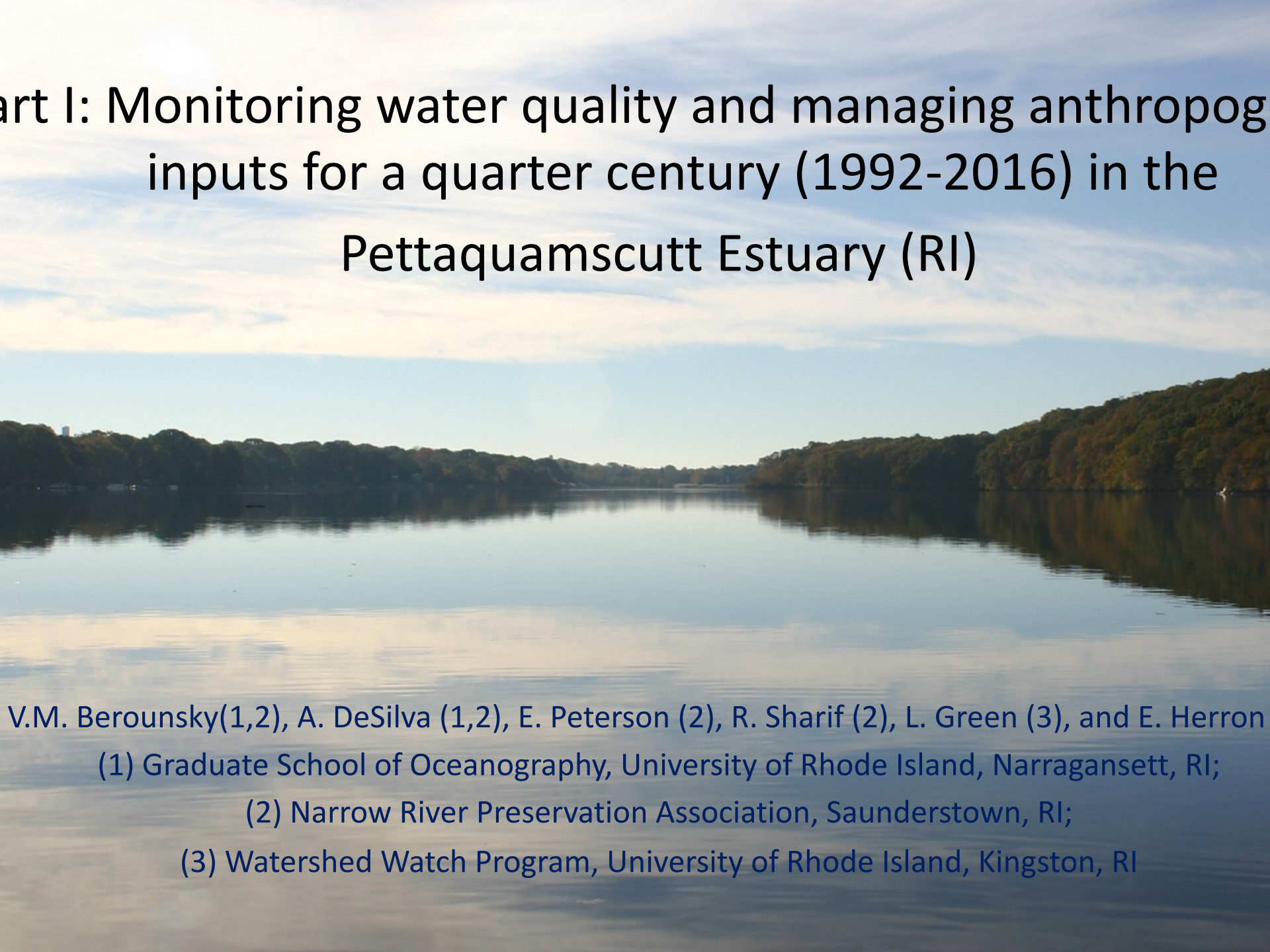
Part I:Monitoring water quality and managing inputs for a quarter century (1992-2016)

Part II: Tracking down human sewage with canine detection



Veronica M. Berounsky, Ph.D.
Graduate School of Oceanography, University of Rhode Island, Narragansett, RI;
And Narrow River Preservation Association, Saunderstown, RI

A seminar for the Horn Point Laboratory,
University of Maryland Center for Environmental Science
Cambridge, MD
May 8, 2019



art I: Monitoring water quality and managing anthropog inputs for a quarter century (1992-2016) in the Pettaquamscutt Estuary (RI)

V.M. Berounsky(1,2), A. DeSilva (1,2), E. Peterson (2), R. Sharif (2), L. Green (3), and E. Herron

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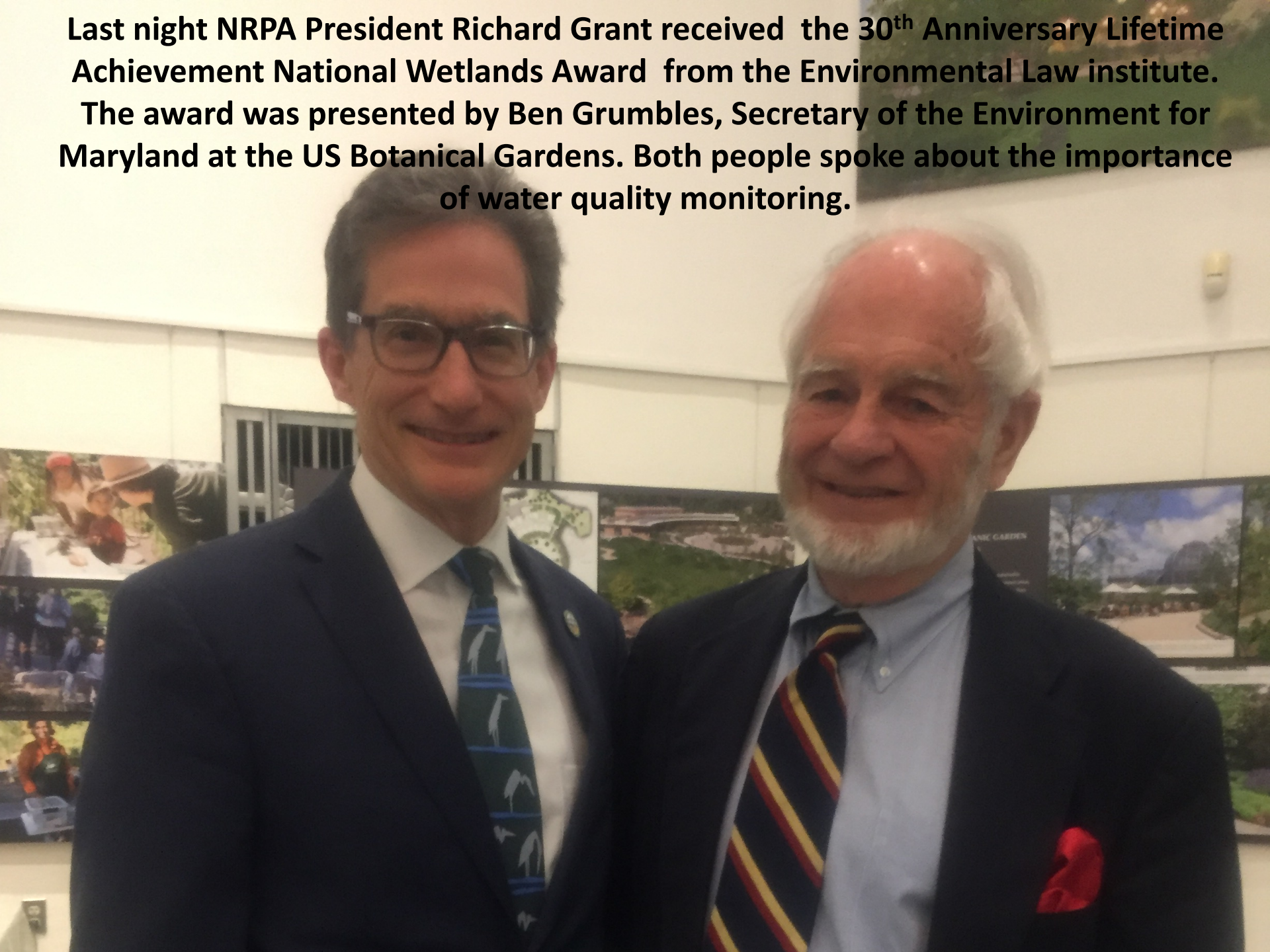
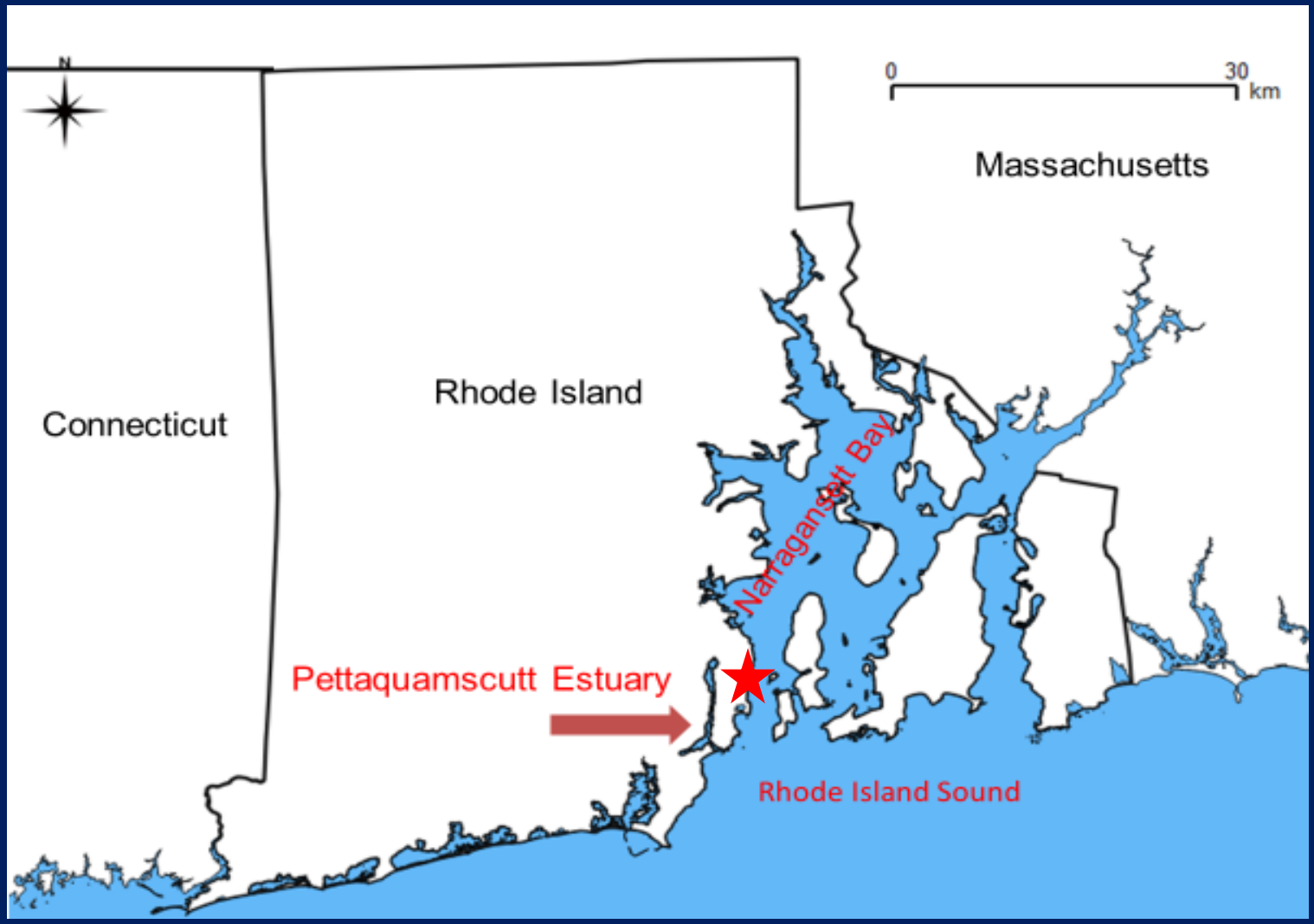
(2) Narrow River Preservation Association, Saunderstown, RI;

(3) Watershed Watch Program, University of Rhode Island, Kingston, RI

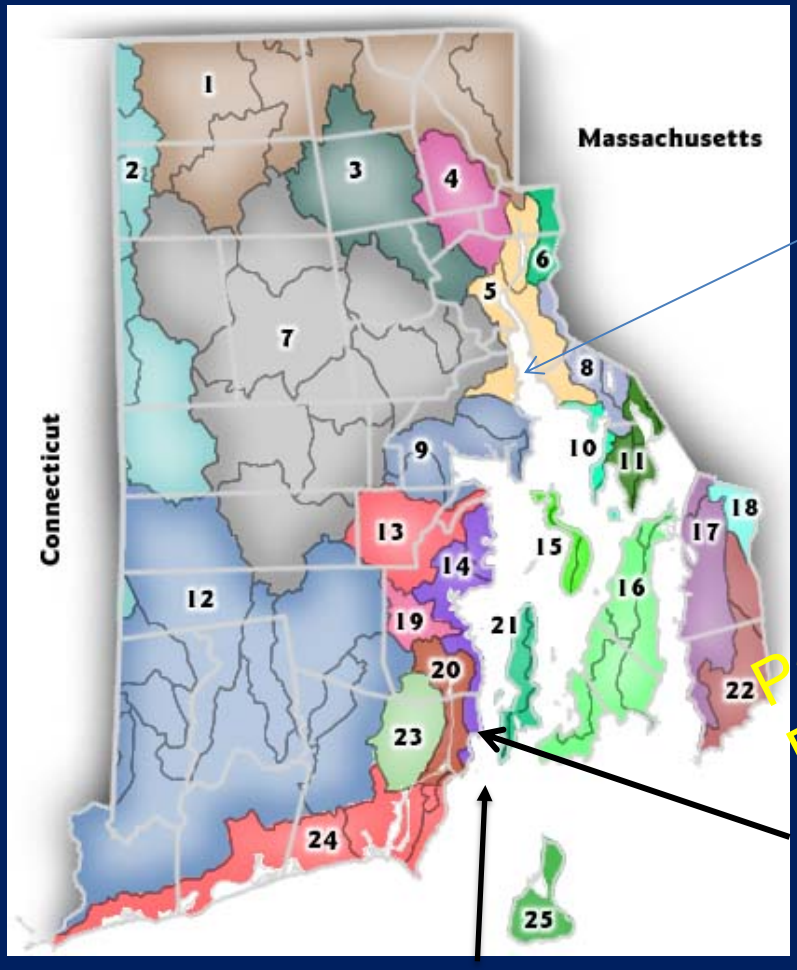

Last night NRPA President Richard Grant received the 30th Anniversary Lifetime Achievement National Wetlands Award from the Environmental Law institute. The award was presented by Ben Grumbles, Secretary of the Environment for Maryland at the US Botanical Gardens. Both people spoke about the importance of water quality monitoring.

Pettaquamscutt Estuary (Narrow River)



= location of GSO. Because of its proximity to GSO, many studies have taken place here, more then you would expect for 7 miles (9km)!

Watersheds of Rhode Island
Pettaquamscutt Estuary Watershed is #20

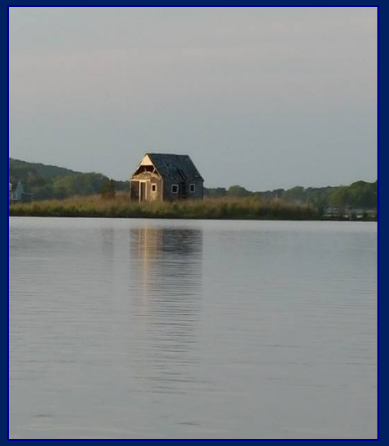


Providence, RI
CERF 1997,
2007, and 2017

Pettaquamscutt Estuary (9km long), Site of Narrow River Restoration and Kayak Trip at CERF 2017

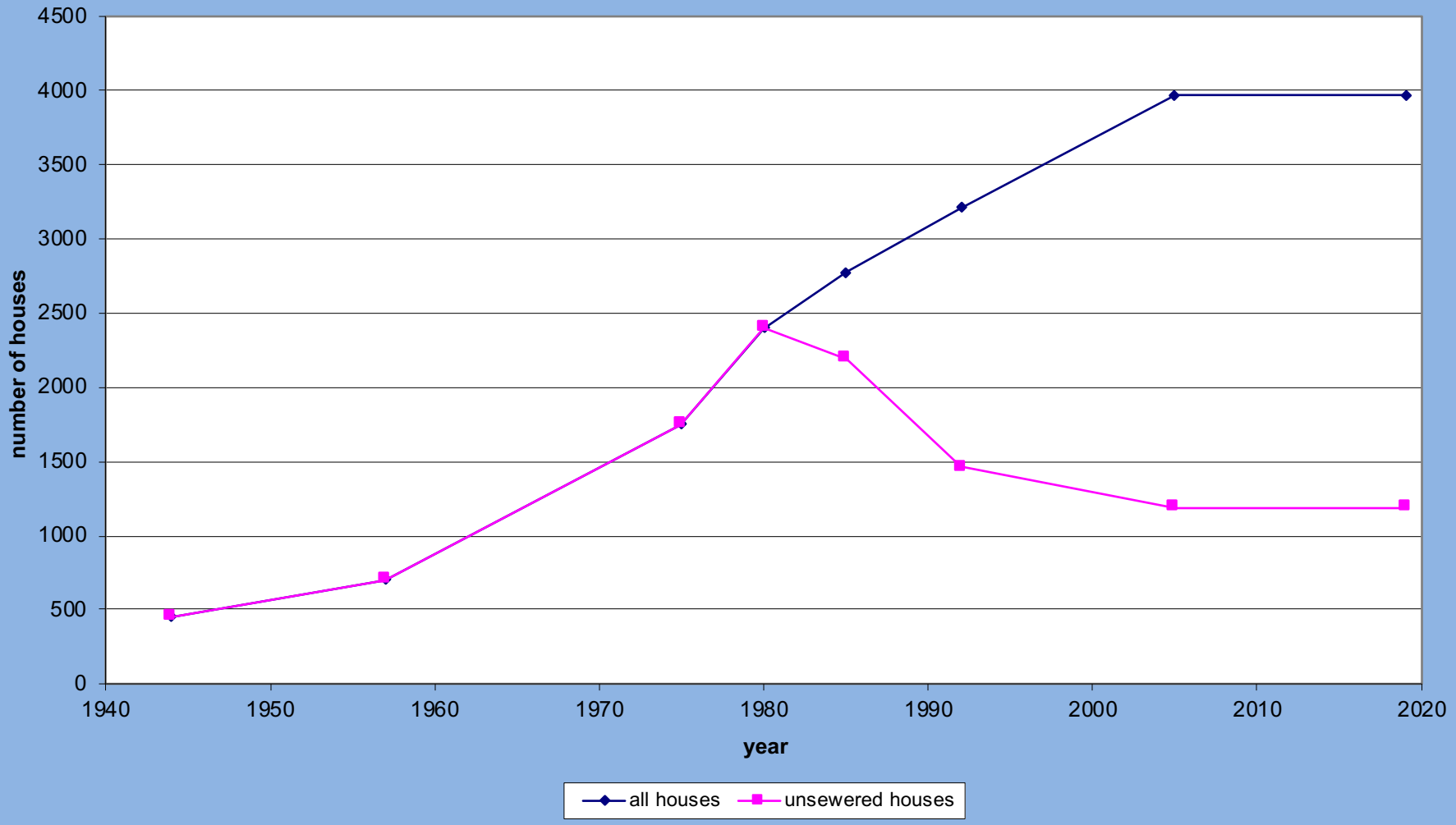
Lower Narragansett Bay

Looking back 25 years ago…



…. at the world and at Narrow River

Looking back more then 25 years ago: Houses in the Narrow River Watershed



Numbers of houses (both as total and as those not connected to a sewer system) in the Narrow River watershed for 1944, 1957, 1975, 1985, 1992, 2005 and 2019. In 1992 monitoring started. By 1999 all the neighborhoods in the watershed were on sewers. Between 2004 and 2010 stormwater abatement systems were built in the neighborhoods. Two more are needed.

Narrow River Watch
Background Information

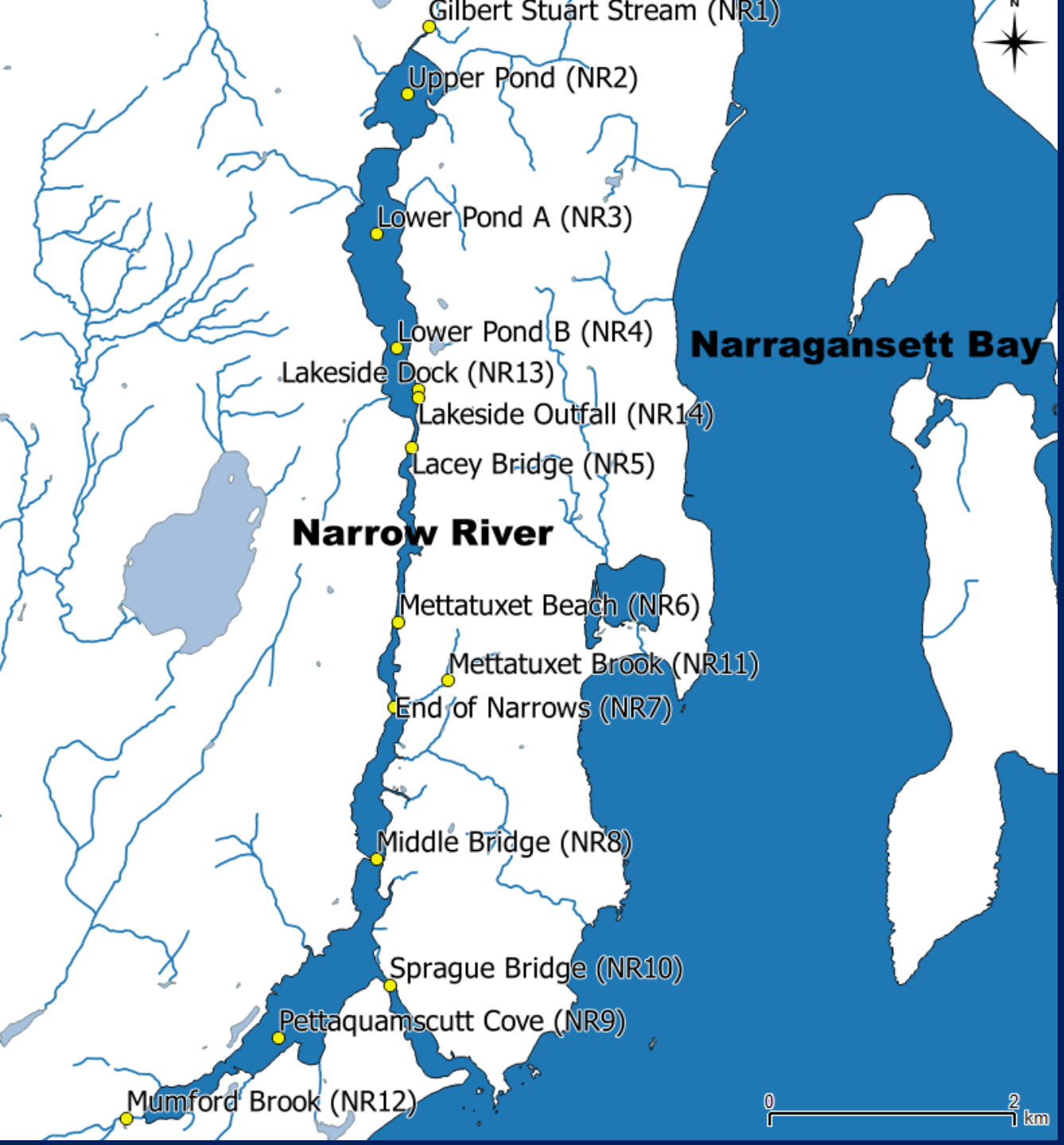
- 1991 - The Narrow River Stormwater Management Project - As part of this project, state funds were allocated for citizen water quality monitoring.
- 1992 - "River Watch" officially begins with 10 locations monitored by volunteers from the Narrow River Preservation Association and is part of the URI Watershed Watch Program (where lab analyses are done)
- 2016 – Completed 25 years of volunteer monitoring of the Narrow River at the 10 original sites, now there are 14 sites.
- The Value of Volunteer Monitors over 25 years:
  - 187 volunteers
  - 7800+ hours: At $25.43/hour* = $198,354. = about $200,000!
    *IndependentSector.com
  - 325 monitoring days
  - ~ 42,250 field readings and ~12,250 lab analyses

Dr. Veronica Berounsky, URI Researcher

Erin Chille, URI Senior

Watershed Watch & River Watch Goals:

- To promote active citizen participation in water quality protection. (So involves citizen-scientists and student-scientists plus university scientists.)
- To educate the public about water quality issues.
- To obtain multi-year surface water quality information in order to ascertain current conditions and to detect trends.
- To encourage sound management programs based upon water quality information.
- Trained citizens collect the water samples, take measurements; URI scientist analyze nutrients & bacteria



Monitoring sites

- Ten in-stream sites monitored since 1992
- Mettatuxet Brook since 1996
- Mumford Brook since 2000
- Lakeside Dock and Outfall since 2004

Historical data available

Narrow River is close to GSO so historical data are available from Gaines, Hanisek, Thorne-Miller, and MERL

What is monitored?

Monitoring Season: May – Oct

Twice a month:

- Temperature
- Salinity
- Dissolved Oxygen
- Chlorophyll

Once a month:

- Bacteria
- Nutrients
- pH

Where:

Most stations = 0.5m

Deep Basins = 0.5 and 3m

Stream =surface

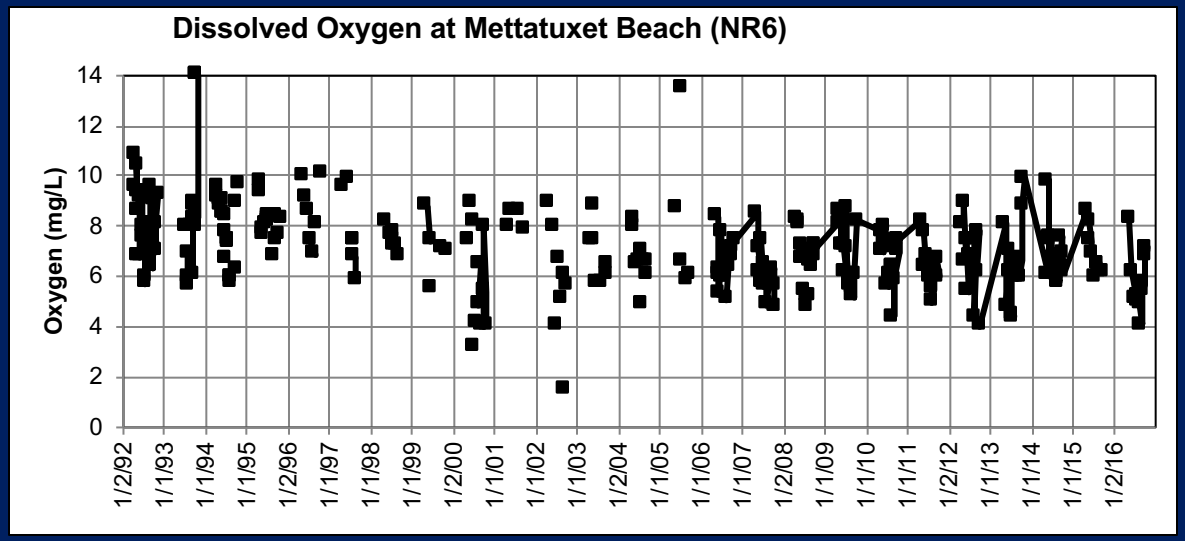
Data at 14 stations!

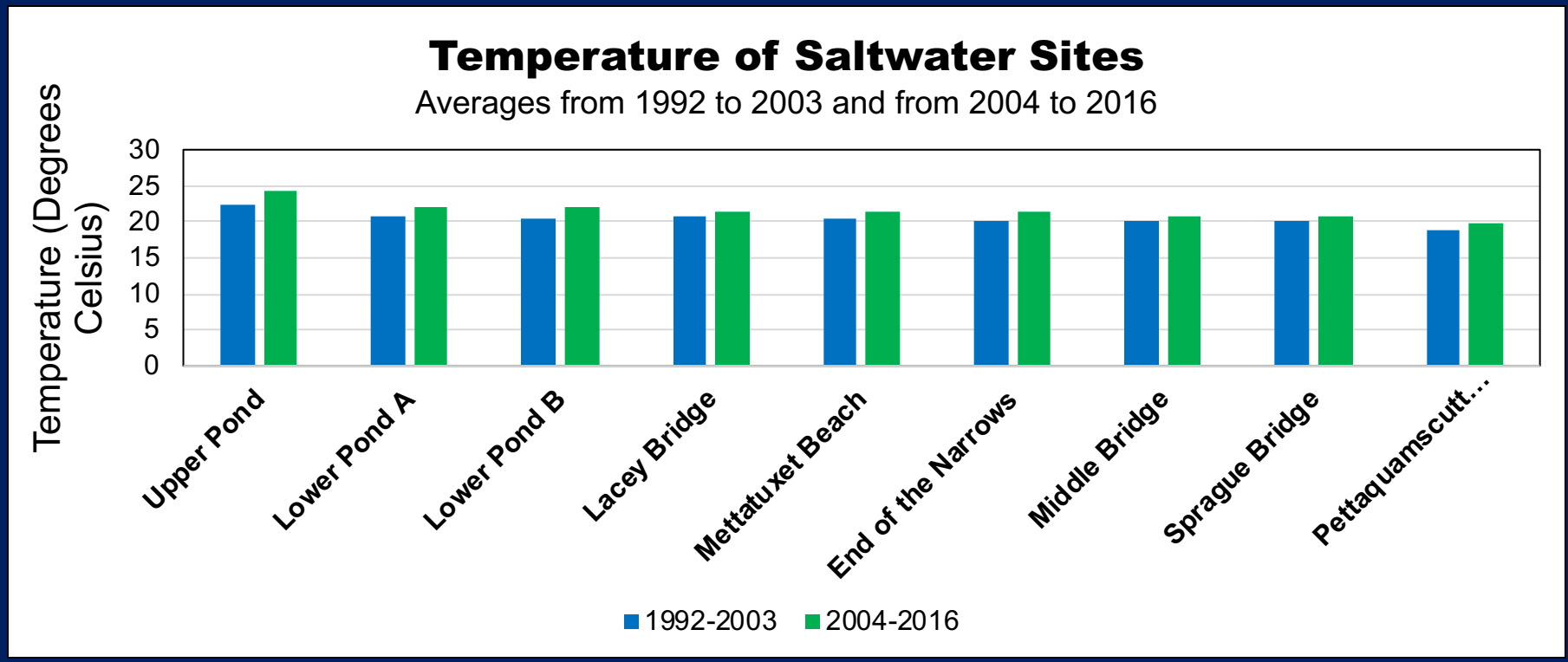
So there are lots of data points!

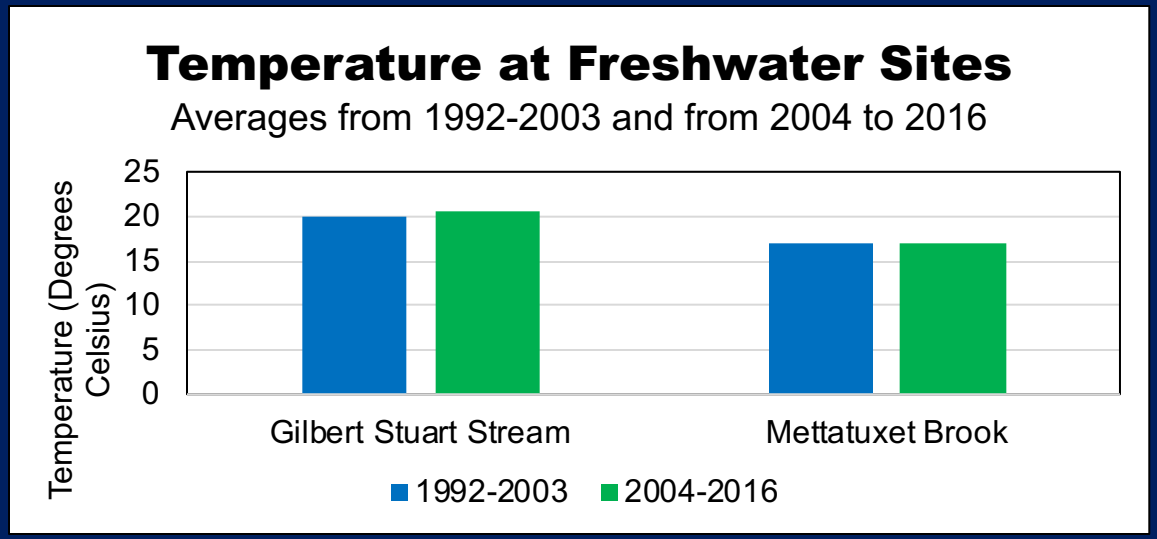
Here's an example ----→

of one site over 25 years

Photo by NRPA



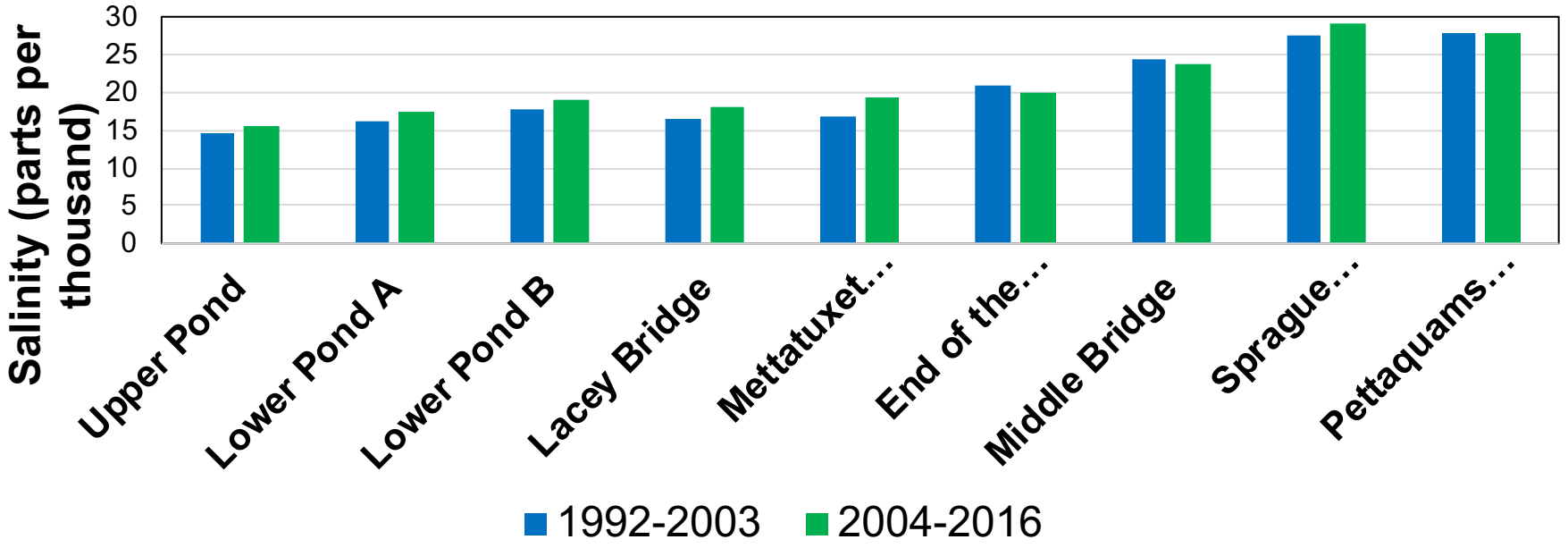




There is so much data, we decided to break it into before and after 2004, when a wider Middlebridge span was finished. Average temperature, an indicator of climate change, is slightly higher in more recent years.

Salinity at Saltwater Sites

Averages from 1992 to 2003 and from 2004 to 2016



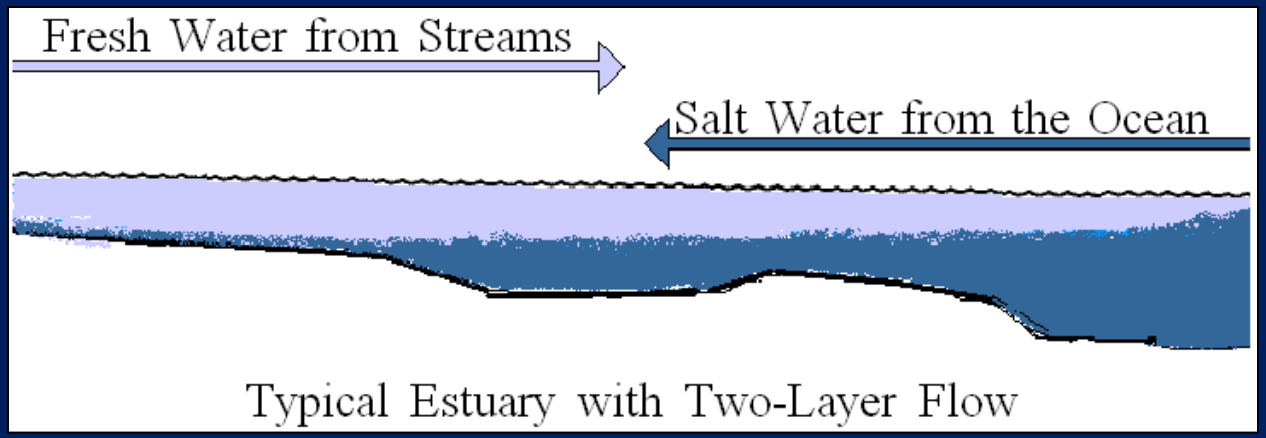
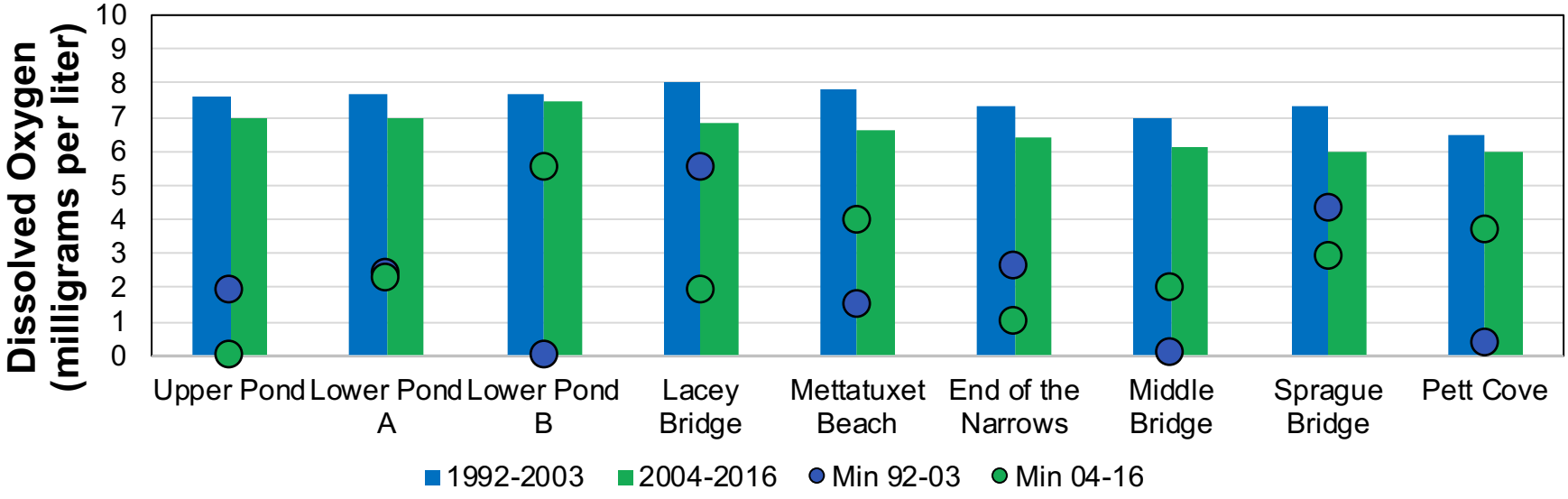


Diagram by David Smith (2008)

There is a gradient of average salinities, with an increase in salinity to the mouth of the River. Higher salinities in recent years suggest better flushing since 2004 and the wider bridge span.

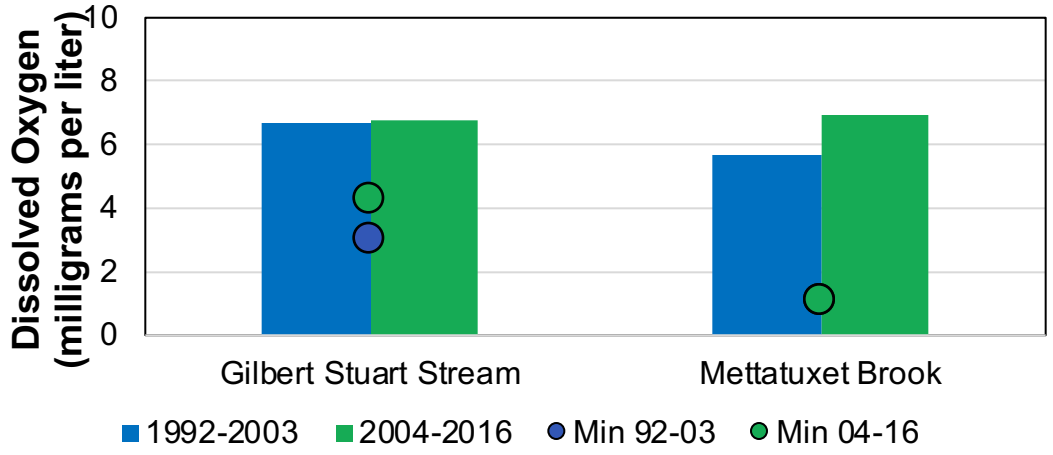
Dissolved Oxygen at Saltwater Sites

Averages from 1992 to 2003 and from 2004 to 2016



Dissolved Oxygen at Fresh Water Sites

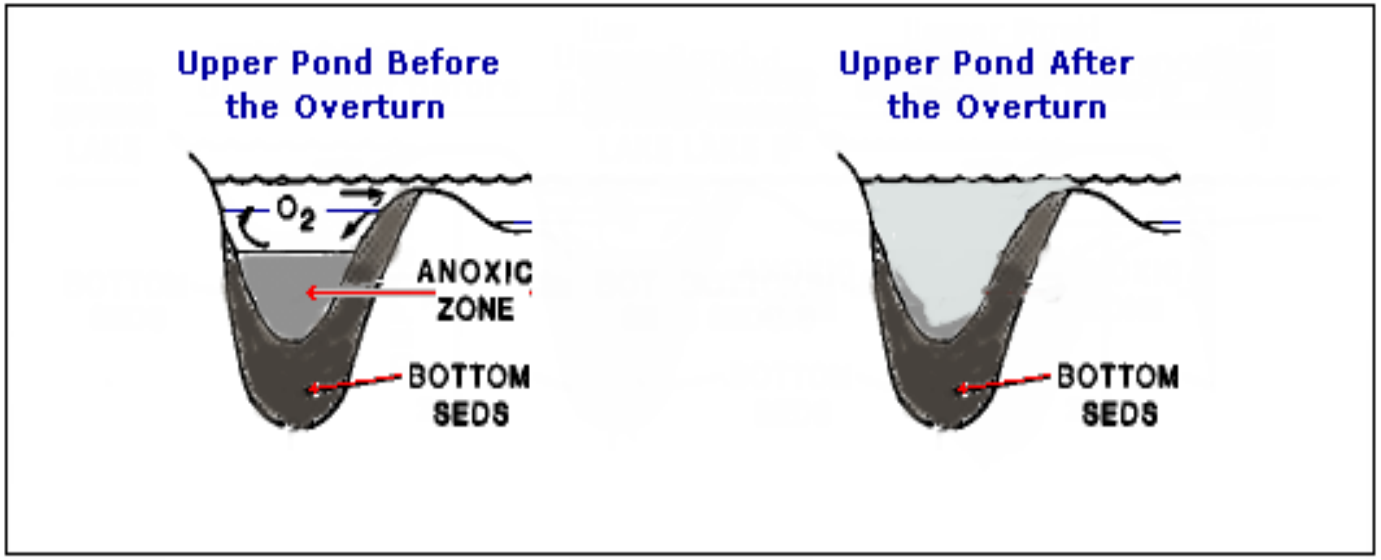
Averages from 1992 to 2003 and from 2004 to 2016



Dissolved Oxygen: less then 2-3 mg/L = hypoxic, averages are well above this value, minimums are often around this value. Note that the only recent (green circle) value at zero was Upper Pond – the ventilation in2007.

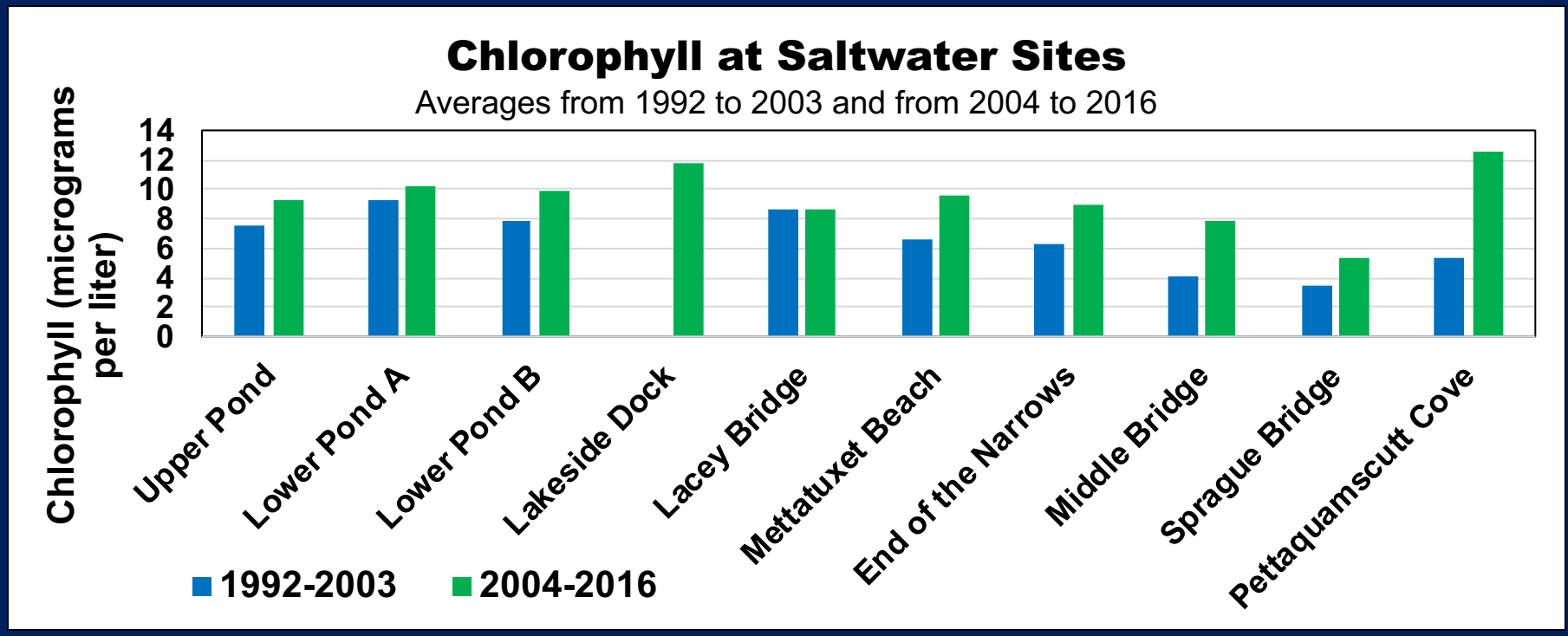
The deep (13 m and 18 m) basins of Pettaquamscutt Estuary are naturally anoxic below 4 m but occasionally ventilations happen:

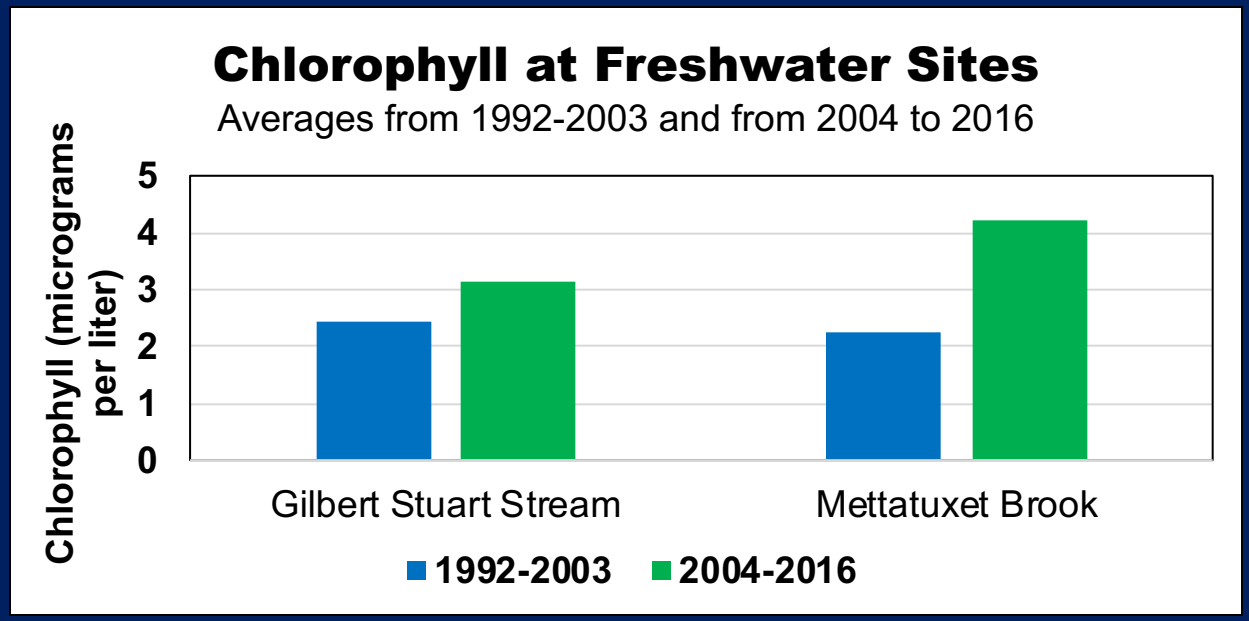
+ After a ventilation the anoxic bottom water spreads and mixes into the surface waters, resulting in nutrient – rich, low oxygen, low pH water throughout the water column.



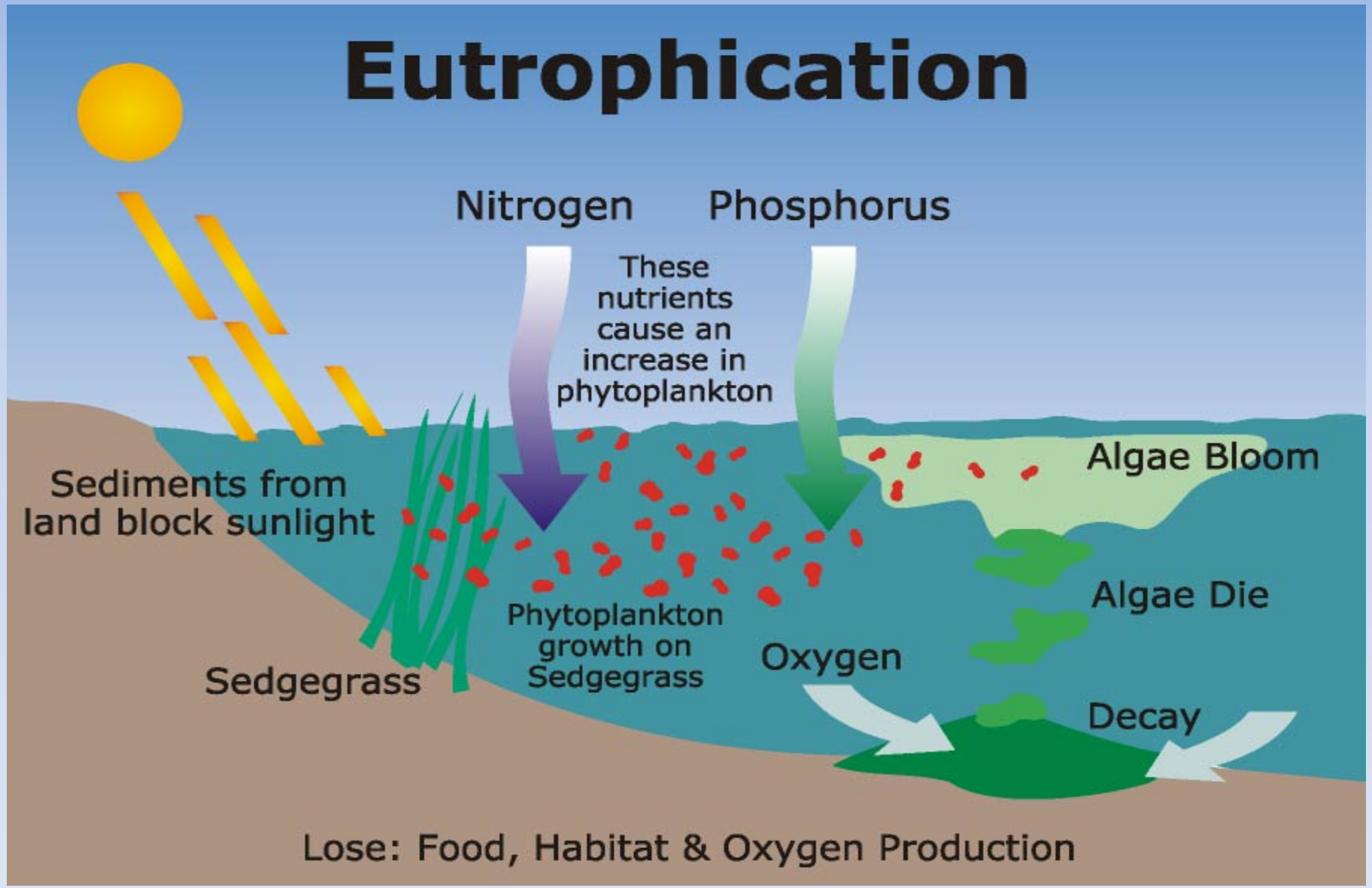
About every 15-20 years the Northern Basin of the Pettaquamscutt Estuary has a ventilation of anoxic bottom water and surface waters look like this due to the precipitation of sulfur.

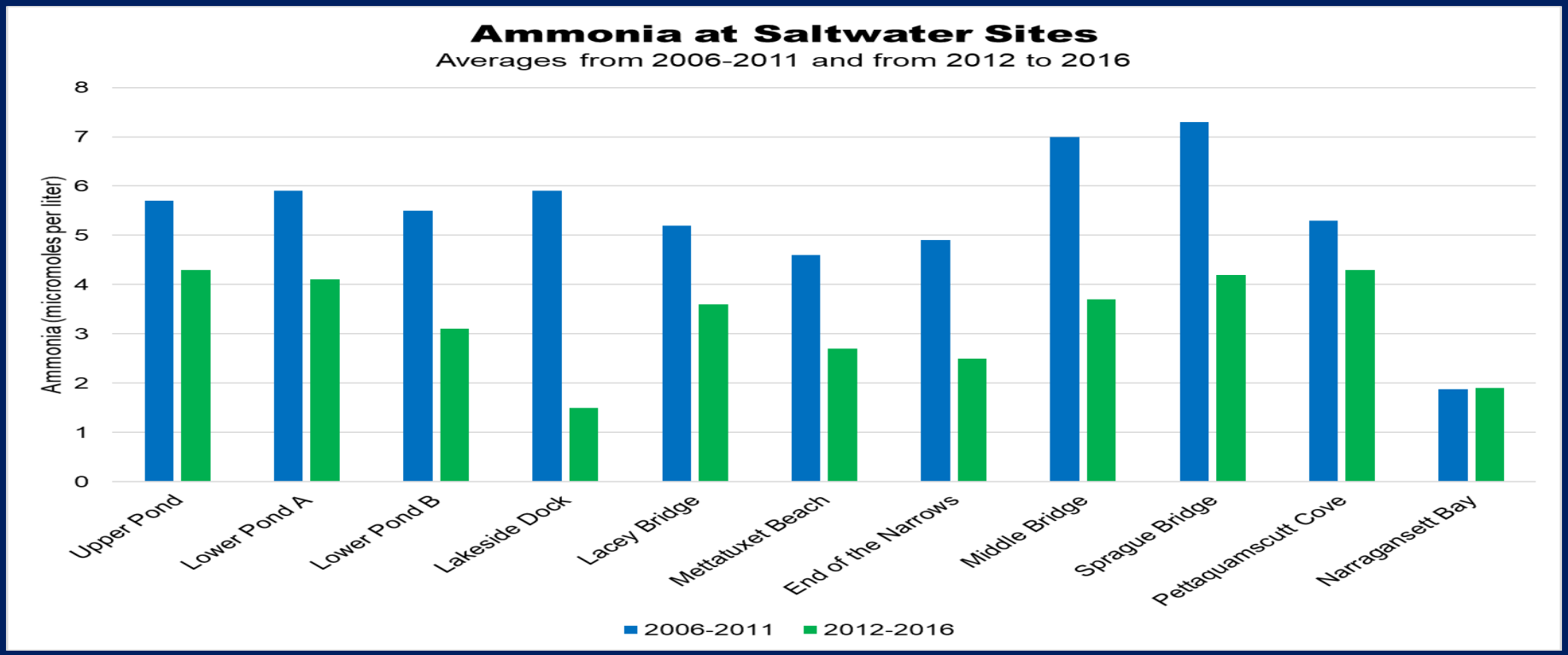
The last ventilation was in October 2007 (just prior to CERF in Providence), previous ones were in 1990, 1972, 1957, and probably in earlier years.

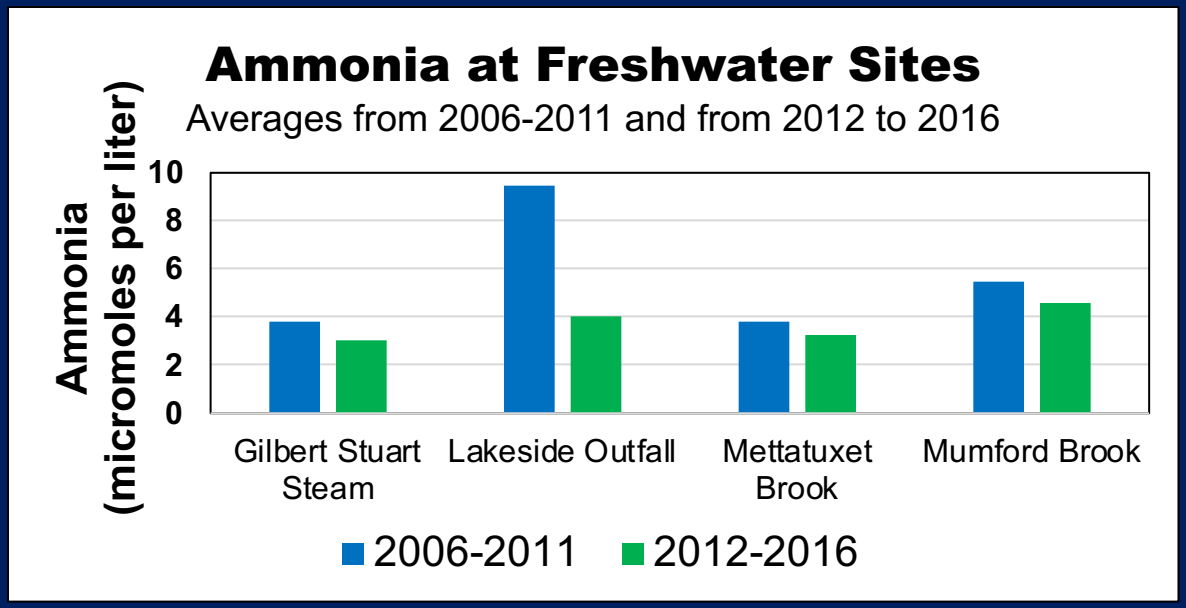




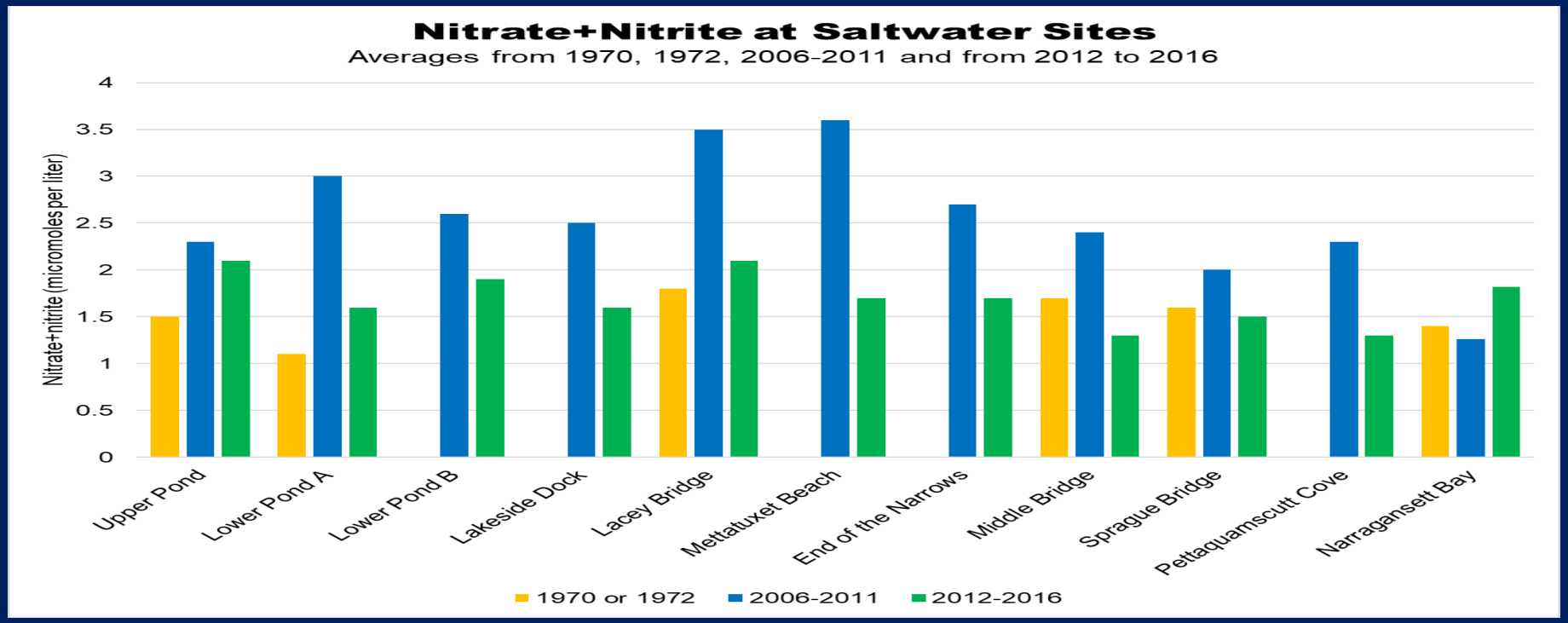
Chlorophyll, an indictor of phytoplankton productivity, is always higher in recent years. Perhaps related to warmer temperatures or more water flow?

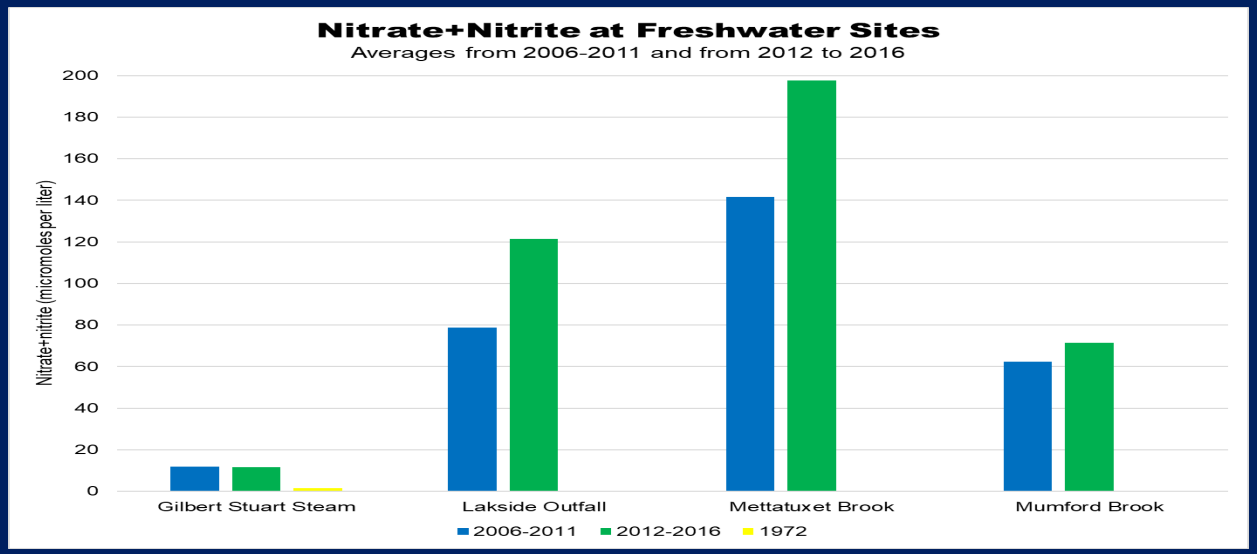

Eutrophication
Nitrogen
Phosphorus
These nutrients cause an increase in phytoplankton
Sediments from land block sunlight
Algae Bloom
Algae Die
Phytoplankton growth on Sedgegrass
Sedgegrass
Oxygen
Decay
Lose: Food, Habitat & Oxygen Production



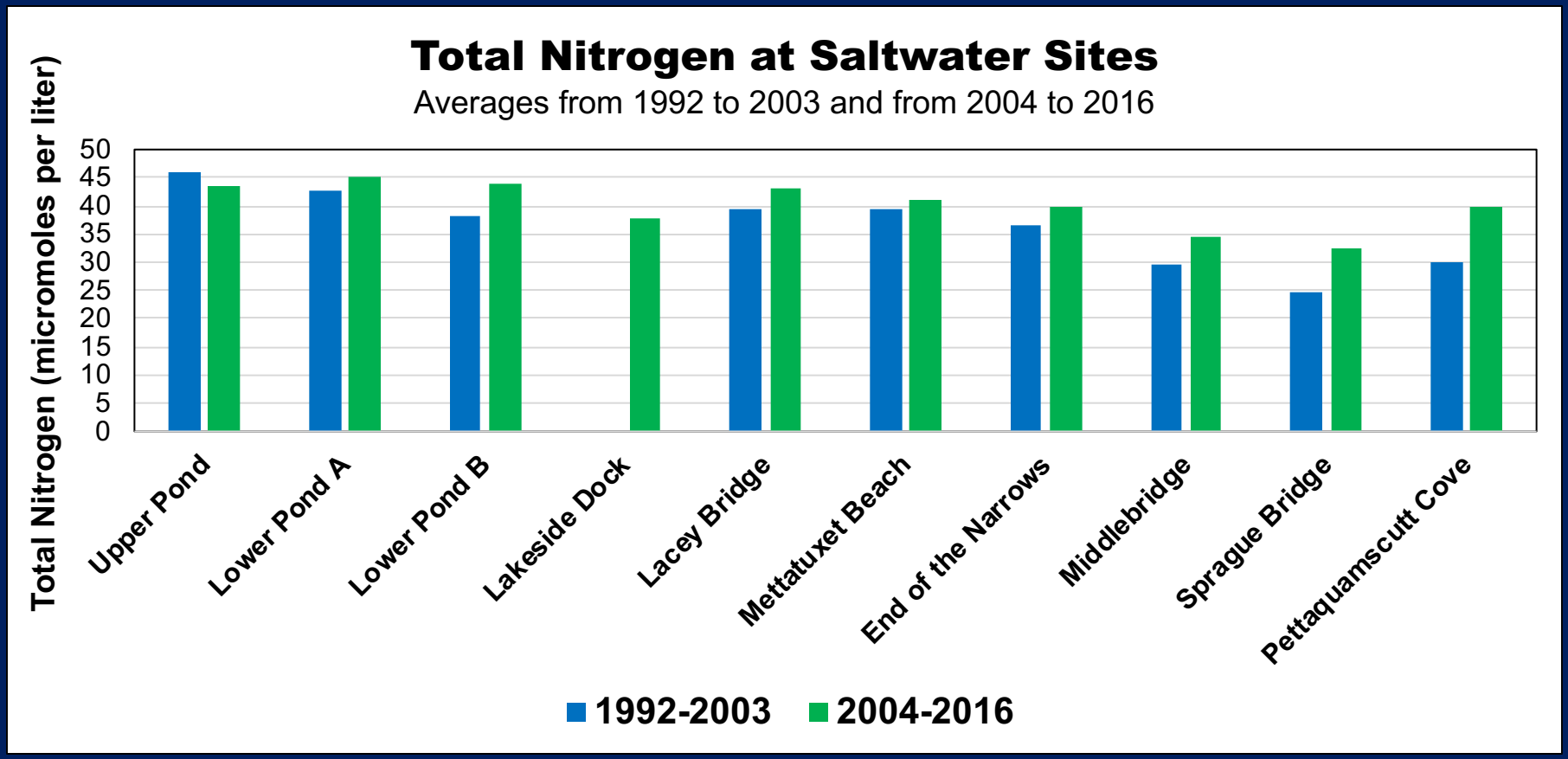


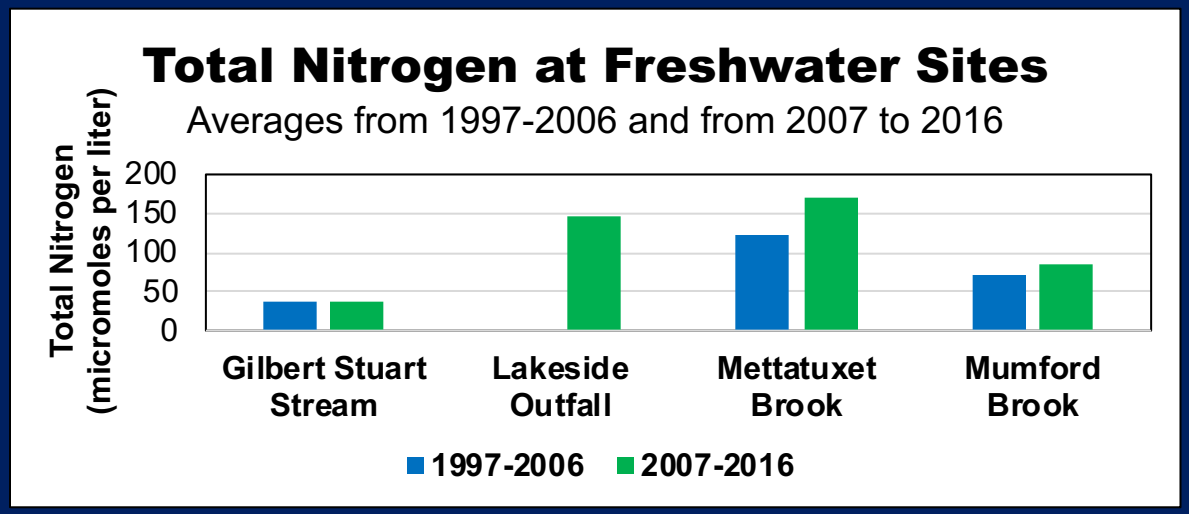
Ammonia, an inorganic form of nitrogen produced by decaying organic matter, excreted by animals, and found coming from leaking septic systems, is **lower in recent years suggesting sewering has helped.** Note Narr. Bay data is low always.



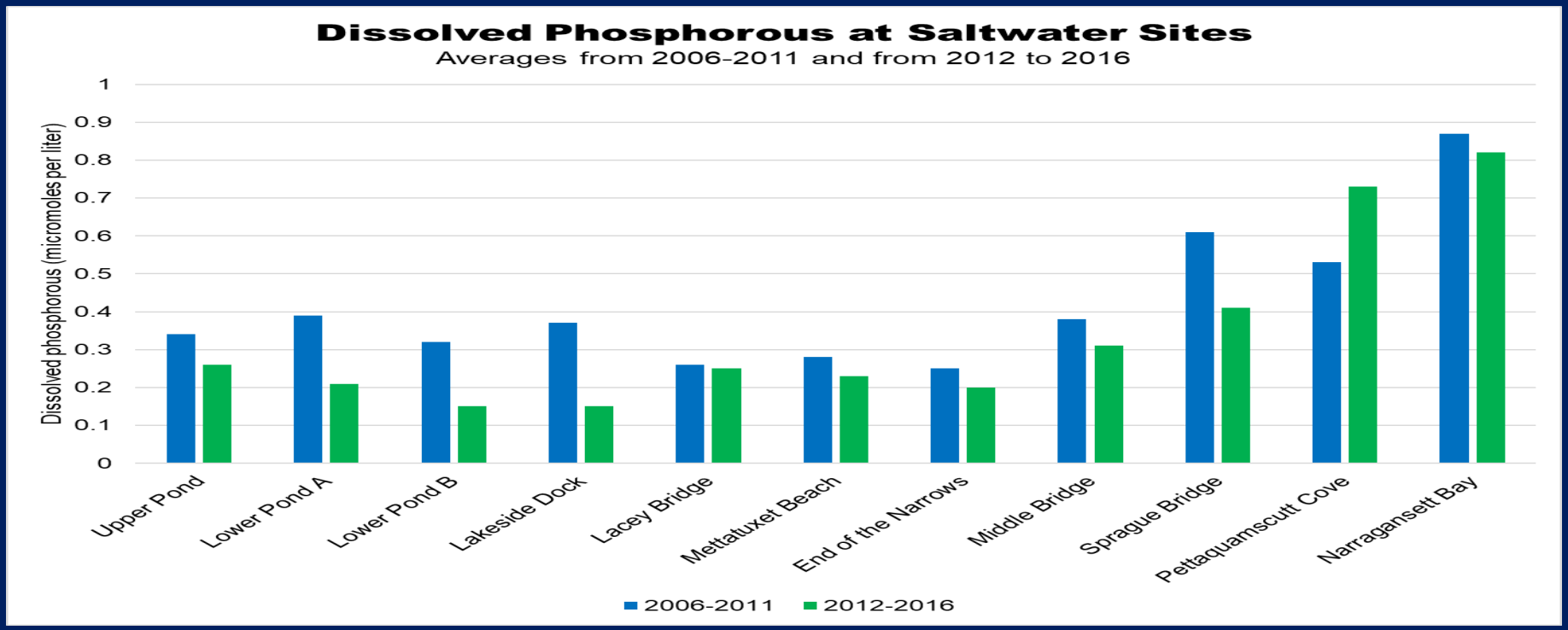


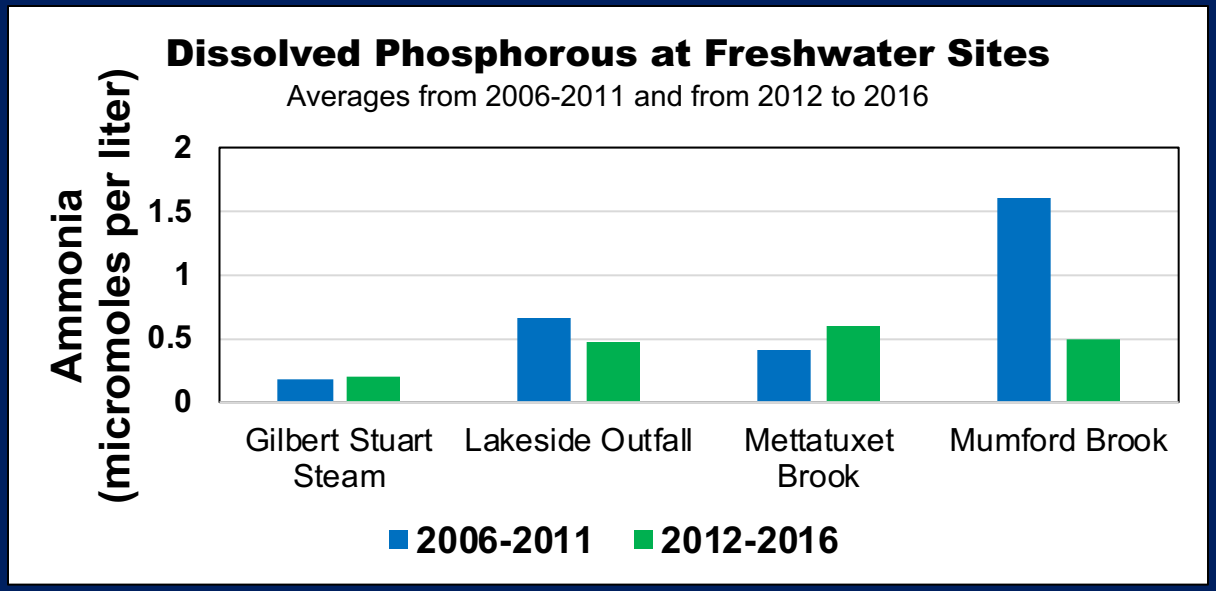
Nitrate+nitrite, inorganic forms of nitrogen found in groundwater and from nitrification is **low in 1970s, then increased with houses, then low in recent years suggesting sewering helped. Narr. Bay data are low but recent years are higher. Note high FW sites.**





Total Nitrogen, the sum of organic and inorganic forms of nitrogen, is **higher in recent years** at all the sites. Also much **higher at FW sources.** This must be **mostly nitrate-nitrite in FW and organic N in SW.**

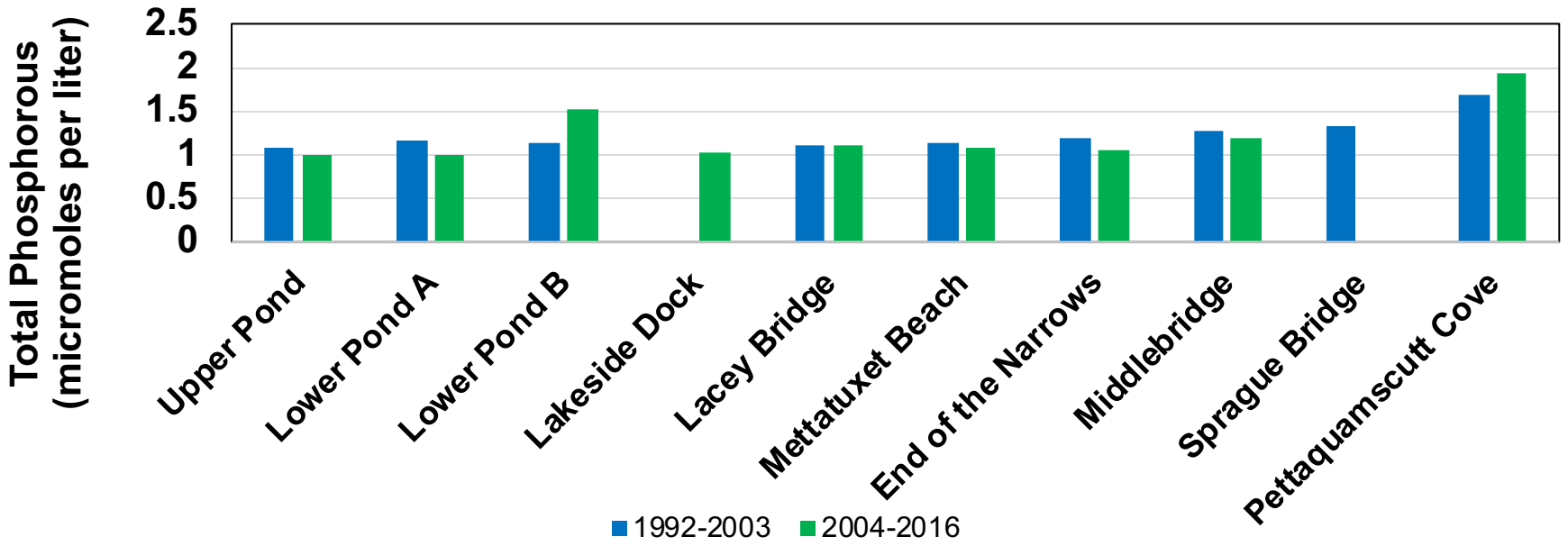




Dissolved inorganic phosphorus, coming from fertilizers, organic waste, and erosion of rocks and sediments, is lower in recent years except for Mumford Brook & Pettaquamscutt Cove Runoff may be a problem. Note Narr Bay sources are high. P range is small anyhow.

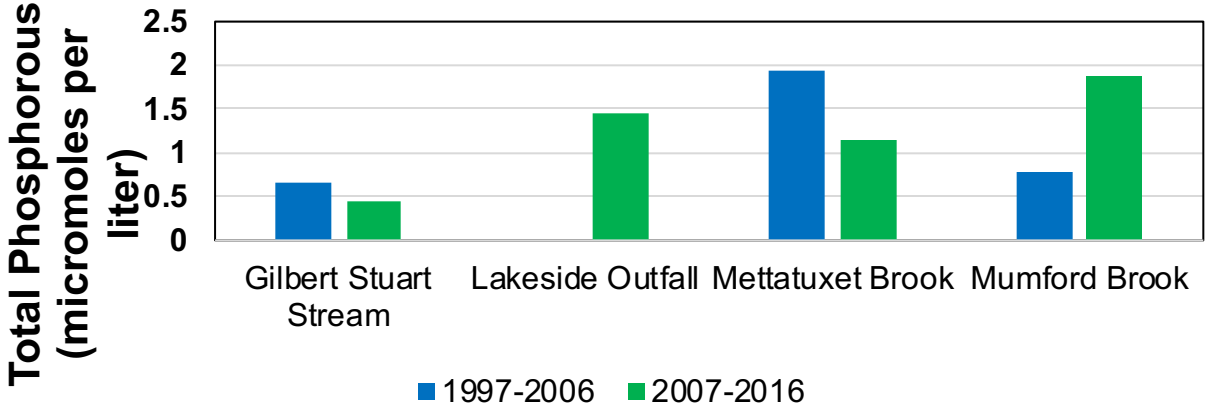
Total Phosphorous at Saltwater Sites

Averages from 1992 to 2003 and 2004 to 2016



Total Phosphorous at Freshwater Sites

Averages from 1997-2006 and from 2007 to 2016



Total Phosphorus, the sum of inorganic and organic phosphorus, is similar between years except higher in recent years at Lower Pond B, Mumford Brook, and nearby Pettaquamscutt Cove, probably due to organics.

Shellfishing Ban due to high bacteria levels

- "Since 1959, the Narrow River has failed to meet state standards for total coliform bacteria levels"
- "In 1979, parts of the Narrow River were closed to shellfishing"
- "Beginning in 1994, the entire expanse of the Narrow River was closed to shellfishing and remains closed today due to high coliform bacteria levels."

from The Narrow River Special Area Management Plan, CRMC, April 1999

In 2001, RI DEM published a TMDL study about bacteria

Fecal Coliform TMDL
for the
Pettaquamscutt (Narrow) River Watershed, Rhode Island

Including:

Narrow River Estuary
Gilbert Stuart Stream
Mumford Brook

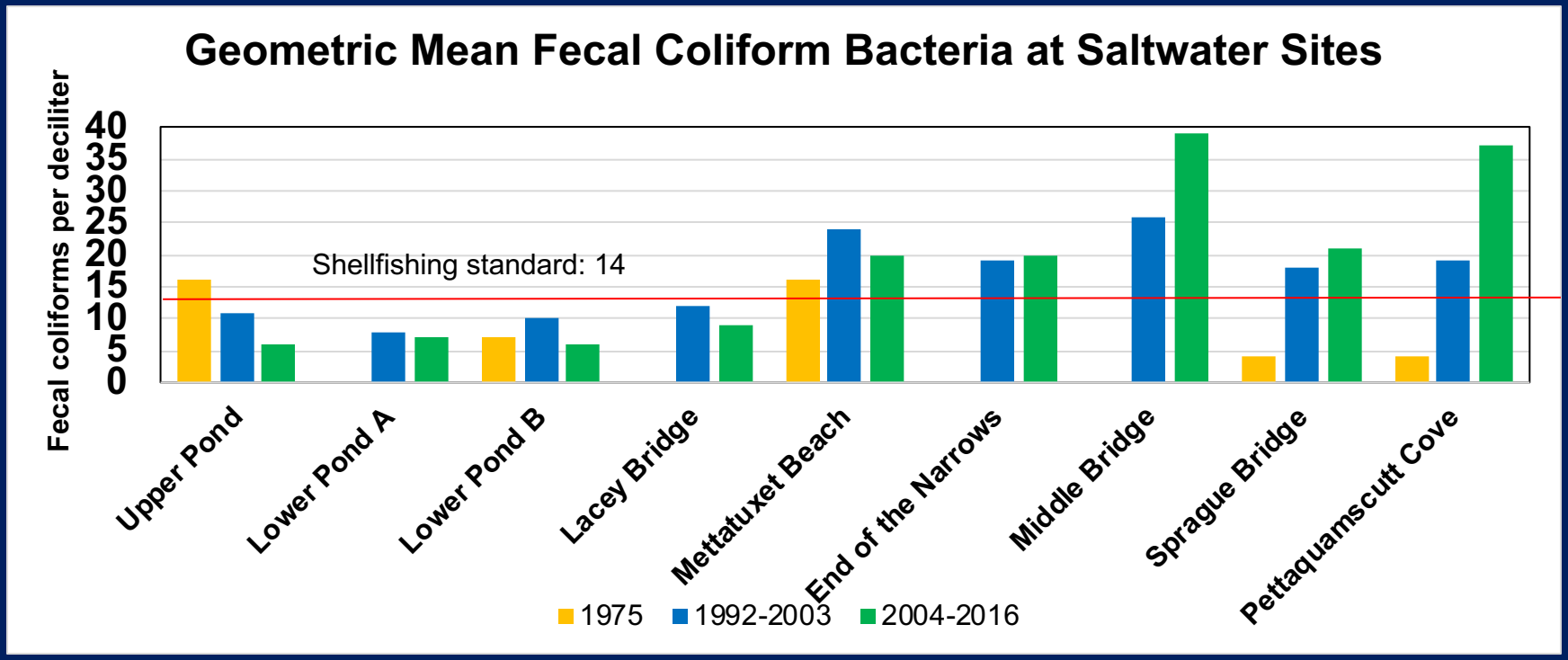
Photograph from Narrow River Preservation Association (NRPA) website - http://www.narrowriver.org/
Reprinted with permission of NRPA

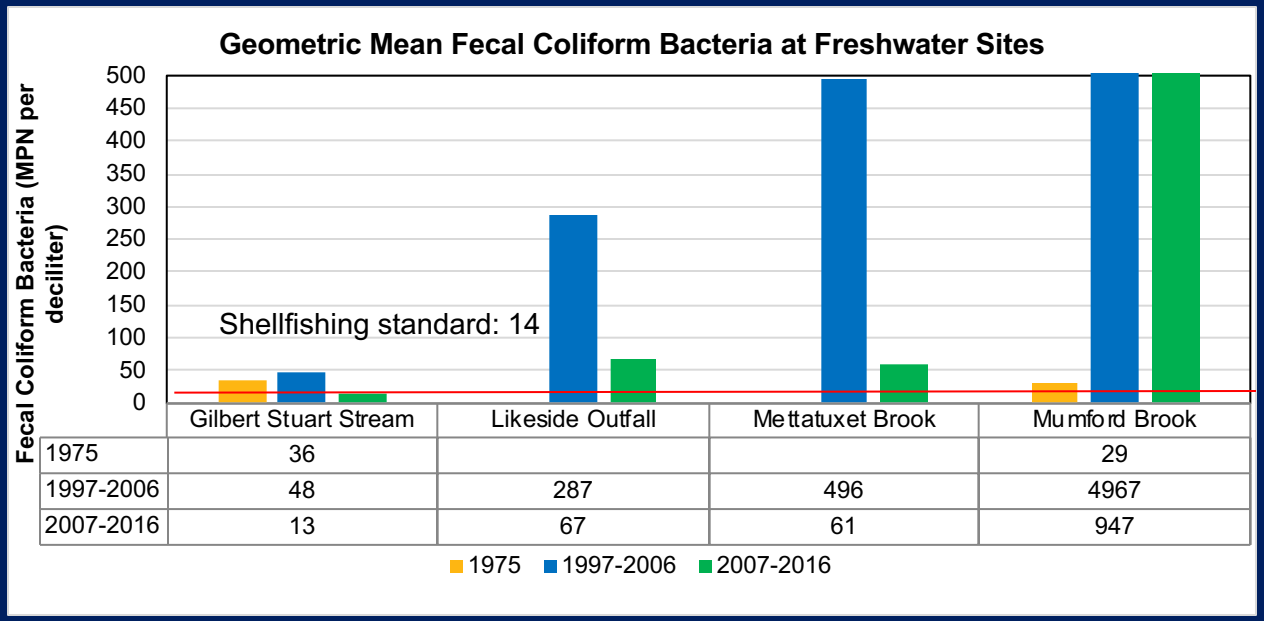
Prepared by:

Office of Water Resources
Rhode Island Department of Environmental Management
235 Promenade Street
Providence, RI 02908

December 2001

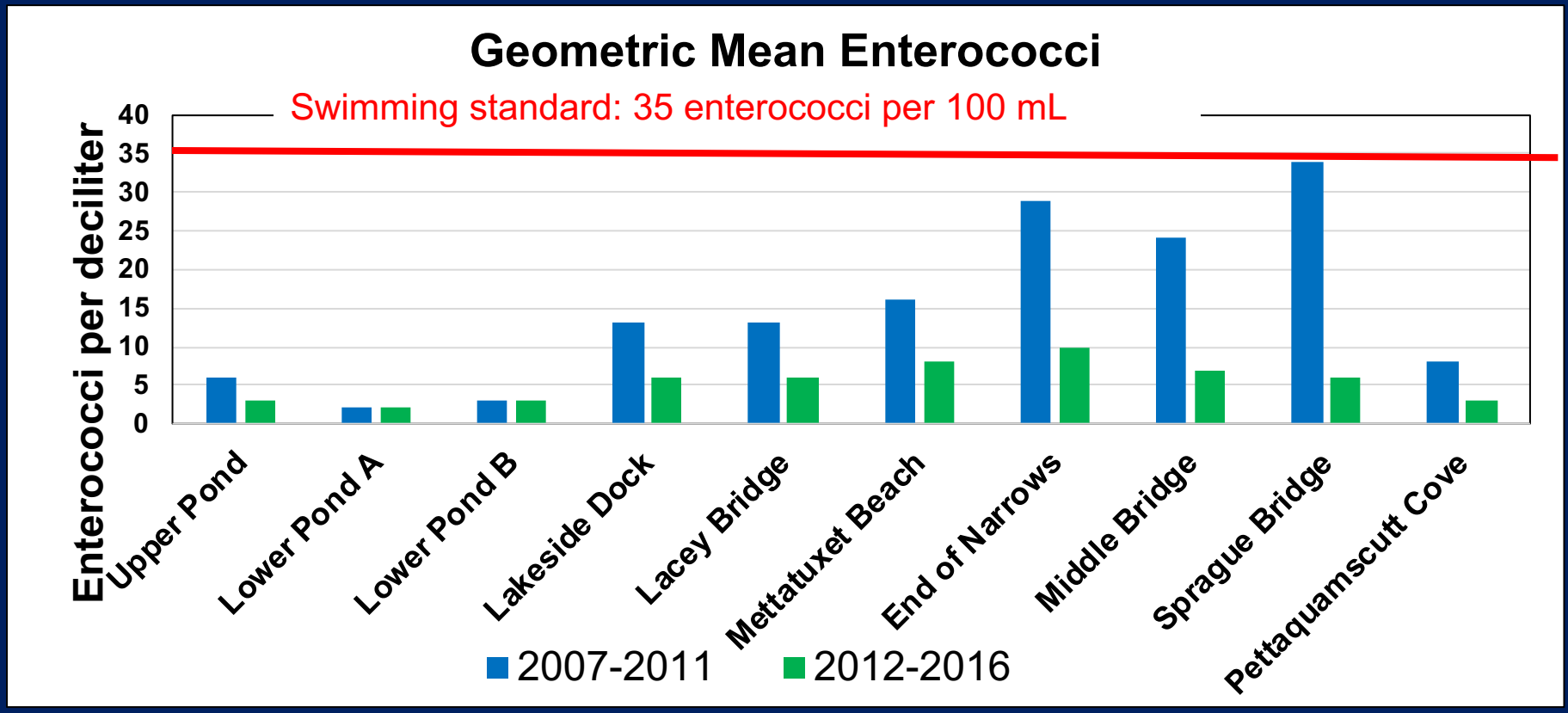
RIDEM/OWR 06/10/02

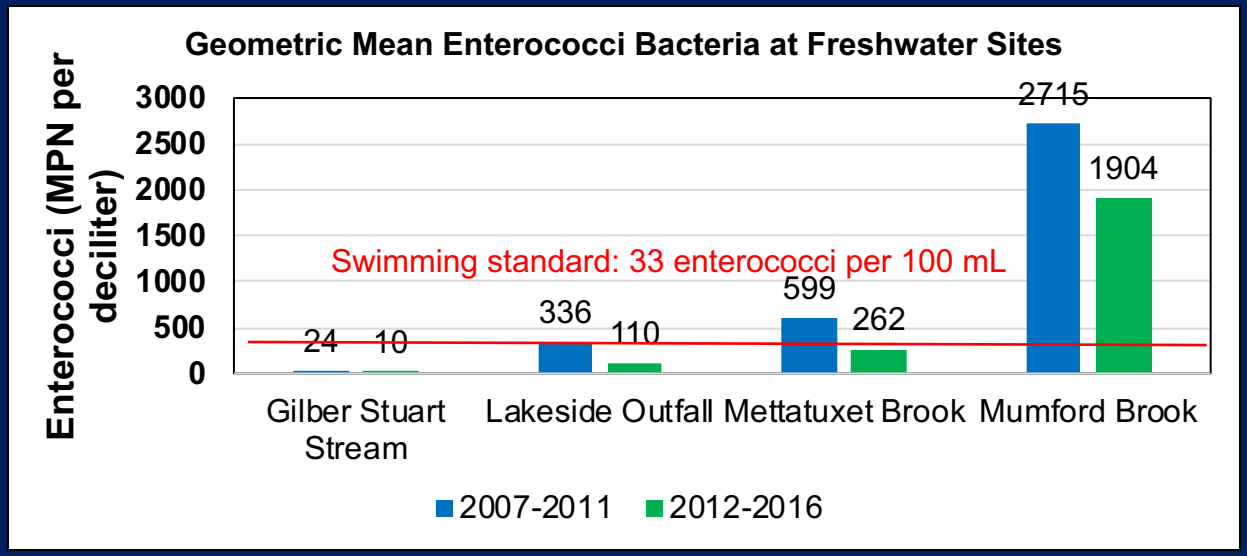




	Gilbert Stuart Stream	Likeside Outfall	Mettatuxet Brook	Mumford Brook
1975	36			29
1997-2006	48	287	496	4967
2007-2016	13	67	61	947

The 1970's data for Fecal Coliform Bacteria and the recent data in some locations are low, suggesting housing added bacteria, but sewers + BMPs help. High recent levels show some problems .





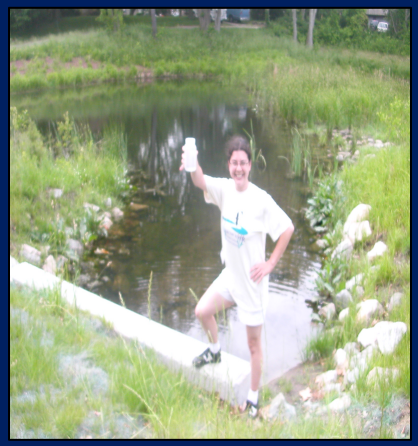
Enterococci Bacteria: Swimming standard. Only have measured since 2007. Lower in recent years except for Pettaquamscutt Cove.

The data has been used in management:

Outhouse removed by Gilbert Stuart Stream 1995

Wider span at Middle Bridge 2004

Edgewater BMP system 2010



Circuit Drive Detention Ponds 2004

Mettatuxet Detention Pond 2006

Recap: What have we learned?

Increasing **temperatures** are typical as indicators of global warming ☹

Dissolved oxygen levels are high enough to support life, despite occasional low oxygen measurements ☺

Increases in **salinity** at sites that are closer to the mouth of the River indicate sufficient inflow of RI Sound water (and with lower nutrient levels) ☺

Fecal coliform bacteria levels suggest the ponds and down to Lacy Bridge and the streams and outfall are improving ☺, but the rest of the river may have some problems. We have not returned to the generally low levels in the 1970's ☹

Enterococci bacteria levels are lower in recent years indicating improvements, swimming continues to be safe☺

Higher **total nitrogen** values in recent years (except for Upper Pond) suggests that the increase in homes, lawns and driveways is counteracting the improvement of municipal sewers for **organic nitrogen (from sewage, fertilizer, animal waste)**☹

Lower recent **ammonia** levels indicate improvements ☺

Lower recent **nitrate plus nitrite** values indicate improvements particularly due to BMPs and municipal sewers ☺

Low **total phosphorus** levels that are similar for all years indicates phosphorus has not been a problem ☺

Lower, recent **dissolved phosphorus** levels are good ☺ but problems may exist at Pettaquamscutt Cove, Gilbert Stuart Stream, and Mettatuxet Brook ☹

Nutrients entering from Lower Narragansett Bay are low ☺

Nitrate plus nitrite levels from the 1970's at various sites are generally low, then higher in mid years, then low again in recent years showing managing helps ☺

Although **chlorophyll** values have increased in recent years, they are still at a good level of production and not a problem. Chlorophyll values in recent years are all higher then earlier years, but still not eutrophic ☺

Not a part of this study but other studies shows that since 2012 **eelgrass** has returned to Narrow River and oysters have too ☺

Mumford Brook, Mettatuxet Brook and the outfall bring in bacteria and nutrients and other data shows that after major rain events, we see elevated levels of bacteria and nutrients -so **stormwater** is still a source ☹

We did not see all this after 10 years of data!

Thanks to our Funders, Partners and Volunteers

Funding:

- RIDEM's Aqua Fund – funded first 3 years of River Watch.
- Towns of Narragansett, North Kingstown, South Kingstown
- EPA equipment grant
- 2007 – The Washington Trust Co.
- US Fish & Wildlife
- Rhode Island Rivers Council
- NRPA

Partners:

- URI Watershed Watch Office
- Eric Peterson, Rahat Sharif: data analysts
- Danielle Perry: SCIwrite intern

Volunteer Monitors

- 187 volunteers
- 325 monitoring days
- ~ 42,250 field readings and ~12,250 lab analyses

River Watch has expanded our knowledge of the condition of the Narrow River. The volunteer monitors are the "eyes on the River" .

But where are the bacteria coming from?

Part II:
Tracking down human sewage with canine detection
Or …What Can Dogs Do?

Veronica M. Berounsky[1], Heidi Travers[2], and Karen Reynolds [3]
[1] Narrow River Preservation Association, [2] RI Dept of Environmental Management, [3] Environmental Canine Services, LLC

Partners:

NARROW RIVER PRESERVATION ASSOCIATION

DEM RHODE ISLAND

ENVIRONMENTAL CANINE SERVICES LLC
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www.ecsk9s.com

TOWN OF NARRAGANSETT RHODE ISLAND

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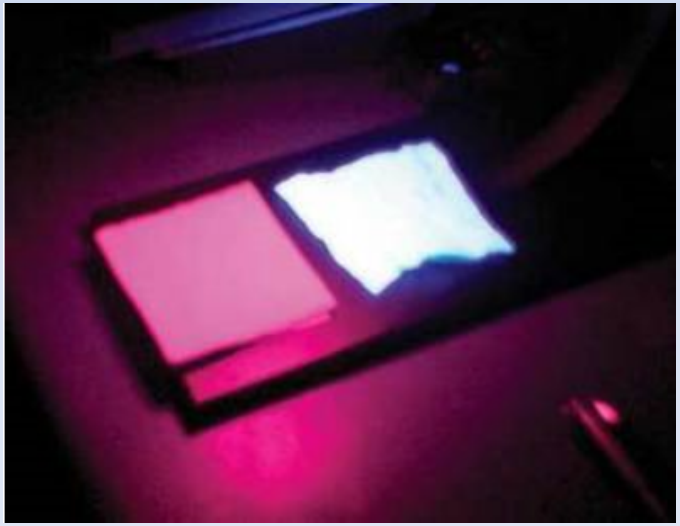
The Nature Conservancy
Protecting nature. Preserving life.™

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

Is the bacteria from Human Sources?
Previous Tracking Techniques Available:

RI DEM often samples in Pettaquamscutt Estuary for Male-Specific Bacteriophage (Coliphage)

DNA testing: expensive, needs reference database



Previous NRPA Studies on the Pettaquamscutt Estuary looked at:
potassium,
fluoride,
surfactants,
fluorescence (optical brighteners)

https://www.waterworld.com/articles/print/volume-22/issue-12/editorial-feature/monitoring-optical-brighteners-helps-track-watershed-pollution.html

And now:
Environmental canine services (ECS)

Helping Improve Surface Water Quality With Sewage Detection Canines

- *10 years experience – Completed over 75 on-site projects in 16 different states and screened several hundred shipped samples from 13 different states*
- *Nationwide service*
  - *8 Canine/Handler Teams, 3 regions*

East Coast
Midwest
West Coast

8 CANINES (6 RESCUED/ADOPTED)

EAST COAST

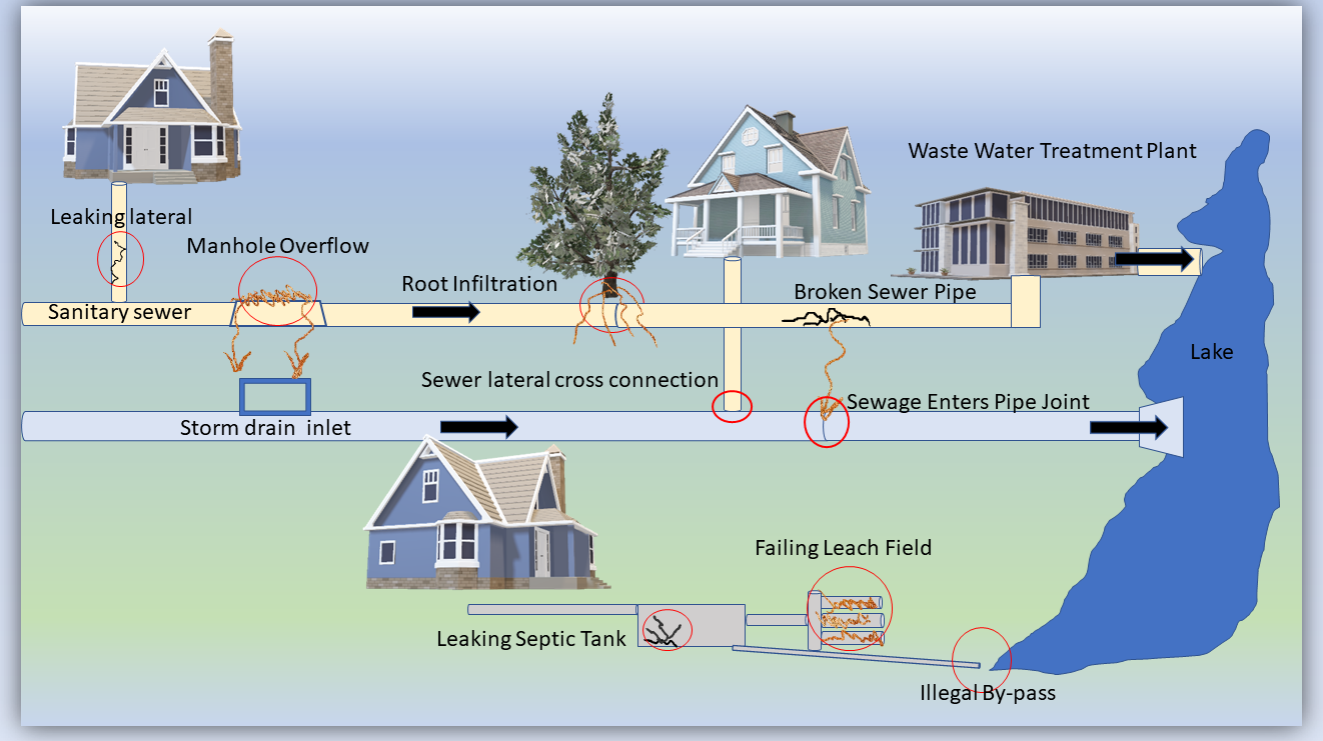
WEST COAST

MIDWEST

WHAT ECS CANINES DETECT

Human sewage in stormwater systems or surface waters from

•Leaking or broken sewer lines •Faulty septic systems •Illicit connections



The canines give an “alert” (bark, sit, down) to the handler when they detect sewage

What the canines don't DETECT:

Animal waste sources

Their detection is for human specific waste

HOW DOES CANINE DETECTION WORK?
STEP 1: SAMPLE, Ship and Sniff in NARROW RIVER: May 22,2018

Water samples taken in areas that had high bacteria values

Photo Courtesy of Veronica Berounsky

Duplicate samples taken for bacteria counts and for shipping to ECS

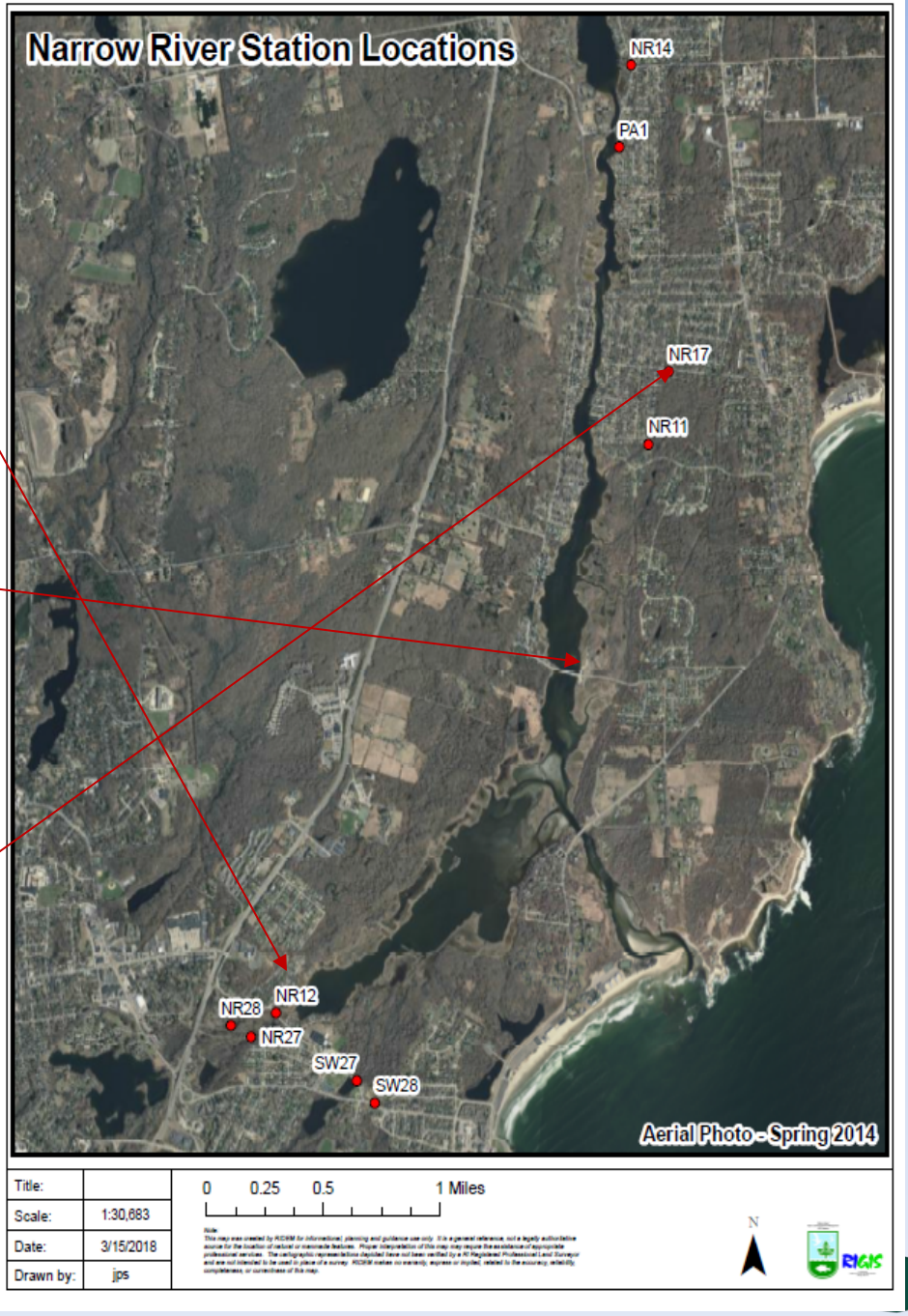
Photo Courtesy of Veronica Berounsky

Photo Courtesy of Veronica Berounsky

Video Example Of Ship And Sniff Scenting By Canine Crush From West Coast Team

Ship and Sniff

Station ID	Male Specific Bacteriophage PFU/100 mL	Fecal Coliform CFU/100 mL	Ship and Sniff Result	Notes
SB02	470	980	++	Positive Control
SW28	<2	42	-	Crooked Brook at Kingston Avenue
SW27	<2	110	-	Crooked Brook at Outlet to Sprague Pond
NR12	<2	520	+ +	Mumford Brook at Mumford Road
NR28	<2	14	-	North Branch Mumford Brook at Power Line
NR27	<2	70	-	South Branch Mumford Brook at Bike Path
NR8	<2	<2	+ +	Narrow River at Middlebridge (WW Station)
NRMB	<2	13	+	Narrow River at Middlebridge at Northeast Corner
NRMetB	<2	5	-	Narrow River at Mettutuxet Beach ~20 ft from shore
NR17	3	5	+ +	Mettatuxet Brook at Mettatuxet Road
SW16	5, <2	280, 120	- -	Duplicate samples taken
Pett01	<2	60	-	Outfall at Pettaquamscutt Avenue
NR14	<2	42	-	Outfall at Lakeside Drive (northern pipe)



Interesting what did NOT have canine alerts: Outfalls at Lakeside Dr or Pettaquamscutt Ave = detention ponds work!

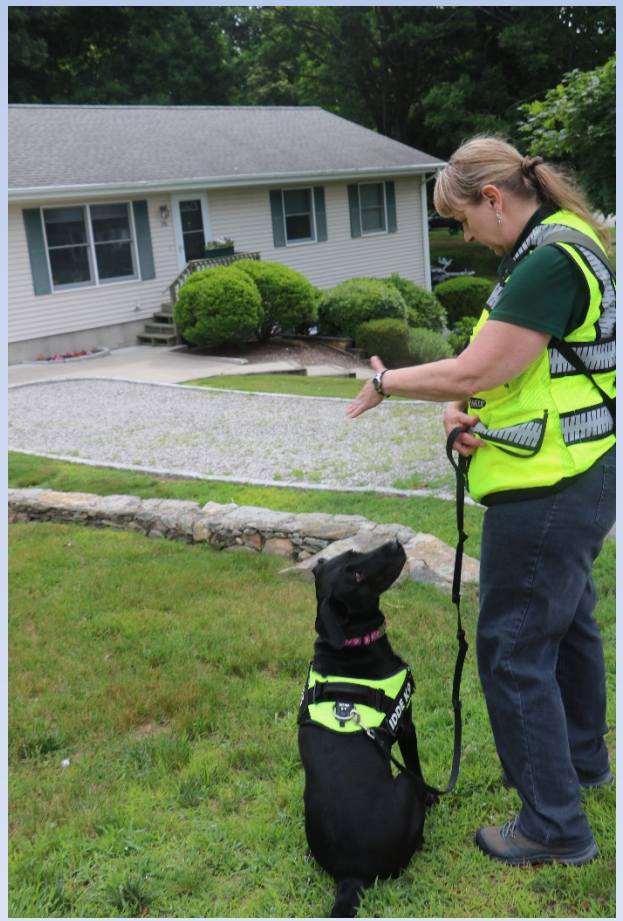
Step2: Onsite Canine Watershed Detection: June 26 and 27, 2018

Photos Courtesy of Veronica Berounsky

Kai and Remi show how they “alert”:
Remi (left) sits
Kai (right) barks

Canine detection attracts a lot of interest and help!

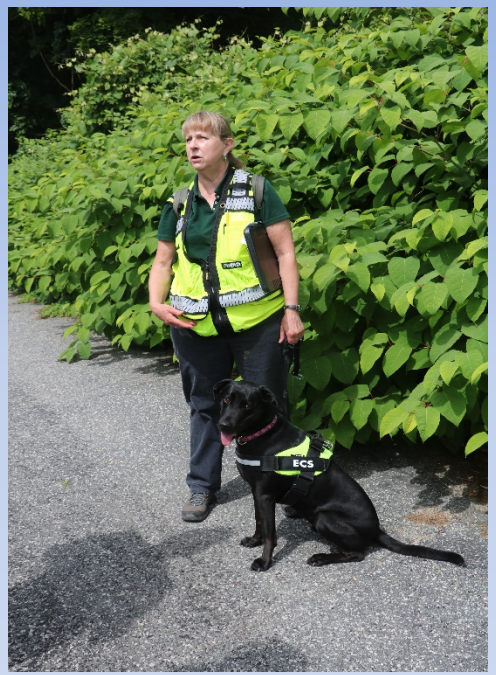
Some examples of unusual work:
Disturbed and replanted topsoil where a tree had been



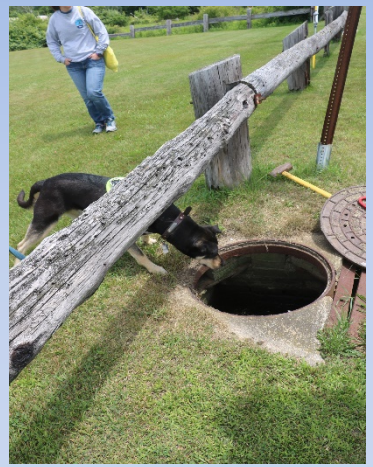
Narrow River Footage

Kai Detecting Sewage
In An Unexpected Place

Detection not near houses.



Middlebridge Area Investigations



Stormwater Outfall & River Water Check: Remi (top) Kai (bottom)

Portable Toilet and Septic Field: Remi

Next Steps: Have met with towns of Narragansett and South Kingstown.
They will use various methods to check on pipes and lines identified to have sewage leaks, such as cameras.

Photo Courtesy of Veronica Berounsky

http://blog.lyttleco.com/septic-tank-maintenance/is-a-septic-system-inspection-necessary-when-buying-a-home

In conclusion:

Canine detection and source tracking of HUMAN sewage was very useful in the Pettaquamscutt estuary and has many advantages and benefits over other methods:

1. **Do not need an actual water sample, can detect sewage (or not) from pipes, infrastructure, grass, soil, etc.**
2. **Results are immediate, do not need to wait 24 hours for lab results.**
3. **Can continue tracking (walk from one catch basin to another, etc.) so can delineate the area of concern.**
4. **Canines can go places that are hard to reach (for example on cobbles).**
5. **Canines are unbiased, do not have preconceived ideas of results.**
6. **Reasonably priced**

Looking for more info on services of these dogs?

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In Conclusion

1. The citizen-scientists volunteer monitors along with the URI Watershed Watch Program provide good quality, long term, multi station data that we would not have otherwise plus gets the community involved.
2. Long term data sets are not only invaluable and useful for looking at changes and trends on a broad scale, but are necessary for seeing delayed responses to management actions.
3. Historical data added to long term data gives perspective.
4. Most indicators of water quality have shown improvement in Narrow River over these 25 years of monitoring (and 20 years since sewers completed) but improvements were not as evident at 10 or 15 years. Does it take 20 plus years for our anthropogenic legacy to go away?
5. Problems remain: nitrogen from streams and bacteria "hot spots"
6. Canine Detection of human sewerage proved very useful. Need towns to follow up.

And for more details, check out www.narrowriver.org

Dogs also help with monitoring!

Sunset over Narrow River