Embayment Nitrogen Loads for Long Island Sound

March 18, 2016
Cold Spring Harbor, NY – EPA Region 2 & Suffolk County

Jamie Vaudrey

Department of Marine Sciences, UConn

with

Charlie Yarish, UConn (2011, 2013)
Chris Pickerell, CCE (2011, 2013)
Lorne Brousseau, CCE (2013)
Justin Eddings, CCE (2013)
Jang Kim, UConn (2013)
Michael Sautkulis, CCE (2013)

MAJOR SUPPORTERS

Long Island Sound Study
A Partnership to Restore and Protect the Sound

Sea Grant
Connecticut

Sea Grant
New York

ADDITIONAL SUPPORT PROVIDED BY

UCONN
COLLEGE OF LIBERAL ARTS AND SCIENCES
DEPARTMENT OF MARINE SCIENCES

UConn IDEA Grant
imagine / develop / engage / apply

Cornell University
Cooperative Extension
of Suffolk County

THE JENIAM FOUNDATION

Field and Lab Support

UConn: Claudia Koerting, Corey Leamy, Roni Ortiz

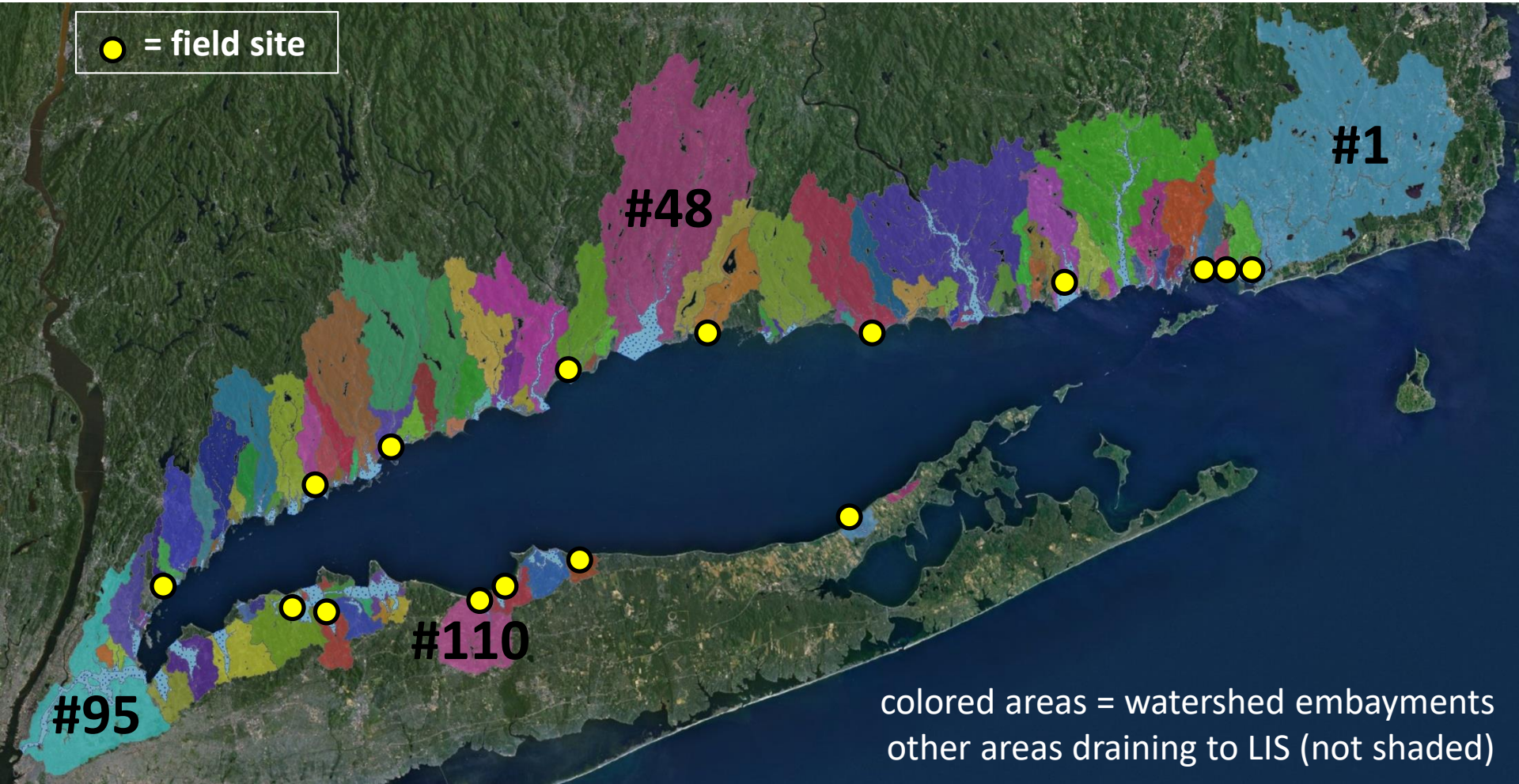
CCE: Nick Krupski, Barry Udelson, Stephen Schott

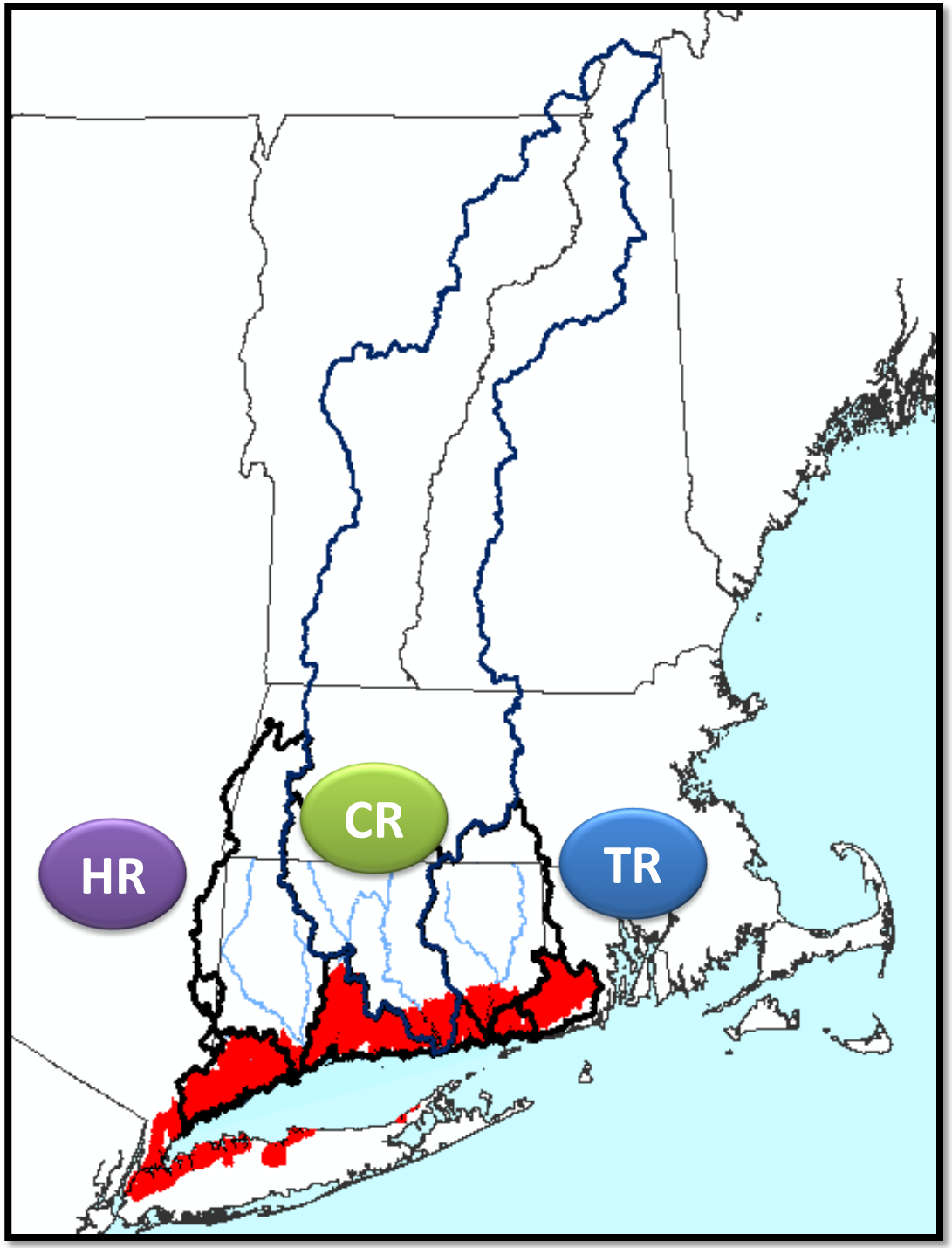
UConn: Josh Carter, Joel Corso, Melissa Cote, Adam Chlus, Jenny Dootz, Amanda Dostie, Kim Gallagher, Rafeed Hussain, Christopher Kunz, Leigha Krize, Marissa Mackewicz, Kelsey Olguin, Rachel Perry, Michelle Slater,

CCE: Carolyn Sukowski

Use N-load to predict problem areas & identify sources of impairment.

- nutrient load to 110 embayments
- eutrophic status in 15 embayments
- use N-load (+) to predict eutrophic status
  - the “+” includes freshwater flushing time and hypsography





Red Area = our study area

embayments and coastal portion of:

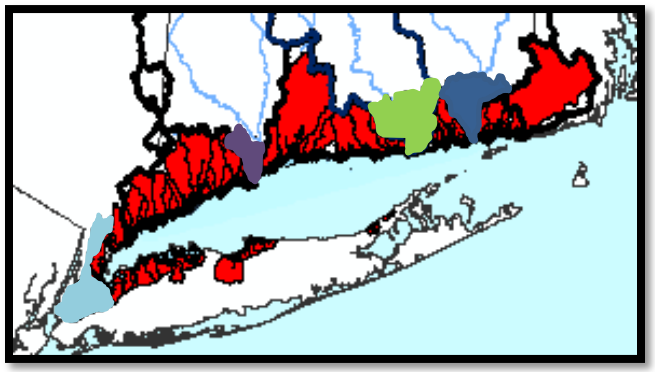
HR – Housatonic River

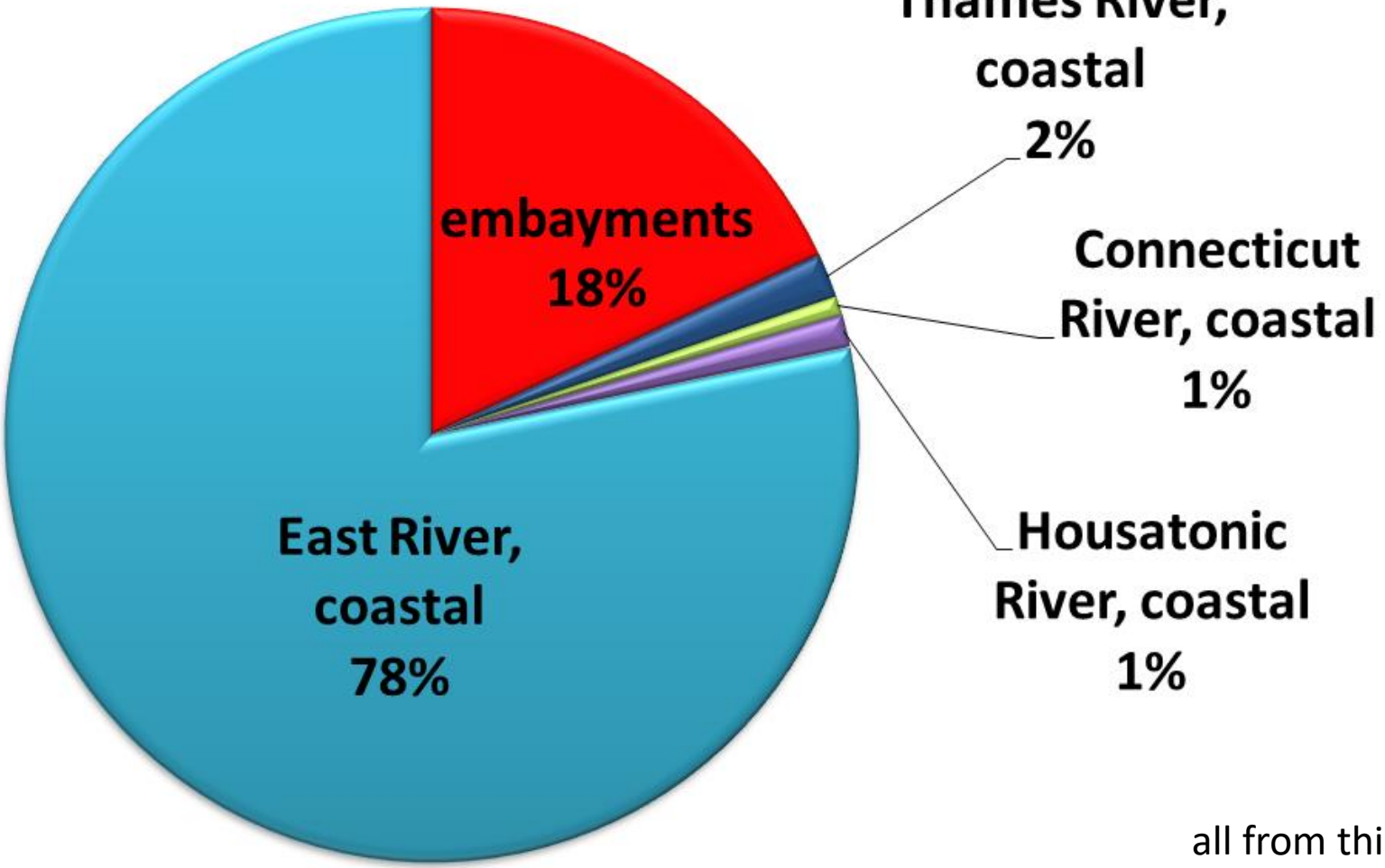
CR – Connecticut River

TR – Thames River

LIS Coastal Watershed

fraction of total nitrogen load attributed to watersheds

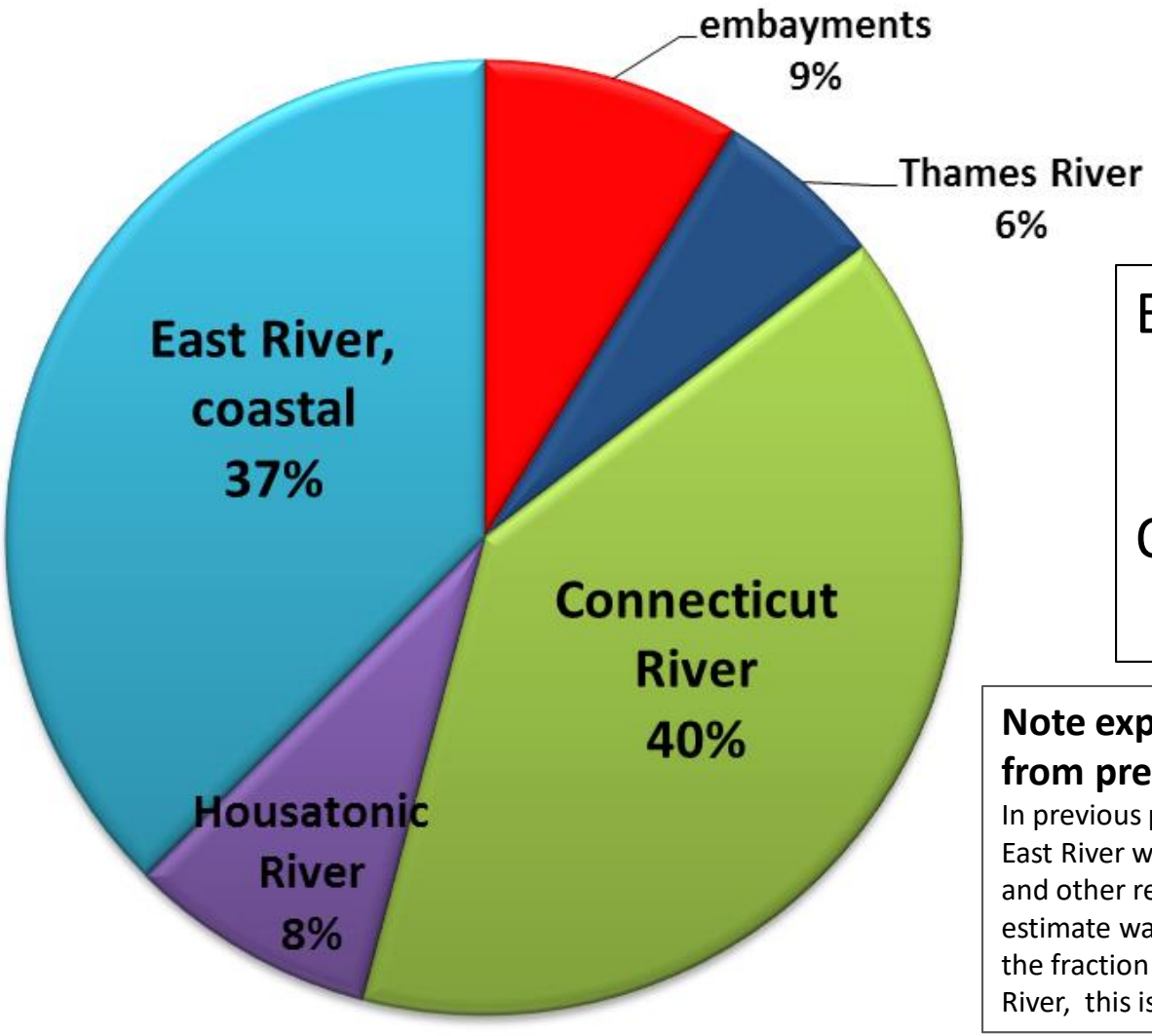


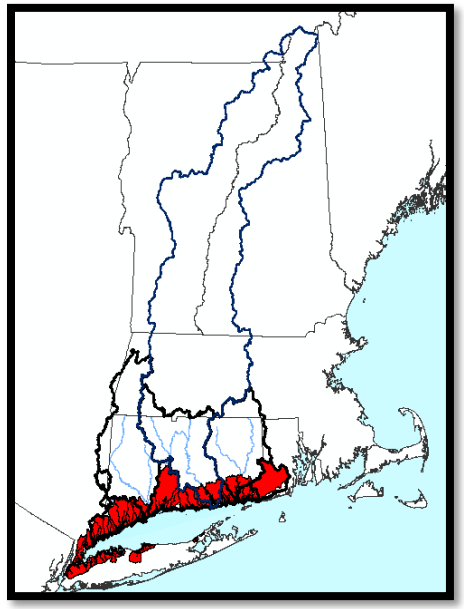


all from this study

LIS Total Watershed

fraction of total nitrogen load attributed to watersheds





East River &
Embayments = this study
Other Rivers = USGS SPARROW estimates

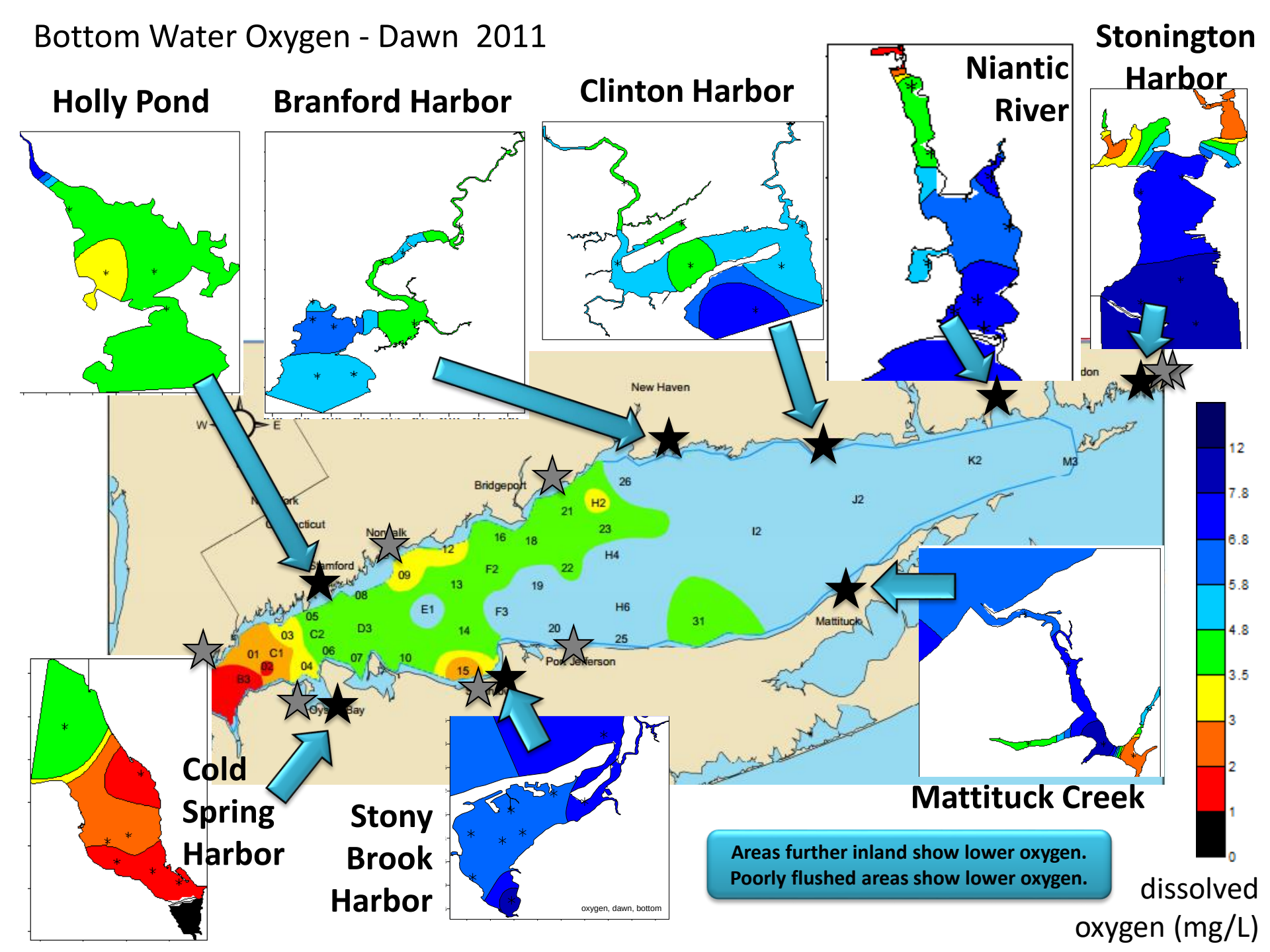
Note explaining why this figure is different from previous presentations:

In previous presentations, an old estimate of N load from the East River was use, dating from 1989. Upgrades to N removal and other reductions in the N Load meant that the 1989 estimate was too large. While our study area does not include the fraction of the Hudson River that may be exiting the East River, this is considered a better estimate of sources.

Embayment Eutrophic Status

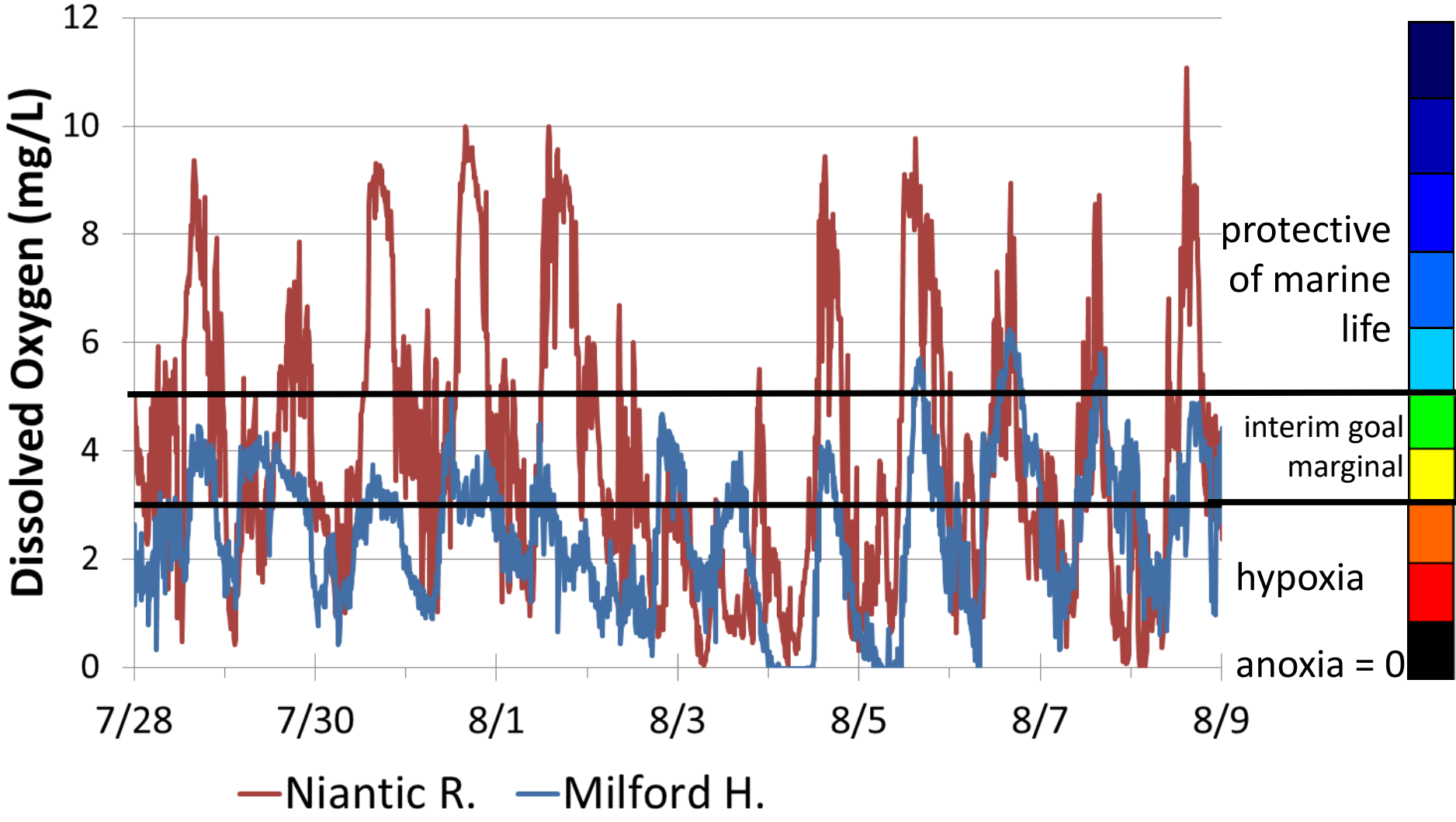
RAPID ASSESSMENT

Bottom Water Oxygen - Dawn 2011



Bays are "panting."
Big swings between highs and lows are hard on marine life.

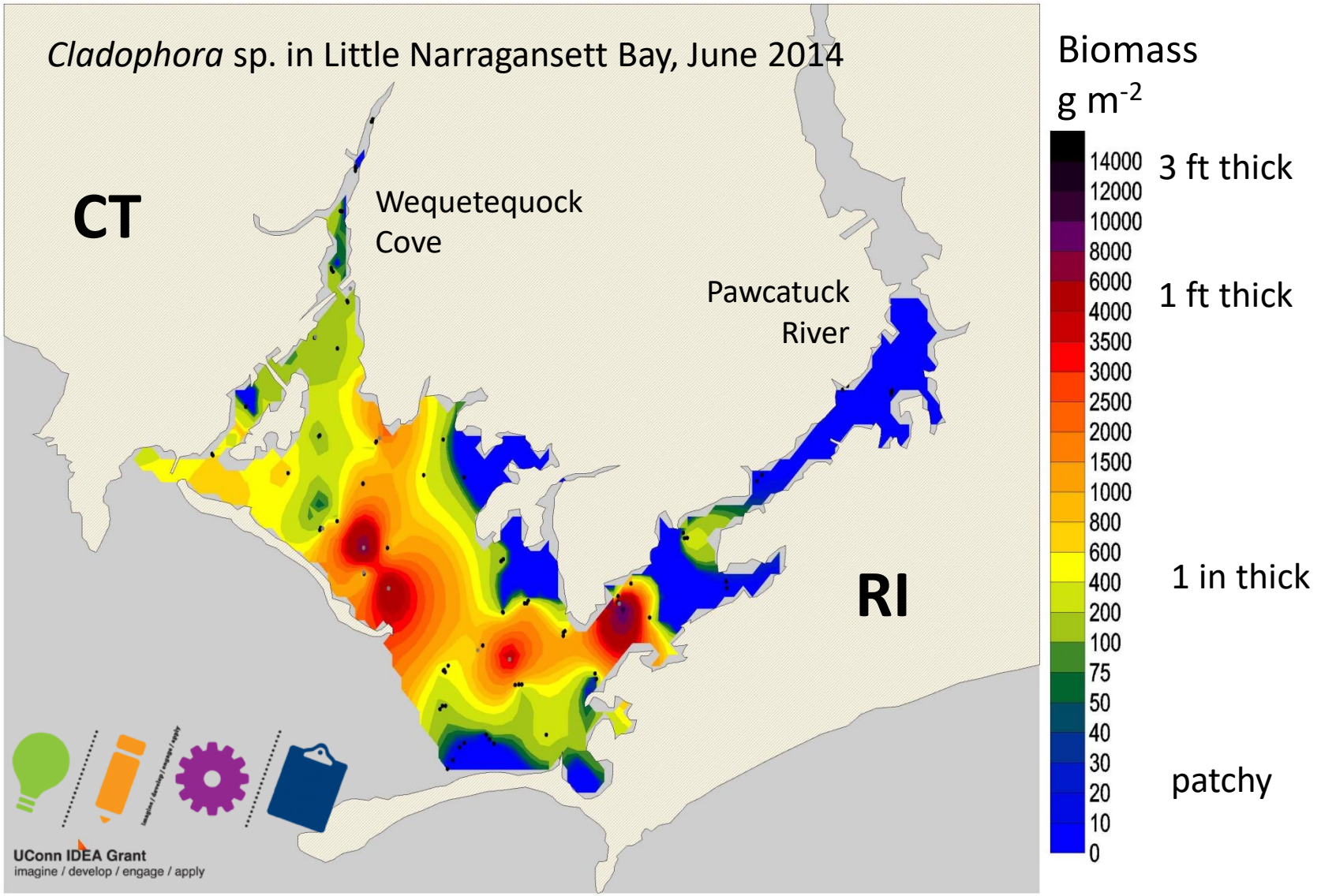
July 28 – August 9, 2014
Oxygen recorded every 15 minutes.



Ulva sp., blade form
Cold Spring Harbor, NY
7/31/12

Charlie Yarish, UConn

Gracilaria sp.
Holly Pond, CT
8/6/12

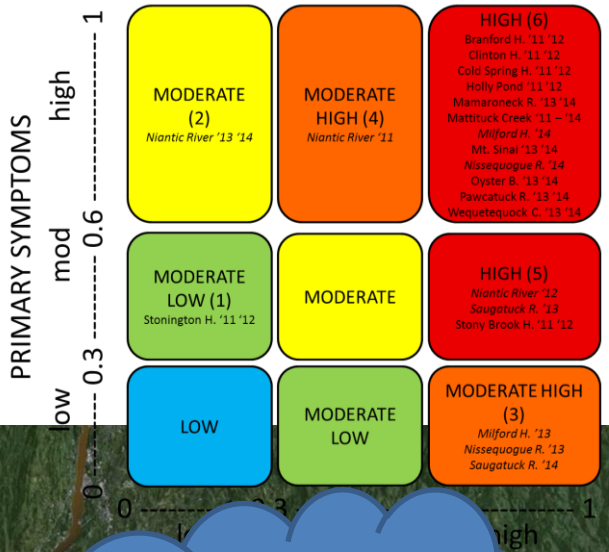


Dostie, A. and J.M.P. Vaudrey (2014) *Characterization Of The Extent And Source Of Nutrients Supporting A Massive Macroalgae Bloom In Little Narragansett Bay, CT*. New England Estuarine Research Society Fall Meeting

NOAA NEAA ASSETS

<u>five symptoms</u>: chlorophyll *a*, macroalgae, low dissolved oxygen, loss of eelgrass, and the occurrence of harmful algal blooms

Nitrogen and phosphorus inputs, residence time, freshwater flow



includes benthos and biological indicators

#1

#48

#110

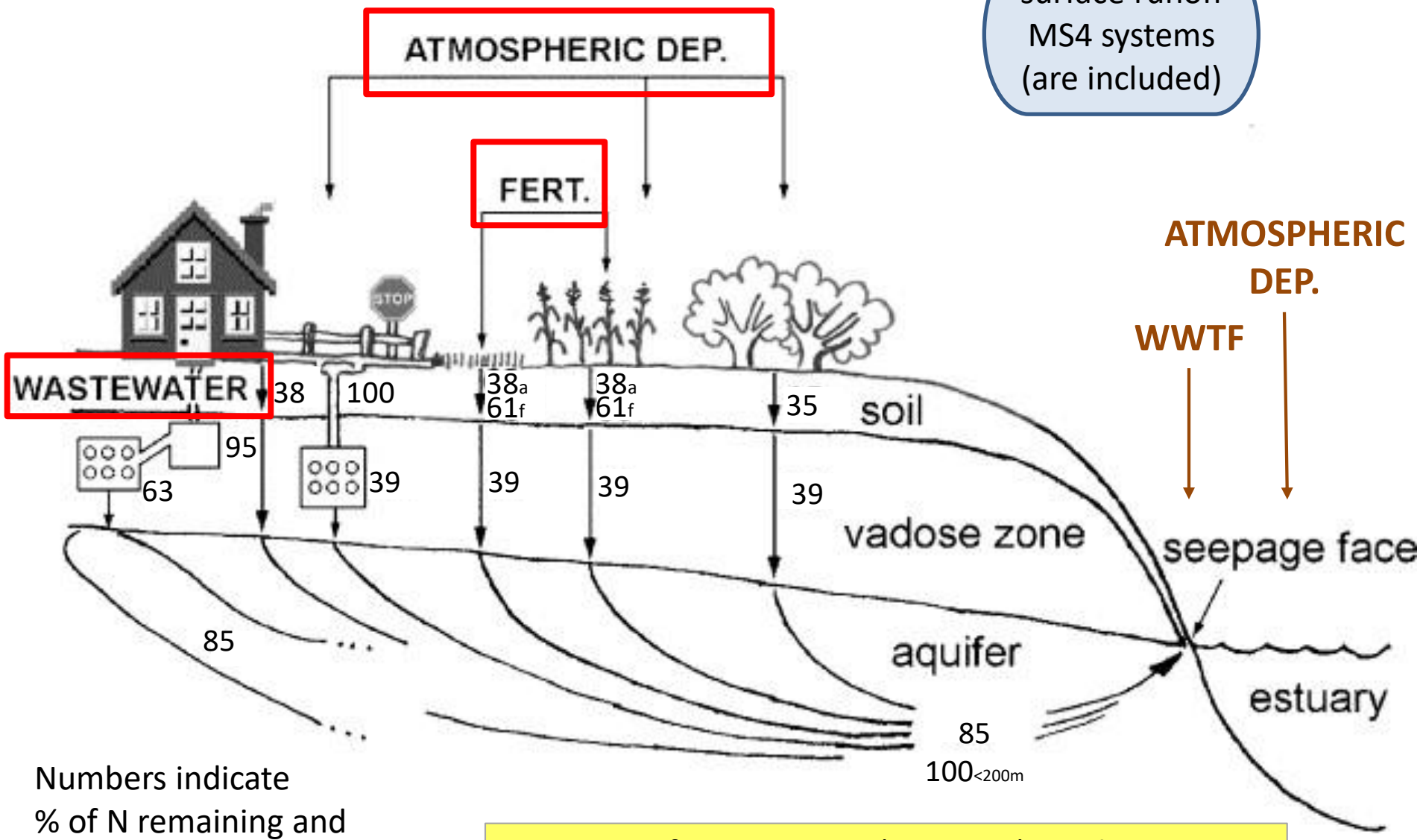
#95

colored areas = watershed embayments
other areas draining to LIS (not shaded)

NITROGEN LOAD

Symbols courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/)

surface runoff
MS4 systems
(are included)

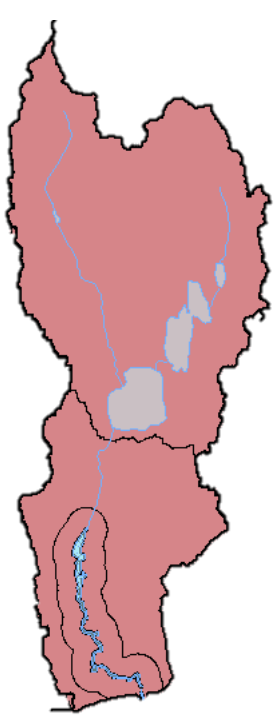


Numbers indicate
% of N remaining and
delivered to the next sector.

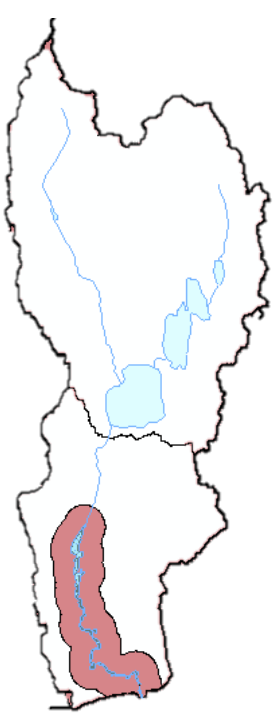
e.g. 8.9% of N to Nat Veg (tree icon) reaches estuary

Valiela, I., M. Geist, J. W. McClelland, and G. Tomasky. 2000. Nitrogen loading from watersheds to estuaries: verification of the Waquoit Bay nitrogen loading model. Biogeochemistry **49:** 277-293.

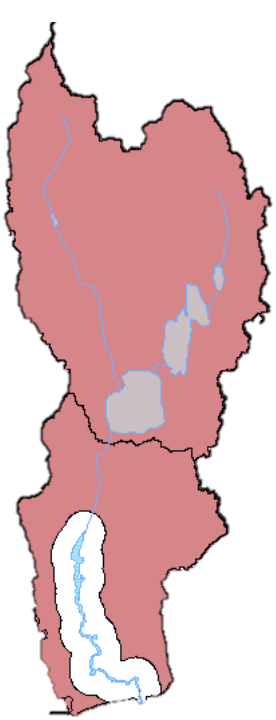
ALL



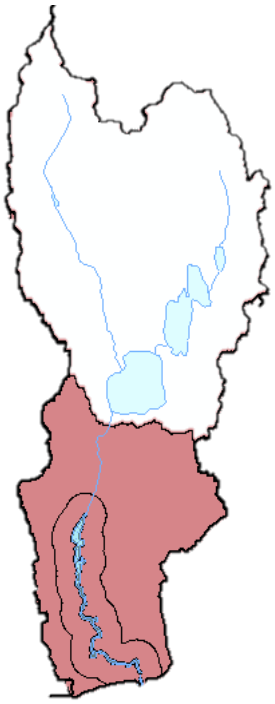
BUFF200



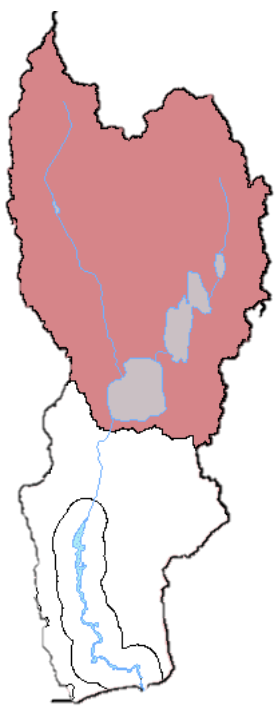
OutBUFF200

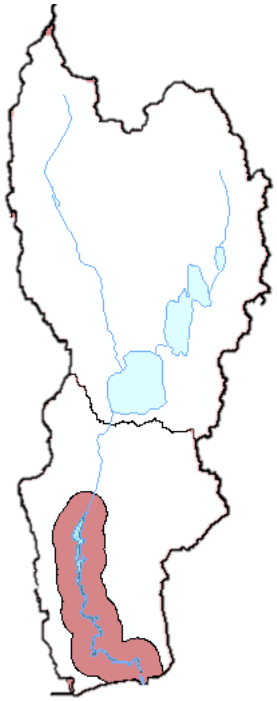


NEAR

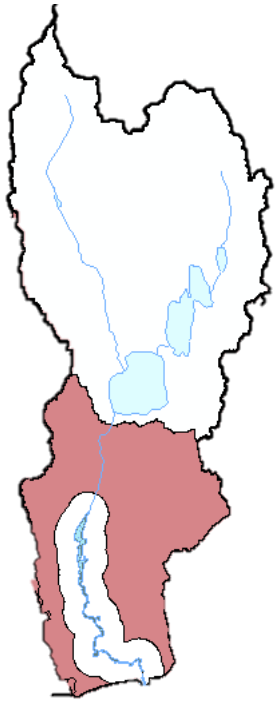


FAR

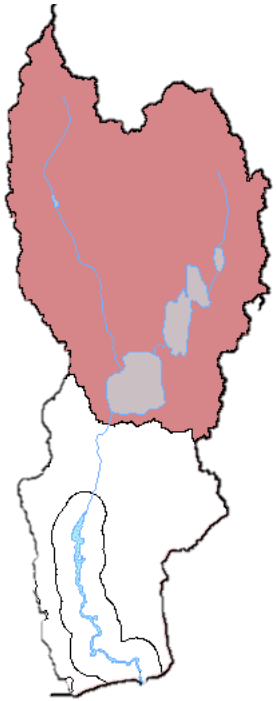




BUFF200_NEAR



OutBUFF200_NEAR

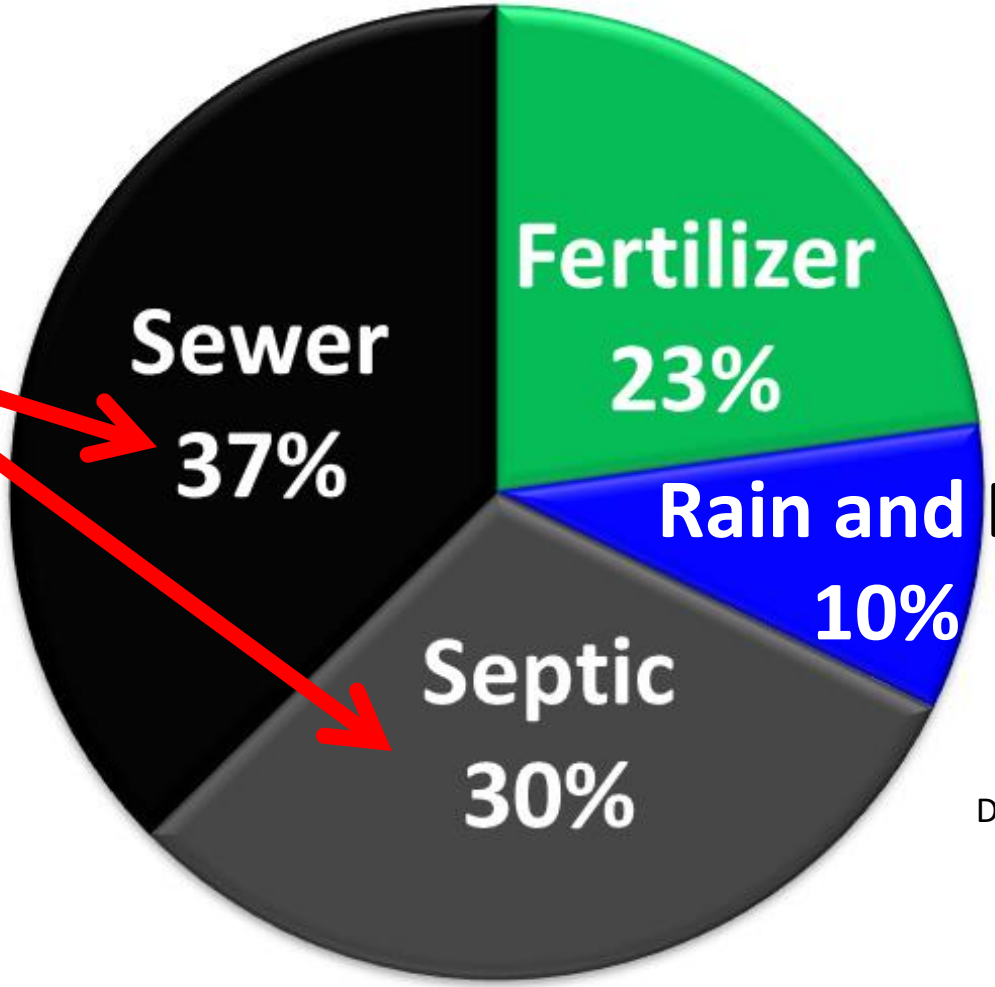


OutBUFF200_FAR

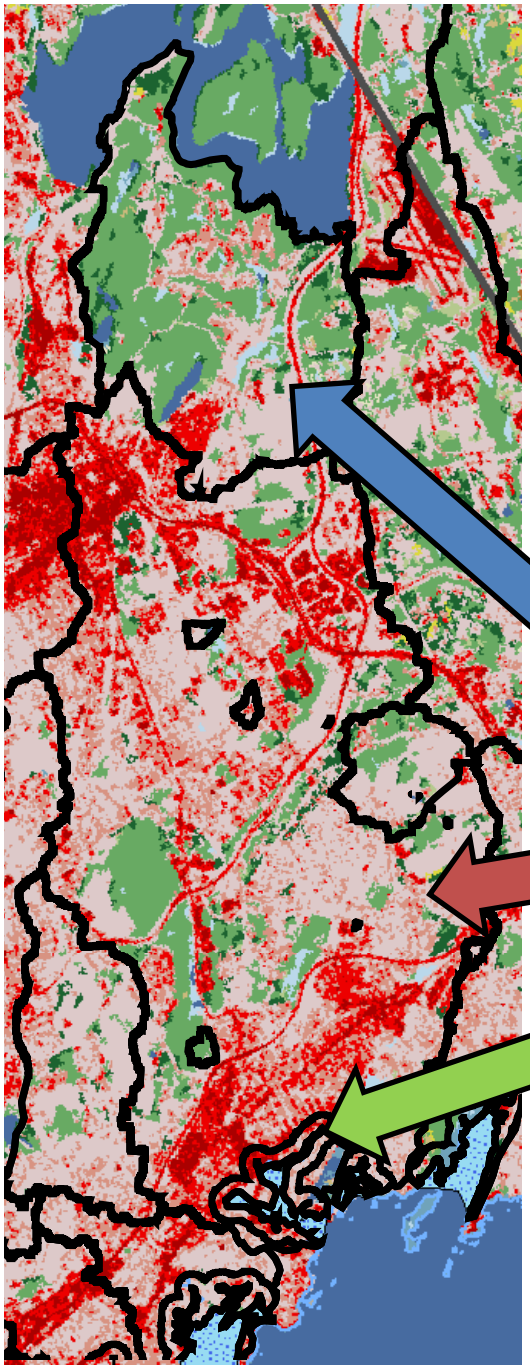
Source of Nitrogen to All Long Island Sound Embayments

67%

of nitrogen is from sewer and septic



Sum of all embayments. Does not include the following rivers: Thames, Connecticut, Housatonic, East River.



modeled nitrogen delivery to water's edge, per person

Septic = varies by location:

OutBUFF200 FAR	**0.8** kg N / person / y
OutBUFF200 NEAR	**1.7** kg N / person / y
BUFF200 NEAR	**2.0** kg N / person / y

AVERAGE for LIS **1.3** kg N / person / y

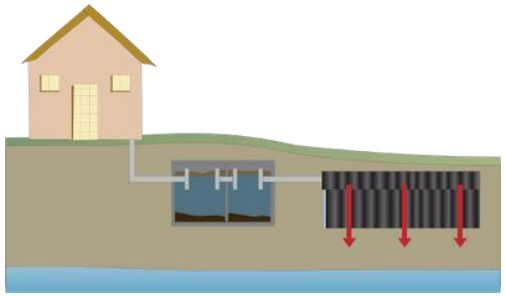
NLCD 2011 – roughly; red = heavily developed, pink = open space, green = natural vegetation, blue = water

* Valiela – 65%; Hanson = 85% for sandy LI; 85% for CT

Waste Water

4.8 kgN/pp/y

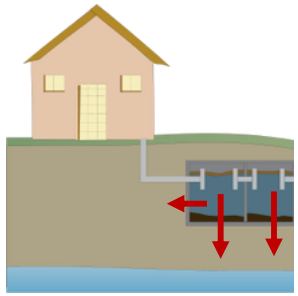
People on Septic



distance from estuary

> 200 m	< 200 m
60%	60%
66%	66%
85% *	100%
33.7%	**39.0%**

People on Cesspools & Suffolk C. Vertical Septic



distance from estuary

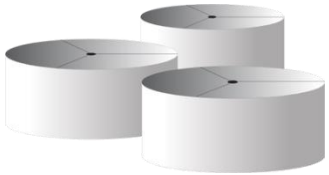
> 200 m	< 200 m
95%	95%
66%	66%
85% *	100%
53.3%	**62.7%**

septic tanks & leaching fields

plume

aquifer

People on Sewer



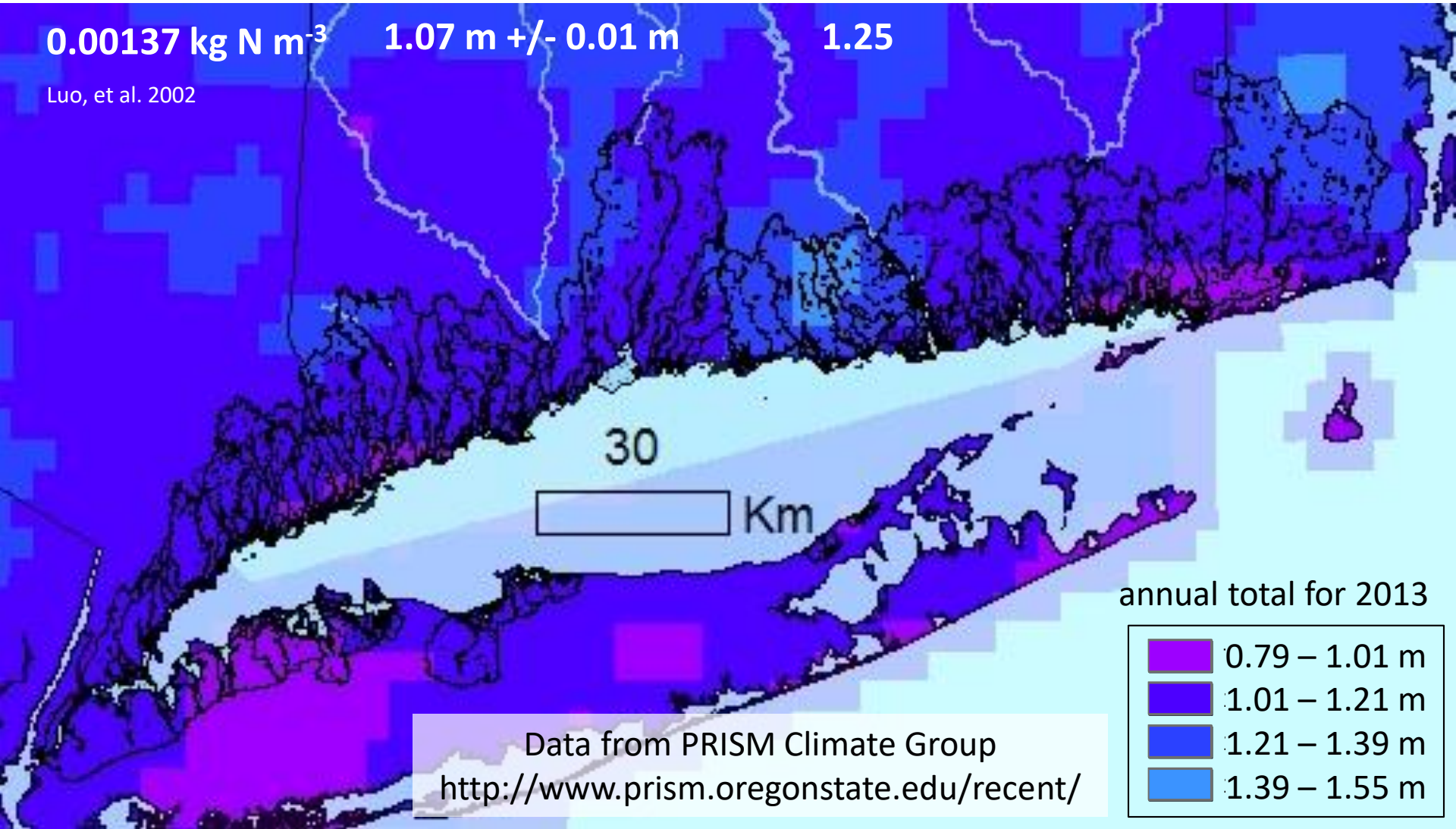
annual reported loads to embayments

100%

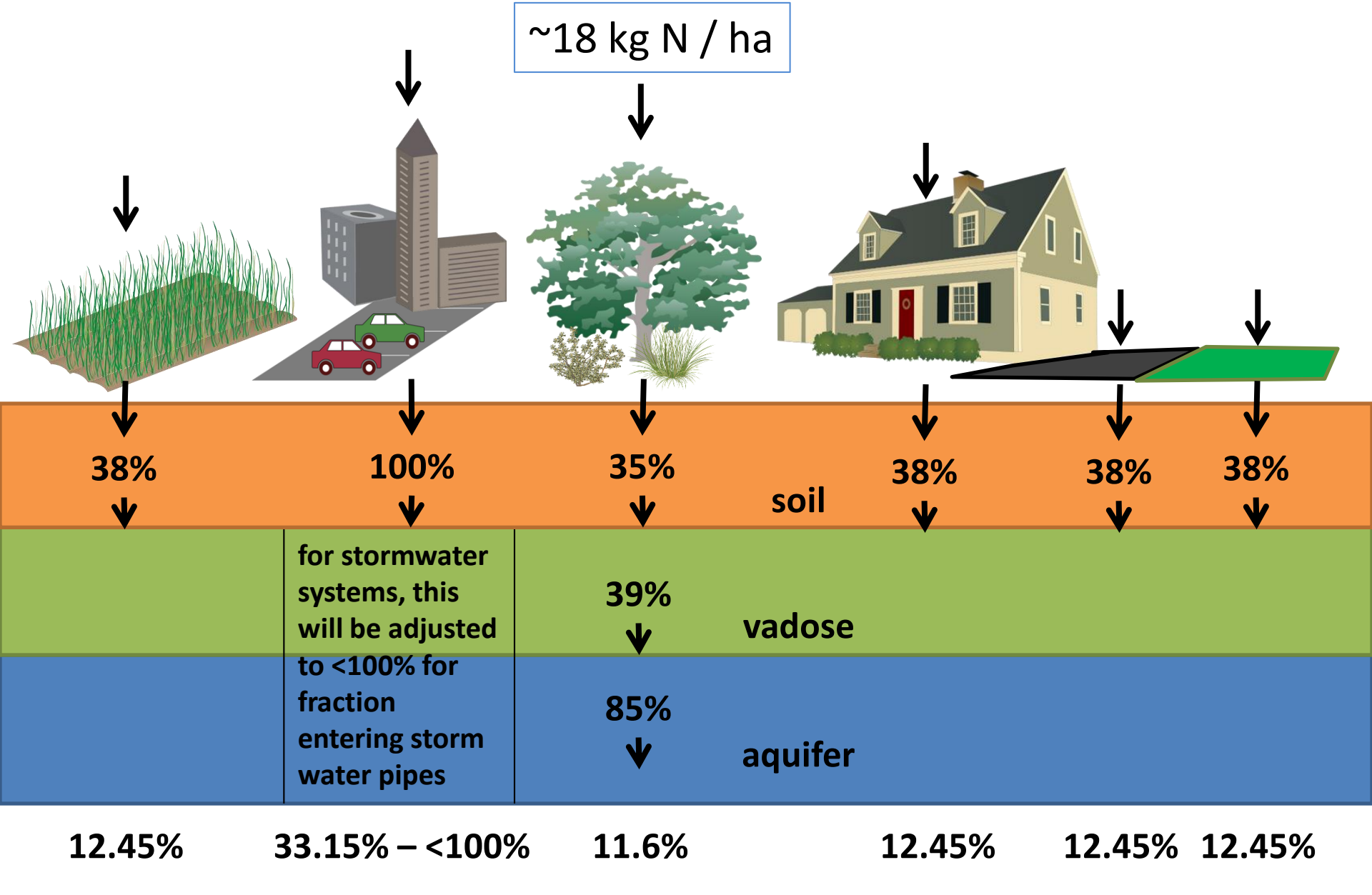
Atmospheric Deposition

Total Atmospheric Deposition ≈ 0.0018 kg N m^{-2} ≈ 18 kg N / ha

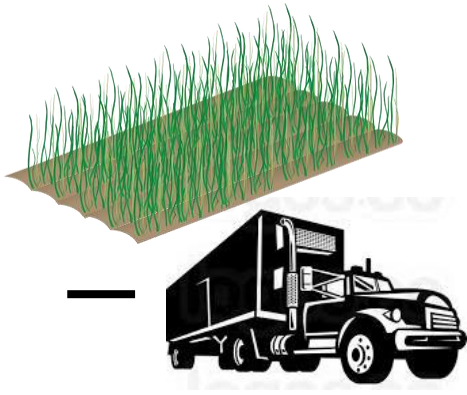
$[TDN]_{wet}$ * Avg. Rainfall * (total : wet)



Atmospheric Deposition



Fertilizer Application



61% not lost as gas

39% vadose

85% aquifer

20.2%

Fertilizer Application

CT –
69.7 kgN/ha/y
range of 62 – 79
LI –
99.8 kgN/ha/y
range of 87– 114
WC –
95.5 kgN/ha/y
range of 84 - 109
Q&B –
93.2 kgN/ha/y
range of 80 - 108

100% at
190 kgN/ha/y
range of 150 - 250

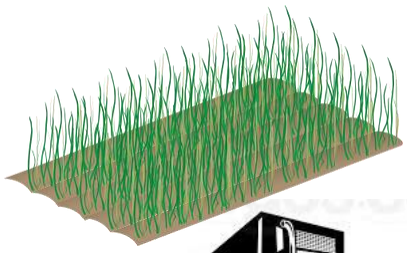
91.7 kgN/ha/y
range of 80 - 110

sports –
132.2 kgN/ha/y
range of 117 - 181
parks –
81.6 kgN/ha/y
range of 72 - 91

20.2%

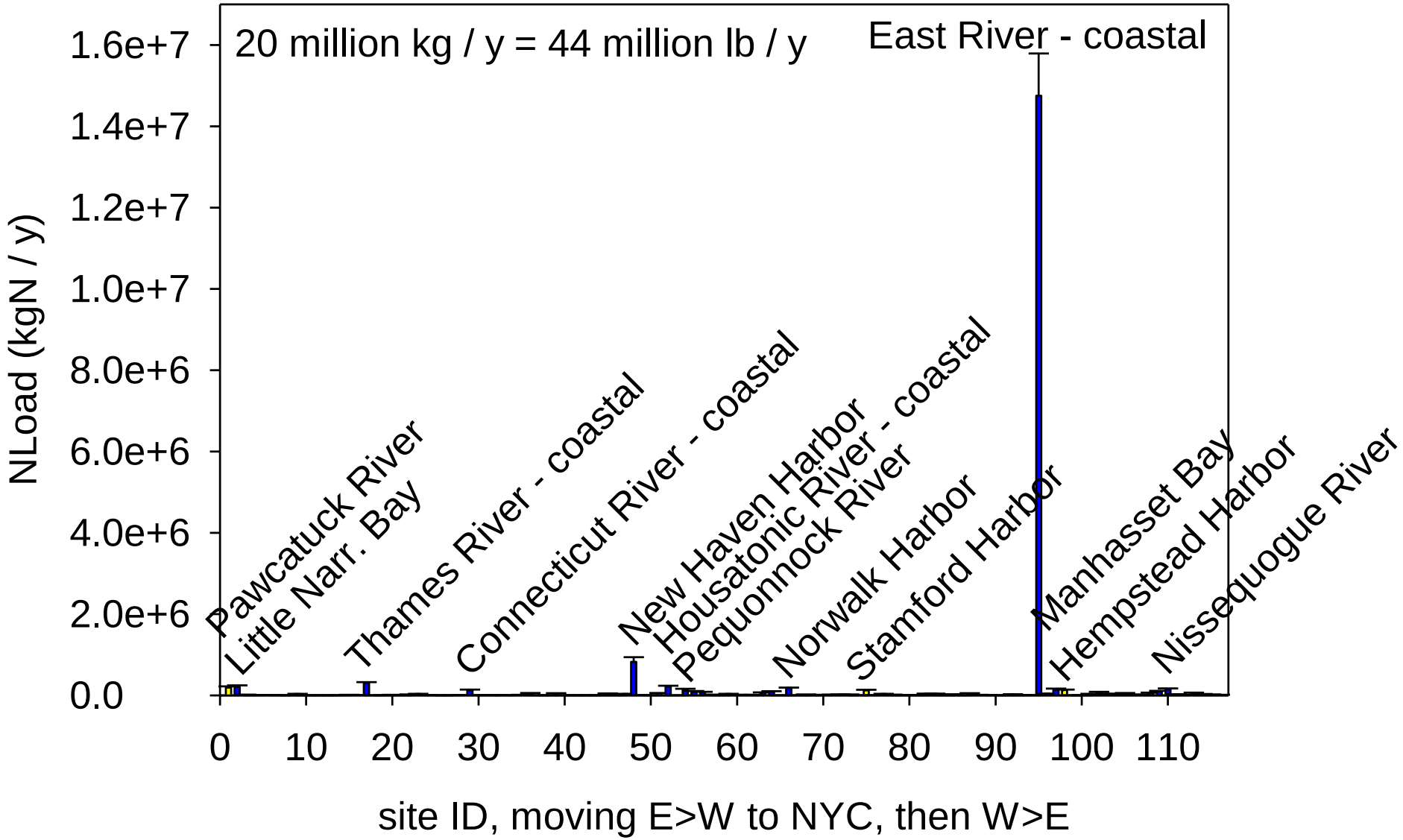
EPA's document: Fertilizer Applied for Agricultural Purposes Exhibit 4-16

100% at
86.0 kgN/ha/y
range of 22 - 168

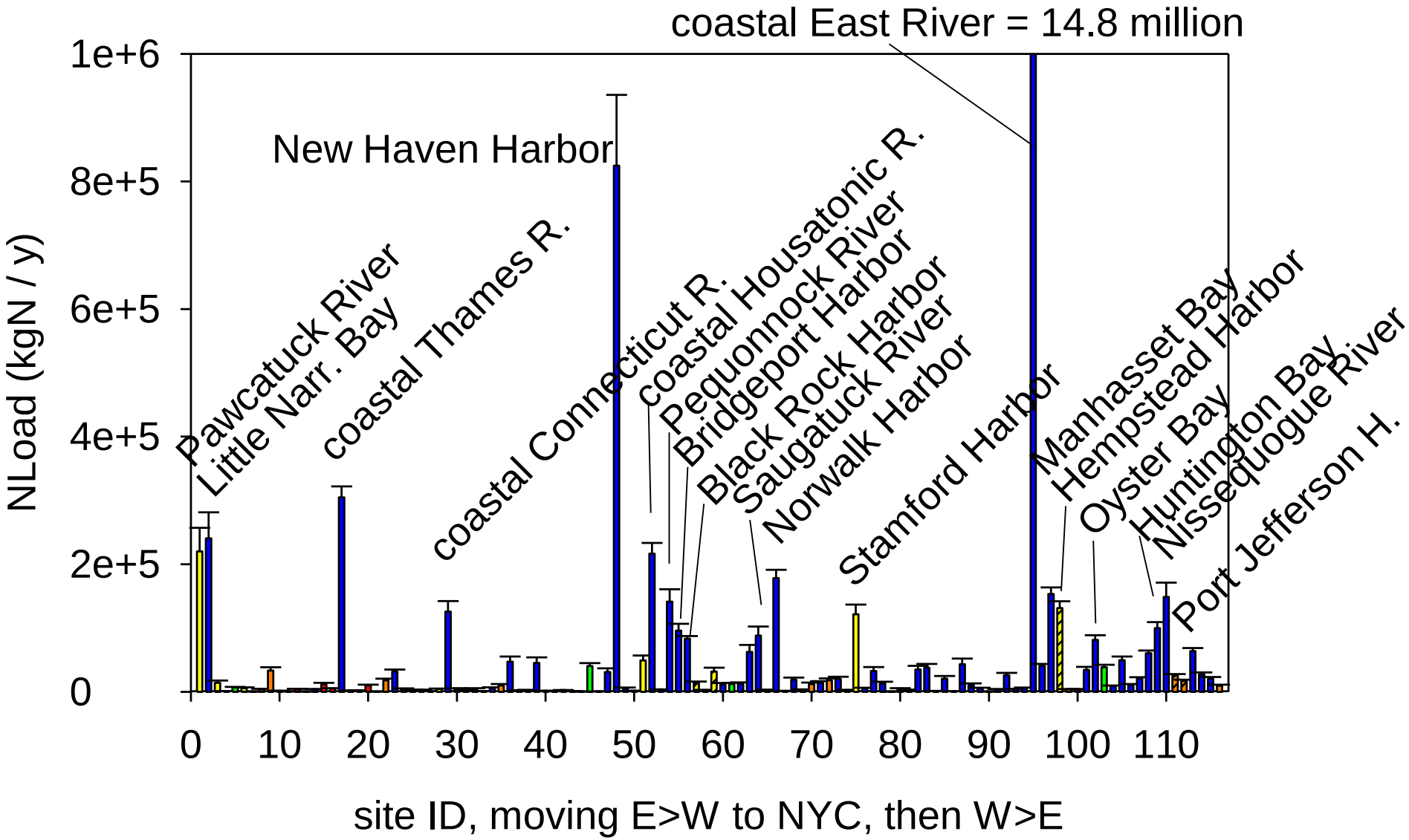


N in crops leaving watershed

TOTAL LOAD (includes Atm Dep to embayment surface)



TOTAL LOAD (includes Atm Dep to embayment surface)

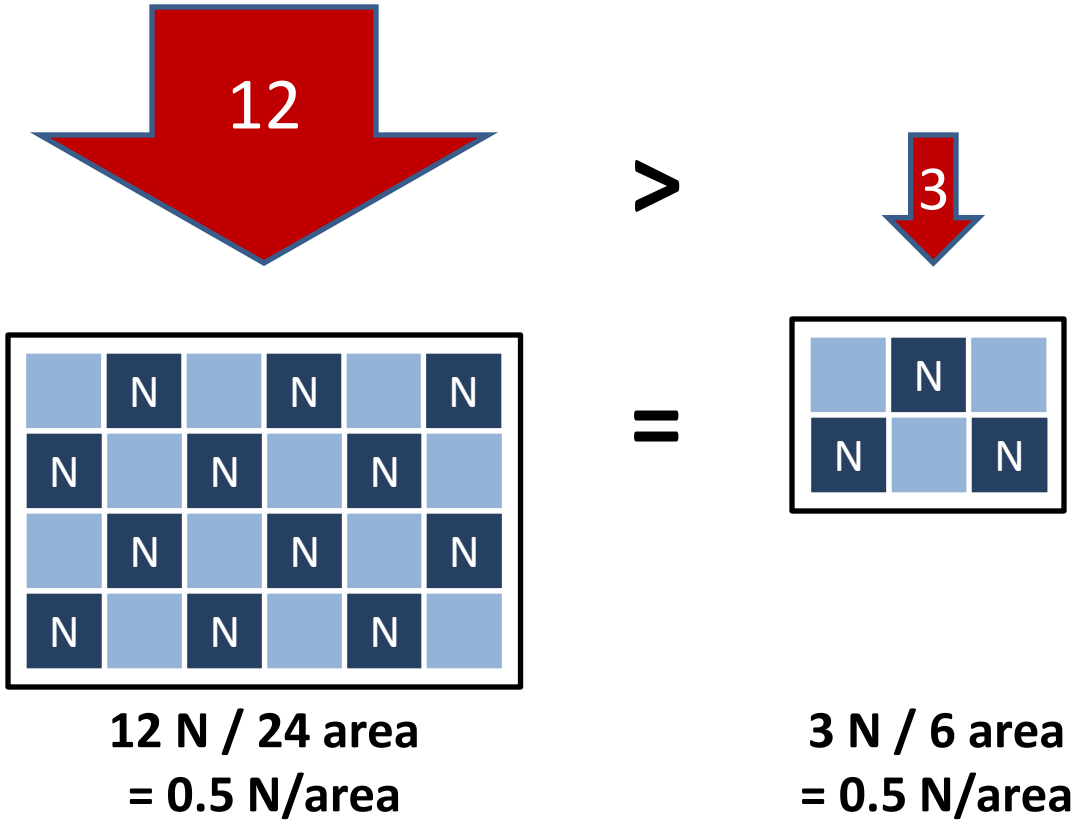


Total load is important to Long Island Sound.

But for water quality in embayments →

nitrogen load ↓

size of embayment 

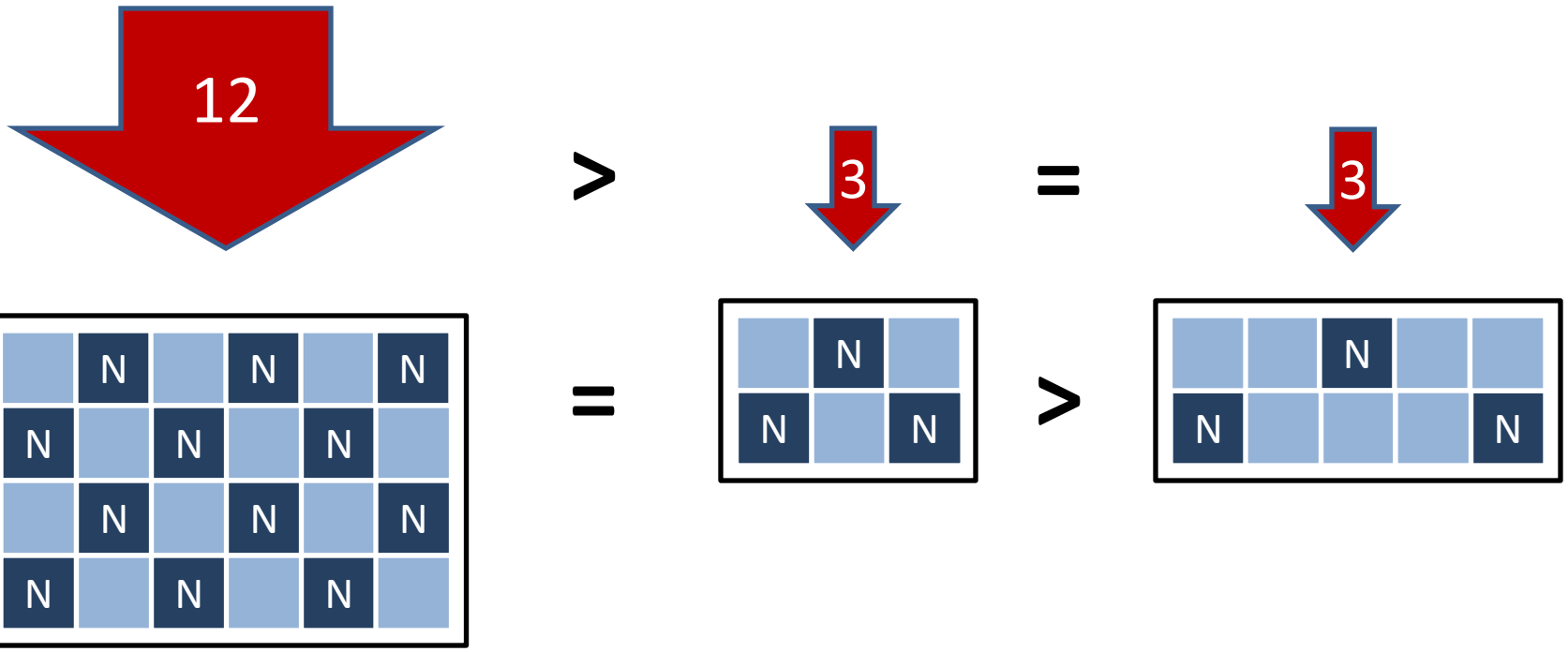


Total load is important to Long Island Sound.

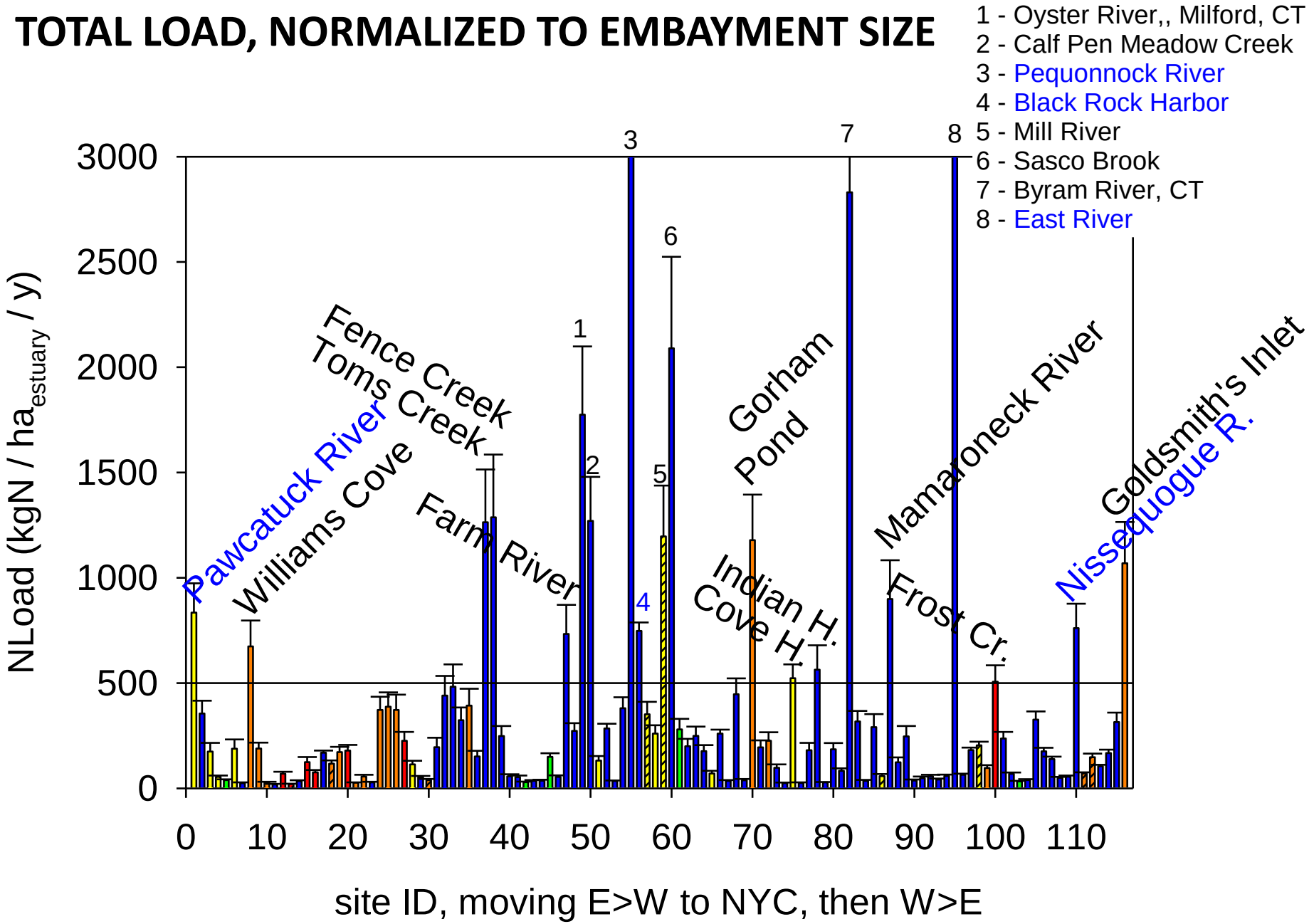
But for water quality in embayments →

nitrogen load

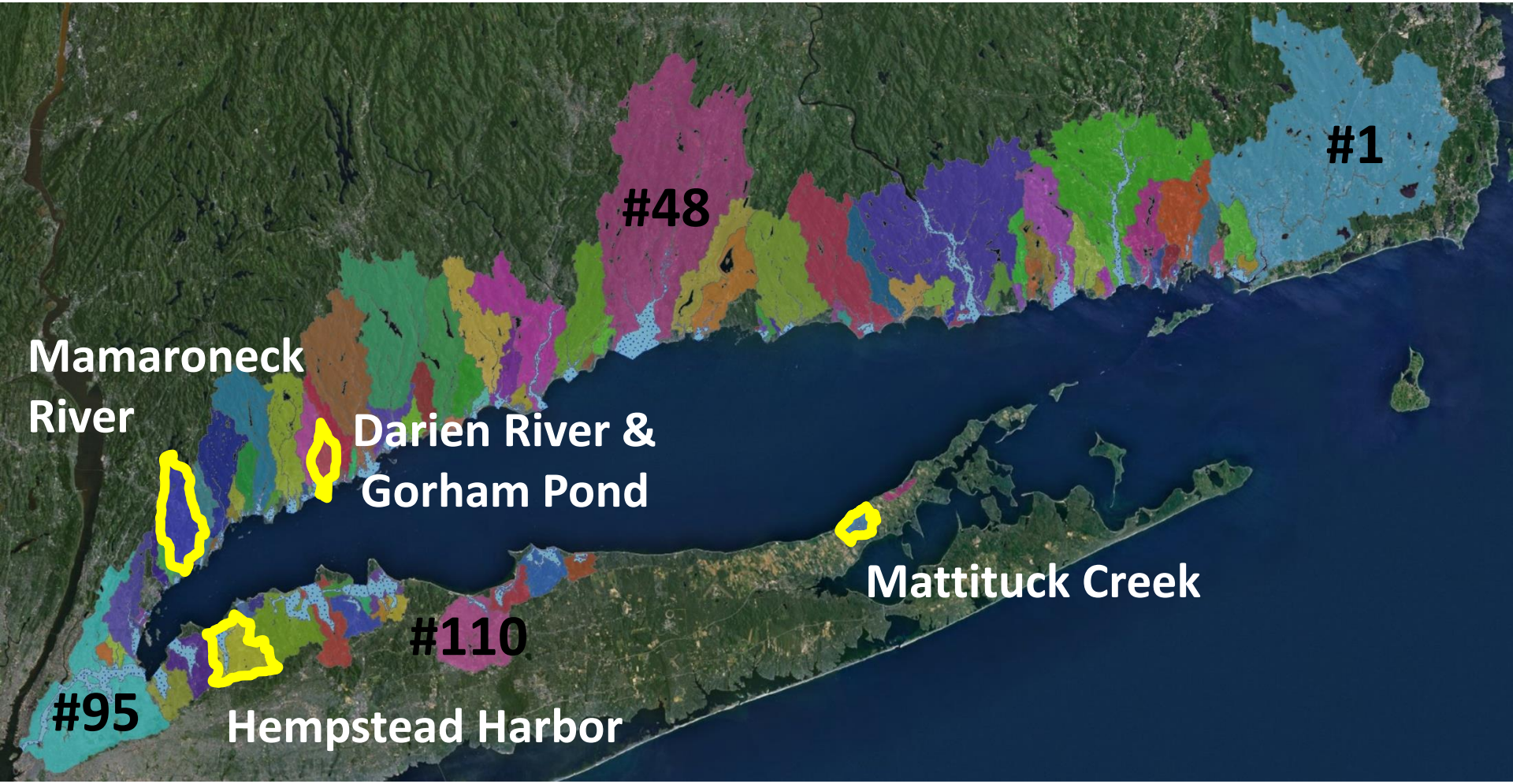
size of embayment



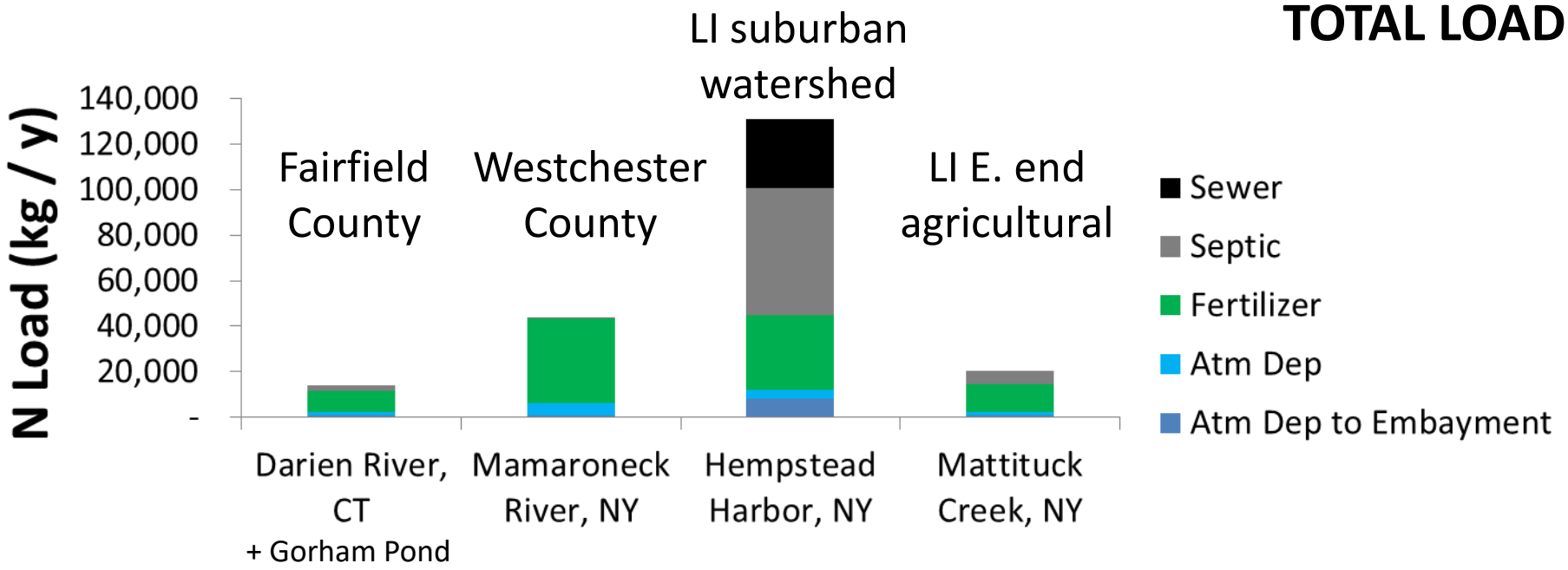
TOTAL LOAD, NORMALIZED TO EMBAYMENT SIZE



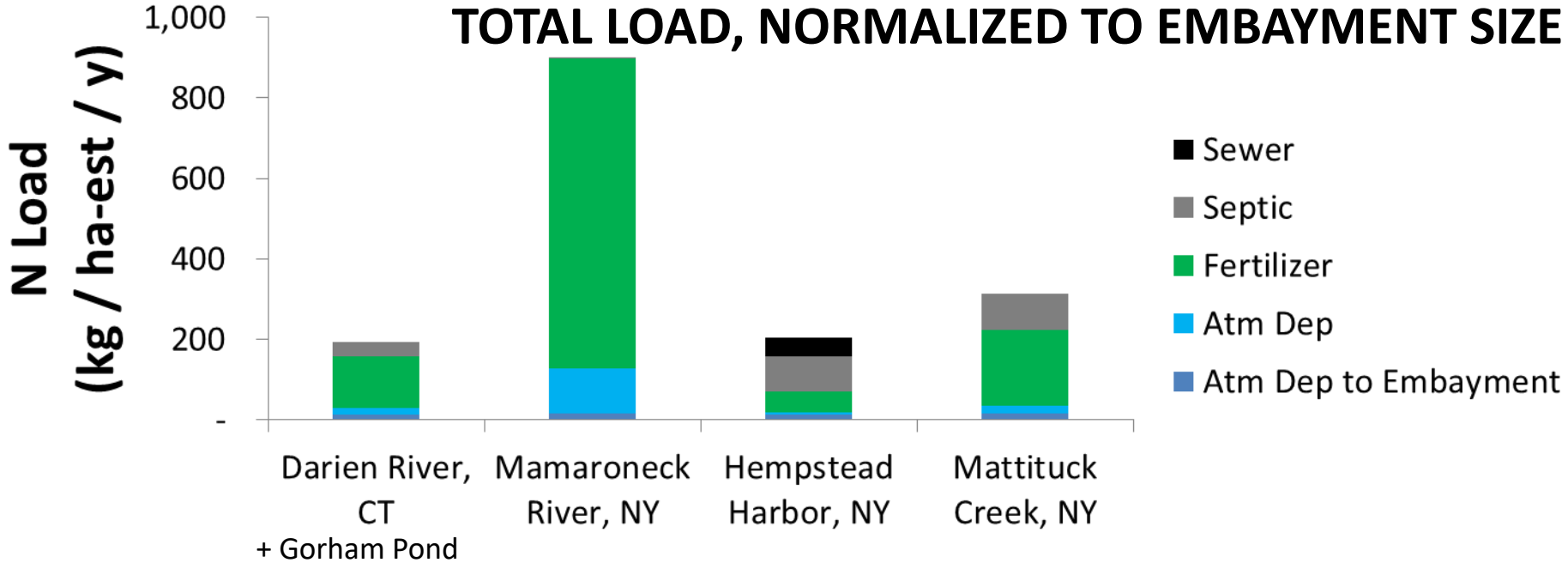
focus in on 4 embayments



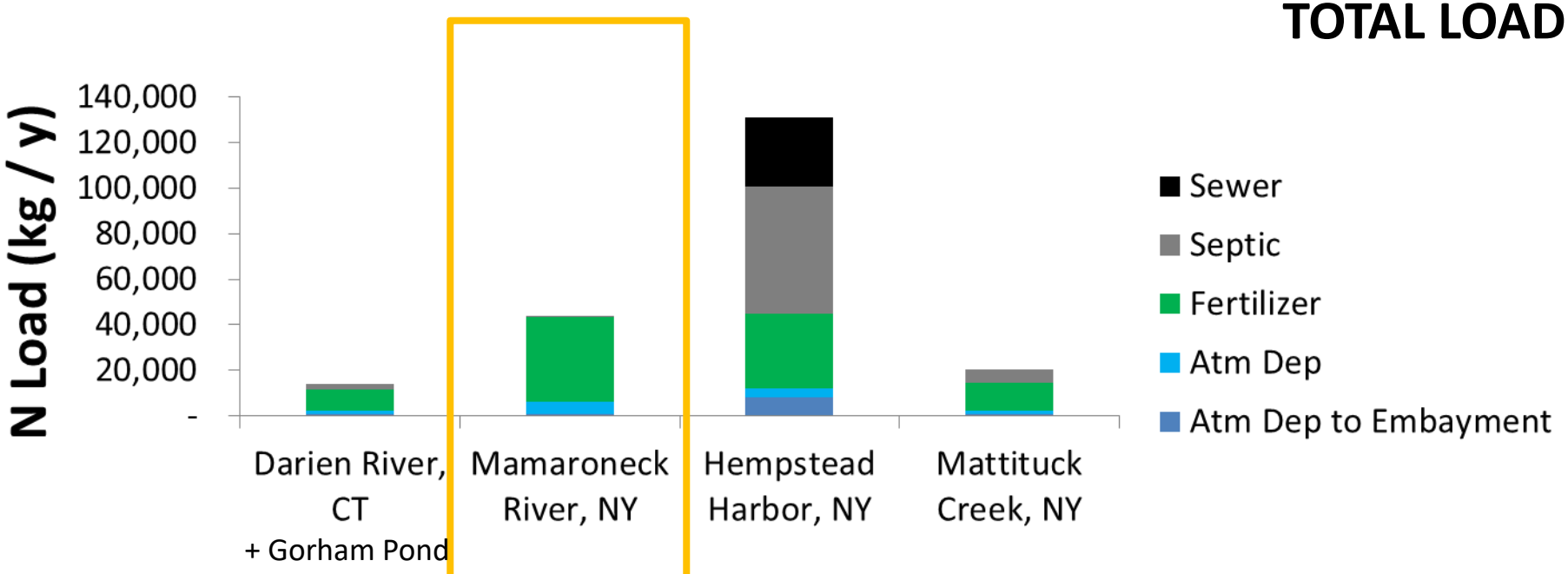
TOTAL LOAD



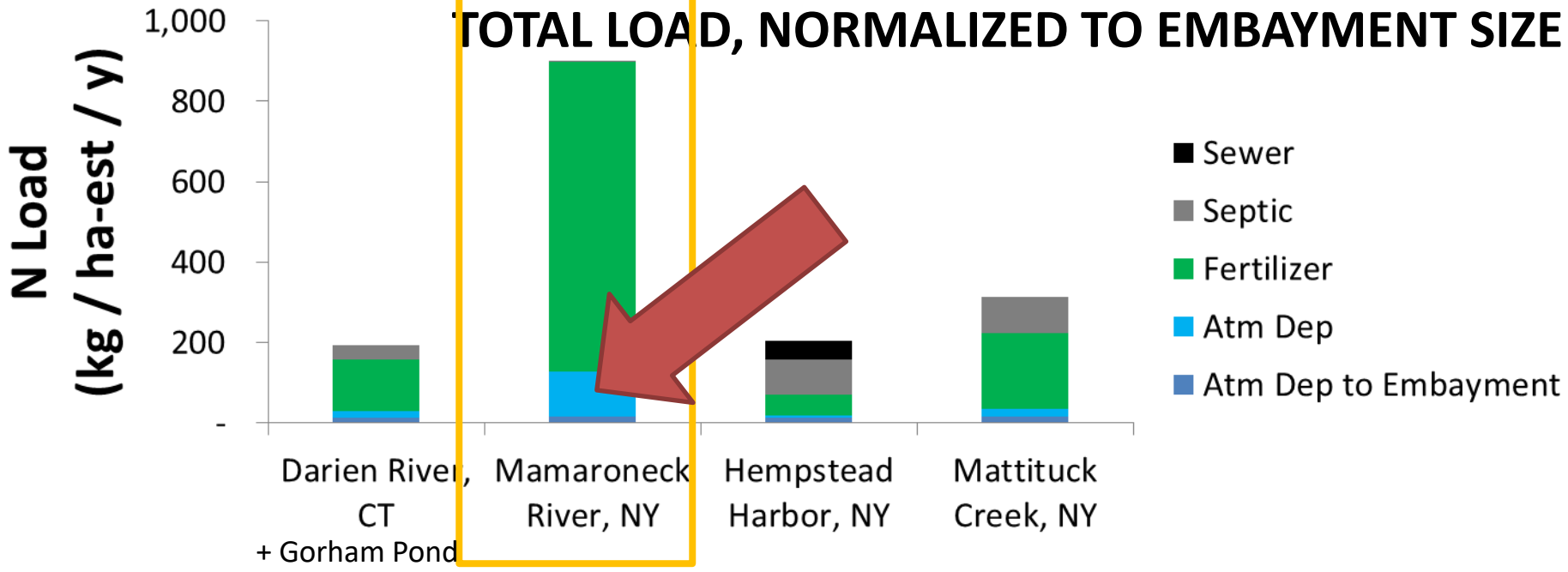
TOTAL LOAD, NORMALIZED TO EMBAYMENT SIZE



TOTAL LOAD



TOTAL LOAD, NORMALIZED TO EMBAYMENT SIZE



Nutrient Bioextraction by Seaweed and Bivalves
→ Charlie Yarish & Jang Kim; UCONN

- Mussels (*Ischadium recurvum*): 217 kg N ha^{-1} yr^{-1} (Kellogg et al., 2013) in Chesapeake Bay.
- Oysters (*Crossostrea virginica*): 331 – 556 kg N ha^{-1} per up to two years (Higgins et al., 2011) in Chesapeake Bay (Kellogg et al., 2013).
- Oysters (*Crossostrea virginica*): 77 kg N ha^{-1} yr^{-1} from Waquoit Bay (MA; Kite-Powell et al., 2006).

Sugar kelp: ~180 kg N ha^{-1} (Dec. – May)

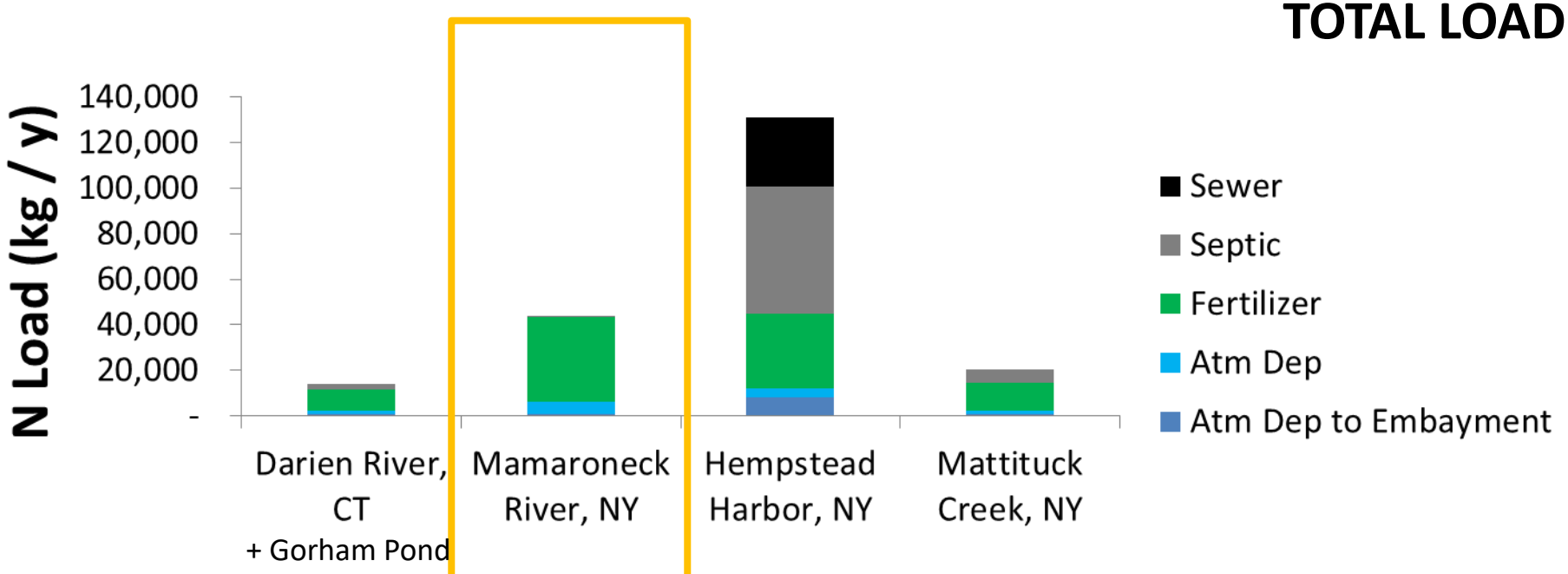
Kim J.K., G.P. Kraemer & C. Yarish 2015. Marine Ecology Progress Series 531:155-166.

***Gracilaria*: ~140 kg N ha^{-1} (July – Oct.)**

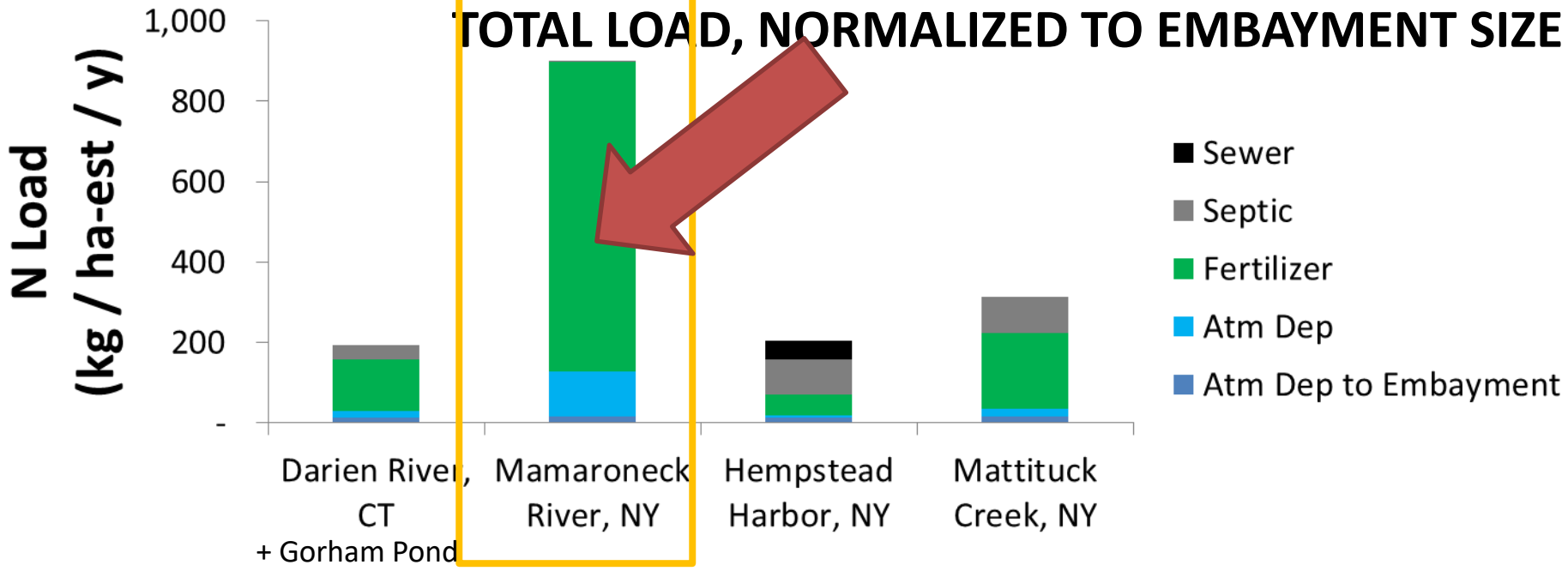
Kim J.K.., G.P. Kraemer & C. Yarish. 2014. Aquaculture 433:148-156.

GOOD FOR HIGH LOAD AREAS AND AREAS WITH A LOT OF ATMOSPHERIC DEPOSITION TO THE EMBAYMENT WATER SURFACE

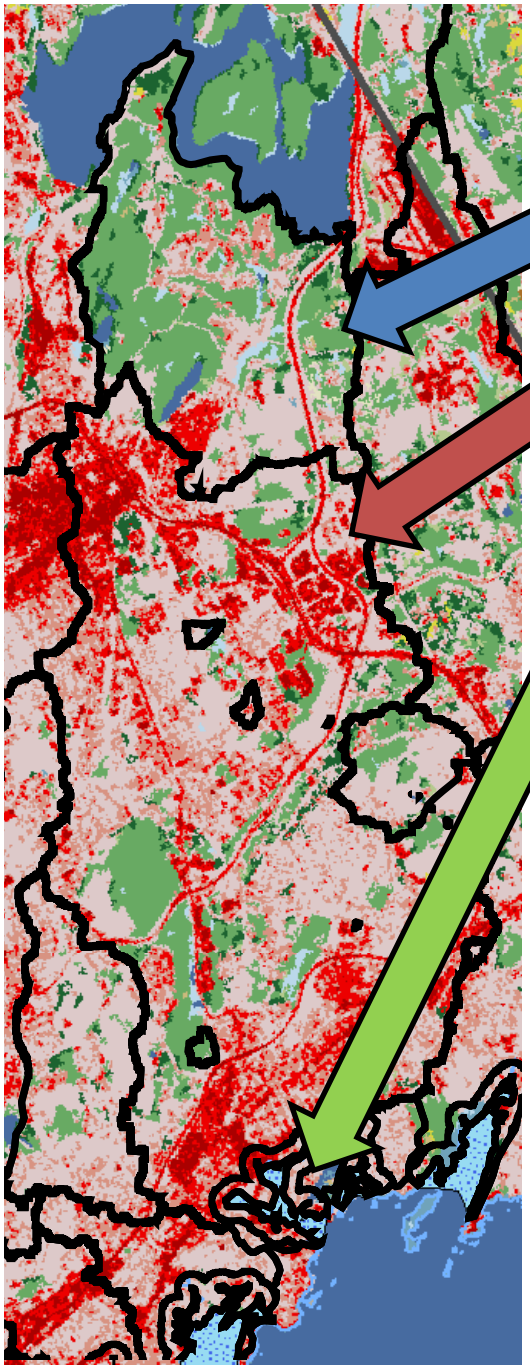
TOTAL LOAD

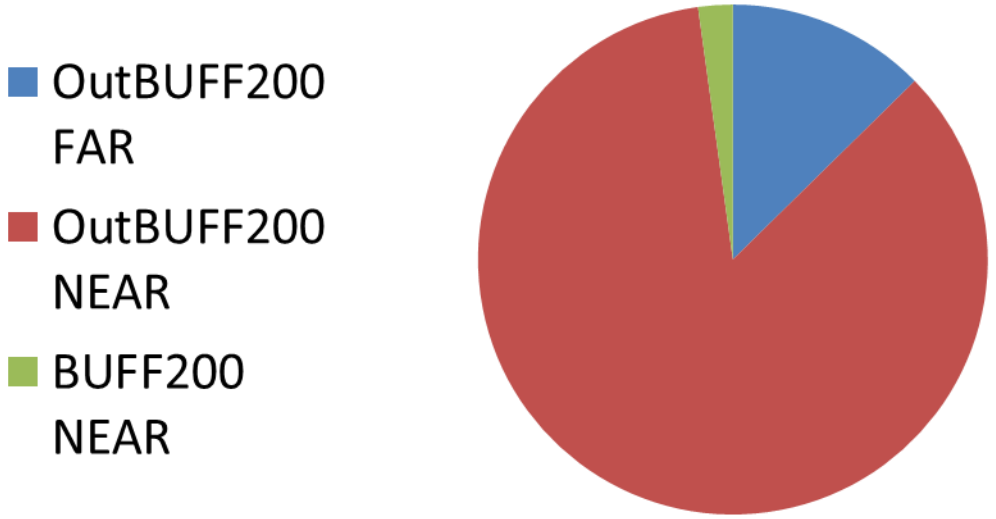


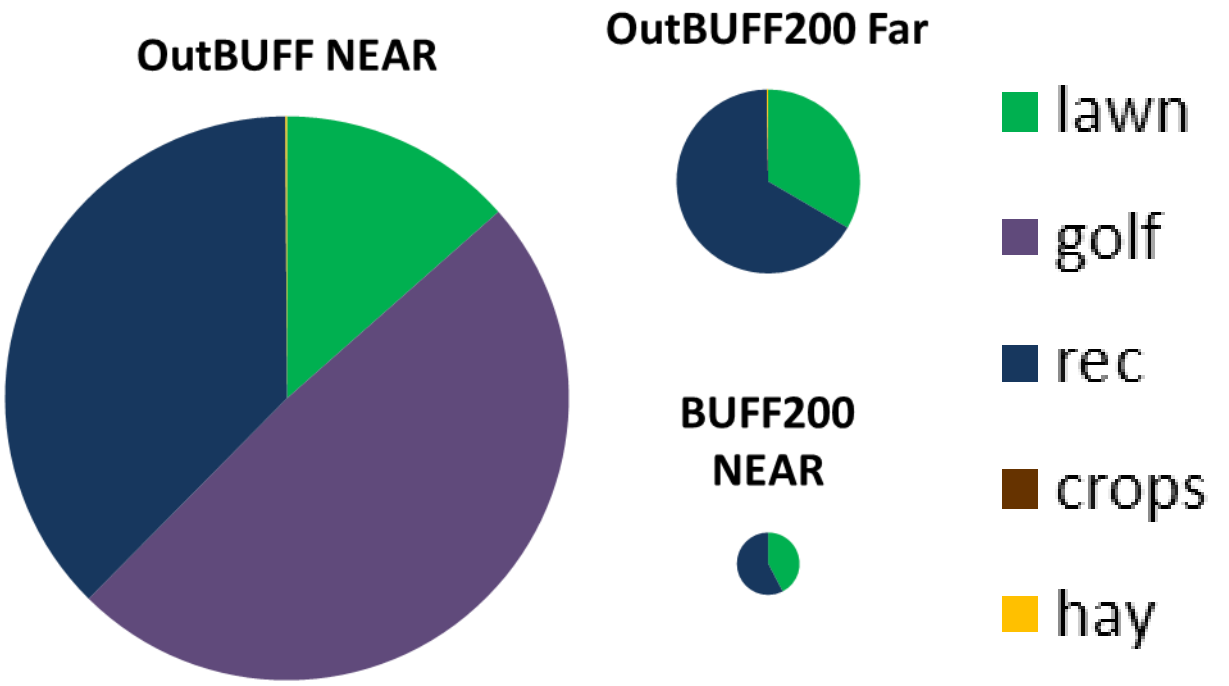
TOTAL LOAD, NORMALIZED TO EMBAYMENT SIZE



FERTILIZER CONTRIBUTION – Mamaroneck River

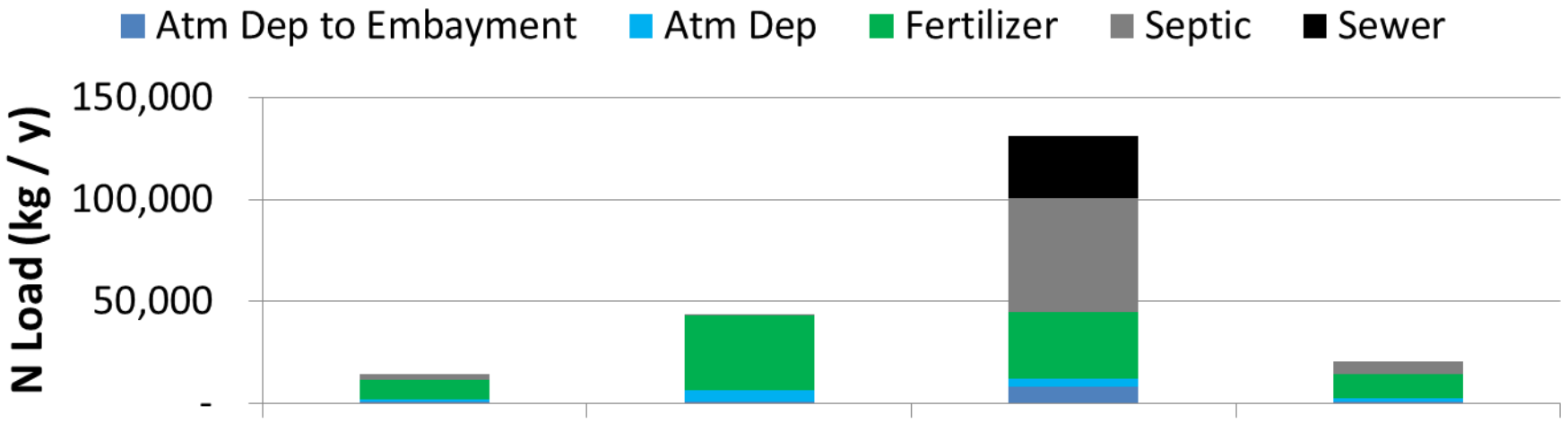


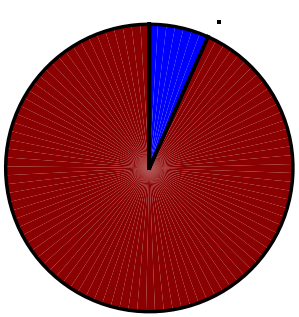




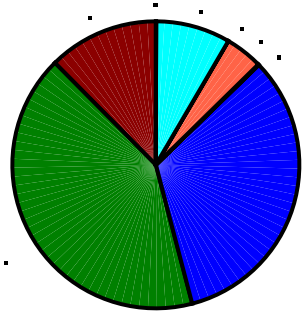
NLCD 2011 – roughly; red = heavily developed, pink = open space, green = natural vegetation, blue = water

FERTILIZER CONTRIBUTION - SOURCE

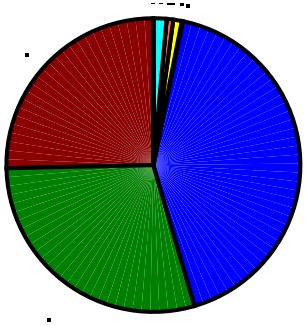




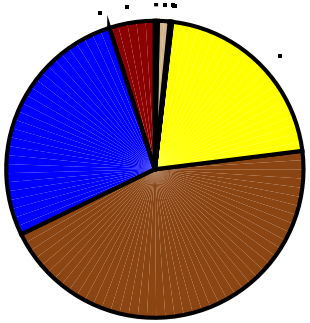
lawn – NEAR



golf – NEAR
parks - NEAR
lawn - NEAR

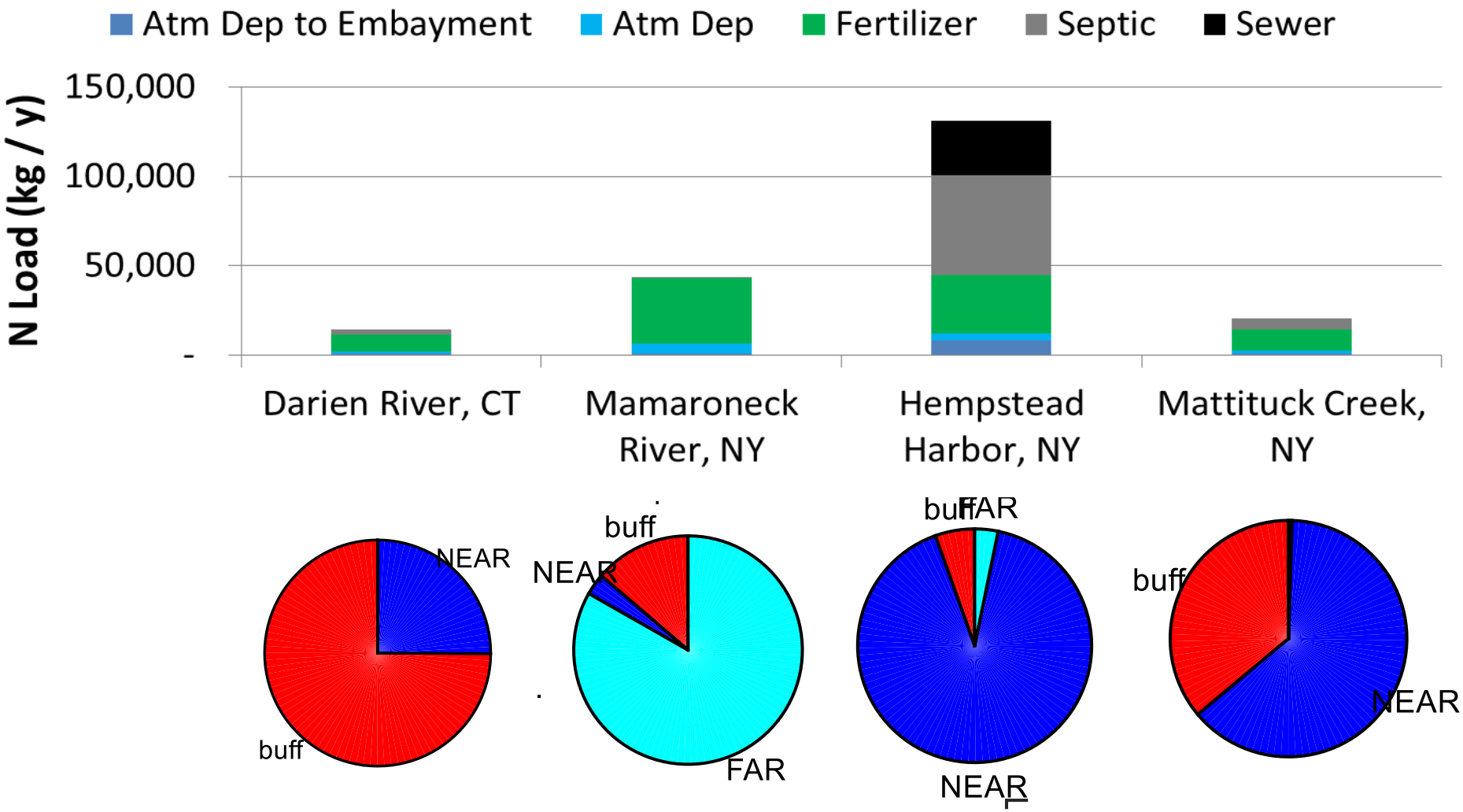


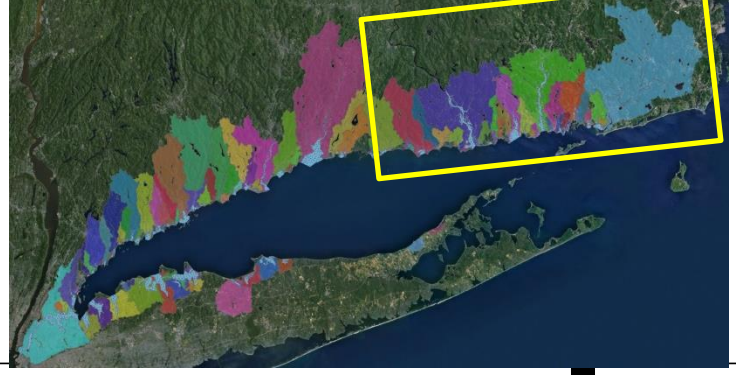
parks - NEAR
golf – NEAR
lawn - NEAR



crops - NEAR
parks – NEAR
hay - NEAR

SEPTIC CONTRIBUTION - SOURCE





atm dep to land
fertilizer
septic
sewer
atm dep to embayment

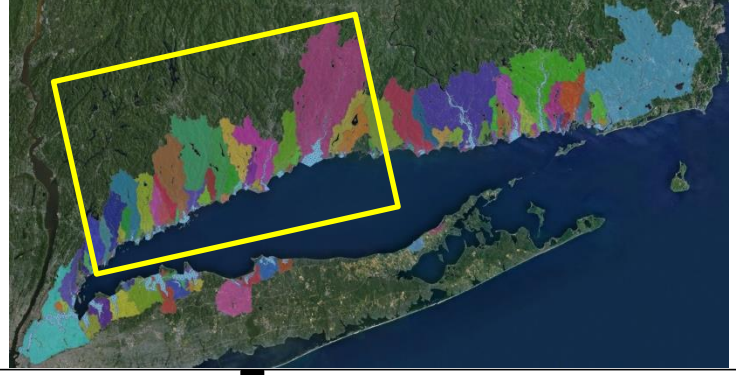
coastal Thames R. = 304,766

N Load (kg N / y)

250000
200000
150000
100000
50000
0

Pawcatuck River
Little Narragansett Bay
Wequetequock Cove
Quanaduck Cove
Stonington Harbor
Quiambog Cove
Wilcox Cove
Williams Cove
Mystic River
Bebee Cove
West Cove
Palmer Cove
Venetian Harbor
Mumford Cove
Poquonock River
Baker Cove
Thames River
Alewife Cove
Goshen Cove
Jordan Cove
Gardners Pond
Niantic River
Niantic Bay
Pattagansett River
Bride Brook
Four Mile River
Threemile River
Black Hall River
Connecticut River
South Cove
Indiantown Harbor
Oyster River
Hagar Creek
Patchogue River
Menunkesucket River
Clinton Harbor
Toms Creek
Fence Creek
Guilford Harbor
Indian Cove

CT



atm dep to land
fertilizer
septic
sewer
atm dep to embayment

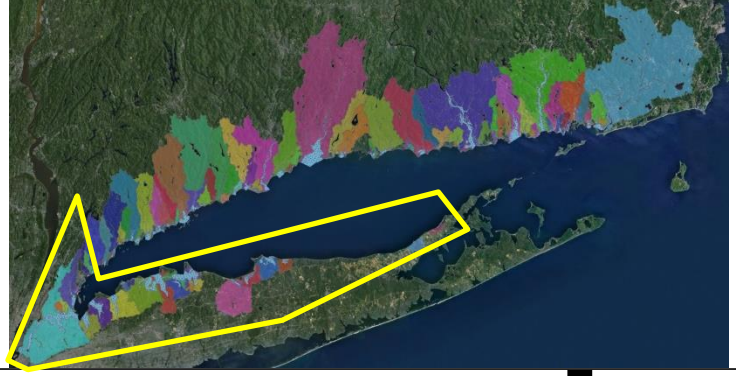
New Haven H. = 824,812

N Load (kg N / y)

250000
200000
150000
100000
50000
0

Sachem Head Harbor
Joshua Cove
Island Bay
Little Harbor
Branford Harbor
Pages Cove
Farm River
New Haven Harbor
Oyster River, Milford
Calf Pen Meadow Creek
Milford Harbor
Housatonic River
Lewis Gut
Bridgeport Harbor
Pequonnock River
Black Rock Harbor
Ash Creek
Pine Creek
Mill River
Sasco Brook
Sherwood Millpond
Compo Cove
Saugatuck R - fresh
Saugatuck River
Cockenoe Harbor
Norwalk Harbor
Sheffield Island Harbor
Five Mile River
Scotts Cove
Gorham Pond
Darien River
Holly Pond
Cove Harbor
Wescott Cove
Stamford Harbor
Greenwich Cove
Mianus River
Indian Harbor
Smith Cove

CT



atm dep to land
fertilizer
septic
sewer
atm dep to embayment

coastal East River = 14.8 million

N Load (kg N / y)

250000
200000
150000
100000
50000
0

Greenwich Harbor
Captain Harbor
Byram River
Kirby Pond
Playland Lake
Milton Harbor
Van Amringe Millpond
Mamaroneck River
Larchmont Harbor
Premium Millpond
Echo Bay
Hunter Island Bay
Eastchester Bay
Westchester Creek
Pugsley Creek
East River
Little Neck Bay
Manhasset Bay
Hempstead Harbor
Dosoris Pond
Frost Creek
Mill Neck Creek
Oyster Bay
Cold Spring Harbor
Lloyd Harbor
Huntington Harbor
Centerport Harbor
Northport Harbor
Northport Bay
Huntington Bay
Nissequogue River
Stony Brook Harbor
Conscience Bay
Port Jefferson Harbor
Mount Sinai Harbor
Mattituck Creek
Goldsmith's Inlet

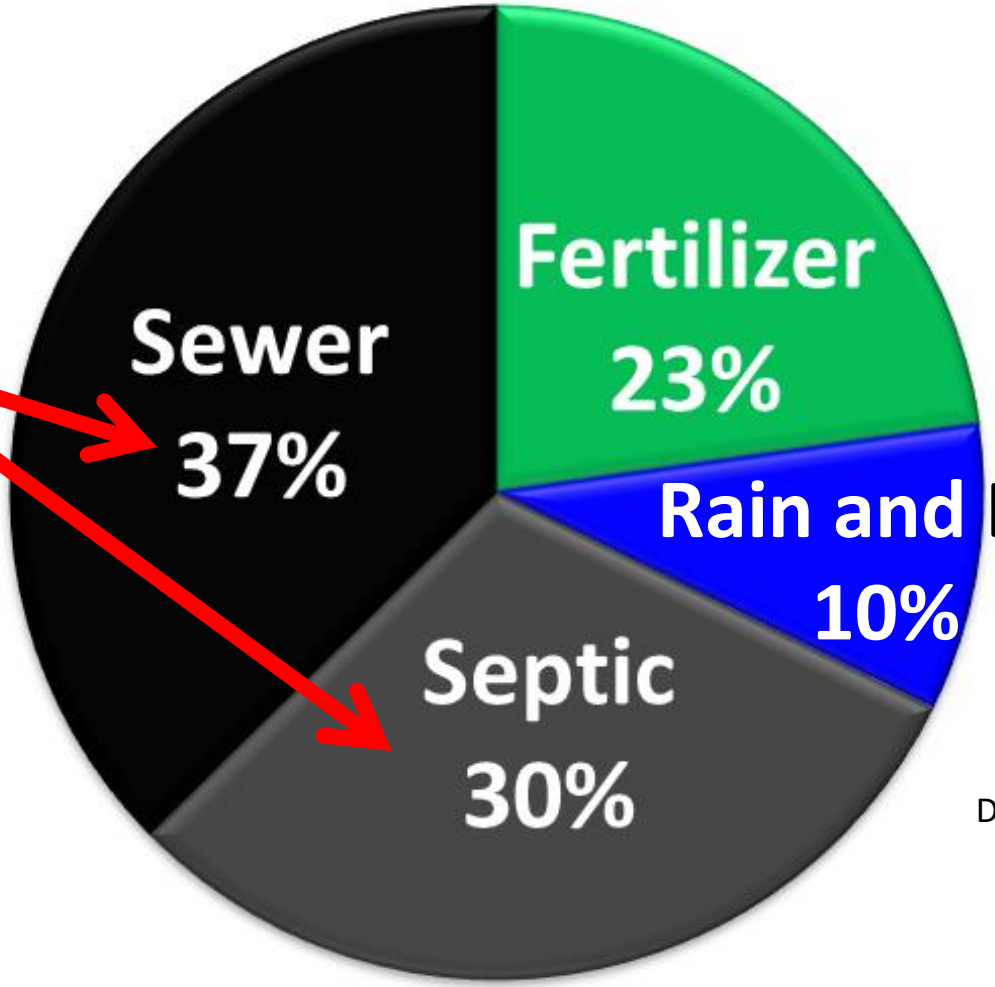
CT

NY

Source of Nitrogen to All Long Island Sound Embayments

67%

of nitrogen is from sewer and septic



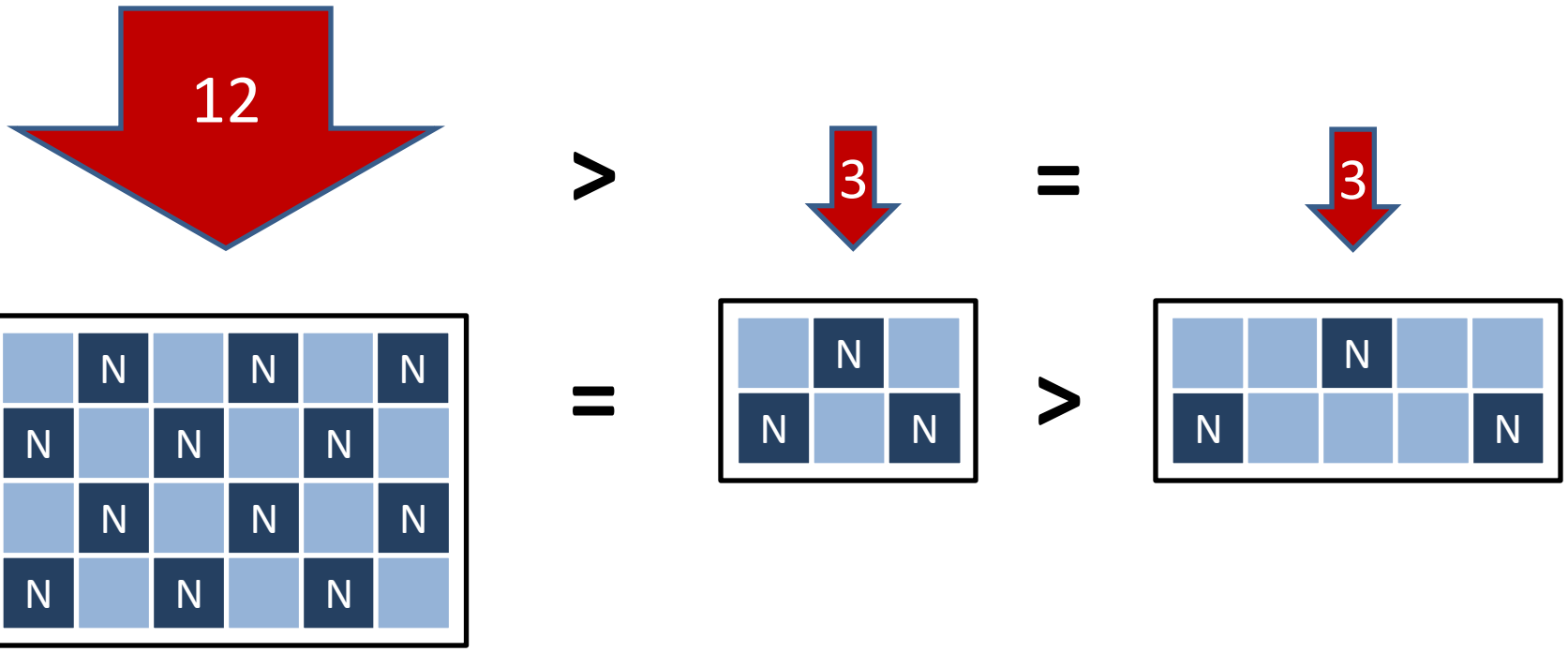
Sum of all embayments. Does not include the following rivers: Thames, Connecticut, Housatonic, East River.

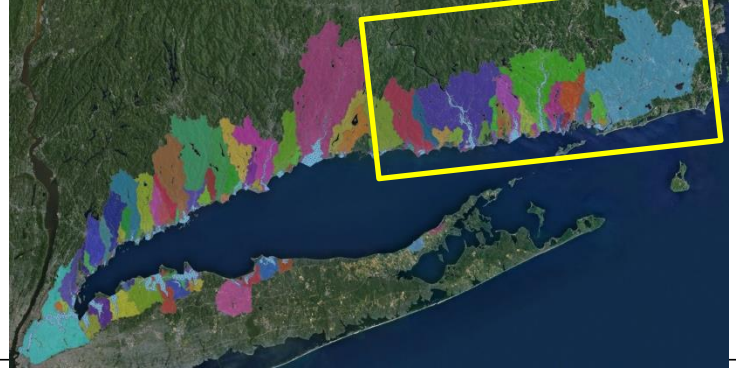
Total load is important to Long Island Sound.

But for water quality in embayments →

nitrogen load

size of embayment





atm dep to land
fertilizer
septic
sewer
atm dep to embayment

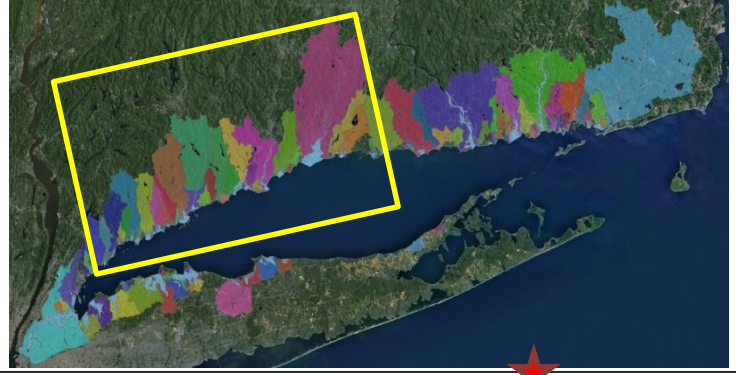
= top 20 sites likely to exhibit symptoms

N Load (kg N / ha-embayment / y)

5000
4000
3000
2000
1000
0

Pawcatuck River
Little Narragansett Bay
Wequetequock Cove
Quanaduck Cove
Stonington Harbor
Quiambog Cove
Wilcox Cove
Williams Cove
Mystic River
Bebee Cove
West Cove
Palmer Cove
Venetian Harbor
Mumford Cove
Poquonock River
Baker Cove
Thames River
Alewife Cove
Goshen Cove
Jordan Cove
Gardners Pond
Niantic River
Niantic Bay
Pattagansett River
Bride Brook
Four Mile River
Threemile River
Black Hall River
Connecticut River
South Cove
Indiantown Harbor
Oyster River
Hagar Creek
Patchogue River
Menunkesucket River
Clinton Harbor
Toms Creek
Fence Creek
Guilford Harbor
Indian Cove

CT



atm dep to land
fertilizer
septic
sewer
atm dep to embayment

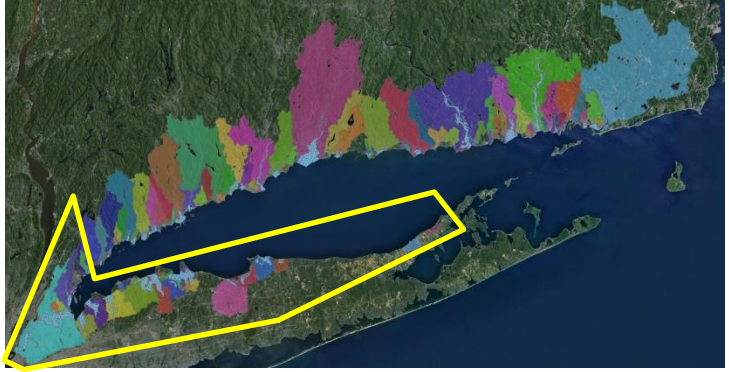
= top 20 sites likely to exhibit symptoms

N Load (kg N / ha-embayment / y)

5000
4000
3000
2000
1000
0

Sachem Head Harbor
Joshua Cove
Island Bay
Little Harbor
Branford Harbor
Pages Cove
Farm River
New Haven Harbor
Oyster River, Milford
Calf Pen Meadow Creek
Milford Harbor
Housatonic River
Lewis Gut
Bridgeport Harbor
Pequonnock River
Black Rock Harbor
Ash Creek
Pine Creek
Mill River
Sasco Brook
Sherwood Millpond
Compo Cove
Saugatuck R - fresh
Saugatuck River
Cockenoe Harbor
Norwalk Harbor
Sheffield Island Harbor
Five Mile River
Scotts Cove
Gorham Pond
Darien River
Holly Pond
Cove Harbor
Wescott Cove
Stamford Harbor
Greenwich Cove
Mianus River
Indian Harbor
Smith Cove

CT



atm dep to land
fertilizer
septic
sewer
atm dep to embayment

= top 20 sites likely to exhibit symptoms

N Load (kg N / ha-embayment / y)

5000
4000
3000
2000
1000
0

Greenwich Harbor
Captain Harbor
Byram River
Kirby Pond
Playland Lake
Milton Harbor
Van Amringe Millpond
Mamaroneck River
Larchmont Harbor
Premium Millpond
Echo Bay
Hunter Island Bay
Eastchester Bay
Westchester Creek
Pugsley Creek
East River
Little Neck Bay
Manhasset Bay
Hempstead Harbor
Dosoris Pond
Frost Creek
Mill Neck Creek
Oyster Bay
Cold Spring Harbor
Lloyd Harbor
Huntington Harbor
Centerport Harbor
Northport Harbor
Northport Bay
Huntington Bay
Nissequogue River
Stony Brook Harbor
Conscience Bay
Port Jefferson Harbor
Mount Sinai Harbor
Mattituck Creek
Goldsmith's Inlet

CT

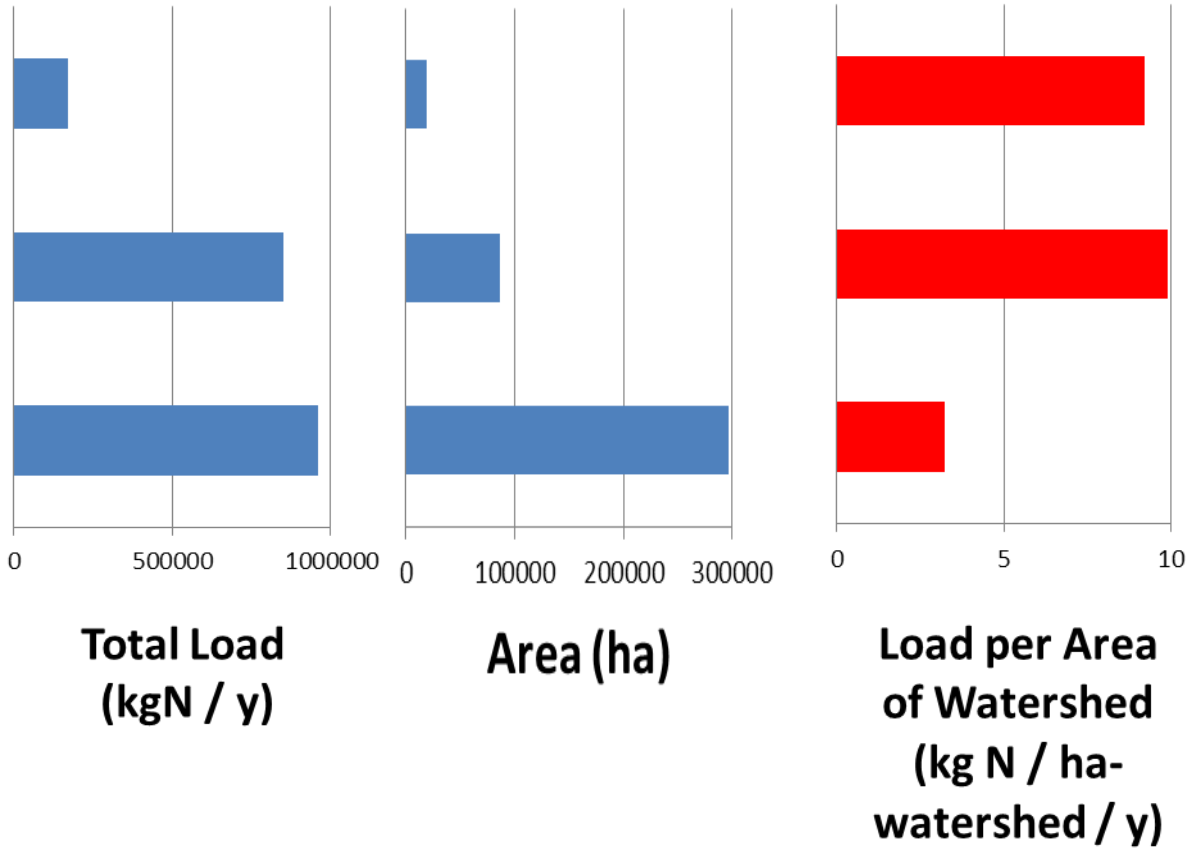
NY

Prioritize within a watershed based on the relative contribution.

less than 200 m from embayment

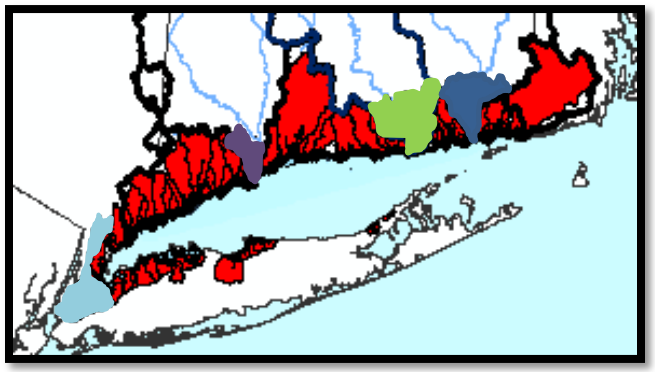
NEAR – drains directly to embayment

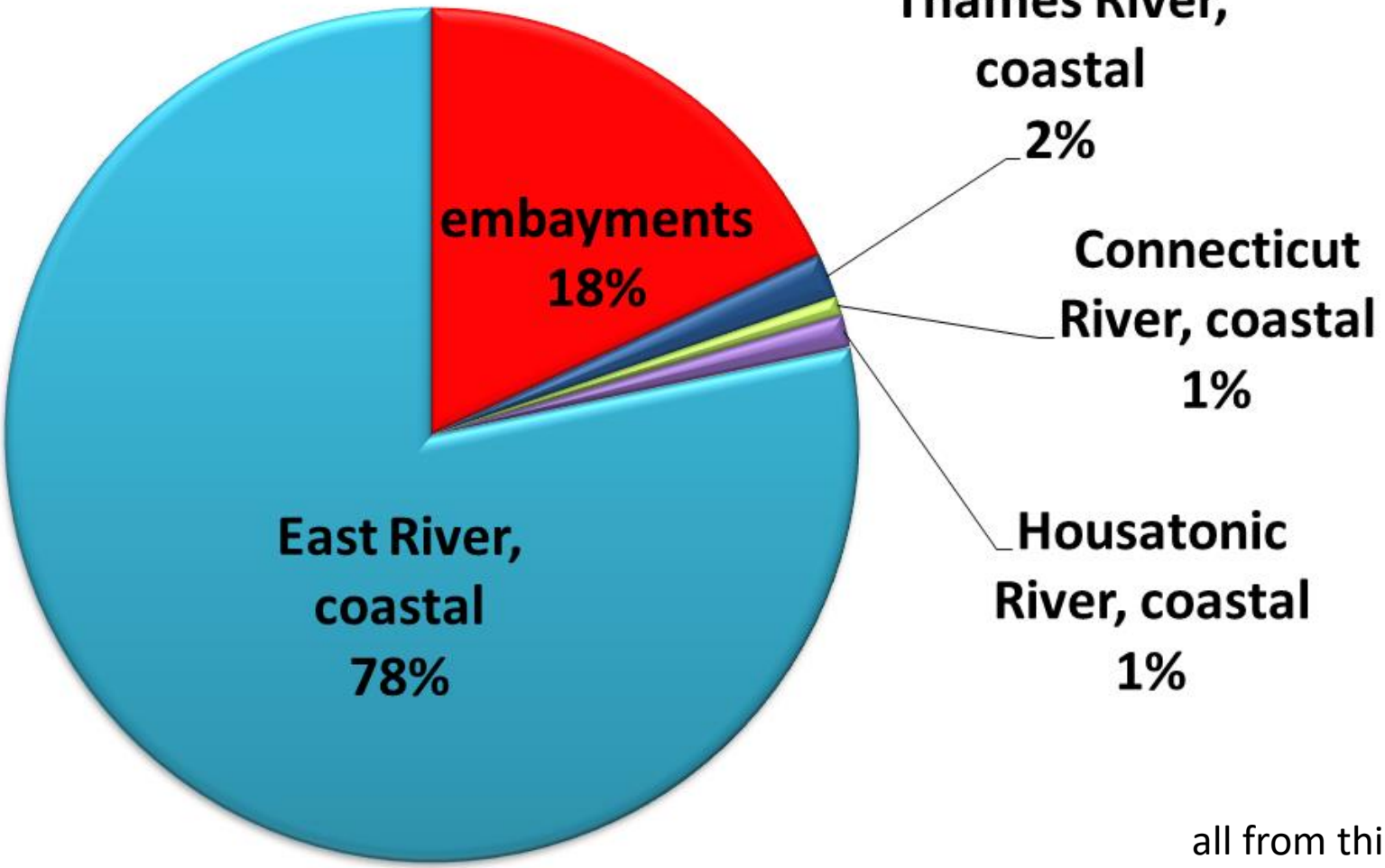
FAR – drains first to a pond



LIS Coastal Watershed

fraction of total nitrogen load attributed to watersheds

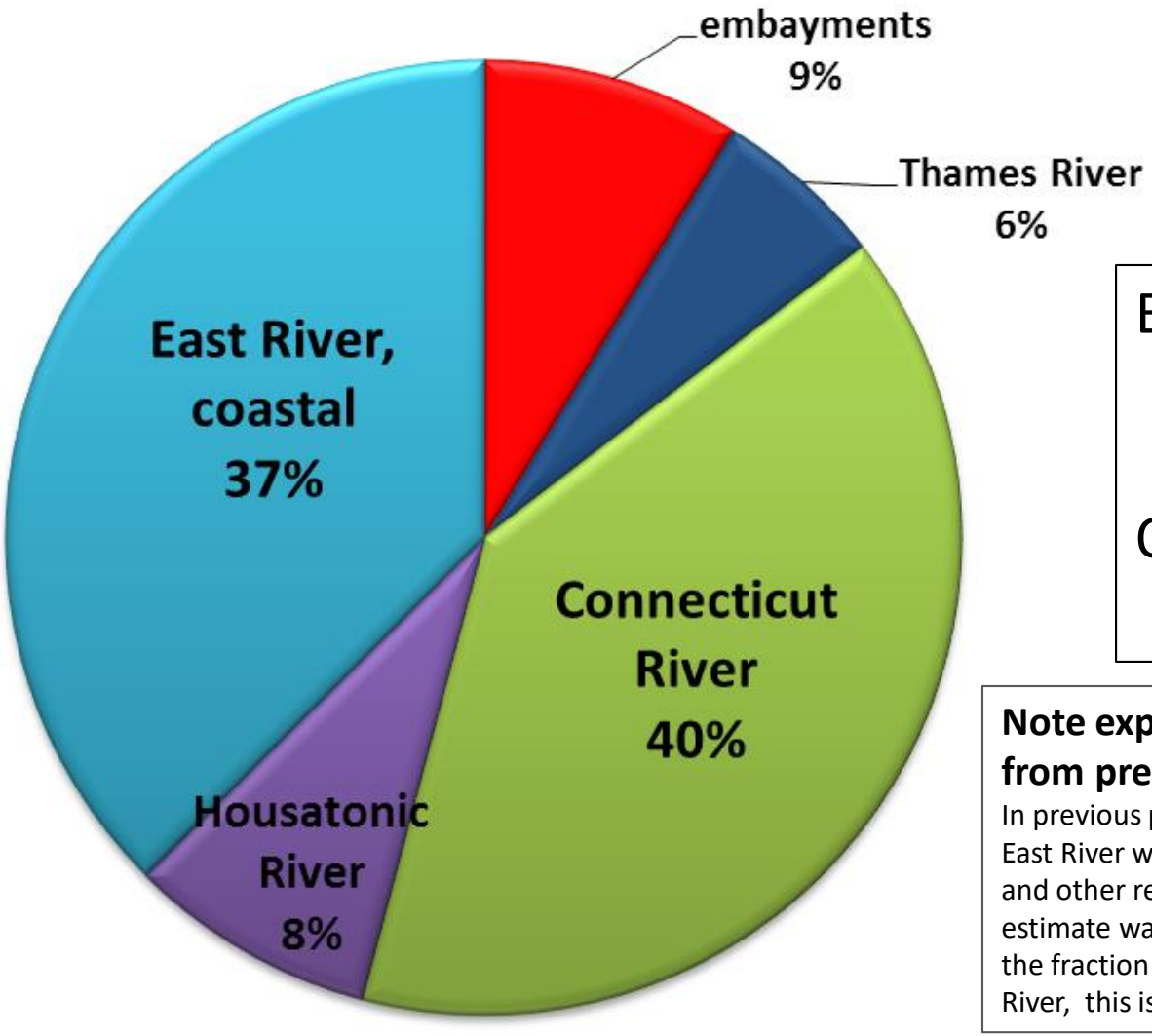


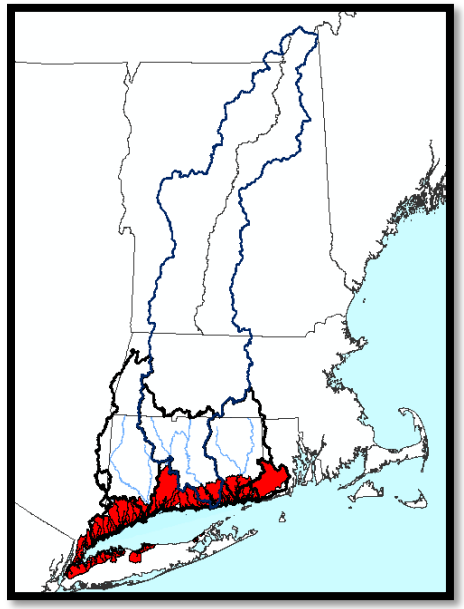


all from this study

LIS Total Watershed

fraction of total nitrogen load attributed to watersheds





East River &
Embayments = this study
Other Rivers = USGS SPARROW estimates

Note explaining why this figure is different from previous presentations:

In previous presentations, an old estimate of N load from the East River was use, dating from 1989. Upgrades to N removal and other reductions in the N Load meant that the 1989 estimate was too large. While our study area does not include the fraction of the Hudson River that may be exiting the East River, this is considered a better estimate of sources.

Embayment load is small compared to the "big 4" rivers – so why should we care?

-- take a note from the environmental movement --

http://www.teletech.com/sites/default/files/styles/article_main/public/csv6i1_benchmark.jpg?itok=cLhzpSJA

http://theoneworldcollective.org/hubs/

http://tightmixblog.com/finding-music-blogs/

http://theoneworldcollective.org/hubs/

Embayments are also experiencing the effects of N loading – see similar conditions within local embayments as we see in LIS.

- people care about their local waters – want to make these areas swimmable, fishable, boatable
- while load to LIS is comparatively small, many embayments are locally affected
- educational opportunity – get people thinking about what they can do locally, makes broader scale changes easier to understand and support

Questions?

Our research group is available to meet with you for longer discussions.

Contact Jamie Vaudrey
jamie.vaudrey@uconn.edu
University of Connecticut

Fertilizer Application - residential

	Long Island	Westchester	Bronx / Queens	CT	TOTAL
number of people interviewed	406	205	106	503	1220
margin of error (%)	4.9	6.8	9.5	4.4	

data from:
Public Perception Survey of Long Island Sound Watershed Residents, 2006.
http://www.stonybrook.edu/commcms/surveys/docs/publicperceptionsurvey.pdf
matches conversations & reports from K. Guillard, UConn

Fertilizer Application - residential

Percent of Homes Using Fertilizer

unit = %	Long Island	Westchester	Bronx / Queens	CT
several applications / year	49	48	45	30
1 application / year	31	26	27	35
less than 1 application / year	2	7	9	6
never	13	18	11	26
don't know	5	1	9	3
declined to answer	0	0	0	0
% homes using fertilizer	85	82	86	73
min	76	69	65	62
max	91	88	99	77

data from:
Public Perception Survey of Long Island Sound Watershed Residents, 2006.
http://www.stonybrook.edu/commcms/surveys/docs/publicperceptionsurvey.pdf
matches conversations & reports from K. Guillard, UConn

Fertilizer Application - residential

Application Rate 1 application = 1 lb N / 1000 sq ft = 49 kg N / ha

Kg N / ha / y — % of homes fertilizing * annual application rate	Long Island	Westchester	Bronx / Queens	CT
several applications / year - avg	83.1	81.4	76.3	50.9
several applications / year - min	72.0	70.6	66.2	44.1
several applications / year - max	96.0	94.1	88.2	58.8
1 application / year	15.2	12.7	13.2	17.2
less than 1 application / year - avg (1/3y)	0.33	1.14	1.47	0.98
less than 1 application / year - min (1/5y)	0.20	0.69	0.88	0.59
less than 1 application / year - max (1/2y)	0.49	1.72	2.21	1.47
don't know (1/y)	2.45	0.49	4.41	1.47
application rate applied to all homes	99.8	95.5	93.2	69.7
min	87.4	84.0	80.3	61.8
max	114.2	109.0	108.0	78.9

http://www.stonybrook.edu/commcms/surveys/docs/publicperceptionsurvey.pdf

Fertilizer Application – parks & rec. fields

survey of lawn care professionals and municipal workers in LIS

fertilizing	data = # responding yes			data = fraction responding yes		
# of times per year	Lawns	Sports Fields	Parks & Rec	Lawns	Sports Fields	Parks & Rec
0.0	0	0	3	0.00	0.00	0.15
1.0	6	3	2	0.07	0.09	0.10
2.0	15	5	5	0.19	0.15	0.25
3.0	22	8	5	0.27	0.24	0.25
4.0	27	17	4	0.33	0.50	0.20
5.0	11	1	1	0.14	0.03	0.05
		avg times per year =		3.27	3.24	2.40

fertilizing rate	fertilizing rate	data = # responding yes			data = fraction responding yes		
(lbs N / 1000 sq ft)	(lbs N / 1000 sq ft)	Lawns	Sports Fields	Parks & Rec	Lawns	Sports Fields	Parks & Rec
0.0	0.00	0	0	2	0.00	0.00	0.10
<0.25	0.13	1	0	1	0.01	0.00	0.05
0.25 to 0.5	0.38	23	5	2	0.30	0.17	0.10
0.6 to 0.9	0.75	29	11	9	0.38	0.37	0.43
1.0	1.00	22	12	7	0.29	0.40	0.33
>1	1.50	2	2	0	0.03	0.07	0.00
			lbs N / 1000 sq ft =		0.72	0.84	0.70

avg times applied * lbsN/1000sq ft =

annual load (lb N / sq ft / y)	2.36	2.71	1.67
annual load (kg N / ha / y)	115.1	132.3	81.6

ASSUMPTIONS –
50% of park & recreational land is fertilized (45-55%)
Of 50% fertilized, 20% is sports fields & 80% is park

91.7 kg N / ha / y

Nitrogen Fertilizer Reductions on Coastal Lawns Through Training and Education, March 2011; data from the pre-workshop survey