EXHIBIT– 13

From:	John Hall
To:	Perkins.Stephen@epamail.epa.gov; Dan Arsenault (Arsenault.Dan@epamail.epa.gov); Ellen Gilinsky <Gilinsky.Ellen@epamail.epa.gov> (Gilinsky.Ellen@epamail.epa.gov)
Cc:	Ted.Diers@des.nh.gov; "Peter H. Rice"; dean_peschel@yahoo.com; "Jennifer Perry"; Sean Greig (sgreig@newmarketnh.gov); Drew Serell; Dana Bisbee; jpeltonen@sheehan.com; Robert R. Lucic; E Tupper Kinder (ekinder@NKMLawyers.com); "David Green (david.green@rochesternh.net)"; "Gallagher, Thomas (Thomas.Gallagher@hdrinc.com)"; "Mancilla, Cristhian"
Subject:	RE: Supplemental Comments by the Great Bay Municipal Coalition re: Draft NPDES Permit No. NH0101311 for the City of Dover, NH; Town of Exeter, NH, NPDES Permit No. NH0100871; Town of Newmarket, NH, NPDES Permit No. NH0100196
Date:	Wednesday, August 15, 2012 6:12:41 PM
Attachments:	Great Bay eelgrass versus 3 year moving average spring flow.pdf Great Bay Transparency changes_buoy_data 2004-2008.pdf Trowbridge Exhibit 71.pdf Trowbridge Exhibit 72.pdf

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Dear Stephen:

These additional/supplemental comments regarding the above referenced permits are submitted on behalf of the Great Bay Municipal Coalition. These comments are based on information not available at the time the permit comment periods closed and therefore constitute timely comments pursuant to applicable NPDES rules and norms of administrative law.

Information Presented to EPA Headquarters Regarding the Proposed Permit Actions

As you are aware, since the publication of the draft NPDES permits for the above referenced facilities the affected communities requested intervention by EPA Headquarters regarding review of the scientific basis for the Region's proposed actions. The Region was copied on that correspondence and, to our knowledge, has received copies of all other information submitted in this context. If that has not occurred, please let us know and copies will be provided. Much of the information used to support that filing was based on documents released by NHDES pursuant to discovery requests which illuminated several documents previously released by EPA Region I under FOIA. These documents and the sworn testimony of several DES officials (Paul Currier and Philip Trowbridge) have further confirmed that there was not a defensible scientific basis for the Region's proposed permit actions. Information presented to the House Oversight Committee in June indicated that the Region's actions with respect to nutrient limitations and impairment designations were heavily influenced by threats of suit by CLF, rather than by a thorough assessment of the available scientific information. Under discovery, it was also revealed that numerous study results had been presented to both EPA and CLF showing (1) nutrient changes had not caused increased algal growth in the system, (2) system transparency was not significantly impacted by algal growth and (3) transparency had not apparently changed over the period of 1990 -2005 when concerns over eelgrass population changes were being raised by CLF and EPA. *These studies concluded that the typical paradigm: increasing nutrients result in increased algal growth causing reduced transparency and eelgrass loss* - was *not applicable to the Great Bay system*. This information and the supporting research (attached herein) were excluded from subsequent DES and EPA analyses and internal peer reviews that claimed "weight of evidence" supported the need to greatly reduce TN levels to protect eelgrass via improved transparency. The information derived under deposition also confirmed that the Region was not properly applying the state's existing narrative standard as the underlying information (e.g., 2009 Numeric Criteria) did not provide a cause and effect demonstration that nitrogen actually caused the decline in eelgrass or cultural eutrophication

adversely impacting designated uses. Mr. Currier and Mr. Trowbridge both acknowledged that the existing state law required such a demonstration to find nutrients were causing narrative criteria violations and the 2009 document did not accomplish this requirement.

As noted above, this information was not readily available in the permit record or as part of EPA's earlier FOIA response. Moreover, the supplemental information is being actively considered by EPA Headquarters with regard to the proposed permit actions. Therefore, this correspondence, the referenced deposition testimony and all the supporting documentation should be considered as supplemental comments and supporting information with regard to the comments already provided to EPA Region I within the original comment period. The specific correspondence that we request to be incorporated as supplemental comments include:

1. May 4, 2012 letter to Administrator Jackson and Inspector General Arthur Elkins including all exhibits
2. Materials presented to EPA Headquarters as part of the June 28, 2012 meeting (which the Region attended by phone)
3. Follow up correspondence from the Mayors of Portsmouth and Dover to Ellen Gilinsky dated June 29, 2012
4. Follow up letter and emails (with exhibits) from John Hall to Ellen Gilinsky regarding the prior studies and current data showing nitrogen is not documented to be responsible for changes in eelgrass populations dated July 13, 2012 and August 2, 2012.
5. Testimony submitted by the Coalition representatives to the House Oversight Committee in advance of the June 4, 2012 hearing, supplemental comments (with attachments) submitted to the Committee on June 8, 2012 and the Committee Report issued in advance of the hearing.

As noted in our correspondence to Ms. Gilinsky, we are currently in the process of gathering all of the final deposition excerpts that are applicable to the recent correspondence sent to EPA (including documents provided on the day of the depositions). Those deposition excerpts will be provided to the Region by the end of next week with a specific explanation as to their applicability to the permit decisions that extensively relied on the prior DES studies and documents.

Other Deposition Highlights Applicable to EPA Decision Making

In addition to this information, as you are aware, EPA Region I was relying on Dr. Short to conclude that TN was the cause of eelgrass declines. The Region was copied on all of the correspondence between the Coalition and Dr. Short which confirmed that he had no objective scientific basis for his various claims that TN caused the decline of eelgrass in the Great Bay estuary, he conducted no specific studies on the causes of changing eelgrass populations in the Great Bay estuary to support such claims and under deposition he admitted these positions were based on his personal opinion. This compilation of correspondence, in EPA's possession, is also to be included as part of the permit comment record for these facilities given the Region's acknowledged reliance on Dr. Short's representations in developing the NPDES permits. These correspondence indicate that the Region's reliance on Dr. Short is not well founded.

Perhaps of greater significance, Dr. Short also acknowledged under oath that 1) Great Bay itself is not a transparency limited system, 2) the Squamscott/Lamprey Rivers are not suitable for eelgrass restoration, 3) he never advised on the ability to achieve better water clarity in these rivers and 4) he never recommended applying a 0.3 mg/l TN standard in these rivers to ensure eelgrass restoration. There had been considerable correspondence between EPA and DES on these topics, given EPA's primary role in providing technical assistance on nutrient criteria development which was excluded from both the permit record and the 2009 Criteria document. Nonetheless, Mr. Trowbridge confirmed that application of the 2009 draft criteria in the tidal rivers would not likely restore eelgrass due to other natural factors currently limiting transparency (CDOM and turbidity) and TN reduction would not materially improve those transparency levels. Therefore, the Region's application of the 0.3 mg/l TN criterion as required to attain the existing state narrative standard for nutrients and to allow eelgrass restoration in the tidal rivers and Great Bay not only lacks a credible scientific basis, its ecological need is actually refuted by the very "experts" who worked to derive those draft criteria. This information also confirms that there is no "eelgrass impairment" in the upper tidal rivers even though current eelgrass levels are below historical levels. The existing natural condition prevents eelgrass restoration and, as acknowledged by Mr. Trowbridge, natural conditions do not constitute impairment or a violation of narrative standards. Thus, EPA has no basis to claim any type of TN induced narrative criteria violation with respect to eelgrass in the upper tidal rivers where these facilities discharge. Please note that the depositions also discussed that macroalgae growth is not apparently impairing eelgrass resources/recovery in Great Bay or Little Bay proper and there is no documented macroalgae concern in the tidal rivers. Therefore, the mere presence of macroalgae growth in the intertidal zone of Great Bay is not documented to be causing narrative criteria violations either. EPA's regulatory assumptions to the contrary are, therefore, not legally or technically defensible.

New Information from PREP

New information released by PREP, discussed in the August 2, 2012 email to Ms. Gilinsky, confirms that TN and, more importantly TIN levels have dropped dramatically in the estuary since 2008, and are now equivalent to 1980's levels. The current TIN levels are now well below those that existed in the estuary when eelgrass populations thrived throughout 1990-2005. Given this information, all of the load reduction analyses relied upon by the Region to assert that major point source TN decreases were needed to attain a protective level of water quality are misplaced. This change in TIN levels appears to be a function of more moderate rainfall conditions that occurred over the past three years (2005-2008 being the wettest four years in the past 100 years) and rebounding eelgrass populations. Please note that the 2009-2011 period was NOT a very low flow period – it simply returned to the range of more typical rainfall and tributary flows. Our analysis of eelgrass response in Great Bay to increased freshwater flow (*which would be expected to have a cause and effect relationship since salinity is altered)* indicates that eelgrass populations in Great Bay are directly impacted by the level of freshwater entering the system, but not transparency. (See attachments – eelgrass versus 3 year moving average spring flows; transparency changes buoy data 2004-2008). Mr. Trowbridge acknowledged that the major flooding and rainfall events occurring in 2006 could have been the cause of the rapid eelgrass decline at that time. Moreover, the extreme flow conditions occurring in 2006 did have a dramatic effect on estuary wide water quality – as evidenced by the attached analysis of CDOM influencing system transparency levels. Nonetheless, in 2007-

2008 when transparency rebounded to pre-2006 conditions (and better) eelgrass acreage did not change materially (as reported by Dr. Short). Please also note that May-July (and long term average) transparency levels in Great Bay (2004 to 2005) were well below the 22% incident light target used to derive the 2009 Numeric Criteria used by EPA in calculating the draft permit effluent limits, though eelgrass acreage was considered acceptable and the estuary was not considered impaired for eelgrass at that time. Thus, this multi-year data set, which is among the most detailed for the estuary, also does not appear to support a transparency theory for Great Bay, consistent with state expert testimony discussed earlier. This is the same conclusion was also reached by Dr. Morrison in his detailed 2008 report on factors influencing transparency in the Great Bay system.

Finally, it is noteworthy that eelgrass populations are continuing to rebound in both Great Bay and Little Bay since 2008. We have just received additional verbal reports from oyster farmers that eelgrass are growing throughout Little Bay (previously reported by Dr. Short to contain no eelgrass in 2010). Based on the 2011 survey, Little Bay now has more eelgrass growing than existed in 1996 when Great Bay reached a maximum of 2495 acres. Thus, it is inconceivable that such a recovery would be occurring if existing TN levels, transparency or macroalgae were preventing eelgrass growth as claimed by the draft permits. We also understand that eelgrass acreage in Great Bay continues to increase and may now be back to levels that are considered unimpaired. These conditions should be confirmed by the most recent eelgrass survey recently conducted by Dr. Short.

Based on this supplemental information, imposition of stringent TN reduction requirements under the theory that it is necessary to allow eelgrass restoration in the tidal rivers or Great Bay is not supportable, nor is any claim that nitrogen levels are somehow precluding eelgrass growth in either the tidal rivers or Great Bay/Little Bay. Since the permits are premised on these mistaken theories, they need to be withdrawn. In closing, the Coalition continues to be interested in a dialogue that is based on a review of the relevant site-specific information regarding the actual factors influencing system water quality dynamics, eelgrass populations and nutrient effects.

We look forward to the Region's consideration of this information.

John

John C. Hall
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Fax: 202-463-4207
E-Mail: jhall@hall-associates.com

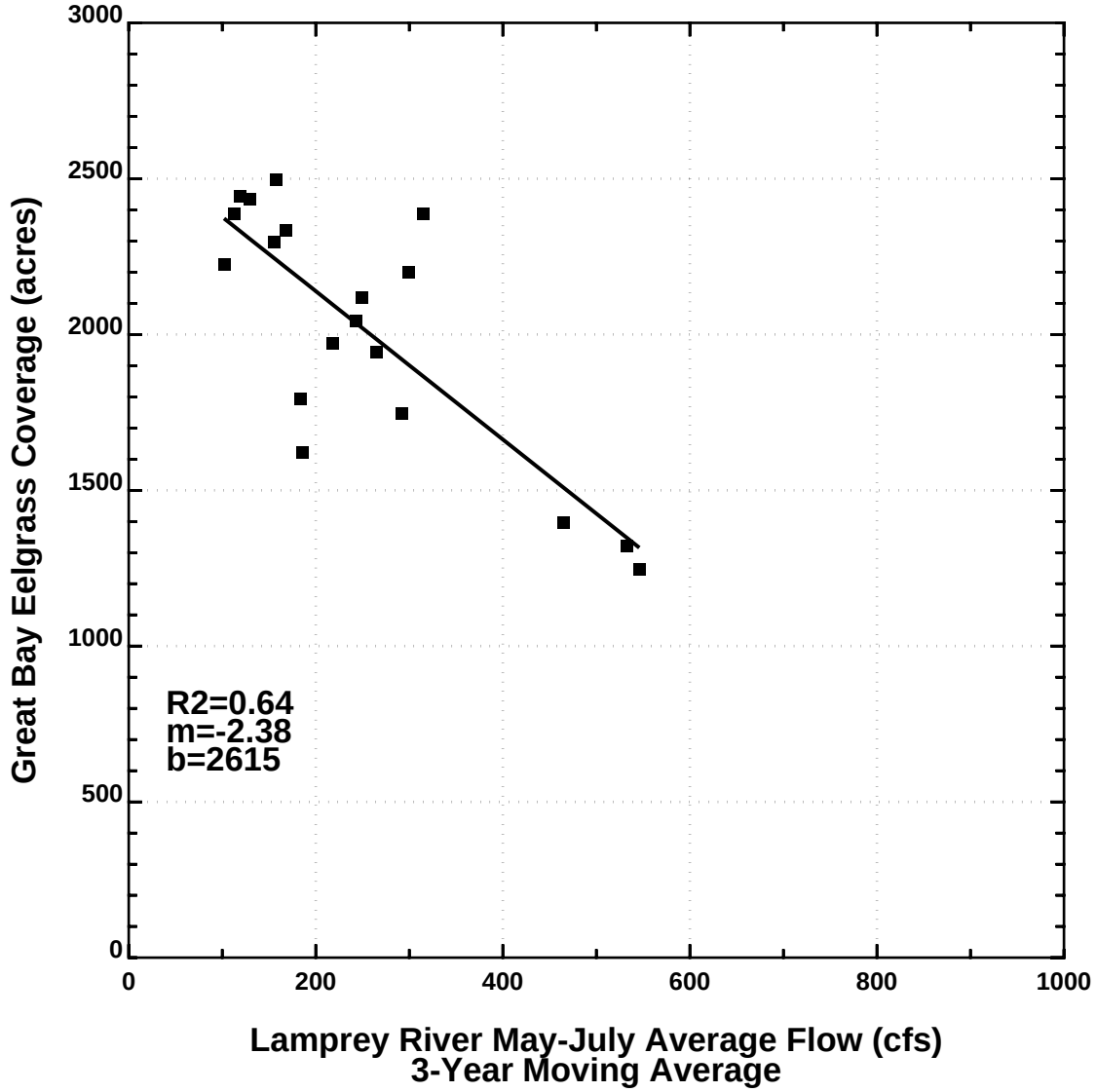

Figure 2. Eelgrass Coverage in Great Bay (1990-2010)

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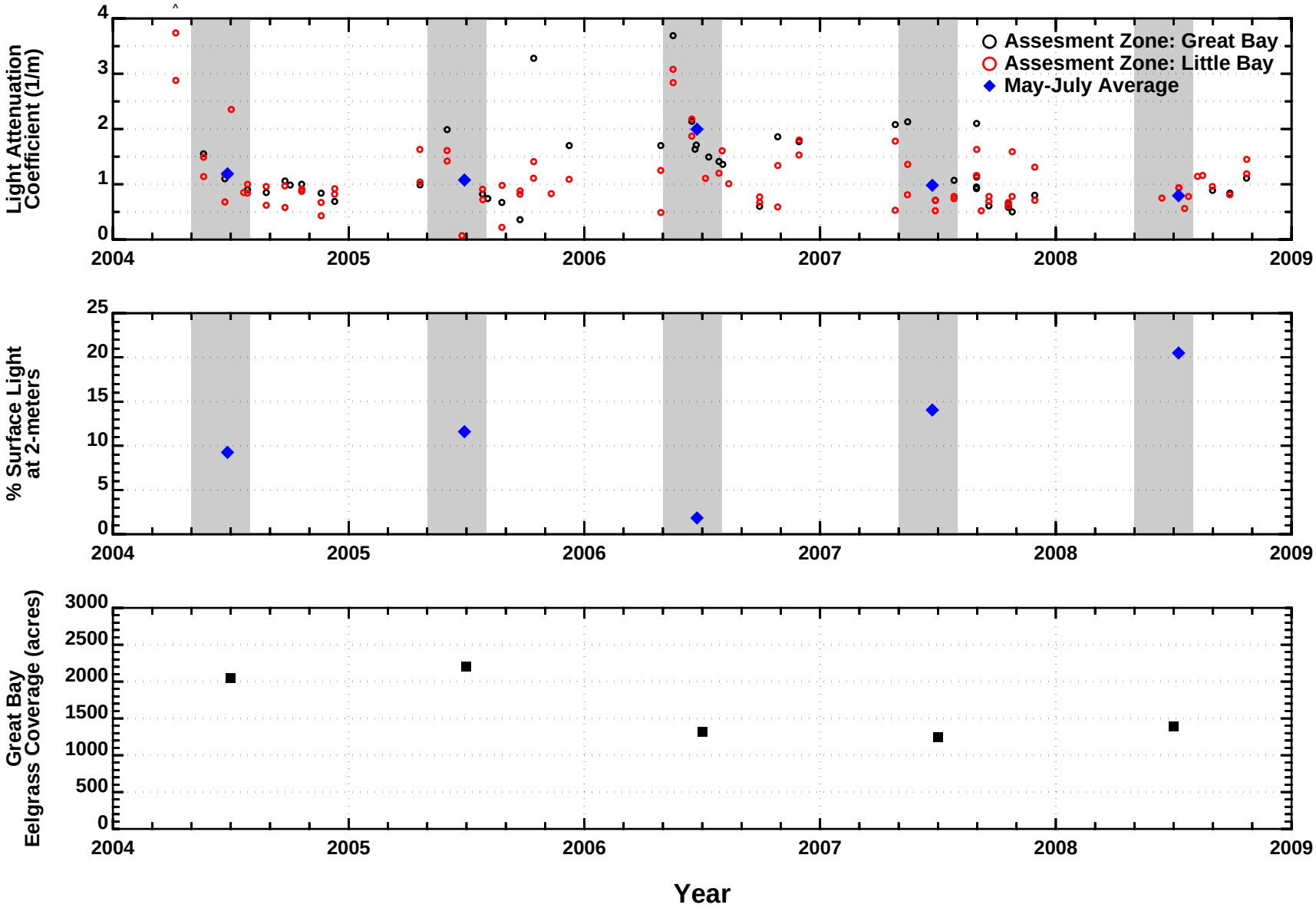


Figure 1. Great Bay & Little Bay Measured Light Attenuation Coefficients and Great Bay Eelgrass Coverage (2004-2008)

/coral1/haas0040/wq/pmkd_cdom_buoy.gdp
DATE: 8/03/2012 TIME: 16:20: 5

Tony Lapa

From:	Trowbridge, Philip
Sent:	Wednesday, November 14, 2007 3:48 PM
To:	'Fred Short'
Cc:	'Hunter, Jennifer'
Subject:	RE: ERF Talk!!
Attachments:	Thursday_020_1430_ptrowbridge.ppt

Hi Fred,

I cannot make it to Durham tomorrow afternoon but I would like to resolve these fundamental misconceptions soon so that I can prepare for the 12/7 meeting.

I propose that we have a phone conversation tomorrow afternoon to get things started. I have attached my power point file, which we can step through slide-by-slide to discuss. We can meet in person during the afternoon on 11/27 or 11/28 on UNH campus or a JEL to discuss in more detail.

I will be out of the office in the morning but **I will be expecting your call at 3:30 pm tomorrow**. You can reach me at 271-8872.

Phil

-----Original Message-----
From: Fred Short [mailto:fred.short@unh.edu]
Sent: Wednesday, November 14, 2007 9:22 AM
To: Trowbridge, Philip
Cc: Hunter, Jennifer
Subject: Re: ERF Talk!!

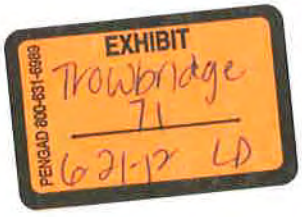
Hi Phil,

Thanks for getting back to me. I think there are some fundamental, major misconceptions that we need to talk about, and I don't think it's something we should try to do over the phone. In my view, the best thing to do would be to sit down together with you and your power point (and Jennifer is welcome) and go through and straighten out the concepts: the ecology of the bay and how it relates to nutrient criteria.

I am available tomorrow afternoon between 3 and 5. Could we meet at 3 at JEL, Fish and Game, or on campus? Otherwise, it would need to be on the 21st early afternoon. Or another alternative would be afternoons during the final week of November, which is relatively open for me at this point except for the 29th.

I do think it's important that we have this discussion prior to the public meeting on December 7. Thanks, Phil.

Best,
Fred



To: Trowbridge, Philip; Trowbridge, Philip
Subject: ERF Talk!!

Hi Phil,

I have some concerns and want to bring them up with you. I was rather upset by your Indicator talk at ERF. You certainly changed things around a lot from what I had seen before and unfortunately, you have gotten the overall picture mixed up. What you outlined in the talk as your future approach is not going to get you any closer to useful indicator criteria. Over the summer, I sort of heard parts of the the algal indicator direction you have been following, but hearing it presented at ERF clearly points out to me that you are heading in the wrong direction.

I think it would be good for us to sit down and talk about this asap. The end process of the direction you are heading will not get you to nutrient criteria that will work for the Great Bay Estuary. I think it's a mistake to dismiss all the other work that's been done on nutrient criteria because it doesn't fit all of the the GBE. You are seriously misunderstanding the ecology of the Estuary at this point and, given the complexity of GBE, you are not going to find an indicator criteria that will work for the Estuary as a whole. The fact that we still have eelgrass in Great Bay does not mean that the whole Estuary is healthy. In fact, as you know, eelgrass has disappeared from all of Little Bay and most of the upper Piscataqua, as predicted by your water quality data. Based on the loading rates and the extinction coefficients you presented at ERF, one would predict that GBE is in trouble and in fact the loss of eelgrass proves that it is. Great Bay itself is "saved" for the time being by the fact that the eelgrass is largely intertidal and receives at low tide the light it needs to survive. Thus, eelgrass will persist in Great Bay long after the rest of the Estuary is dead.

I am available next week M - W and after Thanksgiving.

Fred

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Toward a New Conceptual Model for Nutrient Criteria Development in a New Hampshire Macrotidal Estuary

P. Trowbridge, R. Morrison,
J. Latimer, J. Pennock,
R. Langan, F. Short

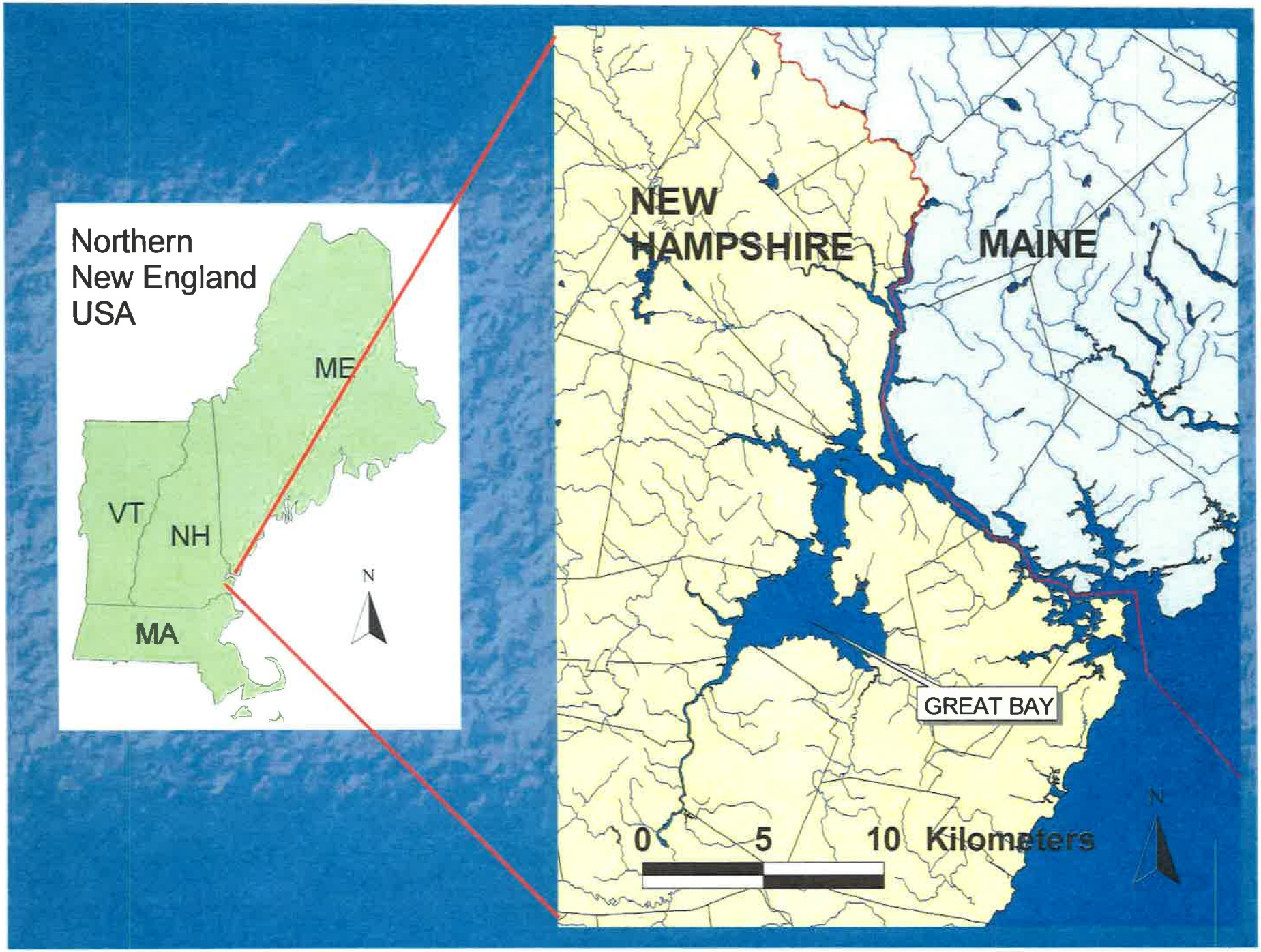
November 8, 2007

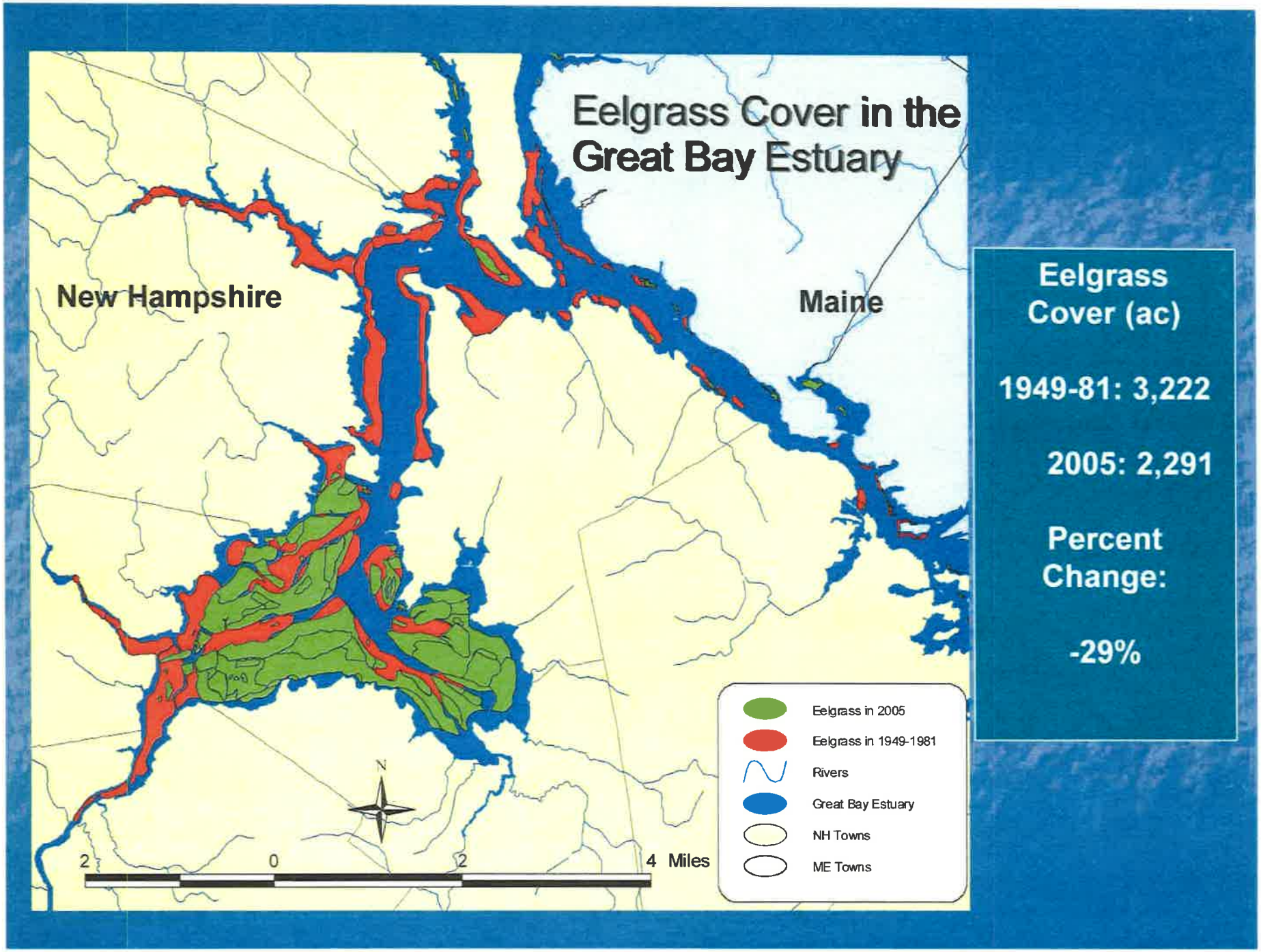
Motivation

- EPA priority for state action
- Historic loss of eelgrass
- Current thinning of eelgrass biomass
- Interest of local stakeholders and experts to act before all is lost

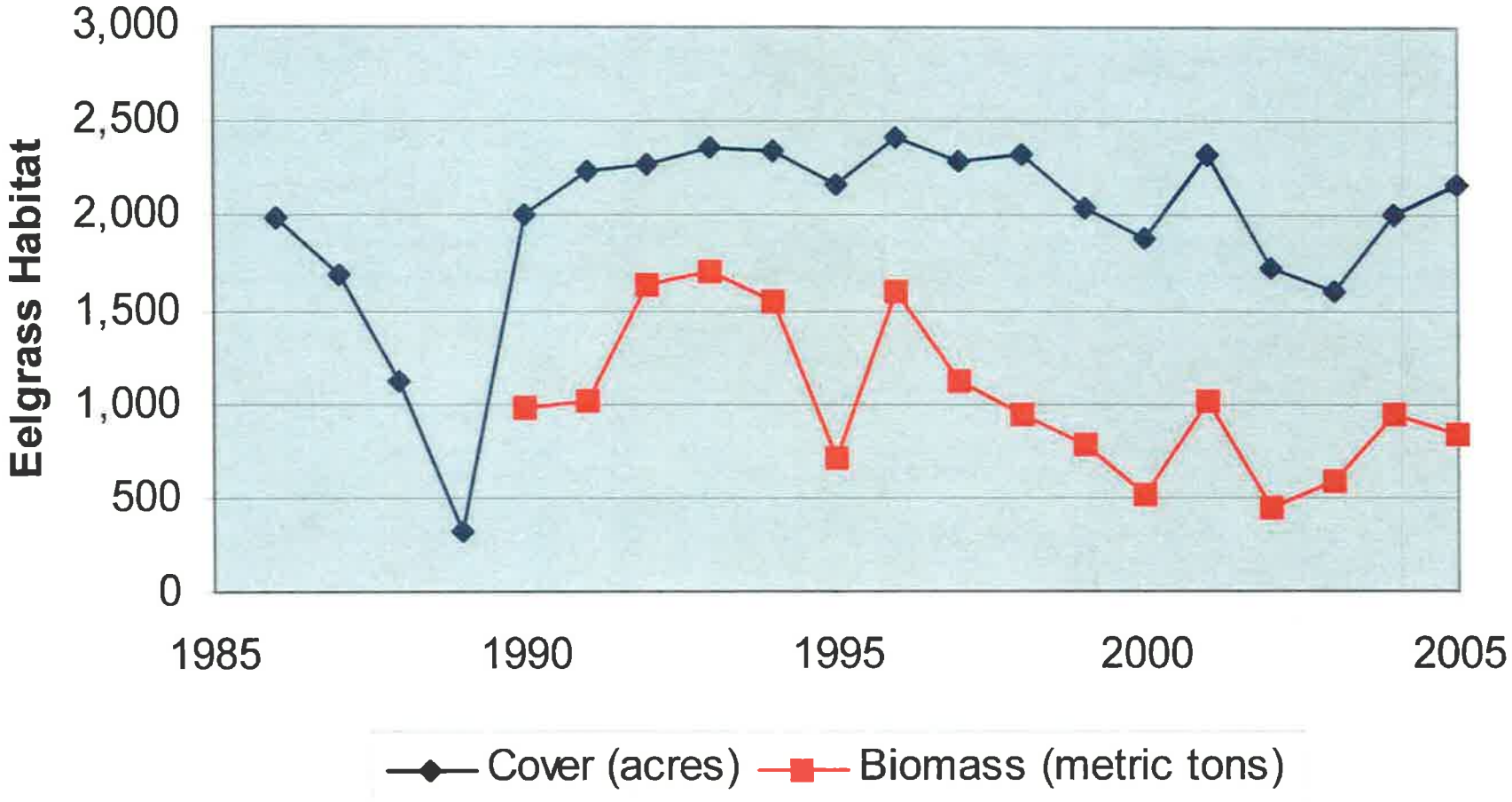
Great Bay Estuary

- Forms the border between NH and ME
- Surface area: 55 km^2
- Ave depth: 3.2 m
- Ave salinity: 26 ppt
- Tidal range: 2.0 to 2.7 m
- Retention time: 20 days
- Drainage area: 1,086 mi^2


Northern
New England
USA
ME
VT
NH
MA
N
NEW
HAMPSHIRE
MAINE
GREAT BAY
0
5
10 Kilometers
N


Eelgrass Cover in the Great Bay Estuary
New Hampshire
Maine
Eelgrass Cover (ac)
1949-81: 3,222
2005: 2,291
Percent Change:
-29%
Eelgrass in 2005
Eelgrass in 1949-1981
Rivers
Great Bay Estuary
NH Towns
ME Towns
N
2 0 2 4 Miles

Recent Eelgrass Trends in Great Bay



Conceptual Model for Nutrient Criteria for Great Bay

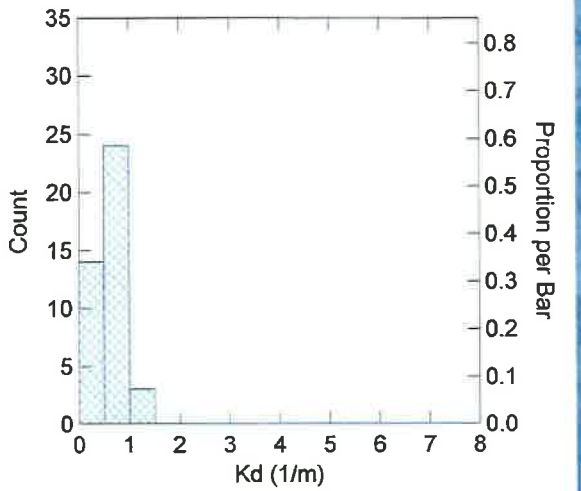
- Eelgrass viability is the target for numeric nutrient criteria development
- Factors affecting eelgrass
  - Light through water (water quality)
  - Light to leaf (epiphytes, macroalgae)
  - Disease

Initial Research Topics

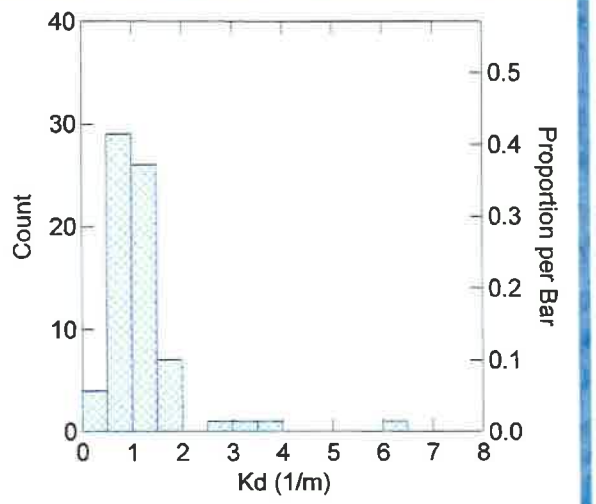
- Current light availability and compare to current eelgrass habitat
- Identify correlations between water quality parameters and light attenuation
- Compare nitrogen loading to Great Bay to other systems with eelgrass loss

Measured Bulk Light Attenuation Through Water in Great Bay

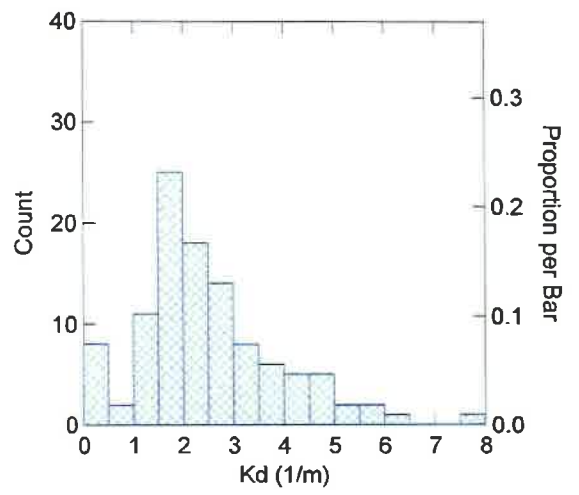
Piscataqua River/ Portsmouth Harbor



Great Bay/ Adams Point



Tidal Tributaries



Piscataqua River/ Portsmouth Harbor	Great Bay/ Adams Point	Tidal Tributaries
n = 41	n = 70	n = 108
Median Kd = 0.58 m^{-1}	Median Kd = 1.01 m^{-1}	Median Kd = 2.17 m^{-1}
Mean Kd = 0.56 m^{-1}	Mean Kd = 1.19 m^{-1}	Mean Kd = 2.45 m^{-1}

Predicted Depth Range for Eelgrass based on Measured Kd

- Piscataqua River/Portsmouth Harbor
  - Z= -1.2 to -2.6 m, Delta = 1.4 m
- Great Bay/Adams Point
  - Z= -0.9 to -1.5 m, Delta = 0.6 m
- Tributaries
  - None (Zmin>Zmax)

Assumes light requirement of 22% of surface light field for eelgrass survival and no effect of leaf epiphytes. Depth datum is MTL.

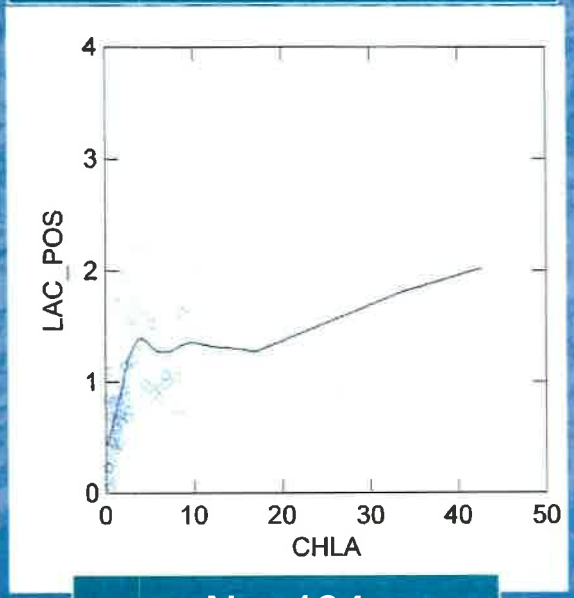
Water Quality Parameters Influencing Light Attenuation

- Phytoplankton (chlorophyll-a)
- Suspended sediments/turbidity
- Colored dissolved organic matter (CDOM)
- Water itself (assumed to be constant)

Use multiple linear regression to find dominant factor influencing light attenuation.

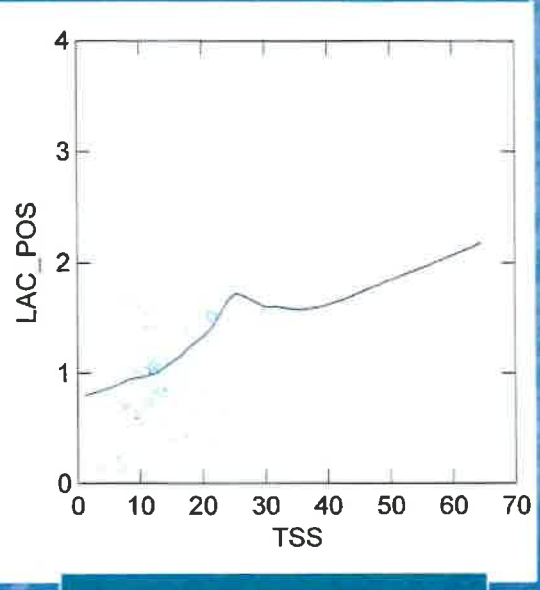
Univariate Regression of Kd vs. Water Quality Parameters

Kd vs Chlorophyll-a



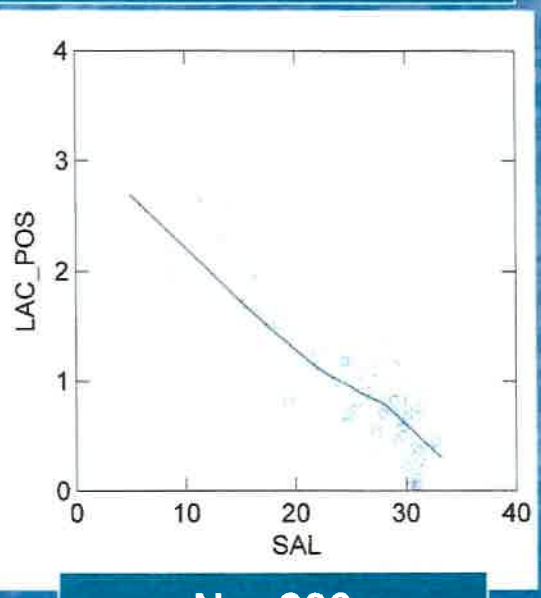
N = 184
R^2 = 0.07

Kd vs TSS



N = 176
R^2 = 0.13

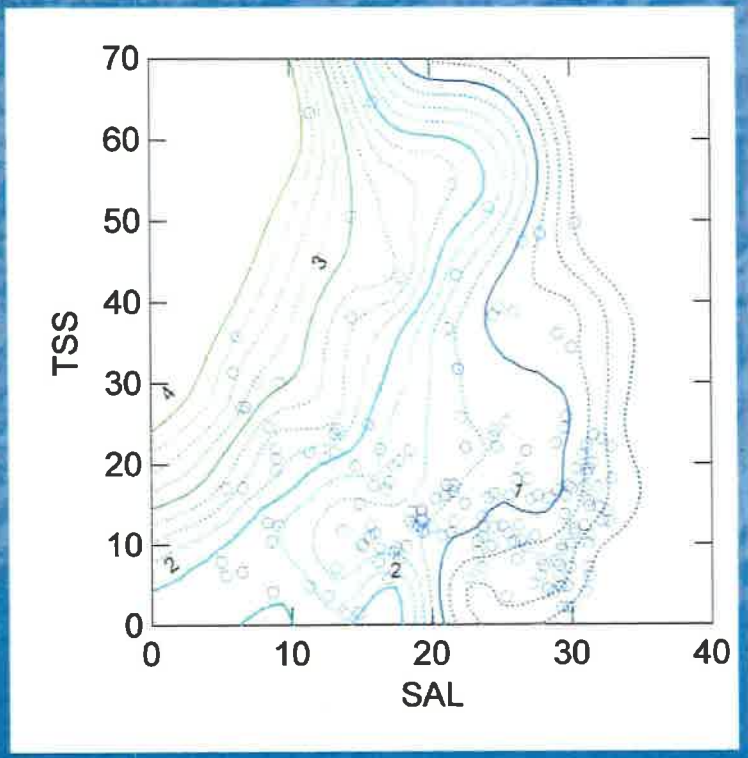
Kd vs Salinity (CDOM)

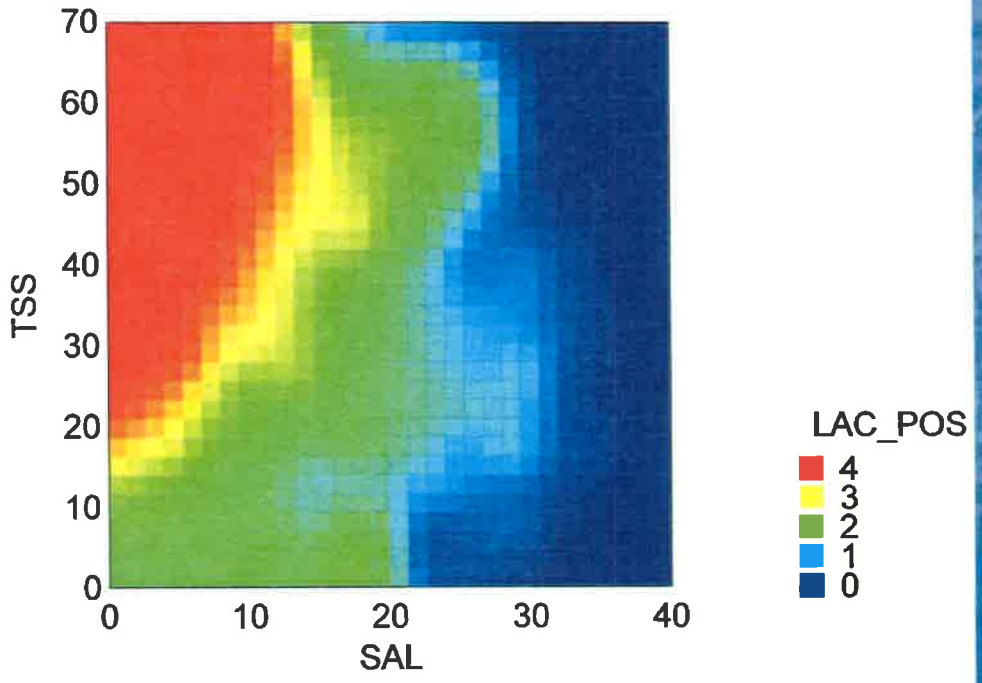


N = 209
R^2 = 0.54

Multivariate Regression of Kd vs. Water Quality Parameters

Multivariate Regression of Kd vs. TSS, Chla, and Salinity (CDOM)
TSS and Salinity are significant, $R^2 = 0.61$, n=176





Nitrogen Loading Rates in Great Bay Compared to Other Systems

Normalized by Surface Area

- **Hauxwell** et al. 2003 Eelgrass disappears at >60 kg/ha/yr
- Great Bay loading rate is 182 kg/ha/yr

Normalized by Volume & Residence Time

- **Latimer** et al. 2007 At 160 mg/m3, less than 5% of eelgrass remains
- Great Bay loading rate is 280 mg/m3 (normalized by RT)
- **Nixon** et al. 2001 Compiled loadings of eelgrass and macroalgae systems
- Great Bay loads were at high end of eelgrass-dominated systems

Nitrogen Loading Rates in Great Bay Compared to Other Systems

Normalized by watershed area

- **Steward & Green 2007** watershed loads to maintain eelgrass 2.4-3.2 kg/ha/yr
- Great Bay watershed loading rate 3.9 kg/ha/yr

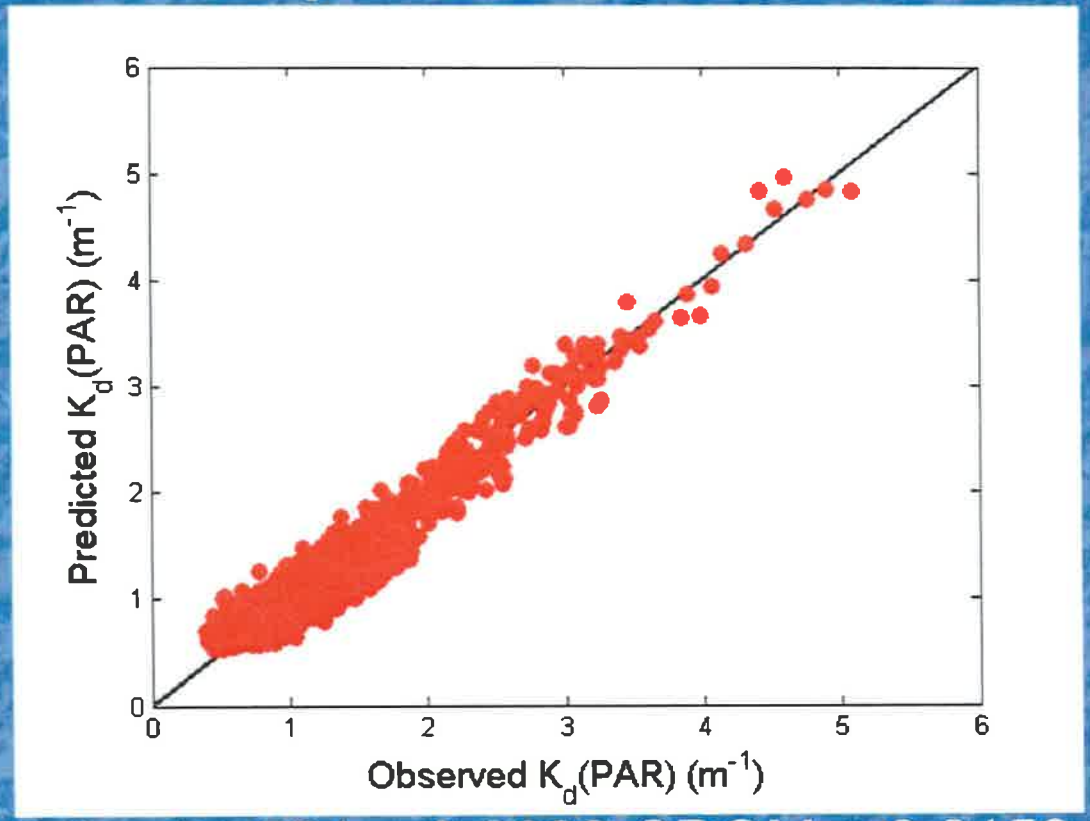
Conclusions from Initial Research

- None of initial hypotheses provided clear answers
- Approach taken by Steward and Green may not be acceptable to stakeholders
- Need to move toward a new conceptual model
  - Suspended sediments as important as nitrogen inputs
  - Macroalgae as primary producer
  - Grab samples inadequate to document relationships

Current Research

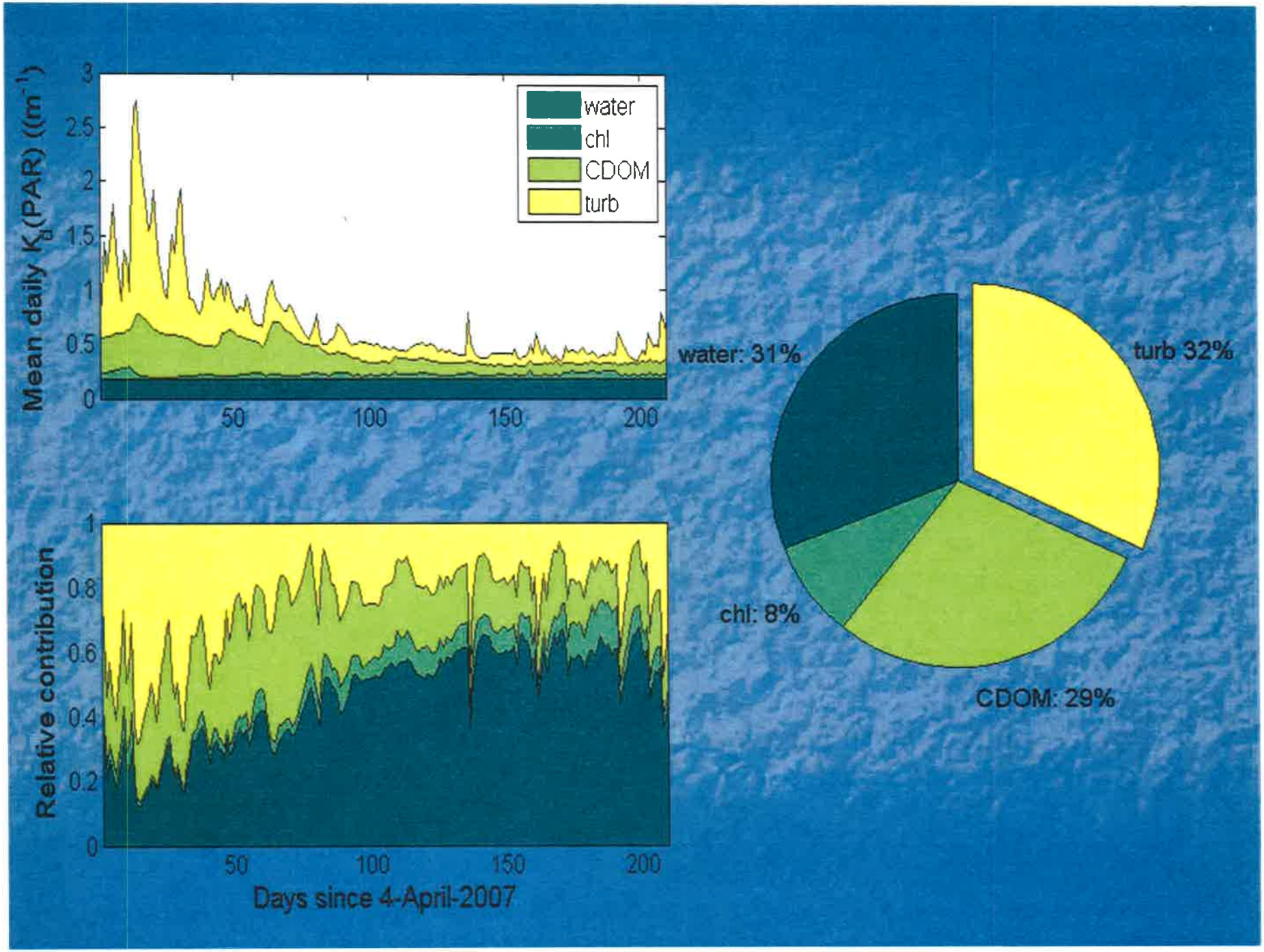
- High frequency monitoring of light attenuation and water quality from a moored array.
- Hyperspectral imagery of estuary to map water quality and macroalgae

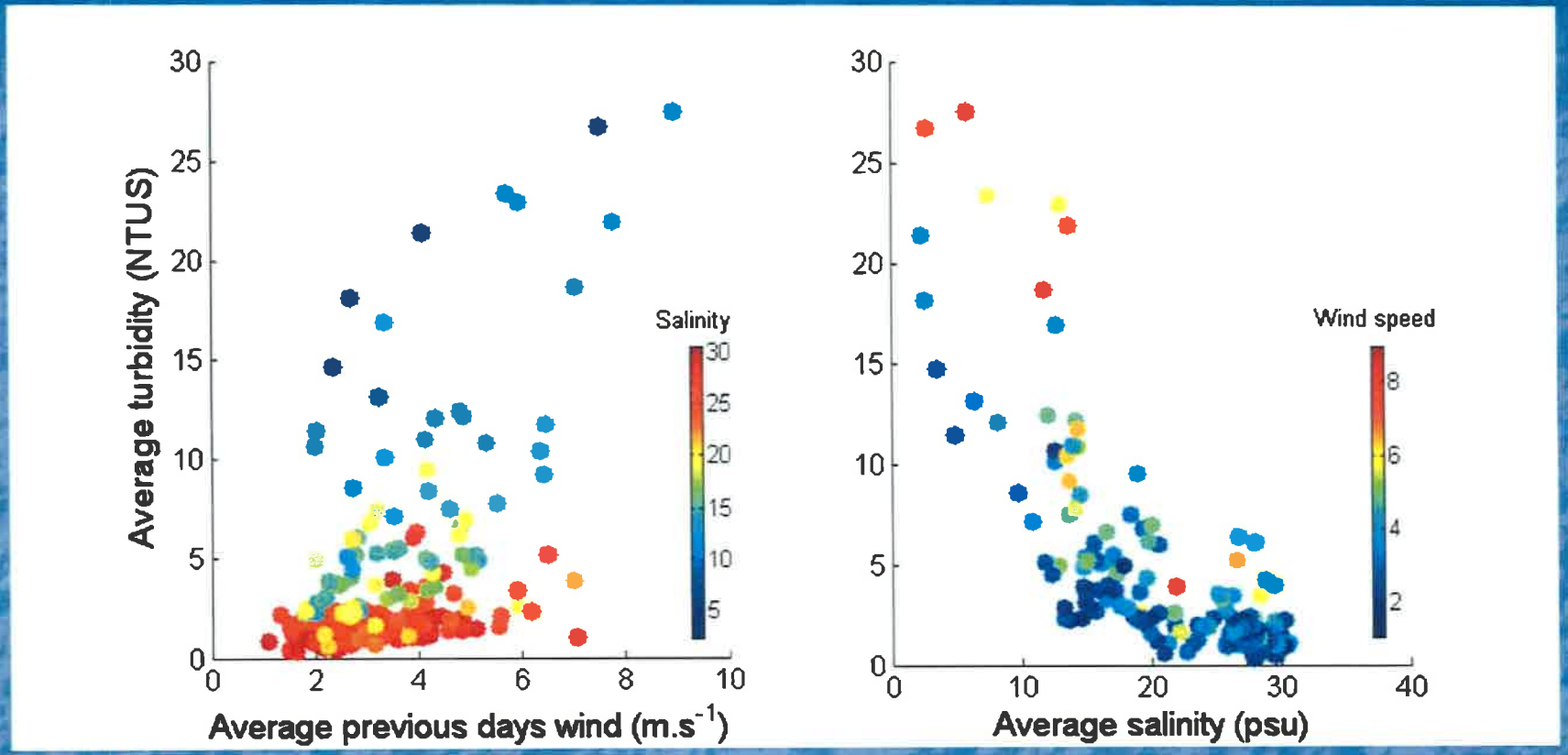
Preliminary Results from Buoy



$Kd(PAR) = 0.3561 + 0.0083.CDOM + 0.0152.Chl + 0.0737.NTUS$

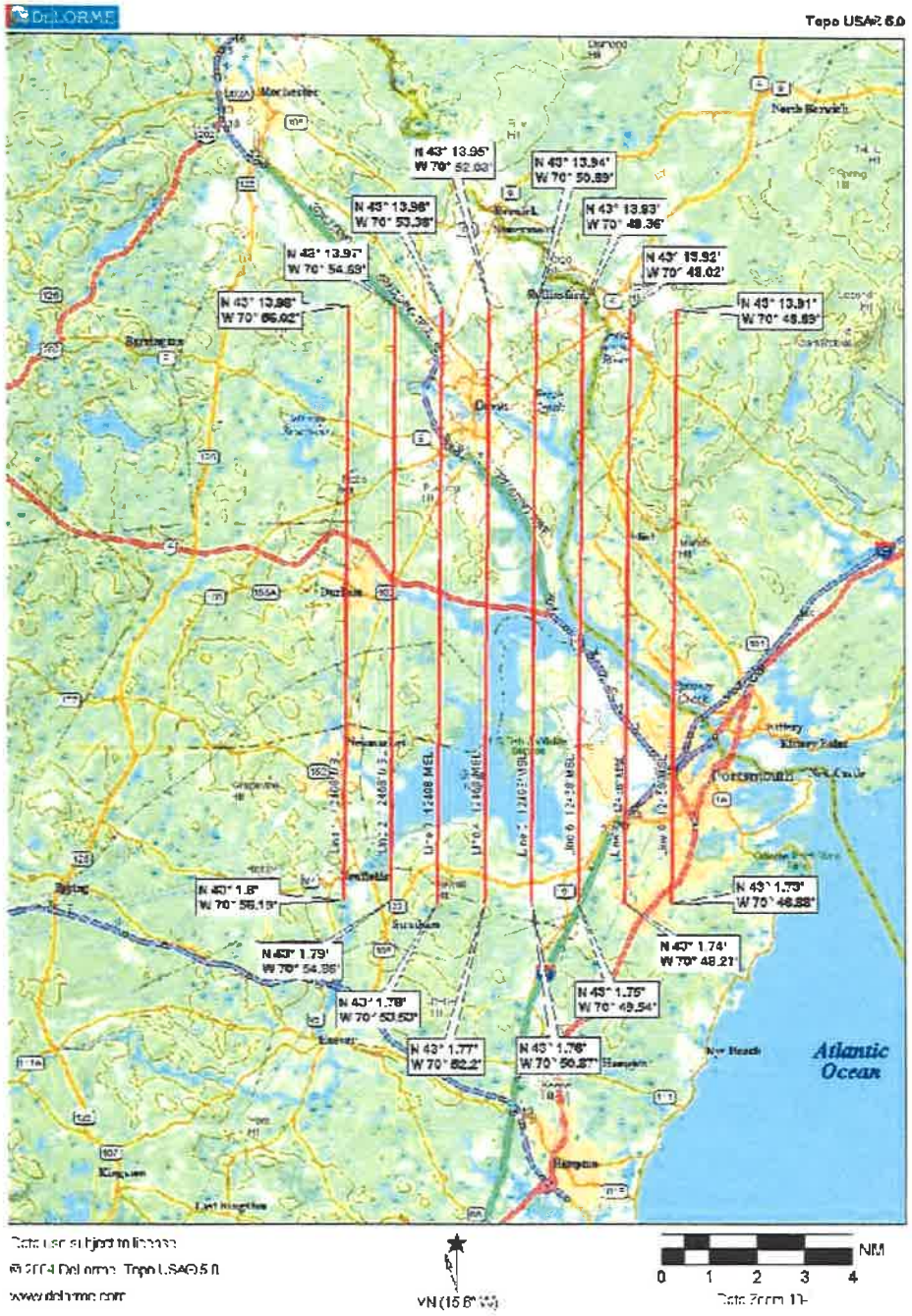
$r^2 = 0.94$, N=3371


Mean daily K_d(PAR) ((m^{-1}))
water
chl
CDOM
turb
water: 31%
turb 32%
chl: 8%
CDOM: 29%
Relative contribution
Days since 4-April-2007



$$\text{Turbidity} = 10^{(1.03 + 0.087.\text{Wind} - 0.041.\text{Salinity})}$$

$$r^2 = 0.75,\ N=207$$



Hyper-spectral Imagery Flight Lines

Imagery Collected on 9/29/07 10/17/07

Conclusions

- Traditional conceptual models for nitrogen-eelgrass relationships do not work for Great Bay.
- Research with high frequency measurements and hyperspectral imagery are shedding light on light attenuation processes.
- Need a different model which includes tidal amplitude, sediment resuspension and macroalage.

Contact Information

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N.H. Department of Environmental Services
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Philip.Trowbridge@des.nh.gov
603-271-8872

EPA/DES Eelgrass presentation

Tony Lapa

From: Trowbridge, Philip
Sent: Thursday, March 20, 2008 1:56 PM
To: 'colarusso.phil@epamail.epa.gov'
Subject: RE: Presentation for eelgrass meeting
Attachments: 20080325 Trowbridge.ppt

Here it is. Let me know if you receive it and it looks OK.

-----Original Message-----
From: colarusso.phil@epamail.epa.gov [mailto:colarusso.phil@epamail.epa.gov]
Sent: Thursday, March 20, 2008 10:30 AM
To: Trowbridge, Philip
Subject: Re: Presentation for eelgrass meeting

Bring it on a flash drive and if you think of it send it along as well.
I'll try to get it loaded on our laptop in advance. Thanks for being a
willing participant.

"Trowbridge, Philip" <Philip.Trowbridge@des.nh.gov>
03/20/2008 10:24 AM

To: Phil Colarusso/R1/USEPA/US@EPA
cc:
Subject: Presentation for eelgrass meeting

Phil,
Do you want the presentations in advance of the meeting or should I
bring it on a flash drive?

+++++++++
Phil Trowbridge, P.E.
Coastal Scientist
N.H. Dept. of Environmental Services
603.271.8872

EXHIBIT
Trowbridge 12
6-21-12 LD
PENGAD 800-631-6989

New Hampshire Estuaries Project

Nutrient Criteria Development for the Protection of Eelgrass in NH's Estuaries

Philip Trowbridge, P.E.

March 25, 2008

NewHampshire EstuariesProject

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

UNIVERSITY of NEW HAMPSHIRE

NewHampshire EstuariesProject

Motivation

- EPA priority for state action
- Historic loss of eelgrass
- Current thinning of eelgrass biomass
- Interest of local stakeholders and experts to act before all is lost

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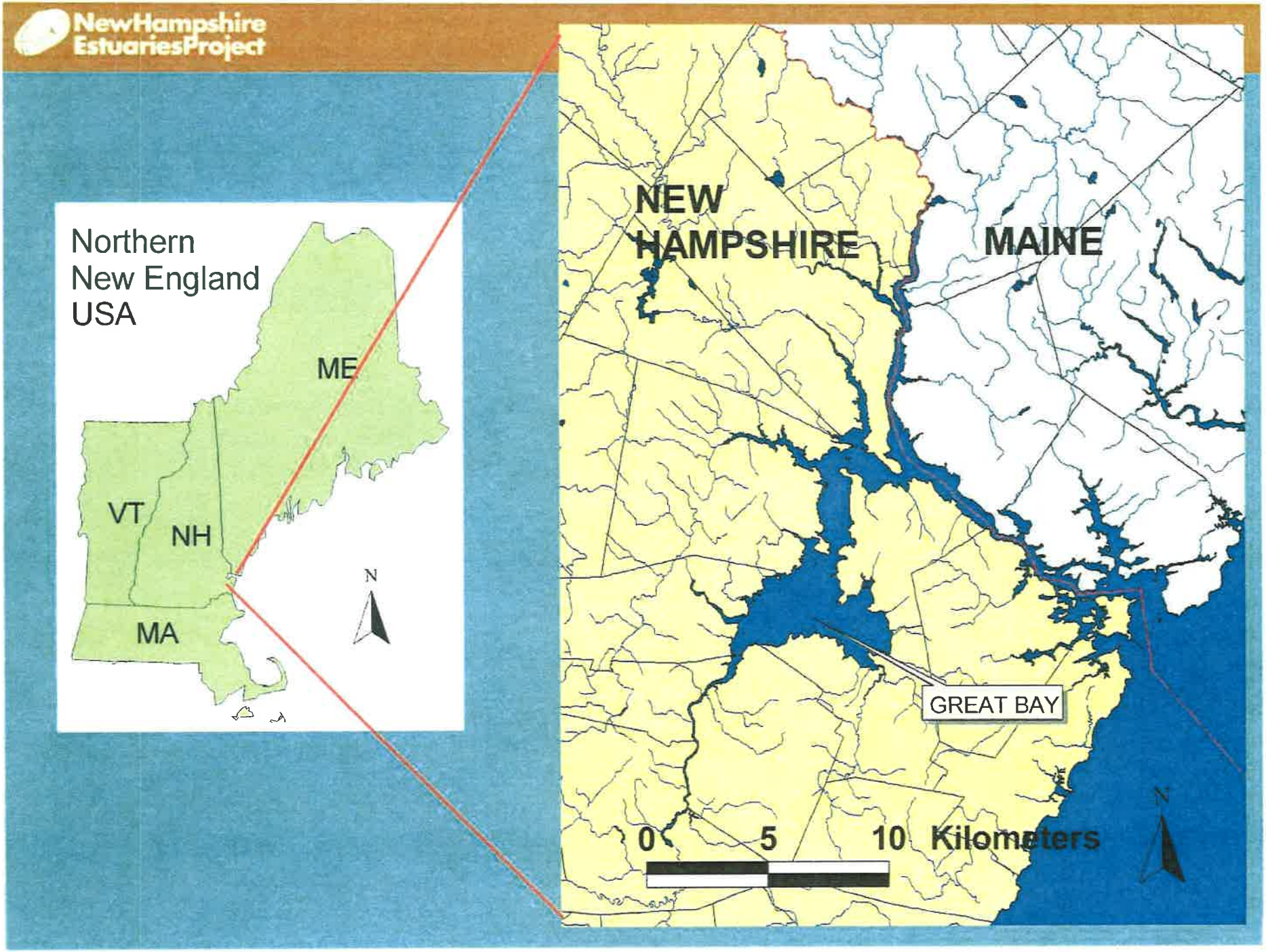
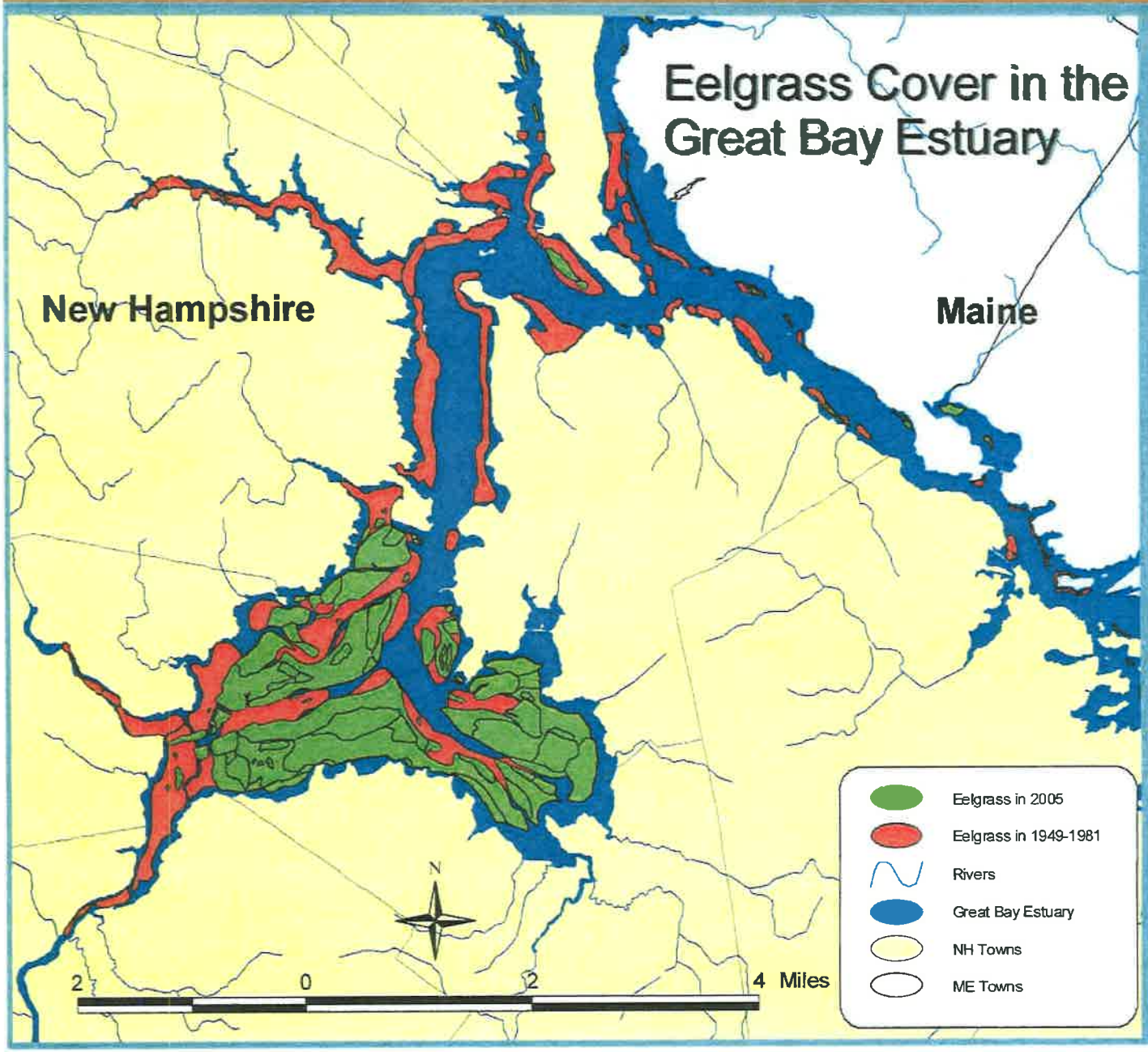
Great Bay Estuary

- Forms the border between NH and ME
- Surface area: 55 km^2
- Average depth: 3.2 m
- Average salinity: 26 ppt
- Tidal range: 2.0 to 2.7 m
- Retention time: 20 days
- Drainage area: 1,086 mi^2


NewHampshire
EstuariesProject
Northern
New England
USA
ME
VT
NH
MA
N
NEW
HAMPSHIRE
MAINE
GREAT BAY
0
5
10 Kilometers
N

NewHampshire EstuariesProject



Eelgrass Cover (ac)

1949-81: 3,222

2005: 2,291

Percent Change:

-29%

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Presentation Outline

- Estuary segmentation
- Eelgrass cover and biomass trends
- Light attenuation trends and causes
- Nitrogen and phosphorus concentrations
- Nitrogen loads to the estuary
- Conclusions and Next Steps

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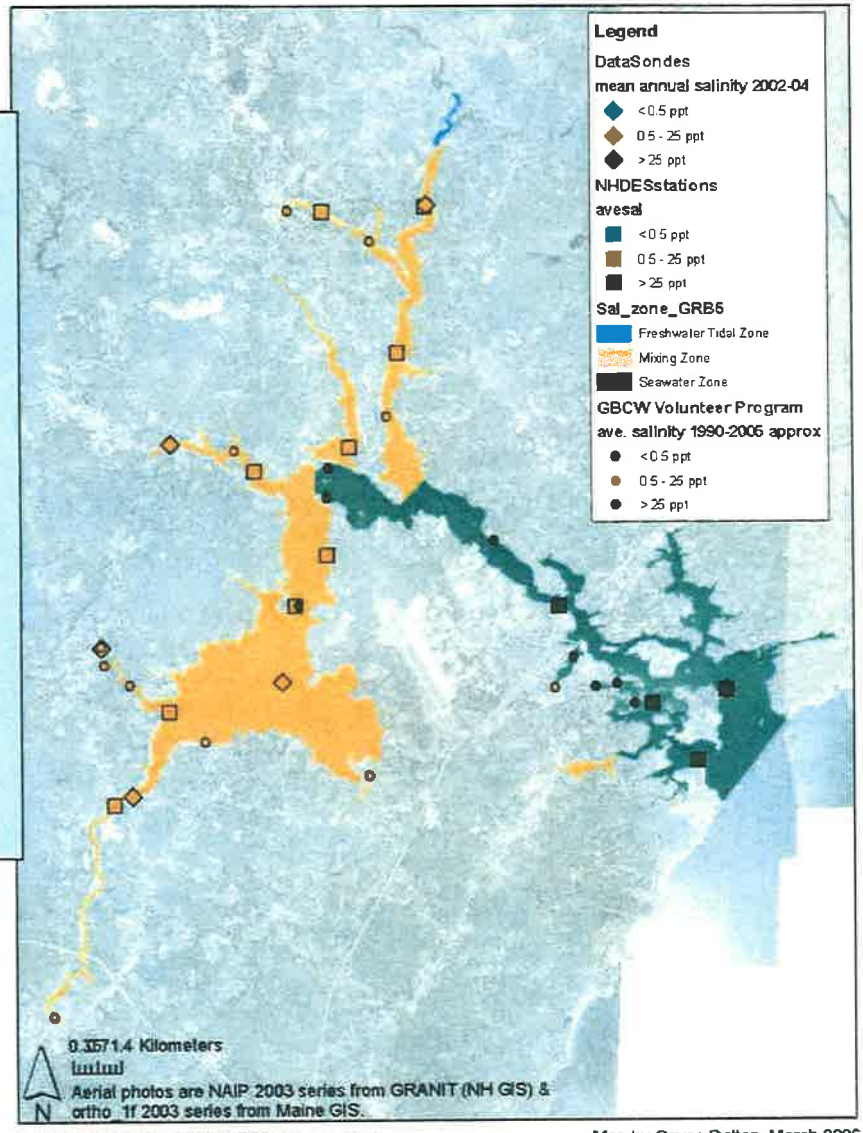
FOURTH DRAFT

ASSETS: Great Bay Salinity Zones
Source data: NHDES, GBCW & GBNERR

Segments of the Great Bay Estuary based on Average Salinity (from NEEA)

0.5-25 ppt: Great Bay and Upper Little Bay (excluding tributaries)

>25 ppt: Portsmouth Harbor, Piscataqua River, Lower Little Bay.



Map by Cayce Dalton, March 2006

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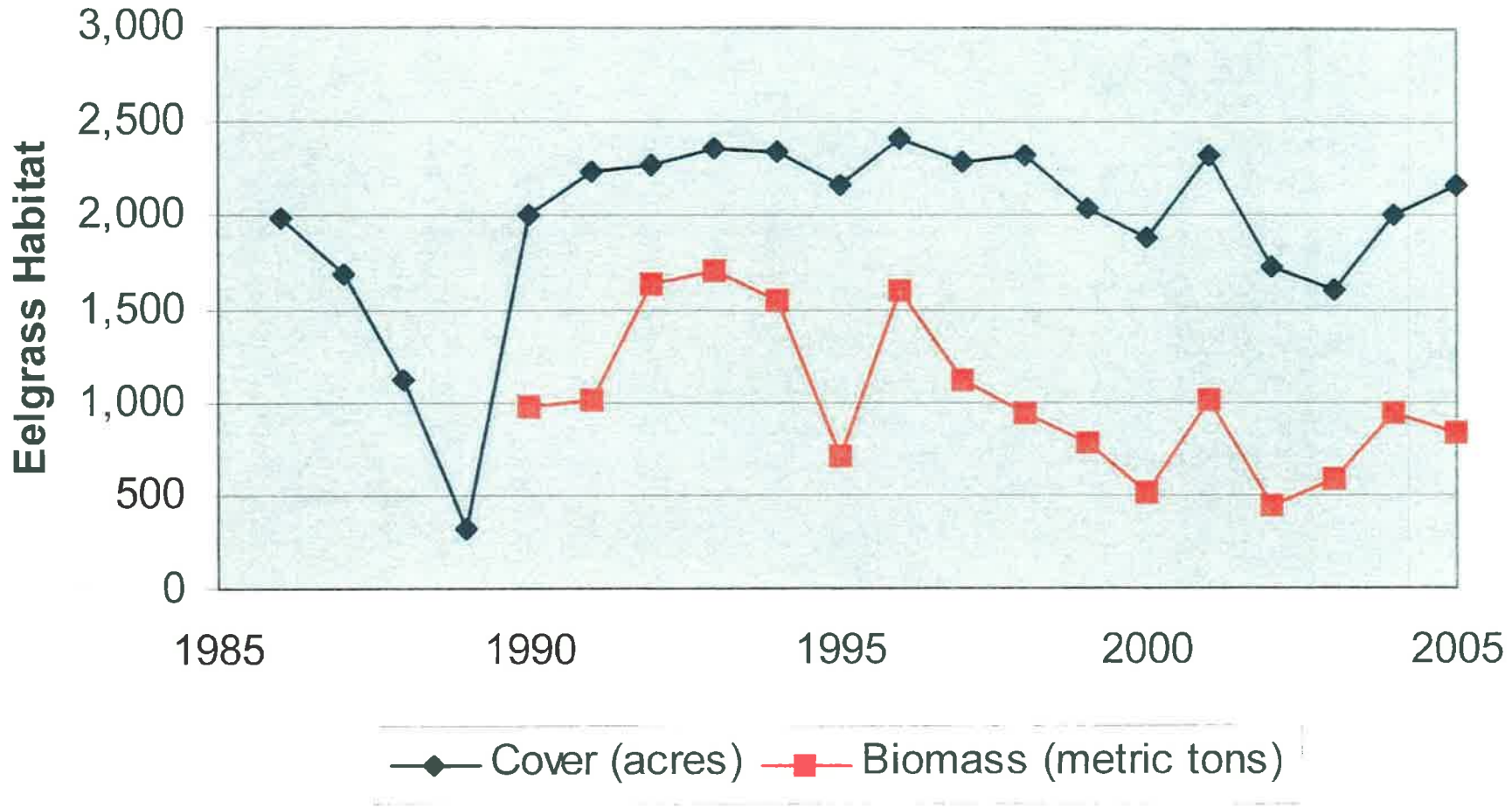
Eelgrass Trends in Great Bay



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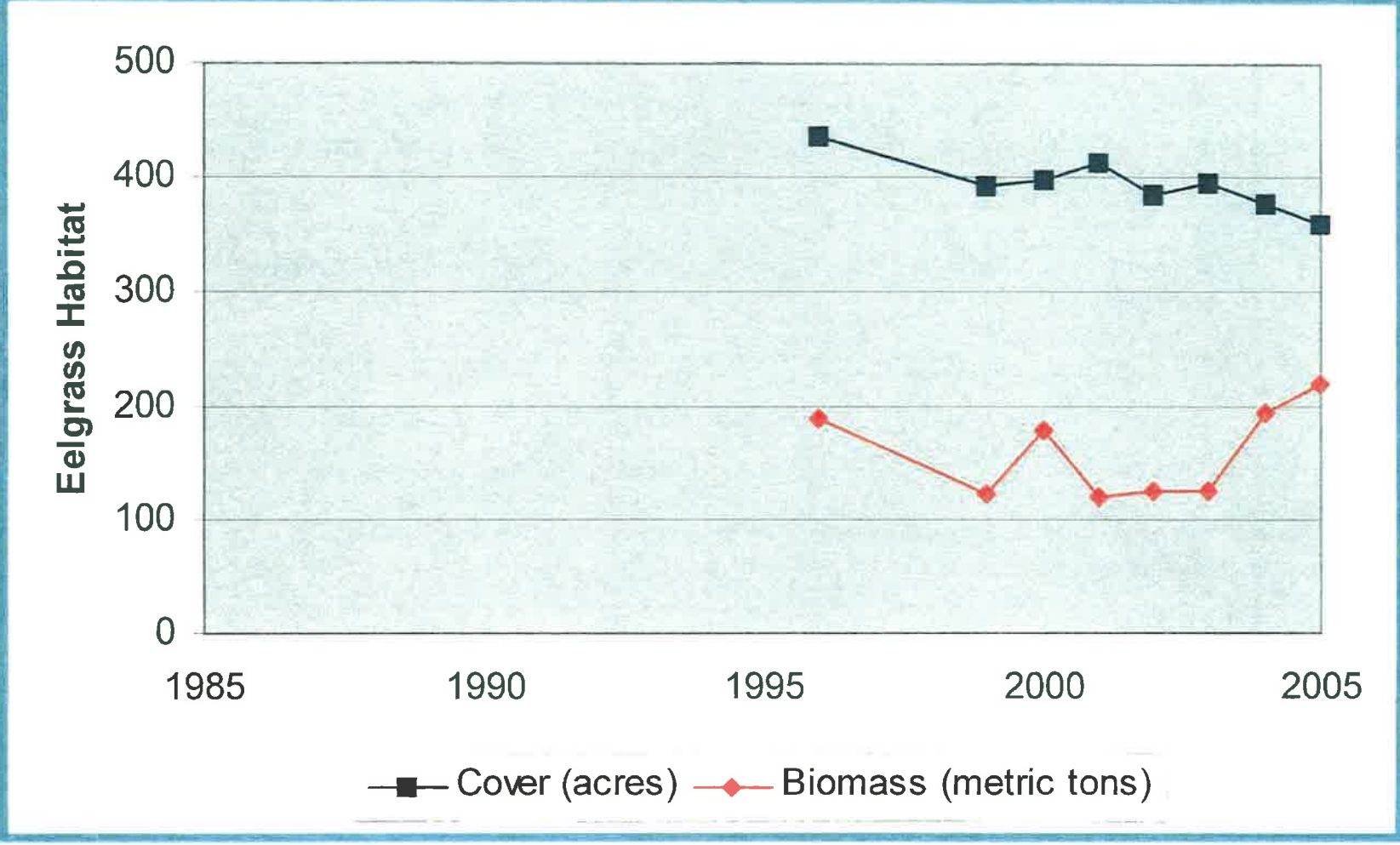
Eelgrass Trends in Little Bay and the Piscataqua River



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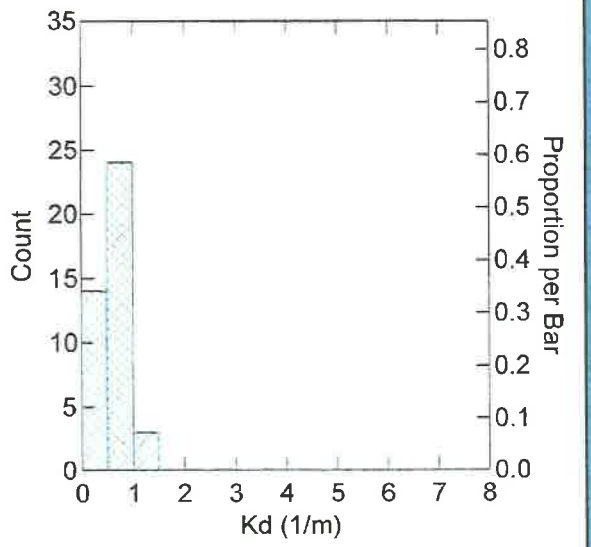
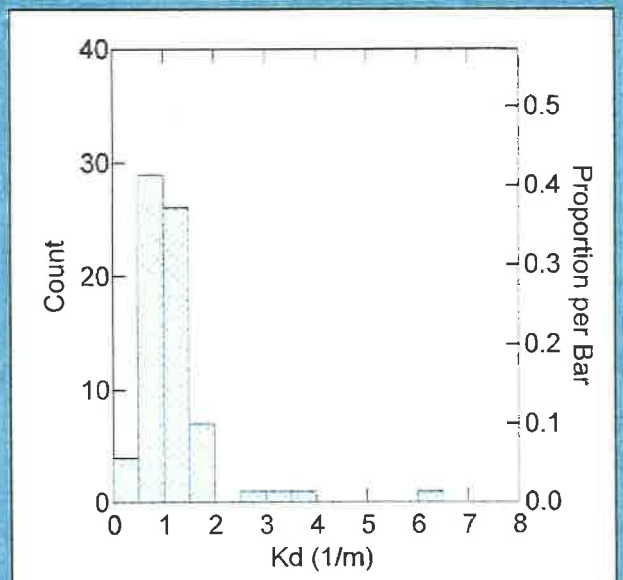
Measured Bulk Light Attenuation Through Water in Great Bay

Piscataqua River/ Portsmouth Harbor



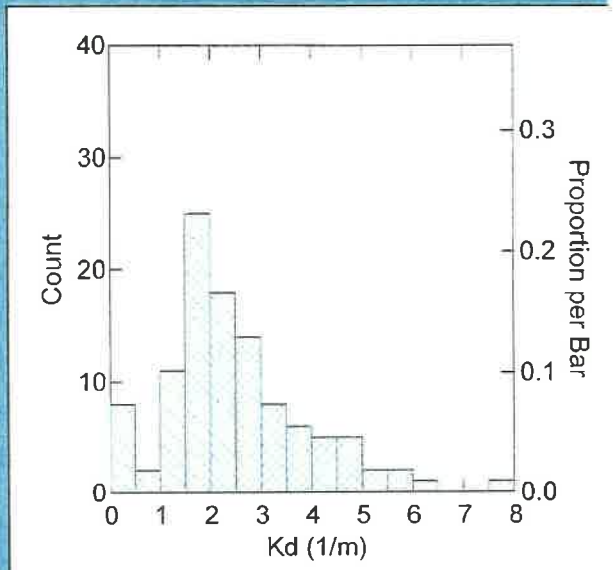
n = 41
Median Kd = 0.58 m^{-1}
Mean Kd = 0.56 m^{-1}

Great Bay/ Adams Point



n = 70
Median Kd = 1.01 m^{-1}
Mean Kd = 1.19 m^{-1}

Tidal Tributaries



n = 108
Median Kd = 2.17 m^{-1}
Mean Kd = 2.45 m^{-1}

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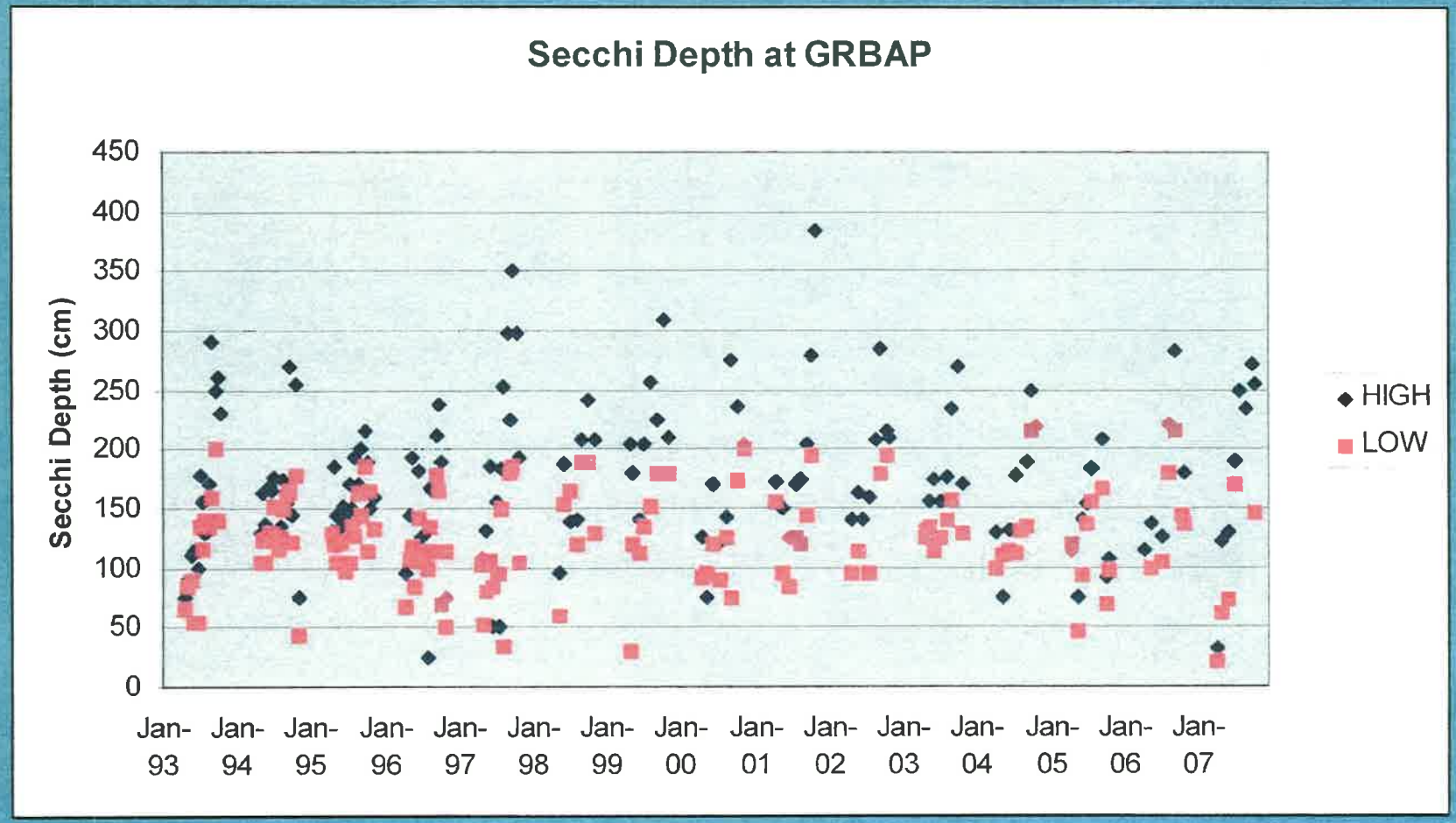
Water Clarity in Great Bay



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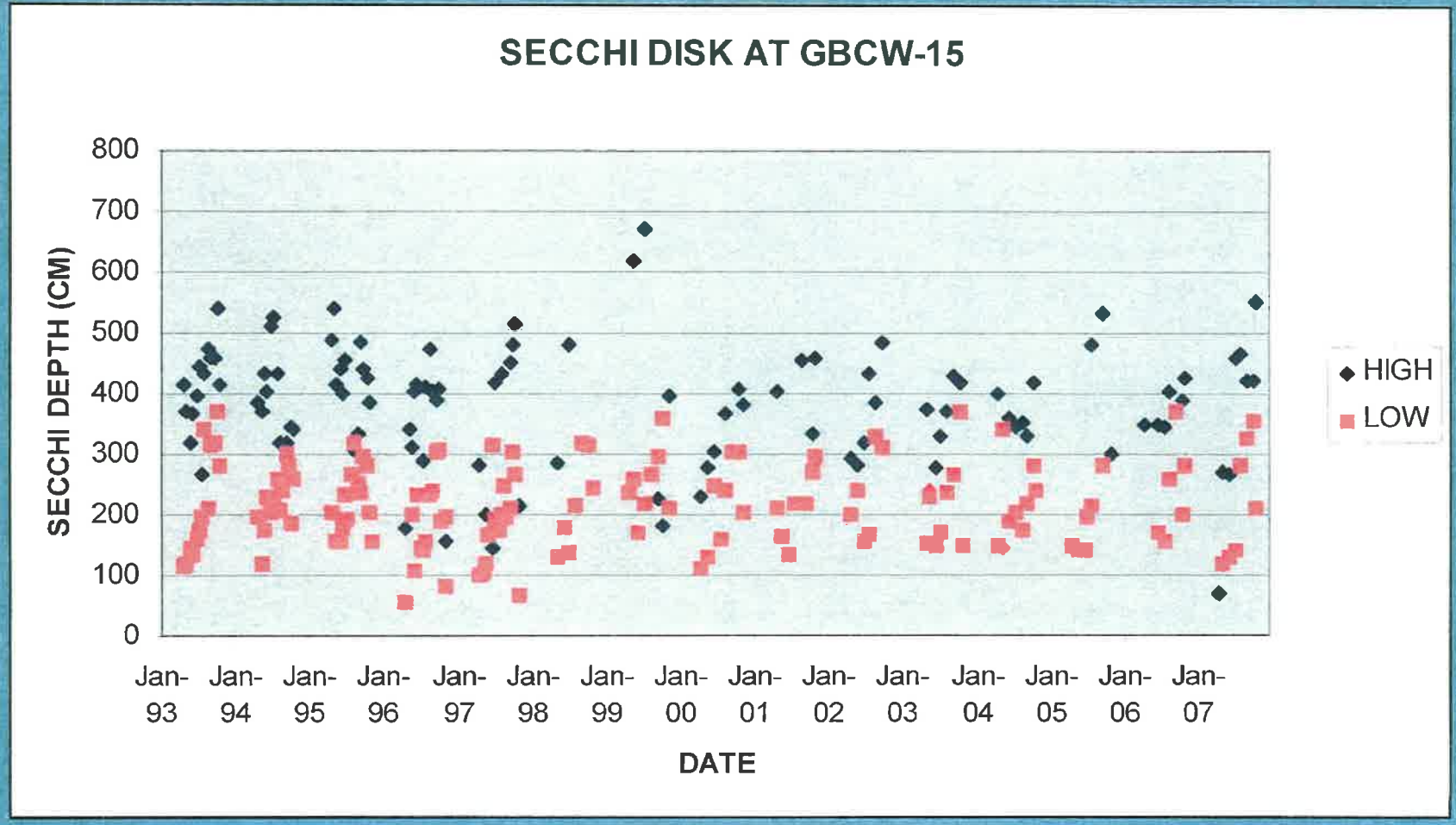
Water Clarity in Piscataqua River



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Water Quality Parameters Influencing Light Attenuation

- Phytoplankton (chlorophyll-a)
- Suspended sediments/turbidity
- Colored dissolved organic matter (CDOM)
- Water itself (assumed to be constant)

Use multiple linear regression to find dominant factor influencing light attenuation.

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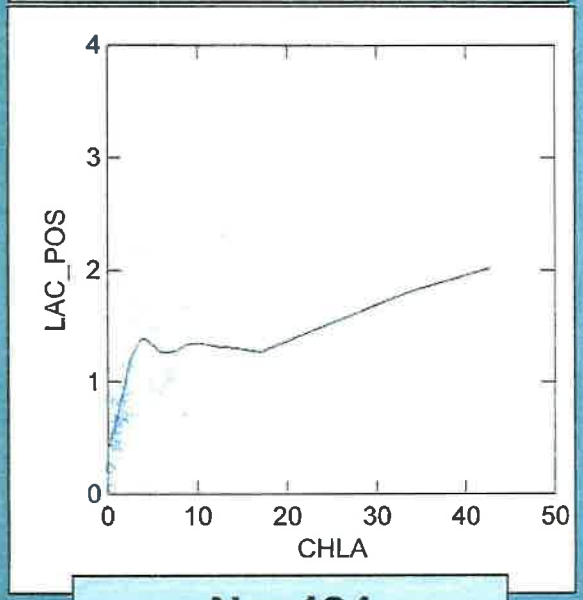
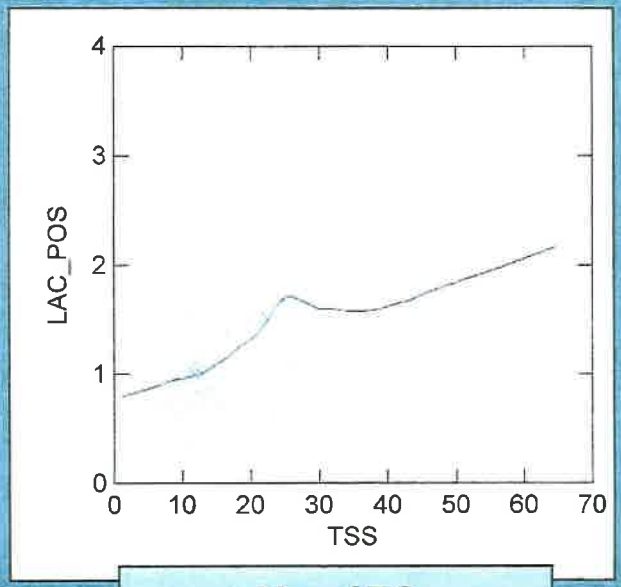
Univariate Regression of Kd vs. Water Quality Parameters

Kd vs Chlorophyll-a



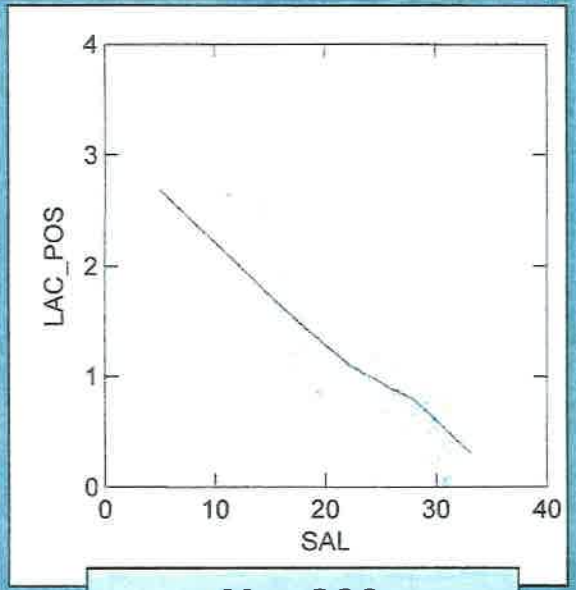
N = 184
R^2 = 0.07

Kd vs TSS



N = 176
R^2 = 0.13

Kd vs Salinity (CDOM)



N = 209
R^2 = 0.54

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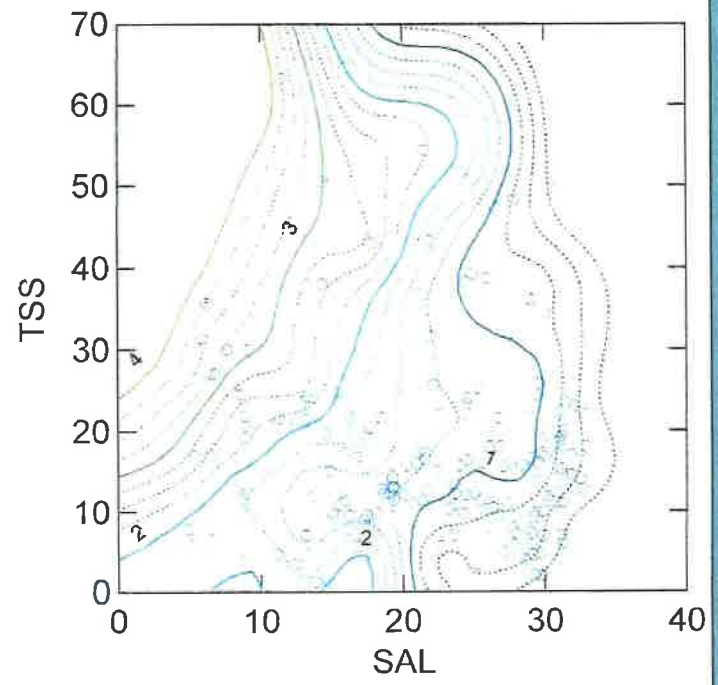
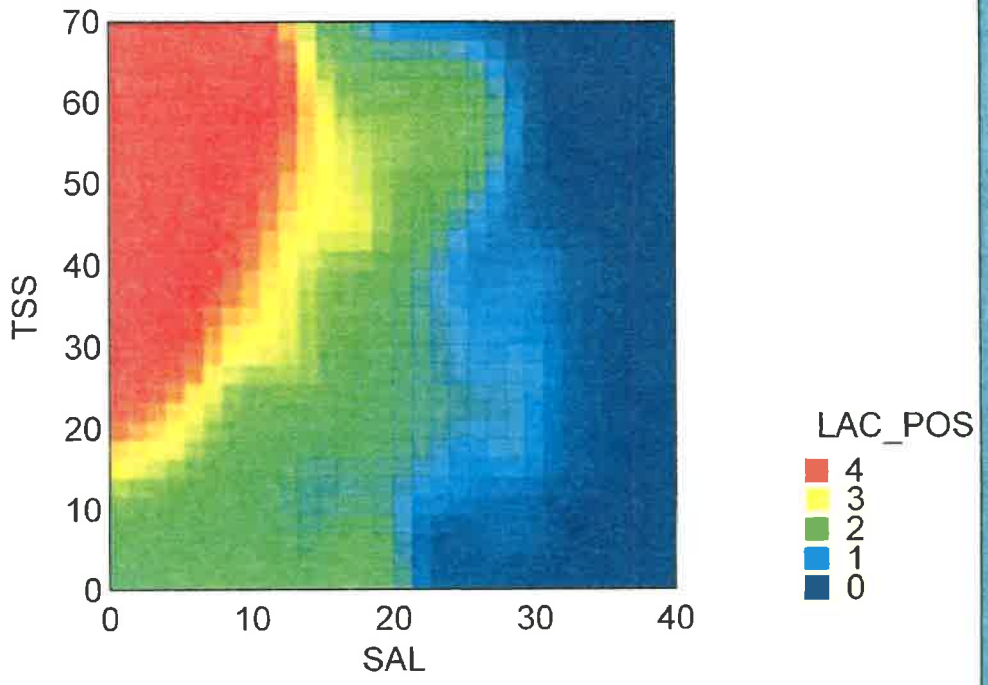
Multivariate Regression of Kd vs. Water Quality Parameters

Multivariate Regression of Kd vs. TSS, Chla, and Salinity (CDOM)
TSS and Salinity are significant, $R^2 = 0.61$, n=176





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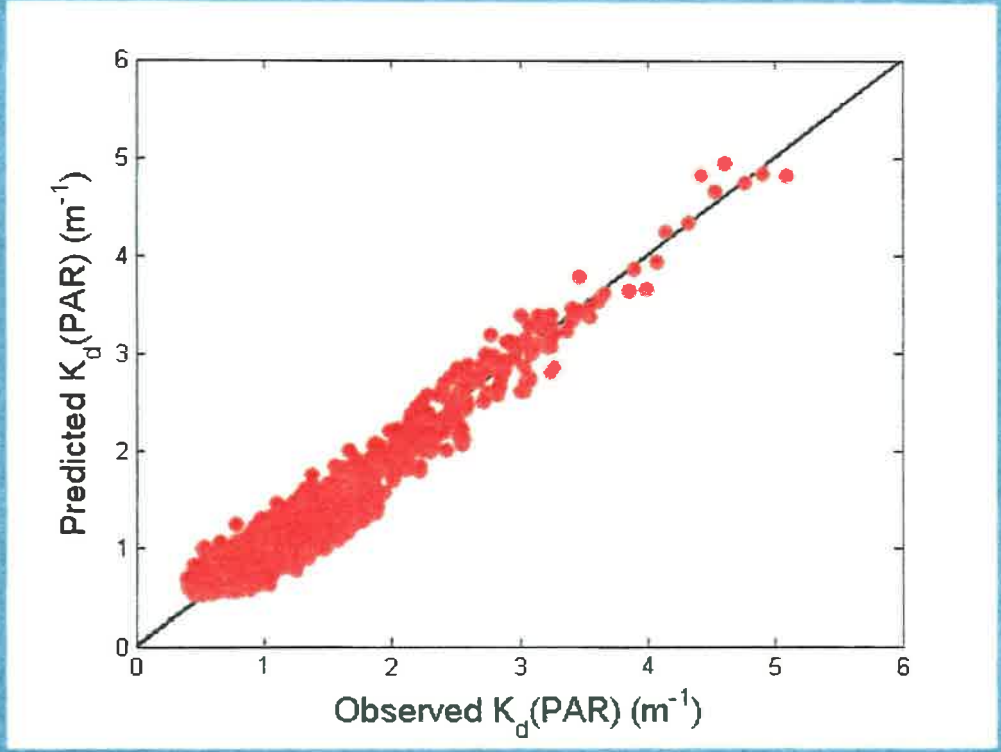
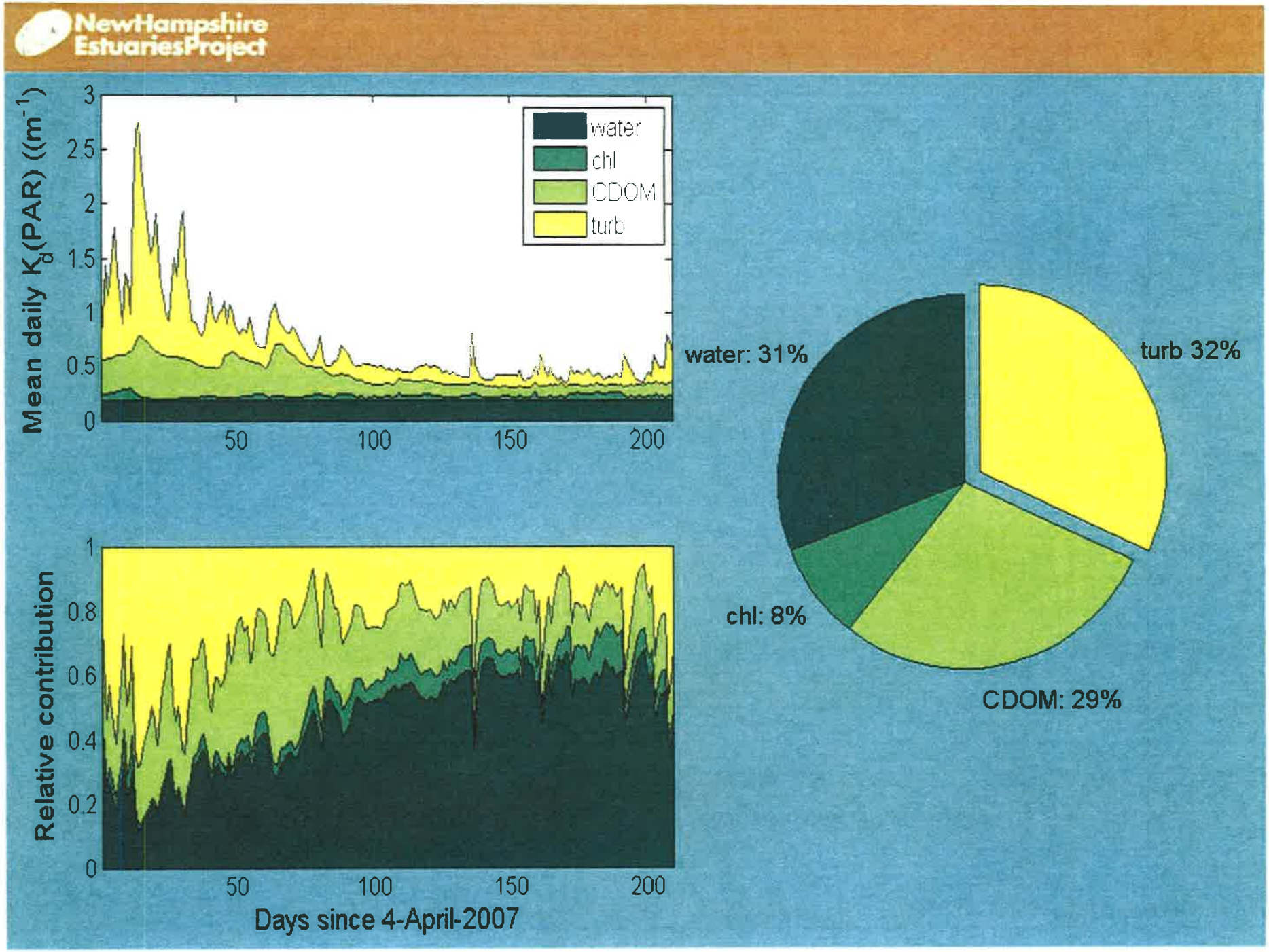
Preliminary Results from Buoy



$$Kd(PAR) = 0.3561 + 0.0083.CDOM + 0.0152.Chl + 0.0737.NTUS$$

$r^2 = 0.94$, N=3371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Mean daily K_d(PAR) ((m^{-1}))
water
chl
CDOM
turb
water: 31%
turb 32%
chl: 8%
CDOM: 29%
Relative contribution
Days since 4-April-2007

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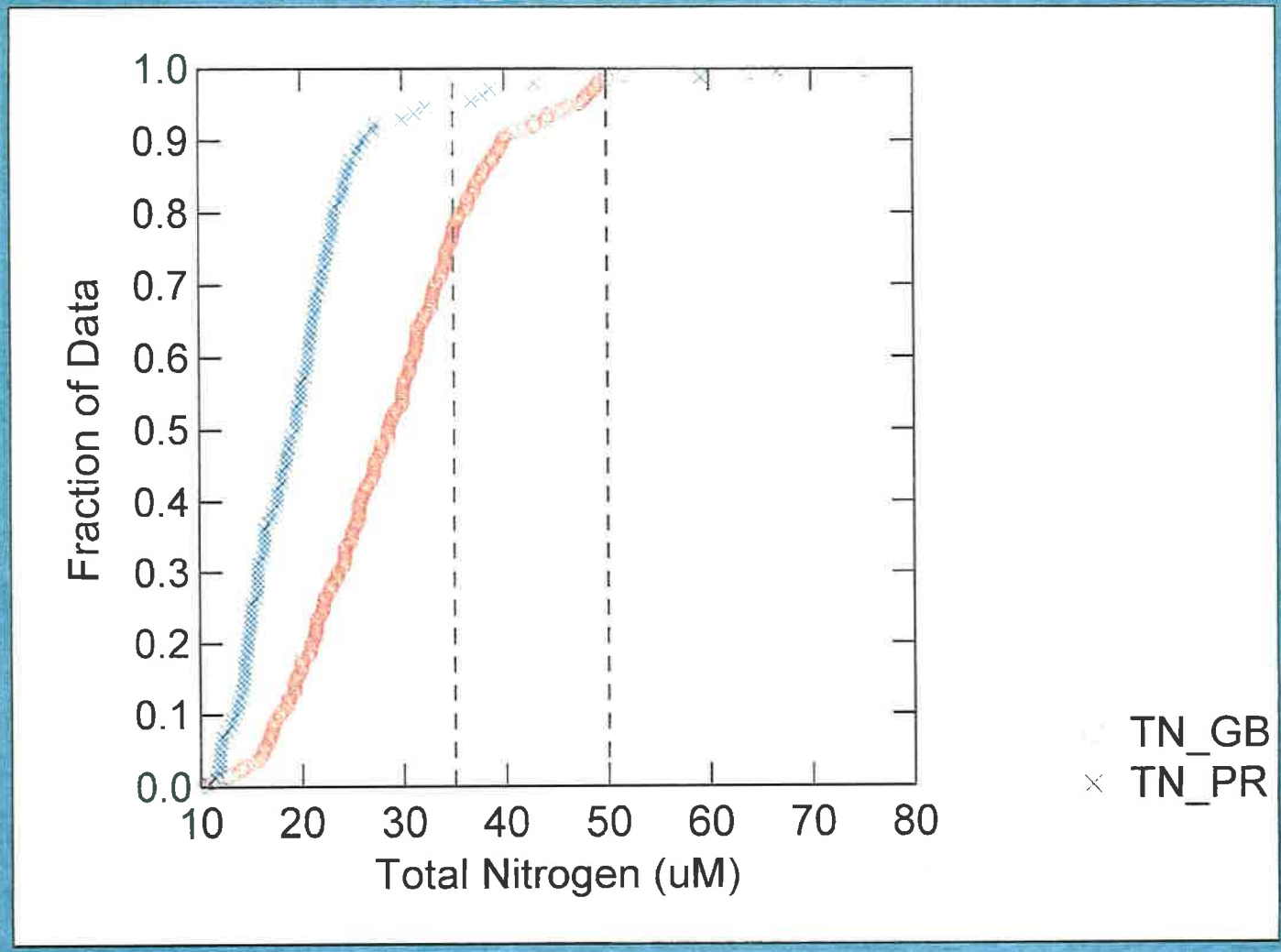
Total Nitrogen Concentrations



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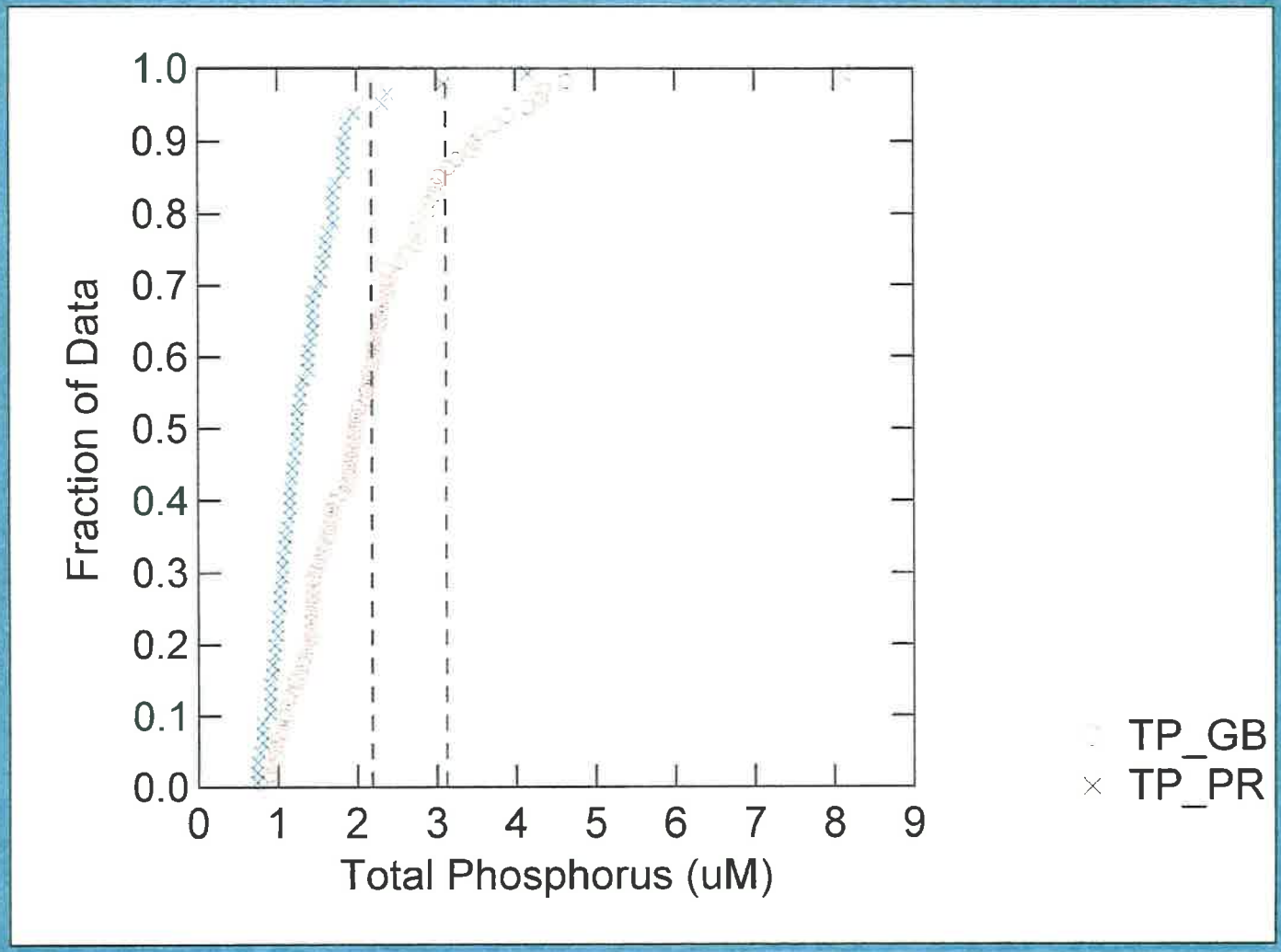
Total Phosphorus Concentrations



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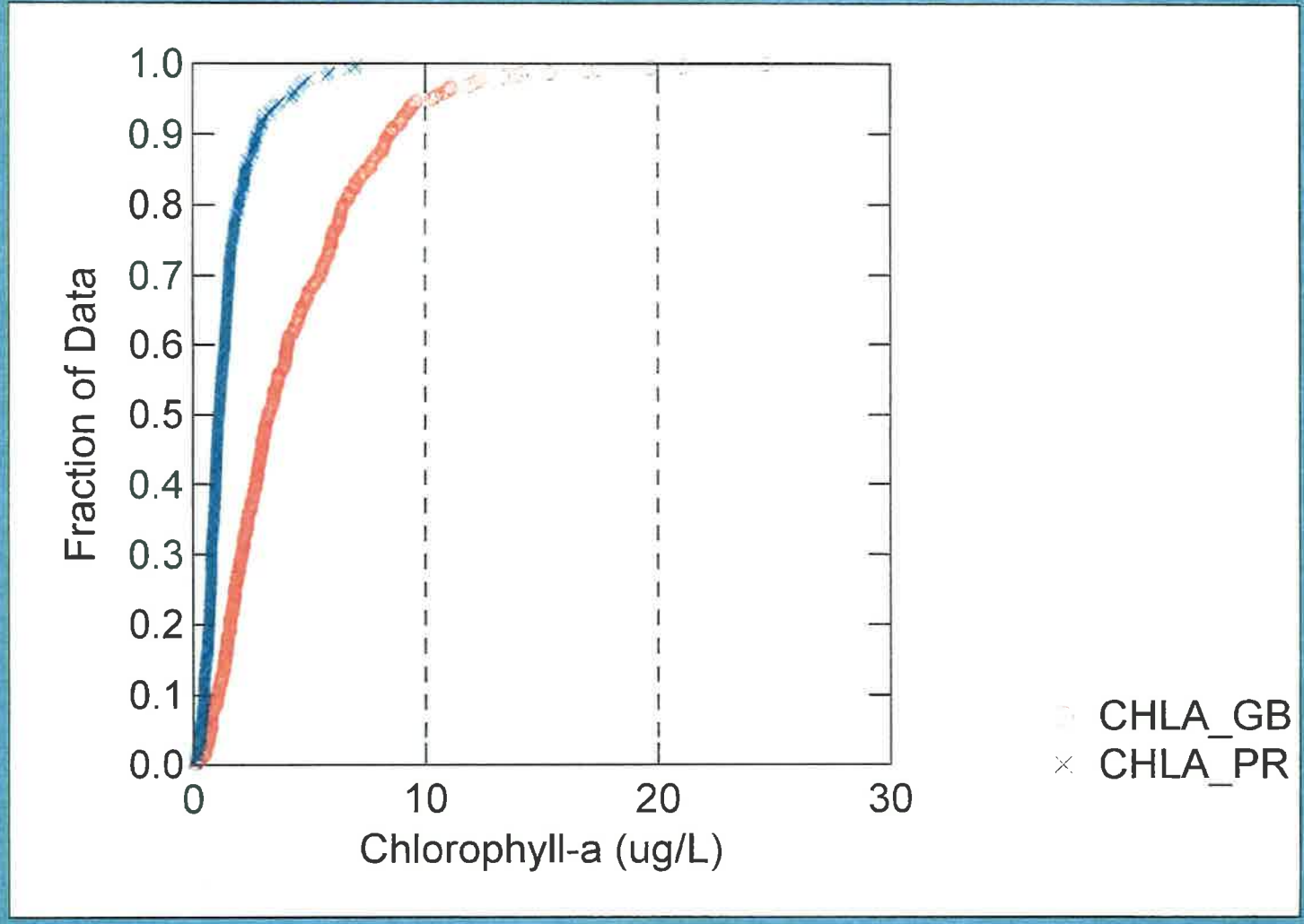
Chlorophyll-*a* Concentrations



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Nitrogen Loading Rates in Great Bay Compared to Other Systems

Normalized by Surface Area

- **Hauxwell** et al. 2003 Eelgrass disappears at >60 kg/ha/yr
- Great Bay loading rate is 182 kg/ha/yr

Normalized by Volume & Residence Time

- **Latimer** et al. 2007 At 160 mg/m3, less than 5% of eelgrass remains
- **Nixon** et al. 2001 Compiled loadings of eelgrass and macroalgae systems
- Great Bay loading rate is 280 mg/m3 (normalized by RT)
- Great Bay loads were at high end of eelgrass-dominated systems

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Conclusions

- Eelgrass biomass declining in Great Bay but no apparent decline in water clarity
- Turbidity and CDOM accounted for 61% of light attenuation in Great Bay [vs. 8% for chl-a]
- Theorize that macroalgae is more of a factor in losses than phytoplankton
- Total nitrogen is >35 uM in 20% of samples from Great Bay, ~0% in the Piscataqua River.
- Intertidal eelgrass beds in Great Bay confound predictions of losses from nitrogen loading.

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Current Research Topics

- Refine estuary segments based on salinity
- Develop nitrogen loading model for watershed to estimate historical loads
- Map 1981 eelgrass coverage from old imagery
- Map water clarity and macroalgae in 2007 from hyperspectral imagery
- Reference concentration approach for TN, TP
- Literature review to justify eelgrass target

Goal: Recommendation for criteria by 12/31/08

NewHampshire EstuariesProject

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