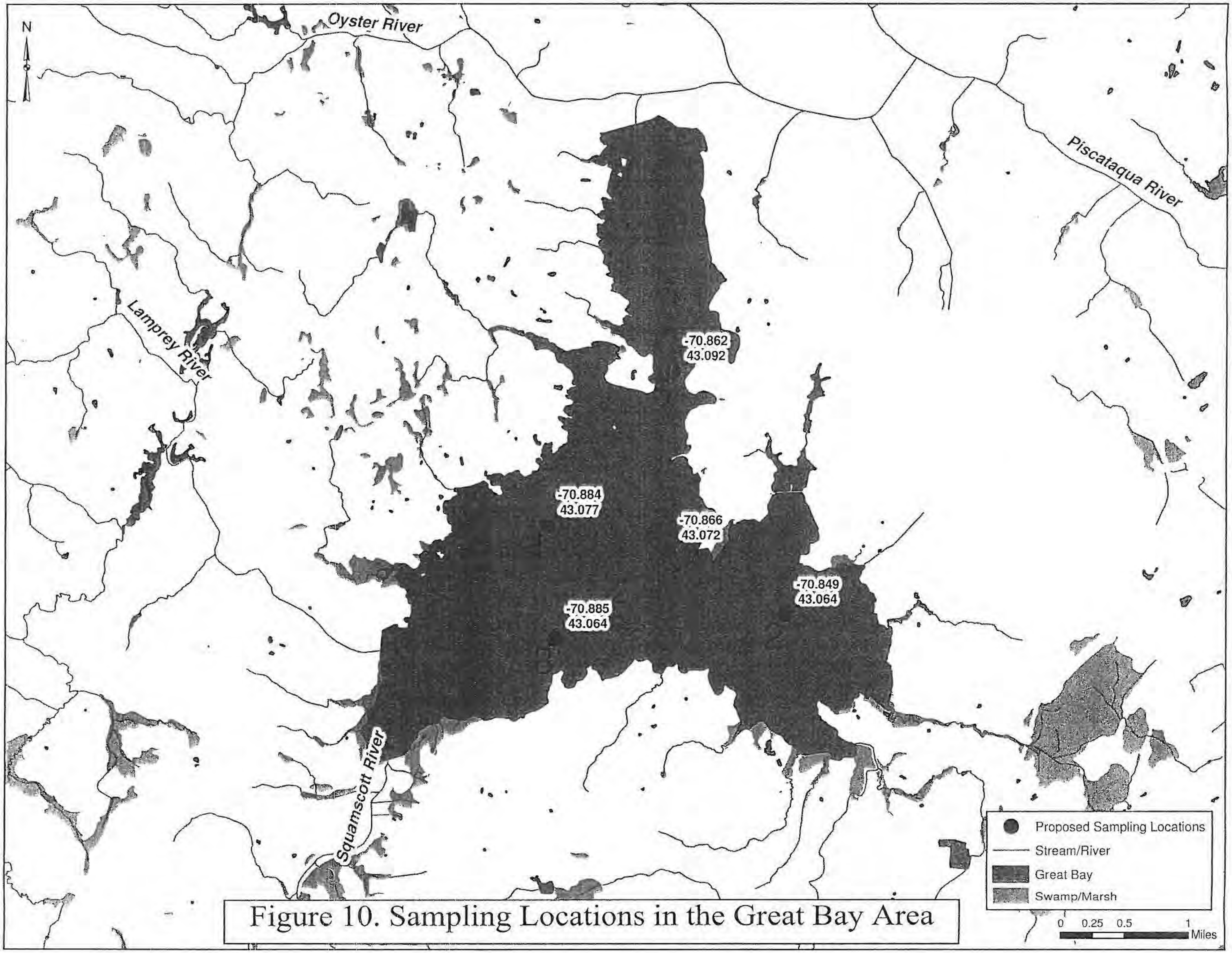


Figure 10. Sampling Locations in the Great Bay Area

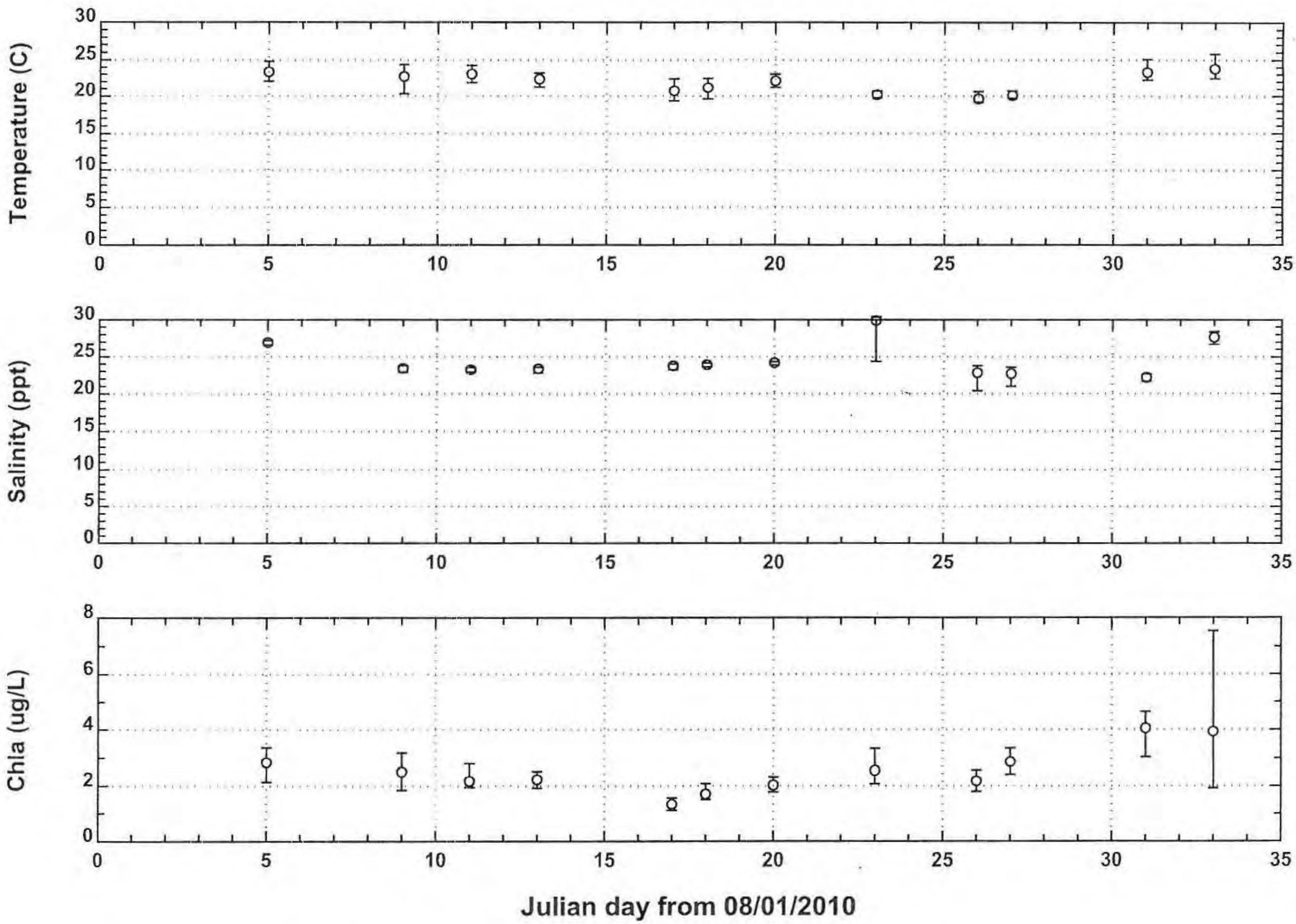


Figure 11. 2010 Great Bay Water Quality Data (Station 1-5)

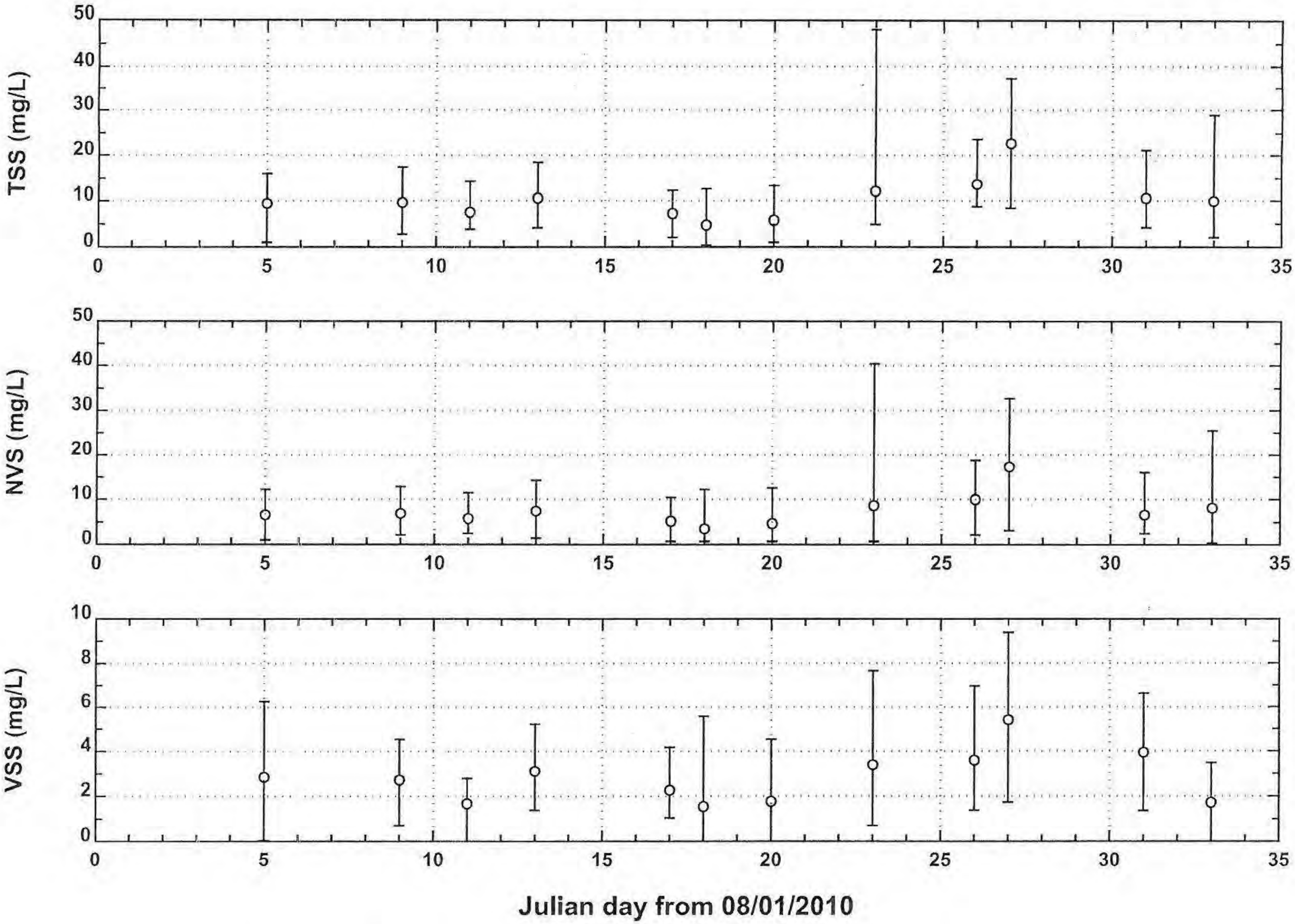


Figure 12. 2010 Great Bay Water Quality Data (Station 1-5)

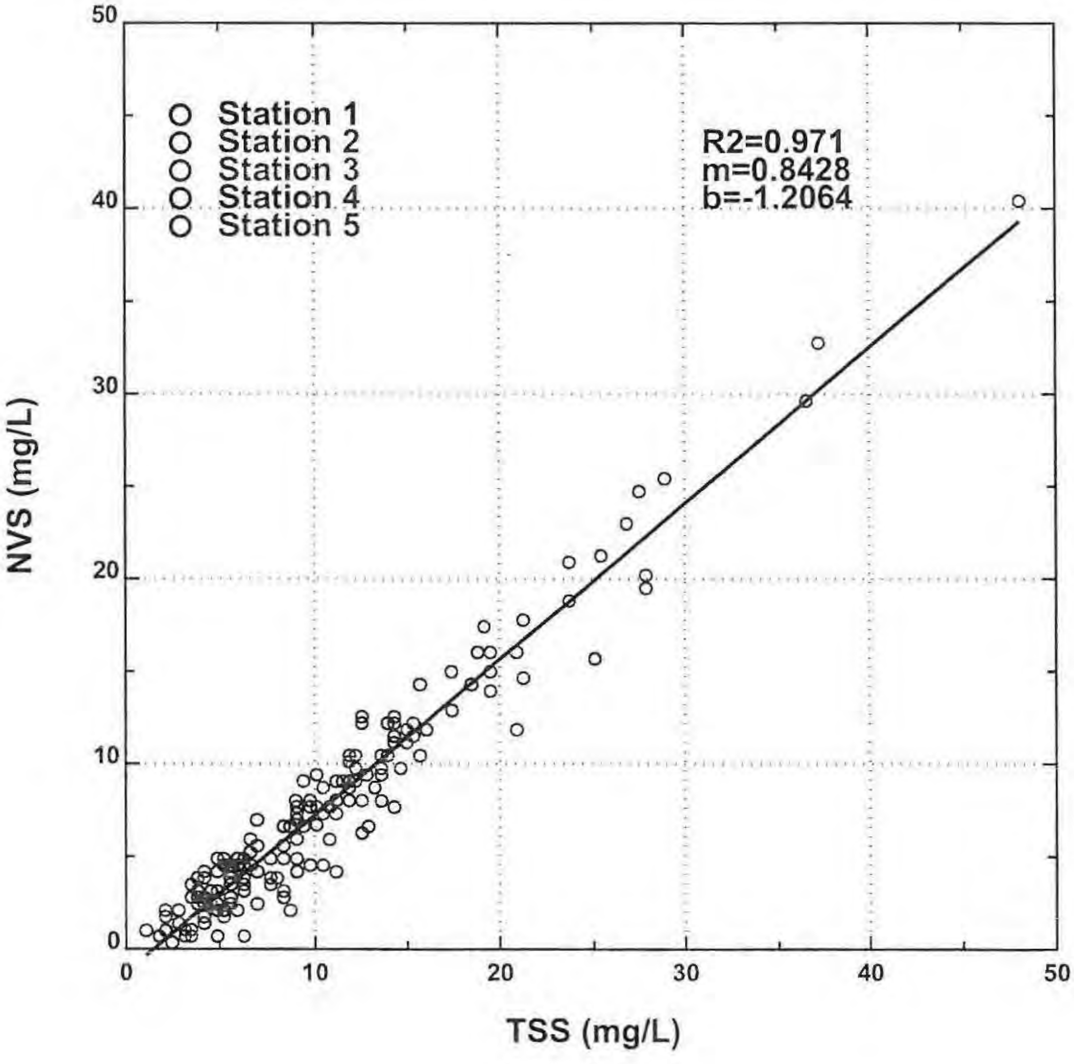


Figure 13. 2010 Great Bay Water Quality Data

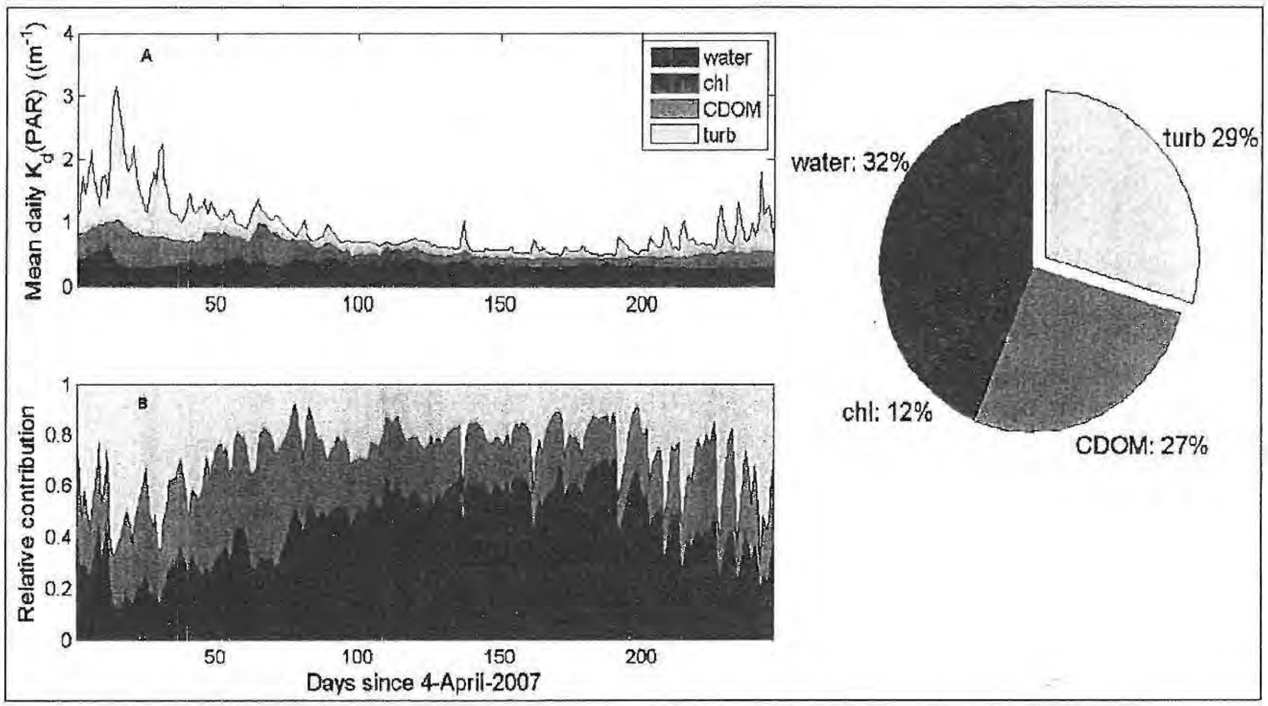


Figure 14. Contributions to Kd (PAR) measured at the Great Bay Buoy (From Morrison et al, 2008)

APPENDIX A

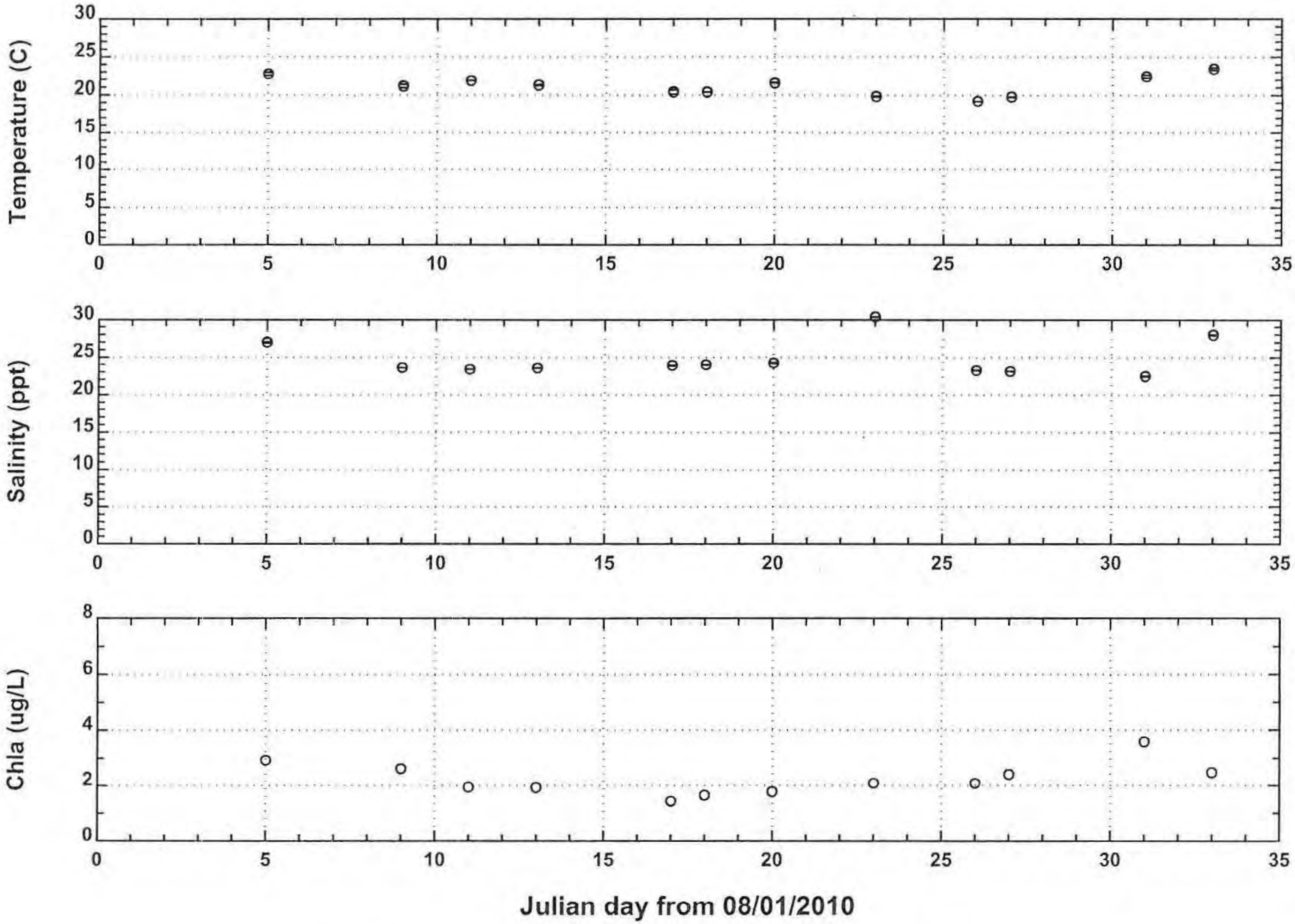


Figure 1-1. 2010 Great Bay Water Quality Data, Station 1

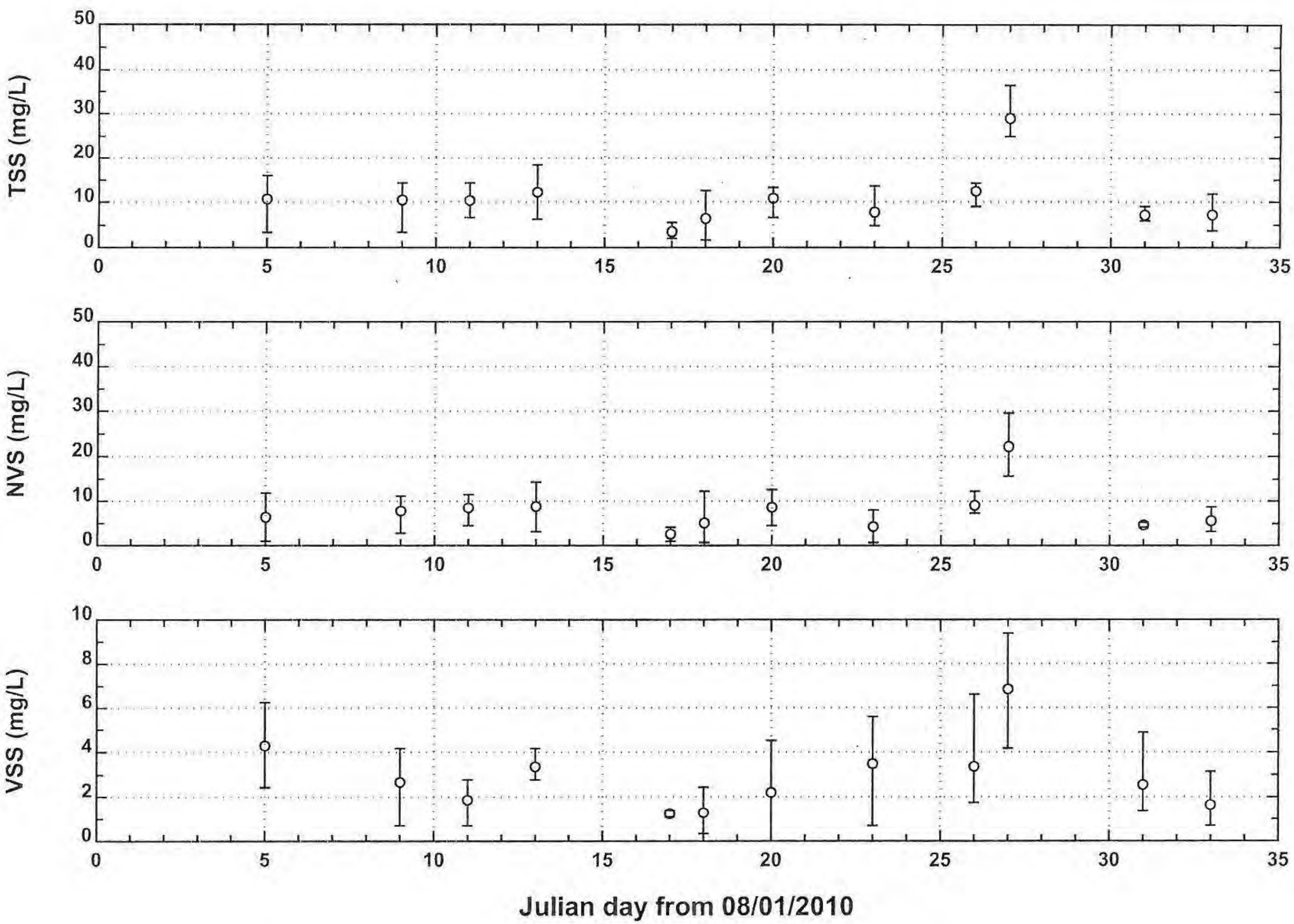


Figure 1-2. 2010 Great Bay Water Quality Data, Station 1

Appendix A

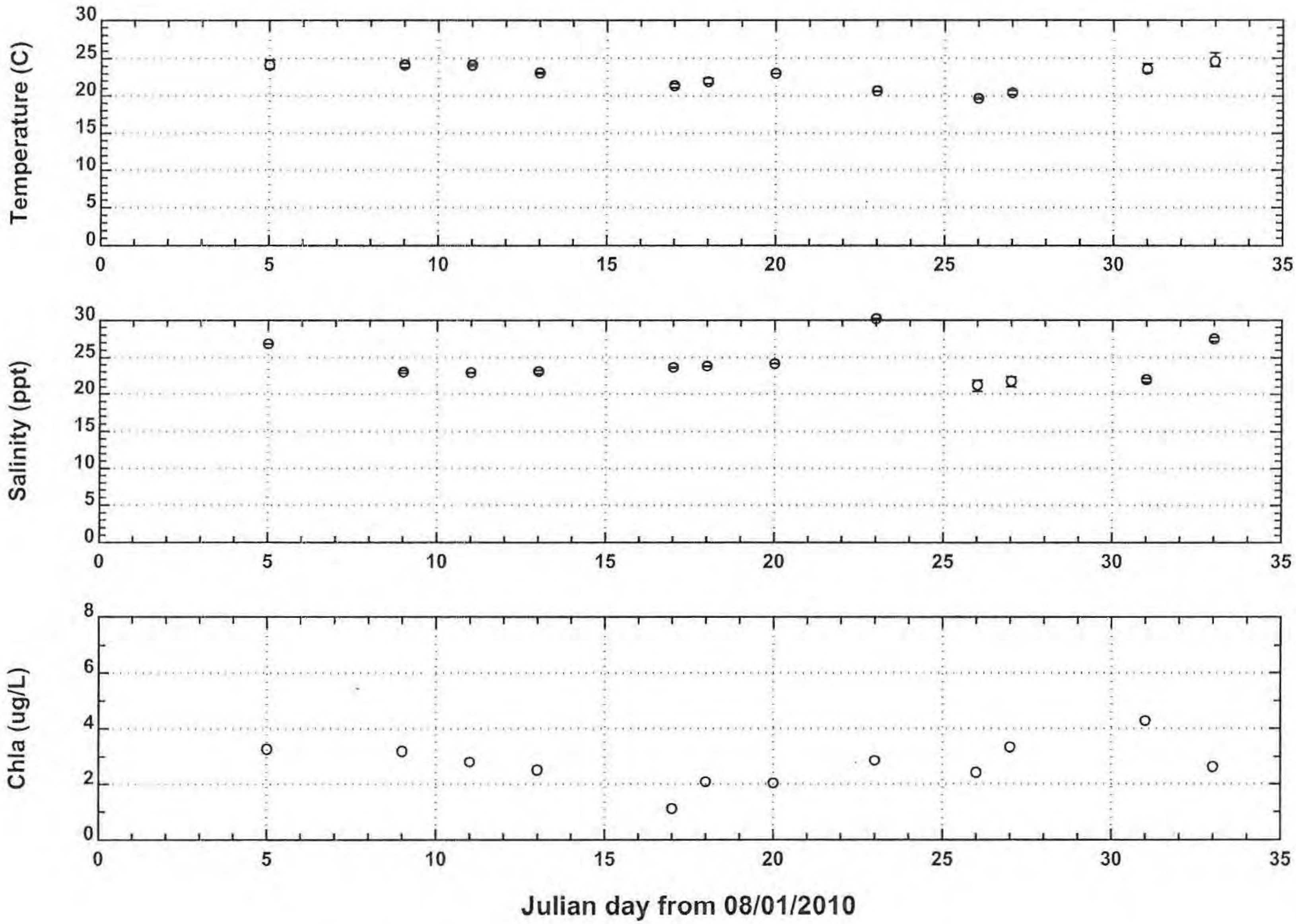


Figure 2-1. 2010 Great Bay Water Quality Data, Station 2

Appendix A

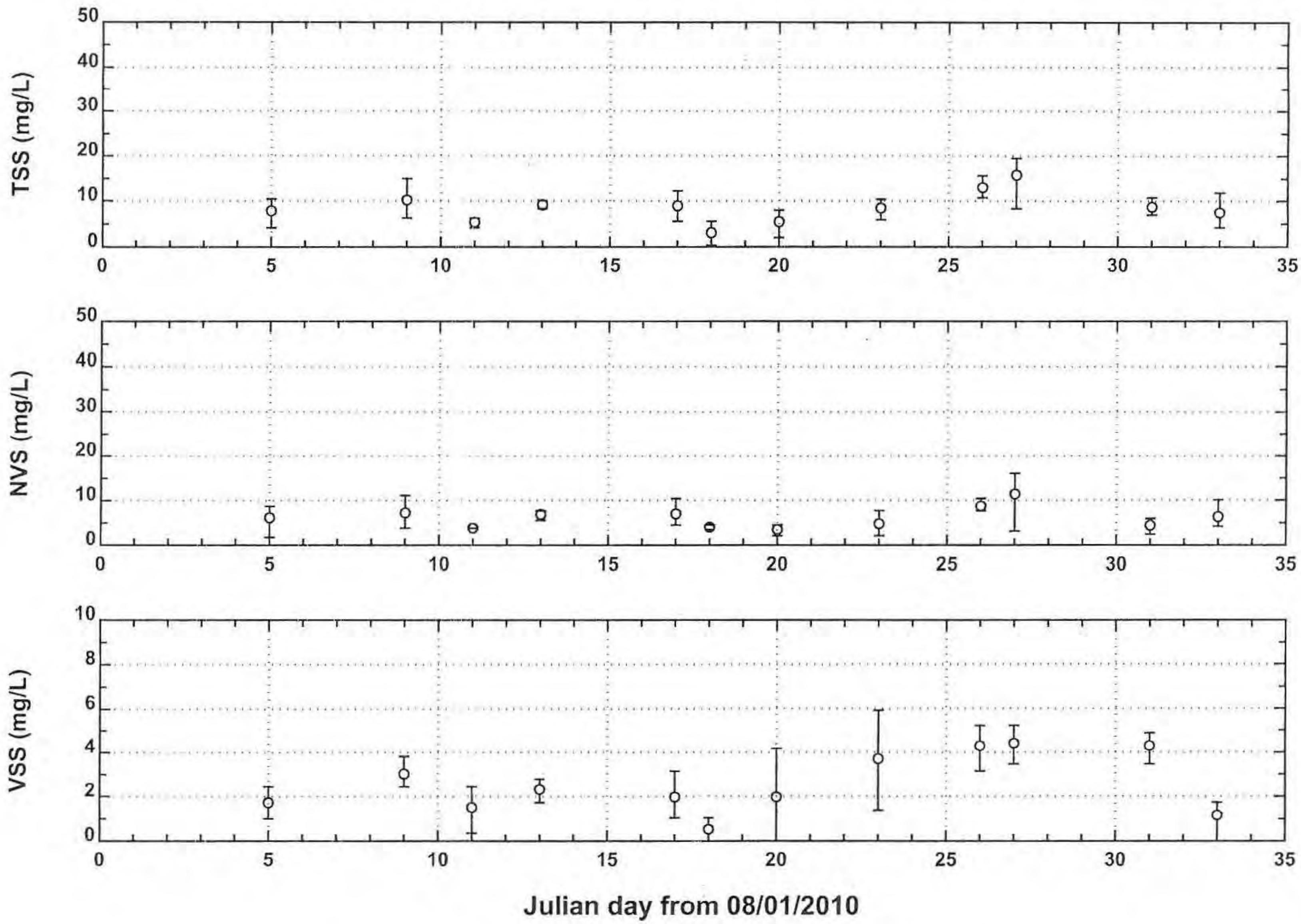


Figure 2-2. 2010 Great Bay Water Quality Data, Station 2

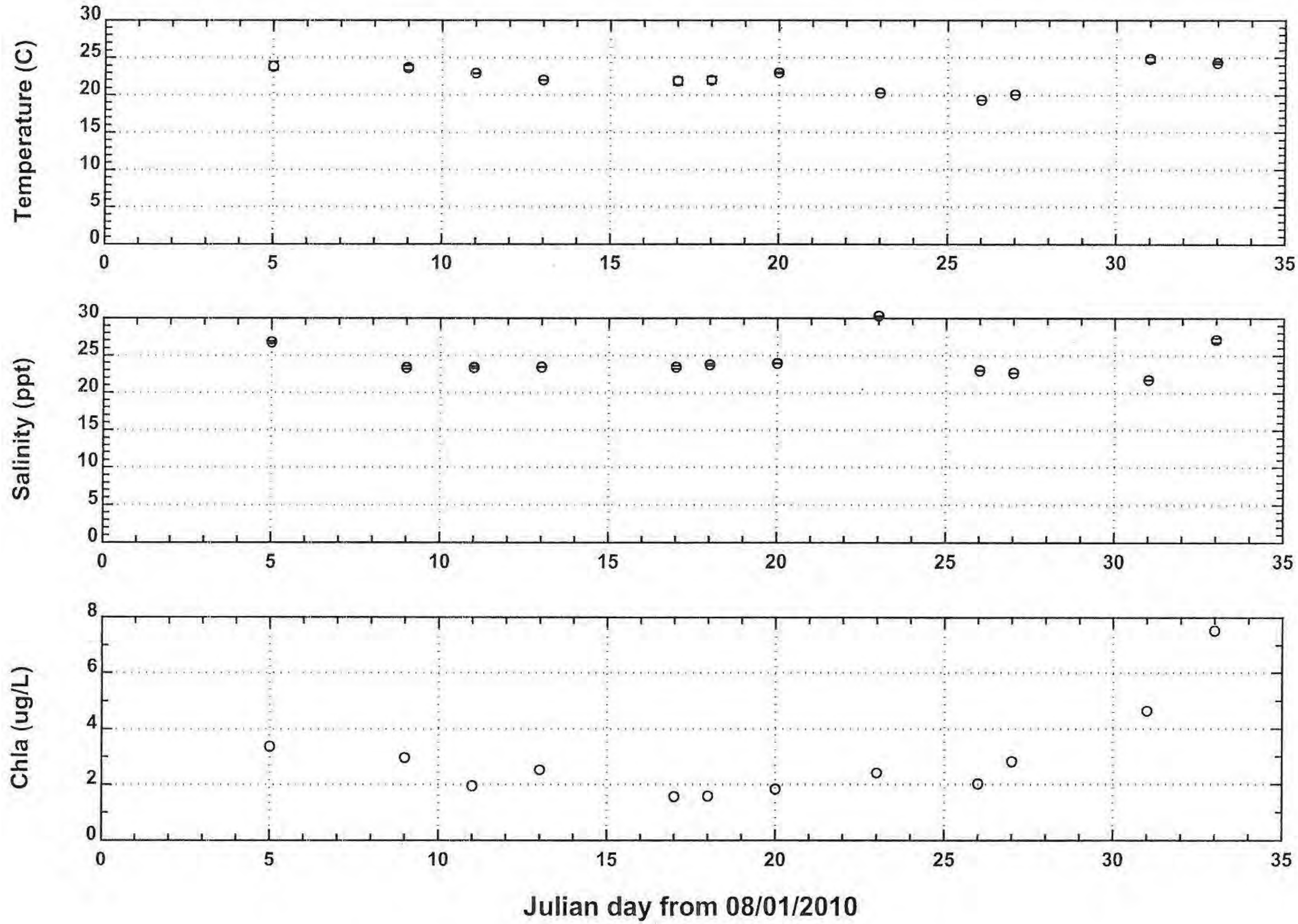


Figure 3-1. 2010 Great Bay Water Quality Data, Station 3

Appendix A

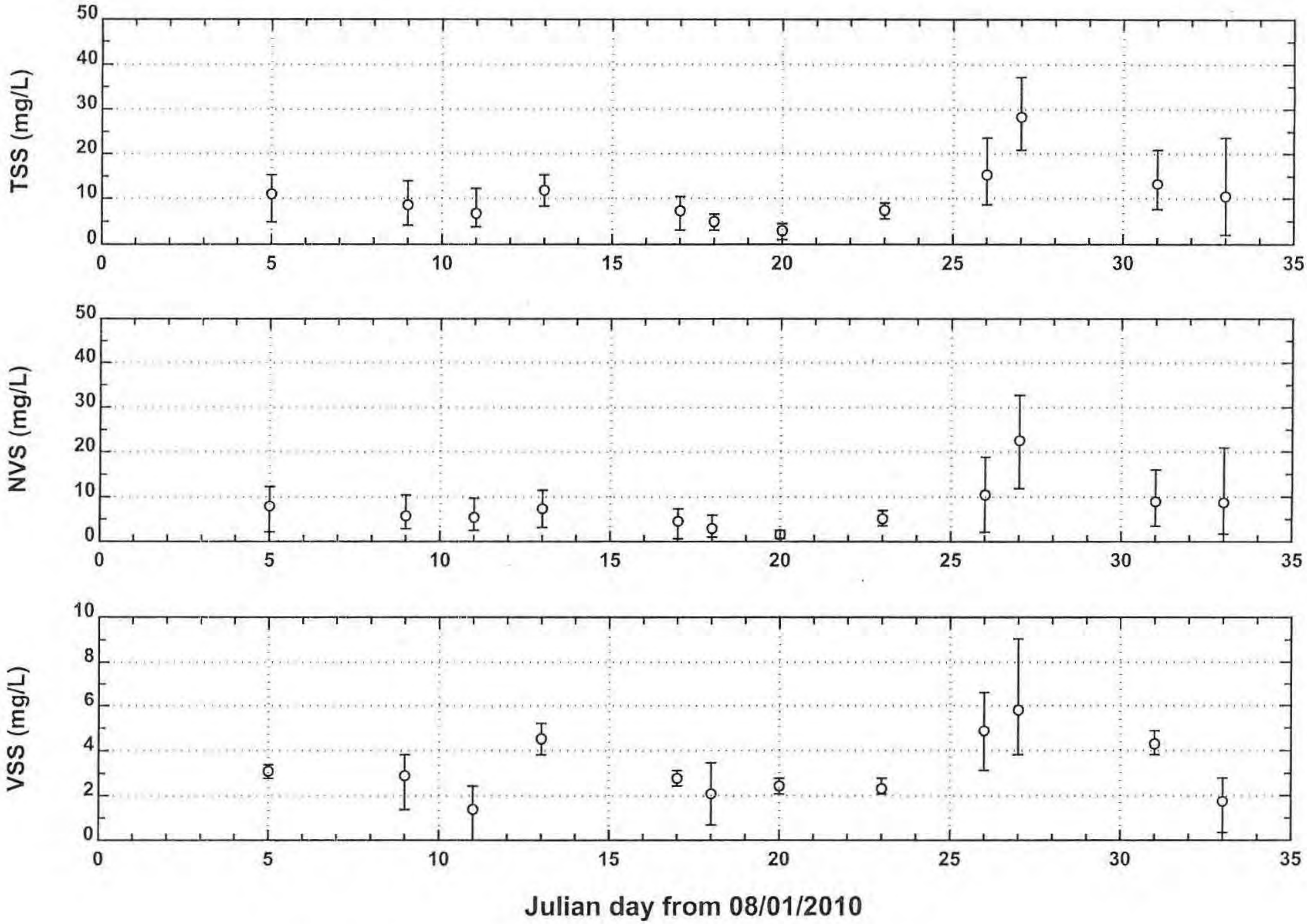


Figure 3-2. 2010 Great Bay Water Quality Data, Station 3

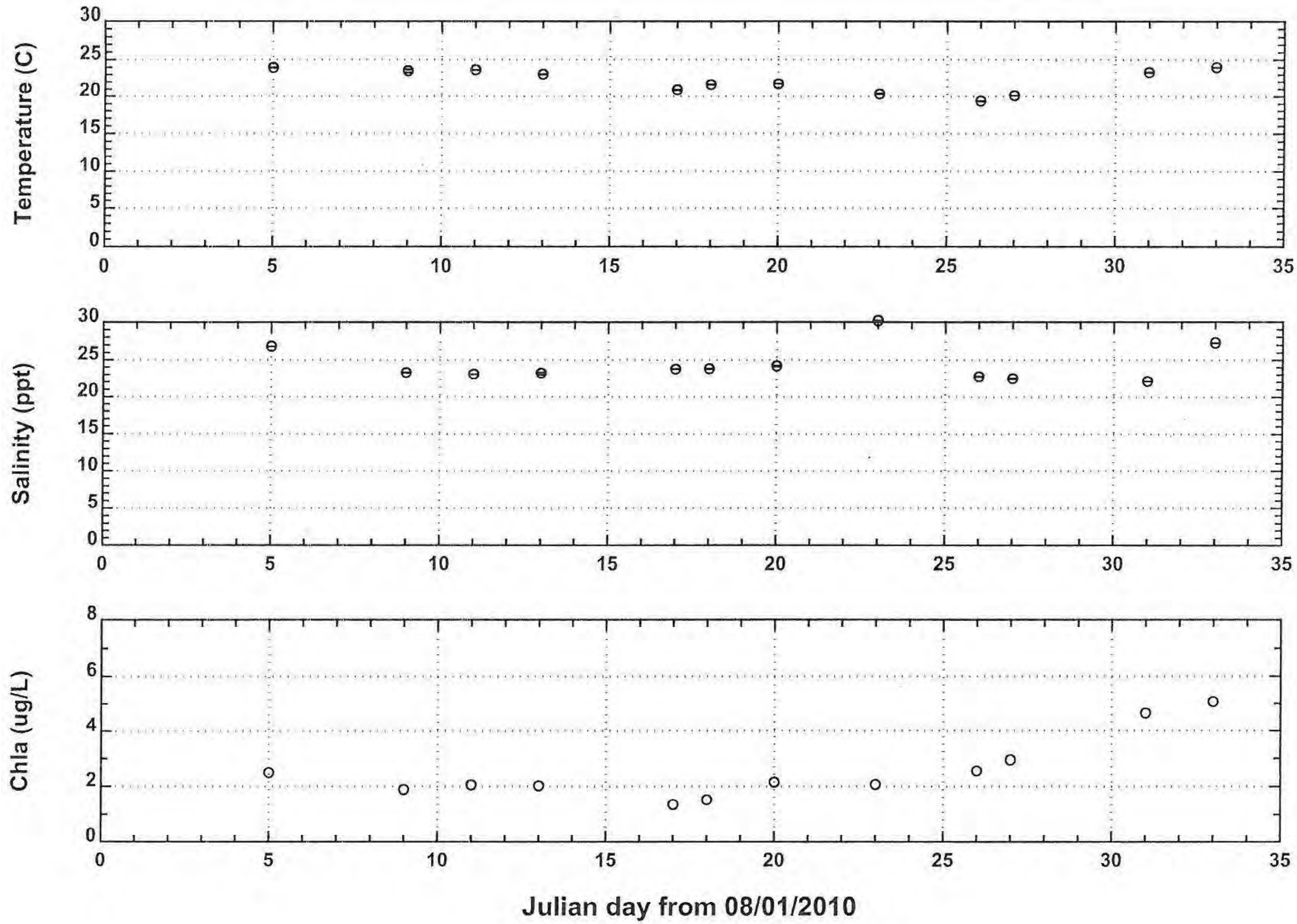


Figure 4-1. 2010 Great Bay Water Quality Data, Station 4

Appendix A

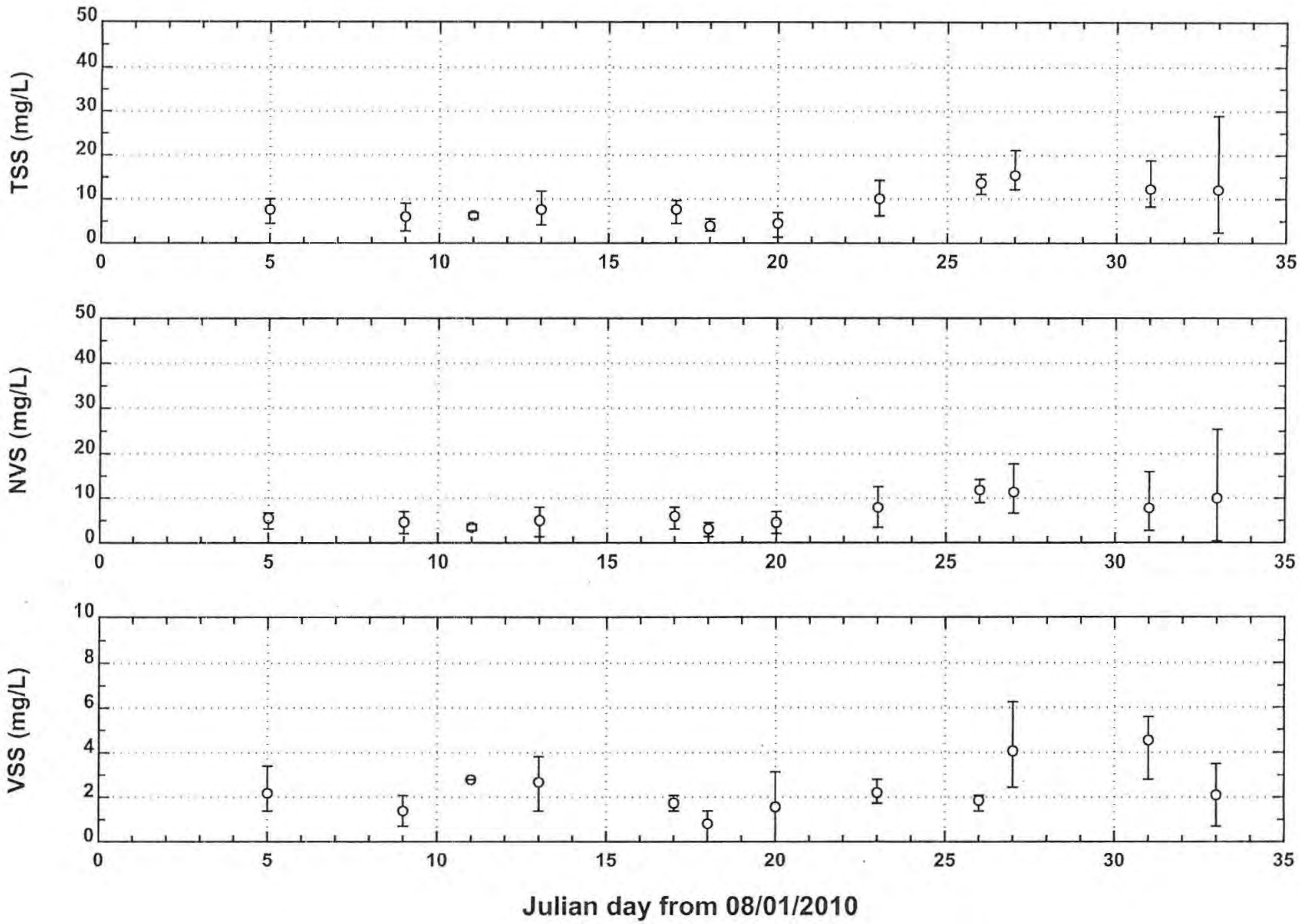


Figure 4-2. 2010 Great Bay Water Quality Data, Station 4

Appendix A

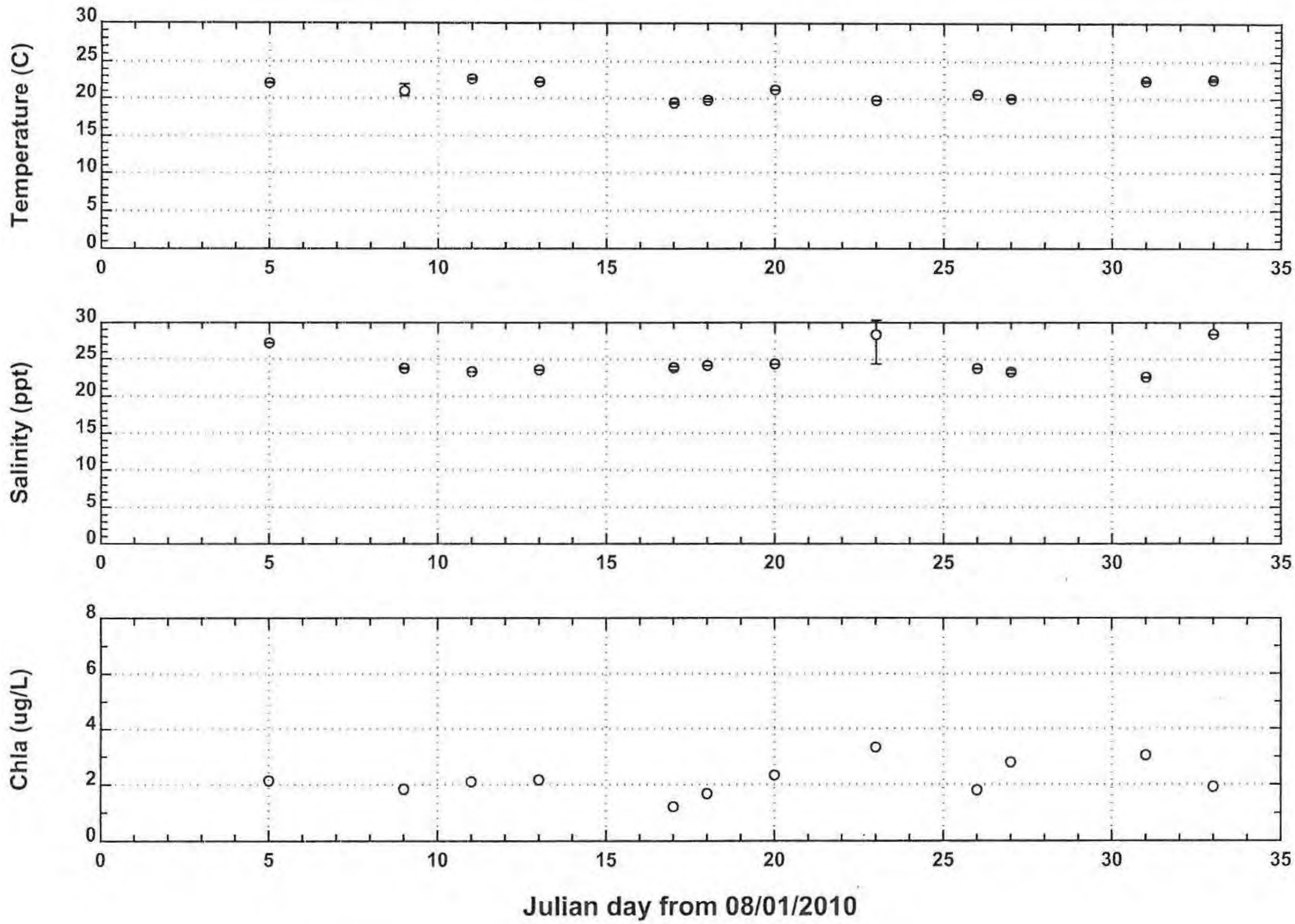


Figure 5-1. 2010 Great Bay Water Quality Data, Station 5

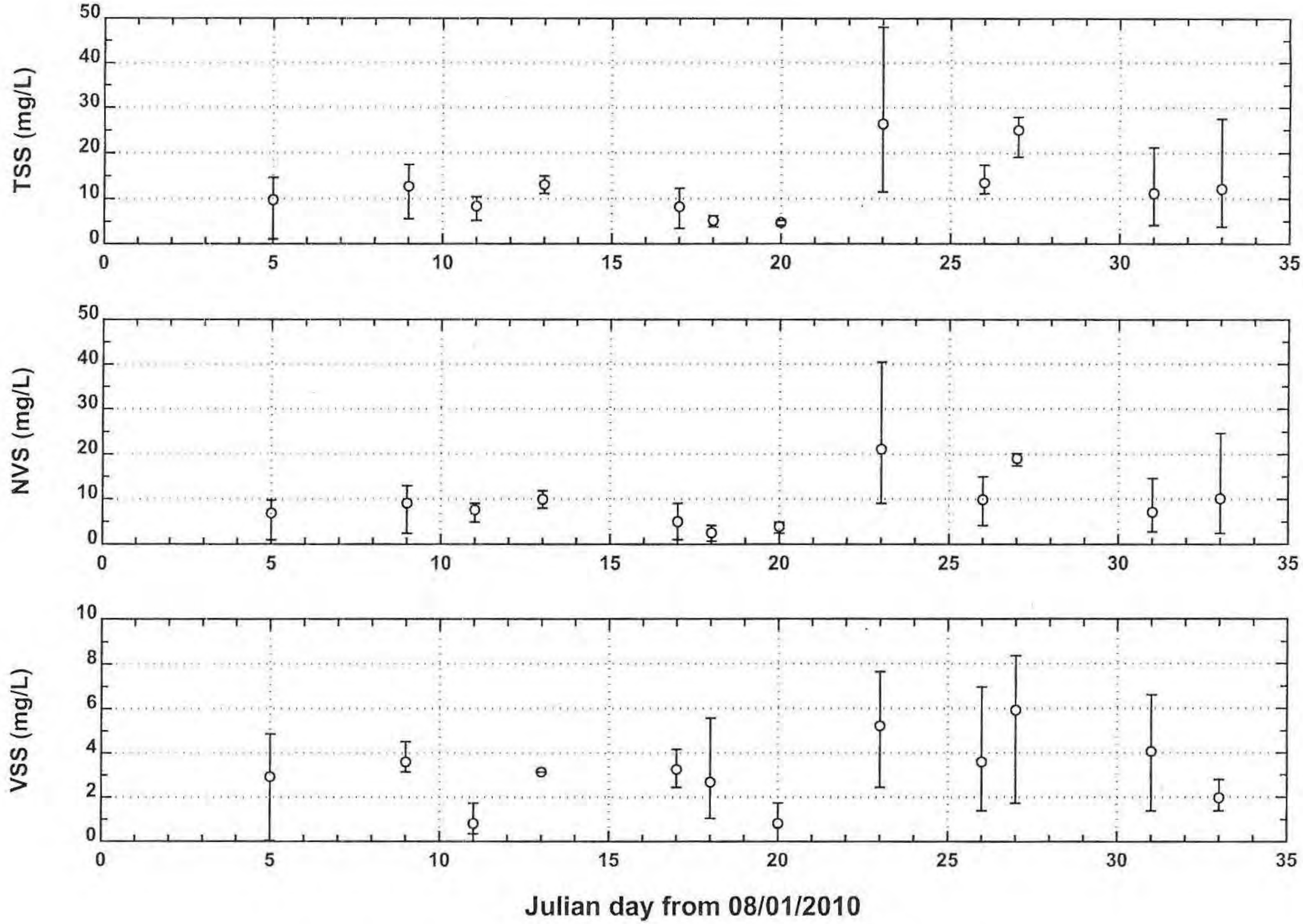


Figure 5-2. 2010 Great Bay Water Quality Data, Station 5

EXHIBIT 11

Trend Analysis – WWTP Loads/Flows

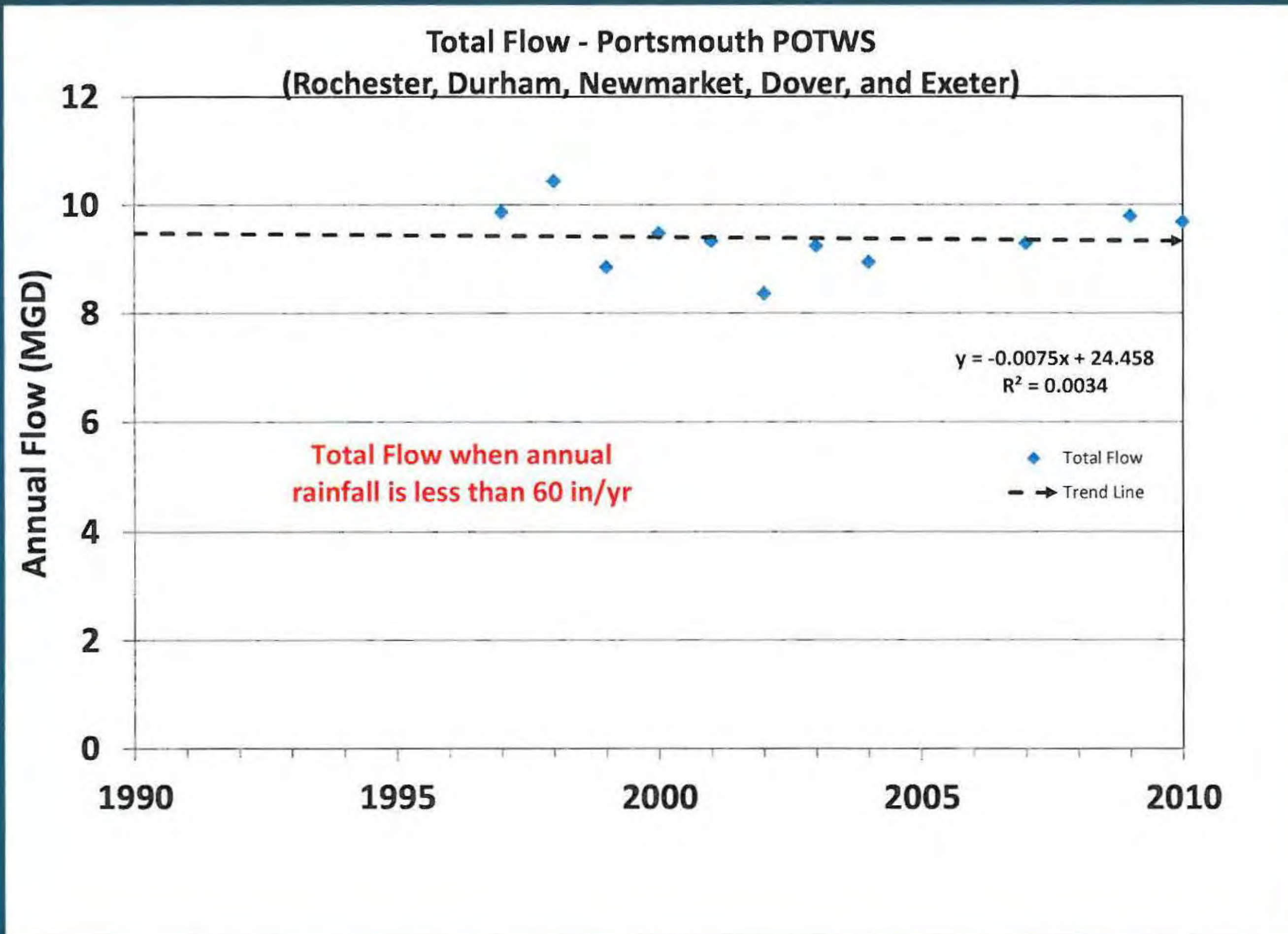
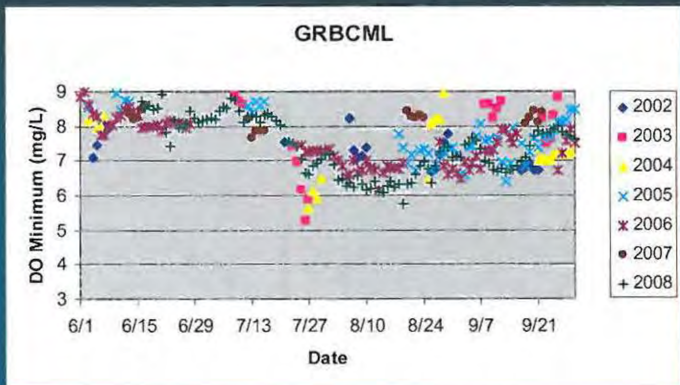
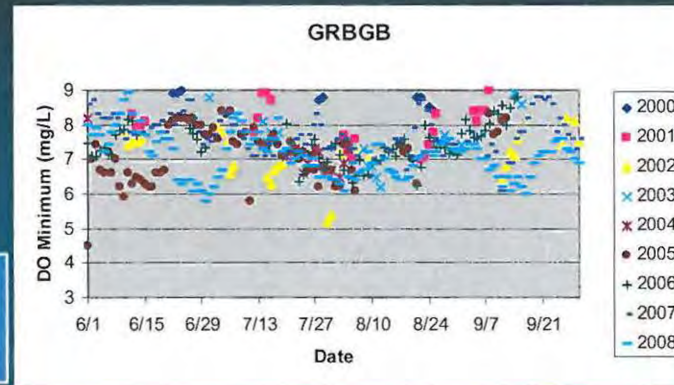


EXHIBIT 12

In-situ Measurements Refine Thresholds for DO Violations



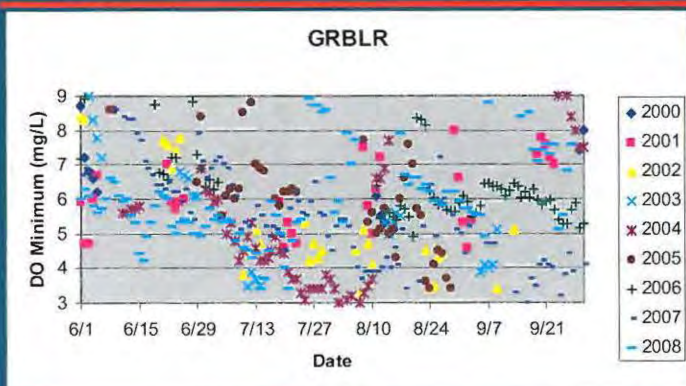
TN=0.30 mg N/L
Chla=3.34 ug/L



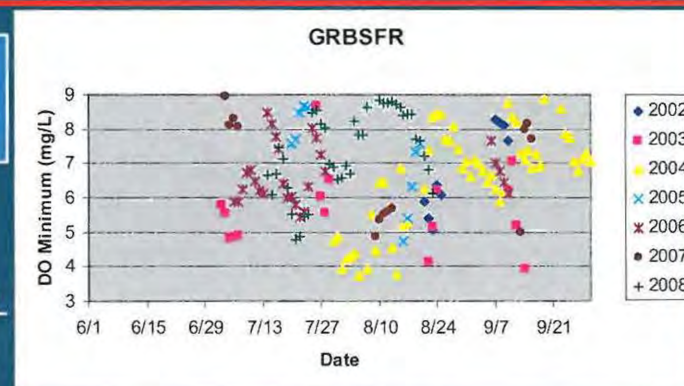
TN=0.39 mg N/L
Chla = 9.32 ug/L

WQS attained

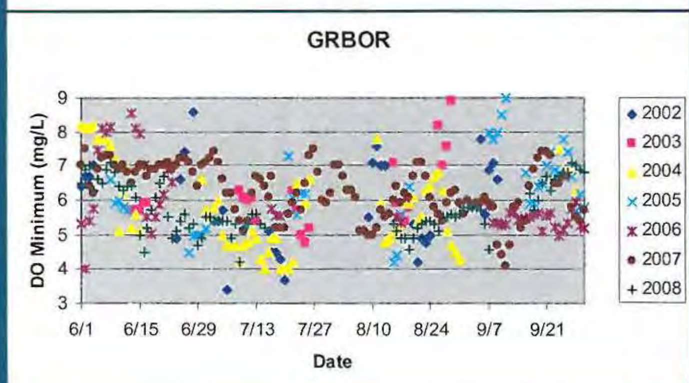
WQS violated



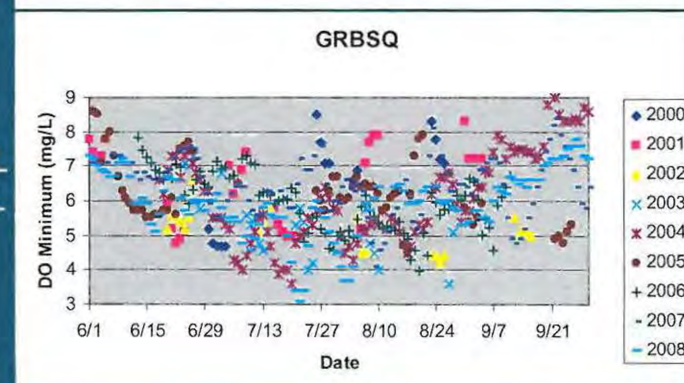
TN=0.45 mg N/L
Chla=7.50 ug/L



TN=0.52 mg N/L
Chla=13.71 ug/L



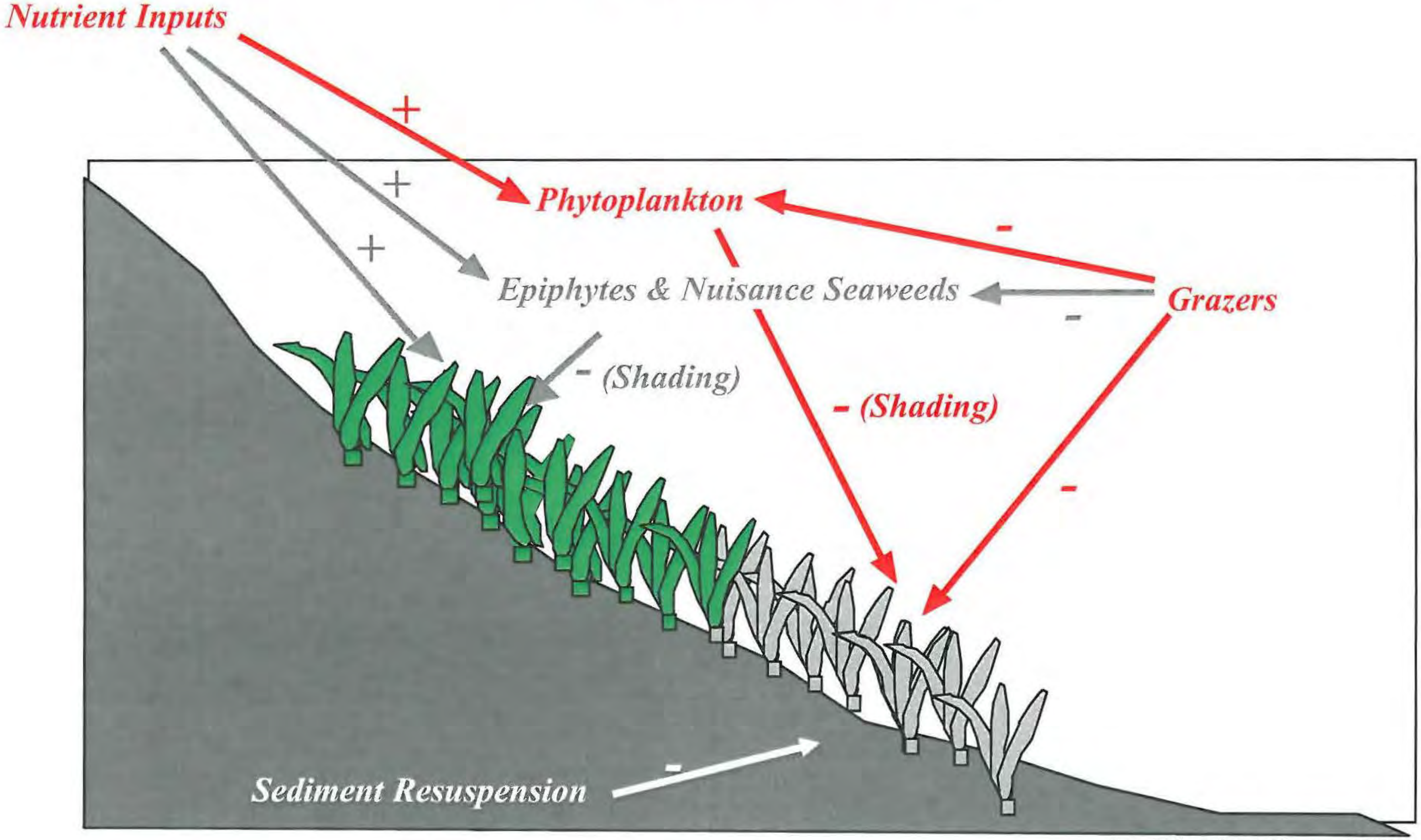
TN=0.57 mg N/L
Chla=14.26 ug/L



TN=0.74 mg N/L
Chla=12.14 ug/L

EXHIBIT 13

Eutrophication I



Modified from Duarte 2002

EXHIBIT 14

Relationship between Light Attenuation Coefficient and TN at Trend Stations

(New Hampshire DES, 2009)

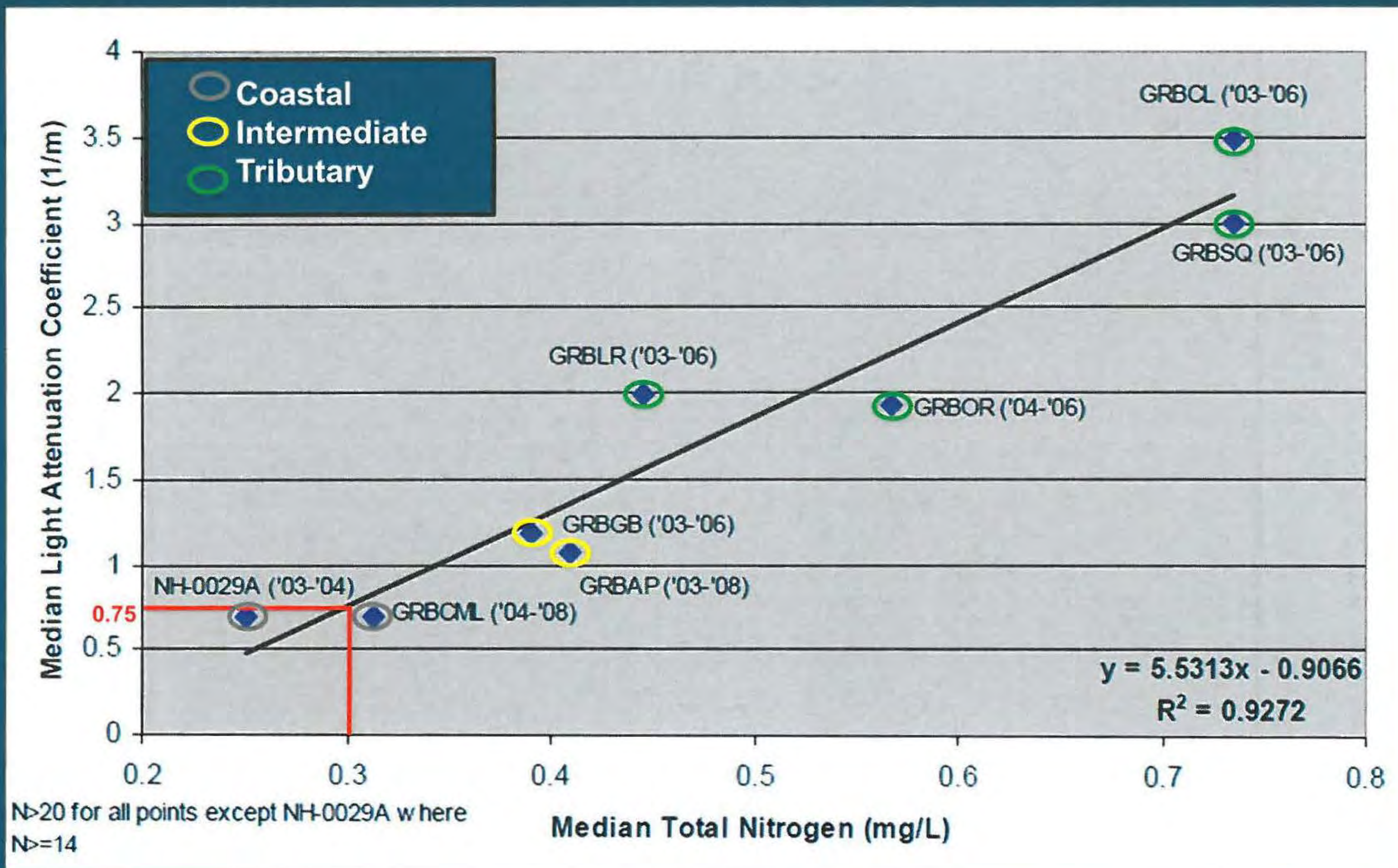


EXHIBIT 15

Major Physical Differences in Sample Locations

- **Estuary Mouth** – High dilution, deeper, greater currents, low solids, low color, minimal detention time
- **Bay** - Moderate dilution, highest detention time, wind resuspension, eelgrass dominated
- **Tidal Rivers** – Lowest dilution, turbulent mixing, stratification, high color, high turbidity

These major physical differences dramatically impact ambient transparency and DO, completely unrelated to nutrient inputs

EXHIBIT 16

Salinity/Dilution TN Covary in GB System

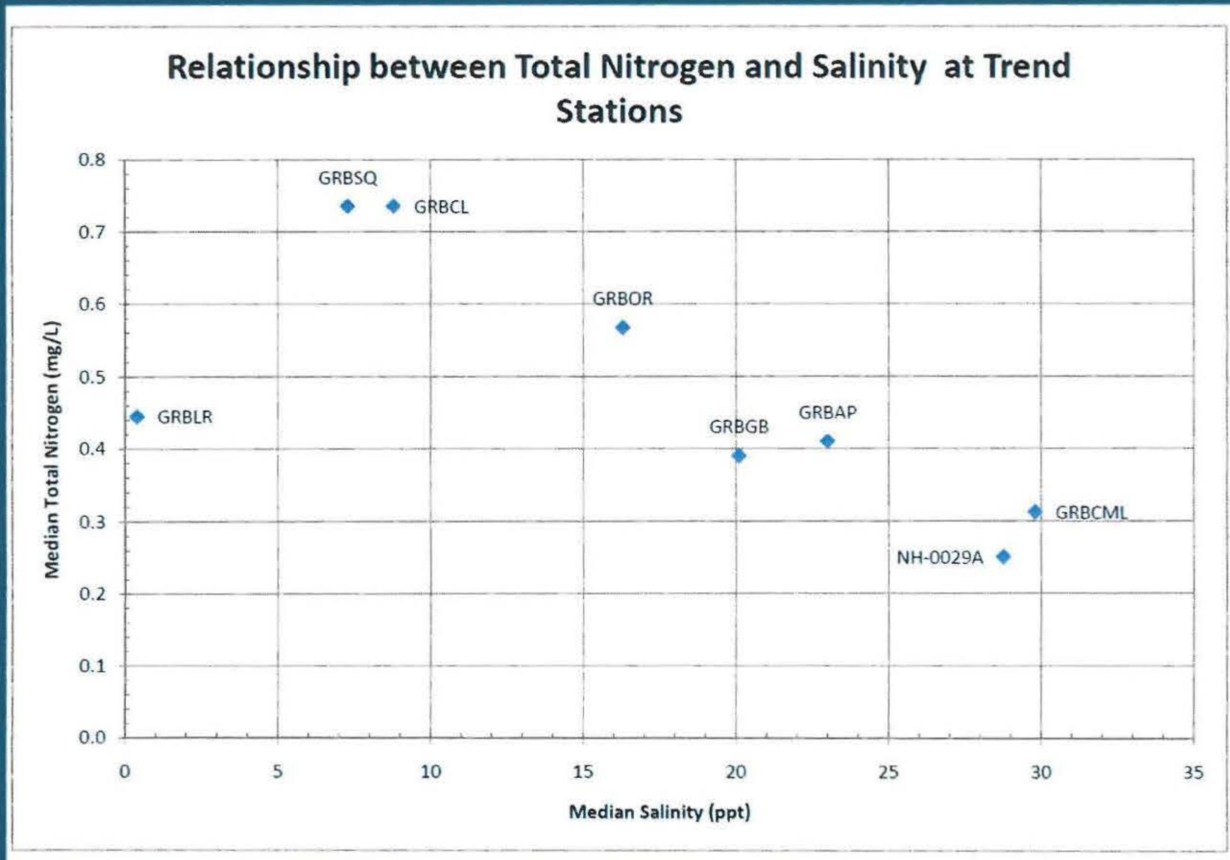


EXHIBIT 17

Covariation between Turbidity and TN at Datasonde Stations

(New Hampshire DES, 2009)

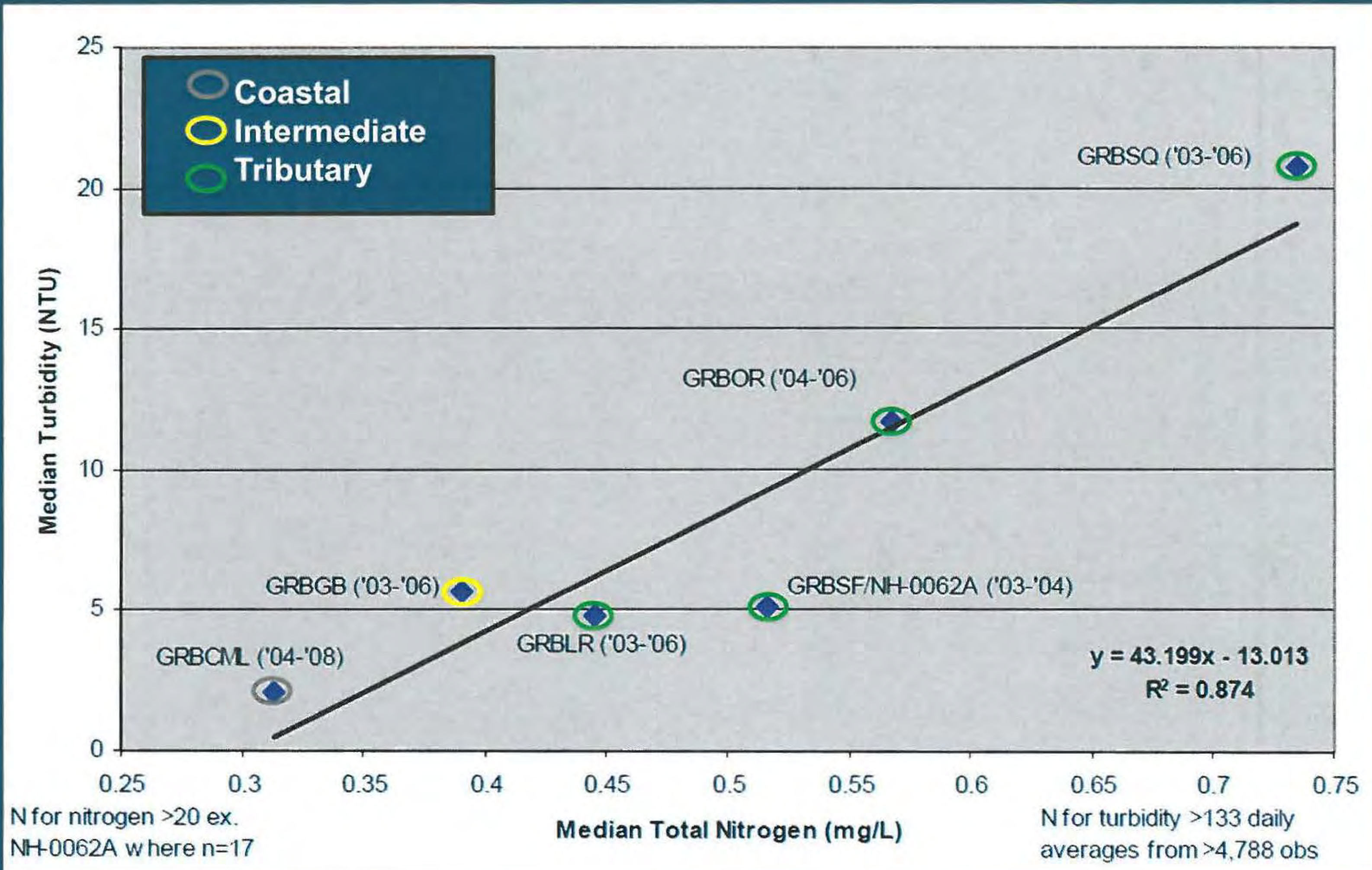


EXHIBIT 18

Salinity/Dilution TN Covary in GB System

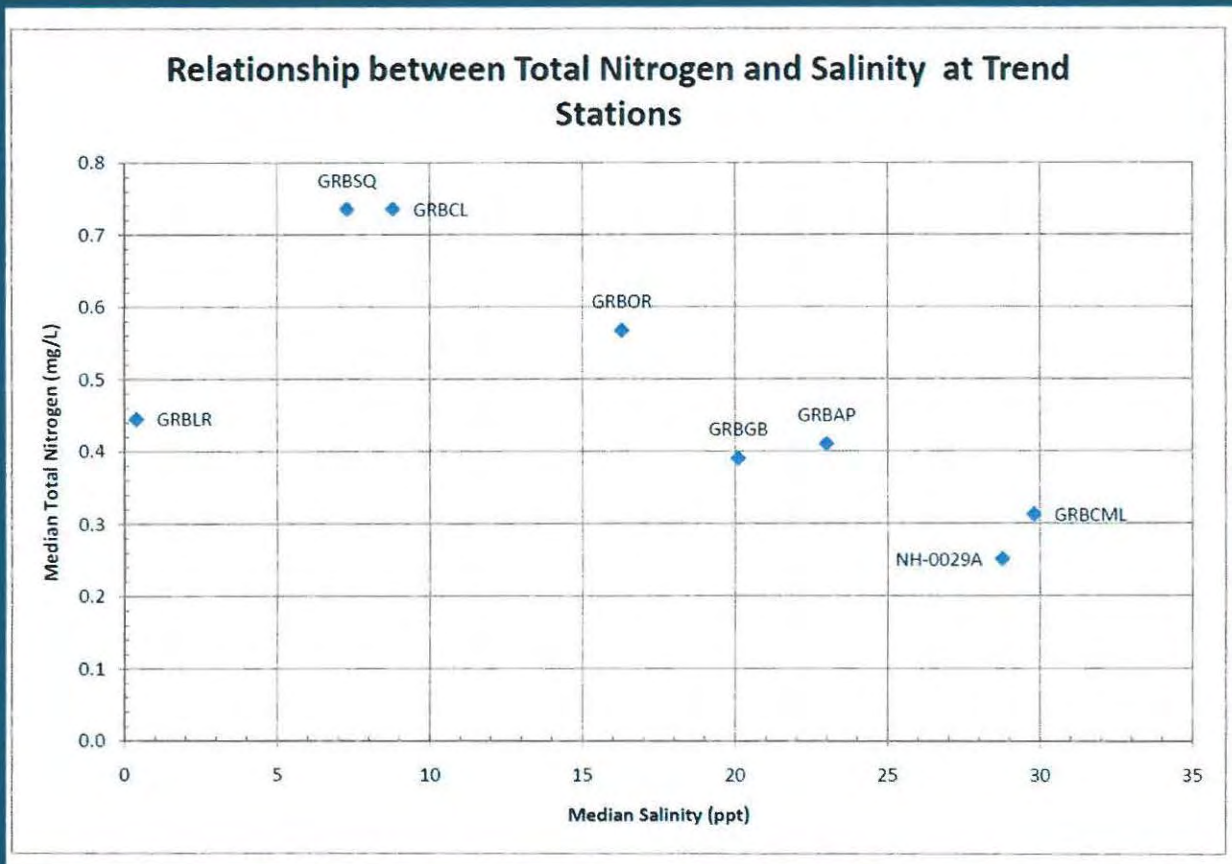


EXHIBIT 19

Color – Salinity/Dilution Covary in GB System –Tidal River Source

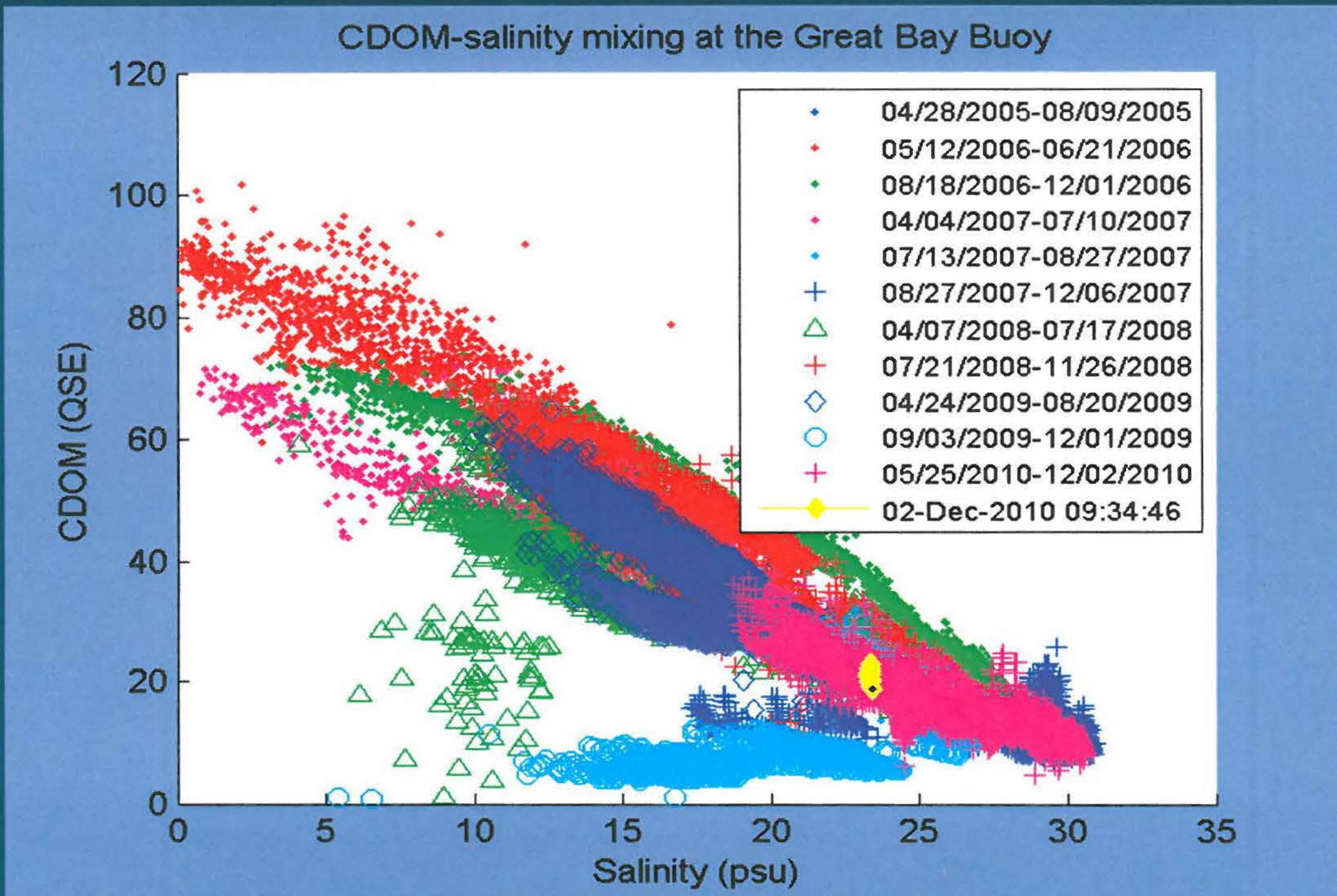
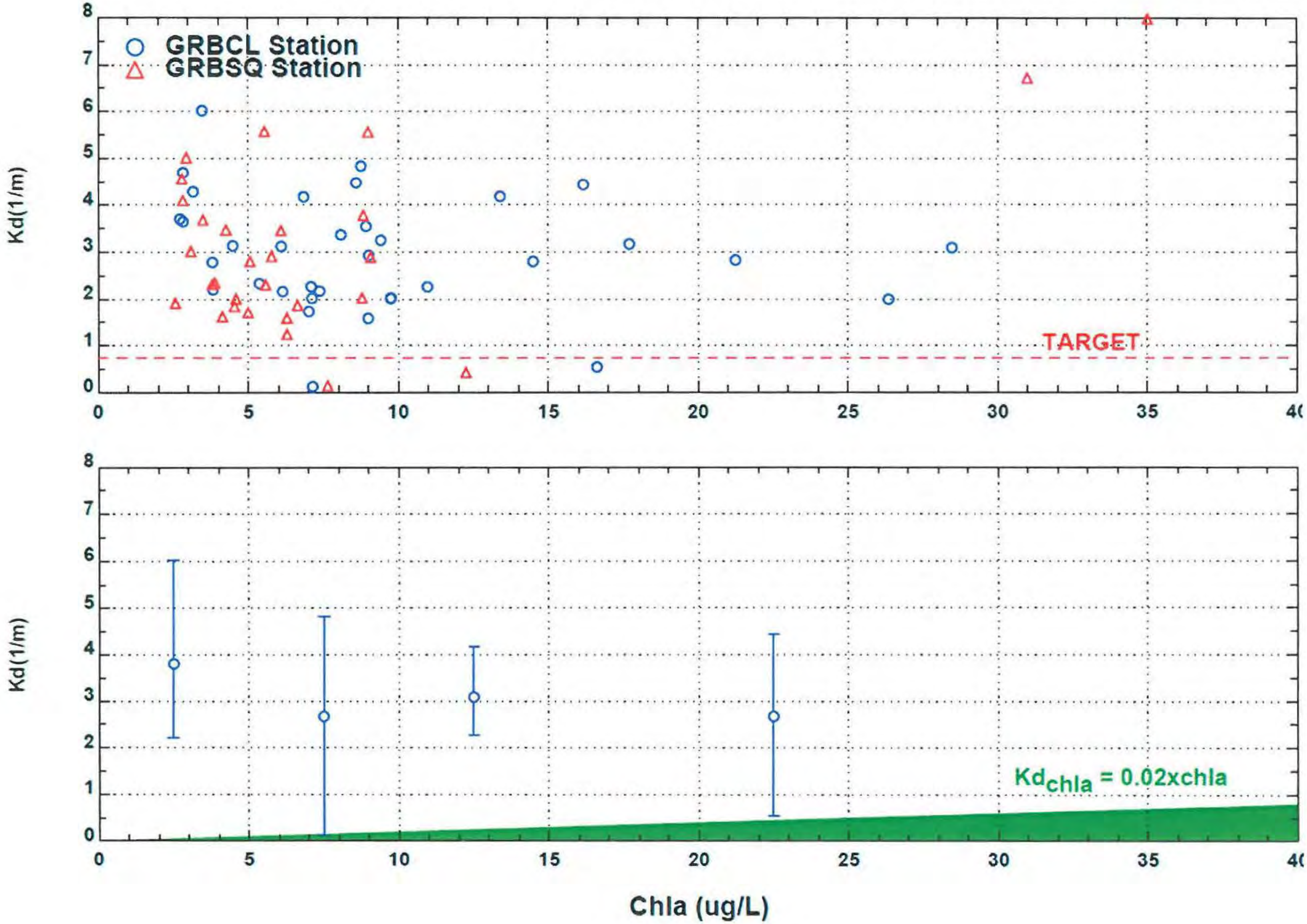


EXHIBIT 20



GRBCL Station
GRBSQ Station
TARGET
Kd(1/m)
Kd(1/m)
Kd_{chla} = 0.02xchla
Chla (ug/L)

EXHIBIT 21

Transparency, Macroalgae, and Epiphyte impacts to eelgrass in the Piscataqua Estuary Assessment
Meeting Minutes
July 29, 2011

Attendees: John Hall, Steve Jones, Larry Ward, Rich Langan, Alison Watts, Dean Peschel, Ted Diers, Phil Trowbridge, Fred Short, Phil Colarusso, and Christian Mancilla

The meeting got a late start as a result of an earlier meeting running longer that planned. Following introductions, John Hall initiated the meeting with an overview of the Memorandum Of Agreement between NHDES and the Great Bay Municipal Coalition followed by a description of the issues the group needs to clarify, which include the extent to which transparency, macroalgae and/or epiphytes are responsible for eelgrass decline in the Piscataqua estuary and whether other important ecological factors need to be addressed to protect the ecological resources of the Bay in addition to nutrient reductions.

John Hall indicated that the Coalition also intends to develop an alternative proposal to the EPA permitting approach that would include a combination of preliminary efforts in an adaptive management framework including (1) treatment plant reductions (2) bioremediation and restoration such as oyster beds and eelgrass replanting (3) recommendations on a watershed non-point source reduction program and (4) additional field studies to ensure reduction efforts are properly targeted. The input Committee would be sought on this proposal also.

A lively discussion followed regarding the amount of research available to confirm the causes of eelgrass decline in the estuary system and the options to resolve an uncertainties regarding the degree of TN control necessary. John Hall indicated that macroalgae are a problem but the research on these species is lacking. John thought a field study might be best for confirming how different TN levels impact eelgrass and macroalgae growth. Phil Trowbridge indicated that some existing studies from Fred Short and Art Mathieson could provide insight on TN impacts and appropriate nutrient target levels. It was requested that the studies be supplied the group. It was also suggested that a mesocosm study could be useful on resolving the appropriate TN conc to protect eelgrass resources. . Fred Short explained that in Great Bay, transparency is not a major issue impacting eelgrass as when the tide is out the eelgrass is exposed and receives sufficient light for growth. The distinction was made between the shallow water systems Great Bay, Little Bay and the tributaries versus the deeper water systems of the Piscataqua and Portsmouth Harbor where transparency may be more of an issue. John Hall indicated that the algal growth information for the Piscataqua River should be reviewed to determine the degree to which nutrients are influencing transparency in that area.

On the topic of epiphytes, Fred Short commented that epiphytes are not and, to his knowledge, never have been a significant problem to eelgrass in the estuary. Epiphytes appear to be controlled by grazers in the estuary and the attached epiphytes that do occur are shed as the older shoots of eelgrass dye off from the plants.

Fred Short indicated that macroalgae were considered the primary problem impacting eelgrass in Great Bay. It was agreed by all that Arthur Mathieson, who was not at the meeting, needs to weigh in on this issue.

There was a discussion on whether addressing TN for DO concerns in the tidal rivers would resolve any TN concerns in the Bay. John Hall indicated that the Squamscott River model was intended to address the relationship between low DO and increased algal growth.

A follow up meeting will be scheduled in the near future to continue the process.

EXHIBIT 22

Great Bay Municipal Coalition nitrogen meeting
9/26/011 9:30- 12:00
NHDES office room A

Present: Alison Watts, Candace Dolan, SWA; Steve Jones, Rich Langdon, Art Matheson, Larry Ward, UNH; Dean Peschel, City of Dover; David Green, City of Rochester; Mark Allenwood, Brown and Caldwell; Sean Greig, Town of Newmarket; Cristhian Mancilla, Tom Gallagher, Hydroqual; John Hall, Hall and Associates; Ted Diers, Phil Trowbridge, NHDES; Jennifer Perry, Town of Exeter.

John Hall: General scope of the current study(s): 3 main activities are identified by the MOA, 1. Modeling of Swampscott River: what is driving it, also hydromantic modeling of Bay including fate and transport. From Portsmouth to the head of Bay are areas to consider, but only Exeter/Swampscott will be detailed. 2. Tech review of factors impacting eel grass health in Great Bay i.e. transparency, epiphytes, macro algae. Which is the main concern? As part of this we will look at background information. 3. WWTF 2 main plants will go to 8 mg/l N, others agreed to see what upgrades needed to get to target N removal rate.

Alison: Clarify goal of these meetings. Is it to get feedback from the group are we going in the correct direction?

Dean: More to identify what people who have been doing work in the estuary over the past years have learned, and ask them to share their knowledge to help guide the studies.

Tom: Information could be then used by the Coalition to guide the restoration process to spend the dollars better.

Ted: This group is a discussion, but not really a "thing": DES would like a "thing" to identify the elements of a holistic approach, information gathering which would result in a better understanding... move to PREP TAC or NERRS TAC, which would give unification of groups, and a more formalized approach for the Bay restoration.

Larry: This group should not be considered a peer review group.

Some general discussion and agreement that this group provides input to the process, but is NOT a peer review.

Steve: The process brings specific questions to the group for discussion.

Rich Langan: Hopes that the end goal is a holistic approach to restoration, and that the "thing" buys into what the goals are so we have a plan on the table... Again, who is going to lead this?

Discussion of Great Bay Loading Model - Phil Trowbridge.

Part 1. Septic survey study, maps Census blocks of what % is sewered, asked each town to proof them, communicate with the towns feedback from 30 of the 52 towns, mostly non-sewered, nothing from other towns. Needs to know if they are reasonable? Will end up with # of people not on sewer, from which will develop estimates of N contribution from septic systems... Also needs Towns to provide N levels in WWTF effluent (current data is 4 years old). It is important to get this information back as soon as possible so can move on to the next step.

Peter: Pease has nitrite and N sampling

Phil: Using the Nitrogen Loading Model (NLM) from WHOI and BU to estimate non-point source loads. NLM chosen because it accounts for atmospheric deposition, fertilizer use, and wastewater to calculate nitrogen delivered to the estuary.

Alison: Another watershed loading model is coming from complex systems (UNH) group. It could be helpful to compare/validate models if relevant.

Phil: Part 2 will be Turf maps: Mapping golf courses, town parks and a model for residential turf, towns will be asked to proof it by supplying info about fertilizer, frequency and product used town properties i.e. schools, ball fields etc. are 10% of the issue. Residential lawns are 10x as large a potential issue. Towns can help identify fertilizer use. 250 separate polygons mapped for the study.

Phil: Part 3 will be Agriculture: Farm specific info is protected by farm bureau. Depends on crop, manure management, smallest unit of data is county level and is protected. Will need town level information.

Next phase will be modeling delivered loads from all sources. After that, DES will estimate cost and cost effectiveness for removing nitrogen from each source in each watershed. Need to decide how we will deal with different species. Model can accommodate different N species (although it is harder). We already know that because of delivery (transport paths) losses closest to estuary will be bigger. E.g. residential septic and turf will be bigger contributors if they are closer to the estuary.

John H. – How will this information be used? What cost effective options exist for limiting TN or DIN loadings from septic tanks?

Phil: We don't know the answer to that question.

ACTION ITEM – Remaining towns to respond to septic survey

Final Notes revised (10/21/2011)

Discussion of Squamscott River Sampling and Model - Tom Gallagher (*this is hard to follow in notes; see attached presentation)*

Tom: We designed a field program on the Squamscott to survey from the Exeter dam down to Great Bay. 10 stations sampled to provide spatial profiles along the Exeter on two sampling days in August. High water/slack low tide and low water/slack high tide. Data sondes were also deployed to understand the DO balance in river. Note that the data is very new so this discussion is preliminary. These data still need a QA/QC check. In the afternoon there is high DO, and the chlorophyll average peak is very high, below outfall (mile 3) the system flushed out. Exeter Lagoons: 490 mg/l chlorophyll.

Sampling was challenged by weather, but some of the chlorophyll in Squamscott ties to low flow . Very little NH4, uptake may transform to NO2 or NO3. The high algal population would explain the substantial nutrient uptake during the first survey. The second survey, much lower algal levels and lower uptake was apparent. Phosphorus may also be uptaken.

Art: anything on uptake by benthic diatoms? Steve: No. Light extinction profound. Perhaps benthic diatoms re-suspend.

Tom: A key question is "How would the river respond if the lagoons were not seeding the system?" Growth rate is impressive. How much is growth from the system, how much re-suspended? Thames River example: salinity dependant death rate for phytoplankton? Death or dilution?

Thoughts: How high would phyto grow without the influence of Exeter WWTF algal discharge? D.O. variation is considerable.

John: This is a significant complication: If we are trying to figure out the acceptable nutrient target for the model in the future when the Squamscott would not have chlorophyll A coming from Exeter. Can we cut the algae level exiting the pond and then resurvey? Is the river being "seeded" and then you have a population increase? The second survey had very little apparent algal growth – so which is the most likely in the future?

Phil: what about the data sondes records collected during the 2011 survey? Cannot interpret what is going on higher up in the system based on data collected at the river mouth. (Tom agreed historical data sondes reflect the Bay, not algal growth or DO in the river.)

What is coming out of the ponds? if you know what is coming out can develop a mass balance.

Art: Can you identify the key organism composition of the phytoplankton populations?

Alison: What are the next steps? Phil to Tom: Data report? Yes. Peter: Can we answer some of the questions for now, with existing (new) information so we can address EPA deadline without having the hydrodynamic model completed? There may be funding issues and would prefer to make sure we're going in the right direction before finalizing model.

Tom: we will report next steps including what has been modeled. So far we have put together the model grid. John: It will be ready fairly soon, it still needs to be updated with bathometry. Phil: Still need QAPP for both data collection and model.

60% of salt marsh in GB is in the Swampscott system. Art: has there been any work on the benthic system or contributions of the salt marshes? It is one of the most important communities in the system.

Steve: we did take one of the datasondes and placed it near the oxbow to see if there is any change there related to the DO regime.

Art: no question there is. It is a large system and needs to be considered.

Discussion of Macroalgae in Great Bay – Art Mathesion *(see attached notes)*
The Swampscott Is dominated by salt marshes and heavy river sediment, not many rocks or seaweeds, no eelgrass seen growing there in past 50+ years. The '73-'81 baseline data was not continued because of funding.

System as a whole is impacted by green tides. There is massive amounts of material which can be taken as indicators of eutrophication. Problems are also algal problems (see notes) in early 80's the lower muddy intertidal shores were open but now are being colonized by opportunistic species. There are now massive greens and reds moving in. Red alga have become more pervasive in the past 12-14 years. Invasive species finding an opportunity.

John: How much is a result of nutrients and how much just opportunity? Art: The two new Asian species have high nutrient requirements and can tolerate desiccation.

Ulva are very efficient in picking up N. Ulva has been present since the 1980s but is now in much greater amounts. What happens when they die? Ulva can reproduce many generations in a year and it has the potential for massive regeneration. High nutrient requirement and high ability to regenerate has given it an opening to colonize. It has moved into a vacuum. It can even uptake ammonia depending on the species. The "cast of characters" has changed in the past 25 years. No question there is a seaweed/nutrient problem in GB (Swampscott not of interest to Art as it is the "land of Spartina grass."). Ammonia and nitrate are the primary nitrogen forms stimulating plant growth. The appropriate allowable level of DIN to control macroalgae in the estuary is not known at this time; but it is currently too high now and reduction needs to begin sooner than later.

John: Are there some studies Art might recommend for more insight? Art: This needs a big literature survey- worldwide. John Raven from Great Britain has done a lot of research on this topic. Always issues with lab/macrocosm experiments. To try and add nutrients in a field test would be unacceptable in the bay!

Steve: Next steps for information. Seaweeds are here what is the problem presented by them? Heavy epiphyte loads vs. eel grass they will overwhelm Zostra and reduce light...they will compete for light and reduce oxygen...they are pulling nutrients but recycling it in decomposition ...what is the impact on D.O.?

Tom: what if inorganic nutrients were reduced to earlier levels (1986 or before). Art: UNH decided in '81 that it cost too much money and asked us to stop long term monitoring... In the early 80's we did not have the problems...

John: Early in season there is a bigger flow and more inorganic nitrogen from non-point; this changes later in the season when point sources may dominate. Which period is of greater concern for these species? Art: Phyto in spring and macro in summer as they require high light and are temperature sensitive. John: If that is so, we may get a big bang for first reductions at the point sources if the timing is right.

Phil: Art and I discussed using the old data to determine what the N was back then. The results show that Total Nitrogen concentrations were less than or equal to 0.3 mg N/L when macroalgae populations were in control. This result supports the existing nutrient criteria for the estuary of 0.3 mg N/L. Peter: by focusing on TN you are driving it lower than may be really necessary. Phil: DIN is important but criteria have developed for TN because uptake by algae can change DIN concentrations.

Peter: if the focus is DIN then the focus should be on DIN (the most reactive form) if the reservoir is in macro algae harvesting it would help.

Phil: We are not seeing anything that changes our approach. Model can make predictions of nitrogen loads in 1986 based on older land use data with input from towns. Tom: If Exeter reduced from 15 to 5, 2 mg would be inorganic...my guess is that Ulva growth would be reduced if they just did TN.

Larry: Look at the literature to find out. Art: you have to remember all the bays are different...real algal problem is within GB proper, there may be areas where algae is accumulating, for instance Nanny's Island. If this is a depository maybe there are opportunities to take it out in targeted areas. General removal from the mudflats too muddy and dangerous. More damage would be done to the mudflat ecosystem. Recommends detailed literature search, is willing to help, but not to manage. John: Could it be done by a student? Steve says there are students available.

Discussion of Restoration – All

Bioremediation with oysters: John: are there particular spots? Rich: Target tidal rivers, implement in other areas in the Bay particularly nursery areas as at that point they are fast growing. Phil: starting a project with NOAA looking at bio extraction in the bay (Ray Grizzle estimates they can remove up to 12 tons through bivalve bioextraction). Cost estimates for oyster restoration are $50,000 per acre. Also there is interest in growing kelp from some people in Maine and there are other ways of growing biomass which would result in removing nitrogen as the product is harvested.

Alison: There is lots of existing information about restoration strategies; PREP Action Plan, rivers advisory committees etc. What we need is to build on these for more specific action plan. Where will be the most effective area? Phil: all the elements are in the PREP management Plan.

John: Septic tanks – If you conclude the tanks are delivering more than they should. Do we have a plan to reduce that?

Phil: We expect that we will see that tanks closer to the estuary will be bigger contributors. One option may be extending sewers? After we know where it is coming from we can better decide. John: extending sewers may only deliver the load more efficiently.

Peter: It seems like a consensus that DIN is the issue, and is the dominant source of the problem, in which case the improvements from the WWTFs will be bigger than thought. Better not to make any strong statements about retrofitting septic tanks at this point. This has been a very useful exercise.

John: This was very useful feedback today on issues related to the appropriateness of the draft TN criteria. We greatly appreciated Art's input on the nitrogen species question and importance of macroalgae control to the system. Other questions addressed previously include how much is transparency a controlling factor in GB? How much are epiphytes an issue or macro algae? I'm not sure that there are any other significant issues left. This group could help guide what specific restoration steps are needed and could be fostered by our municipal coalition.

Peter: lots of people already doing things - how do we bring them together, rather than start a new uncoordinated effort? Phil: the PREP action plan has a list of pending activities already in place. But they need to be done.

Attachments:

1. Mathieson discussion of algal blooms GES.
2. Gallagher Squamscott River WQ Update Sept 26 2011

Post meeting note: As requested, Phil has provided information on the PREP Comprehensive Conservation and Management Plan which is available at: http://www.prep.unh.edu/plan.pdf. The action plans that are directly relevant to nutrient load reductions, oyster restoration, and eelgrass restoration are: WR-5, WR-8, WR-9, WR-10, WR-11, WR-12, WR-13, WR-14, WR-15, WR-16, LR-1, and LR-3. Each action plan has lists of activities, outputs, outcomes, and performance metrics. There is also a theme discussion about reducing nutrient loads on page 12. The plan also covers issues related to stormwater, geomorphology, climate change, and land use. For a holistic restoration approach, all of the actions from the plan should be implemented.

EXHIBIT 23

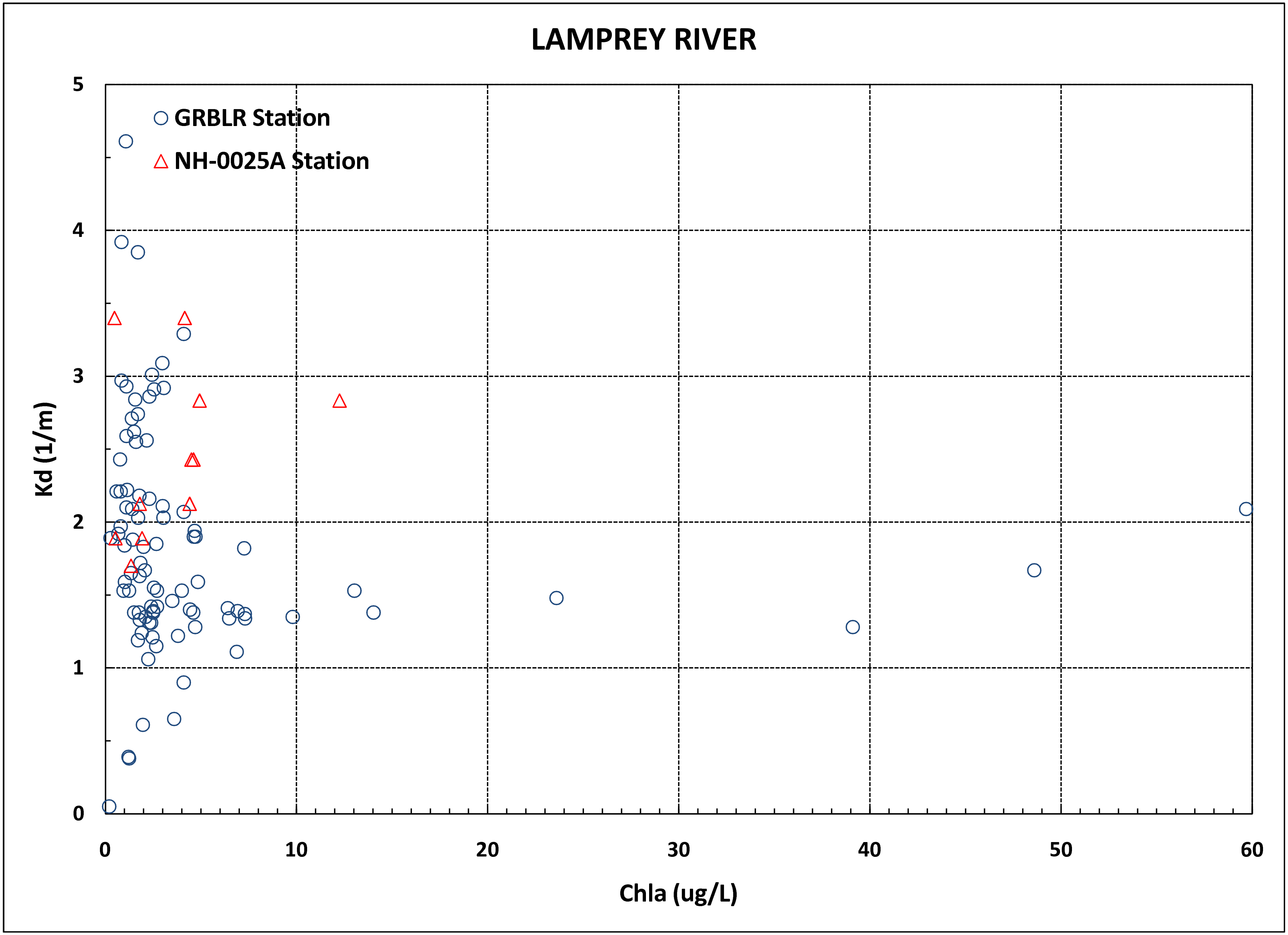

LAMPREY RIVER
GRBLR Station
NH-0025A Station
Kd (1/m)
Chla (ug/L)
0
1
2
3
4
5
0
10
20
30
40
50
60

EXHIBIT 24

Estimated Lamprey River DIN Loads (1990-2010)

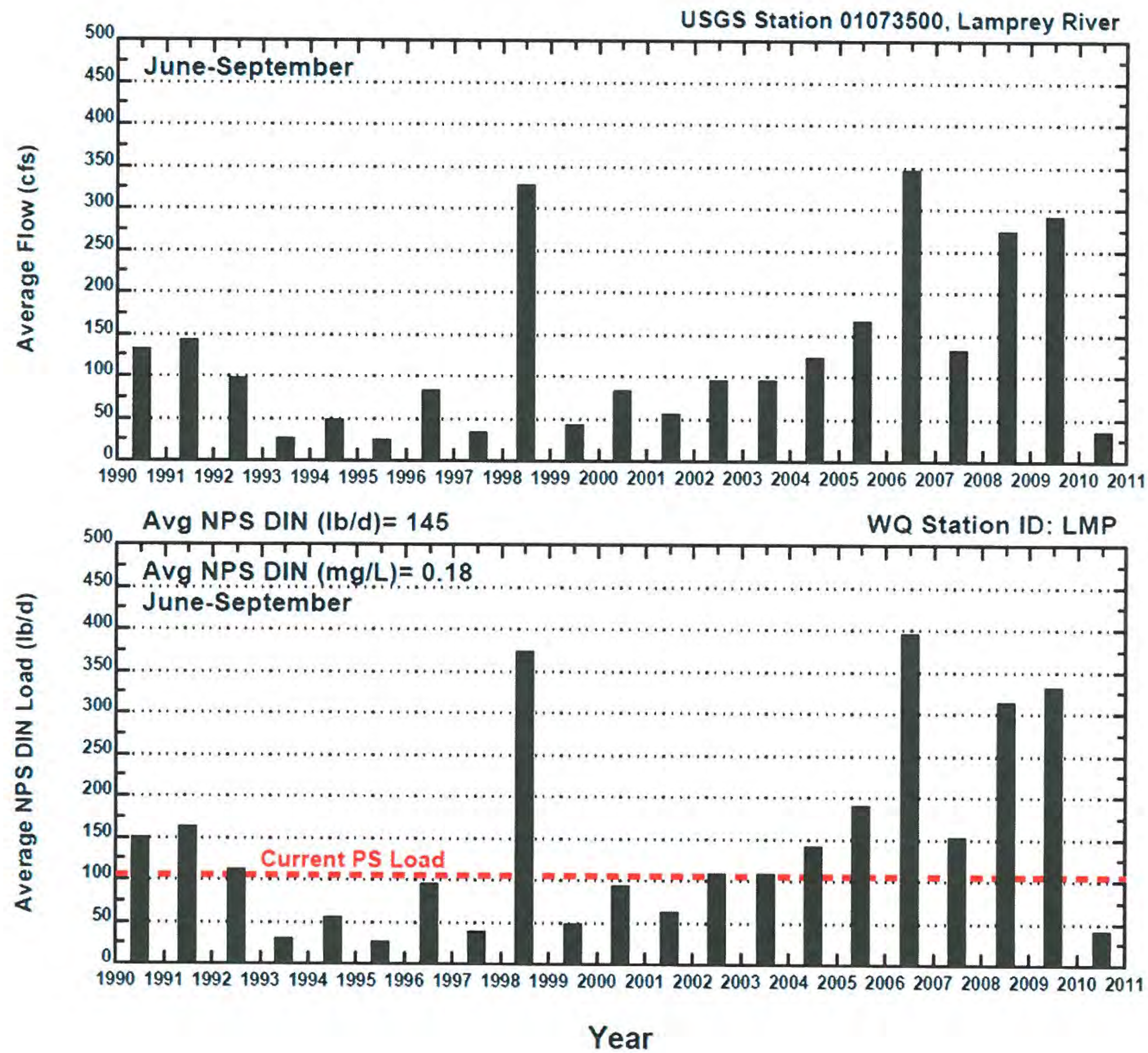
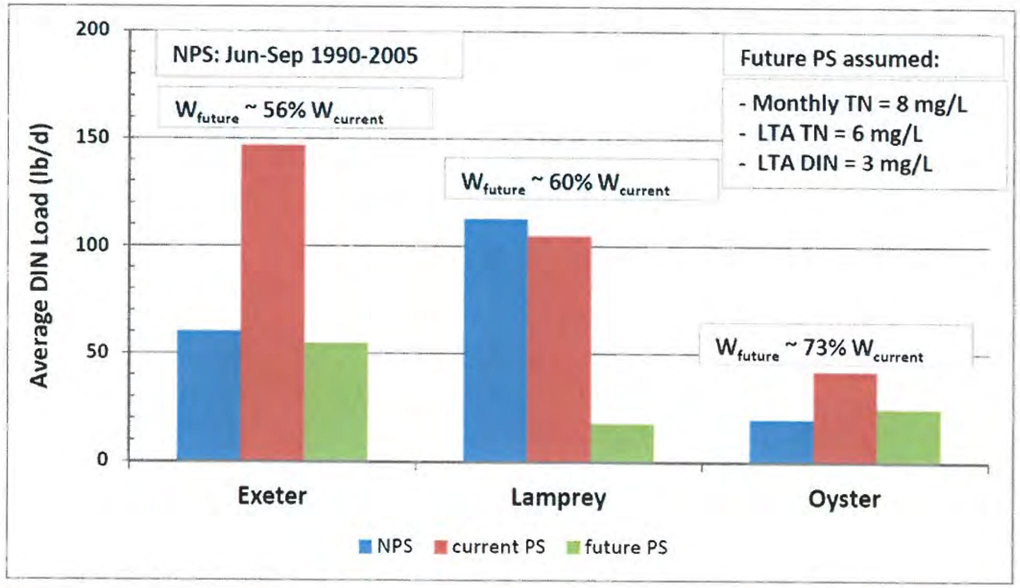


EXHIBIT 25

Major Great Bay DIN Loads (1990-2005)



Total Great Bay DIN Loads (1990-2005)

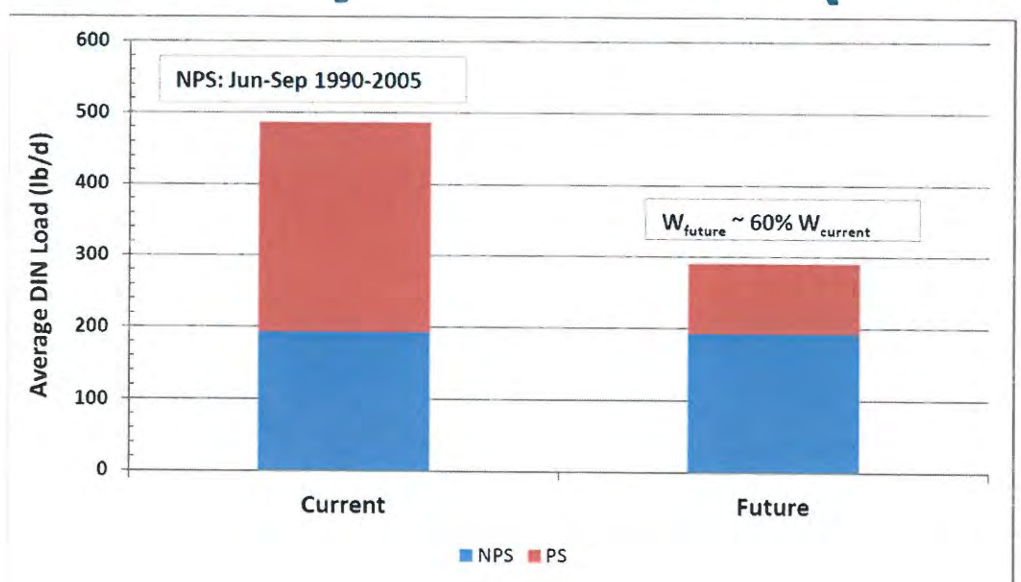


EXHIBIT 26

Rainfall data 1900-2010