

**Water Quality Monitoring Work Group  
TEAMS Online Meeting  
March 23, 2021 – Meeting Summary**



**Attendance**

Jim Ammerman (Chair)—Long Island Sound Study (LISS)/New England Interstate Water Pollution Control Commission (NEIWPCC)  
Dacia Mosso (Meeting Convener)—Tetra Tech  
Chris Bellucci--Connecticut Department of Energy and Environmental Protection (CTDEEP)  
Anthony Caniano—Suffolk County Department of Health Services (SCDHS)  
Carol DiPaolo—Coalition to Save Hempstead Harbor  
Mark Fernandez--Tetra Tech  
Richard Friesner—NEIWPCC  
Michele Golden--New York State Department of Environmental Conservation (NYSDEC)  
Jim Hagy—EPA  
Jim Latimer—EPA  
David Lipsky—New York City Department of Environmental Protection (NYCDEP)  
Kamazima Lwiza-Stony Brook University  
Matt Lyman—CTDEEP  
Michelle McAllister-- Coalition to Save Hempstead Harbor  
Jon Morrison—United States Geological Survey (USGS)  
Bob Nyman--EPA  
Katie O'Brien-Clayton—CTDEEP  
Jim O'Donnell—U. Conn.  
Leah O'Neill—EPA  
Michael Paul—Tetra Tech  
Evelyn Powers—Interstate Environmental Commission (IEC)  
Beau Ranheim—NYCDEP  
Kelly Streich—CTDEEP  
Mark Tedesco—EPA, LIS Office  
Andy Thuman--HDR  
Jamie Vaudrey—University of Connecticut  
Yu-Chen Wang—Tetra Tech  
Bessie Wright—EPA

**Agenda**

Special meeting to review the Tetra Tech Retrospective Analysis Update

**Discussion**

Leah O'Neill thanked Tetra Tech for presenting today and to the work group for taking the time to participate. She passed the floor to Mike Paul of Tetra Tech who presented the information on the attached PDF file (LIS Retrospective Analysis\_v2\_20210323). Mike noted that the overall

team included the LISS, EPA R1, and EPA ORD, in addition to Tetra Tech. The goal is to provide an update on the trend analysis and to get some feedback. This retrospective analysis charge is part of the current ongoing task order with the LISS and the task is to conduct a retrospective analysis of some of the environmental predictors on nutrients, phytoplankton, and zooplankton in LIS and to try to explain any trends identified. Tetra Tech has so far been focused on exploring the phenomenology of the trends and visualizing them, and less so on the causes and predictors. Many people have contributed to the data they are using, which is a subset of the of the compiled water quality data from Phase I/II of the previous LISS nitrogen target work in LIS embayments. Data came from multiple sources as documented in Document D.

This trend analysis used 65 open water sites (>0.5 km from shore) ranging from Throgs Neck to Fishers Island. Most of the data was collected by CTDEEP and IEC over the time period from 1991 to 2019. It consists of 125,000 combined surface and bottom observations, including 12,000 of chlorophyll, 79,000 of nutrients, and 8,000 of Kd, the diffuse attenuation of light. The analysis was organized by the commonly accepted regions, Western Narrows, Eastern Narrows, Western Basin, Central Basin, and Eastern Basin based on previous input suggesting a regional approach.

Total nitrogen and total dissolved inorganic nitrogen were calculated for all stations, and grab data were summarized by region in monthly average for the five regions to provide a continuous stream of data necessary for methods like ARIMA (Auto Regressive Integrated Moving Average). Tetra Tech also imputed some missing monthly data with seasonal trend Loess (locally estimated scatterplot smoothing) fit data. Their first approach, which was shown earlier, was to use general linear modeling and to look at the potential effect of several covariates, including temperature, salinity, and loading. They looked to see if trends over time were influenced by changes in loads, and also changes by region and year. The model was first run Long Island Sound wide and then regionalized, and they also examined the annual average as well as the 10<sup>th</sup> and 90<sup>th</sup> percentiles as well as individual site-dates. There is too much data to display it all on slides so Tetra Tech developed a Shiny App which can be displayed using a web link to view the data on your own and select the specific detailed plots of interest.

Mike then used the link to the Shiny App that is on the PDF file and showed the app on the screen. (The link to the App is: [https://tetrattech-wtr-wne.shinyapps.io/LIS\\_Model\\_Shiny/](https://tetrattech-wtr-wne.shinyapps.io/LIS_Model_Shiny/)). He reviewed the introduction tab which shows all the station locations in regional color coding. The second tab is the model summary where you can choose the measured parameter and how it is presented. As an example he looked at total nitrogen. The bottom of the page has a summary table which shows whether there is a significant linear temporal trend over the period of record for different parameters. Since a general linear model did not seem to be the best approach they did not devote a lot of effort to enhancing the model summary table. The next tab is a prediction page where you can run the general linear model by clicking the start button and watching the animated changes in a chose parameter over time on a regional or individual station basis.

Since feedback indicated that the general linear model was not necessarily the best approach, Tetra Tech then used a de-seasonalizing approach previous used by Matt Lyman and published in the past by Karin Bauer<sup>1</sup>. The next tab show results using this Bauer model, with options for different parameters, different LIS regions, and surface or bottom waters. Data is shown by season and water year. Statistical information is shown in a table at the bottom of the page. Because of a discontinuity in chlorophyll *a* concentration apparent around the year 2000 (see more about later in these notes), they also provided the option to split the data into two different time periods, with a choice of breakpoint from 1999 to 2004. This makes it easier to view some of the apparent changes.

As second approach used previously by Marcus Beck and Jim Hagy in Tampa Bay<sup>2</sup> is shown in the next tab. This the is the weighted regressions on time, discharge, and season (WRTDS) method previously used in rivers by USGS and adapted to estuaries like LIS by substituting salinity for discharge. This tab on the Shiny App provides the same viewing options as the previous tab for the Bauer model, though the data is now presented by water year and month. (A question was raised about the meaning of significance and it was noted that a p value of 0.05 was used to determine that the slope of a line was significantly different from zero.) On the final tab they explored QGAM (Quantile General Additive Models) and other models (Autoregressive Integrated Moving Average, ARIMA; Error Trend and Season (ETS); and Generalized Additive Models, GAMM). They looked for any effects of the of phase of the North Atlantic Oscillation (NAO), temperature, and other parameters on chlorophyll *a* trends but there was little response to the NAO.

Tetra Tech's initial findings include the following:

1. Total nitrogen (TN) across LIS has declined significantly and there is a decline from West to East. This decline is most evident for the 90<sup>th</sup> percentile values.
2. The greatest TN decline has been the Western Narrows, the decline in the rest of the Sound has been less but similar throughout the different basins.
3. The DIN:DIP (Dissolved Inorganic Nitrogen: Dissolved Inorganic Phosphate) ratio has also declined significantly, particularly in the Western Narrows but also in the Central Basin. (Jim Ammerman asked if the data could be expressed in molar ratios and Mike said that could be added.)
4. Kd, the diffuse attenuation of light, declined in the West, suggesting greater water clarity, but increased in the East, suggesting decreased clarity there.
5. Chlorophyll *a* declined significantly in the Narrows and Western Basin, but not in other basins. (Jim O'Donnell asked a question about why the black data points in most graphs fell between the red and green lines. Yu-Chen from Tetra Tech noted that many were annual means and the monthly means were more dynamic. Mike Paul promised a more detailed explanation in the future.)
6. There was a change or discontinuity in chlorophyll *a* from 1999-2001 across all regions that has not been explained. This was true despite the variation in initial chlorophyll values across the regions. Tetra Tech is very interested in this discontinuity and has seen no apparently climatic explanations but is looking into potential foodweb

explanations. They have recently obtained the phytoplankton and zooplankton data from CTDEEP, and will explore changes in phytoplankton and zooplankton composition and potential changes in filter feeding processes. This was also the time period of lobster declines and variable shellfish landings.

7. Remaining tasks (among others) include seasonality, depth, chlorophyll, and plankton. Tetra Tech's focus is chlorophyll *a* and nutrients and it leaving dissolved oxygen issues to investigators at U. Conn. Most of their efforts so far have focused on surface waters, there appear to be similar trends happening in bottom waters and those will be investigated further.
8. Mike finished the presentation and asked participants to use the Shiny App and provide detailed comments on it.

#### Questions and Comments:

1. Kamazima Lwiza had several comments and questions, he suggested that it was not surprising that the NAO did not show an effect because it is primarily a winter phenomenon. He also wondered if Tetra Tech (TT) could look at the impact on LIS of the Gulf Stream moving northward. Kamazima said that that the change in chlorophyll *a* around the year 2000 should be called a "regime shift" and asked if TT could make their data set available for other researchers to download and use. Mike said they did have temperature in their model which might show the Gulf Stream influence and Kamazima said that salinity would be the best indicator. Mike said that the Phase I and II data were complete and could be provided to other investigators, though the data belong to EPA and it was up to Mark and Leah. Leah noted that the data was currently in large layered spreadsheets and could be distributed as needed. Kamazima wonder if a system like NOAA's ERDDAP Server, as used by Jim O'Donnell and others could be deployed. Leah replied that the LISS was currently grappling with the overall data management issue and would be assembling and ad hoc working group to address these challenges.
2. Katie O'Brien-Clayton asked if TT would be maintaining and updating the Shiny App and Mike Paul replied that was on a TT server and would remain there but was readily portable and could be moved to an EPA server later. He noted that EPA was gradually increasing Shiny App use and support and Leah O'Neill and Mark Tedesco agreed and said that it was important that TT was demonstrating the utility of the Shiny App, and that this and other "Open Science" topics would be the subject of much future discussion.
3. Jim Ammerman asked CTDEEP and IEC if there were any methods changes around the time of the year 2000 chlorophyll *a* discontinuity and Matt Lyman replied that there were not. Matt said that they shifted to a finer filter pore size for chlorophyll to see if they had been missing some phytoplankton but that proved not to be true. Matt noted that unfortunately the phytoplankton species collection did not start until 2002 so that could not provide much information to address the discontinuity. Mike then retracted his prior comment about the phytoplankton species information and there followed a

discussion about other potential sources of data from satellites, New York City DEP, or others. Beau Ranheim of DEP said that they had data from the Western Narrows, though it was not currently separated out though that could be done. He was asked if they collected phytoplankton and said that they did up until about 1997 when someone retired.

4. Jim O'Donnell asked if there was any statistical reason to regionalize the data as shown in the first map of the presentation. Mike said no, but those were the historical regions. Jim said that TT had done the background work needed for spatial empirical orthogonal function analysis (EOF) which could help to address the variability and lead to more sensible averaging. He also asked about the whether or not TT had access to the past Dam et al. (2010) report <sup>3</sup> and Mark Tedesco confirmed that they had. There was further discussion about regional climate impacts separate from the NAO including changes in chlorophyll, however, past analysis of cloudiness patterns had shown no trends. Mike Paul said he would get back to Jim O'Donnell about applying empirical orthogonal function analysis to water chemistry as he had done it only for biological data.
5. Jim O'Donnell noted that he really liked the visualization. He said that the decrease in nitrogen was likely the strongest signal seen in this data set, and for other parameters more information on the variability and significance of changes needed to be presented when analyzing trends. This is especially the case for parameters of regulatory significance. Mike agreed and said that significance information was more limited in a presentation than in a report, but that the idea was an important consideration going forward and can be provided. He also said that the code for the Shiny App could be made available on a GitHub site for others to access.
6. Mark Tedesco then returned to the idea of a "chlorophyll a regime shift" around the year 2000 and wondered what else might be associated with it. He noted that there was a collapse in shellfish harvest in the Western Sound in the late 1990s and then of the lobster population just after that. The shellfish decline was due to MSX disease and the lobster collapse mostly increased temperature, though disease and overfishing were probably also involved. Whether there is any connection of either of these to the chlorophyll shift is unclear.
7. Mike asked if there had been any hypotheses to explain the chlorophyll regime shift and Jim O'Donnell said there had been some attempts to model it and the modelers concluded that the data must be wrong.
8. Jim Ammerman again raised the issue of calculating DIN/DIP, TN/TP, and DIN/Si molar ratios as a way to address nutrient limitation issues.
9. There was further discussion of splitting or lumping the data and applying EOF to this large data set. Kelly Streich raised the issue of whether there had been any recent changes since 2016 or 2017, since some of the NY City treatment plants had decreased their nitrogen loads since then. Mike said he had not seen notable changes, though there was limited data during that time period and it had not been analyzed in detail.
10. Leah O'Neill thanked Tetra Tech for their work and the Water Quality Monitoring Work Group for hosting the meeting and asked Mike if he needed comments on the Shiny App

by any specific time period. Mike said a month would be fine but discussions could also run longer. Mike noted that R-savvy participants could run the models behind the Shiny App themselves and thanked Mark Fernandez and Yu-Chen Wang for developing the Shiny App.

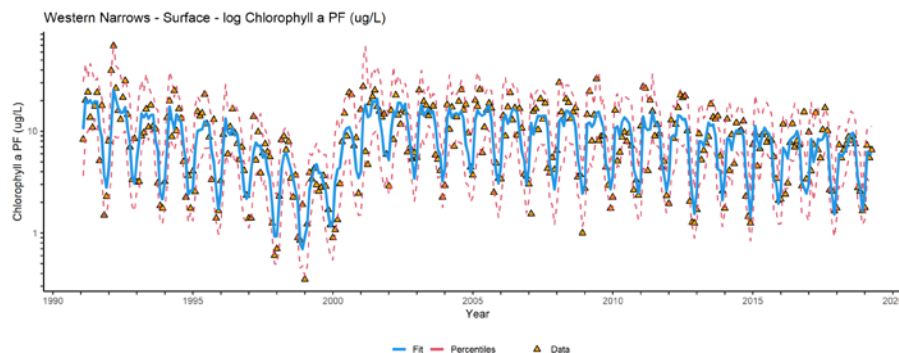
#### References:

1. Bauer, K. M.; Glauz, W. D.; Flora, J. D. *Methodologies for determining trends in water quality data*; Midwest Research Institute: 1984; p 106.
2. Beck, M. W.; Hagy, J. D., Adaptation of a Weighted Regression Approach to Evaluate Water Quality Trends in an Estuary. *Environmental Modeling & Assessment* **2015**, 20, (6), 637-655.
3. Dam, H. G.; O'Donnell, J.; Siuda, A. N. S. *A Synthesis of Water Quality and Planktonic Resource Monitoring Data for Long Island Sound*; Final Report EPA Grant Number: LI-97127501; University of Connecticut: 2010; p 363.

**Post meeting discussion on the chlorophyll  $a$  “regime shift” is presented below.**

#### The LIS Chlorophyll- $a$ “Regime Shift”

During and after the March 23<sup>rd</sup> Work Group meeting there was extensive discussion about the discontinuity on Long Island Sound (LIS) Chlorophyll- $a$  (Chl- $a$ ) concentration around the year 2000, as shown in the figure below from the Tetra Tech Shiny App.



Chlorophyll- $a$  concentration on the LIS Western Narrows from CT DEEP data, similar time-series are found in other LIS basins.

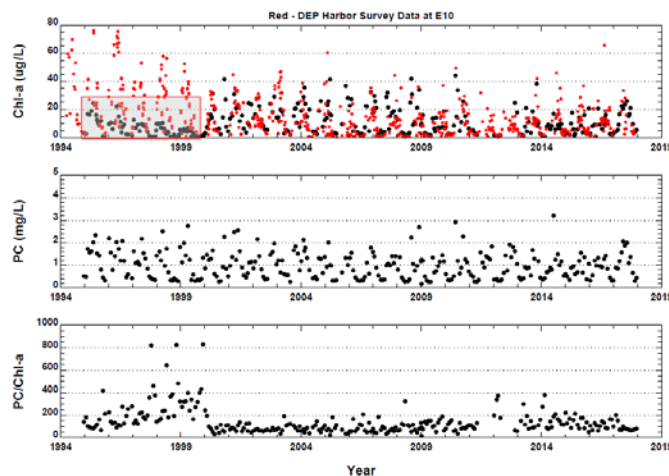
Considerable discussion followed and comments are reported below largely in the order that they were received.

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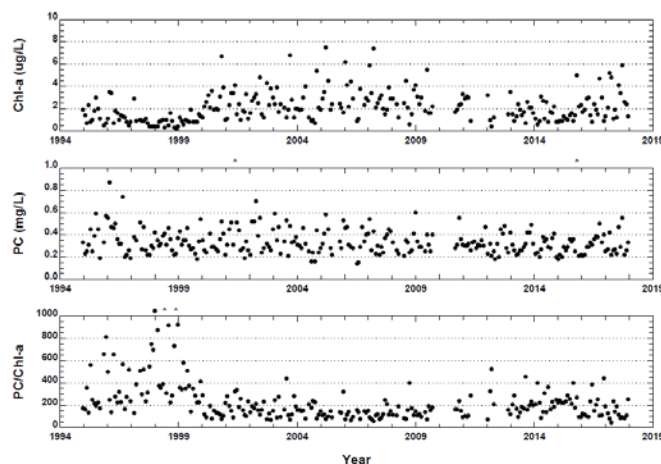
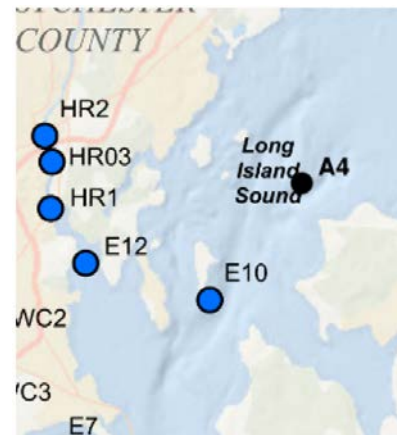
Andy Thuman provided the following comment and the three figures below. “The attached figure presents data for CTDEEP station A4 and DEP station E10 (these 2 stations are about 2.5 miles apart, see map). A4 data are the black circles, E10 data are the red circles and these data



are surface samples. While I may fall into the “there may be a data issue” type as a modeler, the A4 Chl-a data prior to say 2000 (red box in top panel) shows that the CTDEEP Chl-a variability is much less than the DEP variability. From 2000 and onward, the two datasets seem to compare fairly well. Maybe something occurred in the pre-2000 data with data collection and/or analysis? The 3<sup>rd</sup> page shows the CTDEEP data at station M3 (Eastern Sound) and the same low variability Chl-a data pre-2000 shows up. These are just some data observations but may trigger thoughts from others. The middle panel presents CTDEEP PC data and the bottom panel presents the calculated C:Chl-a ratio. You can see the very high C:Chl-a ratios in the pre-2000 data, which are a result of the much lower Chl-a data during this period and the relatively steady PC data over the entire period.”



CTDEEP Monitoring Data at Station A4 (1984-2018)



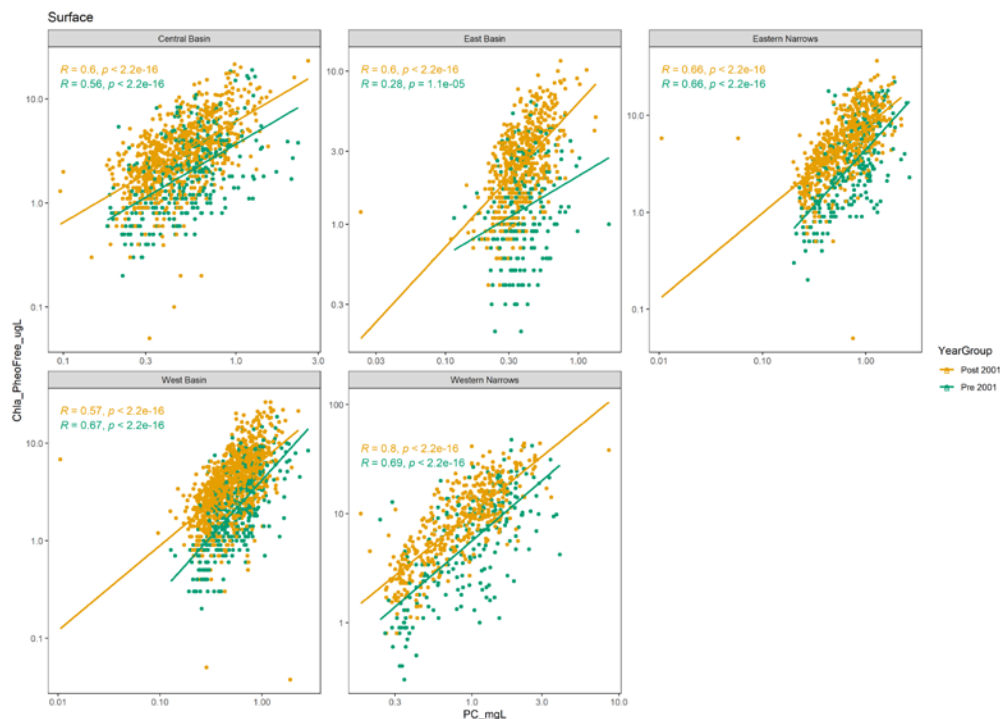
CTDEEP Monitoring Data at Station M3 (1984-2018)

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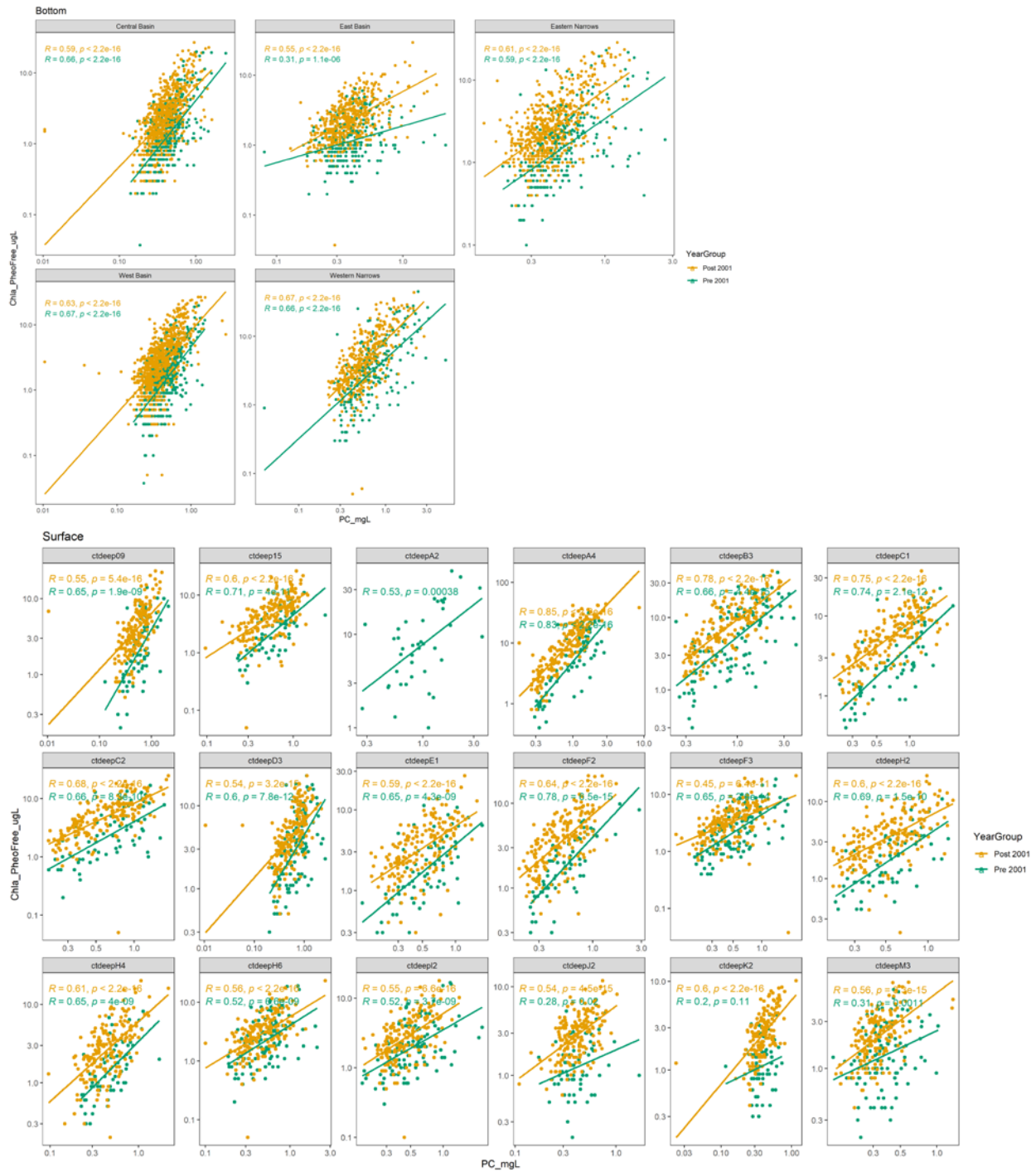
Jim O'Donnell said "Hans Dam, Jim Kremer and Jim Fitzpatrick have both looked at this puzzle from a coastal nutrient perspective and I looked at light, temperature, and river flow. Everyone has been frustrated. I think we need to look in a different direction. Unfortunately, there is no phytoplankton data when it would be useful. The only positive suggestion I can offer is to try to get the DEEP fish survey data for small fish that might influence the density of microzooplankton. If they were released from predation, they could push down the Chl-a. The water depth is too large for the benthos to have an effect."

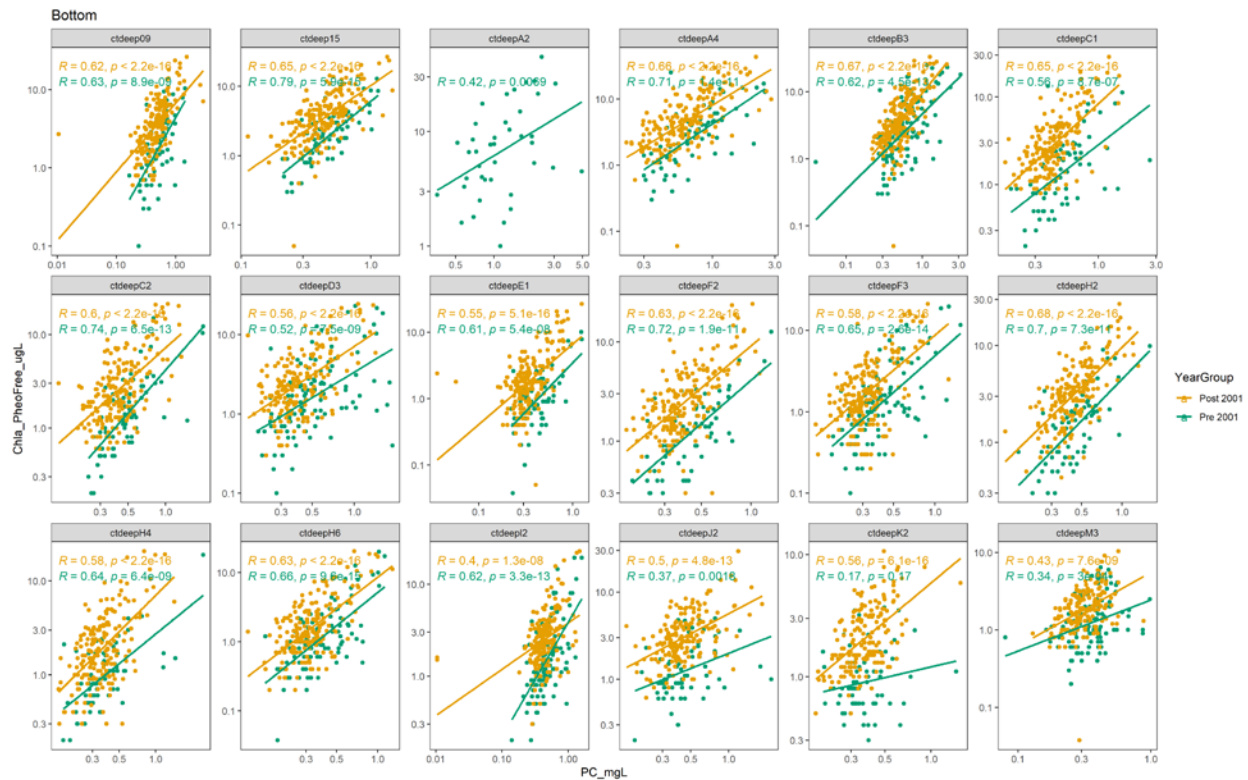
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Mike Paul provided the following four multi-panel figures and said the following "In order to more completely evaluate this PC ~ Chl-a hypothesis, I had YuChen (thanks YuChen) run the attached analysis. We looked at PC ~ Chl-a for every region and every sampling location and I had him code the data as pre-2001 and post-2001. What you can see is the sort of plots we look for when running an analysis of covariance to test for differences in intercepts (bias) but not slopes. Many of the slopes look identical, but pre-2001 data are shifted down (biased). And this happens from West to East across LIS so it is not just a western narrows phenomenon. So, there would have needed to be a LIS subtle shift in carbon: Chlorophyll-a. This does not rule that out--but it does confirm that this is a LIS wide phenomenon and that correcting Chl-a for PC, if there was a method issue, may work to correct this. Note: Clarification from YuChen. Data are Water Year – so post-2001 is 2001 to 2019, pre is 1991-2001."







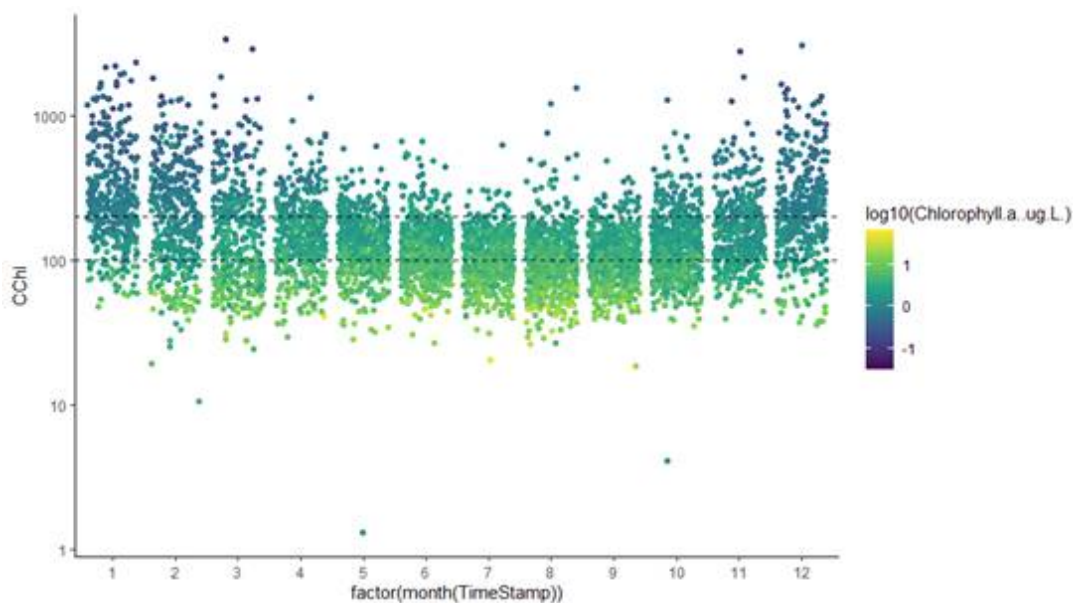
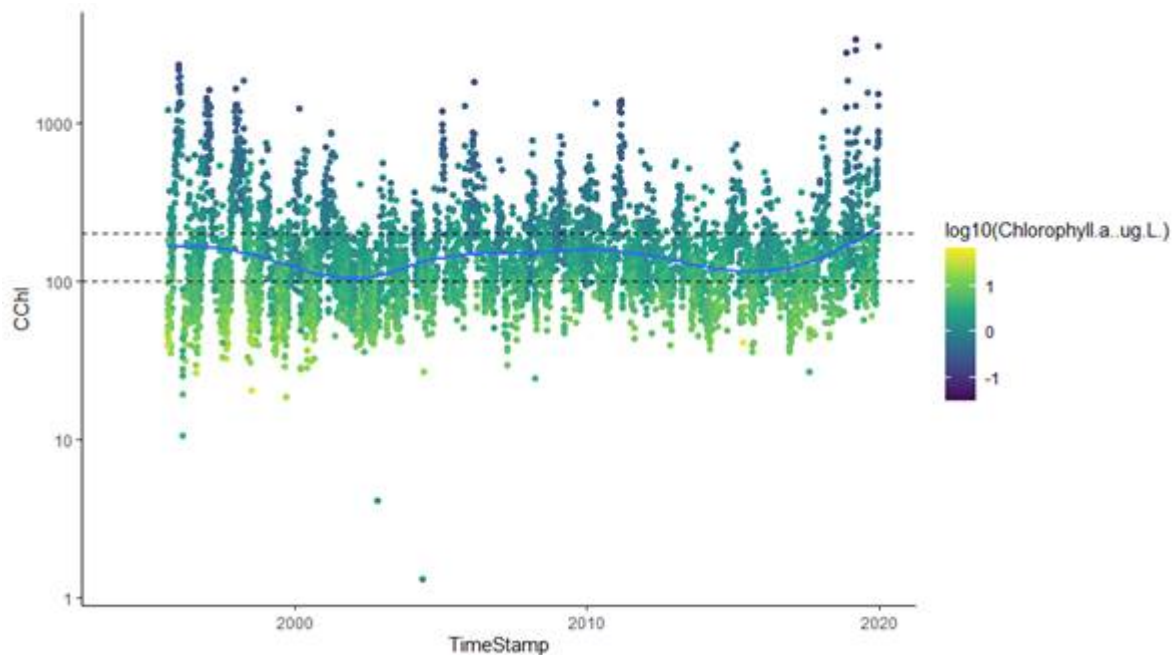


Jim Hagy provided the following two figures and commented “I don’t believe that your graphs are directly addressing the question at hand. They do establish that in many places in LIS there are correlations between PC and Chl-a across large variations in each variable. This is expected simply because phytoplankton contain both Chlorophyll-a and carbon. There is also in your graphs a shift in the relationship. If I’m thinking about it right, Chl-a goes down, but carbon does not, so C:Chl-a should be going up--then down again.

It might be useful to look at the C:Chl-a ratio directly. Here I took a nice data set from Boston Harbor (about 6,000 data points). Wastewater loads were reduced and diverted offshore in the late 1990s, resulting in decreasing Chlorophyll-a. Despite the fact that Chlorophyll-a decreased, the highest values of PC:Chl-a decreased even more than Chl-a. When Chlorophyll-a was low C:Chl-a was perhaps 60-200 and the loess fit to the mean is between 100 and 200 (dotted lines).

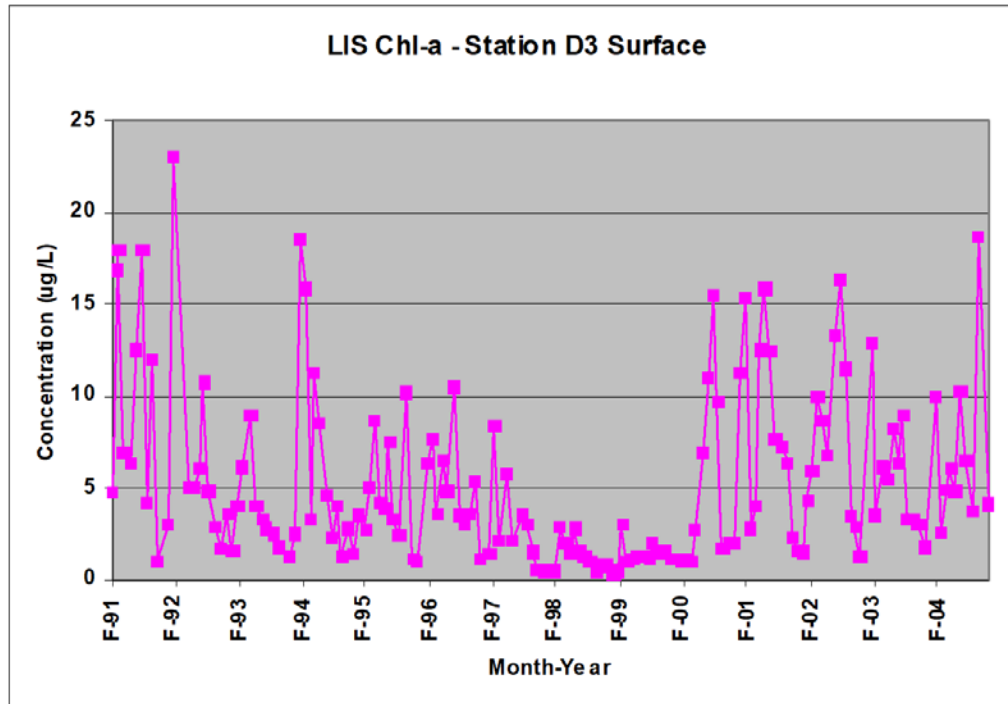
Is the idea with the LIS sound data that we might show based on the ratio of PC to Chl-a that the Chl-a values are probably wrong? That seems to be asking a lot. So far, it’s clear that something is going on, but I’m not seeing it as impossible or even deeply unlikely that it’s real. Do the ratios in the late 1990s go completely out of bounds compared to these data from Boston Harbor? Another question is, how fast does the ratio change. One of my key points arguing against a lab artifact is that the change appears to be gradual (i.e., over several years),

which would require a fairly elaborate explanation if it happened in the lab. The time series of C:Chl-a like this graph would help show that.”

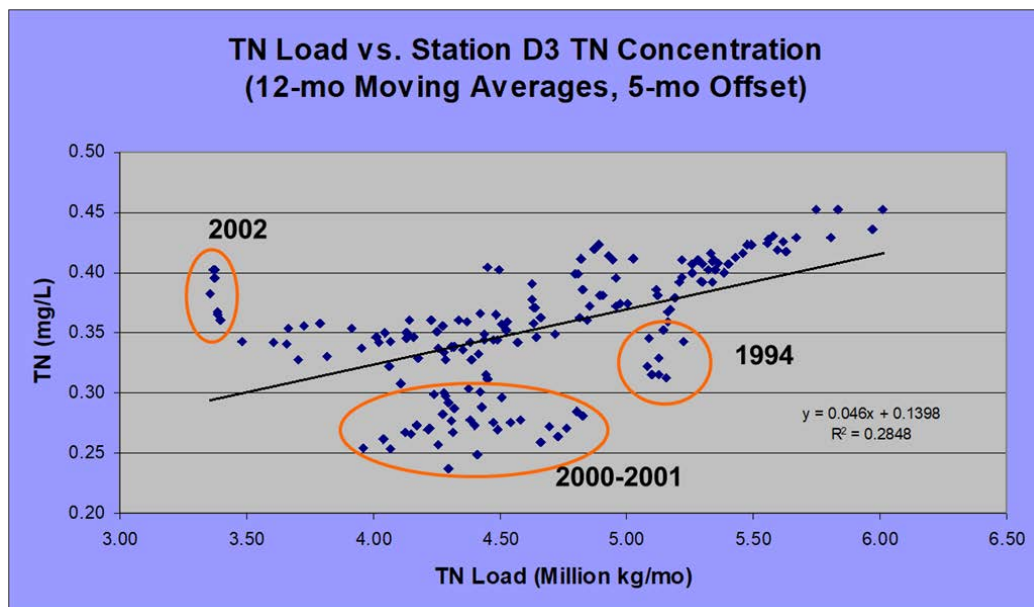


Paul Stacey then provided the following comments and two figures “Sorry I could not attend the meeting on Tuesday. Yes, the puzzling disappearance of Chl-a in the late 1990s. I put the

graph below together shortly after the observations of that downward trend and updated it through 2004 for Station D3, off Norwalk. Station D3 has always been interesting as it seems to exhibit trends and conditions that are swamped by variability at most other stations, at least to my descriptive statistics eye.



In the graph below I highlighted some years that fell off the relationship, though I can't recall the range of years included in the graph. But, nothing special about the late 1990s.



I do recall talking to Candace Oviatt who observed a similar drop off of Chl-a in Narragansett Bay during the late 1990s, and I think we speculated that early warming may have caused exceptional coincident grazing by blue mussels and an early zooplankton hatch that rapidly depleted Chl-a, but my memory is hazy, and it was speculation, of course.

I'm am puzzled by the data that Andy provided and why the A4 and E10 stations differ. The hydrology and tidal effects of the western sound may have played a role since NYC is a rich source of nutrients and it takes time for production to occur. It almost looks like A4 was regularly sampled on an outgoing tide, and E10 on an incoming tide, or the residence time at E10 is longer. Are there PC data for E10, Andy? That might help explain it.

Katie O'Brien-Clayton checked the distribution of tides during CT DEEP sampling of Station A4. She said the following and provide the summary table below (complete spreadsheet available on request). "I ran a quick query and pivot table. We're split pretty well between ebb and flood tides when we visit A4."

Row Labels	Count of Tide Stage
1 = Ebb	173
2 = Ebb Slack	29
3 = Flood	185
4 = Flood Slack	38
<b>Grand Total</b>	<b>425</b>

Katie also mentioned a dissertation<sup>1</sup> that described changes in LIS phytoplankton and zooplankton due to increased temperatures from climate change, several related papers have also been published<sup>2,3,4</sup>. She also noted a published paper on "regime shifts" in zooplankton of the Northeast continental shelf<sup>5</sup>, and a related paper documents similar shifts in fish recruitment<sup>6</sup>. These are all listed in the references at the end.

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Paul Stacey responded to Katie's comments on the tides, "Yeah, I thought that would likely be the case for the DEEP surveys, but I wonder if the Harbor surveys might be scheduled on tides rather than time. Probably not, but worth a check to eliminate that possibility. It also might be interesting to look at monthly tide/sampling data through the years to see if by some unexpected coincidence, there was a tide bias during peak bloom periods or something. Very unlikely, seeing the consistent seasonal pattern in the DEEP data, but you never know. Tidal scheduling actually might be a way to eliminate a complicating factor for a trend analysis, but is tough to pull off. I'm also thinking time of day might enter a bias. We know there's a diel pattern to DO, and I expect that Chl-a might respond as well with increases throughout the day with more hours of sunlight exposure and phototaxis response. But it would be a very difficult pattern to detect without better understanding of mixing and transport features, etc. Even small differences in sampling depth could make a difference for surface concentrations. Always the problem with limited sampling intensity. That's what makes it so much fun and interesting."



Paul later expanded on some of his previous comments. “The Chl-a phenomenon was not exclusive to LIS. Candace Oviatt had given me a call and asked if we were seeing anything unusual in LIS. As I recall, she was seeing unusually low Chl-a levels during that period in Narragansett Bay as well. It would be worth a check, to look at her data/Narragansett Bay data, and talk to her about it. They may also have some taxonomic data for NB since they’re better equipped and skilled at those sorts of things at URI and the EPA lab.

Much of our speculation is a distant memory, but I think the late 90’s was an unusual period for cold winters and strong stratification because bottom water warming lagged and surface water warmed quickly. 1998 was a record warm year at that time I believe. Anyway, we speculated that biological timing of blue mussel feeding and zooplankton blooms may have been off, as well as perhaps phytoplankton blooms. I know the modelers dismissed the concept of a locust effect and concluded the data were wrong but, hey, they’re modelers! Aren’t all models wrong?

Anyway, the temperature sequence may provide some insight into phytoplankton and zooplankton blooms (unfortunately we weren’t sampling zooplankton then, but Hans Dam and George McManus might provide some observational data), and the potential for a grazing effect. Perhaps it will confirm my fading memory that the temperature patterns were unusual and stratification may have been as well. The “missing” Chl-a may well have been in organism guts, or settled as fecal pellets before samples were taken. As we all know, monthly sampling can be misleading when biological reactions can be on the order of days. A chat with Gary Wikfors might also add insight as he is certainly the expert of shellfish feeding and nutrition.

And, perhaps plots of temperature and water parameters would be a better indicator of the Chl-a effect than a time series if plotted that way, or at least a focus on time and temperature components. Maybe precipitation, too, especially the spring floods when delivery of nutrients may peak. I don’t recall the weather patterns a timing of river discharge peaks for those years, but I know Kamazima looked at that in the past, and found some decent correlations between river discharge and nutrients, which I had also seen in my years ago analysis of Station D3, with appropriate lag times considered, and found some anomalous years, some which could be explained, others – who knows? The blue TN load graph above – the 2002 drought year is pretty noticeable, but the analysis would have to be redone by someone more competent than I am, including the N-loads and the question of the offset. Done a long time ago by an unskilled statistician – me. I’ve sent this around on occasion, too, and not sure anyone looked. Maybe the time is right now. And Station D3 was the only station where these descriptive statistics seem to work with this level of clarity – kind of a bellwether.

Finally, I suggest that DOC and PC data be plotted as well – surface and bottom. Chl-a is a poor indicator of standing crop, and productivity, though it’s often used that was for lack of any other measures. Carbon stocks may be a helpful indicator through the years, and capture some of the senescent or processed biomass after the phytoplankton has died or been consumed and released as fecal material. It would be especially useful in the Central and Eastern basins where



stormwater C loading would likely be less of an impact. It would be an easy addition with the Shiny set up as it is and to compare to Chl-a and TN without conflating the two.”

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Most recently, Chris Bellucci of CT DEEP responding to the following question from Leah O’Neill. “We wanted to reach out to get your take on CTDEEPs historical dataset, as a follow-up to Tetra Tech’s presentation at our last Water Quality workgroup call. Tetra Tech is looking into the Chl-a ‘regime shift’ around the year 2000 – see graphs below from their presentation. My notes from the call have Matt saying CTDEEP did not alter their sampling methodology. Before moving forward, we wanted to confirm that CTDEEP did not make any changes to its sampling or analysis methods during that time. Or if you have thought about possible explanations for this phenomenon, as Jim O’Donnell mentioned he had looked at wind patterns as a cause.”

Chris replied “The decreasing trend into about the year 2000 was not only present throughout the Sound (i.e., every station) but was also seen in other monitoring programs on the east coast (i.e., Mass Bays). It seemed pretty clear that it was a regional, probably climatic-driven event, so we had no reason to question our data.”

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#### References

1. Rice, E. Long-Term Warming And The Size And Phenology Of Long Island Sound Plankton. City University of New York, New York, 2014.
2. Rice, E.; Stewart, G., Analysis of interdecadal trends in Chlorophyll-a and temperature in the Central Basin of Long Island Sound. *Estuarine, Coastal and Shelf Science* **2013**, *128*, 64-75.
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4. Rice, E.; Stewart, G., Decadal changes in zooplankton abundance and phenology of Long Island Sound reflect interacting changes in temperature and community composition. *Marine Environmental Research* **2016**, *120*, 154-65.
5. Morse, R. E.; Friedland, K. D.; Tommasi, D.; Stock, C.; Nye, J., Distinct zooplankton regime shift patterns across ecoregions of the U.S. Northeast continental shelf Large Marine Ecosystem. *Journal of Marine Systems* **2017**, *165*, 77-91.
6. Perretti, C. T.; Fogarty, M. J.; Friedland, K. D.; Hare, J. A.; Lucey, S. M.; McBride, R. S.; Miller, T. J.; Morse, R. E.; O’Brien, L.; Pereira, J. J.; Smith, L. A.; Wuenschel, M. J., Regime shifts in fish recruitment on the Northeast US Continental Shelf. *Mar. Ecol.-Prog. Ser.* **2017**, *574*, 1-11.