Transcript
EPA Tools and Resources Webinar
Coastal Nutrient Management: Research Update
November 20, 2019

Lisa Matthews: Okay, well hello again everyone. My name is Lisa Matthews. Thank you for joining us this afternoon for EPA Tool and Resources webinar series. Today's presentation will discuss new research from EPA that develops and describes methods to quantify water quality and habitat status and trends in coastal waters for the purpose of nutrient management. If you have a science question during or after the presentation, we ask that you please type it in to the chat pod. We will read those questions aloud and go through as many as we can once the presentation has ended. You can listen through your computer speakers or through the phone line and Erin has typed that number into the chat pod. We are going to post the slides from today's webinar on the EPA Research website by the end of the day tomorrow and we will also following up with a recording in the next week or so. At this point, I'll like to turn it over to Dr. Bill Fisher. Bill is the Associate Director of EPA's Center for Environmental Measurement and Modeling and he will introduce today's presenter.

Bill Fisher: Thank you, Lisa. Dr. James Hagy is an ecologist with the Center for Environmental Measurement and Modeling. He is with the Gulf Ecosystem Measurement and Modeling Division in EPA's Office of Research and Development. He started working with the EPA 18 years ago as a post-doctoral student after completing his PhD at the University of Maryland Center for Environmental Science where he studied the effects of nutrient pollution, eutrophication, and low dissolved oxygen on Chesapeake Bay. Dr. Hagy's research continues to focus on the effects of nutrient pollution, principally on water quality and biotic conditions of estuaries and coastal waters and especially, on analysis of ecological processes and environmental measurement of low dissolved oxygen, or hypoxia. For the past ten years, he has worked extensively with the EPA Office of Water, EPA Regions, and several state and local agencies to provide scientific information, review, and other technical support for management of nutrients and hypoxia. Today, my friend and colleague Jim Hagy will provide some of his insights in how we can better characterize nutrient pollution goals for management action. His presentation is titled Coastal Nutrient Management Update. Jim, I turn it over to you. Thank you.

[Exchange between Jim and Erin to resolve technical issues]

Jim Hagy: Thank you very much, Bill, for the introduction and Lisa Matthews for the invitation to present the webinar today and especially to the 129 or so people who are connected in to the webinar and also to my colleagues to Narraganset, Rhode Island, where I'm speaking who have joined me in the room for the presentation. What I'm going to talk about today is, or was inspired by a recent product that we delivered that included a variety of research publications that were done by my colleagues at the Office of Research and Development. These publications represent a sustained effort to investigate nutrient effects and ways to quantify those and ways to use that information in nutrient management on the part of people around Office of Research and Development who work also been used in a variety of technical support activities that I've been involved in and that many others have been involved in as well that covers the presentation today.

Let me get into my slides. One of the things that... well first of all, just to get you all oriented to the topic - nutrient pollution is a pervasive water quality problem in the United States and indeed around the world. We have it in all of our coastlines. There are impacts from nutrients to aquatic life to human health and aesthetic value of our ecosystems. Sources of nutrients are both local to those waters and in many cases, far field and are delivered either by air or by rivers that deliver nutrients into coastal areas. Public interest in nutrients as a topic is historically kind of hot and cold in that we have big events, harmful algal blooms, that grab the headlines or we have, in some cases, low dissolved oxygen events that kill fish or shellfish and grab the headlines. And then, it kind of disappears from the public consciousness although my experience has been that people who have been involved as stakeholders tend to be more and strongly consistently engaged.

Just to emphasize some of the points I was talking about. Three kinds of impacts associated with nutrients are hypoxia, or low dissolved oxygen which has been documented as I've mentioned on many of our coastal waters around the water, loss of sea grass habitat and sea grasses are important habitats for coastal ecosystems because of the function they play for aquatic life and also for their impact on the bio-geochemistry of coastal ecosystems. They are particularly sensitive to nutrients for a variety of reasons. Of course, the real headline grabbers lately have been harmful algal blooms which have a variety of effects on aquatic life and also human uses of coastal ecosystems. All of these are things that are a concern when it comes to managing nutrients. One of the things about nutrients is that we know a lot at this point about the causes of nutrient effects, the mechanisms that nutrients move into coastal ecosystems, and the processes that lead to some of these impacts. We know this in substantial part because we've been researching it as a scientific community for a very long time.

I wanted to present this graph which comes from a clever tool that Google produced called the NGRAM Viewer that allows you to compare how often certain words appear. If you type in "freshwater eutrophication" and put that in with "coastal eutrophication," this tool pulls up what we as scientists already knew to be true which is that the lake peoples got the jump on coastal scientists in terms of understanding the effects of nutrients in ecosystems. Right as I was graduating from college and moving into my science career, the topic of coastal eutrophication was taking cues from lake science and beginning to apply them and trying to understand what things were directly analogous and also applied in coastal zones and what kinds of things were different. A big one, of course, was which nutrient should we be concerned about - nitrogen or phosphorous, or both? This isn't to say that interest in lake science has dropped off but rather the relative magnitude of these things are changing compared to all other things. If you were to put football into this graph, then eutrophication drops off and then you would have a lot of discussion of football.

Many people as they're looking at nutrients for management purposes and different kinds of ecosystems are able to take the science that we produce and diagram out all of the different kinds that we're concerned about that, the causes, the effects, the factors that are modulating those. I don't want to have you focused on what's in the diagram but rather the fact that we can make these diagrams and that people who are concerned can look at what are the drivers, the sources of nutrients, what are the processes that are important, and what are the aquatic life effects.

So, before I get into the rest of the talk and really what I want to focus on here, I want to point out that I'm not going to talk about how we should manage coastal systems or technologies for reducing nutrients or particular social or economic strategies but rather some of the key things that are scientific in nature about how we can quantify things that are needed by people who are engaged in that activity. The way that EPA, through its headquarters and through Regions and also involving ORD, has been pursuing supporting nutrient management around the country is through cooperative engagements. If you've been to any of the Office of Water's regional nutrient management workshops, these are examples of finding people who are concerned or ready to move forward on some kind of nutrient management activity, maybe have an idea about the approaches that they want to consider, and they say, "how can you, with your experience, help us apply this in our particular area?" The work that I'm talking about, as well, is part of that strategy so in a way, this is the Tools and Resources webinar series, I've struggled with this a little bit because we aren't creating a website where you can go and just get your answer. I think most of our localities and our states wouldn't think that it could be distilled to that anyways. They're concerned with their local information and local concerns and they want collaborative, scientific support to tackle some of the tricky questions that come up as they're implementing those policies.

Some of these challenges that come up are how do we get a nutrient management program started? How do we get people interested, motivated to do something, and sustain it to the point that we've achieved the goals that we've set out? What are some of the analytical methods that can be applied at scale? So you might be able to go and measure dissolved oxygen at a point or go out and quantify the amount of harmful algae but if you're trying to manage a whole state's coastal waters, what are the methods that we can use? Coastal waters are temporally and spatially complex and many states and other groups grapple with how to deal with temporal and spatial complexity. Then, one of the things we've learned over the years in studying nutrient effects in water quality in coastal systems is that the mean doesn't always tell you what you need to know. You might be as concerned about extremes. So if you think about harmful algae, "how often do high biomass events occur" isn't a question that is well addressed by "what is the mean amount of biomass day-in and day-out". Similarly, with oxygen, we're often concerned with "how often you have events of low concentrations that have a biotic effect" as opposed to "what the mean dissolved oxygen concentration."

To kind of put my experience in context, these are engagements that I've had in recent years with various people around the country to talk about their nutrient management challenges and provide scientific support. I'll emphasize that across ORD, there's many, many more people in more places where we've been doing work but these are the places that I've been doing work and the problems that I've been talking about come up over and over again in these kinds of places. That's where my experience, I've put a symbol on here, which are the issues that are most coming up in different places. You see that oxygen is occurring in places, sea grass loss is important only in places that naturally have sea grasses. Harmful algal blooms are also fairly widespread.

So, to distill this down to just one more level, I was involved in some work with the state of Florida and with EPA in that area trying to grapple with how to establish numeric criteria there. The state of Florida identified that sea grass was an important aquatic life use in their state and therefore there was a need to address this challenge of bringing science to scale to the enormous number of estuaries that we have in Florida and I'll talk about that in just a second.

I was part of a work group of people from Georgia and South Carolina that were looking at the dynamic tidal environments there, the kind of oxygen issues there and how they contrast from places like the Gulf of Mexico or Chesapeake Bay that people are very familiar with. There was an interest in considering ecosystem metabolism as a parameter that we could focus on and quantify the effect of nutrient with and I'll talk a little bit about that.

Then, in Texas, and really in these across a lot of our warm water systems and actually recently I've learned that this can happen in New England as well, dissolved oxygen can be very, very dynamic and this poses a challenge for resolving “what is the natural patterns, can we reasonably set dissolved oxygen criteria that never have an effect on aquatic life? or are there places where aquatic life figure out how to make a living and utilize habitat despite periodic stressful environments?" So, establishing what is the signal of a healthy, dynamic, productive coastal system from a nutrient-impacted productive dynamic coastal system poses a challenge. California, as well, has different situations in San Francisco Bay. There is enormous nutrient inputs in San Francisco Bay but the bay itself has been resilient to those nutrient inputs for a long time but recently, there have been cracks appearing in the facade and an interest in considering what chlorophyll-a limits might be useful management targets for beginning to tackle nutrients there.

I want to start with this study that I did with a colleague Catharine Gross who was at EPA only for a short while. What we looked at was cases where nutrients had been managed in a system and where some success has been achieved, either by complete success, declaration that we achieved our goals or those goals were partially achieved through implementation of management actions and see if we could find some common attributes that might be useful for others to consider as they shape their management programs. I present this in part because I think this is something that as we have more successes around the country, we need to keep looking at what we've been doing and what's working and why it's working and why it's not working.

So what we did was identified a number of themes, what were the antecedents or what were the things that preceded the implementation of a management action. Was it a crisis where some big event happened and there was a big outcry and people said "we must do something!" Governance was about how did the people who were involved organize their policy action. Their Strategy was did we organize this policy to achieve an ecological goal. An example being Tampa Bay which set a sea grass restoration goal or were there nutrient load or concentration goal or were there a single set of actions. The strategy was "we're going to do this and after we're done, things will be solved." The Action(s) was about what nutrient loads were dealt with. The Leadership was about similar to governance but a little bit different aspects of it. Finally, the theme of what category of success. We had some where the goals they that set were achieved by their own account and at the time we were writing the paper, those goals were still achieved. In some cases, they made it part way. In some cases, they made it part way and then things started getting worse again and we wanted to understand maybe why those were happening. We had 17 sites which is really a fairly small sample. We hope to have a much larger one and I would say keeping records and ways to study these efforts could be useful.

What we did was use the multiple correspondence analysis to see which characteristics fit together and were more associated with each other and with the outcome, particularly goals achieved. What we found was, again these are four points that you might want to consider in shaping a management program, would be (1) leadership by a dedicated watershed management agency. So somebody said, "this is my responsibility to shape this." (2) Governance through bottom-up collaboration so you're involving a lot of the stakeholders as opposed to someone riding in from out-of-town and saying "okay, this is how we need to do this." (3) Numeric targets based on an ecological target and we think this relates to engagement. If you have an ecological goal, people understand why we're what we're trying to achieve and what the benefits of that may be. Finally, and (4) this a case with nutrients in many cases, it's easy to identify to largest source and begin tackling that and as soon as you do that, the smaller sources may come relatively more important and you end up ultimately needing to realize that all the sources need to be controlled. So, this is a publication that we published in the Journal of Environmental Management.

Let me move onto Florida where I mentioned sea grass is a nutrient sensitive aquatic life use. The thing that we were trying to do was use that as a hook to ultimately develop numeric nutrient criteria, including chlorophyll-a criteria. To achieve that, there's a fairly simply, really, chain of linkages, ecologically linkages, involving principally light. So, we start with deciding how deep sea grasses grew or how deeply we want them to go. In the case of Florida, the state decided they wanted to achieve, to the extent possible, recovery of sea grasses to the depth that they had previously occurred, according to whatever historical records we had. The light that is needed to grow at that depth so there's been a number of studies that look at how much light sea grasses need. It's a moving target, it's context dependent but it's important if you want to be able to go to the next step which is to understand how much chlorophyll-a you can have and still have that much light and then finally the nutrients. I'm going to show a little bit about step one and two.

One of the things we had a lot of in Florida is detailed bathymetric maps so soundings at either gridded the symmetry at great resolution or lots and lots, thousands and hundreds of thousands of bathymetric soundings. Then, we also had detailed polygon coverages of sea grass maps, which depending on where in the state, were either every two years or much more sporadic than that. We needed, as is often the case for management application, something that was consistent. A way to calculate how deep the sea grasses were growing that we could apply everywhere instead of saying, "well in this one estuary, we did it this way and in this estuary we did it that way" and then you're forced to explain why that’s reasonable and so forth. So the realization that we made that we could develop an algorithm that could pick a spot, look at all of the depths that occur in that area, and categorize the points at various depths that were either in sea grass or not and draw relationship, figure out an operational definition of what would be the depth of colonization, we validated that as well, and then run this computer script to do it over and over again such that we could get either means and distributions of depth of colonization in a segment that might be used for management purposes or if we're interested in a little more detail, you could make a map and see it within segments. This kind of approach was used to describe the kind of water clarity goals and chlorophyll goals that we wanted to see throughout the state of Florida where there were sea grasses. Ultimately, the Florida Department of Environmental Protection set their criteria for the state and this information set in to various extent to different places into those discussions. The work has been published in Estuaries and Coast and a lot of the work was done by my colleague Marcus Beck, I should point that out as well.

One of the things that we could do since we're able to automate this was process all of the sea grass maps every two years in Tampa Bay or, in fact, we could do it for all of the sea grass maps in the whole state and watch how the depth of colonization changed over time through this process of recovery that many of us know Tampa Bay experienced. Also, see how the amount of light that was available at whatever depth sea grasses were growing to at different points in their recovery, how that changed and this is useful both for understanding where other people might want to, what goals you might want to set based on light elsewhere, and then also to understand what to expect in a recovering system. As we begin to make more estuaries recover from nutrient pollution, we want to have a good idea of what to expect as they recover so that people aren't surprised, we could communicate successfully about the success of our management programs.

Moving onto the issue of low dissolved oxygen, Georgia and South Carolina had a workshop as I mentioned where the discussion there was about using metabolism, which they wanted to infer from the day and night patterns in dissolved oxygen that we can see, with the increasingly available continuous dissolved oxygen data. Many, many states are finding that they're able to put out DO (dissolved oxygen) sensors and are thinking, "well what can we do with this data, what is the most powerful thing we could do?" In Florida and Texas, where we have some places where naturally low conditions may occur, a challenge is how do we distinguish natural DO (dissolved oxygen) patterns from those that are the result of anthropogenic impacts.

And so, here, open water methods, these are not new methods. Howard Odum described the idea of using dissolved oxygen differences in day and night many, many years ago but one of the things that we're able to do now that we have more data… first of all, is to apply it extensively and second of all, tackle some of the challenges that we face in coastal waters. One of which is that dissolved oxygen patterns are variable in space as well as time and with tides, water is moving around so those tidal patterns that affect DO (dissolved oxygen) end up messing up your analysis of metabolism. We developed a method where you could figure out what the tidal effect is and filter that out if you will to get a better estimate of metabolism over time. It worked especially well in Sapelo Island which is one area where you could potentially apply it in Georgia and South Carolina. That work we published in Limnology and Oceanography Methods and again, it's a category of analyses that are increasingly possible because of the types of data that we can collect and that many states and localities are collecting and it's also something that we could automate and put into computer programs that can be made freely available. Although admittedly, not always something that just anyone can pick up and use as of yet.

So, just to wake you all up, I want to use a baseball metaphor. Let me just do a little time check here, yeah, we're doing okay. Because the point that I'm trying to make is that increasingly, we're collecting lots and lots of interesting, rich data sets with sensors, with satellite remote sensing, with mapping tools and the challenge is that the things that we're looking for, in terms of describing water quality changes related to nutrients, might have been not very obvious in the past but we can potentially make them obvious. This is, the baseball example comes from the Houston Astros which are accused of using a video camera to feed a video signal of the catcher, signing what pitch they were going to make and then they would send that to the dugout and people in the dugout would relay that back to the batter by banging on metal trashcan lids with baseball bats. A data scientist, believe it or not, did a bang up job of making this thing which people were kind of wondering how they were doing it, they were accusing them of whistling or something like that, and they analyzed the mean sound level during these baseball games immediately preceding different kinds of pitches and found that was a shift in the mean which was subtle information suggestive of what they thought might be going on. And so he went to the next level and said, "look, I've got all of this data, let's analyze this by frequency and look at the intensity" and what they found was that these, when you bang a trash can lid with a baseball bat, it makes a whole frequency response that doesn't sound like people cheering, it sounds like completely something else. So, here's the take home message: what is subtle becomes obvious when you have right kind of data and continuous oxygen data and some of the new ecological data of nutrient time-series and various things like that are ripe for using to inform our policy [inaudible].

So, here, this was an example of a data set collected by the National Park Service in the Upper Laguna Madre of Texas. A ten-year record in the critical summer season when they were worried about dissolved oxygen, they had 42,000 measurements after QA (quality assurance) and these occur on 1,800 separate days where we could calculate the daily minimum, for example, or any other kind of parameters that you would want. This graph that you're looking at is actually just one number per day. If you graph all 42,000, you just have a big wall of black. It's a tremendously rich data set and so we can quantify the kind of dynamics that are occurring at different days, in all different kinds of ways. If you have new data and you want to say, "well, if this what we see at this place that we think is okay, is this data from this other place like this or not?" We want to compare, often times people would compare the mean and say, "well is the mean DO (dissolved oxygen) the same?" Well as I was discussing, we understand that variability in DO is a much more important parameter relative to nutrients and ecosystems than the mean is. So just as a simple example of the kind of thing you can do. This is a quantile-quantile plot so each point represents the fifth or the tenth or the median or the 95th percentile of oxygen in the reference data set plotted against the same quantile in the new data set and you can see how the distribution of the reference site and the new site compares across the entire range of values. Are the low values lower or the low values similar? Are the high values the same or are the high values higher? That kind of thing. So, like the one in the lower left is consistently lower across all the percentiles. The one in the upper left is very similar at high levels but has higher DO (dissolved oxygen), higher minimums if you will than the reference site did. So, this is a sensitive way and other kinds of tools like this you can calculate the variability and uncertainty around these things using computer intensive analytical techniques that we wouldn't have talked about using, particularly in a management context a number of years but they're very attractable things today.

So, San Francisco, and this is my final example, is a bay that receives very high nutrient inputs from the very large population that lives in the watershed and immediately around the bay but has been somewhat resilient compared to other coastal ecosystems to nutrients. One of the things that we were looking at and I was a part of a work group looking at the issue of chlorophyll-a thresholds is what are ways that we could use to detect that things are beginning to change and find a scientific rationale for chlorophyll-a thresholds that we could link to something we're concerned with. So, here's an example for two end points: harmful algal blooms and for low dissolved oxygen. In both cases, we have an aquatic life-based definition, there's a HAB (harmful algal bloom) alert level that people who are experts in the toxic algae say these are the cell counts that we think you need to have be below before you start having effects. In the case of oxygen, a similar thing - 80% saturation which as far as the rest of the country is concerned, those are very high levels but that's what the local people say is their action level. And so, these are conditional probabilities. So instead of saying "how does the mean dissolved oxygen vary when you increase chlorophyll-a?"... that would be sort of another kind of approach you could use. We instead say, "what is the probability that we don't achieve this goal of 80% [saturation] if chlorophyll is at this level or less, or if it's at this higher level or less?" And one could look at it at different ways like if the goal is to make sure that we have 80% or more saturation at least half of the time, you could set one limit for chlorophyll. If you could say we want a high degree of confidence that we achieve that then you could set a lower chlorophyll-a that's based on a confidence limit, an upper confidence limit. And the same kind of analysis could be done for HABs (harmful algal blooms) and this work is described along with some other analyses in a paper led by Martha Sutula who's from the California community and I and some other colleagues from ORD were involved in working on that.

So, let me just bring it back around to the way that we want to work on nutrient management in coastal zones in particular because of their complexity. The idea is, as we've done in the past, to use collaborative work to support nutrient management in whatever states are interested in moving forward on particular issues in their state. In order to do that, we're continually working to develop new methods and approaches that we can bring, demonstrate in that collaborative work and share our experience from one state to another where is there is analogous problems. These things could address things like quantification of aquatic life use end points, better understanding risk and uncertainty in the water quality analyses, and ways of considering spatial and temporal variability. So, again, as someone who goes around to New England and the Mid-Atlantic and the Gulf Coast and occasionally the West Coast, I see things and other colleagues like me see things that are coming up over and over again and we can bring that information together with folks that have the most knowledge at the local issues and concerns and we put those things together to develop effective ways to scientifically to address the nutrient management challenges. And with that, I'll conclude.