

APNEP Scientific and Technical Advisory Committee

North Carolina Department of Environment & Natural Resources Regional Office
Fall Meeting Notes, October 15, 2009

STAC Members Present: Richard Anderson, Mark Brinson, Robin Dennis, Don Field, Joel Fodrie, Joe Fridgen, Dick Hamilton, Peter Kalla, Wilson Laney, Robert Reed, Ken Stolte, William Porter, Enrique Reyes, Wayne Robarge, Joe Rudek.

Agency Science & Technical Liaisons Present: Kathy Rawls (NC-DMF), Kelly Ibrahim (NC-DSWC)

Guests and Invited Speakers: Gary Shenk (USEPA), Paul Angermeier (Virginia Tech), Amy Villamagna (Virginia Tech), Marion Deerhake (RTI), Jing Lin (NCSU), Heather Jacobs (Pamlico Tar River Foundation), Anna Maria Garcia (USGS)

APNEP Staff Present: Lori Brinn, Dean Carpenter, Todd Herbert, Jimmy Johnson, Chad Smith.

Call to Order: Wilson Laney, STAC Co-Chair, called the meeting to order at 10:05 AM and welcomed all the committee members, staff, agency liaisons and guests. Wilson noted the meeting theme is the second in our series on Ecosystem-Based Management (EBM), and will deal with models to support EBM.

APNEP Update: Dean Carpenter

- Dean welcomed everyone as well. He introduced APNEP staff, noted committee member resignations which had occurred since the last meeting, and introduced new members who were present with us at this meeting for the first time.
- The next two STAC meetings have already been scheduled for February 2 (winter) and May 5 (spring).

Nutrient Modeling as a Tool to Support Ecosystem-Based Management: Gary Shenk, U.S.

Environmental Protection Agency. **note: presentations can be found in their entirety on the STAC website in the "members only" section. "Rough outlines" are provided in the notes.*

- Dissolved oxygen (DO) and nutrients are the two primary indicators that the Chesapeake Bay Program (CBP) staff is using for water quality. As the nutrients are reduced CBP should attain their oxygen goals, and as they reduce sediments they should attain their submerged aquatic vegetation (SAV) goals. Gary provided a list of CBP partners, including the governors of Virginia and Pennsylvania, and other states and federal agencies. Gary noted that he would address how they are using models to address the total maximum daily load (TMDL) allocations.
- Gary reviewed the CBP Decision Support System and how the models are used within that framework.
- Gary first reviewed the CBP Land Use Change Model. He noted that all the models are complex. This one has two sub-models: a Growth Allocation Model (GAME) and a Cellular Automata model (CB-SLEUTH). Gary explained what the two sub-models do. The GAME model predicts future urban area. The CB-SLEUTH takes information on slope, impervious cover and so forth, and forecasts the location of future development. The algorithm is run repeatedly, using a Monte-Carlo approach, to yield probabilities for land conversion.
- There have been a number of watershed models used since the 1980's. Their complexity has been growing at an exponential rate, which modelers embrace. The questions have also been getting

ever more complex. Early models indicated that non-point source inputs were the major problem, not point sources. The new supports the CBP TMDL and is being developed by multiple partners, including EPA, UM-CES, USGS, NRCS, CRC, VPI.

- The Phase 5 Watershed Model improvements over Phase 4 include much finer segmentation and improved functionality. The model entails automated file creation and modification in a LINUX scripting environment.
- The model is open-source and is already available on the web. It is already in use for various studies. Once completed more use is anticipated. Virginia will be using it for some low-flow and water quality studies.
- Scenario-Builder feeds data into the model. The need for this was two-fold. In the past, inputs were done by spreadsheet, but that isn't possible now.
- Gary presented some sample input and output.
- The Estuarine Model is a mass-balance type, run through time. The latest version has circulation and hydrodynamics, water quality (DO, clarity, N, P, and sediment); algae; zooplankton; SAV, oysters; benthos and Atlantic menhaden.
- Gary explained the refined designated uses for Chesapeake Bay and tidal tributary waters. The Bay is divided into habitats, each habitat with bottom, middle and upper layers, each in turn with a defined oxygen level. They use it to determine the appropriate water quality based on living resources within that habitat. They can look at distributions through space and time, to determine if they match what you would expect to see in a healthy ecosystem.
- Gary explained how they will use the entire system for TMDL re-allocation. The 2003 allocation goals were not met, so CBP staff is in negotiations with state representatives regarding how to re-allocate the TMDL. The "pie" to be allocated is 200,000 pounds of N. This is of concern to the states.
- A question was asked if these models could be applied in other systems and what sort of potholes might we run into if we applied the models to Albemarle Sound. Gary noted they made them open source, specifically so others would use them.
- Another question pertained to why the 2003 goals were not met. Gary advised they were difficult and expensive. CBP can say what needs to be done from a scientific perspective, but the program has a budget which is about one percent of what would be needed. Farmers are business people, so you either have to pass a law, or pay them to implement appropriate measures. Assessors can say what is needed, but the pressures have to come through the political system.
- A question was asked if the model has been used to hindcast and draw conclusions as to why SAV changes have occurred. Gary said that the data from Bob Orth (VIMS) was used to predict where SAV was expanding and where it was shrinking.
- A question was asked whether there was wetland modeling in the Bay. Gary indicated there aren't that many wetlands in the upper part of the Bay, so they aren't included. Tidal wetlands are a feature of the estuarine model. They aren't predicting changes in wetlands, but others are doing so.

Modeling the Atmospheric Deposition of Nutrients: Robin Dennis, U.S. Environmental Protection

Agency. **note: presentations can be found in their entirety on the STAC website in the "members only" section.*

"Rough outlines" are provided in the notes.

- Robin indicated that he would address in more detail the CMAQ model, which Gary had addressed. Robin noted that the STAC likely hadn't been exposed much to air quality models. He noted that he would show us the rate of N deposition across the Albemarle-Pamlico (A-P) region, discuss the special case of ammonia, as well as touching on some other topics.
- Robin explained the model and its constituents. Fossil fuel combustion that produces N and sulfur oxides and agricultural production that produces ammonia are the main sources. The

partitioning between gases and particles, which is determined by ammonia availability, greatly affects concentrations.

- Robin noted that he would demonstrate CMAQ performance. The deposition estimates were adjusted for precipitation. Model wet deposition estimates are compared with National Atmospheric Deposition Program (NADP) estimates. Precipitation-corrected wet sulfate (SO₄) deposition has the least uncertainty because the outputs are monitored at the source. If we have the right inputs, the model is good.
- Robin reviewed what deposition looks like across the A-P Region.
- Robin addressed where the N is originating. He showed the airshed which contributes a majority of N deposition to the A-P region. The airshed extends from northern Florida, into Pennsylvania and Maryland. The multi-state dimension makes management more complex.
- Robin presented deposition forecasts to 2020. The Clean Air Act regulations are expected to reduce emissions significantly over time. Even with these emission reductions, the relative contributions from each state don't change all that much. Robin showed the predicted changes. There is more than a 50 percent reduction in oxidized-N emissions in the A-P. However, the reduction in total N is much less, however, due to reduced-N increases.
- Robin shared his conclusions. Regional atmospheric deposition models like CMAQ can provide useful information for EBM related to the questions of how much, what form, and source. This isn't a trivial exercise, and more work is needed on how the models relate to each other.
- Robin indicated that this information is available and that he is the contact person.

Watershed Nutrient Transport Models: Marion Deerhake, RTI International's Global Climate Change and Environmental Science Unit. **note: presentations can be found in their entirety on the STAC website in the "members only" section. "Rough outlines" are provided in the notes.*

- Marion noted that she is the Project Manager for the project, but Michele Cutrofello was the Principal Investigator. Keith Little, Randy Waite and Anne Rea were also involved and provided support.
- The work done was for the Aquatic Nutrient Enrichment case study. The Neuse case study site was chosen due to data richness and availability. RTI did three of the case studies, and they involved more than one location. The other basin, besides the Neuse, was the Potomac.
- Marion reviewed the study methods. They needed to incorporate atmospheric deposition effects over the watershed in ecological assessment of receiving water bodies, and must use methods that allowed for extrapolation.
- They used SPARROW, which empirically relates N source loads within each defined watershed catchment to in-stream N loads. Other assets include NOAA's National Estuarine Eutrophication Assessment (NEEA) which examined more than 140 US estuaries.
- One point of the study was to take the two assessment methodologies and create a link between them.
- A 2002 base year was used, and SPARROW was calibrated to those data. For the 2002 run, the overall conclusion was that eutrophication potential was high, and condition was "bad." This was a screening level, annual assessment. They attempted to determine if reductions in atmospheric N deposition load would help the estuary improve eutrophic conditions. The study revealed that other land-based N sources so dominate in-stream N loads that reductions in atmospheric deposition do not make much difference. Marion indicated that the work is available on the web. She encouraged us to contact Michele if we had specific questions.
- Gary Shenk indicated that it seemed to him that this was a good way to use SPARROW. He noted that the national developers seemed resistant to using SPARROW in this way, and he asked if Marion's team worked with them in this way.
- A question was asked about why N was a parameter used for a standard, and ammonia isn't?

Robin noted the air quality criteria were set in the 1970's from a human health perspective, and no one considered ammonia. Robin noted that we have never been close to an SO₂ standard violation, but ammonia is a big gorilla on the plate. The lawyers are saying that the standard can't be changed without changing the Clean Air Act. Marion noted that this work was done as part of a court-ordered action.

Nutrient Modeling within the North Carolina Division of Water Quality: Jing Lin, North Carolina Division of Water Quality. **note: presentations can be found in their entirety on the STAC website in the "members only" section. "Rough outlines" are provided in the notes.*

- Jing noted that she had put some figures on the screen comparing the Chesapeake Bay to the A-P Sounds. The Bay is the largest estuary in the US but the A-P is the second, in terms of surface area. One major difference is depth. The average depth in the Bay is 7.6 m, whereas in the A-P the average is 4.5 m. The areas are: Bay = 64,000 square miles; A-P = 30,880 square miles. The Bay has a 7-month residence time, whereas the A-P has an 11-month residence time. A longer residence time usually means more problems, but that is not necessarily true for the A-P. In the Bay there are some problems zones where the DO is zero at times. In the A-P region the sounds are generally without problems, with regard to DO or chlorophyll. The problems are more in the tributaries, like in the Neuse River estuary.
- There are only three places which emerge nutrient-related problems: the Tar-Pamlico, the Neuse, and Falls Lake in the upper Neuse Basin. She noted there are a couple places in the basin which are impaired by turbidity.
- The model suggested that Washington is the critical region. Chlorophyll-a was violated 18 percent of the time at Washington; with the concentration reaching as high as 70 micrograms per liter (state standard is 40). The model suggested that a 45-percent total nitrogen (TN) reduction was needed to avoid any chlorophyll-a violation. Considering model uncertainty, PS treatment technology and other factors, EPA accepted a 30-percent reduction target.
- The Neuse River TMDL was developed using three models. CE-Qual W2 (NEEM); a Bayesian Ecological Response Network (Neu-BERN); and the Water Analysis Simulation Program (WASP) which was applied by EPA.
- The third problem area is Falls Reservoir. This one is driven by state legislation, Senate Bill 981, which requires a nutrient management strategy be developed for any water supply. Jing showed us a graphic to illustrate what is happening in the Falls Reservoir. The map showed the percentage of time in which the standard has been violated. The highest level of violation consistently occurred in the upper portion of the reservoir, from below Ellerbe Creek into the headwaters. As you move downstream, conditions are better.
- The model package being applied to Falls Reservoir is EFDC. The data used for calibration were from 2005-2007. Jing noted that 2006 was a relatively wet year, and 2005 and 2007 were both very dry. Jing showed us how the model performed with lower and higher chlorophyll-a concentrations. She presented model results statistics. Interesting findings from the model include information regarding what is limiting algal growth in the reservoir. Limiting factors include nutrient and light upstream, and nutrients at the downstream end of the reservoir. In the upper portion of the reservoir P is limiting, but as you move downstream P and N limitations are about equal, each 50 percent of the time.
- A question was asked if they had been able to draw any conclusions about changes in land use, relative to the violations. Jing noted they didn't have enough data at that time, to say whether there was a trend or not.

Network Modeling of Estuarine Nitrogen Cycling: Bob Christian, East Carolina University. **note: presentations can be found in their entirety on the STAC website in the “members only” section. “Rough outlines” are provided in the notes.*

- Bob has been working with other colleagues for some years on what is called network ecology. His focus today will be on applications of some of this network approach to the issue of eutrophication. Often work on eutrophication is disconnected from trophic structure and dynamics, as well as other biological parameters. Network analysis has the potential to do some cross-bridging between the two.
- Network ecology is as an approach to ecology based on the perception of nature as networks of interactions. These networks of nodes, which are compartments, standing stocks, are connected by flows (arcs) and it is presumed that they do model what nature really is.
- Bob addressed N cycling, as well as briefly touch on food webs. Network analysis is actually plural. It is a group of analyses which are good at categorizing system parts relative to others, evaluating indirect interactions and relationship(s), and index system-level conditions.
- Bob’s focus today is on the Neuse River Estuary, with a turnover time of about 50 days. His research team became involved because of some work they had done in the 1980’s. Bob noted that network analysis provides an opportunity to pull together data from a variety of studies done for different reasons, and ask if the data make sense when put in the context of each other.
- Two more measures derived from network analysis: Finn Cycling Index (FCI) gives you an idea of how much of the total flow is involved in cycling, and second is to look at the total dependence by one compartment on another. Bob explained that within the 16 seasons, 90 percent of the N was caught up in cycling, but only about 10 percent is involved in transport. There is a pronounced cycle evident, with phytoplankton more dependent on the sediments during the summer. In winter pelagic cycling is more important.
- Bob explained exports of loaded nitrate-N. He also reviewed the effects of Hurricane Floyd. Bob noted the latter analysis shows that a lot of N can be blown out of the system, during hurricane flow conditions.
- In summary, processing of N is substantially more than loading, i.e., recycled N dominates processing. Recycling is associated with the short turnover times of microorganisms during the relatively long residences times, etc.
- It becomes much more complicated when you look at the entire food web.
- A question was asked if there was any difference in the recycling behavior after the hurricane. Bob indicated that was an extrapolation. They had data from the 1980’s, and the hurricane came in 1999, so they don’t have any data to assess. Bob noted that research following Hurricane Floyd, there was a very quick return (a matter of months) in terms of nutrient concentrations. Salinity took a month longer. For chlorophyll, the lag was longer by a couple of months.

Modeling and Mapping of Ecosystem Services and Human Well-Being: Paul Angermeier, Virginia Polytechnic Institute and State University. **note: presentations can be found in their entirety on the STAC website in the “members only” section. “Rough outlines” are provided in the notes.*

- Paul noted that this is a new project, just beginning, and they have no results yet. They are primarily here to learn. There are a large number of collaborators. They have a lot of experience with fishes, and little in the A-P Basin
- Freshwater ecosystems are very threatened, based on global assessments. Current management of ecosystems is failing to protect aquatic biodiversity.
- A figure depicted the relationships between ecosystem services, human well-being, and biodiversity conservation. These relationships haven’t been well-documented.
- A flow diagram depicted potential costs and benefits among ecosystem condition, conservation

actions, ecosystem management policies, human well-being, and so forth. Their work will focus on conservation actions, capacity to provide services, biodiversity, etc.

- Paul's research team selected the A-P Basin for a variety of reasons. Paul presented an ecological profile for the A-P. There are four large rivers and three physiographic regions; the second largest estuary in the US, eight diadromous fish species; 350 bird species; major fisheries for blue crabs and oysters; three million people, many animal and plant species at risk; 11 federally endangered animals, and climate change impacts coming.
- Four main things to address: what are the spatial linkages among biodiversity conservation? Aquatic ecosystem services (AES) and human well-being (HWB) across a landscape. When and where do actions and practices to conserve biodiversity enhance or diminish delivery of valued AES? When and where do different conservation actions reinforce or undermine each other's societal benefits provided via AES? And to what extent does biodiversity contribute to HWB?
- They have many partners: APNEP, Audubon NC, EDF, TNC, USFWS (Pete Benjamin) and USGS (Andrea Ostroff). They have enough funding for two years of work. They are looking for more partners. They are looking to build this to a larger group. They will focus on four AES: water supply, water purification, N regulation and wildlife-based recreation (bird-watching and fishing).
- There are seven tasks: define and map current capacity for focal AES; define and map current flows of focal AES; define and map current conservation actions; define and map current human well-being; analyze spatial relations among components in Task 1-4; develop and map scenarios of plausible future conditions in the A-P; and conduct workshop to present findings to stakeholders.
- Possible conservation actions include: establish reserves, restore wetlands, and riparian zones; apply easements, and implement best management practices.
- Products will largely be maps. They will produce conservation actions; availability of focal services, threats to service availability use of focal services, and maps of human well-being.
- Their conceptual model of N regulation capacity was less complicated than the models presented earlier. Loading, conversion and retention are the three main elements.
- Paul closed with a map showing forest, wetland and swine lagoon land cover in the A-P watershed. He noted there is a lot of spatial variation, and in terms of N regulation. Also, the map indicates that the retention, versus regulation areas will be largely separate. The ability of catchments to work things out isn't very good, because of the spacing of the loading and retention capabilities.
- A question was asked if they were working with economists to monetize the services. Paul responded, "No." They realize that may be ultimately important and they want to create products that lend themselves to valuation.
- Another question was asked about real estate values being in the list for human well-being. The answer being "not yet."

Panel Discussion, Integrating Nutrient Models to Support Ecosystem-Based Management in the Albemarle Pamlico Basin: Leadoff speaker, Gary Shenk.

- Gary had some questions about how the APNEP and STAC want to attack these issues. He had some questions: What are the ecological endpoints? What are the stressors? Is there a conceptual model? He wanted to know what the resources are that the program has to get some of this modeling done. Also, what is the constituency? Does the STAC help the modelers and scientists answer these questions?
- Are there ecological end points? Dean noted that APNEP has gone through an indicator development process that includes developing those endpoints. APNEP has six resource components: living aquatic, water, wetlands, terrestrial, atmospheric, and human dimensions.

- They are working with the managers to develop specific targets.
- Gary asked if the program has the resources to support a modeling effort. He noted that APNEP could piggyback off other efforts; hire people internally; or get grants to do the work. The CBP do all these approaches. CBP funds specific modeling work and EPA does some. Dean noted that APNEP currently has a very small budget, especially in comparison to Chesapeake Bay. Dean wanted to discuss what the best mechanism is for getting the work done here. The STAC has done six technical issue papers, and another could be used to address this issue.
 - Richard Anderson indicated that he wasn't sure about the value of integrating this into a massive model. There is physical work going on, and the challenge will be to understand if that is getting us where we want to go. He is interested in the ecosystem service benefits of restored oyster reefs, on a more local scale.
 - Gary asked Robin if he has already broken out atmospheric loading, and are those available. Robin indicated they are available through the Coastal Carolinas Program at EPA. They are available for use, but there has been nothing to which to hook up. Gary noted the watershed portion between Robin's model and Jing's model is missing. Robin noted they have been using the output to determine where they should be looking. He wasn't sure that we have as big a driver here. TMDL's address smaller pieces of landscape. In a way, it is more a boon than a bane if you want to address the entire system. Robin noted that we haven't really thought about the entire basin yet. We are coasting on the Neuse 30 percent. We don't have another target in terms of regulations which is being forced upon managers.
 - Joe Rudek noted that some presentations he saw on the Neuse and on the Tar-Pamlico indicate that many management actions are being taken, but you aren't seeing any benefits. You are seeing reduced loading, but increased chlorophyll. Adaptive management requires some monitoring in order to assess your assumptions. NC-DWQ has recommended looking at small watersheds; atmospheric loading; and finally storm water regulations and whether those should be expanded over the entire basin. The TMDL management Team is trying to get some things going.
 - Jing clarified that the initial goal was to have 30-percent N reduction. Later, the model was refined for 1998 and 2000. Between 1995 and 1998 there was already some decreasing trend. The 1998-2000 period met the less than ten percent standard. One model said that an additional five percent reduction was needed, but another said things were fine. Joe Rudek noted that there was just recently a huge fish kill, so there is still work needed.
 - Gary asked if he understood the monitoring was rather sporadic. Is that correct that there is no consistent, long-term monitoring of the rivers? Jing thought that the MODMON was ongoing. It was stated that monitoring in the estuary was ongoing for a long time. There isn't much intensive monitoring above that point. Joe Rudek noted that basins are done every five years, and one year during that interval is intensive. It includes both biological and chemical.
 - Gary noted that monitoring is difficult to do in a free-flowing river, unless you have 20-25 stations per year, and at ten-year time series. Monitoring one year out of five, will not yield meaningful data for adaptively managing. He asked if this group was interested in having a larger monitoring program.
 - Marion suggested that we consider test-driving the ASET system. Another thing is the obvious gap in state policy with regard to deposition and how to reduce inputs. The water and air quality divisions need to come together and look at the entire system. It will be difficult to craft common regulations. She felt that it would be beneficial to develop common philosophy.
 - Peter Kalla indicated that there is another potentially beneficial modeling effort. It is about restoration and protection at the watershed scale. North Carolina is being used for the pilot project because it is data-rich. The ultimate goal is to come up with a product that can be used all over the country. The project is called the Watershed Index Project.
 - Gary noted that developing these types of models is expensive, but linking them is less costly.

Sometimes you can pay relatively little and get models hooked together. It isn't trivial but it is cheaper than developing them from scratch.

- Wilson noted that we had deferred our lunchtime discussion until now, and asked members or guest to toss out any additional topics of interest. These would be used for future issue papers, theme-based meetings, or workshops. There were none forthcoming. Wilson asked that members who thought of any send them to Dean via e-mail.

Meeting adjourned at 3:06 PM.