Delaware Center for the Inland Bays Scientific and Technical Advisory Committee Meeting

February 1, 2019 - 9:00 AM to 12:00 PM
DNREC Lewes Field Facility

Attendees:

STAC MEMBERS	CIB STAFF	OTHER
Scott Andres, Chairman	Chris Bason	Aaron Givens
Ed Whereat	Marianne Walch	Dominic DiToro
Sergio Huerta	Andrew McGowan	A. G. Robbins
Chris Main	Michelle Schmidt	Ashley Norton
Claire Simmers	Bob Collins	Guni Ozbay
Robin Tyler		Amanda Zahorik
Andrew Homsey		Bruce Thompson
Bill Ullman		Nicole Rodi
Tyler Monteith		Kate Fleming
Ellen Dickey		Jeffrey Cornwell
Kathy Coyne		Ben Anderson
Bob Stenger		Mike Bott
Richard Watson, Secretary		Stacie Flood
		Mike Owens
		Olivia Devereaux
		Mark Nardi
		Bill Hitz

The Meeting was called to order at 9:05 AM by Chairman Scott Andres

STAC Announcements – *Dr. Scott Andres* - None

CIB Announcements – *Dr. Marianne Walch*

1. Sea Grant Proposals are due February 8, 2019
2. USGS Water Resources Research National Competitive Grants Program due in two weeks. Marianne will send the announcement to all STAC Members.
3. 2019 STAC Meeting Dates
    a. February 1.
    b. April 26,
    c. July 26, and
    d. November 1

The meeting focused on the issues and experience in development and use of estuary hydrodynamic and water quality models and the lessons that can be applied to modelling of the inland bays.

Speakers

"A lifetime of modelling and lessons learned" by Dr. Dominic DiToro of the University of Delaware

What can a model do for you? A model is more like a violin and not like a radio. It must be operated by trained personnel. Models often get a bad reputation because they have not been operated by trained personnel. In addition, you need a quantitative estimate of what the result should be to actually determine what is going on when you view the model results. Dr. DiToro cited the example of modelling performed on the Potomac Estuary in 1982 as part of their phosphorus removal program. They were trying to determine "what" was causing the high phosphorus concentrations. Were the high concentrations caused by a point source? A release of sludge from the bottom of the estuary? Upon analysis, it was found that the nitrogen levels had not increased so a sludge loading was ruled out. The model provided information on what to expect (baseline) which helped identify the source of phosphorus loading being released from the sediments.

Dr. DiToro then discussed how models can be used in remediation. If you install a wastewater treatment system as part of your remediation, you should have some idea what the expected effluent will be and how it will impact the environment. Generally, a mass balance calculation should be performed. Without the predicted outcome, you really have no idea how successful your remediation work has been.

With respect to the Delaware Center for Inland Bays model, Dr. DiToro indicated that it is an unusual situation and suggested using available models. He made the following suggestions for improvement to the existing model:

1. Compare the known loadings with available water quality observations – are you getting reasonable agreement (e.g., removal of Rehoboth WTP loading);
2. Identify unusual concentrations (excess) of nitrogen and phosphorus and low dissolved oxygen;
3. Interpolate survey data; and
4. Eliminate unnecessary stations if you are not getting useful data.

He suggested possibly contracting with a local University to review model and data. You need to know how accurate your results are

***Question "What does the model cost to develop (typically 20% 0f cost)"* -** The majority of the cost is the collection of the required field data. DCIB should check with DNREC to determine what

data is currently available. Most eutrophication models have not changed in the past twenty years.

Question "Does DNREC operate models in the recommended manner for other water bodies in the state?" – Yes (Sergio Huerta) – DNREC operates many different models with the challenge being obtaining the quality input data required. They have contracted with companies to assess the quality of the databases used. Often for contracted laboratory work, there is insufficient QA/QC and documentation of the work performed and in some cases missing data. In order to fuel a model with reliable data, there is a question about the reliability of existing data.

Data collection is performed often for "legal reasons" and not scientific reasons. Dr. DiToro suggested that it was not a good idea to wait until you had collected all of the data that you believe that you need. Initial calculations should be performed to make sure that your assumptions are correct and that you are obtaining the answers that you expected. He indicated that the goal of the modelling should be developing the simplest model that works. It was also suggested that the data may be generally correct and could be cleaned up by eliminating the outliers. There was a general discussion about options for models including one example of a model that was prepared with an Excel spreadsheet that worked perfectly. Accurate calibration of the model is also critical. Dr. DiToro also cited Kirby's Law which states that "Everything out of computer is wrong until demonstrated correct".

Question "Politics – The way it has always been so nothing can change" Politics is often the reason why the problem is the way it is. Unless you understand the sources and the loadings, you can not solve the problem and can not effect the needed changes. He cited the Potomac Estuary study in which the unknown mechanism was the phosphorus coming out of the sediment.

"Modelling diel-cycling hypoxia in the inland bays" by Dr. Damien Brady of the University of Maine (via internet)

Dr. Brady addressed the general issues of water quality modelling in Delaware's Inland Bays by discussing where we have been and where should we go. He provided the following brief timeline of work performed:

1988-1990 - Water quality dataset was developed for use with CE-QUAL-W2 Water Quality Model. This was the same model that was used for the Chesapeake Bay modelling. In 1998 the TMDLs were developed from the output of this model. Model is highly resolved in the Indian River area which is critical. The model incorporated benthic algal model, which was innovative for the time. Model exists "somewhere" and should be available.

1998-2000 – Generalized Environmental Modelling of Surface Water System (GEMSS – Ettinger and Associates) was used; the model summarized all of the data available at that time. Summaries of the output data are still available.

Current water quality models do not use data later than 2000 which means that almost 19 years of data are available but not incorporated. During 2001 and 2002, significant additional data had been collected. Dr. Brady reviewed the model resolution (about 2 meters in the Indian River area) and discussed other aspects of the model.

Dr. Brady indicated that models can be incredibly useful and are not more than data analysis tools; they represent what we know of a system and allow us to ask why is it not acting the way we think that it should. Dr. Brady then offered the following as to how models are useful:

1. Establish TMDLs;
2. Estuarine productivity for aquaculture;
3. Evaluate zones of hypoxia;
4. Testing hypotheses (e.g., groundwater discharge as a nutrient source);
5. Provide data visualization;
6. Consulting firms only do what is asked; you need to visualize output and ask the right questions;

He indicated that you do not need "in-house" modelling capability necessarily but you do need to be able to ask the right questions to make the modelling efficient and useful. He then reviewed the estuary conditions that must be addressed for nitrogen and phosphorus.

For the modelling, Dr. Brady indicated that the physics of the system must be accurately represented. He offered the following:

1. The tidal cycle must be accurately incorporated into the model.
2. The temperature variations must be known (e.g., power plant database).
3. Volumetric flow data must be included; the original model was run using data from 1990. The depth of the Indian River has changed significantly since then. In order to properly assess flushing, you must have good data.
4. Salinity predictions should be obtained for new model even though they are difficult to obtain in mixing (meso-haline) zones.
5. Unstructured transport grids would be very useful in the new model.
6. The model should be run with current hydrographs and projected hydrographs. Year 1998 was a very wet year and was used to calibrate the model. Model was validated with Year 2000 data. Since then there have been 19 years of hydrographs that can be used.
7. Diel-cycling hypoxia should be incorporated, most models are not designed to capture this data. Most dissolved oxygen sampling does not account for variation in DO concentrations.
8. Spatially intensive sampling efforts should be considered.

Dr. Brady provided additional review of data plots for the previous model and other models. He particularly noted the Pepper Creek modelling. Phosphorus storage is also a consideration with the hypoxia and should be considered particularly in shallow areas. He will forward additional data to Andrew McGowan.

Question - Is it your view that diel-cycling will be major water quality issue? Yes, ultimately water quality standard violations will occur, particularly in shallow areas.

Question – Will the calculation methods in the new model be the same? Yes.

Question – In your research at Pepper Creek, did you follow the fish through the hypoxic zones? Was there any short term movement by the fish? Yes, the fish moved with the tide and ultimately left the bay when the hypoxic zones fully developed. There was extended discussion on this issue.

Question – What areas of improvement are needed for the new model? The original model determined the levels of nitrogen and phosphorus required for healthy dissolved oxygen. If the model did not do a good job, did it setup the wrong TMDLs? No, diel-cycling of oxygen data was not available at the time the models were run. The model is setup for longer time steps(weeks) and could be adjusted to account for diel-cycling by changing the time step.

Question - How well are the loadings going? A general discussion concluded that we could estimate the loads better now.

"Benthic Nutrient Cycling in Mid-Atlantic Coastal Systems" by Dr. Jeffrey Cornwell of UMCES

Dr. Cornwell focused on sediment issues and began his presentation by describing the various research areas on which he has been working. These areas include:

1. Impacted coastal areas in the Chesapeake Bay, New York, the Delaware River, San Francisco Bay, Philadelphia Water System, and the Delaware Bays (St. Jones, Assawoman, and Indian River);
2. Shallow photic systems (Chincoteague Bay, Tampa Bay, Florida Bay estuary and wetlands, and Long Island Bays);
3. Oyster Restoration projects; and
4. various wetlands restoration and dredged material related projects.

Dr. Cornwell then reviewed the nitrogen cycle specifically as it relates to sediment loading. Nitrogen is a major control within the coastal systems He indicated that the following were major controls that affect nutrient loading:

1. Overlying Water Dissolved Oxygen (e.g., Chesapeake Bay);
    a. Low DO leads to high P fluxes from the sediment;
    b. Low DO limits nitrification and leads to low rates of denitrification and high rates of ammonium fluxes; and
    c. Low DO can cause the loss of micro-fauna that promote denitrification (20-30% ultimate fate for nitrogen).
    d. Not much denitrification in spring and none in the summer doe to low oxygen concentration; and

    e. You need nitrate to denitrify.
2. Photo-synthetically Active Radiation (PAR) – showed Dr. Cornwell sowed the impact of photosynthesis by comparing various nutrient fluxes under light and no light conditions;
3. Animal Activity – they ventilate and mix sediments;
    a. Animals key in Jamaica Bay study;
    b. Worms and amphipods tend to increase denitrification;
    c. Clam aquaculture leads to higher effluxes of ammonium with no change to denitrification; and
    d. Oysters in bottom aquaculture tend to increase denitrification.
4. pH – Described study in Sassafras River in Northern Chesapeake Bay - Elevated pH result from blooms taking out CO2. Elevated fluxes of soluble reactive P and ammonium result in higher pH values which inhibits nitrification/denitrification;
5. Organic matter; and
6. Season and temperature – (e.g., spring blooms in Chesapeake Bay in cooler conditions).

Dr. Cornwell then briefly described sampling and testing methods and discussed "sediment memory". The most labile components of algal organic matter (including C, N, and P) are re-mineralized in weeks. Year to year carryover of labile organic matter is relatively small. Sediment inorganic P can be a legacy in some circumstances particularly with increasing anoxia.

He then made the following recommendations:

1. The sampling should account for seasonal variability. He suggested conducting a minimum of three sampling times with four preferred.
2. There should be spatial variability accounted for by having at least eight sites with duplicate cores and sixteen additional sites with single cores.
3. For modelling you need to analyze for grain size, pore water chemistry, solid phase analyses.
4. Sampling locations should be representative of different environmental conditions including dead end canals, open water "clean" sites, and shallow and deep sites.

Question – With shellfish with high densities everywhere, is dominant specie influencing? Yes, with increasing surface area oxygenated by the animals increasing nitrification and denitrification. Oxygen is injected on a three dimensional basis. Coring must be done to capture the differences. Because the organisms are pumping, there is a concern that you do not know how many animals are within the area being sampled.

Question – For cyanobacteria with pH greater than 9.2, are these systems N or P limited? Yes, P is limited; however, when the nitrogen level decreased the algae decreased. These blooms can sustain themselves by bringing in nutrients from the bottom but what is the trigger for the bloom. There was substantial further discussion.

Question – Are there fish kills in high pH areas? The ammonium was taken up fairly quickly so concentration did not get too high and there were no fish kills. The DO level remained the dominant condition.

"Developing a Terrestrial and Management Model" by Olivia Devereaux of KCI Technologies

Ms. Devereaux described the Terrestrial and Management model's purpose as a means of improving the water quality in the Inland Bays. The model will:

1. Identify the sources of contaminants, where they come from and how can they be controlled;
2. Determine which management actions can be targeted to control the pollutants;
3. Assess the effect of management actions on water quality delivered to the Inland Bays via:
    a. Change in land use;
    b. BMP's;
    c. Cropping Actions; and
    d. Other actions.
4. Assess the impact of climate change on pollutant loads delivered to the bays.

She then described the "What If" questions a Terrestrial/Management model can answer:

1. Stormwater requirements for inches treated;
    a. Runoff reduction; and
    b. Stormwater Treatment.
2. New Development/Land Use changes;
3. Agricultural tillage management;
4. Wastewater spray irrigation impact;
5. Climate change impacts Hydrologic changes); and
6. Combinations of BMP's on limiting nutrient application s and runoff.

There are two existing models that can be used to evaluate the effects of management actions and climate change: Chesapeake Bay's CAST Model and the USGS Sparrow Model. The CIB Terrestrial and Management Model could simply use data from Sparrow and CAST.

SPARROW models **SPA**tially-**R**eferenced **R**egression **O**n **W**atershed Attributes (https://water.usgs.gov/nawqa/sparrow/#) are used to estimate long-term average values of water characteristics, such as the amount of a contaminant that is delivered downstream, on the basis of existing monitoring data, location and strength of contaminant sources, and characteristics of the landscape. Modeling results can help managers determine how to reduce loads of contaminants and design protection strategies; design strategies to meet regulatory requirements; predict changes in water quality that might result from management actions; and identify gaps and priorities in monitoring.

CAST Model (https://cast.chesapeakebay.net/Documentation/BMPsModelsGeography)
Chesapeake Assessment Scenario Tool (CAST) is a web-based nitrogen, phosphorus and sediment load estimator tool that streamlines environmental planning. Users specify a geographical area, and then select Best Management Practices (BMPs) to apply on that area. CAST builds the scenario and provides estimates of nitrogen, phosphorus, and sediment load reductions. The cost of a scenario is also provided so that users may select the most cost-effective practices to reduce pollutant loads.

Ms. Devereaux indicated that CIB would have to develop a management action calculator that would calculate the reduced loading that specific set of BMP's would cause. The Sparrow model would provide the loading rates based upon the various hydrologic conditions for each land use. To address climate change, several hydrographs, both actual and projected, would be used. Recent available monitoring data would also be incorporated into the model. She reviewed other key aspects of operating the model.

To address climate change, a number of additional hydrologic simulations can be created and used as alternative base conditions from the average hydrology. Users of the proposed Inland Bays Model will be able to select various management practices and one of several hydrologic conditions to determine the impact on nitrogen, phosphorus and sediment at a stream or to the Inland Bays. The effect of BMP's and land use changes can be assessed with the various climate change conditions.

Ms. Devereaux discussed various considerations of the impacts to agriculture and infrastructure that should be considered when modelling including properly addressing the time scales and source assessments. She also stated that the model itself should not be that difficult to operate.

Question – Should we analyze for tidal flooding conditions? Yes, tidal inundation (flooding) conditions are one of the most asked about scenarios.

Question – Should we include hurricanes in average hydrology? Yes, because they are expected to increase in intensity and frequency due to climate change. There will likely be more frequent hurricanes of greater intensity.

Question – Are the updated Delaware stream statistics incorporated into Sparrow? No, there was a brief discussion**.**

Question – In the Sparrow Model are there extreme events built into the statistics of flow and response in the Sparrow dataset? No, you would have to run the model with different year hydrographs to create the synthetic hydrograph conditions desired.

Question – Is this model being used in Delaware or any areas nearby? This is a hybrid approach but the models are each well tested.

Question – What are estimated costs to operate the model? Can it be operated in-house at DCIB? She needs to review all available data and would then be able to give an answer.

Question – Does DNREC use this approach and these models? DNREC uses CAST for Chesapeake Bay; not sure about other models. In addition, some spreadsheet models are also used. If models are used regionally then costs could be reduced. Sparrow personnel are interested in using the model for unique applications and are very interested in the Inland Bays model application.

Question – How difficult is Sparrow to use? Some modifications may be necessary based upon what questions are being addressed. How easy the model is to use depends upon the qualifications of the person operating the model.

Panel Discussion – All presenters

Question – Both new models (Water Quality and Hydrologic) will function as a tool and are essential for the DCIB in the3ir decision making process. DCIB wants to spend taxpayer money in most efficient manner. How "good" or "bad" is our current model? What is the level of uncertainty which is guiding our approach to get nutrients out of the bay?

[Dr. Brady] The existing model is like a 19-year-old car; it can run and be repaired but it is not as efficient as a current model. Monitoring data and site conditions have changed significantly since the time when the model was first operated. ***[Dr. DiToro]*** I would not recommend using the old model when more up to date models are available. It is probably easier to use currently available models

Question – What continuous data monitoring network is needed? [Dr. DiToro] Without looking closely at the available data, we can not answer this question. The difficult part is to get the data to "work". A lot of data may be available but you need a sense for quantitative analyses (that is the hard part). ***[Dr. Brady]*** You should target 4 to 5 sampling locations in the headwaters area which are critical in terms of habitat. Establish a good hydrologic database is very useful. ***[Dr. DiToro]*** It is critical that you get loadings correct. If loadings are wrong, everything is wrong ***[Ms. Devereaux]*** You must get a good monitoring database; you can check the reasonableness of the data with the Sparrow model before you use the data as input to the estuary model.

Question – We are trying to link environmental and human health databases in Public Health and are trying to grasp the extremes of the data. How would you envision pulling all of this data together? [Dr. DiToro] It will be difficult unless you have a good definition of the question that you are trying to solve with the data. Try picking a question that you have a fair chance of solving. Start with a simple model with something that you have a fair chance of having success and progress from there.

Question – For sediment analyses, what is the right mix of using literature data versus collected new data? [Dr. Cornwell] You want to capture a range of behavior rather than number of sites. You need more site specific data for shallow systems because it is more complicated. You also need sufficient data to properly calibrate the shallow areas. You usually can't get enough data unfortunately to simply perform mass balance calculations so you use the model to determine

what is going on. ***[Dr. Ditoro]*** Sediments models have usually not been calibrated properly. You have to consider the impact of the algae and nutrient cycling.

Question – We have been talking about two different types of models. Where do they intersect? How can we manage them properly? [Dr. Brady] Where are most susceptible areas to allocate for proper distribution of limited resources? Models are used to determine sub-watershed TMDL's. Models should answer the "what if" questions on loading; you have to get the loadings correct. General discussion followed.

Question – How are we setting ourselves up to keep pace with the biological communities and their effect on the physical and chemical processes going forward? [Dr. Cornwell] Some work is being done on various species such as oysters and submerged aquatic vegetation. ***[Dr. DiToro]*** It has changed over the years but models usually do not include individual species. General discussion continued.

Question – Can we look at specifics such as soft shell clams? [Dr. DiToro] It is difficult to get specific data usually do to budget constraints. In some cases, there is a lack of understanding. ***[Dr. Cornwell]*** here is a substantial amount of data that we are not capturing. Models are more like chemical models trying to imitate biological processes. More knowledge of biological processes is needed.

New Business – no new business

The meeting was adjourned