LONG ISLAND SOUND STUDY

A Partnership to Restore and Protect the Sound

Systemwide Eutrophication Model (SWEM) Workshop Summary

Science and Technical Advisory Committee

October 23-24, 2003

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Preface

The Long Island Sound Study Science and Technical Advisory Committee sponsored a workshop on the Systemwide Eutrophication Model (SWEM) on the campus of Stony Brook University on October 23-24, 2003. The workshop focused on helping participants understand the key components of SWEM through a combination of presentations by the principal architects of the model, HydoQual, Inc., prepared responses to previously submitted questions, and interactive group discussion. HydroQual presented the three major components of SWEM, the hydrodynamic submodel, the eutrophication submodel, and the sediment submodel, in detail. They also presented initial model applications performed to date. In addition, a session was held to present some of the ongoing monitoring of Long Island Sound being performed and the potential to integrate it with ongoing modeling.

The workshop was successful in transferring information about the Long Island Sound Study's use of the SWEM model, and the basic theory, structure, code, calibration, and application of the model to the recently reformed LISS Science and Technical Advisory Committee. HydroQual is also moving toward an open code platform for its hydrodynamic and water quality modeling.

This report provides a brief summary of each work shop presentation, along with the follow-up discussion. Supporting materials for presentations are included in the appendix. It is hoped that the workshop and this summary will support the use and application of SWEM by members of the LIS technical community, and foster greater interaction among modelers, researchers, and managers in developing and implementing programs to better understand and manage eutrophication in Long Island Sound.

Mark Tedesco, Director
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Long Island Sound Study
Science and Technical Advisory Committee

Systemwide Eutrophication Model (SWEM) Workshop
October 23-24, 2003, Stony Brook University, Wang Center

STAC Co-chair Dr. Larry Swanson opened the workshop at 9:02 AM. Brief introductions were made around the room. The workshop attendees are listed in **Appendix 1**. Swanson provided a brief review of the reasons for the meeting and a review of the agenda for the next two days. Mark Tedesco introduced the two new LISS STAC Fellows, Travis Baggett from Marine Sciences Research Center, Stony Brook University, and Alison Branco from Department of Marine Sciences, UCONN.

1. Management Overview

Mark Tedesco provided an historical overview of the Long Island Sound Study's efforts to model and manage eutrophication. In 1986 the LISS Technical Advisory Committee that existing at that time recommended a modeling approach to support hypoxia management. The TAC recommendations were documented in a 1986 modeling workshop report. The LISS supported preliminary model development in 1987 followed in 1988-89 by intensive data collection for a three-dimensional, coupled set of hydrodynamic and water quality models called LIS 3.0. HydroQual, Inc. was selected to develop the water quality model while NOAA initiated the hydrodynamic model.

Initial monitoring, research, and modeling supported development of nitrogen control policies in phases. In 1990, the states of New York and Connecticut joined with EPA adopt a nitrogen cap to freeze nitrogen loadings at 1990 levels. In 1994, the LIS 3.0 model was approved for use by an independent Model Evaluation Group. LIS 3.0 was used with other data on water quality, resource impacts, control technologies, and cost to assess management options. In 1998, a 58.5 percent reduction target for enriched sources of nitrogen in NY and CT was approved. In 2001 a Total Maximum Daily Load (TMDL) was established that made the reduction goals enforceable under the Clean Water Act. The TMDL specifies allowable pollutant loads and includes commitments to reassess every five years.

Concurrently with the development and application of LIS 3.0, the New York City Department of Environmental Protection (NYCDEP) began development of a systemwide eutrophication model, called SWEM, to better support management assessments affecting both Long Island Sound and New York Harbor. NYCDEP initiated a comprehensive field data collection effort in 1994-95 to supplement the LIS data from 1988-89. In 1999, another independent Model Evaluation Group approved the model for use and in 2001 the LISS accepted it for use.

Currently, there is a Nutrients Work Group under both the LISS and the New York/New Jersey Harbor Estuary Program that directs application of SWEM. The LISS is committed to using SWEM and other updated information and tools to perform the five-year assessment of the TMDL and to complete a revised draft TMDL by September 2004. Mr. Tedesco then highlighted the role of the workshop in aiding current management understanding of eutrophication in LIS, giving direction to research, monitoring, and future model development necessary to support the 10-year TMDL assessment. A copy Tedesco's presentation is provided in **Appendix 2**.

Discussion: Art Glowka asked how much this program has cost. Tedesco responded that for LIS 3.0 the Long Island Sound Study provided $3 million for model development and $3 million for data collection and monitoring. Glowka asked about the cost for SWEM. Tedesco responded that SWEM development was supported by NYCDEP, not the LISS, and that he didn't know the costs of the program. John St. John responded that $5 million has been spent on the SWEM field program and an additional $5 million on modeling. Robert Wilson asked which years were used for the model, and clarification on the costs. Tedesco responded that the ongoing monitoring costs are left out of the total.

2. Systemwide Eutrophication Model — Part I: Hydrodynamic Submodel

Jim Fitzpatrick provided a brief review of the SWEM modeling framework. The SWEM model is composed of three components. A hydrodynamic model that drives the two additional components, an eutrophication model and a sediment flux model. Fitzpatrick noted that HydroQual will attempt to respond in their presentations to all the questions that were prepared and submitted to them in advance, but will also provide written responses following the meeting (The written responses to the questions are provided in **Appendix 3.)**

2.1 Hydrodynamic Submodel

Dr. Alan Blumberg presented **"Calibration and Validation of the SWEM Hydrodynamic Submodel."** The Princeton Ocean Model (POM) is the basis for the hydrodynamics. The model grid has a larger domain than the one used for LIS 3.0, spanning from the NY Bight, out to the shelf break, north up the Hudson River to Albany, and the entirety of LIS. The forcing functions were described including airport observations for atmospheric forcing, ocean boundary conditions, and freshwater inflows. Important dates were listed including: initial calibration 10/88 – 10/89, skill assessments 10/94 – 9/95, 10/98 – 9/99, 10/00 – 9/01, and in progress skill assessment 10/01 – 9/02. Supporting material for Blumberg's presentation is provided in **Appendix 4**.

Discussion: Johan Varekamp: Does solar radiation include cloudiness? Blumberg: Yes atmospheric term from clouds observed at Ambrose. Duane Waliser: Exchange coefficient? Blumberg: Varies with wind speed. Varekamp: Is the river flow temperature included. Blumberg: Yes.

Blumberg continued his presentation by showing a slide of CT River flow averages from 1980 to present. The year 88-89 was shown to be near the average while 94-95 was somewhat low.

Discussion: Swanson: How do you increase volume to account for offset where gauge is? Fitzpatrick: Runoff coefficient based on drainage basin and NOAA data, so it is accounted for, but is fairly small. Frank Bohlen offered it was approximately 10%. Duane Waliser presented a scatter plot of cubed wind speed (mixing) vs. shortwave downwelling (stratification) showing where the calibration years occurred on the plot. The two years are fairly representative, but there is a lot of variability in the data. John Mullaney indicated '94 is a pretty typical year for annual runoff, but said the CT River is not necessarily indicative of most of CT.

Blumberg continued and reviewed the observation stations used in model calibration and skill assessment. Blumberg identified the model output used in skill assessment as hindcast data.

> **Discussion:** Swanson:, At what point, when there is divergence, do you see a problem? Blumberg: If you miss stratification it can be a problem. Temperature correlation needs to be around 0.7 or more. Usually go back and refine load (freshwater input and river temperature).

Blumberg continued by reviewing the ability of the model to capture annual cycles. Model output used for comparison is the single model grid point closest to observation location. Bohlen pointed out that the instantaneous observations were being compared to 34-hour model data. Blumberg stated that the LIS correlations for temperature were mostly above 0.9, and salinity correlations ranged from 0.6 for the bottom to 0.8 for the surface.

> **Discussion:** Swanson: Why is 88-89 so much more scattered? Blumberg: There is much more data as a result of the LISS field program. Bohlen: Points out that all the years might have this much scatter if there were more data available. Bohlen also mentions East River as possible source of disagreement. Stacey: There is some suspicion of East River data. Bohlen: We should have a list of data sources so that researchers can evaluate for themselves. Blumberg: There is a lot of scatter between the sources. Varekamp: Slope of these points should be shallower than 1:1. Mattice: Would 88-89 data show as much scatter as it did for NYH? Fitzpatrick: Data is not as far out in LIS, so if scatter is related to those data there is probably not as much scatter here. Swanson:, What is considered the surface? Blumberg: The uppermost CTD data point. If it is not within the top 10% of the water column, it cannot be considered surface data. So model surface is the top 10%, but data not averaged over top 10%, it's just a single CTD point.

Blumberg continued and discussed the location of tidal gauges and current meters used for model calibration. Tidal stations included Sandy Hook, Willets Point, and Montauk Point, which had some problems because the gauge was located on the LIS side and the model grid point was on the Atlantic side, otherwise model was in good agreement with observations. The current meters were located at Collage Point, which the model predicted very well, and Station H (middle sound), which showed less agreement. Blumberg hypothesized that the agreement would be better if the model grid spacing was less in the vicinity of Station H.

> **Discussion:** Dan Codiga: Typically the tidal component of flow is captured very well by models, and the non-tidal flow less so; is the difference between the modeled and observed fields here primarily due to tidal or non-tidal flow? Blumberg: Eighty-eight to eighty-nine (88-89) has more vertical structure, and that creates a problem. The model does better with tidal than meteorological data. Mickey Weiss: Why is the N/S component near the bottom not a good match? Blumberg: Model grid boxes are large and bottom bathymetry is not resolved, so if the current meter is near the channel the model won't be able to account for that. Waliser: Which component is the most important? Blumberg: Bottom friction is most important, horizontal diffusion is tiny. Spatial resolution is most tunable parameter, and the best way to do better is to get more boxes. Mattice: College Point data is among the best, what would 88-89 look like? Blumberg: The results are in a paper available from me. The surface would be close to the data, but the bottom would be about ½ the amplitude of the data. Weiss: In regards to bottom velocity, why would better topography not impact E/W but would impact N/S? Blumberg: Grid

box size is an issue here. Weiss: Bias appears to be south, bottom velocity is important for transport and hypoxia issues. Fitzpatrick: E/W velocity is main velocity and it is doing better with that component. Bohlen: Is E/W component as important as the N/S one? It's something to think about. Bottom roughness changes a lot and very quickly, this is a problem with large grid boxes. Cross sound (N/S) error could be from many sources. Waliser agrees that the model may be averaging well but one point measurement may not compare well to model output that represents an average for the grid box.

Blumberg continued by describing the modeled NY Harbor (NYH) to LIS exchange. Upon removal of tidal exchange a residual of ~100m^3/sec from the LIS into the NYH remains. The annual mean circulation is: at the bottom, from LIS into NYH, at the surface from NYH to LIS, with vertical eddies forming along the river.

Discussion: Codiga: Are vertical velocities inferred from continuity or are they calculated directly as "w" [vertical component of velocity] in the model? Blumberg: Calculated directly, big changes (partly due to eddies), account for big difference between different models. Stacey: Net movement is fairly standard, but SWEM favors surface movement. St. John: This will be addressed in the water quality section. Glowka: What is the data source? Bloomberg: We used bottom based ADCP observations from NOAA. Codiga: How is the comparison of yearly means? Bloomberg: They are all about the same. Codiga: Is there much season variation? Bloomberg: Not much. Glowka: Where are the instruments located? Bloomberg: Closer to the shore than mid-channel.

Blumberg finalized his presentation by identifying the key points, which are: the hydrodynamic behavior is reproduced by the model over a variety of conditions, calibration and validation are acceptable, but more current and salinity/temperature stations would be helpful, and that attention to detail is important to get things correct. In summary Blumberg said that there is room for improvement, but this is a very comfortable position to be in.

Mark Tedesco thanked Blumberg for his presentation and the meeting broke at 11:15.

Tedesco called the meeting to order at 11:30. Tedesco recognized Art Glowka to present a citizen's perspective on the East River dynamics.

2.2. Citizen's Perspective

Art Glowka presented his perspective on tidal flow in the East River, and its effects on Western Long Island Sound. He encouraged the researchers working on issues within LIS to focus more efforts on understanding the biology of the Sound in addition to the physical oceanography.

Workshop adjourned for lunch at 12:15.

Mark Tedesco called the meeting back to order at 1:15. At this time he introduced David Conover, Dean and Director of MSRC, Stony Brook University. Conover welcomed the workshop participants.

3. Systemwide Eutrophication Model – Part II: Eutrophication Submodel

3.1 Eutrophication Submodel

Jim Fitzpatrick provided an introduction of the SWEM Eutrophication Submodel. Included was a history of the WASP/RCA water quality models and the present application of the RCA Eutrophication framework. A nutrient cycle diagram was presented which detailed N, P, Si, and DO sources and sinks. Supporting material for Fitzpatrick's presentation is provided in **Appendix 5**.

> **Discussion:** Varekamp: No denitrification term? Fitzpatrick: Yes, because usually doesn't occur in the water column. It is included in the sediment submodel.

Fitzpatrick continued and presented a diagram of the kinetics of the nutrients. The equation of algal growth in the model was described as S_p = growth – respiration – grazing – settling. Growth rate is a function of temperature and is based on the Epply curve idea. A parameter is included, β, which acts to adjust the curve for the different temperature optimums of different algal assemblages.

> **Discussion:** Varekamp:, Is β from data or can it be fiddled with? Fitzpatrick: It can be fiddled with. Nicole Goebel: What is the rational for choosing coefficients. Fitzpatrick: Pick some, see how it does with DO and growth, etc., and then tweak it. It is a tuning exercise, largely because it is and assemblage of many species. Cuomo: Are we not seeing a maximum summer assemblage [b/c the optimum temp is higher than usual real-world temperatures]? Fitzpatrick: The growth curve doesn't fall off very sharply, but yes if the temperature increases it may change the species composition.

Fitzpatrick continued and described the growth rate as a function of light. A negative feedback occurs as more growth leads to increased attenuation of light and a decrease in the amount of light that reaches a particular depth. Additionally, different background extinction coefficients are given to different areas of the grid domain with near shelf-break grid boxes having the lowest coefficient and NYH and vicinity having the highest. Photo-inhibition is also considered as shallowest layer has decreased growth at highest zenith angles. While the daily solar cycle is reproduced in the model, weather induced adjustments to the incident light are not included.

> **Discussion:** Varekamp: Is size of depth slices an issue here? Fitzpatrick: Have to balance depth of slice with ability to compute. Bohlen: Could you handle more k [extinction coefficient] data? Fitzpatrick: Yes, we are just data limited.

Fitzpatrick continued by describing the growth rate as a function of nutrients. Michaelis determinations of limiting nutrients and Michaelis constants are used. Algal loss due to zooplankton grazing was described and it was noted that this area contributed to some uncertainty in the model. Zooplankton grazing rates are obtained from 94-95 data of zooplankton biomass increase and it is assumed that all increase is due to algal loss. It was noted that additionally zooplankton data would help in this area.

> **Discussion:** Cuomo: Assimilation rates of zooplankton are not 100%, so there are nutrients going back into the system. Fitzpatrick: Yes, some of that is accounted for in the cycling.

Fitzpatrick continued by describing some calibration problems that were experienced. The dissolved oxygen (DO) predicted by the model is not matching field data. Some of the problem is suspected to be the result chemical and thermal toxicity, neither of which was observed in field studies. Another problem was the lack of benthic filter feeders in the model. Settling rates were adjusted to better represent this and to increase agreement with observed data.

> **Discussion:** Cuomo: Does this [benthic filtration] change during the course of the year? Fitzpatrick: Yes it is driven by temperature. Stacey: Could residence time be an issue here rather than biogenic filtration? Fitzpatrick: Hydrodynamic model should take care of that, but it is still not enough to fix the problems with chlorophyll and DO not matching the data. Tried everything and the only explanation was biogenic filtration. Stacey: Did you see an unexplained loss of N in the monitoring data? Fitzpatrick: We will show this, but it is all linked together so the interrelationships are consistent. Stacey: As modeling progresses, changes in species composition because of differences in availability of different forms of nutrients would be good to include. Fitzpatrick: Yes it would be good, but it is very demanding computationally.

Fitzpatrick recognized John St. John who took over to present the model calibration data.

3.2 Model Calibration

St. John identified the data needed for the calibration process including: freshwater from tributaries, CSO/storm water, and atmospheric deposition.

> **Discussion:** Latimer: Wet and dry atmospheric deposition included? St. John: Wet values were measured, and literature and historic values were used to get dry data. Stacey: Was atmospheric loading even across the model domain or not. Fitzpatrick doesn't think the model was able to do change that. So, yes it is uniform.

St. John continued and described the SWEM field monitoring program and the subsequent calibration procedure. The model results were also compared to the observed data.

> **Discussion:** Todd Fake: Did you identify locations of poor agreement? St. John: No but we could. Bohlen: Averages from model output are 10 day averages? Fitzpatrick: Observations are instantaneous. Swanson: What is acceptable error? St. John: We make an overall qualitative judgment of "is the model capturing the pattern structure." Bohlen: Some of the scatter could be because of the 10 day average vs. instantaneous, making it hard to compare model to snap-shot measurements. Fitzpatrick agreed and briefly expanded upon that point. Swanson: This is scary because it gets translated into exact numbers when policy is made. Fitzpatrick: That is not really what happens. HydroQual emphasizes looking at the model for relative differences.

Due to a lack of time, St. John skipped ahead in his presentation to give the primary productivity measurements. It was agreed to that St. John would resume his presentation the next day, time allowing.

> **Discussion:** Stacey: Are there primary productivity issues, in particular the East River where shellfish were targeted as the cause of low productivity? St. John: It certainly represents an area where further research is needed. Varekamp: The POC matches OK, but not the Si, maybe

diatoms aren't as important as the model has them. Fitzpatrick: That's something that's being studied right now. Nicole Goebel: Is model data available for the last 2 years b/c Goebel has field data re: primary productivity? Fitzpatrick: No, the model hasn't been run for those 2 years yet, but it would be good to do that. Swanson: what is the cost for a single model question? St. John: About $5000 for a single run.

With time allowing on the second day, John St. John completed his presentation on model calibration. He opened by identifying some calibration issues including: the vertical mixing coefficient are regionally adjusted in specific model regions, benthic filtration was determined to be important for the East River DO balance, zooplankton grazing is parameterized primary production measurements are limited, and a need for additional data. Vertical mixing adjustments were necessary to get DO agreement with observed data. The parameter that is most sensitive that allows adjustment is the vertical mixing coefficient. Adjusting the vertical mixing coefficient doesn't significantly change the vertical distribution of salinity, which we don't like, but it was the only way to get DO in the lower layer correct. These issues with DO balance would be a good area for more research.

Discussion: Kremer: Are these changed regions changed uniformly? Fitzpatrick: Yes, e.g., all of the Western Sound changed the same, but maybe not the same as other areas changed. Cuomo: Is this year round. Fitzpatrick: No, seasonal. The problem is during the summer (we have higher DO than data), spring and fall is good. Cuomo: I have data showed NH_4 and sulfide (in presence of O_2) coming out of sediments during spring and fall. Gordon Taylor mentioned that blooms maybe a cause for this. Cuomo agreed and added that increased temperature should also be considered. St. John: The hydrodynamic model picks up vertical temperature stratification well. Kremer: How are the submodels coupled? (Question not answered?) Bohlen: Changed areas (i.e., where vertical mixing was changed to fix DO agreement) are very similar in terms of physical regime except along the New Jersey shore. Are the O_2 dynamics on the New Jersey shore similar to the other spots? Cuomo responded they were opposite. St. John suggested that differences might occur where water treatment outfalls occurred. Codiga: The four 'changed' areas may not all be similar in terms of the sedimentary environment, but in terms of the water column they are: each is a site where density stratification will build in quite strongly. This suggests the model is not mixing as much as it should when stratification is present. Are the hydrodynamic parameters fixed? St. John: parameters are not tunable because of the turbulence closure scheme. Codiga: Could choose a different closure scheme that improves simulation of stratified conditions. St. John: Yes, but we are not currently doing that.

St. John finished the calibration portion of his presentation by discussing model grid issues in Jamaica Bay. Vertical mixing was strongly related to tides. Where water movement was 45^o to grid setup, the DO was bad, but was improved by changing the vertical mixing.

3.3 Review of Model Application to Nitrogen Load Reduction Scenarios

St. John discussed one model application that examines the reduction of nitrogen input to the system. Using SWEM, they turned off all C and calculated DO response differences from baseline (see bar graph for C vs. N (or other background)). Identifying DO average from summer, the overall results show C is more important, except in western LIS. St. John noted that looking at max summer temperature instead of average N is more important in most areas on an instantaneous effect basis. In

LIS 3.0, there is a linear relationship between decreased N and increased DO, the question was posed "Does this hold up in SWEM?" Fifteen management zones, and 10 response locations were chosen. The model was then run without C and N in each of these zones one at a time to show management the different effects of these regions.

> **Discussion:** Kremer: Using a linear response? St. John: Yes. It looked linear enough to do this simplification. Then some scenarios could be chosen to run the full model on to include non-linearity. This is ongoing now using SWEM, this can be seen in the preliminary results. It is still linear, not perfectly, but does maintain approximate linearity. Tedesco: Do you look at averaging periods other than 10 days? St. John: Yes we are looking at it right now, but it looks like going smaller won't work very well.

St. John continued and examined the relative relationship between LIS 3.0 and SWEM loads. SWEM results in less response at "hot spots" due to N loads being reduced from the CT River. SWEM also calculated a greater response to reduction of N load from the East River.

> **Discussion:** Varekamp: Is this caused by advection in the hydrodynamic submodel? St. John: We don't know the answer to that yet. Maybe because we are not fixing the boundary at the Battery, that is something that we had to do in LIS 3.0 and that wasn't good. So SWEM is better because the model boundaries are far from loading centers and we can change loads without changing boundary conditions. Stacey: SWEM has more differences between upper and lower East River? St. John: True. Next is to use the simplified matrix to come up with management scenarios to test with the model.

The workshop adjourned for the day at 4:19 PM.

End of DAY 1.

DAY 2

Mark Tedesco called the meeting to order at 8:45 AM. He recognized Jim Fitzpatrick who gave a presentation on the Sediment Flux Submodel.

4. Systemwide Eutrophication Model — Part III: Sediment Flux Submodel

4.1 Sediment Flux Submodel

Supporting material for Fitzpatrick's presentation is provided in Appendix 6. Fitzpatrick identified the partitioning of particulate organic matter (POM) based on Westrich and Berner 1984, which partitioned by the rate of reactivity.

> **Discussion:** Varekamp volunteered that he had data more specific to LIS. Varekamp: How do you get these coefficients? Fitzpatrick: We use values from a book by DiToro. Cuomo: Westrich and Berner (1984) conducted their experiments under oxic conditions. Fitzpatrick: Yes the reaction rates would be different but so far these coefficients are working across a variety of sites, but accretion rate data for LIS would help. Jim Kremer: Are these coefficients fixed? Fitzpatrick: Yes. Bohlen: It is a sensitivity issue, if we get a major event that stirs the sediment what would that mean? Fitzpatrick: Resuspension events are not accounted for in the model. Latimer: Does it account for bioturbation? Fitzpatrick: Yes. Kremer: Is it fair to say that the definition is defined by measurements. Fitzpatrick: Yes. Cuomo: Is there ammonia in the bottom water? Fitzpatrick: Yes, that is being computed by the eutrophication model. Kremer: How thick is the bottom layer? Fitzpatrick: Ten percent of the depth of the water column.

Fitzpatrick continued and explained the Nitrate, Silica, and Sulfide flux models. He noted that for the vertical profile of Oxygen and Nitrate, the model is overestimating some, but shows spatial gradient.

> **Discussion:** Varekamp: Partitioning coefficient calibration is made on iron sulfide burial rates? Fitzpatrick: Right.

Fitzpatrick continued and described the partial mixing of nutrients with the benthic biomass. He noted that a detrital source of Si was added to get silica right because it was being underestimated, and that non-linear dissolution of biogenic silica is incorporated. As oxygen goes toward zero, particle mixing in the benthic environment is reduced in the model due to oxygen stress.

> **Discussion:** Cuomo: What is the depth of the bioturbation layer? Fitzpatrick: Surface layer is 10cm. Cuomo pointed out that surface dwellers don't affect oxygen in the lower layers. Fitzpatrick responded that two bioturbation effects are incorporated in the model. Mixing factor is only determining mixing between aerobic and anaerobic layer and we are assuming well-mixed layers. Brief discussion followed.

Fitzpatrick continued and displayed graphs of the calibration data and model drift over time.

Discussion: Robert Armstrong: The fit for P is good, why aren't the O_2 and NH_4 as good? Fitzpatrick: That is true, it may be because the triggering event of low oxygen is so sudden. Varekamp: These model runs were only within the submodel? Fitzpatrick: Yes, only to calibrate the submodel.

Fitzpatrick completed his presentation by comparing the model against observations. In nutrient addition experiments, the model does well with nutrients NH_4, NO_3, SOD (sediment oxygen demand), but not as well with P. Comparing the model to MERL data, the model didn't match well with pore water. Fitzpatrick suggested that the MERL tidal simulation plunger might have forced water into sediments. The partitioning coefficient for P and diffusion coefficient is different from that of Chesapeake Bay, but everything else was the same. With these adjustments, match is much better with MERL and Chesapeake Bay, where issues existed before. It was decide that the diffusion coefficients would have to be site specific. Looking specifically and how the model worked in LIS proved difficult due to lack of data. There was some evidence of spatial gradient being picked up by the model. The model missed a few high NO_3 fluxes, but they were very small relative to NH_4, the SOD was overestimated a little, and the P flux is not too bad. When the model is compared to SWEM 94-95 data it is found that the model underestimates SOD in a few places. Changes were made to P coefficients, but overall coefficients are the same across 6 systems with a few exceptions.

The workshop broke at 10:05 and returned from break at 10:30.

Mark Tedesco called the meeting to order and suggested returning to the previously submitted questions. The questions were answered and are included among the written responses to the questions **(Appendix 3.)** With time allowing, Tedesco recognized John St. John, who continued his presentation on the model calibration process [summarized in workshop summary sections 3.2 and 3.3].

St. John recognized Jim Fitzpatrick who presented the model organization.

5. Model Organization and Input/Output Structure

Supporting material for Fitzpatrick's presentation is provided in Appendix 4. Fitzpatrick explained the finite differencing scheme that was used for the mass balance equations. The model uses a central differencing scheme to reduce numerical dispersion.

Discussion: Varekamp: Where do you get the volumes and flows? Fitzpatrick: Hydrodynamic model gives those to us. Varekamp: Can you clarify the sigma vs. z-level grid system? Fitzpatrick: RCA user's manual describes a lot of the input/output structure.

Fitzpatrick continued by describing the RCA file structure used. The complete RCA manual will be available for review. Some important points are: the inputs are each in a different file, there is an option to echo inputs as a check and an option for global dumps of all water quality information. Time steps can be varied for certain segments that require shorter steps, integration can then be made to the rest with bigger steps. The model interpolates from data to get boundary conditions for all points when needed. Based on a standard Pentium 2.4Ghz processor, execution time for the ECOMSED is ~ 4 days or 48hrs/yr cycled 2 times, and 3 days or 12 hrs/yr cycled 6 times for the RCA. Storage requirements are 5.3GB for ECOMSED hourly averaged output, and 200MB for 10 day averaged global dumps and 3.5 day averaged detailed dumps.

> **Discussion:** Armstrong: Are you planning to provide the source code? Fitzpatrick: Yes, but one routine is proprietary, the split time-step, so it will not be made available to the public, but will be available to LIS applications. Todd Fake: What platforms will be supported? Fitzpatrick: It is a FORTRAN program, so any Linux, UNIX or Windows platform should work. Fake: Will you be working on a multithread version? Fitzpatrick: Yes. Armstrong: Are you expecting us to tell you about any improvements we find and make? Fitzpatrick: Others do that and we are certainly happy to hear that kind of feedback.

The meeting was adjourned for lunch at 12:00.

Larry Swanson called the meeting back to order at 12:45. At this time he opened the floor to questions about the SWEM model.

6. Questions and Discussion Regarding the SWEM Model

Swanson opened the session by posing some general questions about potential uses of the model. In particular, he would like to see the model used to ask questions related to the dilution of pesticides, such as the pesticide put into the NYC sewer system to combat West Nile virus. Fitzpatrick explained that the model could be used to limit state variables to the one of interest by writing a subroutine that can be added to the model by replacing another subroutine. Swanson also asked if the model could be used to test how this year's hypoxia events may have been driven by salinity (as opposed to temperature). Fitzpatrick: You would need to run the hydrodynamic model for the year of interest, which means getting all the inputs and boundary conditions correct. Then you could update all the water quality inputs and update the model. Each of those input generations and model runs take about a month for people with the necessary skills and equipment. Some development would be needed to get to that type of application.

St. John talked about how the model has been used to simulate bacterial contamination from sewage treatment malfunction. The model is commonly used by the NYCDEC to determine whether or not shellfish beds should be closed. Fitzpatrick: Short-term plume conditions are mostly driven by microscale weather and rain runoff. St. John: This type of refinement could be done, but is not currently available.

Robert Wilson: Is the model capturing vertical mixing? St. John: We believe the overall pattern is being captured. Fitzpatrick: The overall average is believed to capture the pattern, at least for temperature and salinity.

Kremer: If two-fold vertical changes fixed it and changing a ton of ecological parameters doesn't, then does that mean that the physics are wrong? Bohlen: In the physical model, few factors have the potential to affect the model accuracy, but in the eutrophication model there are tons of them. So maybe you have overlooked a parameter or you have got the processing of them wrong. Perhaps there are not enough time steps. Kremer: But in this situation it could be either the physical or the eutrophication that is wrong. Fitzpatrick: Remember the geometric structure issues in Jamaica Bay. We don't know if that is the whole problem in LIS, but we had to do something. Also remember that you can run both and compare the conventional vs. the Laws/Chalup kinetics, this would be a good point for more research in the academic community.

Stacey: Did you look at whether loading or delivery was off? Fitzpatrick: We would have to be very far off to result in this, but the totals match up pretty well, so we don't think we are that far off.

Varekamp: So you decrease vertical mixing, but if you put those lower vertical-mixing coefficients into the hydrodynamic model it couldn't reproduce salinities? Fitzpatrick: Because of turbulence closure we can't test that, but yes, it probably couldn't.

Stacey: Adjustment made to stratification, which is the one thing that has good, frequent, and the least questionable data. And this change made huge differences in the load reduction priorities. Isn't that the wrong place to make changes? Fitzpatrick: This is a grid resolution issue again, but the mixing coefficient is a good way to adjust it. But again, we are just as uncomfortable with it as you are as a manager. However, it seems to be working and is the best approximation we could do. Varekamp: Maybe another avenue of research would be to try and do a tracer experiment to look at this diffusion, possibly with SF_6. Everyone agreed that this might be a good idea.

Tedesco: If model over predicts bottom water DO, how does it do in those areas with surface DO and how does a change to vertical mixing affect that? Fitzpatrick: Haven't looked at it. Kremer points out that the effect of air-sea exchange is so large that temperature effect on solubility would potentially wipe those out or make them less noticeable.

7. Integrating Monitoring with Modeling

7.1 PT Barnum Ferry Observing System

Duane Waliser presented the current status of the ferry observing system. The data collected includes: meteorological data, oceanographic data, cross-sectional current data from a bottom mounted ADCP, and long and short wave radiation. The data collection was chosen to compliment the MySound program data. The advantages of this system are the continuous real-time data with cross sound variability, and the ADCP provides "top to bottom" current profiles. Initial results show a land/sea bias in wind speed and temperatures. More information can be found on the SoundScience web-page at http://www.sunysb.edu/soundscience.

7.2 ELIS (New London - Orient Point) ferry observations / FOSTER-LIS

Dan Codiga presented an update on the Eastern LIS ferry sampling program. His presentation is available as a PowerPoint presentation (**Appendix 8**). Codiga noted that the location of the sampling is useful for examining Sound to shelf transport in the Eastern Sound. The advantages of the ADCP are that it is able to resolve subtidal components of flow, which are vital for understanding salt and heat flux, and for understanding hypoxia.

Discussion: Varekamp: Are you calculating volume transport? Codiga: Not yet, but they are straight forwardly calculated with the data on hand, and will be pursued next. Kremer: Are you measuring chlorophyll? Codiga: Yes, we are, and we encourage others to realize it is available for them to work with.

7.3 MySound In-situ Monitoring

Frank Bohlen presented the current status of the MySound project. More information can be found on www.mysound.uconn.edu

Discussion: Fitzpatrick: Do you have NO_3 and NH_4 sensors? Bohlen: They are still very expensive and not very reliable, so we haven't invested in them. Cuomo: How often are the stations serviced? Bohlen: About once a month, or more if problems arise.

7.4 CTDEP Monitoring

Paul Stacey presented the current status of the CTDEP water quality monitoring project. More information can be found on http://dep.state.ct.us/wtr/lis/monitoring/monsum.htm.

Discussion: Cuomo pointed out that she sees hypoxia persisting in the bottom few centimeters of the water that is not observed in the CTDEP survey data.

7.5 NYCDEC NYC Harbor Survey Program

Beau Ranheim presented an overview of the harbor survey program. More information can be found on http://www.nyc.gov/html/dep/html/news/depnewshwqs.html. Measurements of water quality are focused on bacteria, but DO and CTD profiles are also collected. The instruments are shore or dock based and provide 90 years of data for NYH. Currently there are 6 Western LIS stations located in the central channel. The PCR techniques being used have a goal of a 3 hour turnaround for fecal coliform and entrococcus bacteria. The sampling schedule is 1/week May – October and 1-2/month during the winter. Annual reports are available from Ranheim.

7.6 National Coastal Assessment Program

Larry Swanson gave a presentation of the current state of the National Coastal Assessment Program. More information can be found on http://www.epa.gov/emap/nca/.

8. Open Discussion

Tedesco opened discussion on where the modeling programs should go by asking members present to take the opportunity to make recommendations to the STAC who will make recommendations to the EPA.

Kremer: Monitoring focuses on measuring stock variables, we should think about the key rates that should be measured. We need to facilitate the model being run for more years, like recent few years, when there is a lot of data available. We need to focus on finding ways to make it easier and faster to run the model. Bohlen: Essential to remember that in '86 when modeling was recommended we were trying to get a framework for system evaluation. The model should be a guide for studying processes to show where the missing data is and where we lack understanding. More attention needs to be paid to model sensitivity. Codiga: We need to devise, and begin using, more quantitative measures of the skill to assess the model. Fitzpatrick: Skill assessment is easier for hydrodynamic component because the observations are there. Water Quality data are more sparse and things are patchy, so you have to aggregate. Others have too few errors to do a significant skill assessment. Need to choose applicable statistical test.

Waliser: Need to look at the subtidal signal. St. John: That is being looked at by hydrodynamic model. The water quality component still doesn't have enough observations. Waliser: Maybe it's worth a new intensive sampling period (e.g., just for a summer) to develop a very good database that could then be used to test model sensitivity. Kremer: Are there ways we could move toward a condition where the model is more adaptable to new data sets and continuously iterate and make it better. Fitzpatrick: There are many more loads than other systems so that makes the issue harder. Mattice: Seems we all agree that the model is good for predictions and planning, but sensitivity study is important. Iteration between model and observations is most important. Fitzpatrick: We could remove LIS as a sub-grid and just run the model for a specific portion, reducing the model run and time effort. Anthony Tseng: Data is not objective enough especially considering variability of parameters over time of day. The nature of the data is important, QA/QC, goals of sampling program, etc. With more objective sampling scheme you could make more objective assessments. And remember it might be possible to get data from outside sources (e.g. atmospheric deposition from the acid rain network). Stacey: Maybe we should mistrust the data instead of the model because at least the model has rate and process information. Waliser: Data assimilation would give you much better abilities. Armstrong, we need to think carefully about what we need. Fitzpatrick: Sediment flux, sediment trap measurements would be good.

The workshop adjourned for the day.

Appendices

Appendix 1 – Attendance list

Appendix 2 - SWEM Model Workshop:Current Application to LIS TMDL

Appendix 3 – HydroQual Presentation PDF file Part I
Appendix 4 – HydroQual Presentation PDF file Part II
Appendix 5 – HydroQual Presentation PDF file Part III
Appendix 6 – HydroQual Presentation PDF file Part IV
Appendix 7 – HydroQual Presentation PDF file Part V

Appendix 8 - Update on ELIS Ferry Sampling

Appendix 9 – HydroQual: Answers to Previously Submitted Questions

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