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UNIVERSITY OF MARYLAND CENTER for ENVIRONMENTAL SCIENCE

CHESAPEAKE BAY:
WATER QUALITY MONITORING PROGRAM
ECOSYSTEMS PROCESSES COMPONENT (EPC)

QUALITY ASSURANCE PROJECT PLAN
FY2010

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MARYLAND CHESAPEAKE BAY WATER QUALITY MONITORING PROGRAM

ECOSYSTEMS PROCESSES COMPONENT (EPC)

Quality Assurance Project Plan
For the Period:
July 1, 2009 – June 30, 2010

____
Walter Boynton, Professor and Principal Investigator
University of Maryland Center for Environmental Science
Chesapeake Biological Laboratory

____
Lisa Wainger, Research Associate Professor and Principal Investigator
University of Maryland Center for Environmental Science
Chesapeake Biological Laboratory

____
Thomas Parham, Director and Principal Investigator
Maryland Department of Natural Resources

____
Bruce Michael, Quality Assurance Officer
Maryland Department of Natural Resources

PREPARED FOR:
Maryland Department of Natural Resources
Tidewater Ecosystems Assessment
580 Taylor Avenue, D-2
Annapolis, MD 20401

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University of Maryland Center for Environmental Science
Chesapeake Biological Laboratory (**CBL**)
1 Williams Street
Solomons, MD 20688

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PREFACE

This document describes and references other documents describing data management and analysis for the Chesapeake Bay Water Quality Monitoring Program Ecosystems Processes Component (EPC). This program is funded through the Maryland Department of Natural Resources Resource Assessment Administration Tidewater Ecosystems Assessment Division.

Many sections and references refer to or are exactly the same as those included in:

Maryland Department of Natural Resources (MDDNR). 2008. *Quality Assurance Project Plan for the Maryland Department of Natural Resources Chesapeake Bay Tidal Monitoring Programs Data Management and Analysis for the Period July 1, 2008 – June 30, 2009.*

LIST OF PREPARERS

Editors:

Eva M. Bailey, Senior Advanced Faculty Research Assistant (IV), University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, 1 Williams Street, Solomons, Maryland 20688.

Walter R. Boynton, Professor, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, 1 Williams Street, Solomons, Maryland 20688.

Renee J. Karrh, Tidewater Ecosystem Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, D-2, Annapolis, Maryland 21401.

Contributors:

Lisa A. Wainger, Research Associate Professor, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, 1 Williams Street, Solomons, Maryland 20688.

Maria A. C. Ceballos, Laboratory Research Technician, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, 1 Williams Street, Solomons, Maryland 20688.

1.0 INTRODUCTION

1.1 Project Description and Rationale

The Ecosystem Processes Component (EPC) of the Maryland Biomonitoring Program has been active since the beginning of the program in August, 1984. During the initial phase of the Biomonitoring program the EPC was involved in intensive field operations aimed at making rate measurements of sediment-water exchanges of oxygen and nutrients at many locations in the Bay and vertical deposition of organic matter at a few selected locations. These efforts represented a major departure from most monitoring programs in that rate measurements were being made in a monitoring context. These data were essential for the development of the sediment component of the Chesapeake Bay water quality model, still one of the most sophisticated models in existence.

Following this effort the EPC became involved with SAV habitat work and documented the need for better water quality measurements in littoral zones to determine SAV habitat suitability. In addition, an innovative measurement program was developed to monitor epiphyte growth on SAV above-ground biomass, a major stressor of SAV communities in eutrophic systems.

At the same time the EPC pioneered the use of two measurement systems for water quality measurements. Coupling continuous monitoring (ConMon) measurements made with modern equipment with measurements made during the early 1960s in the Patuxent River, we were able to show the importance and utility of such measurement systems and to show that rate measurements (community production and respiration) based on these data were very responsive to nutrient loading rates. Initial deployments of sensor systems in a few tributary rivers (Patuxent, Pocomoke, and Back Rivers) were followed by the development of the current ConMon Program. ConMon sites have been developed in many areas of the Bay tributary rivers and the data set is very large. Under initial funding from the National Science Foundation, we obtained a surface water mapping system capable of rapid measurement of a suite of water quality variables. This system was tested and reviewed by a variety of groups and eventually evolved into the present day Dataflow mapping program. The program has focused on littoral areas of Bay tributaries and is used as a tool for examining SAV habitat and indicators of estuarine health. In recent years, use and interpretation of Dataflow measurements has been the major focus of EPC activities.

In FY 2010, EPC of the Biomonitoring Program enters yet another phase. In this newest phase, we are focusing on interpretation of ConMon and Dataflow information and relating results to management actions and plans. Furthermore, we will be making an effort to translate findings into forms useful to the public in web-based presentations. There will be no field-based portion of this program.

1.2 Data Analysis Objectives

The EPC program uses data generated by the Chesapeake Bay Water Quality Monitoring Program and its partners.

The key goals of the EPC program FY2010 include the following:

- **Assess Water Quality Criteria:** The primary goal will be to evaluate available data sets with new methods to assess water quality criteria attainment or failure for key variables (e.g., water transparency, dissolved oxygen concentrations and chlorophyll concentrations); we will likely emphasize analyses involving dissolved oxygen initially because of the importance of DO in habitat suitability and because there are established DO criteria that can be assessed. We will focus our analysis efforts on ConMon and Dataflow data sets. These programs have been active for a number of years and both data sets (ConMon = fixed site continuous data; Dataflow = intensive spatial mapping at monthly intervals) will be utilized. Data from other sources (long-term fixed site data, river input monitoring data and watershed modeling data) will be used as needed. The spatial focus of this work will be the shallow waters of Bay tributaries, essentially a littoral zone evaluation. Larger spatial scales will be examined as need arises. The temporal focus of this work will be varied, depending on the data set being examined. ConMon data are obtained at 15 minute intervals for 7 months per year (for three consecutive years) at most sites. Thus, time scales from hours to inter-annual scales can be examined. Dataflow data are spatially intensive but collected on a monthly basis (April – October) for three consecutive years. Hence, temporal analyses are restricted to seasonal and inter-annual time scales.

- **Developing Basic Linkages:** Some portions of this work will be focused on assessment (criteria attainment or failure) of littoral zone water or habitat quality. An additional effort will involve relating assessment results to direct management options, primarily those related to nutrient management. Another way to state this objective is to say we will explore water quality results relative to watershed conditions such as nutrient loading rates to seek explanations for observed conditions. There will likely be a comparative ecology approach wherein results, for example, from several sites having different nutrient loading characteristics are combined in one analysis to see if system responses are similar and to increase the signal to noise ratio. We will aim to control for varying physical conditions among sites and seek to establish the variables with the highest explanatory power. Comparative analyses can be a powerful tool in water quality analyses, as limnologists have long known.

- **Water Quality Metrics and Web Pages:** There is a strong desire to continue to develop metrics of Bay system performance, especially metrics that are meaningful to the general public that can be reported over the web. We are acutely aware of this need. In our last Interpretive Report we suggested a series of possible metrics. One goal of this work will be to produce management-relevant metrics from the endpoints of quantitative analyses and to work with appropriate people at MD-DNR to add these to established web pages.

- **Coordination:** Activities in the EPC program are coordinated with other components of the Maryland Chesapeake Bay Water Quality Monitoring Program including analytical methodologies, data storage and transmission, quality assurance protocols and reporting schedules.

1.3 Key Project Personnel

Walter R. Boynton, Professor, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, 1 Williams Street, Solomons, Maryland 20688.

Lisa A. Wainger, Research Associate Professor, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, 1 Williams Street, Solomons, Maryland 20688.

Eva M. Bailey, Senior Advanced Faculty Research Assistant (IV), University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, 1 Williams Street, Solomons, Maryland 20688.

Maria A. C. Ceballos, Laboratory Research Technician, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, 1 Williams Street, Solomons, Maryland 20688.

2.0 DATA MANAGEMENT, VERIFCATION AND DOCUMENTATION

Data management, verification (acceptance criteria) and documentation are described in the individual Quality Assurance Project Plans for each monitoring component as well as other accessory documents.

These documents are referenced in:

Maryland Department of Natural Resources (MDNR). 2008. *Quality Assurance Project Plan for the Maryland Department of Natural Resources Chesapeake Bay Water Quality Monitoring Program—Chemical and Physical Properties Component for the Period July 1, 2008 - June 30, 2009.*

Maryland Department of Natural Resources (MDNR). 2008. *Quality Assurance Project Plan for the Maryland Department of Natural Resources Chesapeake Bay Shallow Water Monitoring Program for the Period July 1, 2008 - June 30, 2009.*

Maryland Department of Natural Resources (MDDNR). 2008. *Quality Assurance Project Plan for the Maryland Department of Natural Resources Chesapeake Bay Tidal Monitoring Programs Data Management and Analysis for the Period July 1, 2008 – June 30, 2009.*

Updates and changes made in the above documents for FY2010 will be incorporated into EPC data management, verification and documentation.

3.0 DATA ANALYSIS AND REPORTING

3.1 Water Quality Criteria Assessment with ConMon DO Measurements

3.1.1 Overview

The ConMon monitoring program provides detailed time series of water quality information that could be applied to water quality assessments in Maryland. These data streams offer some of the best information for understanding daily to interannual dynamics of DO and other conditions relevant to sustaining aquatic organisms. Therefore, we propose to examine ConMon data in terms relevant to regulatory compliance and use the data to develop new indicators of estuarine condition or health.

3.1.2 Background

Based on a history of observing DO measurements of many estuaries, we hypothesize that the shape of a DO histogram (DO concentration vs. frequency of observation) will have higher and narrower peaks (i.e., be spiky or "healthy") in relatively low nutrients systems but have lower peaks and heavier tails (i.e., be "obese") in eutrophic systems (Figure 3.1-1). The basis for this hypothesis is the observation that in low nutrient systems, DO tends to weakly oscillate in the vicinity of DO saturated conditions. However, in nutrient enriched systems, DO concentrations tend to oscillate very strongly in response to high levels of daytime production (DO released via photosynthesis) and equally high rates of nighttime respiration (DO consumption by all plants and

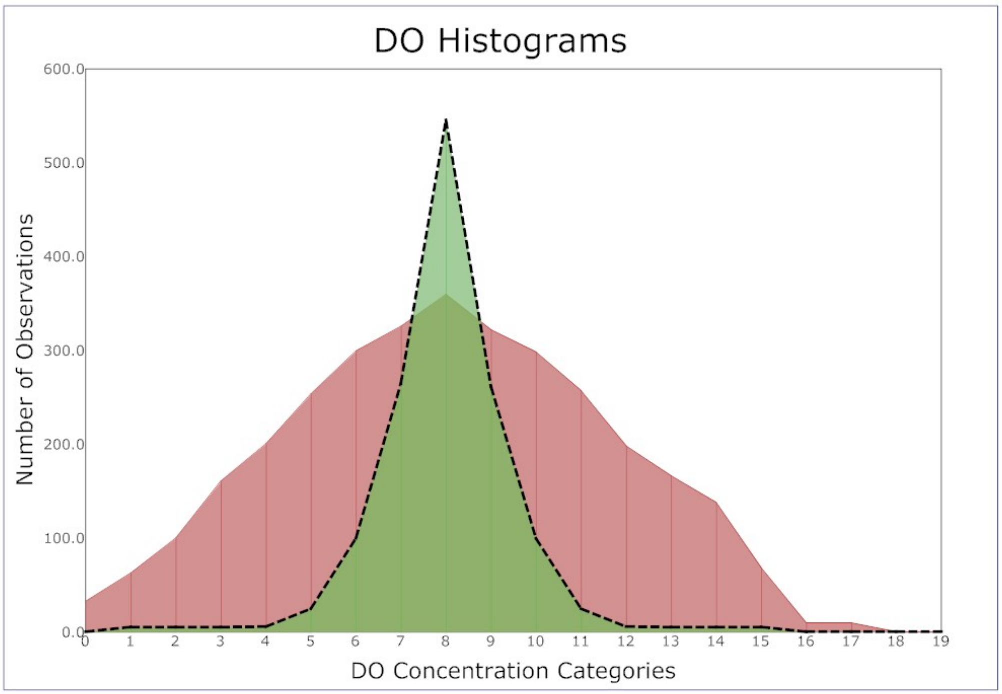


Figure 3.1-1. A conceptual diagram of expected DO frequency plots for "healthy" and nutrient "obese" sites in Chesapeake Bay tributaries.

animals). If this relationship is found to hold in many systems, we expect this will serve as a new indicator of estuarine condition. To make use of this indicator for management, a Bay Program goal could be to move these histograms from the obese to the healthy distributions.

We plan to test this hypothesis by examining the distribution of values in a DO frequency distribution (histogram) in which the categories in the frequency distribution are DO levels, and the frequency is calculated as total observations over some fixed time period (day, week or month). We may be able to measure important differences in distributions through descriptive statistics (moments) such as kurtosis and skewness, but will also examine several methods that are available to test differences between distributions. For example, we will compare fitted (shape) parameters for a given distribution to test their ability to distinguish eutrophic conditions as well as test the fit of different distributions (Figure 3.1-2 shows alternative distributions). The indicator of system health will likely be based on defining particular ranges of moments or distribution (shape) parameters that correspond to eutrophic or healthy systems.

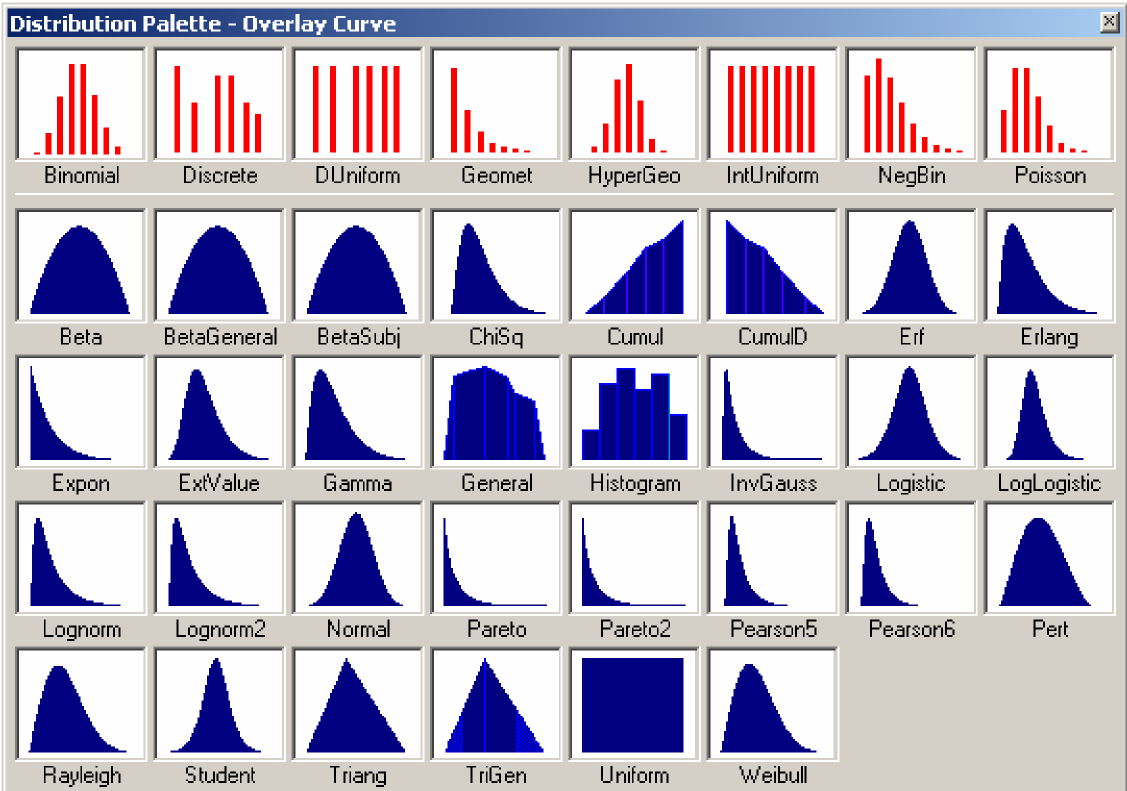


Figure 3.1-2. Types of probability distributions that could be fit to histograms of DO observations (from BestFit software).

3.1.3 Methods

We will be reviewing ConMon data from many Bay sites. Based on this review activity, we will select a series of sites for further analysis. Guidelines to be used in selecting sites include the following: 1) quality of the data time series (e.g., lack of data collection failures); 2) length of the data time series with longer time series at sentinel stations receiving higher priority; 3) proximity of sites to management actions that have decreased nutrient loading rates; 4) sites that provide a range of nutrient load conditions from extreme (e.g., Back River) to less extreme sites (e.g., some Coastal Bay sites).

The primary tools for evaluating ConMon data in different systems will be the frequency histogram and the cumulative frequency distribution. These distributions of DO conditions over time will allow Bay managers to better understand stresses within a system and compliance with water quality regulations in shallow water habitats. To create the frequency distributions of DO conditions, we will apply time series analysis to ConMon data streams and generate, for example, a function that describes the probability of DO being less than a threshold value over any period of time (1 day, 7 day or 30 day). A moving window analysis (typical of many time series methods) would be adapted to evaluate DO conditions (e.g., pass/fail) during a given period of time and how frequently given conditions occur. The moving window analysis will generate the data necessary to create a frequency histogram (e.g., to determine number of 7-day periods where DO stayed below 2 mg/L) and the cumulative frequency distribution of those occurrences. A cumulative distribution function (cdf) will be fit (using statistical software) to the cumulative frequency distribution, which will allow the user to judge the probability of failing DO conditions in the vicinity of a monitoring station.

As previously mentioned, we will use several tests to compare distributions that will be fit to the histograms. We have software available (BestFit) to test which distributions offer the best fit to data and will make use of other statistical programs (SAS or R) to evaluate characteristics of the distributions among estuarine sites. To test whether cdfs of different systems are alike, we will apply a Kolmogorov-Smirnov test, or similar test. This test can also be applied to examine deviation of a system from an ideal distribution. Therefore, this approach may be useful for examining regulatory requirements through time.

3.2 Ecosystem Production and Respiration from ConMon Data Sets

3.2.1 Overview

Rates of primary production and community respiration are fundamental characteristics of aquatic ecosystems. The late oceanographer J. D. H. Strickland (1961) once noted that a lack of interest and understanding of aquatic production would not be unlike a lack of interest in these processes in agricultural situation – not a likely occurrence! However, the production and respiration characteristics of estuarine systems have been far less well studied or monitored than is the case of lakes. Since it is well-established that these rates are sensitive to nutrient loading rates (e.g., Nixon *et al.* 1992; Kemp *et al*. 2005; Boynton and Kemp 2006), reliable estimates of these rates would serve both as an index of system performance as well as an indicator of system response to nutrient load reductions. We propose to investigate rate processes calculated from ConMon data to generate another metric for evaluating eutrophication and ecosystem health.

3.2.2 Background

The original method for making estimates of community production and community respiration was developed by Odum and Hoskins (1958) for estuarine waters. The original technique involved making several measurements of dissolved oxygen during a diel period with particular emphasis on sampling near dawn and near dusk so as to obtain DO minimum and maximum values, respectively. Temperature and salinity measurements also needed to be collected. In practice, investigators generally were able to obtain 4 to 6 observations during a diel period due to the laborious nature of sampling and making DO determinations.

To compute production and respiration rates, DO concentration was plotted as function of time and the rate of change in DO was then computed. This rate of change curve was then “corrected” for DO diffusion between air and the water column. To make this correction, percent saturation of DO was computed using the temperature and salinity observations. When water was supersaturated during daylight periods (>100% saturated) DO diffuses from the water to the atmosphere and hence the rate of change curve was underestimating production. Under these circumstances the rate of change curve was increased by the amount of oxygen estimated to have diffused from the water to the atmosphere.

Air-water diffusion was estimated by applying a diffusion coefficient to the gradient in DO saturation between water and atmosphere. Diffusion coefficients have been estimated with a variety of techniques and values of about 0.5 g O_2 m^{-2} hr^{-1} at 100% saturation gradient have often been used in shallow and generally protected estuarine situations (Caffrey 2004). In practice, this correction amounts to 5 -30% of the corrected rate of change curve. Once the curve has been corrected, the positive rate of change curve is integrated and is an estimate of community production. Similarly, the negative portion of the rate of change curve is integrated and is an estimate of nighttime respiration. Gross primary production (i.e., net production plus the respiratory losses associated with this production) is estimated by obtaining an average of hourly nighttime respiration, multiplying this value by the hours of daylight and then adding this value to the net daytime production estimate. While very useful, the original technique suffered because of the laborious nature of data collection and the time-consuming nature of the graphing and correcting rate of change curves. Nevertheless, numerous studies adopted the technique and confirmed the responsive nature of these rates to nutrient or organic matter inputs (Oviatt *et al*. 1993).

During the last several decades several things have changed in the monitoring/research world that have made it far more feasible and affordable to consider using open water community metabolism measurements as components of monitoring programs in estuarine systems. First, several generations of in-situ devices have come into common use, each providing more reliable measurements of DO, temperature, salinity, pH and more recently chlorophyll-a and turbidity. These devices now have the capability of making these measurements in a reliable fashion for periods of one to two weeks in nutrient-enriched estuarine ecosystems. The addition of wiper blades and other self-cleaning devises have further enhanced the reliability of these devices.

These in-situ sondes are capable of making rapid (~ 20 measurements/minute; more frequently measurements are made at a frequency of 4/hour), repeated measurements thus ensuring that a fine-scale record of diel changes in concentrations is captured. In addition, computational capacity and associated software have improved greatly. It is now possible to readily store and manipulate the large data files associated with a group of continuously recording sondes. It is also possible, as we will describe in detail later in this SOW, to develop programs to compute metabolism variables, thus largely removing the time consuming nature of these analyses. Thus, reliable data sets collected at frequencies amenable for metabolism calculations and computer hardware and software more than capable of conveniently storing and making calculations have combined to make these community-scale processes very attractive.

3.2.3 Methods

There are at present a very large number of sites for which metabolism computations might be applied. ConMon-like measurements began about 1998 at three sites in the Pocomoke River. During 2005 there were 39 sites being monitored in Maryland tributary rivers of Chesapeake Bay and the Maryland Coastal Bays. At most of these sites, measurements are collected from April through October and sites remain active for three consecutive years; in a few cases, more years of data are available. Thus, at a specific site, there is the potential for about 210 measurements of production and respiration per year and a total of about 630 measurements during a three year deployment cycle. Such a relatively large set of rate process measurements would certainly help us better understand the status and trends of these systems as nutrient and sediment loads are modified by management actions.

Based on earlier work by Burger and Hagy (1998) for calculating water column metabolism from near-continuous monitoring data, an automated Excel spreadsheet (Metabolism.xls) was developed by D. A. Jasinski. The worksheet was automated using Microsoft's Visual Basic for Applications (VBA) programming language. Briefly, the steps the spreadsheet undertakes are as follows:

1. An excel file, containing the continuous monitoring data configured by the user in a requisite format (Figure 3.2-1) is read into the spreadsheet.

2. Dates and times are reformatted into a continuous time variable or serial number.

3. Sunrise and Sunset times for each date are calculated based on the latitude and longitude of the station.

4. Rows are inserted into the dataset to create an observation at sunrise and sunset on each day.

5. Each observation in the dataset is assigned a daypart – Sunrise, Day, Sunset, or Night

6. Each observation is assigned to a "Metabolic Day". Each metabolic day begins at sunrise on the current day and continues to the observation immediately before sunrise on the following day.

7. For sunrise/sunset observations created in Step 4, values for water temperature, salinity, dissolved oxygen and dissolved oxygen saturation are calculated by taking the mean of the observations immediately before and after sunrise and sunset.

8. The change in DO, time, air/sea exchange and oxygen flux is calculated between each consecutive observation.

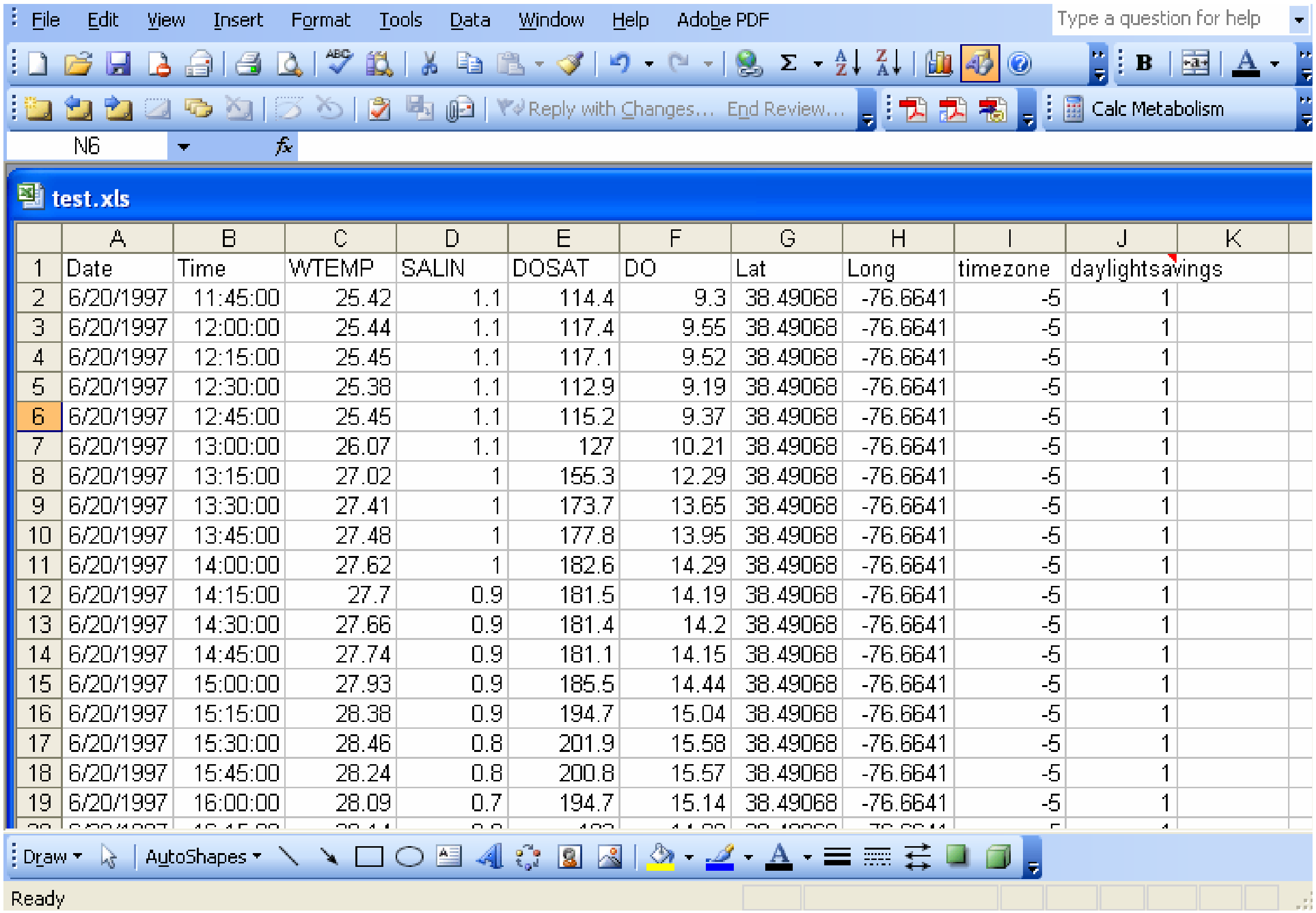
9. The minimum and maximum DO values are calculated between sunrise and sunset on each day and these values are labeled "metabolic dawn" and "metabolic dusk".

10. Sums of the changes in DO, time, air/sea exchange and DO flux (step 8) are calculated for each metabolic day for the periods between sunrise and metabolic dawn, metabolic dawn and metabolic dusk, metabolic dusk and sunset, and sunset and the following sunrise.

11. From these sums, 6 metabolic variables are calculated and these include: rn, rnhourly, pa, pa_star, pg, pg_star.

These variables are defined as follows:
rn = Nighttime (sunset to following sunrise) summed rates of DO flux corrected for air/water diffusion.
rnhourly = rn divided by the number of nighttime hours
pa = The sum (both positive and negative) of oxygen flux (corrected for air-water diffusion) for the dawn, day and dusk periods.

pa_star = summed oxygen flux (corrected for air-water diffusion) for the day period
pg = pa + daytime respiration. Daytime respiration = rnhourly * (number of hours of daytime+dawntime+dusktime).
pg_star = pa_star + daytime respiration as defined above.



	A	B	C	D	E	F	G	H	I	J	K
1	Date	Time	WTEMP	SALIN	DOSAT	DO	Lat	Long	timezone	daylightsavings	
2	6/20/1997	11:45:00	25.42	1.1	114.4	9.3	38.49068	-76.6641	-5	1	
3	6/20/1997	12:00:00	25.44	1.1	117.4	9.55	38.49068	-76.6641	-5	1	
4	6/20/1997	12:15:00	25.45	1.1	117.1	9.52	38.49068	-76.6641	-5	1	
5	6/20/1997	12:30:00	25.38	1.1	112.9	9.19	38.49068	-76.6641	-5	1	
6	6/20/1997	12:45:00	25.45	1.1	115.2	9.37	38.49068	-76.6641	-5	1	
7	6/20/1997	13:00:00	26.07	1.1	127	10.21	38.49068	-76.6641	-5	1	
8	6/20/1997	13:15:00	27.02	1	155.3	12.29	38.49068	-76.6641	-5	1	
9	6/20/1997	13:30:00	27.41	1	173.7	13.65	38.49068	-76.6641	-5	1	
10	6/20/1997	13:45:00	27.48	1	177.8	13.95	38.49068	-76.6641	-5	1	
11	6/20/1997	14:00:00	27.62	1	182.6	14.29	38.49068	-76.6641	-5	1	
12	6/20/1997	14:15:00	27.7	0.9	181.5	14.19	38.49068	-76.6641	-5	1	
13	6/20/1997	14:30:00	27.66	0.9	181.4	14.2	38.49068	-76.6641	-5	1	
14	6/20/1997	14:45:00	27.74	0.9	181.1	14.15	38.49068	-76.6641	-5	1	
15	6/20/1997	15:00:00	27.93	0.9	185.5	14.44	38.49068	-76.6641	-5	1	
16	6/20/1997	15:15:00	28.38	0.9	194.7	15.04	38.49068	-76.6641	-5	1	
17	6/20/1997	15:30:00	28.46	0.8	201.9	15.58	38.49068	-76.6641	-5	1	
18	6/20/1997	15:45:00	28.24	0.8	200.8	15.57	38.49068	-76.6641	-5	1	
19	6/20/1997	16:00:00	28.09	0.7	194.7	15.14	38.49068	-76.6641	-5	1	

Figure 3.2-1. Screen shot showing the requisite input format needed by Metabolism.xls for calculation of metabolism variables.

Air-water diffusion of oxygen is considered in these computations and the diffusion correction is based on the difference between observed DO percent saturation and 100% saturation multiplied by a constant diffusion coefficient. For these preliminary computations a diffusion coefficient of 0.5 g O_2 m^{-2} hr^{-1} was selected as generally representative of conditions frequently encountered in tributary situations (Caffrey 2004).

One of the primary assumptions of this method is that temporal changes in DO measured by the continuous monitors are due solely to metabolism (i.e., oxygen production from photosynthesis and oxygen loss from respiration) occurring at the station and not due to advection of water masses with different oxygen conditions moving past the instrument. Because Chesapeake Bay is a tidal system, this may not always be the case. Depending on the hydrodynamics of a given station, this assumption may be more or less realistic and may also be variable from date to date. One way of censoring dates where DO is affected by advection is to preview the data graphically prior to metabolism calculations and determine if there is a relationship between salinity and DO. Large changes in salinity suggest moving water masses and therefore, advection. These dates could then be flagged and reviewed before metabolism variables are calculated. Another way of dealing with advection is to incorporate in the code a method of detecting changes DO associated with changes in salinity. It might then be possible to apply a site specific correction factor to remove the advection affect on DO.

3.2.4 Specific Activities

The following is a listing the specific activities to be conducted in this effort.

1. A series of ConMon sites will be selected (based on analyses completed in FY 09). We anticipate that these sites will be from high nutrient impact areas, less impacted sites and from the few sites that have served as sentinel sites. A multi-year (> 3 years) record is especially important because interannual scales of variability will likely make relationships to changing nutrient loading rates stronger. We fortunately have conducted these computations for 5-6 sites in the Maryland Bay and for about 14 sites in the Potomac River estuary. Thus, we have significant experience in conducting these computations.
2. Production (P) and respiration (R) rates will be computed for these sites using data collected between April and October. In theory, about 700 P and R values could be developed for each site and each year. In practice, something closer to 500 estimates would be developed from each site; days are lost to data gaps and to physically dominated diel DO patterns. This is still a huge number of rate measurements and these provide excellent input data for statistical analyses.
3. We will qualitatively (graphically) and quantitatively compare these data with a “standard site”, that being the 1963 data from the Patuxent River estuary collected during the pre-eutrophic period in that system. We expect to see significant changes in magnitude and seasonal pattern in P and R.

We will actively work with DNR staff to adapt these analyses to a web format. This format will attempt to use these data to explain the concept of nutrient obesity, a term that seems to translate eutrophication to the public.

3.3 Understanding Spatial Structure of Water Quality for Water Quality Criteria Assessment Using DATAFLOW and Fixed Monitoring Stations

3.3.1 Overview

Although DATAFLOW results have generally been evaluated in terms of instantaneous compliance with SAV habitat criteria, further analysis would make fuller use of this database for understanding water quality in estuaries. We propose to conduct GIS (geographical information systems), geostatistical and other statistical analyses of DATAFLOW results to evaluate the character and persistence of structure in shallow water conditions (e.g., downriver trends) and to provide increased insights into system dynamics. We will test the relationship between water quality characteristics and SAV extent and abundance to examine the predictive ability of SAV habitat criteria. The results of this analysis would have uses for immediate regulatory needs as well as long-term research goals into water quality drivers.

A specific application of these results would be to assist in interpreting fixed station and ConMon monitoring sites in terms of what spatial area they are likely to represent for water quality assessments. The degree of spatial heterogeneity in a system and whether that heterogeneity can be described in a consistent manner (i.e., by defining strata or correlates) will determine the representativeness of a given monitoring station. Therefore, any patterns discerned through this analysis could be used to evaluate the area over which monitoring station results could be transferred and what future placement of monitoring stations would best represent water quality conditions.

Eventually, this analysis could serve to explain the degree to which water quality is controlled by regional or proximal conditions. For example, patchiness in chlorophyll concentrations may be partly explained by examining water residence time, local sources of nutrients, or other conditions in addition to more well-studied drivers such as timing of the spring freshet. Our analyses provide a means to describe and distinguish regional trends and local patchiness and seek causal factors at multiple scales.

3.3.2 Methods

The focus of the analysis will be to examine the presence of spatial patterns within the water quality data and evaluate the intersection of that pattern with SAV distribution. We plan to use the Potomac data as an initial case study to develop comparison methods and to assess the availability and quality of complementary data (i.e., spatial data for explanatory variables). Three specific approaches to examining spatial pattern and testing potential explanatory variables are described below.

1. **Assess spatial patterns:** Estuaries have natural geophysical forcings that suggest likely patterns in water quality. For example, down-river salinity gradients are one result of the physical setting of estuaries between freshwater and saltwater systems. In our initial evaluation of DATAFLOW results, we have also observed cross-river gradients in water quality parameters and some correlations with depth. These initial results are not surprising given established circulation patterns, but the results of DATAFLOW have not been adequately linked to physical forcings to allow full interpretation of findings. Our analysis will use geostatistical methods to detect spatial pattern. We will evaluate our ability to represent and describe gradients and other data structures within different seasons and annually.
2. **Assess correlations:** To begin exploring relationships between endpoints and drivers, we will test correlations among water quality parameters and other spatial data sets using methods such as a Kappa Index of Agreement. We expect to conduct tests of similarity using multiple “window” sizes (areal extents) so as not to limit the agreement to a pixel by pixel comparison.
3. **Evaluate water quality within SAV beds:** Using GIS analysis, we will intersect water quality interpolations with mapped SAV beds (from Virginia Institute of Marine Science database) to examine the predictive ability of habitat quality variables. Further, we will develop summary statistics to examine effects of water quality on SAV distribution and abundance.

3.4 Interaction with DNR and Chesapeake Bay Program Staff on Analysis Coordination Activities

While we have indicated specific approaches to analysis issues in the preceding sections we realize that there may be alternate approaches that better meet program needs and goals. To assure that our work is coordinated with other Chesapeake Bay Program and MD-DNR analytical activities, EPC PIs will participate in appropriate Program meetings.

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5.0 SOFTWARE AND COMPUTER PROGRAM REFERENCES

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SAS: Copyright © 2009 SAS Institute Inc., SAS Campus Drive, Cary, NC 27513 (www.sas.com)

R: Copyright © 1989, 1991 Free Software Foundation, Inc., 59 Temple Place, Suite 330, Boston, MA 02111-1307 (www.r-project.org)

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6.0 LOG OF SIGNIFICANT CHANGES

Fiscal Year	Date Initiated	Program	Description
FY2009	03/07/08	Dataflow (DF)	Station XBF0956 renamed XBF7254 by MDDDNR; location not changed.
FY2010	07/01/09	EPC	No field-based program included in FY2010.