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MARYLAND ENVIRONMENTAL SERVICE

A MAPPING SURVEY OF THE SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN THE UPPER CHESAPEAKE BAY

Final Report

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ABSTRACT

From July 27 to August 3, 1998 a study was conducted to measure sediment-water nutrient and oxygen exchanges, bottom water and sediment characteristics at 35 stations distributed in the upper Chesapeake Bay (Figure 3-1). These stations were chosen to sample a variety of habitats including dredged channels, non-channel deep locations, and relatively shallow non-channel areas. These measurements provided data that were used to compare sediment-water exchanges (fluxes) in dredged channels and non-channel locations. Contour maps of relevant parameters were constructed and visually examined for spatial flux gradients in the upper bay. These stations ranged in depth from 4 to 24 meters and varied in bottom water temperature (23.7 to 28.3 C) and salinity (0.0 to 16.5 ppt). Ten of the 35 stations were located in dredged channels. An analysis of variance (ANOVA) was used to examine differences between the habitat groups (channels, non-channels > 6 meters, and non-channels < 6 meters). No statistically significant differences in sediment-water exchanges were found between the channel and non-channel deep groups. Only mean sediment oxygen consumption (SOC) at the shallow stations was significantly higher than the other groups. This result was not surprising since sediment oxygen consumption (SOC) is highly correlated with bottom water dissolved oxygen concentrations, and shallow stations had higher bottom water dissolved oxygen concentrations compared to deeper stations. In addition to these comparisons the study revealed significant gradients in a variety of sediment-water fluxes across the upper bay. For example, ammonium (NH_4^+) ranged from 0.0 μM N m^{-2} hr^{-2} to 838 μM N m^{-2} hr^{-2}, and phosphate (PO_4^{-3}) ranged from -19.2 μM P m^{-2} hr^{-1} to 73.3 μM P m^{-2} hr^{-1}. Combined nitrite and nitrate (NO_2^- + NO_3^-) fluxes were quite variable and ranged from –98.8 μM N m^{-2} hr^{-2} to 121 μM N m^{-2} hr^{-2}. These differences clearly demonstrate the spatial variation in sediment-water fluxes present within upper Chesapeake Bay and the need to include this variation when making regional assessments. Integrated flux estimates based upon interpolated data using *Surfer* ™ mapping software for the area surveyed (829 km^2) revealed that for ammonium (NH_4^+), approximately 135,600 kg N d^{-1} (298,678 lb N d^{-1}) entered the water column of the upper bay from the sediments in July 1998. In comparison, approximately 3,932 N d^{-1} (8,667 lb N d^{-1}) was contributed by the Susquehanna River during July 1998. The estimate for integrated dissolved inorganic phosphorus (PO_4^{-3}) from the sediments was 19,401 kg P d^{-1} (42733 lb P d^{-1}) compared to 442 kg P d^{-1} (974 lb P d^{-1}) from Susquehanna River flow. These comparisons clearly show the large influence sediments can have on nutrient processes in this region of the Chesapeake Bay.

2. INTRODUCTION

2.1. Background

During the past decade a great deal has been learned about the effects of both natural and anthropogenic nutrient inputs (*e.g.* nitrogen and phosphorus) to estuarine waters on such important features as phytoplankton production, algal biomass, and deep water oxygen conditions (*e.g.* Nixon, 1981, 1988; Boynton *et al.*, 1983; D'Elia *et al.*, 1983; Garber *et al.*, 1989, and Kemp and Boynton, 1992). While our understanding of estuarine ecosystem function is not complete, important pathways regulating nutrient utilization and regeneration relevant to water quality have been identified. Research conducted in Chesapeake Bay and other estuaries indicate that estuarine sediments play an important role in estuarine ecosystem function and may serve as a source or sink for nutrients and organic matter (Boynton *et al.*, 1995). Of particular importance, high rates of algal primary production and biomass levels can be sustained through summer and fall periods by benthic recycling of essential nutrients with little external nutrient input.

Nutrients and organic matter enter the Bay from a variety of sources, including sewage treatment plant effluents, fluvial inputs, local non-point drainage and direct rainfall on Bay waters. These dissolved nutrients are rapidly incorporated into particulate matter via biological, chemical and physical mechanisms. Much of the particulate material sinks to the bottom and is potentially available for remineralization, thus serving as a large internal source of both nitrogen and phosphorous to the water column (Boynton *et al.,* 1991). The regenerative capability and large nutrient storage capacity of bottom sediments contribute to a potentially large return flux of nutrients from sediments to the water column to sustain further algal growth.

From 1993 through 1997, sediment-water oxygen and nutrient exchanges were measured in the vicinity of Pooles Island, and less frequently in the Back and Patapsco Rivers as well as at Site 104 which is just north of the Bay Bridge at Annapolis. A single set of measurements was made prior to 1993 at the Deep Trough area just south of the Bay Bridge at Annapolis and at a site five miles north of Pooles Island. Based on these studies, several general patterns have emerged. Gradients exist in the magnitude of sediment-water oxygen and nutrient exchanges within the upper portion of the Chesapeake and along the entire length of the Bay system (Cowan and Boynton, 1996). Sediment-water nutrient exchanges are larger in areas having low dissolved oxygen (typically deep waters) compared to areas with well oxygenated bottom water. Sediment-water fluxes were temporarily enhanced (one summer period) at a relatively shallow water (<10 meters) site which had recently received dredged material.

It appears that controlled bottom placement of dredged material produces larger sediment-water exchanges than does hydraulic placement. These enhanced nutrient releases which were observed in the Pooles Island area appear to last for about one year (*i.e.* if placement occurred during the winter months, sediment-water exchanges were enhanced during the following summer but had returned to pre-placement rates by the next summer). It is probable that enhanced rates observed at a controlled bottom placement sited resulted because a large fraction of the dissolved nutrients contained in the placed sediments had been retained during placement and were therefore available for release to the water column. In the case of hydraulically placed sediments interstitial dissolved nutrients were largely washed from sediments during the placement process and hence were not available in the sediment column to support enhanced sediment nutrient releases during the summer period immediately following placement. It thus appears, at least at the shallow disposal site in the vicinity of Pooles Island, that hydraulic placement produces an immediate nutrient release as the dredged material is placed while controlled bottom placement produces a delayed nutrient release.

While there has been significant progress in the description of the magnitude of sediment-water oxygen and nutrient exchanges in the upper bay in recent years, there are some clear issues that have not been addressed. One of these involves sediment processes in the dredged channels, which are distinctive features of this region of the Bay. Prior to this study, preliminary measurements of sediment-water exchanges had only been made at five channel sites. Because the spatial coverage of sediment-water flux measurements in the upper bay remains limited, a study was initiated in July of 1998 to survey sediment-water fluxes across a broad region of upper Chesapeake Bay and to place the results from previous studies within the context of the entire upper Chesapeake Bay. Thirty five stations distributed across a range of depths and bottom types were surveyed in July of 1998 in order to observe broad scale patterns and gradients in nutrient exchanges in upper Chesapeake Bay sediments.

2.2. Objectives

The measurements made during this study include estimates of net sediment-water oxygen and nutrient exchanges (fluxes), nutrient content of surface sediments, and measurement of water quality conditions in near-bottom waters. These data were collected to complete the following tasks:

1. Produce quantitative contour maps of relevant sediment-water exchanges in the upper bay;

2. Produce quantitative contour maps of carbon, nitrogen, phosphorus, and total chlorophyll-a in surface sediments of the upper bay;

3. Produce quantitative contour maps of dissolved oxygen, ammonium, phosphate, and nitrite plus nitrate in bottom waters of the upper bay;

4. Compare and contrast sediment-water fluxes between channel sites and non-channel sites in the upper bay and

5. Examine the data for possible use in statistical models which were designed to predict sediment-water exchanges using a few easily measured water quality parameters.

3. ACQUISITION AND ANALYSIS OF UPPER BAY SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES DATA

3.1. Location of Stations

During July 1998, abbreviated sediment-water oxygen and nutrient exchanges (MINI-SONE) measurements (single sediment cores) were taken at 35 stations in the upper bay. Several criteria were taken into consideration when selecting these thirty-five stations. The stations were arranged to provide spatial coverage of the upper bay, ranging from the Deep Trough Area (just south of the bay bridge at Annapolis) north to the mouth of the Elk River. Wherever appropriate, each station that was located in a dredged channel also had a companion station on the adjacent non-channel area. Some of the stations were located in areas that are potential construction sites for dredged material containment islands. Eight of the stations were selected because they were part of a preliminary study that was conducted in August 1997 (Cornwell and Boynton, 1999). Positioning of these stations allowed for comparison along a depth, salinity and eutrophication gradient. Table 3-1 summarizes station names, station abbreviations, latitude and longitude derived from the on board differential global positioning system (DGPS), and sampling date information. Figure 3-1 shows the location of the 35 stations. Some of the stations, such as the Pooles Island Reference station, have been monitored during other similar studies.

3.2. Sampling Frequency

The sampling frequency for this program was based on the seasonal patterns of sediment water exchanges observed in previous studies conducted in Chesapeake Bay region (Kemp and Boynton, 1980, 1981; Boynton *et al.*, 1982; and Boynton and Kemp, 1985). These studies indicated that fluxes were generally highest during warm periods of the year (June - September). Accordingly, many sediment-water surveys were conducted with monthly measurements during the summer period. However, since the upper bay activity was a spatially intensive survey, one set of measurements, in July 1998, was completed at 35 sampling sites.

3.3. Field Methods

Details concerning methodologies are described in the Quality Assurance Plan (Rohland *et al.*, 1998) and an overview is provided below.

3.3.1. Water Column Profiles

At each of the 35 upper bay stations, vertical water column profiles of temperature, salinity and dissolved oxygen were measured at 2 meter intervals from the surface to the bottom. Turbidity of surface waters were measured using a Secchi disc.

Table 3-1. Location, depth and description (channel or non-channel) of stations in the upper Chesapeake Bay sampled in July 1998.
Latitude and longitude values are expressed as degrees.
Depth is measured in meters.
Stations that were sampled in 1997 as well as 1998 are indicated with an (*).

Station	Latitude (degrees)	Longitude (degrees)	Description	Channel Areas	Depth (meters)
UB01	39.42833	76.04333	NON-CHANNEL		5.0
UB02	39.42500	76.02500	NON-CHANNEL		5.0
DC01	39.42463	76.01873	CHANNEL	C & D Approach Channel	13.5
UB03	39.39750	76.11833	NON-CHANNEL		4.0
UB04	39.38667	76.10667	NON-CHANNEL		6.5
DC02	39.38333	76.09000	CHANNEL	C & D Approach Channel	14.5
UB05	39.34500	76.19167	NON-CHANNEL		9.0
DC03	39.34167	76.18333	CHANNEL	C & D Approach Channel	11.0
UB06	39.28950	76.34133	NON-CHANNEL		4.5
PLIS	39.27142	76.28883	NON-CHANNEL*		4.5
UB07	39.27767	76.21900	NON-CHANNEL		7.0
NACL	39.26462	76.23625	CHANNEL*	C & D Approach Channel	12.0
UB08	39.22033	76.37150	NON-CHANNEL		6.0
UB09	39.21552	76.27783	NON-CHANNEL		5.0
UB10	39.18500	76.32000	NON-CHANNEL		6.0
DC04	39.17787	76.28852	CHANNEL	Tolchester Channel	12.0
UB11	39.17167	76.33333	NON-CHANNEL		5.0
FMCL	39.23707	76.55102	CHANNEL*	Fort McHenry Channel	10.5
FFOF	39.23382	76.55427	NON-CHANNEL*		6.0
BWCL	39.19095	76.47662	CHANNEL*	Brewerton Channel (West)	16.0
BWSL	39.19387	76.47520	NON-CHANNEL*		6.0
BECL	39.15975	76.37240	CHANNEL*	Brewerton Channel (Eastern Extension)	12.0
BESL	39.16207	76.37102	NON-CHANNEL*		6.0
DC06	39.12163	76.39662	CHANNEL	Craighill Channel (Upper Range)	17.0
UB12	39.12167	76.38000	NON-CHANNEL		7.0
UB13	39.10167	76.33333	NON-CHANNEL		8.0
DC07	39.09500	76.30000	CHANNEL	Swan Point Channel	11.0
UB14	39.09783	76.28800	NON-CHANNEL		8.0
CHCL	39.05845	76.39158	CHANNEL*	Craighill Channel (Entrance)	13.0
CHSL	39.05850	76.38677	NON-CHANNEL*		11.0
UB15	39.05667	76.33333	NON-CHANNEL		13.5
104-D2	38.99383	76.35833	NON-CHANNEL		24.0
104-DR	38.99517	76.37267	NON-CHANNEL		18.0
UB16	38.96667	76.36667	CHANNEL	Eastern Channel (Kent Island)	17.0
UB17	38.96667	76.36117	NON-CHANNEL		7.5

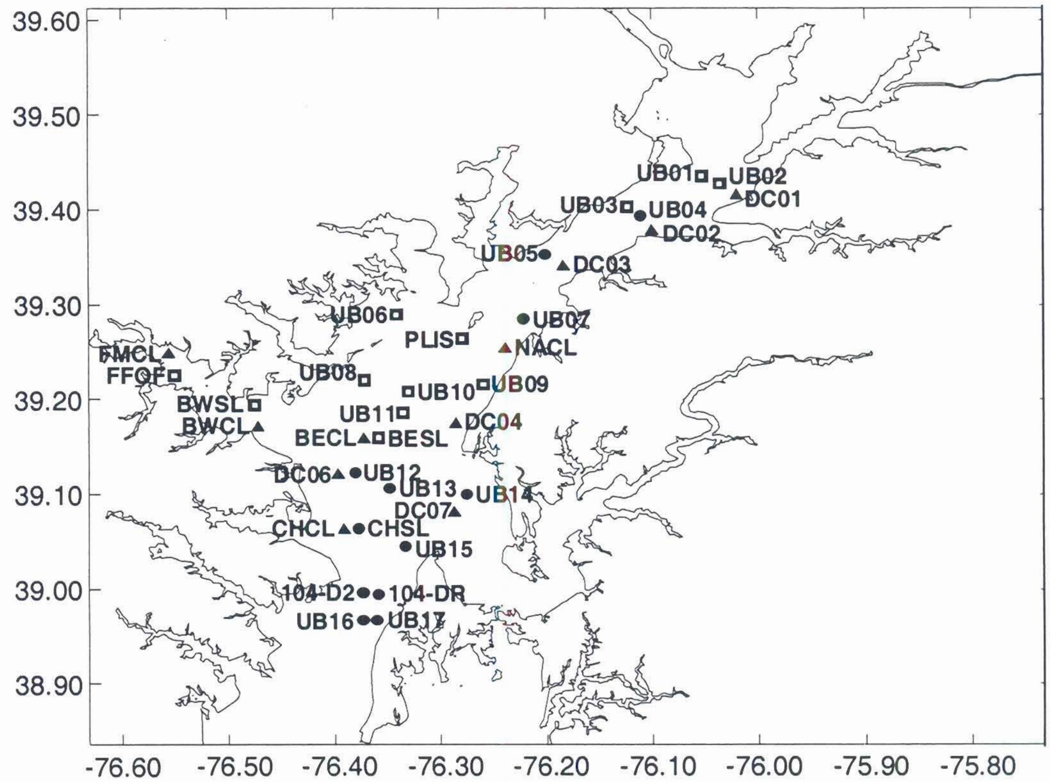

Figure 3-1. Locations of stations in the upper Bay that were sampled in July 1998.

▲ *Indicate sites located in channels.*

○ *Indicate non-channel sites with depths of six meters or less.*

● *Represent the non-channel sites that have depths greater than six meters. Coordinates and depths of these stations can be found in Table 3.1.*

3.3.2. Water Column Nutrients

Near-bottom (approximately 1/2 meter above the bottom) water samples were collected using a high volume submersible pump system. Samples were filtered, where appropriate, using 0.7 µm GF/F filter pads, and immediately frozen. Samples were analyzed by Nutrient Analytical Services Laboratory (NASL) for the following dissolved nutrients: ammonium (NH_4^+), nitrite (NO_2^-), nitrite plus nitrate ($NO_2^- + NO_3^-$) and dissolved inorganic phosphorus corrected for salinity (DIP or PO_4^{-3}).

3.3.3. Sediment Profiles

At each of the 35 upper bay stations an intact sediment core was used to measure the redox potential (Eh) of the sediment porewater. Sediment redox (mV) was measured at the sediment surface, one and 2 centimeters below the surface and every 2 centimeters thereafter to 10 cm depth. Additionally, surficial sediments were sampled for total and active sediment chlorophyll-a to a depth of 1 cm. Particulate carbon (PC), particulate nitrogen (PN), particulate phosphorus (PP), were sampled to a depth of 1 cm.

3.3.4. Sediment Flux Measurements

The protocols used in MINI-SONE flux estimates are an abbreviated set of measurements of the standard SONE techniques. MINI-SONE stations use a single sediment core with no blank. Intact sediment cores constitute a benthic microcosm where changes in oxygen, nutrient and other compound concentrations are determined.

A single intact sediment core was collected at each station using a modified Bouma box corer. These cores were then transferred to a Plexiglas cylinder (15 cm diameter x 30 cm length) and inspected for disturbances from large macrofauna or cracks in the sediment surface. If the sample was satisfactory, the core was fitted with an O-ring sealed top containing various sampling ports, and a gasket sealed bottom (Figure 3-2). The core is then placed in a darkened, temperature controlled holding tank where overlying water in the core is slowly replaced by fresh bottom water to ensure that water quality conditions in the core closely approximate in situ conditions.

During the period in which the flux measurements were taken, the cores were placed in a darkened temperature controlled bath to maintain ambient temperature conditions. The overlying water in a core was gently circulated with no induction of sediment resuspension via stirring devices attached to oxygen probes. Oxygen concentrations were recorded and overlying water samples (35 ml) are extracted from each core every 60 minutes during the incubation period. MINI-SONE cores were incubated for 3 hours with a total of 4 measurements taken. As a water sample is extracted from a core, an equal amount of ambient bottom water was added to replace the lost volume. Water samples were filtered and immediately frozen for later analysis for ammonium (NH_4^+), nitrite (NO_2^-), nitrite plus nitrate ($NO_2^- + NO_3^-$) and dissolved inorganic phosphorous (DIP or PO_4^{-3}). Oxygen and nutrient fluxes were estimated by calculating the mean

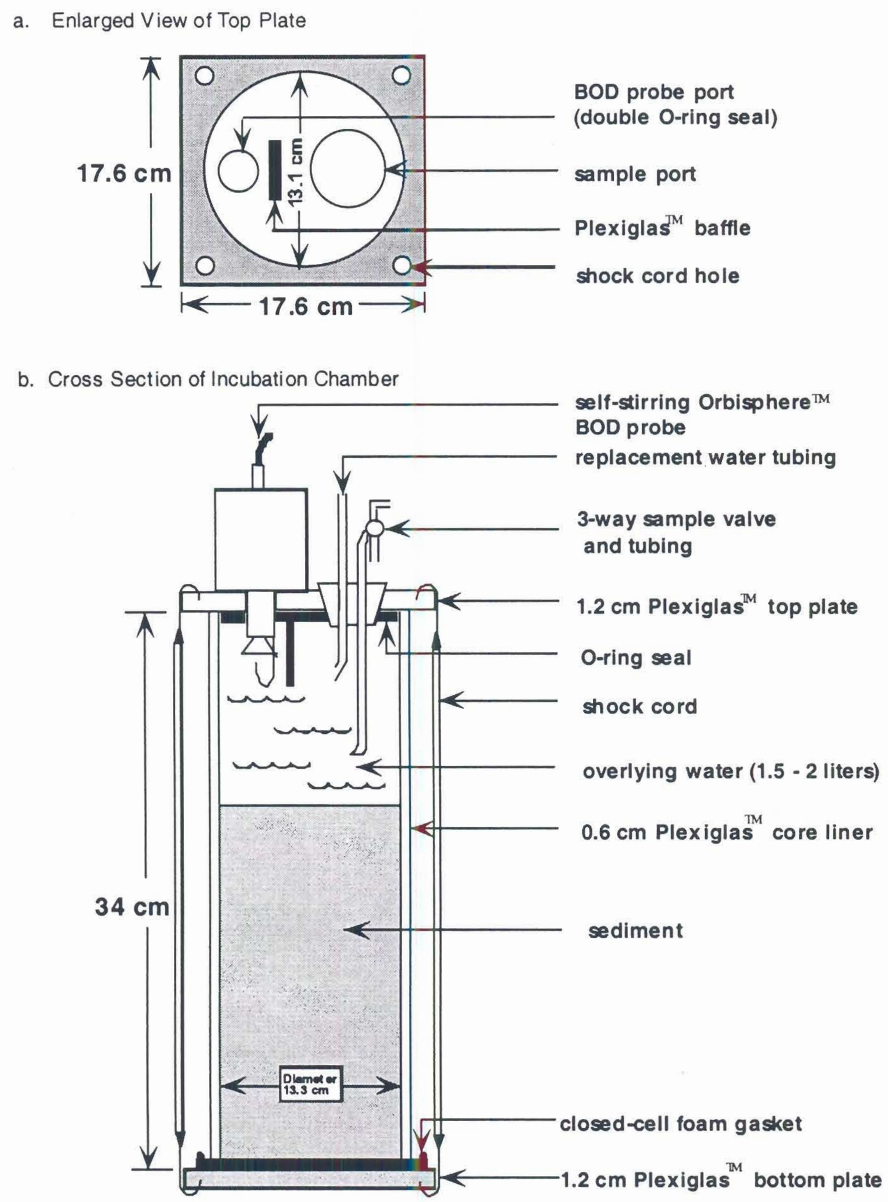

Figure 3-2. Diagram of the Incubation Chamber

rate of change in concentration over the incubation period and converting the volumetric rate to a flux using the volume:area ratio of each core.

3.3.4.1. Criteria for accepting, rejecting and modifying variable slopes used in calculating net sediment water fluxes

Nutrient concentrations are plotted against time of sampling and the slope of this curve is used to calculate net sediment-water exchanges. The following steps assume that all data have been previously verified following normal protocols.

1. If the slope of the nutrient concentrations vs time plot is statistically significant, the slope is used in calculating fluxes without modification.

2. Occasionally, there are plots which indicate a clear increasing or decreasing trend in concentrations over time but which have **one** data point which diverges strongly (either higher or lower concentration) from the trend. We consider these divergent data to represent contaminated samples (either by addition of the compound or addition of water having a much lower concentration of the compound) and they are not used. The slope is recalculated using lower degrees of freedom and a higher "r" value as a criteria for significance. If the slope is statistically significant, it is used in calculating fluxes.

3. If the concentration vs. time plots are erratic (*i.e.* no statistically significant increasing or decreasing trend in concentration over time) and if the difference in concentration among variables is **greater than** twice the detection limit for that variable, the data for that variable are considered to be non-interpretable. The slope is not calculated and the entry for that variable in the datafile file is recorded as "NI".

4. If the concentration vs. time plots are erratic (*i.e.* no statistically significant increasing or decreasing trend in concentration over time) and if the difference in concentration among variables is **less than** twice the detection limit for that variable, then the slope is taken to be zero and the net sediment-water flux is reported as zero. Occasionally, statistically significant slopes have been found for some variables (mostly nitrite and dissolved inorganic phosphorus) where concentration differences over the incubation period do not exceed twice the reported detection limit. These slopes are used to calculate net sediment-water exchanges.

3.4. Chemical Analyses

Methods for the determination of dissolved and particulate nutrients were as follows: ammonium (NH_4^+), nitrite (NO_2^-), nitrite plus nitrate ($NO_2^- + NO_3^-$), and dissolved inorganic phosphorus (DIP or PO_4^{-3}) are measured using the automated method of EPA (1979); particulate carbon (PC) and particulate nitrogen (PN) samples were analyzed using an Elemental Analyzer; particulate phosphorus (PP) concentration was obtained by acid digestion of muffled-dry samples (Aspila *et al.*, 1976); methods of Strickland and Parsons (1972) and Shoaf and Lium (1976) were followed for chlorophyll-a analysis.

3.5. Data Management Procedures

All field data was recorded on specially prepared field data sheets with the initials of the person recording the data indicated on each data sheet. The raw data sheets were reviewed for possible missing data values due to sample collection problems prior to data entry.

3.5.1. General Information Related to Data Sets

3.5.1.1. Naming Conventions

Data files were given unique names, a combination of an alpha code reflecting the name of the data set, the type of data set and a numeric descriptor which indicated the number of the cruise.

3.5.1.2. Incorporation of Error Codes in Data Tables

In order to keep a record of problems experienced while collecting data a one or two letter alpha code (Table 3-2) was entered in the data table which described the problems associated with questionable parameter values. Valid entries from the Sediment Data Management Plan (EPA, 1989) were used and where necessary additional codes have been added.

3.5.1.3. Data Tables QA/QC Control

Data recorded by instruments in the field were entered directly onto specially prepared data sheets. Data from samples analyzed by Nutrient Analytical Services Laboratory (NASL) were returned in written format. Data were keyed into Lotus using the specific data set layout developed during the continuing effort begun in August 1989 to standardize all EPC data files. Hard copies of the files were manually checked for errors.

Data files were corrected, a second printout produced which was re-verified by a different staff member.

Table 3-2. Error Codes listed below provide specific explanations for data not recorded in Appendix B. *(This table is also addded at the beginning of Appendix B for reference).*

Analysis Problem Code	DESCRIPTION
A	Laboratory accident
B	Interference
C	Mechanical/materials failure
D	Insufficient sample
N	Sample Lost
P	Lost results
R	Sample contaminated
S	Sample container broken during analysis
V	Sample results rejected due to QA/QC criteria
W	Duplicate results for all parameters
X	Sample not preserved properly
AA	Sample thawed when received
BB	Torn filter paper
CC	Pad unfolded in foil pouch
EE	Foil pouch very wet when received from field, therefore poor replication between pads, mean reported
FF	Poor replication between pads; mean reported
HD	Particulate and chlorophyll-a samples only taken at -1.0 cm of the Eh profile
HH	Sample not taken
JJ	Amount filtered not recorded (Calculation could not be done)
LL	Mislabeled
NA	Not applicable
ND	No duplicate samples taken
NI	Data for this variable are considered to be non-interpretable
NN	Particulates found in filtered sample
PP	Assumed sample volume (pouch volume differs from data sheet volume; pouch volume used)
QQ	Although value exceeds a theoretically equivalent or greater value (*e.g.*, PO4F>TDP), the excess is within precision of analytical techniques and therefore not statistically significant
RR	No sample received
SD	All sampling at station discontinued for one or more sampling periods
SS	Sample contaminated in field
TF	Dissolved oxygen probe failure
TL	Instrument failure in research laboratory
TS	Dissolved oxygen probe not stabilized
TT	Instrument failure on board research vessel
UU	Analysis discontinued
YB	No blank measured in this program
YY	Data not recorded
WW	Station was not sampled due to bad weather conditions, research vessel mechanical failure, VFX array lost or failure of state highway bridges to open

3.5.2. Description of Individual Data Sets

3.5.2.1. Upper Bay Data Sets

Appendix B of this report contains data tables listing variables measured during July, 1998. The data collected at each upper Bay station were organized into five data files:

WATER COLUMN PROFILES (Filename: **UPHPmmyy**, Table B-1) contain temperature, salinity and DO data measured at two meter intervals in the water column.

WATER COLUMN NUTRIENTS (Filename: **UPNTmmyy**, Table B-2) report bottom water dissolved nutrient concentrations.

SEDIMENT PROFILES (Filename: **UPSPmmyy**, Table B-3) include redox potential and selected sediment measurements of PC, PN, PP, total and active chlorophyll-a concentrations.

CORE DATA (Filename: **UPCDmmyy**, Table B-4) lists dissolved oxygen and nutrient measurements in flux chambers.

SEDIMENT-WATER FLUX (Filename: **UPFXmmyy**, Table B-5) is a summary table providing oxygen and nutrient flux data.

3.6. Nutrient Analysis Quality Assurance/Quality Control (QA/QC) Checking

NASL at the Chesapeake Biological Laboratory provides nutrient analyses to University, State and Federal agencies. As part of the laboratory's QA/QC program, NASL participates in cross calibration exercises with other institutions and agencies whenever possible. Some examples include:

- Particulate carbon and nitrogen cross calibration with Woods Hole Oceanographic Institution and Horn Point Environmental Laboratory.

- International Council for the Exploration of the Sea (ICES) inorganic nutrient round-robin communication. This will result in an international inter-comparison report to be issued in the near future.

- Comparisons of dissolved nutrient analyses conducted at Horn Point Environmental Laboratory, Bigelow Laboratory, the University of Delaware and the University of New Hampshire.

- Quarterly cross calibration exercises with Virginia Institute of Marine Science (VIMS) and Old Dominion University (ODU). The most recent inter-comparison (November 1995) confirmed all parameters routinely analyzed by these laboratories as part of the Chesapeake Bay Monitoring Program. Samples from various salinities and nutrient regimes were analyzed under this exercise.

- Environmental Protection Agency (EPA) unknown audits for various nutrients have been conducted.

- EPA audits of known nutrients were analyzed using samples in different salinity water while looking for possible matrix effects.

NASL has analyzed National Institute of Standards and Technology (NIST) and National Research Board of Canada reference materials, primarily estuarine sediment, as a check for their particulate and sediment carbon, nitrogen and phosphorus methods.

As part of the Chesapeake Bay Mainstem Monitoring Program, the laboratory analyzes approximately ten percent of the total sample load for QA/QC checks. These samples include laboratory duplicates and spike analyses.

Specific procedures include inorganic nitrogen (NH_4^+, NO_2^-, NO_2^- + NO_3^-) and DIP or PO_4^{-3} for which a standard curve usually comprising five concentrations encompassing the expected range for that particular sample set, are analyzed at the beginning of each new run. A standard, which is treated as a sample, is analyzed at least every 20 samples. Baseline corrections are determined either manually or automatically, depending on the instrument providing the analysis. Data needed to calculate concentrations are recorded along with the sample concentration in laboratory notebooks, a carbon copy of which is provided to Dr Boynton. This procedure is also carried out for other parameters performed by the laboratory. Precision and limits of detection for the variables measured are provided in the Quality Assurance Plan (Rohland *et al.*, 1998).

4. RESULTS AND DISCUSSION

4.1. Overview: Snapshot in time

One of the most defining characteristics of estuarine ecosystems is variation across time and space. Systems such as the Chesapeake Bay contain a variety of habitats from broad shallow shoals to deep dredged channels that vary significantly in depth, temperature, and salinity at any given time. In addition, Chesapeake Bay exhibits substantial spatial variation in eutrophication due to both point source and diffuse loading to the Bay. The goals of this study were to identify spatial patterns of sediment-water oxygen and nutrient exchanges across different regions of the upper bay and to estimate the total nutrient contribution made by sediments during a single period of time. In addition, these data help place results from previous studies of oxygen and nutrient exchanges into the regional context of the upper Chesapeake Bay, including dredged channels as well as non-channel portions of the Bay. These data were collected across a wide range of habitats in the upper bay during one week in July 1998, and thus provide a snapshot in time. However, ten of the thirty five stations sampled in 1998 were also sampled during a similar period in 1997 and provide the opportunity to gain insight into the temporal variability of this system as well.

4.2. River Flow and Temporal Variation

Of the several factors that impose temporal variability on these systems, river flow is one of the most important because it is an excellent index of nutrient and organic matter loadings to estuarine systems. Loadings are an important external forcing function to bay ecology, influencing overall water quality and the magnitude of sediment-water exchanges. In upper Chesapeake Bay, the Susquehanna River is by far the greatest contributor of river flow, varying considerably both seasonally and inter-annually. For example, yearly mean river flow varied by more than a factor of two between 1996 and 1997 (64,800 cfs and 30,300 cfs, respectively), but was near the long-term average in 1998 (43,300 cfs). On shorter time scales, significant differences in flow are observed seasonally as well as monthly. For example, mean flow during July 1997 was 9,130 cfs, but was 21,600 cfs in July 1998 (Figure 4-1). For this and other reasons, including inter-annual temperature differences, there can be significant variation in the magnitude of sediment-water fluxes during similar months of the year.

4.3. Spatial Variation: Gradients and Contour Maps

In addition to temporal variation, spatial variation is also an important component in the upper bay and increases the difficulty of making regional estimates. In order to visually evaluate large scale spatial patterns, contour maps were created for each parameter of interest using *Surfer* ™ mapping software. The mapping process began by taking the actual data from the 35 stations and creating a standard spatial grid of 0.01 degrees latitude and longitude (0.98 km^2) around these locations. Interpolated values were then assigned to the standard grid nodes using a kreiging process. Contour maps of each parameter were then created from the interpolated data.

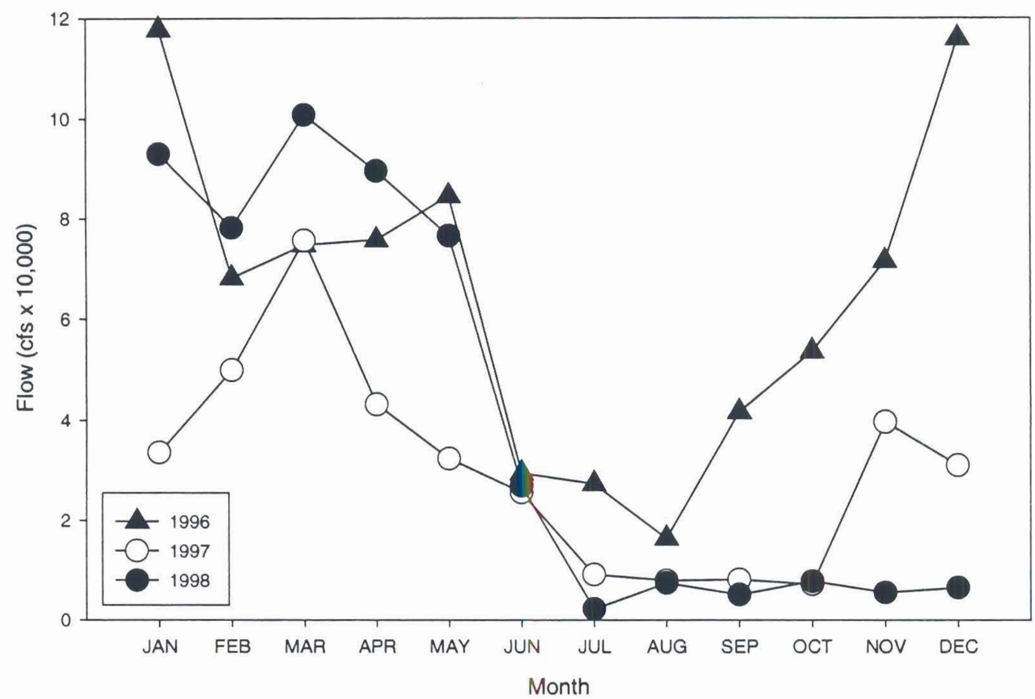

Figure 4-1. Line graph of mean monthly streamflow (cfs) entering the Chesapeake Bay from the Susquehanna River during 1996, 1997 and 1998.

As a way of evaluating the potential influence of dredged channels on upper Bay sediment-water fluxes, contour maps were created with the entire data set, as well as with a subset of data in which the dredged channel stations had been excluded. Interpolated data are of course most reliable in areas that are well sampled and for this reason station locations as well as contour lines are shown on all of these diagrams.

4.4. Physical Characteristics

4.4.1. Temperature

Across all stations in 1998, bottom water temperatures ranged from 28.3 C at station UBO2 (northernmost station sampled) to 23.7 C at station 104-D2. In general, bottom water temperatures were strongly correlated with station depth. Of the ten stations sampled during both years, mean bottom water temperature was slightly lower in 1997 (24.9 C) compared to 1998 (25.31 C). However, no statistically significant difference was detected with ANOVA ($P > 0.05$).

4.4.2. Salinity

As expected, salinity exhibited a strong spatial gradient along the axis of the bay. Bottom water salinity ranged from 0.0 ppt at several of the northernmost stations to 16.5 ppt at station UB16, one of the southernmost stations.

4.4.3. Bottom Water Oxygen Concentration

Across all stations in 1998, bottom water dissolved oxygen (DO) concentrations ranged from 0.16 mg l^{-1} at station FMCL to 7.29 mg l^{-1} at station PLIS. As with temperature, bottom water dissolved oxygen was well correlated with station depth. Ten stations had DO concentrations below 2.0 mg l^{-1} at depths ranging from 7.5 to 24.0 meters. These values are typical of summer values found in the upper bay.

4.5. Sediment Nutrient Characteristics

4.5.1. Sediment Total Chlorophyll-a

Sediment total chlorophyll-a values across the upper Bay ranged from a low of 22.2 mg m^{-2} at station UB06 to a high of 270.7 mg m^{-2} at station 104-D2. Contour maps of sediment chlorophyll-a concentration are shown in Figure 4-2. Sediment chlorophyll-a is an important index of labile material that is available for decomposition and regeneration of nutrients. Previous studies have shown that standing stocks of sediment chlorophyll-a can be a good predictor of certain sediment-water fluxes when a one month time lag (necessary for decomposition), is taken into account (Cowan and Boynton, 1996; Boynton *et al.*, 1998c). However, ammonium flux (NH_4^+) is often well correlated with current stocks of sediment chlorophyll-a, and in this study a significant correlation was found ($r^2 = 0.34$).

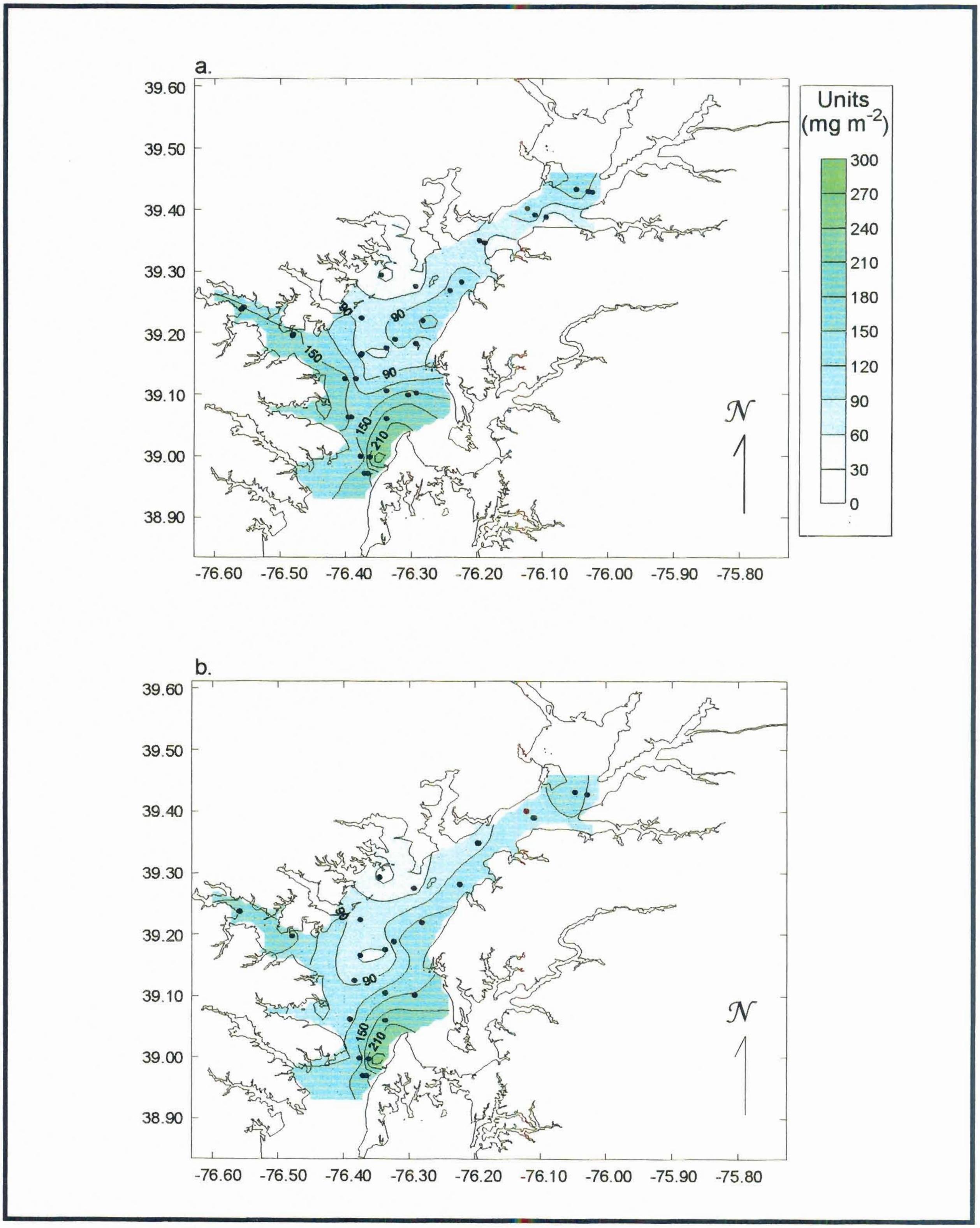

Figure 4-2. Contour maps of sediment total chlorophyll-*a* concentrations (mg m^{-2}) in July 1998 generated from:

a. 35 channel and non-channel stations in the upper Bay and

b. 23 non-channel stations in the upper Bay.

4.5.2. Sediment Particulate Organic Carbon

Sediment particulate organic carbon (PC) content (% sediment dry weight) for all stations ranged from 0.60% dry weight at station UB17 to 4.650% dry weight at station FFOF. Contour maps of sediment particulate organic carbon content are shown in Figure 4-3. In general values were highest in the eastern and central regions of the study area with lowest values in the north.

4.5.3 Sediment Particulate Organic Nitrogen

Sediment particulate organic nitrogen (PN) content (% sediment dry weight) for all stations ranged from 0.076% dry weight at station UB17 to 0.480% dry weight at station FFOF. Contour maps of sediment nitrogen content are shown in Figure 4-4. Sediment PN concentrations generally decreased from the upper to lower portions of the study area and where higher on the western shore.

4.5.4 Sediment Particulate Phosphorus

Sediment particulate phosphorus (PP) content (% sediment dry weight) for all stations ranged from 0.01% dry weight at station UB17 to 0.54% dry weight at station CHSL. Contour maps of sediment phosphorus content are shown in Figure 4-5.

4.6. Sediment-water Nutrient and Oxygen Exchanges and Dissolved Nutrient Concentrations

The wide spatial coverage of this study makes it possible to compare a variety of sediment-water exchanges (fluxes) among deep dredged channel locations, deep non-channel areas, and shallow shoal areas. In order to facilitate the analysis of sediment-water exchanges, the non-channel sites were divided into two groups, one less than 6 meters deep, and the other greater than 6 meters deep. This was done to balance the sample size among the groups. In addition, spatial contour maps were constructed to evaluate spatial gradients within the upper Bay. The use of spatially interpolated data also allowed the estimation of Bay-wide integrated values. Bottom water nutrient concentrations are discussed with each relevant parameter.

4.6.1. Sediment Oxygen Consumption (SOC)

Both the range of values and the patterns observed in sediment oxygen consumption (SOC) across the Bay were not surprising. As was expected, SOC was well correlated with bottom water oxygen concentrations ($r^2 = 0.60$). Across all stations, sediment oxygen consumption ranged from 0.0 g O_2 m^{-2} d^{-1} at stations 104-D2, 104-DR and UB16 up to –4.44 g O_2 m^{-2} d^{-1} at

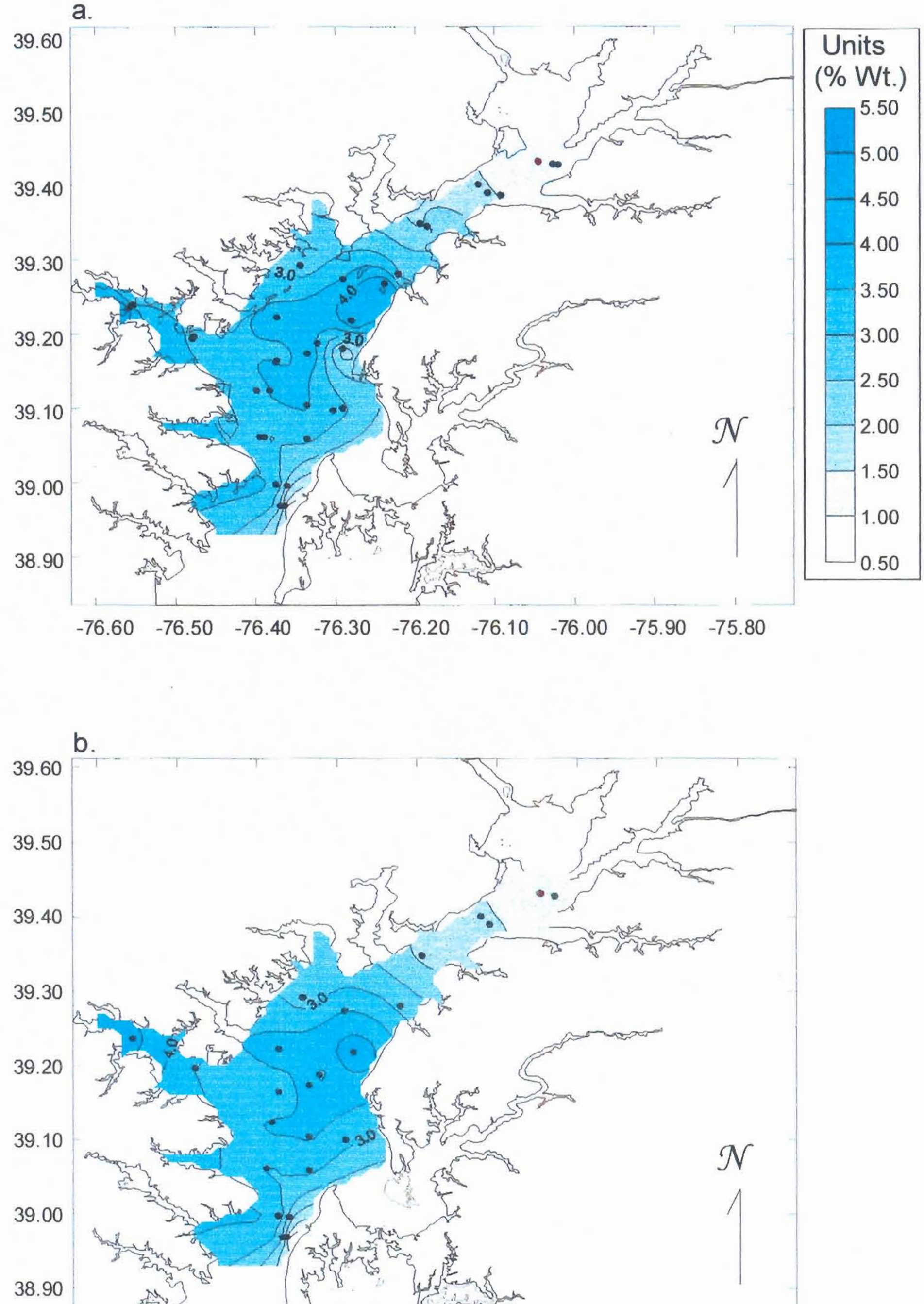

Figure 4-3. Contour maps of sediment particulate organic carbon concentrations (% dry wt. C) in July 1998 generated from:

a. **35 channel and non-channel stations in the upper Bay and**
b. **23 non-channel stations in the upper Bay.**

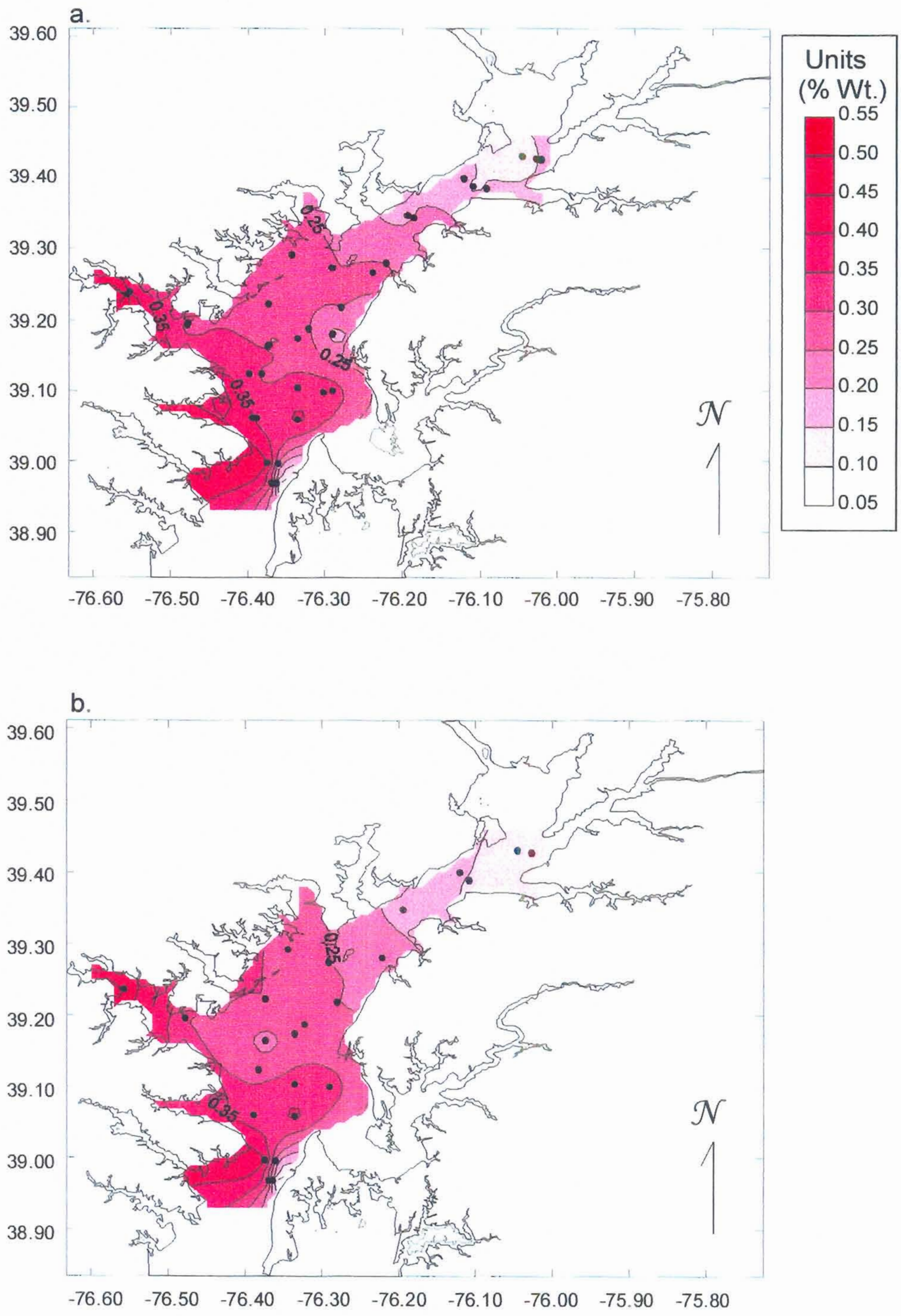

Figure 4-4. Contour maps of sediment particulate nitrogen concentrations (% sediment dry weight) in July 1998 generated from:

a. 35 channel and non-channel stations in the upper Bay and

b. 23 non-channel stations in the upper Bay.

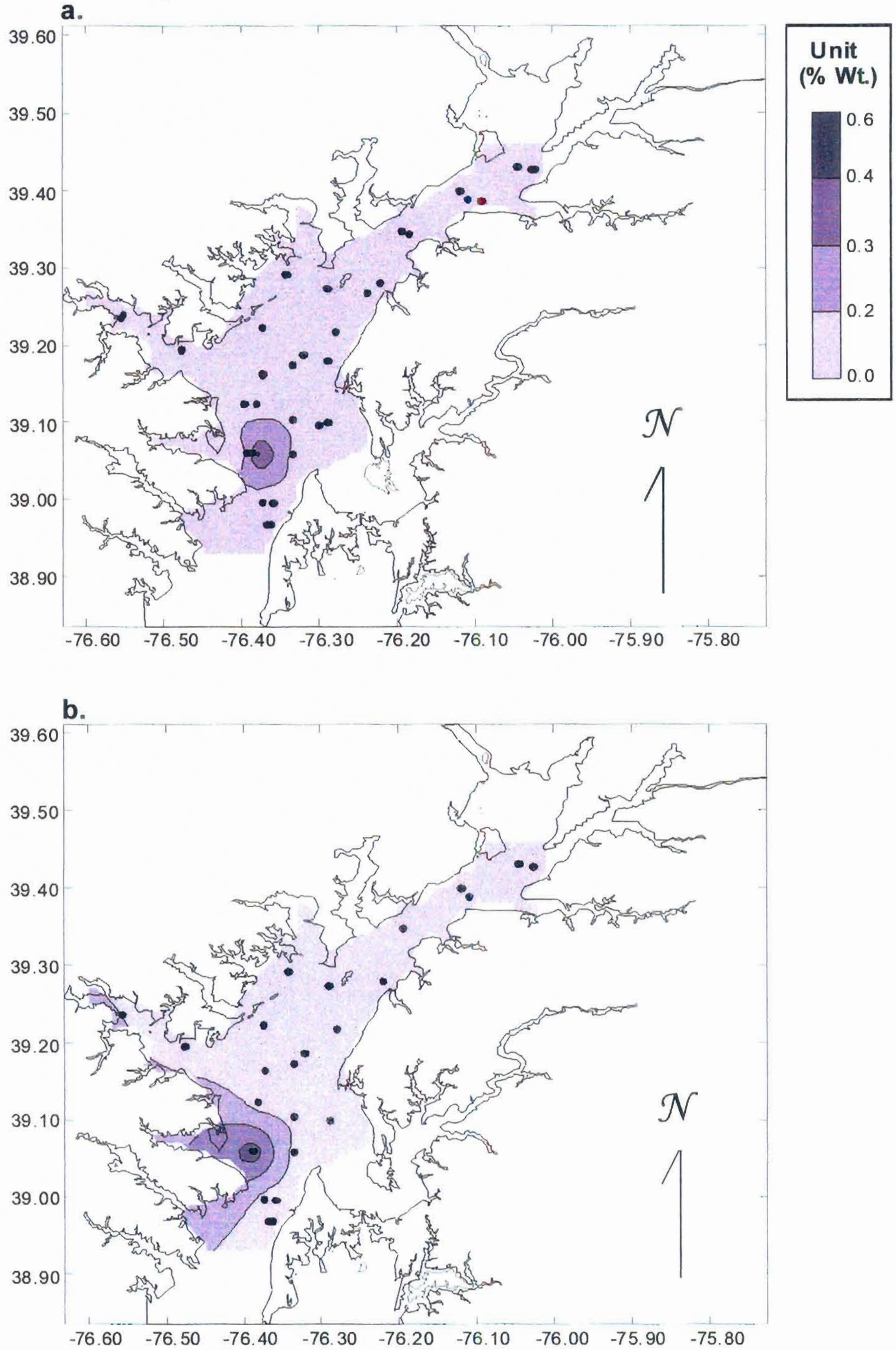

Figure 4-5. Contour maps of sediment particulate phosphorus concentrations (% sediment dry weight) in July 1998 generated from:

a. 35 channel and non-channel stations in the upper Bay and

b. 23 non-channel stations in upper Bay.

station UB07 (Figure 4-6). Contour maps of SOC in the upper Bay illustrate spatial gradients of SOC across the upper Bay for all stations sampled, and with dredged channels excluded (Figure 4-7). In addition, a contour map of bottom water dissolved oxygen is shown in Figure 4-8. These maps visually illustrate the relationship between bottom water oxygen concentrations and sediment oxygen consumption (SOC). When stations are grouped by depth and habitat type, (*i.e.* dredged channel vs. non-channel) SOC rates were found to be significantly higher ($P < 0.05$) at stations less than 6 meters deep compared to those deeper than 6 meters (Figure 4-9). While the mean SOC value of dredged stations was smaller (-0.66 g O_2 m^{-2} d^{-1}) than the mean value of non-channel stations (-1.41 g O_2 m^{-2} d^{-1}) there was no statistically significant difference between the deep groups. This result is likely due to high variance among the non-channel channel stations coupled with a relative small sample size. Of the ten stations also sampled in 1997, no statistically significant difference was found in SOC between 1997 and 1998 data (Figure 4-10).

4.6.3 Ammonium (NH_4^+) Flux

Ammonium flux (NH_4^+) across the upper Bay ranged from 838 μM N m^{-2} hr^{-1} at station UB15 to undetectable (0.0 μM N m^{-2} hr^{-1}) at station BECL (Figure 4-11). Contour maps of the ammonium flux (NH_4^+) across the upper Bay revealed strong east-west gradients that were not substantially affected by the removal of the dredged channel stations in the calculation of flux contour lines (Figure 4-12). Bottom water ammonium (NH_4^+) concentrations were highest in the eastern (Patapsco River) and southern regions surveyed and decrease northward along the Bay axis (Figure 4-13) and exhibited gradients similar to the sediment-water flux. This is not surprising since ammonium flux is often highly correlated with bottom water ammonium concentrations (*e.g.* Boynton *et al.* 1998c). When grouped by habitat type (channels, non-channel < 6 meters, and non-channel > 6 meters), no significant difference in ammonium flux was found among the groups. However, the mean ammonium flux at the shallow stations was slightly smaller (181 μM N m^{-2} hr^{-1}) than either the deep or channel stations (222 μM N m^{-2} hr^{-1} and 239.7 μM N m^{-2} hr^{-1}, respectively; Figure 4-9). An inter-year comparison of ammonium flux at the ten stations sampled in both 1997 and 1998 revealed no significant differences (Figure 4-10).

Contouring of any of the variables in the vicinity of the mouth of the Severn or Middle Rivers is an artifact of the interpolation scheme. In these two instances there were no stations in the immediate area so it is recommended that the extrapolations of flux or bottom water be ignored. Interpolated data are of course most reliable in areas that are well sampled and for this reason station locations as well as contour lines are shown on all of these diagrams.

4.6.4 Nitrite + Nitrate (NO_2^- + NO_3^-) Flux

Combined nitrite plus nitrate flux (NO_{23}) across the upper Bay ranged from + 121 μM N m^{-2} hr^{-1} out of the sediment at station DC03 to –98 μM N m^{-2} hr^{-1} into the sediment at station UB02 (Figure 4-14). However, only two stations (UB05 and DC03), that were near each other, exhibited substantial positive flux out of sediments. The exact reasons for this are not known but dissolved oxygen concentrations in bottom waters were high at these stations and high dissolved

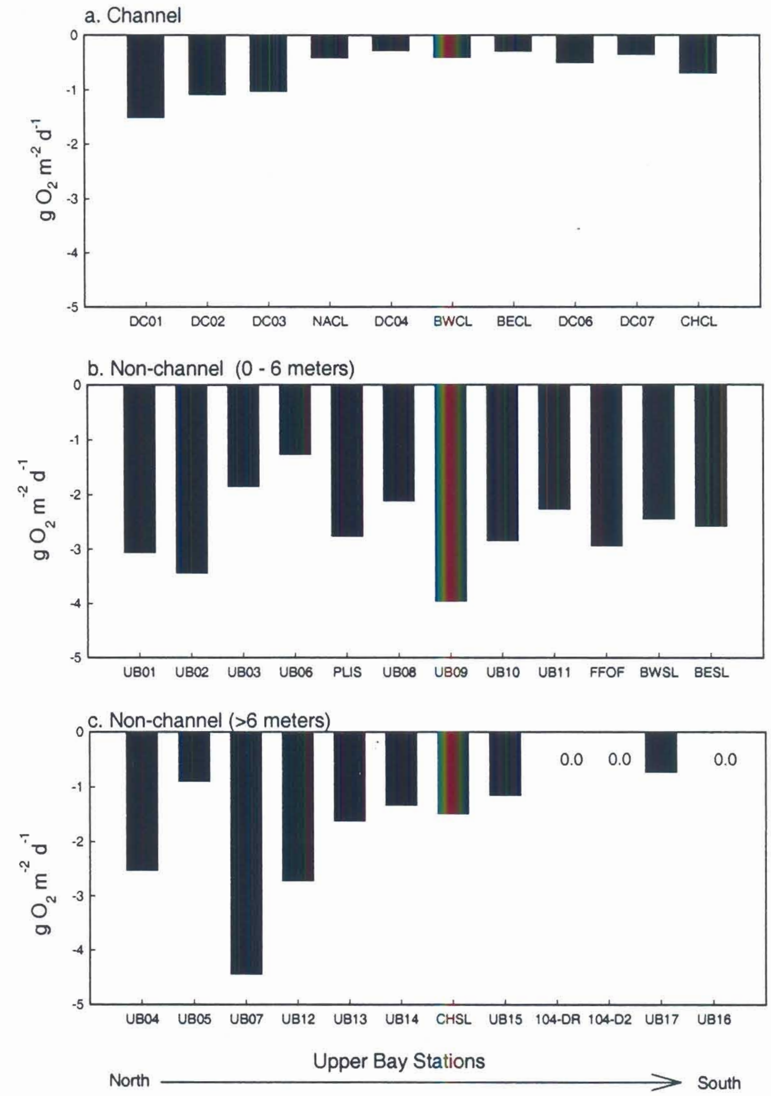

Figure 4-6. Sediment oxygen consumption (SOC) for upper Chesapeake Bay in July 1998 at:

a. channel stations,

b. non-channel stations (0-6 meters), and

c. non-channel stations (> 6 meters).

For exact station locations refer to Table 3-1 and Figure 3-1. In general the bars in the panels above are arranged from North to South. Zero's indicate no net sediment water exchange. Refer to Section 3.3.4.1. for explanation about non-interpretable data.

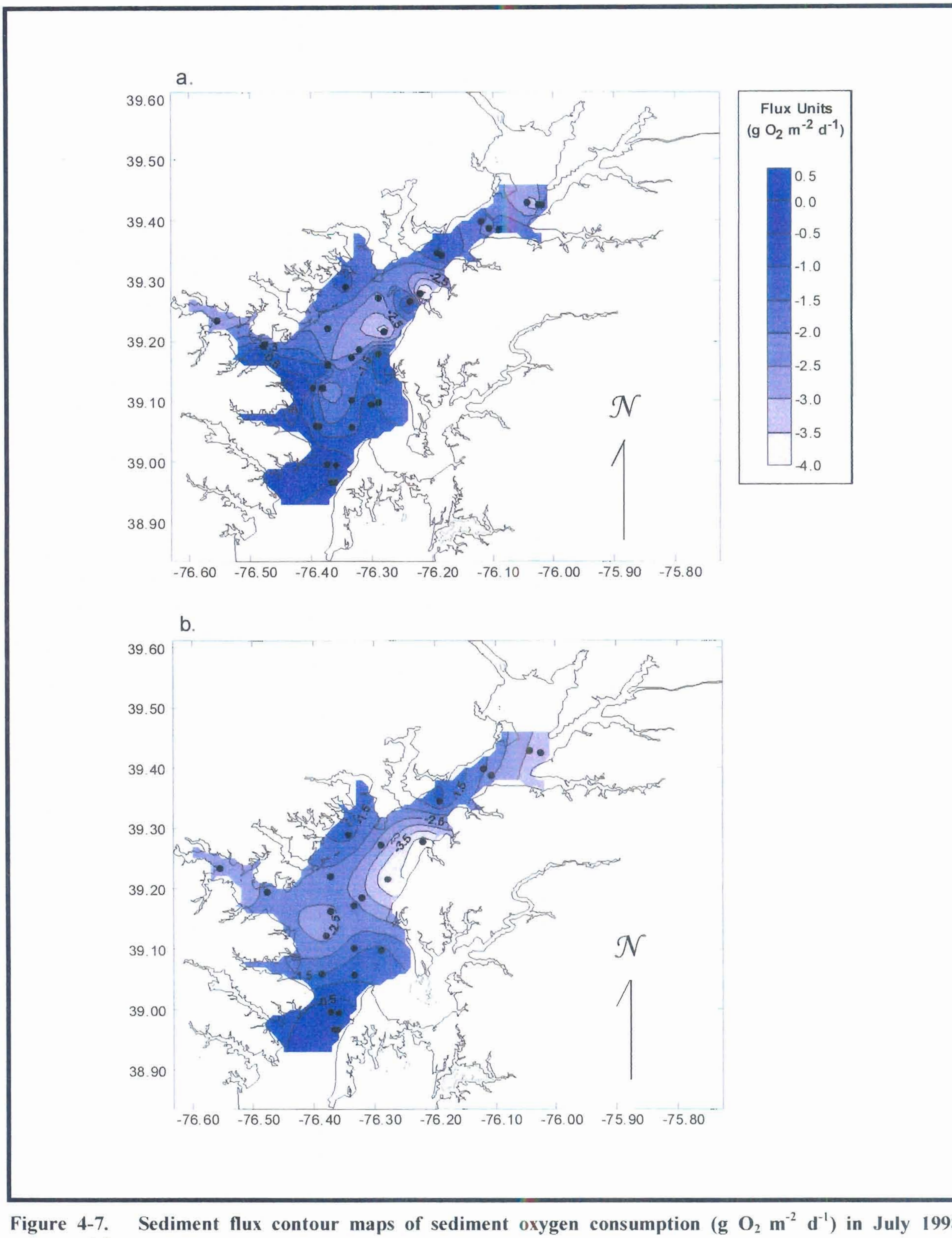

Figure 4-7. Sediment flux contour maps of sediment oxygen consumption (g O_2 m^{-2} d^{-1}) in July 1998 generated from:

a. 35 channel and non-channel stations in the upper Bay and

b. 23 non-channel stations in the upper Bay.

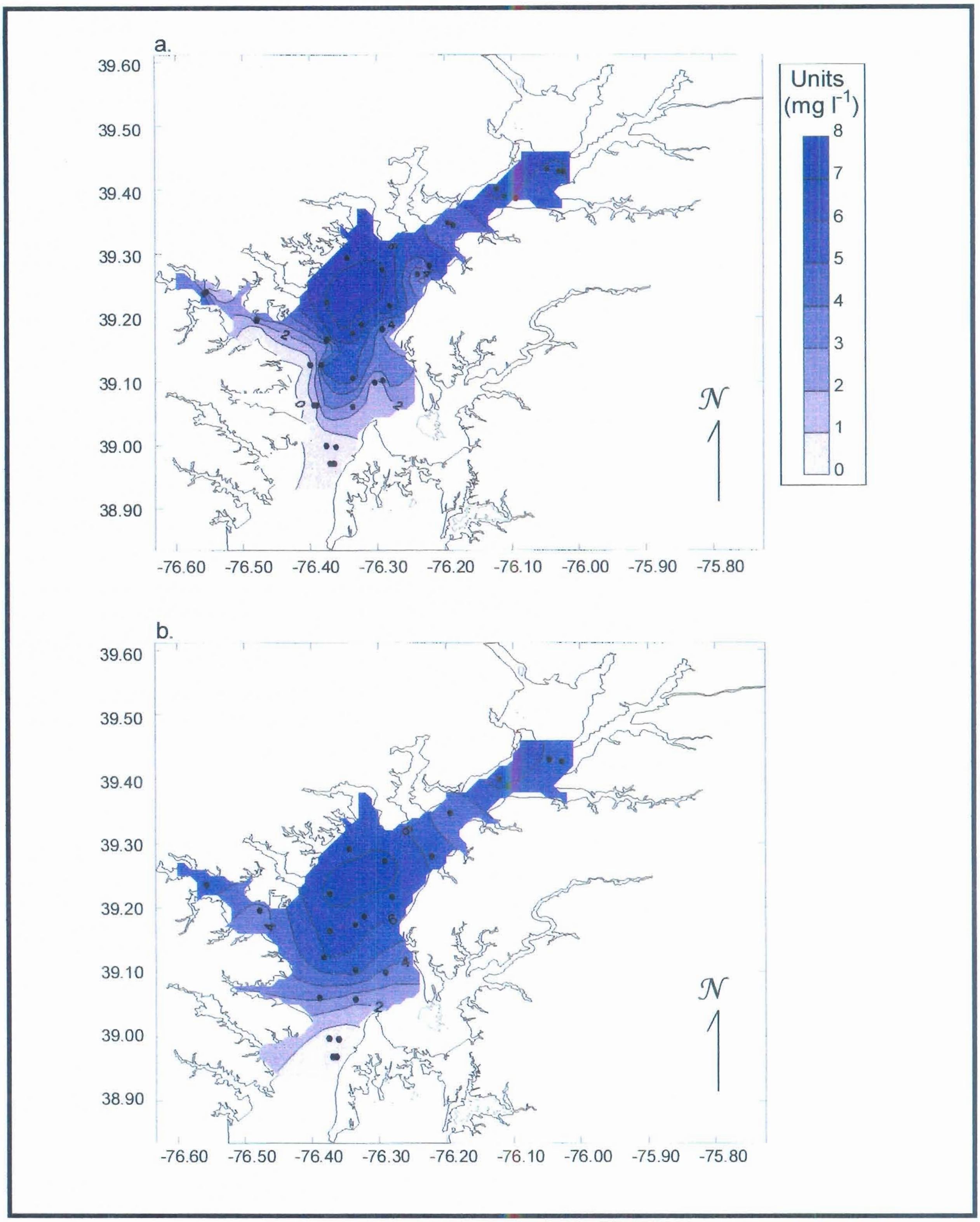

Figure 4-8. Contour maps of bottom water dissolved oxygen concentrations (mg l^{-1}) in July 1998 generated from:

a. 35 channel and non-channel stations in the upper Bay and

b. 23 non-channel stations in the upper Bay.

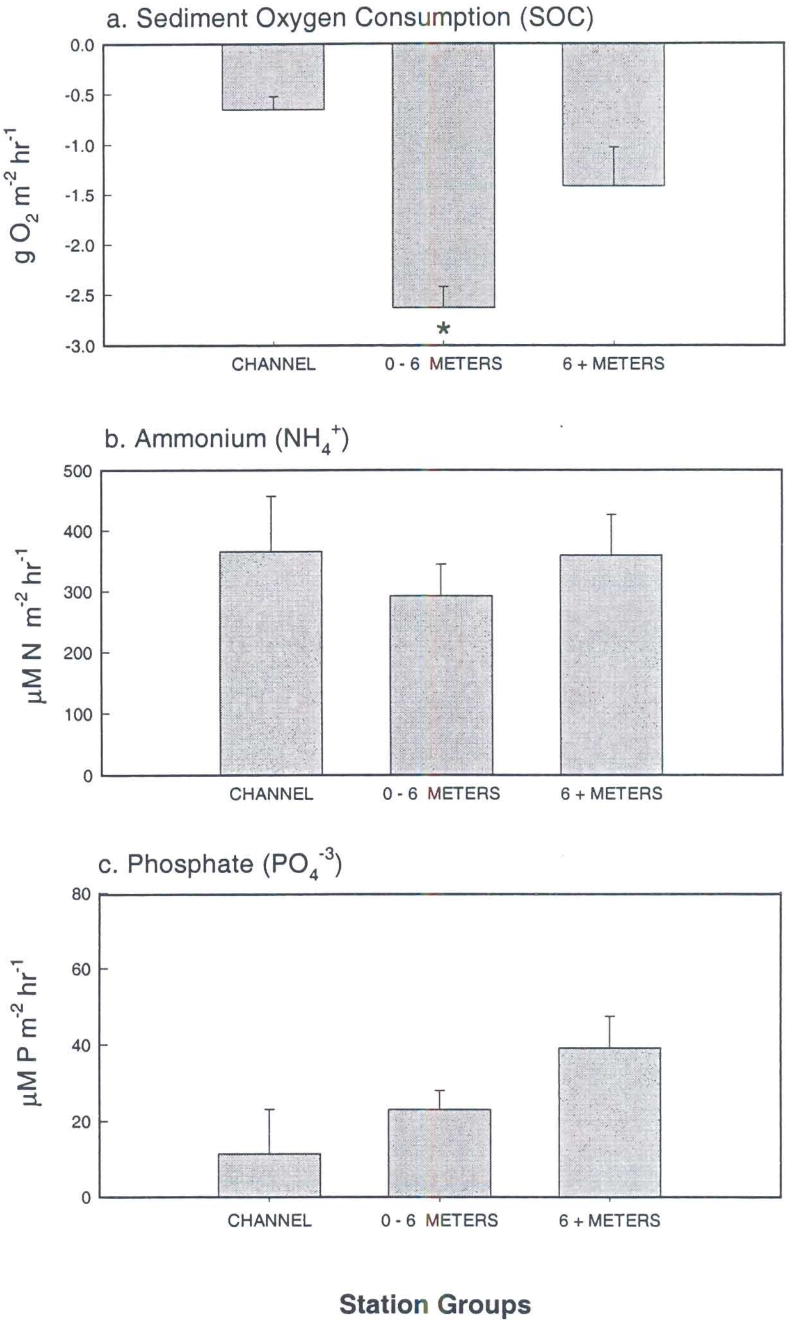

Figure 4-9. Sediment-water flux (± 1SE) averaged by station depth in the upper Bay in July 1998 for:
a. sediment oxygen consumption (SOC),
b. ammonium (NH_4^+), and
c. phosphate (PO_4^{-3}).
**** shallow stations (0-6 meters) differing significantly from other groups ($p < 0.05$).***

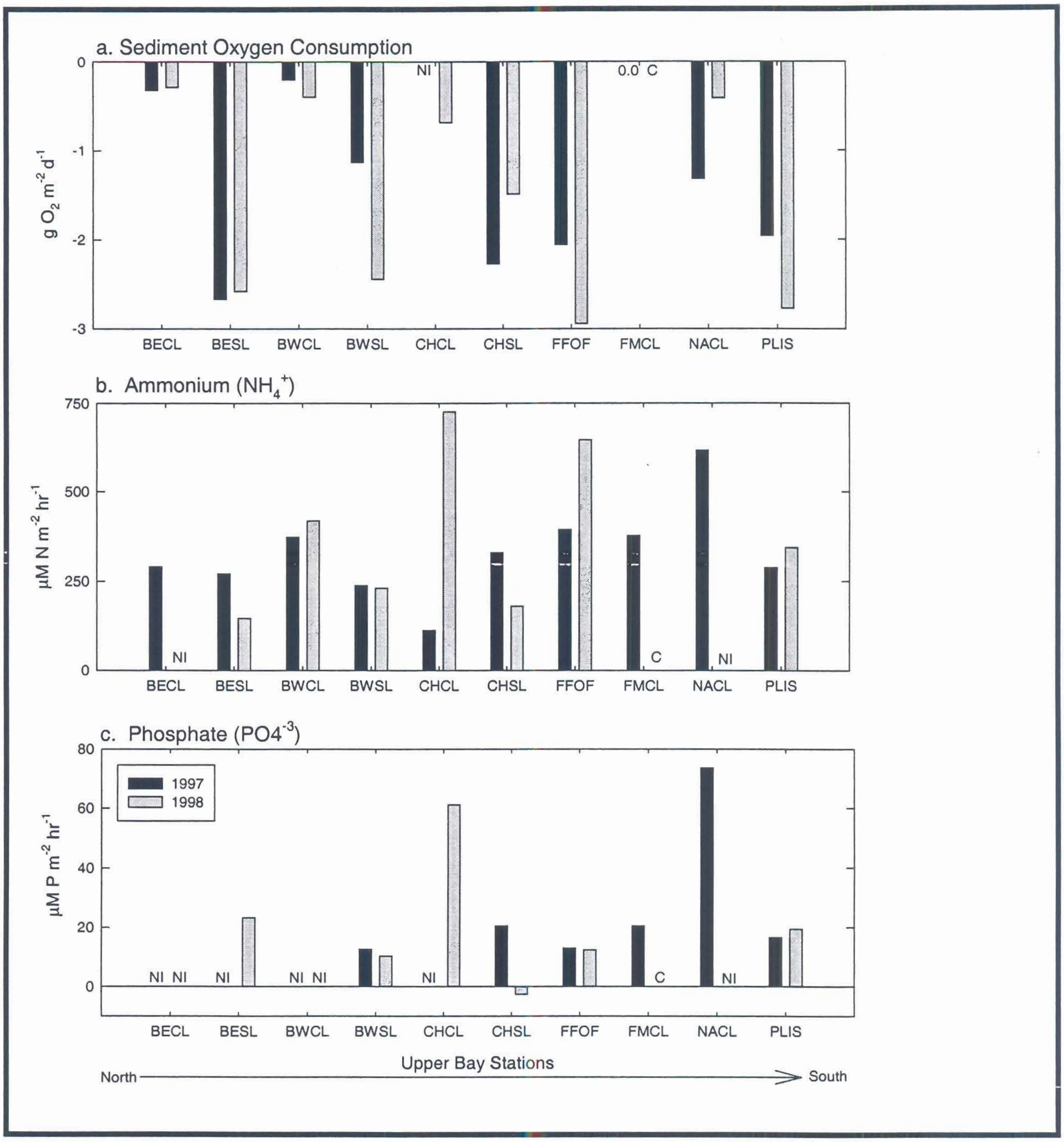

Figure 4-10. Bar graphs of flux values of:

a. sediment oxygen consumption (g 0_2 m^{-2} d^{-1}),

b. ammonium (µM N m^{-2} hr^{-1}) and

c. phosphate (µM P m^{-2} hr^{-1}) observed at stations in the upper Chesapeake Bay that were sampled in both 1997 and 1998.

"NI" indicates that the analysis of the data collected was not interpretable.

"C" indicates that no data were collected due to a mechanical or materials failure on board the research vessel.

For exact station locations refer to Table 3-1 and Figure 3-1. In general the bars in the panels above are arranged from North to South. Zero's indicate no net sediment water exchange. Refer to Section 3.3.4.1. for explanation about non-interpretable data.

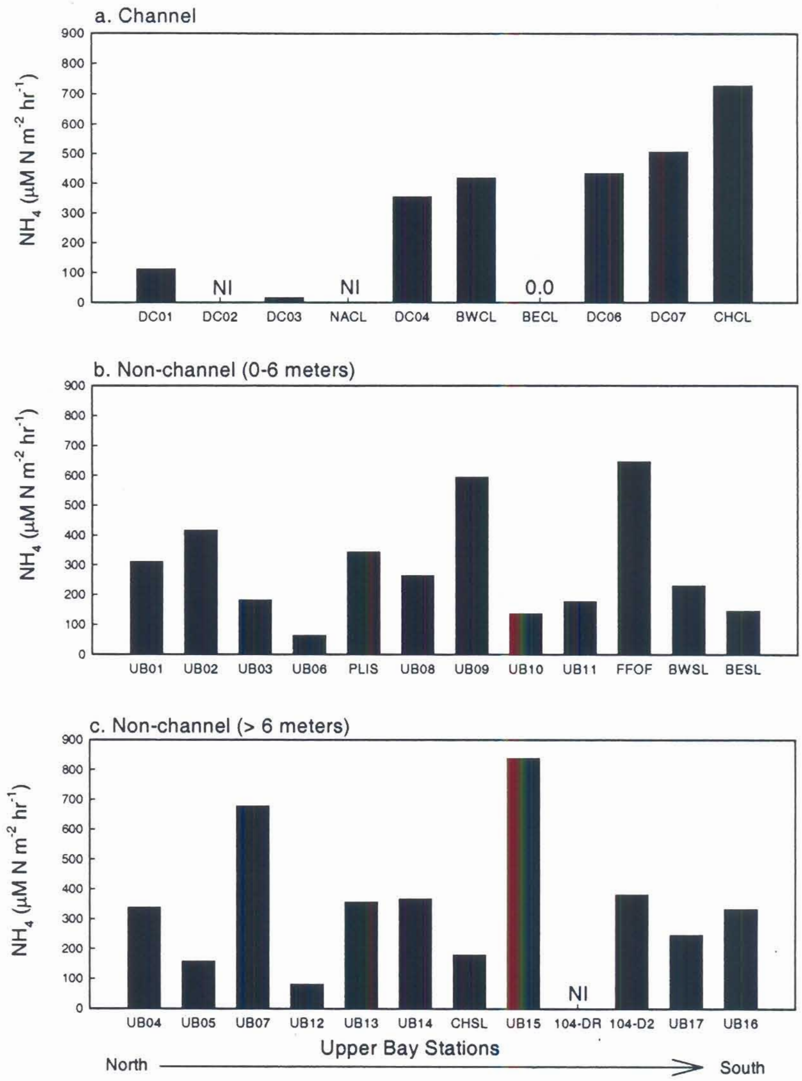

Figure 4-11. Sediment-water ammonium flux (NH_4^+) for upper Bay in July 1998 at:

a. **channel stations,**

b. **non-channel stations (0-6 meters), and**

c. **non-channel stations (> 6 meters).**

"NI" represents non-interpretable data.

For exact station locations refer to Table 3-1 and Figure 3-1. In general the bars in the panels above are arranged from North to South. Zero's indicate no net sediment water exchange. Refer to Section 3.3.4.1. for explanation about non-interpretable data.

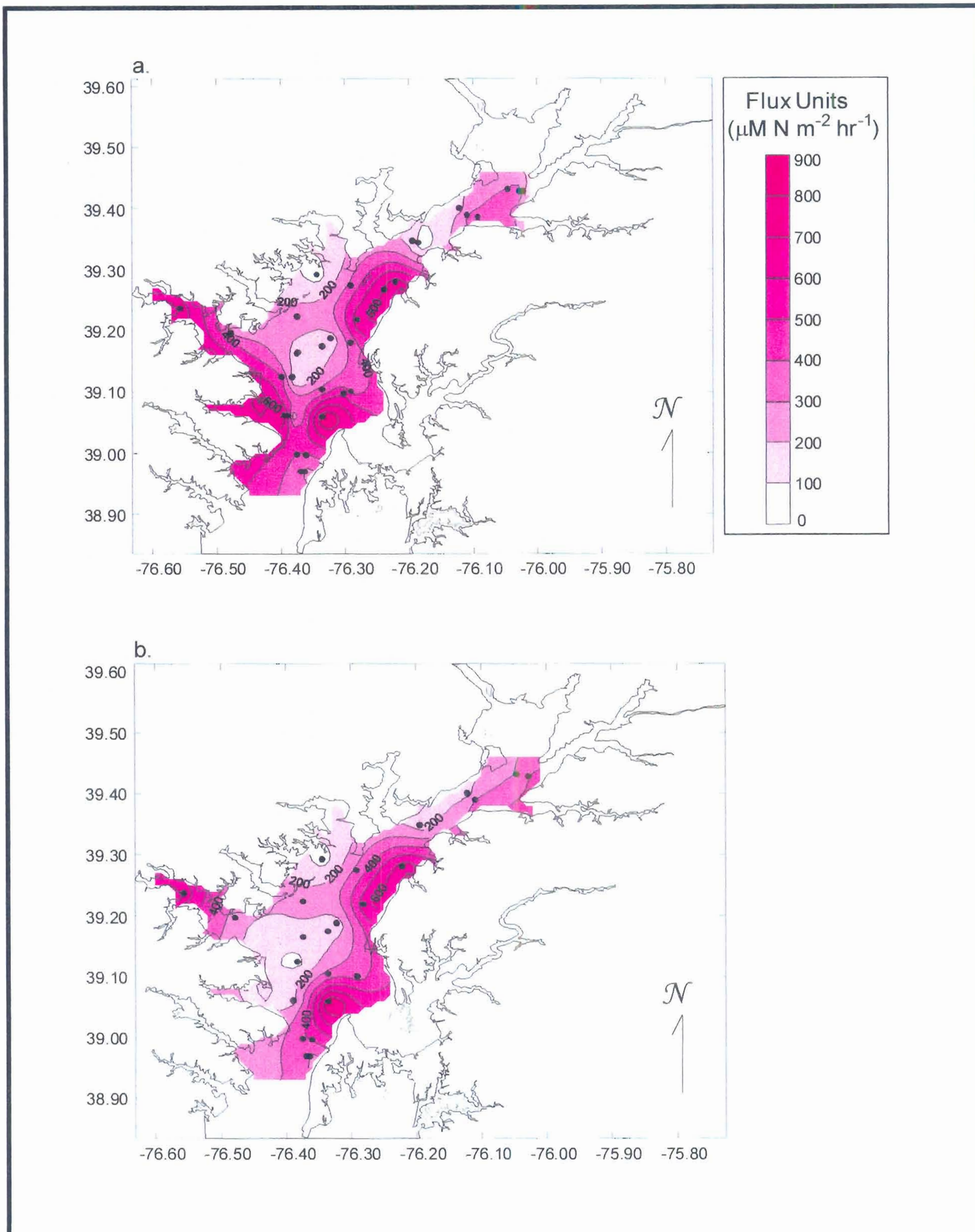

Figure 4-12. Sediment flux contour maps of ammonium ($\mu M\ m^{-2}\ hr^{-1}$) in July 1998 generated from:
a. 35 channel and non-channel stations in the upper Bay and
b. 23 non-channel stations in the upper Bay.

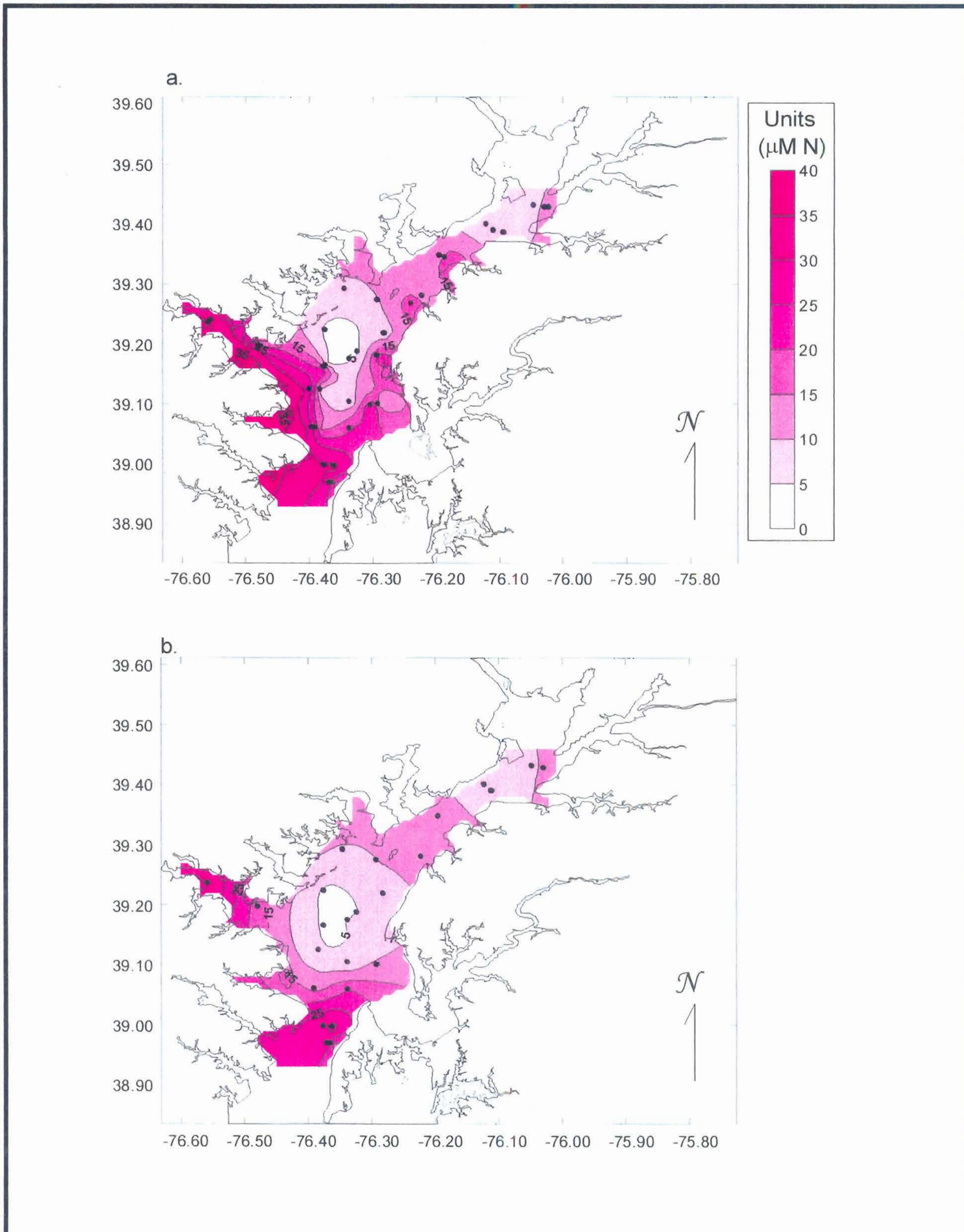

Figure 4-13. Contour maps of bottom water ammonium concentrations (µM N) in July 1998 generated from:
a. 35 channel and non-channel stations in the upper Bay and
b. 23 non-channel sites in the upper Bay.

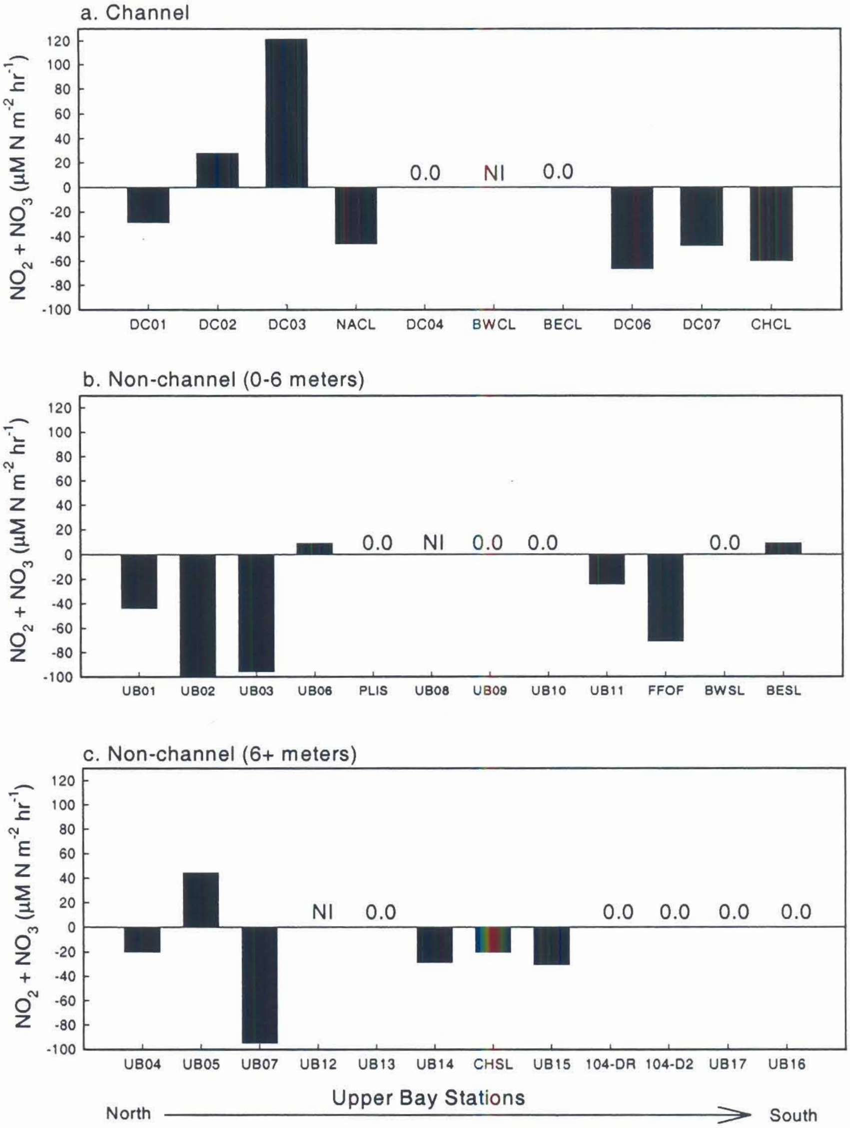

Figure 4-14. Sediment-water nitrite plus nitrate flux ($NO_2^- + NO_3^-$) for upper Bay in July 1998 at:

a. channel stations,

b. non-channel stations (0-6 meters), and

c. non-channel stations (> 6 meters).

"NI" represents non-interpretable data.

For exact station locations refer to Table 3-1 and Figure 3-1. In general the bars in the panels above are arranged from North to South. Zero's indicate no net sediment water exchange. Refer to Section 3.3.4.1. for explanation about non-interpretable data.

oxygen levels are needed to support positive nitrite plus nitrate (NO_{23}) fluxes. Most other stations exhibited either a nearly zero or negative nitrite-nitrate (NO_{23}) flux (Figure 4-14). Contour maps of combined nitrite plus nitrate flux are dominated by a few locally high values but were generally not significantly affected by the removal of the channel stations (Figure 4-15). Bottom water nitrite plus nitrate (NO_{23}) concentrations exhibited a very pronounced north-south gradient along the axis of the Bay with the highest values in the north indicating a substantial nitrite plus nitrate source from the Susquehanna River (Figure 4-16). Because of station to station variation in nitrite plus nitrate (NO_{23}) flux within each habitat type, no significant differences were identified (Figure 4-17). Significant station to station variation also eliminated any possible inter-annual differences at those stations sampled in 1997 and 1998 (Figure 4-18).

4.6.5. Phosphate (PO_4^{-3}) Flux

Across all the sampled stations, phosphate (PO_4^{-3}) flux varied from a minimum of –19.2 μM P m^{-2} hr^{-1} (into the sediment) at station DC06, to a maximum of 73.3 μM P m^{-2} hr^{-1} (out of the sediment) at station UB02 (Figure 4-19). Flux contour maps indicate a strong east-west gradient across the Bay, which does not seem to be significantly affected by removal of the channel stations (Figure 4-20). Bottom water phosphate concentrations also don't seem to be affected by the removal of the channel stations from the contour maps (Figure 4-21). When grouped by habitat type (dredged channel vs. non-channel shallow and deep), no significant difference in phosphate (PO_4^{-3}) flux was found among the groups (Figure 4-9). However, the mean phosphate flux at the deep > 6 meters non-channel stations was the highest among the groups at 39.2 μM P m^{-2} hr^{-1}, followed by the shallow group at 23.04 μM P m^{-2} hr^{-1}, and then by the channel stations at 11.5 μM P m^{-2} hr^{-1} (Figure 4-9). An inter-annual comparison of phosphate (PO_4^{-3}) flux at the ten stations sampled in 1997 and 1998 did not reveal any statistically significant differences in phosphate flux in part due to high variability and low sample size (Figure 4-10).

4.5. Integrated sediment-water flux estimates

The high-resolution spatial data collected for this study made it possible to obtain integrated estimates of sediment-water exchanges for the entire survey area of the upper Bay and to compare these estimates to nutrient loads from the Susquehanna River and other sources. The reason for making such comparisons is to place various internal (sediments) and external (river) nutrient sources into perspective and thereby identify dominant from minor sources. The integrated flux estimates were achieved with the use of *Surfer* ™ mapping software by interpolating actual data from the thirty five (35) stations onto a standard spatial grid of 0.01 degrees latitude and longitude (0.98 km^2). The interpolated values within each cell can be summed to obtain the integrated flux estimate across the entire mapped area. For these estimates the interpolated surface area of the upper Bay was equivalent to 829.4 km^2. Nutrient loading to the upper Bay from the Susquehanna River for July 1998 was estimated with an ANCOVA ($r^2 = 0.98$) constructed from past nutrient concentrations and concurrent river flow. Using Susquehanna River flow for July 1998 the estimated loads were calculated. Nutrient

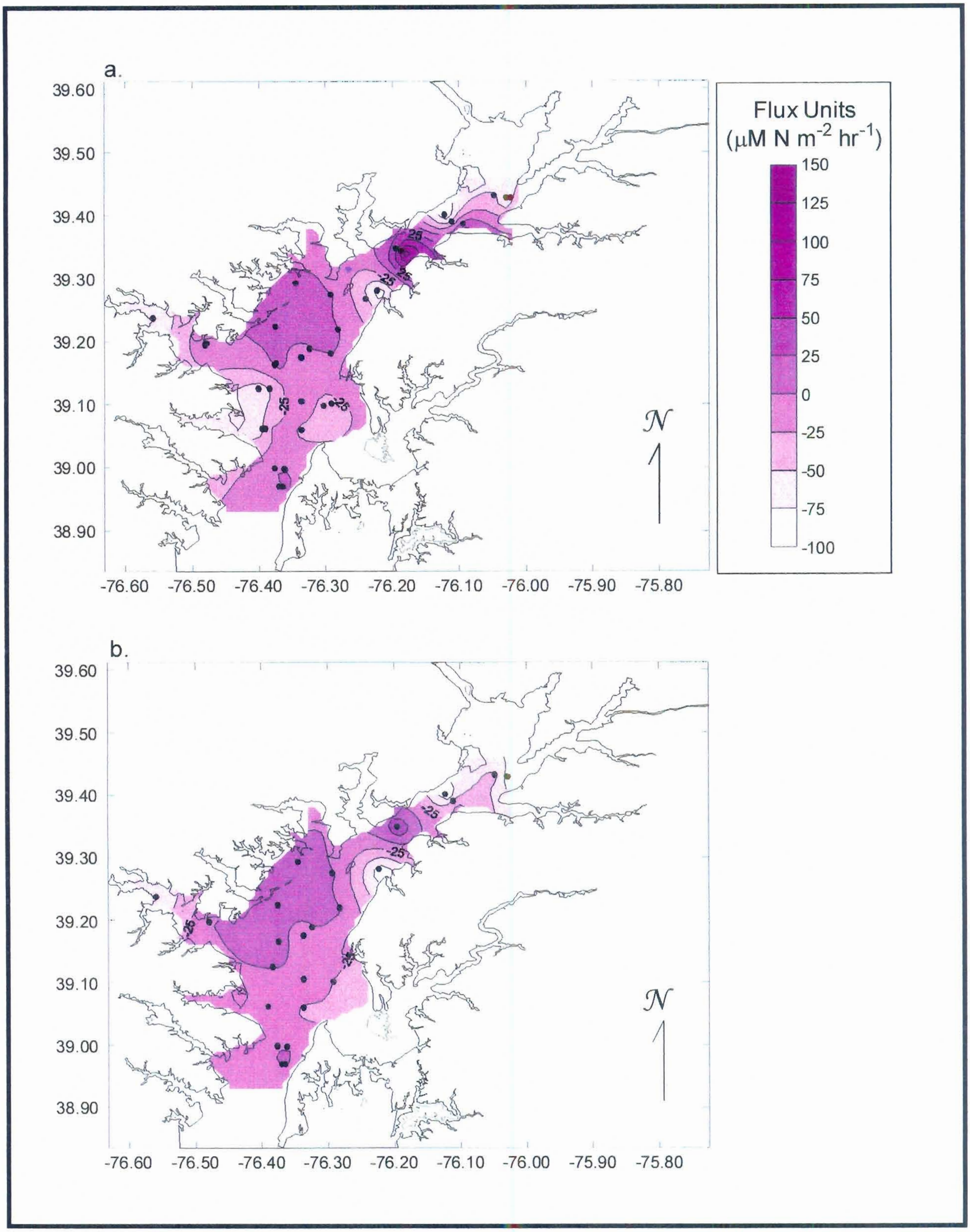

Figure 4-15. Sediment flux contour maps of nitrite plus nitrate ($\mu M\ N\ m^{-2}\ hr^{-1}$) in July generated from:
a. 35 channel and non-channel stations in the upper Bay and
b. 23 non-channel sites in the upper Bay.

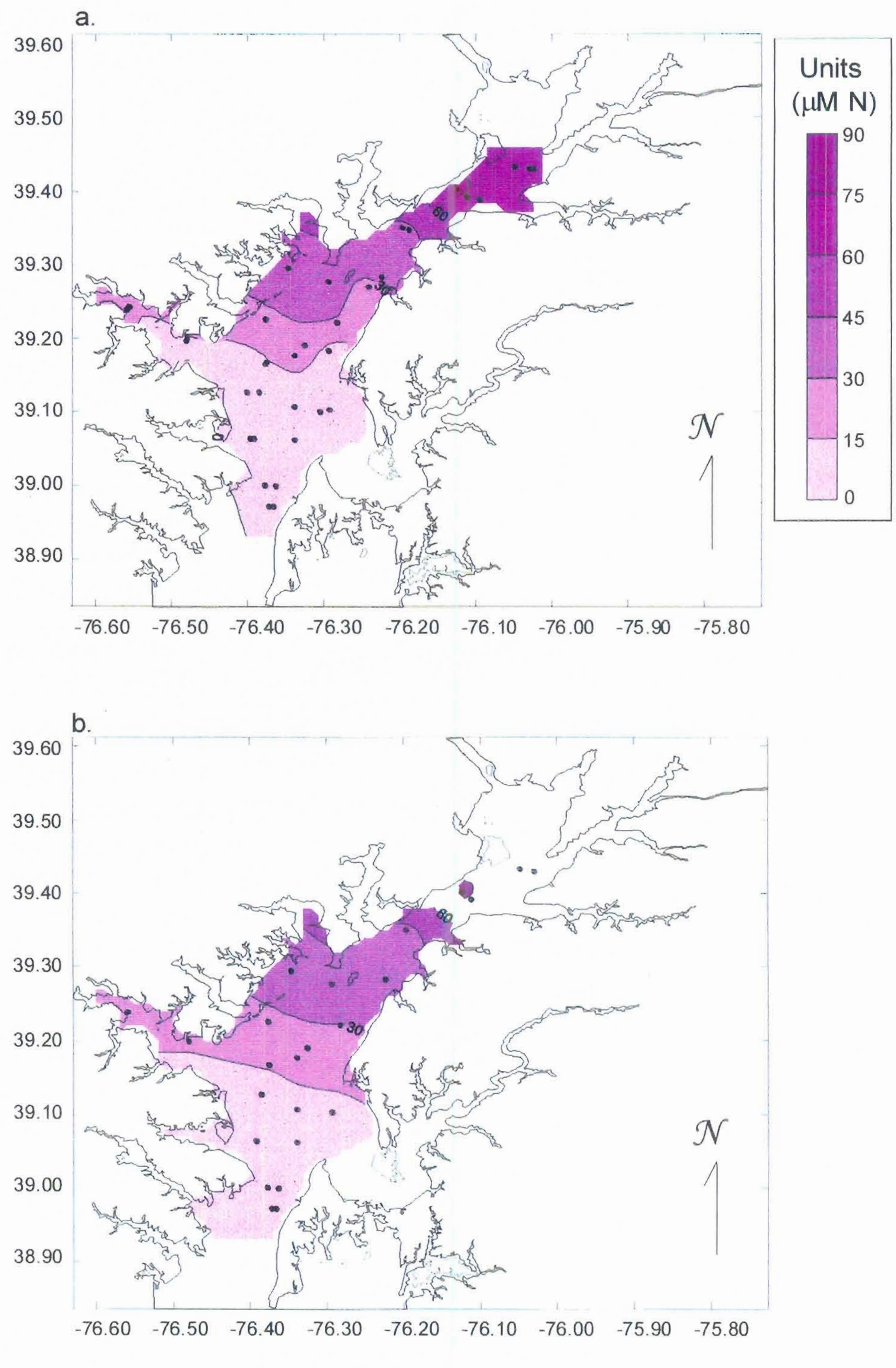

Figure 4-16. Contour maps of bottom water nitrite plus nitrate concentrations (μM N) in July 1998 generated from:

a. 35 channel and non-channel stations in the upper Bay and

b. 23 non-channel sites in the upper Bay.

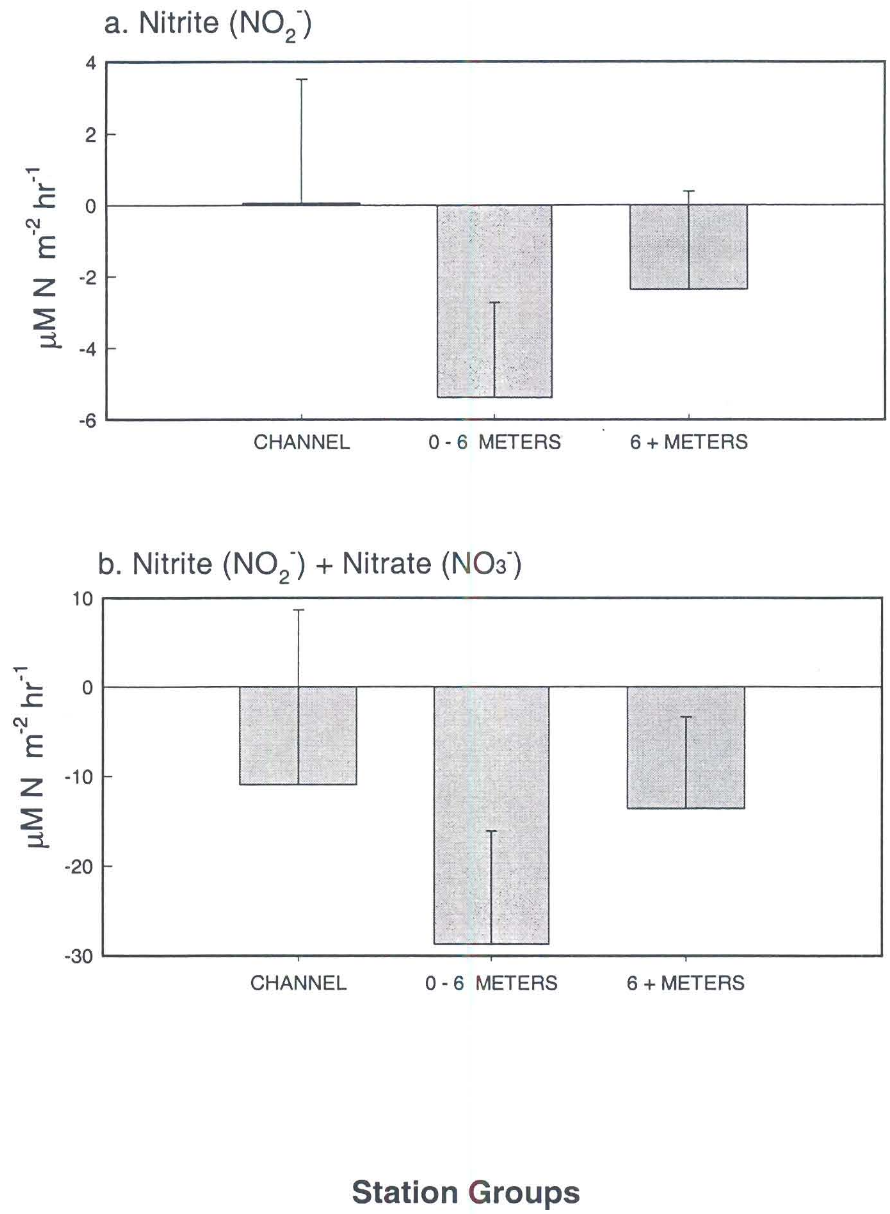

Figure 4-17. Sediment-water flux (± 1SE) averaged by station depth in the upper Bay in July 1998 for:
a. nitrite (NO_2^-) and
b. nitrite plus nitrate (NO_2^-) + (NO_3^-).

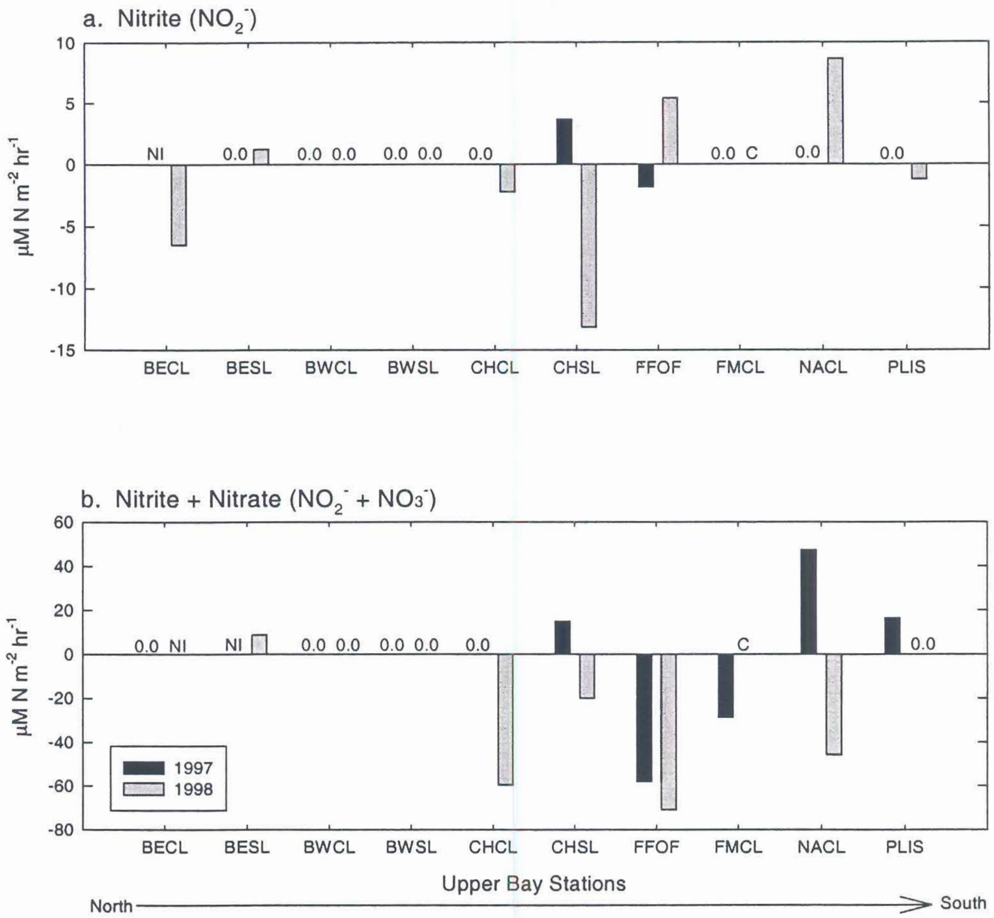

Figure 4-18. Bar graphs of flux values of:

a. nitrite (μM N m^{-2} hr^{-1}) and

b. nitrite plus nitrate (μM N m^{-2} hr^{-1}) observed at stations in the upper Bay that were sampled in both 1997 and 1998.

"NI" indicates that the analysis of the data collected was not interpretable.

"C" indicates that no data were collected due to a mechanical or materials failure on board the research vessel.

For exact station locations refer to Table 3-1 and Figure 3-1. In general the bars in the panels above are arranged from North to South. Zero's indicate no net sediment water exchange. Refer to Section 3.3.4.1. for explanation about non-interpretable data.

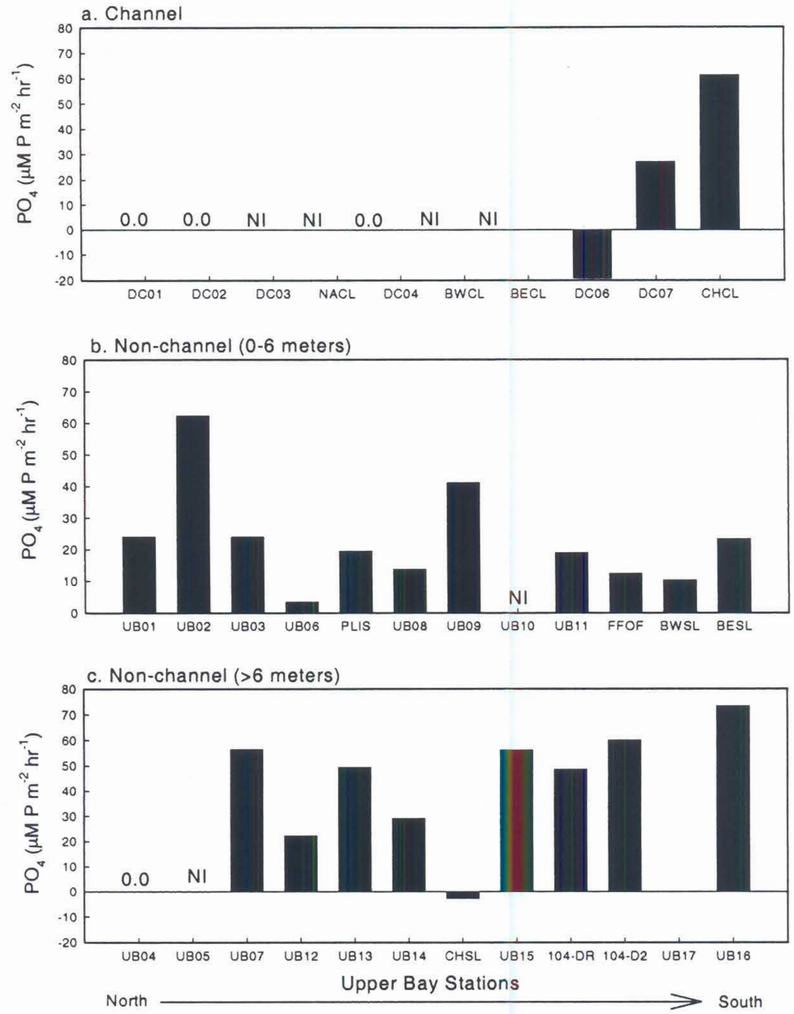

Figure 4-19. Sediment-water phoshpate (PO_4^{-3}) for upper Bay in July, 1998 at:

a. channel stations,

b. non-channels stations (0-6 meters), and

c. non-channels stations (> 6 meters).

"NI" respesents non-interpretable data.

For exact station locations refer to Table 3-1 and Figure 3-1. In general the bars in the panels above are arranged from North to South. Zero's indicate no net sediment water exchange. Refer to Section 3.3.4.1. for explanation about non-interpretable data.

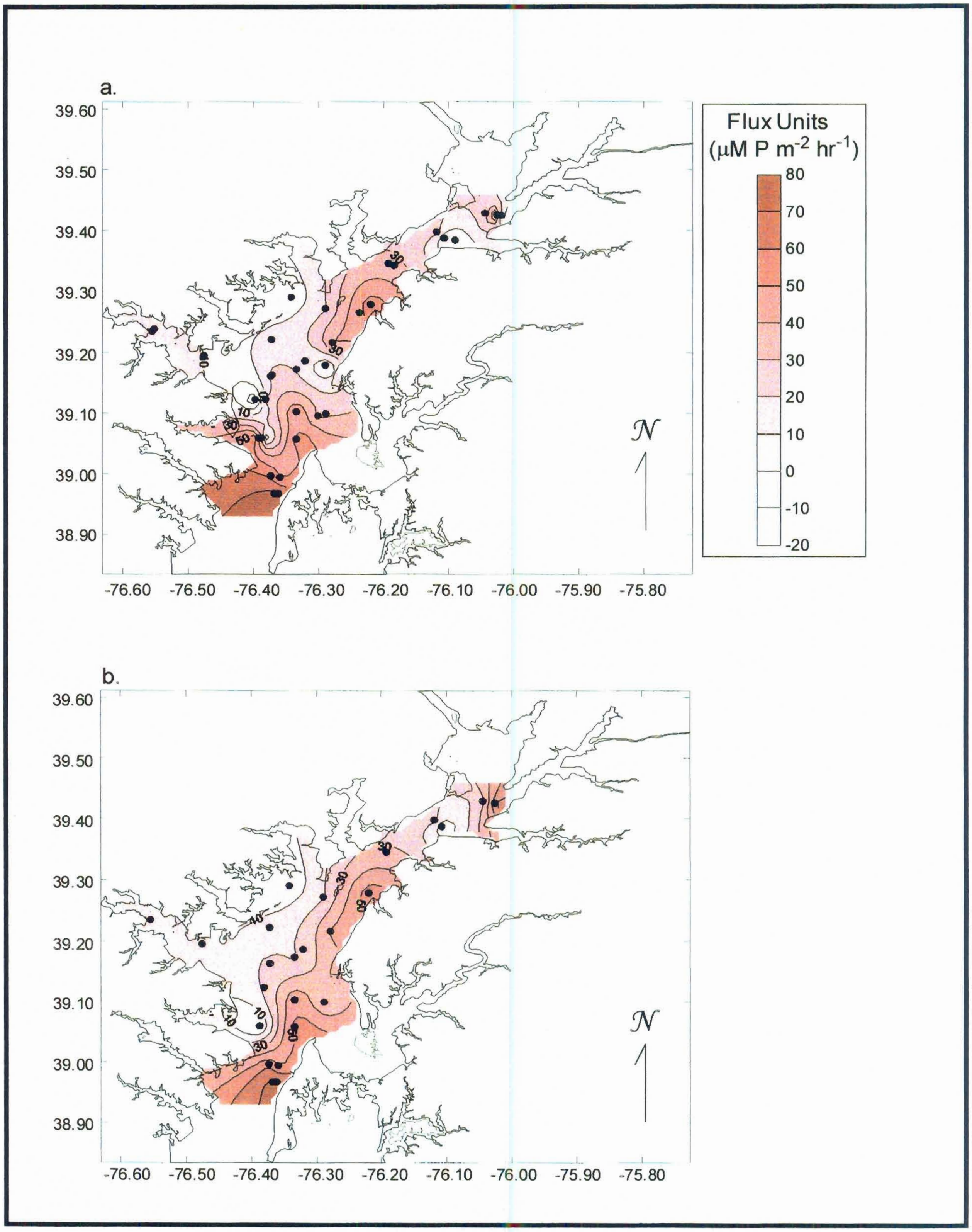

Figure 4-20. Sediment flux contour maps of phosphate (µM P m^{-2} hr^{-1}) in July 1998 generated from:
a. 35 channel and non-channel stations in the upper Bay and
b. 23 non-channel stations in the upper Bay.

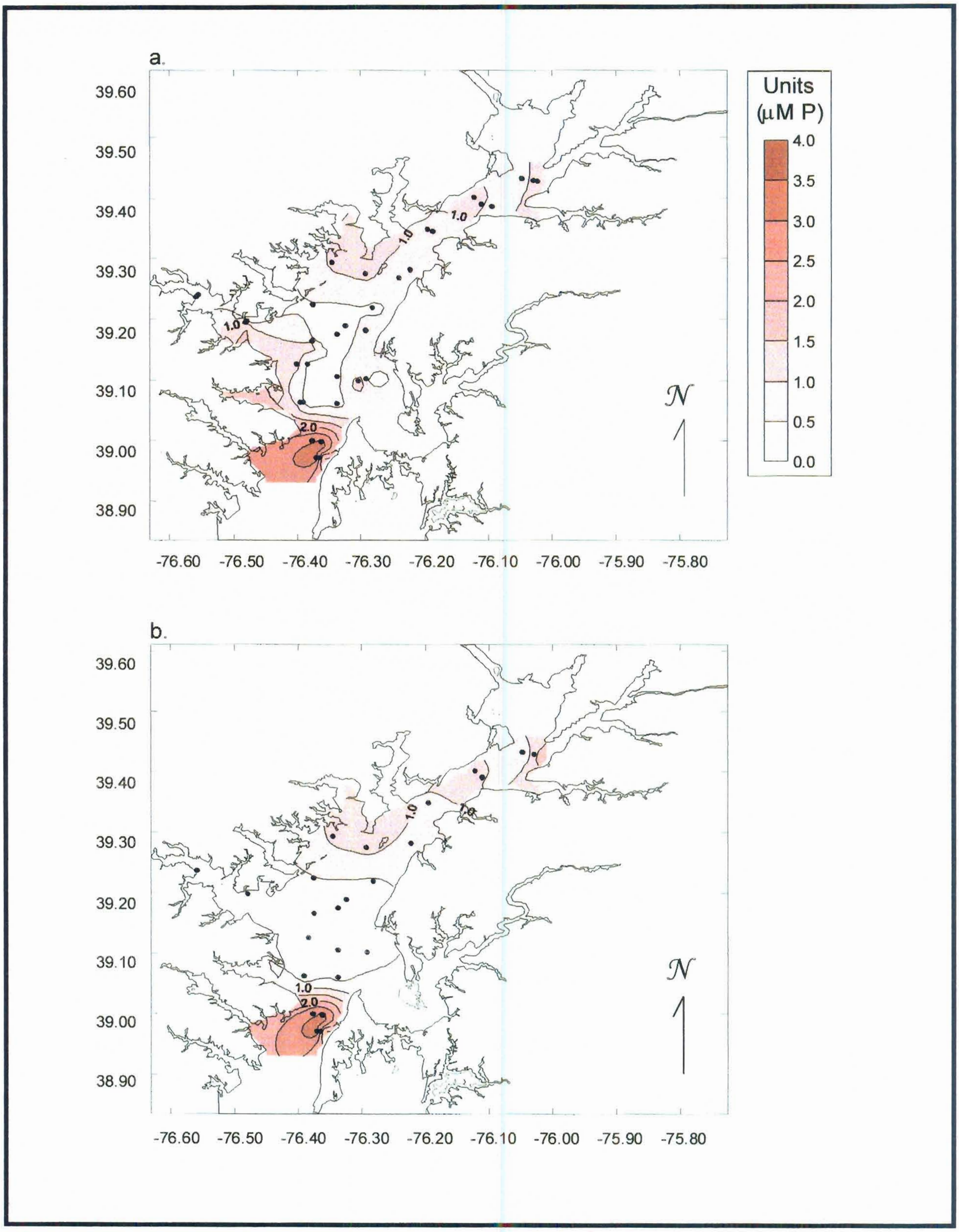

Figure 4-21. Contour maps of bottom water phosphate concentrations (µM P) in July 1998 generated from:
a. 35 channel and non-channel stations in the upper Bay and
b. 23 non-channel stations in the upper Bay.

loading estimates from both sources are shown in Table 4.1. In addition, nutrient loads from the largest waste water treatment plant in the upper Bay, and airborne deposition of nitrogen to the upper Bay are also shown for comparison. An examination of these nutrient sources clearly shows that sediment-water nutrient exchanges can have a significant effect on nutrient loading to Bay waters during summer months when external loading is minimal. For example, ammonium loading to the Bay from the Susquehanna was approximately 3,932 kg N d^{-1} (8661 lb N d^{-1}), while from the sediments it was 135,600 kg N d^{-1} (298,678 lb N d^{-1}), some 34 times larger. Thus, in July of 1998 the flux of ammonium (NH_4^+) out of the sediments clearly represents a substantial internal source of nitrogen for phytoplankton utilization. Also for comparison purposes we estimated the difference in net sediment-water flux when dredged channel habitats are removed from the calculation. This would provide a first order estimate of the integrated sediment-water exchanges without the influence of the dredged channels. For ammonium (NH_4^+), the net effect would be a reduction in total ammonium flux by 13.65% or 18,441 kg N day^{-1} (40,619 lb N d^{-1}) less entering the water column of the upper Bay. For phosphate the difference is not as dramatic with an increase of 2.14% or 415 kg P d^{-1} (914 lb P d^{-1}) entering the water column. This value of reduced P flux is comparable to the total loading due to Susquehanna River flow during July 1998. For combined nitrate plus nitrite flux (NO_{23}), the difference would be a 8.6% or a 516 kg N day^{-1} (1137 lb N d^{-1}) decrease in the amount of nitrate plus nitrate entering the sediments from the water column. While there are many sources of error associated with these estimates, these numbers still provide a much improved estimate of the contribution made by dredged shipping channels in the upper Bay and the overall impact of upper Bay sediments on regional scale nutrient sources.

4.8. Discussion

One of the goals of this study was to compare sediment-water exchanges in channel and non-channel habitats. Results from both the visual comparisons of flux contour maps, as well as the statistical comparison of habitat groups (channel vs. non-channel) indicate small differences between these habitats. No statistical difference was seen in any of the sediment-water fluxes between the channel stations and non-channel deep stations. A visual inspection of flux contour maps shows minimal differences between those contour maps created with all stations sampled and those created without the channel stations. These results seem to indicate that sediment-water fluxes in channel habitats are not sufficiently different from other deep water fluxes to have a substantial impact on integrated fluxes of the upper Bay. However, this conclusion is not entirely supported by differences seen in some of the integrated flux estimates calculated from the *Surfer* TM contour maps. For ammonium (NH_4^+) flux, an estimate of a 13.65% decrease in sediment-water flux without shipping channels may warrant further investigation. However, for other fluxes such as phosphate (PO_4^{-3}), a 2.14% increase in flux with shipping channels may be negligible.

However, another result of this study was the confirmation and identification of large gradients in sediment-water exchanges within the upper Bay. This illustrates the potential importance of high resolution spatial monitoring of these processes in order to measure and identify locally important regions or hot spots that may have a significant impact on Bay ecology. The tradition of using a few fixed monitoring sites will rarely identify regions of intense activity that may

Table 4-1. Estimated nutrient loading to Upper Chesapeake Bay July 1998. Sediment-water exchanges estimated with all stations included and without the influence of channel stations.

[1] *Susquehanna River loads calculated from nutrient concentration measurements supplied by Maryland DNR, and river flow measurements from USGS.*

[2] *Data from* **Boynton** *et al. 1998. Pooles Island G-west comprehensive Monitoring Program Final Report.*

[3] *Data collected from* **Boynton** *et al. 1998. An Environmental Evaluation of Back River with Selected Data from Patapsco River.*

[4] *Data estimated from* **Boynton** *et al. 1995. Inputs, Transformations, and Transport of Nitrogen and Phosphorus in Chesapeake and Selected Tributaries. Estuaries. Vol. 18:285-314.*

[5] *These percentages are estimates (either increases or decreases) of the change in sediment water exchanges in the Upper Bay under conditions where channels are present (column B) and by assuming that no channels were present (column C).*

A	B	C	D	E	F	G
	Sediment Water Exchanges					
Nutrients	All stations kg d^{-1} (lb d^{-1})	Without channels kg d^{-1} (lb d^{-1})	Net difference Without channels % Change[5]	Susquehanna River[1] kg d^{-1} (lb d^{-1})	Back River Waste Water Treatment[3] kg d^{-1} (lb d^{-1})	Mean annual Atmospheric Deposition[4] kg d^{-1} (lb d^{-1})
NH_4^+	135,600 (298,678)	117,090 (257,907)	-13.65%	3,932 (8,661)		795 (1,751)
$NO_2^- + NO_3^-$	-6,002 (-13220)	5,485 (12,081)	+8.6%	57,284 (126,176)		1,295 (2,852)
PO_4^{-3}	19,401 (42,733)	18,986 (41,819)	+2.14%	442 (974)		36 (79)
TDN					3,200 (7,048)	
TDP					60 (132)	

migrate annually or seasonally depending on the behavior of forcing functions (e.g. river flow) within the Bay. Only a more spatially inclusive method, such as that employed in this study or a field calibrated statistical model is capable of identifying these potentially important regions.

The inter-annual comparison of the 10 stations sampled in 1997 and 1998 indicates that there was minimal difference in fluxes between the years. This result is logical since Susquehanna River flow during the months of June, July and August was not substantially different between 1997 and 1998. High site to site variation also contributed to finding no statistical inter-annual variation at these sites. It is likely however, that sediment-water fluxes would differ greatly under "high flow" years and subsequently higher external loading conditions.

4.9. Future Activities

While it is clear that biogeochemical processes taking place within sediments can play a large role in determining water quality conditions throughout the water column, they are often difficult and expensive to measure. While the results of this study provide a great deal of information, the data represent a snapshot in time, and do not address seasonal or inter-annual variation. Understanding and measuring this variation is important for making regional baseline assessments and for making management decisions about water quality issues relevant to the Bay. In recent years the accumulation of substantial data has allowed the development of statistical models that may offer an alternative to the direct measurement of sediment-water exchanges. The use of these predictive models may offer several advantages over traditional methods by significantly increasing both the spatial and temporal coverage of an estuary while simultaneously decreasing the cost and effort needed to collect relevant data. Although results from model simulations may not be as accurate as traditional methods, the improvement in temporal and spatial coverage within a region may more than compensate for a small decrease in accuracy by identifying regions of intense activity that may be missed by less spatially inclusive approaches. Previous studies have shown that parameters such as temperature, salinity and bottom water dissolved oxygen concentrations correlate well with certain sediment-water fluxes. (*e.g.* Boynton *et al.*, 1980, 1998; Cowan and Boynton, 1996; Cowan *et al.*, 1996). In addition, bottom water dissolved nutrient concentrations also influence diffusion gradients and sediment-water exchanges (e.g., Boynton and Kemp, 1985; Sundby *et al.*, 1992). Several studies have shown that the supply of organic matter to the sediment surface can have a strong influence on the magnitude of certain fluxes (*e.g.*, Kelly and Nixon, 1984; Nixon, 1981; Cowan and Boynton, 1996). In fact some studies have shown that surficial sediment chlorophyll-a concentrations used as an index of labile organic matter can be well correlated with ammonium flux and indeed explain much of the observed variation associated with this measurement (e.g., Boynton *et al.*, 1995; Cowan and Boynton, 1996). While sediment-water flux models have been most well developed from data collected on Patuxent River, we believe the same approach will be valid and useful on larger systems such as Chesapeake Bay.

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APPENDIX A
UPPER BAY PARAMETER LIST

INTRODUCTION

Table A-1 lists the variables used in the upper bay study and is modified from the Ecosystem Processes Component Data Dictionary (Boynton and Rohland, 1990). The variables are sorted in alphabetical order using the table name. The table has five columns: table name is followed by the one to eight character CHESSIE variable name, a parameter description, the unit of measure and the unit abbreviation used in the upper bay data tables.

Table A-1. Variable and Parameter List
Modified from Boynton and Rohland (1990).

TABLE NAME	CHESSEE VARIABLE NAME	PARAMETER DESCRIPTION	UNIT	UNIT ABBR
AA VIAL NO	SAMPLEID	Basic identification number for water samples.	Number	
BLANK SLOPE DIP	BS_DIP	Time rate of change of phosphorus concentration in a blank chamber.	Micromoles per liter per minute	$\mu M/(l \bullet min)$
BLANK SLOPE DO	BS_DO	Time rate of change of dissolved oxygen concentration in a blank chamber.	Milligrams per liter per minute	$mg/(l \bullet min)$
BLANK SLOPE H2S	BS_H2S	Time rate of change of hyrodgen sulfide concentration in a blank chamber.	Nanomoles per liter per minute	$nM/(l \bullet min)$
BLANK SLOPE NH4	BS_NH4	Time rate of change of ammonium concentration in a blank chamber.	Micromoles per liter per minute	$\mu M/(l \bullet min)$
BLANK SLOPE NO23	BS_NO23	Time rate of change of nitrite plus nitrate concentration in a blank chamber.	Micromoles per liter per minute	$\mu M/(l \bullet min)$
BLANK SLOPE Si(OH)4	BS_DSI	Time rate of change of siliceous acid concentration in a blank chamber.	Micromoles per liter per minute	$\mu M/(l \bullet min)$
CHLa ACTIVE	CHL_A	The total chlorophyll-a of a water sample is acidified and measured fluorometrically. Active chlorophyll-a is then determined by subtracting the value obtained following acidification from the total chlorophyll-a value.	Micrograms per liter	$\mu g/l$
CHLa TOTAL	CHL_T	The total chlorophyll-a concentration of a water sample determined by extraction in 90% acetone and measured fluorometrically. This value includes active chlorophyll-a and some undefined chlorophyll-a degredation products.	Micrograms per liter	$\mu g/l$
COND	COND	Conductivity of water.	Millimhos per centimeter	mmho/cm
CORE DEPTH	CORE_Z	Depth either above or beneath (negative values) the sediment water interface at which measurement was taken; a core depth of zero represents the sediment water interface.	Centimeters	cm
CORE H_2O DEPTH	COREWATZ	Height of water above the sediment surface in a sediment-water flux chamber.	Meters	m
CORE H_2O VOL	CORE_WAT	Total volume of water overlying sediment in a sediment-water flux chamber.	Milliliters	ml

Table A-1. Variable and Parameter List (Continued)

TABLE NAME	CHESSEE VARIABLE NAME	PARAMETER DESCRIPTION	UNIT	UNIT ABBR
CORE NO	CORE_NO	Chamber replicate identifier.	Alpha or numeric	
CORR DIP	DIP_CORR	Dissolved inorganic phosphorus concentration of a filtered water sample which has been corrected for salinity effects.	Micromolar	μM
DATE	DATE	Date of sample collection or measurement, alphanumeric.	Day, Month, Year	DDMMMYY
DIP	DIP_MOL	Dissolved inorganic phosphorus concentration of a filtered water sample.	Micromolar	μM
DIP FLUX	DIP_FLUX	Net flux of dissolved inorganic phosphorus across sediment water interface.	Micromolar phosphorus per square meter per hour	$\mu MP/(m^2 \cdot hr)$
DIP FLUX MEAN	DIP_MFLX	Average of triplicate dissolved inorganic phosphorus flux determinations at a station.	Micromolar phosphorus per square meter per hour	$\mu MP/(m^2 \cdot hr)$
DO	DISOXY	Dissolved oxygen concentration.	Milligrams per liter	mg/l
DIP SLOPE	DIP_SLP	Time rate of change of dissolved inorganic phosphorus concentration in overlying waters of a sediment-water flux chamber.	Micromolar phosphorus per liter per minute	$\mu MP/(l \cdot min)$
DO FLUX	DO_FLUX	Net flux of dissolved oxygen across sediment-water interface. DO flux is synonomous with sediment oxygen consumption (SOC).	Grams oxygen per square meter per day	$gO_2/(m^2 \cdot day)$
DO FLUX MEAN	DO_MFLX	Average of triplicate dissolved oxygen flux determinations at a station.	Grams oxygen per square meter per day	$gO_2/(m^2 \cdot day)$
DO SAT	DOSAT	Measured oxygen concentration relative to oxygen saturation concentration at sample temperature and salinity.	Percentage	%
DO SLOPE	DO_SLP	Time rate of change of dissolved oxygen concentration in overlying waters of a sediment-water flux chamber.	Milligrams O_2 per liter per minute	$mg/(l \cdot min)$
Eh CORR	EH_CORR	Eh corrected = Eh measured + 244mV. This gives Eh relative to the hydrogen electrode.	Millivolts	mV

Table A-1. Variable and Parameter List (Continued)

TABLE NAME	CHESSEE VARIABLE NAME	PARAMETER DESCRIPTION	UNIT	UNIT ABBR
Eh MEAS	ORP	A measure of the chemical environment (oxidizing or reducing) at a specific depth in the sediment column measured relative to a calomel electrode.	Millivolts	mV
GEAR CODE	GEAR	Sampling Gear Code.	See Boynton and Rohland, 1990	
H2O %	H2O_SED	The percentage (by weight) of water loss by drying for a specified section of the sediment column.	Grams of water per 100 grams of wet sediment	%
H2S	H2S_MOL	Hydrogen sulfide concentration of a filtered water sample.	Micromolar	μM
H2S FLUX	H2S_FLUX	Net flux of dissolved hydrogen sulfide across sediment water interface.	Micromolar sulfur per square meter per hour	$\mu MS/(m^2 \bullet hr)$
H2S FLUX MEAN	H2S_MFLX	Average of triplicate hydrogen sulfide flux determinations at a station.	Micromolar sulfur per square meter per hour	$\mu MS/(m^2 \bullet hr)$
H2S SLOPE	H2S_SLP	Time rate of change of hydrogen sulfide concentration in overlying waters of a sediment-water flux chamber.	Micromolar sulfur per liter per minute	$\mu MS/(l \bullet min)$
NH4	NH4_MOL	Ammonium concentration of a filtered water sample.	Micromolar	μM
NH4FLUX	NH4_FLUX	Net flux of dissolved ammonium across sediment water interface.	Micromolar nitrogen per square meter per hour	$\mu MN/(m^2 \bullet hr)$
NH4 FLUX MEAN	NH4MFLX	Average of triplicate ammonium flux determinations at a station	Micromolar nitrogen per square meter per day	$\mu MN/(m^2 \bullet day)$

Table A-1. Variable and Parameter List (Continued)

TABLE NAME	CHESSEE VARIABLE NAME	PARAMETER DESCRIPTION	UNIT	UNIT ABBR
NH4 SLOPE	NH4_SLP	Time rate of change of ammonium concentration in overlying waters of a sediment-water flux chamber.	Micromoles nitrogen per liter per minute	μMN/(l • min)
NO2	NO2_MOL	Nitrite concentration of a filtered water sample.	Micromolar	μM
NO2 FLUX	NO2_FLUX	Net flux of dissolved nitrite across sediment water interface.	Micromolar nitrogen per square meter per hour	μMN/(m^2 • hr)
NO2FLUX MEAN	NO2_MFLX	Average of triplicate nitrite flux determinations at a station.	Micromolar nitrogen per square meter per hour	μMN/(m^2 • hr)
NO2SLOPE	NO2_SLP	Time rate of change of nitrite concentration in overlying waters of a sediment-water flux chamber.	Micromolar nitrogen per liter per minute	μMN/(l • hr)
NO2+NO3	NO23_MOL	Nitrite + nitrate concentration of a filtered water sample.	Micromolar	μM
NO2+NO3 FLUX	NO23FLUX	Net flux of dissolved nitrite + nitrate across sediment water interface.	Micromolar nitrogen per square meter per hour	μMN/(m^2 • hr)
NO2+NO3 FLUX MEAN	NO23MFLX	Average of triplicate nitrite + nitrate flux determinations at a station.	Micromolar nitrogen per square meter per hour	μMN/(m^2 • hr)
NO2+NO3 SLOPE	NO23_SLP	Time rate of change of nitrite + nitrate concentration in overlying waters of a sediment-water flux chamber.	Micromolar nitrogen per liter per minute	μMN/(l • min)

Table A-1. Variable and Parameter List (Continued)

TABLE NAME	CHESSEE VARIABLE NAME	PARAMETER DESCRIPTION	UNIT	UNIT ABBR
PC	PC_WAT	Particulate organic carbon concentration of a water sample.	Micrograms per liter	$\mu g/l$
PN	PN_WAT	Particulate organic nitrogen concentration of a water sample.	Micrograms per liter	$\mu g/l$
PP	PP_WAT	Particulate phosphorus concentration of a water sample.	Micrograms per liter	$\mu g/l$
SALIN	SALIN	Salinity of water at sample depth.	Parts per thousand	ppt
SAMPLE DEPTH	SDEPTH	Sample depth from surface of water.	Meters	m
SECCHI DEPTH	SECCHI	Depth from water surface to which Secchi disk can be seen.	Meters	m
SED CHLa ACTIVE	CHLA_SED	The total chlorophyll-a sediment section sample is acidified and measured fluorometrically. Active chlorophyll-a is then determined by subtracting the value obtained following acidification from the total chlorophyll-a value.	Milligrams per square meter	mg/m^2
SED CHLa TOTAL	CHLT_SED	The total chlorophyll-a concentration of a sediment section sample determined by extraction in 90% acetone and measured fluorometrically. This value includes active chlorophyll-a and some undefined chlorophyll-a degredation products.	Milligrams per square meter	mg/m^2
SED PC	PC_SED	Percentage by dry weight of particulate organic carbon for a specified section of the sediment column.	Grams carbon per 100 grams of dry sediment	% (wt)
SED PN	PN_SED	Percentage by dry weight of particulate organic nitrogen for a specified section of the sediment column.	Grams nitrogen per 100 grams of dry sediment	% (wt)
SED PP	PP_SED	Percentage by dry weight of particulate phosphorus for a specified section of the sediment column.	Grams phosphorus per 100 grams of dry sediment	% (wt)

Table A-1. Variable and Parameter List (Continued)

TABLE NAME	CHESSEE VARIABLE NAME	PARAMETER DESCRIPTION	UNIT	UNIT ABBR
SESTON	SES_MG	Concentration as dry weight of total particulates in a water sample (seston).	milligrams per liter	mg/l
SILICATE FLUX	DSI_FLUX	Net flux of dissolved silicate across sediment water interface.	Micromolar silicate per square meter per hour	μMSi/(m^2 • hr)
SILICATE FLUX MEAN	DSIMFLUX	Average of triplicate silicate flux determinations at a SONE station.	Micromolar silicate per square meter per hour	μMSi/(m^2 • hr)
SILICATE SLOPE	DSISLOPE	Time rate of change of silicate concentration in overlying waters of a sediment-water flux chamber.	Micromolar silicate per liter per minute	μMSi/(l • min)
Si(OH)4	DSI_MOL	Silicious acid concentration of a filtered water sample.	micromolar	μM
STATION	STATION	Sampling station identifier.	See Appendix B Table 3-1	
TDN	TDN_MOL	Total dissolved nitrogen concentration of a filtered water sample.	Micromolar nitrogen per liter	μMN/l
TDP	TDP	Total dissolved phosphorus concentration of a filtered water sample.	Micromolar phosphorus per liter	μMP/l
TEMP	WTEMP	Temperature of water at sample depth.	Degrees Centigrade	C
TIME	TIME	Time of day that sample was collected using 24-hour clock.	Hours, minutes in 24-hour time	HHMM
TIME DELTA	TIME_DEL	Time difference between samples.	Minutes	MM

Table A-1. Variable and Parameter List (Continued)

TABLE NAME	CHESSEE VARIABLE NAME	PARAMETER DESCRIPTION	UNIT	UNIT ABBR
TIME SUM	TIME_SUM	Summation of the time elapsed from beginning of incubation of a sediment-water flux chamber.	Minutes	MM
TOTAL DEPTH	TDEPTH	Total depth of water column at station.	Meters	m

DATE: 11th April, 1992

APPENDIX B

UPPER BAY DATA FILES
(JULY 1998)

Table 3-1. Location, depth and description (channel or non-channel) of stations in the upper Chesapeake Bay sampled in July 1998.
Latitude and longitude values are expressed as degrees.
Depth is measured in meters.
Stations that were sampled in 1997 as well as 1998 are indicated with an (*).

Station	Latitude (degrees)	Longitude (degrees)	Description	Channel Areas	Depth (meters)
UB01	39.42833	76.04333	NON-CHANNEL		5.0
UB02	39.42500	76.02500	NON-CHANNEL		5.0
DC01	39.42463	76.01873	CHANNEL	C & D Approach Channel	13.5
UB03	39.39750	76.11833	NON-CHANNEL		4.0
UB04	39.38667	76.10667	NON-CHANNEL		6.5
DC02	39.38333	76.09000	CHANNEL	C & D Approach Channel	14.5
UB05	39.34500	76.19167	NON-CHANNEL		9.0
DC03	39.34167	76.18333	CHANNEL	C & D Approach Channel	11.0
UB06	39.28950	76.34133	NON-CHANNEL		4.5
PLIS	39.27142	76.28883	NON-CHANNEL*		4.5
UB07	39.27767	76.21900	NON-CHANNEL		7.0
NACL	39.26462	76.23625	CHANNEL*	C & D Approach Channel	12.0
UB08	39.22033	76.37150	NON-CHANNEL		6.0
UB09	39.21552	76.27783	NON-CHANNEL		5.0
UB10	39.18500	76.32000	NON-CHANNEL		6.0
DC04	39.17787	76.28852	CHANNEL	Tolchester Channel	12.0
UB11	39.17167	76.33333	NON-CHANNEL		5.0
FMCL	39.23707	76.55102	CHANNEL*	Fort McHenry Channel	10.5
FFOF	39.23382	76.55427	NON-CHANNEL*		6.0
BWCL	39.19095	76.47662	CHANNEL*	Brewerton Channel (West)	16.0
BWSL	39.19387	76.47520	NON-CHANNEL*		6.0
BECL	39.15975	76.37240	CHANNEL*	Brewerton Channel (Eastern Extension)	12.0
BESL	39.16207	76.37102	NON-CHANNEL*		6.0
DC06	39.12163	76.39662	CHANNEL	Craighill Channel (Upper Range)	17.0
UB12	39.12167	76.38000	NON-CHANNEL		7.0
UB13	39.10167	76.33333	NON-CHANNEL		8.0
DC07	39.09500	76.30000	CHANNEL	Swan Point Channel	11.0
UB14	39.09783	76.28800	NON-CHANNEL		8.0
CHCL	39.05845	76.39158	CHANNEL*	Craighill Channel (Entrance)	13.0
CHSL	39.05850	76.38677	NON-CHANNEL*		11.0
UB15	39.05667	76.33333	NON-CHANNEL		13.5
104-D2	38.99383	76.35833	NON-CHANNEL		24.0
104-DR	38.99517	76.37267	NON-CHANNEL		18.0
UB16	38.96667	76.36667	CHANNEL	Eastern Channel (Kent Island)	17.0
UB17	38.96667	76.36117	NON-CHANNEL		7.5

Table 3-2. Error Codes listed below provide specific explanations for data not recorded in Appendix B.
(This table is also addded at the beginning of Appendix B for reference).

Analysis Problem Code	DESCRIPTION
A	Laboratory accident
B	Interference
C	Mechanical/materials failure
D	Insufficient sample
N	Sample Lost
P	Lost results
R	Sample contaminated
S	Sample container broken during analysis
V	Sample results rejected due to QA/QC criteria
W	Duplicate results for all parameters
X	Sample not preserved properly
AA	Sample thawed when received
BB	Torn filter paper
CC	Pad unfolded in foil pouch
EE	Foil pouch very wet when received from field, therefore poor replication between pads, mean reported
FF	Poor replication between pads; mean reported
HD	Particulate and chlorophyll-a samples only taken at -1.0 cm of the Eh profile
HH	Sample not taken
JJ	Amount filtered not recorded (Calculation could not be done)
LL	Mislabeled
NA	Not applicable
ND	No duplicate samples taken
NI	Data for this variable are considered to be non-interpretable
NN	Particulates found in filtered sample
PP	Assumed sample volume (pouch volume differs from data sheet volume; pouch volume used)
QQ	Although value exceeds a theoretically equivalent or greater value (*e.g.*, PO4F>TDP), the excess is within precision of analytical techniques and therefore not statistically significant
RR	No sample received
SD	All sampling at station discontinued for one or more sampling periods
SS	Sample contaminated in field
TF	Dissolved oxygen probe failure
TL	Instrument failure in research laboratory
TS	Dissolved oxygen probe not stabilized
TT	Instrument failure on board research vessel
UU	Analysis discontinued
YB	No blank measured in this program
YY	Data not recorded
WW	Station was not sampled due to bad weather conditions, research vessel mechanical failure, VFX array lost or failure of state highway bridges to open

SEDIMENT OXYGEN AND NUTRIENT EXCHANGES
IN UPPER CHESAPEAKE BAY:

TABLE B-1.1. **MARYLAND ENVIRONMENTAL SERVICE**
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
WATER COLUMN PROFILES: Vertical profiles of temperature, salinity, dissolved oxygen and other characteristics at Upper Bay stations

FILENAME : **UPHP0798**
REVISED : 19981130

STATION	DATE	TIME	TOTAL DEPTH (m)	SECCHI DEPTH (m)	GEAR CODE	SAMPLE DEPTH (m)	TEMP (C)	COND (mmho/cm)	SALIN (ppt)	DO (mg/l)	DO SAT (%)
UB01	19980727	910	5.0	0.8	WP05	0.5	28.1	0.2	0.0	5.58	71.4
						1.0	28.0	0.2	0.0	5.64	72.1
						3.0	28.0	0.2	0.0	5.74	73.4
						4.5	28.0	0.2	0.0	5.89	75.3
UB02	19980727	932	5.0	0.8	WP05	0.5	28.4	0.3	0.0	5.44	70.0
						1.0	28.4	0.3	0.0	5.44	70.0
						3.0	28.4	0.3	0.0	5.42	69.7
						4.5	28.3	0.3	0.0	5.32	68.4
DC01	19980727	1023	13.5	0.9	WP05	0.5	28.4	0.3	0.0	5.70	73.4
						1.0	28.4	0.3	0.0	5.70	73.4
						3.0	28.3	0.3	0.0	5.75	73.8
						5.0	28.1	0.3	0.0	6.05	77.5
						7.0	28.1	0.3	0.0	5.95	76.2
						9.0	28.0	0.3	0.0	6.18	79.0
						11.0	27.9	0.3	0.0	6.49	82.8
						13.0	27.9	0.3	0.0	6.43	82.0
UB03	19980727	1300	4.0	0.8	WP05	0.5	27.8	1.3	0.3	6.53	83.3
						1.0	27.8	1.3	0.3	6.54	83.5
						3.5	27.8	1.3	0.3	6.44	82.1
UB04	19980727	1200	6.5	0.9	WP05	0.5	27.9	1.6	0.5	6.54	83.7
						1.0	27.9	1.6	0.5	6.50	83.2
						3.0	27.7	2.7	1.1	6.21	79.4
						5.0	27.6	2.4	1.0	5.87	74.9
DC02	19980727	1124	14.5	1.1	WP05	0.5	28.1	1.4	0.4	6.56	84.1
						2.0	27.8	2.0	0.7	6.02	76.9
						4.0	27.6	2.6	1.1	5.99	76.5
						6.0	27.6	2.6	1.1	5.79	73.9
						8.0	27.6	2.7	1.1	5.75	73.4
						10.0	27.6	2.8	1.2	5.72	73.1
						12.0	WW	WW	WW	WW	WW
						14.0	27.6	2.8	1.2	5.73	73.1
UB05	19980727	1416	9.0	1.0	WP05	0.5	27.7	4.2	1.9	7.47	96.0
						1.0	27.7	4.2	2.0	7.44	95.6
						3.0	27.4	5.9	3.0	6.94	89.2
						5.0	26.9	7.2	3.7	5.65	72.3
						7.0	26.7	9.0	4.8	4.30	55.1
						8.5	26.6	9.5	5.1	4.11	52.7
DC03	19980727	1500	11.0	1.5	WP05	0.5	WW	WW	WW	WW	WW
						1.0	WW	WW	WW	WW	WW
						3.0	WW	WW	WW	WW	WW
						5.0	WW	WW	WW	WW	WW
						7.0	WW	WW	WW	WW	WW
						9.0	26.9	7.3	3.8	5.20	66.6
						10.5	26.8	8.7	4.6	4.32	55.4

TABLE B-1.1. **MARYLAND ENVIRONMENTAL SERVICE**
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
WATER COLUMN PROFILES: Vertical profiles of temperature, salinity, dissolved oxygen and other characteristics at Upper Bay stations

FILENAME : **UPHP0798**
REVISED : 19981130

STATION	DATE	TIME	TOTAL DEPTH (m)	SECCHI DEPTH (m)	GEAR CODE	SAMPLE DEPTH (m)	TEMP (C)	COND (mmho/cm)	SALIN (ppt)	DO (mg/l)	DO SAT (%)
UB06	19980728	755	4.5	0.7	WP05	0.5	26.7	3.9	1.8	7.55	95.1
						1.0	26.7	4.1	1.9	7.43	93.7
						3.0	26.7	6.1	3.1	7.16	90.9
						4.0	26.7	6.1	3.1	6.81	86.5
PLIS	19980728	913	4.5	0.4	WP05	0.5	26.5	7.7	4.0	7.16	91.0
						1.0	26.5	7.7	4.0	7.17	91.2
						3.0	26.5	7.7	4.0	7.29	92.7
UB07	19980728	940	7.0	1.3	WP05	0.5	26.7	6.0	3.0	7.38	93.7
						2.0	26.5	7.6	4.0	6.34	80.6
						4.0	26.5	8.6	4.5	5.86	74.8
						6.5	26.5	8.5	4.5	5.77	73.6
NACL	19980728	1038	12.0	1.4	WP05	0.5	26.4	8.1	4.2	6.88	87.6
						2.0	26.4	8.6	4.6	6.21	79.1
						4.0	26.4	8.5	4.5	6.22	79.2
						6.0	26.4	8.6	4.5	6.15	78.3
						8.0	26.2	12.0	6.6	4.54	58.4
						10.0	25.6	15.5	8.8	2.35	30.2
						11.5	25.4	16.2	9.3	2.08	26.7
UB08	19980728	710	6.0	0.9	WP05	0.5	26.6	7.3	3.8	7.40	94.3
						1.0	26.8	7.6	3.9	7.32	93.6
						3.0	26.7	8.6	4.6	7.46	95.6
						5.5	26.7	8.9	4.7	7.36	94.3
UB09	19980728	1130	5.0	0.8	WP05	0.5	26.8	10.8	5.9	8.29	107.3
						2.0	26.3	10.6	5.8	7.06	90.5
						4.5	26.2	11.2	6.1	6.80	87.1
UB10	19980728	1400	6.0	0.9	WP05	0.5	27.9	12.4	6.9	12.42	164.7
						1.0	27.7	12.3	6.8	12.80	169.0
						3.0	26.3	11.8	6.5	7.49	96.3
						5.5	26.2	12.0	6.6	6.19	79.5
DC04	19980728	1332	12.0	1.2	WP05	0.5	27.3	11.6	6.4	10.89	142.4
						1.0	27.0	11.6	6.4	10.07	131.0
						3.0	26.2	11.8	6.5	6.86	88.1
						5.0	26.2	12.4	6.9	7.44	95.7
						7.0	26.0	13.0	7.2	6.86	88.2
						9.0	24.8	18.6	10.8	2.33	29.9
						11.5	24.6	20.0	11.7	2.44	31.3
UB11	19980728	1455	5.0	0.9	WP05	0.5	27.5	12.4	6.9	11.36	149.6
						2.0	26.1	12.2	6.8	7.27	93.3
						4.5	27.5	12.4	6.9	6.43	84.7
FMCL	19980730	857	10.5	1.4	WP05	0.5	C	C	C	C	C
						2.0	C	C	C	C	C
						4.0	C	C	C	C	C
						6.0	C	C	C	C	C
						8.0	C	C	C	C	C
						10.0	23.8	19.4	11.3	0.16	2.0

TABLE B-1.1. **MARYLAND ENVIRONMENTAL SERVICE**
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
WATER COLUMN PROFILES: Vertical profiles of temperature, salinity, dissolved oxygen and other characteristics at Upper Bay stations

FILENAME : **UPHP0798**
REVISED : 19981130

STATION	DATE	TIME	TOTAL DEPTH (m)	SECCHI DEPTH (m)	GEAR CODE	SAMPLE DEPTH (m)	TEMP (C)	COND (mmho/cm)	SALIN (ppt)	DO (mg/l)	DO SAT (%)
FOFF	19980730	938	6.0	0.7	WP05	0.5	26.8	12.7	7.0	7.00	91.1
						2.0	27.0	13.2	7.3	7.38	96.5
FFOF						4.0	26.9	13.2	7.4	7.22	94.4
						5.5	26.8	13.5	7.5	5.45	71.1
BWCL	19980730	1040	16.0	0.7	WP05	0.5	27.6	9.6	5.1	10.31	134.7
						2.0	27.4	10.8	5.9	7.90	103.3
						4.0	26.5	12.8	7.1	1.90	24.6
						6.0	26.2	14.0	7.9	1.99	25.8
						8.0	25.7	14.8	8.4	1.09	14.0
						10.0	25.2	16.3	9.3	0.47	6.0
						12.0	24.7	17.6	10.1	0.30	3.8
						14.0	24.1	20.2	11.9	0.34	4.3
						15.5	23.9	21.4	12.7	0.50	6.4
BWSL	19980730	1027	6.0	0.6	WP05	0.5	27.6	11.7	6.4	9.94	130.8
						2.0	27.2	11.8	6.5	8.02	104.9
						4.0	26.6	13.7	7.7	3.44	44.8
						5.5	26.3	13.9	7.8	3.53	45.8
BECL	19980728	1543	12.0	0.8	WP05	0.5	27.2	12.6	7.0	10.07	132.0
						1.0	27.3	12.7	7.0	10.56	138.6
						3.0	26.2	12.7	7.1	7.74	99.6
						5.0	26.0	13.6	7.6	6.22	80.1
						7.0	25.2	16.8	9.7	3.50	44.9
						9.0	24.8	18.9	11.0	2.54	32.6
						11.5	24.3	20.8	12.3	1.94	24.9
BESL	19980729	1326	6.0	1.1	WP05	0.5	27.7	12.9	7.2	11.24	148.7
						2.0	26.3	14.0	7.8	6.83	88.4
						4.0	26.3	14.2	8.0	6.63	86.0
						5.5	26.2	14.3	8.0	6.36	82.4
DC06	19980729	1132	17.0	0.9	WP05	0.5	26.9	13.5	7.6	9.36	122.3
						2.0	26.6	13.9	7.8	7.52	98.0
						4.0	26.6	14.4	8.1	6.82	89.0
						6.0	26.4	15.3	8.7	4.83	63.0
						8.0	26.2	15.6	8.9	4.04	52.6
						10.0	26.0	16.3	9.4	3.39	44.0
						12.0	24.6	20.2	11.8	0.29	3.7
						14.0	24.3	21.6	12.8	0.16	2.1
						16.5	24.2	21.8	12.9	0.23	3.0
UB12	19980729	1030	7.0	1.1	WP05	0.5	26.6	13.0	7.2	8.93	116.0
						2.0	26.4	14.5	8.2	7.39	96.1
						4.0	26.3	15.1	8.5	6.68	86.9
						6.5	26.3	15.3	8.7	5.98	77.8
UB13	19980729	950	8.0	1.2	WP05	0.5	26.5	13.9	7.8	8.09	105.1
						1.0	26.1	13.9	7.8	7.44	96.1
						3.0	26.1	14.2	8.0	6.77	87.4
						5.0	26.1	14.5	8.2	6.81	88.0
						7.5	25.9	15.2	8.6	5.33	68.8

TABLE B-1.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
WATER COLUMN PROFILES: Vertical profiles of temperature, salinity, dissolved oxygen and other characteristics at Upper Bay stations

FILENAME : **UPHP0798**
REVISED : 19981130

STATION	DATE	TIME	TOTAL DEPTH (m)	SECCHI DEPTH (m)	GEAR CODE	SAMPLE DEPTH (m)	TEMP (C)	COND (mmho/cm)	SALIN (ppt)	DO (mg/l)	DO SAT (%)
DC07	19980729	738	11.0	1.4	WP05	0.5	26.6	13.9	7.8	8.05	104.8
						2.0	26.6	13.9	7.8	7.97	103.8
						4.0	26.5	14.0	7.9	7.85	102.2
						6.0	26.1	15.3	8.7	6.23	80.8
						8.0	24.8	19.9	11.7	0.57	7.3
						10.5	24.6	20.7	12.2	0.18	2.3
UB14	19980729	700	8.0	1.4	WP05	0.5	26.6	13.3	7.4	8.38	109.0
						1.0	26.5	13.3	7.4	7.90	102.6
						3.0	26.5	13.4	7.5	7.60	98.6
						5.0	26.4	13.5	7.6	7.55	97.9
						7.5	25.8	16.3	9.3	3.48	45.1
CHCL	19980729	1415	13.0	0.6	WP05	0.5	28.7	16.6	9.5	15.19	207.2
						2.0	26.8	16.3	9.3	10.20	134.6
						4.0	25.9	16.5	9.5	5.35	69.5
						6.0	25.7	17.2	9.9	4.20	54.5
						8.0	25.5	17.6	10.2	3.33	43.1
						10.0	25.3	18.3	10.6	2.23	28.8
						12.5	24.3	21.0	12.4	0.52	6.7
CHSL	19980730	648	11.0	1.1	WP05	0.5	26.7	14.2	8.0	8.62	112.6
						2.0	26.8	14.4	8.1	8.29	108.5
						4.0	26.8	16.4	9.4	6.51	85.8
						6.0	26.0	17.1	9.9	3.36	43.8
						8.0	25.8	17.8	10.3	3.34	43.5
						10.5	25.6	18.2	10.5	3.03	39.4
UB15	19980729	900	13.5	1.2	WP05	0.5	26.5	16.2	9.2	8.03	105.3
						2.0	26.1	16.2	9.3	6.68	87.0
						4.0	26.1	16.3	9.3	6.63	86.3
						6.0	26.1	16.6	9.5	6.47	84.3
						8.0	26.1	16.7	9.6	6.20	80.8
						10.0	25.7	17.2	9.9	4.11	53.3
						12.0	25.1	18.6	10.8	2.14	27.6
104-D2	19980730	1339	24.0	0.8	WP05	0.5	28.4	16.6	9.6	12.23	166.0
						2.0	27.4	7.0	3.6	8.92	115.1
						4.0	26.9	16.6	9.5	6.22	82.2
						6.0	26.5	16.8	9.6	5.08	66.8
						8.0	26.2	17.0	9.8	4.07	53.2
						10.0	26.0	17.2	9.9	3.81	49.7
						12.0	24.5	21.1	12.5	0.16	2.1
						14.0	23.8	23.7	14.2	0.10	1.3
						16.0	23.3	25.4	15.3	0.10	1.3
						18.0	23.2	26.3	15.9	0.11	1.4
						20.0	23.2	26.3	15.9	0.14	1.8
						22.0	23.2	26.3	15.9	0.11	1.4
						23.5	23.2	26.3	15.9	0.18	2.3

TABLE B-1.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
WATER COLUMN PROFILES: Vertical profiles of temperature, salinity, dissolved oxygen and other characteristics at Upper Bay stations

FILENAME : **UPHP0798**
REVISED : 19981130

STATION	DATE	TIME	TOTAL DEPTH (m)	SECCHI DEPTH (m)	GEAR CODE	SAMPLE DEPTH (m)	TEMP (C)	COND (mmho/cm)	SALIN (ppt)	DO (mg/l)	DO SAT (%)
104-DR	19980730	1255	18.0	1.0	WP05	0.5	27.6	14.8	8.4	10.11	134.4
						2.0	27.1	15.8	9.0	8.25	109.2
						4.0	26.7	16.5	9.5	6.51	85.8
						6.0	26.7	16.6	9.5	6.17	81.2
						8.0	26.3	17.1	9.8	4.61	60.4
						10.0	26.0	17.4	10.1	3.87	50.5
						12.0	24.8	20.5	12.1	1.26	16.3
						14.0	24.1	23.0	13.7	0.21	2.7
						16.0	23.4	25.4	15.3	0.24	3.1
						17.5	23.4	25.5	15.4	0.36	4.6
UB16	19980803	630	17.0	1.4	WP05	0.5	25.4	15.4	8.8	7.99	102.5
						2.0	25.5	16.1	9.2	6.46	83.1
						4.0	25.4	16.5	9.4	6.21	79.9
						6.0	24.9	21.4	12.6	0.90	11.7
						8.0	24.8	22.6	13.4	0.25	3.3
						10.0	23.9	25.2	15.2	0.25	3.2
						12.0	23.5	26.5	16.1	0.27	3.5
						14.0	23.5	26.6	16.2	0.30	3.9
						16.5	23.4	27.2	16.5	0.42	5.4
UB17	19980803	725	7.5	1.5	WP05	0.5	25.2	15.4	8.8	7.01	89.6
						1.0	25.3	15.4	8.7	7.12	91.0
						3.0	25.3	16.0	9.1	6.41	82.1
						5.0	25.2	18.8	11.0	3.63	46.9
						7.0	24.7	22.5	13.4	0.85	11.1

SEDIMENT OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY:

TABLE B-2.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
WATER COLUMN NUTRIENTS: Dissolved and particulate nutrient concentrations in bottom waters at Upper Bay stations

FILENAME : **UPHNJL98**
REVISED : 19981208

				DISSOLVED NUTRIENTS						
STATION	DATE	TOTAL DEPTH (m)	SAMPLE DEPTH (m)	NH_4^+ (μM)	NO_2 (μM)	$NO_2^-+NO_3^-$ (μM)	TDN (μM)	CORR DIP (μM)	TDP (μM)	$Si(OH)_4$ (μM)
UB01	19980727	5.0	4.5	8.4	1.95	64.80	UU	0.58	UU	UU
UB02	19980727	5.0	4.5	13.1	3.59	64.90	UU	1.71	UU	UU
DC01	19980727	13.5	13.0	11.7	3.89	66.40	UU	1.40	UU	UU
UB03	19980727	4.0	3.5	5.3	5.27	78.00	UU	1.21	UU	UU
UB04	19980727	6.5	5.0	6.9	4.67	69.40	UU	0.96	UU	UU
DC02	19980727	14.5	14.0	7.3	4.84	68.20	UU	0.93	UU	UU
UB05	19980727	9.0	8.5	13.4	2.13	40.50	UU	0.95	UU	UU
DC03	19980727	11.0	10.5	18.7	2.43	42.90	UU	0.81	UU	UU
UB06	19980728	4.5	4.0	9.2	0.62	40.40	UU	1.10	UU	UU
PLIS	19980728	4.5	3.0	10.0	1.00	42.30	UU	1.11	UU	UU
UB07	19980728	7.0	6.5	12.2	2.20	44.00	UU	0.92	UU	UU
NACL	19980728	12.0	11.5	19.1	0.98	13.70	UU	0.63	UU	UU
UB08	19980728	6.0	5.5	3.8	0.52	25.40	UU	0.47	UU	UU
UB09	19980728	5.0	4.0	7.7	0.94	28.20	UU	0.38	UU	UU
UB10	19980728	6.0	5.0	5.0	0.80	23.10	UU	0.19	UU	UU
DC04	19980728	12.0	11.0	23.5	0.69	2.85	UU	1.00	UU	UU
UB11	19980728	5.0	4.5	5.4	0.73	21.10	UU	0.22	UU	UU
FMCL	19980730	10.5	10.0	34.7	1.09	14.60	UU	0.34	UU	UU
FFOF	19980730	6.0	5.5	34.5	1.60	19.30	UU	0.12	UU	UU
BWCL	19980730	16.0	15.5	33.0	0.42	0.39	UU	1.53	UU	UU
BWSL	19980730	6.0	5.5	16.9	0.97	16.00	UU	0.10	UU	UU
BECL	19980728	12.0	11.0	25.3	0.38	1.60	UU	1.38	UU	UU
BESL	19980729	6.0	5.5	4.3	0.52	15.50	UU	0.27	UU	UU
DC06	19980729	17.0	16.5	28.2	0.56	2.17	UU	1.06	UU	UU
UB12	19980729	7.0	6.5	5.6	0.40	9.04	UU	0.12	UU	UU
UB13	19980729	8.0	7.5	6.9	0.41	10.47	UU	0.46	UU	UU
DC07	19980729	11.0	10.0	27.1	0.59	2.63	UU	1.44	UU	UU
UB14	19980729	8.0	7.5	11.5	0.38	9.19	UU	0.34	UU	UU
CHCL	19980729	13.0	12.5	27.8	0.68	3.74	UU	0.74	UU	UU
CHSL	19980730	11.0	10.5	13.9	0.35	5.90	UU	0.24	UU	UU
UB15	19980729	13.5	12.0	20.8	0.41	4.21	UU	0.37	UU	UU
104-D2	19980730	24.0	23.5	31.9	0.14	0.16	UU	3.37	UU	UU
104-DR	19980730	18.0	17.5	29.9	0.12	0.73	UU	3.05	UU	UU
UB16	19980803	17.0	16.0	28.2	0.11	1.39	UU	3.19	UU	UU
UB17	19980803	7.5	7.0	16.6	0.11	1.01	UU	1.04	UU	UU

SEDIMENT OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY:

TABLE B-3.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Upper Bay stations

FILENAME : **UBSPJL98**
REVISED : 19981130

STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg m^{-2})	SED CHLa ACTIVE (mg m^{-2})	
UB01	19980727	924	1.0	81	325						
			0.0	-157	87						
			-1.0	-225	19	1.19	0.130	0.050	104.6	45.1	(1 cm)
			-2.0	-253	-9						
			-3.0	HH	HH						
			-4.0	-242	2						
			-5.0	HH	HH						
			-6.0	-267	-23						
			-7.0	HH	HH						
			-8.0	-305	-61						
			-9.0	HH	HH						
			-10.0	-353	-109						
UB02	19980727	957	1.0	68	312						
			0.0	-100	144						
			-1.0	-219	25	1.10	0.130	0.080	104.6	44.5	(1 cm)
			-2.0	-285	-41						
			-3.0	HH	HH						
			-4.0	-275	-31						
			-5.0	HH	HH						
			-6.0	-283	-39						
			-7.0	HH	HH						
			-8.0	-284	-40						
			-9.0	HH	HH						
			-10.0	-317	-73						
DC01	19980727	1033	1.0	77	321						
			0.0	45	289						
			-1.0	-71	174	1.37	0.190	0.090	95.7	48.6	(1 cm)
			-2.0	-164	80						
			-3.0	HH	HH						
			-4.0	-261	-17						
			-5.0	HH	HH						
			-6.0	-273	-29						
			-7.0	HH	HH						
			-8.0	-281	-37						
			-9.0	HH	HH						
			-10.0	-271	-27						
UB03	19980727	1328	1.0	85	329						
			0.0	-31	213						
			-1.0	-228	16	1.56	0.160	0.070	101.1	46.2	(1 cm)
			-2.0	-241	3						
			-3.0	HH	HH						
			-4.0	-269	-25						
			-5.0	HH	HH						
			-6.0	-262	-18						
			-7.0	HH	HH						
			-8.0	-265	-21						
			-9.0	HH	HH						
			-10.0	-256	-12						

TABLE B-3.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Upper Bay stations

FILENAME : **UBSPJL98**
REVISED : 19981130

						SURFICIAL SEDIMENT PARTICULATES					
STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg m^{-2})	SED CHLa ACTIVE (mg m^{-2})	
UB04	19980727	1250	1.0	108	352						
			0.0	48	292						
			-1.0	-99	145	1.57	0.140	0.070	87.1	32.2	(1 cm)
			-2.0	-206	38						
			-3.0	HH	HH						
			-4.0	-239	5						
			-5.0	HH	HH						
			-6.0	-267	-23						
			-7.0	HH	HH						
			-8.0	-260	-16						
			-9.0	HH	HH						
			-10.0	-264	-20						
DC02	19980727	1140	1.0	104	348						
			0.0	-18	226						
			-1.0	-6	238	1.45	0.160	0.080	25.5	7.2	(1 cm)
			-2.0	-68	176						
			-3.0	HH	HH						
			-4.0	-159	85						
			-5.0	HH	HH						
			-6.0	-177	67						
			-7.0	HH	HH						
			-8.0	-223	22						
			-9.0	HH	HH						
			-10.0	-204	40						
UB05	19980727	1445	1.0	87	331						
			0.0	-142	102						
			-1.0	-344	-100	1.89	0.170	0.050	22.2	6.5	(1 cm)
			-2.0	-379	-135						
			-3.0	HH	HH						
			-4.0	-395	-151						
			-5.0	HH	HH						
			-6.0	-409	-165						
			-7.0	HH	HH						
			-8.0	-368	-124						
			-9.0	HH	HH						
			-10.0	-449	-205						
DC03	19980727	1528	1.0	56	300						
			0.0	60	304						
			-1.0	-24	220	2.54	0.240	0.030	34.4	7.7	(1 cm)
			-2.0	-104	140						
			-3.0	HH	HH						
			-4.0	-164	80						
			-5.0	HH	HH						
			-6.0	-181	63						
			-7.0	HH	HH						
			-8.0	-194	50						
			-9.0	HH	HH						
			-10.0	-179	65						

TABLE B-3.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Upper Bay stations

FILENAME : **UBSPJL98**
REVISED : 19981130

STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg m^{-2})	SED CHLa ACTIVE (mg m^{-2})
UB06	19980728	825	1.0	103	347					
			0.0	26	270					
			-1.0	-236	8	2.74	0.280	0.110	112.4	42.7 (1 cm)
			-2.0	-258	-14					
			-3.0	HH	HH					
			-4.0	-450	-206					
			-5.0	HH	HH					
			-6.0	-403	-159					
			-7.0	HH	HH					
			-8.0	-401	-157					
			-9.0	HH	HH					
			-10.0	-359	-115					
PLIS	19980728	925	1.0	34	278					
			0.0	-80	164					
			-1.0	-219	25	3.56	0.250	0.100	143.6	56.2 (1 cm)
			-2.0	-260	-16					
			-3.0	HH	HH					
			-4.0	-216	28					
			-5.0	HH	HH					
			-6.0	-269	-25					
			-7.0	HH	HH					
			-8.0	-277	-33					
			-9.0	HH	HH					
			-10.0	-278	-34					
UB07	19980728	1012	1.0	100	344					
			0.0	62	306					
			-1.0	-69	175	2.87	0.250	0.050	54.1	15.3 (1 cm)
			-2.0	-231	13					
			-3.0	HH	HH					
			-4.0	-223	21					
			-5.0	HH	HH					
			-6.0	-203	41					
			-7.0	HH	HH					
			-8.0	-163	81					
			-9.0	HH	HH					
			-10.0	-248	-4					
NACL	19980728	1050	1.0	131	375					
			0.0	105	349					
			-1.0	2	246	4.63	0.260	0.090	97.3	37.5 (1 cm)
			-2.0	-132	112					
			-3.0	HH	HH					
			-4.0	-85	160					
			-5.0	HH	HH					
			-6.0	-159	85					
			-7.0	HH	HH					
			-8.0	-220	24					
			-9.0	HH	HH					
			-10.0	-278	-34					

TABLE B-3.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Upper Bay stations

FILENAME : **UBSPJL98**
REVISED : 19981130

STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg m^{-2})	SED CHLa ACTIVE (mg m^{-2})	
UB08	19980728	714	1.0	129	373						
			0.0	55	299						
			-1.0	-60	185	3.78	0.300	0.070	87.7	20.3	(1 cm)
			-2.0	-216	28						
			-3.0	HH	HH						
			-4.0	-243	1						
			-5.0	HH	HH						
			-6.0	-301	-57						
			-7.0	HH	HH						
			-8.0	-307	-63						
			-9.0	HH	HH						
			-10.0	-290	-46						
UB09	19980728	1156	1.0	114	358						
			0.0	21	265						
			-1.0	-197	47	4.48	0.250	0.090	136.3	49.7	(1 cm)
			-2.0	-241	3						
			-3.0	HH	HH						
			-4.0	274	518						
			-5.0	HH	HH						
			-6.0	-261	-17						
			-7.0	HH	HH						
			-8.0	-287	-43						
			-9.0	HH	HH						
			-10.0	-311	-67						
UB10	19980728	1420	1.0	105	349						
			0.0	176	420						
			-1.0	98	342	3.33	0.250	0.070	120.7	41.6	(1 cm)
			-2.0	42	286						
			-3.0	HH	HH						
			-4.0	-223	21						
			-5.0	HH	HH						
			-6.0	-235	9						
			-7.0	HH	HH						
			-8.0	-252	-8						
			-9.0	HH	HH						
			-10.0	-296	-52						
DC04	19980728	1342	1.0	121	365						
			0.0	99	343						
			-1.0	-159	85	1.58	0.180	0.070	50.4	19.1	(1 cm)
			-2.0	-342	-98						
			-3.0	HH	HH						
			-4.0	-309	-65						
			-5.0	HH	HH						
			-6.0	-319	-75						
			-7.0	HH	HH						
			-8.0	-405	-161						
			-9.0	HH	HH						
			-10.0	-402	-158						

TABLE B-3.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Upper Bay stations

FILENAME : UBSPJL98
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STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg m^{-2})	SED CHLa ACTIVE (mg m^{-2})	
UB11	19980728	1507	1.0	148	392						
			0.0	171	415						
			-1.0	136	380	4.00	0.280	0.110	54.6	12.6	(1 cm)
			-2.0	109	353						
			-3.0	HH	HH						
			-4.0	61	305						
			-5.0	HH	HH						
			-6.0	-136	108						
			-7.0	HH	HH						
			-8.0	-210	34						
			-9.0	HH	HH						
			-10.0	-299	-55						
FMCL	19980730	910	1.0	136	380						
			0.0	-195	49						
			-1.0	-249	-5	3.44	0.360	0.120	149.5	77.2	(1 cm)
			-2.0	-266	-22						
			-3.0	HH	HH						
			-4.0	-266	-22						
			-5.0	HH	HH						
			-6.0	-276	-32						
			-7.0	HH	HH						
			-8.0	-287	-43						
			-9.0	HH	HH						
			-10.0	-266	-22						
FFOF	19980730	952	1.0	86	330						
			0.0	-244	0						
			-1.0	-272	-28	4.65	0.480	0.150	156.8	70.8	(1 cm)
			-2.0	-272	-28						
			-3.0	HH	HH						
			-4.0	-316	-72						
			-5.0	HH	HH						
			-6.0	-415	-171						
			-7.0	HH	HH						
			-8.0	-390	-146						
			-9.0	HH	HH						
			-10.0	-398	-154						
BWCL	19980730	1137	1.0	90	334						
			0.0	-208	36						
			-1.0	-241	3	3.40	0.280	0.090	149.8	86.0	(1 cm)
			-2.0	-242	2						
			-3.0	HH	HH						
			-4.0	-226	18						
			-5.0	HH	HH						
			-6.0	-226	18						
			-7.0	HH	HH						
			-8.0	-248	-4						
			-9.0	HH	HH						
			-10.0	D	D						

TABLE B-3.1. **MARYLAND ENVIRONMENTAL SERVICE**
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Upper Bay stations

FILENAME : **UBSPJL98**
REVISED : 19981130

						SURFICIAL SEDIMENT PARTICULATES					
STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg m^{-2})	SED CHLa ACTIVE (mg m^{-2})	
BWSL	19980730	1033	1.0	98	342						
			0.0	8	252						
			-1.0	-114	131	3.43	0.300	0.100	156.8	63.2	(1 cm)
			-2.0	-177	67						
			-3.0	HH	HH						
			-4.0	-266	-22						
			-5.0	HH	HH						
			-6.0	-451	-207						
			-7.0	HH	HH						
			-8.0	-395	-151						
			-9.0	HH	HH						
			-10.0	-411	-167						
BECL	19980728	1616	1.0	135	379						
			0.0	-118	126						
			-1.0	-278	-34	3.89	0.320	0.110	88.9	29.6	(1 cm)
			-2.0	-369	-125						
			-3.0	HH	HH						
			-4.0	-393	-149						
			-5.0	HH	HH						
			-6.0	-318	-74						
			-7.0	HH	HH						
			-8.0	-335	-91						
			-9.0	HH	HH						
			-10.0	-366	-122						
BESL	19980729	1137	1.0	110	354						
			0.0	124	368						
			-1.0	53	297	2.97	0.230	0.080	54.1	15.3	(1 cm)
			-2.0	22	266						
			-3.0	HH	HH						
			-4.0	117	361						
			-5.0	HH	HH						
			-6.0	-240	4						
			-7.0	HH	HH						
			-8.0	-230	14						
			-9.0	HH	HH						
			-10.0	-257	-13						
DC06	19980729	1137	1.0	134	378						
			0.0	-20	224						
			-1.0	-272	-28	3.07	0.340	0.110	166.4	96.6	(1 cm)
			-2.0	-301	-57						
			-3.0	HH	HH						
			-4.0	-312	-68						
			-5.0	HH	HH						
			-6.0	-312	-68						
			-7.0	HH	HH						
			-8.0	-295	-51						
			-9.0	HH	HH						
			-10.0	-282	-38						

TABLE B-3.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Upper Bay stations

FILENAME : **UBSPJL98**
REVISED : 19981130

						SURFICIAL SEDIMENT PARTICULATES					
STATION	**DATE**	**TIME**	**CORE DEPTH (cm)**	**Eh MEAS (mV)**	**Eh CORR (mV)**	**SED PC %(wt)**	**SED PN %(wt)**	**SED PP %(wt)**	**SED CHLa TOTAL (mg m^{-2})**	**SED CHLa ACTIVE (mg m^{-2})**	
UB12	19980729	1054	1.0	145	389						
			0.0	112	356						
			-1.0	115	359	3.6	0.280	0.080	86.3	31.0	(1 cm)
			-2.0	113	357						
			-3.0	HH	HH						
			-4.0	-163	81						
			-5.0	HH	HH						
			-6.0	-238	6						
			-7.0	HH	HH						
			-8.0	-415	-171						
			-9.0	HH	HH						
			-10.0	-348	-104						
UB13	19980729	1000	1.0	58	302						
			0.0	66	310						
			-1.0	-120	124	3.53	0.330	0.110	142.2	72.6	(1 cm)
			-2.0	-240	4						
			-3.0	HH	HH						
			-4.0	-273	-29						
			-5.0	HH	HH						
			-6.0	-265	-21						
			-7.0	HH	HH						
			-8.0	-265	-21						
			-9.0	HH	HH						
			-10.0	-268	-24						
DC07	19980729	752	1.0	131	375						
			0.0	-175	69						
			-1.0	-251	-7	3.08	0.330	0.100	171.8	97.1	(1 cm)
			-2.0	-269	-25						
			-3.0	HH	HH						
			-4.0	-235	9						
			-5.0	HH	HH						
			-6.0	-291	-47						
			-7.0	HH	HH						
			-8.0	-292	-48						
			-9.0	HH	HH						
			-10.0	-282	-38						
UB14	19980729	710	1.0	105	349						
			0.0	9	253						
			-1.0	-235	9	3.08	0.320	0.090	155.7	82.5	(1 cm)
			-2.0	-249	-5						
			-3.0	HH	HH						
			-4.0	-287	-43						
			-5.0	HH	HH						
			-6.0	-348	-104						
			-7.0	HH	HH						
			-8.0	-332	-88						
			-9.0	HH	HH						
			-10.0	-324	-80						

TABLE B-3.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Upper Bay stations

FILENAME : **UBSPJL98**
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STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg m^{-2})	SED CHLa ACTIVE (mg m^{-2})	
CHCL	19980729	1543	1.0	125	369						
			0.0	-131	113						
			-1.0	-251	-7	3.19	0.360	0.100	158.9	72.6	(1 cm)
			-2.0	-263	-19						
			-3.0	HH	HH						
			-4.0	-251	-7						
			-5.0	HH	HH						
			-6.0	-241	3						
			-7.0	HH	HH						
			-8.0	-256	-12						
			-9.0	HH	HH						
			-10.0	-272	-28						
CHSL	19980730	650	1.0	145	389						
			0.0	-146	98						
			-1.0	-231	13	2.93	0.320	0.540	114.3	46.8	(1 cm)
			-2.0	-247	-3						
			-3.0	HH	HH						
			-4.0	-243	1						
			-5.0	HH	HH						
			-6.0	-220	24						
			-7.0	HH	HH						
			-8.0	-223	21						
			-9.0	HH	HH						
			-10.0	-258	-14						
UB15	19980729	903	1.0	108	352						
			0.0	-246	-2						
			-1.0	-310	-66	3.08	0.360	0.100	209.2	114.1	(1 cm)
			-2.0	-329	-85						
			-3.0	HH	HH						
			-4.0	-291	-47						
			-5.0	HH	HH						
			-6.0	-331	-87						
			-7.0	HH	HH						
			-8.0	-403	-159						
			-9.0	HH	HH						
			-10.0	-435	-191						
104-D2	19980730	1347	1.0	YY	YY						
			0.0	-375	-131						
			-1.0	-289	-45	3.36	0.410	0.080	270.7	168.7	(1 cm)
			-2.0	-394	-150						
			-3.0	HH	HH						
			-4.0	-399	-155						
			-5.0	HH	HH						
			-6.0	-409	-165						
			-7.0	HH	HH						
			-8.0	-403	-159						
			-9.0	HH	HH						
			-10.0	-393	-149						

TABLE B-3.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Upper Bay stations

FILENAME : **UBSPJL98**
REVISED : 19981130

						SURFICIAL SEDIMENT PARTICULATES					
STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg m^{-2})	SED CHLa ACTIVE (mg m^{-2})	
104-DR	19980730	1257	1.0	15	259						
			0.0	-167	77						
			-1.0	-196	49	1.94	0.190	0.050	120.2	72.6	(1 cm)
			-2.0	-195	49						
			-3.0	HH	HH						
			-4.0	-222	22						
			-5.0	HH	HH						
			-6.0	-223	21						
			-7.0	HH	HH						
			-8.0	-275	-31						
			-9.0	HH	HH						
			-10.0	D	D						
UB16	19980803	733	1.0	111	355						
			0.0	-300	-56						
			-1.0	-303	-59	2.62	0.310	0.060	187.9	112.9	(1 cm)
			-2.0	-320	-76						
			-3.0	HH	HH						
			-4.0	-323	-79						
			-5.0	HH	HH						
			-6.0	-375	-131						
			-7.0	HH	HH						
			-8.0	-390	-146						
			-9.0	HH	HH						
			-10.0	-399	-155						
UB17	19980903	812	1.0	65	309						
			0.0	-154	90						
			-1.0	-203	41	0.60	0.076	0.010	120.7	63.8	(1 cm)
			-2.0	-219	25						
			-3.0	HH	HH						
			-4.0	-230	14						
			-5.0	HH	HH						
			-6.0	-252	-8						
			-7.0	HH	HH						
			-8.0	-270	-26						
			-9.0	HH	HH						
			-10.0	-301	-57						

SEDIMENT OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY:

TABLE B-4.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
CORE DATA: Dissolved nutrient and oxygen concentrations in Upper Bay sediment-water flux chambers

FILENAME : **UPCDJL98**
REVISED : 19981130

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg l^{-1})	AA VIAL NO	NH_4^+ (μM)	NO_2^- (μM)	$NO_2^-+NO_3^-$ (μM)	DIP (μM)
UB01	19980727	1	10	25	0	0	5.75	2	9.7	1.93	65.00	0.66
			11	25	60	60	4.46	3	12.6	1.93	64.20	0.96
			12	25	60	120	3.52	4	14.8	1.85	63.90	1.13
			13	25	60	180	2.85	5	16.8	1.73	64.00	1.21
UB02	19980727	1	11	0	0	0	5.03	7	15.4	3.62	64.60	1.44
			12	0	60	60	3.79	8	16.8	3.51	64.30	1.84
			13	0	60	120	2.90	9	20.5	3.39	64.30	2.27
			14	0	60	180	2.15	10	23.4	3.34	62.70	2.12
DC01	19980727	1	11	50	0	0	5.76	12	11.80	3.47	60.70	1.01
			12	50	60	60	4.99	13	13.10	3.65	60.70	1.28
			13	50	60	120	4.45	14	15.70	3.69	60.10	1.05
			14	50	60	180	3.96	15	15.00	3.99	60.00	1.03
UB03	19980727	1	13	45	0	0	4.94	27	8.1	5.15	78.10	1.16
			15	45	120	120	4.26	28	8.6	4.88	77.60	1.36
			16	45	60	180	3.72	29	10.5	4.73	77.60	1.52
			17	45	60	240	3.20	30	12.0	4.48	76.00	1.45
UB04	19980727	1	13	55	0	0	5.21	22	7.30	4.68	69.80	1.18
			15	55	120	120	3.44	23	13.20	4.34	69.90	1.19
			16	55	60	180	2.79	24	15.90	4.23	69.40	1.18
			17	55	60	240	2.12	25	16.90	4.07	69.20	1.05
DC02	19980727	1	12	55	0	0	5.39	17	7.1	4.80	68.00	0.91
			13	55	60	60	4.99	18	8.5	4.76	68.20	0.93
			14	55	60	120	4.63	19	9.2	4.74	68.60	1.07
			15	55	60	180	4.31	20	7.9	4.71	68.60	0.91
UB05	19980727	1	15	25	0	0	3.68	32	13.40	2.09	40.10	1.05
			16	28	63	63	3.38	33	14.80	2.04	40.00	0.82
			17	25	57	120	3.15	34	15.40	1.98	40.70	1.04
			18	25	60	180	2.96	35	15.00	1.98	40.80	0.97
DC03	19980727	1	16	20	0	0	3.77	37	12.0	2.22	43.60	1.06
			17	20	60	60	3.72	38	12.1	2.17	42.80	0.79
			18	20	60	120	3.27	39	11.1	2.05	43.40	0.79
			19	20	60	180	2.98	40	12.3	1.95	44.40	0.95
UB06	19980728	1	9	40	0	0	6.58	47	9.00	0.62	40.70	1.05
			10	40	60	60	6.09	48	9.40	0.62	41.00	1.08
			11	40	60	120	5.73	49	12.10	0.61	40.80	1.10
			12	40	60	180	5.38	50	10.40	0.59	40.90	1.13

TABLE B-4.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
CORE DATA: Dissolved nutrient and oxygen concentrations in Upper Bay sediment-water flux chambers

FILENAME : **UPCDJL98**
REVISED : 19981130

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg l^{-1})	AA VIAL NO	NH_4^+ (µM)	NO_2^- (µM)	$NO_2^-+NO_3^-$ (µM)	DIP (µM)
PLIS	19980728	1	10	30	0	0	6.85	52	10.2	1.02	42.30	1.15
			11	30	60	60	5.65	53	12.6	1.01	42.70	1.55
			12	30	60	120	4.74	54	15.5	0.98	42.10	1.53
			13	30	60	180	4.04	55	18.5	0.99	42.40	1.68
UB07	19980720	1	11	15	0	0	5.18	57	13.50	2.21	43.80	1.09
			12	15	60	60	3.60	58	20.00	2.27	43.30	1.52
			13	15	60	120	2.65	59	24.00	2.34	42.30	1.97
			14	15	60	180	1.53	60	26.70	2.41	42.10	2.15
NACL	19980728	1	12	10	0	0	1.27	62	24.7	1.05	13.80	0.68
			13	10	60	60	1.10	63	20.3	0.97	13.80	0.85
			14	10	60	120	0.97	64	22.1	1.23	13.10	0.67
			15	10	60	180	0.85	65	24.2	1.25	12.80	0.75
UB08	19980728	1	8	55	0	0	6.90	42	4.9	0.74	26.30	0.48
			9	55	60	60	5.98	43	6.8	0.51	24.80	0.54
			10	55	60	120	5.22	44	10.6	0.56	25.00	0.70
			11	55	60	180	4.62	45	11.2	0.51	25.60	0.82
UB09	19980728	1	13	5	0	0	6.05	67	9.4	1.03	28.00	0.54
			14	5	60	60	4.55	68	13.0	0.94	28.30	1.06
			15	5	60	120	3.57	69	17.3	0.93	27.80	1.06
			16	5	60	180	2.87	70	20.6	0.94	28.10	1.33
UB10	19980728	1	15	35	0	0	6.03	77	5.0	0.81	24.00	0.90
			16	35	60	60	5.29	78	5.6	0.76	22.90	0.43
			17	35	60	120	4.49	79	8.7	0.81	22.80	0.71
			18	35	60	180	3.74	80	7.6	0.70	22.80	0.93
DC04	19980728	1	14	55	0	0	0.45	72	23.8	0.61	2.41	0.95
			15	55	60	60	0.35	73	24.7	0.60	3.80	1.34
			16	55	60	120	0.28	74	27.6	0.56	1.99	0.92
			17	55	60	180	0.21	75	30.8	0.67	2.13	0.95
UB11	19980728	1	16	25	0	0	6.04	82	5.6	0.74	21.00	0.28
			17	25	60	60	5.33	83	6.6	0.72	21.00	0.45
			18	25	60	120	4.67	84	7.7	0.72	20.80	0.62
			19	25	60	180	4.04	85	9.4	0.70	20.50	0.67
FMCL	19980730	1	10	50	0	0	C	C	C	C	C	C
			11	50	60	60	C	C	C	C	C	C
			12	50	60	120	C	C	C	C	C	C
			13	50	60	180	C	C	C	C	C	C

TABLE B-4.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
CORE DATA: Dissolved nutrient and oxygen concentrations in Upper Bay sediment-water flux chambers

FILENAME : **UPCDJL98**
REVISED : 19981130

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg l^{-1})	AA VIAL NO	NH_4^+ (µM)	NO_2^- (µM)	NO_2^-+NO_3^- (µM)	DIP (µM)
FFOF	19980730	1	10	50	0	0	7.02	137	36.6	1.48	19.00	0.39
			11	50	60	60	6.05	138	40.9	1.51	18.40	0.57
			12	50	60	120	5.37	139	44.7	1.52	17.90	0.62
			13	50	60	180	4.71	140	48.7	1.58	17.70	0.63
BWCL	19980730	1	12	55	0	0	0.52	146	34.00	0.17	0.22	2.01
			13	55	60	60	0.38	147	35.00	0.09	0.79	1.70
			14	55	60	120	0.29	148	39.20	0.16	0.25	1.59
			15	55	60	180	0.21	149	38.60	0.11	0.87	1.74
BWSL	19980730	1	12	30	0	0	3.64	142	20.00	1.10	15.90	0.22
			13	30	60	60	2.79	143	21.60	1.16	15.40	0.28
			14	30	60	120	2.20	144	22.40	1.07	15.30	0.35
			15	30	60	180	1.69	145	24.60	1.07	0.39	1.57
BECL	19980728	1	17	30	0	0	0.35	87	28.60	0.43	1.17	1.39
			18	30	60	60	0.21	88	38.80	0.57	1.66	1.60
			19	30	60	120	0.12	89	31.30	0.35	0.97	1.28
			20	30	60	180	0.06	90	29.50	0.27	1.01	1.29
BESL	19980729	1	14	30	0	0	6.37	122	4.3	0.51	13.30	0.20
			15	30	60	60	5.50	123	5.8	0.52	13.40	0.29
			16	30	60	120	4.73	124	6.5	0.52	13.80	0.39
			17	30	60	180	4.03	125	7.6	0.54	13.50	0.73
DC06	19980729	1	12	50	0	0	0.49	117	36.1	1.02	3.14	1.43
			13	50	60	60	0.33	118	34.5	0.56	1.91	1.09
			14	50	60	120	0.19	119	38.5	0.95	2.18	1.12
			15	50	60	180	0.10	120	43.8	0.51	1.67	1.02
UB12	19980729	1	12	5	0	0	6.37	112	6.6	0.54	9.34	0.32
			13	5	60	60	5.56	113	6.2	0.42	8.83	0.18
			14	5	60	120	4.86	114	7.8	0.43	8.47	0.36
			15	5	60	180	4.22	115	8.1	0.46	9.46	0.46
UB13	19980729	1	11	35	0	0	5.52	107	7.4	0.36	9.56	0.30
			12	35	60	60	4.88	108	10.3	0.41	9.39	0.72
			13	35	60	120	4.30	109	13.3	0.47	9.15	1.08
			14	35	60	180	3.85	110	25.4	0.48	9.31	1.54
DC07	19980729	1	9	40	0	0	0.40	97	27.5	0.44	2.95	1.57
			10	40	60	60	0.28	98	30.7	0.42	2.96	1.89
			11	40	60	120	0.16	99	34.1	0.43	2.33	1.98
			12	40	60	180	0.07	100	39.1	0.50	1.97	2.22

TABLE B-4.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
CORE DATA: Dissolved nutrient and oxygen concentrations in Upper Bay sediment-water flux chambers

FILENAME : **UPCDJL98**
REVISED : 19981130

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg l^{-1})	AA VIAL NO	NH_4^+ (μM)	NO_2^- (μM)	NO_2^-+NO_3^- (μM)	DIP (μM)
UB14	19980729	1	8	20	0	0	3.64	92	15.3	0.46	8.62	0.37
			9	20	60	60	3.21	93	20.5	0.47	8.42	0.63
			10	20	60	120	2.91	94	20.5	0.51	8.31	0.78
			11	20	60	180	2.63	95	21.7	0.56	8.09	0.90
CHCL	19980729	1	16	35	0	0	0.80	127	27.6	0.47	3.76	1.96
			17	35	60	60	0.51	128	35.2	0.60	3.13	2.66
			18	35	60	120	0.28	129	40.0	0.43	2.63	3.15
			19	35	60	180	0.14	130	44.7	0.42	2.39	3.37
CHSL	19980730	1	8	0	0	0	3.34	132	13.80	0.64	5.83	0.46
			9	0	60	60	2.69	133	15.20	0.50	6.45	0.77
			10	0	60	120	2.19	134	15.90	0.42	5.63	0.43
			11	0	60	180	1.77	135	18.60	0.44	5.29	0.39
UB15	19980729	1	10	25	0	0	2.26	102	21.50	0.28	3.96	1.26
			11	25	60	60	1.77	103	27.30	0.30	3.74	1.56
			12	25	60	120	1.48	104	32.80	0.30	3.44	2.08
			13	25	60	180	1.27	105	38.70	0.41	3.37	2.36
104-DR	19980730	1	14	35	0	0	0.06	151	28.1	0.10	0.14	3.20
			15	35	60	60	0.03	152	27.5	0.08	0.55	3.49
			16	35	60	120	0.03	153	31.0	0.08	0.13	3.85
			17	35	60	180	0.03	154	30.4	0.07	0.47	4.13
104-D2	19980730	1	15	10	0	0	0.03	156	44.3	0.44	0.29	5.30
			16	10	60	60	0.03	157	46.0	0.10	0.14	5.59
			17	10	60	120	0.03	158	52.9	0.14	0.11	6.05
			18	10	60	180	0.03	159	52.8	0.12	0.46	6.84
UB16	19980803	1	8	10	0	0	0.09	161	30.30	0.21	0.08	3.19
			9	10	60	60	0.06	162	29.80	0.08	0.83	3.64
			10	10	60	120	0.05	163	31.30	0.10	0.21	4.14
			11	10	60	180	0.05	164	33.70	0.11	0.16	4.45
UB17	19980803	1	9	0	0	0	0.95	166	15.60	0.15	0.96	1.04
			10	0	60	60	0.72	167	20.40	0.19	0.83	0.92
			11	0	60	120	0.52	168	18.70	0.25	1.22	0.92
			12	0	60	180	0.36	169	20.40	0.17	0.88	0.95

SEDIMENT OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY:

Page No.

TABLE B-5.1. MARYLAND ENVIRONMENTAL SERVICE

SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY

SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [$gO_2/(m^2.day)$] and nutrients [mMN, P, Si and S/(m^2.hr)]

FILENAME : **UPFXJL98**
REVISED : 19981130

			---- CORE ----		----	DO	----	----	NH4	----
			H2O				FLUX			FLUX
STATION	DATE	NO	VOL	DEPTH	SLOPE	FLUX	MEAN	SLOPE	FLUX	MEAN
			(ml)	(m)	[mg/(l.min)]	[$gO_2/(m^2.day)$]		(μMN/min)	[μMN/(m2.hr)]	
UB01	19980727	1	1840	0.132	-0.016067	-3.06	-3.06	0.039167	311.1	311.1
UB02	19980727	1	2090	0.150	-0.015883	-3.44	-3.44	0.046167	416.5	416.5
DC01	19980727	1	1470	0.106	-0.009900	-1.51	-1.51	0.017500	111.0	111.0
UB03	19980727	1	1860	0.134	-0.009600	-1.85	-1.85	0.022667	182.0	182.0
UB04	19980727	1	1890	0.136	-0.012914	-2.53	-2.53	0.041476	338.4	338.4
DC02	19980727	1	1750	0.126	-0.006000	-1.09	-1.09	NI	NI	NI
UB05	19980727	1	2190	0.158	-0.003983	-0.90	-0.90	0.016667	157.6	157.6
DC03	19980727	1	2110	0.152	-0.004700	-1.03	-1.03	0.001667	15.2	15.2
UB06	19980728	1	1860	0.134	-0.006600	-1.27	-1.27	0.007857	63.1	63.1
PLIS	19980728	1	1720	0.124	-0.015567	-2.77	-2.77	0.046333	344.0	344.0
UB07	19980728	1	2160	0.155	-0.019833	-4.44	-4.44	0.072667	677.5	677.5
NACL	19980728	1	1720	0.124	-0.002317	-0.41	-0.41	NI	NI	NI
UB08	19980728	1	1616	0.116	-0.012667	-2.12	-2.12	0.037833	263.9	263.9
UB09	19980728	1	2180	0.157	-0.017533	-3.96	-3.96	0.063167	594.4	594.4
UB10	19980728	1	2150	0.155	-0.012783	-2.85	-2.85	0.014762	137.0	137.0
DC04	19980728	1	2060	0.148	-0.001317	-0.28	-0.28	0.039833	354.2	354.2
UB11	19980728	1	1970	0.142	-0.011100	-2.27	-2.27	0.020833	177.2	177.2
FMCL	19980730	1	C	C	C	C	C	C	C	C
FFOF	19980730	1	2240	0.161	-0.012683	-2.94	-2.94	0.066833	646.2	646.2
BWCL	19980730	1	2250	0.162	-0.001700	-0.40	-0.40	0.043000	417.6	417.6
BWSL	19980730	1	2200	0.158	-0.010733	-2.45	-2.45	0.024333	231.1	231.1
BECL	19980728	1	1750	0.126	-0.001600	-0.29	-0.29	NI	NI	NI
BESL	19980729	1	1920	0.138	-0.012983	-2.58	-2.58	0.017667	146.4	146.4
DC06	19980729	1	2220	0.160	-0.002183	-0.50	-0.50	0.045167	432.8	432.8
UB12	19980729	1	2200	0.158	-0.011917	-2.72	-2.72	0.008571	81.4	81.4
UB13	19980729	1	1680	0.121	-0.009317	-1.62	-1.62	0.049167	356.5	356.5
DC07	19980729	1	1840	0.132	-0.001850	-0.35	-0.35	0.063667	505.7	505.7
UB14	19980729	1	2320	0.167	-0.005550	-1.33	-1.33	0.036667	367.2	367.2
CHCL	19980729	1	1800	0.129	-0.003683	-0.69	-0.69	0.093500	726.5	726.5
CHSL	19980730	1	1660	0.119	-0.008683	-1.49	-1.49	0.025167	180.3	180.3
UB15	19980729	1	2040	0.147	-0.005433	-1.15	-1.15	0.095167	838.0	838.0
104-DR	19980730	1	2140	0.154	0.000000	0.00	0.00	NI	NI	NI
104-D2	19980730	1	1640	0.118	0.000000	0.00	0.00	0.054000	382.3	382.3
UB16	19980803	1	2380	0.171	0.000000	0.00	0.00	0.032500	333.9	333.9
UB17	19980803	1	2150	0.155	-0.003283	-0.73	-0.73	0.026548	246.4	246.4

TABLE B-5.1. MARYLAND ENVIRONMENTAL SERVICE
SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY
SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [$gO_2/(m^2.day)$] and nutrients [mMN, P, Si and S/(m^2.hr)]

FILENAME : **UPFXJL98**
REVISED : 19981130 Part 2 of 3

STATION	DATE	NO	---- CORE ---- H2O VOL (ml)	DEPTH (m)	---- NO2 ---- SLOPE [μMN/(l.min)]	FLUX [μMN/(m^2.hr)]	FLUX MEAN	---- NO23 ---- SLOPE [μMN/(l.min)]	FLUX [μMN/(m^2.hr)]	FLUX MEAN
UB01	19980727	1	1840	0.132	-0.001133	-9.00	-9.00	-0.005500	-43.68	-43.68
UB02	19980727	1	2090	0.150	-0.001600	-14.43	-14.43	-0.010952	-98.80	-98.80
DC01	19980727	1	1470	0.106	0.002881	18.28	18.28	-0.004500	-28.55	-28.55
UB03	19980727	1	1860	0.134	-0.003600	-28.90	-28.90	-0.011905	-95.58	-95.58
UB04	19980727	1	1890	0.136	-0.002514	-20.51	-20.51	-0.002436	-19.87	-19.87
DC02	19980727	1	1750	0.126	-0.000483	-3.65	-3.65	0.003667	27.70	27.70
UB05	19980727	1	2190	0.158	-0.000917	-8.67	-8.67	0.004667	44.12	44.12
DC03	19980727	1	2110	0.152	-0.001550	-14.12	-14.12	0.013333	121.44	121.44
UB06	19980728	1	1860	0.134	-0.000167	-1.34	-1.34	0.001071	8.60	8.60
PLIS	19980728	1	1720	0.124	-0.000167	-1.24	-1.24	0.000000	0.00	0.00
UB07	19980728	1	2160	0.155	0.001117	10.41	10.41	-0.010167	-94.79	-94.79
NACL	19980728	1	1720	0.124	0.001167	8.66	8.66	-0.006167	-45.79	-45.79
UB08	19980728	1	1616	0.116	-0.001310	-9.14	-9.14	NI	NI	NI
UB09	19980728	1	2180	0.157	0.000000	0.00	0.00	0.000000	0.00	0.00
UB10	19980728	1	2150	0.155	-0.000595	-5.52	-5.52	0.000000	0.00	0.00
DC04	19980728	1	2060	0.148	NI	NI	NI	0.000000	0.00	0.00
UB11	19980728	1	1970	0.142	-0.000200	-1.70	-1.70	-0.002833	-24.09	-24.09
FMCL	19980730	1	C	C	C	C	C	C	C	C
FFOF	19980730	1	2240	0.161	0.000560	5.41	5.41	-0.007333	-70.90	-70.90
BWCL	19980730	1	2250	0.162	0.000000	0.00	0.00	NI	NI	NI
BWSL	19980730	1	2200	0.158	0.000000	0.00	0.00	0.000000	0.00	0.00
BECL	19980728	1	1750	0.126	-0.000857	-6.47	-6.47	0.000000	0.00	0.00
BESL	19980729	1	1920	0.138	0.000150	1.24	1.24	0.001071	8.88	8.88
DC06	19980729	1	2220	0.160	NI	NI	NI	-0.006900	-66.12	-66.12
UB12	19980729	1	2200	0.158	0.000000	0.00	0.00	NI	NI	NI
UB13	19980729	1	1680	0.121	0.000700	5.08	5.08	0.000000	0.00	0.00
DC07	19980729	1	1840	0.132	0.000000	0.00	0.00	-0.005950	-47.26	-47.26
UB14	19980729	1	2320	0.167	0.000567	5.68	5.68	-0.002833	-28.37	-28.37
CHCL	19980729	1	1800	0.129	-0.000286	-2.22	-2.22	-0.007683	-59.70	-59.70
CHSL	19980730	1	1660	0.119	-0.001833	-13.13	-13.13	-0.002810	-20.13	-20.13
UB15	19980729	1	2040	0.147	0.000750	6.60	6.60	-0.003450	-30.38	-30.38
104-DR	19980730	1	2140	0.154	-0.001500	-13.86	-13.86	0.000000	0.00	0.00
104-D2	19980730	1	1640	0.118	0.000000	0.00	0.00	0.000000	0.00	0.00
UB16	19980803	1	2380	0.171	0.000000	0.00	0.00	0.000000	0.00	0.00
UB17	19980803	1	2150	0.155	0.000000	0.00	0.00	0.000000	0.00	0.00

TABLE B-5.1. MARYLAND ENVIRONMENTAL SERVICE

SEDIMENT-WATER OXYGEN AND NUTRIENT EXCHANGES IN UPPER CHESAPEAKE BAY

SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [$gO_2/(m^2.day)$] and nutrients [mMN, P, Si and S/(m^2.hr)]

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		---- CORE ----			---- DIP		----
			H2O				FLUX
STATION	DATE	NO	VOL	DEPTH	SLOPE	FLUX	MEAN
			(ml)	(m)	[µP/(l.min)]	[µMP/(m².hr)]	
UB01	19980727	1	1840	0.132	0.003033	24.09	24.09
UB02	19980727	1	2090	0.150	0.006917	62.40	62.40
DC01	19980727	1	1470	0.106	0.000000	0.00	0.00
UB03	19980727	1	1860	0.134	0.003000	24.09	24.09
UB04	19980727	1	1890	0.136	0.000000	0.00	0.00
DC02	19980727	1	1750	0.126	0.000000	0.00	0.00
UB05	19980727	1	2190	0.158	NI	NI	NI
DC03	19980727	1	2110	0.152	NI	NI	NI
UB06	19980728	1	1860	0.134	0.000433	3.48	3.48
PLIS	19980728	1	1720	0.124	0.002617	19.43	19.43
UB07	19980728	1	2160	0.155	0.006050	56.41	56.41
NACL	19980728	1	1720	0.124	NI	NI	NI
UB08	19980728	1	1616	0.116	0.001967	13.72	13.72
UB09	19980728	1	2180	0.157	0.004381	41.23	41.23
UB10	19980728	1	2150	0.155	NI	NI	NI
DC04	19980728	1	2060	0.148	0.000000	0.00	0.00
UB11	19980728	1	1970	0.142	0.002233	18.99	18.99
FMCL	19980730	1	C	C	C	C	C
FFOF	19980730	1	2240	0.161	0.001283	12.41	12.41
BWCL	19980730	1	2250	0.162	NI	NI	NI
BWSL	19980730	1	2200	0.158	0.001083	10.28	10.28
BECL	19980728	1	1750	0.126	NI	NI	NI
BESL	19980729	1	1920	0.138	0.002817	23.35	23.35
DC06	19980729	1	2220	0.160	-0.002000	-19.17	-19.17
UB12	19980729	1	2200	0.158	0.002333	22.16	22.16
UB13	19980729	1	1680	0.121	0.006800	49.31	49.31
DC07	19980729	1	1840	0.132	0.003400	27.00	27.00
UB14	19980729	1	2320	0.167	0.002900	29.04	29.04
CHCL	19980729	1	1800	0.129	0.007867	61.12	61.12
CHSL	19980730	1	1660	0.119	-0.000369	-2.64	-2.64
UB15	19980729	1	2040	0.147	0.006367	56.07	56.07
104-DR	19980730	1	2140	0.154	0.005250	48.50	48.50
104-D2	19980730	1	1640	0.118	0.008467	59.94	59.94
UB16	19980803	1	2380	0.171	0.007133	73.28	73.28
UB17	19980803	1	2150	0.155	NI	NI	NI