



Narragansett Bay

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Spatial and Temporal Patterns in Water Quality Conditions in Narragansett Bay's Coves and Embayments in 2008

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Executive Summary

DATAFLOW is a boat-mounted, flow-through water quality monitoring tool. It allows researchers to cover large areas of estuarine open water at high speeds while continuously collecting spatially referenced surface water quality data. In Narragansett Bay RI, this tool could serve as an excellent complement to ongoing water quality monitoring efforts by providing data and maps for the many shallow coves and embayments in the Bay. Although these areas can be prone to water quality issues, they are generally monitored less frequently than deeper, open water areas of the Bay. In 2008, researchers from the Narragansett Bay National Estuarine Research Reserve used DATAFLOW to survey and map summer/fall water quality conditions in the Bay's West Passage, Greenwich Bay, Greenwich Cove, and Wickford Harbor sections. These data show that water quality conditions throughout most of the study area were generally typical of conditions in Narragansett Bay during this time of year. However, these cruises also detected a few discrete areas of high chlorophyll a levels; in one particular case, very high levels over 200 ug l^{-1} were documented directly adjacent to the East Greenwich Wastewater Treatment Facility in Greenwich Cove. These data do not demonstrate cause and effect, but they do suggest that further DATAFLOW monitoring of the Cove should be considered, as should the establishment of a fixed-site water quality monitoring station near the Facility. DATAFLOW has proven to be an excellent tool for documenting the degree and spatial extent of problematic water quality conditions in the shallow areas of Narragansett Bay. Funding should be identified to support using DATAFLOW to survey targeted coves and embayments on a rotational basis to more comprehensively monitor water quality conditions throughout Narragansett Bay.

Introduction

Water quality conditions in Narragansett Bay, RI are monitored annually by a suite of complementary programs that are components of a larger umbrella program known as the Narragansett Bay Window (Sherman 2006). This is a collaborative monitoring program among partners such as the Rhode Island Department of Environmental Management, the National Oceanic and Atmospheric Administration (NOAA), the Narragansett Bay National Estuarine Research Reserve (NBNERR), the Narragansett Bay Commission, the University of Rhode Island, Roger Williams University and Brown University. The primary water quality components of the Bay Window program are a network of fixed-site monitoring stations and the mobile Mariner Shuttle surveys. The fixed-site monitoring program is a collaborative effort among multiple university and government agencies to establish a spatially comprehensive network of water quality monitoring stations throughout Narragansett Bay (Deacutis and Kiernan 2006). These stations are equipped with multi-probe Yellow Spring Instruments (YSI) water quality dataloggers affixed to either surface buoys (open-water stations), or PVC tubes or similar housings (shore-based stations). The Mariner Shuttle program uses a ship-towed shuttle that is equipped with water quality sensors and has the ability to undulate between surface and bottom waters (Berman et al. 2006). The shuttle follows an established transect around the primary passages of Narragansett Bay on a monthly basis. The fixed-station monitoring program is temporally robust, but spatially limited; the Mariner Shuttle program is less robust temporally, but more so spatially. Although a third component of Bay Window, the Insomniac program (Deacutis and Kiernan 2006), collects vertical water quality profiles at dozens of stations in upper Narragansett Bay 2-3 times per summer, there remains a need for a spatially robust water quality monitoring and mapping program in the numerous shallow coves and embayments in Narragansett Bay (Oviatt and Kiernan, personal communication).

A high spatial resolution water quality mapping effort has been ongoing in portions of Chesapeake Bay since at least 1992 (e.g., Smail et al. 2005). This program incorporates an innovative technology known as DATAFLOW. DATAFLOW is essentially a flow-through water quality monitoring system that can be mounted on a small boat and used to map surface water quality parameters at speeds of up to 20 knots or more. The system is equipped with a YSI 6000-series datalogger to measure water quality and a GPS to simultaneously measure spatial location for each data point. The Maryland Department of Natural Resources and others have been effectively monitoring and mapping tributaries of Chesapeake Bay using DATAFLOW technology as a powerful complementary component to other ongoing water quality programs, some of which are similar to components of the Bay Window program in Narragansett Bay.

The goal of this study was to use DATAFLOW to map water quality conditions in targeted portions of Narragansett Bay, RI. Specifically, the NBNERR used DATAFLOW on four dates in the summer and fall of 2008 to map conditions in portions of Narragansett Bay's West Passage, Greenwich Bay, Greenwich Cove, and Wickford Harbor. This work follows a successful pilot program by the NBNERR using DATAFLOW in Greenwich Bay in 2007. The target area was expanded in 2008 to begin

the process of using DATAFLOW to map water quality conditions in the shallow coves and embayments throughout Narragansett Bay. The hope is to develop a plan and secure funding for mapping selected coves on an annual rotating basis. Water quality is generally not monitored in most coves, even though these are often surrounded by extensive residential development and are therefore prone to low dissolved oxygen and other signs of impaired water quality due to increased nutrient loading levels. Thus, two of the targeted coves for DATAFLOW mapping, Greenwich Bay and Wickford Harbor, were included in this 2008 mapping effort.

Methods

The DATAFLOW unit used by the NBNERR in 2008 is essentially a flow-through monitoring tool used to collect water quality and spatial location data in real-time. The unit is mounted on the NBNERR R/V *Mercenaria*, and consists of an intake unit mounted to the transom of the boat, a series of intake and exhaust tubes, a set of two instruments for collecting and displaying data, a GPS, and a 12 volt marine power supply (Fig. 1). Surface water is brought up through the intake using a small in-line bilge pump, pumped past a pre-calibrated and programmed YSI 6600 V2 datalogger, and pumped back into the Bay. The datalogger records water quality conditions as the water moves past its sensors and at the same time a GPS unit (Garmin GPSmap 168 GPS) records latitude and longitude. Both data streams are simultaneously fed into a second hand-held YSI 650 meter where all data points are stored into a seamless file. Water is collected from the bottom of the intake, which sits approximately 0.5 m below the surface of the water and the system typically pumps water at a rate of approximately 24 l min⁻¹.

Four DATAFLOW cruises were undertaken in 2008 to survey and map water quality conditions in Greenwich Bay, Greenwich Cove, Wickford Harbor, and portions of the West Passage of Narragansett Bay. The cruises were conducted on 7/25, 8/12, 9/10, and 10/09/2008. All cruises were undertaken on the *Mercenaria*, which left from the floating dock at the base of T-wharf on Prudence Island, RI between approximately 0830 and 0900. For each cruise, the DATAFLOW flow-through system was installed and initiated prior to leaving the dock.

During each cruise, field teams tried to closely follow a pre-defined cruise track that was input into the boat's onboard GPS unit. In general, the boat traveled directly to Greenwich Bay, then followed a series of parallel transects back and forth throughout Greenwich Bay, including into Greenwich Cove. The boat then re-entered the West Passage, followed a broader-scale series of parallel transects until reaching the mouth of Allen Harbor, and finished by covering most of Wickford Harbor (Fig. 2). This approach was used to cover as much of the study area as possible during each cruise in order to facilitate the development of interpolated water quality maps based on individual data points (see below).

Data points were collected every 4 seconds during each cruise using the YSI 6600 V2 datalogger equipped with a ROX ® optical dissolved oxygen probe. Parameters collected include temperature, specific conductivity, salinity (which is calculated from specific

conductivity), dissolved oxygen (% saturation and concentration), pH, turbidity, chlorophyll fluorescence, and spatial location (i.e., latitude and longitude). The cruise also stopped at six pre-established calibration stations to calibrate the in-line YSI 6600 V2 datalogger with supplemental water quality data and to collect complementary data not captured with the datalogger. This includes data on secchi depths (using a 20 cm disc), light extinction coefficients (calculated from PAR data obtained with a handheld Li-Cor meter [model Li-1400]), and chlorophyll a. All three parameters were collected according to established NBNERR protocols (Appendix I).

After each cruise was completed, the boat returned to Prudence Island, and all equipment was off-loaded, taken to the NBNERR facility, and cleaned. All collected data were downloaded, edited, stored, and imported into GIS software in order to develop interpolated maps of selected water quality parameters. Each of these steps was done in accordance with established DATAFLOW protocols at the NBNERR (Appendix I).

Means and ranges of each parameter were calculated for each of the four cruises. This was augmented with additional descriptive data (e.g., cruise times, previous rainfall, tide heights, etc.) that were also compiled for each cruise. Data were further broken into four discrete areas (West Passage, Greenwich Bay, Greenwich Cove, and Wickford Harbor) by extracting data subsets in ArcView (version 3.2a) to make comparisons among different regions of the study area. Maps of selected conditions, parameters, and areas were developed using ArcView and Spatial Analyst (refer to Appendix I for details on how interpolated maps were created in Spatial Analyst). Additional analyses included making direct comparisons to similar DATAFLOW data from 2007, examining relationships between water quality and precipitation events, and assessing the value of the additional water quality data collected at the calibration stations.

Results and Discussion

Basic Data Summaries

On each cruise, data were collected from between 3488-3888 individual locations, for a total of 14540 locations where data were collected throughout the study area in 2008 (Table 1). Surface water temperatures averaged 21.6 °C across the study period and steadily declined from July through November (Table 1). Mean salinities generally ranged between 28-29 ppt, reflecting the polyhaline conditions of much of the study area (although lower values between 15 and 19 ppt were found on 7/25/2008 in portions of western Wickford Harbor). Dissolved oxygen saturations were generally high, with mean values per cruise ranging between approximately 80-110%, and mean dissolved oxygen concentrations ranged between 5.6-8.8 mg l⁻¹. Mean turbidity levels were quite low, although patches of highly turbid water (35-76 NTU) were documented. Finally, mean chlorophyll values per cruise ranged from 7.1-14.7 ug l⁻¹). However, higher concentrations over 38 ug l⁻¹ were detected in some areas, including one patch in Greenwich Cove that had concentrations over 200 ug l⁻¹. In comparison, chlorophyll data

collected in Greenwich Cove with DATAFLOW in 2007 had a maximum value of 78.2 ug l⁻¹ (6/7/2007). On the four other cruises in 2007, chlorophyll concentrations did not exceed 23.5 ug l⁻¹, indicating that the conditions seen on 8/12/2008 represented a short-term, localized phytoplankton bloom in Greenwich Cove.

Spatial Patterns

Spatial patterns emerged when considering mean values of water quality parameters among the four discrete sections of Narragansett Bay (i.e., the West Passage, Greenwich Bay, Greenwich Cove, and Wickford Harbor), and these patterns were probably related to the size, depth, and geomorphology of each water body. For example, the larger, deeper West Passage contained waters that were cooler; higher in salinity, pH, and dissolved oxygen levels; and lower in turbidity and chlorophyll levels than each of the other regions (Fig. 3). In direct contrast, the small and shallow Greenwich Cove contained waters that were the least saline; had the lowest pH and dissolved oxygen levels, and highest turbidity and chlorophyll concentrations; and were warmer than all but Wickford Harbor. Waters in Greenwich Bay and Wickford Harbor generally fell between these two extremes.

Using GIS, it was possible to examine spatial patterns for selected data on a finer scale. For example, chlorophyll a concentrations were relatively uniform throughout most of the study area on the 8/25/2008 cruise. However one small area in the middle of Greenwich Cove (adjacent to the Greenwich Cove Wastewater Treatment Facility) contained very high chlorophyll levels over 200 ug l⁻¹. These data are displayed by using Spatial Analyst to interpolate values among individual data points for a smooth display (Fig. 4), and by color-coding individual data points based on parameter values (Fig. 5). In each case, the greatly elevated chlorophyll values in the small area of Greenwich Cove on this particular data are clearly visible on each map.

Calibration Stations

Supplemental water quality data collected at calibration stations were useful for comparing and validating some of the data from the YSI 6600 V2 datalogger. For example, a significant negative relationship was seen between secchi depth and datalogger turbidity (simple least squares linear regression; n=24 [6 stations x 4 dates]; r²=0.35; p=0.012), and a significant positive relationship was observed between light extinction coefficients (K_d values from the Li-Cor meter) and datalogger turbidity (simple linear regression; r²=0.44; p=0.001). Further, a significant negative relationship was also found between secchi depth and K_d (simple linear regression; r²=0.26; p=0.035). The significant relationships between these three indicators of *in situ* light levels indicate that each can serve as a quality control check against the other two. A significant positive relationship was also seen between datalogger turbidity and chlorophyll concentrations at the 6 calibration stations (simple linear regression; r²=0.43; p=0.001). The r² value for this relationship suggests that approximately 43% of the

variability in turbidity is directly due to the amount of chlorophyll that is present in the water column. Comparisons between datalogger and grab sample chlorophyll concentrations at the calibration stations were not conducted since grab samples have not been processed yet.

Precipitation Effects

Prior rain events did not necessarily translate into phytoplankton blooms and high chlorophyll concentrations in the study area. For example, the July 25 cruise was preceded by 87 mm (3.5 inches) of rain in the three-day period prior to the cruise (Table 1). Although elevated chlorophyll levels were observed in portions of Greenwich Cove, these were still an order of magnitude lower than the concentrations seen in the Cove on the August 12 cruise, which was preceded by only 7.1 mm (0.3 inches) of rain during the previous three-day period. This is an admittedly small sample size, but it at least suggests that rain events that flush land-based, non-point source nutrients into Narragansett Bay cannot be used to definitively predict the magnitude and extent of chlorophyll concentrations in these areas of Narragansett Bay.

Conclusions and Monitoring Implications

DATAFLOW clearly has the capability to rapidly and effectively collect high-resolution water quality data from the surface waters of Narragansett Bay. These data can then be manipulated within GIS software to produce equally high-resolution maps of important water quality parameters. This technology is limited in that it can only collect data from the surface water (approximately 0.5 m depth). However, the ability to collect such a large amount of data over a relatively large spatial scale in a minimal amount of time makes DATAFLOW a valuable tool for monitoring and mapping water quality in Narragansett Bay. It should serve as an excellent complement to other efforts currently underway in the Bay, and it has many applications including hypoxia mapping, correlating turbidity with seagrass distribution, post-storm event mapping, and tracking chlorophyll blooms. In particular, DATAFLOW should be highly effective for mapping water quality in the numerous smaller coves and embayments found throughout Narragansett Bay, where shallow depths minimize the need for both surface and deep-water sampling, and where the effects of land-based practices on estuarine water quality can be acute. The initiation of a standardized and ongoing DATAFLOW monitoring effort would also be timely in light of expected changes to the Narragansett Bay ecosystem due to large-scale management projects including upgrades to wastewater treatment facilities and the completion of the combined sewer overflow project.

The specific uses of DATAFLOW in Narragansett Bay include:

- Surveying and mapping water quality conditions in shallow coves and embayments;
- Identifying areas where problem water quality conditions exist;

- Determining the spatial extent of any problem areas;
- Determining if target areas are conforming to established water quality standards;
- Surveying around existing fixed-site water quality monitoring stations to place data from these sites into a broader spatial perspective;
- Surveying simultaneously with the Mariner Shuttle to place data from its deep-water cruisetrack into a broader spatial perspective;
- Identifying areas where additional fixed-site monitoring stations (temporary or permanent) should be located; and
- Tracking changes in water quality at large spatial scales over time using multi-year repeated monitoring efforts.

References

Berman, M., E. Calderone, J. Jossi, C. Melrose, and C. Oviatt. 2006. Mariner shuttle: cutting edge technology circling the Bay. 41°N 13(1):12-13.

Deacutis, C., and S. Kiernan. 2006. Sensors monitor water quality in Narragansett Bay. 41°N 13(1):7-9.

Sherman., K. 2006. The Bay Window program: monitoring and assessing changing fisheries yields, ecology, and water quality in Narragansett Bay. 41°N 13(1):2-3.

Smail, P.W., W.R. Boynton, R.M. Stankelis, E.K.M. Bailey, M. Ceballos, and J. Cammarata. 2004. Spatially intensive shallow water quality monitoring of the Patuxent River. Pages 33-70 in W.R. Boynton and R.M. Stankelis (eds.), Maryland Chesapeake Bay Water Quality Monitoring Program Ecosystems Processes Component (EPC) Level One Report No. 21 Interpretive Report. University of Maryland Center of Environmental Science Technical Report Series No. TS-447-04-CBL.

Smail, P.W., W.R. Boynton, R.M. Stankelis, E.M. Bailey, H.L. Soulen, E. Buck, K. Johnson, and S. Stein. 2005. Spatially intensive shallow water quality monitoring of the Patuxent River. Pages 37-76 in R.M. Stankelis, P.W. Smail, and W.R. Boynton (eds.), Maryland Chesapeake Bay Water Quality Monitoring Program Ecosystems Processes Component (EPC) Level One Report No. 22 Interpretive Report. University of Maryland Center of Environmental Science Technical Report Series No. TS-492-05-CBL.

Table 1. Temporal variability in weather, water quality, tide, and other data among each of the 2008 DATAFLOW cruises. Time and height of observed low tide were taken from the NOAA PORTS Quonset Point monitoring station (<http://tidesandcurrents.noaa.gov/nbports/nbports.shtml?port=nb>). Weather parameters were taken from field calibration logs. Rain data were taken from the NBNERR weather station on Prudence Island. All water quality data were taken directly from the DATAFLOW datalogger output file.

	Cruise Date			
	07/25/2008	08/12/2008	09/10/2008	10/09/2008
Personnel	Raposa Durant Dapp	Stankelis Durant	Raposa Durant	Raposa Durant
Cruise start time	0809	1002	0849	0853
Cruise end time	1248	1506	1328	1325
Time of low tide	1012	1442	1400	1354
Low tide height (ft)	0.23	1.04	0.70	0.99
Sea conditions	Calm	Calm	Calm-choppy	Calm-choppy
Weather conditions	Partly sunny	Partly sunny- overcast	Sunny	Sunny- Overcast
Cloud cover (%)	40	Not recorded	0	90
Wind speed/direction (mph)	N/5-10	Not recorded	NW/10-15	Not recorded
Mean secchi depth (m)	1.7	1.69	1.64	2.21
Mean light extinction (Kd)	0.99	1.31	0.91	0.81
Rain previous 3 days (mm)	87.9	7.1	7.0	2.0
# wq data points collected	3488	3888	3796	3368
# calibration stations	6	6	6	6
Water temperature mean (C)	24.80	23.51	21.16	16.94
Water temperature range (C)	21.98-26.61	21.35-25.48	19.86-22.47	16.11-18.16
Salinity mean (ppt)	28.13	28.85	29.98	28.19
Salinity range (ppt)	15.67-31.80	21.34-31.54	25.58-31.80	23.07-29.94
pH mean	7.53	7.70	7.76	7.82
pH range	7.12-7.85	7.24-8.35	7.30-8.17	7.36-8.16
DO mean (mg/l)	5.66	6.60	6.75	8.83
DO range (mg/l)	2.25-7.70	2.46-10.28	3.21-9.48	6.18-11.86
DO mean (%)	80.16	91.62	90.48	108.19
DO range (%)	32.30-108.50	34.30-143.30	43.40-128.90	74.90-146.40
Turbidity mean (NTU)	1.53	2.70	3.08	1.53
Turbidity range (NTU)	0-75.90	0.30-34.50	0.20-46.20	0.40-8.20
Chlorophyll mean (ug/l)	8.06	14.67	7.06	10.87
Chlorophyll range (ug/l)	0.70-38.80	0.90-239.30	0.50-18.80	2.30-36.00

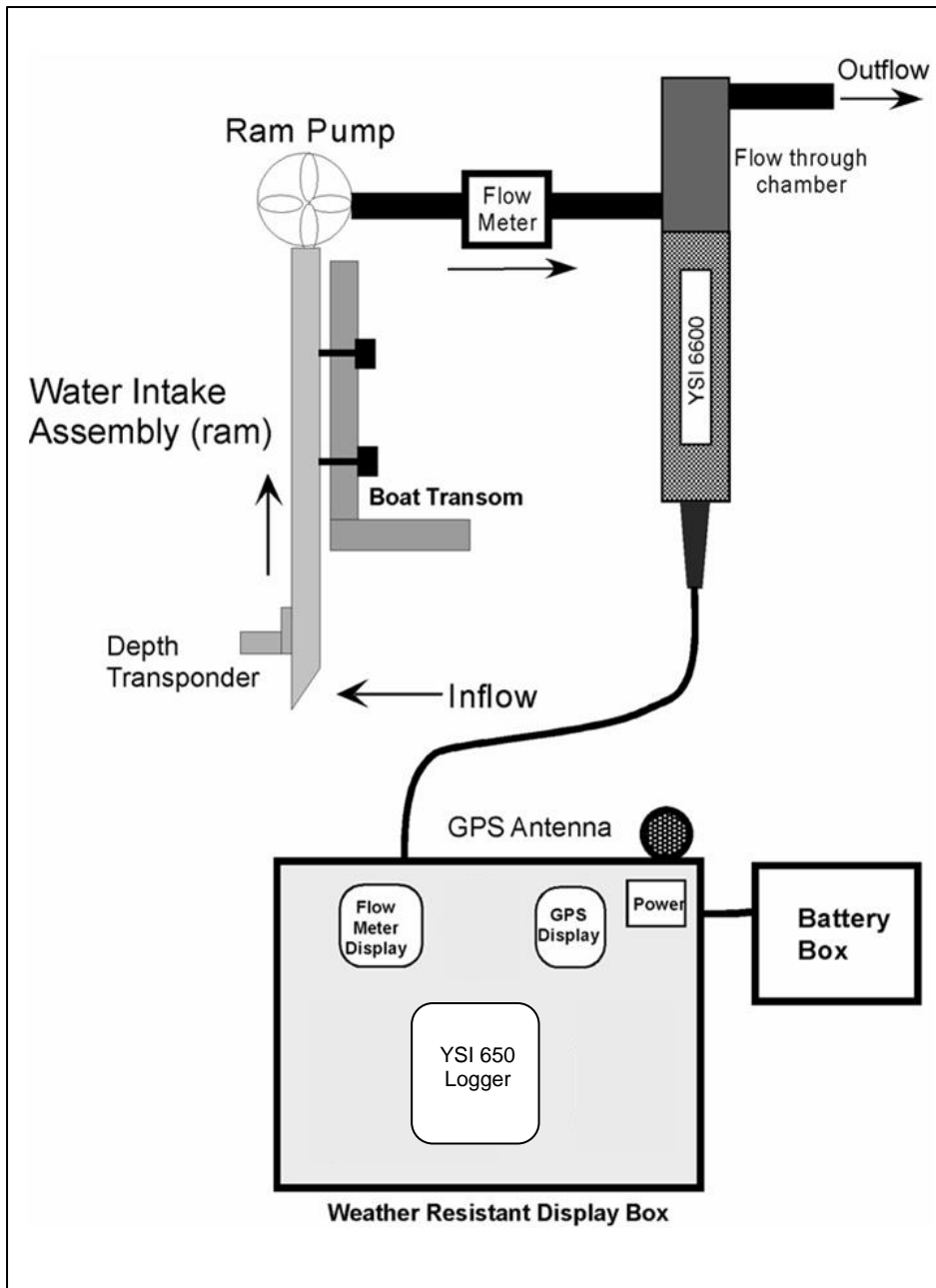


Figure 1. The DATAFLOW setup: Water is brought up through a ram unit mounted on the boat transom and then passed through a flow-through system that includes a YSI datalogger. Data are collected and stored with a series of instruments, which, along with the system's bilge pump, is powered by a marine battery. This schematic diagram of DATAFLOW version 5.5 is a modified reproduction from Smail et al. (2004).

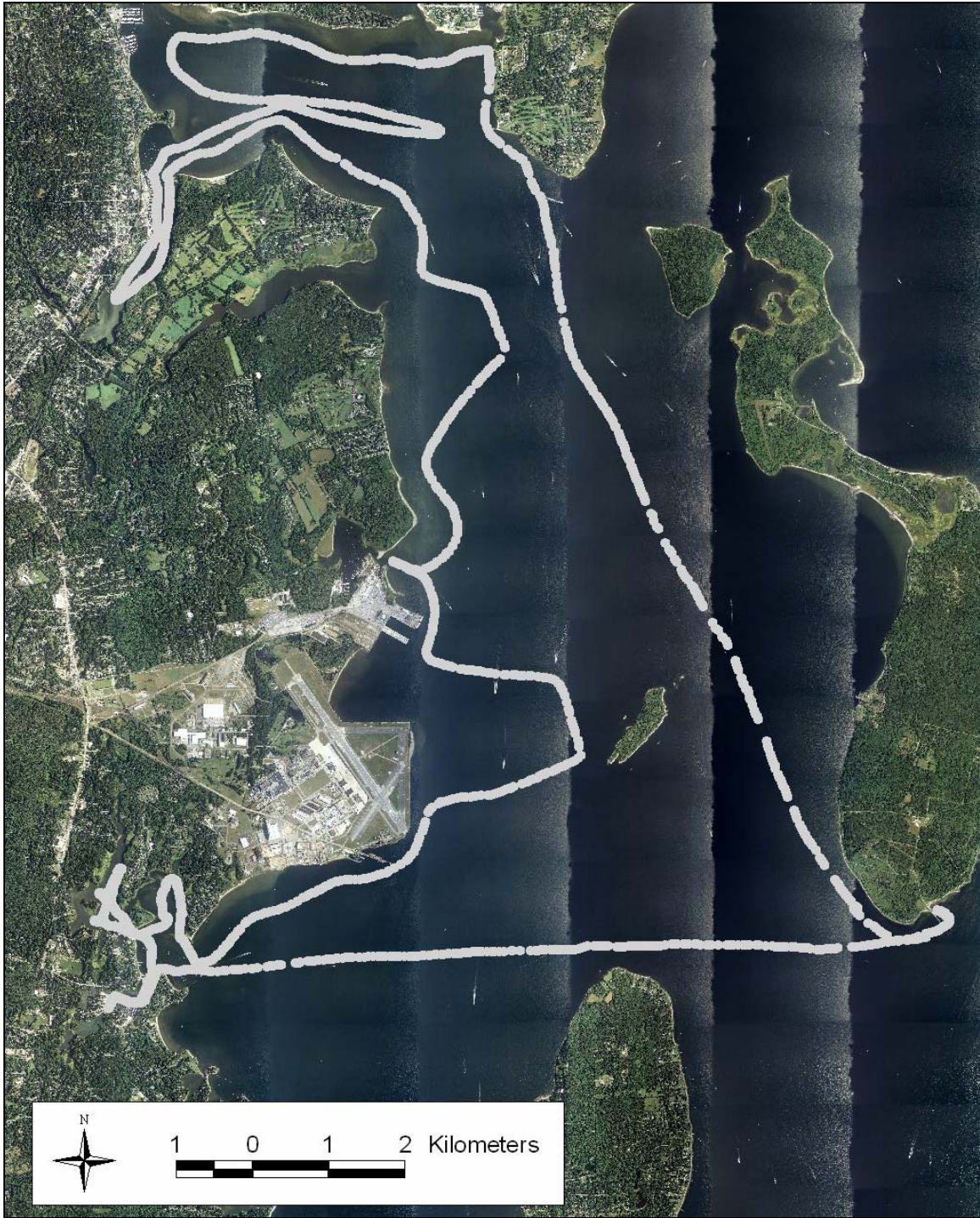


Figure 2. Representative DATAFLOW cruise track (7/25/2008) covering portions of Narragansett Bay's West Passage, Greenwich Bay, Greenwich Cove, and Wickford Harbor.

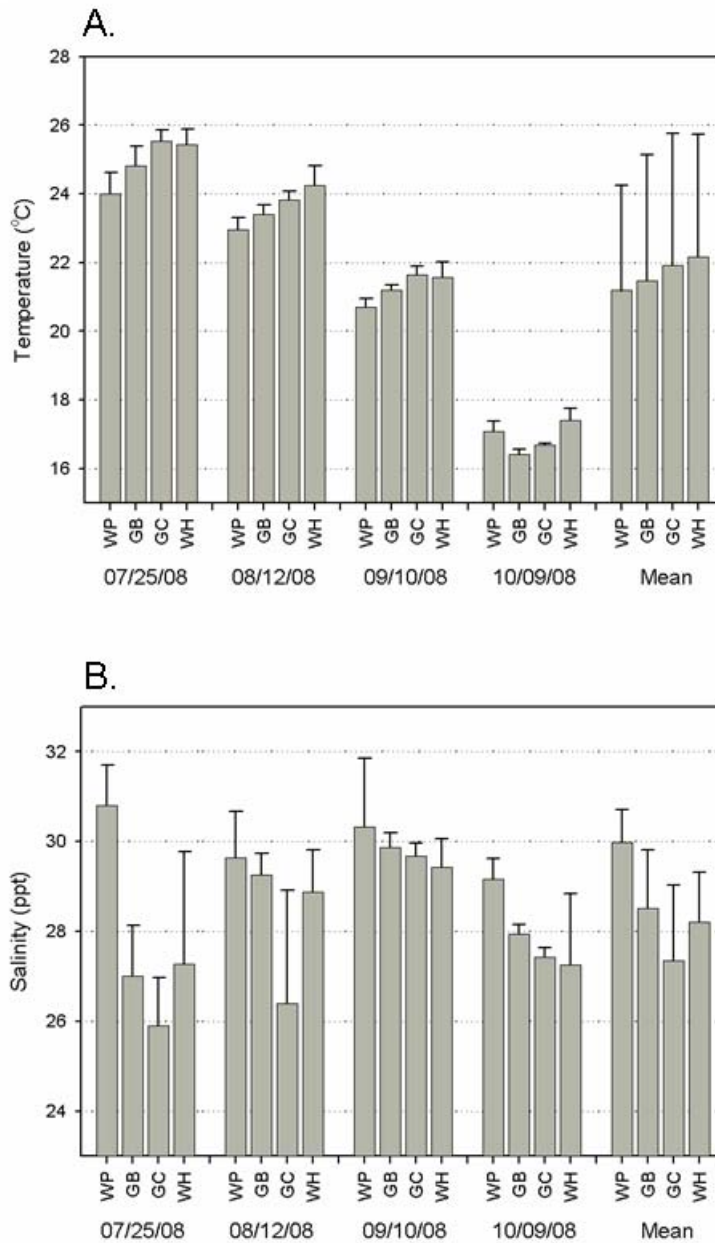


Figure 3. Water quality conditions (mean and standard error) in the West Passage (WP), Greenwich Bay (GB), Greenwich Cove (GC), and Wickford Harbor (WH) on each DATAFLOW cruise, and then averaged across all cruises. A) temperature, B) salinity.

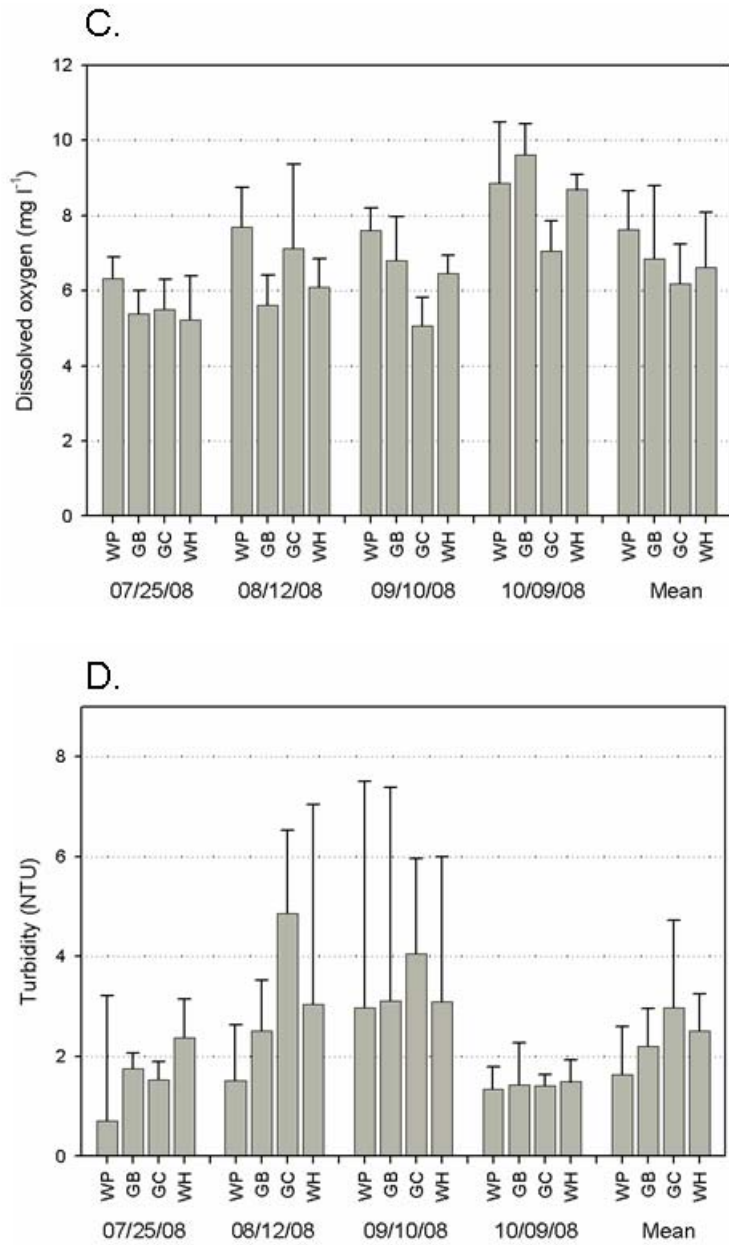


Figure 3, continued. C) dissolved oxygen concentration, D) turbidity.

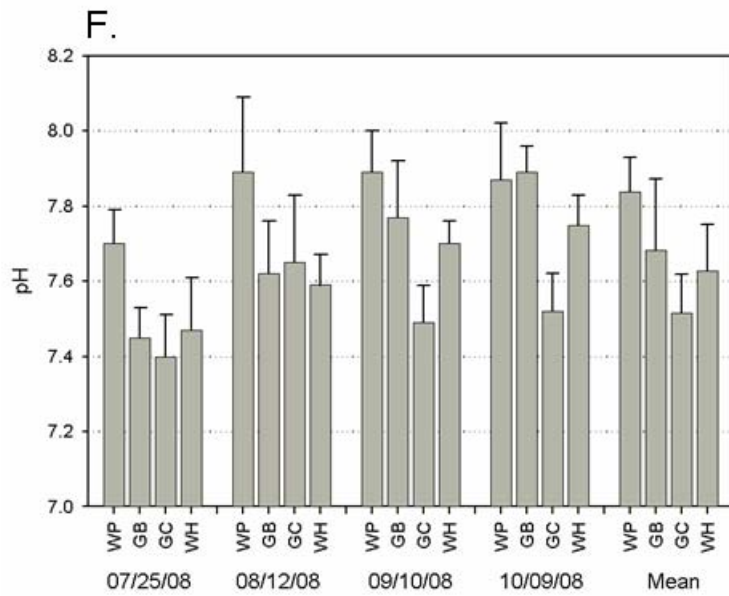
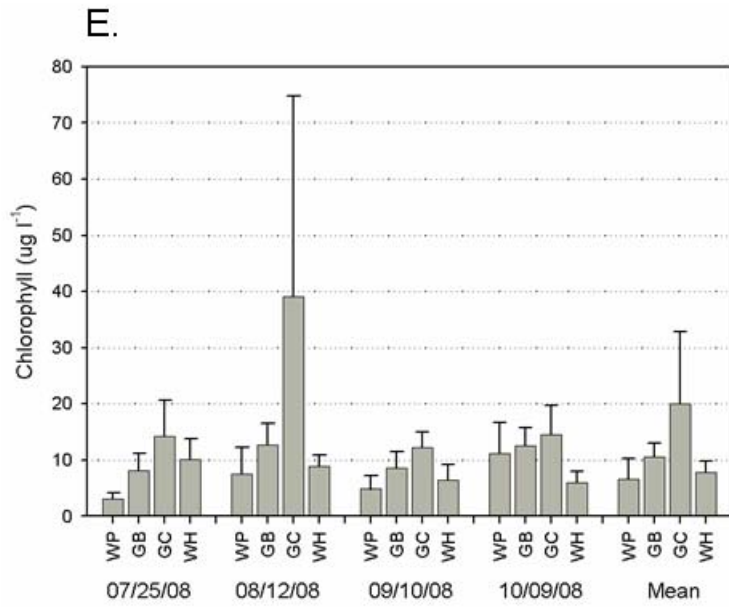


Figure 3, continued. E) chlorophyll, F) pH.

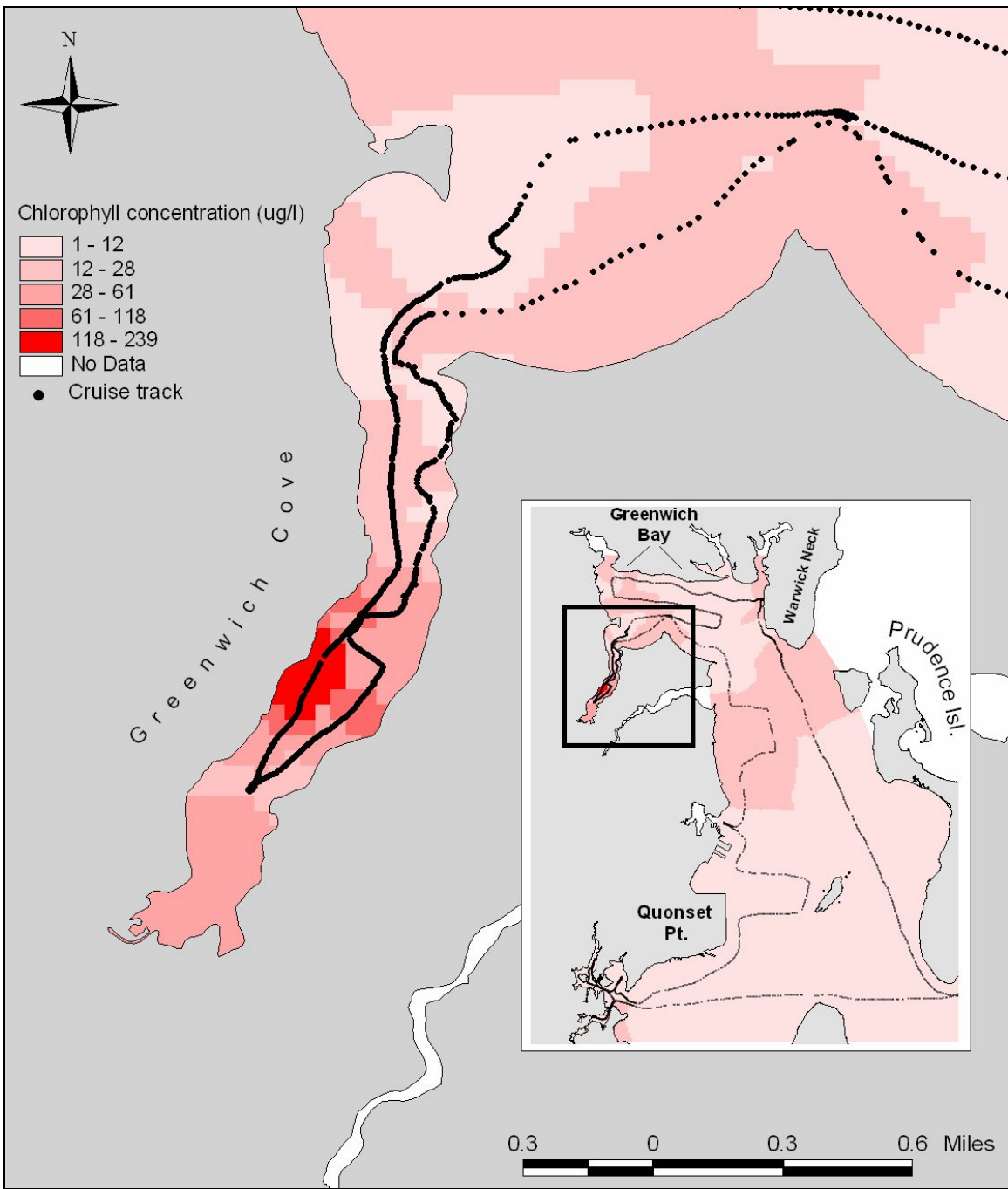


Figure 4. Map of Greenwich Cove showing interpolated chlorophyll a concentrations from the 8/12/2008 DATAFLOW cruise. Note the locus map, which shows concentrations over the larger area of the entire cruise.

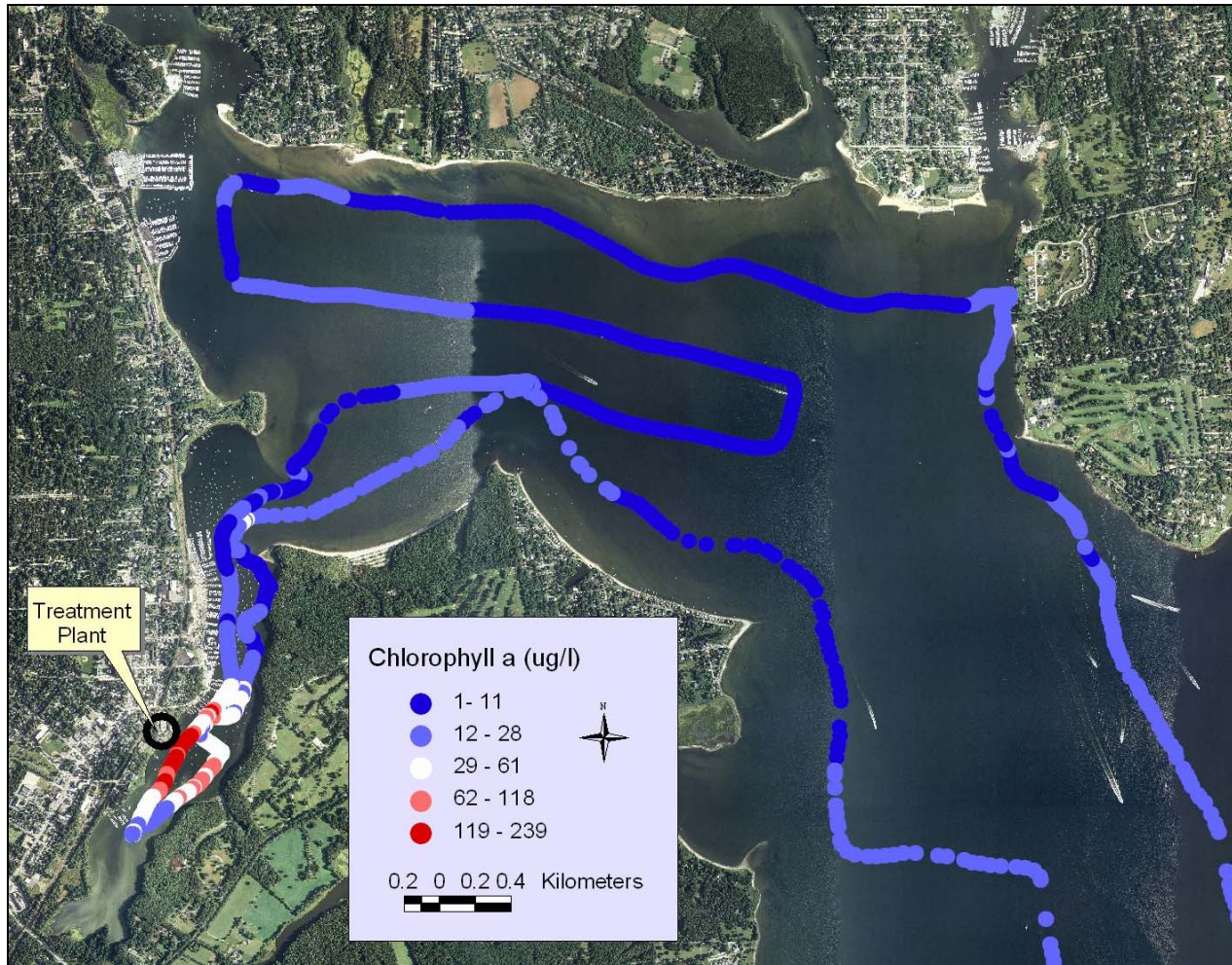


Figure 5. Map of Greenwich Bay and Greenwich Cove showing chlorophyll a concentrations along the 8/12/2008 DATAFLOW cruisetrack. Note the very high concentrations in the middle of the Cove, directly adjacent to the East Greenwich Wastewater Treatment Facility.

Appendix I. NBNERR DATAFLOW protocols

A. Preparing for launch

➤ **General**

- 1) Print datasheets;
- 2) Print map of the cruise track;
- 3) Input cruise track into *Seawolf* GPS unit.

➤ **YSI datalogger calibration**

- 1) Change the DO membrane of the datalogger 1 day before the datalogger DO calibration. DO calibration is done the day of the cruise;
- 2) Check the wipers of the optical probes;
- 3) Calibrate the datalogger the day before the cruise (see Deployment Calibration Notes + DO Calibration Notes);
- 4) The day before the cruise assemble the equipment. Use the Dataflow cruise checklist and bring everything to T-Wharf. Clean up checklist and reprint.

➤ **Dataflow unit**

- 1) Charge the main battery overnight before the cruise;
- 2) Install the datalogger upside down on the dataflow unit;
- 3) Put the datalogger cover on;
- 4) Plug the cable from the dataflow unit to the datalogger;
- 5) Plug the other end of the cable to the 650 (handheld);
- 6) Put the ram inside its pipe at the back of the boat;
- 7) Put tape around the ram to cover the space between the pipe and the ram;
- 8) To prime the system, fill the black hose that connects the ram to the dataflow unit with seawater. Turn all power switches to the 'ON' position making sure that water also fills the bilge pump. Attach the 2 black hoses:

one from the ram to the dataflow unit, the other one from the dataflow unit to the bottom of the datalogger cover;

9) Attach the transparent hose to the top of the datalogger cover;

10) Plug the dataflow unit to the battery.

➤ **Connecting the 650 MDS to the datalogger/running the datalogger using the 650 MDS**

1) Be sure 650 is connected to the datalogger before turning it on;

2) Turn on the 650 MDS (green power button);

3) Highlight DATALOGGER MENU and hit enter (the button with the arrow pointing left);

4) The 650 will connect to the datalogger;

5) Be sure that the flowing things are turned on in the report menu (6): date and time, Sp.Cond, Sal, DO%, DO mg/l, Depth (in meters), pH, and Batt. Volts;

6) Hit ESC; go to 1-RUN; and hit “Discrete Sample”;

7) Be sure the sampling interval is set for 4 seconds;

8) The datalogger should be all set to run at this point;

9) ESC back to main menu;

10) Back at the main menu go to Logging set-up and be sure that the interval is set for 4 seconds and that Store Lat and Long is checked;

11) ESC back to main menu;

12) Back at the main menu highlight DATALOGGER RUN and hit enter;

13) The 650 should say “Connecting” to the datalogger (this may take a couple of seconds);

14) Once it has connected, on the left side of the screen will be the 650 set-up;

15) Highlight START LOGGING and press enter;

- 16) Change the file name to reflect the date of the cruise (ex: DF080207);
- 17) Hit right arrow key to highlight OK and press enter;
- 18) This will begin logging the datalogger data;
- 19) To stop the unit hit STOP LOGGING and the 650 will disconnect from the datalogger;
- 20) Double check that the file is in the 650 by ESC to the main menu and going into FILE and then DIRECTORY. The file should be the last in the list;
- 21) To turn off the 650, ESC back to the main menu, once here hit the power button.

B. On the water – Calibration stations

➤ General

- 1) Check regularly if water is coming out of the transparent hose;
- 2) For each station:
 - Record station information: station number, date, crew initials, depth, time on/off station, weather and sea conditions, GPS latitude/longitude;
 - While 2 persons are doing the Li-Cor profile, the third measures the secchi depth and filters seawater for chlorophyll-a concentration analysis;
 - Record the datalogger information: temperature, salinity, sp. conductivity, DO %, DO mg/L, turbidity, depth, pH and chlorophyll concentration.

➤ Li-Cor profile

- 1) Connect the underwater light sensor and deck light sensor cables to the Li-Cor handheld;
- 2) Both light sensors have to be on the sunny side of the boat. The deck sensor cannot be in shade;
- 3) Record time start/time end;
- 4) Downcast: take readings from the underwater cell at the surface, then at 0.25 m, 0.50 m, 0.75 m, 1.00 m, and 1.25 m;

- 5) Upcast: Take a second set of measurements at 1.25 m, then at 1.00 m, 0.75 m, 0.50 m, 0.25 m, and surface;
- 6) Wait 20 seconds at each depth before recording the data;
- 7) Data are recorded on hardcopy paper, and are also saved on the handheld by pressing 'ENTER' at each depth interval.

➤ **Secchi Disk**

- 1) Drop the secchi disk over the sunny side of the boat;
- 2) Record the depth (in meters) at which the secchi disk disappears.

➤ **Chlorophyll**

- 1) Rinse the 60 cc syringe 3 times with surface seawater;
- 2) Place a filter pad in the filter apparatus with the “snowy side” (not the one with lines/mesh) up;
- 3) Collect 20ml of surface seawater with the syringe;
- 4) Empty slowly the syringe in the filter apparatus;
- 5) Open the syringe: pour a few drops of DI inside + 2 drops of magnesium carbonate (be sure to shake the bottle before using it). Close the syringe. Hold it up pushing out as much air as you can. Then, push the liquid in the syringe into the filter apparatus;
- 6) Take a small aluminum pouch. Put the filter in (the chlorophyll side up) and using tweezers fold the filter in two without touching it with your fingers. Close the pouch and label it with the name/date (e.g. DF for dataflow, so the name would be: DF063007 for a sample collected the 30th of June 2007), the volume filtered, and the station number;
- 7) Put the pouch in a glass jar with dessicant in the cooler.

C. Backing-up data

- 1) Conduct a post deployment calibration check of the datalogger (see Post Deployment Notes + DO Calibration Notes);
- 2) Upload the data from 650 to the computer:

- Connect the 650 using the serial cable to the back of the computer. You must disconnect the datalogger serial cable from COM Port 1 and use this same COM Port to upload data from the 650;
- Go into the ECOWATCH program and click COMM, COM-1, # (to open file);
- Go to FILE on the 650 and hit enter;
- Go to UPLOAD to PC; hit enter;
- The 650 and the EcoWatch program should show the progress of file uploading;
- The file can be found under File-Open-Name of file;
- It can also be found on the C-Drive under ECOWINN-Data folder;
- On handheld select: file → upload → select filename → enter;
- To export data to excel: double click the data file → file → report → select data → ok → save new document (RPT format); then go to excel → data → import → select the document name you want → select fixed with → create columns.

D. Data Editing

- 1) Once in Excel, highlight entire dataset and autofit all columns to contents;
- 2) Visually inspect the dataset to look for glaring errors, edit/delete data as necessary;
- 3) Sort data by latitude; delete any data at the beginning and/or end of the dataset that do not contain proper latitude readings;
- 4) Sort data by longitude;
- 5) Convert any positive longitude data points to negative (i.e., by typing in adjacent cells “=0-x”, with x being the incorrect longitude. Then cut and paste the corrected data into the dataset;
- 6) Delete any longitude data at the beginning and/or end of the dataset that do not contain proper longitude readings; look for longitude values of zero and delete these as well;
- 7) Save file as an xls workbook as well as in DBF4 format.

E. Mapping

- 1) In ArcView 3.2a start a new project and set the View Property Map Units to feet;

- 2) Under the Window menu, go to the Project name ('Untitled' in it has not yet been named);
- 3) Add a new table, which will be the .DBF4 table created from Excel;
- 4) In View, add an Event Theme based on the table that was just added. The X-field will be longitude and the Y-field will be latitude;
- 5) Highlight the new event theme in the project's Table of Contents and then convert this to a shapefile (under the Theme menu). Give the new shapefile a name and save it to an appropriate location;
- 6) Reproject the shapefile to Rhode Island State Plane Feet
 - In ArcView, open the Project Utility extension and select the shapefile;
 - Set the coordinate system to "Geographic", name to "GCS_american_1927 [4267]", and units to "degree [9102]";
 - Click "no" when prompted if you would like to save the coordinate system information;
 - For the new projection, set the coordinate system to "Projected", name to "NAD_1983_Rhode_Island [32130]", and units to "Foot_MA [9004]". Also click on the Datum tab and set the geographic transformation to "NAD_1927_To_NAD_1983_NADCON";
 - Select a name and location for the newly projected shapefile;
 - Confirm for the transformation to proceed;
 - Add the shapefile to the ArcView View if desired.
- 7) Under the File menu add the Spatial analyst extension;
- 8) Under the Surface menu, click 'Interpolate Grid' and input appropriate information based on the current project into the popup window;
- 9) In the next pop-up window, use input 'IDW' for Method, select the water quality parameter of interest for the z-value field, use the nearest neighbors function with 12 neighbors and a power of 2 with no barriers. These values can be changed as necessary if the output grid needs to be modified;
- 10) The resulting interpolated grid can then be manipulated to change the color scheme as well as the classification scheme.