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**2003 Great Bay
Organic Nitrogen (PON & DON) and
Light Extinction (PAR) Monitoring Program**

A Final Report to

The New Hampshire Estuaries Project

Submitted by

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Introduction

Nitrogen is most often considered to be the limiting nutrient for plant growth in marine waters. As a result, knowledge of nitrogen loading and ambient water-column concentrations are considered to be critical to understanding the response of aquatic ecosystems to nutrient over-enrichment—a process known as eutrophication when it results in the excess production of organic matter.

Plant production in many estuarine systems may also be limited by light availability as a result of high levels of turbidity in the water resulting from sediments, dissolved organic matter, and phytoplankton in the water column. Light limitation resulting from human-induced increases in turbidity is known to be particularly deleterious to seagrass production/distribution in some ecosystems and also play an important role in determining how phytoplankton respond to nutrient enrichment.

EPA is developing water quality criteria for estuaries that require knowledge of both total nitrogen and light availability (measured as photosynthetically active radiation, PAR). Through the National Estuarine Research Reserve (NERR) System-Wide Monitoring Program (SWMP), inorganic nutrient concentrations, chlorophyll-a concentration, and a number of hydrographic and water quality parameters are sampled on a monthly basis at 7 sites in the Great Bay system. In addition, these same parameters, as well as bacteria concentrations, are measured at a number of sites in Great Bay and Hampton Harbor through the National Coastal Assessment (NCA) funded through the EPA.

This project takes advantage of these existing monitoring activities to collect and analyze for particulate organic nitrogen (PON), dissolved organic nitrogen (DON) and photosynthetically active radiation (PAR) at a up to 10 existing sample sites in the New Hampshire seacoast region. When combined with existing dissolved inorganic nitrogen measurements, PON and DON allow the entire Total Nitrogen (TN) pool to be quantified. PAR measurements provide, for the first time, an estimate of the light availability in the system.

Project Goals and Objectives

UNH completed this project under contract to the NH Estuaries Project (Project ID #02-M-4; CE #711790). The project goals and objectives per the contract were to:

- (1) conduct PON and DON monitoring for the April – December sampling season at the Lamprey River (LR), Squamscott River (SQ), Oyster River (OR), Great Bay (GB) and Coastal Marine Lab (CML); Cocheco River (NCA72); Salmon Falls River (NCA78); Bellamy River (NCA64) and Hampton Harbor (NCA 7) sites; and

(2) conduct PAR monitoring for the April – December sampling season at as many of the sites above as possible.

The goal was to provide 125 measurements of each parameter during the sampling period. The final work product was agreed to be an Excel data file containing hydrographic, PON, DON and PAR data for all of these sites.

Methods

The methods for this project followed the procedures specified in the approved QA Project Plan (Pennock and Trowbridge, 2003).

Results and Discussion

In this first year of sampling, we discovered that logistical limitations associated with the various types of sampling (e.g. boat vs. automobile vs. pier) and the constraints of the individual programs (e.g. NCA time limitations that limited PAR measurements) required modification of the original sampling plan. Overall, as shown in the table below, we were able to obtain 43 discrete estimates for the attenuation coefficient (PAR), 79 measurements for particulate carbon and nitrogen (PC/PN), 83 measurements of total dissolved nitrogen (TDN) and 75 measurements of dissolved organic nitrogen (DON). We performed replicate analyses on all parameters except for PAR (statistics were generated from triplicate estimates at 3 different locations). Laboratory analyses fell within the accepted guidelines detailed in the approved QA Project Plan (Pennock and Trowbridge, 2003).

Statistical analysis on replicate data showed the following error estimates for field replicates:

| Parameter | Location | Stations | Analyses | Mean | SD | % SE |
|-----------|---------------------|----------|----------|--------|-------|-------|
| PAR | All Data | 43 | 43 | -2.129 | - | - |
| PAR | Adams Point QA | 3 | 3 | -0.700 | 0.010 | 1.43% |
| PAR | Great Bay QA | 3 | 3 | -0.640 | 0.036 | 5.63% |
| PAR | Squamscott River QA | 3 | 3 | -1.680 | 0.075 | 4.49% |
| POC | All Data | 79 | 147 | 1.076 | - | 7.5% |
| PON | All Data | 79 | 147 | 0.119 | - | 9.3% |
| TDN | All Data | 83 | 160 | 0.388 | - | 18.6% |
| DON | All Data | 75 | 156 | 0.236 | - | 29.2% |

This analysis suggests that our estimates of light attenuation should be expected to be good to +/- ~5%. For POC, a parameter that is not called for in the monitoring program but which is obtained for no additional cost as part of the PON analysis, field replicates were good to +/- 7.5%, while PON measurements showed a slightly higher percent error of 9.3%. TDN measurements, which require a significant amount of analytical processing, showed a percent error of 18.6% for field replicates. DON, which is a calculated parameter that combines the errors associated with field collection, TDN analysis

and the error associated with the analysis of NH₄, NO₃ and NO₂ displayed the highest error, 29.2% for field replicates.

Overall for 2003, we were not able to collect the number of PAR measurements that we had originally hoped as a result of our inability to perform these measurements at the NCA stations or from stations that were sampled by automobile (e.g. CML and all stations during April). We performed significantly more than the estimated 125 analyses for PON and DON as a result of our desire to obtain strong estimates of the field variability associated with each measurement.

The CD included with this report contains data files in an Excel format that include the following parameters: Record #; Funding Source for Sampling Effort; Sample Date; Site/Station Name; Tidal Stage; GPS Latitude; GPS Longitude; Bottom Depth; Sample Depth; Temperature; Salinity; Oxygen Concentration; Oxygen Percent Saturation; pH; Total Dissolved Nitrogen (TDN); Dissolved Organic Nitrogen (DON); Particulate Organic Carbon (POC); Particulate Organic Nitrogen (PON); and Attenuation Coefficient (ATTN).

Data for inorganic nutrient and chlorophyll-a concentration collected as part of the NERRS SWMP program will be submitted to the NERRS CDMO. Upon acceptance, these data can be accessed by following the links to: (a) NERR Data; (b) NERR Data and Associated Metadata; (c) NERR SWMP Nutrient Data; and (d) Great Bay (GRB) at the NERR CDMO web site <http://cdmo.baruch.sc.edu/home.html> .

Conclusions and Recommendations

The PON, DON and PAR monthly monitoring program provides important data on nitrogen concentration and light availability in the Great Bay estuary. When combined with the NERRS SWMP program, these data provide comprehensive coverage of the Great Bay estuary and allow total nitrogen concentrations to be calculated for use in nutrient criteria measurements.

This first year's sampling procedures were not as consistent as desired as a result of logistical limitations in meshing these additional samples into the existing NCA and GB SWMP sampling programs. These issues were generally resolved as the year moved along, however, additional efforts and support will be required to insure that the data collected through these different programs are ultimately as seamless as possible.

References

Pennock and Trowbridge (2003) UNH Nutrient and Light Extinction Monitoring Program Quality Assurance Project Plan, Version 4, Final. University of New Hampshire and NH Estuaries Project, August 8, 2003.

2003 Organic Nitrogen (PON & DON) and Light Extinction (PAR) Monitoring Program Meta-Data (Appendix 1)

Research Methods

Monthly monitoring is conducted during ice-free seasons (generally April through December) as part of the GB NERR System-Wide Monitoring Program and National Coastal Assessment at the following locations:

| Funding Source | Station Name | Station ID | Tide Stage | Lat Deg | Lat Minute | Long Deg | Long Minute |
|----------------|------------------------------|------------|------------|---------|------------|----------|-------------|
| NERR | Adams Point | AP | L&H | 43 | 5.495 | 70 | 51.821 |
| NERR | Great Bay | GB | L | 43 | 4.367 | 70 | 52.311 |
| NERR | Lamprey River | LR | L&H | 43 | 4.697 | 70 | 56.092 |
| NERR | Oyster River | OR | Variable | | | | |
| NERR | Squamscott Railroad Bridge | RR | L | 43 | 3.182 | 70 | 54.754 |
| NERR | Squamscott Chapman's Landing | SQ | L&H | 43 | 2.500 | 70 | 55.569 |
| NERR | Coastal Marine Lab | CML | L&H | | | | |
| NCA | Coheco River | CR | Variable | 43 | 11.717 | 70 | 51.452 |
| NCA | Salmon Falls | SF | Variable | 43 | 11.857 | 70 | 49.251 |
| NCA | Bellamy River | BR | Variable | 43 | 8.055 | 70 | 50.865 |
| NCA | Hampton Harbor | HH | Variable | 42 | 53.766 | 70 | 49.502 |

Samples are generally collected by small boat except for the Coastal Marine Lab site, which is accessed by vehicle. During certain periods of particularly stormy weather or when the channel markers are not present (generally in April), a subset of the normal stations may be sampled by vehicle; these cases are noted in the meta-data.

At each station, a hand-held YSI multi-probe is used to measure temperature, salinity, dissolved oxygen, dissolved oxygen percent saturation and pH (for NCA stations), in the surface water (~0.5m). Nutrient samples are collected in acid-washed and DI-water rinsed 1-liter HDPE bottles at ~0.5m depth, placed on ice in a cooler and processed upon return to the laboratory. Photosynthetically Active Radiation (PAR) profiles are made at as many stations as possible using a LiCor Quantum Irradiance Meter.

All nutrient processing and analysis methods and PAR profiling methods are detailed in the 2003 UNH Nutrient and Light Extinction Monitoring Program Quality Assurance Project Plan (Pennock & Trowbridge, 2003).

Deviations in Sampling Procedures for 2003

January

- Icing Conditions; no samples collected.

February

- Icing Conditions; no samples collected.

March

- Icing Conditions; no samples collected.

April

- NERR samples collected by vehicle due to the lack of channel markers.
- PAR measurements not taken as a result of vehicle-based sampling.
- No nutrient samples collected on NCA surveys as a result of logistical problems.

May

- PAR measurements not possible during NCA surveys due to logistical limitations.
- Limited nutrient samples collected on NCA surveys as a result of logistical problems.

June

- PAR measurements not possible during NCA surveys due to logistical limitations.
- LR High Tide DON and PON samples lost due to analytical lab problems.

July

- PAR measurements not possible during NCA surveys due to logistical limitations.

August

- PAR measurements not possible during NCA surveys due to logistical limitations.

September

- PAR measurements not possible during NCA surveys due to logistical limitations.

October

- PAR measurements not possible during NCA surveys due to logistical limitations.

November

- PAR measurements not possible during NCA surveys due to logistical limitations.
- Two November surveys (see December note below).

December

- PAR measurements not possible during NCA surveys due to logistical limitations.
- December sampling carried out at the end of November as a result of tidal cycle limitations in early to mid-December (last pre-icing opportunities).