Wells (WEL) NERR Nutrient Metadata
January 2004-December 2004
Latest Update: July 22, 2025

I. Data Set & Research Descriptors

1. Principal investigator(s) and contact persons

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Other Contacts and Programs: None

2. Research Objectives

**Monthly Grab Program:**
The monthly grab samples provide data for 5 additional water quality variables to supplement the 30-minute interval data stream from the YSI 6600's. Grabs are collected from a similar depth stratum as the YSI datalogger (within 1m of the depth of the probes) at each site. These variables (nitrate, nitrite, ammonium, phosphate, silicate and chlorophyll a) are important indicators of estuarine trophic status and point and non-point sources of nutrient enrichment. Although limited, these data enable estimation of average trophic status, and may demonstrate seasonal patterns. Our datalogger monitoring design allows for gradient analysis from head of tide to inlet in the Webhannet estuary, allowing comparison of the Little River and Webhannet River estuaries at their inlets, where they exchange water directly with the Atlantic Ocean. Monthly grab data provide the basis for investigation of questions regarding watershed and marine inputs of nutrients in Wells NERR estuaries, and nutrient influence on trophic status as indicated by chlorophyll a.

**Diel Sampling Program:**
At the Webhannet Inlet site, the monthly grab samples are augmented with a 24-hour sampling series (at 2 hr intervals for a total of 24 samples – 2 replicate samples per 2 hr interval). These data can provide estimates of temporal variation in nutrients and chlorophyll on the scale of hours, providing a context for interpretation of data collected less frequently. This finer scale information will also inform interpretation SWMP grab sample data. These data can be used to investigate the relationship between nutrients, chlorophyll, and dissolved oxygen, an integrator of water column metabolism.

3. Research Methods

**Monthly Grab Program:**
Monthly grab samples are collected at 2 sites in the Webhannet River Estuary and 2 sites in the Little River Estuary. These sites coincide with the four data sonde sites: Head of Tide (HT), Skinner Mill (SM), and Inlet (IN) in the Webhannet River; and the Mouth (LM) in the Little River. All grab samples are taken within a 24-hour period, and efforts are made to sample between +/- 3 hours slack-low tide. Efforts are also made to allow for a previous dry period of 72 hours prior to sampling, however this was not always possible due to lengthy periods of inclement weather. Sampling events are staggered each month at the optimal low tide, given constraints of scheduling of Reserve personnel. Replicate (N=2) 1-liter samples are collected at a depth of 0.5 meters below the water

surface at the HT, SM, and LM sites. Replicate (N=2) samples at the IN site are taken by pumping the sample up through the ISCO sampler. All samples are collected in 1-liter wide-mouth amber Nalgene bottles that were previously washed with Fisher brand Versa-Clean and water, acid washed (10% HCl), rinsed (3x) with distilled-deionized water, dried, and rinsed (3x) with ambient water prior to collection of the sample. Samples are immediately placed on ice in a dark cooler, and returned to the laboratory for immediate processing.

**Diel Sampling Program:**
Diel samples are collected once a month, during the same 24-hour period as our grab sample collection, at the Webhannet River Inlet (IN) datalogger site. An ISCO 6700 automated sampler is deployed on a floating dock at the Wells Harbor pier. As with the grab samples, efforts are made to begin the automated sampling between +/- 3 hours slack-low tide. Efforts are also made to allow for a previous dry period of 72 hours prior to sampling, however this was not always possible due to lengthy periods of inclement weather. Sampling events are staggered each month at the optimal low tide, given constraints of Reserve personnel scheduling. Two replicate samples of 1-liter each are taken every 2-hours over the 24-hour period for a total of 24 samples. All samples are pumped into ISCO 1-liter polypropylene wedge sample bottles that were previously washed with Fisherbrand Versa-Clean and water, acid washed (10% HCl), rinsed (3x) with distilled-deionized water and dried prior to collection of the sample. The ISCO sampler is filled with ice and/or frozen gel packs prior to deployment, and at the end of the 24-hour period the sample bottles are immediately capped, kept in the dark, and returned to the laboratory for immediate processing.

Once back in the Wells NERR laboratory, samples are shaken and processed for nutrient and Chlorophyll-a analysis. All samples are filtered at the Wells NERR. The Chl-a analysis is completed on-site at the Wells NERR laboratory with a Turner Designs 10-AU field fluorometer, and the nutrient analysis takes place at the University of New Hampshire Estuarine and Coastal Chemistry Laboratory, Ocean Process Analysis Lab (OPAL) or at Virginia Institute of Marine Science (VIMS).

The nutrient processing methodology includes filtering 50 mL of a sample through 25 mm, 0.45 µm HV Millipore Durapore® membrane filters using a Becton, Dickinson and Co. (BD) 60mL polyethylene syringe with Luer-Lok® tip locked to a Millipore Swinnex 25 mm polypropylene filter holder. If a sample is particularly turbid, a 25 mm PALL A/E Glass Fiber Filter is used to filter the sample prior to filtering through the 0.45 µm Millipore filter, although this happens very rarely. The liquid volume of the filtered sample is collected into a Fisherbrand 50 ml polypropylene centrifuge tube (after rinsing collection tube (3x) with sample) and placed in the freezer until brought down to the University of New Hampshire or mailed overnight delivery to VIMS for analysis.

The Chl-a processing methodology here at the Wells NERR Research Laboratory follows the non-acidification method, “A Procedure For Measuring Extracted Chlorophyll a Free From The Errors Associated With Chlorophyll b and Pheopigments”, adapted from the EPA Method 445.0: “In Vitro Determination of Chlorophyll a and Pheophytin a in

Marine and Freshwater Algae by Fluorescence." This methodology involves filtering 200-1000 mL of a sample through 47 mm Whatman® GF/F filters using a vacuum pump and filter flask apparatus, and to determine the Chl-a concentration we use a Turner Designs 10-AU Field Fluorometer.

All laboratory glassware, centrifuge tubes, syringes, filter holders, 1-liter graduated cylinders, and forceps were previously washed with Fisherbrand Versa-Clean and water, rinsed (3x) with distilled-deionized water and dried prior to filtration of the sample; and rinsed (3x) between samples with distilled-deionized water to avoid any contamination.

4. Site location and character

The Wells National Estuarine Research Reserve is located in York County, within the Town of Wells, on the coast of southern Maine and faces the Atlantic Ocean. The Wells NERR is approximately 31 km (20 miles) south of Portland, Maine and 110 km (70 miles) north of Boston, Massachusetts. The Reserve encompasses 1,690 acres along the Gulf of Maine coastline of tidally-flushed wetlands, riparian and transitional upland fields and forests within the Little River Estuary and the larger Webhannet River Estuary. Both estuaries arise in the sandy glacial outwash plain about eight miles inland. Both rivers empty into Wells Bay, a sandy basin stretching for approximately ten miles along the Atlantic coast. Bordering each river's inlet are double spit barrier beaches attached to the mainland. The backbarrier system in the Webhannet River Estuary is approximately 5 sq. km and is composed of large intertidal marshes (predominantly S. patens and S. alterniflora), intertidal sand and mud flats, and tidal channels. The watershed for the Webhannet River estuary covers an area of 35 sq. km and has a total of 6 streams, brooks or creeks, which enter the estuary. These tributaries flow across sand and gravel deposits near the headwaters and the impermeable sandy muds of the Presumpscot Formation in the lower reaches.

The watershed for the Little River estuary covers an area of 84 sq. km and has a total of 2 tributaries. The backbarrier system in the Little River Estuary is approximately 2.51 sq. km and is composed of large intertidal marshes (predominantly S. patens and S. alterniflora), intertidal sand and mud flats, and tidal channels. The Webhannet River is connected to the ocean via Wells Inlet, which has a spring tidal prism of 28,200,000 cub. m (Ward 1993). The Little River is connected to the ocean by an unstructured, double spit system and is one of the few tidal inlets along the southern Maine coast that is not stabilized by either natural outcrops or artificial jetties. The force and volume of tidal action affect the salinity level of both rivers. In the Wells region, the annual mean wave height is almost 20 inches. These estuarine systems are dominated by semi-diurnal tides having a range of 8.5 to 9.8 feet. The volume of freshwater influx into both estuaries is moderate to low (on the order of 0.5 cubic meters/second), especially in the summer, because of the rivers' relatively small drainage areas and the presence of deep glacial deposits. The relatively low flows from these two rivers taken in with the 20 inch per year average runoff of the area surrounding the estuaries combine to form a fresh water flow, which is dwarfed by tidal flushing. Twelve-foot tides dwarf the freshwater flow into the Webhannet estuary, which has a drainage area of 14.1 square miles. The

Merriland River and Branch Brook meet south of Route 9 to form the Little River, which drains an area of 10.75 sq. miles. The Webhannet estuary, fed by both Blacksmith and Depot Brooks, is adjacent to the harbor and greatly developed land. It offers a valuable opportunity for comparison with the relatively pristine Little River estuary. The land use of the Webhannet estuary include a total of 15% for wetland, fresh water, and tidal marsh; a total of 63.7 % for woodland; and a total of 18.6% for developed land compared to a total of 5.7% development in the Little River estuary (WNERR RMA 1996; Holden 1997).

The following information regarding annual weather patterns in the area was supplied by Maine State Climatologist Professor Gregory A. Zielinski extracted from "Monthly Station Normals of Temperature, Precipitation, Heating and Cooling Degree Days 1971-2000", Climatography of the United States No. 81, National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, NC. and "Daily Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1971-2000", Climatography of the United States No. 84: "Average monthly temperatures range from 21.6F in January to 66.7F in July with daily highs averaging just below freezing in January and lows around 11F. Daily highs in July average around 76F and daily lows around 57F. The sea breeze often keeps daily highs lower during the summer than areas inland. Annual average temperature is 44.6F. Annual precipitation is 47.07 inches, including the water equivalent of snowfall, with monthly averages ranging from 3.01 inches in July to 4.77 inches in October. August receives just 3.02 inches on average. Annual snowfall is
around 66 inches." According to Zielinski, "cool ocean temperatures keep down the number of afternoon showers and especially thunderstorms resulting in low summer precipitation amounts."

There are two sampling sites in the Webhannet River estuary. These are located at the Head of Tide (HT), and at the Inlet (IN). The tidal range at each of these sites is 2.6-2.9 meters. There are two sampling sites in the Little River estuary, the Little River Mouth (LM) and Skinner Mill (SM). The tidal range of the Little River estuary is 2.6-3.0 meters (Mariano and FitzGerald, 1988).

The Head of Tide site is located 4 miles south of the Wells Reserve, just downstream of the Webhannet Falls (freshwater) and 10 feet east of Route One (43 deg 17' 54.25227" Latitude, 70 deg 35' 13.82728" Longitude). Route One is used heavily with traffic all year, especially during the summer tourist months. This site has soft mud, sand, and a rocky substrate, and the low and high tide depth is relatively shallow. The salinity range here is 0-31 ppt, with a mean of 3.6 ppt. These headwaters of the Webhannet are relatively undeveloped. This site is located just 10 feet east of the Route One bridge, and is our roving site.

The Skinner Mill (SM) site is located approximately 20 meters downstream from the intersection of the Merriland River (tributary to Merriland/Branch/Little River estuary) and Skinner Mill Road (at 43 deg 20' 47.69" N Latitude, 70 deg 33' 14.21" W Longitude). This site is approximately 3 meters downstream from the Watershed Evaluation Team

(Educational water quality program at Wells NERR) site L5. Substrate is rock, salinities are always less than 1 ppt. Originally, the site was thought to have some tidal influence, although the data has proven otherwise.

The Inlet site is located 1.5 miles south of the Wells Reserve, at the Wells Harbor pier (43 deg 19' 12.44804" Latitude, 70 deg 33' 13.82728" Longitude). The mouth of the Webhannet estuary forms an extensive wetland/salt marsh area, which is surrounded by development. Wells Harbor, which was most recently dredged in 1971, has moorings for approximately 200 commercial fishing and recreational boats. The mouth of the river flows between two jetties to the Atlantic Ocean. This channel was dredged in 1974. This site has a predominately sand substrate and is characterized by strong current during incoming and outgoing tides. The maximum depth of the Inlet site is 3 meters. The salinity range here is 7-35 ppt, with a mean of 31 ppt. The Inlet site is heavily impacted at the Wells Harbor dock and is our long-term monitoring site.

The Little River Mouth site is located 1,270.78 meters upstream from the mouth of the estuary, and 813.94 meters direct from the Wells NERR Coastal Ecology Center (43 deg 20.413 Latitude, 70 deg 32.441 Longitude). The tidal range of the Little River estuary is 2.6-3.0 meters (Mariano and FitzGerald, 1988). The Little River sites existed in a shallow and relatively pristine system with a sandy to mud bottom and a salinity range of 0 - 32 ppt. There are two major freshwater inputs, the Merriland and Branch Brook Rivers, which converge to form the Little River. The Little River Mouth site is our comparative system site.

Note: Both original Little River Mouth sites were abandoned in prior years due to problems with heavy sediment movement in the inlet of the Little River. We were forced to relocate the site twice. The first location (N 43 deg 20.176 Latitude, W 70 deg 32.497 Longitude) was located in the main channel of the river, just inland of a spit, beside a bank. The second location (N 43 deg 20.083 Latitude, W 70 deg 32.585 Longitude) was located 1/8 mi. southwest of the first site, within an inlet, just inland of a spit. The second site was located in an area of much lower current than the first site and often drains completely during low tides. It was also placed within a pool next to incipient low marsh peat that retains calm water during low tides.

5. Coded variable definitions

Reserve code:
wel = Wells NERR

Station codes:
in = Webhannet River Inlet
sm = Skinner Mill (on Merriland R.)
ht = Head of Tide at Webhannet R.
lm = Little River Mouth

Program code:
nut = nutrient sampling program

These abbreviations are combined to form the sample name as follows:
welinnut = sample taken from Webhannet River Inlet as part of the Wells NERR nutrient sampling program

The monitoring codes are set as "1" to indicate grab samples and "2" to indicate diel samples. Replicates are also given specific codes. Grab samples in which a duplicate sample are indicated by "1" for first sample and a "2" for second sample. Diel samples are always labeled with a "1" since only one sample is taken at each 2 hr 4 min interval.

6. Data collection period

Diel Sampling, every 2 hours, 4 minutes as follows:

| Site | Start Date | Start Time | End Date | End Time |
|---|---|---|---|---|
| IN | 01/21/04 | 12:00 | 01/22/04 | 02:28 |
| IN | 02/24/04 | 15:30 | 02/25/04 | 14:14 |
| IN | 03/25/04 | 12:00 | 03/26/04 | 10:44 |
| IN | 04/20/04 | 13:40 | 04/21/04 | 12:24 |
| IN | 05/26/04 | 10:30 | 05/27/04 | 09:14 |
| IN | 06/22/04 | 10:30 | 06/23/04 | 09:14 |
| IN | 07/21/04 | 09:30 | 07/22/04 | 08:14 |
| IN | 08/19/04 | 07:55 | 08/20/04 | 06:39 |
| IN | 09/23/04 | 07:20 | 09/24/04 | 06:04 |
| IN | 10/20/04 | 08:00 | 10/21/04 | 06:44 |
| IN | 11/16/04 | 10:27 | 11/17/04 | 09:11 |
| IN | 12/16/04 | 08:24 | 12/17/04 | 07:08 |

Grab Sampling

| Site | Start/End Date | Start Time | End Time |
|---|---|---|---|
| IN | 01/22/04 | 11:55 | 11:57 |
| IN | 02/25/04 | 14:25 | 14:28 |
| IN | 03/26/04 | 10:21 | 10:23 |
| IN | 04/21/04 | 08:17 | 08:18 |
| IN | 05/27/04 | 10:13 | 10:15 |
| IN | 06/23/04 | 10:13 | 10:15 |
| IN | 07/22/04 | 09:50 | 09:52 |
| IN | 08/20/04 | 09:34 | 09:36 |
| IN | 09/24/04 | 06:37 | 06:39 |
| IN | 10/21/04 | 07:25 | 07:27 |
| IN | 11/17/04 | 10:35 | 10:37 |
| IN | 12/17/04 | 08:28 | 08:30 |

| Site | Start/End | Start | End |
|---|---|---|---|

| | Date | Time | Time |
|---|---|---|---|
| HT | Jan: ice, no sampling. | | |
| HT | Feb: ice, no sampling. | | |
| HT | Mar: ice, no sampling. | | |
| HT | 04/21/04 | 08:34 | 08:36 |
| HT | 05/27/04 | 10:46 | 10:48 |
| HT | 06/23/04 | 09:50 | 09:52 |
| HT | 07/22/04 | 09:09 | 09:12 |
| HT | 08/20/04 | 09:10 | 09:12 |
| HT | 09/24/04 | 06:24 | 06:26 |
| HT | 10/21/04 | 07:01 | 07:03 |
| HT | 11/17/04 | 10:25 | 10:27 |
| HT | 12/17/04 | 08:05 | 08:07 |

| Site | Start/End Date | Start Time | End Time |
|---|---|---|---|
| SM | Jan: ice, no sampling. | | |
| SM | Feb: ice, no sampling. | | |
| SM | Mar: ice, no sampling. | | |
| SM | 04/21/04 | 08:54 | 08:56 |
| SM | 05/27/04 | 11:05 | 11:07 |
| SM | 06/23/04 | 10:33 | 10:36 |
| SM | 07/22/04 | 10:40 | 10:42 |
| SM | 08/20/04 | 09:44 | 09:46 |
| SM | 09/24/04 | 06:58 | 07:00 |
| SM | 10/21/04 | 06:45 | 06:47 |
| SM | 11/17/04 | 10:53 | 10:55 |
| SM | 12/17/04 | 07:50 | 07:52 |

| Site | Start/End Date | Start Time | End Time |
|---|---|---|---|
| LM | Jan: ice, no sampling. | | |
| LM | Feb: ice, no sampling. | | |
| LM | 03/26/04 | 12:10 | 12:12 |
| LM | 04/21/04 | 09:25 | 09:30 |
| LM | 05/27/04 | 13:25 | 13:30 |
| LM | 06/23/04 | 11:22 | 11:24 |
| LM | 07/22/04 | 11:10 | 11:12 |
| LM | 08/20/04 | 10:20 | 10:22 |
| LM | 09/24/04 | 07:28 | 07:30 |
| LM | 10/21/04 | 08:15 | 08:17 |
| LM | 11/17/04 | 09:45 | 09:47 |
| LM | 12/17/04 | 09:50 | 09:52 |

7. Associated researchers and projects

Please visit our website http://www.wellsnerr.org/research.htm for further information on the Wells NERR research program. The Research Program at the Wells NERR conducts and supports research, monitoring, workshops, and research/resource management planning of relevance at local, regional and national levels. The overall aim of our work is to produce science-based information needed to sustain or restore Gulf of Maine coastal habitats and resources, especially those found in salt marsh estuaries and watersheds. During 2000-2001 twenty-three different studies (involving 79 scientists, students, and staff from the Reserve, 26 academic institutions and 19 resource management groups) focused on several related themes:1) the quality of water resources in salt marsh estuaries and watersheds 2) land conservation strategies to protect coastal watersheds 3) factors controlling salt marsh accretion, erosion and plant community vigor 4) the value of salt marsh as habitat for fish, shellfish and birds, and 5) restoration of salt marsh habitat degraded through human actions.

Estuarine Water Resource Quality

Water quality is monitored continuously at several stations with automated instruments as part of a NERRS system-wide monitoring program, as well as bimonthly at 15-20 stations through our WET volunteer monitoring program. The WET program also monitors two important biological parameters: fecal coliform bacterial contamination (an indicator of human health risk) and phytoplankton productivity (an indicator of estuarine health). These data have 1) allowed us to identify several bacterial "hot spots" that we will be working to eliminate, 2) are used to identify and open areas safe for shellfishing, and 3) have uncovered a relation between tides and low dissolved oxygen (a stressful condition for marine life) that needs further study. Our water quality work has contributed to the designation of several Priority Watersheds in coastal Southern Maine by the Maine Department of Environmental Protection.

Coastal Conservation Strategies

The Stewardship program has been developed in response to requests for support from the conservation community to increase the quantity, quality and ecological integrity of conserved lands in our region. Research staff organize and facilitate meetings, workshops, and communications for about 20 partner conservation groups. A key element of the Stewardship program is the Conservation Resource Center, a Reserve staffed GIS facility with a growing database able to provide maps of property, natural features and other data needed to develop effective conservation goals and strategies. Successful projects completed by the Stewardship Program include a conservation lands map of Southern Maine coastal towns and a series of Conservation Strategy Reports for 7 coastal watersheds within these towns. The Reserve has a particular interest in educating communities about the ecologic and economic benefits of land conservation, especially along estuarine and riverine shorelines.

Salt Marsh Habitats and Communities

Factors that control the dynamics and vigor of salt marsh plant communities and marsh peat formation consequently determine the ability of a salt marsh to persist in the face of sea level rise. Through a combination of experimental manipulations and long-term

monitoring, a number of multi-year studies are currently producing data to answer questions concerning the sustainability of salt marsh habitats in this region. These studies are looking at nutrient-plant relations, plant community responses to physical and hydrologic disturbance, and the relative contribution of short-term natural events (e.g., storms) and human activities (dredging, tidal restriction) on patterns of sediment accretion and erosion. The Reserve's marshes and beaches are already among the best studied sites in the U.S. with regard to long term accretion and erosion (over thousands of years).

Habitat Value For Fish, Shellfish, and Birds

The Reserve combines long-term monitoring with periodic surveys and short-term experiments to identify species and measure trends and changes in populations of fish, crustaceans, clams and birds. We have 10 years of data on upland and shore birds with which to assess the status of resident and migratory avian populations, and 8 years of wading bird data that we use as a gross level indicator of salt marsh health, which appears to be stable. Our periodic larval, juvenile and adult fish surveys have produced the best available data for fish utilization of salt marsh estuaries in the Gulf of Maine. In the coming year we plan to develop a long-term monitoring program for finfish that will be coordinated with other sites within the Gulf of Maine and along the east coast. Since 1994 we have been conducting surveys and field experiments to look at the survival and growth of hatchery seed, juvenile and adult softshell clam with regard to habitat characteristics and predation by the invasive green crab.

Salt Marsh Degradation and Restoration

Salt marsh ecosystems in the Gulf of Maine have sustained themselves in the face of sea-level rise and other natural disturbances for nearly five thousand years. Since colonial times large areas of salt marsh (up to half of the total area) have been lost through diking, draining and filling. Today, the remaining marshland is fairly well protected from outright destruction, but during the past 100 years, and especially since the 1950's, salt marshes have been divided into fragments by roads, causeways, culverts and tide gates. Most of these fragments have severely restricted tidal flow, leading to chronic habitat degradation and greatly reduced access for fish and other marine species. Since 1991, the Wells Reserve has been studying the impact of these restrictions on salt marsh functions and values, and the response of salt marshes to tidal restoration. We have been working to promote an awareness of the damage being done and the benefits of salt marsh restoration throughout the Gulf of Maine.

Research Program Update:

In addition to the Reserve-sponsored projects outlined above, numerous visiting investigators will be involved in on-site research. Topics include: the effects of land use, sea level, and climate on estuarine productivity; the relationship between soil nutrients and plant community patterns; the influence of soil salinity on plant community interactions; the effect of tidal restriction on marsh peat accretion; the comparative ecology of fringe marshes and back barrier marshes; habitat use by upland birds, and the ecology of Lyme disease.

The Wells NERR Research Dept. is working on the following projects: "Ecological processes, energy pathways, and the impact of human activities on Maine marsh-estuarine secondary production: a salt marsh panne model". We used stable isotopic tracers (15N additions and naturally abundant 13C) coupled with secondary production measurements (nekton, invertebrates) to track energy flow on the high marsh surface in southern Maine salt marsh systems. The project is still under way.

"Ecological Functions of Fringing Salt Marshes Susceptible to Oil Spills in Casco Bay, Maine". We examined the ecological function of 9 different fringing marsh systems in Casco Bay that ranged from undisturbed to disturbed. Physical parameters measured included sedimentation rates, total suspended solids, and tidal range. Biological parameters included primary production, macroinvertebrate community composition and secondary production (4cm sediment cores), and resident and transient nekton community composition (fyke net). The project is still under way.

"BENTHIC HABITAT CORRELATES OF JUVENILE FISH DISTRIBUTION IN THE BIGELOW BIGHT AND ADJACENT ESTUARIES: LINKAGES BETWEEN FISH, HABITATS, SUBSTRATE AND HUMAN ACTIVITY". This project was a collaboration between the Wells N.E.R.R. and several members of the local fishing community. Through the use of beam trawls, gill nets, fish traps, van veen ponar, and a sediment profile imager (SPI camera), we are attempting to correlate benthic habitat type to juvenile groundfish and invertebrate assemblages in estuarine, nearshore, and offshore habitat. Stations were also
established near dredge spoil dump sites as well as sewage outflow to determine the impacts of human activity on the coast to benthic habitat. The project is still under way.

The Wells NERR Research Dept. also completed the work on the following project:
In partnership with the York Rivers Association and the Town of York, the Wells Reserve conducted a survey of the York River watershed. In this survey, volunteers looked for sources of pollution within a 250-foot buffer of the river and its tributaries (erosion, trash and debris and runoff from roads and lawns could have a negative impact on water quality). Most pollutants entering water bodies come from such undefined sources. Therefore, this type of survey is the best way to begin to address the problems of pollution in a water body. The idea of the project was to work with the community and landowners to help them understand the problems that come from these types of pollution and learn activities they might be able to do on their own land that would help prevent this pollution from entering the water. The results of the survey will become part of a Watershed Management Plan to improve and restore the water quality of the York River.

The Wells NERR Research Dept. is involved with the following CICEET Projects-

Project Title: Estuarine Responses to Dredging: Analysis of Sedimentary and Morphological Change in Back Barrier Marsh to Aid Local Management and Develop a Regional Management Tool Principal Investigator (s): Michele Dionne, Wells NERR,

ME; Duncan Fitzgerald, Boston University; Joe Kelley, University of Maine; David Burdick and Larry Ward, University of New Hampshire

Management Issue: Coastal management tool for assessing the impacts of dredging in estuaries. Project Summary: An adequate supply of sediment is essential for maintaining salt marshes. Human activities, such as channel dredging and tidal restriction due to road construction, can alter water flows in estuaries and result in dramatic changes in salt marsh sediment supply, affecting the speed of salt marsh erosion. The objective of this project is to determine the impact of dredging and tidal restriction on salt marshes in the Wells NERR. A digital coastal management guide will be created on CDROM, providing coastal managers with useful conceptual models for predicting the impacts of dredging and other activities that affect water flow and sediment deposition in salt marshes.

II. Project Title: Microbial Source Tracking in Two Southern Maine Watersheds. A two-year project written by Maine Sea Grant associate Kristen Whiting-Grant, and funded by Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), involving Wells NERR, UNH Jackson Estuarine Lab (JEL), USM Muskie School, AmeriCorps and the Maine Conservation Corps. We are pioneering the use in Maine of genetic analysis as a means of determining the source species associated with bacterial contamination in the Webhannet and Little River Estuary. Volunteers collect water samples from streams and the estuaries, staff test for and isolate E. coli. At JEL, a genetic technique (ribotyping) creates a genetic fingerprint of the bacteria which is compared to known sources. The project was completed in 2003, although outreach is ongoing by Kristen Whiting-Grant, Maine Sea Grant and Cooperative Extension, located at Wells NERR.

The following information on CICEET taken directly from its website: (http://www.ciceet.unh.edu)

Other Onsite Research:
Michele Dionne, Wells NERR, Nancy McReel, Chuck Lubelczyk.
Project Title: Effect of herbivory by deer on forest regeneration

June Ficker
Project Title: Monitoring avian productivity and survivorship

Outside Researchers:
Theresa Theodose, Ph.D., University of Southern Maine
Project Title: Relationships between soil nutrient availability and species composition of a high salt marsh in southern Maine.

David Burdick, Ph.D. and Roelof Boumans, Ph.D.
University of New Hampshire, University of Maryland
Project Title: Sediment dynamics in salt marshes: functional assessment of accretionary biofilters

Peter Rand, M.D., Chuck Lubelczyk, Robert Smith, M.D.
Maine Medical Center
Project Title: Ecological determinants of the spread of the tick vector of Lyme disease and other pathogens.

8. Distribution

NOAA/ERD retains the right to analyze, synthesize and publish summaries of the NERRS System-wide Monitoring Program data. The PI retains the right to be fully credited for having collected and processed the data. Following academic courtesy standards, the PI and NERR site where the data were collected will be contacted and fully acknowledged in any subsequent publications in which any part of the data are used. Manuscripts resulting from this NOAA/OCRM supported research that are produced for publication in open literature, including refereed scientific journals, will acknowledge that the research was conducted under an award from the Estuarine Reserves Division, Office of Ocean and Coastal Resource Management, National Ocean Service, National Oceanic and Atmospheric Administration. The data set enclosed within this package/transmission is only as good as the quality assurance and quality control procedures outlined by the enclosed metadata reporting statement. The user bears all responsibility for its subsequent use/misuse in any further analyses or comparisons. The Federal government does not assume liability to the Recipient or third persons, nor will the Federal government reimburse or indemnify the Recipient for its liability due to any losses resulting in any way from the use of this data.

NERR water quality data and metadata can be obtained from the Research Coordinator at the individual NERR site (please see Section 1. Principal investigators and contact persons), from the Data Manager at the Centralized Data Management Office (please see personnel directory under the general information link on the CDMO home page) and online at the CDMO home page http://cdmo.baruch.sc.edu/. Data are available in text tab-delimited format, Microsoft Excel spreadsheet format and comma-delimited format.

II. Physical Structure Descriptors

9. Entry verification

Excel data files containing measured values (except for Chl-a which is analyzed at Wells NERR) received from the University of New Hampshire Ocean Process Analysis Lab / Estuarine and Coastal Chemistry Laboratory (OPAL) or from Virginia Institute of Marine Science (VIMS) are used to generate calculated parameter values. Both directly measured and calculated values were entered into this document by Cayce Dalton from files and notes kept by Scott Orringer, Jim Dochtermann and/or Cayce Dalton, and from files delivered by OPAL and by VIMS. The SWMP technicians at Wells NERR were responsible for a visual QA/QC to make sure no entry errors are present. The original Excel files received from UNH and VIMS are archived on the Wells NERR server and a

Maxtor One Touch external hard drive. Edited files containing additional calculated parameters are archived on the Maxtor One Touch external hard drive.

10. Parameter Titles and Variable Names

Required NOAA/NERRS System-wide Monitoring Program water quality parameters are denoted by an asterisks "*". Nutrient parameters sampled at the Wells NERR in this sample period are the Tier I parameters: ammonium (NH4+), nitrate (NO3-) and nitrite (NO2-) or combined nitrate + nitrate, orthophosphate, and chlorophyll a; and the Tier II parameter: Silicate.

Phosphorus:

| Parameter | Variable Name | Units of Measure |
|---|---|---|
| *Orthophosphate | PO4F | mg/L as P |

Nitrogen:

| Parameter | Variable Name | Units of Measure |
|---|---|---|
| *Nitrite + Nitrate, Filtered | NO23F | mg/L as N |
| *Nitrate, Filtered | NO3F | mg/L as N |
| *Ammonium, Filtered | NH4F | mg/L as N |

Other Lab Parameters:

| Parameter | Variable Name | Units of Measure |
|---|---|---|
| Silicate, Filtered | SiO4F | mg/L as SI |
| *Chlorophyll a | CHLA_N | µg/L |

Notes:
Time is coded based on a 2400 hour clock and is referenced to Eastern Standard Time (EST).

Reserves have the option of measuring either NO23, or if NO2 can be shown to be a minor constituent of NO23, then NO23 can be substituted for NO3 and NO2.

11. Measured and Calculated Laboratory Parameters

Variables Measured Directly
Nitrogen species: NO23, NH4 and some NO3
Phosphorus species: PO4F
Other: CHLA_N, SiO4F

Computed Variables
none

Note: Data coded "C" in the comments column are calculated.

## 12. Limits of Detection

Method Detection Limits (MDL), the lowest concentration of a parameter that an analytical procedure can reliably detect, have been established by the University of New Hampshire Estuarine and Coastal Chemistry Laboratory and at the Lachat Instrument website (http://www.lachatinstruments.com/applications/AppsSearch.asp). Table 1 lists the current MDL values, which are reviewed and revised periodically.

Method Detection Limits (MDL) for measured water quality parameters. The following MDL's were provided by the laboratory at the time the data indicated were provided.

| | PO4F mg/L | NH4F mg/L | NO3F mg/L | NO23F mg/L | SiO4F mg/L |
|---|---|---|---|---|---|
| OPAL data | 0.0009 | 0.0042 | 0.0070 | n/a | n/a |
| VIMS data | 0.0015 | 0.0054 | n/a | 0.0010 | 0.0080 |

NOTE regarding Chlorophyll *a* limits of measurement:
The following article describes the method used:
"Method 445.0 *In Vitro* Determination of Chlorophyll *a* and Pheophytin *a* in Marine and Freshwater Algae by Fluorescence"
Elizabeth J. Arar and Gary B. Collins
Revision 1.2, September 1997
National Exposure Research Laboratory, Office of Research and Development, USEPA, Cincinnati, OH 45268

The above article states in section 1.2:
"Instrument detection limits of 0.05 µg chl *a*/L and 0.06 µg pheo *a*/L in a solution of 90% acetone were determined by this laboratory. Method detection limits (MDL) using mixed assemblages of algae provide little information because the fluorescence of other pigments interferes in the fluorescence of chlorophyll *a* and pheophytin *a*. A single lab estimated detection limit for chlorophyll *a* was determined to be 0.11 µg/L in 10 mL of final extraction solution. The upper limit of the linear dynamic range for the instrumentation used in this method evaluation was 250 µg chl *a*/L."

NOTE on Data Reporting & Rounding for OPAL data:
According to Lachat Instruments (1-800-247-7613), the Quick Chem 8000, while running with the 2.0 software, has a precision to 4 decimal places (rounding up from 5).

## 13. Laboratory Methods

Section 13, Part I: Analyses conducted by Ocean Process Analysis Laboratory at University of New Hampshire (OPAL).

The following information is taken from the website below as directed from Pallavi Mittal (Research Technician) from the UNH Estuarine and Coastal Chemistry Laboratory.

http://www.lachatinstruments.com/applications/AppsSearch.asp
NH4 QuickChem Method 31-107-06-1-A 0.07 to 3.57 µM
NO3 and NO2 31-107-04-1-A 0.005 to 5 µM N/L 0.07 to 70 mg N/L
PO4 31-115-01-1-1 1 to 100 µM P/L 0.03 to 3.23 µM P
SiO2 31-114-27-1-B 0.03 to 5 µM SiO2/L 0.5 to 100µM SiO2/L

**Parameter: Orthophosphate, PO4F**
Method References:
University of New Hampshire Estuarine and Coastal Chemistry Laboratory

Revision Date: 6/27/2001
PO4 31-115-01-1-1 1 to 100 µM P/L 0.03 to 3.23 µM P

Orthophosphate in Seawaters
Method No: 31-115-01-1-I
Product Line: Flow Injection Analysis
Matrix: Brackish or seawater

Range

| Analyte | Range | MDL | Units |
|---|---|---|---|
| Phosphate, ortho | 1 to 100 | 0.25 | µM P/L |

Principle
Ammonium molybdate and antimony potassium tartrate reacts in an acid medium with phosphate to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue-colored complex by ascorbic acid. The color produced is proportional to the phosphate concentration in the sample. Though there is a density difference between seawater and reagent water the bias is less than 2%. Though the method is written for seawater and brackish water it is also applicable to non-saline sample matrixes. The method is calibrated using standards prepared in deionized water. Once calibrated, samples of varying salinities (0 to 35 ppt) may be analyzed. The determination of background absorbance is necessary only for samples, which have color absorbing at 880 nm.

Interferences
Silica forms a pale blue complex, which also absorbs at 880 nm. This interference is generally insignificant as a silicate concentration of approximately 5 mg SiO2/L would be required to produce a 0.14 µg P/L positive error in orthophosphate. See Section 11.2. High iron can cause precipitation of and subsequent loss of phosphate from the dissolved phase.
Using ascorbic acid as the reductant, the color intensity is not influenced by variations in salinity. Stannous chloride reductant does show a significant salt effect.

Turbidity is removed by filtration.
Hydrogen sulfide effects, such as those occurring in samples from deep anoxic basins, can be treated by simple dilution since high sulfide concentrations are most often associated with high phosphate values.

Special Apparatus
Please see Parts and Price list for Ordering Information
Heating Unit
Glass calibration vials must be used for this method (Lachat Part No. 21304)

Preservation Method:
The nutrient processing methodology includes filtering 50 ml of a sample through 25 mm, 0.45 µm HV Millipore Durapore® membrane filters using a Becton, Dickinson and Co. (BD) 60ml polyethylene syringe with Luer-Lok® tip locked to a Millipore Swinnex 25 mm polypropylene filter holder. If a sample is particularly turbid, a 25 mm PALL A/E Glass Fiber Filter is used to filter the sample prior to filtering through the 0.45 µm Millipore filter. The liquid volume of the filtered sample is collected into a Fisherbrand 50 ml polypropylene centrifuge tube (after rinsing collection tube (3x) with sample) and placed in the freezer until brought down to the University of New Hampshire for analysis.

**Parameter: Nitrate + Nitrite, NO23F**
Method References:
University of New Hampshire Estuarine and Coastal Chemistry Laboratory

Revision Date: 2/27/2001
NO3 and NO2 31-107-04-1-A 0.005 to 5 µM N/L 0.07 to 70 mg N/L

Nitrate/Nitrite in Brackish Waters or Seawater
Method No: 31-107-04-1-A
Product Line: Flow Injection Analysis
Matrix: Brackish or seawater

Range

| Analyte | Range | MDL | Units |
|---|---|---|---|
| Nitrate + Nitrite | 1.25 to 5.0 | 0.03 | µM N |

Principle
Nitrate is quantitatively reduced to nitrite by passage of the sample through a copperized cadmium column. The nitrite (reduced nitrate plus original nitrite) is then determined by diazotization with sulfanilamide under acidic conditions to form a diazonium ion. The resulting diazonium ion is coupled with N-(1-naphthyl)ethylenediamine dihydrochloride. The resulting pink dye absorbs at 520 nm. Nitrate concentrations are obtained by subtracting nitrite values, which have been previously analyzed, from the nitrite + nitrate values.

Though the method is written for seawater and brackish water, it is also applicable to non-saline sample matrixes.
The method is calibrated using standards prepared in deionized water. Once calibrated, samples of varying salinities (0 to 35 ppt) may be analyzed. The determination of background absorbance is necessary only for samples which have color absorbing at 540 nm. The salt effect is less than 2%.

Interferences
No Interferences

Special Apparatus
Please see Parts and Price list for Ordering Information
No Special Apparatus

Preservation Method:
The nutrient processing methodology includes filtering 50 ml of a sample through 25 mm, 0.45 µm HV Millipore Durapore® membrane filters using a Becton, Dickinson and Co. (BD) 60ml polyethylene syringe with Luer-Lok® tip locked to a Millipore Swinnex 25 mm polypropylene filter holder. If a sample is particularly turbid, a 25 mm PALL A/E Glass Fiber Filter is used to filter the sample prior to filtering through the 0.45 µm Millipore filter. The liquid volume of the filtered sample is collected into a Fisherbrand 50 ml polypropylene centrifuge tube (after rinsing collection tube (3x) with sample) and placed in the freezer until brought down to the University of New Hampshire for analysis.

**Parameter: Ammonia, NH4F**
Method References:
University of New Hampshire Estuarine and Coastal Chemistry Laboratory

Revision Date: 6/6/2001
NH4 QuickChem Method 31-107-06-1-A 0.07 to 3.57 µM

Ammonia (Phenolate) in Brackish Waters

Method No: 30-107-06-1-A
Product Line: Flow Injection Analysis
Matrix: Brackish waters
EPA Ref No: 350.1

Range

| Analyte | Range | MDL | Units |
|---|---|---|---|
| Ammonia | 0.1 to 20.0 | N/A | mg N/L |

Principle
This method is based on the Berthelot reaction. Ammonia reacts with alkaline phenol, then with sodium hypochlorite to form indophenol blue. Sodium nitroprusside

(nitroferricyanide) is added to enhance sensitivity. The absorbance of the reaction product is measured at 630 nm, and is directly proportional to the ammonia concentration.

Interferences
EDTA is added to the sample in-line to prevent precipitation of calcium and magnesium as the hydroxides.
Color, and turbidity may interfere. Turbidity is removed by manual filtration. Sample color may be corrected for by running the samples through the manifold without color formation.
Residual chlorine must be removed prior to analysis.
The matrix can vary from fresh to deep-sea water salinity with no effect.

Special Apparatus
Please see Parts and Price list for Ordering Information
Heating Unit (Lachat Part No. A85100)

Preservation Method:
The nutrient processing methodology includes filtering 50 ml of a sample through 25 mm, 0.45 µm HV Millipore Durapore® membrane filters using a Becton, Dickinson and Co. (BD) 60ml polyethylene syringe with Luer-Lok® tip locked to a Millipore Swinnex 25 mm polypropylene filter holder. If a sample is particularly turbid, a 25 mm PALL A/E Glass Fiber Filter is used to filter the sample prior to filtering through the 0.45 µm Millipore filter. The liquid volume of the filtered sample is collected into a Fisherbrand 50 ml polypropylene centrifuge tube (after rinsing collection tube (3x) with sample) and placed in the freezer until brought down to the University of New Hampshire for analysis.

**Parameter: Silicate, SiO4F**
Method References:
University of New Hampshire Estuarine and Coastal Chemistry Laboratory

Revision Date: 4/3/2001
SiO2 31-114-27-1-B 0.03 to 5 µM SiO2/L 0.5 to 100µM SiO2/L

Silicate in Brackish or Seawater
Method No: 31-114-27-1-B
Product Line: Flow Injection Analysis
Matrix: Brackish or seawater

Range

| Analyte | Range | MDL | Units |
|---|---|---|---|
| Silicate | 1.25 to 5.0 | 0.01 | µM Si |

Principle
Soluble silica species react with molybdate at 37 °C and pH of 1.2 to form a yellow silicamolybdate complex. This complex is subsequently reduced with stannous chloride

to form a heteropoly blue complex which has an absorbance maximum at 820 nm. The intensity of the color is proportional to the concentration of "molybdate reactive" silica.

Though the method is written for Brackish and Seawater, it is also applicable to non-saline sample matrixes.

The method is calibrated using standards prepared in deionized water. Once calibrated, samples of varying salinities (0 to 35 ppt) may be analyzed. The determination of background absorbance is necessary only for samples which have color absorbing at 820 nm.

Interferences
Sample turbidity may interfere. Remove turbidity by filtration with a 0.45 µm pore diameter membrane filter prior to analysis.
Sample color may be subtracted by analyzing the samples with a substitute color reagent which does not contain molybdate. This is done by replacing the molybdate/sulfuric acid reagent with a solution containing 16 mL of sulfuric acid per liter.

Special Apparatus
Please see Parts and Price list for Ordering Information
Heating Unit (Lachat Part No. A85100)

Preservation Method:
The nutrient processing methodology includes filtering 50 ml of a sample through 25 mm, 0.45 µm HV Millipore Durapore® membrane filters using a Becton, Dickinson and Co. (BD) 60ml polyethylene syringe with Luer-Lok® tip locked to a Millipore Swinnex 25 mm polypropylene filter holder. If a sample is particularly turbid, a 25 mm PALL A/E Glass Fiber Filter is used to filter the sample prior to filtering through the 0.45 µm Millipore filter. The liquid volume of the filtered sample is collected into a Fisherbrand 50 ml polypropylene centrifuge tube (after rinsing collection tube (3x) with sample) and placed in the freezer until brought down to the University of New Hampshire for analysis.

Section 13, part II: Analysis conducted at Virginia Institute of Marine Science (VIMS)

**Parameter: Orthophosphate, PO4F**
Method References: Virginia Institute of Marine Science Analytical Service Center. SKALAR Method: O-Phosphate / Total Phosphate Catnr. 503-365.1, issue 042993/MH/93-Demo1. Murphy, J. and J.P. Riley. 1962. A modified single solution method for the determination of phosphate in natural waters. Analytica Chim. Acta 27 : 31-36. EPA 600/R-97/072 Method 365.5 Determination of Orthophosphate in Estuarine and Coastal Waters by Automated Colorimetric Analysis. IN: Methods for the Determination of Chemical Substances in Marine and Estuarine Environmental Matrices - 2nd Edition. National Exposure Research Laboratory, Office of Research and Development . U.S. EPA, Cincinnati, Ohio 45268.

Method Descriptor: Instrumentation: SKALAR San-Plus continuous flow autoanalyzer. Ammonium molybdate and antimony potassium tartrate react in a sulfuric acid environment to form an antimony-phospho-molybdo complex, which is reduced to a blue colored complex by ascorbic acid. Reaction is heat catalyzed at 40°C and measured colorimetrically at 880nm. The range is 1-50 ppb. Preservation Method: 100ml of a sample is filtered through 0.45µm Millipore filters using a vacuum-pump and a filtering flask apparatus. If samples are extremely dirty a 47mm GF/C filter may be used to filter the sample prior to filtering through the 0.45µm Millipore filter. The liquid volume of the filtered sample is collected into a Nalgene bottle and placed in the freezer until shipment time arrives the following day.

**Parameter: Nitrate + Nitrite, NO23F**

Method References: Virginia Institute of Marine Science Analytical Service Center. SKALAR Method: Nitrate + Nitrite/ Total Dissolved Nitrogen Catnr. 461-353.2 issue 120293/MH/93128060. U.S. EPA. 1974 Methods for Chemical Analysis of Water and Wastes, pp. 207 -212. Wood, E.D., F.A.G. Armstrong and F.A. Richards. 1967. Determination of nitrate in seawater by cadmium-copper reduction to nitrite. J. Mar. Biol. Assoc. U.K. 47: 23. Grasshoff, K., M. Ehrhardt and K. Kremling. 1983. Methods of Seawater Analysis. Verlag Chemie, Federal Republic of Germany. 419 pp. EPA 600/R-97/072 Method 353.4 Determination of Nitrate and Nitrite in Estuarine and Coastal Waters by Gas Segmented Flow Colorimetric Analysis. IN: Methods for the Determination of Chemical Substances in Marine and Estuarine Environmental Matrices – 2nd Edition. National Exposure Research Laboratory, Office of Research and Development U.S. EPA, Cincinnati, Ohio 45268.

Method Descriptor: Instrumentation: SKALAR San-Plus continuous flow autoanalyzer. Nitrate is reduced to nitrite by a copper/cadmium sulfanil column. The nitrite ion then reacts with sulfanilamide to form a diazo compound. This compound then couples with n-1-napthylenediamine dihydrochloride to form a reddish/purple azo dye and is read colorimetrical at 540 nm. Nitrate concentration is obtained by subtracting the corresponding nitrite value from the NO3- + NO2- concentration. The color development chemistry is the same as that used in Nitrite. Range is 0 -1.2 mg/L.

Preservation Method: 100 ml of a sample is filtered through 0.45 µm Millipore filters using a vacuum-pump and a filtering flask apparatus. If samples are extremely dirty a 47mm GF/C filter may be used to filter the sample prior to filtering through the 0.45 µm Millipore filter. The liquid volume of the filtered sample is collected into a Nalgene bottle and placed in the freezer until shipment time arrives the following day.

**Parameter: Ammonia, NH4F**

Method References: Virginia Institute of Marine Science Analytical Service Center. U.S. EPA. 1974. Methods for Chemical Analysis of Water and Wastes, pp. 168-174. Standard Methods for the Examination of Water and Wastewater, 14th edition. p 410. Method 418A and 418B (1975). Annual Book of ASTM Standards, Part 31. "Water", Standard 1426-74, Method A, p 237 (1976). EPA 600/R-97/072 Method 349.0.

Determination of Ammonia in Estuarine and Coastal Waters by Gas Segmented Continuous Flow Colorimetric Analysis. IN: Methods for the Determination of Chemical Substances in Marine and Estuarine Environmental Matrices - 2nd Edition. National Exposure Research Laboratory, Office of Research and Development U.S. EPA, Cincinnati, Ohio 45268.

Method Descriptor: Instrument is SKALAR San-Plus continuous flow autoanalyzer. Alkaline phenol and hypochlorite react with ammonia to form indophenol blue that is proportional to the ammonia concentration. The blue color formed is intensified with sodium nitroprusside. Reaction is heat catalyzed at 37°C and is measured colorimetrically at 660 nm. The range is 0.01  2.0 mg/L.

Preservation Method:  100 ml of a sample is filtered through 0.45 µm Millipore filters using a vacuum-pump and a filtering flask apparatus. If samples are extremely dirty a 47 mm GF/C filter may be used to filter the sample prior to filtering through the 0.45 µm Millipore filter. The liquid volume of the filtered sample is collected into a Nalgene bottle and placed in the freezer until shipment time arrives the following day.

**Parameter: Silicate**

Method References:
Virginia Institute of Marine Science Analytical Service Center. Technicon Industrial Systems Method: Silica. 1973. Technicon Auto-analyzer II Industrial Method No. 186-72W, Silicates in Water and Seawater.

U.S. EPA. 1982. Methods for Chemical Analysis of Water and Wastewater, 18th edition. Method 4500-Si F. Automated Method for Molybdate-Reactive Silica. pp. 4-122 through 4-123. Grasshoff, K., M. Ehrhardt and K. Kremling. 1983. Methods of Seawater Analysis. Verlag Chemie, Federal Republic of Germany. pp. 175-180.

Method Descriptor:
Instrumentation: SKALAR San-Plus continuous flow autoanalyzer. The determination of soluble silica is based on the reduction.

Preservation Method:
100 ml of a sample is filtered through 0.45um Millipore filters using a vacuum-pump and a filtering flask apparatus. If samples are extremely dirty a 47 mm GF/C filter may be used to filter the sample prior to filtering through the 0.45µm Millipore filter. The liquid volume of the filtered sample is collected into a Nalgene bottle and placed in the refrigerator until shipment time arrives the following day. Samples may be kept up to 28 days.

Section 13, part III: Analysis conducted at Wells NERR.
Analyses conducted by Wells NERR.

**Parameter: Chlorophyll a, CHLA**

Method References:
Wells National Estuarine Research Reserve Coastal Ecology Center Laboratory
Strickland, J.D.H., and Parson, T.R. 1972. A Practical Handbook of Seawater Analysis. Fish. Res. Bd. Canada 167:310.
TD-10-AU-005-CE Field Fluorometer Operating Manual. Version 1.4. April 1999. Turner Designs, 845 West Maude Avenue, Sunnyvale, CA 94086.
EPA - Method 445.0. In Vitro Determination of Chlorophyll a and Pheophytin a in Marine and Freshwater Algae by Fluorescence.
Using the Turner Designs Model 10 Analog, The 10AU Digital, Or the TD-700 Fluorometer with EPA Method 445.0. January 19, 1999. Turner Designs, 845 West Maude Avenue, Sunnyvale, CA 94086.
A Procedure For Measuring Extracted Chlorophyll a Free From The Errors Associated With Chlorophyll b and Pheopigments. Turner Designs, 845 West Maude Avenue, Sunnyvale, CA 94086. This method was developed by Dr. Nicholas A. Welschmeyer of Moss Landing Marine Laboratories, Moss Landing, CA. A paper by Dr. Welschmeyer, Fluorometric Analysis of Chlorophyll a in the presence of Chlorophyll b and Pheopigments, which details his research, appears in Limnology and Oceanography (June 1994).

Method Description:
Instrumentation: Turner Designs 10-AU-005-CE Field fluorometer.
The Chl-a processing methodology here at the Wells NERR Research Laboratory follows the non-acidification method, "A Procedure For Measuring Extracted Chlorophyll a Free From The Errors Associated With Chlorophyll b and Pheopigments", adapted from the EPA Method 445.0: "In Vitro Determination of Chlorophyll a and Pheophytin a in Marine and Freshwater Algae by Fluorescence." The method used requires filtering a known quantity of water through a glass fiber filter (47 mm GF/F). The sample is steeped in 90% acetone at least 2 hours and not exceeding 24 hours at 4oC, in the dark. The samples are centrifuged and read on the fluorometer. If the samples cannot be read within that time period, they are stored in the research freezer.

Preservation Method:
This methodology includes filtering 600-1000 ml of a sample through 47 mm Whatman® GF/F filters using a vacuum pump and filter flask apparatus. The Whatman type GF/F filter is either folded immediately after sample filtering, enclosed in a waxed paper envelope, placed in a petri dish, wrapped with aluminum foil, placed in a sealed freezer bag, and placed in the freezer until it is ready for analysis, or directly placed in 90% acetone for 2-24 hours for immediate analysis. The final concentration of Chl-a = (F x v)/V; where F = the direct fluorescence reading, v = volume of the extract, and V = volume of sample filtered.

<u>14. Reporting of Missing Data and Data with Concentrations Lower than Method Detection Limits (MDL)</u>

General note on missing data:
For details on deleted data, see the Deleted Data Section (12. If additional information on missing data is needed, contact the Research Coordinator at the reserve submitting the data.

Nutrient/Chla comment codes and definitions are provided in the following table. Missing data are denoted by a blank cell " " and commented coded with an "M". Laboratories in the NERRS System submit data that are censored at a lower detection rate limit, called the Method Detection Limit or MDL. MDL's for specific parameters are listed in the Laboratory Methods and Detection Limits Section (Section II, Part 14) of this document. Measured concentrations that are less than this limit are replaced with the minimum detection limit value and comment coded with a "B" in the variable code comment column. For example, the measured concentration of NO23F was 0.0005 mg/L as N (MDL=0.0008), the reported value would be 0.0008 with a "B" placed in the NO23F comment code column. Calculated parameters are comment coded with a "C" and if any of the components used in the calculation are below the MDL, the calculated value is removed and also comment coded with a "B". If a calculated value is negative, the value is removed and comment coded with an "N".

Note: The way below MDL values are handled in the NERRS SWMP dataset was changed in November of 2011. Previously, below MDL data from 2002-2006 were also coded with a B, but replaced with -9999 place holders. Any 2002-2006 nutrient/pigment data downloaded from the CDMO prior to December November of 2011 will contain -9999s representing below MDL concentrations.

| Comment Code | Definition |
|---|---|
| A | Value above upper limit of method detection |
| B | Value below method detection limit |
| C | Calculated value |
| D | Data deleted or calculated value could not be determined due to deleted data, see metadata for details |
| H | Sample held beyond specified holding time |
| K | Check metadata for further details |
| M | Data missing, sample never collected or calculated value could not be determined due to missing data |
| P | Significant precipitation (>/=0.25 inches occurred within 24 hours of sampling, >/=0.5 inches within 48 hours of sampling, and >/=0.75 inches occurred within 72 hours of sampling) |
| U | Lab analysis from unpreserved sample |
| S | Data suspect, see metadata for further details |

OPAL = University of New Hampshire Ocean Process Analysis Laboratory
VIMS = Virginia Institute of Marine Science

NOTE on nutrient analysis labs:
**January 2004:** All data analysis done at OPAL

**February-April 2004:** Split analysis NH4 and PO4 conducted at OPAL and NO23 and SiO4 conducted at VIMS
**May-December 2004:** All VIMS

General note on NO3F and NO23F:
NO2F was shown to be a minor constituent of NO23F in 2003, thus it was decided to test for NO23F only without determining NO2 separately (as described in CDMO's Nutrient and Chlorophyll Monitoring Program and Design, March 2004). However, at the time of this decision, the January samples were in the process of analysis at OPAL. OPAL used a method of determining NO3F and NO2F directly, and calculating NO23F (instead of NO23F and NO2F directly, then calculating NO3). OPAL had determined NO3F and intended to determine NO2F shortly afterward. However, they never completed their analysis and these samples were lost without NO2F ever being analyzed, and thus all NO23F values for January are missing. All following samples were analyzed by VIMS for NO23 only. The column for NO3F is included in the dataset for the purpose of representing January's data only, since we did not intend to determine or calculate NO3F in 2004.

General note on samples processed at VIMS:
These samples were transported multiple times. First they were transported to OPAL by Wells NERR staff in multiple trips throughout the year. Then in September 2004, they were retrieved from OPAL and brought back to Wells NERR by Wells NERR staff, stored for a period of time and shipped to VIMS later via overnight delivery. The samples remained frozen throughout all storage and travel.

General note on Chlorophyll A: all samples processed at Wells NERR.

<u>January 2004 Notes</u>
NH4F, NO3F and PO4F conducted at OPAL lab.

Missing nutrient data: OPAL was not able to process NO2F. NO23F is therefore also missing for this month, since their method involved sampling NO2 and NO3 individually. SiO4F was not processed.

Missing nutrient data 1/22/2003.
Sites welhtnut (Webhannet head of tide), wellmnut (Little River Mouth) could not be sampled due to ice.
welsmnut (Little River, Skinner Mill) site had not yet been created.
The final four diel samples at site welinnut could not be sampled because intense cold froze the ocean water as it traveled through intake tube, blocking further sampling.

Holding time for NH4F, NO3F and PO4F: data for this month were provided by OPAL in December of 2004.

Holding time for CHLA_N at all sites.

Samples were filtered and frozen immediately. They were thawed and processed at Wells NERR on 12/21/04.

February 2004 Notes
NH4F and PO4F conducted at OPAL lab.
NO23F and SiO4F were conducted at VIMS lab.

Missing nutrient data:
Sites welhtnut (Webhannet head of tide), wellmnut (Little River Mouth) could not be sampled due to ice.
Welsmnut (Little River, Skinner Mill) site had not yet been created.

Missing PO4F datum: No datum for the following sample was returned from OPAL, without explanation. The sample was collected and analyzed for other parameters.
welinnut 2/24/04 17:34

Holding time for NO23F at all sites: Samples were processed at VIMS in April 2005.

Holding time for NH4F and PO4F: Data for this month were provided by OPAL in January of 2005.

Holding time for CHLA_N at all sites.
Samples were filtered and frozen immediately. They were thawed and processed at Wells NERR on 12/16/04.

March 2004 Notes
NH4F and PO4F conducted at OPAL lab.
NO23F and SiO4F were conducted at VIMS lab.

welsmnut (Little River, Skinner Mill) site had not yet been created.

Missing NH4F, NO23F, PO4F and SiO4F data: this sample was apparently lost at OPAL.
welinnut 3/25/04 12:00

Holding time for NH4F and PO4F: Data for this month were provided by OPAL in January of 2005.

Holding time for NO23F and PO4F at all sites.
Samples were processed at VIMS in April 2005.

Holding time for CHLA_N at all sites.
Samples were filtered and frozen immediately. They were thawed and processed at Wells NERR on 12/16/04.

April 2004 Notes
NH4F and PO4F conducted at OPAL lab.

NO23F and SiO4F were conducted at VIMS lab.

Missing NO23F and SiO4F data:
welhtnut 4/21/2004, 08:34
Vial containing sample cracked and contaminated sample.

Holding time for NH4F and PO4F: Data for this month were provided by OPAL in January of 2005.

Holding time for NO23F at all sites.
Samples were processed at VIMS in April 2005.

Holding time for CHLA_N at all sites.
Samples were filtered and frozen immediately. They were thawed and processed at Wells NERR on 12/21/04.

May 2004 Notes
NH4F, NO23F, PO4F and SiO4F were conducted at VIMS lab.

Missing NH4F, PO4F, NO23F and SiO4F data:
welhtnut 5/27/2003, 10:15.
This sample was either lost or contaminated in shipping.

Holding time for NH4F, PO4F and NO23F at all sites.
Samples were processed at VIMS in April 2005.

June 2004 Notes
NH4F, NO23F, PO4F and SiO4F were conducted at VIMS lab.

Holding time for NH4F, PO4F and NO23F at all sites.
Samples were processed at VIMS in April 2005.

July 2004 Notes
NH4F, NO23F, PO4F and SiO4F were conducted at VIMS lab.

Holding time for NH4F, PO4F and NO23F at all sites.
Samples were processed at VIMS in April 2005.

August 2004 Notes
NH4F, NO23F, PO4F and SiO4F were conducted at VIMS lab.

Holding time for NH4F, PO4F, and NO23F at all sites.
Samples were processed at VIMS in April 2005.

Missing sample: the following sample was lost or damaged in shipping, so NH4F, PO4F, NO23F and SiO4F are missing.
welinnut 8/20/2004 6:39

September 2004 Notes
NH4F, NO23F, PO4F and SiO4F were conducted at VIMS lab.

Holding time for NH4F, PO4F and NO23F at all sites.
Samples were processed at VIMS in April 2005.

October 2004 Notes
NH4F, NO23F, PO4F and SiO4F were conducted at VIMS lab.

Holding time for NH4F, PO4F and NO23F at all sites.
Samples were processed at VIMS in April 2005.

Missing sample: the following sample was lost or damaged in shipping, so NH4F, PO4F, NO23F and SiO4F are missing.
welsmnut 10/21/2004 6:45

November 2004 Notes
NH4F, NO23F, PO4F and SiO4F were conducted at VIMS lab.

Holding time for NH4F, PO4F, NO23F and SiO4F at all sites.
Samples were processed at VIMS in April 2005.

December 2004 Notes
NH4F, NO23F, PO4F and SiO4F were conducted at VIMS lab.

Holding time for NH4F, PO4F, NO23F and SiO4F at all sites.
Samples were processed at VIMS in April 2005.

15. QA/QC Programs

Precision:
Field Variability – True field replicates are taken at each site during grab sampling. Both replicate grabs are taken one immediately after the other.
Laboratory Variability – none
Inter-organizational splits – same samples were not split or analyzed by two different labs

Accuracy:

Sample Spikes – information unavailable
Standard Reference Material Analysis – see lab protocols
Cross Calibration Exercises – WNERR did not participate in cross calibration exercises.

16. Other Remarks

**On 07/22/2025 this dataset was updated to include embedded QAQC flags and codes for anomalous/suspect, rejected, missing, and below detection limit data.** System-wide monitoring data beginning in 2007 were processed to allow for QAQC flags and codes to be embedded in the data files rather than using the original single letter codes used for the nutrient and pigment dataset along with the detailed sections in the metadata document for suspect, missing, and rejected data. Please note that prior to 2007, rejected data were deleted from the dataset so they are unavailable to be used at all. Suspect, missing, rejected and below minimum detection flags and appropriate three letter codes were embedded retroactively for dataset consistency. The QAQC flag/codes corresponding to the original letter codes are detailed below.

| Flag/code | *If also C* | Historic Letter Code | Historic Code Definition |
|---|---|---|---|
| <1> [SUL] | | A | Value above upper limit of method detection |
| <-4> [SBL] | <-4> [SCB] | B | Value below method detection limit |
| *no need to flag/code unless combined* | | C | Calculated value |
| <-3> [GQD] | <3> [GCR] | D | Data deleted or calculated value could not be determined due to deleted data, see metadata for details |
| <1> (CHB) | | H | Sample held beyond specified holding time |
| <0> (CSM) unless other flag | | K | Check metadata for further details |
| <-2> [GDM] | <-2> [GCM] | M | Data missing, sample never collected or calculated value could not be determined due to missing data |
| <-3> [SNV] and <1> [SCC] for components | | N | Negative calculated value |
| (CRE) or F_Record {CRE} | | P | Significant precipitation (reserve defined, see metadata for further details) |
| <0> (CUS) | | U | Lab analysis from unpreserved sample |
| <1> (CSM) | | S | Data suspect, see metadata for further details |

The following precipitation data was obtained by the Wells NERR weather station located at the "Laudholm Farm" station (for more information see meteorological data set for 2004 for Wells NERR).

Monthly precipitation totals:
January

| Date | Rain Amount (mm) |
|---|---|
| 2 | 01.0 |
| 3 | 03.0 |
| 12 | 02.0 |
| 13 | 01.0 |
| Jan total | 07.1 |

February

| Date | Rain Amount (mm) |
|---|---|
| 3 | 08.6 |
| 4 | 04.1 |
| 6 | 09.7 |
| 7 | 05.6 |
| 21 | 05.3 |

| | |
|---|---|
| 22 | 01.0 |
| Feb total | 34.3 |

March

| Date | Rain Amount (mm) |
|---|---|
| 5 | 03.8 |
| 6 | 01.3 |
| 8 | 00.8 |
| 15 | 01.0 |
| 16 | 01.0 |
| 19 | 00.3 |
| 20 | 03.6 |
| 21 | 06.1 |
| 25 | 01.3 |
| 26 | 00.5 |
| 27 | 08.6 |
| 31 | 22.1 |
| March total | 50.3 |

April

| Date | Rain Amount (mm) |
|---|---|
| 1 | 41.1 |
| 2 | 46.0 |
| 4 | 04.3 |
| 5 | 02.0 |
| 12 | 00.3 |
| 13 | 37.6 |
| 14 | 03.8 |
| 15 | 01.3 |
| 18 | 00.3 |
| 23 | 07.4 |
| 24 | 00.8 |
| 25 | 04.1 |
| 26 | 16.0 |
| 27 | 09.1 |
| April total | 174.0 |

May

| Date | Rain Amount (mm) |
|---|---|
| 3 | 13.5 |
| 4 | 12.7 |
| 10 | 01.5 |
| 11 | 00.3 |
| 15 | 12.7 |
| 16 | 06.9 |
| 18 | 08.6 |

| | |
|---|---|
| 21 | 03.6 |
| 22 | 18.3 |
| 23 | 13.7 |
| 24 | 27.9 |
| 25 | 00.3 |
| 26 | 00.3 |
| 27 | 05.6 |
| 28 | 19.1 |
| May total | 144.8 |

June

Partial data only available for this month.

| Date | Rain Amount (mm) |
|---|---|
| 1 | 04.3 |
| 2 | 04.1 |
| 3 | 11.7 |
| 7 | 00.3 |
| 9 | 11.4 |

July

| Date | Rain Amount (mm) |
|---|---|

No data available for this month.

August

Partial data only available for this month.

| Date | Rain Amount (mm) |
|---|---|
| 26 | 00.3 |
| 30 | 02.8 |
| 31 | 08.4 |

September

| Date | Rain Amount (mm) |
|---|---|
| 8 | 03.3 |
| 9 | 56.4 |
| 10 | 00.5 |
| 17 | 03.8 |
| 18 | 45.2 |
| 27 | 00.3 |
| 28 | 06.6 |
| 30 | 01.3 |
| Sept total | 117.3 |

October

| Date | Rain Amount (mm) |
|---|---|
| 1 | 00.3 |
| 2 | 06.9 |

| | |
|---|---|
| 12 | 06.6 |
| 14 | 03.3 |
| 15 | 10.4 |
| 16 | 20.3 |
| 30 | 13.7 |
| 31 | 01.0 |
| Oct total | 62.5 |

November

| Date | Rain Amount (mm) |
|---|---|
| 2 | 03.8 |
| 3 | 06.6 |
| 4 | 09.7 |
| 5 | 08.6 |
| 7 | 00.3 |
| 8 | 00.3 |
| 20 | 00.3 |
| 21 | 00.8 |
| 24 | 26.7 |
| 25 | 07.9 |
| 28 | 25.7 |
| Nov total | 90.4 |

December

| Date | Rain Amount (mm) |
|---|---|
| 1 | 24.9 |
| 3 | 04.6 |
| 7 | 20.1 |
| 8 | 00.3 |
| 10 | 10.7 |
| 11 | 06.1 |
| 13 | 00.3 |
| 20 | 03.6 |
| 23 | 27.7 |
| 24 | 00.3 |
| 27 | 00.3 |
| Dec total | 98.6 |