(NERR) Estuarine Surface Water Nutrient, Suspended Sediment, and Chlorophyll a Data for the North Inlet and Winyah Bay Estuaries

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DATASET TITLE:	North Inlet-Winyah Bay National Estuarine Research Reserve's (NERR) Estuarine Surface Water Nutrient, Suspended Sediment, and Chlorophyll a Data for the North Inlet and Winyah Bay Estuaries, Georgetown, South Carolina: 1993-2001				
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DATA FILE INFORMATION:	***This condensed metadata is from the original, more extensive metadata*** created on 3/22/2004 by Ginger Ogburn-Matthews. If needed, the original may be accessed at: **http://links.baruch.sc.edu/Data/NERRWCHEM/metadata/NERR.WCHEM.1993-2001.pdf** Links and email addresses in the original have not been updated as those locations and people may no longer be available. The data manager identified on this page should be contacted for any questions about the data.				
Data File Name	Water_Chemistry_NERRWCHEM__6_1993_2001_Continuation_of_LTERDWS.zip				
Beginning Date	02-Jun-1993				
End Date	18-Dec-2001				
RESEARCH LOCATION:	North Inlet Estuary	Clambank Creek (CB)	Debidue Creek (DC)	Oyster Landing (OL)	Thousand Acre (TA)
Geographic Description	The North Inlet-Winyah Bay National Estuarine Research Reserve is located on the southeastern coast of the United States on the Atlantic Ocean in two tidal estuaries, North Inlet and Winyah Bay, near Georgetown, South Carolina. The North Inlet estuary, located approximately 10 km east of Georgetown, is a bar-built Class C type estuary (Pritchard, 1955). The North Inlet estuary is composed of numerous winding tidal creeks, and is considered a pristine tidal estuary due to minimal anthropogenic impacts. The watershed drains a 24.8 km2 area of mostly pine forest and a moderately developed residential watershed to the north. The Winyah Bay estuary, classified as a Class B type estuary by Pritchard (1955), which originates in the Blue Ridge Mountains of North Carolina, is one of the largest river-estuary ecosystems on the Eastern Seaboard. It is located 14.4 km south of the mouth of North Inlet Estuary. Winyah Bay drains the sub-basins of 6 major rivers, which are heavily impacted by agriculture, mining, and industry. The rivers drain approximately 46,736 km2 of uplands and marshes.	The Clambank Creek monitoring site is located roughly in the center of the NIW reserve. The site is surrounded by a Spartina marsh and drains associated uplands. Salinity ranges from 0 to 36. The bottom is mostly comprised of oyster shell hash and some fine sediment. This site is considered pristine and is influenced by its close proximity to the Inlet mouth.	The Debidue Creek monitoring site is located in an ocean-dominated Spartina marsh that was formerly surrounded by pine-dominated uplands. The site is approximately 1 km south of the Debordieu Colony, a large development built on man-made canals that drain into the northern portion of Debidue Creek, and as a result, may be considered an impacted site. Salinity can range from 0 to 36 parts per thousand and average tidal flux is approximately 2 meters. The creek has an average depth of 2.2 m MHW and an average width of 70 m MHW at the sample site. The bottom is mostly comprised of oyster shell hash with some fine sediment and detritus.	The Oyster Landing monitoring site is considered a fairly pristine and undisturbed area. Samples are collected at the end of the Oyster Landing pier from the floating dock, which is adjacent to the location of the NIW NERR weather station. The pier stretches into the upper reaches of Crab Haul Creek in the mid-western portion of North Inlet and is approximately 2.8 km from the headwaters of Crab Haul Creek. The creek drains pine forested uplands and wetlands. Salinity can range from 0 to 36 parts per thousand and average tidal flux is approximately 1.4 m. The creek has an average depth of ~2 m MHW and an average width of ~150m MHW at the sample site. The bottom is mostly comprised of oyster shell hash with some fine sediment and detritus.	The Thousand Acre monitoring site is located in Thousand Acre marsh tidal creek, near the creek mouth. Prior to 7/19/1999, the sampling location was approximately 30 meters northeast of the west bridge of Thousand Acre marsh. Heavy siltation near the creek bank caused inaccurate measurements at this original site and, on 7/19/1999, the sampling location was moved and samples were collected at the NW corner of the west bridge, about 15 meters from the mouth of the creek. At this new location, creek depth is approximately 2 meters MHW and creek width is approximately 10 meters. The creek empties into the northeastern side of the midportion of Winyah Bay and drains the Thousand Acre Marsh and surrounding pine forested uplands and vegetated wetlands. Salinity ranges from 0 to 26 parts per thousand and tidal flux is approximately 1meter. The bottom is mostly composed of fine sediments and detritus. Georgetown, the homeport for a number of heavy industries, including a steel plant, paper mill, chemical plant, and a coal fired plant. Most are located on the southern side of Winyah Bay, 5 km upstream from the Thousand Acre site. A public sewage treatment plant, which discharges into the bay, is also located in Georgetown.
Location Bounding Box					
West Bounding Coordinate					
East Bounding Coordinate					
North Bounding Coordinate					
South Bounding Coordinate					
OR if single point location					
Latitude		33.3339	33.3603	33.3494	33.2992
Longitude		-79.193	-79.1681	-79.1928	-79.26
Elevation					
TAXONOMIC COVERAGE:					
Taxonomic Protocols					
Organisms studied					

KEYWORD INFORMATION

KEYWORDS: ammonia, chemistry, chlorophyll a, coastal, carbon, dissolved organic carbon, ecosystems, estuarine, estuary, inorganic suspended solids, lter, long-term ecological research, long-term, sediments, water chemistry, tidal creek, marsh, nitrate, nitrite, nutrient chemistry, nutrient cycling, nitrogen, organic suspended sediment, ortho phosphate, particulate organic carbon, phosphate, phosphorus, salinity, salt marsh, sediments, suspended sediments, swamp, tidal creek, tidal elevations, tide, total suspended solids, turbidity, volatile suspended solids, water chemistry, water quality, sediment color, water color, clambank creek, coastal, crab haul creek, debidue creek, debordieu colony, east coast, georgetown county, north inlet, north inlet-winyah bay nerr, south carolina, town creek, clambank creek, oyster landing, crab haul creek, east coast, southeast coast, thousand acre marsh, thousand acree marsh tidal creek, thousand acre rice field, winyah bay, water column, surface waters

ABSTRACT:

Abstract:
A one 1000 ml (one Liter) water sample was collected every 20 days at 2 hour and 4 minute intervals for 2 complete tidal cycles (26 hours) with an ISCO automated water sampler at a depth of 0.5 meters below the water's surface. The water samples were brought into the lab and analyzed for salinity, chlorophyll a, nitrogen (total whole and dissolved, ammonia, and nitrate-nitrite), phosphorus (total and dissolved and ortho phosphate), dissolved organic carbon, suspended sediment (total suspended sediment, inorganic suspended sediment, organic suspended sediment), and suspended sediment color. Tide stage based on published NOAA tide charts for each sample were also included in the database. Samples were simultaneously collected from three of the four sample sites. Three sites are located in salt marsh tidal creeks found in the North Inlet Estuary. These samples are taken at the end of Oyster Landing dock (OL) in Crab Haul Creek, the upper reaches of Debidue Creek (DC) near the boundary between Hobcaw Barony and the Debordieu Colony, and Clambank Landing Dock (CB) in Clambank Creek. The other site is located adjacent to the Winyah Bay Estuary. The Thousand Acre (TA) samples are taken near the mouth of a small tidal creek that connects the Thousand Acre Marsh to Winyah Bay. For more information on the sample sites, see the Description of Geographic Extent Section.

Purpose:
The NERR 20 day water chemistry (NERRWCHEM) database is essentially a continuation of the Long-Term Ecological Research Daily Water Sample 1978-1993 (LTERDWS) database whose purpose was to monitor nutrient cycling in the North Inlet Estuary, Georgetown, SC (see Cross Reference Section). The NERR 20 day water chemistry program was initiated in June of 1993 to continue the monitoring of nutrients in the North Inlet Estuary systemand also to continue the long-term database on the nutrient concentration dynamics of the North Inlet salt marsh estuarine system. Because the LTERDWS water sampling collections were taken every day at 10:00am EST, it was determined that the nutrient data are biased for Spring high tides; not all tides levels would be represented. The new NERRWCHEM sampling protocols (based on a 10 day cycle) sample all tidal stages over the years. A larger purpose of this monitoring program is to combine the water chemistry, chlorophyll a, and suspended sediment monitoring data with other existing North Inlet ecological monitoring data to provide ecosystem level information and understanding.

METHODS:

Field Collection Procedures and Protocols (Overall Field Collection Protocol)
1000 ml (one Liter) samples were collected every 20 days at 2 hour and 4 minute intervals, for 2 complete tidal cycles (26 hours), with an ISCO automated water sampler at a depth of 0.5 meters below the water's surface. Because the LTERDWS water sampling collections were taken every day at 10:00am EST, it was determined that the nutrient data were biased for Spring high tides; not all tides levels would be represented. "The complex interaction of a daily temporally fixed sampling design with seasonal, tidal, and diurnal cycles can result in serious aliasing and reduced usefulness of estuarine data" (Hutchinson and Sklar, 1993). The new NERRWCHEM sampling protocols "takes into account both solar and lunar influences and their interactions in order to represent actual estuarine conditions". It was determined that a 10 day sampling cycle (or multiples of 10) would represent all tidal stages when run over the years. A 20-day schedule was selected for the NERRWCHEM project because if a 10-day interval was chosen, the water technician could not process all the sites samples in a timely fashion, and a 30 day schedule did not produce enough data points for the year.

Justification for use of the autosampler technique can be found in the 1992 Calibration Study Ancillary Data. {During this study comparisons were made between the water chemistry results obtained from the LTER DWS and the proposed NERRWCHEM sampling protocols. There were no significant differences observed between the two methods, except for an increase in sediment load found in the autosampler samples.} In the NERRWCHEM: all sampling periods start and end at low tide. The start times for sites located in the North Inlet Estuary are the predicted low tide times (EST) from the NOAA tide chart for Charleston, South Carolina. The start times for the Winyah Bay site (TA) are the predicted low tide times from the tide chart plus one hour and 30 minutes (the calculated lag time between North Inlet and Thousand Acre based on water quality data logger water level data). Sampling sites included Oyster Landing (OL), Thousand Acre (TA), Clambank Creek (CB), and Debidue Creek (DC) over the course of the database (see the Description of Geographic Extent section for more information on the sample

Laboratory Procedures and Protocols (Overall Laboratory Protocol)
Samples were generally processed within a 48 hours of collection. Salinity values were determined using a hand-held refractometer in the laboratory. Seventy-five to 500 ml of the water samples were filtered through a preweighed, precombusted Whatman GFF 0.7 micrometer (nominal pore size) glass fiber filter to separate the particulates from the dissolved portion of the sample. Samples were shaken before filtering began; the amount of water filtered was determined by how much sediment and other solids were in the sample. During the winter, in the absence of phytoplankton blooms and when sedimentation was low, up to 500 ml of sample were filtered. During the summer, especially after periods of heavy rains, it wasn't possible to filter such a large volume. The determining factor in the amount of water filtered was the amount necessary to obtain a good sample of suspended solids on the filter, in order to get beyond the minimum detection limits of the TSS analysis.

The filtered aliquots for TNF, TPF, NN, OP, and NH4, and non-filtered aliquots (or what remained on the 0.7 micrometer filter) for TNW and TPW, were analyzed with a Technicon AutoAnalyzer. Filtered aliquots were also used for DOC analysis with a Shimadzu Carbon Analyzer. Non-filtered samples were used in the Sequoia-Turner Fluorometer for chlorophyll a analysis and for the TSS, ISS, and OSS analyses.

The Technicon and the Carbon Analyzer produced output printouts with raw nutrient value concentrations and DOC values. With the Technicon model used for this database, there were no peak heights (as there were for the LTERDWS database); the technicon converted the peak heights directly into a nutrient concentration. Results from all other analyses were recorded by hand.

Laboratory Procedures and Protocols (Total Nitrogen - Total Phosphorus (TNW, TNF, TPW, TPF)
Non-filtered water samples were used in the procedure to determine TNW and TPW concentrations. The filtrate (less than 0.7 micrometers) was used in the procedure to determine the TNF and TPF concentrations. The TN & TP method is a combination of two methods listed below, but in general the procedure consists of an alkaline persulfate oxidation followed by automated analysis for nitrogen (as nitrate) and phosphorus (as phosphate) on a Technicon AutoAnalyzer. Oxidation reagent blanks (ORB) are run with each batch of persulfate digestion reagents.

With alkaline persulfate digestion, all nitrogen in the sample was oxidized to nitrate, which was then reduced by cadmium and analyzed as nitrite. The precision and recovery of this method compared favorably with a Kjeldahl procedure (D'Elia et al., 1977). The main advantage of the persulfate oxidation is the speed and convenience with which it was accomplished. Unlike the Kjeldahl method, which recovered only organic and NH4 - nitrogen, the persulfate oxidation also included NO3 and NO2 nitrogen.

This semi-automated procedure combines the persulfate oxidation with automated nitrate and phosphate analysis to provide simultaneous analysis for total persulfate nitrogen (TPN) and total persulfate phosphorus (TTP) (Glibert et al., 1977). Glibert's procedure has been further modified to use smaller sample sizes, so that the digestion flask can double as the sampler tray cup (Loder 1978). With this method, many samples can be run quickly with a minimum of handling.

Laboratory Procedures and Protocols (Dissolved Organic Carbon (DOC))
Water samples are filtered through a precombusted (24 hr at 450 degrees C) Whatman GFF 0.7 micrometer glass fiber filter. The filtrate samples are purged of inorganic carbon by adding 10 percent Hydrochloric Acid and sparged with ultra zero grade air. A 40 microliter aliquot is injected, via an autosampler, into a Shimadzu TOC-500 Organic Carbon Analyzer. A nondispersive infrared gas analyzer is utilized to measure the carbon dioxide produced and samples are run in triplicate with means reported.

Laboratory Procedures and Protocols (Ortho phosphate (OP))
The filtrate (<0.7 µm) was used in the procedure to determine the OP concentration. The basic method was the Technicon Industrial Method No. 155-71W (1973), which was a modification of the Murphy and Riley (1962) single solution method. The method depended on the formation of a phospomolybdate blue complex, the color of which is read at a wavelength of 880 nanometers.

Laboratory Procedures and Protocols (Nitrite-Nitrite)
The filtrate (less than 0.7 micrometers) was used in the procedure to determine the NN concentration. The basic method was Technicon Industrial Method No. 158-71W/B, which utilizes the reaction in which nitrate was reduced to nitrite by a copper-cadmium reductor column. The nitrite ion then reacted with sulfanilamide under acidic conditions to form a diazo compound. This compound then coupled with N-1-napthylethylenediamine dihydrochloride to form a reddish-purple azo dye.

Laboratory Procedures and Protocols (Ammonia (NH4))
The filtrate (<0.7 micrometer) was used in the procedure to determine the NH4 concentration. This method was dependent upon the Berthelot Reaction, during which the formation of a blue colored compound closely related to indophenol occurred when the solution of an ammonium salt was added to sodium phenoxide, followed by the addition of sodium hypochlorite (Glibert and Loder 1977). A solution of potassium sodium tartrate and sodium citrate was added to the sample stream to eliminate the precipitation of the hydroxides of calcium and magnesium.

Laboratory Procedures and Protocols (Total Suspended Solids (TSS))
After the water sample is well-shaken, a known volume of sample (75 to 500 milliliters depending on the sediment load) is filtered through a precombusted, preweighed Whatman GFF 0.7 micrometer glass fiber filter. (Filters are weighed on an analytical balance with four place accuracy). The filter is dried in a drying oven at low temperature (less than 50 degrees C) until a stable weight is obtained and normalized for the volume filtered.

Laboratory Procedures and Protocols (Suspended Sediment Color)
Starting in June 1988, Suspended Sediment Color was determined for each filter. After recording the weight for the dried filter for TSS above, each filter color was compared with the Munsell Soil Color Chart. When the color patch of the Munsell chart matched the color of the sediment on the filter, the color code from the Munsell Chart was written down on the sediment data sheet along with the rest of the sediment and filter weight information.

Laboratory Procedures and Protocols (Oragnic Suspended Solids (OSS))
After the weight is obtained for total suspended solids, the filters are returned to the muffle furnace and combusted at 450 degrees C for 24 hrs. Filters are reweighed and the final weight is subtracted from the total weight and normalized for the volume of water sample filtered. (Filters are weighed on an analytical balance with four place accuracy).

Laboratory Procedures and Protocols (Inorganic Suspended Solids (ISS))
Inorganic Suspended Solids (ISS) is a calculation of the oxidized weight (weight of filter and the inorganic material which would not volatilize at 450 degrees C) minus the initial precombusted filter weight. Weights are normalized for the volume of water sample filtered.

Laboratory Procedures and Protocols (Chlorophyll a (CHLA))
An appropriate amount of sample (10 or 20 milliliters) is filtered through a 2.5 centimeter, 0.7 micrometer (nominal pore size) GF/F glass fiber filter. The filter is then placed into a scintillation vial with 1 milliliter of saturated magnesium carbonate ($MgCO_3$) and frozen. Samples are removed from the freezer, 9 milliliters of 100 percent acetone are added, and then they are shaken and placed in the refrigerator for 24 hours. The samples are removed from the refrigerator, carefully shaken, and then returned to the refrigerator for an additional 24 hours. After the extraction process is complete, the samples are analyzed with a Fluorometer. Analytical range can be adjusted by changing the volume of sample filtered.

For samples collected from June 2, 1993 to December 20, 1993 a Turner Model 101 Fluorometer with a 430 nanometer filter was used. At the 430 nanometer wavelength, Phaeophytin pigments are indistinguishable from Chlorophyll pigments. As a result, while this fluorometer was in use, a total sample was run first, and then a Phaeophytin a value was obtained by adding 1.0 N Hydrochloric Acid and re-analyzing the sample. The Phaeophytin value was then subtracted from the whole to give the Chlorophyll a value.

Beginning with the January 8, 1994 sample event, a new Sequoia-Turner Model 450 Digital Fluorometer was used with a NB440 nanometer filter. This filter is specific to chl a (FO) only, therefore, it was no longer necessary to analyze Phaeophytin. Researchers attempted to use the 430 nanometer filter (which was used with the old fluorometer) for the July 27, 1994 sampling event in an attempt to return to the original protocol. It was determined that the combination of the Model 450 fluorometer, SC665 Emission filter, and 430 nanometer filter was incompatible, and the resulting data were considered suspect. See the Process Description Section for more information on equations used to determine final Chlorophyll a values for different time periods during the NERRWCHEM database.

Field Collection Procedures and Protocols of Ancillary Data ("Replicate" Sample)
In 2001, sampling protocol changed to include collection of two “duplicate” 1000 milliliter samples for each sample #13 collected. The autosampler was programmed to collect two “grab” samples at intervals of two minutes after the last sample collection time (#13). These additional samples enabled comparisons for analysis of laboratory technique accuracy, sample variation, etc. All “duplicate” samples were worked up with the rest of the “core” event samples. The additional samples are not part of the core database, but are considered ancillary data.

Feild Collection Procedures and Protocols of Ancillary Data (New NERRWCHEM vs LTERDWS sampling protocols: 1992 Calibration Study
LTER DWS samples collected over a 2-week period from 9 November to 24 November, 1992 were compared to samples collected by an autosampler which was the proposed alternative to a person collecting the water sample. The DWS protocol entailed collecting a 1000 milliliter sample by submerging a glass bottle at a depth of 0.5 meters, at approximately 10:00 am every day, and processing the sample immediately. The autosampler was programmed to sample (1000 milliliters) every 5.5 hours at the same depth and was left out for 24 hours at a time. When the DWS sample was collected, the samples from the autosampler were also removed, and the autosampler was reprogrammed to continue sampling at 5.5-hour intervals. The 5.5-hour interval was chosen because it would result in samples collected from every stage of the tide over the 2-week period (Hutchinson and Sklar, 1993). Ice was placed in the autosampler to minimize decomposition or degradation of the samples. This methodology allowed for 5 autosampler samples that were taken within 1 hour of the DWS sample to be processed immediately. An additional four-autosampler samples that were taken within 1 hour of the DWS samples were processed approximately 24 hours after the DWS samples were processed. The data from this study are not part of the core database, but are included as ancillary data. The results and recommendations of the 1992 Calibration Study are unpublished but can be found in the NERRWCHEM hardcopy notebook at the BFML computer lab. For more information on the LTER DWS methodology, please see the LTER DWS Metadata on-line at http://www.baruch.sc.edu/about-data-and-publications

Laboratory Procedures and Protocols of Ancillary Data (Suspeneded Sediment Color)
Suspended Sediment Color was also determined for each filter. After recording the weight of the dried filter for TSS, each filter color was compared with the Munsell Soil Color Chart. When the color patch on the Munsell chart matched the color of the sediment on the filter, the color code from the Munsell Chart was written down on the sediment datasheet along with the rest of the sediment and filter weight information. The data from this study are not part of the core database, but are included as ancillary data.

Field Collection Procedures and Protocols of Ancillary Data (1993. DWS vs 20 day Overlap)
In June of 1993, the NERRWCHEM 20 day sampling overlapped with the LTER DWS sampling regime. In this month both programs were in place, and data from these projects are available for use. The data from this study are not part of the core database, but are included as ancillary data.

VARIABLE DESCRIPTIONS:

Variable Name	Variable Description	Units	Measurement Scale	Code Information	Number Type

Date	the month day and year that the sample was collected, not necessarily processed or analyzed	1-12, 1-31, 1978-1993	datetime			
Site	tidal marsh creek code name within North Inlet Estuary where water sample was collected	TC, CB, OL	nominal			
Time	the time that the water sample was collected at each of the three tidal creek sites	0745 - 1345	datetime			
Total Nitrogen Whole (TNW)	T = Total (i.e. after alkaline persulfate oxidation / digestion); Second letter = element of interest (i.e. phosphorus or nitrogen); Third letter = (F or W) whether sample was from a filtrate having passed through a precombusted 0.7 micrometer GFF Whatman glass fiber filter. F = (filtered aliquot) measurements taken from a filtrate passed through a precombusted 0.7 micrometer GFF Whatman glass fiber filter. W = (whole aliquot) the measurements were taken straight from the water sample bottle and analyzed. TNW = Total Nitrogen Whole, TNF = Total Nitrogen Filtered, TPW = Total Phosphorus Whole, TPF = Total Phosphorus Filtered	0 - 140	ratio		real	
Total Nitrogen Filtered (TNF)		. -1 - 145	ratio		real	
Total Phosphorus Whole (TPW)		. -1 - 14	ratio		real	
Total Phosphorus Filtered (TPF)		. -1 - 10	ratio		real	
Ortho Phosphate (OP)	ortho phosphate levels measured from a filtered aliquot (as described above)	0.0 - 4.3	ratio		real	
Ammonia (NH4)	ammonia levels measured from a filtered aliquot (as described above)	0.0 - 31.7	ratio		real	
Nitrate/Nitirite (NN)	nitrate-nitrite levels measured from a filtered aliquot (as described above)	. -0.1 - 10.3	ratio		real	
Dissolved Organic Carbon (DOC)	dissolved organic carbon levels measured from a filtered aliquot (as described above)	0.0 - 55.6	ratio		real	
Total Suspended Solids (TSS)	total suspended sediments or solids; anything such as zooplankton, algae, sand, etc. that stays on the 0.7 micrometer GFF Whatman filter after filtering the water sample. TSS = total dried sample weight minus the filter weight divided by the volume of water sample filtered.	0.100 - 1007.00	ratio		real	
Inorganic Suspended Solids (ISS)	inorganic suspended sediments (solids); the oxidized weight minus the initial precombusted filter weight divided by the volume of water sample filtered	1.60 - 910.500	ratio		real	
Organic Suspended Solids (OSS)	organic suspended sediments (solids); = total dried sample weight - oxidized weight (weight of filter and the inorganic material which would not volatilize at 450 degrees C) divided by the volume of water sample filtered.	0.000 - 262.900	ratio		real	
Chlorophyll a (Chla a)	chlorophyll a levels measured fluorometrically.	000.1 - 114.1	ratio		real	
Salinity (SAL)	salinity measured in parts per thousand from a refractometer	0 - 40	ratio		real	
Tiide Elevation (TIDEL)	tide elevation or water depth measured from tide staffs attached to pier pilings	0.0 - 3.8	ratio	SL = slack low || FL = flood low || FH = Flood high || SH = slack high || EH = ebb high || EL = ebb low	real	