

WELLS (WEL) National Estuarine Research Reserve
Provisional Water Quality Metadata
January-December 2023
Latest Update: August 25, 2025

I. Data Set and Research Descriptors

1) Principal investigator(s) and contact persons:

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2) Entry verification –

Deployment data are uploaded from the YSI data logger to a Personal Computer (IBM compatible). Files are exported from EcoWatch in a comma-delimited format (.CDF), EcoWatch Lite in a comma separated file (CSV) or KOR Software in an Excel File (.XLS) and uploaded to the CDMO where they undergo automated primary QAQC; automated depth/level corrections for changes in barometric pressure (cDepth or cLevel parameters); and become part of the CDMO's online provisional database. All pre- and post-deployment data are removed from the file prior to upload. During primary QAQC, data are flagged if they are missing or out of sensor range. The edited file is then returned to the Reserve for secondary QAQC where it is opened in Microsoft Excel and processed using the CDMO's NERRQAQC Excel macro. The macro inserts station codes, creates metadata worksheets for flagged data and summary statistics, and graphs the data for review. It allows the user to apply QAQC flags and codes to the data, remove any overlapping deployment data, append files, and export the resulting data file for upload to the CDMO. Upload after secondary QAQC results in ingestion into the database as provisional plus data, recalculation of cDepth or cLevel parameters, and finally tertiary QAQC by the CDMO and assimilation into the CDMO's authoritative online database. Where deployment overlap occurs between files, the data produced by the newly calibrated sonde is generally accepted as being the most accurate. For more information on QAQC flags and codes, see Sections 11 and 12. Jeremy Miller was responsible for QAQC in 2023.

3) Research objectives:

The Webhannet River estuary is located in proximity to heavily used beaches in Wells, Maine. It has a shoreline that is highly developed with residential and commercial structures. The estuary receives water from a 14 sq. mi. watershed that is well forested. We are measuring variations in hydrologic variables in the

Webhannet River estuary at the Head of Tide and at the Inlet. Data from Head of Tide will integrate surface and ground water inputs (from both point and non-point sources) from the freshwater watershed into the estuary. Data from the Inlet will integrate surface and ground water inputs from the freshwater watershed and the estuarine watershed. Differences in data between the Head of Tide and the Inlet will indicate inputs from the estuarine portion of the watershed (on the ebb tide), and inputs from the Gulf of Maine on the flood tide. The instruments will track runoff events via salinity, and will measure pollutant-carrying sediment particles via turbidity. Our working hypothesis is that the freshwater watershed is the primary source of sediment and therefore potential NPS pollutants in the estuary. These two variables will indicate the potential for non-point source pollutants to enter the estuary, and whether they are of upland, estuarine, or Gulf of Maine origin. Other variables measured by the data loggers (DO, temperature, pH, specific conductivity, and water level) will provide important baseline data to track changes in the estuary's physicochemical parameters over the long term. These variables can be affected by changes in human water use, and by natural or human induced changes in Inlet and river channel morphology, climate, and organic loadings. The Inlet site is heavily impacted at the Wells Harbor dock and is our long-term monitoring site. The Head of Tide site is relatively un-impacted, located just east of the US Route One Bridge, and is our roving site. We also collect data at the Skinner Mill site (SM) which acts as the head of tide site for the Little River/Merriland river estuary and at the mouth of the Little River (LM) to have comparative data for a less developed estuary.

4) Research methods:

The Wells NERR YSI monitoring program began in April 1995 at one site (Head of Tide site-HT) and May 1995 at a second site (Inlet site-IN) in the Webhannet River estuary. Two additional sites were added in 2002, Mile Road (ML) site began in March in the Webhannet River estuary and Little River Mouth (LM) in April in the Merriland/Branch/Little River Estuary. For 2004, the Mile Road (ML) site was eliminated and a new site at Skinner Mill (SM) in the Merriland/Branch/Little River Estuary was added. All data loggers have 1/4 inch black vexas mesh wrapped on the outside of the probe protective housing (using rubber bands) of the sonde guard to prevent fouling and unwanted animals. All deployment structures (PVC tubes) described below, are labeled with the Wells NERR information.

A Sutron Sat-Link2 transmitter was installed at the Skinner Mill (welsmwq) station on 5/30/2006 and transmits data to the NOAA GOES satellite, NESDIS ID #3B035008. The transmissions are scheduled hourly and contain four (4) data sets reflecting fifteen minute data sampling intervals. Upon receipt by the CDMO, the data undergoes the same automated primary QAQC process detailed in Section 2 above. The "real-time" telemetry data become part of the provisional dataset until undergoing secondary and tertiary QAQC and assimilation in the CDMO's authoritative online database. Provisional and authoritative data are available at <http://cdmo.baruch.sc.edu>.

A YSI/Xylem STORM telemetry system was installed at the Inlet (welinq) station on 01/15/2014 and transmits data to the NOAA GOES satellite, NESDIS ID #3B04A2B8. The transmissions are scheduled hourly and contain four (4) data sets reflecting fifteen minute data sampling intervals. Upon receipt by the CDMO, the data undergoes the same automated primary QAQC process detailed in Section 2 above. The "real-time" telemetry data become part of the provisional dataset until undergoing secondary and tertiary QAQC and assimilation in the CDMO's authoritative online database. Provisional and authoritative data are available at <http://cdmo.baruch.sc.edu>.

***IMPORTANT CHANGE TO ALL SITES:** In 2004, the YSI Extended Deployment System was used for all deployments. This system consists of a small brush that sweeps all the probes (except for depth) prior to each reading, greatly reducing the problem of biofouling. The Extended Deployment System is reflected in the "EDS" in the sonde model number.

***IMPORTANT CHANGE TO ALL SITES:** As of 2014 all sites were upgraded to the EXO2 datasondes and the use of 6600 series sondes for SWMP data collection was discontinued.

*** IMPORTANT CHANGE TO THE SKINNER (SM) SITE:**

On 5/30/2006 the location of the Skinner Mill (SM) was changed to better reflect a head of tide and head of estuary scenario. The site was moved approximately 100 meters downstream from the original site described in 2004-5 metadata. In addition, a Sutron Sat-Link2 transmitter was installed at this station, and transmits data to the NOAA GOES satellite, NESDIS ID #3B035008. The transmissions are scheduled hourly and contain four (4) datasets reflecting fifteen-minute data sampling intervals. The telemetry data is "Provisional" data and not the "Authentic" dataset used for long term monitoring and study. This data can be viewed by going to <http://cdmo.baruch.sc.edu>."

*** IMPORTANT INFORMATION PERTAINING TO THE INLET (IN) SITE:**

The Inlet site (IN) deployment methods are different than the other sites (SM, HT, LM). A 23 foot, 4 inch diameter high grade PVC tube was installed against a dock piling. Four steel flat bars with bolts were used to attach this 23 foot PVC tube against the dock piling. A stainless steel bolt was inserted through the bottom of the PVC tube to allow the sonde to sit exactly 1.0 meter (3.28 ft) from the bottom, and to increase vertical stability of the depth sensor. Several vertical holes, representative of the sonde guard, were cut out the circumference near the bottom of the PVC pipe to allow water flow to the probes. An "L" shaped steel bar with two end-holes is placed through two created slits about a half of foot from the top of the PVC tube. A stainless steel wire (1/16") is attached to the sonde bail using two stainless steel clips; and to one end of the "L" shaped steel bar for sonde deployment and retrieval. A marine lock is attached through the other end of the "L" shaped steel bar to hold the bar, wire, and sonde in place and for security.

All other sites, Head of Tide (HT), Little River Mouth (LM), and Skinner Mill (SM) are deployed similarly to each other as of 5/30/2006. These sites use a 5 foot, 4 inch diameter, high grade PVC tube. The PVC tube is attached to a 12 foot, heavy steel sign post using a stainless steel bolt at the bottom of the tube, a stainless steel cable wrap at the top, and several thick electrical cable ties in between. The steel signpost was pounded in about 6 feet into the river bottom, such that the bottom of the PVC tube was flat on the river bottom. The PVC tube has one 3 by 1.5 inch PVC transducer glued on the inside bottom of the PVC tube to allow the sonde to sit exactly at a certain height off the bottom (see below). Several vertical holes, representative of the sonde guard, were cut out the circumference near the bottom of the PVC pipe to allow water flow to the probes. An "L" shaped steel bar with two end-holes is placed through two created slits about a half of foot from the top of the PVC tube. A stainless-steel wire (1/16") is attached to the sonde bail using two stainless steel clips; and to one end of the "L" shaped steel bar for sonde deployment and retrieval. A marine lock is attached through the other end of the "L" shaped steel bar to hold the bar, wire, and sonde in place and for security. A flotation buoy is tied to the PVC tubes incase the deployment structure ever gets dislodged. The deployment depth for these sites is such that the probe-end of the data logger is secured 0.15 meters (6 inches) off the bottom.

The Head of Tide (HT) and Inlet (IN) sites report level (m). A sensor offset is entered during pre-deployment calibration to enable depth data to be referenced to the North American Vertical Datum of 1988. The height of a vertical reference point (VRP) on the station is measured annually relative to a nearby geodetic benchmark using survey grade equipment. A sensor offset is then measured as the distance from the VRP to the height of the depth sensor with the sonde resting on the bottom bolt of the well. The sensor offset is then subtracted from the orthometric height of the VRP to calculate the station offset used during calibration. See Section 14) Other Remarks/Notes for more information about station offsets. Information on physical infrastructure, survey methods, and benchmarks is included in the table below.

Site Name	Head of Tide (HT)	Inlet (IN)
Infrastructure Description	Schedule 40 PVC pipe was mounted to the US Highway One Bridge Abutment at the head of tide of the Webhannet river, using custom made stainless steel clamps and brackets which were drilled and anchored into the concrete abutment.	Schedule 40 PVC pipe was mounted to a large dock piling at Wells Harbor at the mouth of the Webhannet river, using custom made stainless steel clamps and brackets which were drilled and anchored into the piling.
Surveying Equipment	Digital Barcoding Level	Total Station. Digital Level
Equipment Model	Leica 1205 TPS, Leica Sprinter 150m	Leica 1205 TPS, Leica Sprinter 150m
Equipment Accuracy	5", 0.002 mm/100 m, 1.5mm	5", 0.002 mm/100 m 1.5 mm
Equipment Target	Leica Aluminum Telescoping Barcode Staff	Leica Aluminum Telescoping Barcode Staff
Survey Mount Used (benchmark)	HT32	9317 C
Survey Mount Description (benchmark)	Watermain access pipe	NOAA Tidal Benchmark
Survey Occupation Date (benchmark)	4/24/2019	THIS BENCHMARK MAINTAINED BY NOAA Survey metadata is not available.
Survey Occupation Duration (benchmark)	3:49:00	NA
Ellipsoid Height (benchmark)	-22.541 m	NA
Vertical RMS (benchmark)	0.047 m	NA
Reference Frame (benchmark)	NAD83(2011) @ 2010.000	NA
"Quick Check" marker for deployment tube (Done at beginning of each deployment)	Permanent Marker (industrial sharpie) and "physical mark" where tube meets brackets.	Permanent Marker (industrial sharpie) and "physical mark" where tube meets brackets.
"Quick Check" for sonde being deployed at the same location (Done at beginning of each deployment)	Bolt at bottom of tube and mark on deployment rope.	Bolt at bottom of tube and mark on deployment rope.
Annual resurveying of VRP (include dates of surveys)	4/17/2019, 8/25/2020, 4/8/2021, 5/20/2022	4/11/2019. 7/2/2020, 4/8/2021, 5/20/2022

Deployment and Data Intervals:

Four to five week variable sampling periods were chosen for all data sondes due to probe fouling, Sensor drift, limited battery power, and to minimize risk of lost data in the event of a malfunction. Measurements of temperature, specific conductivity, salinity, percent saturation, dissolved oxygen, depth, pH, and turbidity are recorded at 15 minute intervals throughout the deployment period.

Calibration and Standards Used:

After the deployment period, the data logger is brought back into the Wells NERR Laboratory for downloading, cleaning, and calibration. These procedures are carried out to the methods described in the YSI Operating Manual. Calibration standards are used for specific conductivity (10 mS/cm), pH (buffer solutions of pH 4, 7, and 10), and turbidity (126 NTU). All calibration standards are purchased from YSI. Conductivity and turbidity standards are purchased from YSI, Inc. During periods when we have an idle YSI logger, the deployments are continuous (retrieved logger is immediately swapped with a newly deployed logger). If no idle logger is available (for example, it is away for repair), after approximately 6-24 hours of down time for cleaning, maintenance and recalibration, the YSI Data logger is redeployed for another sampling period.

QA/QC of Instruments:

At each deployment and retrieval, a YSI Model PRO2030 handheld unit collects temperature, DO mg/L, DO %, and salinity. These parameters are recorded on the calibration/deployment/retrieval data sheets and compared to the sonde data. In addition, at the end of each deployment, the data is immediately downloaded and a graph viewed of the data to look for periods of missing or anomalous data. "Post-calibration" data (using calibration standards) are also recorded, to verify that the probes are still measuring accurately after retrieval. Wells NERR staff follows all post-deployment procedures outlined in the CDMO's Water Quality Monitoring SOP.

5) 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 back barrier 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 back barrier 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 on the general climatology of Maine was taken from the “NOAA National Centers for Environmental Information; State Climate Summaries 2022)

(<https://statesummaries.ncics.org/chapter/me/>)

Maine is located on the eastern margin of the North American continent. Its northerly latitude and geographic location expose the state to both the moderating and moistening influence of the Atlantic Ocean and the effects of hot and cold air masses from the interior of the continent. Maine is also located within the primary storm track of the mid-latitudes. Maine’s climate is characterized by cold, snowy winters and mild summers. Winter average temperatures range from 25°F in the far south to less than 15°F in the northern and interior portions of the state. Summer average temperatures range from near 60°F in the far north to near 70°F in the south. Maine is approximately 90% forested and has more than 3,500 miles of coastline, making forestry, fishery, hunting and fishing, tourism, and ecosystem services all sensitive to a changing climate.

Temperatures in Maine have risen almost 3.5°F since the beginning of the 20th century. Since the mid-1990s, the amount of winter warming has been approximately twice that of summer warming, with persistently above average temperatures occurring since the 1990s. Winter warming is reflected in the number of very cold nights, which has been below average since the late 1990s. However, the number of hot days has not increased. Winter warming has resulted in earlier lake ice-out dates. On Damariscotta Lake, the average ice-out date during the mid-20th century was mid- to late April; it is now early April. The growing season has also lengthened.

Total annual precipitation in Maine reached a historically high multiyear average during the 2005–2009 period. In the harsh winter months, average accumulated snowfall ranges from 40 to 80 inches across the Southern Interior and Northern Interior climate divisions, with the northern tip of the state receiving up to 100 inches. The annual number of 2-inch extreme precipitation events has varied over the period of record, but the 10-year interval from 2005 to 2014 had a record number (nearly double the long-term average, similar to the rest of the northeastern United States. Maine has also been experiencing more short-term dry periods, with extreme drought occurring in 2002, 2016, and 2020. Drought conditions in 2020 contributed to more than 900 wildfires, the most Maine has seen in a decade.

Heat and cold waves, droughts, severe rainstorms, nor’easters, ice storms, and tornadoes are all part of Maine’s normal climate. In general, nor’easters cause more disruption than any other type of extreme weather. Nor’easters are cold-season coastal storms that can generate a tremendous amount of precipitation (in the form of snow, sleet, or freezing rain), strong winds, coastal flooding, and damage to infrastructure. Observed wind speeds from nor’easters are commonly equal to or greater than those from hurricanes that have reached Maine. Nor’easters are prevalent in most years in winter, spring, and fall, while landfalling hurricanes are very rare. Since 1861, only 3 hurricanes have reached Maine with hurricane-force winds, the last being Gloria in 1985. Since 2007, weather-related disasters have been declared in every county in Maine.

There are two sampling sites in the Webhannet River estuary. These are located at the Head of Tide (HT) and at the Webhannet Harbor Inlet (IN). The tidal range at each of these sites is 2.6-2.9 meters.

The Head of Tide site (43 deg 17' 54.05" North, 70 deg 35' 13.54" West) is located 4 miles south of the Wells Reserve, just downstream of the Webhannet Falls (freshwater) and 10 feet east of U.S. Route One. U.S. Route One is used heavily by 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. Depth at mean

high water is 1.1 meters. Max and min measured depths are 0.2 to 1.6 meters, giving a max tidal range of 1.4 meters. 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 U.S. Route One bridge, and is our roving site.

The Inlet site is located 1.5 miles south of the Wells Reserve, at the Wells Harbor pier (43 deg 19' 12.32" North, and 70 deg 33' 48.39" West). 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. Max and min measured depths at the Inlet site are 1.2 to 5.9 meters, giving a max tidal range of 4.7 meters. The maximum depth of the Inlet site is 6.8 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 Skinner Mill (SM) site is located approximately 100 meters downstream from the intersection of the Merriland River (tributary to Merriland/Branch/Little River estuary) and Skinner Mill Road (at 43 deg 20' 40.96" north and 70 deg 32' 57.18" West). This site is approximately 70 meters downstream from the Watershed Evaluation Team (Educational water quality program at Wells NERR) site L5. Substrate is mud/sand bottom, salinities range from 0 ppt on low or outgoing tides and as high as 27ppt on high tides. Max and min measured depths are 0.1 to 1.9 meters, giving a max tidal range of 1.8 meters. Depth at mean high water is 1.3 meters. Data prior to 5/30/2006 is from the original SM site located approximately 70 meters upstream from the current site, which is approximately 20-30 meters beyond the head of the estuary where mixing between fresh and marine waters occur. Please see the 2005 Water quality metadata for a better description of the original site.

The Little River Mouth site is located 0.4 miles from the Wells Reserve. Due to problems with heavy sediment movement in the Inlet of the Little River, we were forced to relocate the site (see 2002 metadata). We designated a new location for the 2003 sampling season, and it has remained since then. It is located just off the bank of the marsh, in the main channel of the river (43 deg 20' 24.55" North, and 70 deg 32' 26.17" West). The first location attempted in 2002 (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 attempted in 2002 (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. Max and min measured depths at this site are 0.3 to 2.4 meters, giving a max tidal range of 2.1 meters. The Little River sites exist 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.

SWMP Station Timeline

Station Code	SWMP Status	Station Name	Location	Active Dates	Reason Decommissioned	Notes
welhtwq	P	Head of Tide	43° 17' 54.05 N, 70° 35' 13.54 W	04/01/1995 00:00 - current	NA	NA
welinwq	P	Inlet	43° 19' 12.32 N, 70° 33' 48.39 W	05/01/1995 00:00 - current	NA	NA

wellmwq	P	Little River Mouth	43° 20' 24.55 N, 70° 32' 26.17 W	04/01/2002 00:00 - current	NA	NA
welsmwq	P	Skinner Mill	43° 20' 40.96 N, 70° 32' 57.18 W	04/01/2004 00:00 – current	NA	NA
weldnwq	P	Drake Island Downstream	43° 19' 44.04 N, 70° 33' 37.08 W	04/01/1996 00:00 - 12/01/1997 00:00	Moved to other WEL projects	The Wells NERR two Drakes Island sites were monitored after 1997 for another project (CICEET-Wells Harbor dredge); they were no longer collecting the dissolved oxygen, percent saturation, and pH parameters.
welmlwq	P	Mile Road	43° 18' 18.00 N, 70° 34' 35.04 W	03/01/2002 00:00 - 12/01/2003 00:00	Unknown	No information available
welupwq	P	Drake Island Upstream	43° 19' 50.16 N, 70° 33' 25.92 W	04/01/1996 00:00 - 12/01/1997 00:00	Moved to other WEL projects	The Wells NERR two Drakes Island sites were monitored after 1997 for another project (CICEET-Wells Harbor dredge); they were no longer collecting the dissolved oxygen, percent saturation, and pH parameters.

6) Data collection period – Included in Annual document

HT:

Deploy Date	Deploy Time	Retrieve date	Retrieve Time
3/28/2023	11:45	4/20/2023	11:00
4/20/2023	11:15	5/11/2023	10:15
5/11/2023	10:30	6/6/2023	12:15
6/6/2023	12:45	7/6/2023	9:30
7/6/2023	9:45	8/4/2023	12:00
8/4/2023	12:15	8/28/2023	11:00
8/28/2023	11:15	9/26/2023	14:15
9/26/2023	14:30	10/25/2023	10:30
10/25/2023	10:45	11/13/2023	10:15

11/13/2023	10:45	12/21/2023	13:00
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IN:

DEPLOY DATE	DEPLOY TIME	RETRIEVE DATE	RETRIEVE TIME
11/23/2022	12:15	1/3/2023	13:00
1/3/2023	13:15	1/30/2023	13:30
1/30/2023	13:45	3/2/2023	14:00
3/2/2023	14:15	4/4/2023	11:00
4/4/2023	11:30	5/10/2023	14:15
5/10/2023	14:45	6/15/2023	12:45
6/15/2023	13:00	7/13/2023	12:30
7/13/2023	12:45	8/14/2023	12:30
8/14/2023	12:45	9/7/2023	12:15
10/13/2023	12:15	10/31/2023	11:45
10/31/2023	12:00	11/30/2023	13:15
11/30/2023	13:30	1/4/2024	11:30

LM:

DEPLOY DATE	DEPLOY TIME	RETRIEVE DATE	RETRIEVE TIME
3/29/2023	13:45	4/24/2023	10:15
4/24/2023	10:30	5/22/2023	09:15
5/22/2023	0930	6/20/2023	09:15
6/20/2023	09:30	7/26/2023	13:45
7/26/2023	14:00	8/23/2023	10:15
8/23/2023	10:45	9/20/2023	10:30
9/20/2023	10:45	10/19/2023	09:45
10/19/2023	10:00	11/14/2023	08:30
11/14/2023	08:45	12/07/2023	15:30

SM:

DEPLOY DATE	DEPLOY TIME	RETRIEVE DATE	RETRIEVE TIME
3/31/2023	14:15	4/28/2023	12:30
4/28/2023	12:45	6/8/2023	10:45
6/8/2023	11:00	7/20/2023	11:30
7/20/2023	11:45	8/22/2023	10:15
8/22/2023	10:30	9/27/2023	12:15
9/27/2023	12:30	10/25/2023	09:30
10/25/2023	10:00	12/6/2023	10:30

7) Distribution –

NOAA retains the right to analyze, synthesize and publish summaries of the NERRS System-wide Monitoring Program data. The NERRS retains the right to be fully credited for having collected and processed the data. Following academic courtesy standards, the NERR site where the data were collected should be contacted and fully acknowledged in any subsequent publications in which any part of the data are used. 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.

Requested citation format:

NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data accessed from the NOAA NERRS Centralized Data Management Office website: <http://www.nerrsdata.org/>; accessed 12 October 2023.

NERR water quality data and metadata can be obtained from the Research Coordinator at the individual NERR site (please see 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 www.nerrsdata.org. Data are available in comma delimited format.

8) Associated researchers and projects

Please visit our website: www.wellsreserve.org/research.htm for further information on the Wells NERR research program and for specific research projects and reports.

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 2016 many different studies involving scores of scientists, students, staff and volunteers 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, 5) restoration of salt marsh habitat degraded through human actions, and 6) understanding the ecology and functions of salt marsh habitat.

NERRS SWMP Program

As part of the SWMP long-term monitoring program, WEL NERR also monitors meteorological and nutrient/chlorophyll data which may be correlated with this water quality dataset. These data are available from the Research Coordinator or online at <http://cdmo.baruch.sc.edu/>.

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).

Monitoring tracks changes in the composition/phenology of larval fishes & invertebrates

The Research Associate and SWMP Coordinator will continue to conduct plankton monitoring at Wells Harbor (SWMP station; welinwq) four times monthly to better understand the community composition, diversity, long-term temporal dynamics, and phenology of ichthyoplankton and invertebrate assemblages within the Webhannet River Estuary. The SWMP Coordinator and Research Associate will oversee a core group of interns and volunteers who will help support these efforts by conducting sampling in the field, and sorting samples in the laboratory. We have expanded our laboratory processing to include separation and identification of all crab larvae to 1) inform our existing work investigating decapod ecology in estuarine systems; 2) improve our understanding of seasonal patterns of crab spawning in Gulf of Maine estuaries; and 3) monitor the arrival of invasive or range expanding species such as the Blue crab (*Callinectes sapidus*).

Related to this, the SWMP Coordinator and Research Director have begun to integrate SWMP data into a community meta-analysis to better understand the impacts of environmental drivers on fish and crab community structure. The Reserve will work with individuals from NOAA's Southwest Fisheries Science Center and Gulf of Maine Research Institute to bring associated monitoring data into the forefront of the peer-reviewed literature and to expand our efforts to understand shifts in larval fish community dynamics in a rapidly warming Gulf of Maine. The Research Director and SWMP Coordinator will continue to pursue the development of a larger manuscript for peer review and publication, describing changes in the phenology and distribution of larval fishes in the Webhannet River Estuary. This continued work will improve upon our techniques for documenting and reporting changes in both fish and invertebrate larval assemblages in our system.

Monitoring the range expansion of blue crabs (*Callinectes sapidus*) into the Gulf of Maine

The blue crab (*Callinectes sapidus*) has been documented in salt marsh pools in the Webhannet and Little River estuaries at the Wells Reserve since 2020, as well as other locations in the northern New England region, indicating a range expansion of this species into the Gulf of Maine. We will monitor seasonal and spatial dynamics of blue crabs (and opportunistically other potential marsh crab species) that includes their spatio-temporal distribution in our estuarine systems by fishing a series of blue crab traps across a gradient of estuarine and salt marsh habitats in the Little River and Webhannet Estuaries. We will engage interns and volunteers to help monitor weekly changes in catch (CPUE), size distribution, sex ratio, and habitat usage over time (April-November). As opportunities arise, and through the facilitation of the newly-formed Gulf of Maine Blue Crab Network (led by Wells NERR), we will collaborate with other researchers in the New England region to catalyze expanded monitoring of this recent range expander and research into its impacts on Gulf of Maine ecosystems. Combined, these efforts will provide valuable information regarding the distribution, population dynamics, and impacts of blue crabs within this new expanded range.

Improving Business Practices to Reduce Mortality in the Lobster Supply Chain:

After being captured, lobsters (*Homarus americanus*) undergo several rounds of handling and processing prior to reaching consumers. Estimates suggest 3-5% of lobsters do not survive this process; this "shrink" in the supply

chain results in tens of millions of dollars of lost revenue annually. This project aims to understand where in the supply chain lobster stress and mortality is greatest, as well as identifying specific causal factors (storage in warm water, rough handling, air exposure, etc.) which could be addressed to reduce lobster mortality. To do this, we are building novel sensor packages capable of monitoring the environmental and handling conditions lobsters are exposed to from the trap all the way to the dealer, and simultaneously measuring lobster viability using heart rate dataloggers coupled with lobster health assessments. The University of Maine is the primary recipient of the grant, but other partners include Saint Joseph's College of Maine and several industry partners. PIs: Ben Gutzler & Jason Goldstein. Funding from NOAA Saltonstall-Kennedy Fisheries Program.

Marine Invader Monitoring and Information Collaborative (MIMIC):

Researcher Associate at the Wells NERR act as State Coordinator for groups of citizen scientist who monitor 12 sites in coastal southern Maine for marine invasive species. Data has been being collected on the presence and absence, and general abundance of 23 priority species as identified by the Massachusetts Office of Coastal Zone Management and MIT SeaGrant.

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.

*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, impacts of the invasive green Crab on salt marsh communities, and the ecology of Lyme disease.

II. Physical Structure Descriptors

9) Sensor specifications –

WEL NERR deployed EXO2 datasondes only during 2023 at all 4 monitoring locations.

Sequence of EXO2 dataloggers:

date, time, temperature, specific conductivity, salinity, dissolved oxygen %, dissolved oxygen mg/L, Depth (in meters) or level, pH, turbidity, Chl_a*, and battery voltage.

*(collected at IN site only)

The following specifications for EXO2 data sondes and probes were taken from the EXO manual.

YSI EXO2 probe specifications:

Parameter: Temperature

Units: Celsius (C)

Sensor Type: Thermistor

Model#: 599870-01

Range: -5 to 50 C

Accuracy: -5 to 35: +/- 0.01, 35 to 50: +/- .005

Resolution: 0.01 C

Parameter: Conductivity

Units: milli-Siemens per cm (mS/cm)

Sensor Type: 4-electrode cell with auto ranging

Model#: 599870-01

Range: 0 to 200 mS/cm

Accuracy: 0 to 100: +/- 0.5% of reading or 0.001 mS/cm; 100 to 200: +/- 1% of reading

Resolution: 0.001 mS/cm to 0.1 mS/cm (range dependent)

Parameter: Salinity

Units: practical salinity units (psu)/parts per thousand (ppt)

Sensor Type: Calculated from conductivity and temperature.

Range: 0 to 70 psu

Accuracy: +/- 1.0% of reading pr 0.1 ppt, whichever is greater

Resolution: 0.01 psu

Parameter: Dissolved Oxygen % saturation

Sensor Type: Optical probe w/ mechanical cleaning

Model#: 599100-01

Range: 0 to 500% air saturation

Accuracy: 0-200% air saturation: +/- 1% of the reading or 1% air saturation, whichever is greater 200-500% air saturation: +/- 5% of reading

Resolution: 0.1% air saturation

Parameter: Dissolved Oxygen mg/L (Calculated from % air saturation, temperature, and salinity)

Units: milligrams/Liter (mg/L)

Sensor Type: Optical probe w/ mechanical cleaning

Model#: 599100-01

Range: 0 to 50 mg/L

Accuracy: 0-20 mg/L: +/-0.1 mg/l or 1% of the reading, whichever is greater

20 to 50 mg/L: +/- 5% of the reading

Resolution: 0.01 mg/L

Parameter: Non-vented Level - Shallow (Depth)

Units: feet or meters (ft or m)

Sensor Type: Stainless steel strain gauge

Range: 0 to 33 ft (10 m)

Accuracy: +/- 0.013 ft (0.004 m)

Resolution: 0.001 ft (0.001 m)

Parameter: pH

Units: pH units
Sensor Type: Glass combination electrode
Model#: 599701(guarded) or 599702(wiped)
Range: 0 to 14 units
Accuracy: +/- 0.01 units within +/- 10° of calibration temperature, +/- 0.02 units for entire temperature range
Resolution: 0.01 units

Parameter: Turbidity
Units: formazin nephelometric units (FNU)
Sensor Type: Optical, 90-degree scatter
Model#: 599101-01
Range: 0 to 4000 FNU
Accuracy: 0 to 999 FNU: 0.3 FNU or +/-2% of reading (whichever is greater); 1000 to 4000 FNU +/-5% of reading
Resolution: 0 to 999 FNU: 0.01 FNU, 1000 to 4000 FNU: 0.1 FNU

Parameter: Chlorophyll
Units: micrograms/Liter
Sensor Type: Optical probe
Model#: 599102-01
Range: 0 to 400 ug/Liter
Accuracy: Dependent on methodology
Resolution: 0.1 ug/L chl a, 0.1% FS

Depth Qualifier:

The NERR System-Wide Monitoring Program utilizes YSI data sondes that can be equipped with either vented or non-vented depth/level sensors. Readings for both vented and non-vented sensors are automatically compensated for water density change due to variations in temperature and salinity; but for all non-vented depth measurements, changes in atmospheric pressure between calibrations appear as changes in water depth. The error is equal to approximately 1.02 cm for every 1 millibar change in atmospheric pressure, and is eliminated for vented sensors because they are vented to the atmosphere throughout the deployment time interval.

Beginning in 2006, NERR SWMP standard calibration protocol calls for all non-vented depth sensors to read 0 meters at a (local) barometric pressure of 1013.25 mb (760 mm/hg). To achieve this, each site calibrates their depth sensor with a depth offset number, which is calculated using the actual atmospheric pressure at the time of calibration and the equation provided in the SWMP calibration sheet or digital calibration log. This offset procedure standardizes each depth calibration for the entire NERR System. If accurate atmospheric pressure data are available, non-vented sensor depth measurements at any NERR can be corrected.

In 2010, the CDMO began automatically correcting Depth/Level data for changes in barometric pressure as measured by the reserve's associated meteorological station during data ingestion. These corrected Depth/Level data are reported as cDepth and cLevel, and are assigned QAQC flags and codes based on QAQC protocols. Please see sections 11 and 12 for QAQC flag and code definitions.

NOTE: older Depth data cannot be corrected without verifying that the depth offset was in place and whether a vented or non-vented depth sensor was in use. No SWMP data prior to 2006 can be corrected using this method. The following equation is used for corrected Depth/Level data provided by the CDMO beginning in 2010:

$$((1013-BP)*0.0102)+Depth/Level = cDepth/cLevel.$$

Salinity Units Qualifier:

In 2013, EXO sondes were approved for SWMP use and began to be utilized by reserves. While the 6600 series sondes report salinity in parts per thousand (ppt) units, the EXO sondes report practical salinity units (psu). These units are essentially the same and for SWMP purposes are understood to be equivalent, however psu is considered the more appropriate designation. Moving forward the NERR System will assign psu salinity units for all data regardless of sonde type.

Turbidity Qualifier:

In 2013, EXO sondes were approved for SWMP use and began to be utilized by reserves. While the 6600 series sondes report turbidity in nephelometric turbidity units (NTU), the EXO sondes use formazin nephelometric units (FNU). These units are essentially the same but indicate a difference in sensor methodology, for SWMP purposes they will be considered equivalent. Moving forward, the NERR System will use FNU/NTU as the designated units for all turbidity data regardless of sonde type. If turbidity units and sensor methodology are of concern, please see the Sensor Specifications portion of the metadata.

Chlorophyll Fluorescence Disclaimer:

YSI chlorophyll sensors (6025 or 599102-01) are designed to serve as a proxy for chlorophyll concentrations in the field for monitoring applications and complement traditional lab extraction methods; therefore, there are accuracy limitations associated with the data that are detailed in the YSI manual including interference from other fluorescent species, differences in calibration method, and effects of cell structure, particle size, organism type, temperature, and light on sensor measurements.

10) Coded variable definitions

Site definitions:

Sampling Station: Inlet at Webhannet River Mouth, at Wells Harbor
Sampling Site Code: IN
Station Code: welinwq

Sampling Station: Head of Tide of Webhannet River
Sampling Site Code: Sampling Site Code: HT
Station Code: welhtwq

Sampling Station: Little River Mouth (Merriland/Branch/Little River estuary)
Sampling Site Code: LM

Station Code: wellmwq

Sampling Station: Skinner Mill (on Merriland R, tributary to Merriland/Branch/Little R estuary)

Sampling Site Code: SM

Station Code: welsmwq

File definitions: 3 letter NERR site code (WEL for Wells NERR); 2 letter YSI deployment site code (see above); data type code (WQ for water quality), month, day, year of deployment (ex: WELINWQ071406 = Webhannet Inlet water quality data from 14 July 2006).

11) QAQC flag definitions –

QAQC flags provide documentation of the data and are applied to individual data points by insertion into the parameter's associated flag column (header preceded by an F_). During primary automated QAQC (performed by the CDMO), -5, -4, and -2 flags are applied automatically to indicate data that is missing and above or below sensor range. All remaining data are then flagged 0, passing initial QAQC checks. During secondary and tertiary QAQC 1, -3, and 5 flags may be used to note data as suspect, rejected due to QAQC, or corrected.

- 5 Outside High Sensor Range
- 4 Outside Low Sensor Range
- 3 Data Rejected due to QAQC
- 2 Missing Data
- 1 Optional SWMP Supported Parameter
- 0 Data Passed Initial QAQC Checks
- 1 Suspect Data
- 2 *Open - reserved for later flag*
- 3 Calculated data: non-vented depth/level sensor correction for changes in barometric pressure
- 4 Historical Data: Pre-Auto QAQC
- 5 Corrected Data

12) QAQC code definitions –

QAQC codes are used in conjunction with QAQC flags to provide further documentation of the data and are also applied by insertion into the associated flag column. There are three (3) different code categories, general, sensor, and comment. General errors document general problems with the deployment or YSI datasonde, sensor errors are sensor specific, and comment codes are used to further document conditions or a problem with the data. Only one general or sensor error and one comment code can be applied to a particular data point, but some comment codes (marked with an * below) can be applied to the entire record in the F_Record column.

General Errors

- GIC No instrument deployed due to ice
- GIM Instrument malfunction
- GIT Instrument recording error; recovered telemetry data
- GMC No instrument deployed due to maintenance/calibration
- GNF Deployment tube clogged / no flow
- GOW Out of water event
- GPF Power failure / low battery
- GQR Data rejected due to QA/QC checks
- GSM See metadata

Corrected Depth/Level Data Codes

- GCC Calculated with data that were corrected during QA/QC

GCM	Calculated value could not be determined due to missing data
GCR	Calculated value could not be determined due to rejected data
GCS	Calculated value suspect due to questionable data
GCU	Calculated value could not be determined due to unavailable data

Sensor Errors

SBO	Blocked optic
SCF	Conductivity sensor failure
SCS	Chlorophyll spike
SDF	Depth port frozen
SDG	Suspect due to sensor diagnostics
SDO	DO suspect
SDP	DO membrane puncture
SIC	Incorrect calibration / contaminated standard
SNV	Negative value
SOW	Sensor out of water
SPC	Post calibration out of range
SQR	Data rejected due to QAQC checks
SSD	Sensor drift
SSM	Sensor malfunction
SSR	Sensor removed / not deployed
STF	Catastrophic temperature sensor failure
STS	Turbidity spike
SWM	Wiper malfunction / loss

Comments

CAB*	Algal bloom
CAF	Acceptable calibration/accuracy error of sensor
CAP	Depth sensor in water, affected by atmospheric pressure
CBF	Biofouling
CCU	Cause unknown
CDA*	DO hypoxia (<3 mg/L)
CDB*	Disturbed bottom
CDF	Data appear to fit conditions
CFK*	Fish kill
CIP*	Surface ice present at sample station
CLT*	Low tide
CMC*	In field maintenance/cleaning
CMD*	Mud in probe guard
CND	New deployment begins
CRE*	Significant rain event
CSM*	See metadata
CTS	Turbidity spike
CVT*	Possible vandalism/tampering
CWD*	Data collected at wrong depth
CWE*	Significant weather event

13) Post deployment information – Included in annual document

14) Other remarks/notes

Data are missing due to equipment or associated specific probes not being deployed, equipment failure, time of maintenance or calibration of equipment, or repair/replacement of a sampling station platform. Any NANs in the dataset stand for “not a number” and are the result of low power, disconnected wires, or out of range readings. If additional information on missing data is needed, contact the Research Coordinator at the reserve submitting the data.

Three of our four sites (SM, LM, and HT) are discontinued through the winter months due to icing in the rivers. See section 6 data collection period for times of site deployment.

The Head of tide (HT): site switched to reporting level on 10/17/2018 12:00. See section 4 for details on vertical control.

The Inlet (IN):

Turbidity data from the 4/4 deployment are noisy. There was a significant rain event during this deployment. There may have also been some algae fouling impacting data during this time.

SpCond/salinity data from 10/15 5:45 to 10/31 11:45 are rejected. The brush wiper was parked directly over the c/t probe causing issues with the probe and data collected.

Reporting of water level began on 9/21/18 and the station offset used subsequently during logger calibration was -2.510 meters. This station offset was calculated in 2016 prior to water level first being reported. Vertical control at the site was improved in 2018, and annual measurements of the vertical reference point have since been made annually. However, the updated station offset was not used during pre-deployment sensor calibration. In coordination with the NERR Data Management Committee and CDMO 2019 level data were subsequently adjusted on 1/14/21 using the station offset calculated from a height measurement of the VRP taken on 4/11/19 for the period from 1/1/20 00:00 to 9/17/20 23:45 and from a height measurement of the VRP taken on 7/2/20 for the period from 9/18/20 00:00 to 12/31/20 23:45.

The sensor offset (measured from the vertical reference point on the top of the well to the depth sensor) was measured in 2016 at -7.350 meters. This value was added to the orthometric height of the station vertical reference point to calculate the station offset.

Data were adjusted by the difference between the station offset used during calibration and the corrected station offset. For data collected during the period from 1/1/20 00:00 to 9/17/20 23:45 the corrected station offset is -2.906 meters, and the data were adjusted by -0.396 meters. For data collected during the period from 9/18/20 00:00 to 12/31/20 23:45 the corrected station offset is -2.896 meters, and the data were adjusted by -0.386.

WELINWQ Station Offset Table

Survey Date	Survey Equipment	Station Offset	Offset Effective Date
04/08/2021	Digital Level	-2.896	04/08/2021 0:00
7/2/2020	Digital Level	-2.896	9/18/20 0:00
4/11/2019	Total Station	-2.906	4/12/19 0:00
7/10/2018	Total Station	-2.895	9/21/18 12:30

Skinner Mill (SM):

Depth data are odd at the 4/28 swap. We believe that due to the shallow nature of this site the bottom became disturbed and impacted the depth port. Data from 4/28 12:45-13:00 are marked 1 GSM CDB.

Significant Rain Events: 4/24, 4/30, 5/20-5/21, and 6/13, 11/22, and 11/27.

*Major rain event on July 3rd and 4th. Visible in all WQ data sets.