Shellfish Monitoring and Adaptive Management for the Herring River Restoration Project

Friends of Herring River &

Town of Wellfleet Shellfish Advisory Board

March 5, 2018

Meeting Agenda

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Martha Craig, Friends of Herring River

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Alana B. Spaetzel, Hydrologic Technician, U.S. Geological Survey

Aquatic Habitat
Sophia Fox, Ph.D., Aquatic Ecologist, National Park Service

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John Portnoy, Ph.D., Ecologist, National Park Service (retired)

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Mark Borrelli, Ph.D., Coastal Geologist, Center for Coastal Studies

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Katie Lavallee, Geoscience Intern, National Park Service and Geoscientists-in-the-Parks

Using Data for Decision-Making
Tim Smith, Restoration Ecologist, National Park Service

Shellfish Stakeholder Sampling Initiative
Friends of Herring River & National Park Service

A video-recording of the meeting, slides, and additional resources are available at:
http://www.friendsofherringriver.org/Monitoring.
Further questions can be directed to Tim Smith (tim_p_smith@nps.gov).

Tides and Salinity

Kelly C. Medeiros
Hydrologic Technician
National Park Service

A comprehensive understanding of tides and salinity in the Herring River is vital to the success of the Herring River Restoration Project. Numerous monitoring efforts have been conducted over the last 13 years to gain a detailed description of water levels in the Herring River prior to tidal restoration.

Long-term monitoring led by the National Park Service has been ongoing since 2005. Two multi-parameter sensors were deployed continuously from spring to fall at Dog Leg (upstream site) and Old Saw (downstream site). These sensors measured water level, salinity and other water quality parameters every 15 to 30 minutes. Additional stations were added throughout the system for an intensive monitoring conducted from 2013 to 2015. During this study, water level, salinity and other water quality parameters were collected at 12 stations spanning upstream and downstream of the Chequessett Neck Road Dike.

These monitoring programs provide baseline data of the current conditions of the restricted Herring River. Tidal range decreases from 3 meters downstream of the dike to 0.5 meters upstream. Not only are high tide levels restricted above the dike, low tide levels are as well, with lower low tides further downstream of the dike. Mean salinity decreases with increasing distance upstream, becoming almost entirely fresh at Dog Leg and above.

These datasets have been and will be used to calibrate and validate the hydrodynamic model developed for the Herring River Restoration Project. The modeled data is compared to the measured data to assess the confidence in the model. As the project moves forward, data will continue to be collected and compared with the model, so it can be adjusted and accuracy improved as necessary.

The planned future monitoring consists of five continuous water level and water quality stations, located from High Toss Road downstream to Old Saw. Multi-parameter sensors similar to those used for past monitoring will collect data in 15-minute intervals. The data from these new stations will be available to the public in real-time via a website, and can also be accessed via an app (see below).

Additional resources:

Real time water quality and water level data from the five continuous stations available at:
https://wqdatalive.com/public/820

Water Quality

Alana B. Spaetzel
Hydrologic Technician
U.S. Geological Survey, New England Water Science Center

The U.S. Geological Survey (USGS) New England Water Science Center (WSC) installed, and has been operating and maintaining, two surface water-quality and one surface-water streamflow monitoring sites in the Herring River Saltmarsh since fall of 2015. The goals of the data collection program are to establish a pre-restoration baseline water-quality dataset, and to evaluate fluxes of nutrients and other water-quality parameters into and out of the saltmarsh. These data provide critical information and feedback needed as part of the adaptive management process being taken to guide management decisions and measure progress toward restoration objections for the Herring River Saltmarsh.

Flow-proportional composite samples are collected weekly for the analysis of total nitrogen, total phosphorus, total suspended solids, total dissolved phosphorus, ammonium, nitrate, dissolved silica, orthophosphate, and iron. The Chequessett Neck Road site contains a structure that houses an automated sampling device for collecting water samples. The automated sampler is used to collect samples at predetermined flow-proportional intervals that represent equal volumes of flow. The targeted sampling rate is two tide cycles, fourteen samples per tide cycle, once a week. The equipment at the Chequessett Neck Road site is designed to collect and composite separate sets of nutrient and sediment samples for inflowing and outflowing tides.

The USGS maintains and operates equipment to support continuous collection of data on dissolved oxygen, pH, specific conductance, and water temperature. The Chequessett Neck Road site contains a structure that houses digital data loggers that record and store all measured data. Data are collected at 5-minute intervals and transmitted hourly via cellular-modem systems to the USGS office and displayed in near-real time on the USGS NWIS webpage.

All data collected under this project are published in the USGS National Water Information System **(NWIS; https://nwis.waterdata.usgs.gov/nwis)**, which is accessible to the public using Station ID: 011058798. A USGS report is being prepared describing project methods, objectives, results and interpretation of results including measured net fluxes of nutrients and sediments at the Chequesset Neck tide gate.

Additional resources:

Water level and quality data from the USGS station (ID: 011058798) at the Chequessett Neck Road Dike available at: https://waterdata.usgs.gov/ma/nwis/uv?site_no=011058798

Animals of the Seafloor

Sophia Fox, Ph.D.
Aquatic Ecologist
National Park Service

In addition to understanding the nutrients, organic matter, and sediments within a system, a knowledge of the organisms that live there provides valuable information on the health of the environment. Cape Cod National Seashore conducted a study to understand the spatial distribution and interaction of flora and fauna in the Herring River estuary. This data can be used to assess habitat suitability for shellfish and evaluate the success of the restoration over time.

A two-part study consisting of a benthic invertebrate survey and an experimental oyster growth study were conducted in 2013-2015. Grab samples of the bed sediment were taken during the summer at 14 sites spanning the upper Herring River to the river inlet at Wellfleet Harbor. Four samples were taken at each site, sieved, and the organisms identified and counted. Abundant organisms were found in all parts of the system, particularly in the brackish estuary with comparable species diversity to other local estuaries. The dominant species however changed with increasing distance upstream. The downstream and lower Herring River samples were predominately amphipods, followed by gastropods and polychaete worms. The organisms found in the upper Herring River were mainly larval insects. No changes were observed in the invertebrate communities from year to year. The differences between the upper and lower river and downstream were driven by salinity, with the upper river being a freshwater environment. Increases in salinity in the system will likely change the invertebrate communities upstream, and significantly enlarge the area of brackish estuary.

The experimental oyster growth study deployed oysters for 60 days at nine locations from High Toss Road upstream to 3 km downstream of the Dike in Wellfleet Harbor. Oyster growth and condition was recorded as well as isotopic analysis. Water quality parameters were measured at each site as well. Results showed that oyster growth was higher in the fall than the spring, and growth and condition increased with distance downstream. The oysters in the fresh environment at High Toss Road perished as expected, while the oysters nearer the harbor exhibited the highest growth rates and best condition.

The results from these studies provide valuable data on the current conditions in the Herring River estuary and can provide insight into potential changes with tidal restoration. Increased tidal flushing and the increased extent of the tidal estuary with higher salinities which will result from the opening of the dike, will significantly expand habitat for marine flora and fauna.

Fecal Coliform Monitoring

John Portnoy, Ph.D.
Ecologist (retired)
National Park Service

Extensive and valuable beds of wild oysters in the Herring River mouth have been closed to harvest since the mid-1980s, when increased State water-quality surveillance showed high fecal coliform (FC) contamination. With little residential development within the watershed, and nearly all using Title V septic systems, it seemed that wildlife was the likely source; however, the reasons for very high concentrations at sampling stations just seaward of the Chequesset Neck dike were not clear. Prompted by proposals to undertake some level of tidal restoration in Herring River, the National Park Service in 2005 undertook intensive water quality sampling to describe the spatial and temporal (tidal) patterns of fecal coliform in the river mouth, to relate bacteria concentrations to current water chemistry and the rate of tidal flushing, and to predict the effects of restored tides and water quality on shellfish water quality.

The NPS study showed that highest FC occurred at low tide and within 1000 meters above and below the Chequessett Neck dike structure. Major rain events extended the area of FC above the water-quality standard for shellfish waters upstream to High Toss Road and downstream nearly to Egg Island. High FC was associated with river (rather than Cape Bay) water having low salinity, pH and dissolved oxygen. Other studies have shown that FC survival in the environment is prolonged by these water-quality conditions. Probably more importantly, hydrodynamic modeling of the Herring River estuary has shown that the existing tidal restriction has reduced flushing of the river mouth with high-quality Cape Cod Bay water 10-15 fold. Studies in similarly diked estuaries on the outer Cape and elsewhere have shown the same direct relationships among the degree of tidal restriction, low salinity, and high FC contamination.

Restoration of tidal flushing with relatively clean seawater should greatly reduce FC contamination by dilution alone. This together with restored salinity, pH and dissolved oxygen, all of which shorten the survival time of FC, should allow the re-opening of wild shellfish beds in the river mouth and protect the extensive aquaculture grants of Wellfleet Harbor just downstream.
To monitor the effects of incremental tidal restoration on shellfish-water quality, the Friends of Herring River will initiate pre-restoration monitoring of fecal coliform in the river during the summer before dike reconstruction begins. Thereafter, this work will be included in a program of comprehensive post-restoration monitoring and adaptive management.

Additional resources:

The following published reports can be accessed at www.friendsofherringriver.org .

Portnoy, J. W. and J. R. Allen. 2006. Effects of tidal restrictions and potential benefits of tidal restoration on fecal coliform and shellfish-water quality. Journal of Shellfish Research, 25(2): 609:617.

Myers, M. and R. F. Ambrose. 2015. Salt marsh reduces fecal indicator bacteria input to coastal waters in southern California. Bulletin of the Southern California Academy of Sciences, 114(2): 76:88.

Bathymetric (sea floor) Mapping

Mark Borrelli, Ph. D
Coastal Geologist
Center for Coastal Studies

Acoustic sidescan sonar mapping is an efficient method to describe the variability in bed characteristics and benthic habitats that has been used for over 60 years. The downward-facing transducer, typically mounted to the ship's hull, emits a sound pulse in two directions, symmetric about a center line. The returned acoustic signal is processed to provide high-resolution imagery and bathymetry. Depending on the sonar used, the swath can range 6-8 m wide per ping, allowing a large area to be mapped in a relatively short period of time. Mapping changes in bathymetry over a large area provides information on recent sediment transport events and can capture signals of specific events. When paired with coring efforts and benthic invertebrate studies, the sonar imagery can be ground-truthed to create a spatially-resolved habitat and bed characteristics map. Mapping efforts such as this are often used by resource management entities as an efficient method for establishing baseline conditions of a resource to compare with future habitat changes caused by both natural and anthropogenic events.

The Center for Coastal Studies developed, tested and completed a method of surveying the sea floor to obtain data on sea-floor bathymetry and benthic habitat using acoustic sidescan sonar mapping. Over forty days were spent mapping Wellfleet Harbor. The 2015-2016 study included 1400 survey lines covered 14,000 acres of the inner and outer harbor and along the shoreline of Great Island. In addition to the bathymetric mapping, over 100 grab samples of bed sediment were taken and analyzed for grain size, organic content, and benthic organisms. Over 10,000 individuals were counted, 117 species were identified, nearly three-quarters of which were bivalves. This dataset provides valuable information about the elevation, substrate, and habitats of the seafloor in Wellfleet Harbor and can be a tool for the restoration project moving forward.

Additional resources:

More information about the Center for Coastal Studies' seafloor mapping work can be found at: http://coastalstudies.org/marine-geology/seafloor-mapping/

Sediment Dynamics

Katie Lavallee
Geoscience Intern
National Park Service & Geoscientists-in-the-Parks Program

Characterizing the bed sediment of a system provides important information about the dominant sediment transport patterns in the area. For example, the size of material deposited is an indication of the energy, or flow of water, acting on the bed. Coarser grained sediment like sand settles at faster rates, allowing sand to be deposited in higher energy environments. Fine-grained material such as silts and clays take longer to settle out of the water column, enabling them to be transported further distances and only deposited in low-energy areas. The type of sediment present also provides information about the source of the material. Describing the baseline sediment characteristics of Wellfleet Harbor is key to understanding current sedimentation trends to inform how the system may respond to reconnection with the Herring River.

Monitoring efforts were conducted by NPS to describe baseline conditions of sediment in Wellfleet Harbor prior to the tidal restoration of the Herring River. Over 50 sediment samples were taken over the last 13 years, in 2004, 2010 and 2017. Five-inch long cores were taken along the edges of shellfish grants in five areas in the harbor: Egg Island, Town Propagation, Powers Landing, Mayo Beach, and Indian Neck. The top 1-cm and bottom 1-5 cm were sub-sampled, to compare surface and subsurface characteristics. Samples were dried, weighed and sorted into six size classes (gravel, coarse sand, medium sand, fine sand, silt and clay) in the lab to determine the grain size distribution of each sample.

Median grain size of all surface and bottom samples from all locations in the harbor were medium to coarse sand (0.3-0.7 mm in diameter). There was no significant difference between surface and bottom grain size and no significant change or trend in grain size over the 13 year time span. The finest sample consisted of 8% silt and clay. The average sample contained 4% or less organic matter. These results show that over inter-annual time scales, the sediment in Wellfleet Harbor has not changed. It is a dominantly sandy environment, with no indication that deposition of fine sediment occurs in the areas of these shellfish grants. Under current conditions, the fine sediments are likely collected in low-energy areas of the harbor or are exported to Cape Cod Bay. This study reinforces historical observations and model predictions that fine deposition is unlikely with the opening of the Chequessett Neck Dike during restoration. If current conditions enabled the deposition of fine sediment, we would observe larger proportions of silt and clay in the bed samples. Since the hydrodynamics of the harbor are unlikely to change with the tidal restoration of the Herring River, this depositional pattern should remain unchanged.

This study is a simple, cost-effective method to describe sediment changes in Wellfleet Harbor and can be repeated in the future.

Additional resources:

Sediment Monitoring in Wellfleet Harbor Summary Report to be published on Friends of Herring River website (www.friendsofherringriver.org).

How Monitoring Data Will Be Used For Implementing the Herring River Project

Tim Smith
Restoration Ecologist
National Park Service

The Herring River Restoration Project will be implemented using a decision-making framework based on the principles of adaptive management, a method frequently used in natural resources, engineering, economics, business, and other interests. At its core, adaptive management relies on monitoring data to gauge how well a project is meeting its objectives and to evaluate and improve predictive models.

The process of incorporating adaptive management into any type of project starts with discussions among project sponsors and stakeholders. Stakeholders are the people and groups who are interested in the project, are affected in some way by the project's outcome, and are willing to engage with the project sponsors to help increase the likelihood of project success and to avoid problems. For the Herring River, numerous informal and formal meetings with individual stakeholders and interest groups have been held since 2008. Beginning in 2014, the Herring River Restoration Committee (HRRC) began working with a group of adaptive management experts from the U.S. Geological Survey (USGS). These USGS scientists work with other federal, state, local, and private land management and conservation groups throughout the U.S. on a wide range of complex natural resource management projects.

Using feedback and information developed through the stakeholder meetings, USGS and the HRRC identified a comprehensive list of ecological and socioeconomic objectives for the Herring River project. In simple terms, the objectives represent what the project seeks to achieve (i.e. benefits) and what is to be avoided (i.e. risks or costs). Restoring native estuarine vegetation communities is one of the basic ecological objectives for the Herring River project. Preventing impacts resulting from tidal flow on roads is a basic socioeconomic objective. After all objectives were developed, HRRC and USGS completed a thorough analysis and identified ways to predict how each would be affected as tidal range is increased and methods to monitor these changes as the project is implemented.

Predictions, or models, of changes caused by increasing tide range in the Herring River are important for understanding how the ecosystem functions and what to expect as the project is undertaken. Predictions also provide the basis for the assessment of data collected as part of the monitoring program. If data show that the actual outcome matches the prediction, we can gain confidence that our understanding of the system and the methods used to make the prediction are sound. Opening of the tide gates at Chequessett Neck Road would continue as planned. If data show that changes are happening outside of the predicted range, we would then reassess some of the assumptions made about how the system functions and the methods used to make predictions. In this case, the tide gates may need to remain at their current setting, or even closed, until the situation is resolved. Depending on the specific circumstances, other actions beyond just managing the tide gates could be necessary.

To fully understand all of the effects of restoring tidal flow to the Herring River monitoring data will include surface and groundwater water levels, salinity, water chemistry, vegetation coverage, benthic invertebrates, and sediment movement. Baseline data collection for all of these is either underway or completed. Post-restoration studies will be undertaken when the Chequessett Neck Road dike is rebuilt and tidal flow begins to increase.

Additional resources:

Information on the project, adaptive management methods can be found at: www.friendsofherringriver.org
Tim Smith can be contacted at tim_p_smith@nps.gov.

Shellfish Stakeholder Science Initiative

Herring River Restoration Project

The Herring River Restoration Project is sponsoring a stakeholder-driven monitoring project to supplement data collected in Wellfleet Harbor. Using the expertise of shellfish stakeholders who experience the hydrodynamic environment of the harbor every day, water samples will be collected and analyzed for suspended-sediment concentration. This new dataset will capture short-term changes and localized patterns of suspended-sediment at highly valuable locations near active shellfishing areas. The data collected as part of this initiative will be shared with the public on the Friends of Herring River website, be compared with ongoing sediment monitoring efforts at Chequessett Neck Road Dike, and used to better understand sediment transport patterns in Wellfleet Harbor.

The most critical locations for this sampling program include: Egg Island, Powers Landing, Town Propagation area, Mayo Beach, Indian Neck, Chipmans Cove, and Duck Creek. These locations are prioritized for their proximity to the Herring River, commercial shellfishing operations, and colocation of previous bed sediment sampling.

Samples will be taken at a set location that is convenient for the volunteer, within or adjacent to their normal work area. At the first round of sampling, a project representative will mark the location with GPS. Sampling will be repeated at this location during the duration of the study. Sampling will begin in May 2018 and continue as long as possible.

Sampling protocol will consist of:

- Grab water samples will be taken every 3-6 weeks on a set day, based on tidal conditions, beginning in May.
- Volunteers will be given datasheets and water bottles and shown the procedure for taking samples.
- Note date and time.
- Note phase of tide and depth of water.
- Note the clarity or visual amount of sediment in the water.
- Record additional remarks including weather or any unusual observations.

The entire sampling (water sample collection and datasheet completion) should take no more than 5 minutes to complete. Volunteers will return samples and datasheets to the Shellfish Office at the Town Pier.

Additional resources:

Further information and instructions will be distributed via the Shellfish Advisory Board and SPAT listservs. The program flyer is accessible at: http://www.friendsofherringriver.org/Monitoring
Contact Katie Lavallee, NPS geoscience intern, at katherine_lavallee@partner.nps.gov for more information or to volunteer.