Monitoring the Ecological Effectiveness of the Penobscot River Restoration Project

NOAA Fisheries Service has been a partner in the Penobscot River Restoration Project (PRRP) in Maine to strategically remove three significant fish migration barriers in order to restore 11 diadromous fish species that are native to the river without disrupting hydropower generation. PRRP aims to improve the Penobscot River's native sea-run fisheries and achieve a balance between these fisheries and hydropower.

Diadromous fish are migratory fish such as river herring, American shad, Atlantic salmon, and American eel that require freshwater environments for part of their lifecycle and the ocean for the rest. But structural barriers such as hydropower dams can restrict or halt these migrations, impacting the health and resiliency of these fish populations.

After years of planning and coordination, efforts to restore these species began in 2012 with the removal of the Great Works Dam, the second dam upstream from the ocean near Old Town, ME.

The Veazie Dam, the lowermost on the river, will be removed this summer. Fish passages will be enabled at the Howland Dam, an additional critical step toward restoring these species. This project is regionally and nationally significant because of its ecosystem-wide approach to reconnecting upriver habitat to the Gulf of Maine.

The PRRP has been a NOAA Fisheries priority for many years, with the agency investing close to $20 million in the project and related activities.

From the beginning, NOAA and its partners have recognized the importance of documenting the effectiveness of a project from which we expect ecosystem-scale benefits. We have demonstrated our commitment to monitoring the project's effectiveness by investing approximately $2 million to date in nine long-term studies on the Penobscot that have collected at least two years of pre-dam removal data. We are hoping that the results of the barrier removals will be apparent when compared to the baseline data collected in these studies.

Six of the nine studies are focused on migratory fish response, which is a level of fisheries monitoring not matched at a dam removal site anywhere else in the country. Two of the other studies focus on the physical and chemical responses of the ecosystem and another evaluates changes to wetland communities along the river.

Cooperating investigators are from the University of Maine, University of Southern Maine, Gulf of Maine Research Institute (GMRI), US Geological Survey, Penobscot Indian Nation, and a local consultant. Funding partners include the Penobscot River Restoration Trust and the Nature Conservancy.

Food web impacts

Two studies of particular interest demonstrate the monitoring program's multidisciplinary approach and the potential for revealing how restoration of watersheds and migratory fish stocks may improve groundfish fisheries.

One is titled "You are What You Eat: Using Stable Isotopes to Assess Freshwater and Marine Food Web Change in Response to Dam Removal."


Steve Coghlan photo

A primary objective of the PRRP is to improve migratory fish passage between the upper reaches of the river and the coastal marine environment. Increasing the connection between river and marine habitats is expected to positively impact the organisms that reside in these environments primarily by providing a consistent food source.

In the freshwater system, spawning migratory fishes such as river herring should bring marine-derived nutrients to lakes and rivers and provide forage for large freshwater predators like smallmouth bass. In the marine system, it is expected that young migratory fishes migrating out of freshwater nursery habitats will be consumed by coastal marine predators like cod and mackerel.

To quantify links between the freshwater and marine environment, researchers from the University of Southern Maine and GMRI are using stable isotopes to estimate the movement of marine and freshwater materials via the migratory fishes across ecosystems before and after the dam removals.

Stable isotope studies are used for studying the flow of nutrients through organisms. Essentially, "you are what you eat," so isotope signatures of fish reflect the isotope values of their food, which, in turn, can be used to gain an understanding of food web position and habitat associations, marine vs. freshwater in this case.

Pre-dam removal data collected from 2009 through 2011 show a strong separation between the freshwater and marine food webs, which is expected in systems that are disconnected by dams. However, preliminary results indicate some level of connectedness even before dam removal.

We believe stable isotopes provide reliable and cost effective indicators of food web change in response to dam removal. The first post-removal investigations of this study will be conducted after the Veazie Dam is removed and full connectivity with the marine environment is restored.

Water quality

In the other study, which is titled "Understanding Lower-river Water Quality and Benthic Macroinvertebrate Communities," the Penobscot Indian Nation Water Resources Program (PIN WRP) is examining select sites in the lower Penobscot River to determine if and how water quality and benthic macroinvertebrate community composition will change with barrier removal.

Benthic macroinvertebrates are bottom-dwelling organisms that are often immature forms of insects such as mayflies and stoneflies. These important components of aquatic food webs are sensitive to water quality conditions. Water quality, which strongly affects ecosystem health, can be evaluated directly by measuring specific water parameters such as dissolved oxygen or it can be inferred by studying the benthic macroinvertebrate communities that are subjected to variations in water quality throughout the year.

In 2009 and 2010, PIN WRP collected aquatic benthic macroinvertebrates from seven locations associated within the impoundment (closed-in) and tailwater areas of the Great Works and Veazie Dams, as well as the tailwater area of the Milford Dam, the third dam on the river. The data collected will be used to assess changes in the aquatic life community structure attributable to dam removal and to determine if water quality criteria established by the state are being attained.

Also in 2009 and 2010, PIN WRP collected water samples and measurements from 10 sites within the Great Works and Veazie Dam project areas to further characterize water quality conditions before dam removal. Water quality was evaluated for physical characteristics such as dissolved oxygen, temperature, clarity, nutrients, and other various pollution indicators. Stations were sampled late-July through late-October in 2009 and mid-June through late-October in 2010 at one-to-two-week intervals. Water temperature also was evaluated at 15 additional locations associated with the Great Works, Veazie, and Howland Dam impounded areas and at select free-flowing reaches upstream.

In general, the pre-dam removal benthic macroinvertebrate and water quality data collected in the lower river show the results that are expected from a large impounded river with a history of industrial use. Acceptable water quality standards are being attained at all the sampling locations.

While a variety of benthic insects were found in the impounded areas, the free-flowing areas generally had more insects and more insect diversity. The continuous temperature data showed that the lower Penobscot River gets quite warm and sometimes exceeds critical temperature thresholds for salmon.

Post-removal monitoring of benthic macroinvertebrates and water quality is beginning in the area of the former Great Works Dam this summer.

As demonstrated by the two example studies described here, long-term monitoring of ecosystem response to the PRRP is important for understanding the project's success. It also may help us document how restoring migratory fish can benefit the marine and freshwater ecosystems they inhabit, including providing a potentially important food source for valuable offshore commercial fish species.

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