USA: Two Dam Removals, One Bypass and One Fish Ladder at The Great Penobscot River Restoration, Penobscot River Watershed, Maine

Breaching the Great Works dam where construction began in June 2012 which would be the first of two major dam removals. Obtained from Penobscot River Restoration Trust online files. – https://www.flickr.com/photos/penobscotrivertrust/7431203902/in/album-72157630262350632/

Beginning the deconstruction of the Veazie dam that begun in the su Restoration Trust online fi https://www.flickr.com/photos/penobscotrivertrust/sets/721

Overview

In an effort to restore eleven species of sea-run fish while resuming energy production levels, a coalition bonded together to restore the second largest river in New England. State and federal agencies, businesses and non-profits banded together to restore the Penobscot River watershed. Two dam removals and the construction of one fish by-pass, and one modernized fish ladder resulted in over 2,000 km of connected migratory fish passage concluding a massive restoration project. The ongoing population decline of Atlantic salmon (*Salmo salar*) sparked this drive for restoration. This habitat may be North America's last hope in restoring this endangered population. Atlantic Salmon thrives in the Penobscot waters and has been historically harvested for centuries by the Penobscot Indian Nation. Dam removal provides benefits for ten other species of catadromous and anadromous fish that migrate through these waters to and from the ocean. The recovery of the fish (striped bass (*Morone saxatilis)*, alewife (*Alosa pseudoharengus)*, rainbow smelt *(Osmerus mordax),* blueback herring (Alosa aestivalis), American shad (*Alosa sapidissima),* Atlantic sturgeon (*Acipenser oxyrhynchus oxyrhynchus),* shortnose sturgeon *Acipenser brevirostrum,* Atlantic tomcod *(Microgadus tomcod)*, sea lamprey (*Petromyzon marinus),* American eel (*Anguilla rostrate))* will affect local food chains, recreational and commercial fishing industries, and the overall resiliency of the ecosystem.

Quick Facts

Project Location:
Penobscot River, 45.0090194, -68.6141733

Geographic Region:
North America

Country or Territory:
United States of America

Biome:
Freshwater

Ecosystem:
Freshwater Rivers & Streams

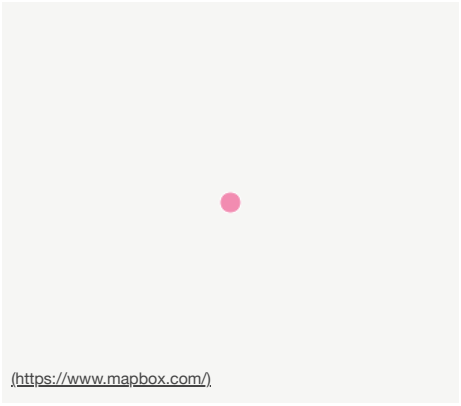
Area being restored:
Greater than 2000 km of river habitat.

Project Lead:
Penobscot River Restoration Trust

Organization Type:
Other

Project Partners:
PPL power corporation, Penobscot Indian Nation, the State of Maine, the U.S. Department of Interior, the National Park Service, NOAA, Black Bear Hydro, LLC, and The Penobscot River Restoration Trust which is compiled of 6 not-for-profit corporations including; the Penobscot Indian Nation, American Rivers, Atlantic Salmon Federation, Maine Audubon, Natural Resources Council of Maine, The Nature Conservancy, and Trout Unlimited.

Location



TIMEFRAME

Project Stage:
Monitoring & Evaluation

Start Date:
1999

End Date:
2016

Planning \ Design:
144

Implementation:
48

Post-Implementation Maintenance:
3

Monitoring & Evaluation:

DEFINING THE PROBLEM

Primary Causes of Degradation

Dams & Hydrology, Fisheries & Aquaculture, Urbanization, Transportation & Industry

Degradation Description

Up to 97% of the historical range of the Atlantic salmon (*Salmo salar*) was severed by the construction of dams in the Penobscot River watershed. Ten other species of migratory fish were affected and other species that interacted with these fish suffered in their absence. These dams were built during a time when hydroelectric power was in high demand and every undammed waterway was viewed as a waste of natural resources. The Nature Conservancy reports that from 1830-2013 only 4% of fish habitat was left available for migratory species, and at its high point the river systems had close to 150 dams. These dams directly affected the marine and aquatic life that depend on this waterway to reproduce. Their life cycles were abruptly disturbed causing all species to adapt to their new environment. For example, when levels of migratory prey fish were reduced, the bald eagle (*Haliaeetus leucocephalus*) targeted waterfowl more often, increasing pressure.

The Penobscot River Trust reports that the river supports spawning of 60-70% of all Atlantic salmon (*Salmo salar)* and the damming of this river is correlated with the severe decline in wild Atlantic salmon stocks and declines in other fish populations. Socio-economically, these dams at one time fueled the industrial boom. The river is still used for electricity production and many of these dams are out of the scope of the dam removal project thereby keeping a large portion of the river disconnected from salmon runs. The two dams removed in this project were both energy producing dams, but both significantly blocked access to the watershed. The Great Works dam, in place since the 1830's and replaced in 1887, was the first dam to be removed. The second dam to be removed was the Veazie dam which was first installed in the 1830's with an updated dam that was completed in 1913.

PLANNING AND DESIGN

Defining the Reference Ecosystem

The reference ecosystem is based on diverse sources of information (e.g. multiple extant reference sites, field indicators, historical records, predictive data).

Reference Ecosystem Description

It has been calculated that these waters before the 1820's damming boom saw the migration of 75-100 thousand Atlantic salmon (*Salmo salar)*, 14-20 million river herring (combination of two species, alewife, *Alosa pseudoharengus*, and blueback herring, *Alosa aestivalis*), and 3-5 million American shad (*Alosa sapidissima)*. Through the damning of the river, overharvesting, and pollution of the river from human expansion, fish abundance has dropped to mere thousands of individuals compared to the large numbers seen before mass human interaction. According to NOAA's climate data, the average temperature in Maine at the earliest recorded date of 1895 averaged ~ 39^0 F compared to 41^0F in 2015. This shift in average temperature may also add a stressor to these fish species in peril. A baseline ecosystem was not present to compare river systems but researchers could monitor how native species respond to the changes in predatory and prey species. These data assisted the researchers in understanding that the removal of the dams would help return the system back to a similar pre-dam state. Population numbers are not expected to reach the pre-European settlement numbers, but are expected to rebound significantly. Due to the lack of a benchmark for how the river flowed before the construction of the dams, there was little reconstruction of the flow of the river. Instead, it has been left to restore itself and has begun to show signs of success.

Project Goals

Clearly, without the removal of the dams, attempts to restore the river would be futile and a waste of resources. Allowing the removal of two of the major dams allowed natural processes to remediate the river. Atlantic salmon recovery was one of main purposes for the restoration. The population of Atlantic salmon is in decline and listed as endangered by the Endangered Species Act of 1973. Historically salmon roamed the length of this river system and were a staple to the diet of Penobscot Indian Nation. Culturally they are a targeted fish for commercial and recreational purposes, and with their species in critical condition, the restoration of this river is seen as one of the last hopes for a comeback of the population. This fish would become the figurehead for the other fish species native to the river including; striped bass (*Morone saxatilis)*, alewife (*Alosa pseudoharengus)*, rainbow smelt *(Osmerus mordax),* blueback herring (Alosa aestivalis), American shad (*Alosa sapidissima),* Atlantic sturgeon (*Acipenser oxyrhynchus oxyrhynchus),* shortnose sturgeon *Acipenser brevirostrum,* Atlantic tomcod *(Microgadus tomcod)*, sea lamprey (*Petromyzon marinus),* and American

eel (*Anguilla rostrate).* All of these species are expected to increase in number post-restoration and can be considered a main target of interest. To achieve this goal, the habitat for reproduction needed to be returned to the fish through dam removal. Dams segmented the river and many energy producing dams owned by the power company PPL had been battling over relicensing. The solution for relicensing came by the purchase of three dams by the Penobscot River Restoration Trust which intended to deconstruct two dams and improve fish passage past the third dam while maintaining current electricity generation needs. The increase of energy outputs of dams upstream was also added providing a win-win solution for PPL, the local towns that relied on the power output, and those in favor of the restoration. These measures were intended to allow the fish access to historical migration sites to reproduce and repopulate the river. After the deconstruction, monitoring systems would be set in place and the altered ecosystem would then be monitored for success.

Monitoring

Start date, including baseline data collection:
Baseline data was collected during the mid 2000's and after each dam was removed, a post monitoring program began.

End Date:
No known date at this time.

Stakeholders

Dam relicensing was a driving factor for the participation of the power companies. After years of relicensing issues, it was beneficial for them to sell three of their dams, and maintain the same power generation output. Acquiring funds for the project demanded the creation of the Penobscot River Restoration Trust and all parties to agree on a major goal of the project. This coalition provided management and funding that powered the restoration. The Penobscot River Nation provided a back bone to the project as their culture and fishing rights have been limited since the additions of the dams. They were very supportive of the project and helped with outreach. One of the major factors in educating the general public was the presentations held at local town community meetings and events where direct community outreach and concerns could be heard. National and statewide outreach would be primarily educated by the media through many different newspaper, and televised news stations. Public involvement helped raise funds for the project as a large portion of the funds were funded by private donations.

PROJECT ACTIVITIES

How this project eliminated existing threats to the ecosystem:
In 2010 the Penobscot River Restoration Trust purchased the Veazie, Howland and Great Works dams for 25 million dollars from the existing power company owners. Planning the removal of the dams would begin and it wouldn't be until 2012 when deconstruction began on the Great Works dam. Beginning the project in June 2012, it was completed by the end of November. The Veazie dam removal followed similarly with the demolition beginning in June 2013 and finishing in November, and the last powerhouse would not be removed until late October 2014. From here the fish could now freely move through most of the river. With an increased flow, the river began to naturally reshape itself exposing sites of rapids that would eventually be used for recreational watersports. This would not be the end, though, as the other dam the trust purchased needed remediation to allow fish passage. The Howland dam was also purchased in 2010 and would remain standing, but a fish passage bypass was created. This required the removal of fifty tons of contaminated soil paid for by funding through the EPA's Brownfield's grant program. This area was historically a tannery, paper mill, plywood factory and eventually a hydropower dam. This drop in water level behind the Howland impoundment was reported to be around five feet and required the area's boat launch to be reconstructed and currently there is more planning for the area to be accessible for recreational activities. This compromise allows for recreational activities to continue while a sufficient solution for migratory fish passage is reached.

How this project reinstated appropriate physical conditions (e.g. hydrology, substrate)",:
The removal of the dams allows a natural sediment flow. Now flow of nutrients and sediment is dictated by the pace of the stream and not by the manual release of water from the dams.

How this project achieved a desirable species composition:
Removal of the dams will allow the fish species to recover naturally over time. These fish will learn to navigate the waters for suitable habitat, take advantage of it and reproduce. Fish stock assessments were completed in 2004 by Kleinschmidt Associates that included electroshock surveys in dam impoundments and dam tail waters to understand the pre-removal population estimates. This data will be compared to post removal data collections. Post monitoring will report whether the system was able to self-heal and reach anticipated population rebounds. This data is still in the collection stage and currently initial reports have proven successful with many species returning with higher population numbers.

How this project reinstated structural diversity (e.g. strata, faunal food webs, spatial habitat diversity):
The increase in fish species populations will increase food sources for birds of prey, predatory fish, fish-eating mammals, scavengers and their competition with the human harvest. Examples of stressed species that would benefit from the increase in migratory prey fish are; bald eagle (Haliaeetus leucocephalus), river otter (Lontra Canadensis) and belted kingfishers (Megaceryle alcyon).

How this project recovered ecosystem functionality (e.g. nutrient cycling, plant-animal interactions, normal stressors):
All taxa in the river will see an increase in available nutrients as there will eventually be a greater balance of decomposers, producers and predators.

How this project reestablished external exchanges with the surrounding landscape (e.g. migration, gene flow, hydrology):
With the natural recovery of the population it is expected that the gene pool will remain similar to its previous state. These populations experienced a population bottleneck where a loss of genes occurred caused by human interaction with the species. Migration routes for the 11 targeted species area now improved and will aid in maintaining optimal gene flow. Non-migratory freshwater fish and other taxa in the system will see an increase in gene flow as their meta populations will have greater connectivity and ability to reproduce with each other.

Activities were undertaken to address any socio-economic aspects of the project:
The loss of hydroelectric power initially was a threat, and in cooperation with the existing owners of the other dams, they increased generation of the remaining dams to fill the voids. This required the Penobscot River Restoration Trust to attend local town meetings and constantly present and educate the public on the benefits of the project. The shutting down of two dams worried those employees to fear for the termination of their employment. This is where the power company had to step in and promise them continued employment.

PROJECT OUTCOMES

Ecological Outcomes Achieved

Eliminate existing threats to the ecosystem:
Two dams have been completely removed from the ecosystem, one major fish by-pass has been installed, and fish ladders have been implemented on many of the remaining dams on the river, greatly improving access for the migratory fish. Many dams will remain fragmenting the watershed and continue to restrict migration routes but they were outside the scope of the restoration.

Reinstate appropriate physical conditions",:
The destruction of these dams has increased the flow of water and exposed sites of rapids unseen for centuries. Sediment and nutrient will now flow at a natural rate without an impoundment restriction for sediments and nutrients to settle behind.

Achieve a desirable species composition:
Only a few years since the removal of these dams a definitive population number for these stocks cannot be concluded. What we do know through the use of many visual count surveys is that many targeted species numbers have begun to increase showing promising results.

Reinstate structural diversity:
With the increase of fish biomass in the ecosystem, holes in the food web have been filled with a greater availability of food sources. This also allows for predatory apex species like the bald eagle to consume the migratory fish species that are lower in the food chain. Population success will aid in returning the food web to a pre-dam state that will improve its ability to be resilient to change.

Recover ecosystem functionality:
Predator - prey interactions will balance as the targeted populations increase, and predators of the fish increase. A surge of abundant prey will also benefit the species currently being consumed by apex predators by relieving predatory pressure improving their numbers. An example of this interaction is how bald eagles have resorted to preying on ducks and other waterfowl in the winter due to low numbers of migratory fish.

Reestablish external exchanges with the surrounding landscape:
The species of fish that are endangered and that saw severe decline during the life of the dams will now be emerging from a population bottleneck. Research is yet to be conducted on this topic. It can be anticipated that the genes that are current will persist with minor variations.

Factors limiting recovery of the ecosystem:
After the removal of the two dams, the addition of improved fish ladders and the fish by-pass, it is now left up to the fish to find a way. The fish stocks still need to be monitored for recovery and enforcement of the fisheries needs to continue as residents may believe the removal of the dams will provide an instant surplus of harvestable fish. The remaining dams on the watershed will hinder the success of the recovery. These dams were out of the target range of the project due to budget limits and the importance of the electricity they produce.

Socio-Economic & Community Outcomes Achieved

Economic vitality and local livelihoods:
In the future, important commercial and recreational fish species will continue to improve and eventually be a source of income to these areas. The U.S. Fish and Wildlife Service's 2010 economic report presented that the reconnection of the river would add $500 million in future benefits to the local economies. Increases in fish populations will also increase the recreational and commercial fishing industry as larger harvests will become sustainable and for-hire guide trips can become more frequent.

Provision of basic necessities such as food, water, timber, fiber, fuel, etc.:
All targeted species populations are anticipated to improve resulting in larger harvests and a more balanced ecosystem.

Cultural dimensions such as recreational, aesthetic and/or spiritual:
Freeing the river has already boosted recreational usage for water sports such as kayaking and canoeing; including the hosting of the American Canoe Association's Whitewater Nationals Regatta. Through the increase of water sport races and competitions, there is hope it will help tourists discover these towns and the opportunities the river brings. The fish return will also support the Penobscot River Nation as the tribe has harvested salmon historically out of the river and have supported every stage of this project. It will aid in the traditions and culture of the values these people uphold and aid them economically. They have not harvested Atlantic salmon since the 1970's showing support for the restoration of the species. These steps towards recovery bring pride to the people who once harvested salmon and give them hope for what is in store in the future.

Regulation of climate, floods, disease, erosion, water quality, etc.:
Water quality and sediment flow should improve post dam removal. Free flowing of the river will improve natural sediment flow.

Has the project had any negative consequences for surrounding communities or given rise to new socio-economic or political challenges?:
The loss of two power generating stations was a concern to the locals that purchased this relatively clean source of electricity. This loss of productivity worried consumers that it would result in increased electricity costs and shortages in the area. The solution to this issue was the increase in energy production at other dams upstream. Staffing from these lost dams were also a local worry and it was reported that staff levels were not expected to change during the project. These issues were a major counterargument towards stalling the restoration and only public

KEY LESSONS LEARNED

Key Lessons Learned

One of the major outcomes of this restoration was the success of the 'hands free' approach. The river was left to repair and repopulate itself after the removal of the dams and the addition of the fish by-pass was complete. Dam removals can be fiscally burdening to stakeholders and it requires an unforeseen collaboration between local, state and government officials. The press was a major key in the support of the project. Using the Penobscot River Restoration Trust's website, one can easily access all publishing by major new sources including: The Bangor Daily News, CBS, Boston Globe, The New York Times, The Guardian, The Portland Press Herald and many other sources. The support from these news services aided in teaching locals and drawing attention to the idea. Without the widespread use of the media this project would have received less support.

LONG-TERM MANAGEMENT

Long-Term Management

Long term management includes electric shock surveys of fish to compare the data to the pre-removal assessments that were completed by Kleinschmidt Associates back in 2004. Other tests include the pit tagging of salmon smelt, and water quality testing of macro-invertebrates. Continued visual surveys at fish ladders are important to monitor the distance the fish travel, and the success of these ladders for movement of the fish. Currently there are citizen scientists helping with the data collection alongside private and government monitoring. NOAA has its own long-term monitoring in place consisting of six major sections. Part of their initial funding for the project set aside money for their long-term study of the ecosystem. They are studying the visual change in channel morphology using set camera stations, as well as using permanent transects to test for changes in the channel geometry by measuring for elevation changes and bed sediment grain size. Water quality monitoring is also in effect checking for indicators in macroinvertebrate communities and chemical changes in the water post dam removal. Habitat and vegetation composition will be monitored with remote sensing and the current photographic stations set up for channel morphology. Fish passage and composition will take up a majority of their post monitoring data collection to determine the success of the project. Recording where these fish decide to reproduce will also give insights on life histories, abundance and timing of passage at the remaining dams. Lastly, they aim to monitor ecosystem function and how the increase of marine-derived nutrients will function in the food web and how other species respond to this.

FUNDING

Sources and Amounts of Funding

Overall, the restoration cost over 60 million U.S. dollars. The U.S. Fish and Wildlife Service contributed 10 million U.S. dollars towards the project as well as overseeing and supporting different key segments, and National Oceanic and Atmospheric Administration (NOAA) invested $7.3 million U.S. dollars through the American Recovery and Reinvestment Act (ARRA) to help rebuild the sea-run fisheries of the Penobscot. A large cost of the project was the purchase of the three dams which cost the Penobscot River Restoration Trust close to 25 million U.S. dollars. The rest of the funding came from government budgets and grants and substantial private citizen funding.

LEARN MORE

Other Resources

http://www.penobscotriver.org/ (http://www.penobscotriver.org/)

Photo album of the Veazie dam, by the Penobscot River Restoration Trust

https://www.flickr.com/photos/penobscotrivertrust/sets/72157634630186040/with/9249525793/
(https://www.flickr.com/photos/penobscotrivertrust/sets/72157634630186040/with/9249525793/)

Other Penobscot River Restoration Trust Pictures

https://www.flickr.com/photos/penobscotrivertrust/sets/ (https://www.flickr.com/photos/penobscotrivertrust/sets/)

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