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CONCEPTUAL RESTORATION MONITORING PLAN FOR FISHERIES RESOURCES AFFECTED BY THE PENOBSCOT RIVER RESTORATION PROJECT

Prepared for the Penobscot River Science Steering Committee
by
The Fisheries Subcommittee

Joan G. Trial - Chair

I. INTRODUCTION

In June 2004, a final agreement was signed by PPL Maine, LLC (PPL), federal, state, tribal and conservation interests effectively resolving outstanding fish passage, tribal, and other issues associated with the Federal Energy Regulatory Commission (FERC) relicensing of PPL's hydroelectric projects located in the lower reaches of the Penobscot River. Among the various components contained in the June 2004 settlement agreement, PPL agreed to sell three hydroelectric projects (Veazie, Great Works, and Howland Dams) to the Penobscot River Restoration Trust for eventual removal[1]. The Penobscot River Restoration Trust is a non-profit conservation coalition comprised of representatives from the Penobscot Indian Nation, American Rivers, Atlantic Salmon Federation, Maine Audubon, Natural Resources Council of Maine, and Trout Unlimited established for the purpose of implementing the purchase and removal of the lower Penobscot River dams. The settlement agreement also provides for improved fish passage at four other PPL dams on the Penobscot River (Orono, Stillwater, Milford, and West Enfield). It is anticipated that successful implementation of the settlement agreement (referred to as Penobscot River Restoration Project, "PRRP") will result in the restoration of various ecosystem functions in the Penobscot River including restoration of diadromous fish resources. Figure 1 below depicts existing hydroelectric dams in the lower Penobscot River including those identified for eventual removal.

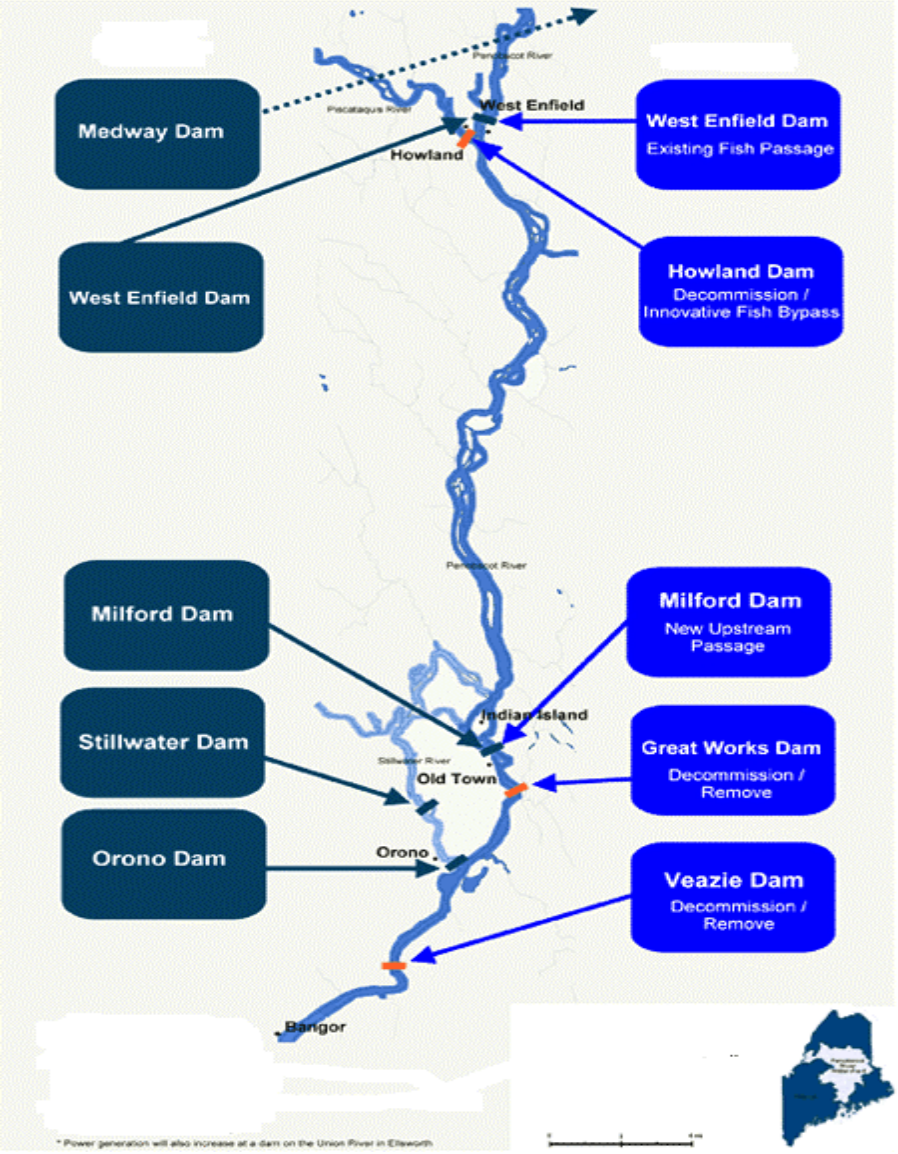
Monitoring the ecosystem response to implementing the PRRP is critical to adaptively managing and conserving diadromous fish resources in the Penobscot River. Because restoration projects can involve a combination of active and passive restoration techniques, each with some level of uncertainty, it is critical to implement a well-designed monitoring plan (USGS 2005). Additionally, because of the spatial and temporal scale of restoration projects, it may be necessary to re-evaluate the restoration effort at various intervals to make necessary adjustments if monitoring indicates that one or more assumptions of the project were incorrect (USGS 2005). Only through a monitoring process closely linked to an adaptive management protocol can the success of ecosystem restoration be adequately evaluated (USGS 2005).

This conceptual plan presents an approach for monitoring restoration of fisheries resources in the Penobscot River. According to the Federal Interagency Stream

[1] The Howland Project may be decommissioned and have a nature-like fishway installed if found feasible.

Restoration Working Group (1998), a conceptual model can be a useful tool throughout the planning process. This monitoring plan has been reviewed and endorsed by the fisheries subcommittee of the Penobscot River Science Steering Committee. The Penobscot River Science Steering Committee was organized by the University of Maine's Mitchell Center and Penobscot River Restoration Trust to organize and oversee scientific research and monitoring related to the restoration project. Members of the fisheries subcommittee include representatives from the Maine Atlantic Salmon Commission, Maine Department of Marine Resources, Maine Department of Environmental Protection, Maine Department of Inland Fisheries and Wildlife, University of Maine, U.S. Fish and Wildlife Service, and NOAA's National Marine Fisheries Service. Comments on a draft plan from fisheries biologist from the Connecticut Department of Environmental Protection, University of New Brunswick, and Michigan State University were incorporated into this conceptual plan.

Figure 1. Relative location of hydroelectric dams in the lower Penobscot River. (From Penobscot River Restoration Trust website with permission).



II. GOALS AND OBJECTIVES

Restoration monitoring has been classified into at least three overlapping categories including: implementation, effectiveness, and validation (Block et al., 2001; USFWS 2000; Federal Interagency Stream Restoration Working Group 1998). Implementation monitoring is used to assess whether or not a directed management action was carried out as designed. Effectiveness monitoring is used to determine whether the restoration action was effective in attaining the desired goals of the project. Validation monitoring is used to verify basic assumptions and scientific understanding concerning the restoration techniques and principals. The types of monitoring particularly relevant to fisheries resources affected by the PRRP are validation and effectiveness monitoring. Thus, this plan focuses on both validation and effectiveness monitoring (hereafter referred to collectively as "restoration monitoring") of diadromous fish resources in the Penobscot River watershed.

According to Roni et al. (2005), the overall goals of a restoration project and the objectives of the monitoring program must be clearly laid out prior to initiating a study to evaluate restoration actions. Goals are typically broad and strategic while objectives should be more specific and quantifiable (Roni et al. 2005). An overall goal of the PRRP is to "restore self sustaining populations of native sea-run fish". To achieve this goal, the PRRP will implement the following specific actions intended to recover diadromous fish populations in the Penobscot River:

- Veazie and Great Works Dams - Decommission and removal;
- Howland Dam - Decommission and install a nature-like fishway;
- Orono Dam - Install new upstream fish trapping facility. Install upstream American eel fishway(s). Continue operation of existing downstream passage facilities.
- Stillwater Dam – Install upstream fishway(s) for American eels. Install new downstream passage facilities.
- Milford Dam - Install new state-of-the-art upstream fishlift and discontinue use of existing Denil fishway. Install upstream fishway(s) for American eels. Install new downstream passage facilities.

Habitat alterations such as those proposed in the PRRP can be expected to result in changes to: 1) total fish biomass and production, 2) temporal and spatial fish community structure (i.e., species richness, distribution of biomass, and production), 3) biomass, production, and community structure of other biotic elements (e.g., mussels, macroinvertebrates, nutrients), and 4) abiotic elements of the ecosystem (Minns et al. 1996). To assess the goal of restoring self-sustaining populations of diadromous fish, monitoring must not only encompass fish populations, but the entire web of aquatic relationships on which diadromous fish depend (USGS 2005). In managing fish assemblages, it is important to determine if other biotic components have increased, decreased, or changed in species composition following habitat restoration activities (Minns et al. 1996). It seems from past diadromous fish recovery efforts that recovery

cannot succeed if all efforts are single-species focused. Successful recovery of diadromous fish requires restoring entire ecosystems.

Studies of fishes can occur at the individual, population, and community levels (Minns et al. 1996). Restoration monitoring in the Penobscot River will be based on indices at each of these levels of organization to understand the range of ecosystem functions potentially affected by the PRRP. Therefore, this plan proposes the following objectives to determine aquatic resource responses to the PRRP:

***Objective 1*:** Monitor abundance, biomass, and production of diadromous (e.g., Atlantic salmon, shortnose sturgeon, Atlantic sturgeon, American shad, river herring[2], rainbow smelt, sea lamprey, and American eel) and resident fish populations.

***Objective 2*:** Monitor diadromous and resident fish assemblages (e.g., species richness, distribution).

Objective 3: Monitor other aquatic resources including nutrients, macroinvertebrates, and mussels .

Objective 4: Monitor abiotic aquatic habitat

To accomplish these objectives, the following key monitoring questions will need to be assessed as part of this restoration monitoring plan. These will form the basis for judging the success of the PRRP in restoration of diadromous fish species to the Penobscot River.

Objective 1: Monitor Fish Abundance, Biomass and Production

- Has diadromous or resident fish abundance, biomass, and production changed in the river?
- Have the number of returning adult diadromous fish in the river changed specifically in response to the PRRP?
- Has juvenile diadromous fish escapement changed in the river?
- Have predator-prey population dynamics changed in the river?

Objective 2: Monitor Fish Assemblages

- Has species richness changed in the river?
- Have spatial fish distributions changed in the river?
- Has the rate of diadromous fish recolonization of historic habitat changed in the river?
- Have upstream and downstream migration and survival rates for diadromous fish changed in the river?
- Has freshwater residency time of diadromous fish changed in the river?
- Has the reproductive fitness of fish in the river been altered?
- Have growth rates changed in the river?

Objective 3: Other Biotic Responses

- Has non-finfish species (e.g., mussels, macroinvertebrates) richness, abundance, or distributions changed in the river?

[2] Alewife and blueback herring

- Have trophic level interactions changed in the river?
- Has production of marine-derived nutrients for various trophic levels changed in the river?

Objective 4: Monitor Abiotic Responses

- Has water quality (temperature, dissolved oxygen, etc.) changed in the river.
- Has the amount of impounded, riffle, or run habitat changed in the river?
- Has habitat for macroinvertebrates and other forage species changed in the river?

III. MONITORING STUDY DESIGN

A. General Approach

There are many potential study designs for monitoring single or multiple restoration actions (Roni et al. 2005). According to Minns et al. (1996), the specification of statistical designs for assessing environmental responses to habitat restoration has been advancing rapidly. Numerous texts and published papers have described alternative approaches for evaluating the effects of habitat restoration projects on ecosystems. Most study designs, however, are generally based on whether data are collected before and after treatment and whether they are spatially replicated or involved in single or multiple sites (Roni et al. 2005; Gerstein 2005).

Four widely used study designs for conducting restoration monitoring include: 1) post-treatment, 2) reference, 3) before-and-after (BA), and 4) BA with a control site. The application of each of these study designs for the PRRP has various strengths and weaknesses. Post-treatment designs are retrospective studies conducted without the benefit of pre-treatment (baseline) data (Roni et al. 2005; Gerstein 2005; Minns et al. 1996). While many studies have conducted post-treatment restoration monitoring studies, there are difficulties with these studies (Harris et al. 2005). The main drawback is that pre-treatment conditions and history are unknown so that considerable variability cannot be taken into account (Harris et al. 2005). Smith (1998) suggests that the results of post-treatment studies are often just preliminary. Because there are pre-treatment data pertaining to diadromous fish resources, aquatic habitat, and water quality for the Penobscot River watershed and opportunities to gather more extensive data, a post-treatment study design is not recommended for restoration monitoring of the PRRP.

The "reference" study design has also been used to monitor habitat restoration activities (Harris et al. 2005; Gerstein 2005). The reference study design compares restored sites to reference sites assumed to be comparable. A reference study of the PRRP is not possible because no other large river system exists in Maine that could be used as a reference site. Habitat throughout much of the large river systems in Maine has already been previously altered through dam construction. Thus, a reference study design is also not recommended.

The BA study design is the recommended approach for many applications involving stream restoration (Kocher and Harris 2005). The BA study design is recommended for studies in which several to many projects are to be sampled (Gerstein 2005). The BA study design allows for knowledge of pre-treatment conditions and natural variability

(Gerstein 2005; Minns et al. 1996). For valid BA studies, good baseline data are required (Koldolf 1995; Minns et al. 1996). The main drawback of the BA design is that results can take years to manifest since it relies on the performance of the habitat restoration. BA study designs have been classified into several different types depending upon observation intensity (number of study sites, reaches, watersheds) and existence of controls (Roni et al. 2005). A common approach is the before-and-after control impact design (BACI) where a control site is evaluated over the same time period as the treatment site. The addition of a control site to a BA study design is meant to account for environmental (natural or otherwise) and temporal trends found in both the control and treatment sites (Roni et al. 2005). A BACI design with a poorly chosen control site can be less powerful than an uncontrolled before-and-after study design (Roni et al. 2005). Because the PRRP involves the lowermost reaches of the Penobscot River, it is expected that the results of the project will affect diadromous fish resources throughout much of the Penobscot River watershed. As a result, suitable control sites are not likely to be available in the watershed. For these reasons, a straightforward BA study design is most appropriate for evaluating the PRRP. To determine whether the project has achieved it objectives, restored conditions should be compared to pre-treatment conditions.

B. Monitoring Parameters

The effects of dam removal activities on biotic and abiotic resources in the Penobscot River could take from several years to decades to be fully manifested in the ecosystem. The transition period following dam removal, natural variations in fish and non-finfish populations, life cycle periods, riparian recolonization, and many other factors will affect the ecosystem response to dam removal in the Penobscot River. Recognizing the levels of funding and staffing needed to perform habitat restoration monitoring studies at a watershed scale, this plan attempts to present an attainable timetable and scale for pre- and post-treatment monitoring.

To monitor the effects of the PRRP, this plan identifies five (5) discrete before-and-after monitoring studies for the Penobscot River: 1) fish population studies; 2) fish movement studies; 3) juvenile migrant sampling, 4) estuarine hydroacoustics study, 5) marine derived nutrient studies, and 6) non-biotic monitoring program. The successful completion of these studies will adequately address the four stated objectives of this monitoring plan. To perform BA studies, pre-treatment data are essential. Fortunately for this study, baseline data pertaining to fisheries, habitat, and water quality is generally available for the Penobscot River watershed. Researchers from the Maine Atlantic Salmon Commission, Maine Department of Fish and Wildlife, University of Maine, Maine Department of Environmental Protection, NOAA Fisheries, Midwest Biodiversity Institute, hydroelectric owners, and others have been collecting biological and environmental data throughout the Penobscot River for many years. Much of these data could be used to portray baseline biological and environmental data for the watershed. The University of Maine's Mitchell Center is currently compiling a literature review and data inventory of past and current research in the Penobscot River and its watershed. The information should be available in 2006 and will be used to further refine monitoring activities identified in this plan.

The sequence and timing of dam removal activities in the Penobscot River may affect the collection of pre- and post-treatment data. At this time, it is not known whether dam

removal at Veazie and Great Works and/or installation of the Howland nature-like bypass will occur simultaneously in a single construction season or individually over several years. To the extent practical, it is recommended that all pre-treatment data be collected concurrently prior to any dam modifications in the river.

Fish Population Studies

Fish population studies will need to be conducted in the Penobscot River before and after dam removal to monitor multiple metrics for fish at the individual, population, and assemblage levels. There are many potential study designs that could be used to monitor the response of fish to restoration actions in the Penobscot River ranging from simple relative abundance studies to complex stock assessments. This plan proposes to continue the use of the Index of Biotic Integrity (IBI) data collection protocols in the Penobscot River to assess the effects of the PRRP. Catch per unit effort data based on standard IBI protocols have been collected in the Penobscot River periodically since 2004 and provide important pre-treatment (baseline) data of fish populations. The continuation of these protocols will ensure continuity of data and facilitate before and after comparisons of restoration effects on fish populations.

Karr (1981) introduced the IBI concept of multimetric indices to assess aquatic assemblages. The IBI method integrates biotic responses by examining population and community patterns and processes (Karr 1981; Karr et al. 1986; NRCS 2003). The IBI uses fish sampling data to indicate the overall health and integrity of a stream.

Currently, sampling protocols are being developed for large Maine rivers (Yoder and Kulik 2003; Yoder 2005). Sample sites have been established in several Maine rivers including the Penobscot River. In 2004, 46 sites were sampled using the protocols throughout the lower, middle, and upper reaches of the Penobscot River and the following tributaries: Mattaawamkeag River, Piscataquis River, and Passadumkeag Stream (Yoder 2005). The Stillwater Branch of the Penobscot River was also sampled. Several sites were re-sampled in 2005 near Old Town and Lincoln, Maine. These studies provide baseline data on diadromous and resident fish resources in the Penobscot River for this restoration monitoring study. To supplement existing baseline data, additional fish community assessment using the developed protocol should occur for two years prior to dam removal and fishway installation activities in the river. Tentatively, sampling should also be repeated during 1, 3, and 5 years following the completion of restoration activities to provide post-treatment monitoring information. This would provide essential data concerning fish abundance, biomass, and fish assemblages (species richness, recolonization, etc.) related to river restoration goals and objectives (see Objectives 1 and 2). For purposes of this conceptual plan, specific sample sites, metrics, and statistical analyses will need to be determined by researchers involved in the PRRP. Its quite possible that additional post-treatment data will be needed beyond the 5th year to adequately assess both small and large-scale changes to fish assemblages in the Penobscot River. Researchers involved in the PRRP will determine the need for additional post-treatment fish community data.

Fish Movement Studies

As part of the PRRP, the Veazie and Great Works Dams will be removed. The Howland Dam may be partially removed and a new, nature-like fishway will be installed.

Implementation of the PRRP will also result in the installation of several new upstream and downstream fish passage facilities at PPL Maine's dams in the lower Penobscot River (see Section II and Figure 1). Dam removals and installation of these new fishways could have a number of effects on diadromous fish assemblages in the river including upstream and downstream migration and survival rates, adult returns, juvenile escapement, colonization, and distribution. To assess the effects of these actions in restoring diadromous fish, pre- and post-treatment fish movement studies will need to be conducted in the Penobscot River. However, because Atlantic salmon are the only anadromous fish species that presently occur in the Penobscot River above the Veazie Dam in any significant numbers, it will not be possible to conduct pre-treatment BA movement studies for other anadromous fish species that may be restored to the river as a result of the PRRP.

Fishway records in the Penobscot River provide useful pre-treatment fish movement information for Atlantic salmon. At present, fishways are monitored at the Veazie and Weldon Dams. The Veazie Dam is the first dam on the Penobscot River while the Weldon Dam is the fifth and final mainstem dam on the Penobscot River. The Veazie Dam fishway has been monitored since 1978 (Baum 1997). At the Weldon Dam, the fishway has been monitored since 1983 (personnel communication, Kevin Bernier, Fisheries Biologist, Brascan Power New England, October 21, 2005). Following implementation of the PRRP, fish passage monitoring data collected at the Milford, Orono, and Weldon Dams can be used to assess post-treatment movements of Atlantic salmon and other diadromous fish species. It is expected that fishway monitoring at the facilities will continue for a number of years following implementation of the PRRP.

A number of upstream and downstream pre-treatment fish passage restoration monitoring studies for Atlantic salmon have been conducted in the lower Penobscot River. During the late 1980s and early 1990s, fish passage effectiveness studies for Atlantic salmon were conducted at PPL Maine hydroelectric dams using radio telemetry (Hall and Shepard 1990a; Hall and Shepard 1990b; Shepard 1989a; Shepard 1989b; Shepard 1991a; Shepard 1991b; Shepard 1991c; Shepard 1993; Shepard 1995; Shepard and Hall 1991). In 2002-2005, upstream Atlantic salmon movement studies were performed in the lower Penobscot River using Passive Integrated Transponder (PIT) tag detection arrays at multiple fishways in the river (Beland and Korsky 2003). The University of Maine is currently conducting a downstream smolt movement study using ultrasonic telemetry techniques in the Penobscot River. These data, along with post-treatment effectiveness testing that will be collected by PPL Maine at the Milford, Orono, and Stillwater[3], may be used to describe the effects of the new fishways on Atlantic salmon movements in the lower Penobscot River. To understand the combined effects of new fishways and the removal of the Great Works and Veazie Dams on anadromous species, movement studies using PIT tags and ultrasonic telemetry should be performed following implementation of the PRRP. These studies will provide essential information concerning migration and survival rates for anadromous fish species and should be conducted under a variety of river conditions including low, median, and high river flows and at dams not affected by the PRRP (Orono, Stillwater, Milford, West Enfield)

[3] The FERC licenses for the Milford, Stillwater, and Orono Dams requires fishway effectiveness studies.

Additional studies concerning Atlantic salmon movements will be needed at the nature-like fishway at the Howland Dam. For purposes of this conceptual plan, at least two (2) years of post-treatment effectiveness and validation studies using radio telemetry techniques, PIT tags, or some other method should be conducted with Atlantic salmon at the nature-like fishway at Howland. Data collected at the nature-like fishway can be contrasted to historical fishway effectiveness data at the Howland Dam to document the effects of the PRRP.

Following implementation of the PRRP, PLL Maine must conduct fishway effectiveness studies at the Milford, Stillwater, and Orono Dams for a variety of anadromous fish species and American eel. With the exception of Atlantic salmon, these data cannot be used for BA study protocols. However, it will provide useful post-treatment information for the river.

Juvenile Migrant Sampling

NOAA Fisheries' Maine Field Station has assessed Atlantic salmon smolt populations in the lower Penobscot River since 2000. The Maine Field Station annually deploys three rotary screw traps to capture migrating smolts downstream of the Veazie Dam. The Maine Field Station has also performed similar assessment work on the Narraguagus, Sheepscot, and Pleasant Rivers. The primary purpose of rotary smolt trapping operations is to sample Atlantic salmon smolts to estimate the number of smolts emigrating, and to gain a better understanding of their ecology. Other species of resident and diadromous fish are routinely collected during trapping operations (Table 1) and rotary screw traps can be effective for collecting American eel, alewives, rainbow smelt, and American shad.

Table 1. Summary of diadromous fish caught per river by rotary screw traps. Penobscot River and Narraguagus Rivers sampled annually since 2000. Sheepscot River sampled in 2002, 2004 and 2005; Dennys River sampled in 2005.

River	Salmon Smolt	Rainbow Smelt	American Eel	Alewife	American shad
Penobscot	5,781	~9,423	1,626	179	0
Sheepscot	409	218	847	8,830	36
Narraguagus	2,312	196	1665	9,861	5
Pleasant	1,280	9	132	1,986	3
Dennys	549	5	25	0	0
Total	10,331	~9,851	4,295	20,856	44

Rotary screw trap data collected in the lower Penobscot River provides useful baseline restoration monitoring data. As part of the BA study design for this restoration monitoring plan, NOAA Fisheries Maine Field Station should deploy and monitor two (2) rotary screw traps in the lower Penobscot River from April through November at least two years prior to dam removal actions. An April – November sampling effort is designed to coincide with the outmigration seasons for smolts, alewives, shad, and American eel. Rotary screw trap should be sampled at least every 24-48 hrs weekly

throughout this period depending upon flow and river conditions[4]. To provide post-treatment monitoring data, this effort should be continued during the 1st, 3rd, and 5th years following implementation of the PRRP or more frequently if feasible. Additional post-treatment data may be needed beyond the 5th year interval to adequately characterize both small and large-scale changes to smolt populations in the Penobscot River. The need for additional post-treatment smolt data will be made by researchers involved in the PRRP following statistical analysis of all data collected following the fifth year of dam removal. Data collected during rotary screw trap sampling may also be used to calibrate proposed estuarine hydroacoustics sampling in the Penobscot River (see below).

Estuarine Hydroacoustics Sampling

Hydroacoustic assessment is an accepted methodology for presence, distribution, biomass, and behavior of fish and other aquatic fauna. Fisheries hydroacoustics are used to detect fish, and other aquatic organisms, by the use of sound transmitted in water. Either fixed or mobile hydroacoustics could be used to assess estuarine fish populations. Any estuarine study will likely also monitor environmental factors including salinity, temperature, and particle transport - all factors influencing fish and prey presence in the estuary. Specific objectives of a hydroacoustic monitoring program are:

- Deploy fixed or operate mobile, commercially available hydroacoustic and environmental monitoring gear to collect data on fish presence, zooplankton presence, and environmental conditions in the Penobscot River estuary.
- Optimize deployments to monitor the entire river width using hydroacoustics.
- Verify targets (fish and other) to lowest group possible using hydroacoustics.
- Optimize and calibrate hydroacoustic gear for monitoring individual fish species and prey abundance.
- Initiate monitoring of phytoplankton abundance.
- Establish indices for determining fish abundance.
- Characterize seasonal fish presence/absence data.
- Characterize the impacts of environmental conditions (primary productivity, temperature, salinity, flow, particle dynamics, prey abundance) on fish presence and movement patterns.

A hydroacoustics study of the Penobscot River estuary will provide important data pertaining to pre-treatment conditions of fish assemblages, ecology, and environmental conditions. In order to provide post-treatment monitoring data, the hydroacoustic study should continue for at least 2-5 years after implementation of the PRRP. Researchers involved in the PRRP will determine the need for additional post-treatment data. In addition to fixed surveys, mobile hydroacoustic surveys of the estuary would also provide important data concerning fish populations.

Marine-Derived Nutrient Studies

Upon their return from the sea, anadromous salmonids provide marine-derived nutrients to freshwater ecosystems through excretion, gametes, and carcasses (Winter et al. 2000). These nutrients can be important to the productivity of the lakes and streams in which

[4] RSTs require at least 6 feet of water depth to work properly. Low and high river flows may limit RST sampling in the river during the proposed sampling period.

they spawn and to their progeny (Winter et al. 2000). These nutrients can be directly consumed by fishes or are reduced by bacteria, invertebrates, and fungi. Increased nutrient production can increase invertebrate, bacteria, and fungi diversity, numbers, and growth rates and then lead to increased fish growth rates (Winter et al. 2000). While the dynamics and ecological significance of nutrient cycling by anadromous fish species assemblages in west coast ecosystems has been well established, the scientific basis and biological significance to Atlantic salmon and other co-evolved east coast anadromous fishes (clupeids, sea lamprey, or Atlantic salmon themselves) is less well studied or understood at this time (Garman and Macko 1998; MacAvoy et al. 2000, Nislow et al. 2004).

To understand the influence of organic materials and nutrients from anadromous fish affected by the PRRP, nutrient concentrations, biomass, isotopic signatures and production of algae, macroinvertebrates, and finfish could be monitored before and after removal of the Penobscot River dams. A detailed description of appropriate methods and statistical analyses of such studies is beyond the scope of this conceptual plan.

Non-Finfish and Abiotic Monitoring Program

Implementing the PRRP will significantly alter aquatic habitat in the lower Penobscot River through removal of the Veazie and Great Works Dams and installation of a nature-like fishway at the Howland Dam. Objectives 3 and 4 of this monitoring plan calls for a BA assessment of non-finfish and abiotic responses important to diadromous fish species in the Penobscot River.

Pre-treatment water quality data (temperature and dissolved oxygen) for the lower Penobscot River has been collected by the Maine Department of Environmental Protection (MDEP), Penobscot Indian Nation, PPL Maine, and others for many years. In 2003, the MDEP published the results of water quality modeling using QUAL2EU for the Penobscot River (MDEP 2003). Using water quality data collected in the river during 1997 and 2001, the MDEP model predicts water quality including temperature and dissolved oxygen throughout the Penobscot River from Millinocket to Bucksport. It is expected that these data along with other data collected by PIN and PPL Maine is adequate to describe pre-treatment water quality conditions in the lower Penobscot River. To assess post-treatment water quality conditions, water quality sampling should occur in the Penobscot River following implementation of the PRRP. Water quality sampling should occur from the Howland Project downstream to Bangor under a variety of river flows including low, median, and high river flows. Specific protocols for water quality monitoring will need to be established by researchers involved in the PRRP.

Aquatic habitat in the vicinity of the Veazie, Great Works, and Howland Dams should also be mapped before and after implementation of the PRRP (including the proposed nature-like fishway at Howland). This information will be essential to describe the effects of the PRRP in restoration aquatic habitat for fish, prey, and macroinvertebrate species in the river. Habitat should be mapped to scale as run, riffle, and pool (at an appropriate scale) and geo-referenced using a Global Positioning System.

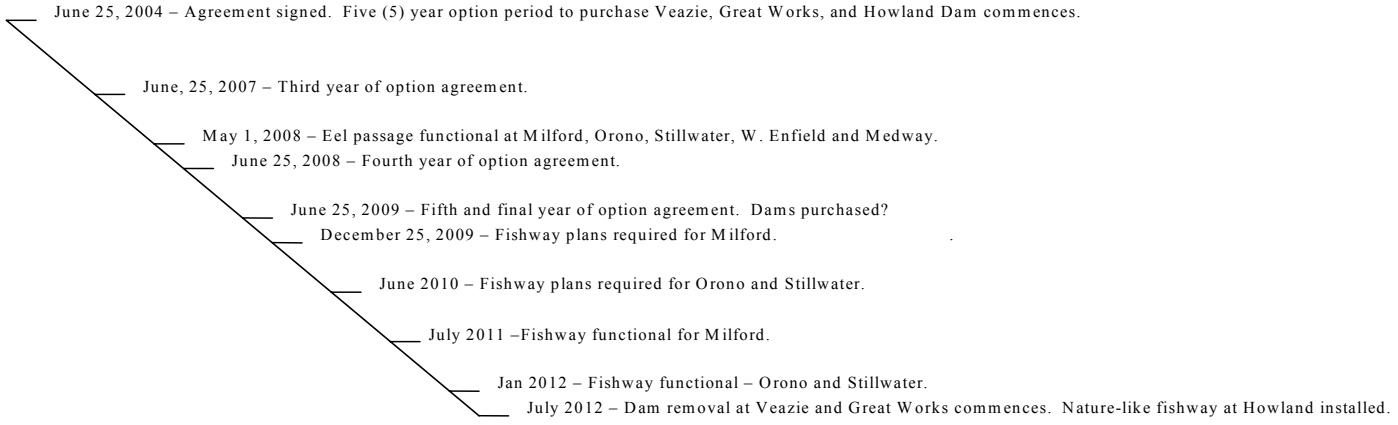
C. Data Analysis

The statistical methods used to analyze data collected during restoration monitoring should be based on the monitoring design, the parameters selected, and the data collected (Roni et al. 2005). There are a number of common multivariate statistical approaches that have been used to test hypotheses regarding restoration activities including parametric tests (e.g., t-tests, analysis of variance), regression and correlation, non-parametric tests (e.g., Mann-Whitney tests, Wilcoxon paired rank test, Kruskal-Wallis analysis of variance), multivariate techniques (e.g., cluster analysis, discriminant analysis), and others. However, a detailed description of appropriate statistical analyses or models is beyond the scope of this conceptual plan. Rather, researchers involved in the PRRP should determine the appropriate statistical analyses.

Ultimately, data collected during monitoring studies should be analyzed to assess the progress of achieving restoration goals for the Penobscot River. The Maine Atlantic Salmon Commission along with other state and federal resource agencies are presently preparing a multi-species fisheries management plan for the Penobscot River. The multi-species management plan will develop species-specific restoration goals for the Penobscot River based upon habitat, water quality, species life history, etc. To assess the success of the PRRP, a whole-life history model could be developed using data collected during monitoring studies. Estimates of age/size specific survival, growth, fecundity, etc. could be weighted by production goals to identify where restoration bottlenecks exist in meeting restoration goals. Also, data collected during restoration monitoring studies could be used to periodically calibrate species-specific restoration goals of the management plan within a whole-life history model.

IV. TIMELINE

The timeline for implementing the PRRP was established by the Penobscot River Comprehensive Settlement Accord filed with the FERC in June, 2004. In accordance with the Settlement Accord, the five-year option period to purchase the Veazie, Great Falls, and Howland Dams expires in June, 2009 (see below). Assuming the dams are purchased on the fifth and final year of the option period and two to three years will be needed to permit dam removal activities, it is anticipated that the Veazie and Great Works Dams could be removed in 2012. The Howland Dam nature-like fishway could also be installed in 2012.



V. FUNDING

The following table provides preliminary cost estimates for conducting BA restoration monitoring studies in the Penobscot River. Cost estimates include sampling, data analysis, and reporting. Potential funding sources for studies have also been identified.

Study	Estimated Number of Years	Annual Cost Estimate ($1,000)	Funding Source
Fish Population Studies	5	50-90	Grants
Smolt Movement (ultrasonic telemetry)	4	125-150	Grants
Adult Salmon Movement (PIT tagging)	4	25--50	Grants
Howland Nature-Like Fishway Effectiveness	2	50-75	Penobscot Partners
Fishway Monitoring	5	75-100	PPL Maine
Milford, Orono, and Stillwater Fishway Effectiveness	2-3	150-200	PPL Maine
Juvenile Migrant Sampling (rotary screw traps)	5	50-75	NOAA PRD/NEFSC
Estuarine Hydroacoustics Sampling	5	150	Grants
Water Quality	3	50	Grants
Habitat Mapping	2	50-75	NOAA Restoration Center
Marine Derived Nutrients	2-3	50-75	Grants

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