NOAA FISHERIES
Northeast Region

# Evaluating the ecological outcomes of the Penobscot River Restoration Project

Rory Saunders, Mathias Collins,
Josh Royte, and Tim Sheehan

January 11, 2013

Diadromous Species Research and Restoration Network, Science Meeting

# Acknowledgements


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Jeff Reardon
Catherine Schmidt
Joan Trial
Tara Trinko Lake
Karen Wilson
Gayle Zydlewski
Joe Zydlewski


# Outline

- Background
  - PRRP 101
  - Guiding images of success
    - Palmer's 5 criteria
- Progression of science interests
- Pre-removal snapshots
  - Abiotic
  - Biotic
- Take Home Messages

# Take Home Messages

- Right project at the right time?
  - Success is no accident
  - Scientists should be in communication with implementers and funders
  - Plan should be what you need, not what you have

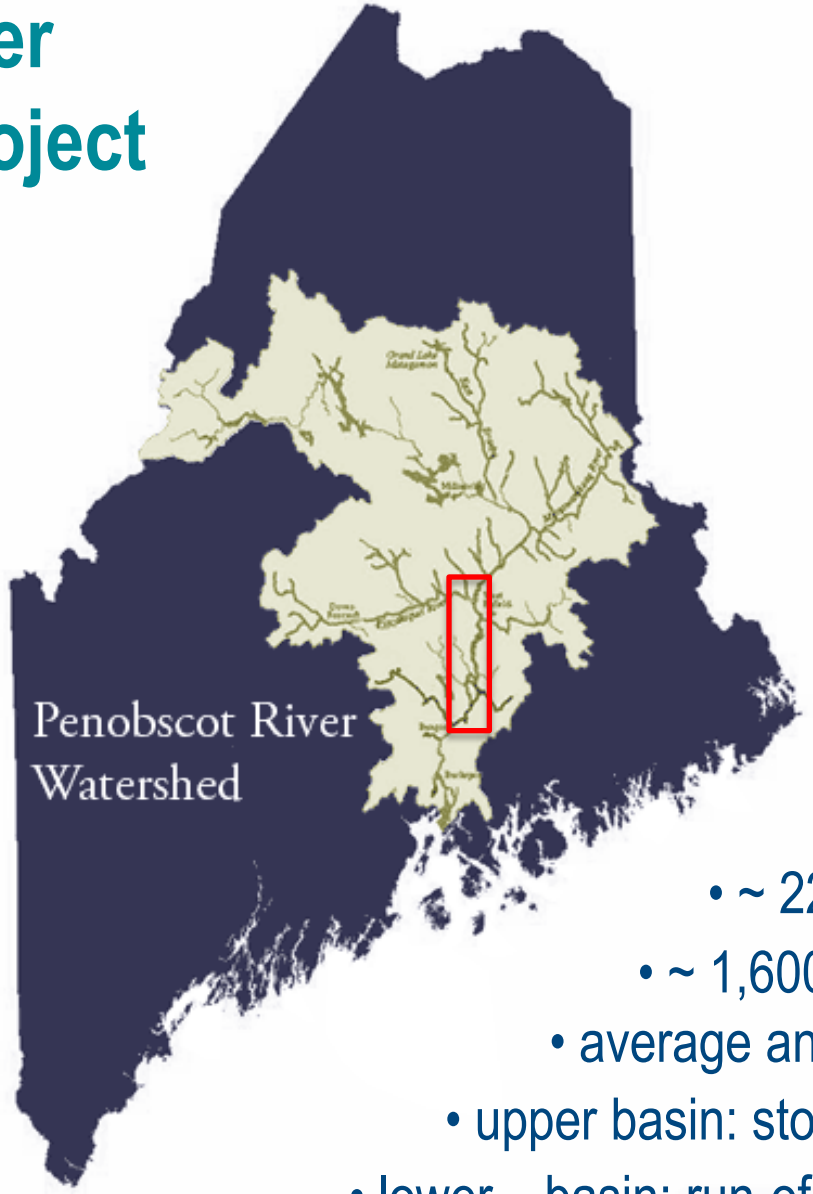
- Socio-economics requires more attention

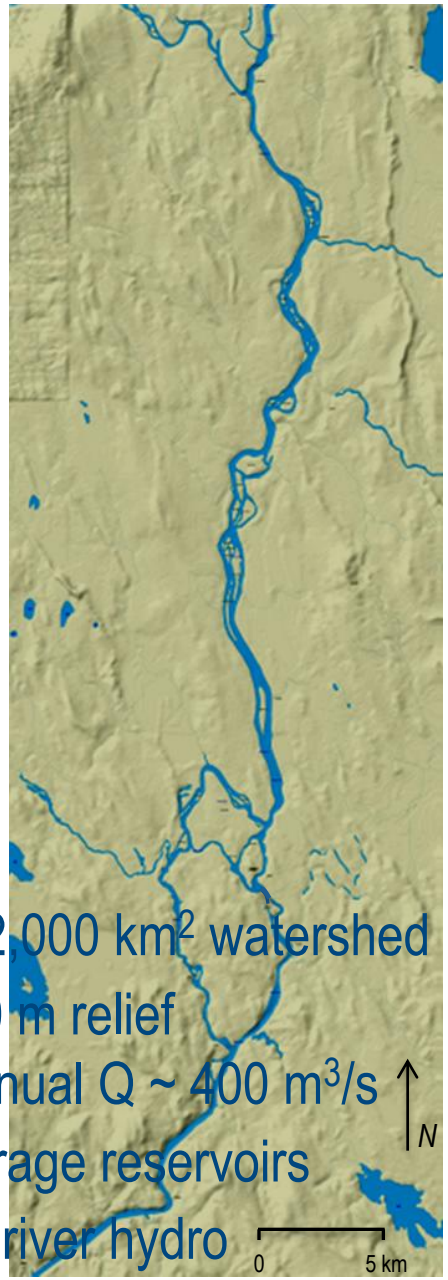
- We need a mutually agreed upon guiding image…soon.

- If the fish do respond, we will have evidence to show that dam removal works.
- If the fish do not respond, we should be able to figure out why.

- What about the shad?

# Penobscot River Restoration Project (PRRP)


- ~ 22,000 km$^2$ watershed
- ~ 1,600 m relief
- average annual Q ~ 400 m$^3$/s
- upper basin: storage reservoirs
- lower basin: run-of-river hydro

# PRRP


## Stillwater Branch

West Enfield

Howland

USGS 01034500:
~ 110 year record

Gilman Falls diversion

Stillwater

Orono

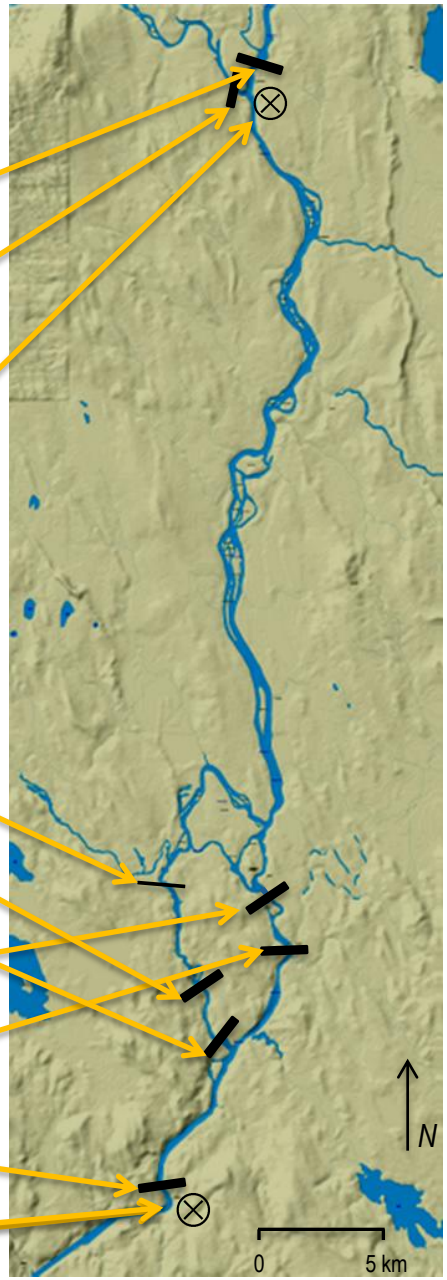
Milford

Great Works

Veazie

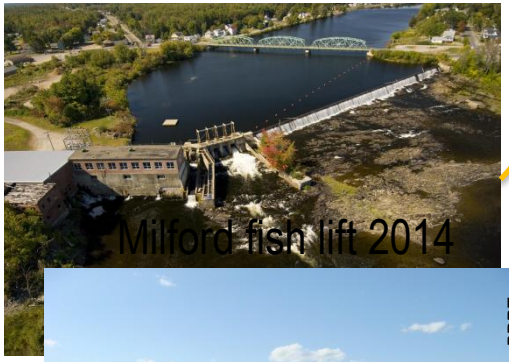
USGS 01036390:
~ 90 year record

river is tidal for ~40 km to here



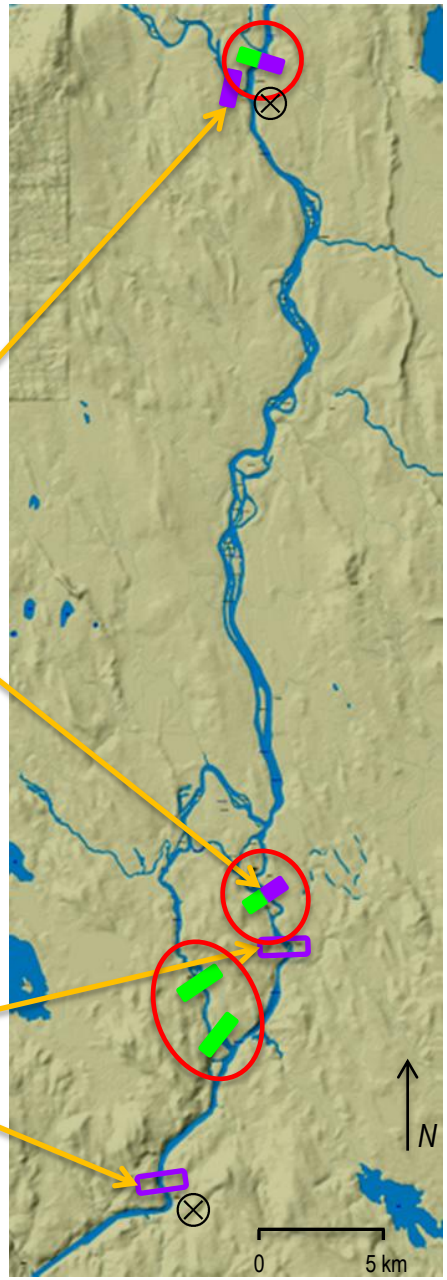
# PRRP


dam removal
fish passage (fp)
enhanced energy (ee)
fp + ee









Existing Conditions Veazie Dam

MMI Engineering


Projected Conditions Veazie Dam
MMI Engineering

Existing Conditions Great Works Dam
MMI Engineering

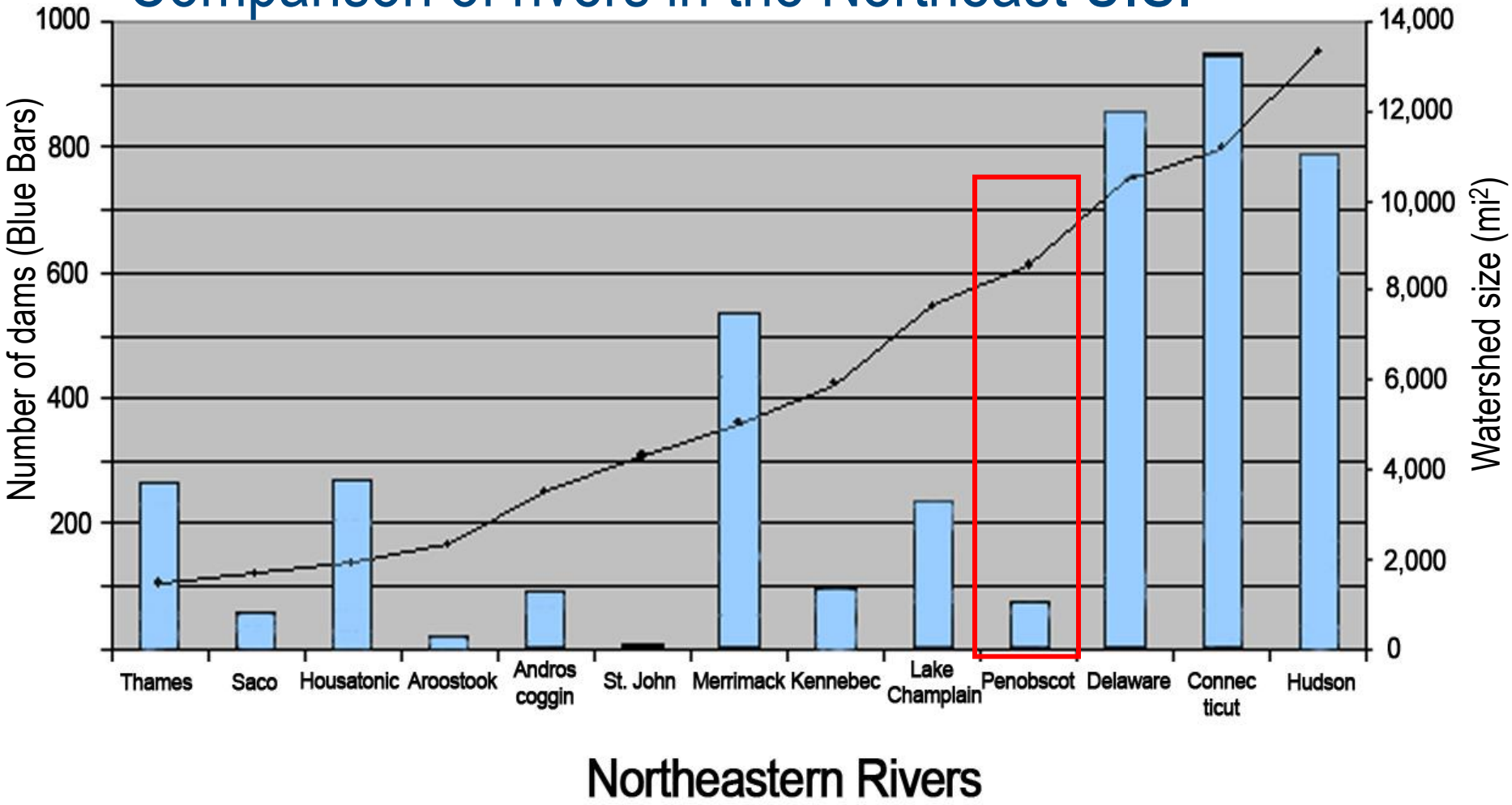
Projected Conditions Great Works Dam
MMI Engineering


Great Works Dam Removal, July 2012
Steve Shepard, USFWS

# Project context – why here?

Slide courtesy of TNC

- Comparison of rivers in the Northeast U.S.



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BY MISTY EDGECOMB
OF THE NEWS STAFF

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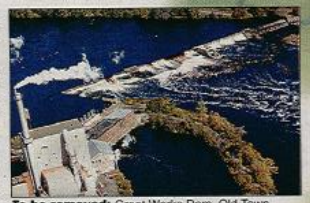
*See Dams, Page A10*



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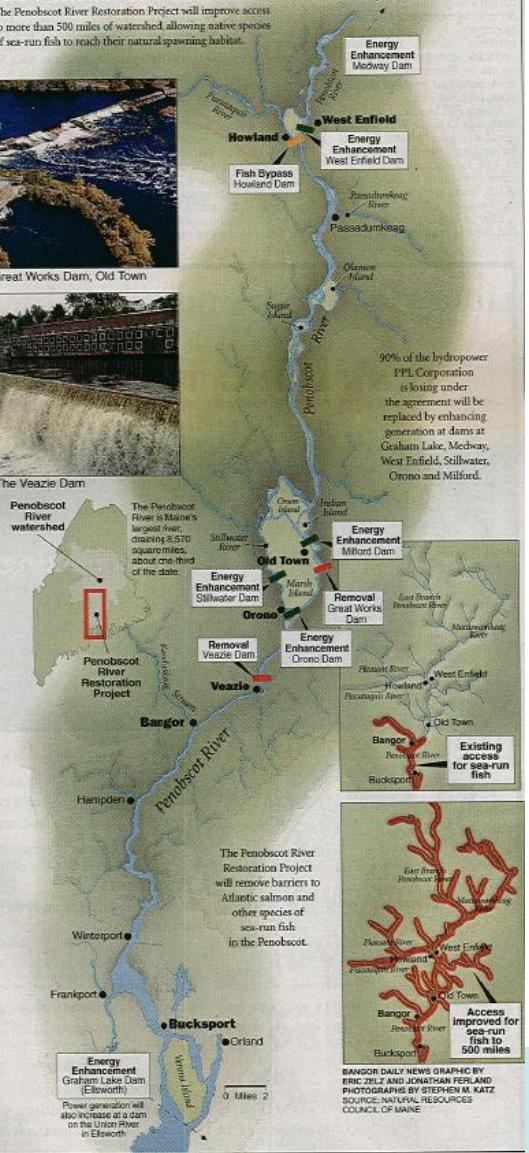



BANGOR DAILY NEWS GRAPHIC BY ERIC ZELZ AND JONATHAN FERLAND
PHOTOGRAPHS BY STEPHEN M. KATZ
SOURCE: NATURAL RESOURCES COUNCIL OF MAINE



# Buying Dams To Save Salmon

## *Pact to Open Up Maine Habitats*

*By* JONATHAN FINER
*Washington Post Staff Writer*

BOSTON, Oct. 6—A coalition of government agencies, environmental groups, a Native American tribe and a power company announced a plan Monday to improve the habitat for threatened Atlantic salmon and other fish in Maine by removing or altering a string of hydroelectric power plants on the state's longest waterway.

"This project is an uncommon collaboration towards a common goal—a renewed Penobscot River," Laura Rose Day, director of the Penobscot River Restoration Project, said in a news conference on the banks of the river, in Old Town, Maine.

Under the terms of the agreement—whose adherents include at least five environmental groups, utility PPL Corp., and the Penobscot Indian Nation—the project will purchase PPL's Veazie, Great Works and Howland dams for approximately $25 million, within five years.

The money will be raised, Day said, from a combination of private donations, and grants from foundations and state and federal government programs.

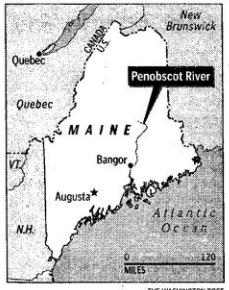
The Veazie and Great Works dams, on the eastern part of river, will be removed, while the U.S. Fish and Wildlife Service will help with the construction of a bypass for the Howland dam, enabling fish to swim around the dam to more than 500 miles of habitat upstream, organizers said. PPL also agreed to improve fish passage at four other Maine dams.

In return for selling those dams, PPL, which owns all of the dams on the lower Penobscot River, will be permitted to boost energy production at six other facilities less disruptive to fish migration, allowing the company to retain 90 percent of its overall power generation. The other parties to the agreement will also drop their opposition to PPL's relicensing efforts at other dams in the state.

"It's a win-win situation" for each of the groups involved, said company Vice President Dennis Murphy.

BY KEVIN BENNETT—BANGOR DAILY NEWS VIA ASSOCIATED PRESS

**James Neptune, a Penobscot Tribal Council member, carries the tribe's flag to the Penobscot River in Orono as a deal to help save the Atlantic salmon is reached among the tribe, PPL Corp., the state and conservation groups.**




THE WASHINGTON POST

The project is designed to provide easier access to the state's vast network of tributaries, ponds and streams for shrinking populations of Atlantic salmon, American shad, alewives, blueback herring, American eels, smelt, striped bass, tomcod and sea lamprey.

Coveted by diners and anglers alike, Atlantic salmon have long been a symbol of Maine, and the first catch of the year was traditionally sent as a gift to the White House.

Between 60 percent and 70 percent of all remaining Atlantic salmon in the United States spawn in the Penobscot, whose watershed drains close to 9,000 square miles, an area about the size of neighboring New Hampshire.

But pollution, industrial logging and an obstructive series of dams conspired to reduce the Atlantic salmon run in which fish return from the sea to spawn in freshwater rivers. The annual run on the Penobscot has dropped to fewer than 1,000 fish, down from as many as 70,000 in the early 19th century, project organizers say. Fishing for Atlantic salmon is now banned in Maine, and the state stopped sending them to the White House in the early 1990s.

Conservation efforts significantly reduced pollution levels on the river in recent years, but did little to restore Maine's fish populations to their earlier heights. Fish hatcheries and stocking initiatives also achieved limited results.

In 1999, the removal of the Edwards Dam, on Maine's Kennebec River, led some fish species to return to long-abandoned habitats. Since then, according to the conservation group American Rivers, 115 dams have been removed from sensitive ecosystems across the country.

"We are expecting similar results," said Chief Barry Dana of the Penobscot Indian Nation. In recent years, its 2,300 members—most of whom live on islands in the Penobscot River—have found it increasingly difficult to feed themselves due to the shrinking fish population.

Several native species have vanished almost entirely from waters above the Penobscot's major dams, he said. The new agreement will "restore the sustenance right for the tribal members to consume fish, as we have on this river for 10,000 years."

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# Highlights

< Back to Highlights

## Penobscot River Restoration Project Takes Major Step Toward Opening 1,000 Miles of Habitat

A new chapter has begun for Maine's Penobscot River. the Penobscot River Restoration Trust took ownership of three dams on the river as part of an ongoing restoration project. This **large-scale, ecosystem-level project** will remove the Veazie and Great Works dams and build a fish bypass around the Howland dam. The Trust purchased the dams from PPL Corporation for $24 million, which included funds provided by NOAA through its **Community-based Restoration Program** and the **Open Rivers Initiative**.

The project will **open up nearly 1,000 miles of river habitat**, long blocked by dams, to eleven species of sea-run fish, such as endangered Atlantic salmon, sturgeon, and river herring.

The three dams are currently used for hydropower generation. The Trust will continue to operate the projects until the time of removal. Energy generation lost as a result of the removals and decommissioning will be replaced by expanding capacity at existing projects primarily within the Penobscot River watershed. When the project is complete, hydropower generation will be maintained at the same levels as before the project began, and may even increase.

The project will also create **new community and economic benefits throughout the watershed**. The removal of the Great Works dam, which was partially funded by NOAA through the **Recovery Act**, will yield nearly $5 million in jobs for the region including engineering, hydrology, construction, science, and local contracting services. Similar benefits are expected for the Veazie Dam removal and Howland bypass construction. With the dams removed, fishers, kayakers, and paddlers will have increased opportunities for recreation on the river.

The purchase was part of collaboration between the Trust, NOAA and other federal and state agencies, the Penobscot Indian Nation, and seven conservation groups. Permits from the Federal Energy Regulatory Commission, Maine Department of Environmental Protection, and the U.S. Army Corps of Engineers were approved earlier this year.

Penobscot River, Veazie dam

**Useful Links**

- Recovery Atlas
- Recovery Act program

Screen capture 7 January 2013

NOAA FISHERIES

# *Open up* vs. *Improved access*

- *Let's take an objective look….*

*Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 4:284–293, 2012
American Fisheries Society 2012
ISSN: 1942-5120 online
DOI: 10.1080/19425120.2012.675971

SPECIAL SECTION: AMERICAN SHAD AND RIVER HERRING

## Evaluating Changes in Diadromous Species Distributions and Habitat Accessibility following the Penobscot River Restoration Project

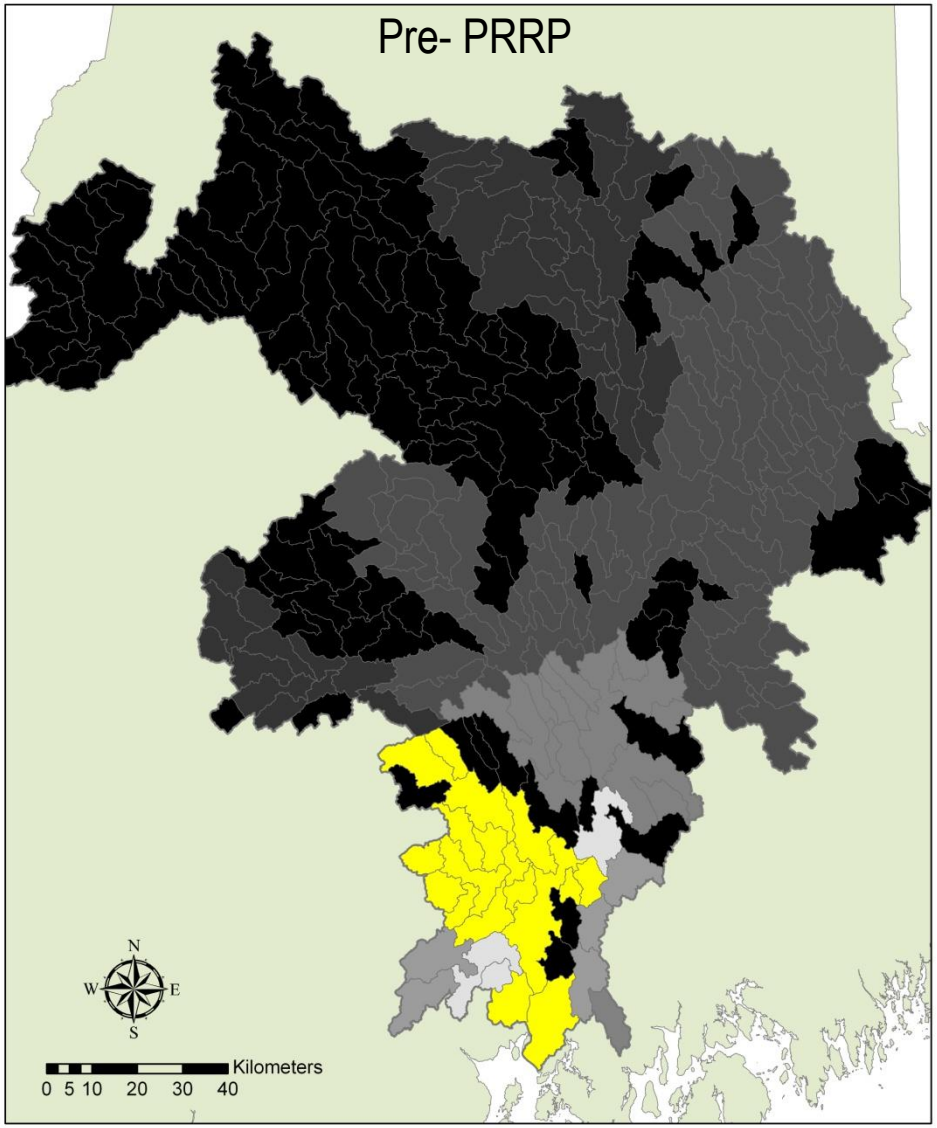
**Tara R. Trinko Lake,* Kyle R. Ravana, and Rory Saunders**
*National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Maine Field Station, 17 Godfrey Drive, Suite 1, Orono, Maine 04473, USA*

***Abstract***

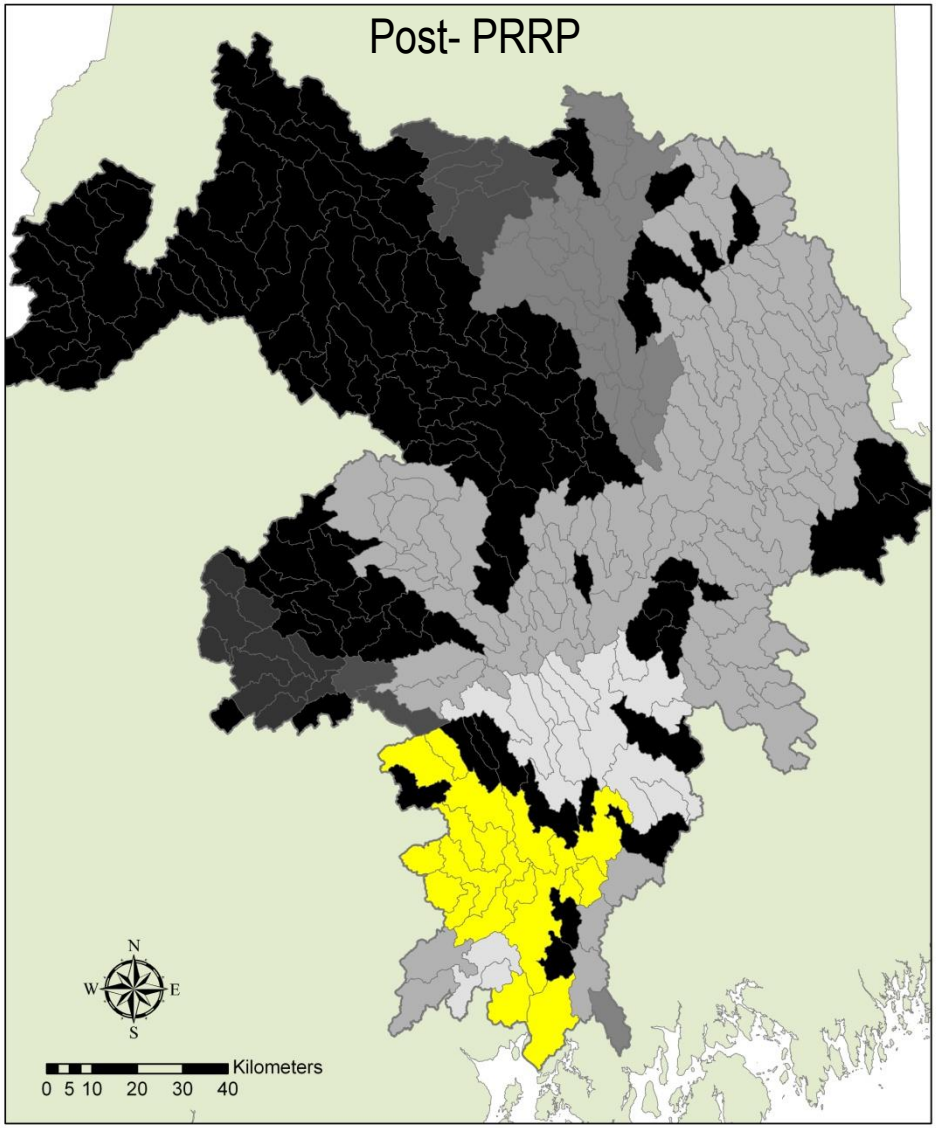
**The Penobscot River basin, covering approximately 22,265 km², is the largest river wholly within Maine and the second largest river system in New England. The Penobscot River Restoration Project (PRRP) is a multimillion-dollar endeavor that aims to restore native sea-run fish through the removal of two main-stem dams and improved fish passage at a third dam on the Penobscot River. We used geographical information systems, accounts of historic ranges, and barrier survey data to estimate species-specific distributions and habitat accessibility for 11 diadromous species before and after the proposed restoration. We predict a range of outcomes in terms of expected distribution and accessibility that are largely based on habitat use and life history differences. For 4 out of 11 species (Atlantic sturgeon *Acipenser oxyrinchus*, shortnose sturgeon *A. brevirostrum*, Atlantic tomcod *Microgadus tomcod*, and striped bass *Morone saxatillis*), the PRRP is anticipated to provide access to 100% of their historic freshwater habitat. However, for alewives *Alosa pseudoharengus*, approximately 69% of the historic spawning and rearing habitat will remain inaccessible due to the presence of other passage barriers. Our results demonstrate that the PRRP is an important step toward ecosystem recovery in the Penobscot River basin but that other restoration activities will be needed to realize the full potential of the PRRP, particularly for alosines. Further, our results provide the first spatial analysis of diadromous fish distribution and access following the PRRP and serve as the baseline for developing a guiding image for expected diadromous fish population responses following the dam removals.**

Diadromous fish populations are important to humans through both commercial and recreational fisheries, but also to ecosystems (Willson and Halupka 1995) through such mechanisms as the delivery of marine-derived nutrients to terrestrial ecosystems (Durbin et al. 1979; Kline et al. 1990); the provision of prey for many species of terrestrial vertebrates (Cederholm et al. 1989), birds (Wood 1986), marine mammals (Cairns and Reddin 2000), and other fish (Schulze 1996); and potential reductions in the predation risks for less abundant fish species (Saunders et al. 2006). The declines of many diadromous fish populations in the Northwest Atlantic are documented (Limburg and Waldman 2009), yet the ecological ramifications of these declines are poorly understood.

In the northeastern United States, the decline of the native suite of diadromous fish has been attributed to dams, overfishing, and pollution (Moring 2005). Marine survival has also become more widely recognized as an important influence in population dynamics, particularly for Atlantic salmon *Salmo salar*. A substantial decline (i.e., regime shift) in the productivity of the marine environment since the early 1990s is correlated with Atlantic salmon population declines throughout their range (Chaput et al. 2005). The historic declines and consequent low abundances in contemporary diadromous populations (particularly for Atlantic salmon in Maine) are largely attributable to the construction and operation of dams (Cutting 1959; NRC 2004; Gephard 2008).




Trinko Lake et al. 2012. Marine and Coastal Fisheries 4:284–293

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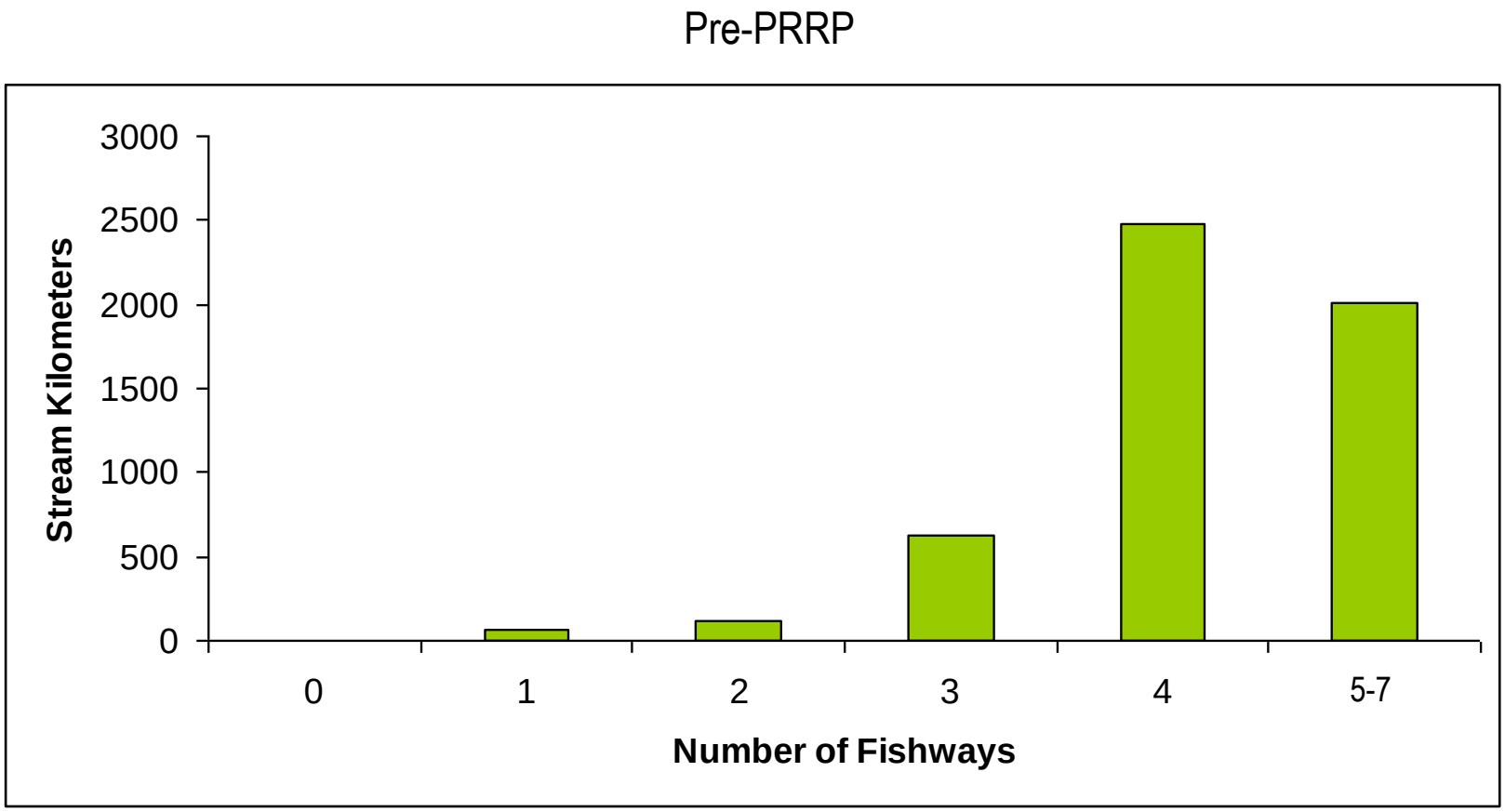

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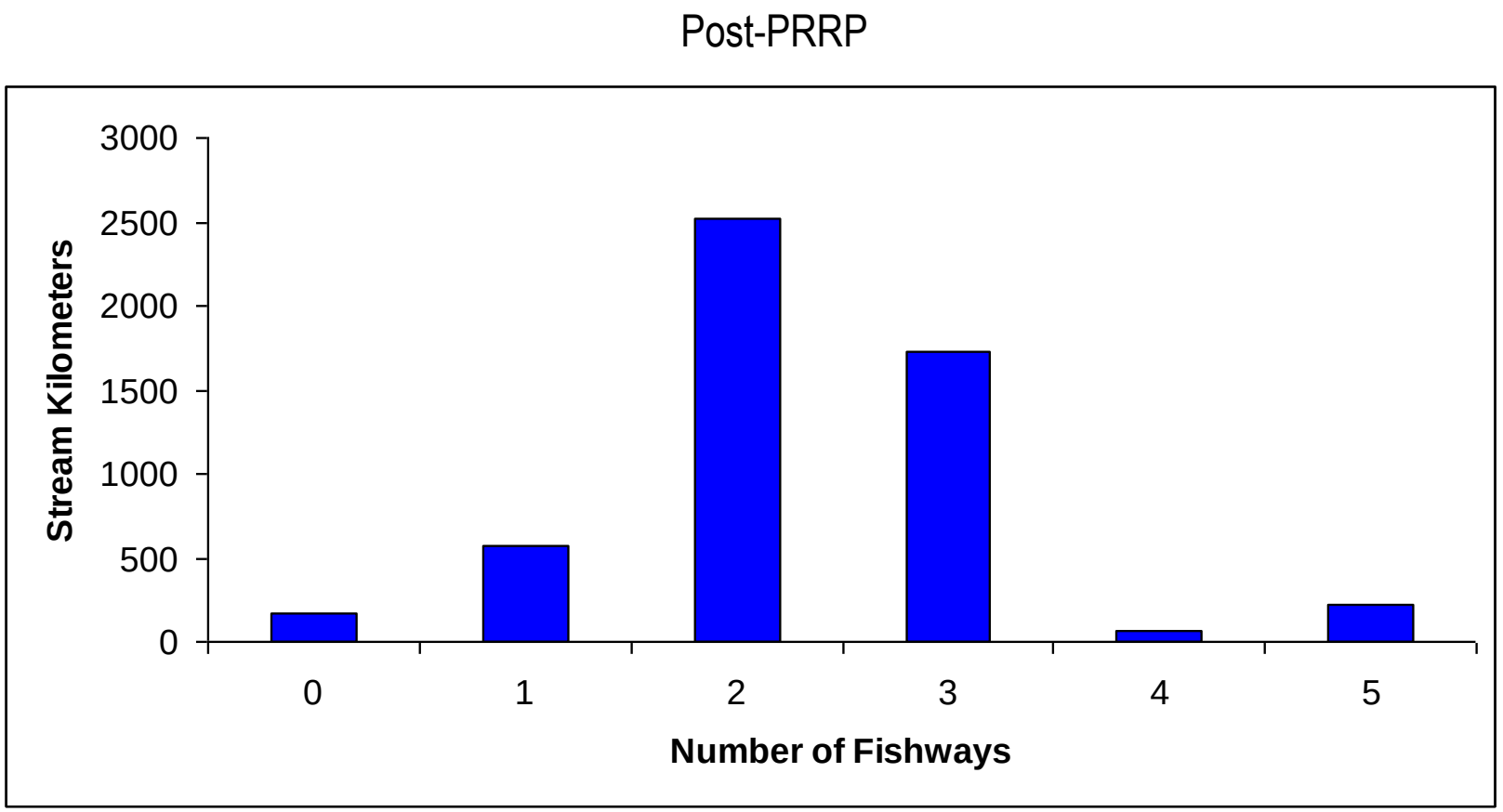

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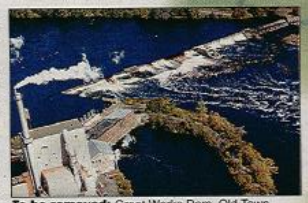
*See Dams, Page A10*



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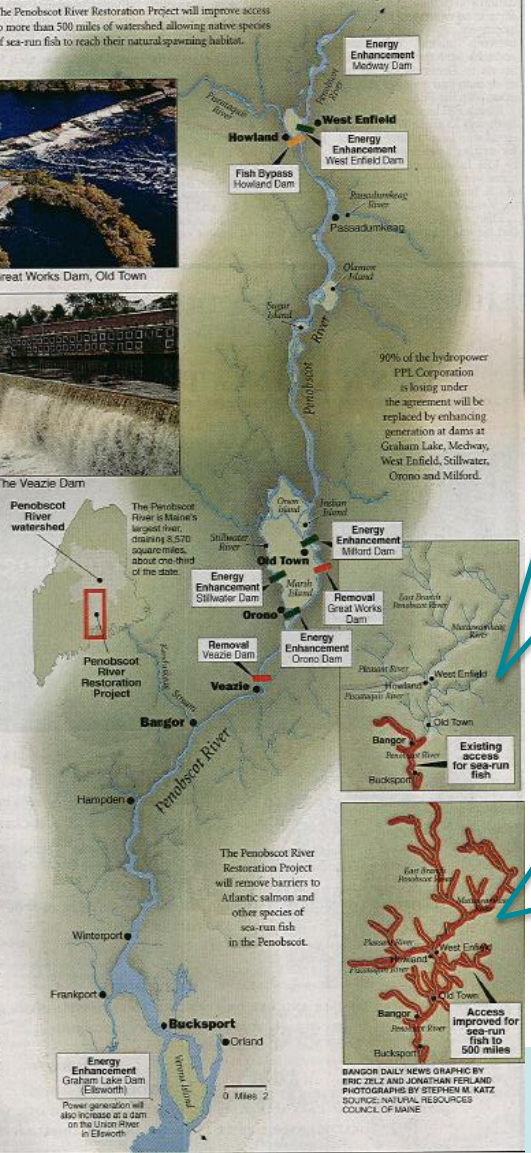


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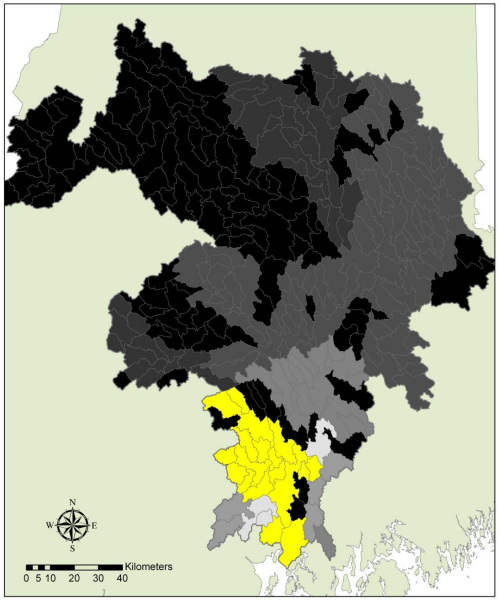
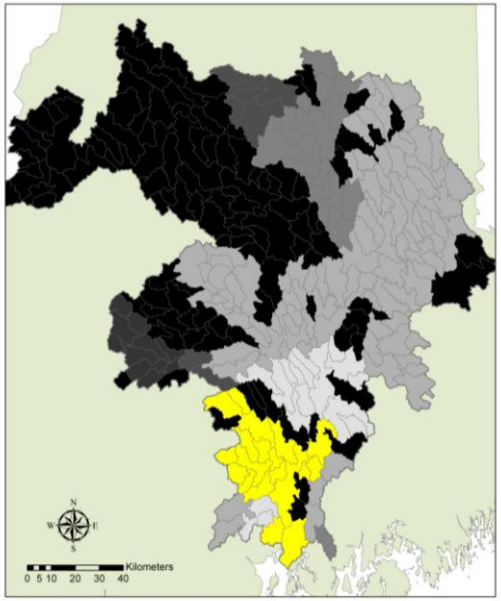


- Lower river species (sturgeon, smelt, and striped bass) will regain 100% unimpeded access to historic habitat
- American shad and blueback herring will gain access to over 93% of historic habitat **IF** they pass up to five fishways (including Milford)
- The majority (66%) of alewife habitat is still inaccessible after implementation of PRRP
- Most habitat for highly migratory species (e.g., salmon) will be above 2-5 dams instead of 4-7 dams

- The science helps us understand:
  - The PRRP is a great first step,
    - The PRRP will open an additional11 miles of habitat AND improve access to 1000s of miles of habitat
    - We need to do more in order to see the PRRP live up to its potential.
  - We need to do more work on developing the “guiding image”
    - *If you don’t know what you want, that is about what you get.*

# What constitutes a successful river restoration project?

•Palmer et al. 2005. Standards for ecologically successful river restoration. J. Applied Ecology 42:208–217

- **Guiding image**
- Ecosystem improvement
- Increased resilience
- No lasting harm
- Pre and post project assessment

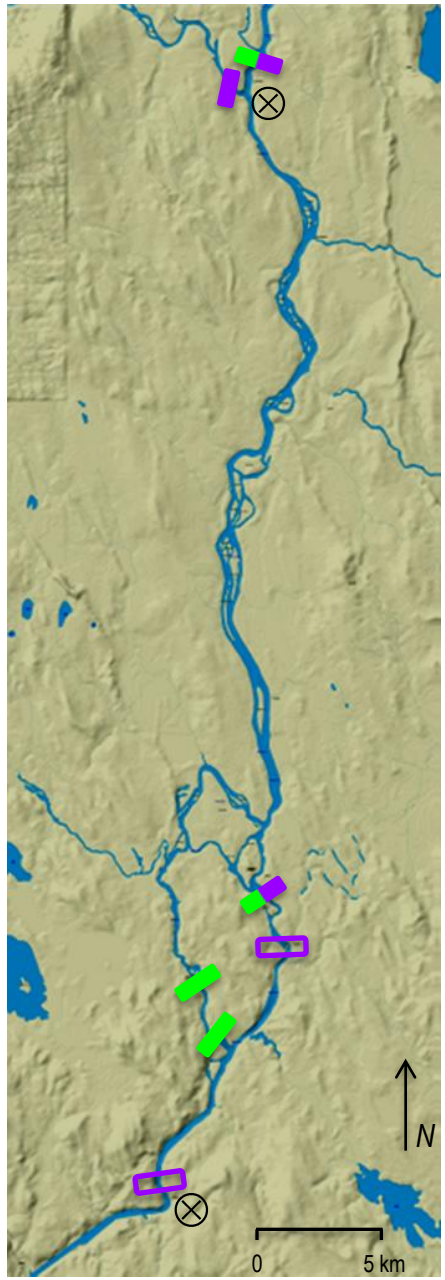
- We have come a long way
  - Alewife restoration
  - Pre-removal science
  - Great Works is out

- We should be proud of our accomplishments
  - But…we need to do more if the PRRP is to live up to its potential.

# Guiding Image –

## Penobscot River Restoration Trust

- Unobstructed access to the entire historic riverine range for 5 “lower river” diadromous species (~15 km);
- Improve access to upstream habitat for 6 “upper river” species by reducing barriers;
- Reconnect trophic linkages between headwater areas and the Gulf of Maine;
- Restore natural fluvial processes to the former impoundments;
- Improve recreational and Penobscot Indian Nation cultural opportunities;
- Maintain basin hydropower generation



# Guiding Image –
## Me. Dept. Marine Resources

- Species-specific objectives, measures, and strategies

- $30M worth of good things to do
  - Funding uncertainty
  - Regulatory uncertainty
  - Staffing changes

- Provide "safe, timely, and effective" passage
  - "Part of the difficulty with passage is the ambiguity in 'safe, timely, and effective.' There is no 'black and white' in the sense that a facility needs to perform at a standard and if it does not, alternatives need to be pursued."
  - **So how much is enough?**

**Operational Plan for the Restoration of Diadromous Fishes to the Penobscot River**

Photo Courtesy of Randy Spencer

**Prepared By:**
Department of Marine Resources
Department of Inland Fisheries and Wildlife

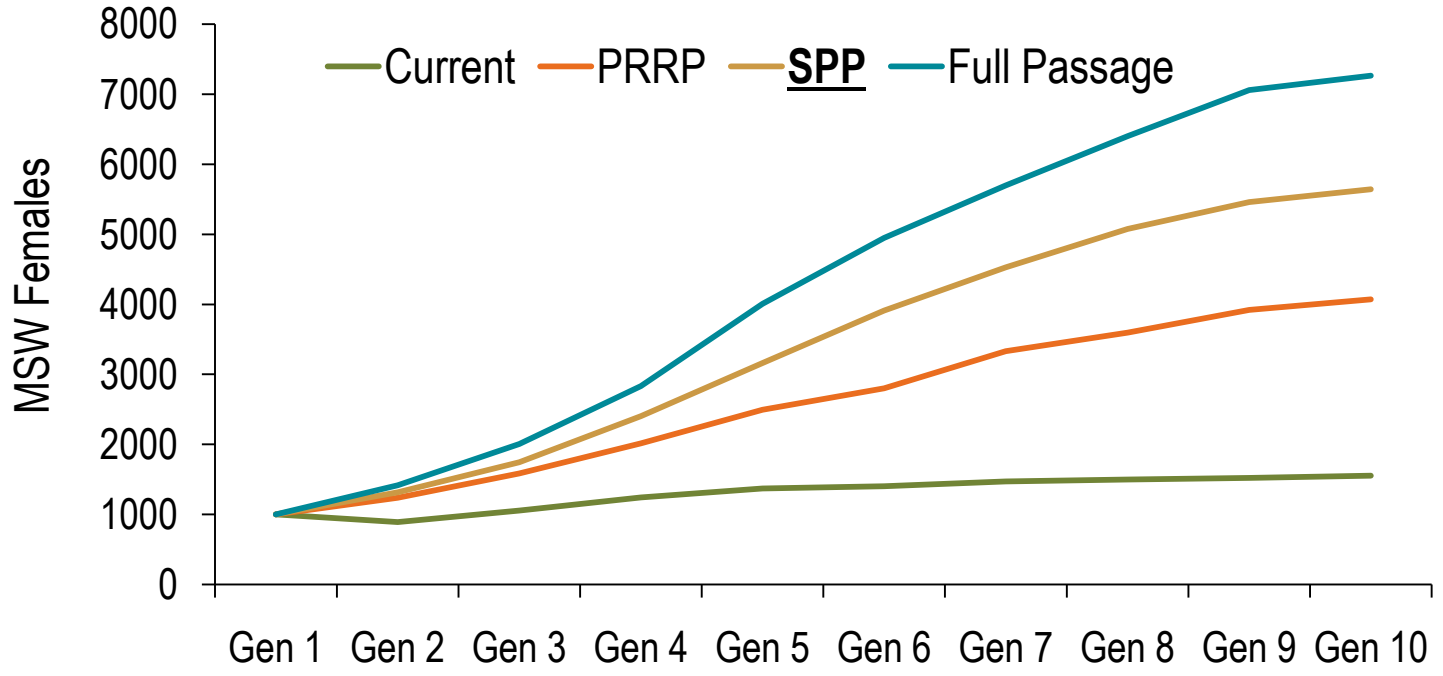
**For Presentation to the Atlantic Salmon Commission:**
Dick Ruhlin, Chair, Member-at-large
George Lapointe, Commissioner of the Department of Marine Resources
R. Dan Martin, Commissioner of the Department of Inland Fisheries and Wildlife

**Editor:**
Melissa Laser, Department of Marine Resources

Approved July 2, 2009

# Guiding Image – NOAA Fisheries Service

- Salmon-specific performance standards at Black Bear Hydro's remaining dams (Exclusive of the West Branch)
  - 96% downstream survival, 95% upstream passage



# Guiding Image Needs To Be

- Developed soon

- Broad enough to be meaningful
- Specific enough to be useful

- Measurable
- Achievable
- Realistic
- Mutually agreeable
  - NGOs
  - Agencies
    - Funding
    - Regulatory
  - Stakeholders

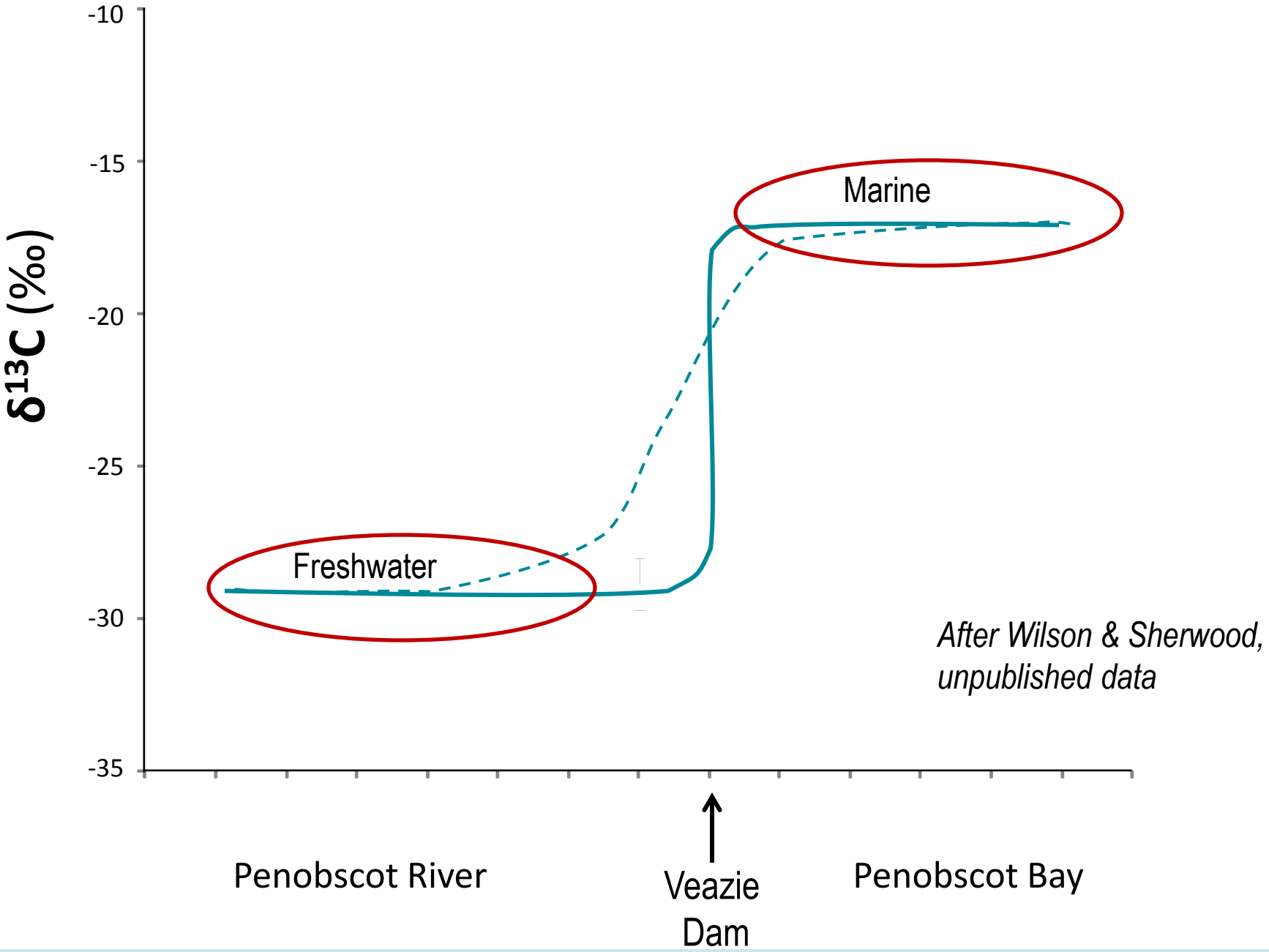
# Some ideas for a defensible guiding image

- Abundance metrics for “umbrella” species
  - MDMR’s phase 1 goals for alewives
    - **Roughly 3.4M alewives per year to Milford**
    - Alosines as the engines that make the river work (MDNE)

- Fish community metrics smoothed
- Trophic linkages restored
  - Relative biomass of diadromous fish is a cline not a cliff

- Focal species become more resilient (self-sufficient)
  - Performance standards will help salmon, but what about the shad?
  - Resilience in endangered species?

- Any feedback and discussion is most welcome here


-10
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δ13C (‰)
Marine
Freshwater
After Wilson & Sherwood, unpublished data
Penobscot River
Veazie Dam
Penobscot Bay

# Why no guiding image to date

- It's hard.
  - Temporal scale – changing cast of characters.
  - Spatial scale – it is a big river with a lot of habitat and a lot of stakeholders.
- No one is charge.
- No one has done this before.
- PRRP grew out of a settlement agreement.

# Outline

- Background
  - PRRP 101
  - Guiding images of success
    - Palmer's 5 criteria
- **Progression of science interests**
- Pre-removal snapshots
  - Abiotic
  - Biotic
- Take Home Messages

# Progression of science interests

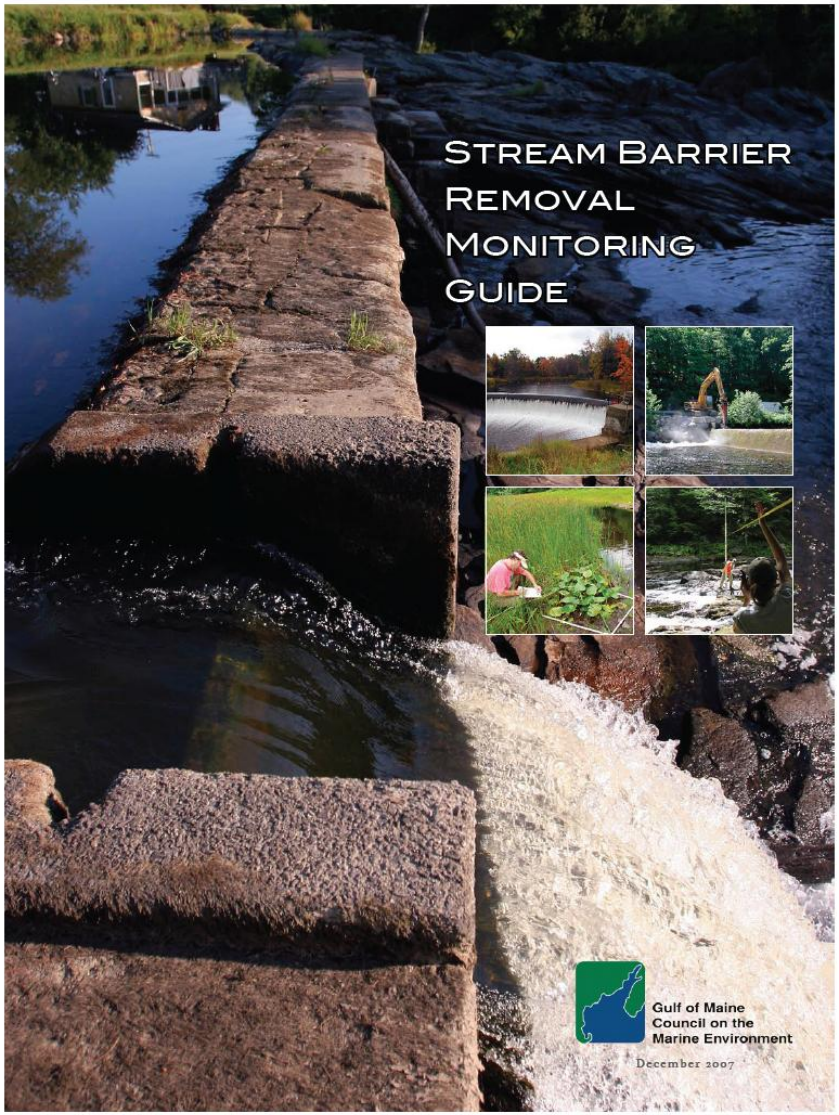
- 2002 – USGS and Maine DMR install and operate PIT array – fish migration studies begin
- 2003 – Penobscot Agreement announced
- 2004 – Penobscot Science Forum
- **2005 - 2008 – Penobscot Science Steering Committee (SSC)**
- 2005 – Ultrasonic telemetry array installed (NOAA, USGS, and UMaine)
- 2007 – Key publications
  - **Barrier Removal Monitoring Guide published – Gulf of Maine Council**
  - Penobscot SSC Monitoring Framework
- 2008
  - NOAA Priorities for PRRP Monitoring published
  - **NOAA and TNC begin substantial investments in monitoring (roughly $100k)**
- 2009 - American Recovery and Re-investment Act (ARRA)
  - Penobscot River Restoration Trust proposal for Great Works Dam removal ($6.1M)
  - **$1.3M – Infrastructure, student salary and tuition, PI salary, contracts, etc.**
- 2010-Present – ARRA-funded projects underway (TNC and NOAA funding)
- 2012 – Great Works removed
- 2013 – Veazie to be removed and post-removal evaluations to begin

# Outline

- Background
  - PRRP 101
  - Guiding images of success
    - Palmer's 5 criteria
- Progression of science interests
- **Pre-removal snapshots**
  - Abiotic
  - Biotic
- Take Home Messages

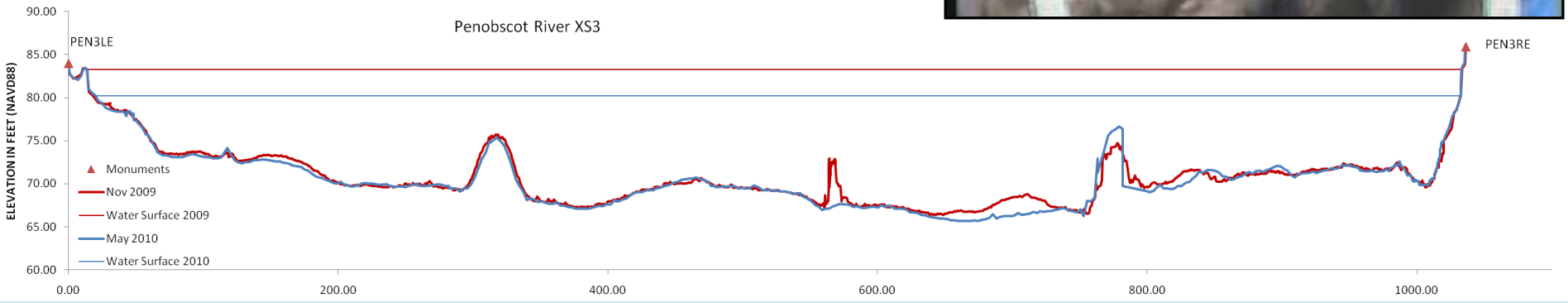
# What questions are being addressed?

- Channel geometry, sediments, and photo monitoring
- Water quality and benthic macroinvertebrates
- Fish migration and habitat use
- Fish community structure
- Riparian, riverine, and marine ecosystem response



# Channel geometry, sediments, and photo monitoring

- Principal Investigator: Alice Kelley, UMaine
- Objectives:
  - Sediment grain size distribution survey
  - Cross section elevation survey
  - Bathymetric survey
  - Photographic monitoring stations




NOAA FISHERIES

# Water quality and benthic macroinvertebrates

- Principal Investigator: Dan Kusnierz, Penobscot Nation
- Objectives:
  - Benthic macroinvertebrate community composition
    - Maine DEP aquatic life model
    - Indices of community structure
  - Water quality changes
    - Temp, DO, conductivity, BOD, E. coli bacteria, total coliform, total suspended solids, turbidity, secchi disc visibility, total P, chlorophyll a, pH

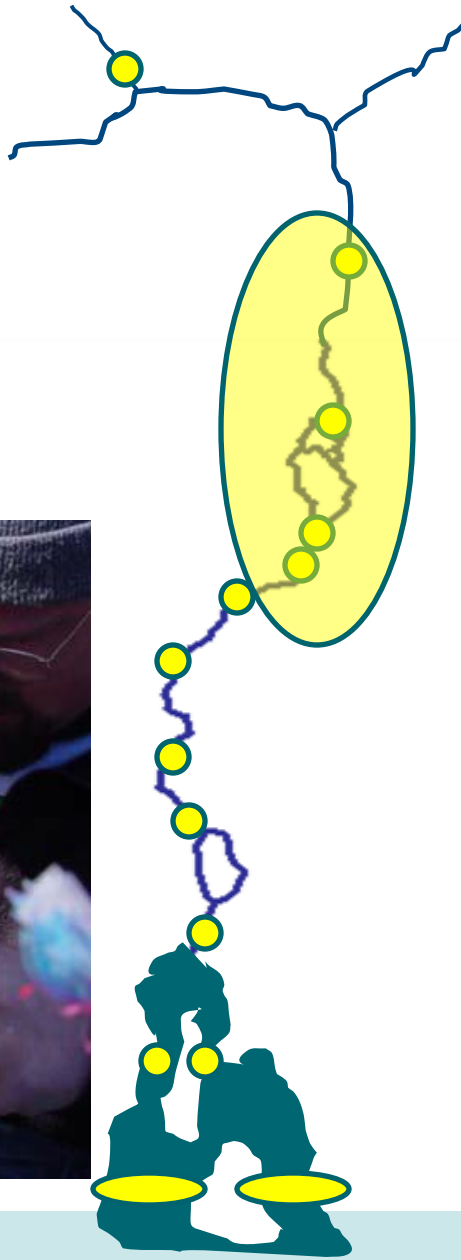
# Upstream passage of diadromous fish

- Principal Investigator: Joseph Zydlewski, USGS
- Objectives:
  - Homing efficiency
  - Migratory delay at fishways
  - Passage rates
  - Environmental and operational variables effecting connectivity

New funding from USGS for radio telemetry!


# Downstream passage of salmon

- Principal Investigators: Joseph Zydlewski, USGS
- Objectives:
  - Characterize downstream survival
    - Focus on areas of higher loss
  - Evaluate path choice
    - Wild vs hatchery

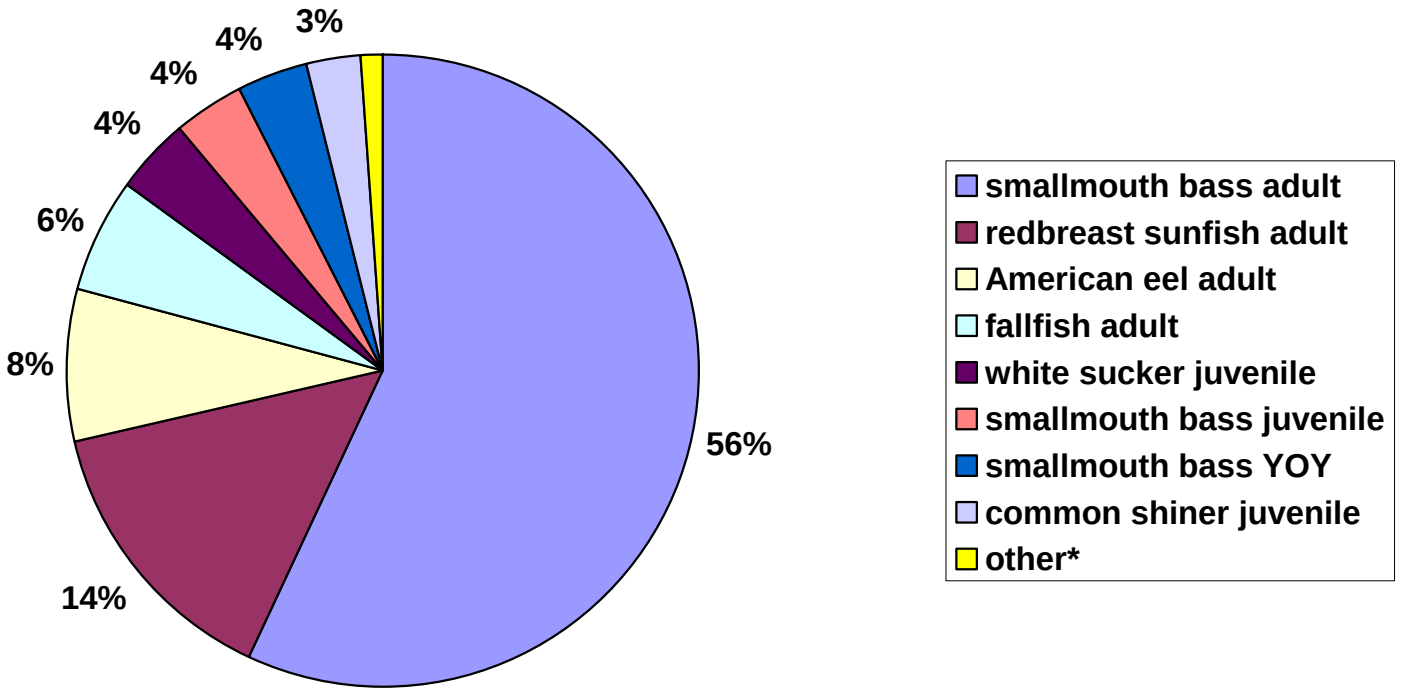


# Fish community – Upper River

- Principal Investigator: Stephen Coghlan, UMaine
- Objectives:
  - Quantify “pre-removal” fish community structure
    - Continue and expand 2008 and 2009 data sets (Kleinschmidt Assoc.)
    - Spring/Fall sampling on 19 “transects”

# Fish community – Upper River

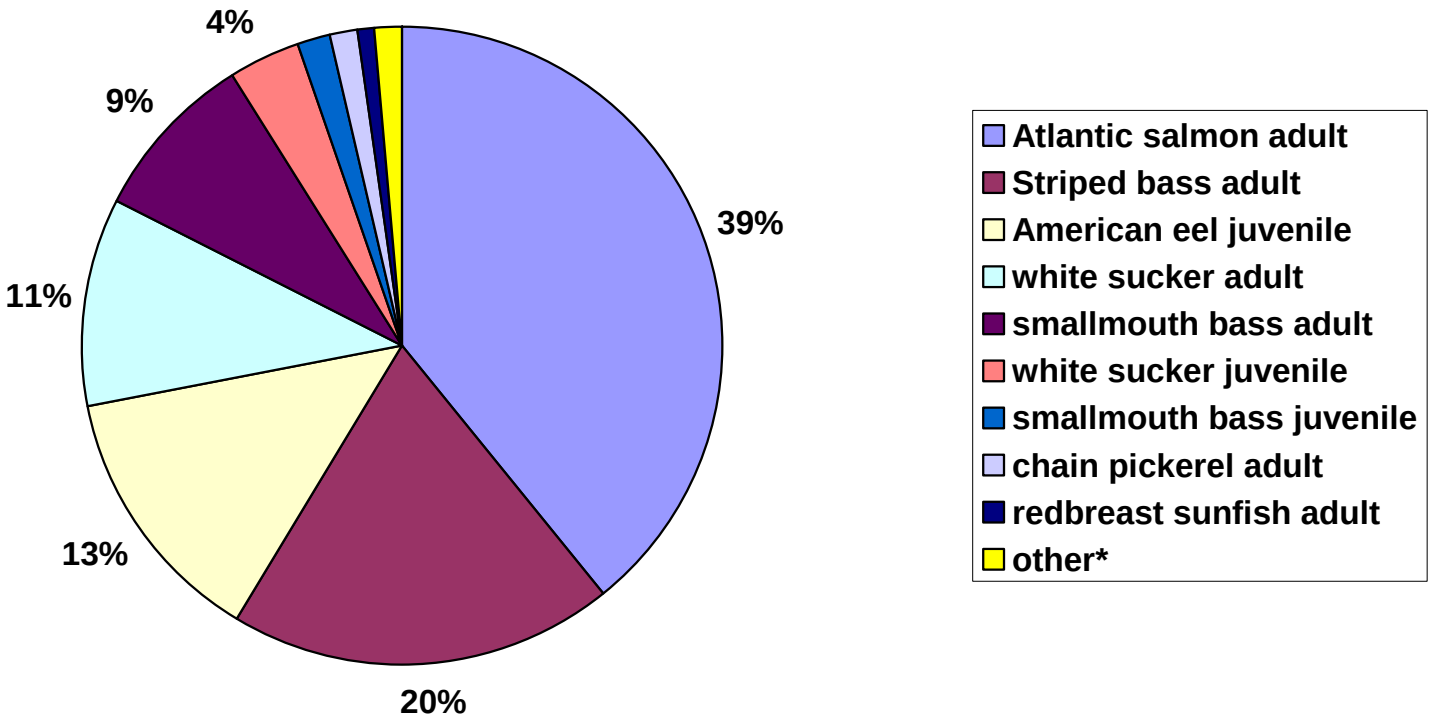
*After Kulik et al 2008. Kleinschmidt Associates*




***common shiner adult, fallfish juvenile, redbreast sunfish YOY, white sucker YOY**

# Fish community – Upper River

*After Kulik et al 2008. Kleinschmidt Associates*




***smallmouth bass YOY, redbreast sunfish juvenile, fallfish adult & YOY, pumpkinseed adult, golden shiner adult, banded killifish adult, American eel elver**

# Riparian, riverine, and marine ecosystem response

- Assessing Marine-Freshwater Food Web Linkages Using Stable Isotopes – Wilson and Sherwood, GMRI
  - More trophic levels =
    - more diverse predator-prey interactions
    - greater prey availability
    - greater ecosystem complexity (i.e., more pathways for food web interactions)
- Wetland and Riparian Habitat Mapping – Boyle and associates
- Bird Community Monitoring – Hunter and Call, UMaine
- Estuarine Fish Community Monitoring – Lipsky, O'Malley, Stevens, Kocik, and Saunders; NOAA

# What about the shad?

- Prior to 2008 (MDMR 2008), no one had looked.
- Now we know:
  - Adult shad are present (Ann Grote, unpublished data)
  - Shad are successfully reproducing in the lower Penobscot River (Christine Lipsky, unpublished data)
  - American shad will have access to 93% of their historic habitat **IF** they pass Milford and West Enfield (Trinko Lake et al. 2012)
    - Fishways that "pass" shad (Haro and Castro-Santos 2012)
    - Artificial propagation (Hasselman and Limburg 2012)

# Take Home Messages

- Right project at the right time?
  - Success is no accident
  - Scientists should be in communication with implementers and funders
  - Plan should be what you need, not what you have

- Socio-economics requires more attention

- We need a mutually agreed upon guiding image…soon.

- If the fish do respond, we will have evidence to show that dam removal works.
- If the fish do not respond, we should be able to figure out why.

- What about the shad?

# Acknowledgements

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Jeff Reardon
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Joan Trial
Tara Trinko Lake
Karen Wilson
Gayle Zydlewski
Joe Zydlewski

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# Guiding Image –
## Me. Dept. Marine Resources

Species-specific objectives, measures, and strategies

- 17.1 Measure: Improve upstream and downstream fish passage effectiveness at tributary dams for juvenile and adult Atlantic salmon within 10 years.
- 17.1.1 Strategy: Review FERC licenses, exemptions and MPA
- 17.1.2 Strategy: Review need/process to install or improve fish passage facilities at FERC non-jurisdictional dams
- 17.1.3 Strategy: Review existing studies and information
- 17.1.5 Strategy: Undertake fish passage improvements
- 17.1.6 Strategy: Assess fish passage improvements

**Operational Plan for the Restoration of Diadromous Fishes to the Penobscot River**

Photo Courtesy of Randy Spencer

**Prepared By:**
Department of Marine Resources
Department of Inland Fisheries and Wildlife

**For Presentation to the Atlantic Salmon Commission:**
Dick Ruhlin, Chair, Member-at-large
George Lapointe, Commissioner of the Department of Marine Resources
R. Dan Martin, Commissioner of the Department of Inland Fisheries and Wildlife

**Editor:**
Melissa Laser, Department of Marine Resources

Approved July 2, 2009

# Guiding Image – Diadromous fish objectives

Species-specific objectives, measures, and strategies

6.0 Objective: Restore alewife populations to self-sustaining levels in historical habitat within 48 years.

6.1 Measure: Restore populations to 13 Phase 1 historical lakes in 16 years (four generations) or less beginning in 2010 or 2011.

6.1.3 Strategy: Stock approximately six adult alewives per surface acre (97,500 total) in Phase 1 lakes annually from 2010 (2011) to 2026 (2027) or until annual return rates to each lake are at least 35 adult per acre for four successive years, which equals annual adult returns at Milford of at least 532,000 fish.

6.1.5 Strategy: Assess and improve if needed upstream and downstream passage at barriers (with cross-reference to other sections of the plan).

6.2 Measure: Restore populations to 18-22 historical lakes (Table 1; Fig. 1) approximately every 16 years after annual return rates to each Phase1 lake is at least 35 adult per acre for four successive years.

6.2.1 Strategy: Use computer model (e.g., USFWS barrier model) to prioritizeremaining lakes to be stocked by lake size, trophic status, number of downstream hydropower and nonhydropower dams, potential natural barriers, and distance to the ocean or to Milford Dam.