

John Waldman Queens College City University of NY Articles

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#### Dramatic Declines in North Atlantic Diadromous Fishes

#### KARIN E. LIMBURG AND JOHN R. WALDMAN

We camined the intens of diadromous (migratery between subsector and feedwater) (then within the North Allantic basis, a region of promouned declines in phierine for many objects marring sectors. Data on these 24 diadromous (22 anadromous) perioria are genera, except for a few high-value forms. For 15 time series, relative abundance had dopped to kee than 90% of historic levels in 13, and to less than 90% of a diadrismo 11. More tracked their buscel levels near the end of the observation period. Many populations period are happly related levels, here at specia had suffered population extitypations, and many specia are now classified as threatened or endangenet. Hobitat fous (especial) downing), overfolving politics, end, intracanding, classics change, manative specia, and aquasalture contributed to defines the diadromous diadromous fishes for which data exist, we show that populations have declined drematically from original baselines. We also discuss the consequences of the or herms of bits enzyment review.

Keywords: diadromous fishes, overfishing, dams and other threats, habitat loss, shifting baselines

## Running Silver

Restoring Atlantic Rivers and Their Great Fish Migrations



John Waldman

#### Can a Resilience Approach Improve Anadromous Fish Restoration?

John Waldman, Biology Department, Queens College, New York Karen A. Wilson, University of Southern Maine, Gorham, Maine Martha Mather, Kansas Cooperative Fish & Wildlife Research Unit Noah P. Snyder, Boston College, Massachusetts

#### POLICY PERSPECTIVE

#### Fish and hydropower on the U.S. Atlantic coast: failed fisheries policies from half-way technologies

J. Jed Brown<sup>1</sup>, Karin E. Limburg<sup>2</sup>, John R. Waldman<sup>3</sup>, Kurt Stephenson<sup>4</sup>, Edward P. Glenn<sup>5</sup>, Francis Juanes<sup>6</sup>, & Adrian Jordaan<sup>7</sup>

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#### Keywords

Anadromous; dams; diadromous; lish passage; hatcheries; hydropower; restoration; rivers; salmon; shad.

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#### Abstract

Globally, diadromous species are at risk from fragmentation by damming of rivers, and a host of other anthropogenic factors. On the United States Atlantic Coast, where diadromous fish populations have undergone dramatic declines, restoration programs based on fishway construction and hatcheries have sustained remnant populations, but large-scale restoration has not been achieved. We examine anadromous fish restoration programs on three large Atlantic Coast rivers, the Susquehanna, Connecticut, and Merrimack with multiple mainstem hydropower dams, most with relatively low generating capacity. Mean passage efficiencies through fishways on these rivers from the first dam to the spawning grounds for American shad are less than 3%. The result is that only small fractions of targeted fish species are able to complete migrations. It may be time to admit failure of fish passage and hatchery-based restoration programs and acknowledge that significant diadromous species restoration is not possible without dam removals. The approach being employed on the Penobscot River, where dams are being removed or provided the opportunity to increase power generation within a plan to provide increased access to habitat, offers a good model for restoration. Dammed Atlantic Coastal rivers offer a cautionary tale for developing nations intent on hydropower development, suggesting that lasting ecosystem-wide impacts cannot be compensated for through fish passage and hatchery technology.

#### The problem of half-way technologies

Lewis Thomas in Liver of the Cell (1974) defined hall-way technologies in medicine as "... the kinds of hings that must be done after the fact, in efforts to compensate for the incapacitating effects of certain diseases whose course one is unable to do much about." Frazer (1992) applied the concept to sea turtle conservation where hatchery-raised individuals are released into the wild rather than addressing the causes of sea turtle decline. We consider an analogous case on the U.S. Atlantic Coast where half way technologies have been employed to re-

store diadromous (freshwater-sea) migratory fish populations that have been severely reduced by the presence of dams.

#### Fishways and hatcheries as half-way recovery technologies

Historically, Atlantic drainages supported runs of about one-dozen diadromous fishes, including Atlantic salmon Salmo salar, American shad Alosa sapidisima, alewile A. pseudoharongue, blueback herring A. aestivaliz, Atlantic

## Diadromy 101 – The Freshwater-Sea Fishes

- Uncommon; an evolutionarily convergence
- Regular movement between fresh water and salt water.
  - Anadromy spawned in rivers, migrates to sea,
    - returns to rivers to spawn
      - Salmons, shads, striped bass, sturgeons, sea lamprey

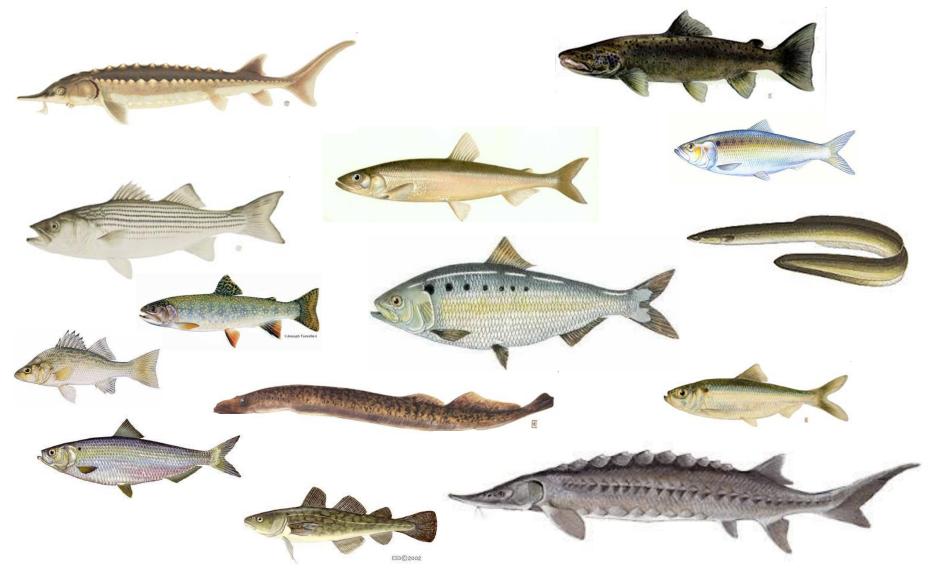




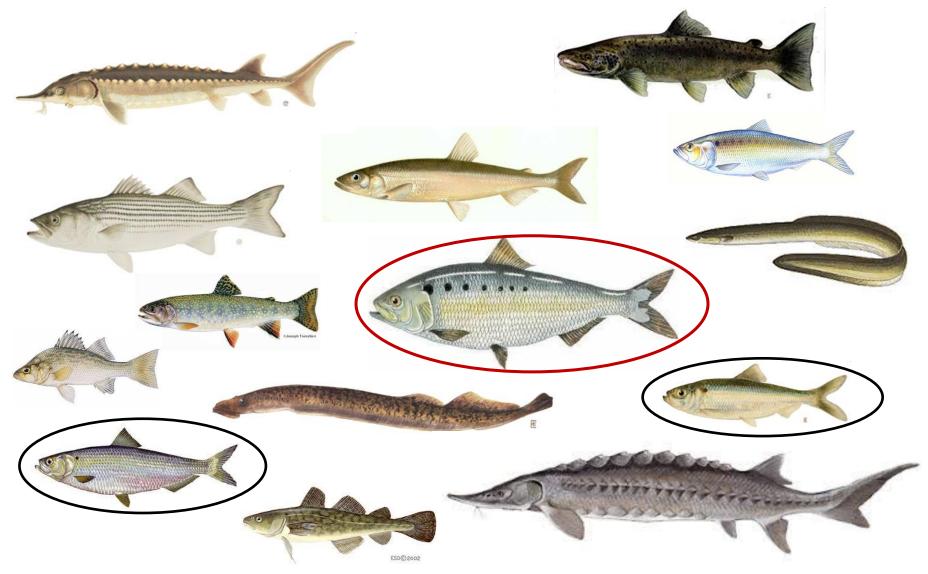
*Catadromy* – spawned at sea,
 migrates to fresh waters, returns to
 sea to spawn

Eels

## The Atlantic Assemblage

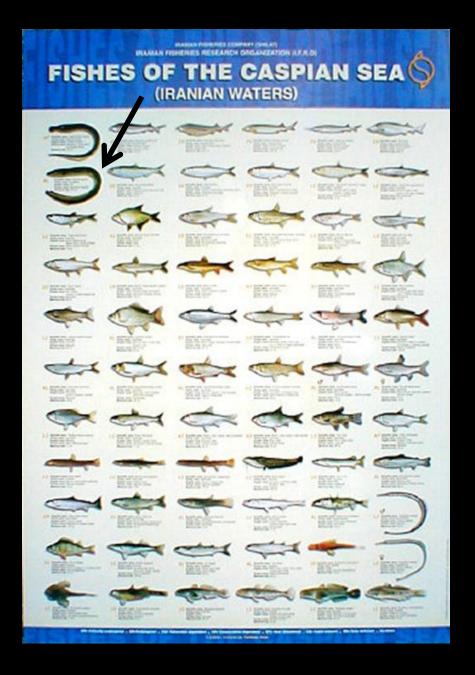


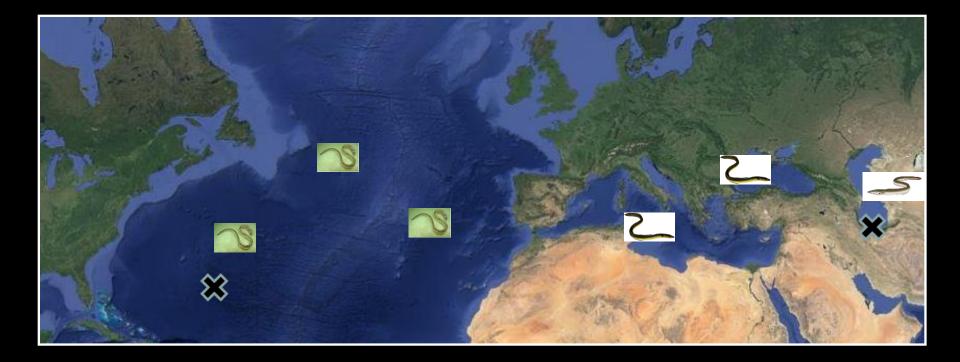
### The Atlantic Assemblage



### More Diadromy 101 - The Migratory Imperative

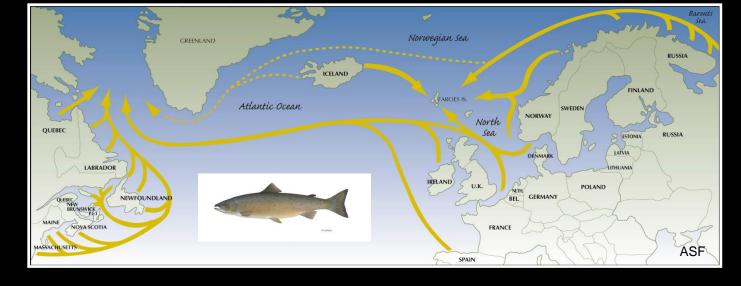


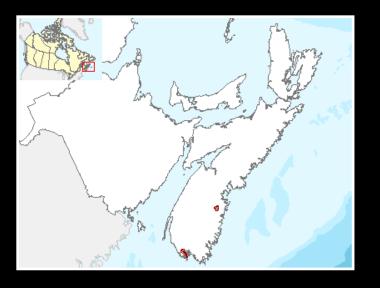




## Distributions – Large & Small







#### Atlantic Whitefish

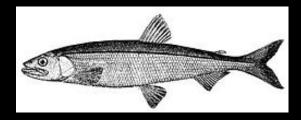


## Costs and Benefits of Diadromy

## <u>Benefits</u>

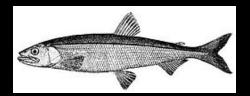
- Relative mortality differences between habitats
- Relative trophic resources between habitats

"Historical advantages have become contemporary curses"

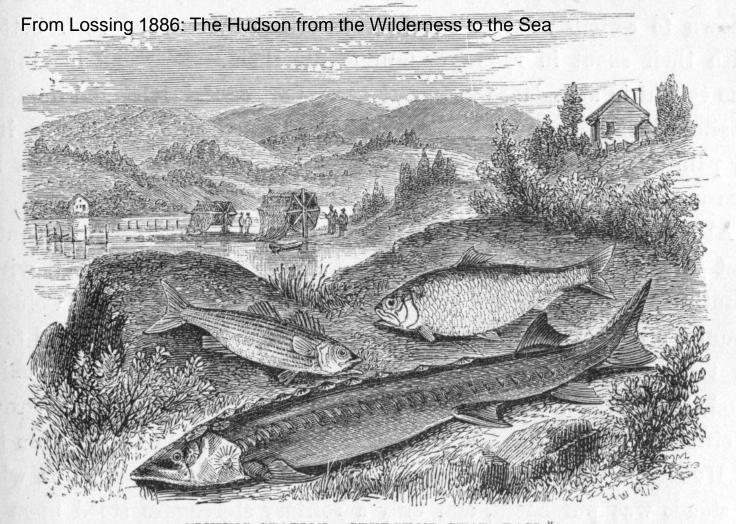


### <u>Costs</u>

- Physiological adjustments
- Migration costs
  - Bioenergetics
  - Predation risk
- Suitability of *two* habitats



### **Diadromous Species are Iconic**



FISHING STATION.-STURGEON, SHAD, BASS.\*

# Diadromy - Why "Home"?

 Certainty of habitat suitability – retained in memory through imprinting

 Fine-tuning to its own migratory circuit, e.g., seasonal timing, age at 1<sup>st</sup> spawning, iteroparity vs. semelparity, morphological adjustments – populations and "races"

# Life History Variation – Lost Anadromous Forms

- Shad
  - Hudson: yellowback, blueback, greenback, golden, pink, pink-faced, locust, chunker, chunk head
  - Potomac: May shad



Atlantic salmon



## More Subtle Anadromous Life History Variation

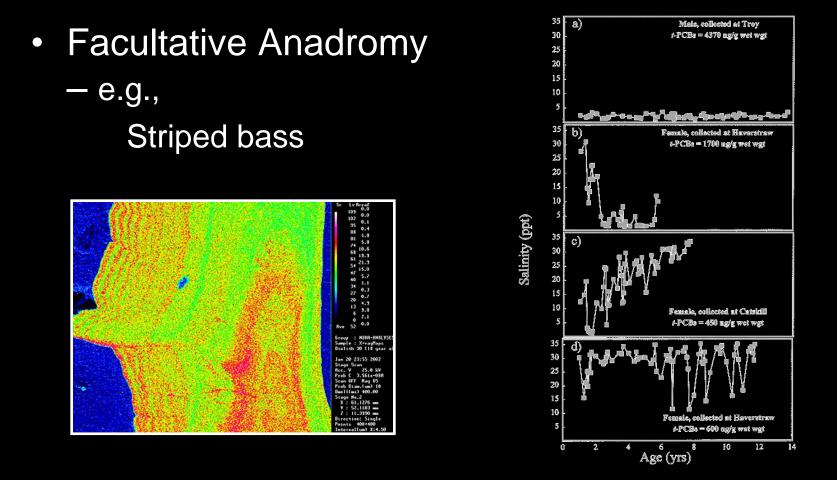


Figure 2. Representative time series of salinity habitation for individual fish displaying (a) resident behavior, (b) a shift from high to low salinity, (c) a shift from low salinity to high salinity, and (d) resident behavior in saline waters with annual migrations to fresher waters

### The Past - Rivers "Ran Silver"

"Alewives came up to the fresh rivers to spawn in such multitudes it is almost incredible, pressing up such shallow waters as will scarce permit them to swim"

William Wood, New England's Prospect, 1634

"... in April there is a fish much like a herring that comes up into the small brooks to spawn, and when the water is not knee deep they will presse up through your hands, yea, thow you beat at them with cudgels, and in such abundance as is incredible."

Capt. Chartles Whitborne, 1616

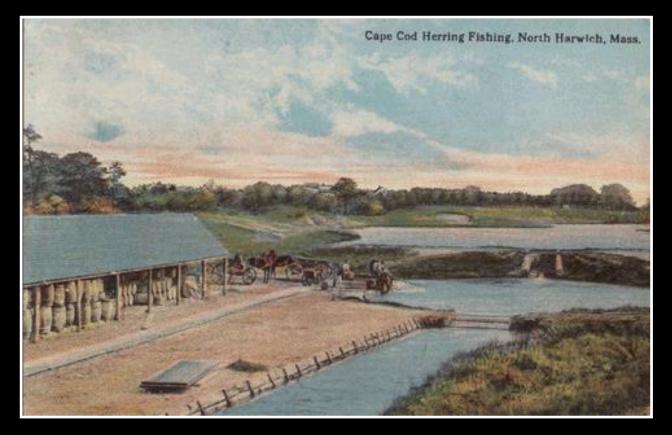
"In a word, it is unbelievable, indeed, undescribable, as also incomprehensible, what quantity is found there. One must behold oneself." William Byrd, Natural History of Virginia, 1728

## Anadromy – An Overly Cooperative Life History?

Alewives

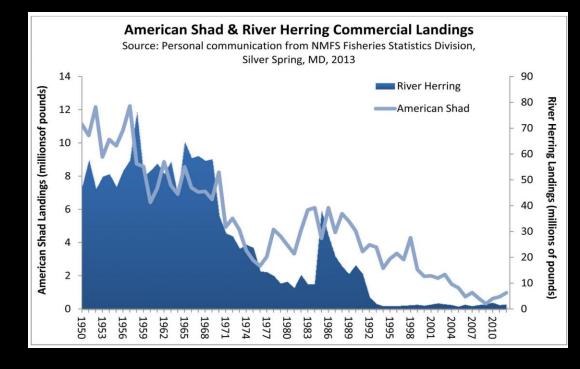


©Heather Perry



## **River Herring Today**

# in the Northeast



MA – total closure since 2005

RI –total closure since 2006

CT – near total closure since 2002

NY – reduced in HR; closed elsewhere

## A Week on the Concord and Merrimack Rivers Henry David Thoreau (1849; trip made in 1839)



Who Hears the Fishes When They Cry?

# Amoskeag Mills









What is the State of Our Anadromous Fishes?

# Changes in Size





# **Species & Population Persistence**

(Limburg & Waldman, Bioscience 2009)

- 22 Species found in Europe, NA, or both
  Insufficient data on ½ (mainly lower value species)
- All others lost populations
  - American shad 70 of 138 lost (51%)
  - ~33% North American Atlantic salmon pops extirpated

Changes in Abundance Atlantic Salmon

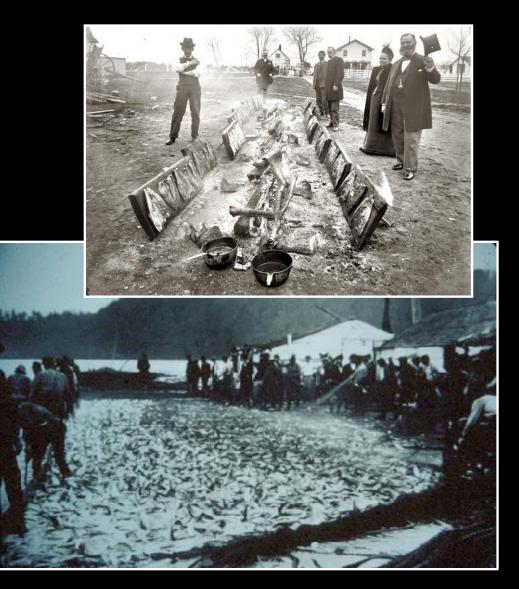
- Historical U.S. estimates 300,000 500,000 annually
- In 2014: <400!
- Federally endangered in Gulf of Maine rivers





### Susquehanna River Shad



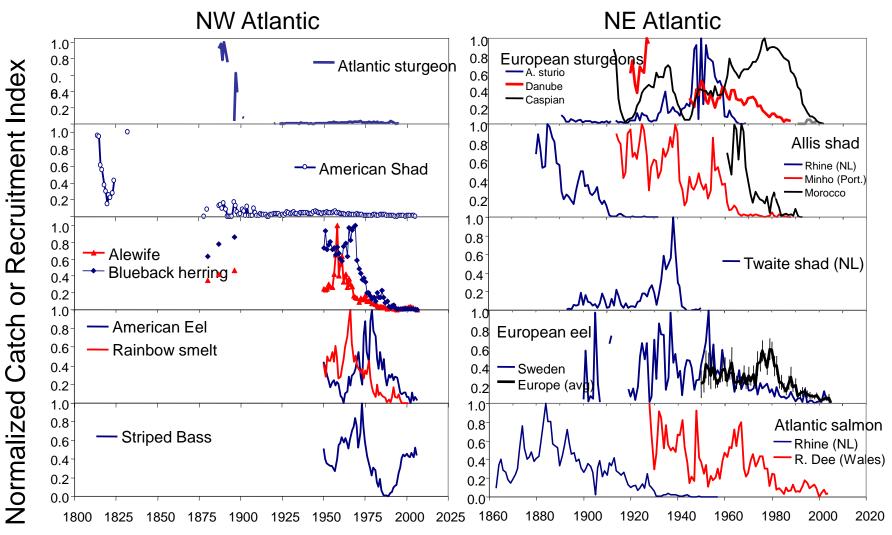


### Susquehanna River Shad



Actual Counts 2014

Conowingo	Holtwood	Safe Harbor	York Haven
10,425	2,528	1,336	8



For 31 time series of N. Atlantic anadromous fishes, relative abundances:

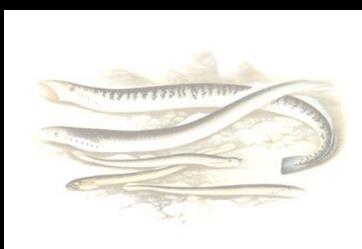
> 98% decline from historic highs in 13,

>90% in additional 11 (Limburg & Waldman: Bioscience 2009)

# What Happened?

The Traditional "Unholy Trinity":

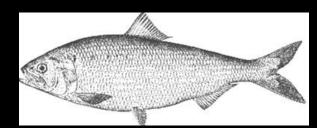
- Dams, Dams, and More Dams
- Overfishing
- Pollution

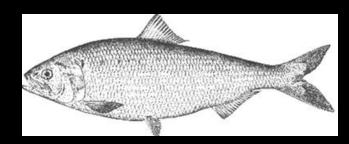


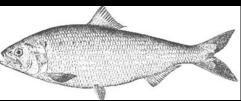


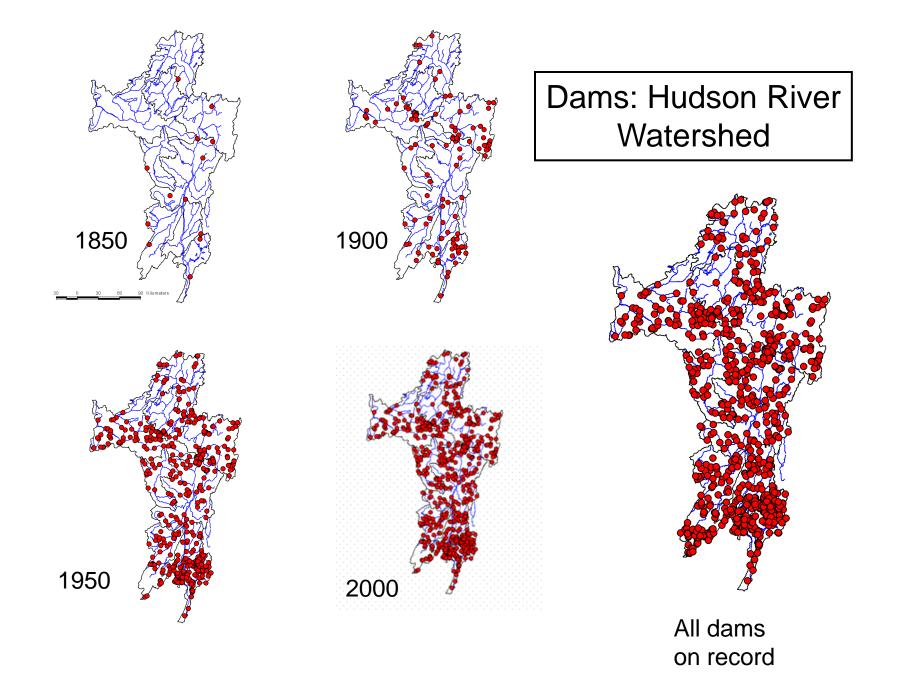
### Swimmable Distance," American Shad

- Originally: 11,221km
- In yr 2000: 6,856 km
- Net Loss: 4,364 km (~40%)





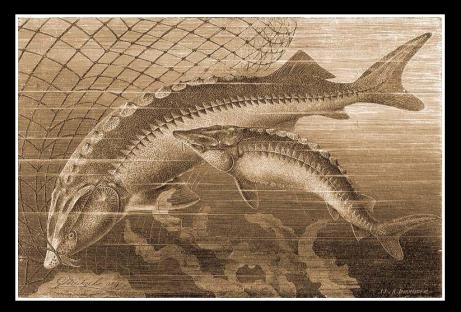








# Overfishing



# Pollution

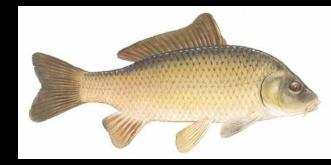


## **Newer Threats**

• Non-Native Species



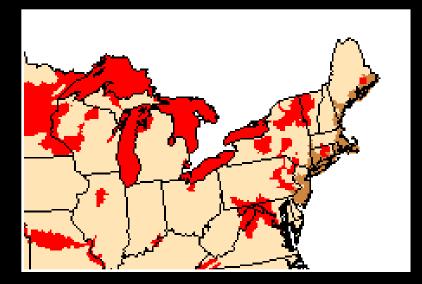








### Climate Change (i.e., Warming)





### Rainbow smelt Osmerus mordax



J. Waldman – Hudson River

## Somewhat Forgotten Threats



## What Does a Natural River Look Like?

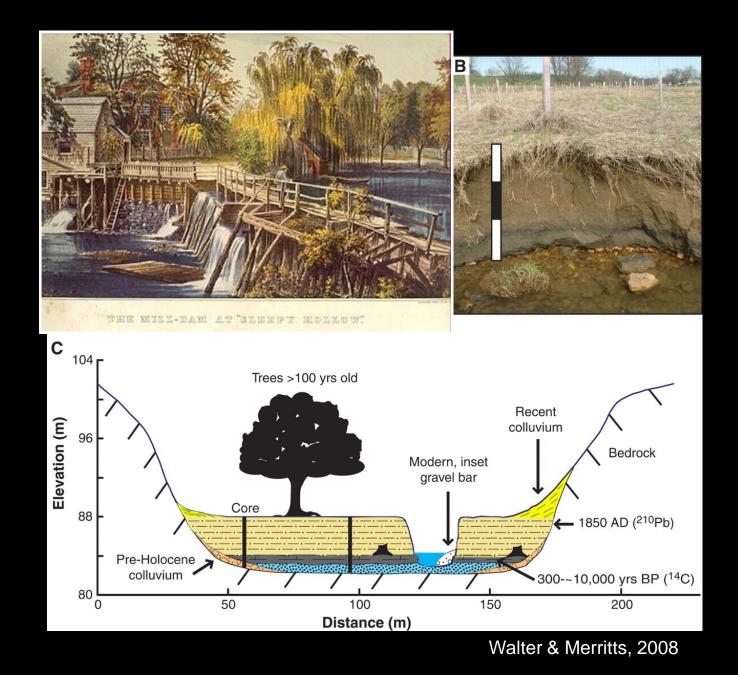


### Single Channel Meandering?

### Or Braided?





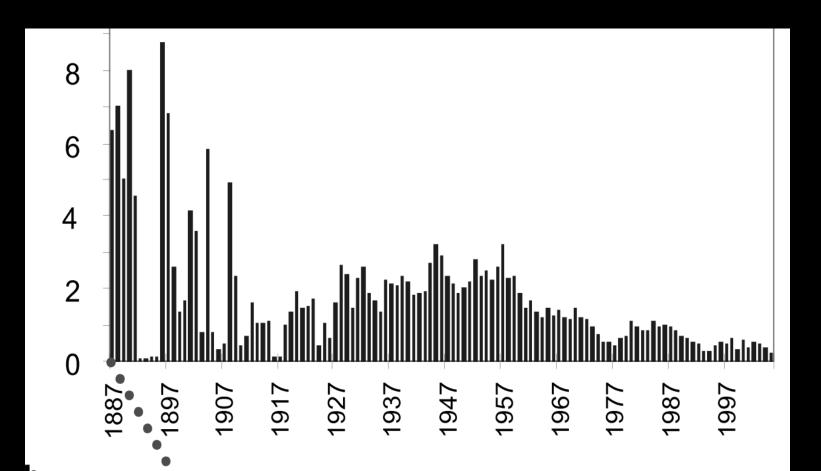


Maybe the Biggest Threat – Loss of Memory The Shifting Baseline Syndrome

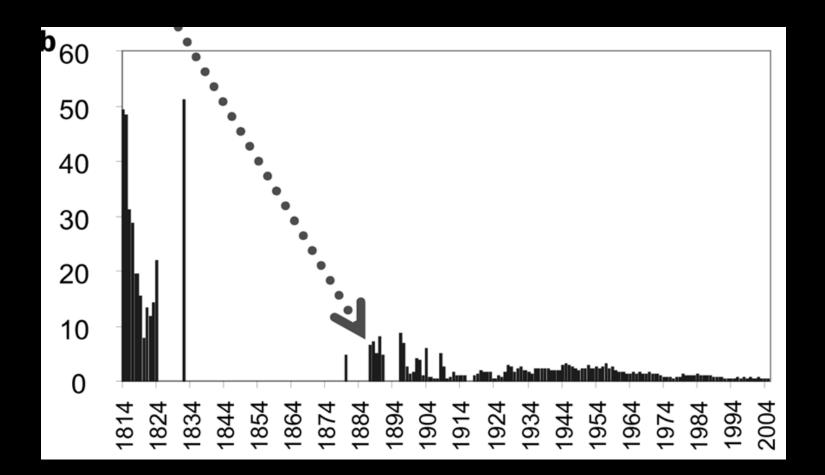
- "Each generation of fisheries scientists accepts as a baseline the stock size and species composition that occurred at the beginning of their careers, and uses this to evaluate changes. When the next generation starts its career, the stocks have further declined, but it is the stocks at that time that serve as a new baseline."
- Daniel Pauly (1995)



# Shad Landings (millions/kg)



## Shad Landings (millions/kg)





# What Can Be Done?

Clue:

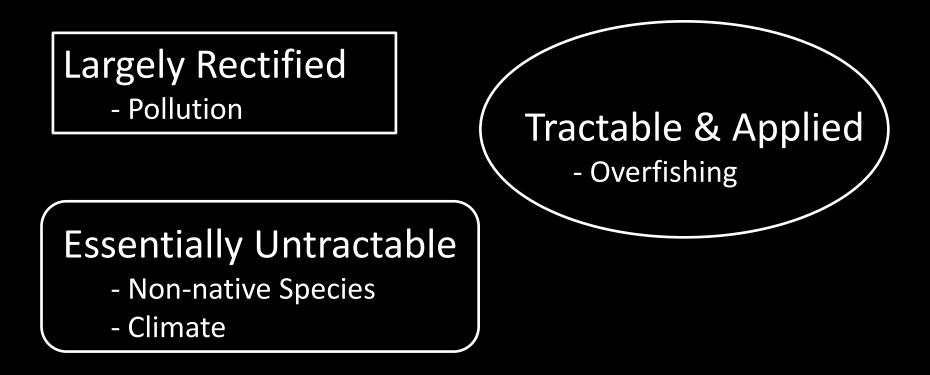
What did the fish say when it swam into the wall?

## Answer: Oh Dam!



Conowingo Dam, Susquehanna River

# Looking Forward on Salient Drivers



# Tractable but Unrectified - Dams

## Dam Removal "Every Dam Should Have an Existential Crisis"



AUGUSTA BARNING

Edwards Dam, Kennebec River, built 1837 (Augusta, Maine)

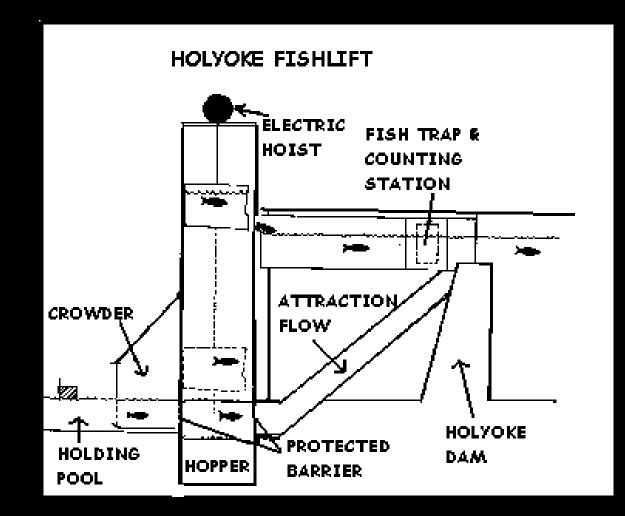
July 1, 1999



## Another Option, Use a Ladder



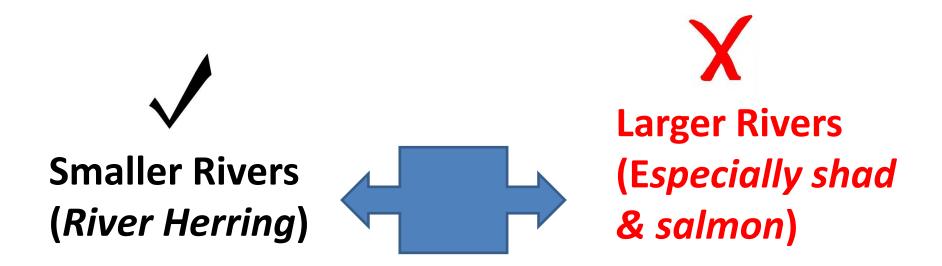
## Another, Take the Elevator



# Finally, Take a Truck



# Looking Forward – Two Divergent Pathways



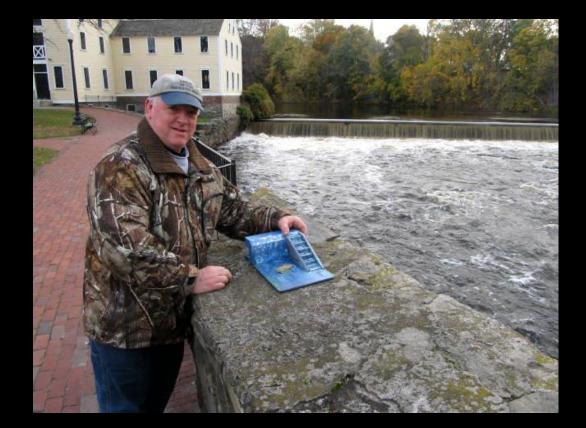
## River Herring – Pre-adapted to Ladders



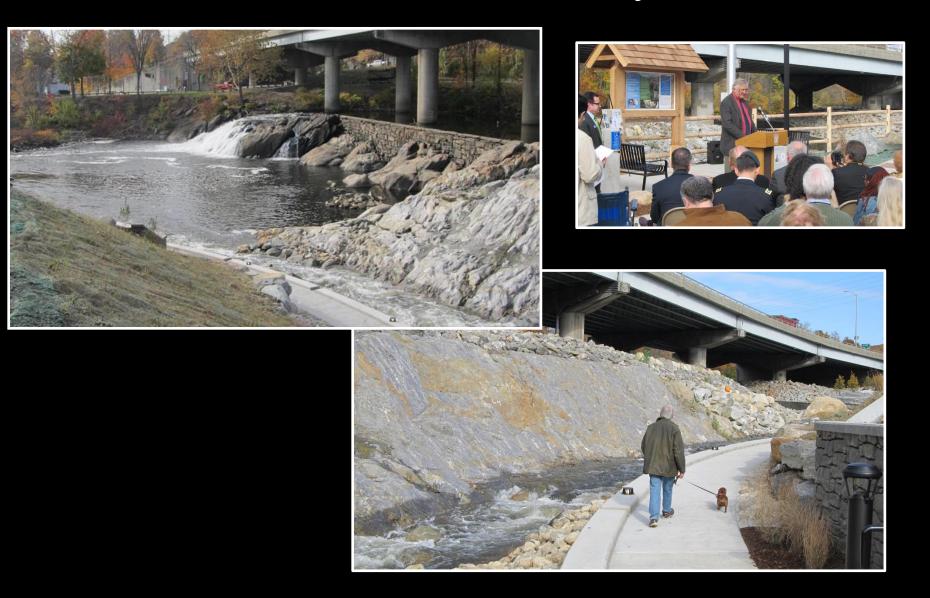


## **Smaller Rivers**

Coalitions: Grassroots Efforts are Essential, but Combined with Agency & NGO Expertise



## Nature-Like Fishways



## Why Isn't Restoration Working (mostly) for Large Rivers? Countervailing Forces of Resilience?

(Positive) "<u>Anti-Allee Effects</u>"

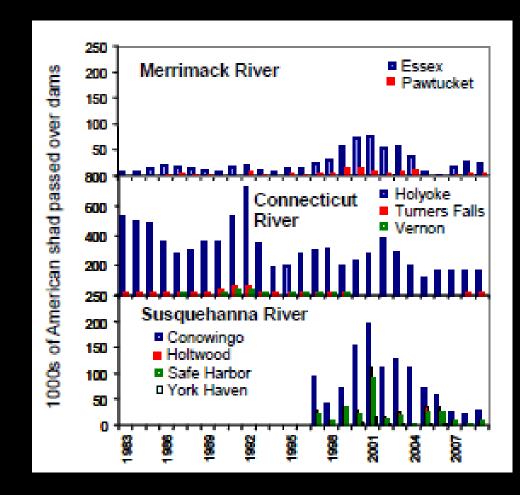
 Allee effects are depensatory, accelerate declines

• Compensation: Truncation of spawning in time and space

(Negative) Loss of "Storage Effect"

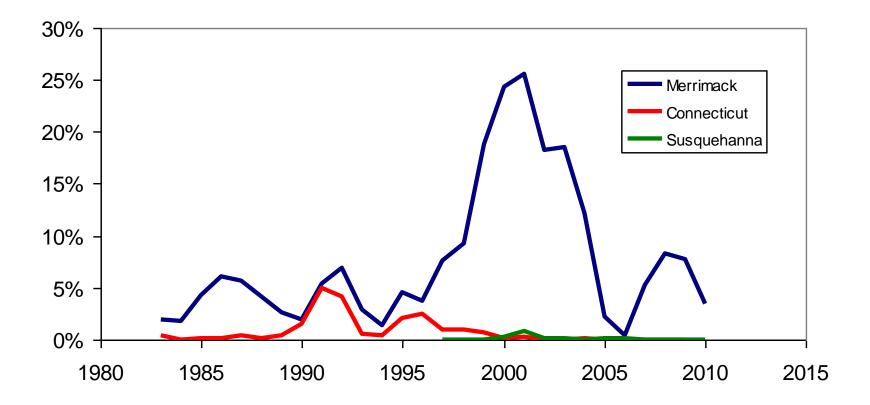
- Storage effect is conservation of biomass so that fecundity is adequate to compensate for lean years
- One-way trips of small, 1<sup>st</sup> time spawners counteracts storage effect – ratchet downwards

## Three Large Atlantic Rivers -The Record of Hydro Fish Passage

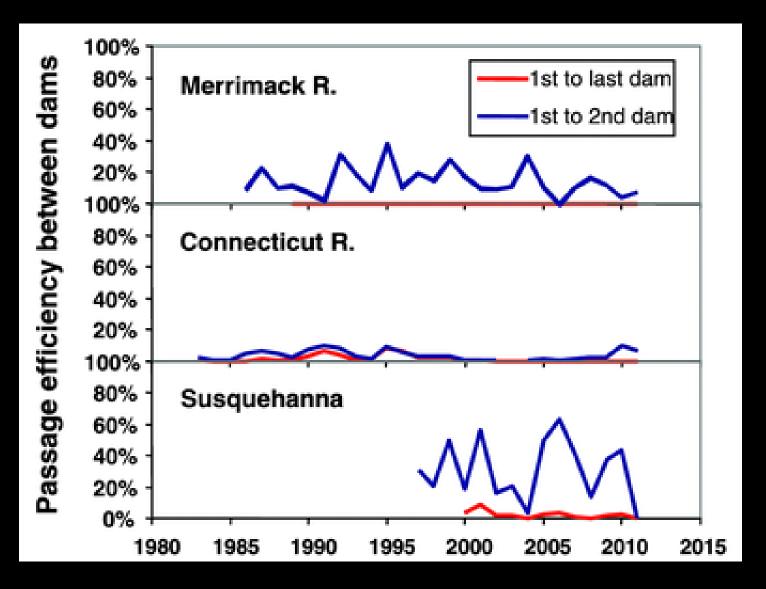


Brown et al. 2013

# Number of Fish Passed as Percent of <u>Target</u>



### Passage Efficiencies



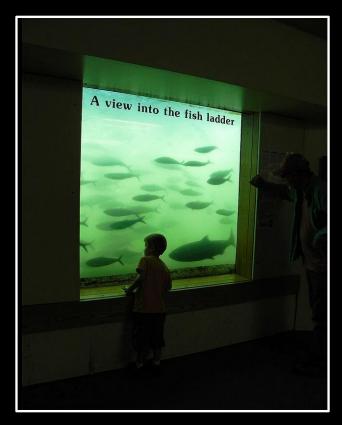
# Is it a Question of Scale?

#### Rainbow Dam on Farmington River, CT

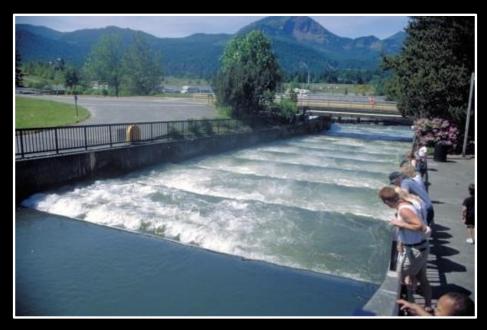


### Shad - An Interesting West Coast Exception

#### Bonneville Dam Columbia River







Some West Coast vs. East Coast Shad Rivers Is there Enough Water for Fish <u>and</u> Hydropower?

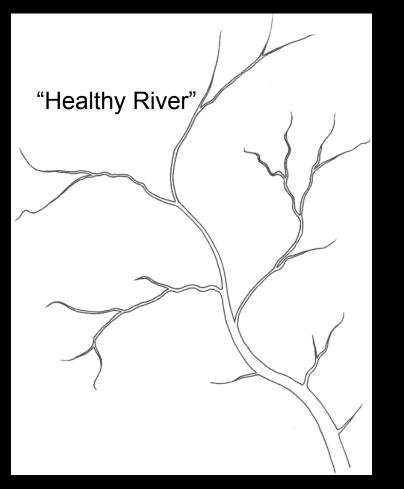
#### Columbia River

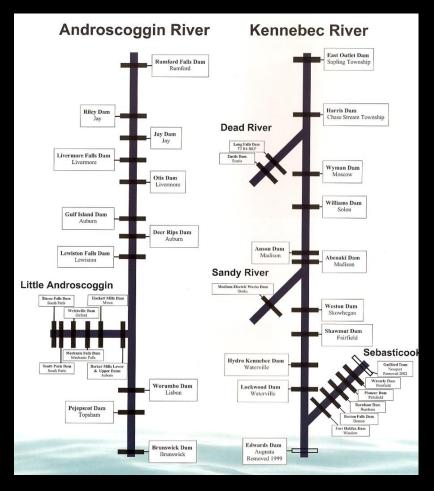
- Bonneville Dam Ladder = 2,000 3,000 cfs
- Columbia R. flow <u>275,000</u> cfs!

#### East Coast Rivers

- Avg. ladder flow = 30-50 cfs
- Connecticut 17,000 cfs
- Delaware 11,700 cfs
- Kennebec 9,100 cfs
- Pawcatuck 675 cfs

#### What Can Be Done? Ultimately - Need to Free Rivers in Space & Time!





Does Habitat Diversity = Life History Diversity = Resilience?

<u>Now</u> is a Potentially Transformative Time for Large Hydro Dams --*Time to "Make Fish"* 

- Recognition that traditional engineered fishways haven't succeeded in restoring stocks
- The energy mix is rapidly changing
  - -e.g., Industrial scale solar and wind power
  - Smart homes
- Dams don't last forever aging and sedimentation
- Many dams are coming up for FERC relicensing

#### The New York Times 🖉

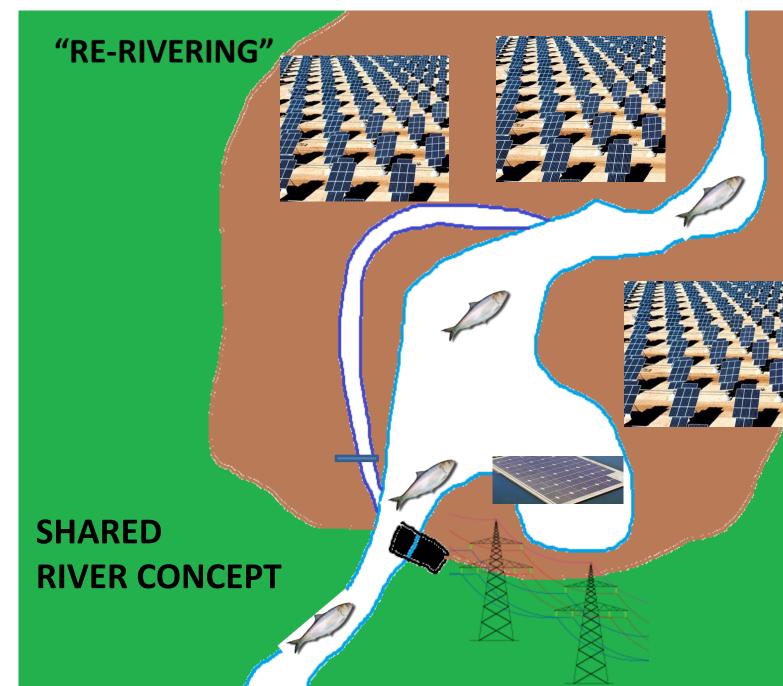
# The Opinion Pages | Op-Ed Contributors Let the River Run Wild

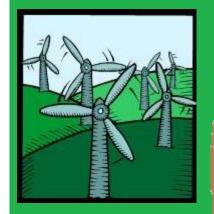
By JOHN WALDMAN, KARIN E. LIMBURG and AMY ROE SEPT. 7, 2014

#### **STATUS QUO**

#### **"RE-RIVERING"**

#### SHARED RIVER CONCEPT







#### SHARED RIVER CONCEPT















#### SHARED RIVER CONCEPT

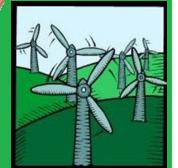


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""Poor shad! Where is thy redress? ... Still wandering the sea in thy scaly armor to inquire humbly at the mouths of rivers if man has perchance left them free to enter ... Armed with no sword ... But mere shad armed with only innocence and a just cause ... Who knows what may avail a crow-bar against that Billerica Dam?"

*"Keep a stiff fin then, and stem all the tides thou mayst meet."*