East, West, Home is (Not) Best: History of American Shad stocking in the U.S.

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* Dan did most of the work! See References

LOCAL AND GLOBAL INITIATIVES:

HOW SCIENCE SUPPORTS MANAGEMENT ACTIONS ON DIADROMOUS FISH

Introduction: Notes from Karin's Fisheries class

Fish stocking dates back to the ancients.

In the U.S., stocking has been practiced since at least the mid-1800s, when fish culturing techniques were brought over from Europe and applied to species that were feared to be in trouble.

- The **American Fisheries Society** started out as **The American Fish Culturist's Association** in 1870.
- Among the species stocked early on: **shad**, striped bass, Atlantic salmon, trout

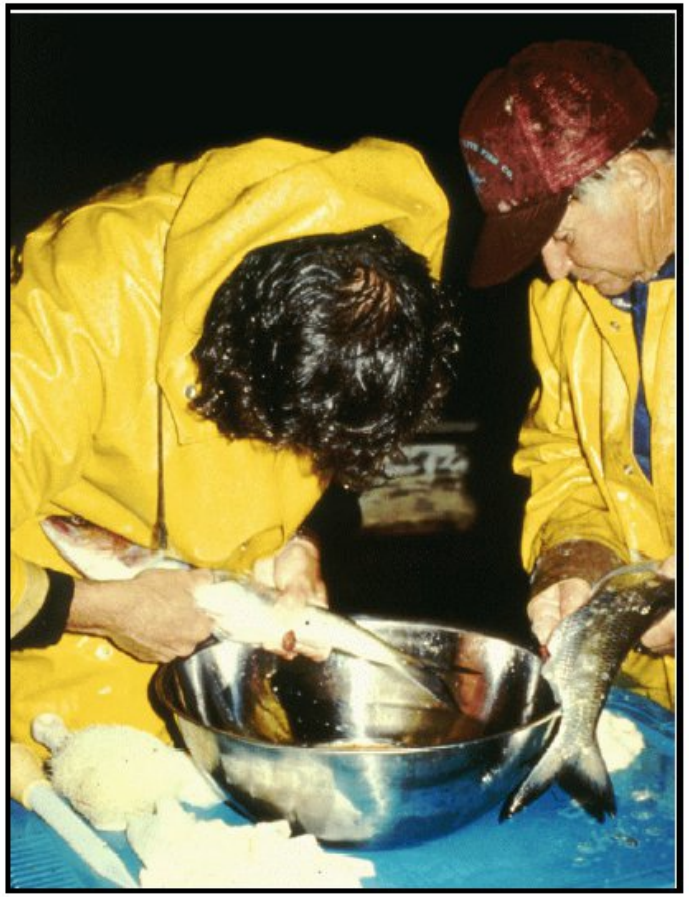
Stocking today is practiced in the U.S. by state and Federal agencies, as well as by private landowners.

Why stock fish?

- **moving** species to suitable, but uncolonized, habitat
- providing **more constant access** to the fish
- increasing fish **availability** to more kinds of users
- creating **new fishing industries** as a result of newly created habitat
- **managing exotic species** (e.g., introducing *Oncorhynchus* to Great Lakes to deal with alewives)
- overharvested species (**restoration stocking**)

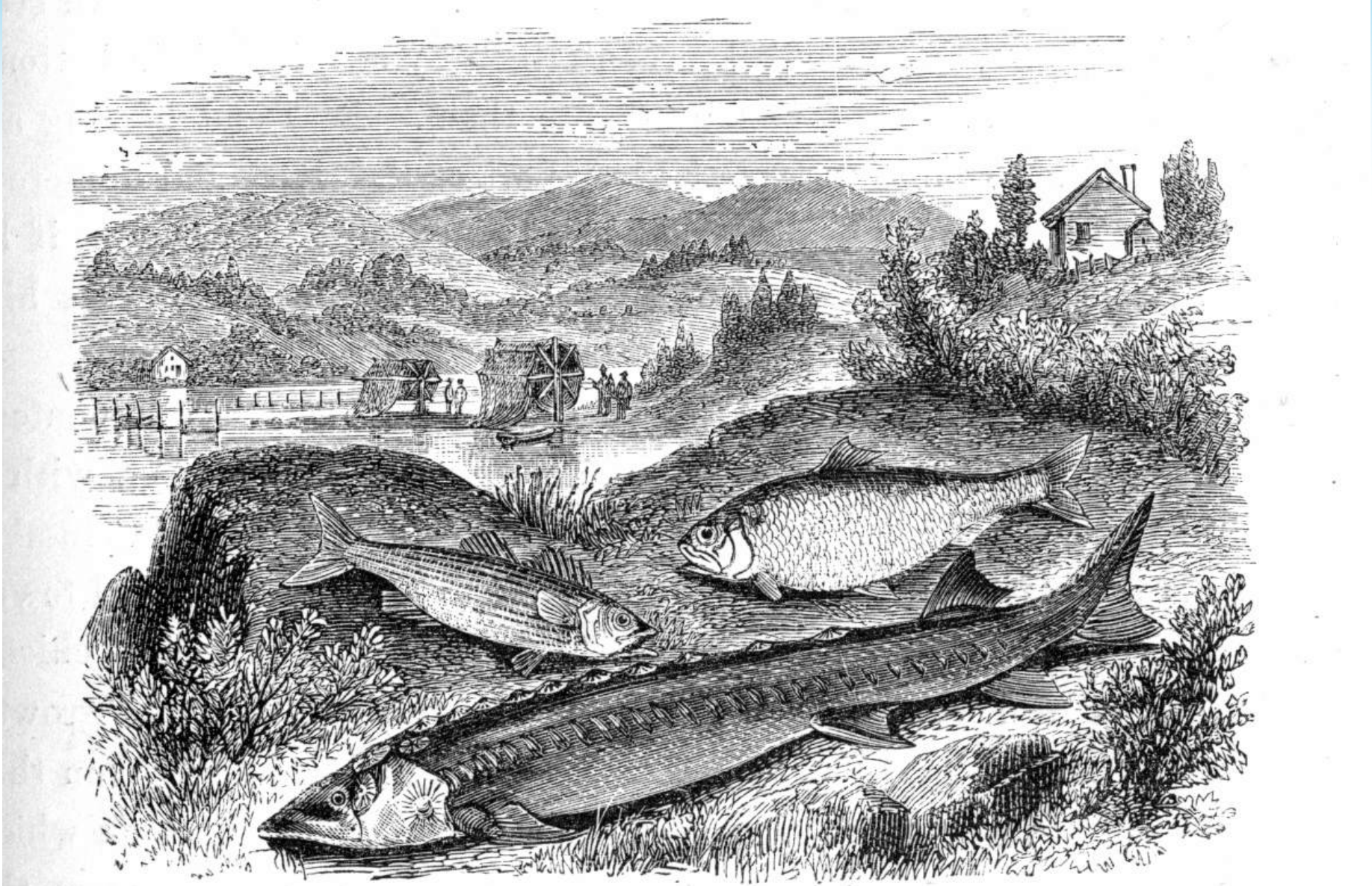
Restoration stocking: bump up populations of overexploited/ endangered/ heritage species (examples: **American shad** in Chesapeake Bay...)

☞ There's a long history of stocking American shad in the U.S.



Field stripping and fertilization of shad eggs for delivery to the USFWS's Harrison Lake Hatchery.
Photo Credit: David Hawxhurst

Potomac River Restoration



FISHING STATION.—STURGEON, SHAD, BASS.*

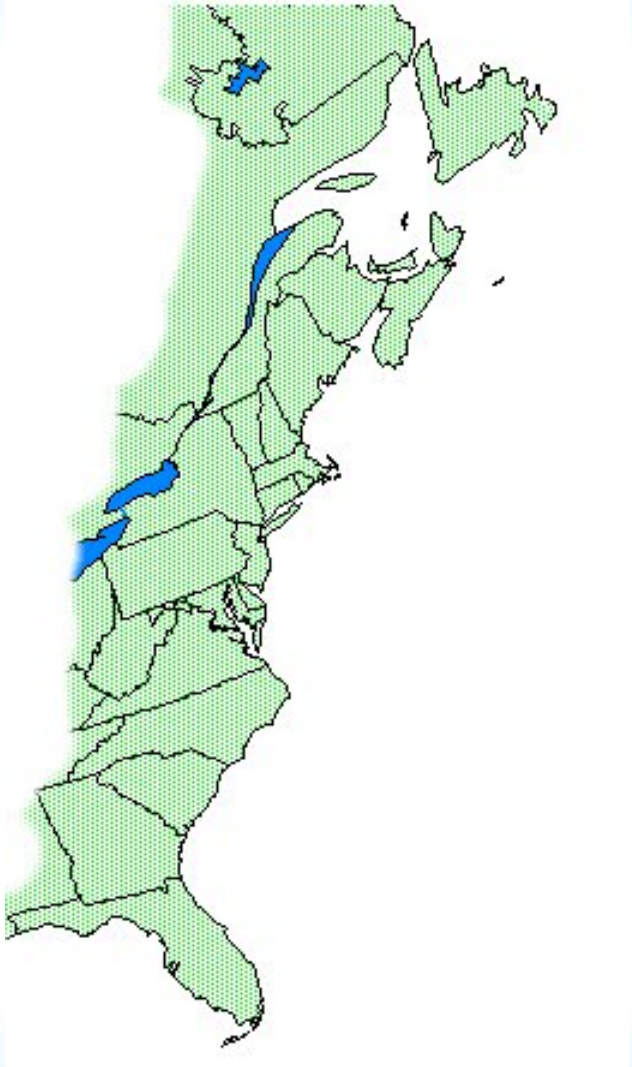
Lossing (1876)

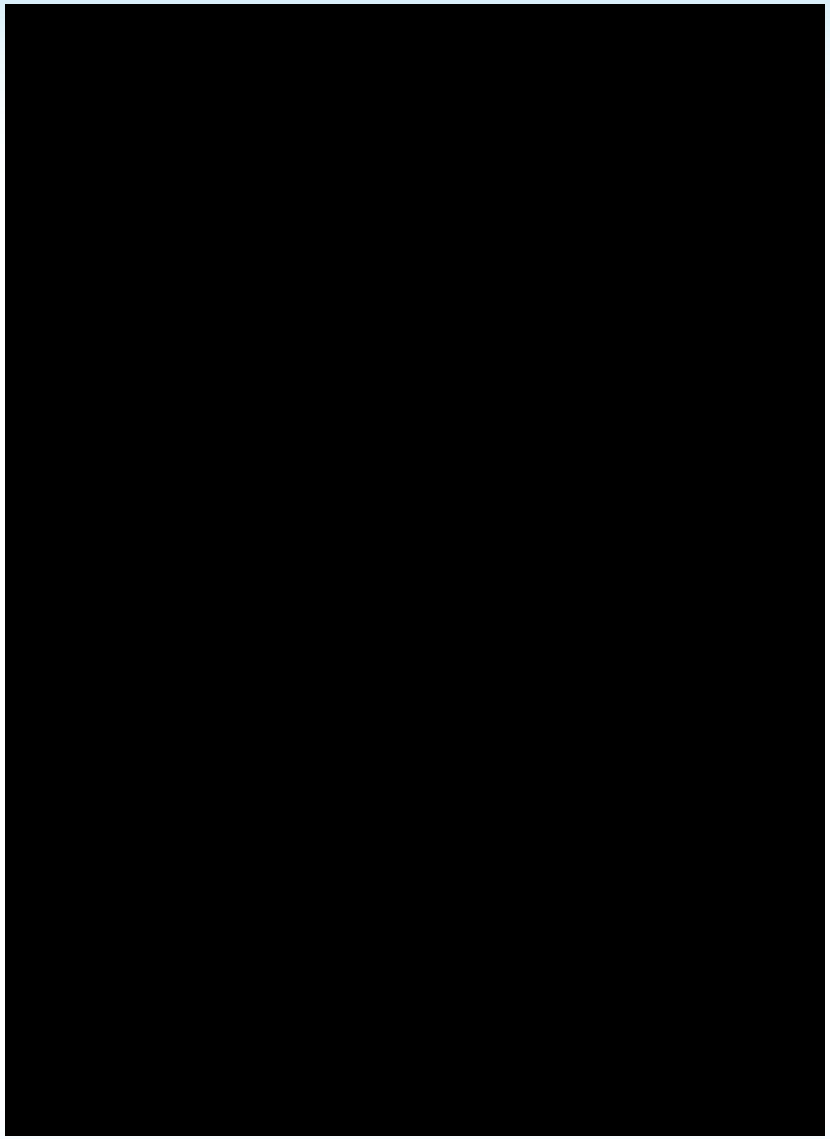
SHAD CULTURE.

By Wm. Clift.

TAFS Volume 1, Issue 1

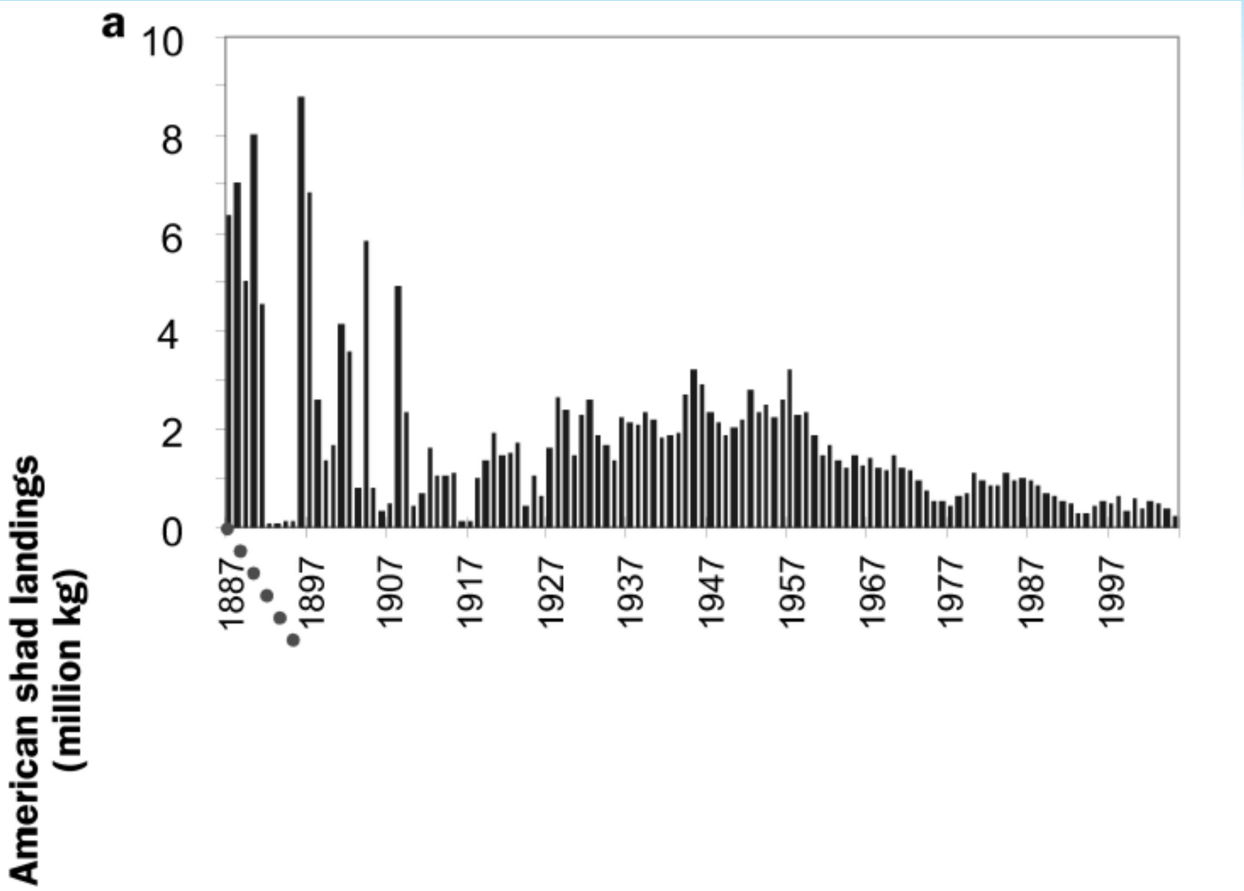
The shad (*Alosa præstabilis*) stands very high among, if not at the head of, the luxuries which our rivers afford. A seven-pound specimen, in the month of June, taken fresh from the Connecticut, and cooked by a housewife who has had her birth and education in that famous valley, leaves little to be desired in the way of epicurean delight. The fish from this stream stand so high in the market that the placard, "Connecticut River Shad," probably sells a great many more fish in all our large cities than come from that stream. As compared with the southern shad, they are unquestionably fatter and of finer flavor; but, as compared with the fish that come from other streams along the Connecticut and Rhode Island shores, there is not much ground for the distinction. I have eaten quite as fine shad from the Quinebaug and the Pawcatuck, before the race became extinct in those rivers, as the best ever taken at Saybrook and Lyme. It is not improbable that they follow the law of the grains and fruits.





Limburg et al. 2003

Fishery records for American shad – U.S.



Limburg & Waldman 2009

The New York Times

FISH AND FISHERIES.

REPORT OF THE UNITED STATES COMMISSIONER.

GENERAL HISTORY OF FISH CULTURE—FISHES ESPECIALLY WORTHY OF CULTIVATION—EFFORTS MADE FOR THE PROPAGATION OF SHAD.

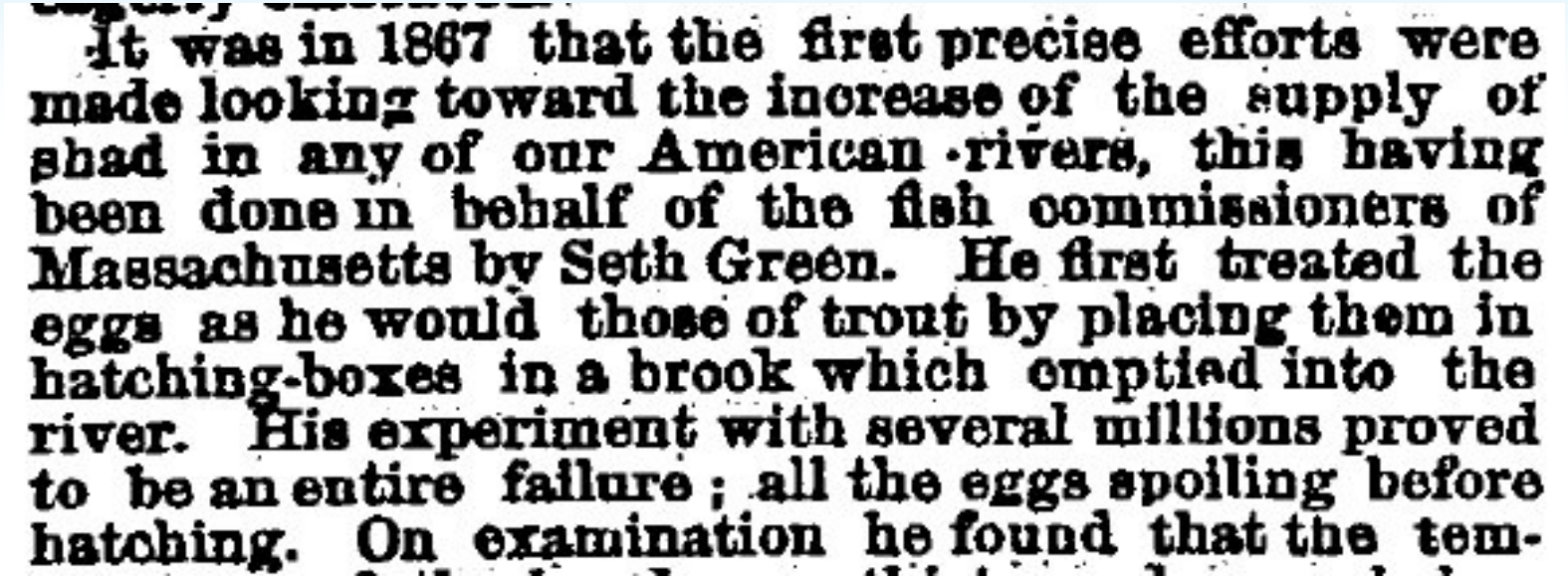
From Our Own Correspondent.

WASHINGTON, Thursday, Nov. 26, 1874.

The New York Times (1874)

FISHES ESPECIALLY WORTHY OF CULTIVATION.

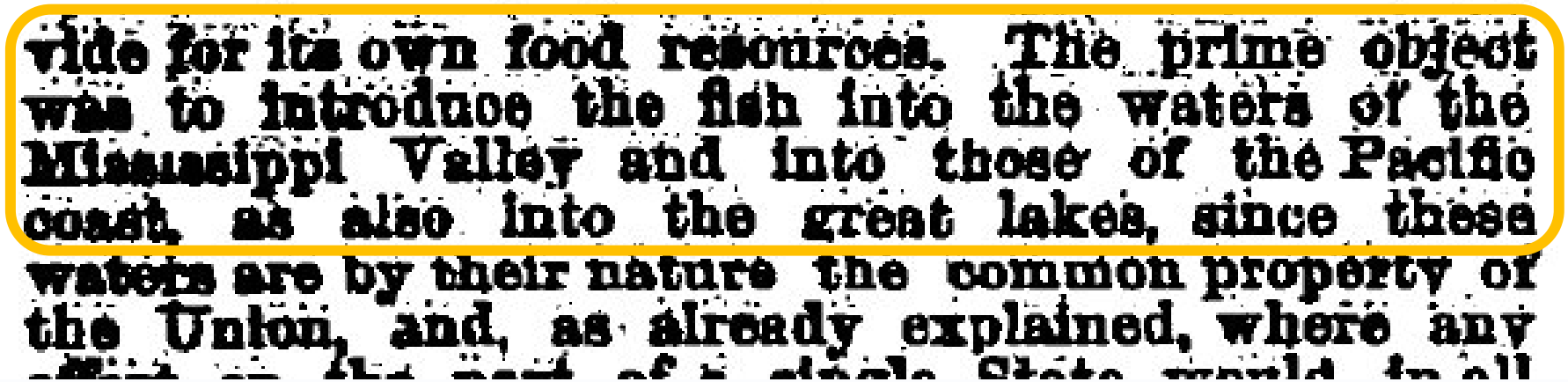
Among these fishes the American shad, *Alosa sapidissima* may be considered as holding the chief place, occupying in its distribution, as it does, the entire eastern border of the United States from the Saint John's River in Florida to the Gulf of Saint Lawrence, and even occurring in limited numbers in the waters emptying into the Gulf of Mexico. Its abundance in the early history of the country was such as to excite the unbounded astonishment of those who beheld it for the first time. With scarcely an exception, every river on the Atlantic coast within the limits mentioned was invaded in the Spring by immense schools, which in their upward course furnished an ample supply of the best food, first to the aboriginal inhabitants, and then to their European supplanters and their descendants. The fisheries were established on the river banks



It was in 1867 that the first precise efforts were made looking toward the increase of the supply of shad in any of our American rivers, this having been done in behalf of the fish commissioners of Massachusetts by Seth Green. He first treated the eggs as he would those of trout by placing them in hatching-boxes in a brook which emptied into the river. His experiment with several millions proved to be an entire failure; all the eggs spoiling before hatching. On examination he found that the tem-

1st mention of Seth Green, the engineer of shad stocking in the U.S.

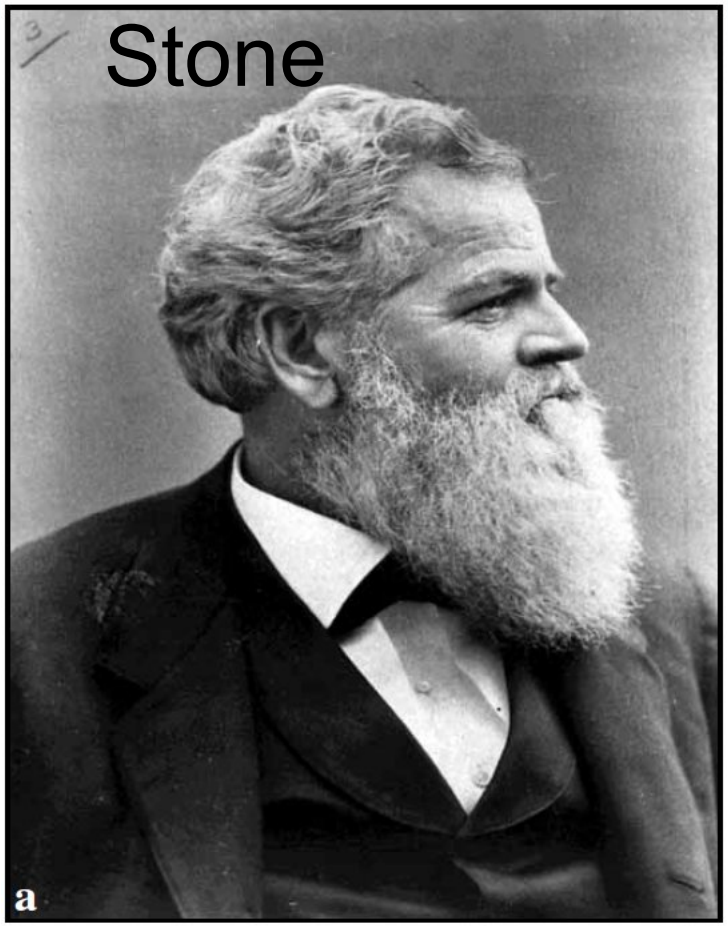
The Federal mandate:



vide for its own food resources. The prime object was to introduce the fish into the waters of the Mississippi Valley and into those of the Pacific coast, as also into the great lakes, since these waters are by their nature the common property of the Union, and, as already explained, where any

“The father of American fish culture”

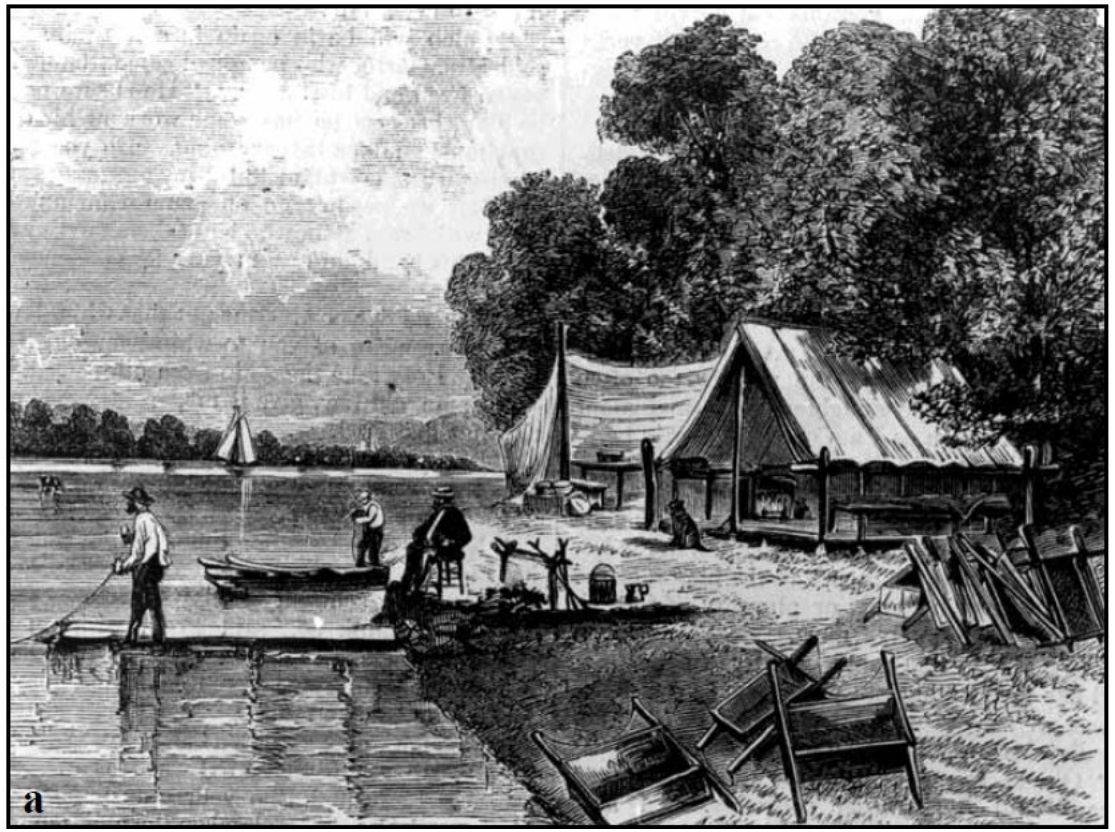
Seth Green Stone



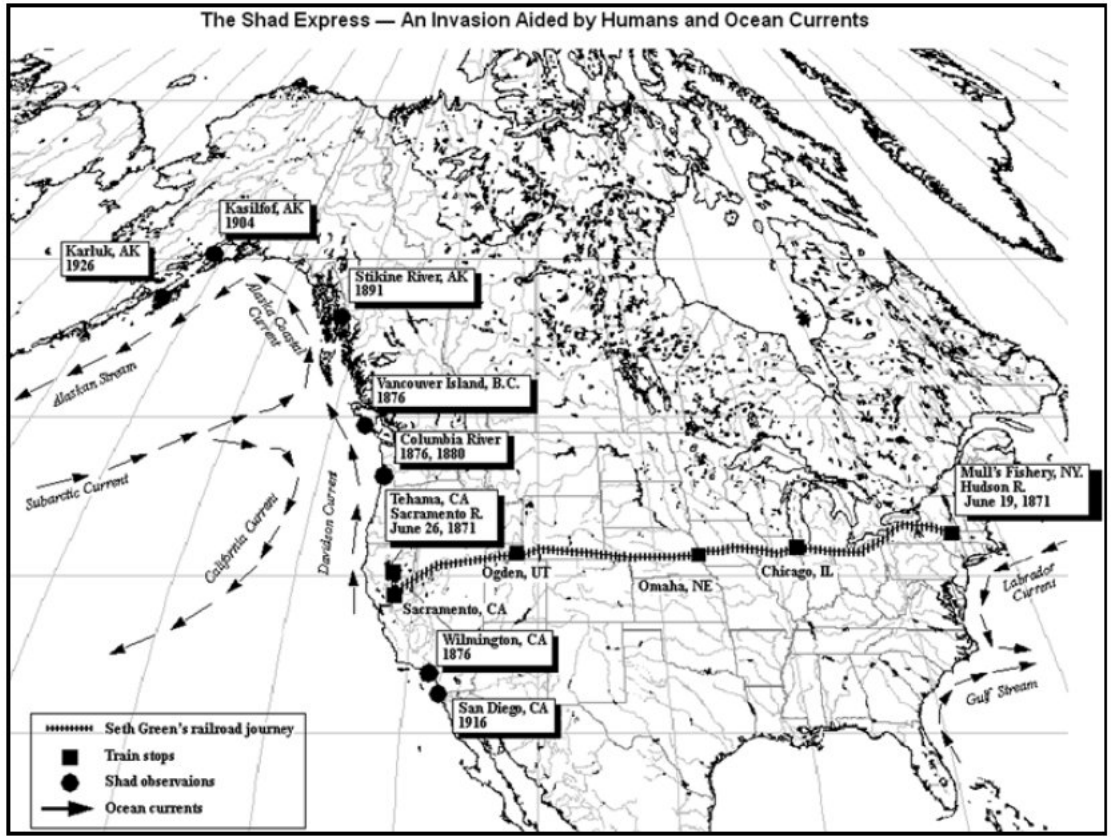
Livingston

One of the first to transport shad after Green

Seth Green's shad hatchery on the Hudson River



Original train trip (1871) + subsequent observations



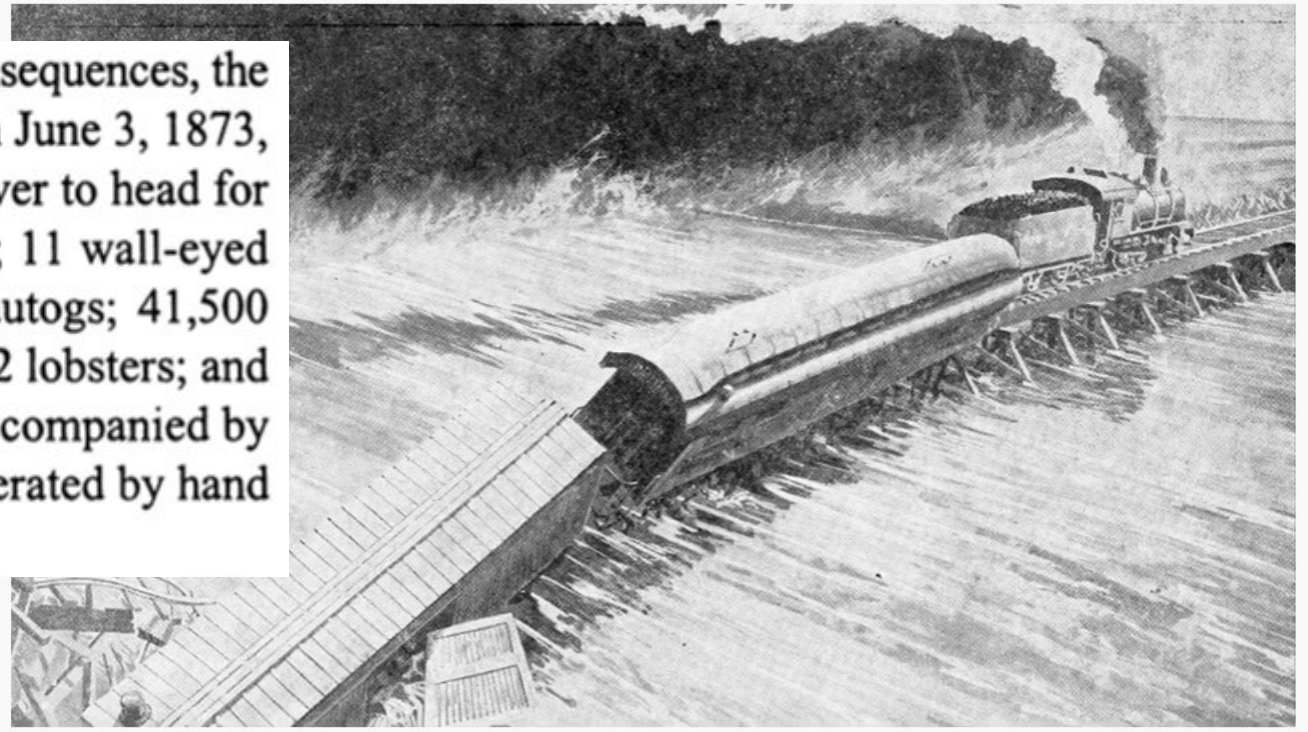
The new Transcontinental Railroad!

Fish transport disaster, 1873, Elkhorn River, Nebraska!

Livingston Stone's ambitious plan: transport in specially designed "aquarium car"

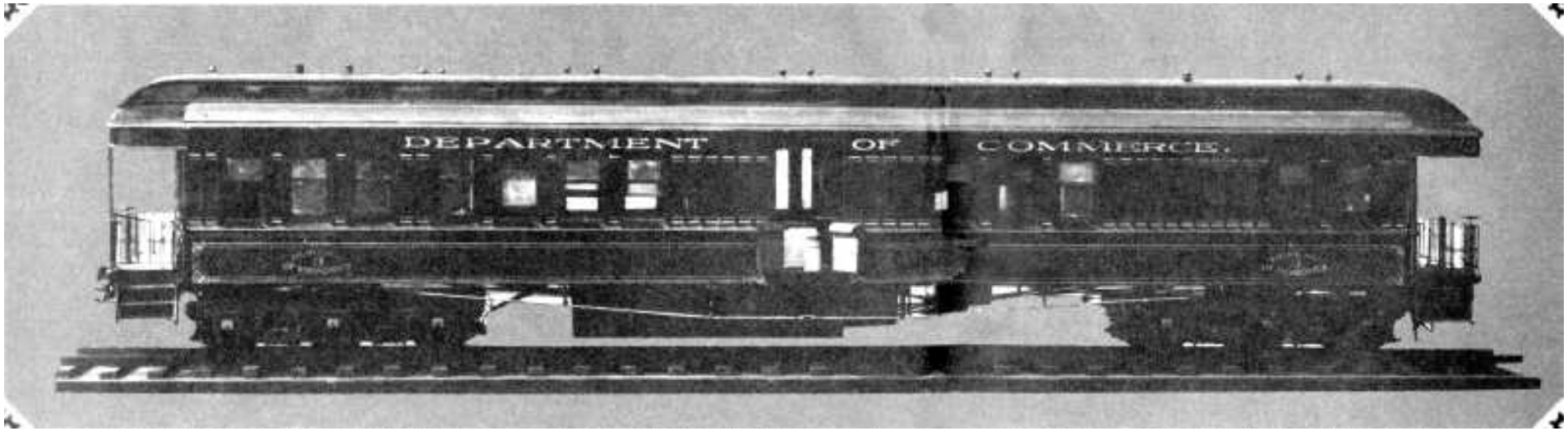
With no one considering the possible environmental consequences, the aquarium car rolled out of Charlestown, New Hampshire, on June 3, 1873, its tanks filled with some of the most unlikely emigrants ever to head for California. The piscine passengers included 60 black bass; 11 wall-eyed pike; 190 yellow perch; 12 bullheads; 110 catfish; 20 tautogs; 41,500 saltwater and freshwater eels; 1,000 trout; 20,000 shad; 162 lobsters; and one barrel of oysters from Massachusetts Bay. They were accompanied by Stone and three assistants, who kept the water constantly aerated by hand and changed it every two hours.[22]

D. Kinsey 1997. The Fish Car Era. *Railroad History* 177:43-67

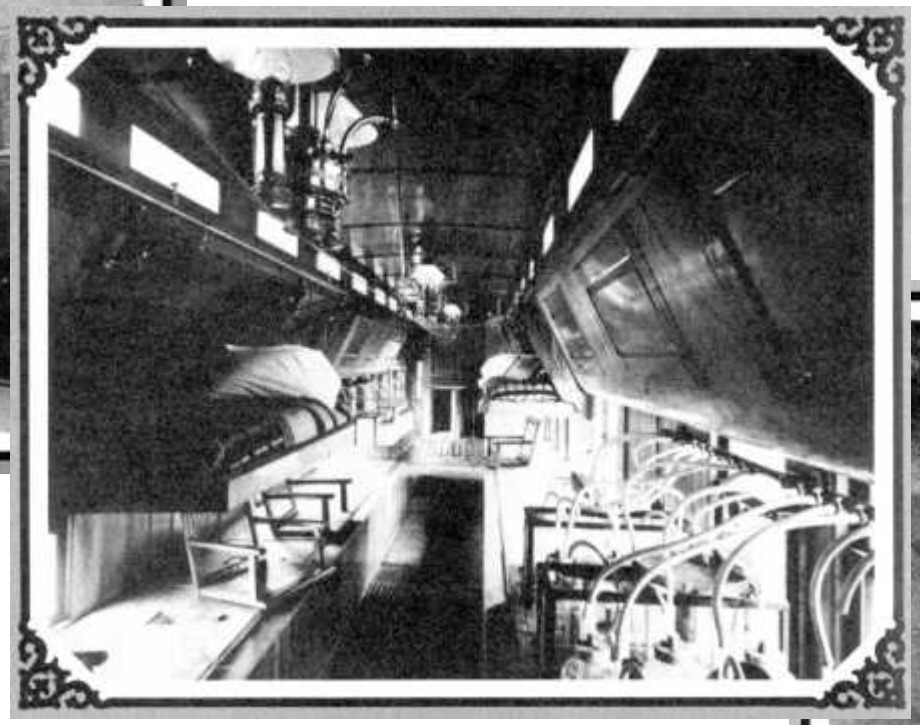


Bridge collapse…ker-splash!

Undeterred, this was followed by more and more “fish planting” by the young United States Fish Commission, with 60 years of train transport – shad was a premiere species



“The fish car era”



U.S. National Archives

"Wisconsin Fish Commission"
Mid-Continent Railway Museum

The U.S. Fish Commission was in the business of fish stocking; gave billions of fish to states for free. Over 72 billion (7.2×10^{10}) fish stocked 1900-1920 !

Columbia River:
910,000 fry
1885-1886

Willamette River:
550,000 fry
1886

Sacramento River:
619,000 fry
1876-1880

Source rivers

Recipient rivers

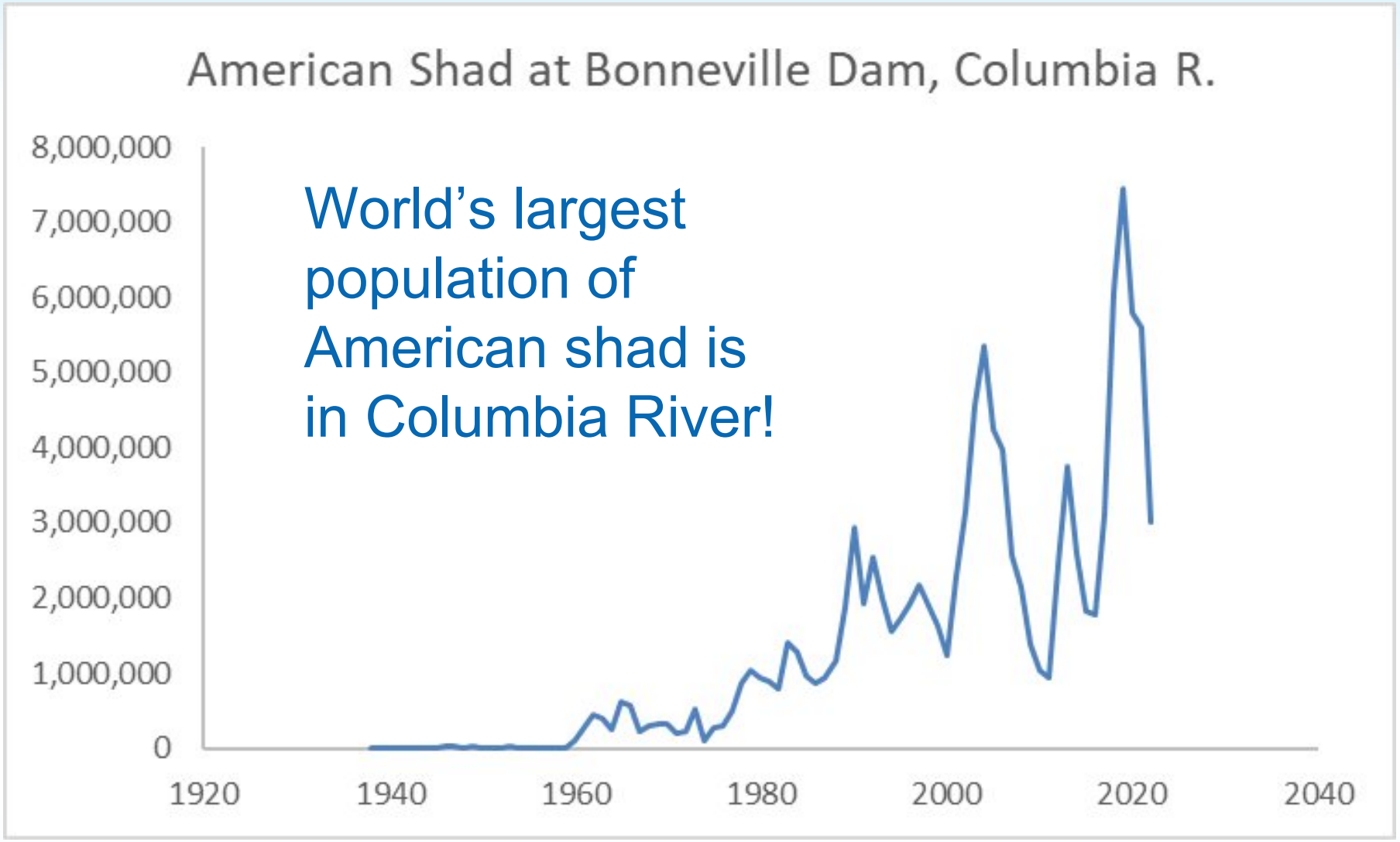
Kamchatka Peninsula &
Anadyr River, Siberia
1980s (?)

East-coast origin shad were rapid dispersers on the N. American Pacific coast – and beyond!

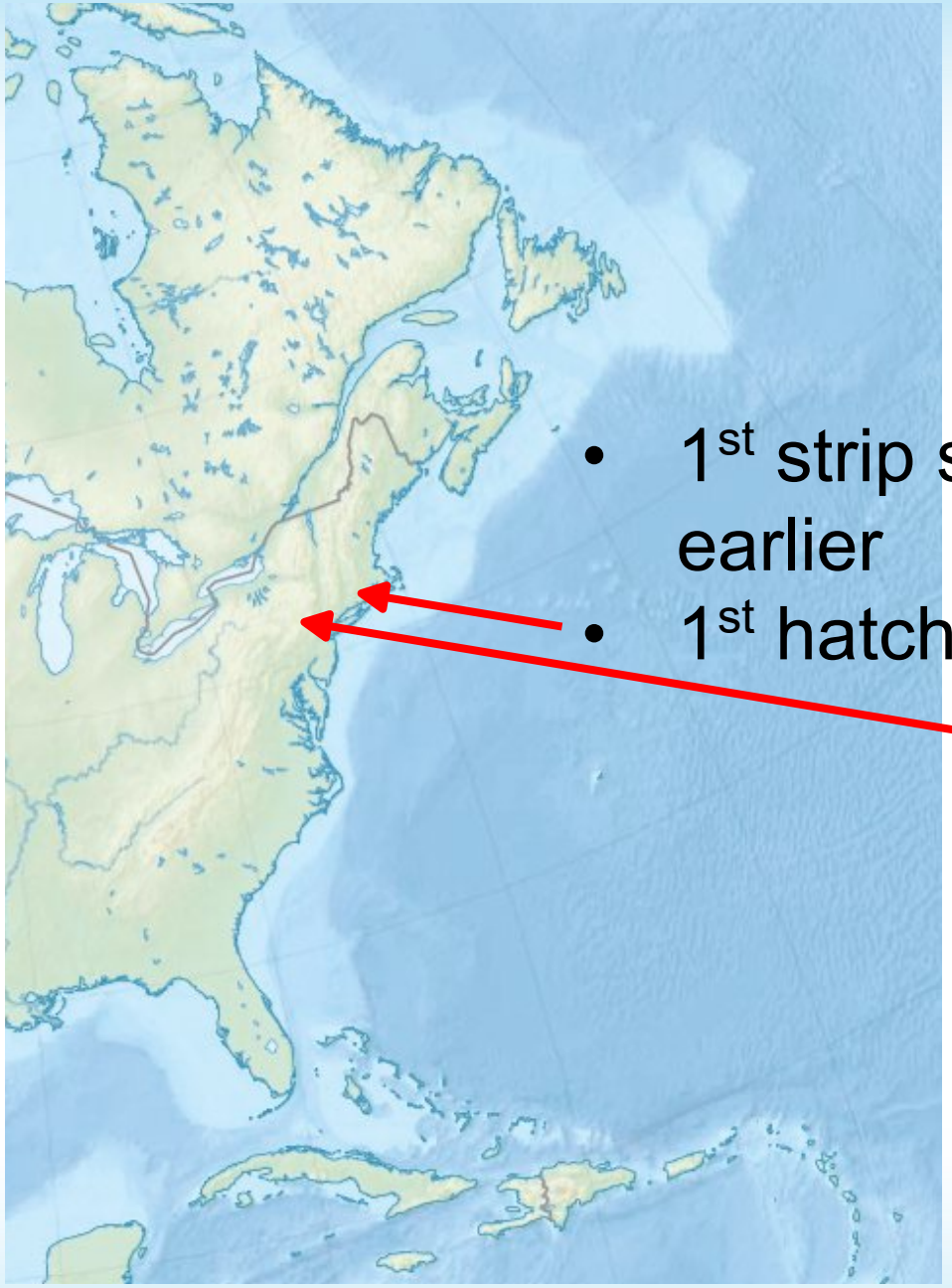
Why the rapid, successful colonization?

American shad proceeded to colonize the Columbia River, with numbers growing exponentially as more parts of the river were dammed, creating reservoir-like stretches

Seems favorable for young American shad



https://www.fpc.org/webapps/adultsalmon/Q_adultcounts_dataquery.php

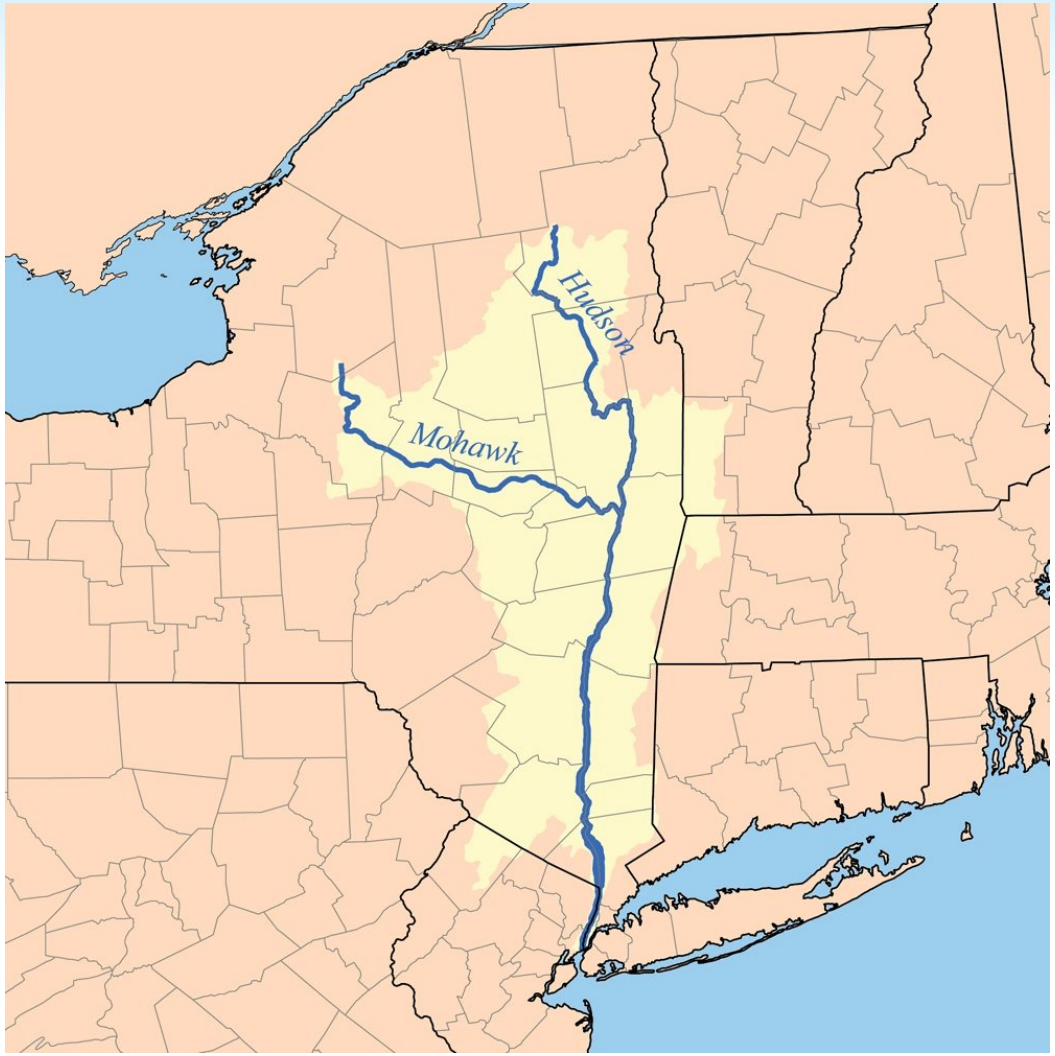


Meanwhile, along the East Coast…within-basin and interbasin stocking also has a long history

- 1st strip spawning of shad in 1848 or earlier
- 1st hatchery in Connecticut River, 1867

Hudson River in 1895:

- 33,322,500 fry stocked from in-river spawning
- 54,511,000 fry stocked from Delaware and Susquehanna! → *"There is little doubt that the fresh blood has invigorated and improved the stock" (Cheney, 1895)*

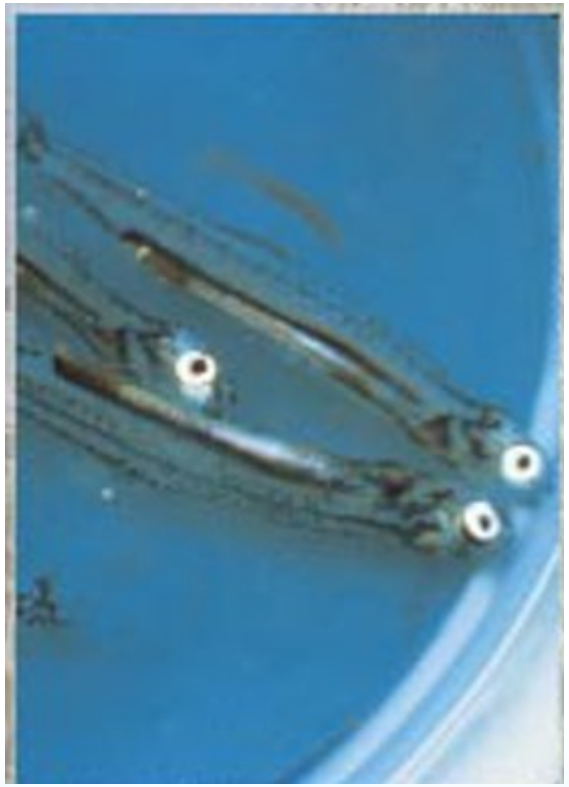


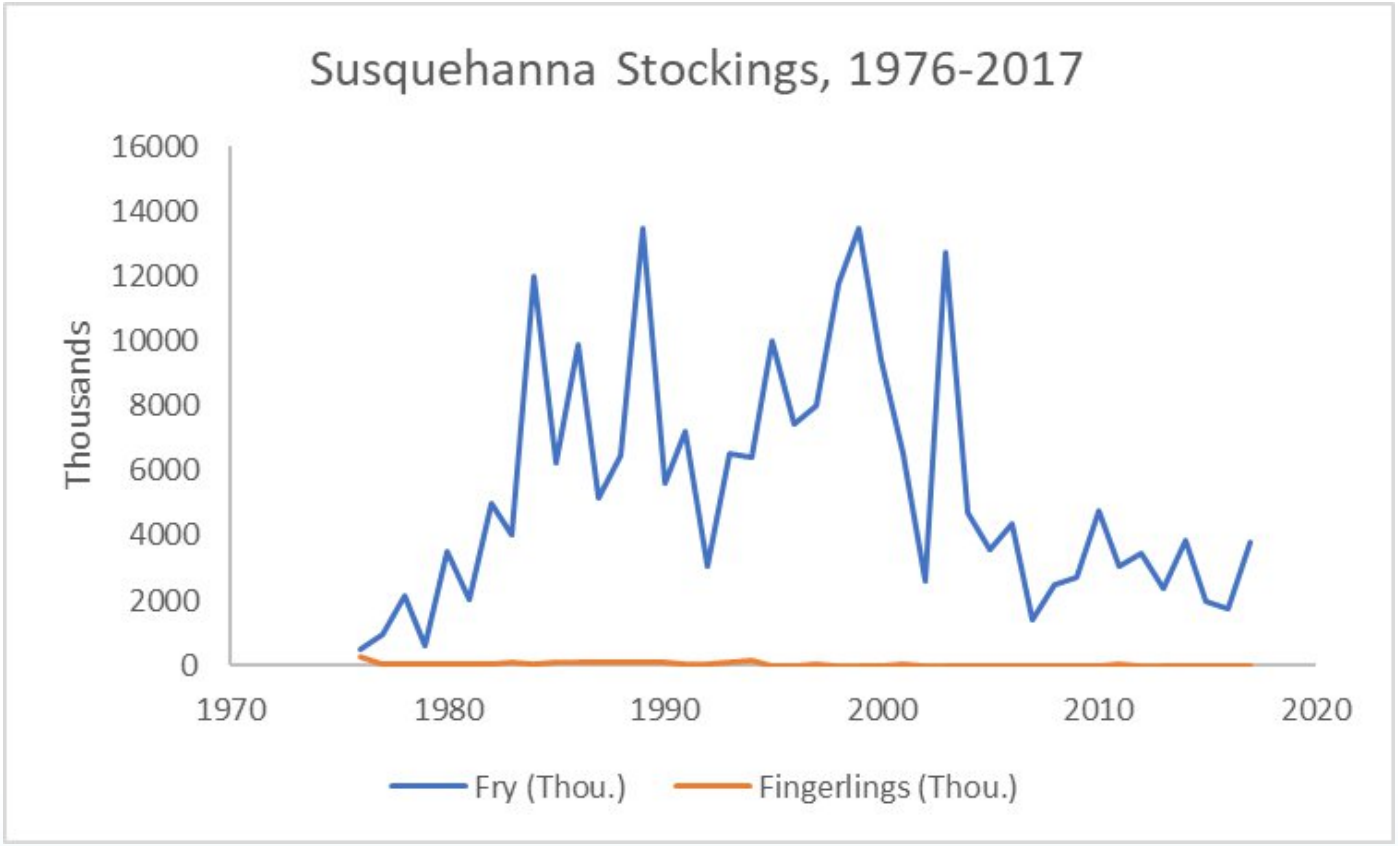
The fear in the Hudson was that with demand soaring and too many nets in the water, “it is extremely doubtful…if the Hudson can be considered a self-sustaining shad river” (Cheney, 1895)

In sum, stocking was a common practice in the 1800s and was seen as a way to enhance the food supply of the U.S.

Shad was regarded as a critically important fish, and thus transplantation was widely practiced.

Today on the East Coast of N. America, there is much less stocking. Mostly in Susquehanna River, which has 4 main-stem dams.



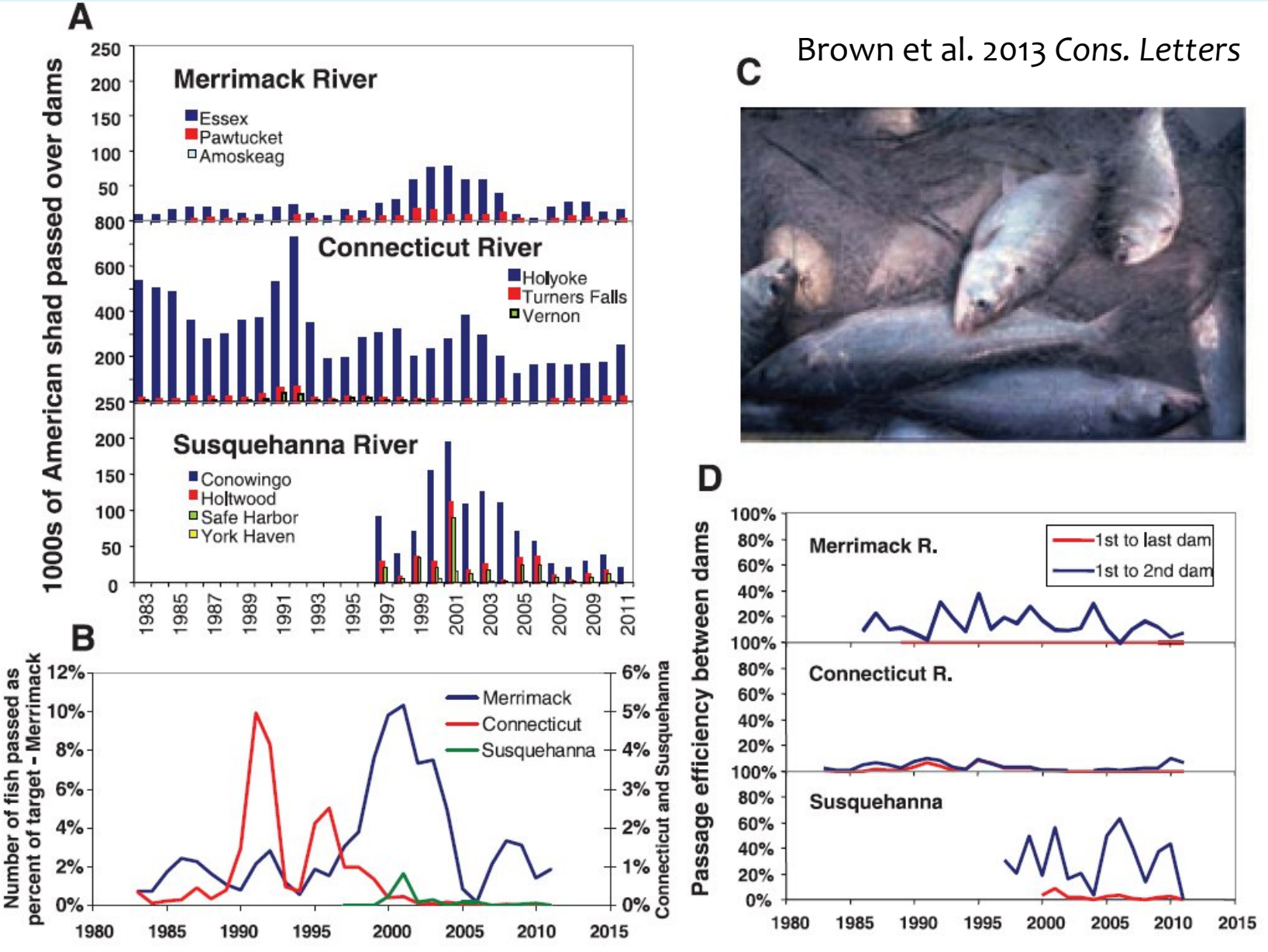


Data from 2020 Benchmark Stock Assessment of American Shad (ASMFC)

General failure of fish passage in Northeastern U.S.

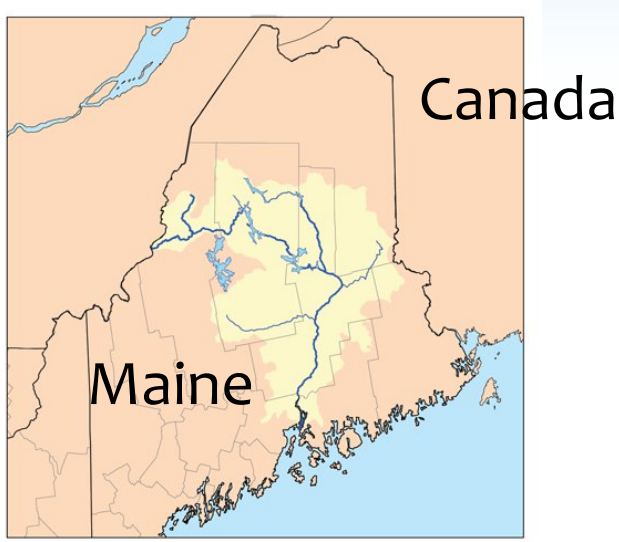
- Failed to meet targets
- Passage up above dams to spawning grounds extremely low

Brown et al. 2013 *Cons. Letters*



Bailey and Zydlewski (2013) asked,
"To stock, or not to stock?"

- Used a model to study this, with Penobscot R. in Maine as case study.
- Penobscot had 3 mainstem dams, 2 of which were removed.



Over-all result: stocking is effective if the starting population is extremely depleted (i.e. 10% of "recovered")

Otherwise, diminishing returns

Other effects on East Coast:

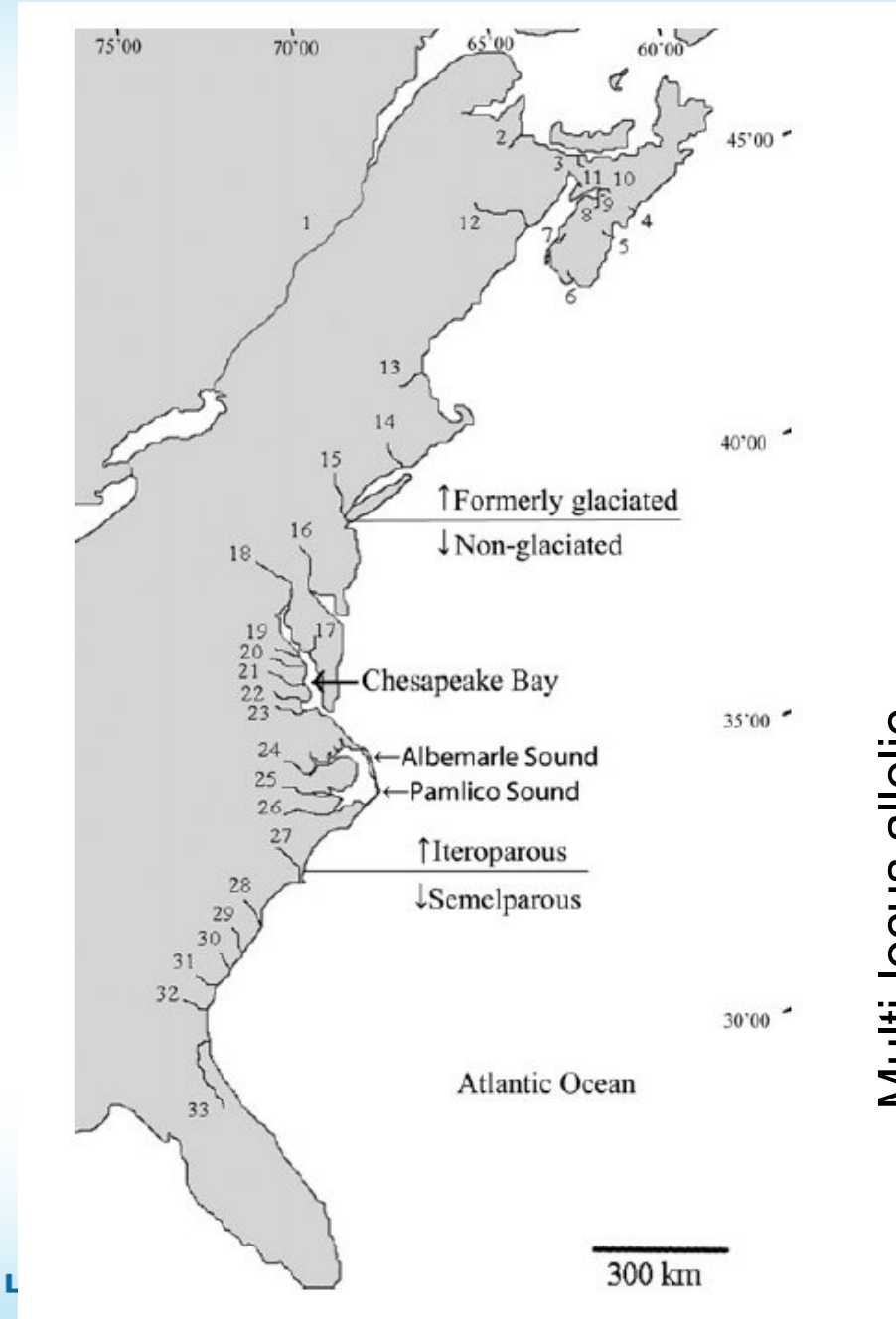
MOLECULAR ECOLOGY

Molecular Ecology (2013) 22, 1558–1573 doi: 10.1111/mec.12197

Genetic diversity and differentiation in a wide ranging anadromous fish, American shad (*Alosa sapidissima*), is correlated with latitude

DANIEL J. HASSELMAN,* DANIEL RICARD,†‡ and PAUL BENTZEN*

(Dan's Ph.D. research)



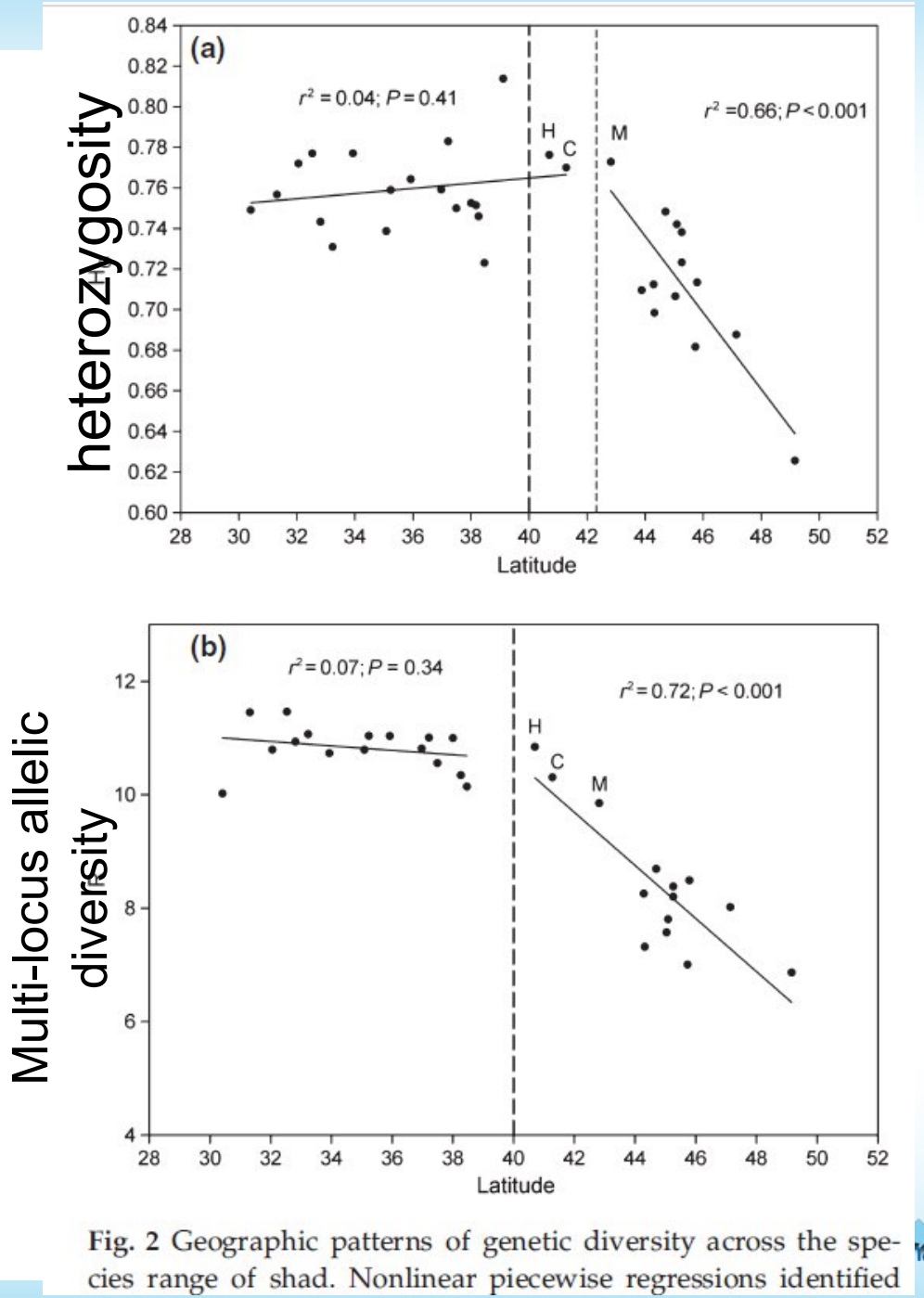
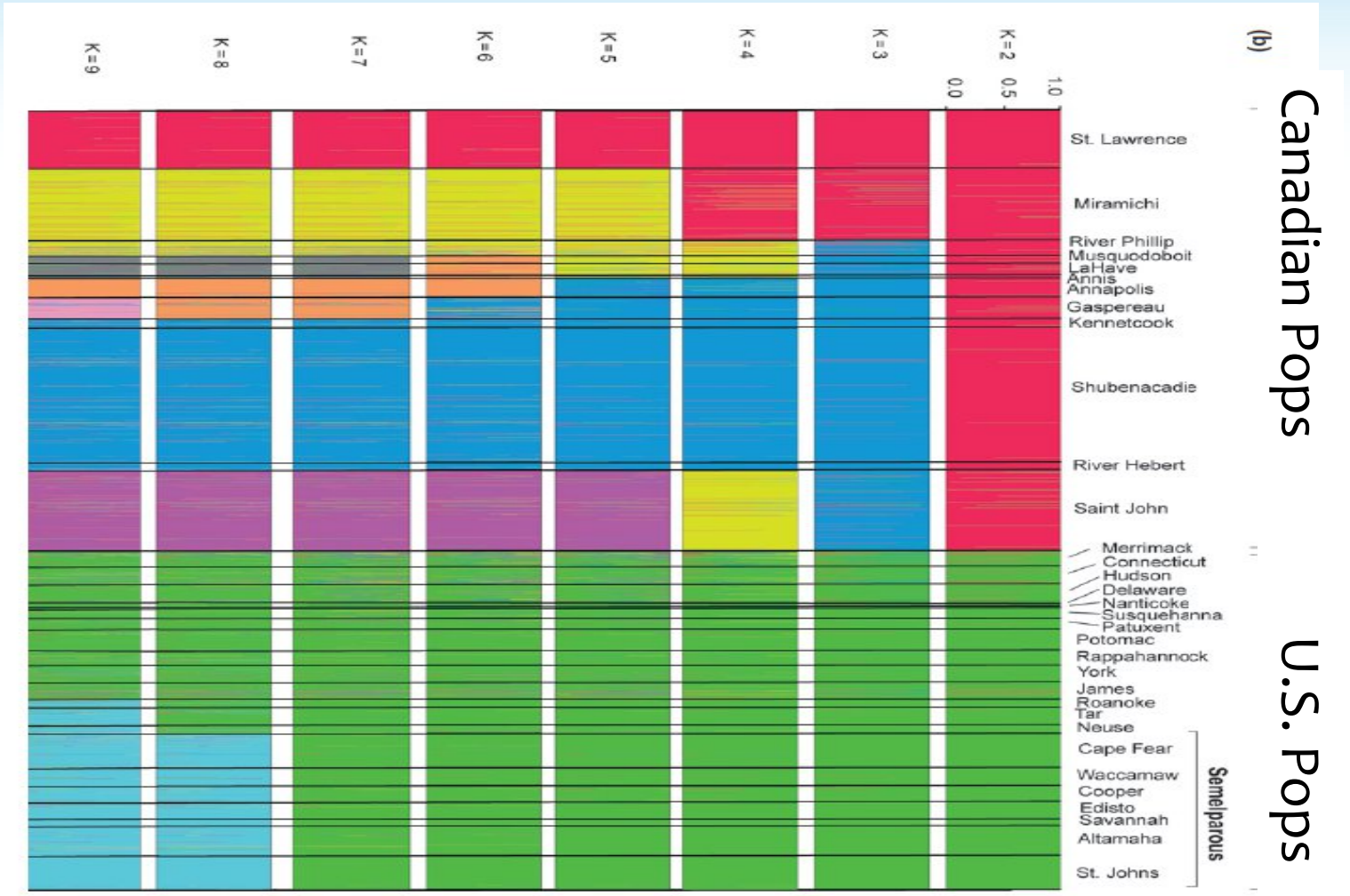


Fig. 2 Geographic patterns of genetic diversity across the species range of shad. Nonlinear piecewise regressions identified

U.S. doesn't show much variation compared to Canada



Hasselman et al. (2013) found 9 genetically distinct population groupings:

- 7 in Canada
- 2 in U.S.

Far less inter-basin stocking in Canada!

Effects of American shad stocking on the North American Pacific coast

Contrary to expectations, shad was not hugely popular as a new food fish

Concern (especially today) about competing with native Pacific salmon species

Some view American shad as a “nuisance invasive” out West

Nevertheless, recreational fishing for shad has some popularity even “Out West”

Shad anglers at Bonneville Dam.

P. Cooney – The Fisheries Blog, June 16, 2013

American shad have adopted a new ecological role in the Western rivers and Pacific Ocean

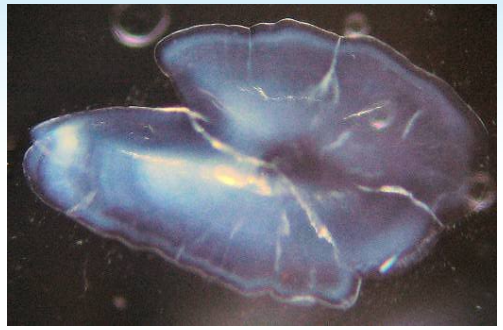
Generally, quite under-studied however

Young of year shad in Sacramento River

American shad on the Pacific coast offer new understandings of evolution in novel environment:

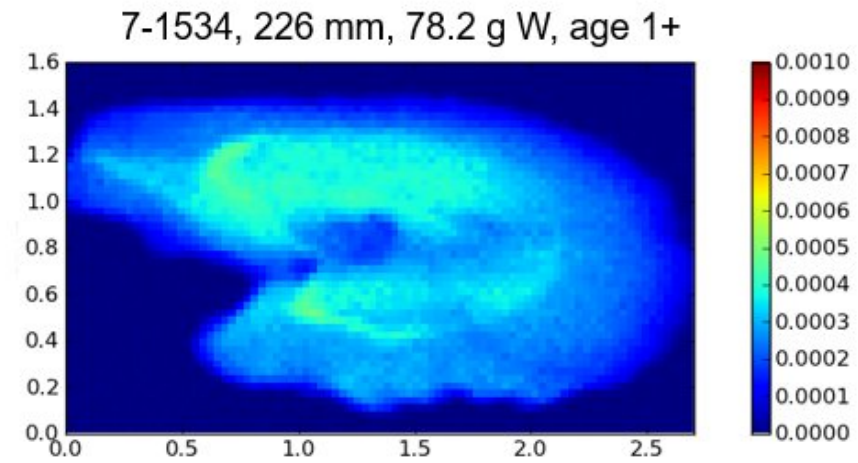
Differences in life history

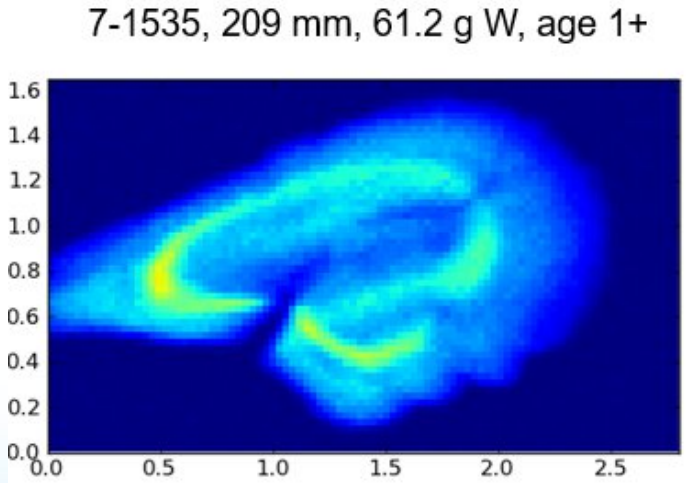
- Altered spawning cycle → fall rather than spring
- Prolonged residency in-river or in-estuary
  - “Mini-shads” that are larger than yearlings but sub-adult; resident in Columbia R.
  - Development of partial migration in San Francisco Bay Estuary
  - Completely land-locked in Millerton Lake, CA

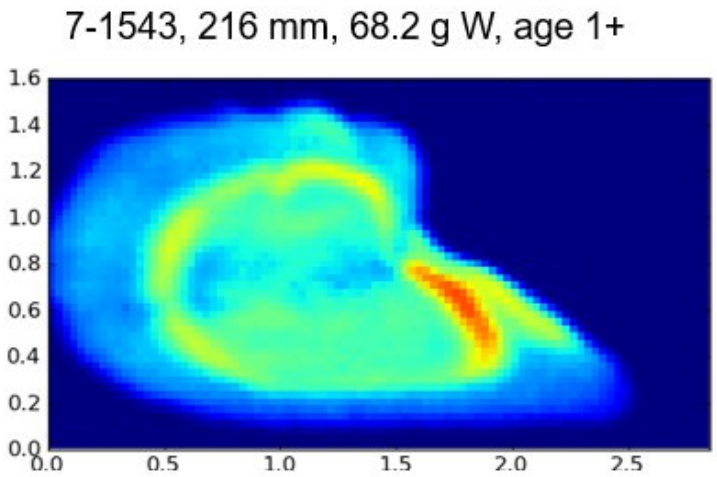


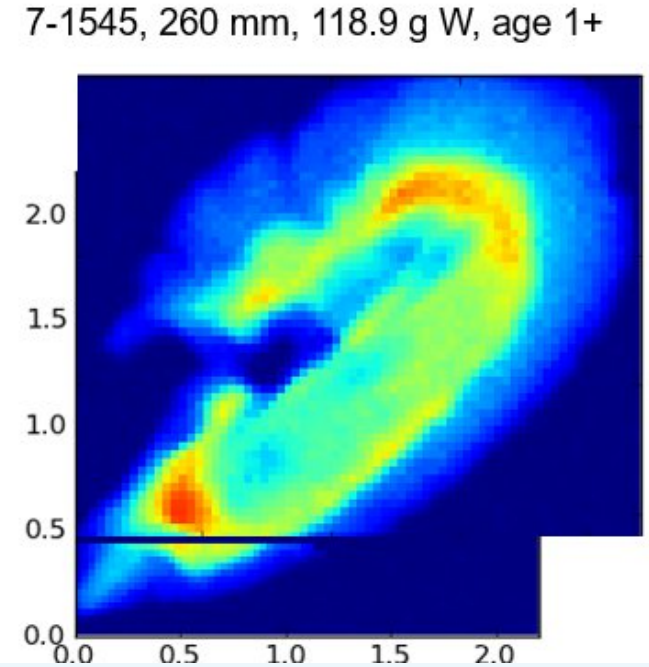
Low but variable Sr indicates that “Mini-shad” may actually have moved into brackish water, then back upstream – or else among different freshwater habitats

Strontium in “mini-shad otoliths, Columbia River, 2007. Analyzed at Cornell U. synchrotron, Oct-2011.









The Paradox of the Dammed:

A question that has bothered some of us

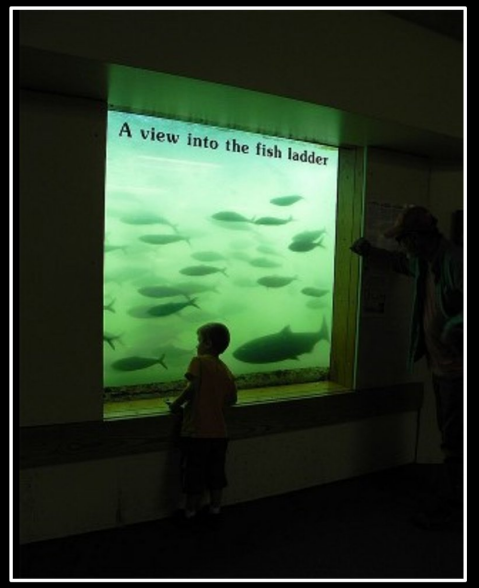
Why are shad doing so well out West, and so poorly in the East, when both coasts have large rivers that are heavily dammed?

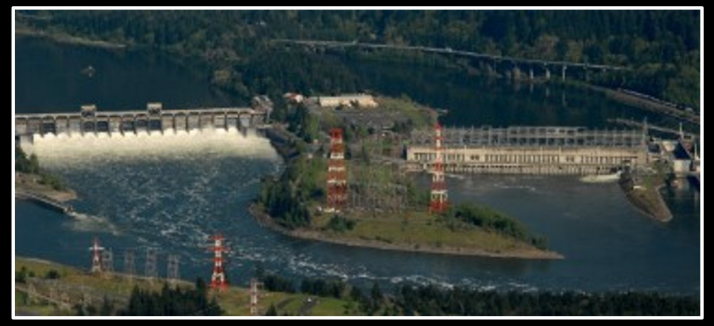
Bonneville
Conowingo

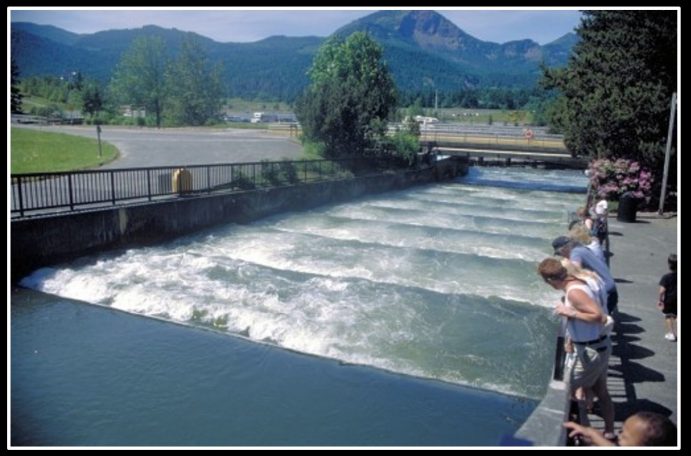
John Waldman's take: the dam passages in Western rivers have flows that exceed the flows of some Eastern rivers!

Shad - An Interesting West Coast Exception

Bonneville Dam
Columbia River







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

Columbia River

- Bonneville Dam Ladder = 2,000 – 3,000 cfs

Average Flow:

- Columbia River 275,000 cfs!

East Coast Rivers

- Avg. ladder flow = 30-50 cfs

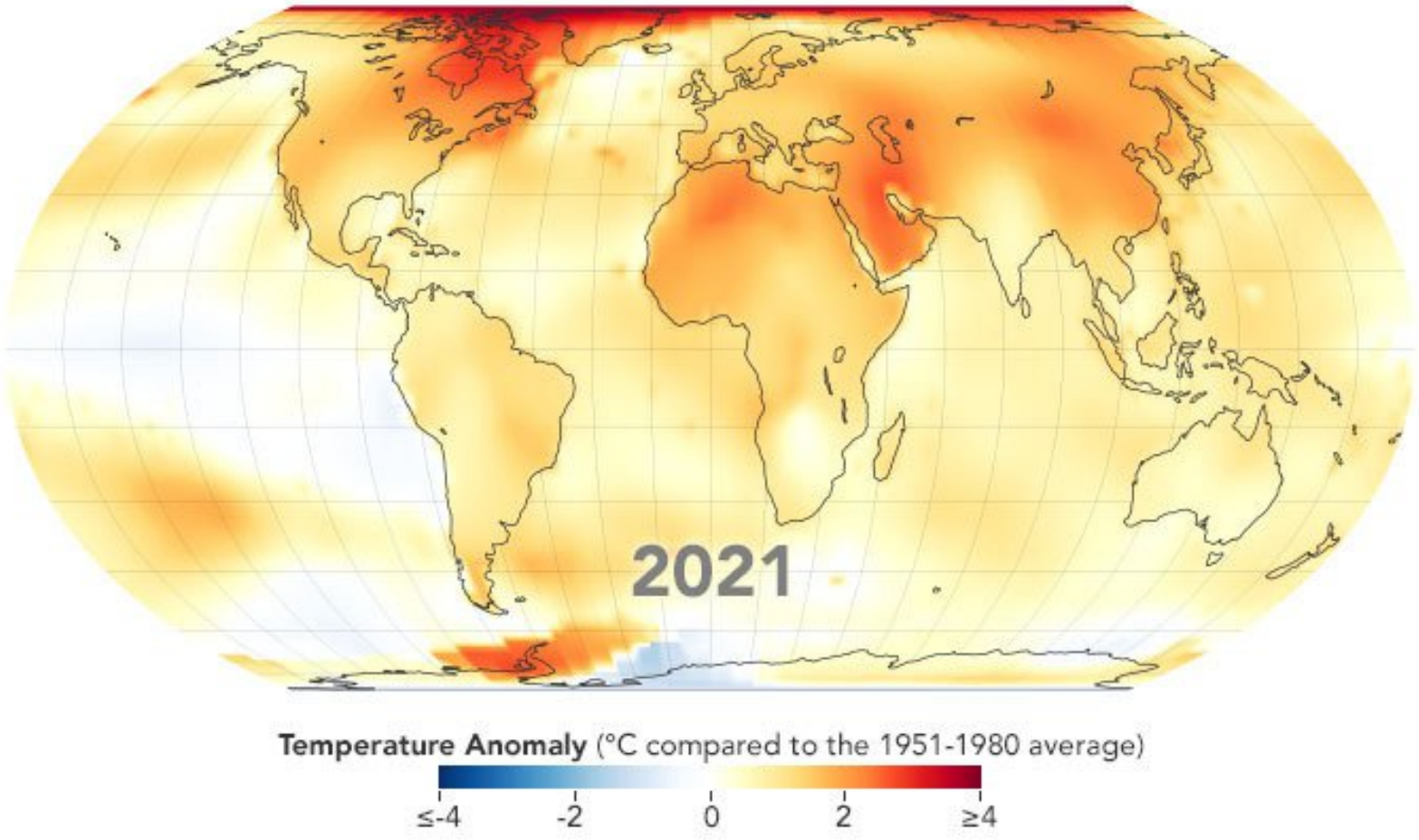
Average Flows:

- Connecticut 17,000 cfs
- Delaware 11,700 cfs
- Kennebec 9,100 cfs
- Pawcatuck 675 cfs

cfs = cubic foot per second

1 cfs = 0.0283 m^3/s

Bi-Coastal American Shad in a Warming World – Where will it do best?

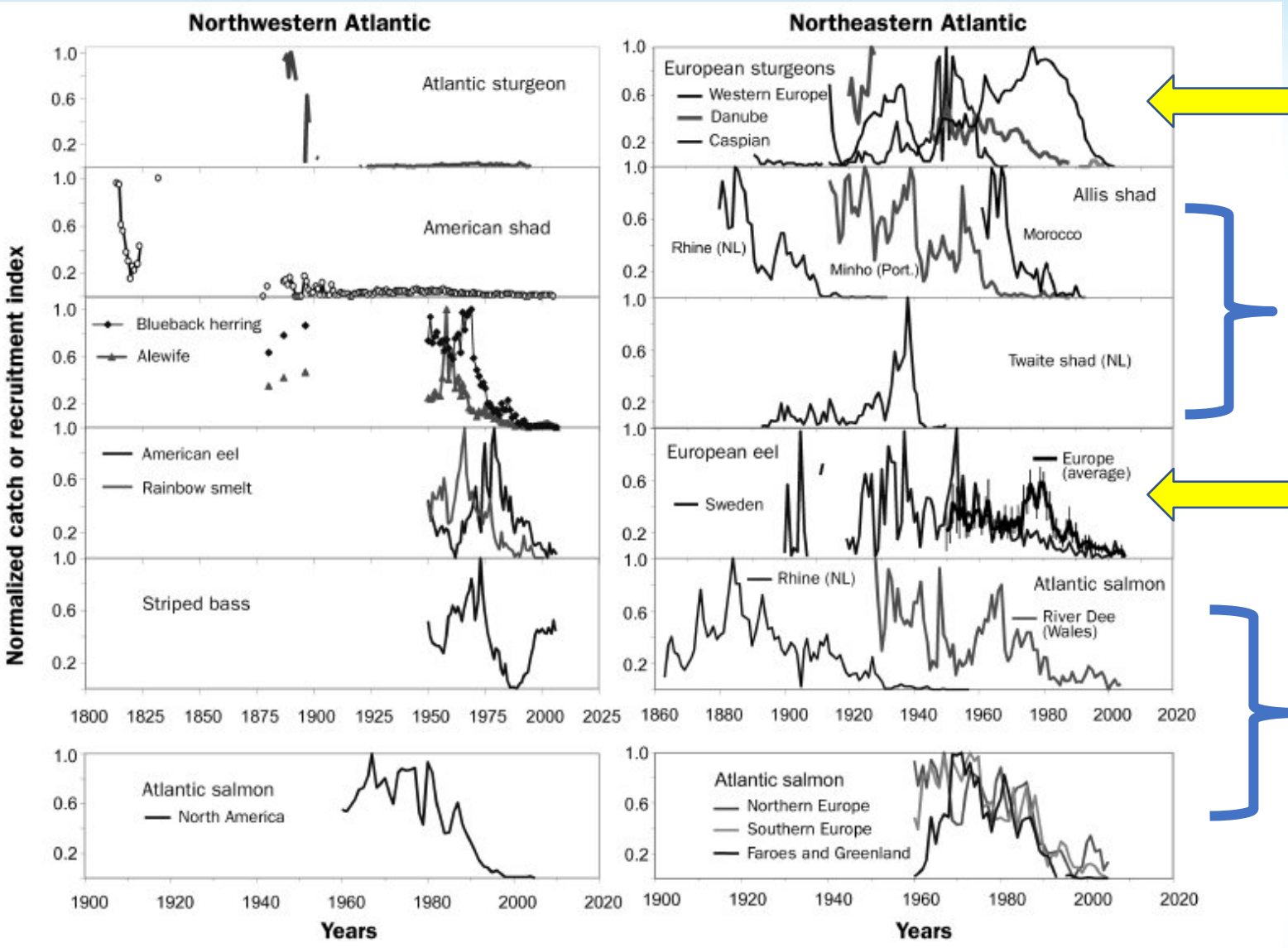


https://earthobservatory.nasa.gov/world-of-change/global-temperatures

Dramatic Declines in North Atlantic Diadromous Fishes

KARIN E. LIMBURG AND JOHN R. WALDMAN

December 2009 / Vol. 59 No. 11 • BioScience 955



Sturgeons

Shads

Eels

Bass and salmons

Figure 1. Normalized time series of indices of abundance of selected north Atlantic diadromous species. European eel includes standard errors of means for nine regions. The lower two panels compare Atlantic salmon. For type of index, maxima, minima, percentage change, and data sources, see table 2. Unless otherwise stated, northwestern Atlantic data are US summary statistics.

Another thing to add to the declaration:

Hydropower is NOT “clean and green” !!

(but could it be???)

This will be a key factor in stocking success.

Some good reading.

Atlantic States Marine Fisheries Commission (ASMFC). 2020. American Shad 2020 Stock Assessment.

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Hasselman, D.J., D. Ricard, and P. Bentzen. 2013. Genetic diversity and differentiation in a wide ranging anadromous fish, American shad (*Alosa sapidissima*), is correlated with latitude. Mol. Ecol. 22: 1558-1573.

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