Setting the baseline: the historical decline of diadromous fish and ecological connections lost

Dr. Adrian Jordaan
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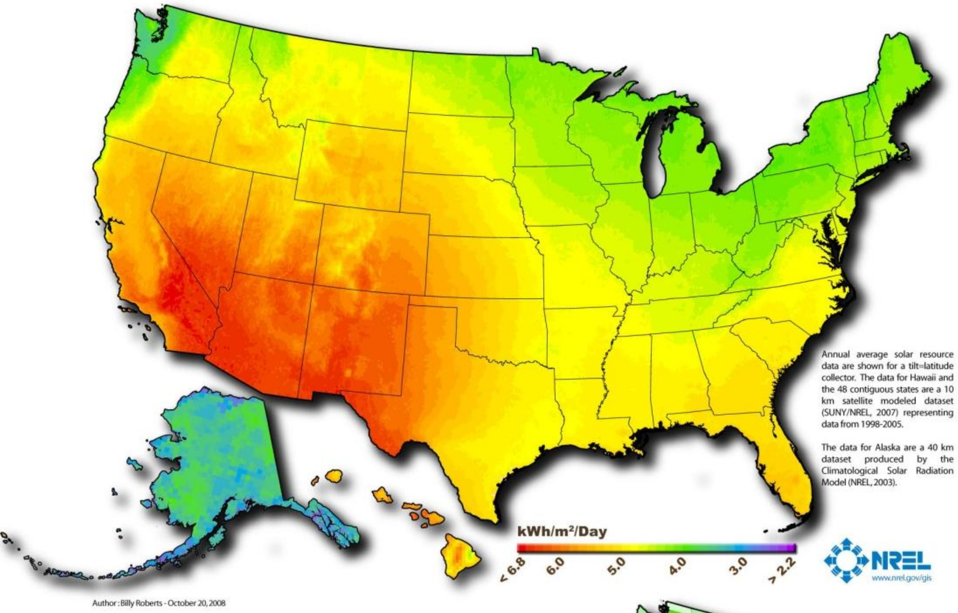
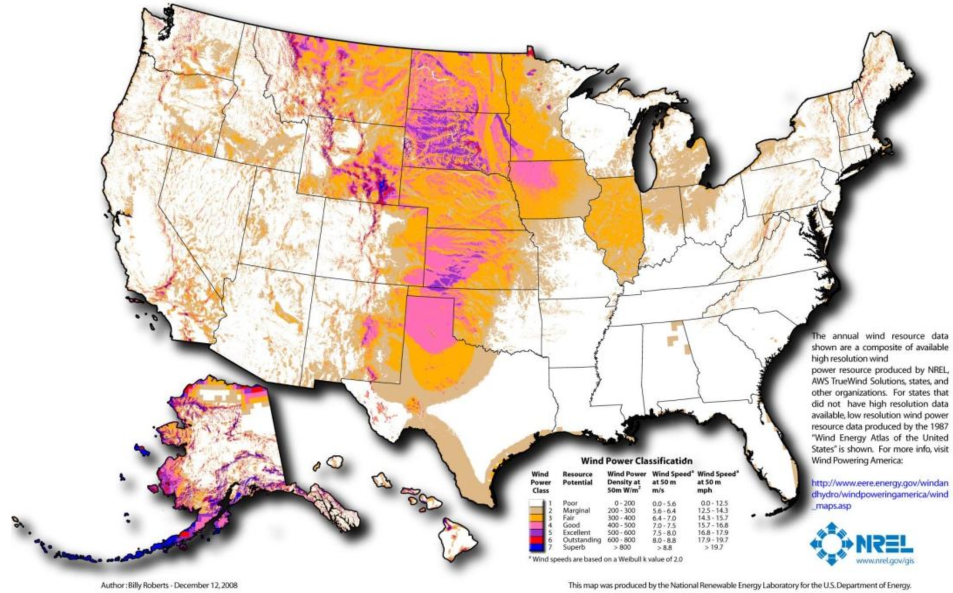
University of Massachusetts Amherst

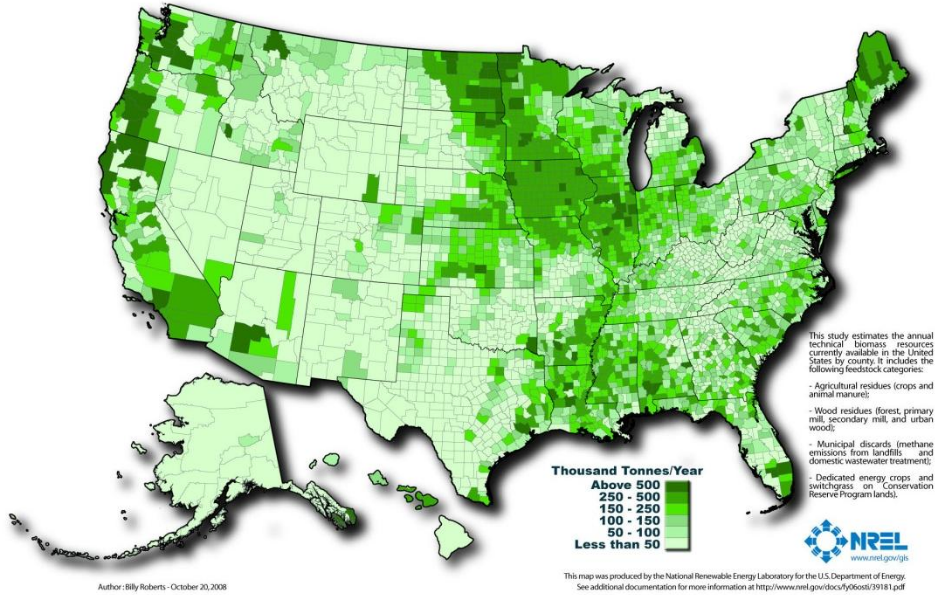
Power consumption is heterogeneous

Credit: **NOAA/DMSP**

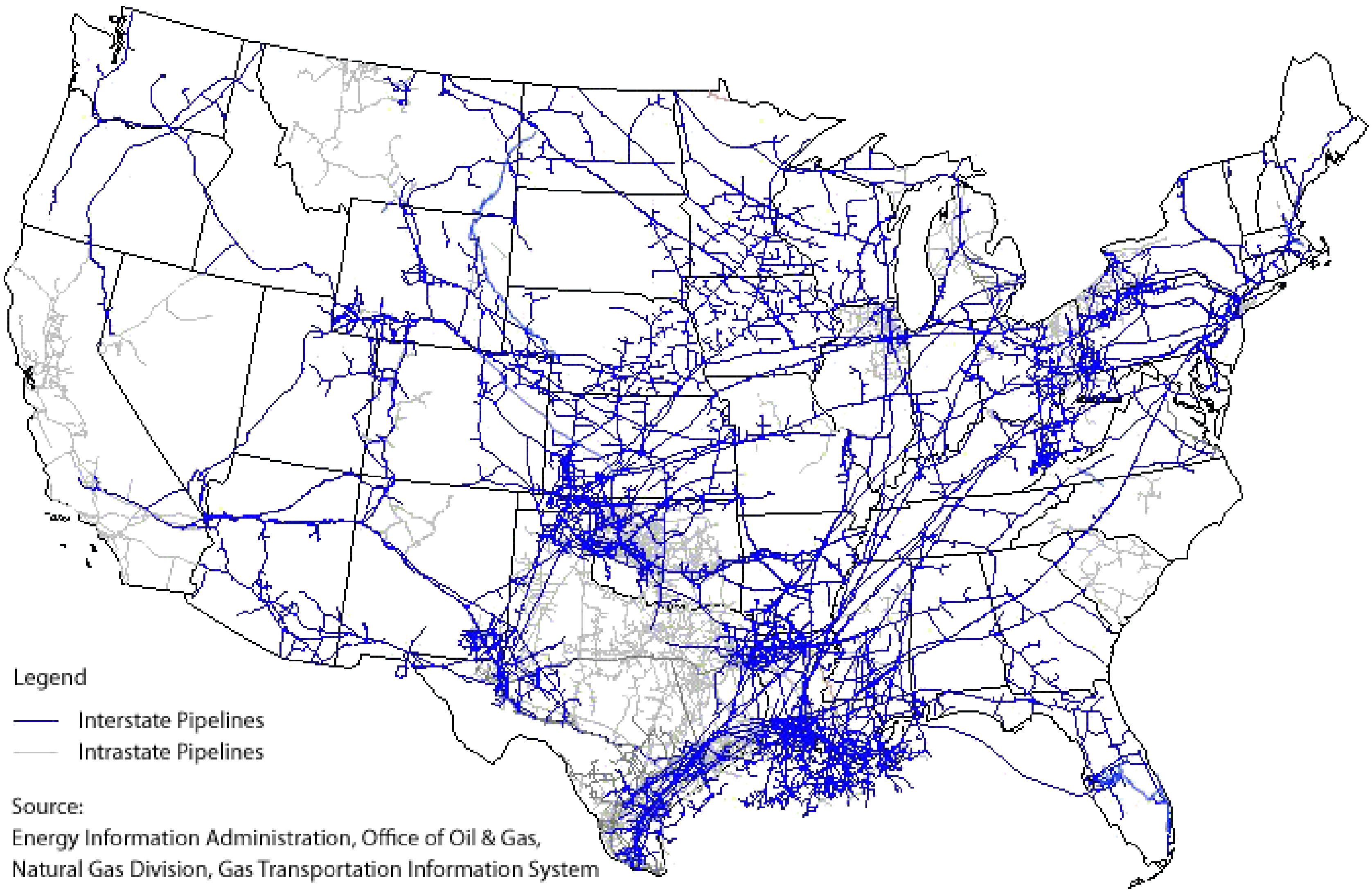
Productive capacity as well





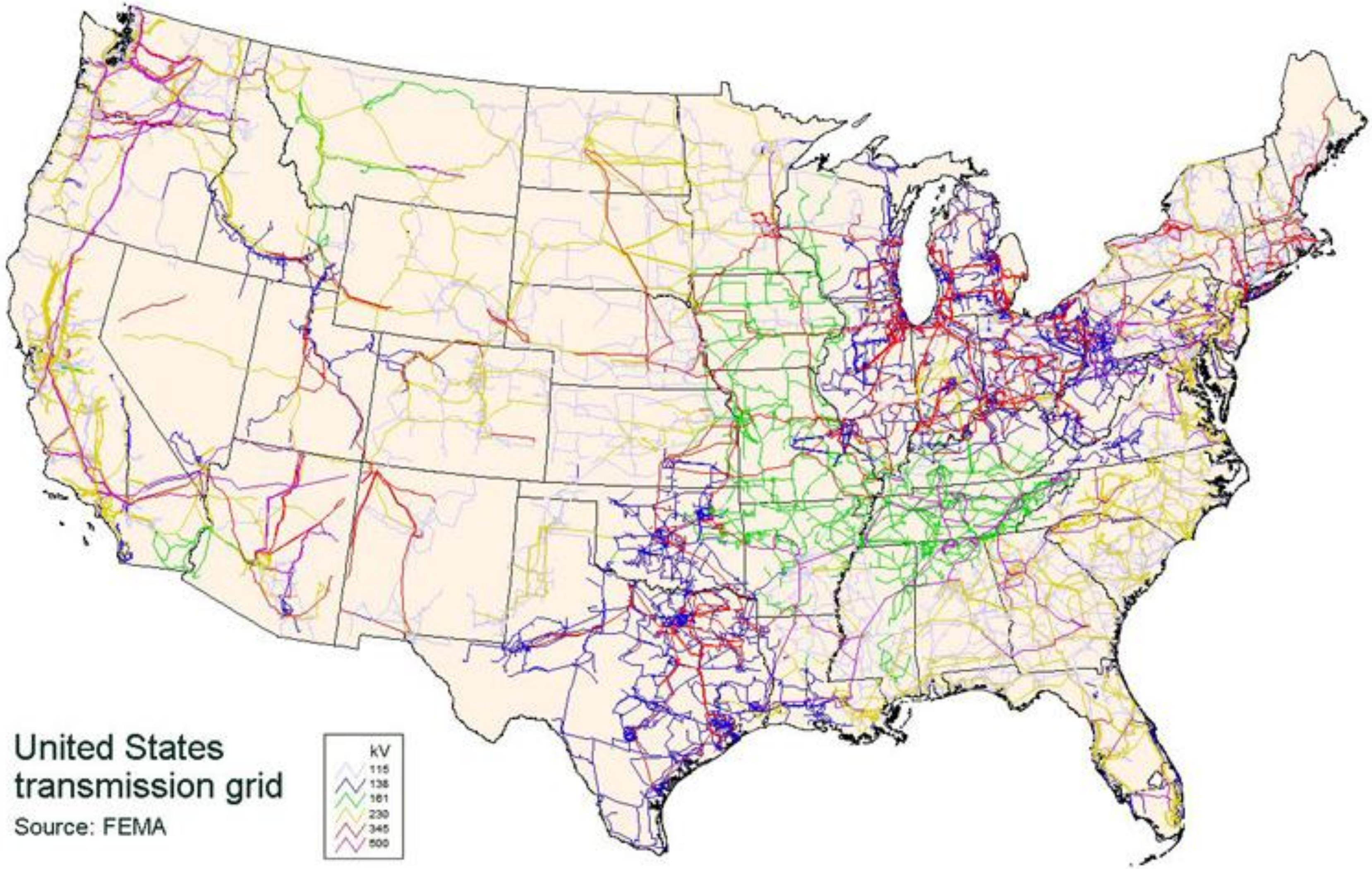


Thus the need for transmission



Credit: Ron Santini, Department of Geography, College of Earth and Mineral Sciences, The Pennsylvania State University.

Thus the need for transmission



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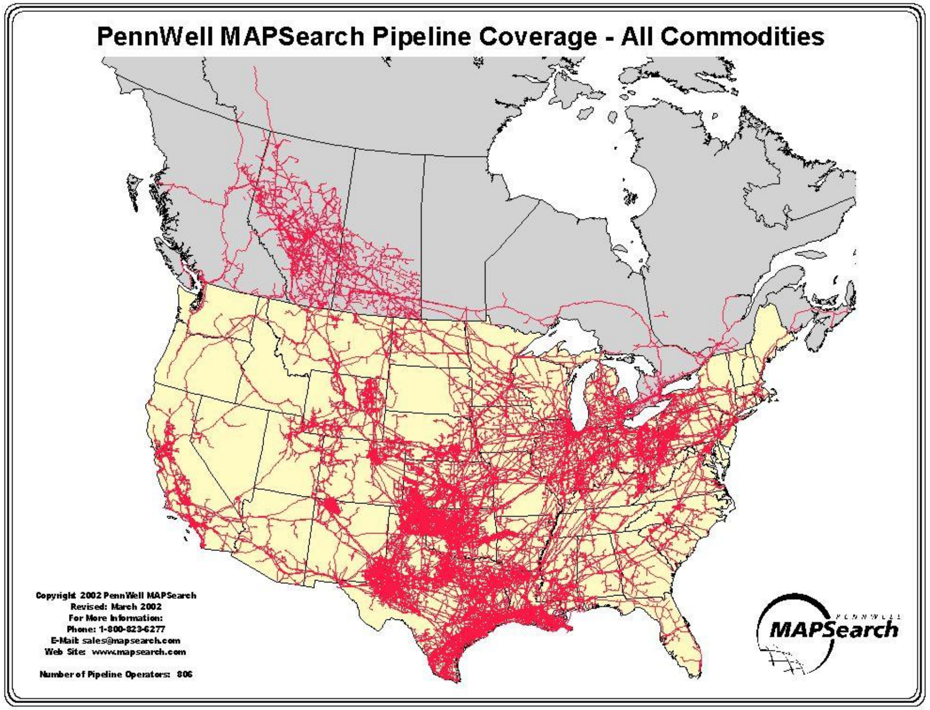
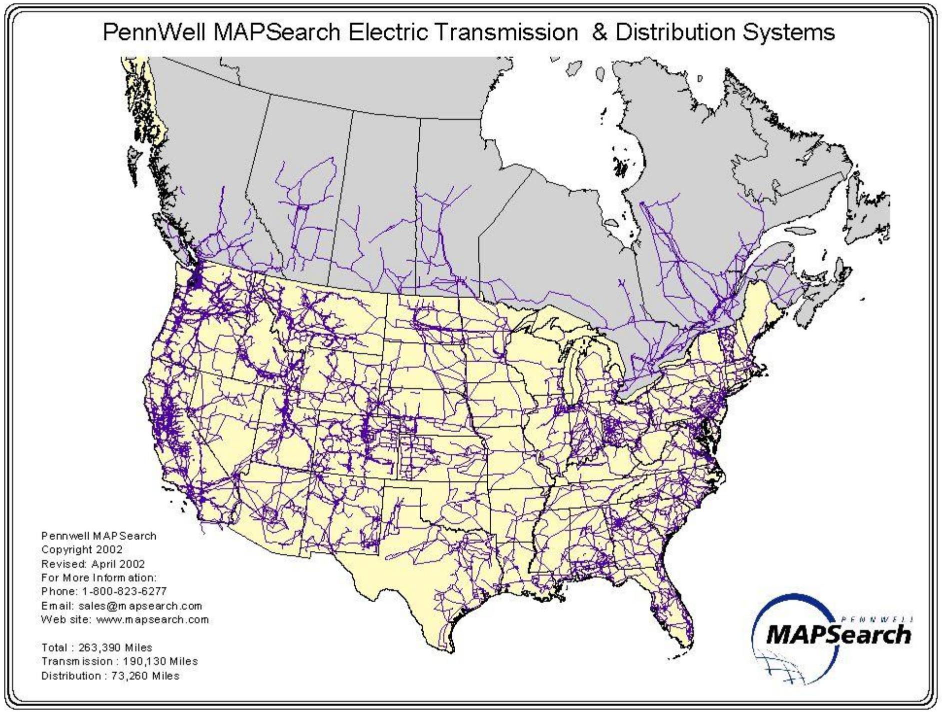
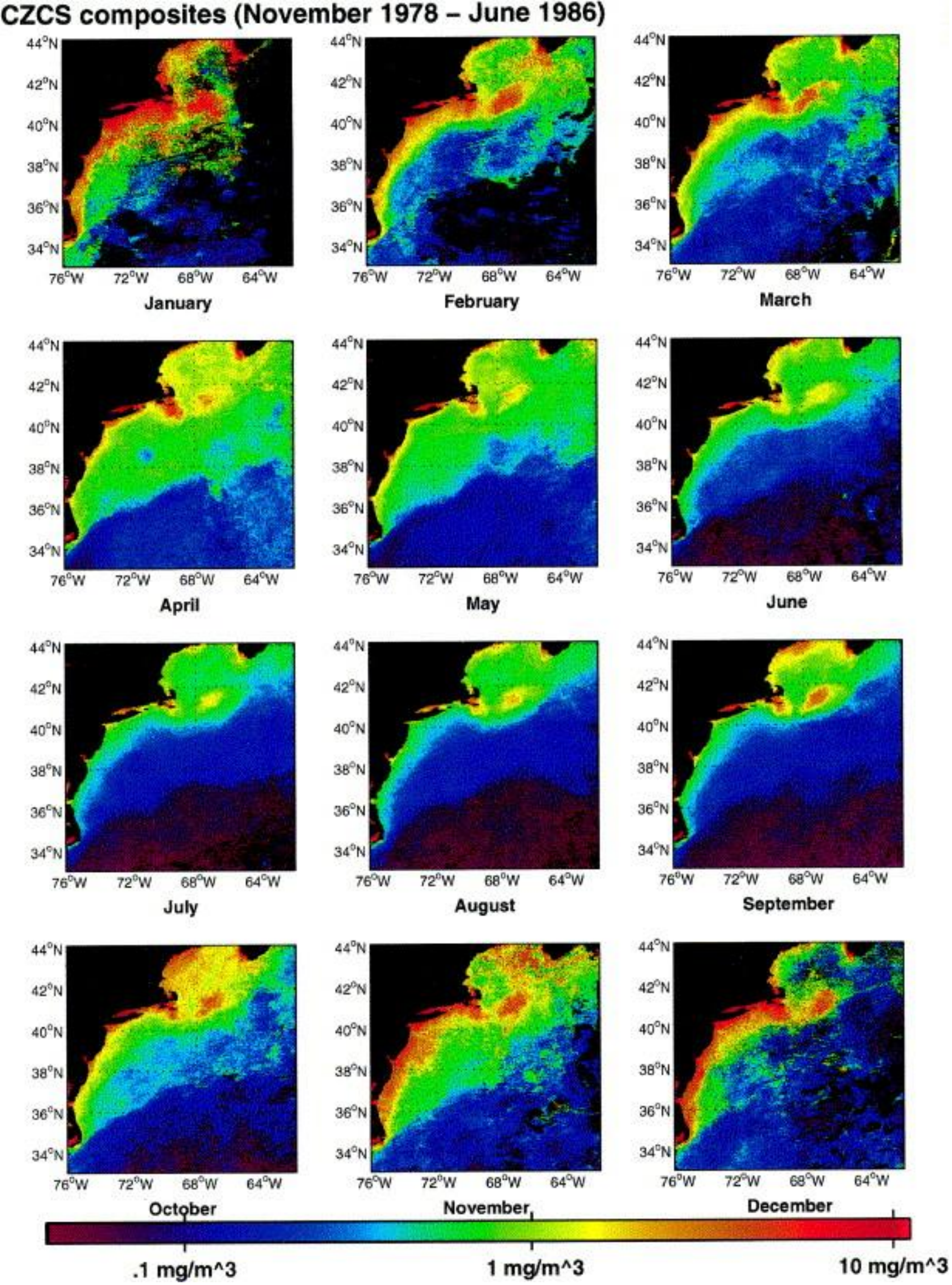




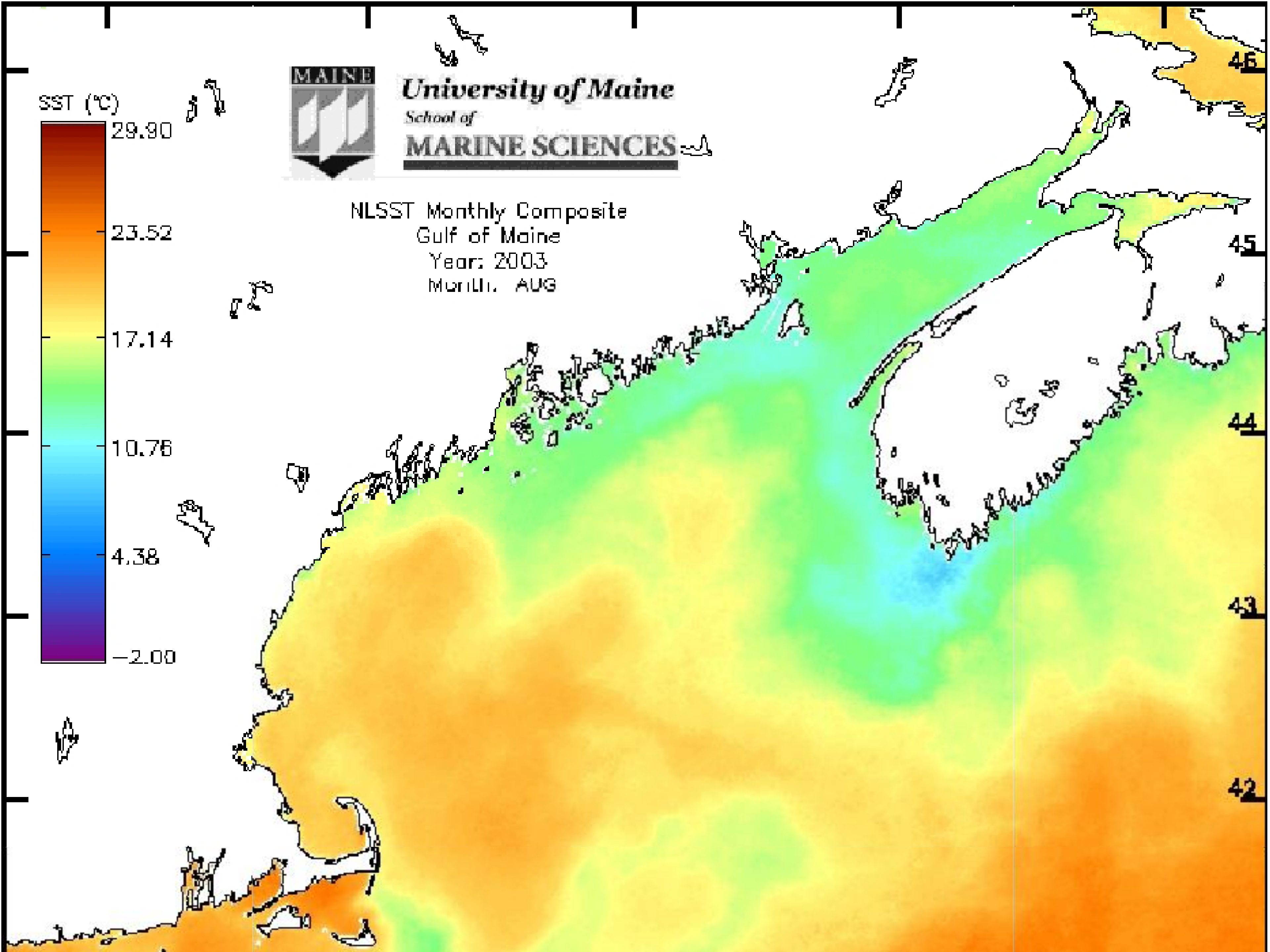
Credit: The PennWell Organization



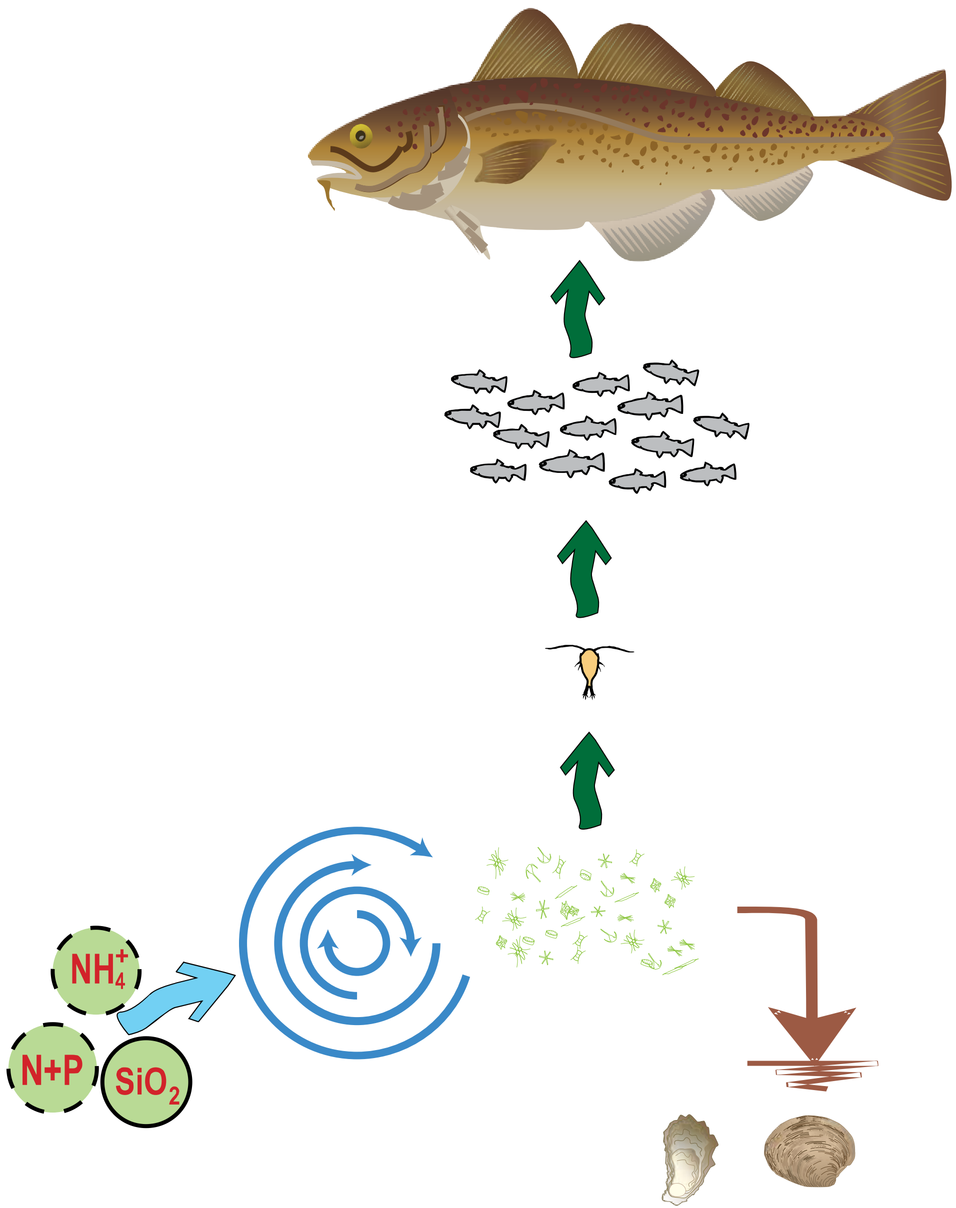
Ecosystems have heterogeneity in energy production

- Chlorophyll biomass
- Highest in winter, associated with shelf-break
- Coastal hotspots in summer

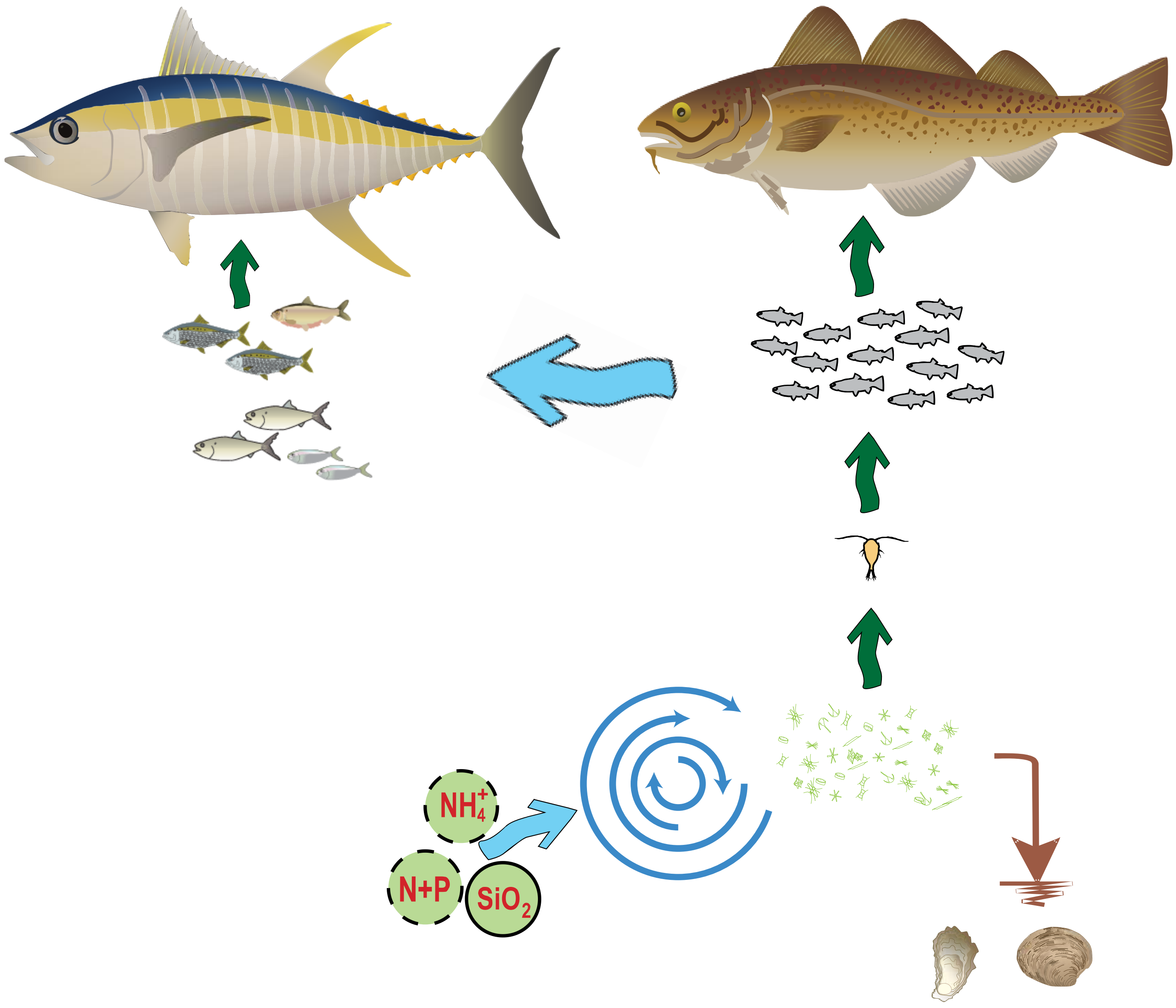
Yoder et al. 2001. Cont. Shelf Res. 21: 1191-1218


SST (°C)
29.90
23.52
17.14
10.76
4.38
−2.00
University of Maine
School of
MARINE SCIENCES
NLSST Monthly Composite
Gulf of Maine
Year: 2003
Month: AUG
46
45
44
43
42

Idealized food web



Idealized food web, with transmission



Transmission (for this presentation)

Atlantic sturgeon
(*Acipenser oxyrinchus oxyrinchus*)

American eel (*Anguilla rostrata*)

Credit: http://www.boatingonthehudson.com/

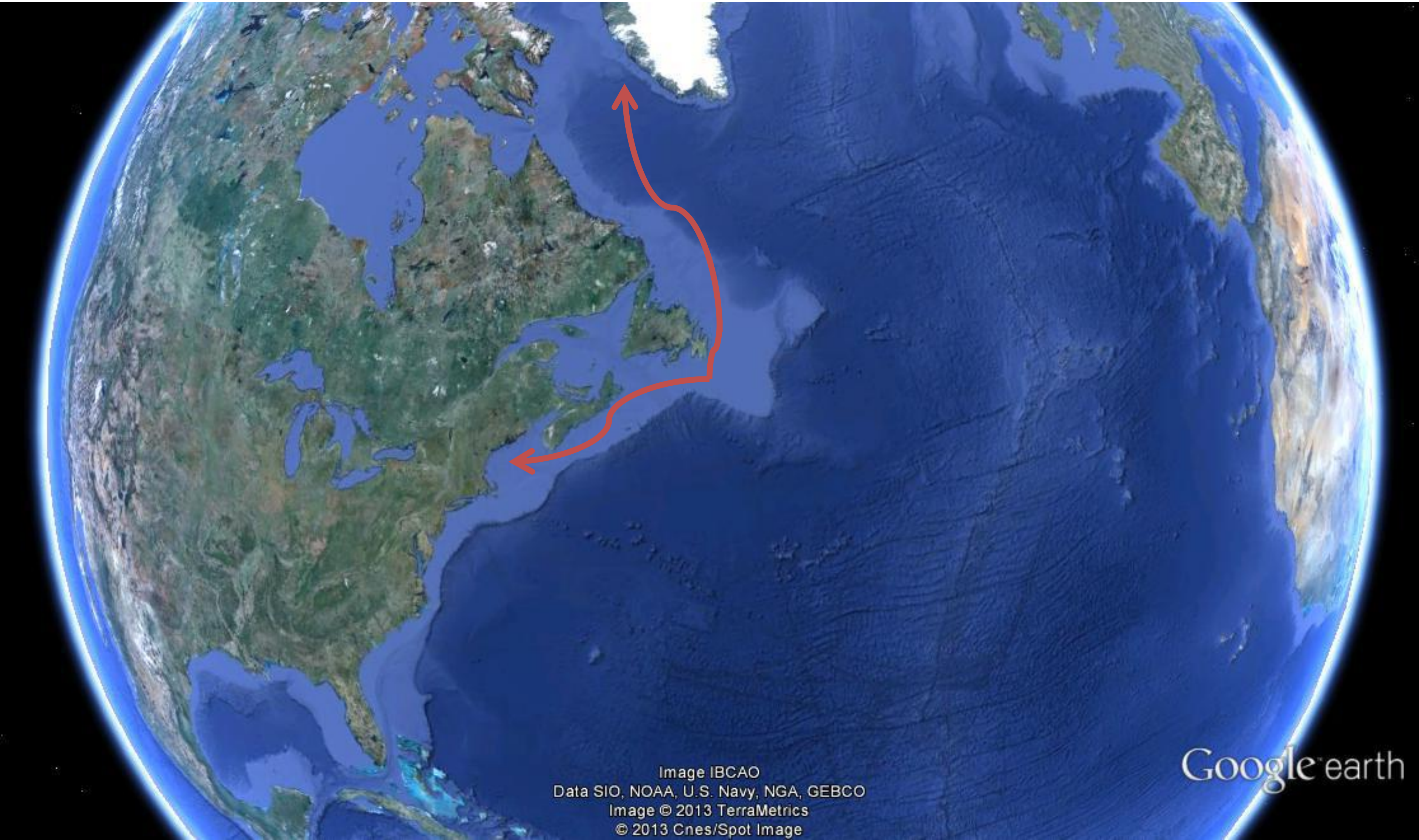
Atlantic salmon (*Salmo salar*)

Credit: http://www.travel2canada.com

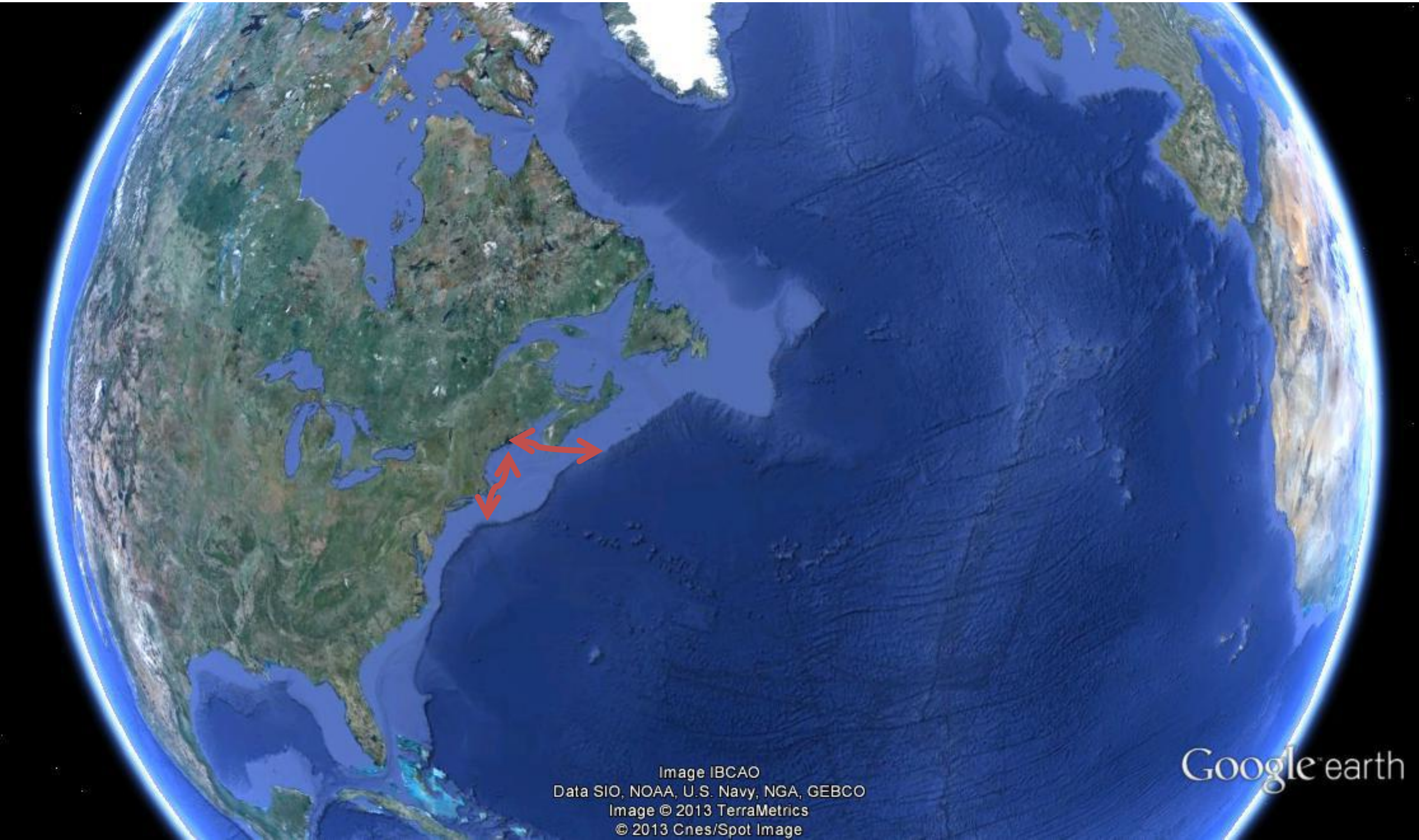
River herring: Alewife (*Alosa pseudoharengus)*
and blueback herring (*Alosa aestivalis*)

Credit: Tim Watts

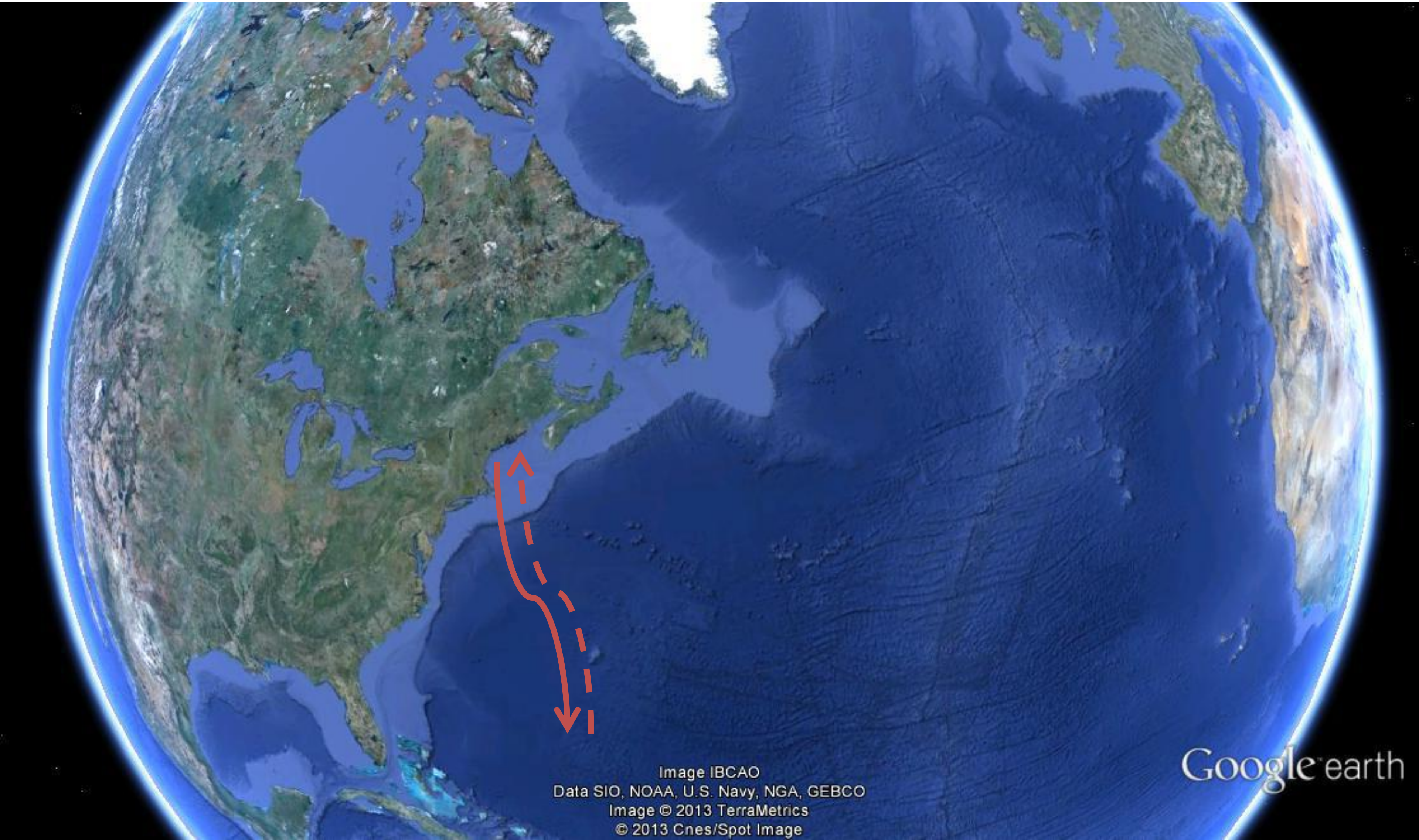
Atlantic salmon migration



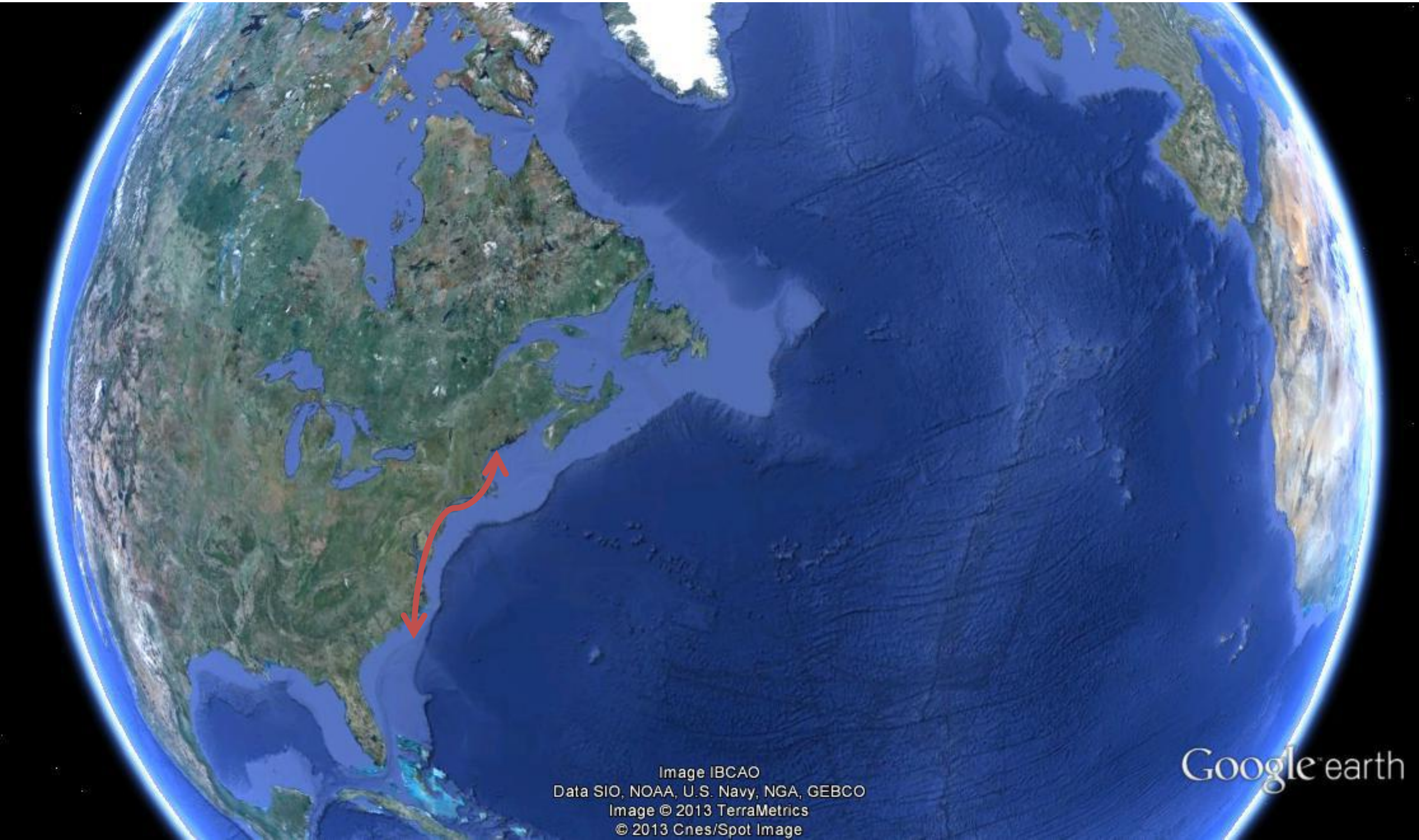
River herring migration



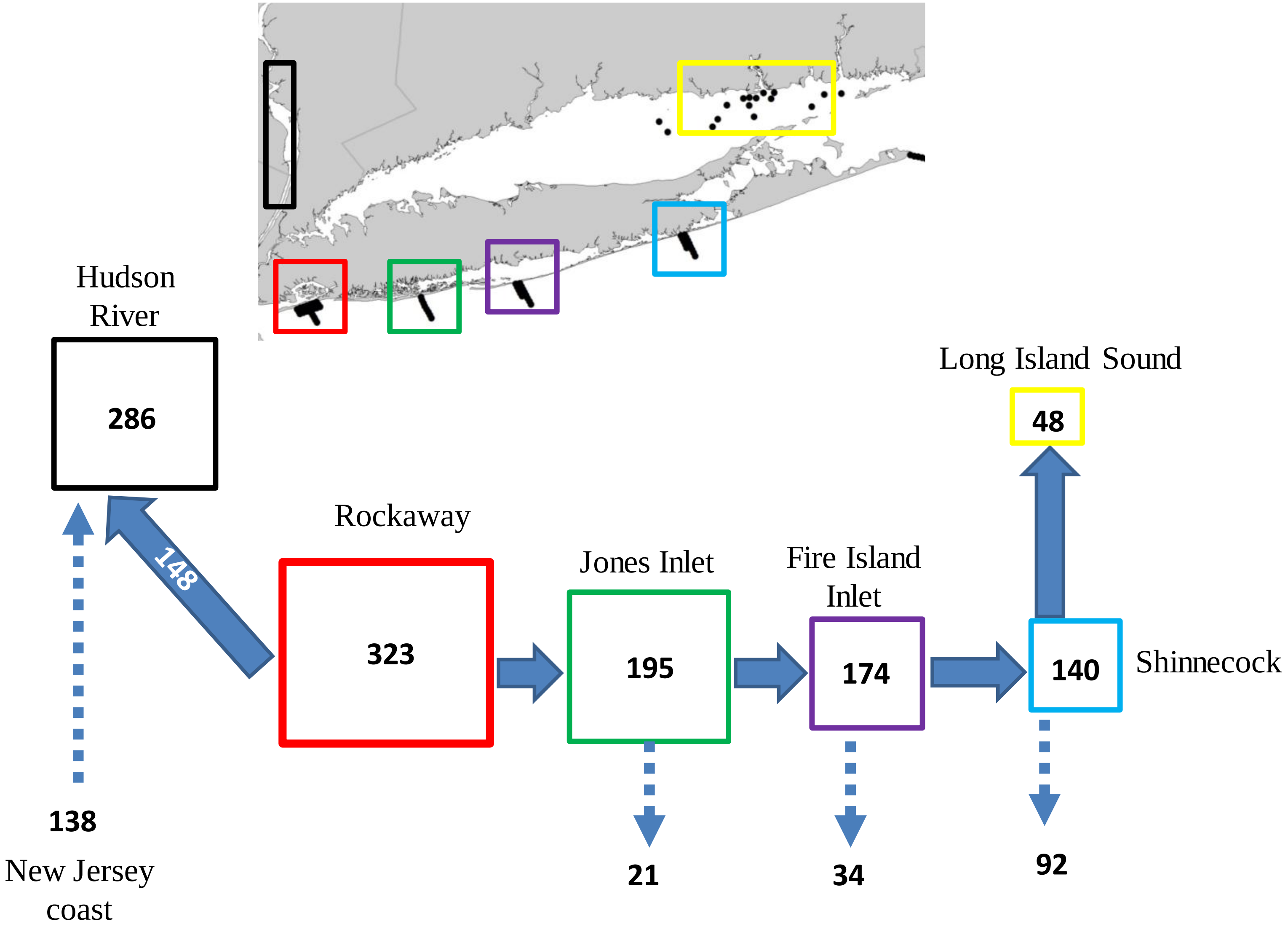
American eel migration



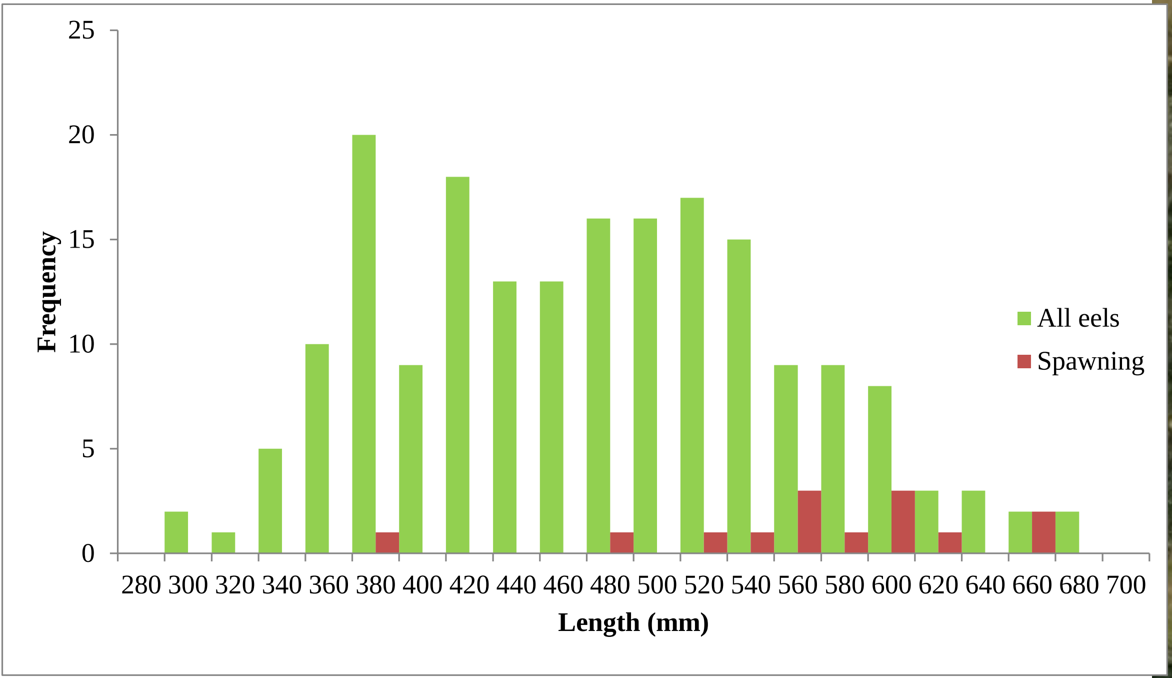
Atlantic sturgeon migration



Atlantic sturgeon migration



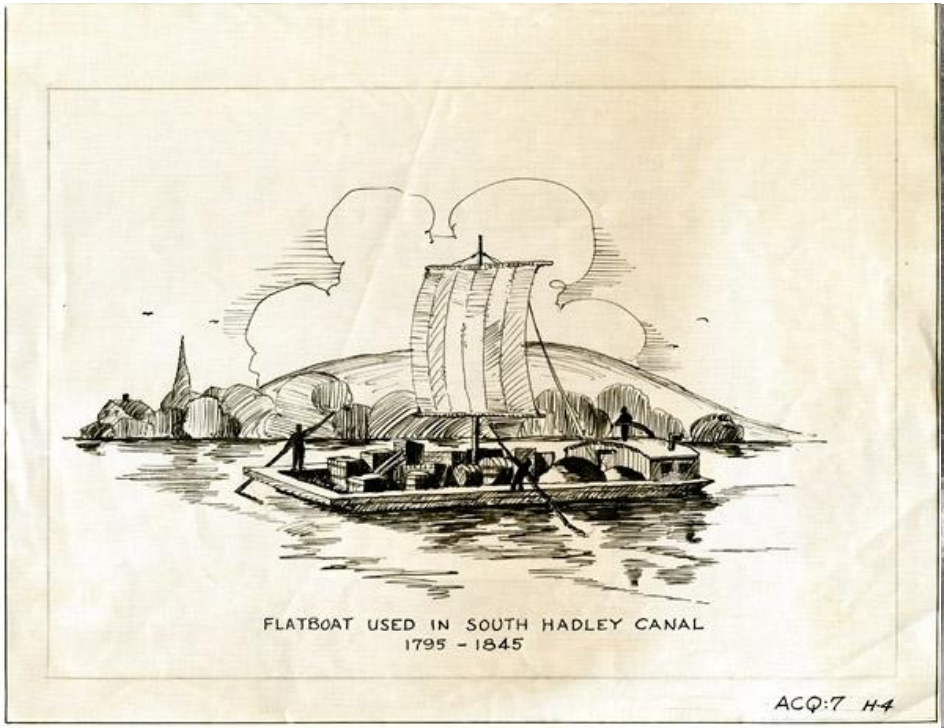
American eel migration from the Carman's River

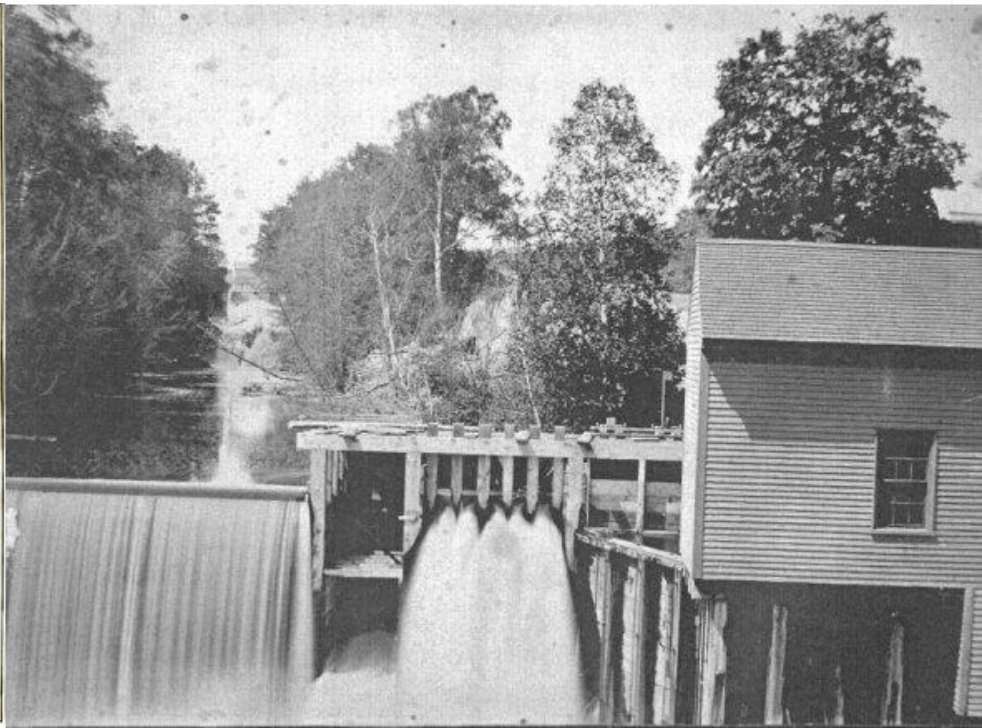


The industrial revolution

- Rivers were seen as sources of power and navigation

- Damming was required for both





Legacy of waterway obstruction

Dam Construction 1600 - 1900

Mill Dams

1600s - 1800s

Whitten, M.M. *The Gunpowder Mills of Maine*

Logging Dams

Late 1700s - 1900s

Wilson, D.A. *Logging and Lumbering in Maine*

Hydroelectric Dams

Late 1800s - present

9 watersheds in Maine, cataloged dams

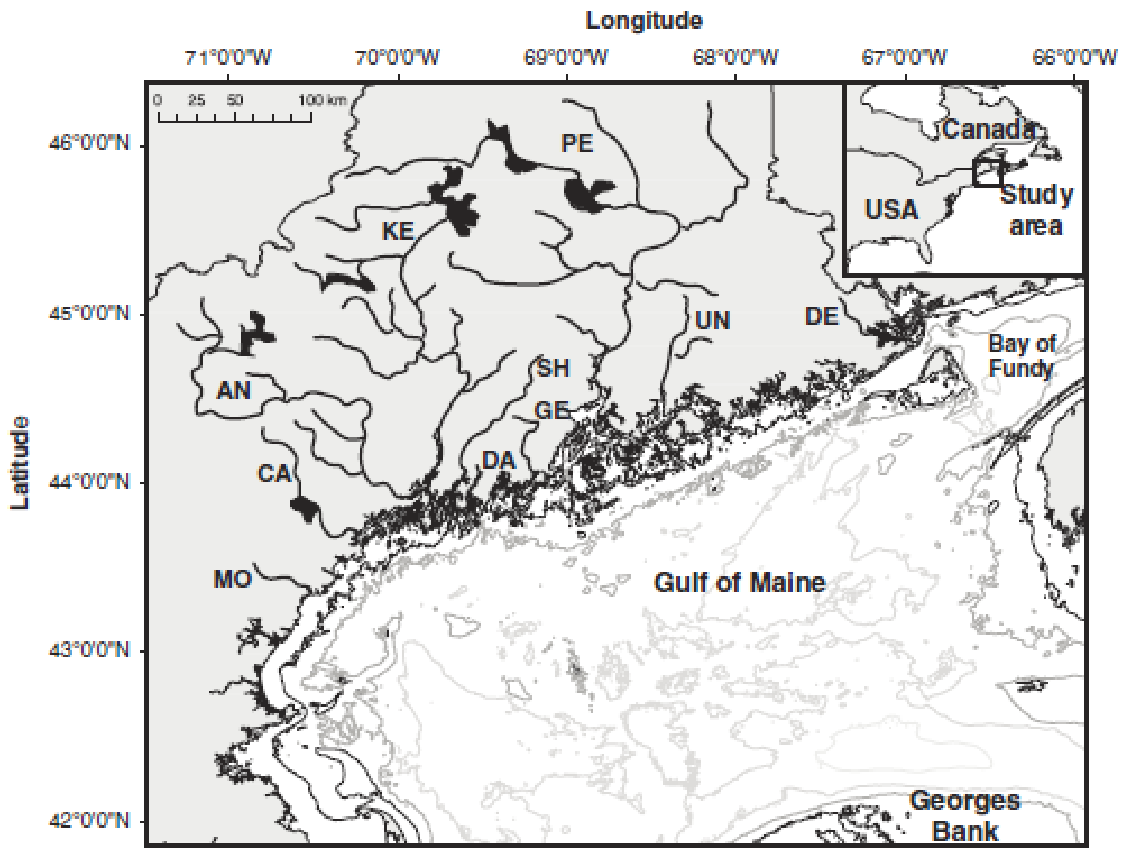
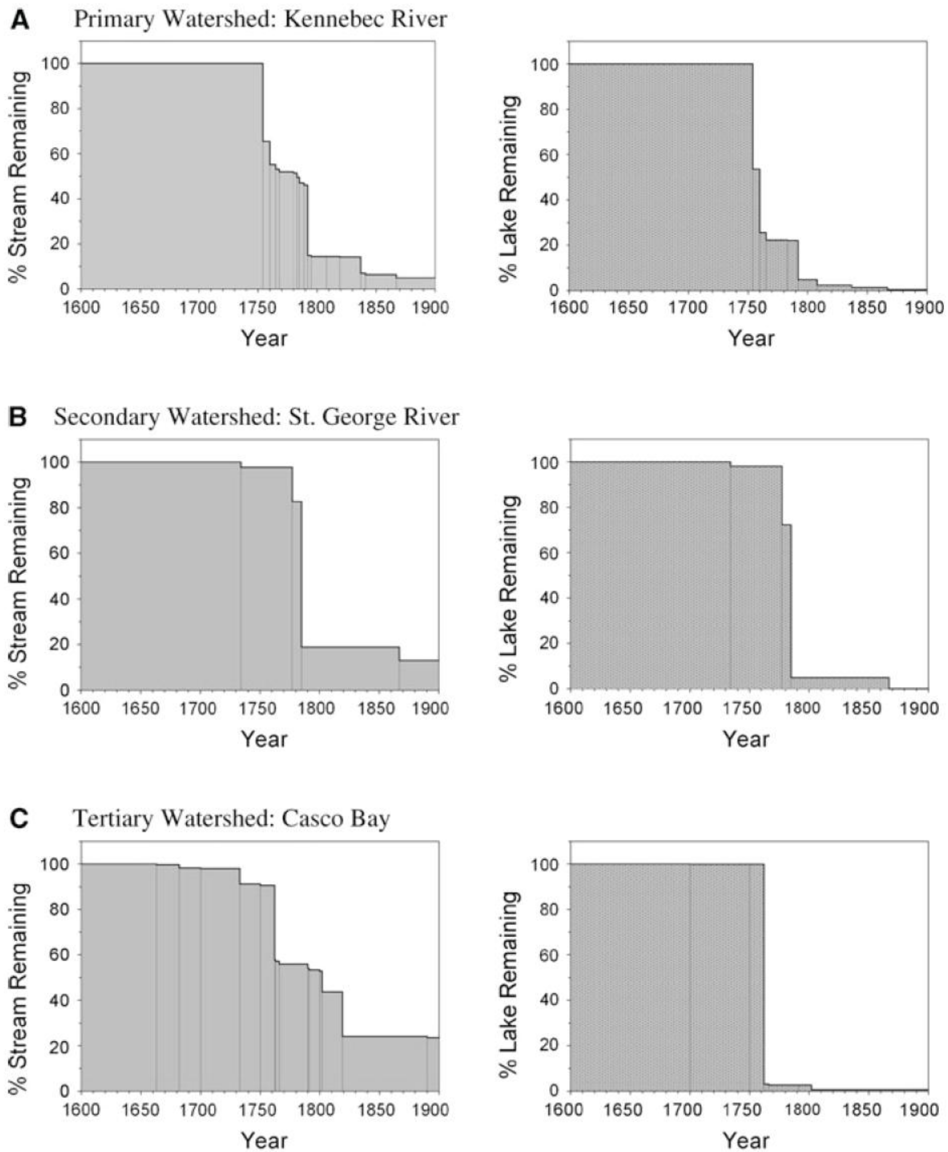


Figure 1. State and Gulf of Maine with historical river herring watersheds assessed for lost habitat due to damming: the Mousam River (MO), the Presumpscot River and Casco Bay (CA), the Androscoggin River (AN), the Kennebec River (KE), the Sheepscot River (SH), the Damariscotta River (DA), the St. George River (GE), the Penobscot River (PE), the Union River (UN), and the Dennys River (DE). Depth contours for the Gulf of Maine at 100, 200, 300, and 400 meters are also shown. The inset map displays the study location. Abbreviation: km, kilometers.

Timeline of obstruction and habitat loss

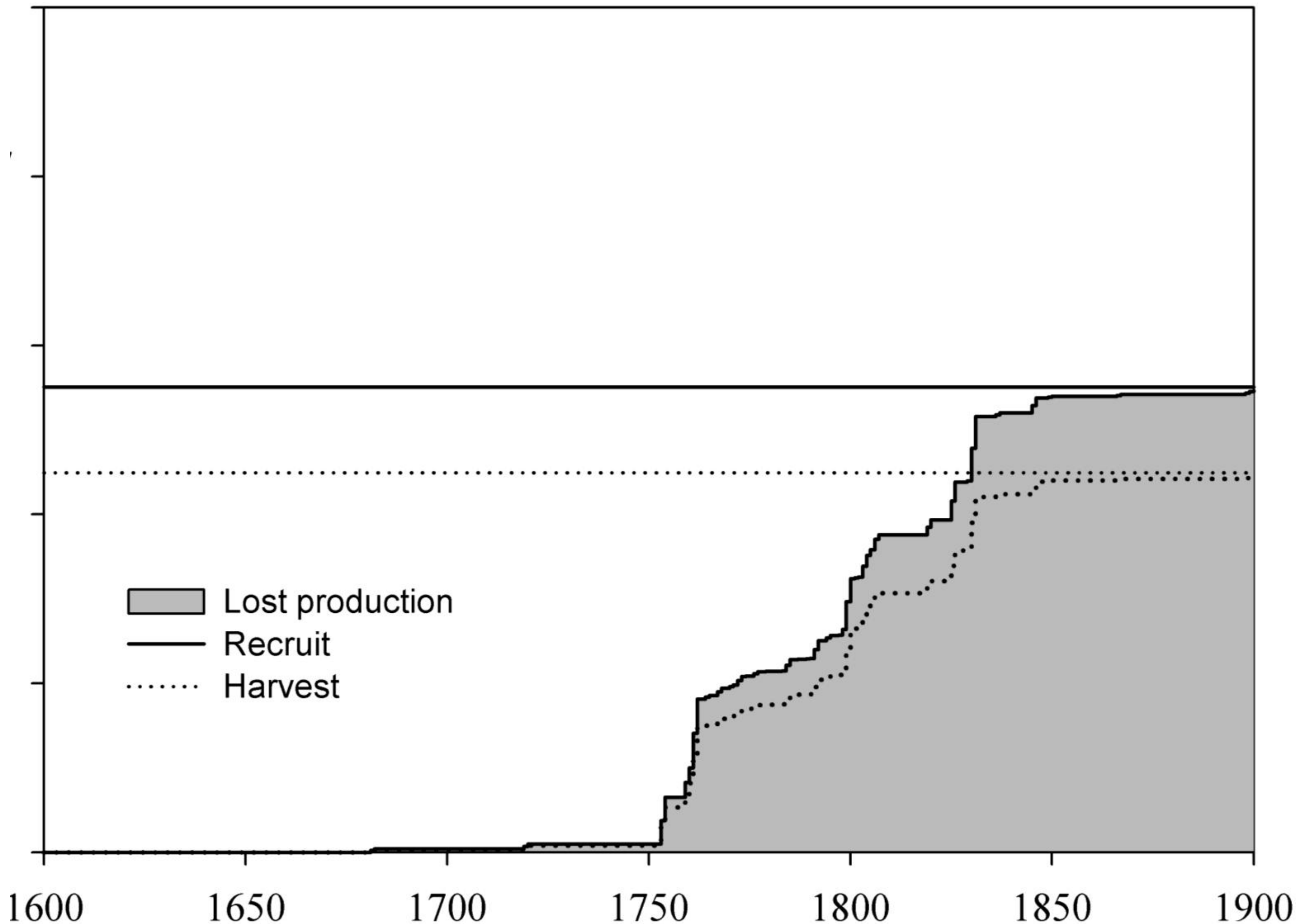


Declines start in 1700s, accelerate from 1750 to 1800

<u>By 1850:</u>
< 5% virgin lake area remaining in all watersheds

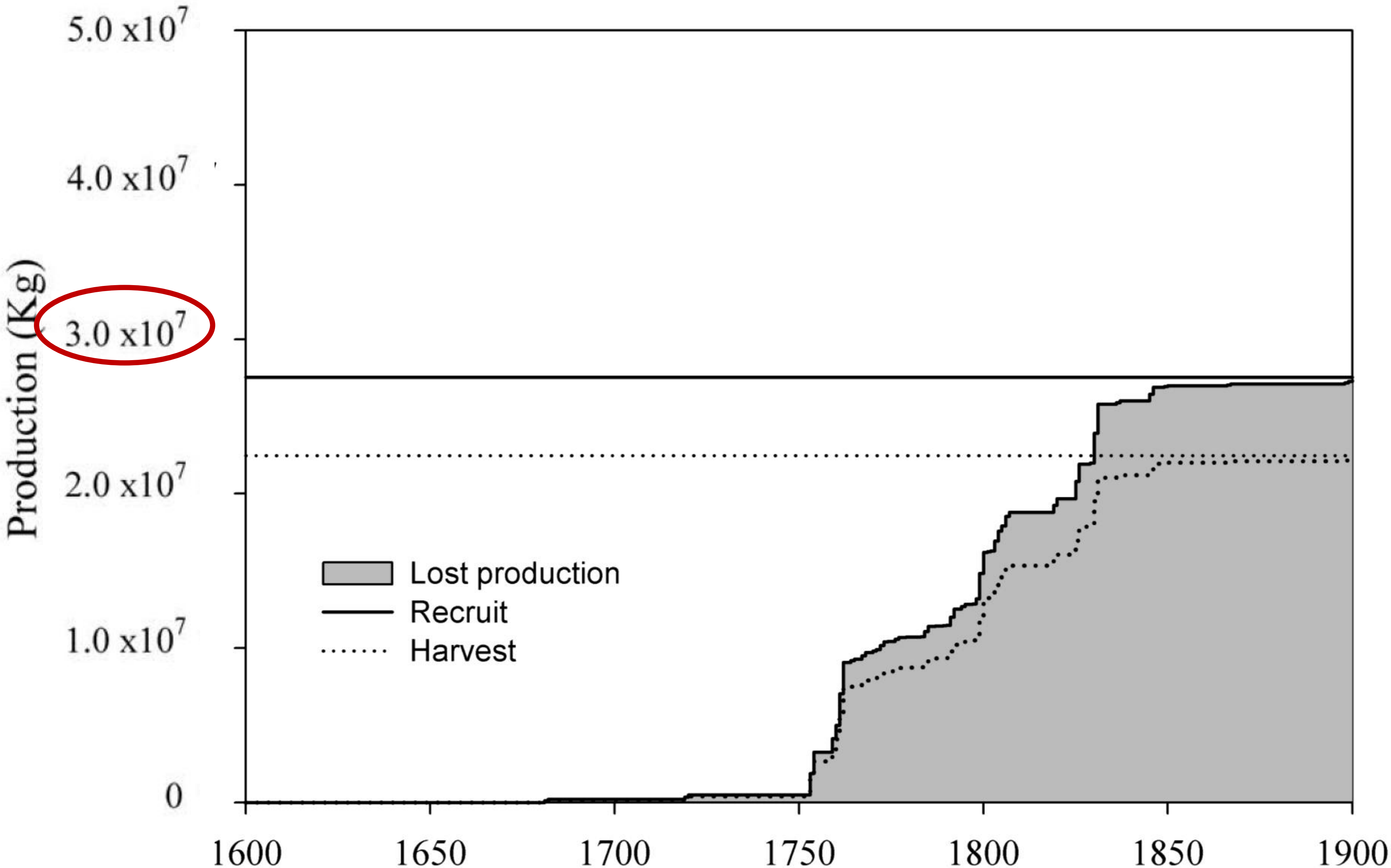
Hall et al. 2010. Landscape Ecology 26:95-107

Lost production



Hall et al. 2012. Bioscience.62: 723–731

Lost production



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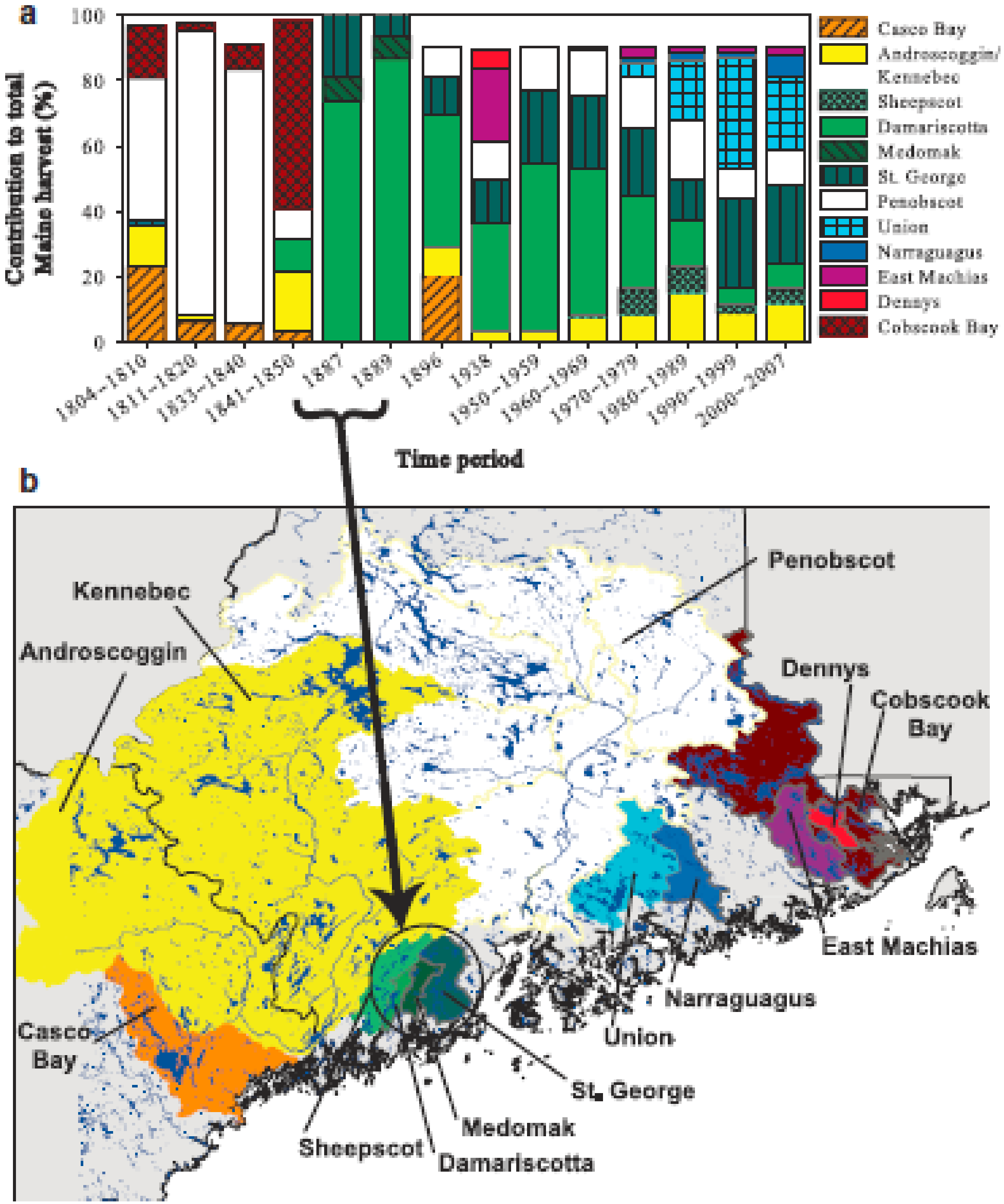
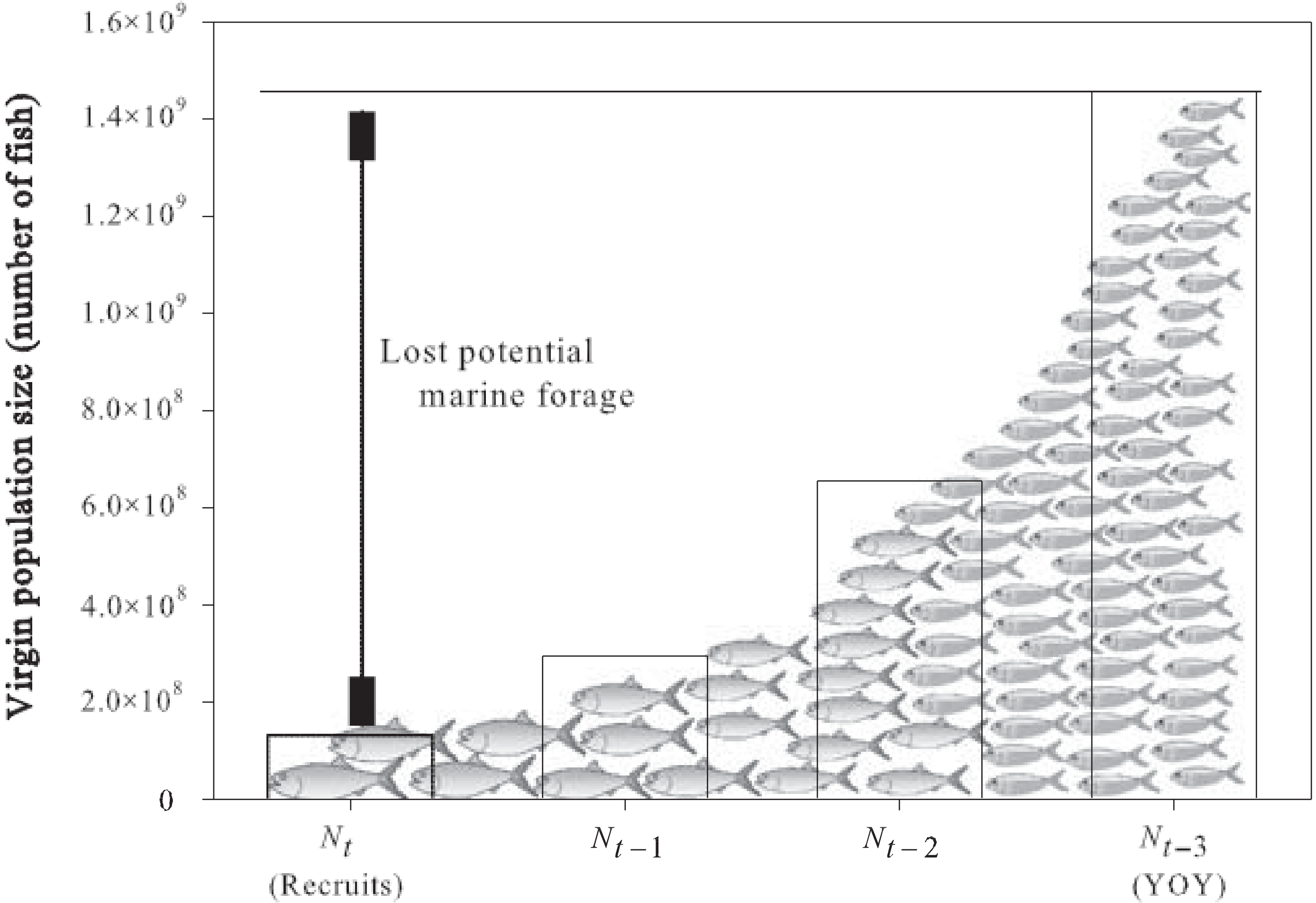


Fisheries lose contribution from larger watersheds

Coastal ponds become main location of harvest

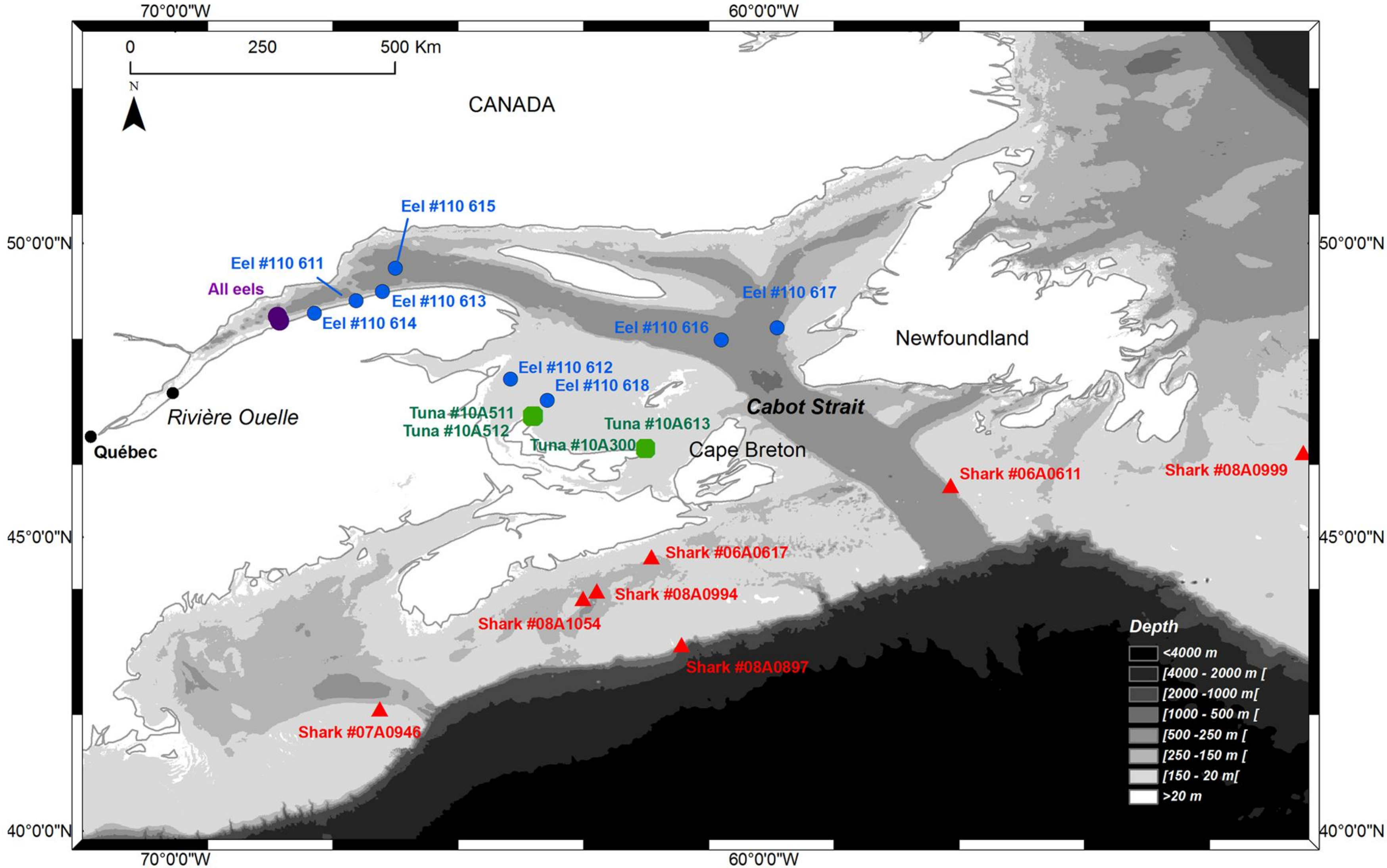
Hall et al. 2012. Bioscience.62: 723–731

Lost forage



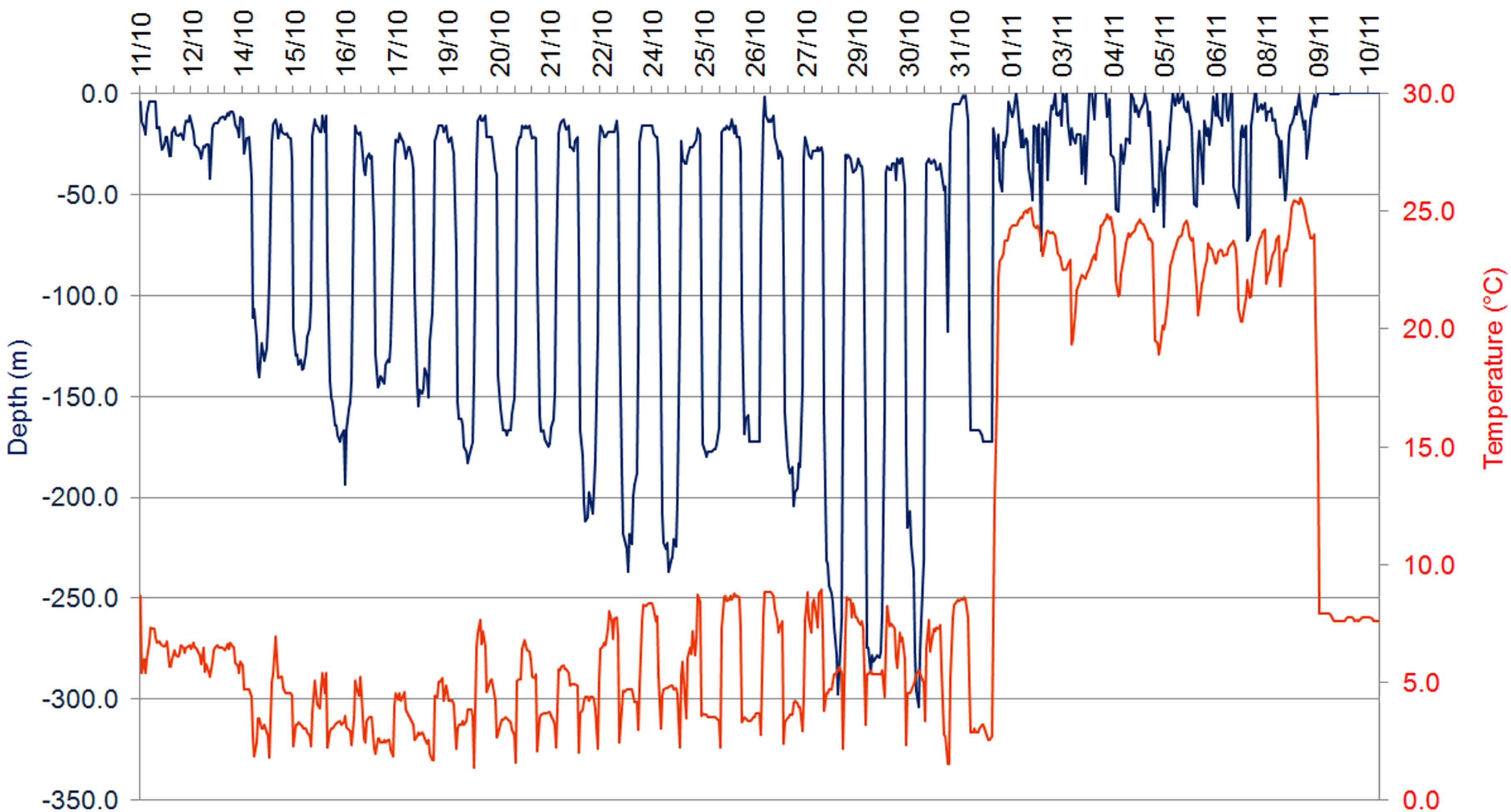
Hall et al. 2012. Bioscience.62: 723–731

Connection to predators



Béguer-Pon et al. 2012. PLoS ONE 7(10): e46830.

Connection to predators



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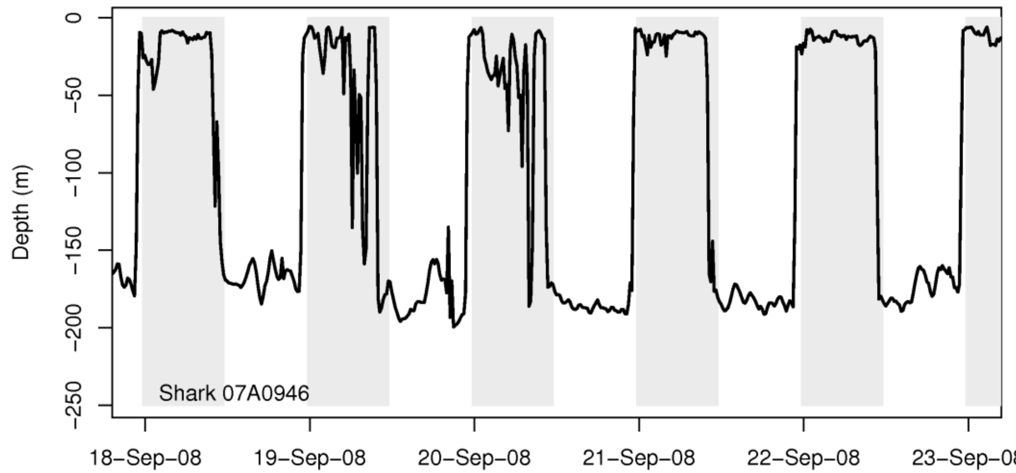
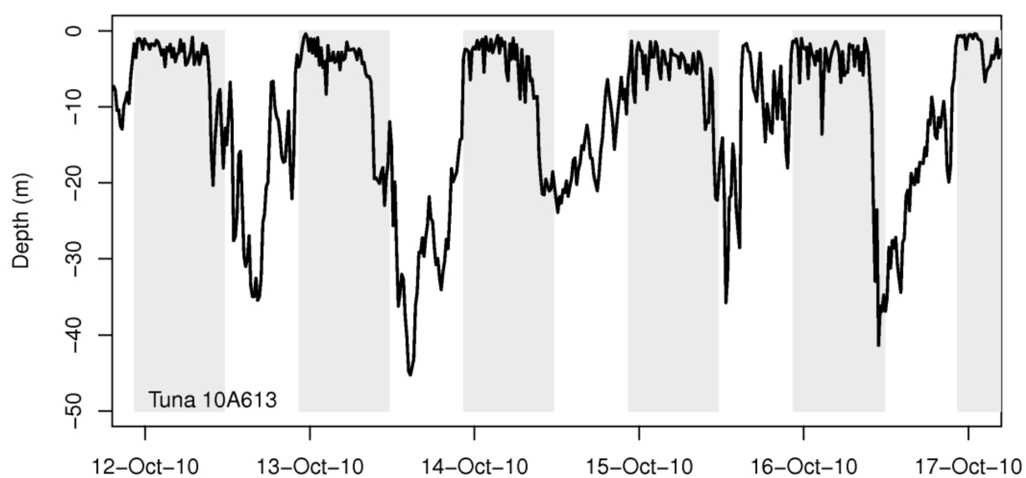
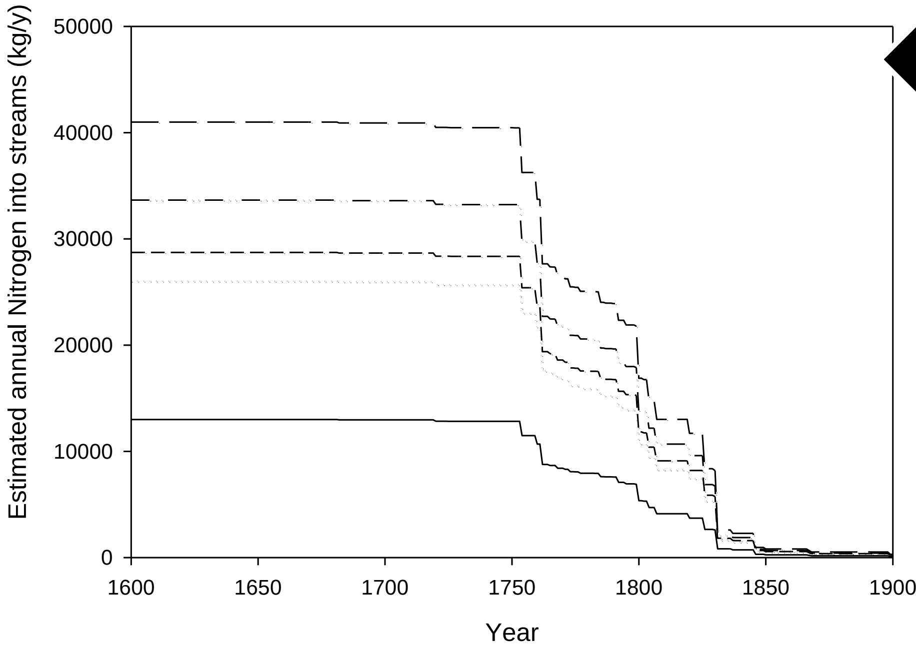
Connection to predators





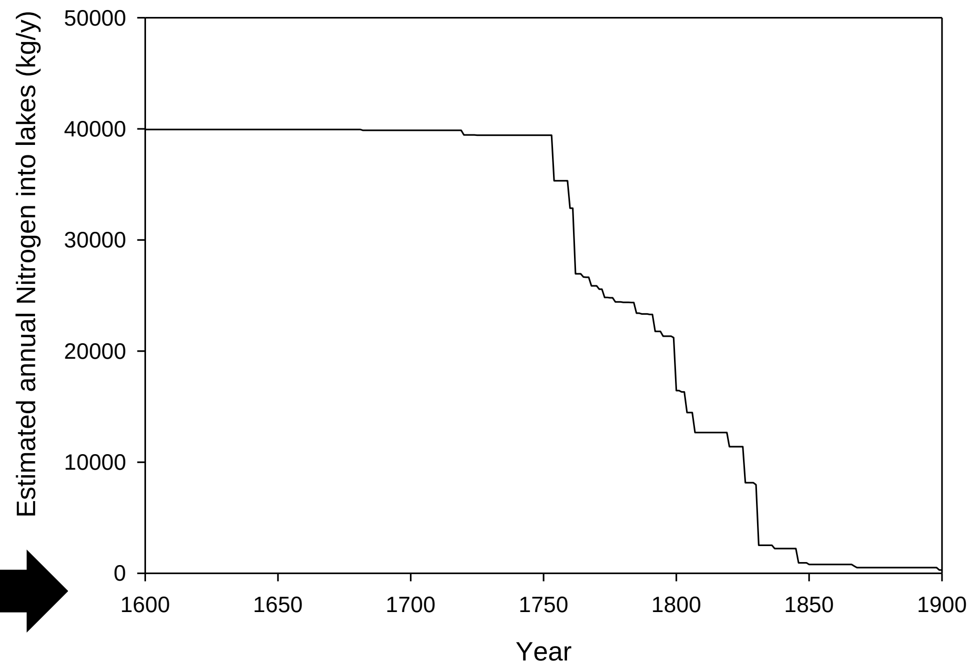
Béguer-Pon et al. 2012. PLoS ONE 7(10): e46830.

Lost marine derived nutrients



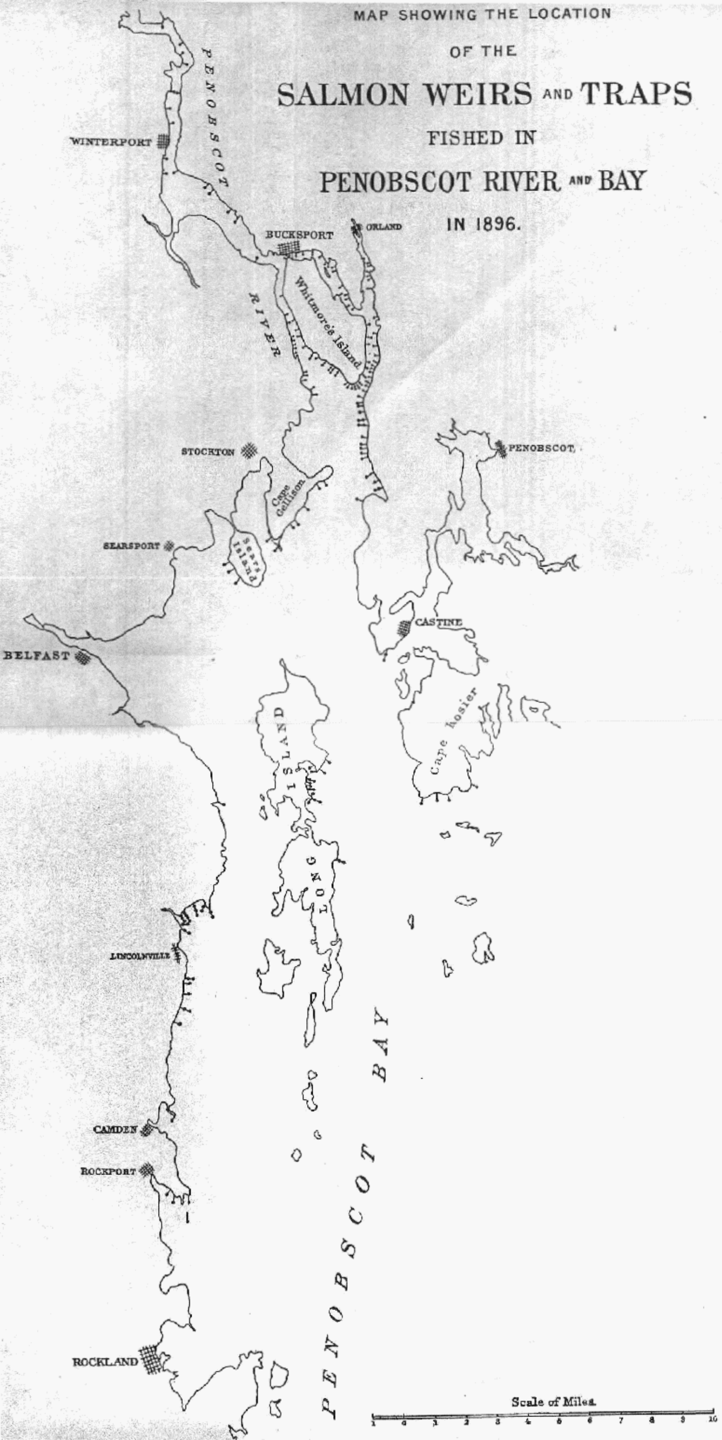
Streams data used:
(1)Estimates of nitrogen input from Walters et al. 2009, calculated per fish.
(2)Historic numbers of fish produced for each watershed estimated by Hall et al. 2012
(3)Assumed exponential decaying migration distances, most migrate short distance, some migrate full distance

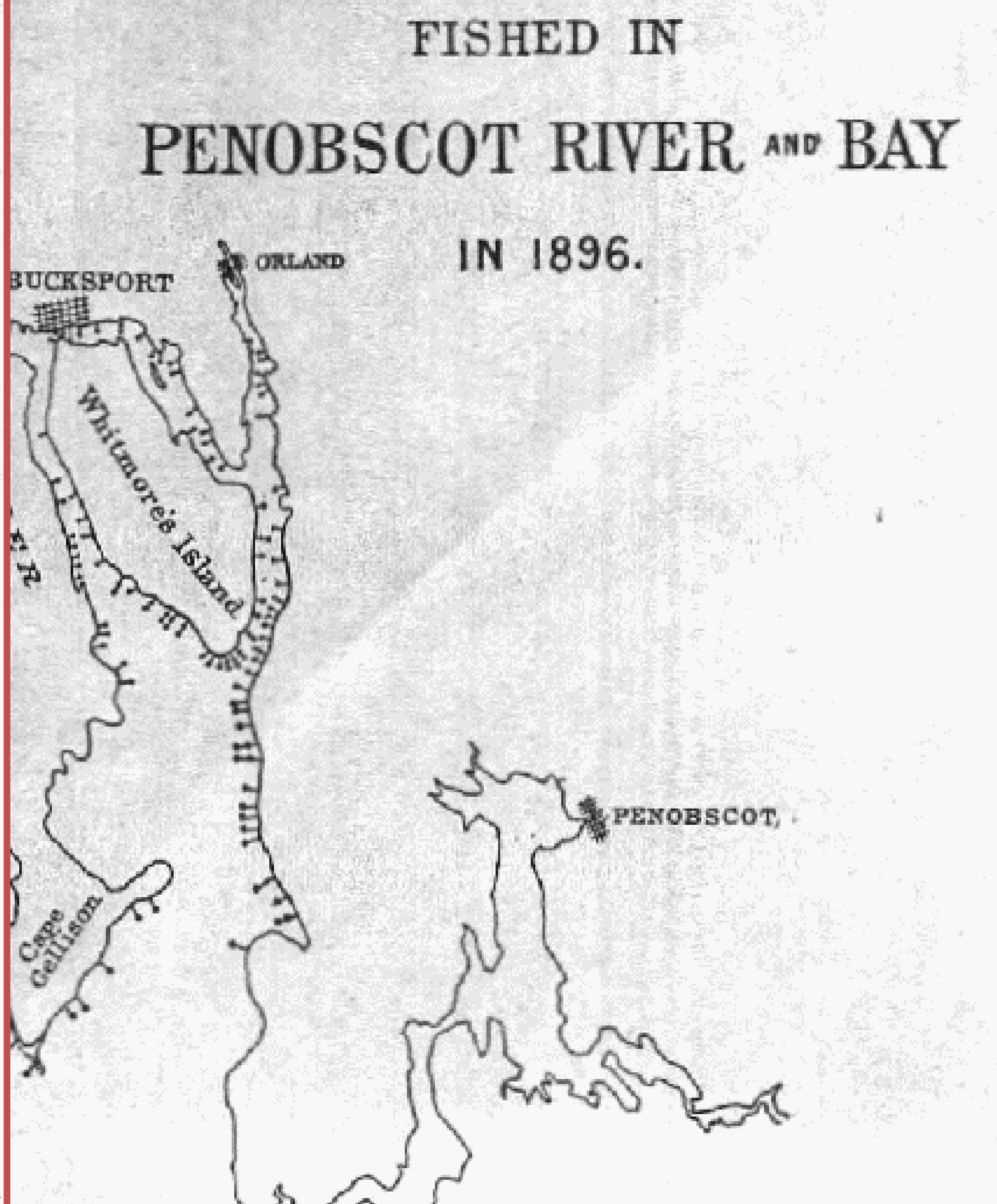
Lake data used:
(1) Estimates of nitrogen input from Durbin et al. 1979, calculated per area.
(2) Historic accessible spawning area produced for each watershed estimated by Hall et al. 2012



Overharvest

From: Kahnle et al. 2007 Am. Fish. Soc. Symposium 56: 347-363; Image: Ed Friedman (FOMB)


MAP SHOWING THE LOCATION
OF THE
SALMON WEIRS AND TRAPS
FISHED IN
PENOBSCOT RIVER AND BAY
IN 1896.
PENOBSCOT
WINTERPORT
BUCKSPORT
ORLAND
RIVER
Whitmore's Island
STOCKTON
PENOBSCOT
Cape Gellison
SEARSPORT
Sears Island
CASTINE
BELFAST
ISLAND
Cape Rosier
LONG
LINCOLNVILLE
CAMDEN
ROCKPORT
ROCKLAND
PENOBSCOT BAY
Scale of Miles.


FISHED IN
PENOBSCOT RIVER AND BAY
IN 1896.
ORLAND
BUCKSPORT
Whitmore's Island
PENOBSCOT
Cape Gellison

Towns.	1895.			1896.		
	No. of salmon.	Weight.	Value.	No. of salmon.	Weight.	Value.
		Pounds.			*Pounds.*	
Brooksville (Cape Rosier)	163	2,092	$283	146	1,626	$190
Bucksport	205	2,885	448	245	2,729	471
Camden	64	964	136	71	990	139
Castine	77	1,150	207	93	1,166	156
Hampden	30	510	102	32	448	90
Islesboro	474	6,551	1,042	643	8,265	1,313
Lincolnville	205	3,240	583	297	3,503	525
Matinicus and Ragged Islands	65	780	109	182	1,627	175
Northport	286	4,066	697	418	5,401	810
Orland	78	1,077	202	152	1,802	306
Orrington	65	1,101	165	82	1,150	161
Penobscot	485	7,270	1,313	959	12,483	1,992
Searsport	458	7,278	1,456	426	5,112	818
South Brewer	63	1,071	161	170	2,380	309
Stockton and Prospect	629	10,067	1,713	829	10,471	1,590
Verona	908	12,555	2,337	1,421	17,761	3,172
Winterport	140	2,354	402	237	3,311	499
Total	4,395	65,011	11,356	6,403	80,175	12,716

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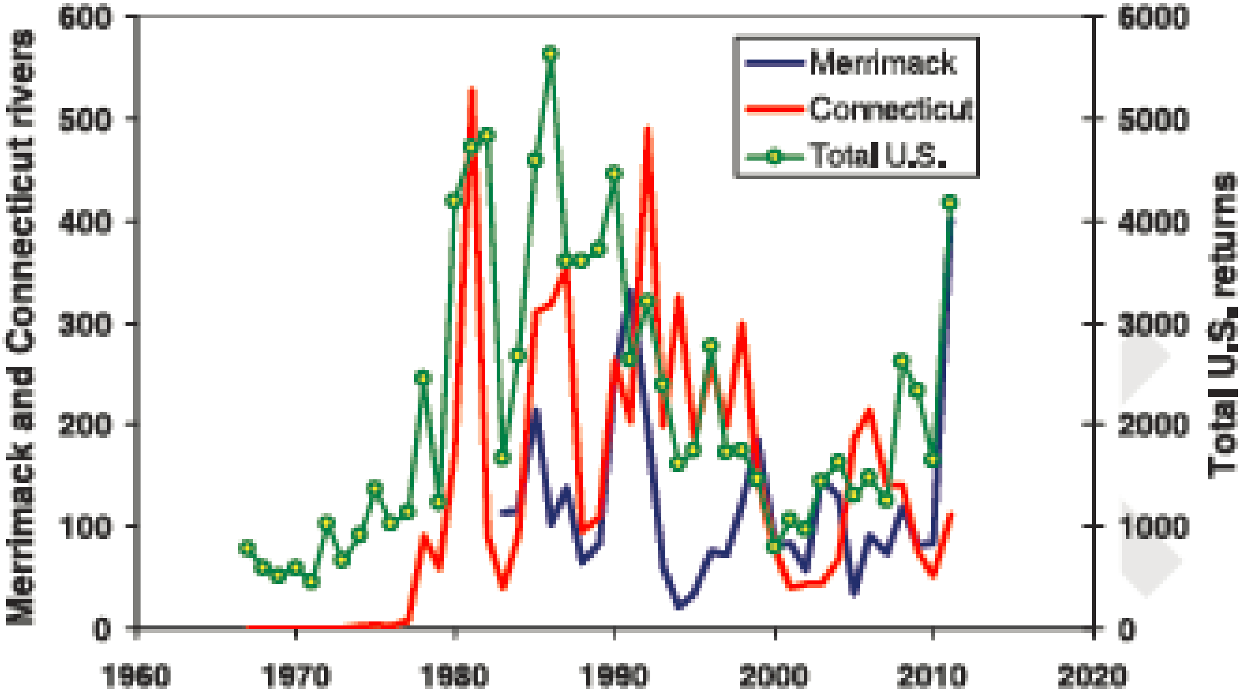
Fishways: half-way technology? Atlantic salmon returns



Brown et al. In Press. Conservation Letters.

Contemporary population declines

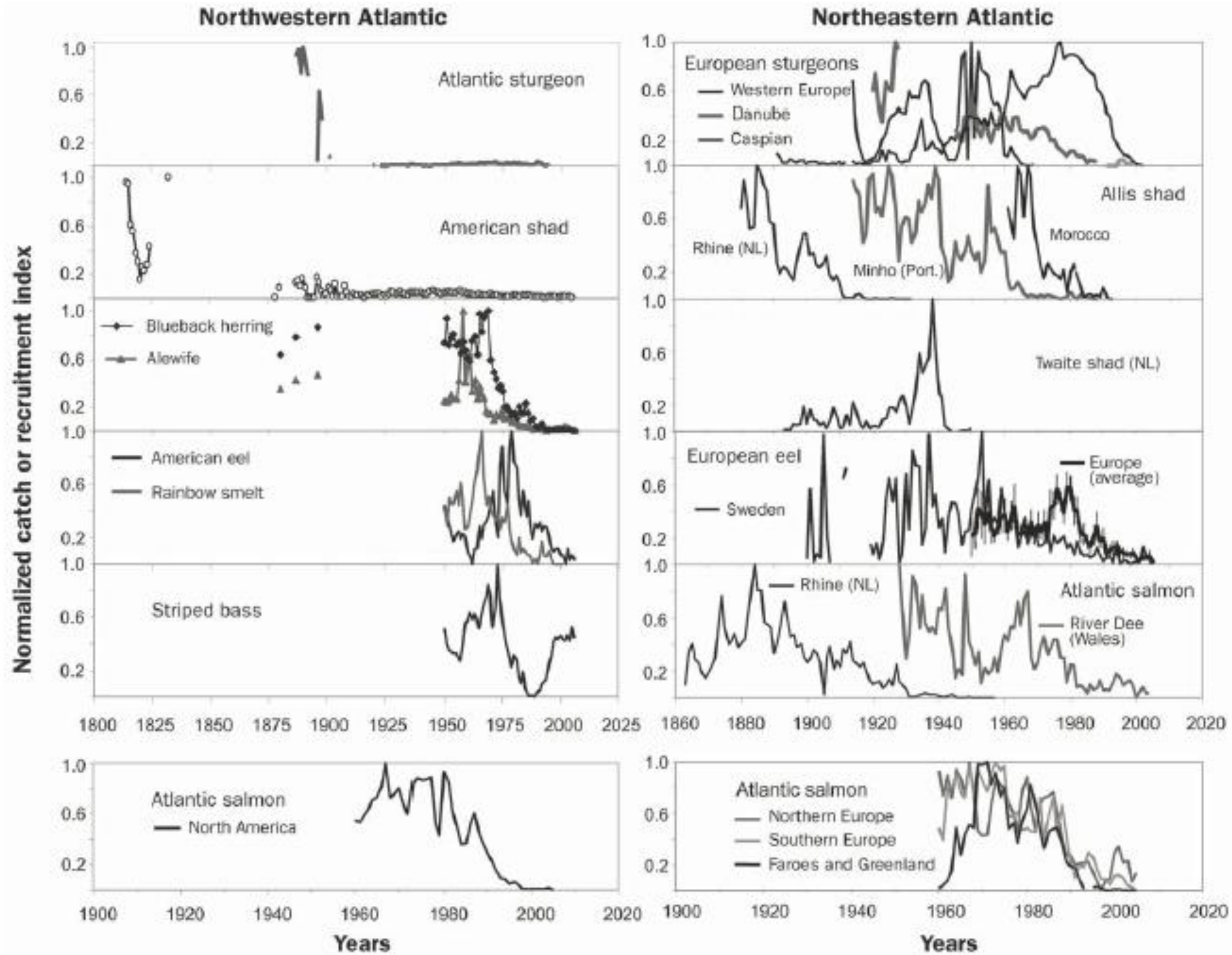
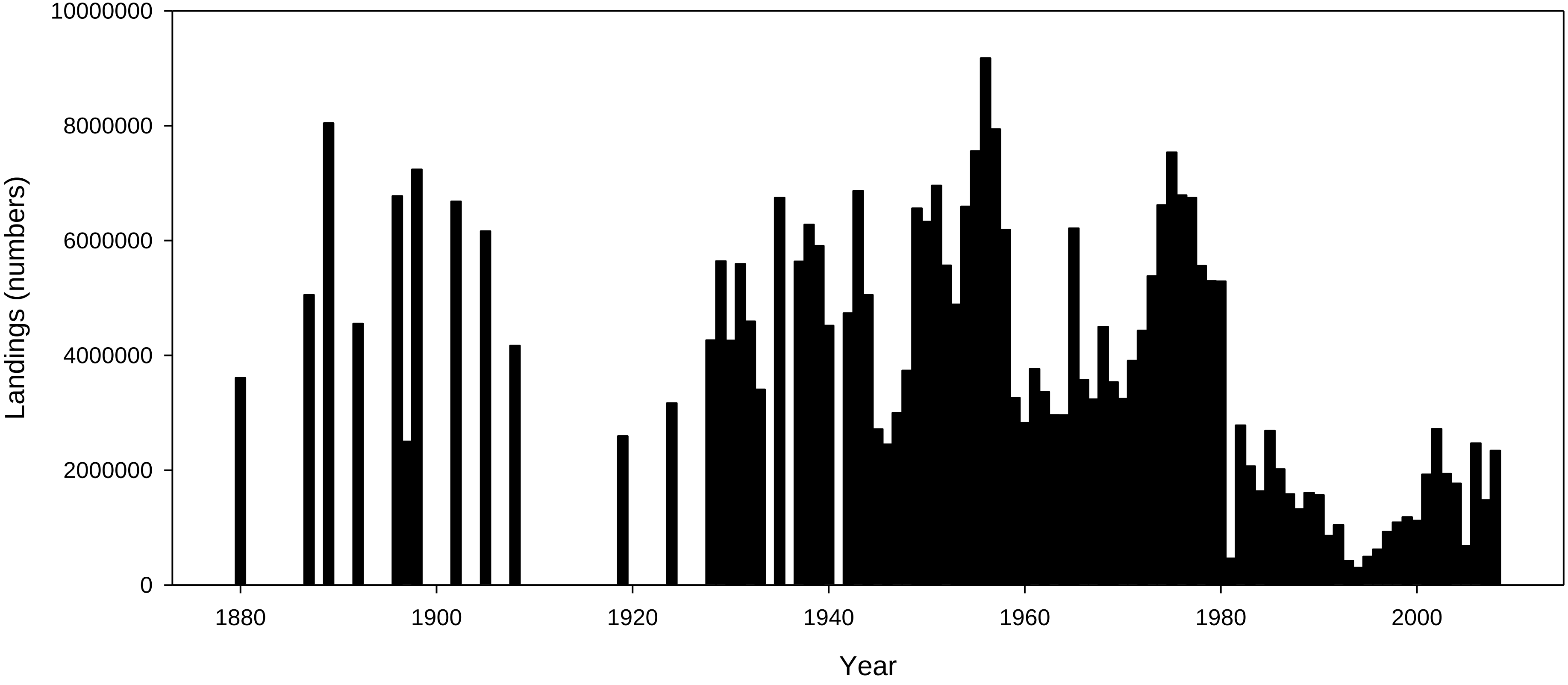
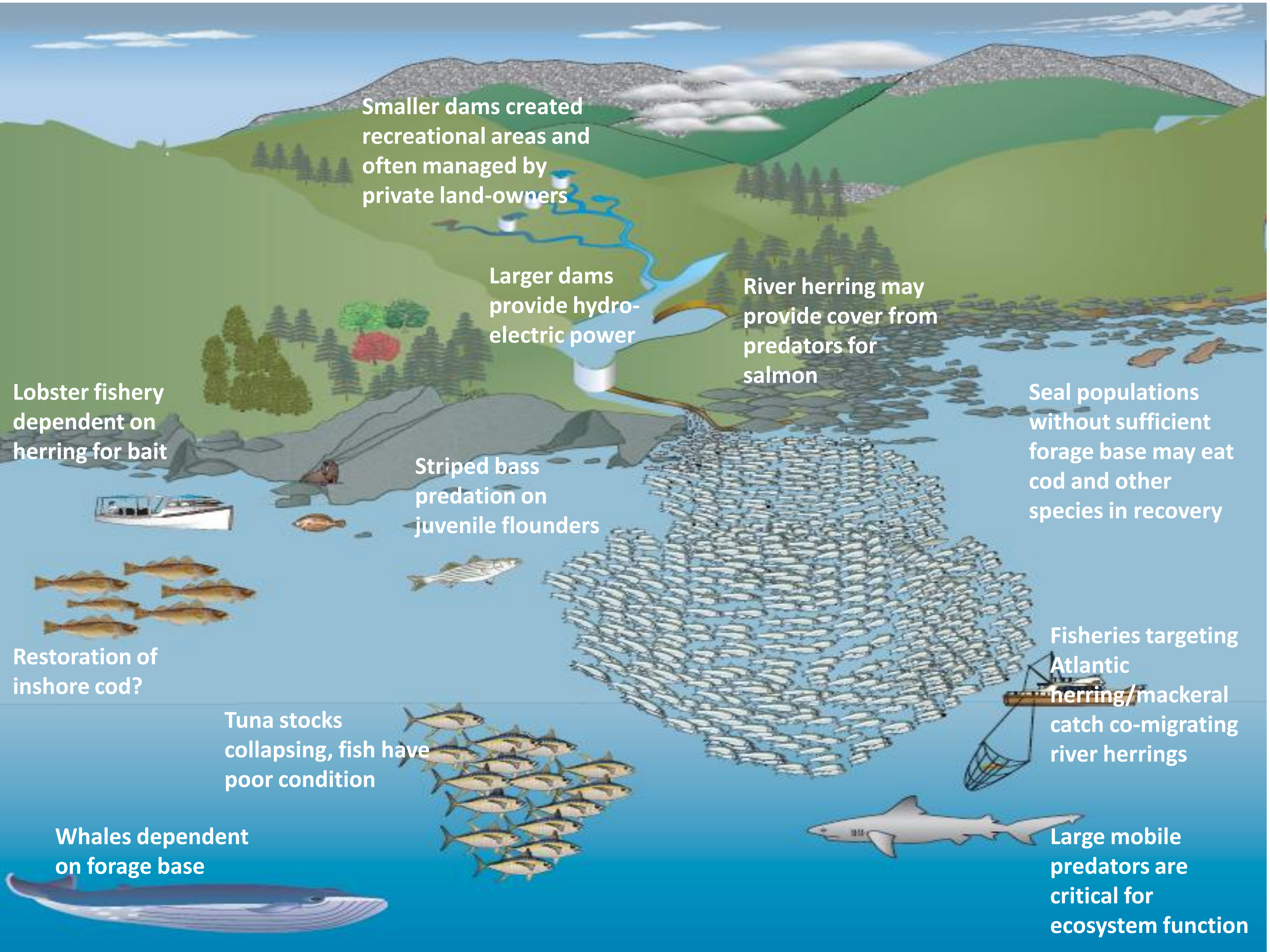


Figure 1. Normalized time series of indices of abundance of selected north Atlantic diadromous species. European eel includes standard errors of means for nine regions. The lower two panels compare Atlantic salmon. For type of index, maxima, minima, percentage change, and data sources, see table 2. Unless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

Limburg and Waldman 2009. BioScience 59: 955–965.

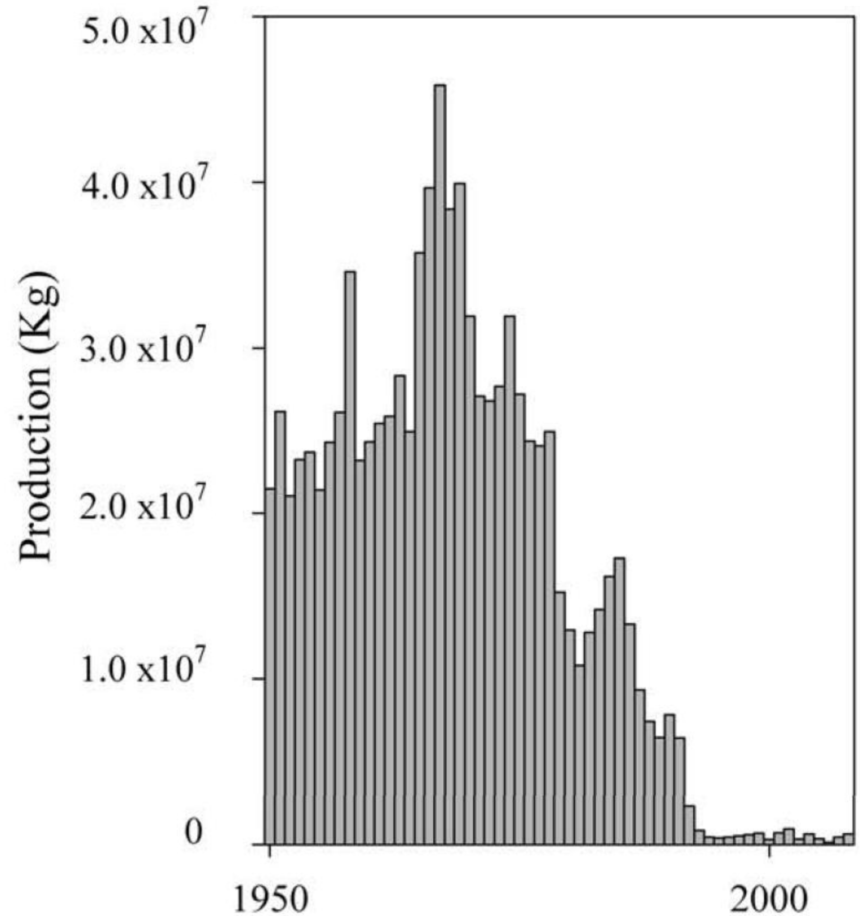
Maine landings
Population decline limits resilience?




Smaller dams created recreational areas and often managed by private land-owners
Larger dams provide hydro-electric power
River herring may provide cover from predators for salmon
Lobster fishery dependent on herring for bait
Striped bass predation on juvenile flounders
Seal populations without sufficient forage base may eat cod and other species in recovery
Restoration of inshore cod?
Fisheries targeting Atlantic herring/mackeral catch co-migrating river herrings
Tuna stocks collapsing, fish have poor condition
Whales dependent on forage base
Large mobile predators are critical for ecosystem function

River herring declines

- Precipitous drop through 1980s
- Listed as a species of concern by NOAA in 2006
- Current petition for listing under the Endangered Species Act



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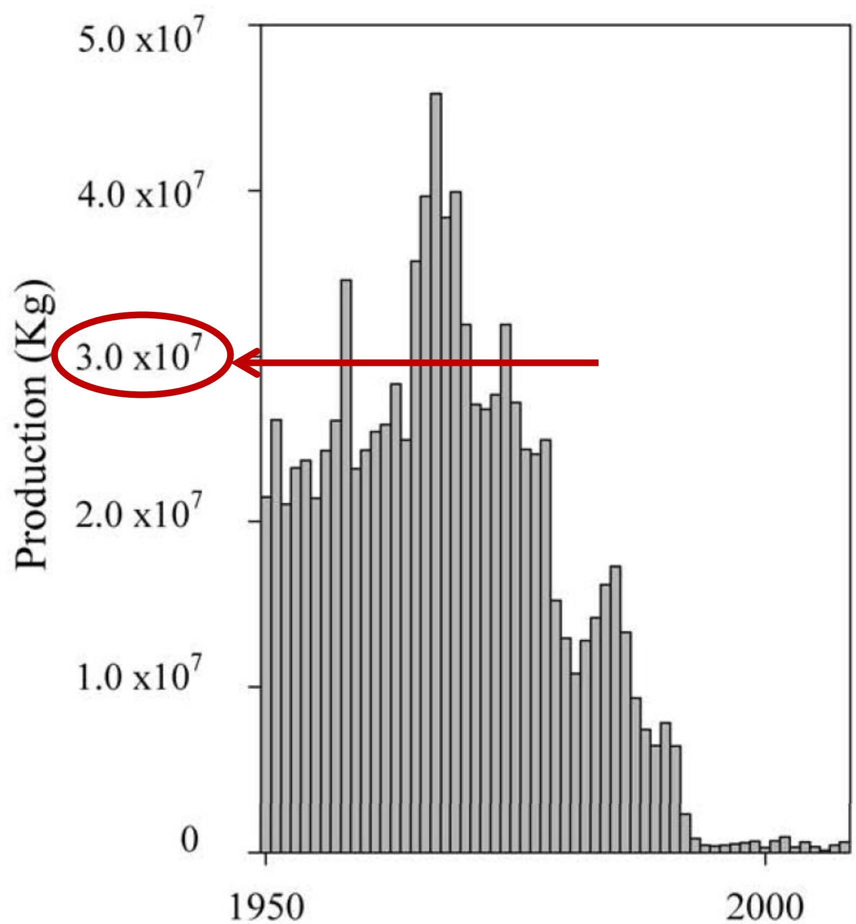


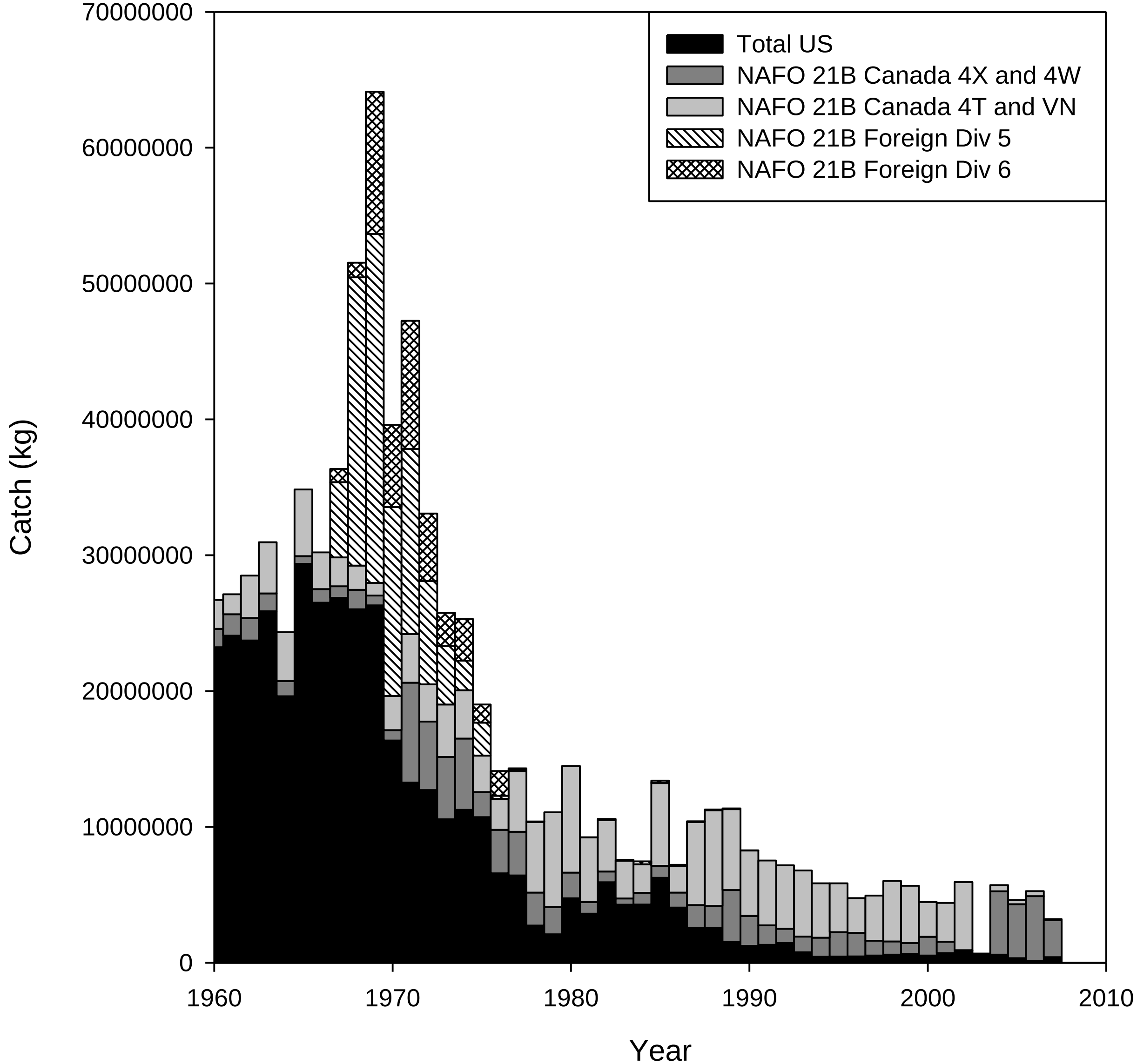
Counts

River	State	Species	Time series	Flow data?	Flow time series
Union River	Maine	RH	1982-2007	No	
Androscoggin River	Maine	RH	1983-2008	Yes	1914-present
Saco River	Maine	RH	1993-2007	Yes	1917-present
Saint Croix River	Maine	RH	1981-1994	Yes	1929-present
Damariscotta River	Maine	RH	1977-2007	No	
Exeter River	New Hampshire	RH	1975-2007	Yes	1997-present
Lamprey River	New Hampshire	RH	1972-2007	Yes	1935-present
Taylor River	New Hampshire	RH	1976-2007	No	
Cocheco River	New Hampshire	RH	1976-2007	Yes	1995-present
Winnicut River	New Hampshire	RH	1977-1991, 1998-2007	Yes	2003-present
Oyster River	New Hampshire	RH	1976-2007	Yes	1935-present
Monument River	Massachusetts	A, BB	1980-2007	No	
Mattapoisett River	Massachusetts	RH	1988-2007	No	
Nemasket River	Massachusetts	RH	1996-2007	No	
Parker River	Massachusetts	RH	1972-1978, 2000-2007	Yes	1946-present
Merrimack River	Massachusetts	RH	1983-2009	Yes	1924-present
Gilbert-Stuart River	Rhode Island	RH	1981-2007	No	
Nonquit River	Rhode Island	RH	1999-2007	No	
Buckeye River	Rhode Island	RH	2003-2007	No	
Connecticut River	Connecticut	RH	1966-2007	Yes	1929-present
Chowan River	North Carolina	A, BB	1972-2003	Yes	1950-present

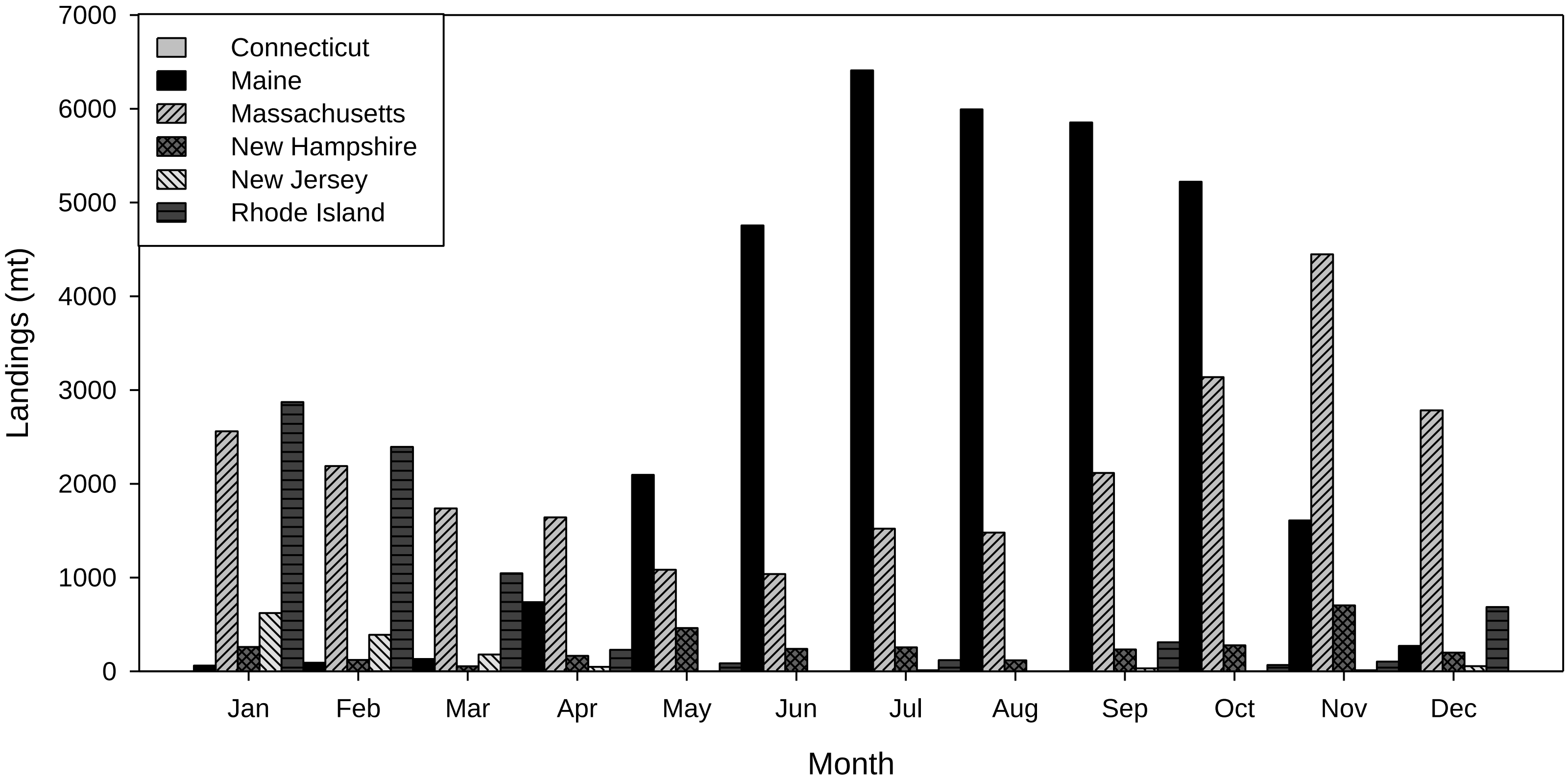
Relationships to counts

- Runs with longer time series appear to be impacted by directed fisheries
- Runs with shorter time series have variable relationships with flow/climate indices
  - Summer flow 4 years previous
  - Fall flow 4 years previous
  - Spring flow
- Bycatch, primarily in Atlantic herring fisheries, appears to be playing some role

Overharvest continues



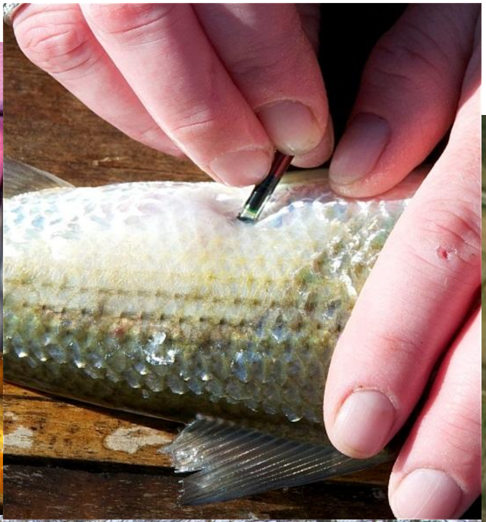
Overharvest continues



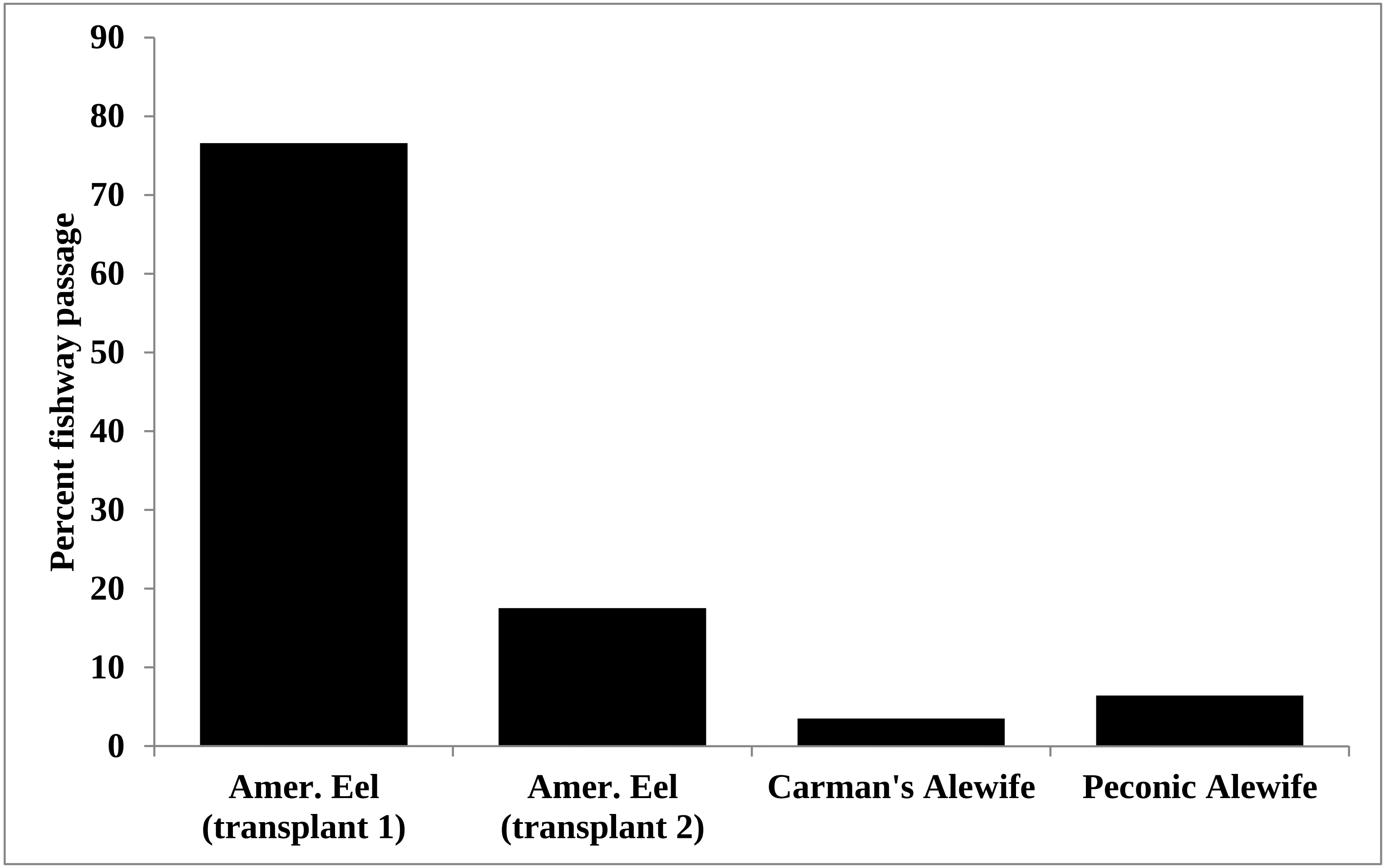
Restoration challenges

- Every river has unique challenges, and has different drivers of population trends
- But key factors appear to be:
  - Dams, flow characteristics and fish passage
  - Fisheries mortality (direct and indirect)
- Thus rebuilding of whole ecosystems requires local solutions in multiple jurisdictions

Carman’s River - Restoration



Carman's River fishway use



Fishway impacts

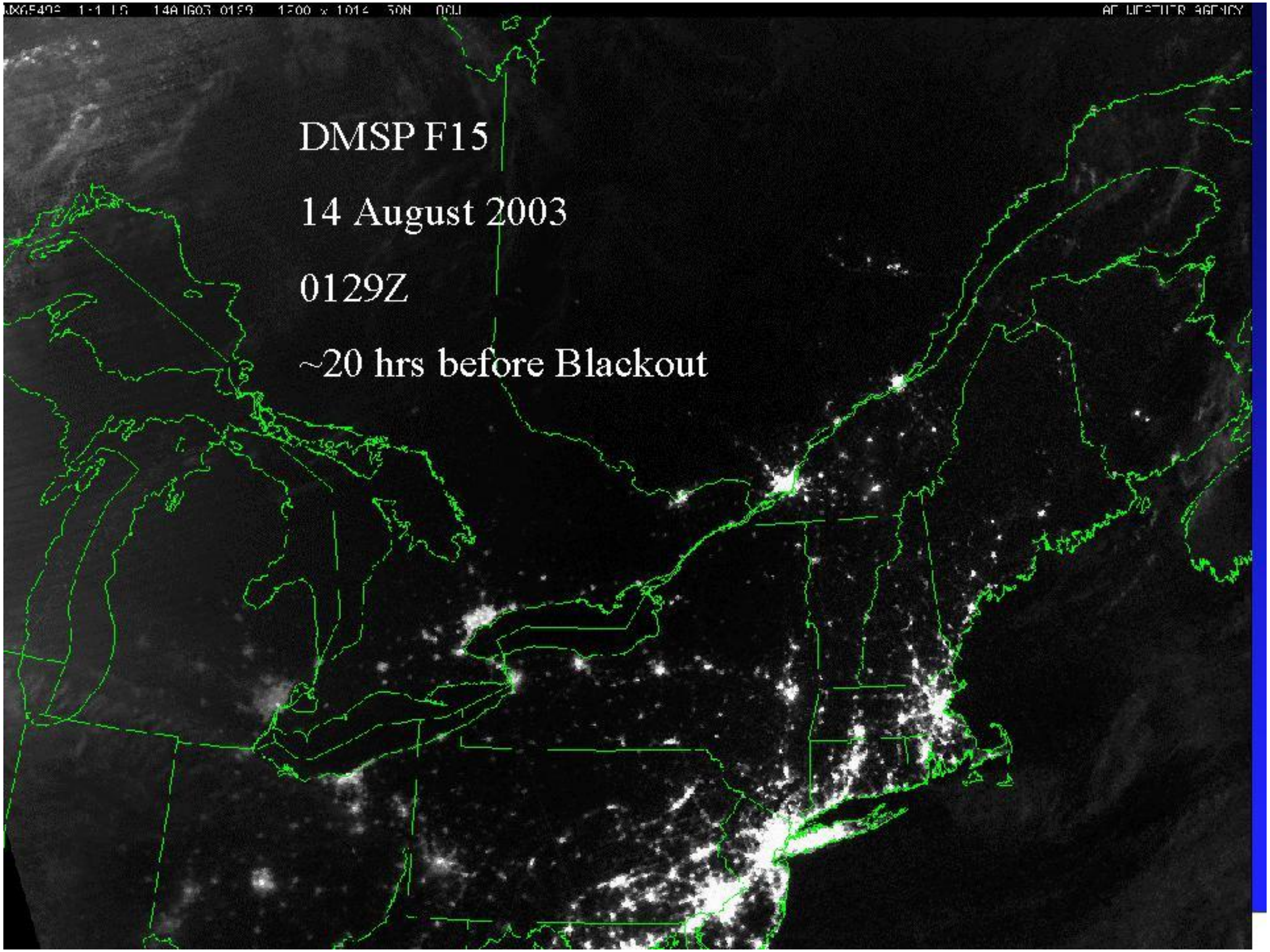
- Do fish use it?
- Interaction with flow?
- Is upstream habitat useable?
- Does it alter ecological characteristics, and for example increase predation risk?

Fishways can be dangerous place

Conclusions

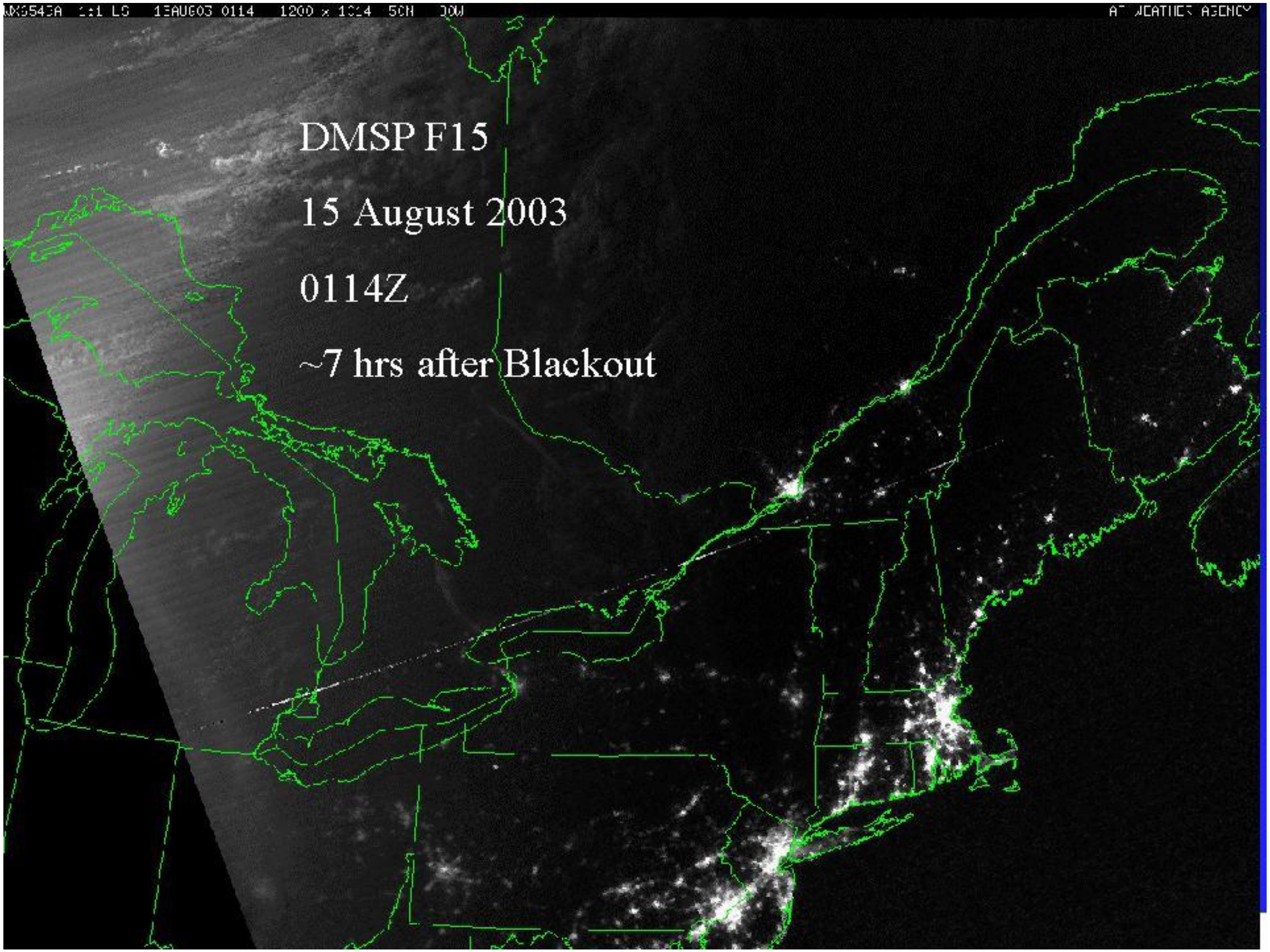
- Long-term declines due to damming and habitat loss have rendered populations susceptible to numerous impacts
- Interaction of these impacts varies by river
- Migrations key to understanding ecological connections and consequences of population declines

Transmission failure



Credit: Air Force Weather Agency

Transmission failure



Credit: Air Force Weather Agency

Acknowledgements

- DSRRN organizers
- Sturgeon: Michael Frisk, Keith Dunton. State Wildlife Grant and NOAA protected species grant
- Carman's: Matthew Sclafani, Michael Frisk, Kellie McCartin, Corey Humphrey, Bryan Oakley, Alex Haro. NY Sea Grant Funding
- Historical: Carolyn Hall, Karen Alexander, Bill Leavenworth, Emily Klein, Michael Frisk. Lenfest Ocean Program Funding
- Halfway technology: Jed Brown, Karin Limburg, John Waldman, Kurt Stephenson, Edward Glenn, Francis Juanes
- Run Counts: Jake Kritzer, NFWF funding and data from Claire Enterline, Kevin Sullivan, Gary Nelson, public documents/websites