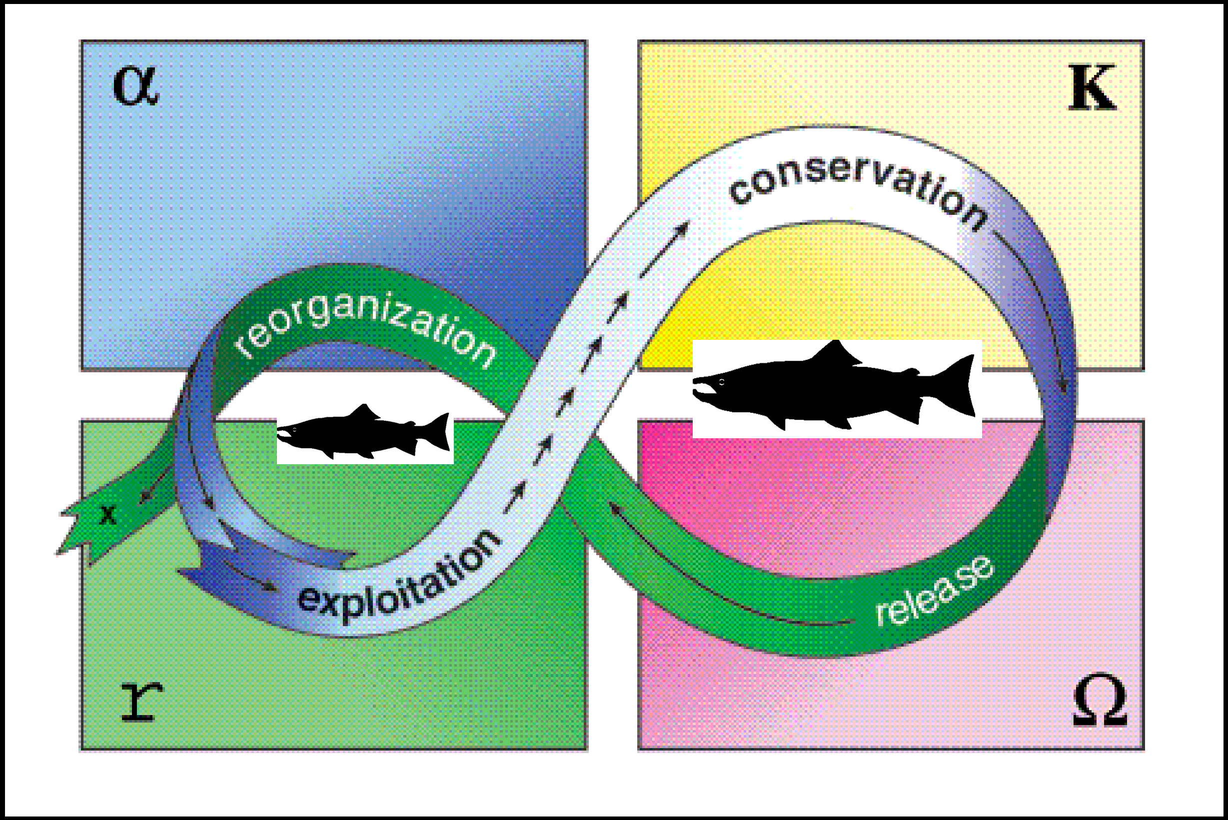
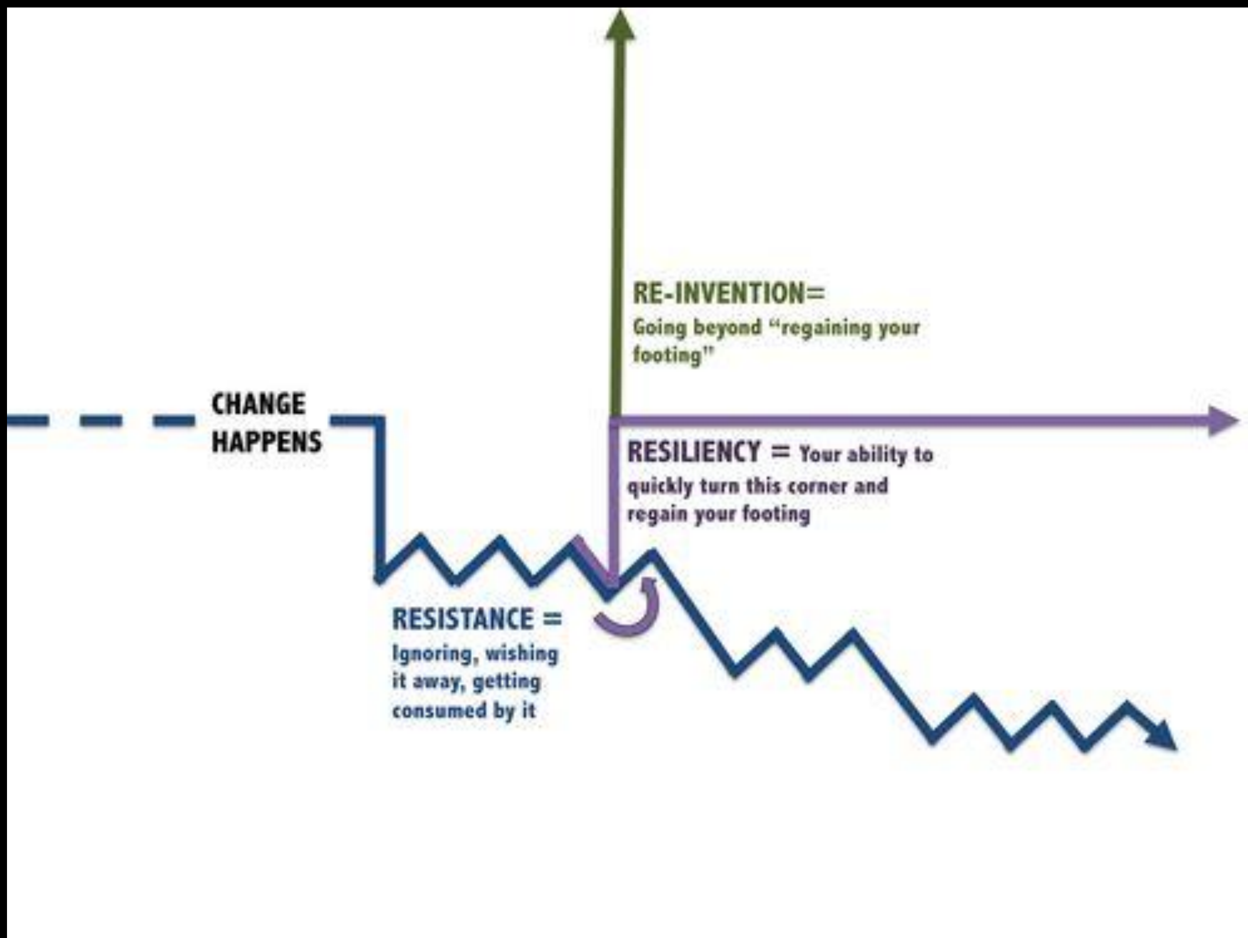
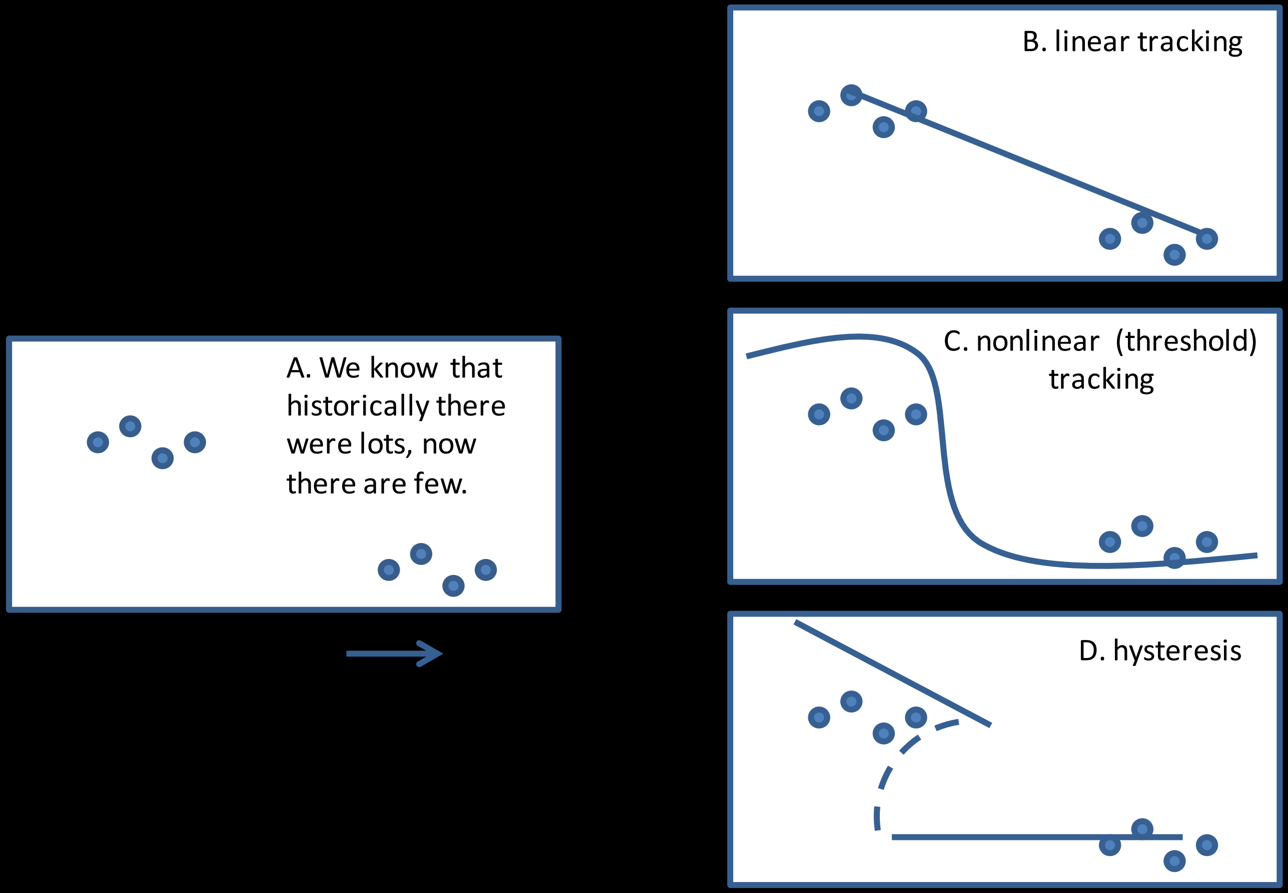
"Is Resilience Theory Useful to Anadromous Fish Restoration?"

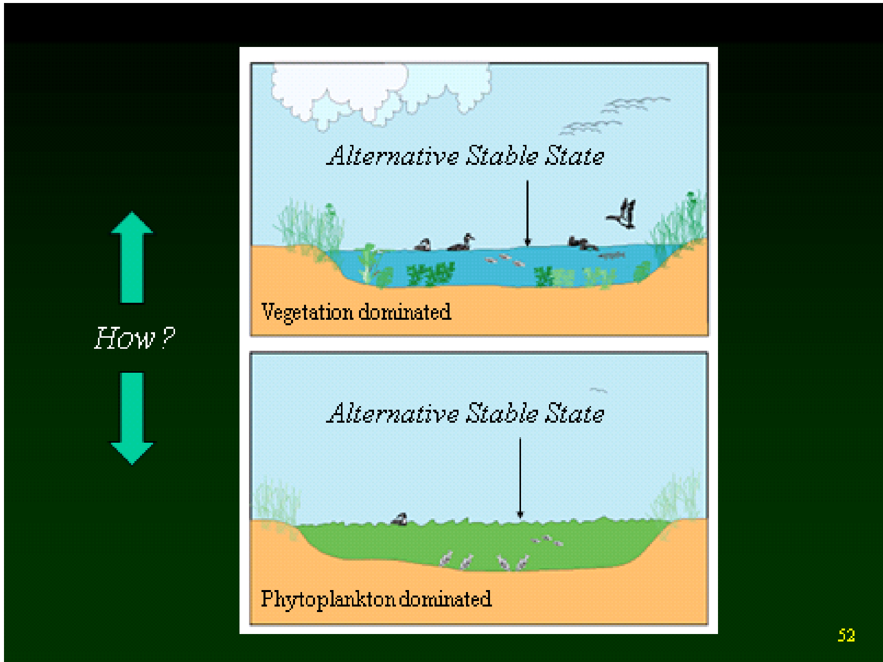


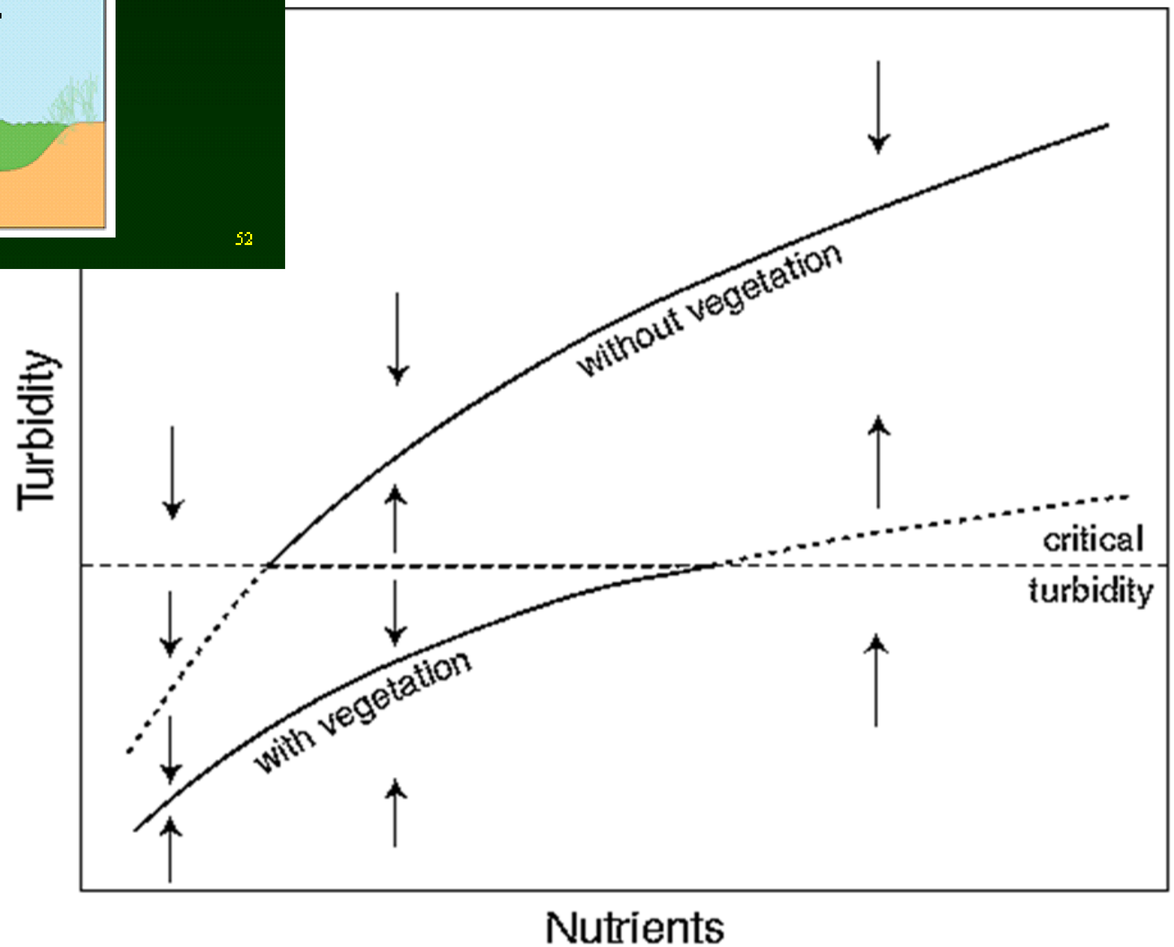
Resistance vs. Resilience



Three Kinds of Declines

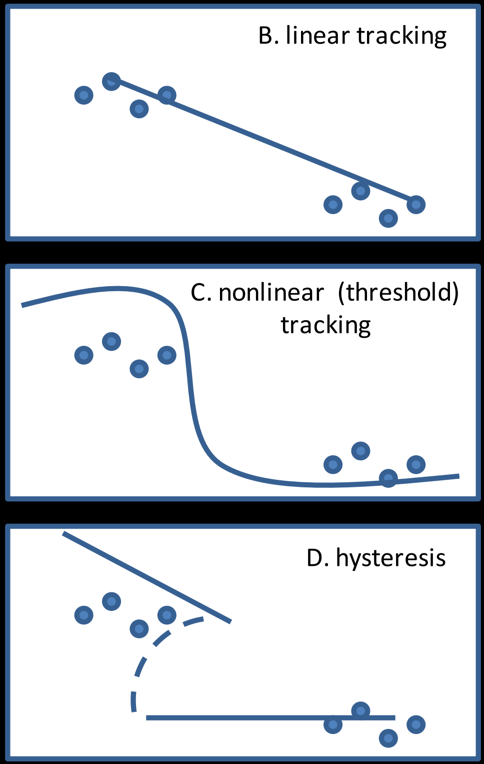



How ?
Alternative Stable State
Vegetation dominated
Alternative Stable State
Phytoplankton dominated
52


Turbidity
without vegetation
critical
turbidity
with vegetation
Nutrients

Initial Question

- **Diadromous fishes have declined *big-time* —but by which pattern?**



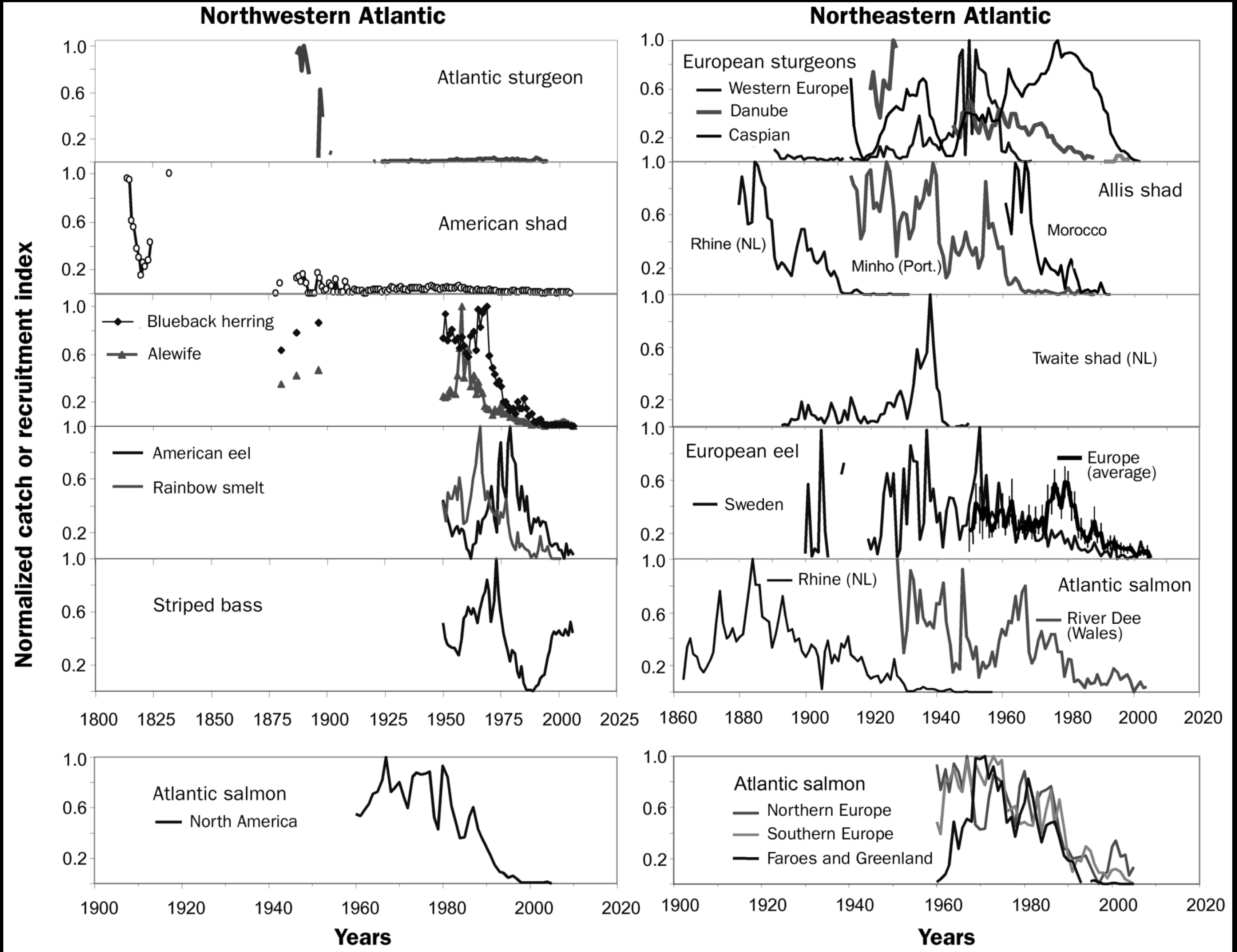
BioScience *December 2009 / Vol. 59 No. 11*

Dramatic Declines in North Atlantic Diadromous Fishes

KARIN E. LIMBURG AND JOHN R. WALDMAN

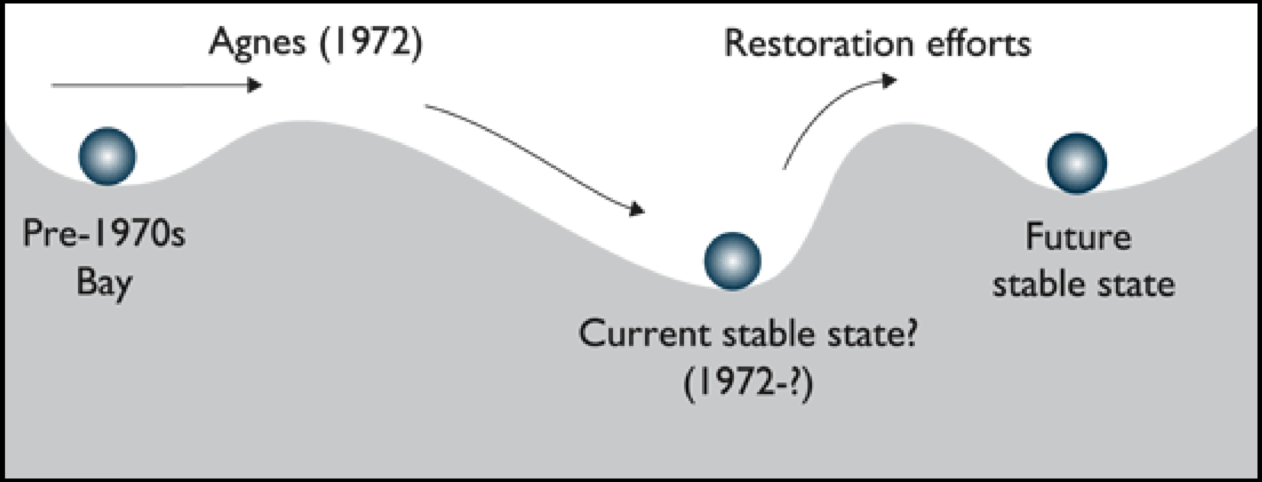
We examined the status of diadromous (migratory between saltwater and freshwater) fishes within the North Atlantic basin, a region of pronounced declines in fisheries for many obligate marine species. Data on these 24 diadromous (22 anadromous, 2 catadromous) species are sparse, except for a few high-value forms. For 35 time series, relative abundances had dropped to less than 98% of historic levels in 13, and to less than 90% in an additional 11. Most reached their lowest levels near the end of the observation period. Many populations persist at sharply reduced levels, but all species had suffered population extirpations, and many species are now classified as threatened or endangered. Habitat loss (especially damming), overfishing, pollution, and, increasingly, climate change, nonnative species, and aquaculture contributed to declines in this group. For those diadromous fishes for which data exist, we show that populations have declined dramatically from original baselines. We also discuss the consequences of these changes in terms of lost ecosystem services.

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



Northwestern Atlantic
Northeastern Atlantic
Normalized catch or recruitment index
Atlantic sturgeon
American shad
Blueback herring
Alewife
American eel
Rainbow smelt
Striped bass
European sturgeons
Western Europe
Danube
Caspian
Allis shad
Rhine (NL)
Minho (Port.)
Morocco
Twaite shad (NL)
European eel
Sweden
Europe (average)
Atlantic salmon
Rhine (NL)
River Dee (Wales)
Atlantic salmon
North America
Atlantic salmon
Northern Europe
Southern Europe
Faroes and Greenland
Years
Years

Alternative Stable States
'Flip Happens'



Some More Questions

- Are the low numbers now observed across many species and populations of anadromous fishes an **alternative stable state** or the later stages of **monotonic declines**?
- How can we tell the difference?

Some More Questions

- How does resilience play a role in shaping these patterns?
- Does the answer influence how these species are managed for restoration?

One Set of Ways of Looking at Resilience

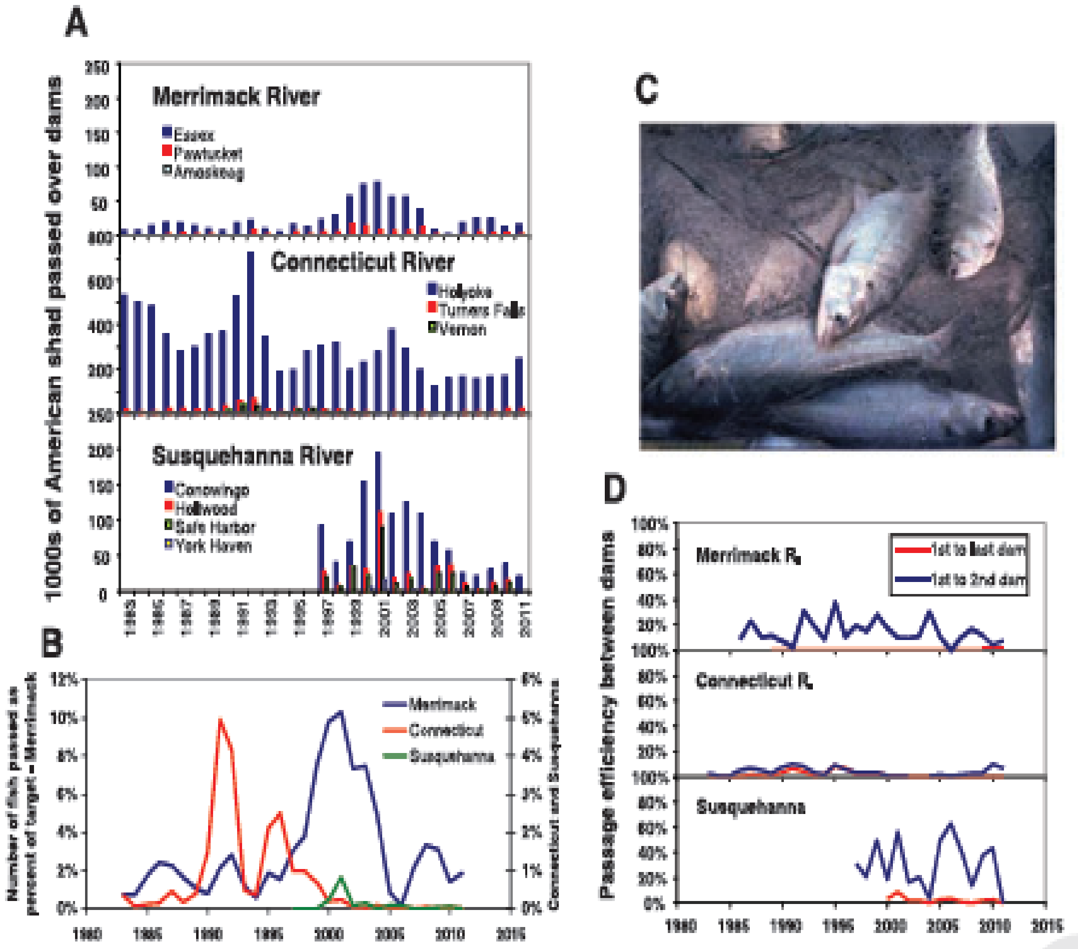
- ***Extrinsic Factors*** *that* ***Test*** *the Resilience of Anadromous Fishes*
- ***Extrinsic Factors*** *that* ***Contribute*** *to Resilience in Anadromous Fish Restorations*
- ***Intrinsic Factors*** *that* ***Contribute*** *to the Resilience of Anadromous Fishes*

Barriers


Chesapeake Boating


NYC Dept Of Parks & Recreation

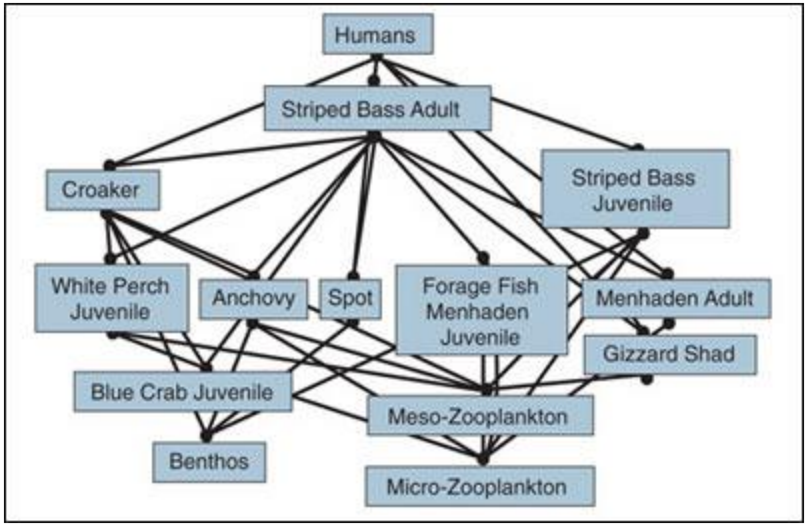
"Ineffective" Passage



Brown et al. Fish & hydropower on the U.S. Atlantic coast: failed fisheries Policies from half-way technologies. ***Conservation Letters***

Interspecific Interactions

Predatory & Competitive



Species Dependences

ASF

Interspecific Interactions

Riverine Predatory Gauntlet, e.g. Hudson River

Circa 1600

- white perch, yellow perch, striped bass, chain pickerel

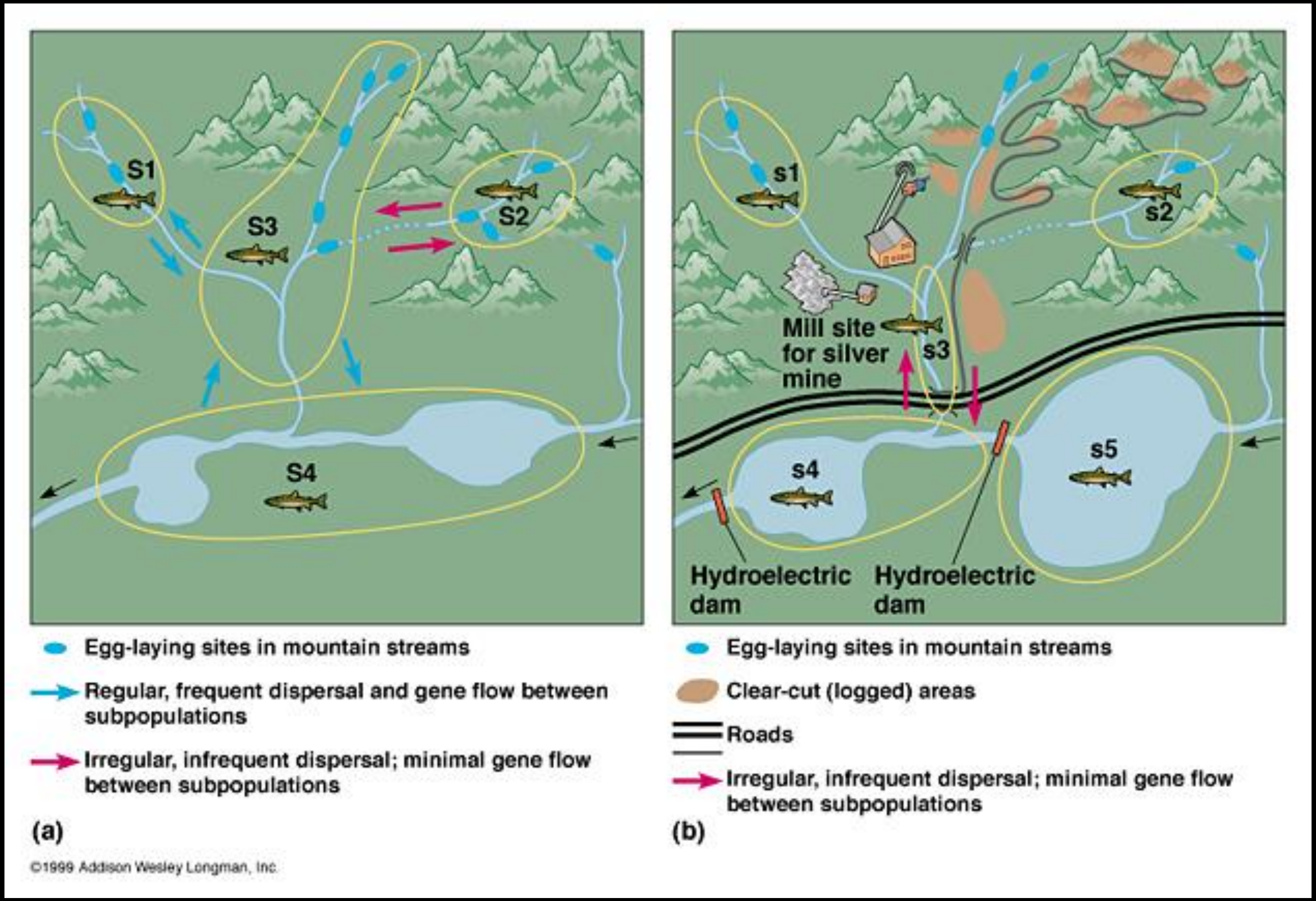
Circa 2013

- white perch, yellow perch, striped bass, chain pickerel

plus

- largemouth bass, smallmouth bass, walleye, northern pike, rock bass, black crappie, channel catfish

Watershed Modifications

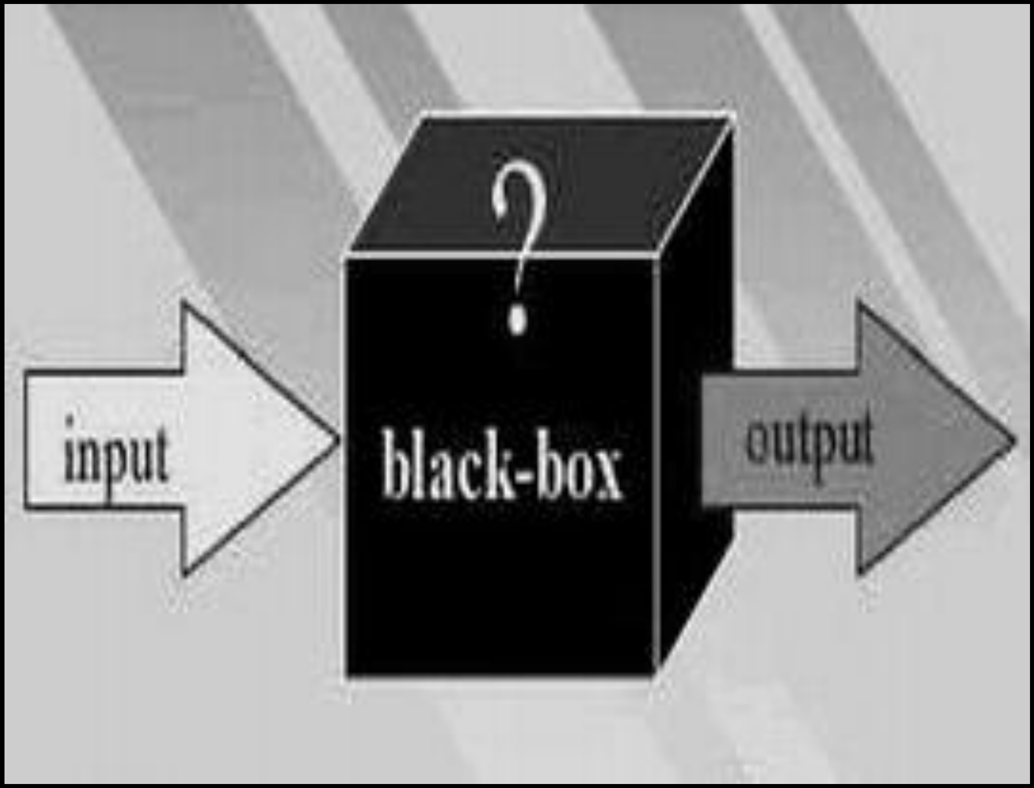


Climate Change

<u>Phenologies</u>

- *Penobscot*
  Atl Salmon 1986-2001
  +1.3 days/year
- *Androscoggin*
  Alewives 1983-2001
  +1.2 days/year

Marine Factors

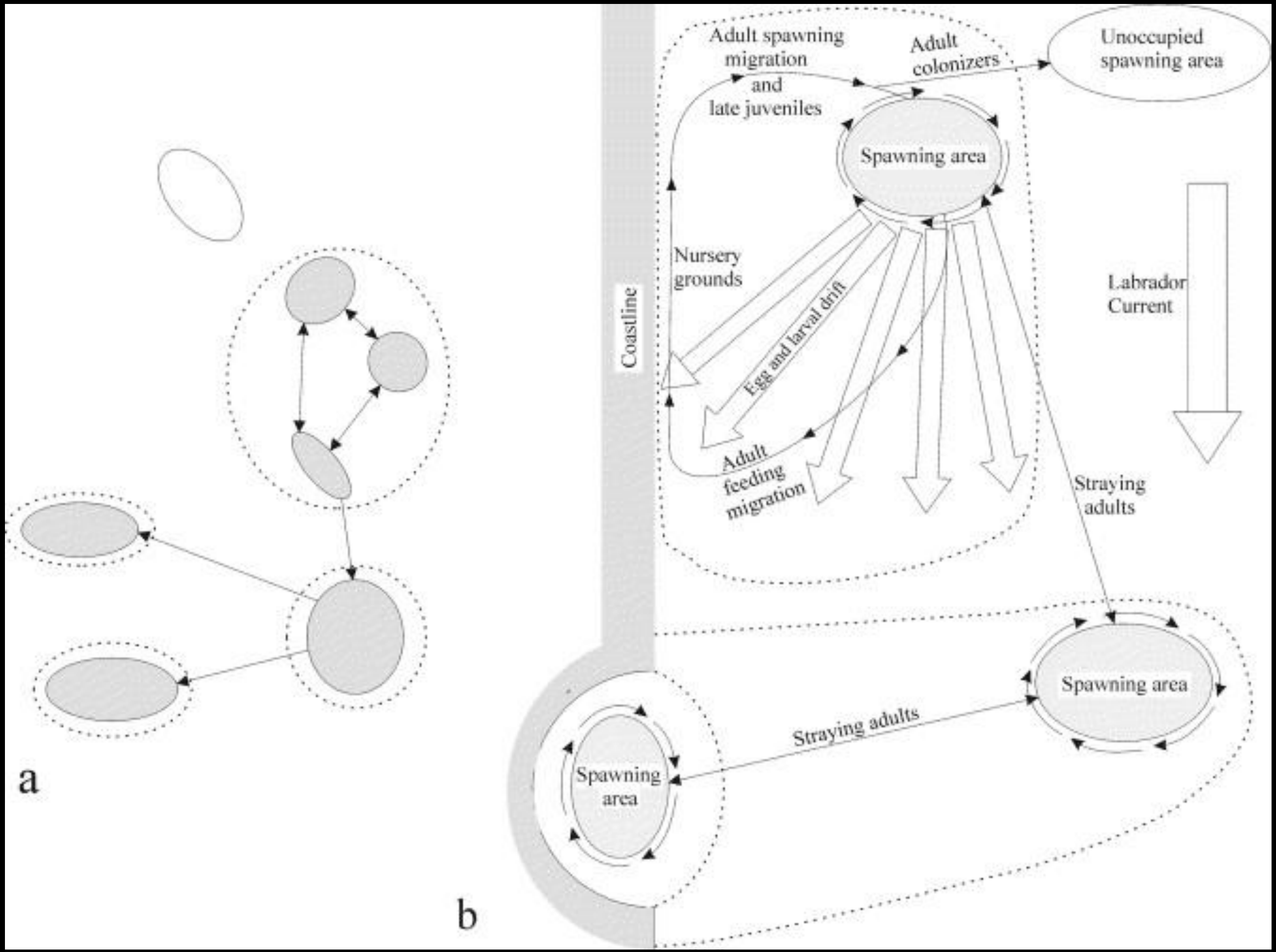


Extrinsic Factors that Contribute to Resilience in Anadromous Fish Restorations

- **The Dynamic Nature of Rivers**
- **Habitat Heterogeneity**
- **Riparian Zone Habitat Quality**
- **Habitat Connectivity**
- **Refuge**
- **Quality of Spawning Habitat**

Intrinsic Factors that Contribute to the Resilience of Diadromous Fishes

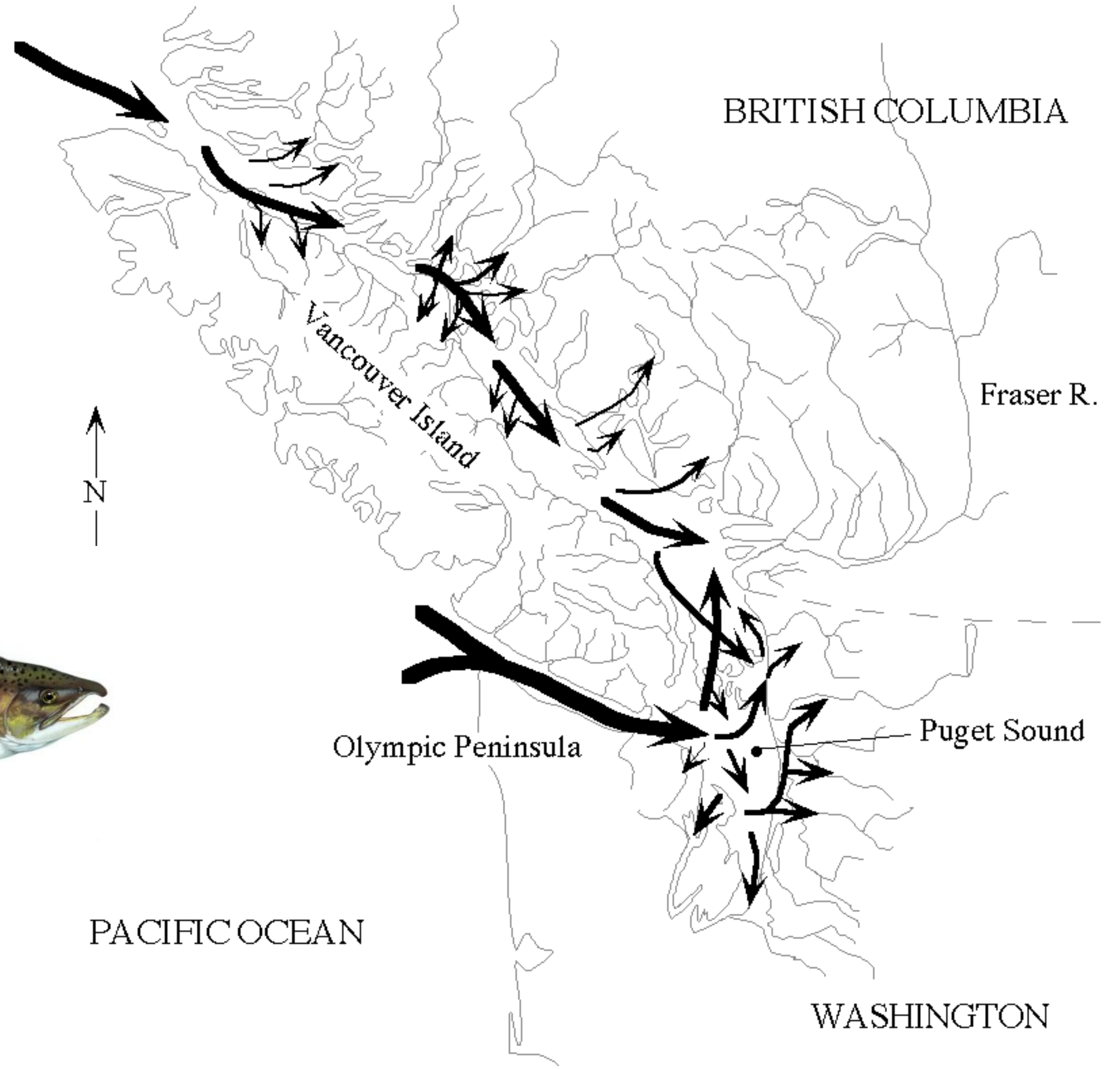
Metapopulation Structure



Spawning Adjustments in Time and Space

- Tracking Climate Change – phenologies
- Combating Allee Effects

Homing and Straying

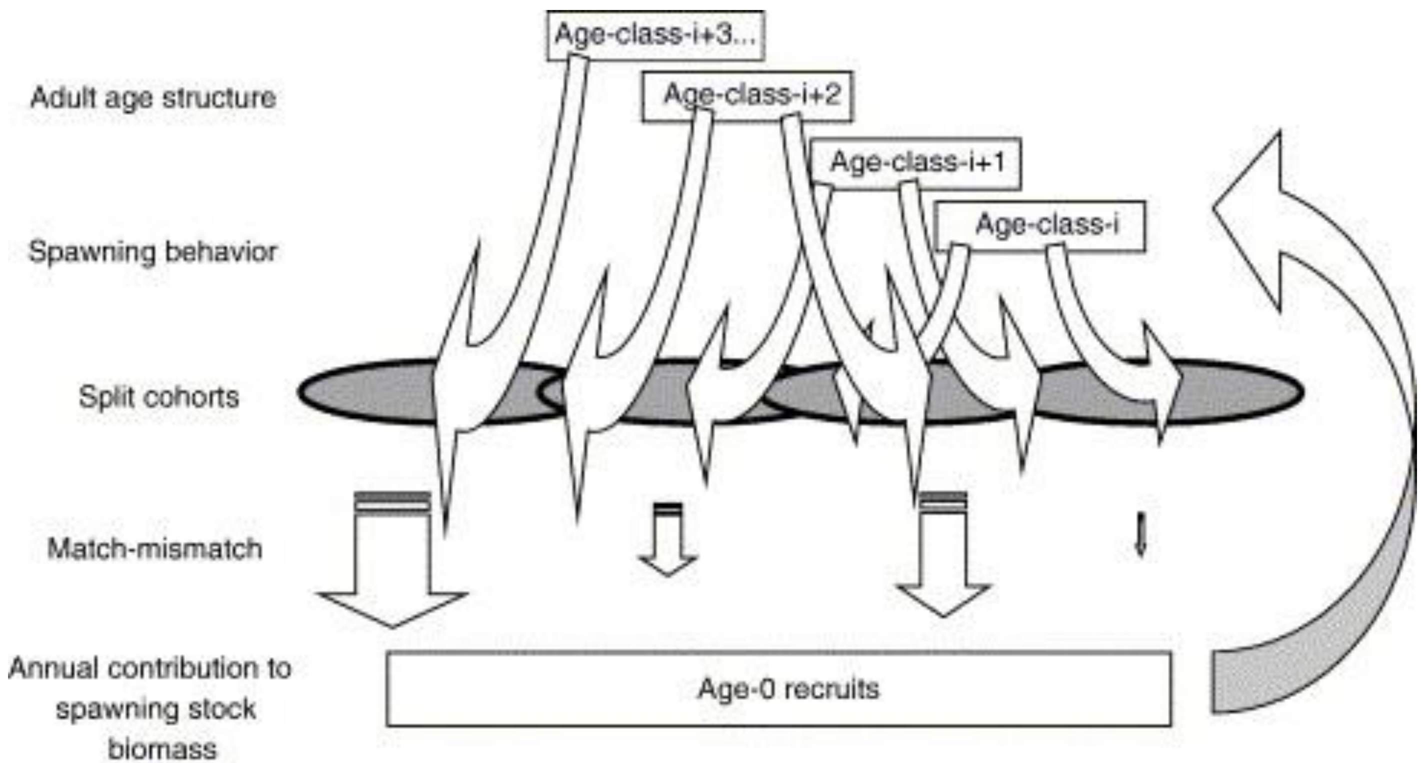


Among-Stock Differences

(Largely due to <u>among-river</u> physical differences)

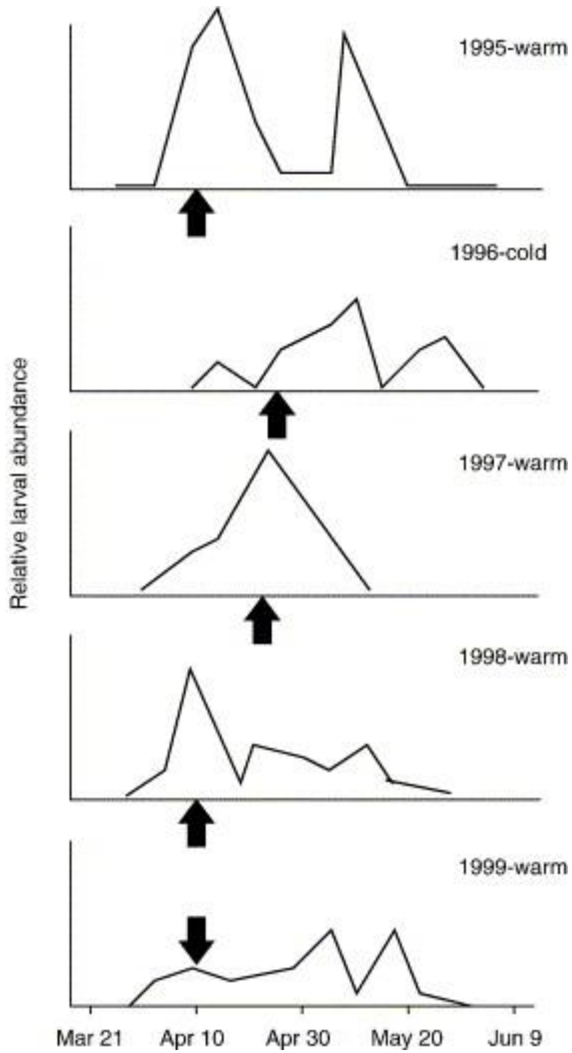
- A century of catch data, tagging, meristics, morphometrics, protein electrophoresis, scale shape, fatty acids, DNA, etc.
- Restigouche Indians, New Brunswick – salmon as tribal symbol, could immediately tell river of origin of a salmon
- Striped bass "bake-off"

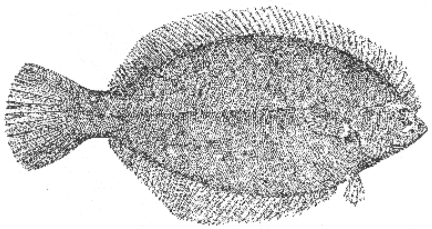
Within-Stock Phenomena
The Storage Effect:
Strong Recruitments Stored in Adult Biomass



Secor 2007

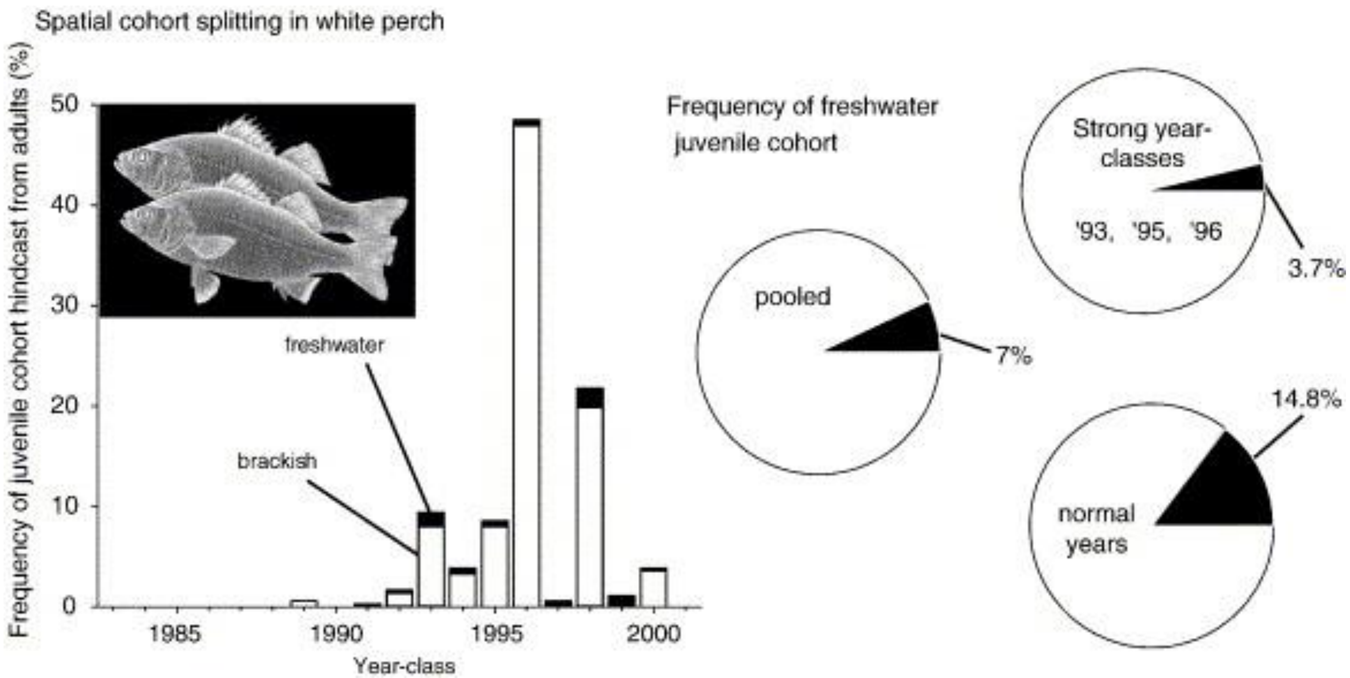
Temporally-Split Cohorts





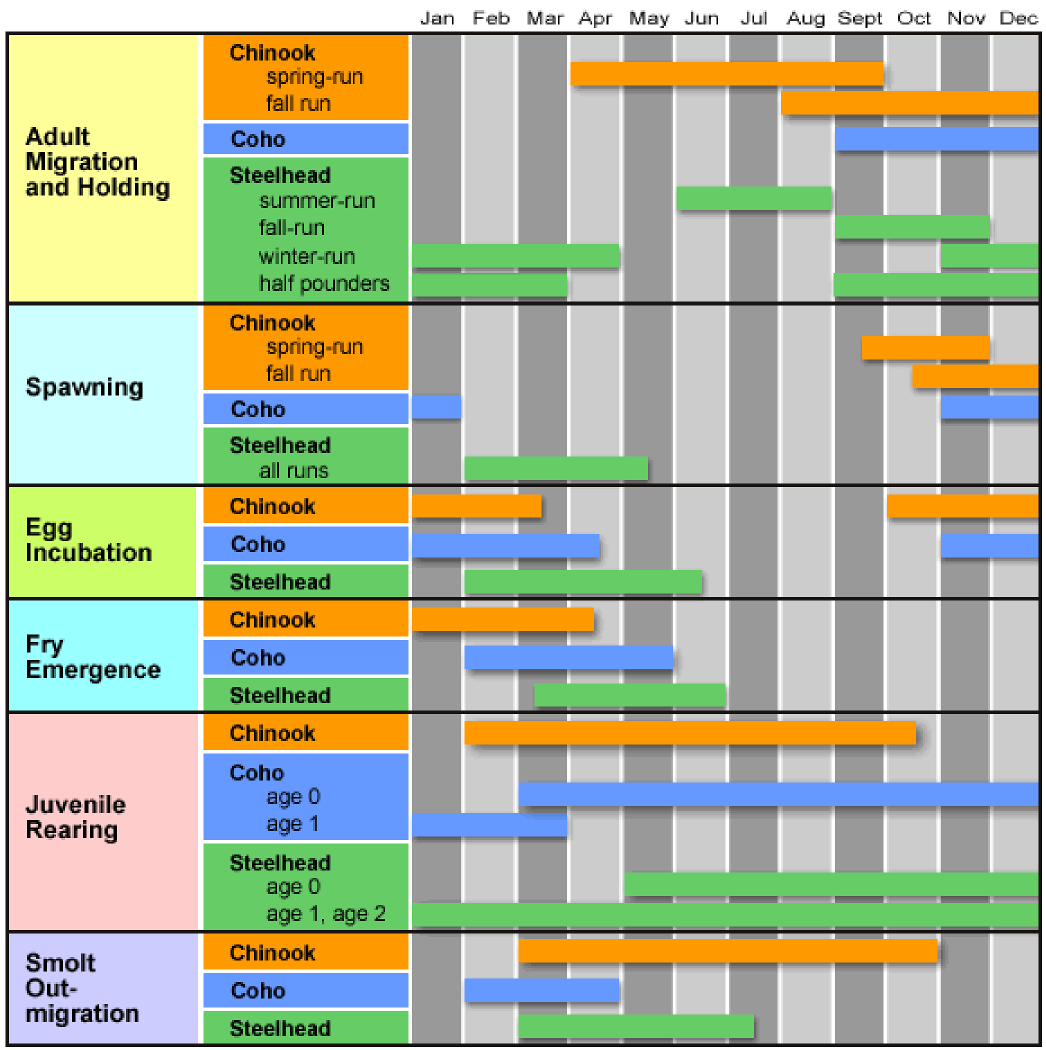
Back-calculated birth dates
Great South Bay, NJ
Secor 2007
(from Sogard et al. 2001)

Spatially-Split Cohorts



Patuxent River
Secor 2007

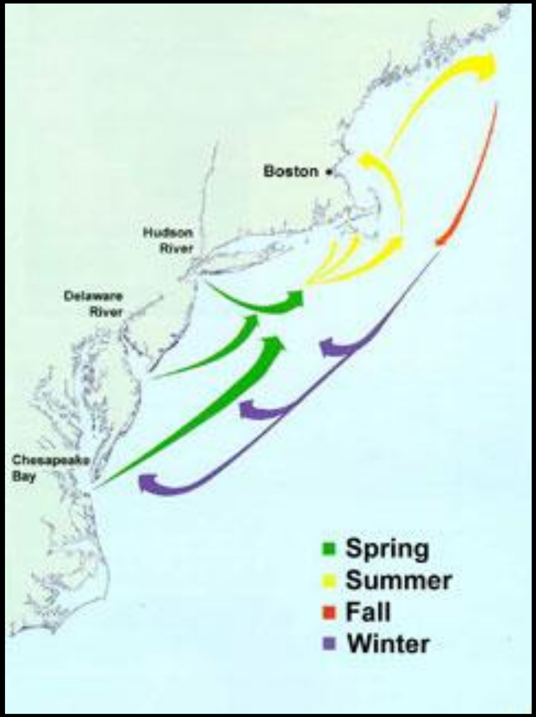
Portfolio Effect
(Within-Stock Differences)



Trinity River, CA

Portfolio Effect
(Within-Stock Differences)

- How much within a population is driven by in-river vs. marine differences?



Portfolio Effect – Atlantic Coast

American Shad

- Hudson River - ‘yellowback,’ ‘blueback,’ ‘greenback,’ ‘golden,’ ‘pink’ ‘pink-faced,’ ‘locust,’ ‘chunker’ (exceptionally deep bodied), ‘chunk head’ (Mansueti & Kolb 1953)
- Potomac & North Carolina - ‘May shad’ came later; fatter, deeper bodied, thicker caudal peduncle (Chapman 1875, Smith 1907)

Portfolio Effect – Atlantic Coast
River Herring

Potomac (Chapman 1875) –

- ‘Branch’ - alewife
- ‘glut’ - blueback
- ‘Poplar-back’ – yellow backs, gone by 1875
- ‘dunbellies’ – gold dust flanks, a few left 1875
- ‘May flipper’ – small, fat, delicious, higher jumper, no longer in gluts by 1875

Behavorial Variation

- Striped bass - “contingents”
- “Facultative anadromy” – striped bass, brook trout
- Precocious spawning – Atlantic salmon
- Fall spawning – Atlantic sturgeon

One Common Denominator to Intrinsic Factors that Contribute to Resilience is *Life History Variation!*

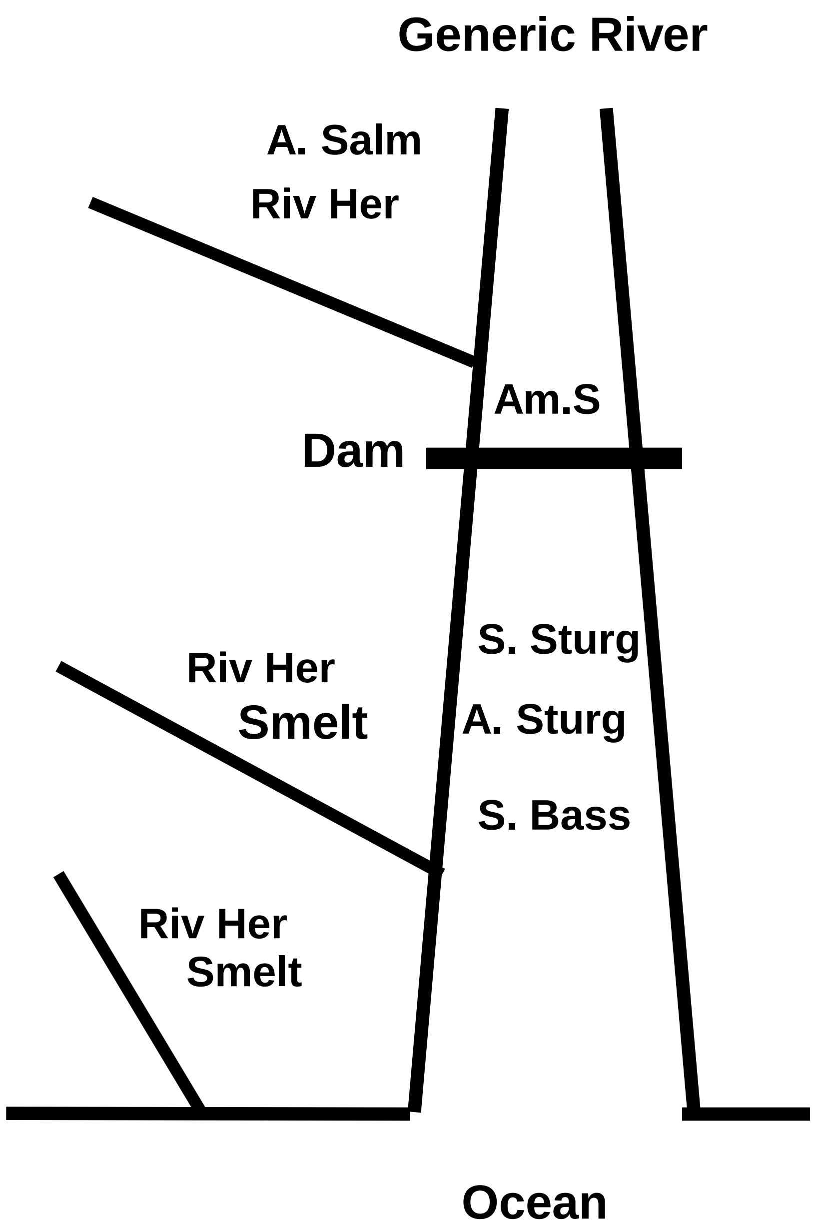
- We've done okay with among-population differences by default through the existence of discrete rivers, but . . .
- We've done poorly characterizing and understanding within-river variation!

Why is Within-River Variation Important?

- Fine tuning
- Bet hedging
- Reduces intraspecific competition
- Maximizes production from distinct ecosystem components

Is There a <u>*Resilience Spectrum*</u> Among Anadromous Species?

1) Damming
2) Overfishing
3) Contamination



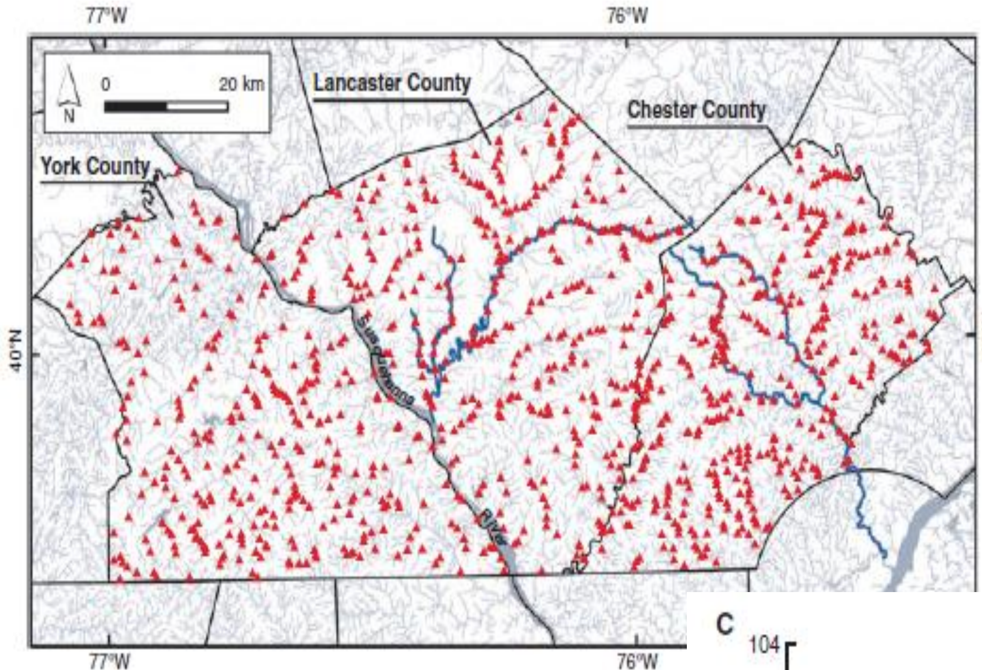
Multiple Strong Drivers

- Atl salmon – dams, fishing, oceanic black box
- Am shad – dams, fishing, oceanic black box
- River herring (large systems) – dams, bycatch

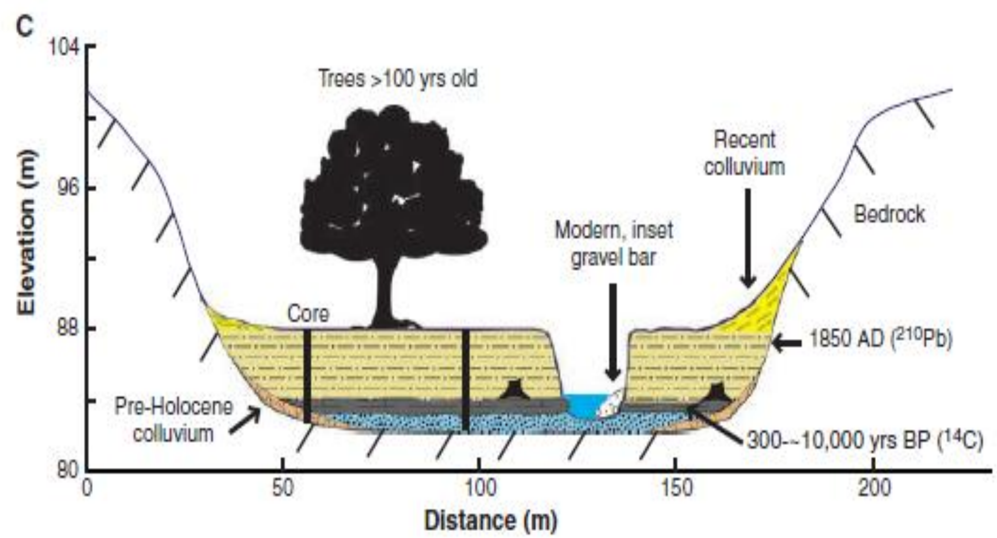
Single Strong Driver

- Shortnose sturgeon - dams
- Striped bass – fishing
- Atl sturgeon – fishing
- Smelt - climate
- River herring (small systems) - dams

What Should a River Look Like?



N = 1025 19th Century Dams



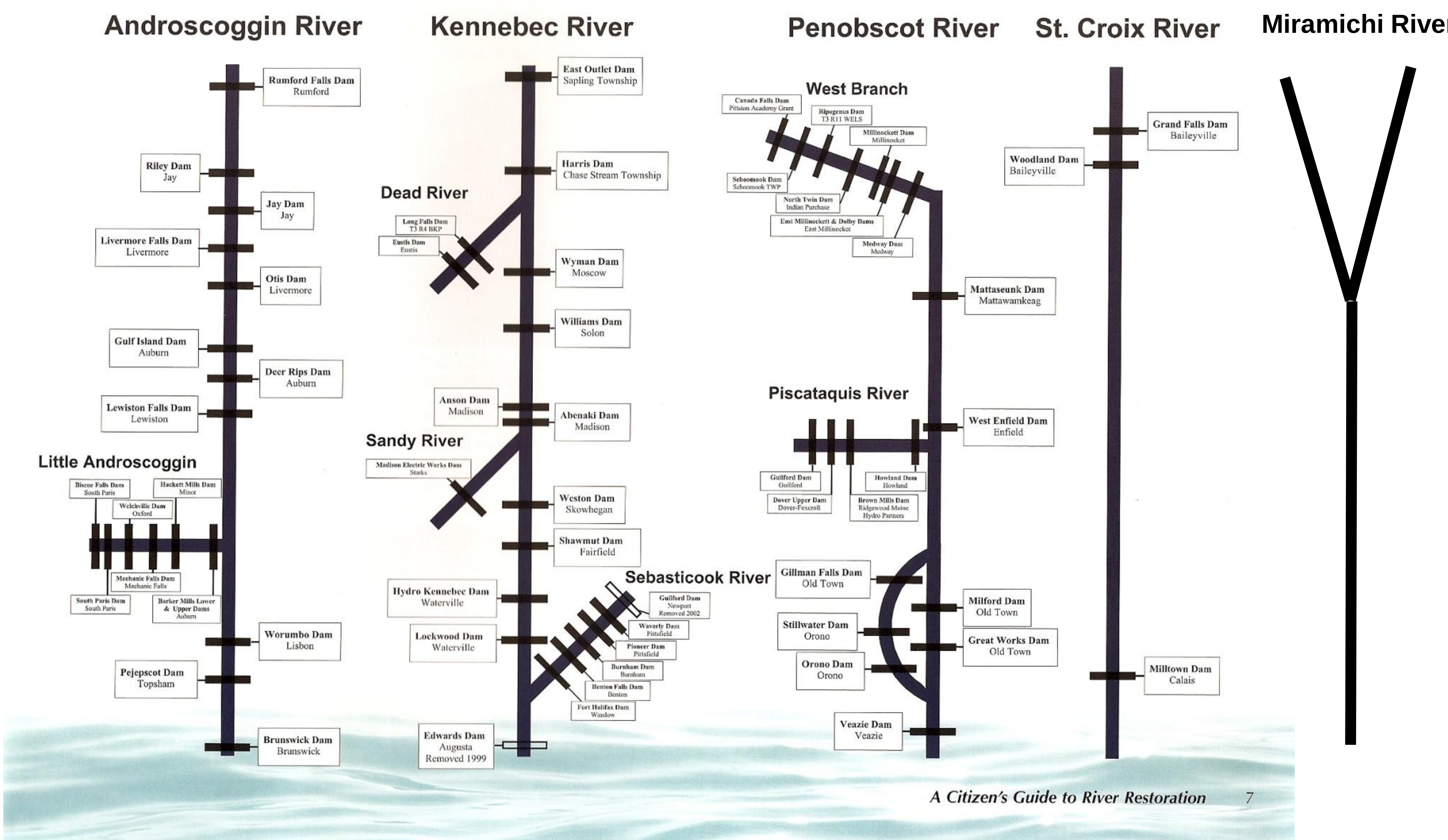
Walter & Merritts. 2008.
Natural streams & the legacy
of water powered mills. Science

1000 Years of Lower Mississippi

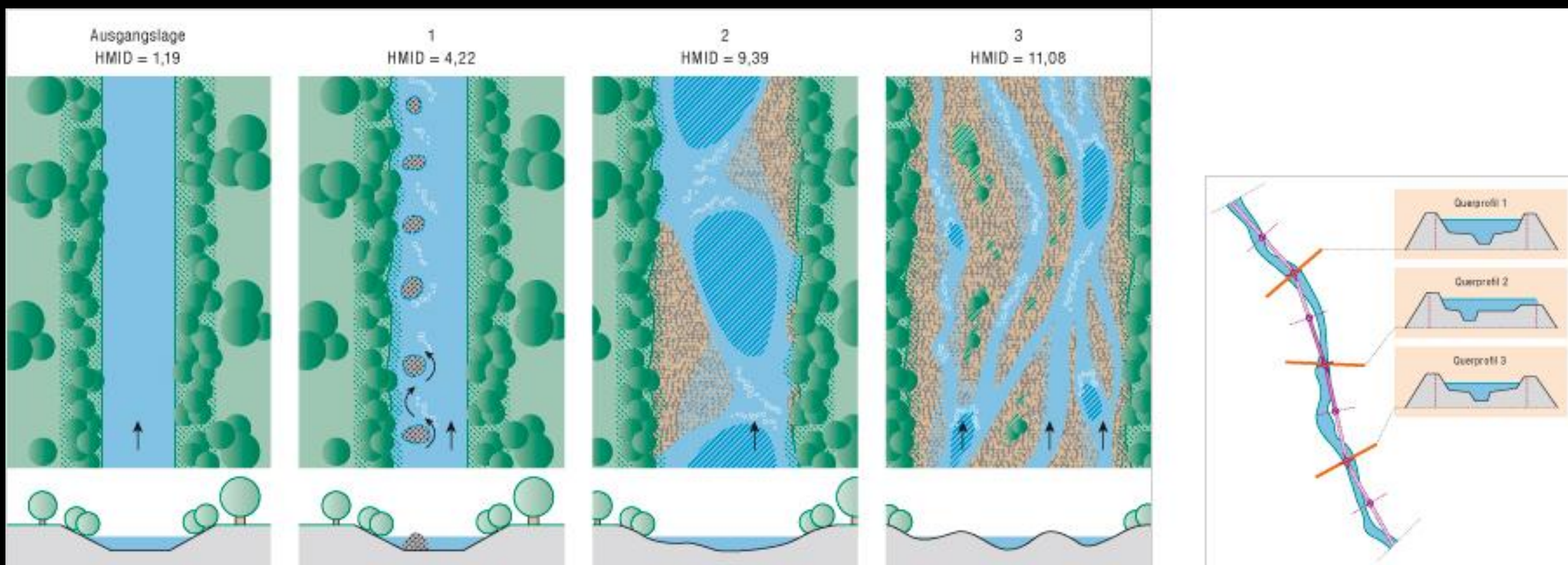
Geological Investigation of the Alluvial Valley of the Lower Mississippi River


Nebraskaland Magazine/Nebraska Game and Parks Commission

Resistance & Complexity



Rebuilding Desirable Complexity



Anamorph

Our Original Questions

- Nature of declines?
- Locked into a stable state?

Is One Answer:

More River Heterogeneity =

More Life History Variation =

More Resilience?