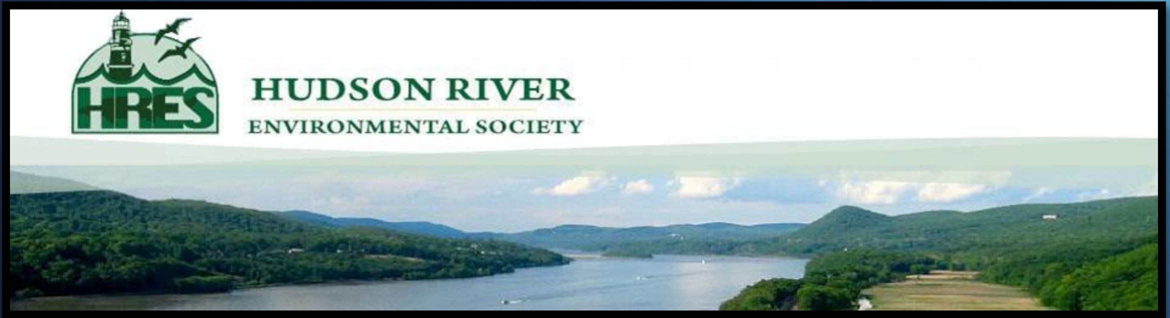
UNIVERSITY OF MARYLAND CENTER FOR ENVIRONMENTAL SCIENCE
CHESAPEAKE BIOLOGICAL LABORATORY

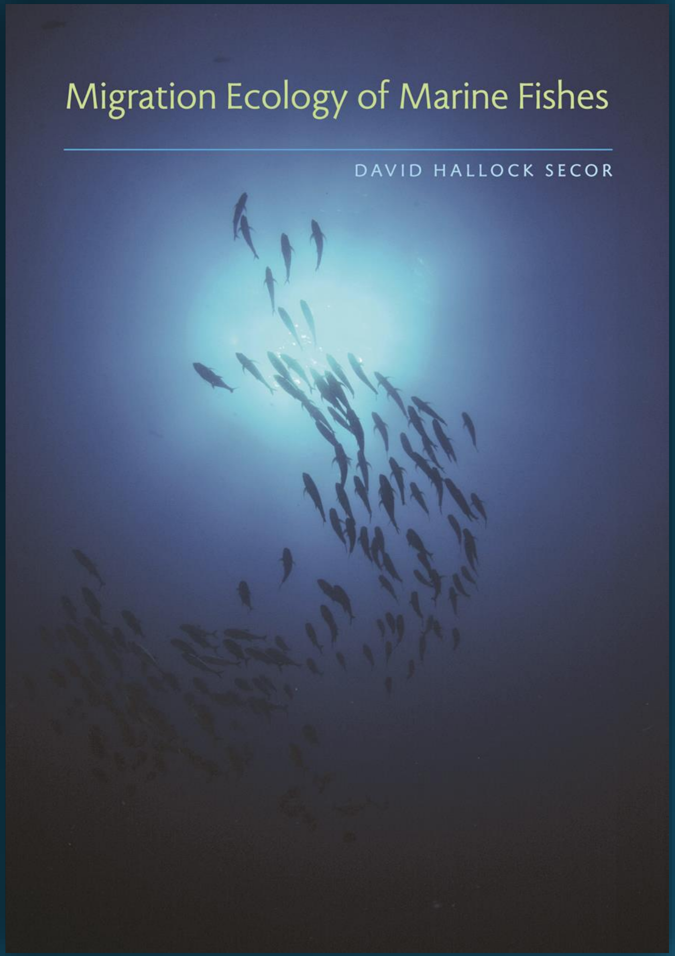
Dave Secor

Adaptation to Climate Change: Can we better equip Hudson River fishes to succeed?



2019 Hudson River Symposium ,Vassar College 8 May

Adaptation to Climate Change

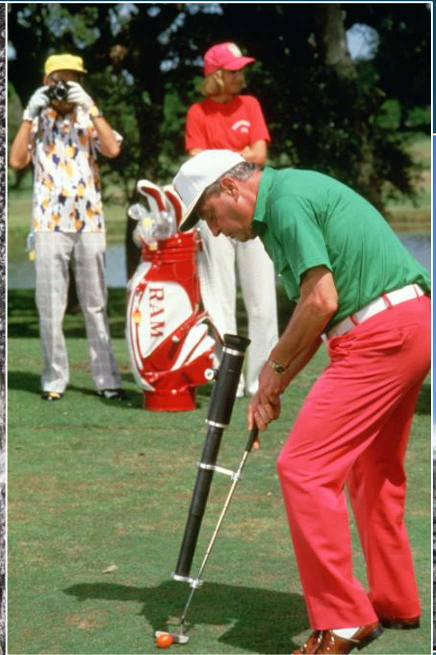


Stewardship goals must broaden to accommodate nonstationary ecosystems through expanded reference points, those that relate to population resilience, stability and persistence.

or,

Equip fish to succeed in uncertain times

Equipped to succeed?



Human's greatest success story??

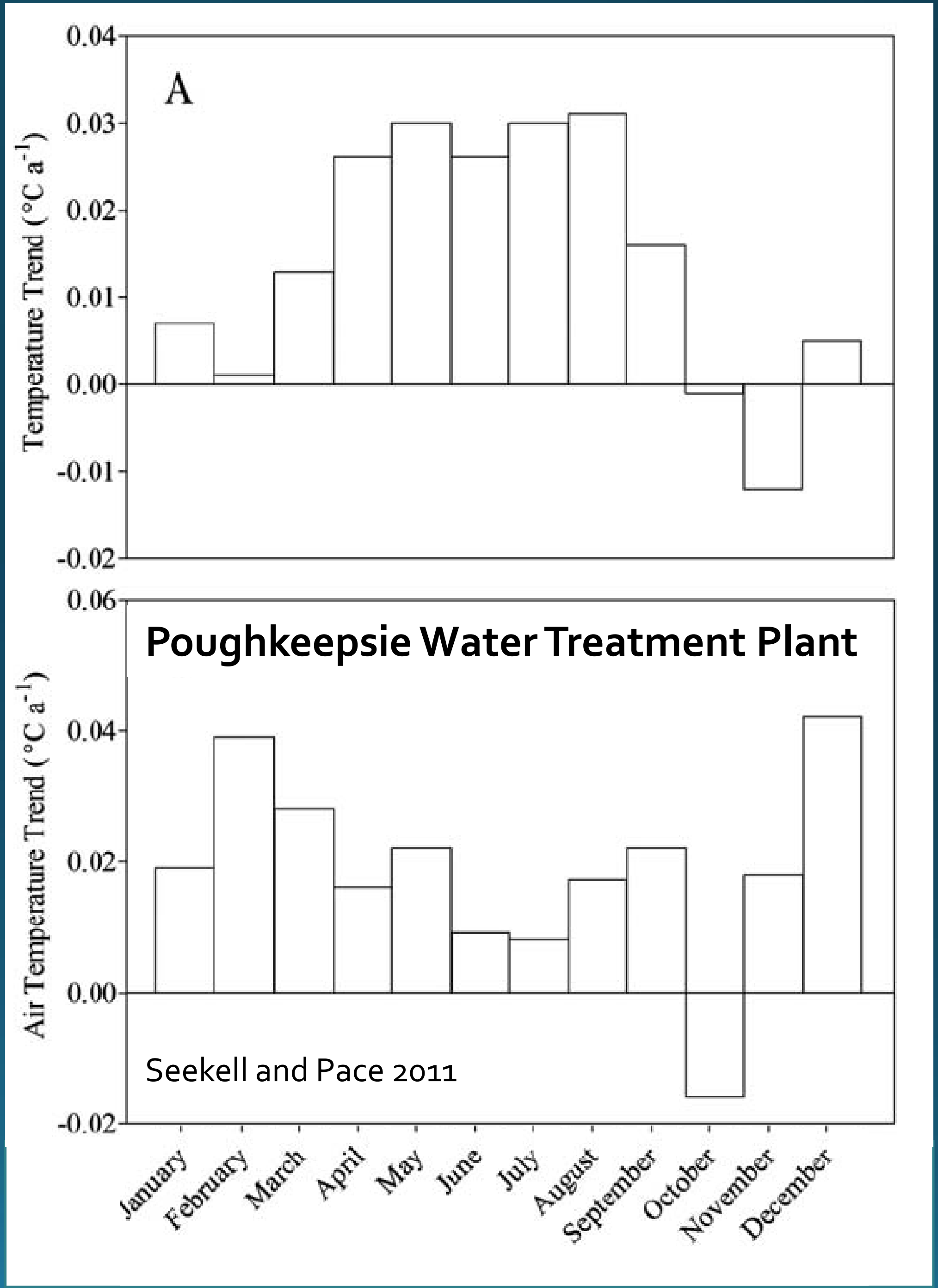
How to succeed as a fish: don't go it alone! Individual fish rarely succeed but populations do.

- Uncertain times: Emerging trends of climate forcing in the Hudson River Estuary
- Success in the Hudson River Estuary: the diadromous tribe
- Hudson River fish's bag of tricks
  - Changed life history traits in white perch
  - Multiple migration behaviors in striped bass and eels
- Stewardship of success in uncertain times: the portfolio effect

Warming: Subtle but increasing (Seekel and Pace 2011)

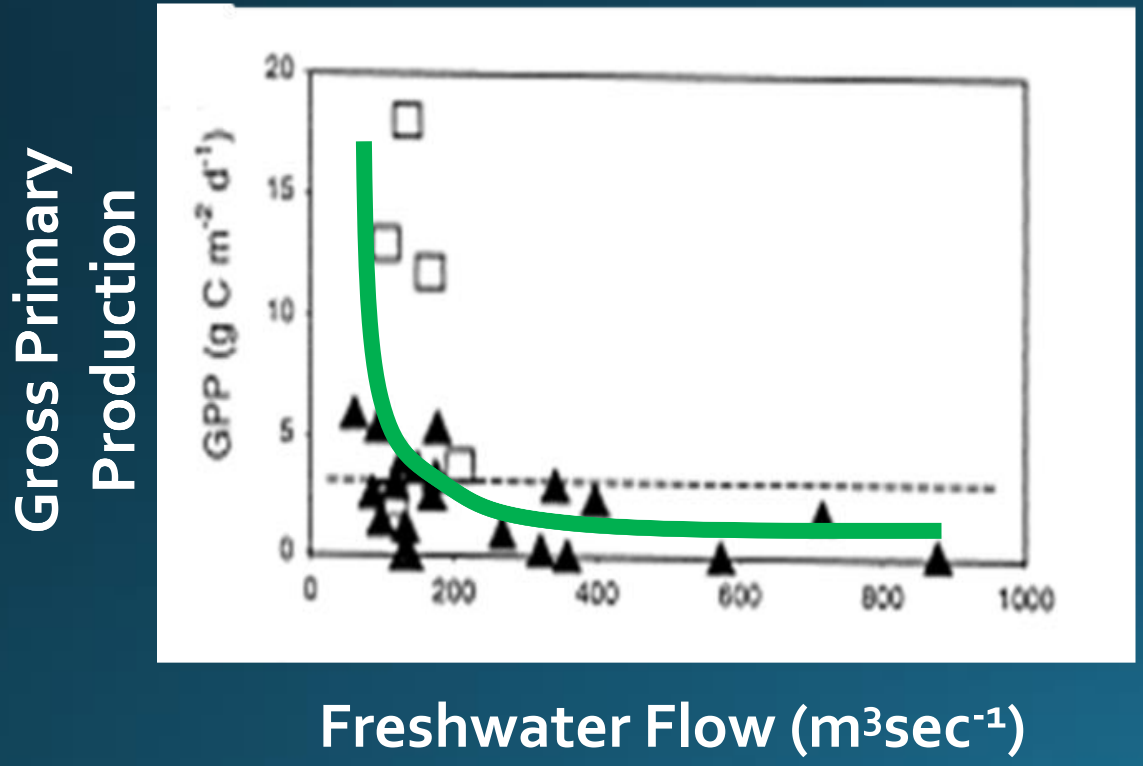
1908-2008:

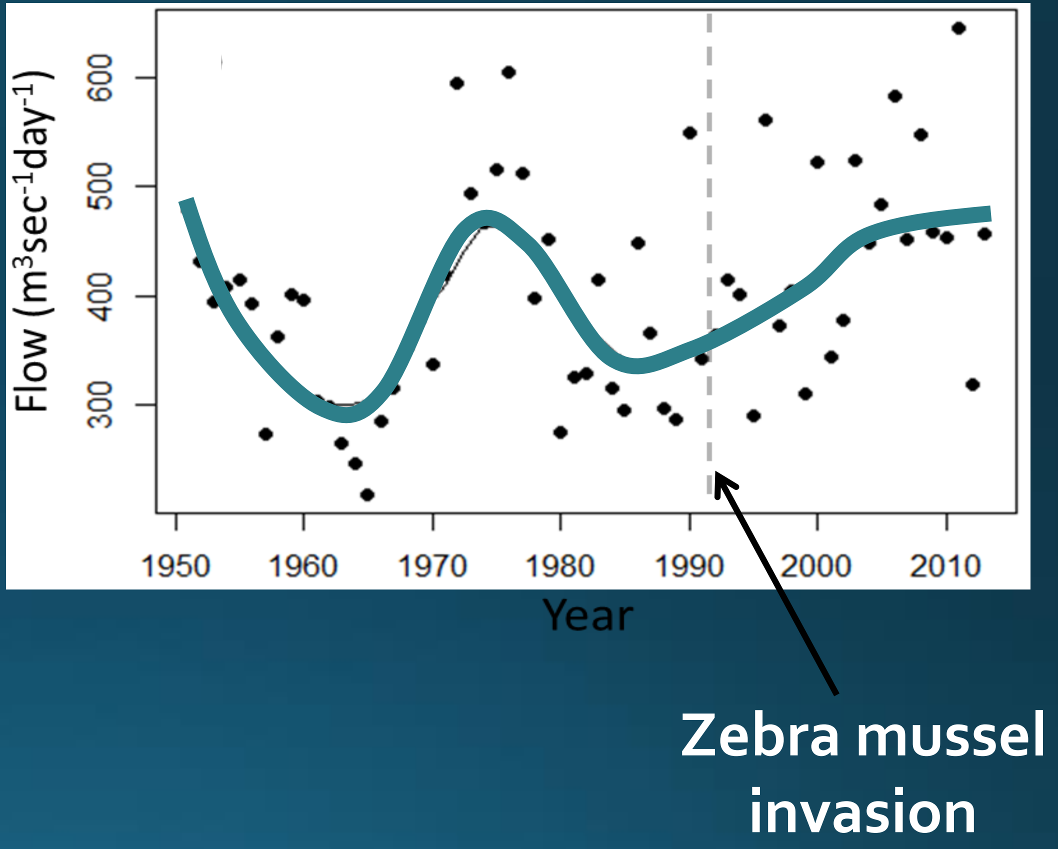
- 1 C increase since 1946; 0.015 C yr^{-1}
- Correlated with air temperature
- Non-uniform across seasons



Flow: Master Switch (Howarth 2000)

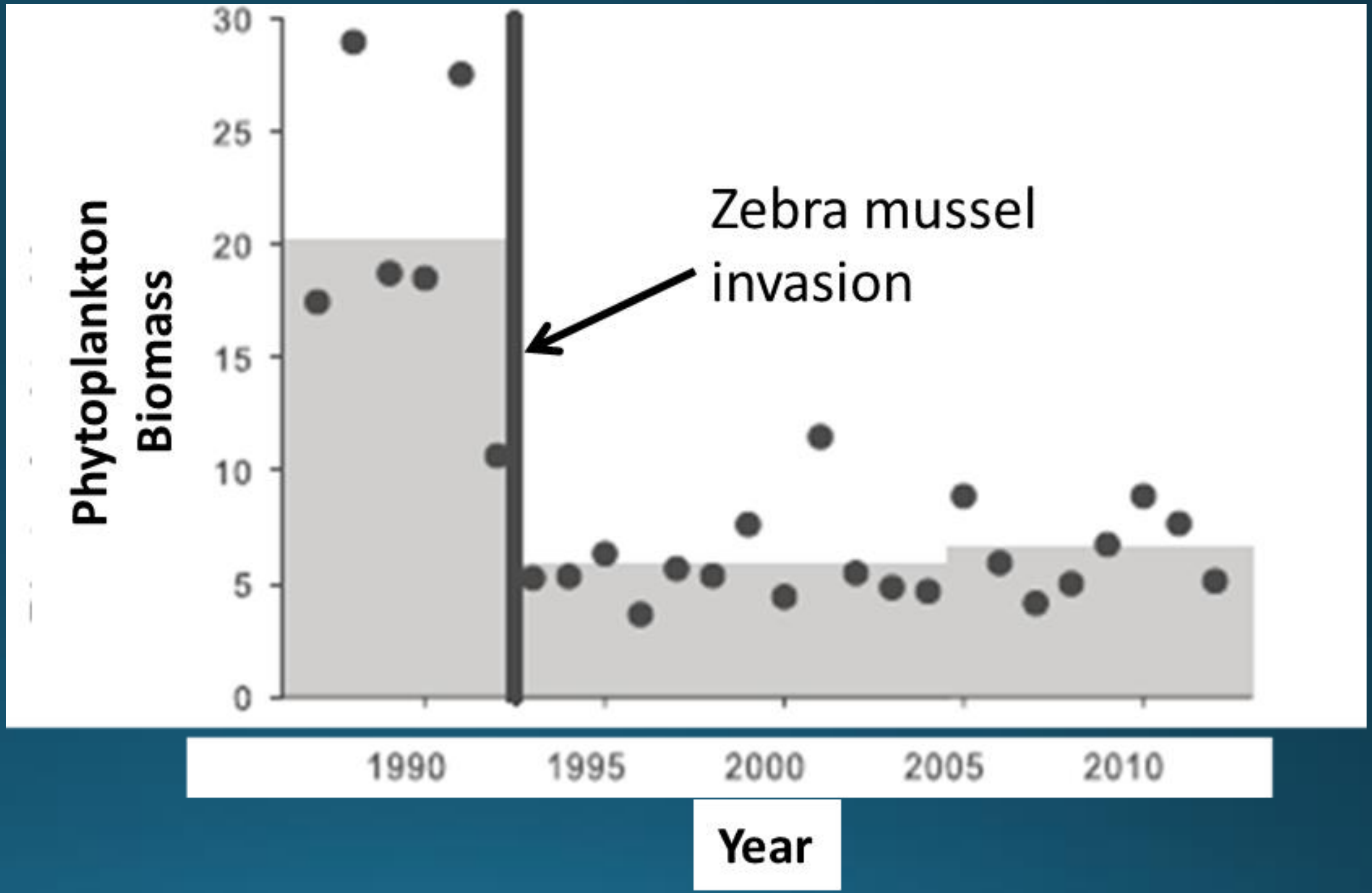
- Retention, primary production inversely related to flow
- 20% increase since 1950





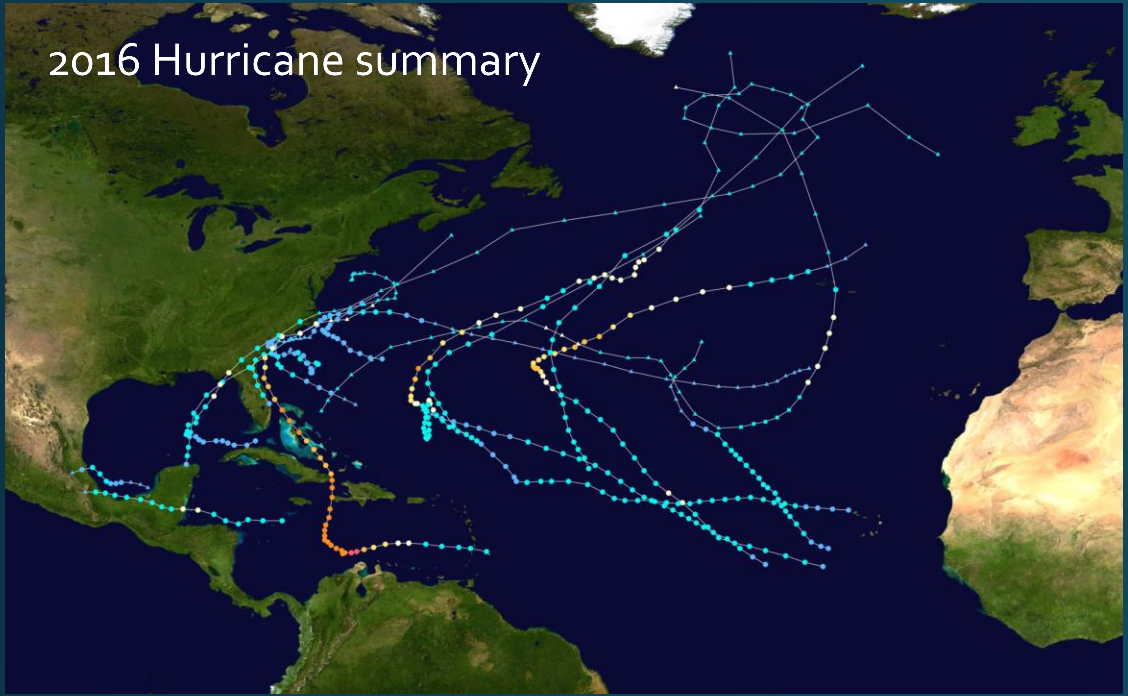
Zebra mussels invaded tidal freshwater in 1991

- Reduced productivity
- Effects amplified flow effects
- **Ecosystem shift**



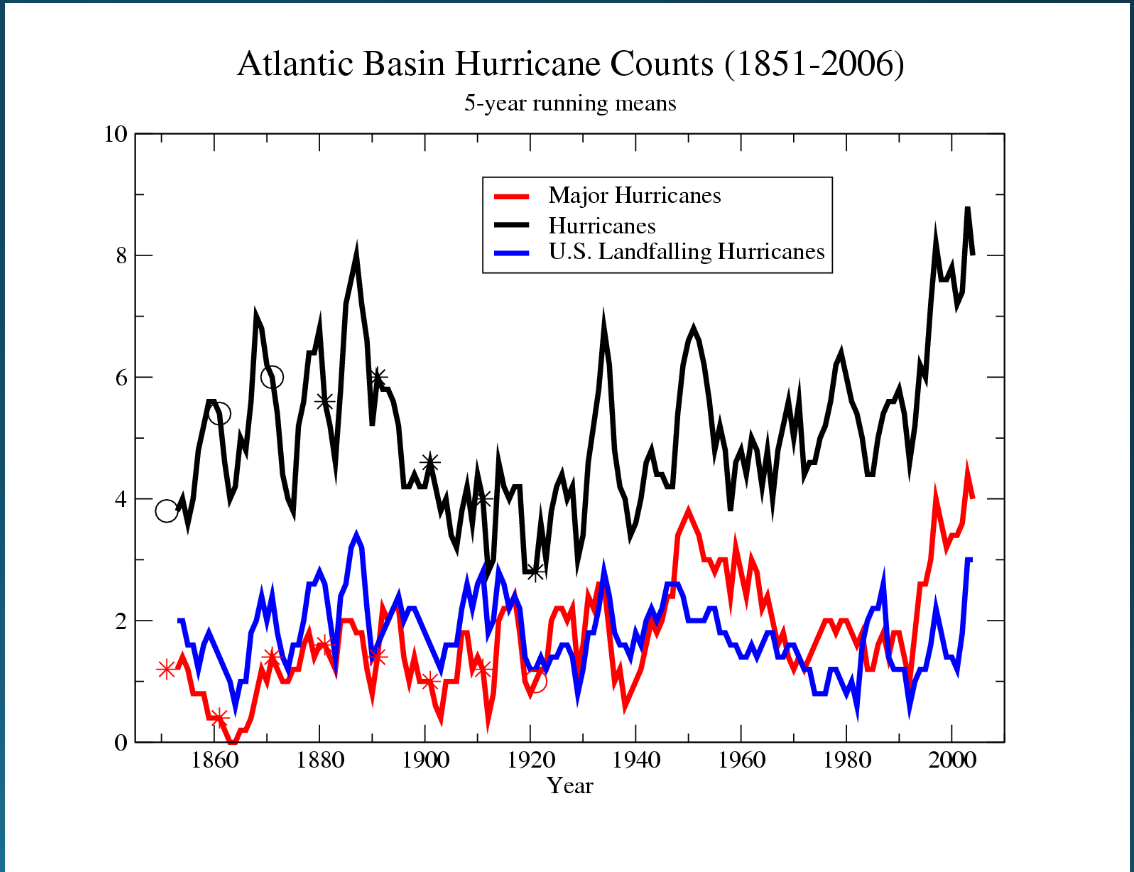
* Indexed by chlorophyll-a concentration (μg/L)

Figure: Strayer et al. (2014)



Wikimedia Commons

Increased intensity and frequency of extratropical storms



https://www.gfdl.noaa.gov/global-warming-and-hurricanes/

Double Hit (summer '11)

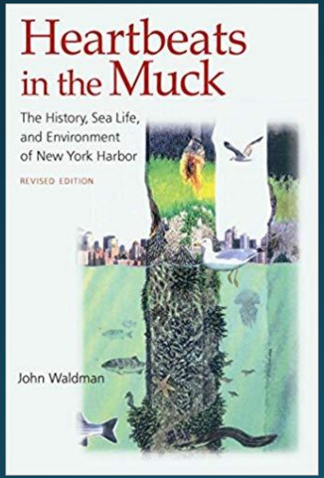
TS Irene

TS Lee

The Striped Bass Who Ate Manhattan – an exception within the NY diadromous tribe?

Species	HR Status	Among other Mid Atlantic, NE systems…
Atl sturgeon	Stable	Largest
Shortnose sturgeon	Large, Recovered	Largest
Striped bass	Large, harvested	One of two largest (Ches) Overfished
Alosa spp	Declining (shad)	Unknown; Genus fully represented, recently supported harvest
American eel	Ubiquitous	Unknown
White perch	Ubiquitous, dominant	Unknown

*Presenter's interpretations based on ASMFC assessments, scientific reports, Waldman 2006



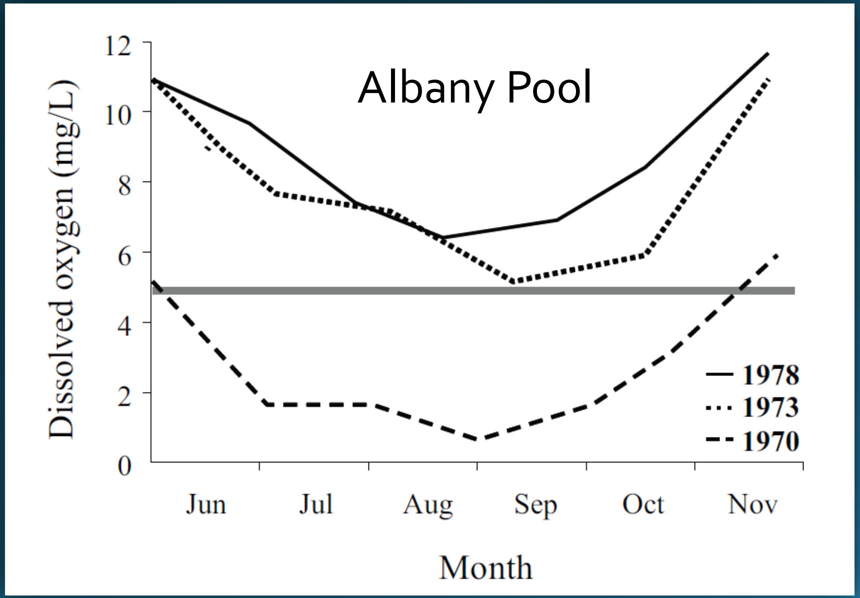
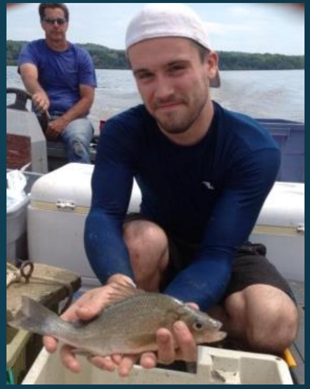
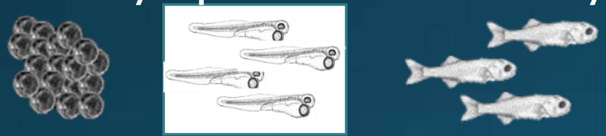


Figure from Woodland et al. 2009. Am. Fish. Soc. Symp. 69: 589-604.

Life Cycle Adaptation to Climate (Ecosystem) Change: White Perch

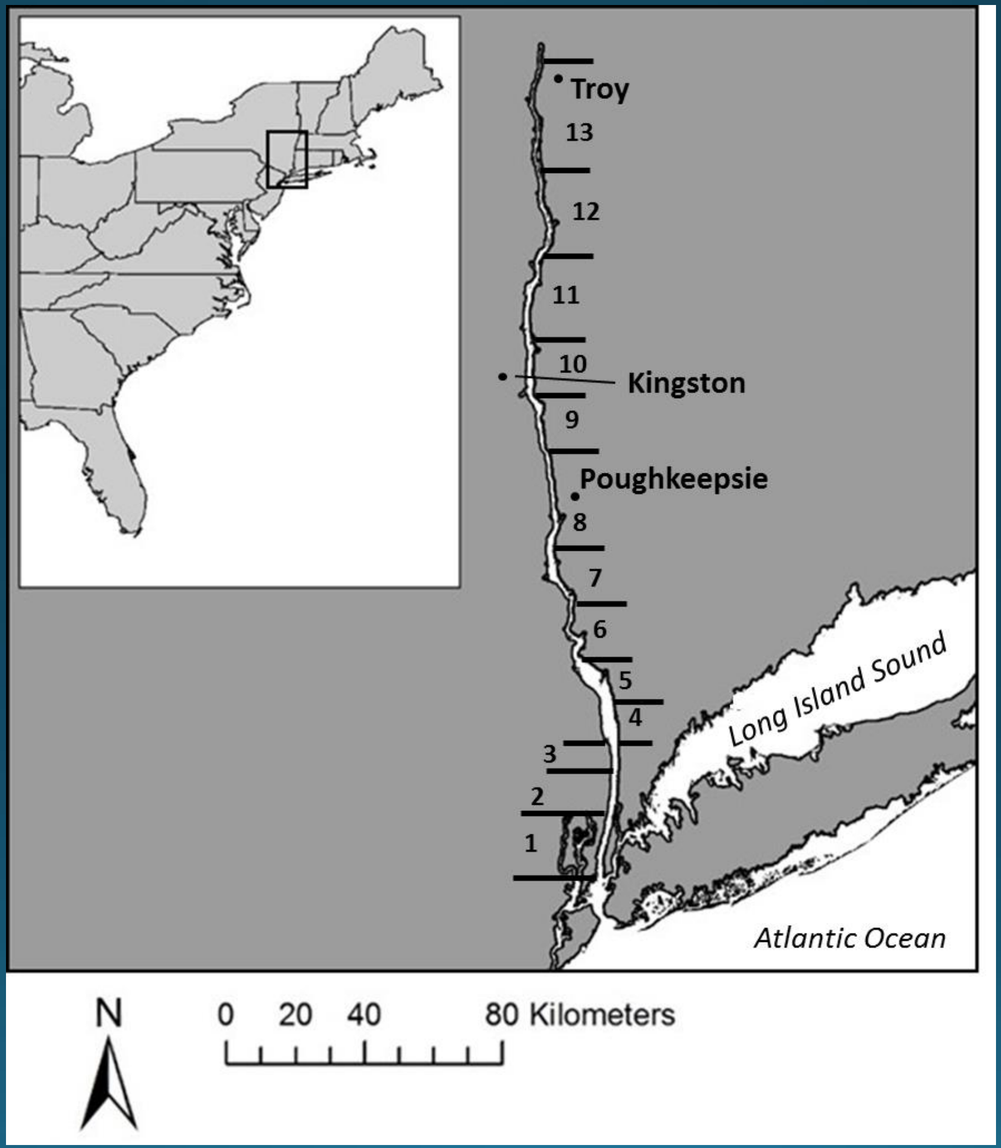


- Utility companies have sponsored fish monitoring programs since 1974
  - Estimate standing stocks
  - 13 river sections
- Three separate surveys
  - Ichthyoplankton survey



  - Beach seine survey

  - Fall shoal survey



Gallagher, B. and D. Secor. 2018. Intensified environmental and density-dependent regulation of white perch recruitment after an ecosystem shift in the Hudson River Estuary. Canadian Journal of Fisheries and Aquatic Sciences 75:36-46.

Data providers:

- John Young
- David Strayer

HUDSON RIVER FOUNDATION

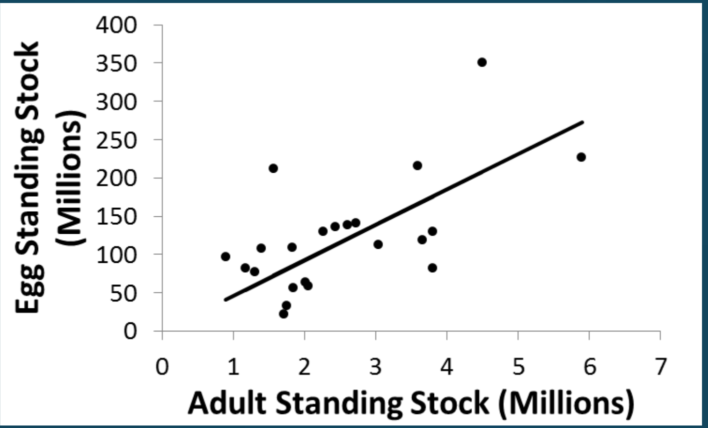
Life Cycle Analysis

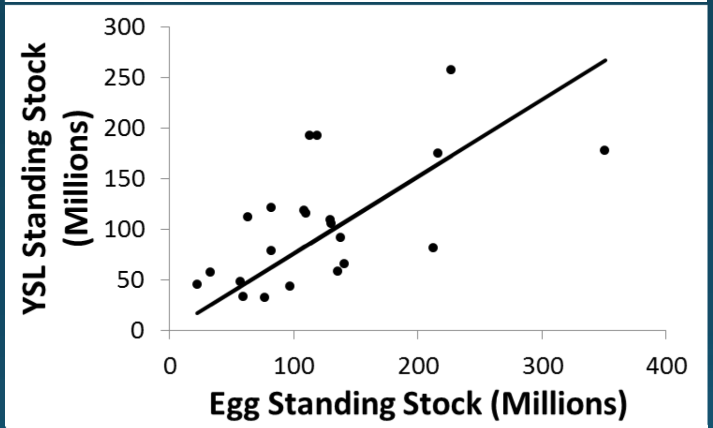
- Standing stocks of early life-stages were proportional to that of their previous stage

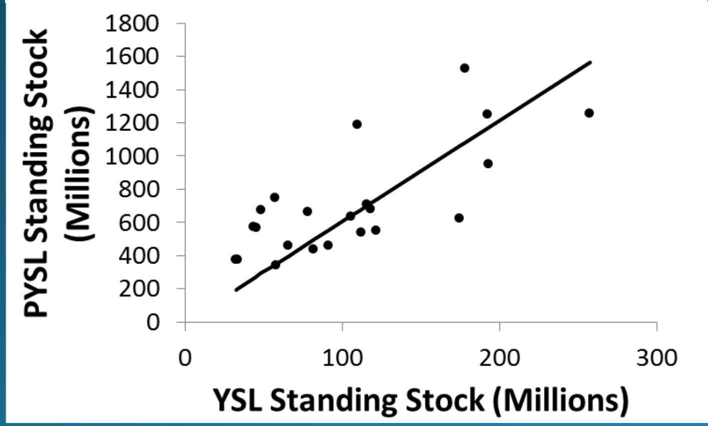
- All early life-stages were proportional to adults

- **Adult abundance controls larval abundance**

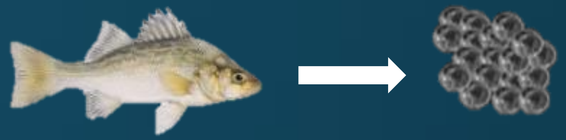
  - Density-independent



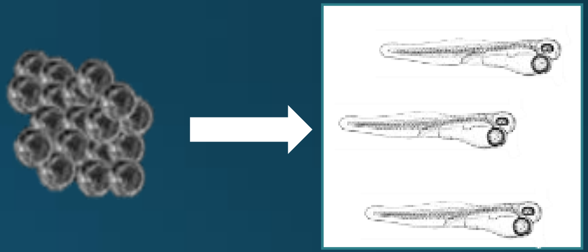




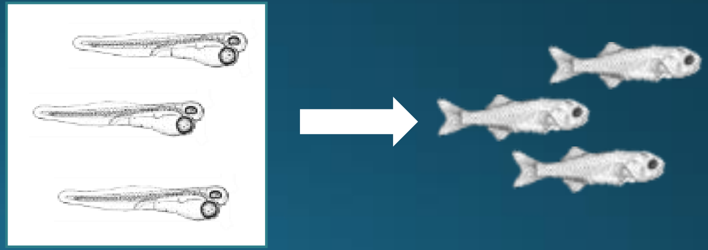
<u>x</u> <u>y</u>



$R^2 = 0.38$

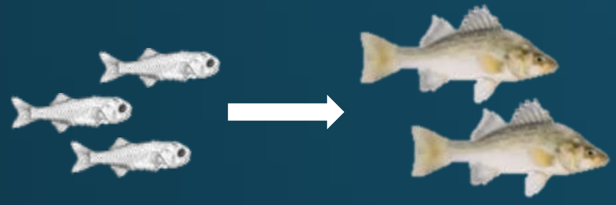


$R^2 = 0.36$

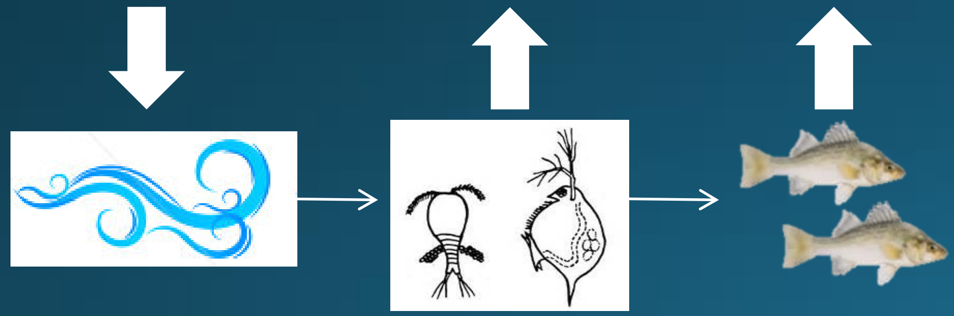


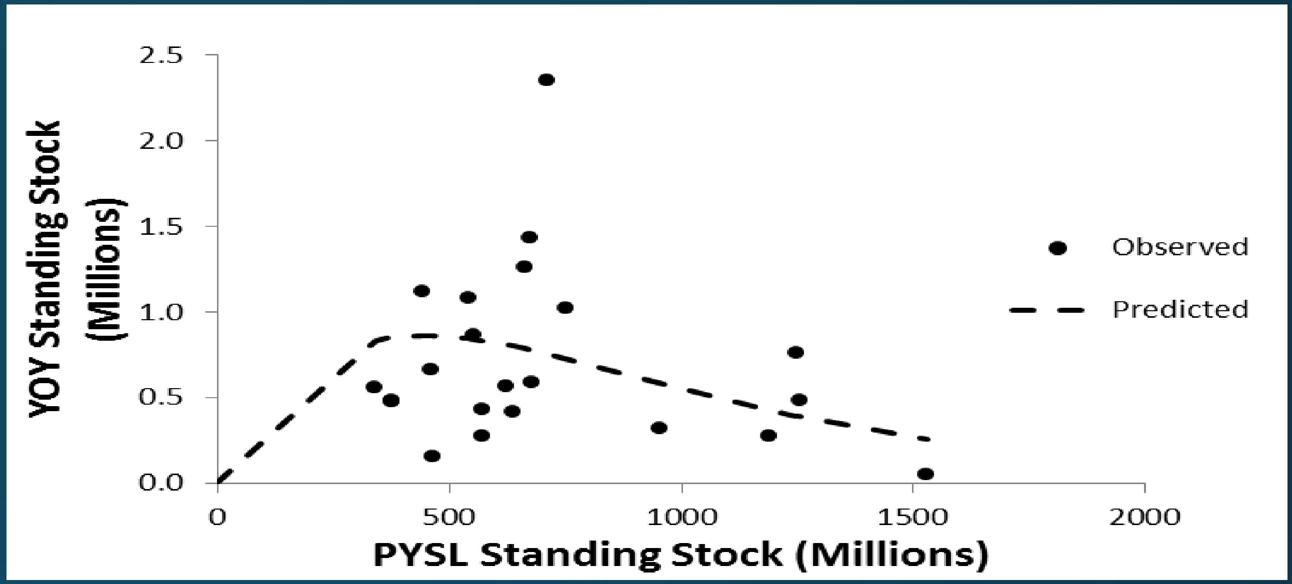
$R^2 = 0.49$

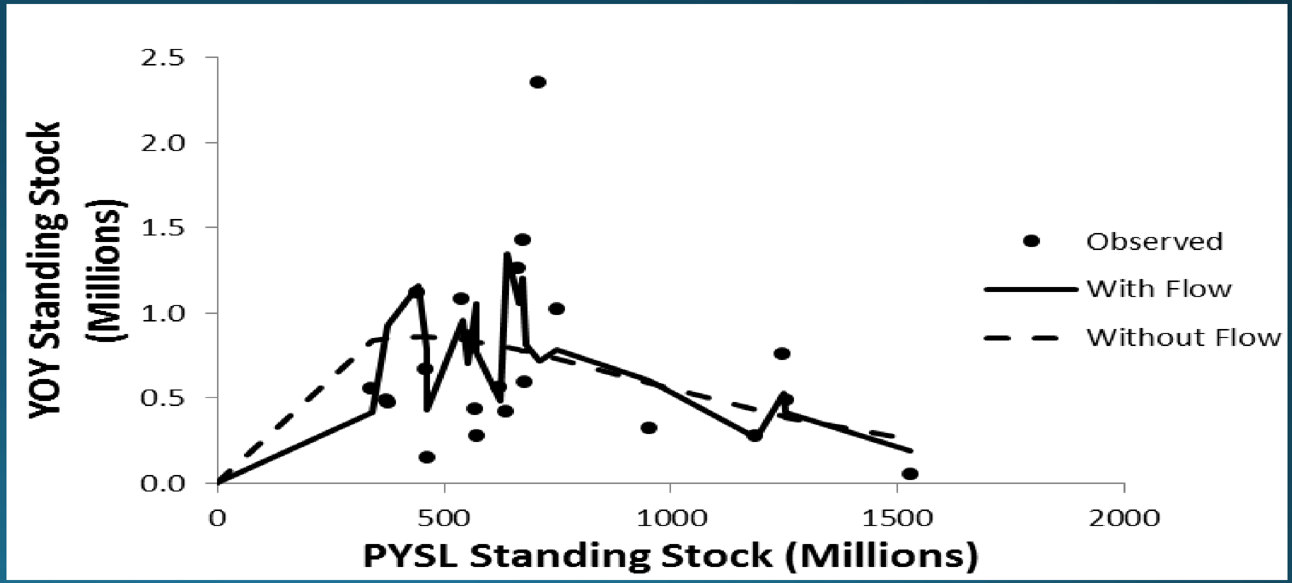
Life Cycle Analysis



- **Strong density-dependence** at high PYSL abundance
  - Higher mortality
- Model selection supported the inclusion of freshwater flow during the PYSL period
  - **Negative effect**

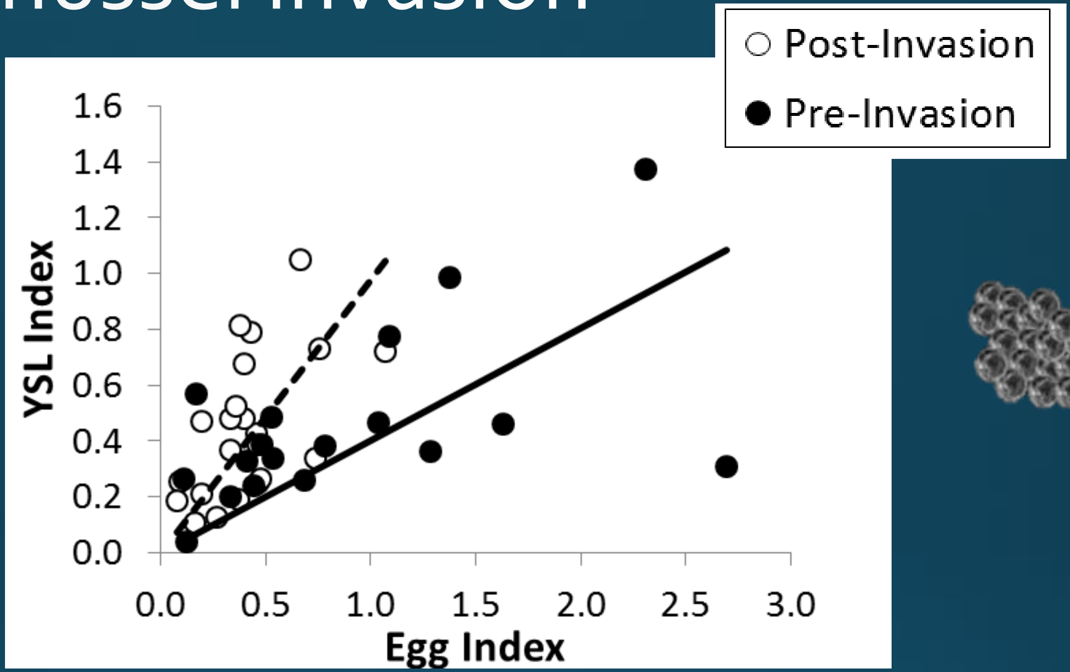


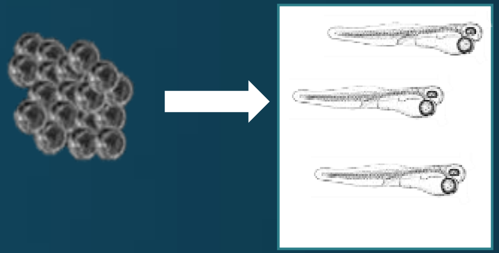


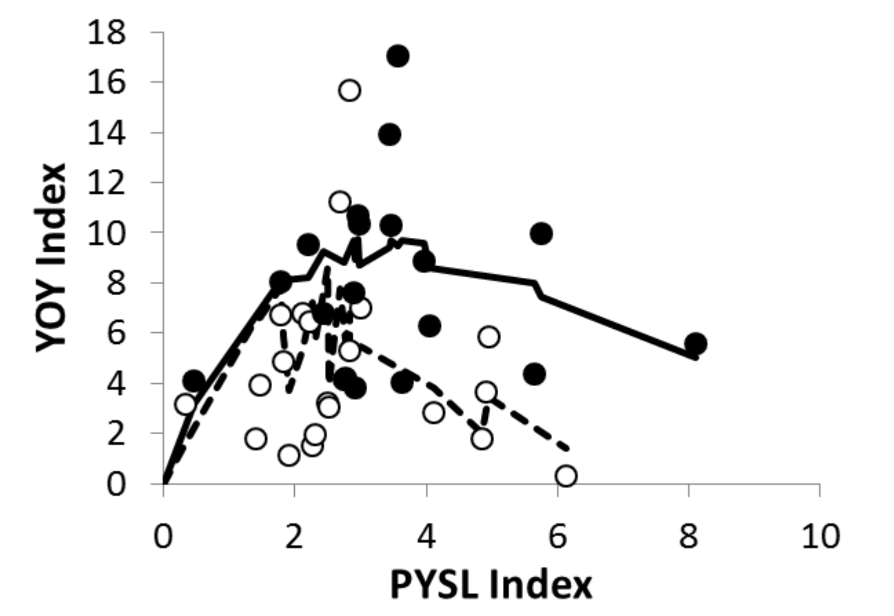


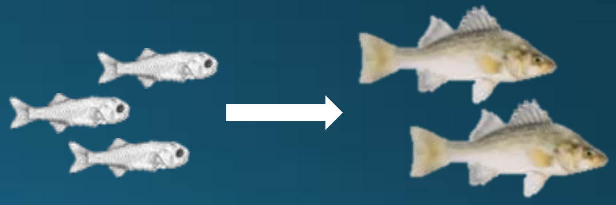
Effects of the zebra mussel invasion

- Egg production decreased 50%
- Egg-YSL relationship became steeper
- YOY abundance decreased 40%
- YOY production showed increased sensitivity to density-dependence and flow

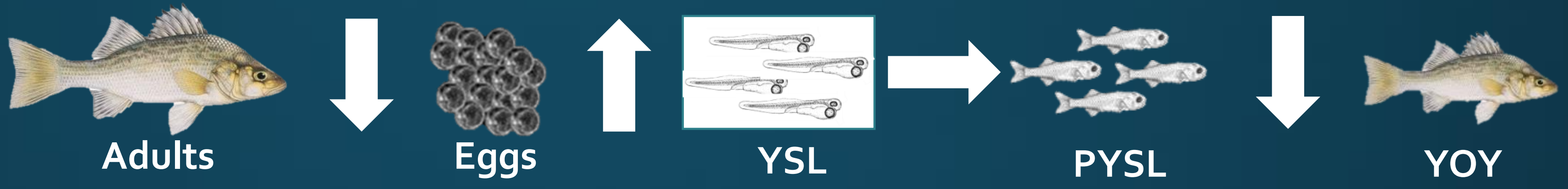






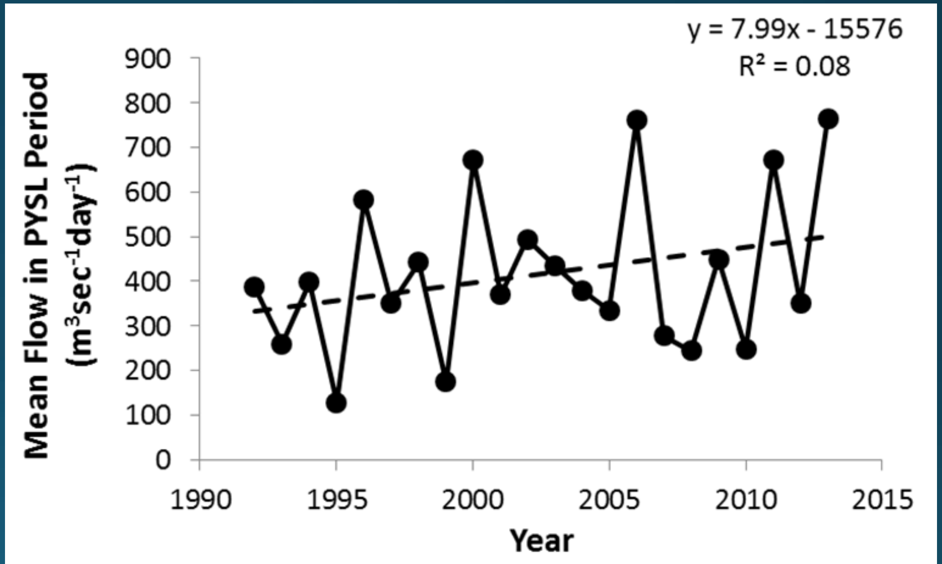


Life Cycle Adaptation to Climate (Ecosystem) Change: White Perch



- Life cycle sensitivity to flow increased after zebra mussel invasion
- YSL survival apparently compensated for reduced egg production
- YOY production decreased and showed increased sensitivity to flow followng zebra mussel invasion
- Flow during PYSL period increased

  by 2% per year from 1992-2013
- Flow to increase by 10-15% by 2100 (Najjar et al. 2009)



Hudson River Striped Bass Contingents

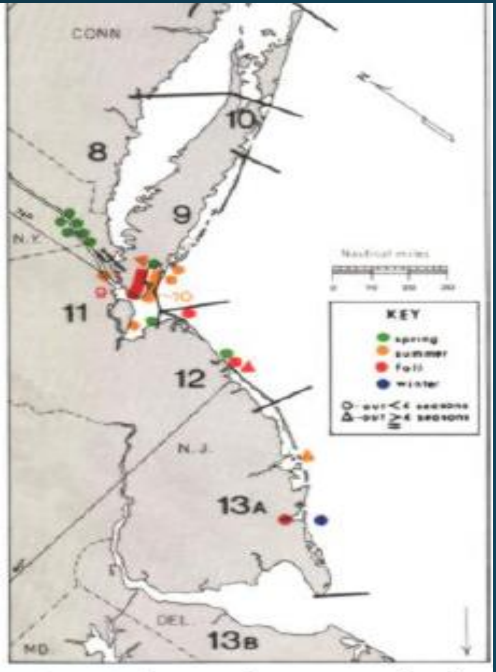
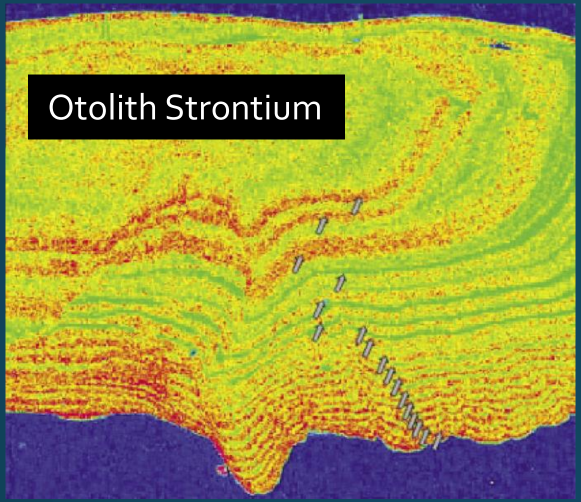


FIGURE 19.—Recaptures from summer tagging, Area 11, New York Bay.

Clark. 1968. TAFS.



Secor, D. H. and P. M. Piccoli. 1996. Age- and sex-dependent migrations of the Hudson River striped bass population determined from otolith microanalysis. Estuaries 19:778-793.

Zlokovitz, E. R. and D. H. Secor. 1999. Effect of habitat use on PCB body burden in fall-collected, Hudson River striped bass (*Morone saxatilis*). Can. J. Fish. Aquat. Sci. 56 (Suppl.1):86-93.

Ashley, J. T. F, D. H. Secor, E. Zlokovitz, J. E. Baker and S. Q. Wales. 2000. Linking habitat use of Hudson River striped bass to accumulation of polychorinated biphenyl congeners. Environ. Sci. Tech. 34:1023-1029.

Secor, D. H., J. R. Rooker, E. Zlokovitz and V. S. Zdanowicz. 2001. Identification of riverine, estuarine, and coastal contingents of Hudson River striped bass based upon otolith elemental fingerprints. Mar. Ecol. Prog. Ser. 211:245-253.

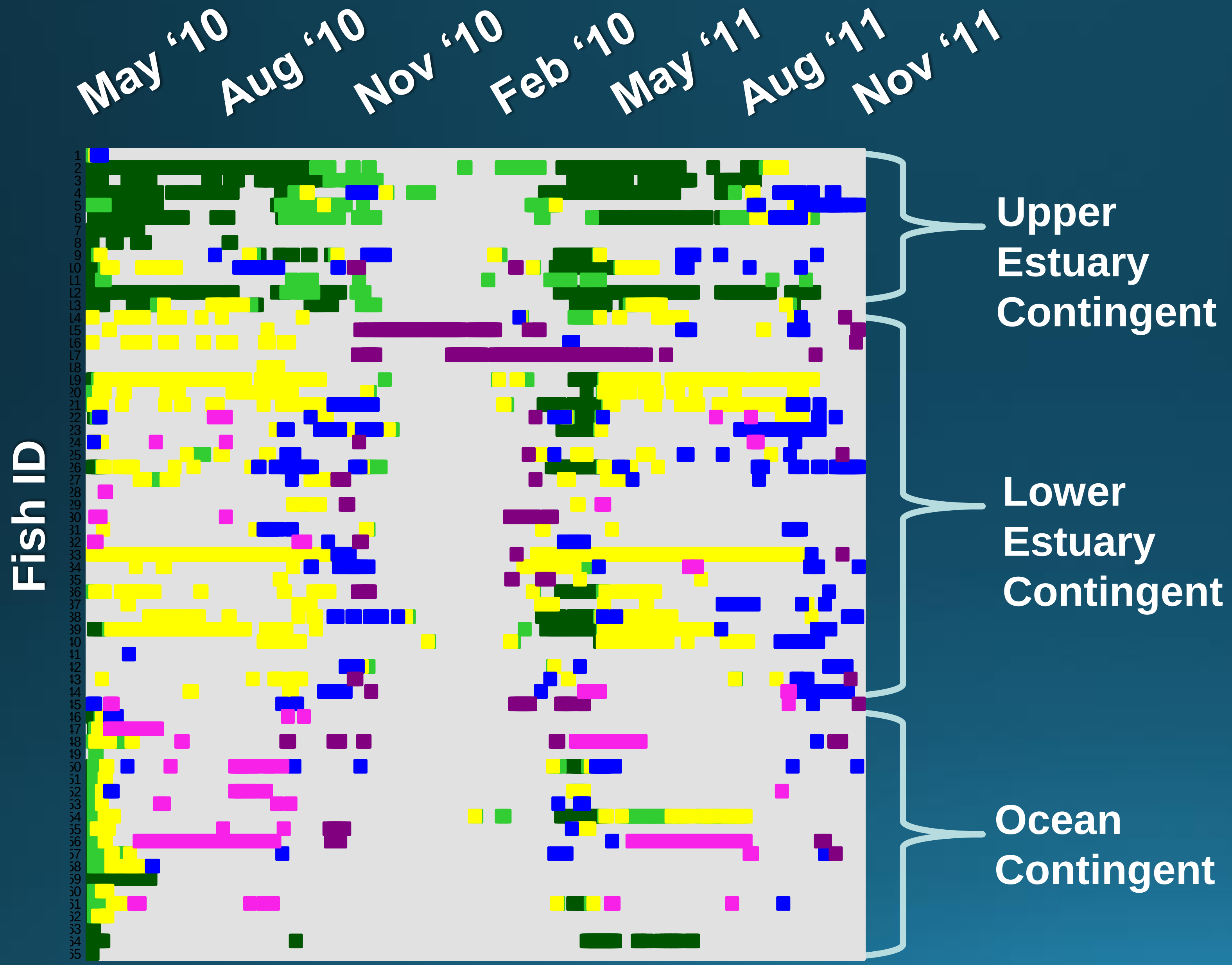
Zlokovitz, E.R., D.H. Secor, and P.M. Piccoli. 2003. Patterns of migration in Hudson River striped bass as determined by otolith microchemistry. Fisheries Research 63: 245-259

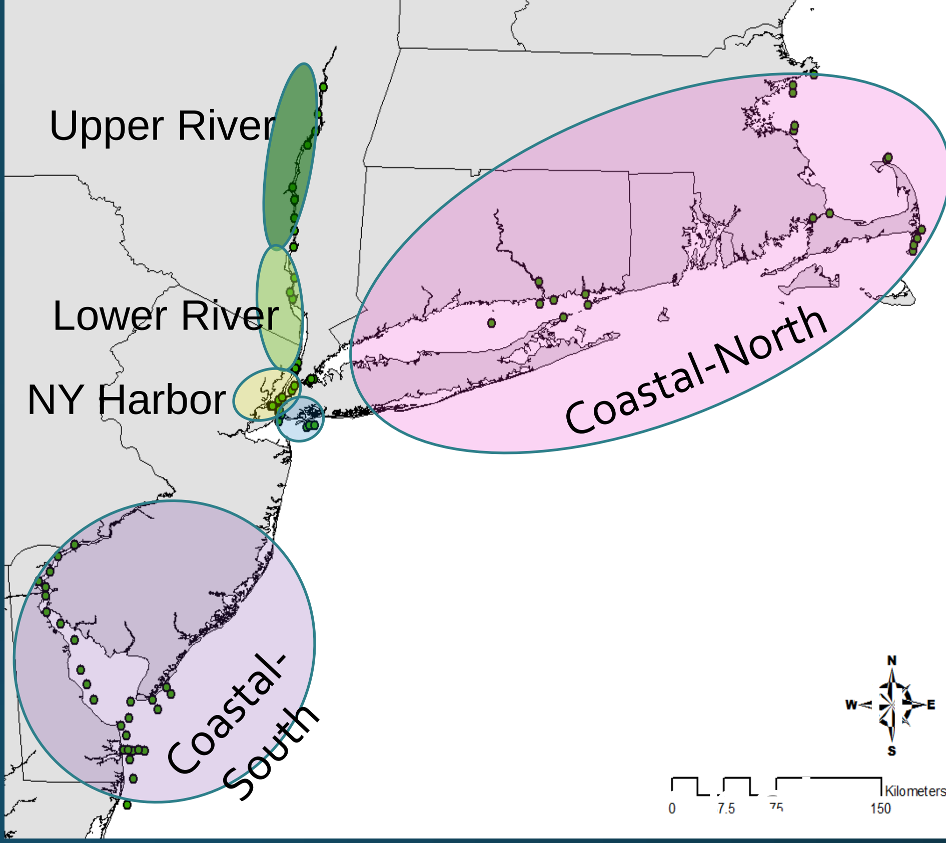
Wingate, R.L. and D.H. Secor. 2007. Intercept telemetry of the resident contingent of Hudson River striped bass: migration and homing patterns. Trans. Am. Fish. Soc. 136: 95–104

Gahagan, B.I., D.A. Fox, and D.H. Secor. 2015. Partial migration of striped bass: Revisiting the contingent hypothesis. Marine Ecology Progress Series 525: 185-197

Bailey, H. and D.H. Secor. 2016. Coastal evacuations by fish during extreme weather events. Scientific Reports. 6:30280 | DOI: 10.1038/srep30280

Hudson River Striped Bass Migration Sheet Music





HUDSON RIVER FOUNDATION
for Science & Environmental Research, Inc.

Gahagan, B.I., D.A. Fox, and D.H. Secor. 2015. Partial migration of striped bass: Revisiting the contingent hypothesis. Marine Ecology Progress Series 525: 185-197

Striped Bass Provincials

Resident to Hudson River

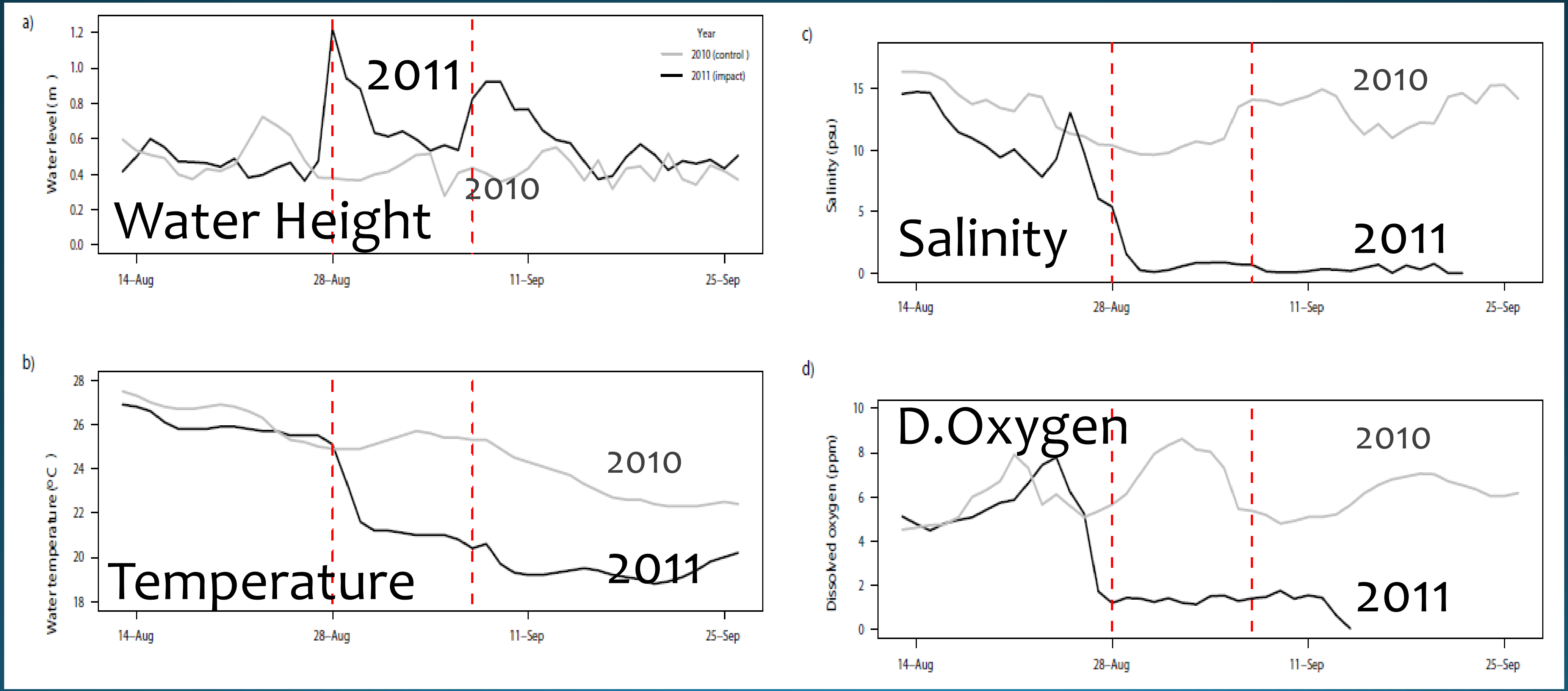
New York Harbor denizen

Double Hit (summer ‘11)

TS Irene TS Lee

?

TS Irene TS Lee



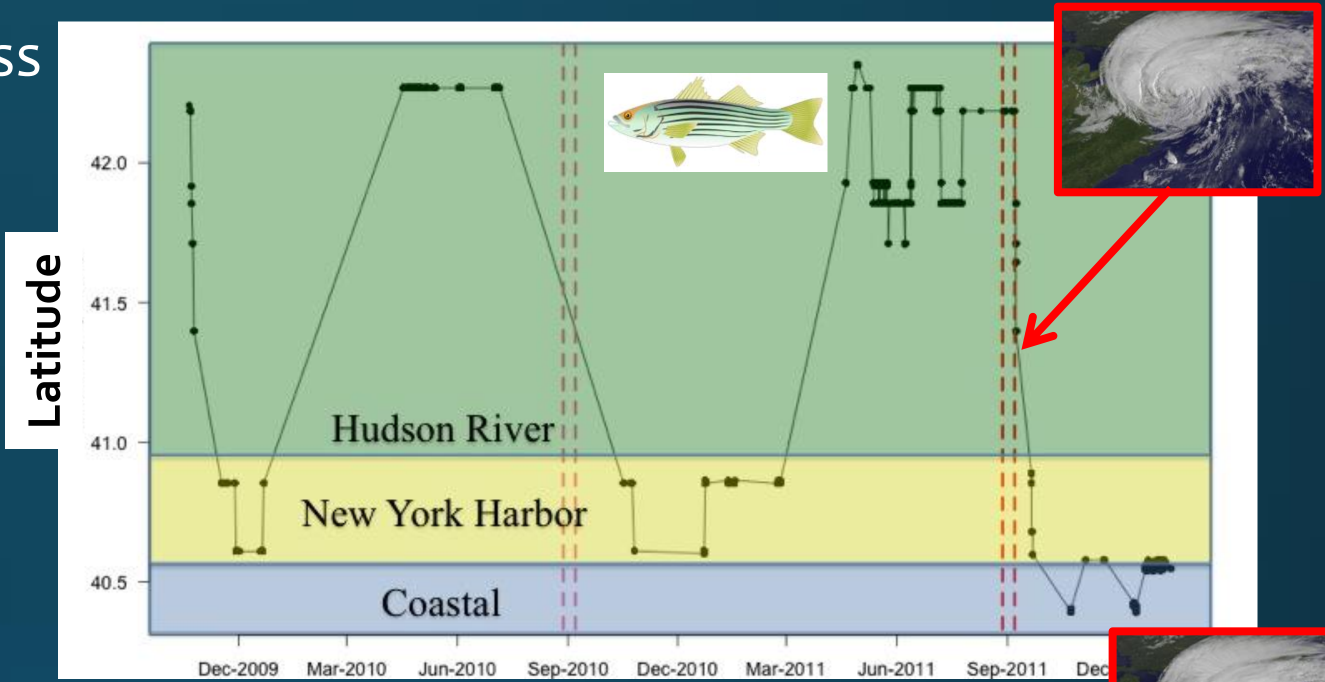
Event Driven Evacuations by HR Striped Bass

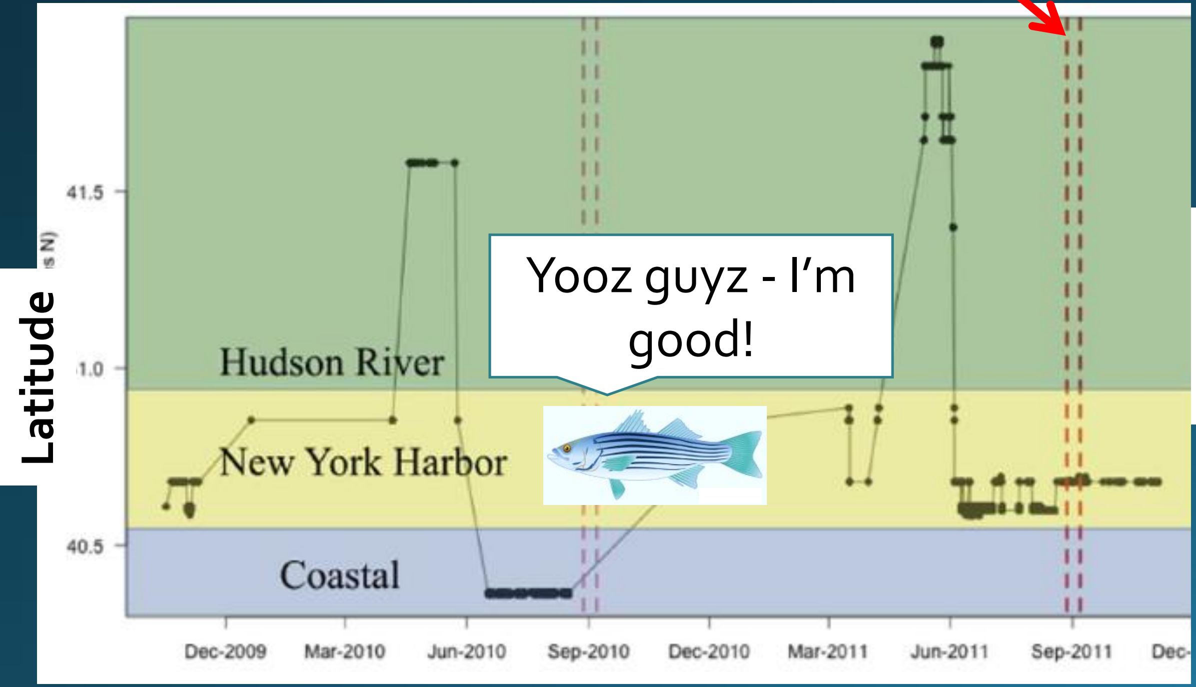
H. Bailey and D. Secor (2016)

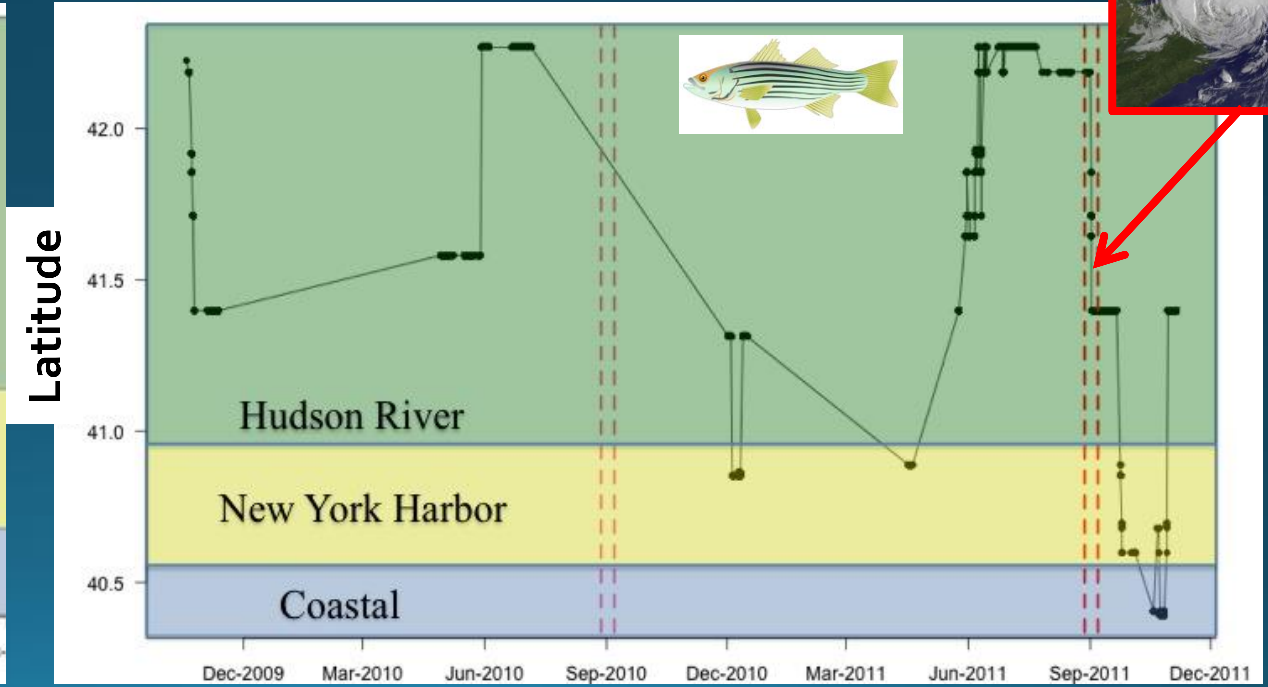

SCIENTIFIC REPORTS

OPEN Coastal evacuations by fish during extreme weather events

Helen Bailey & David H. Secor

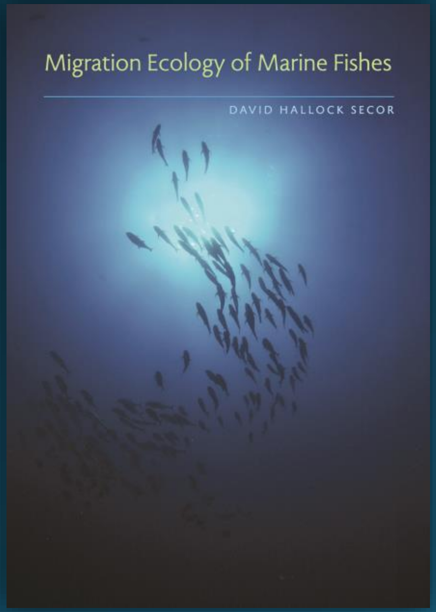


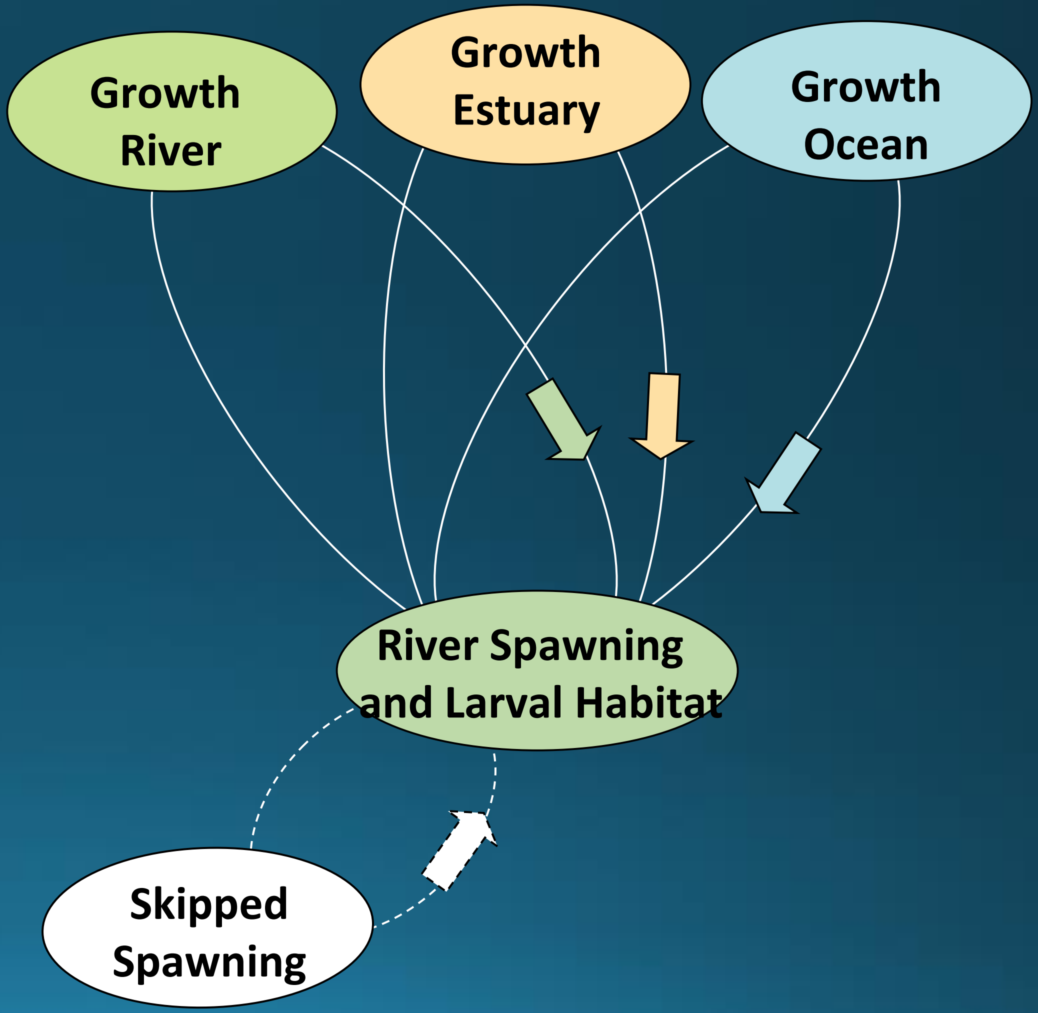




Incomplete Evacuation

- Migration is a collective behavior, giving rise to modes of behaviors within groups (aka contingents)
- Partial migration is fundamental (latent) to all animals, whether expressed or not
- As an emergent behavior partial migration allows,
    - Adaptation
    - Persistence
    - Rapid colonization





Promoting Stability: the Portfolio Effect

Minimizing Risk

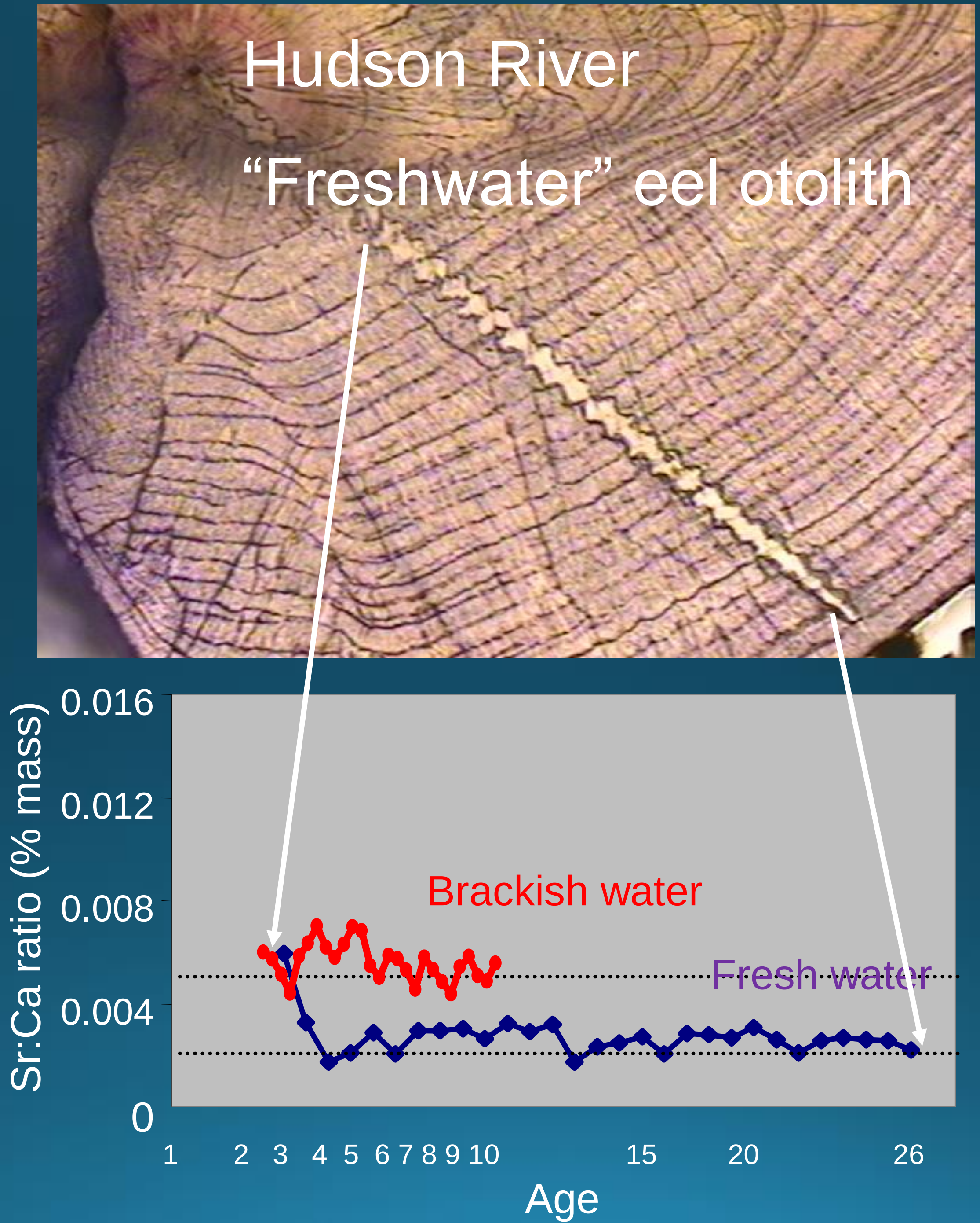
Environmental
Vagaries

Varying Outcomes

Certain Outcome

Many Hudson River eels completed their life cycle w/o entering freshwater

These fish showed higher densities, higher growth rates and lower parasite burdens



Morrison, W. E., D. H. Secor, and P. M. Piccoli. 2003. Estuarine habitat use by Hudson River American eels. Am. Fisheries Society Sympos. 33: 87-99.

Morrison, W.E. and D.H. Secor. 2003. Demographic attributes of yellow-phase American eels in the Hudson River Estuary. Can. J. Fish. Aquat. Sci. 60: 1487-1501

Morrison, W.E. and D.H. Secor. 2004. Abundance of yellow-phase American eels in the Hudson River Estuary. Trans. Am. Fish. Soc. 133: 896-910.

Arslan, Z. and Secor, D.H. 2005. Analysis of trace transition elements and heavy metals in fish otoliths as tracers of habitat use by American eels in the Hudson River estuary. Estuaries. 28: 382-393.

Cairns, D.K., D.H. Secor, W.E. Morrison, and J.A. Hallet. 2009. Salinity-linked growth in anguillid eels and the paradox of temperate-zone anadromy. J. Fish Biol. 74: 2094–2114

Secor, D.H. 2015. American Eel: When Does Diversity Matter? Fisheries 40: 462-463.

Secor. 2015. Fisheries 40:462

I urge the USFWS to give lost freshwater habitats much greater weight as a principal threat...

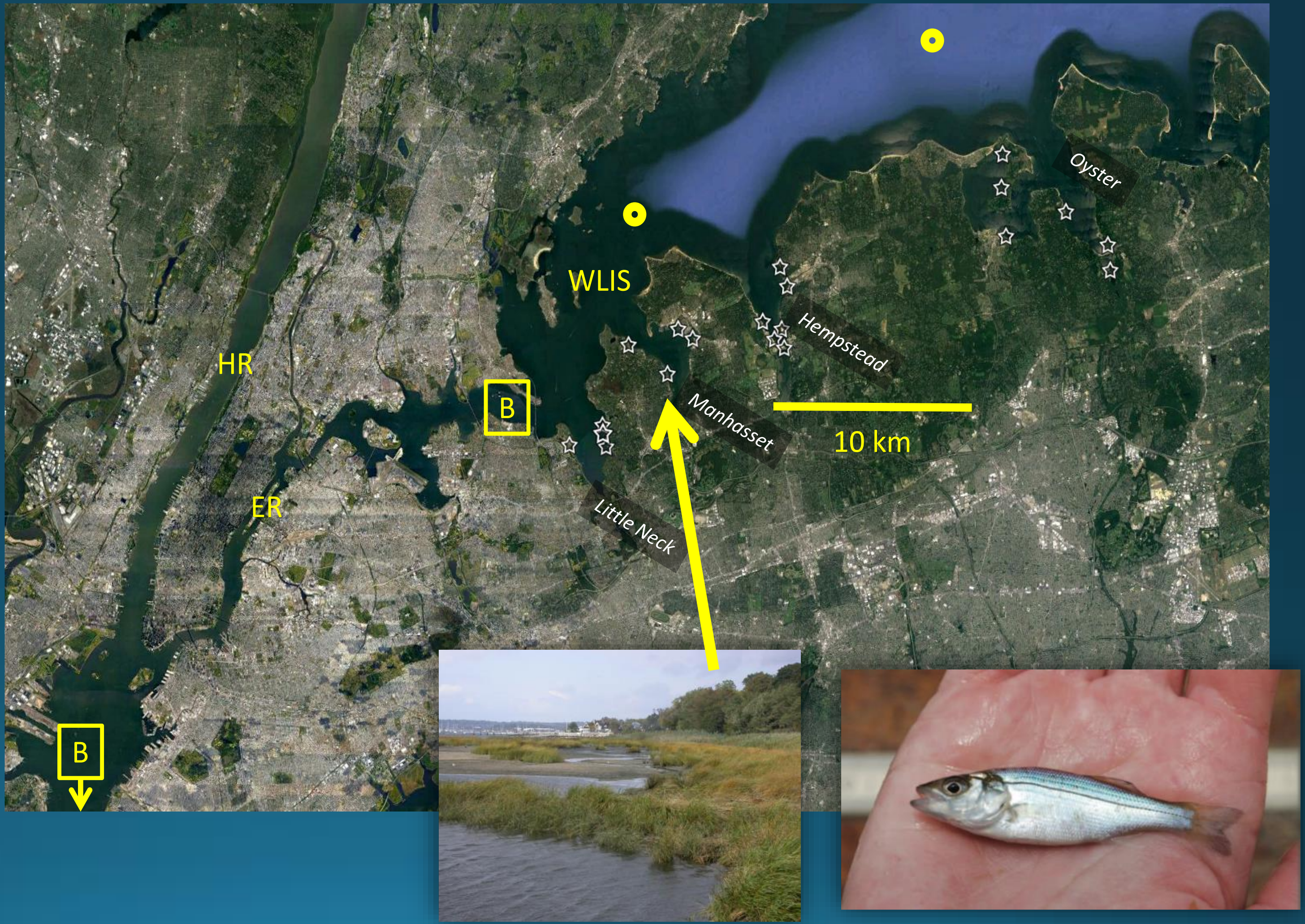
'eels do not rely on freshwater ecosystems'

- Proliferation of low-head dams has curtailed eel access to US watersheds by as much as 80% (ASMFC 2006)
- Eels can complete their life cycle outside of non-tidal freshwater systems
- Justification not to protect American eels under ESA – eels do not rely on non-tidal systems (USFWS 2007, 2015)

Single investment: <u>Eels no longer equipped to succeed!</u>

Coming Attractions? NY Harbor Storm surge barriers, estuarine impoundments

Rendering of storm surge barrier at V. Straits



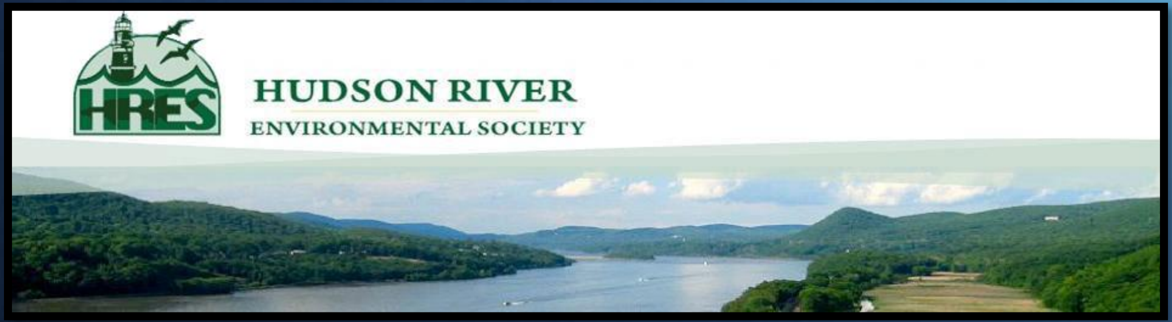
Loss of “extra-HR” nurseries for striped bass and other diadromous species

Diminished Portfolio Effect

Dave Secor

Adaptation to Climate Change: Can we better equip Hudson River fishes to succeed?

- Bag of Tricks: Fish life cycles and migration behaviors produce latent capacity to adapt to climate/ecosystem change
- Bag of Tricks requires maintenance of diversity in life history (age structure, migration behaviors) and habitats (freshwater, estuarine and coastal).



2019 Hudson River Symposium ,Vassar College 8 May