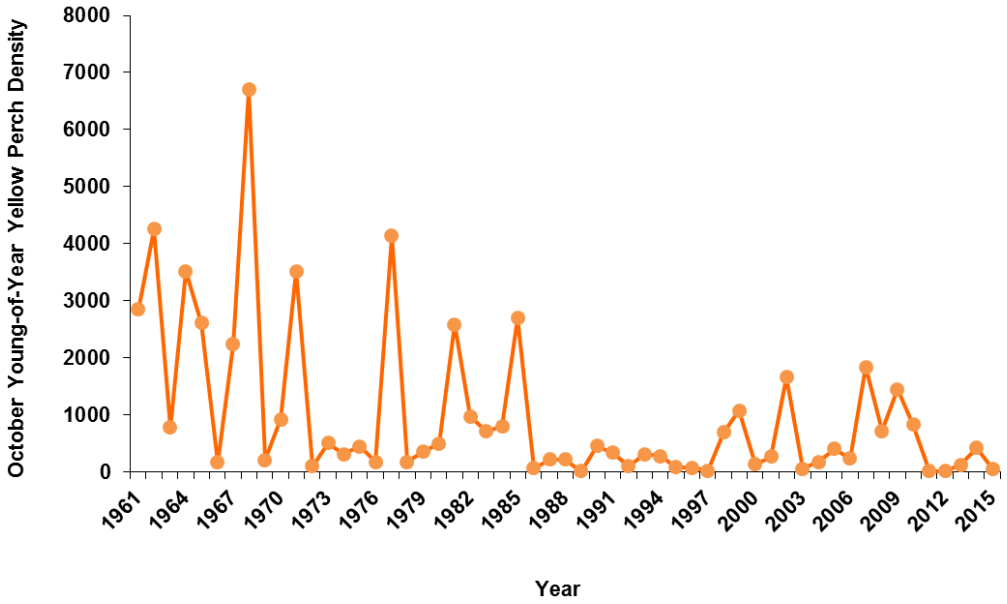
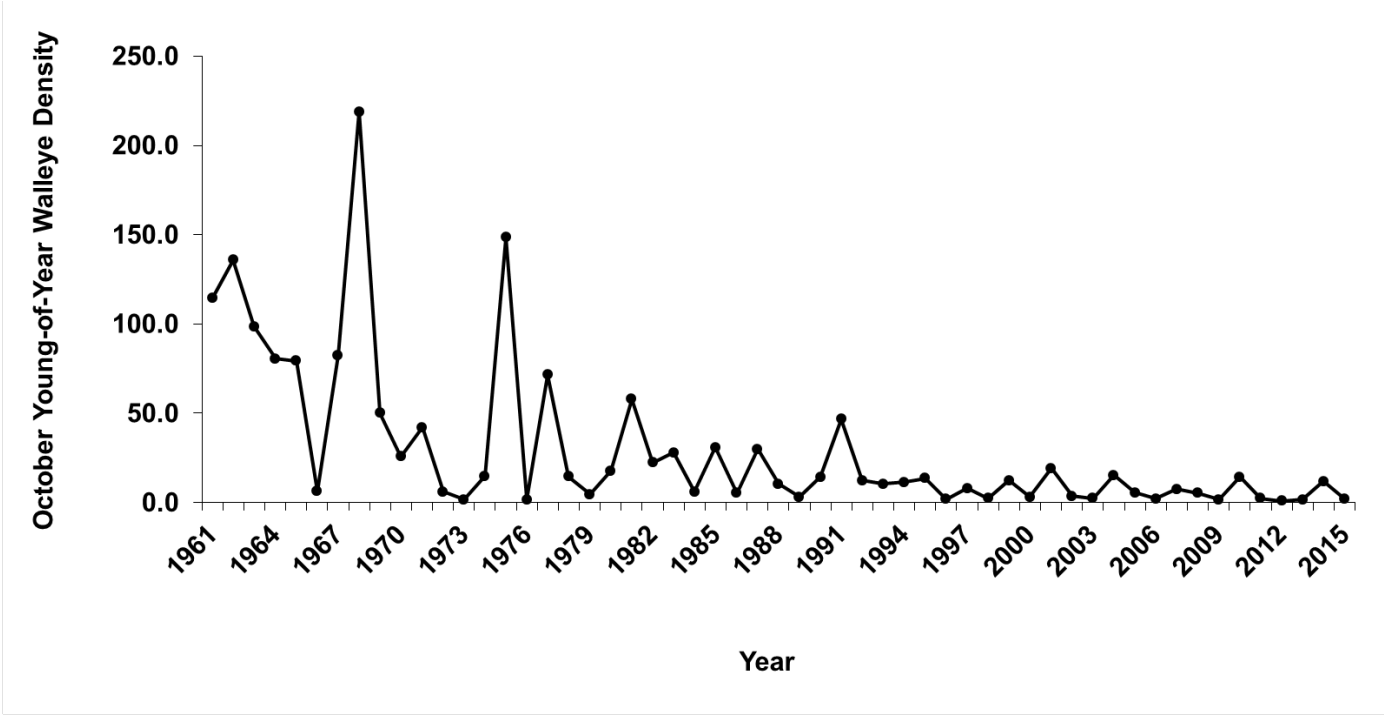
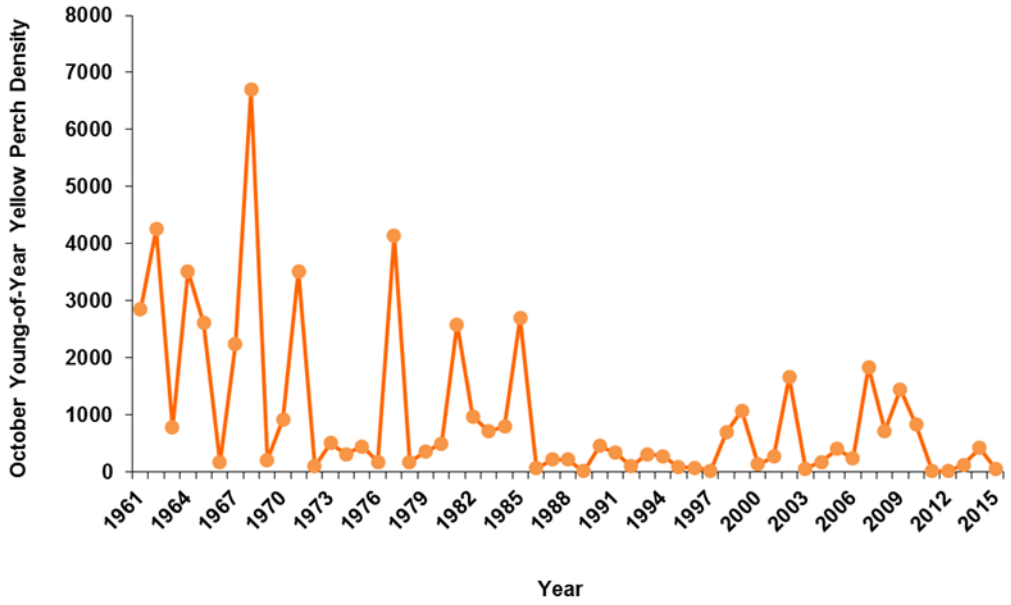
Many Observed Changes Likely Due to Combined Actions of Invasives and Other Physical Changes

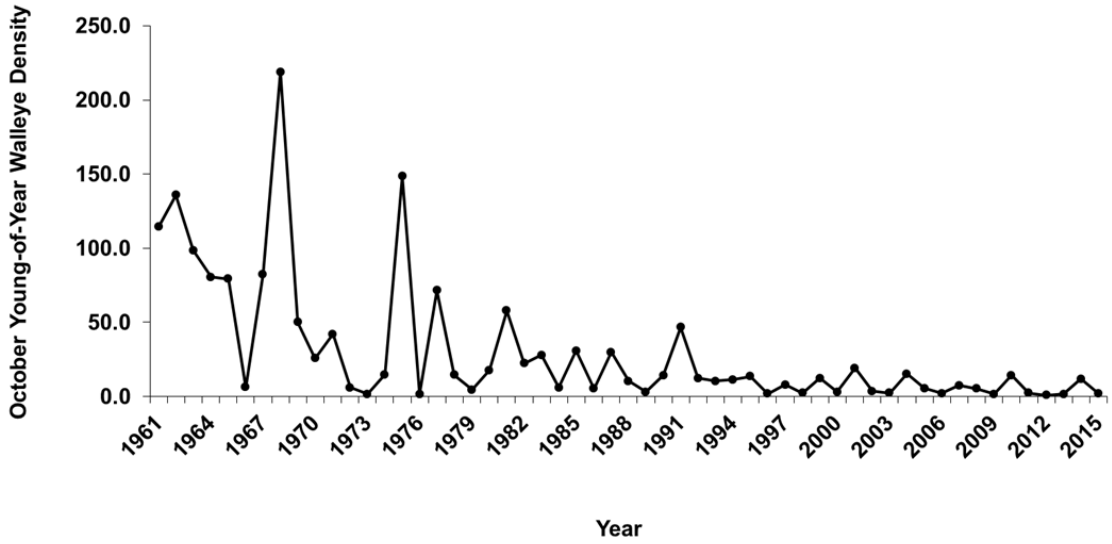


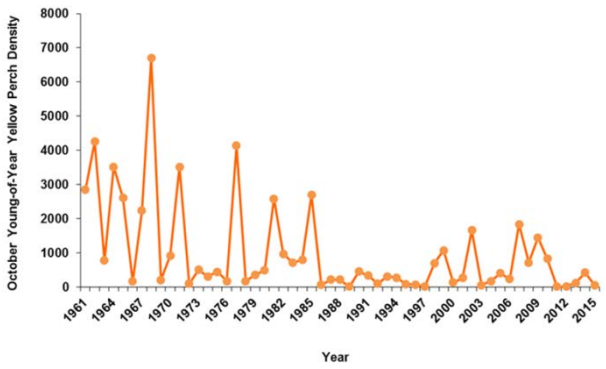
Production of Fall Juvenile Percids Has Declined

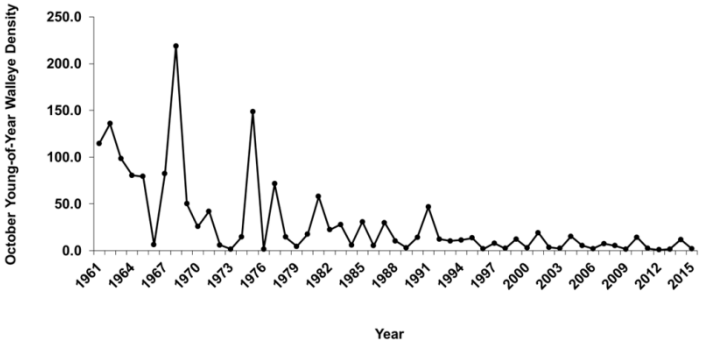




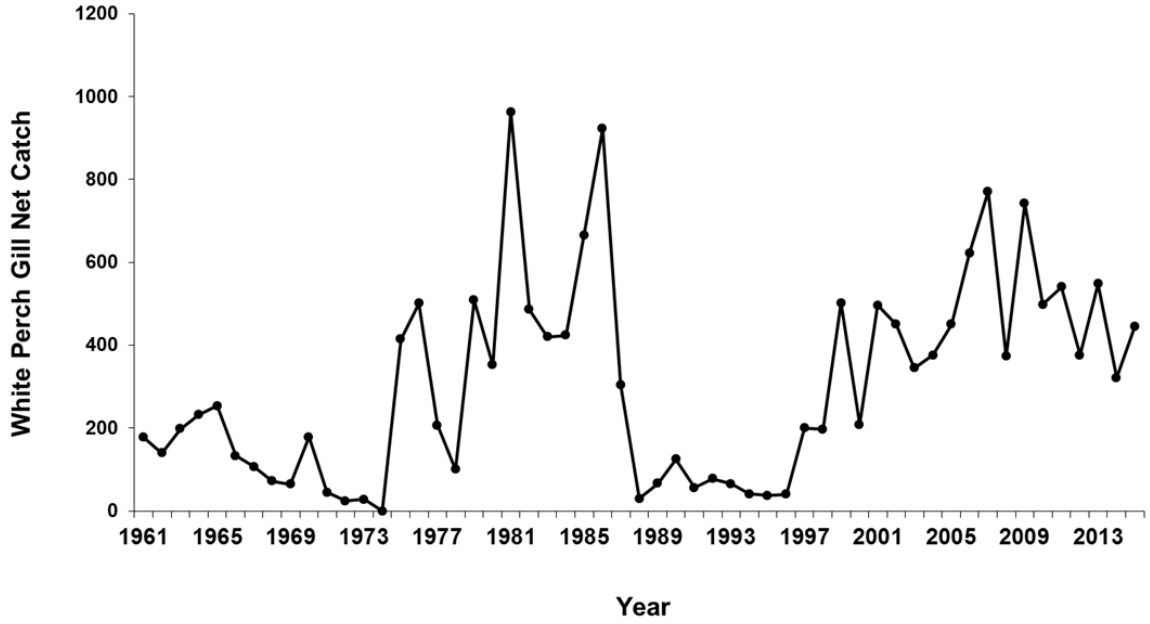
This Can't Be Blamed on Cormorants, Because They Eat Very Few Fish at These Sizes

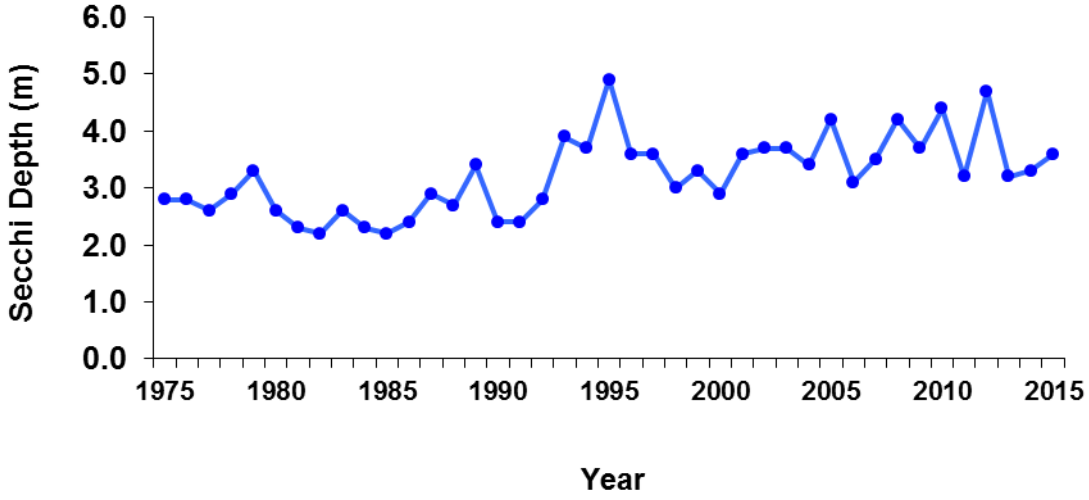


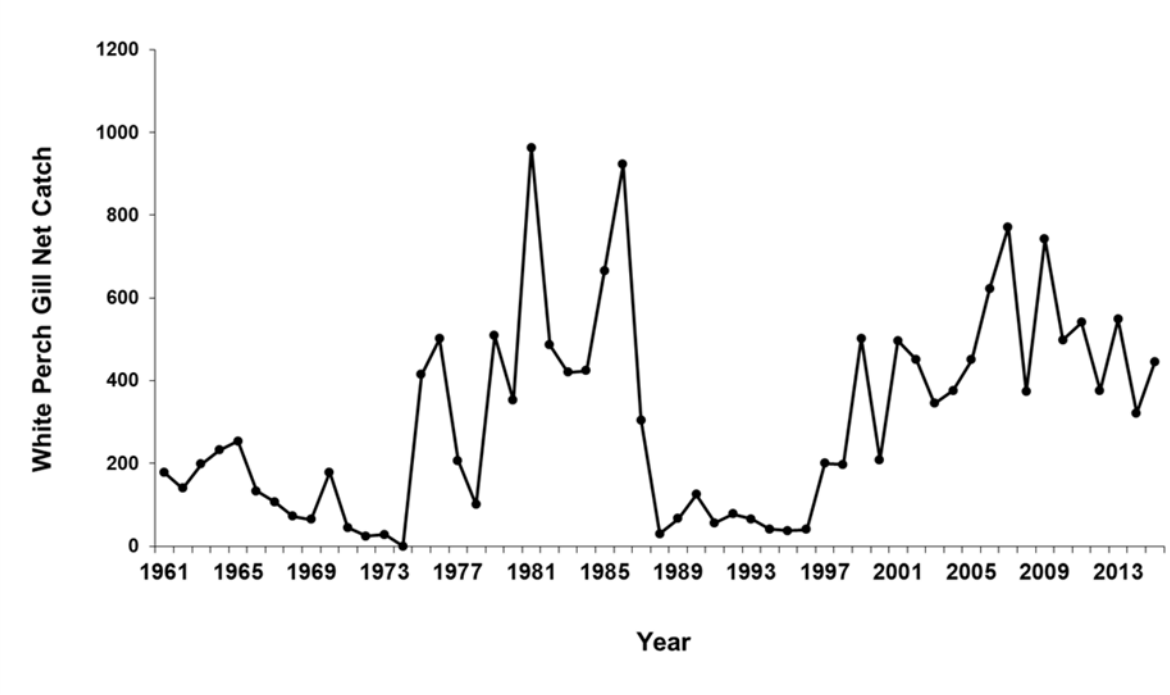




We Did Not See Declines in Percid Production When White Perch Were Abundant in the 80s





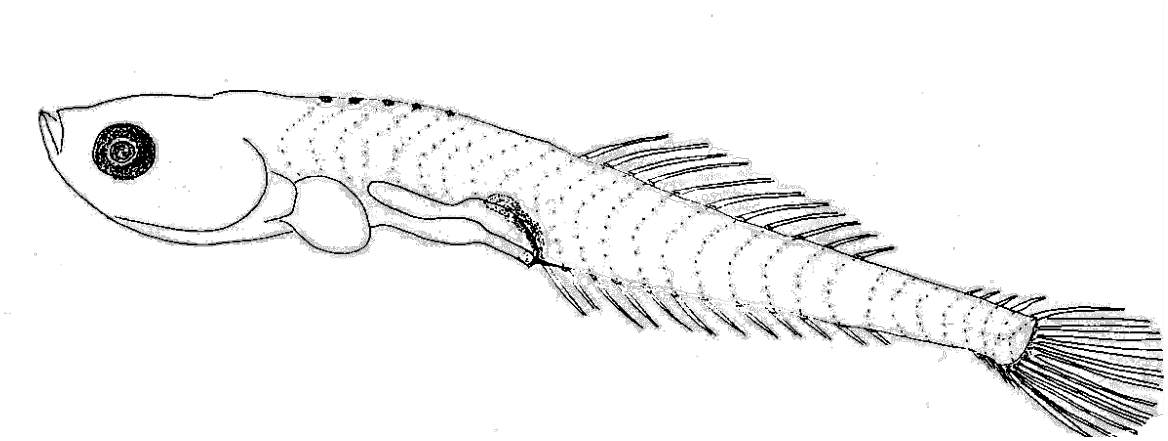


But There May Be Increased Predation on Percid Larvae Due to Increases in White Perch COMBINED With Increases in Water Clarity

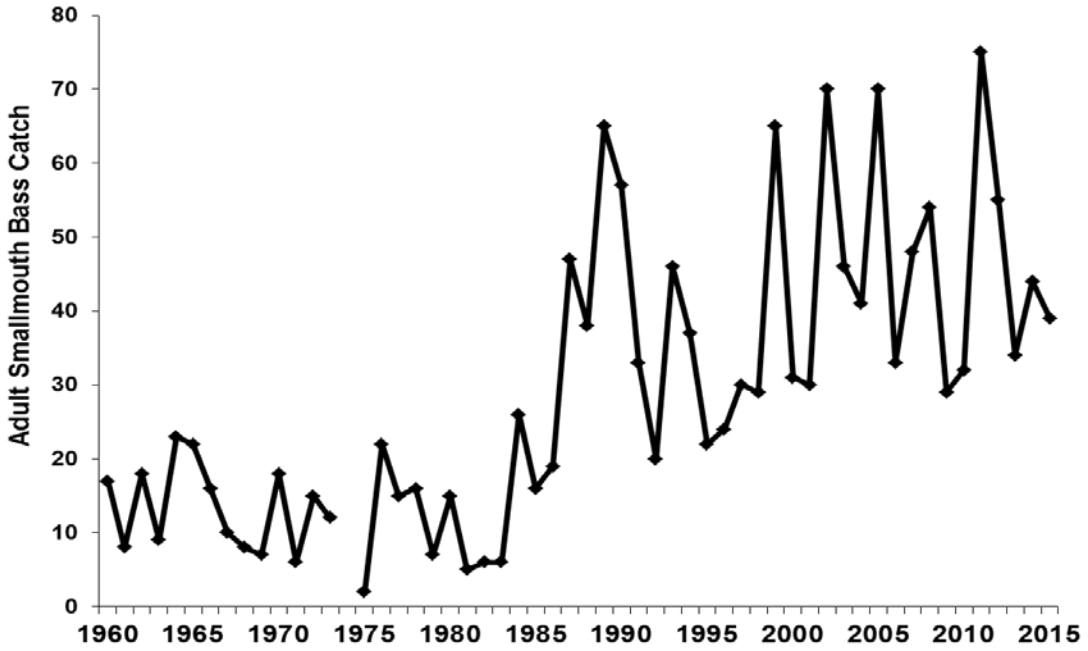
Larval fish that were once provided good cover from predators by the algal productivity of the lake ---

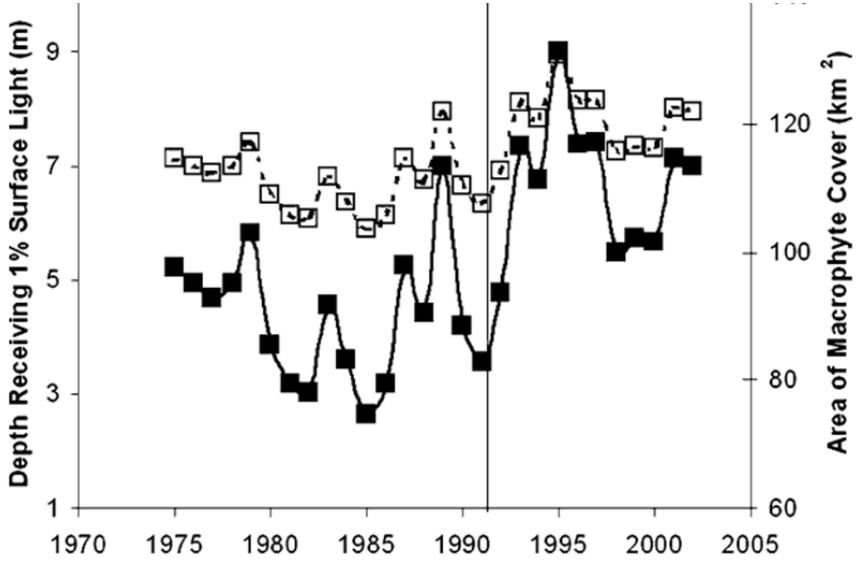
Larval fish that were once provided good cover from predators by the algal productivity of the lake ---

Become much more visible

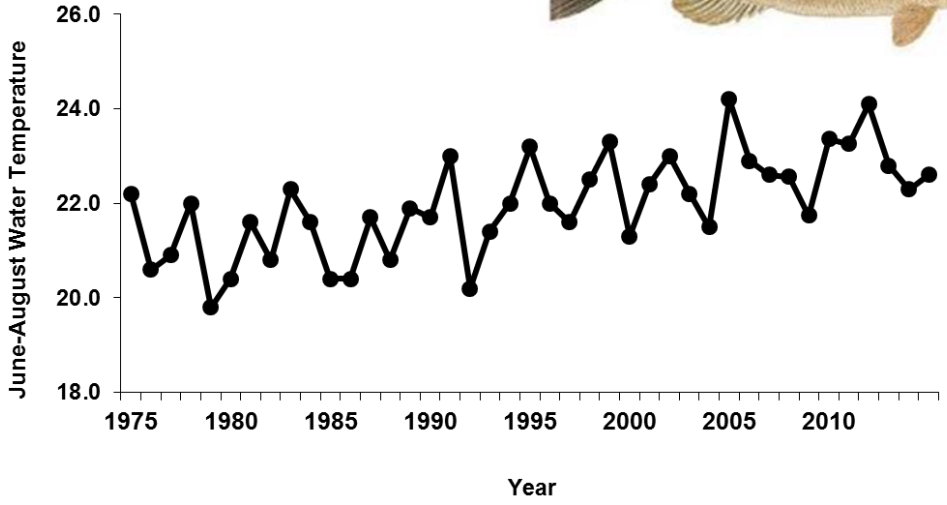


Not All Sport Fish Have Declined in Abundance During the Era of Invasives

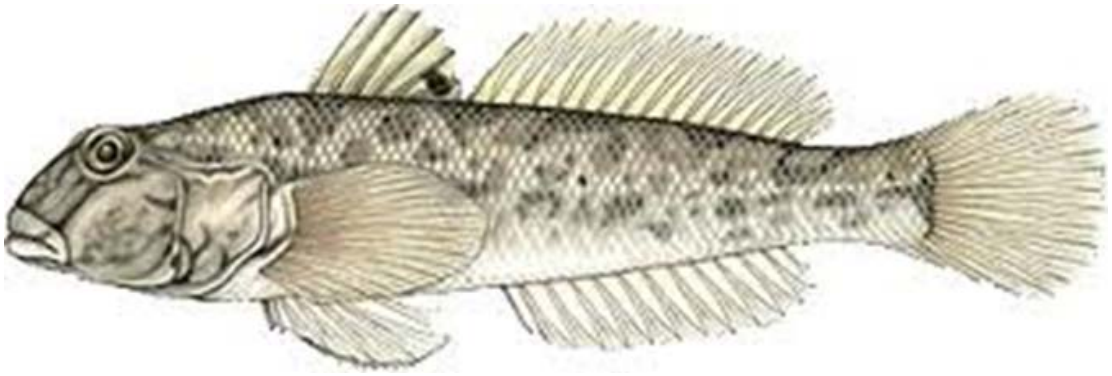




Both Species of Bass Likely Benefit From Changes In the Lake, Some Directly Related to Invasives



The Round Goby



Piscivores Love ‘em – Improved Growth

They Reproduce All Season – Young of Year Piscivores Love ‘em

Cormorants Love ‘em

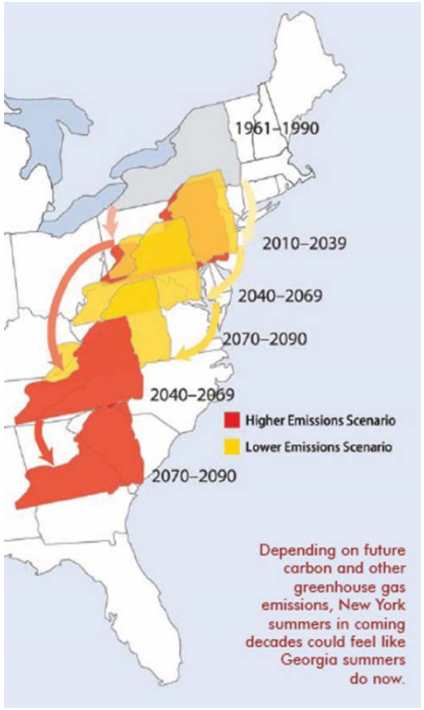
They Eat Mussels

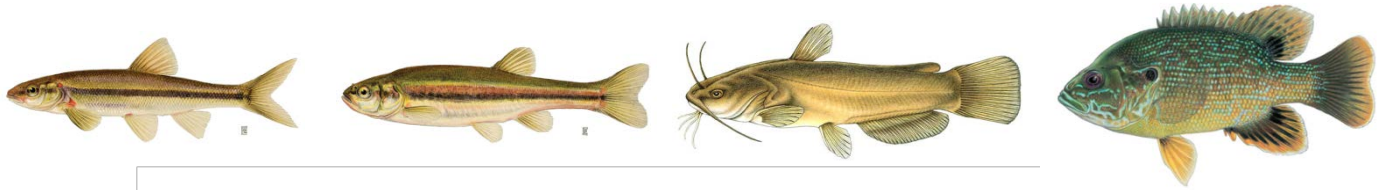
They Eat Fish Eggs

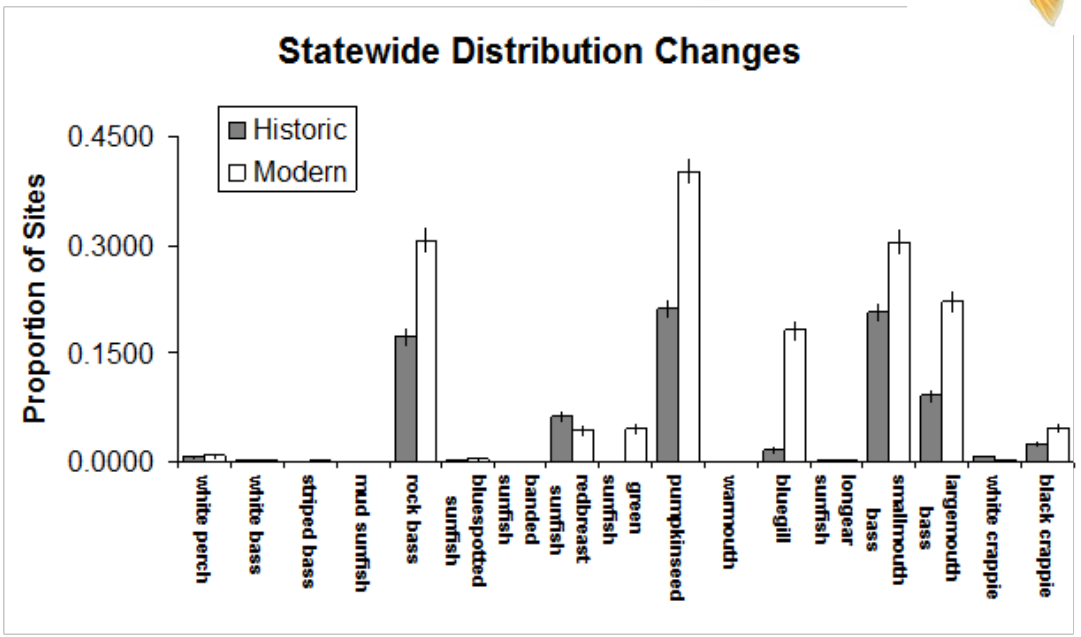
They Eat Benthic Invertebrates

They May Reduce Angler Catch Rates

Climate Change and the Homogenization of New York's Stream Fish Fauna







Emmeline Moore

New York State Department of Conservation
1920-1944

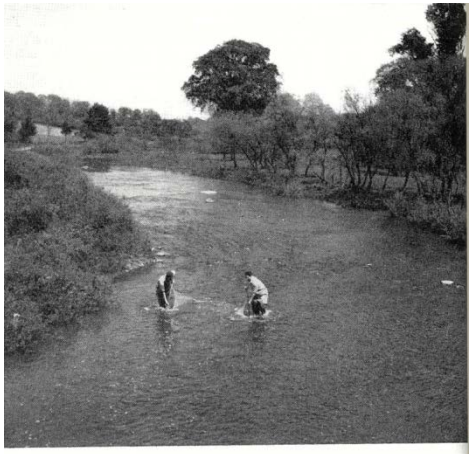
Chief Aquatic Biologist
1934-

Leader of the Biological Surveys of New York Watersheds

New York State Watershed Surveys 1926-1939

IGURE 6. Reeve Bailey, John Greeley, and Ed Raney in front of the survey vehicle loaded
ith seines and other sampling gear. Photograph by U.B. Stone.

For an excellent history, see Daniels 2011 Fisheries 36:179-189

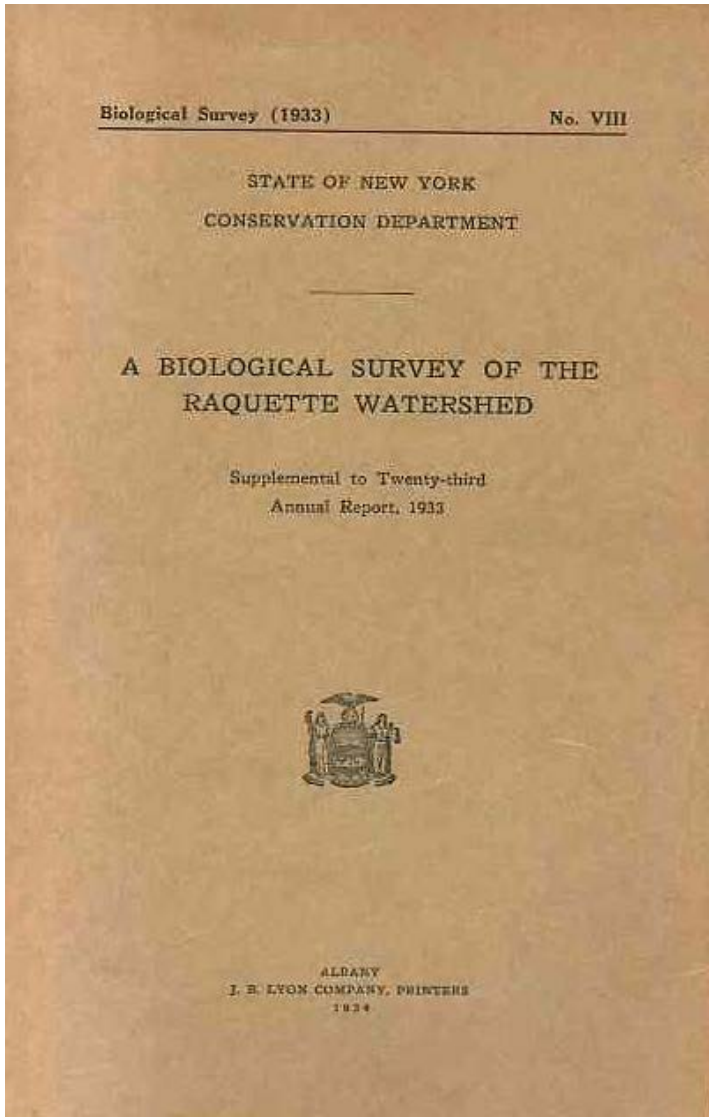


Seining for fish distribution studies, French Creek near Pennsylvania State li

New York State Watershed Surveys

1926-1939

4000+ Sample Sites

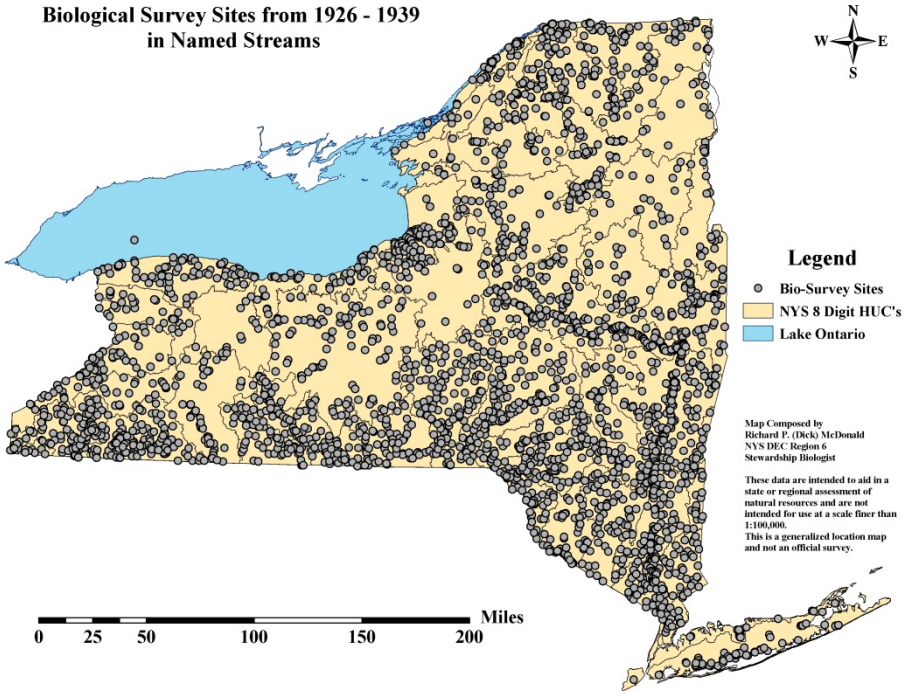

Biological Survey (1933) No. VIII

STATE OF NEW YORK
CONSERVATION DEPARTMENT

A BIOLOGICAL SURVEY OF THE RAQUETTE WATERSHED

Supplemental to Twenty-third Annual Report, 1933

ALBANY
J. B. LYON COMPANY, PRINTERS
1934

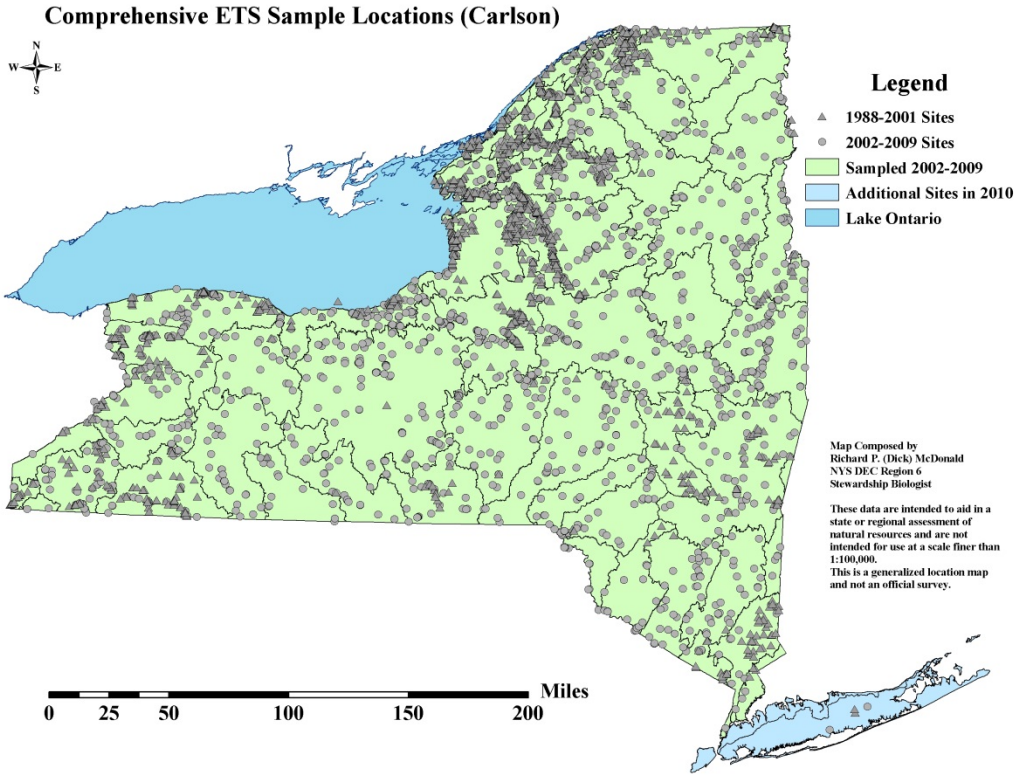


Modern Stream Survey

2002-2009

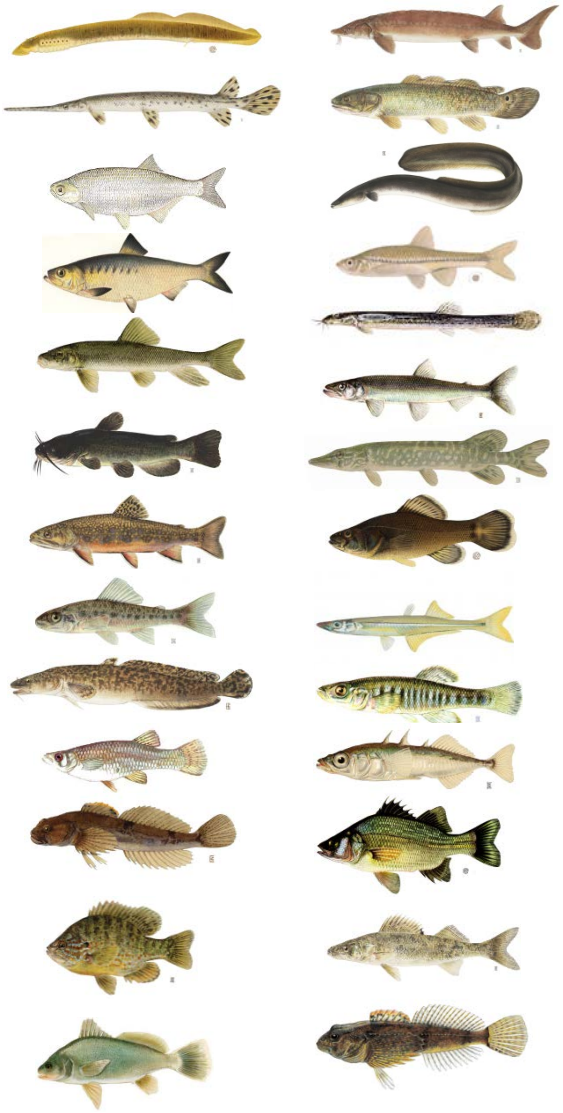
3000+ Sample Sites

Doug Carlson, NYS DEC



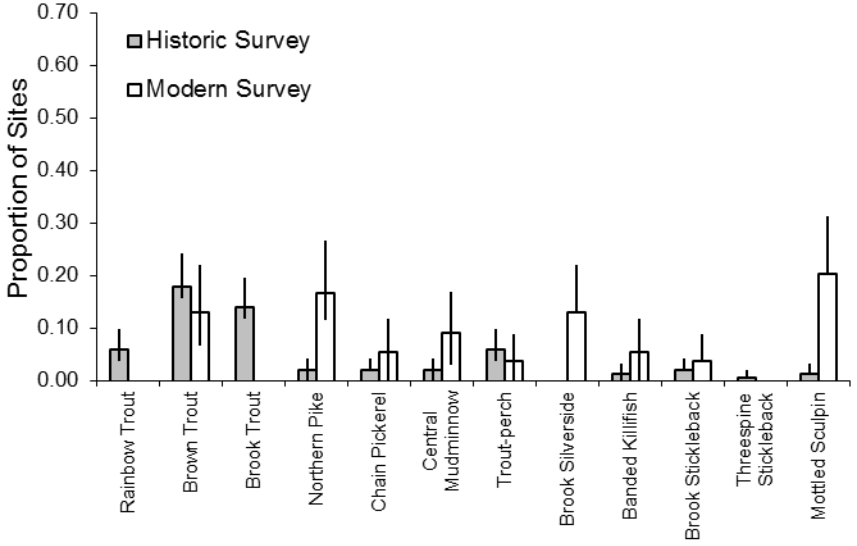
Bob Daniels, NY State Museum

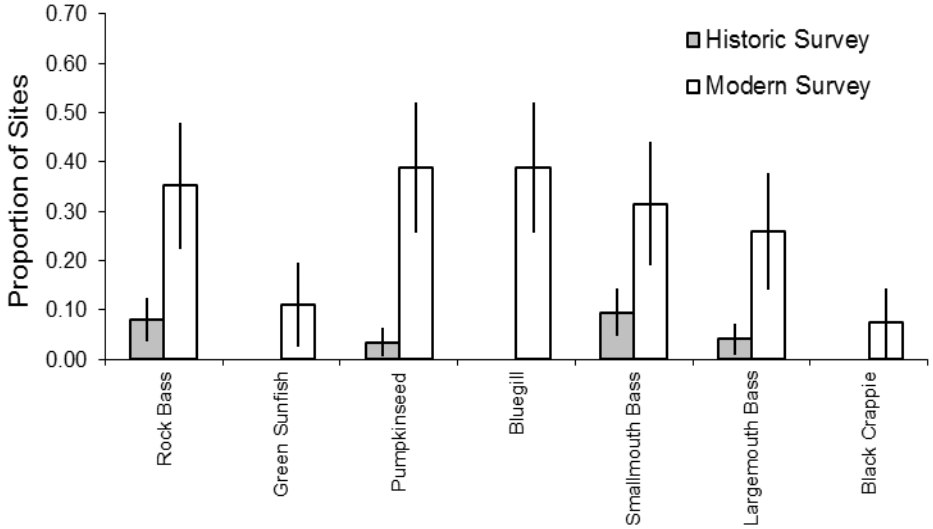
Combined, the Surveys Collected 161 Species from 27 Families

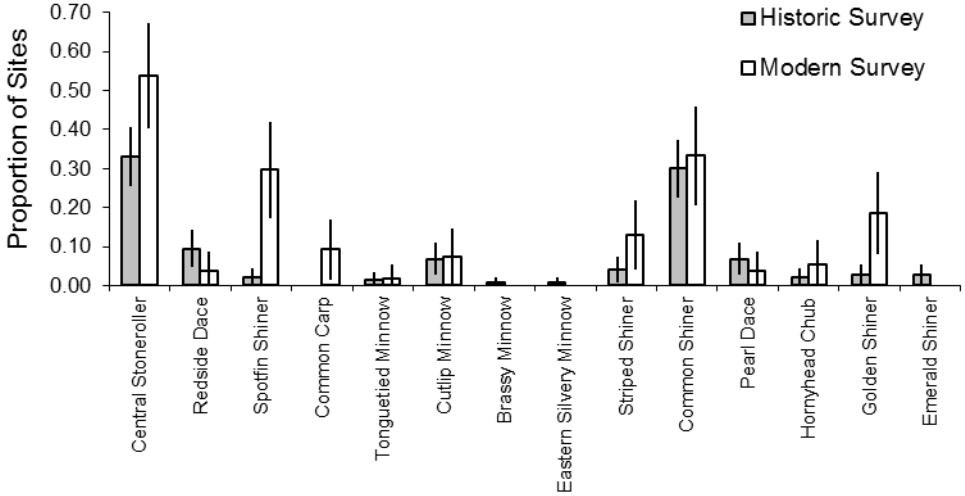


Family	Number of Species	
	Historic	**Modern**
Petromyzontidae	**5**	**6**
Acipenseridae	**1**	**1**
Lepisosteidae	**1**	**1**
Amiidae	**1**	**1**
Hiodontidae	**1**	**1**
Anguillidae	**1**	**1**
Clupeidae	**4**	**4**
Cyprinidae	**47**	**45**
Catastomidae	**13**	**14**
Cobitidae	**0**	**1**
Ictaluridae	**9**	**8**
Osmeridae	**1**	**1**
Salmonidae	**7**	**6**
Esocidae	**6**	**7**
Percopsidae	**1**	**1**
Aphredoderidae	**1**	**1**
Gadidae	**1**	**1**
Atherinopsidae	**1**	**1**
Fundulidae	**2**	**2**
Poeciliidae	**0**	**1**
Gasterosteidae	**4**	**4**
Cottidae	**2**	**2**
Moronidae	**3**	**3**
Centrarchidae	**14**	**13**
Percidae	**21**	**19**
Scianidae	**1**	**1**
Gobiidae	**0**	**1**
Total	**148**	**147**

Some examples – Genesee River Watershed



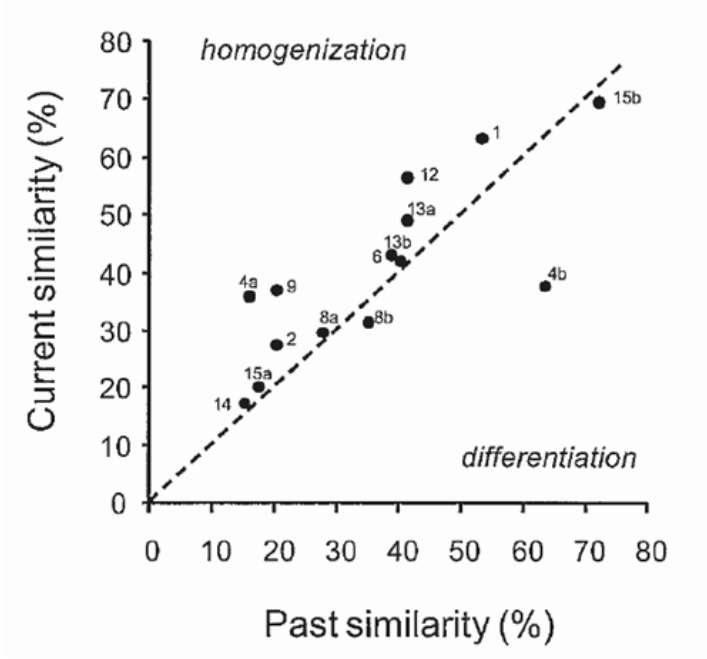




Homogenization of Fish Faunas Across the United States

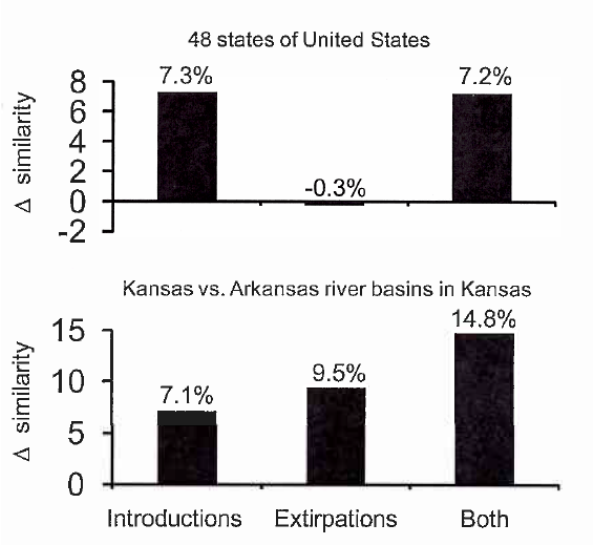
Frank J. Rahel*

Fish faunas across the continental United States have become more similar through time because of widespread introductions of a group of cosmopolitan species intended to enhance food and sport fisheries. On average, pairs of states have 15.4 more species in common now than before European settlement of North America. The 89 pairs of states that formerly had no species in common now share an average of 25.2 species. Introductions have played a larger role than extirpations in homogenizing fish faunas. Western and New England states have received the most introductions, which is a reflection of the small number of native fishes in these areas considered desirable gamefish by settlers.



Rahel 2000. Science 288:854-856
Rahel 2010. AFS Symposium 73:311-326

Homogenization generally thought to result from widespread species introductions and extirpations of endemics



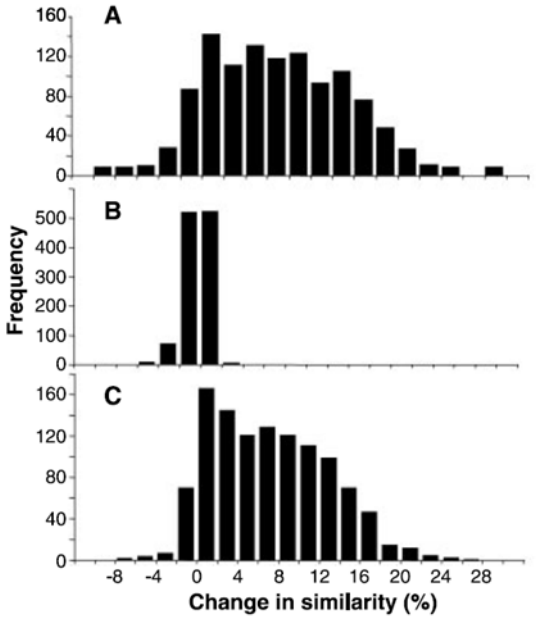
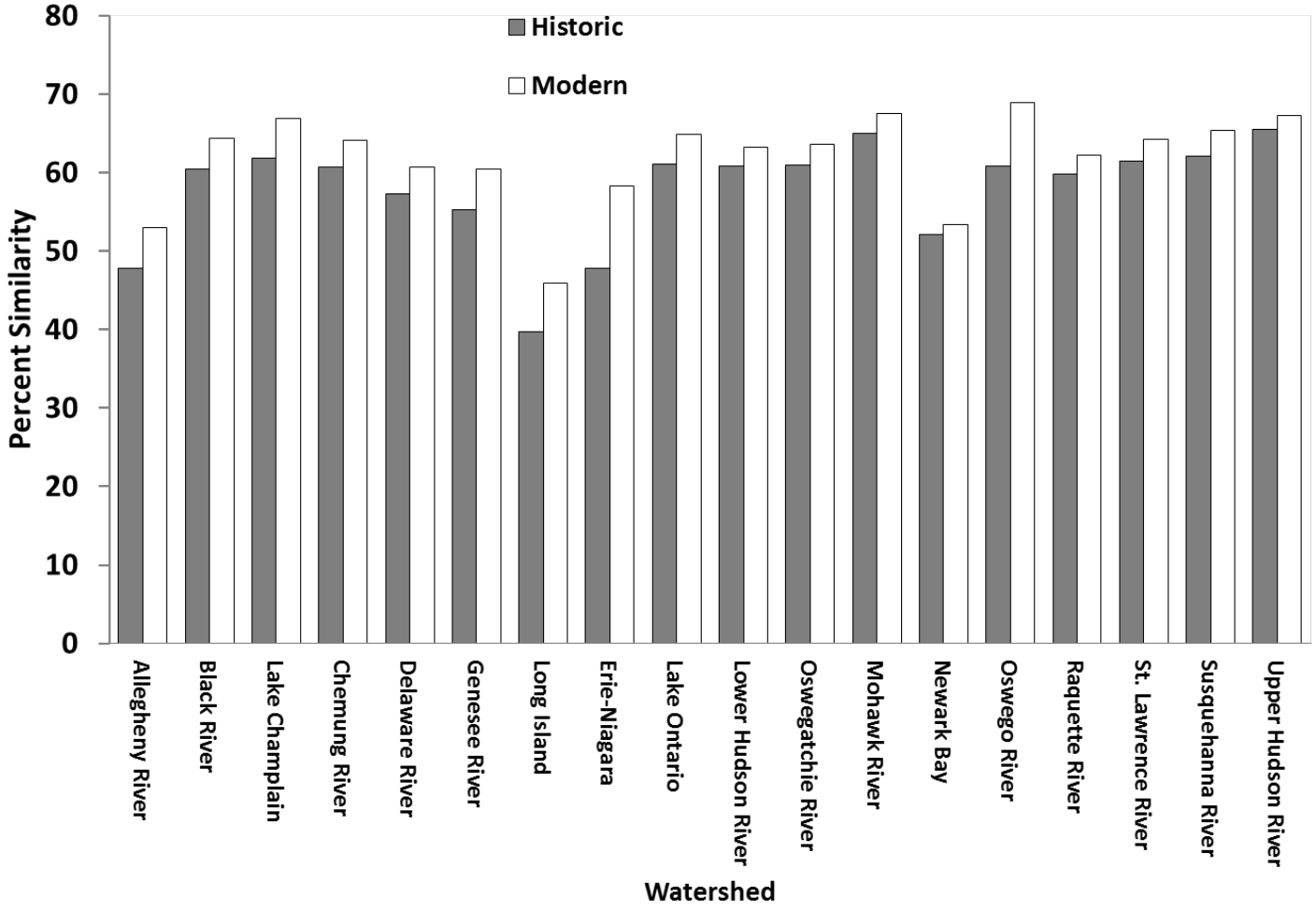


Fig. 2. Changes in similarity of fish faunas among 1128 pairwise combinations of the 48 coterminous United States. Change was measured as current similarity minus historical similarity with Jaccard's coefficient of similarity. (**A**) Change in similarity based on combined effects of species extirpations and introductions. Distribution is skewed toward positive values, which indicate that fish faunas have become more similar with time by an average of 7.2%. (**B**) Change in similarity based on species extirpations only. Extirpations have caused a negligible change in the similarity among state fish faunas. (**C**) Change in similarity based on introductions only. Distribu-

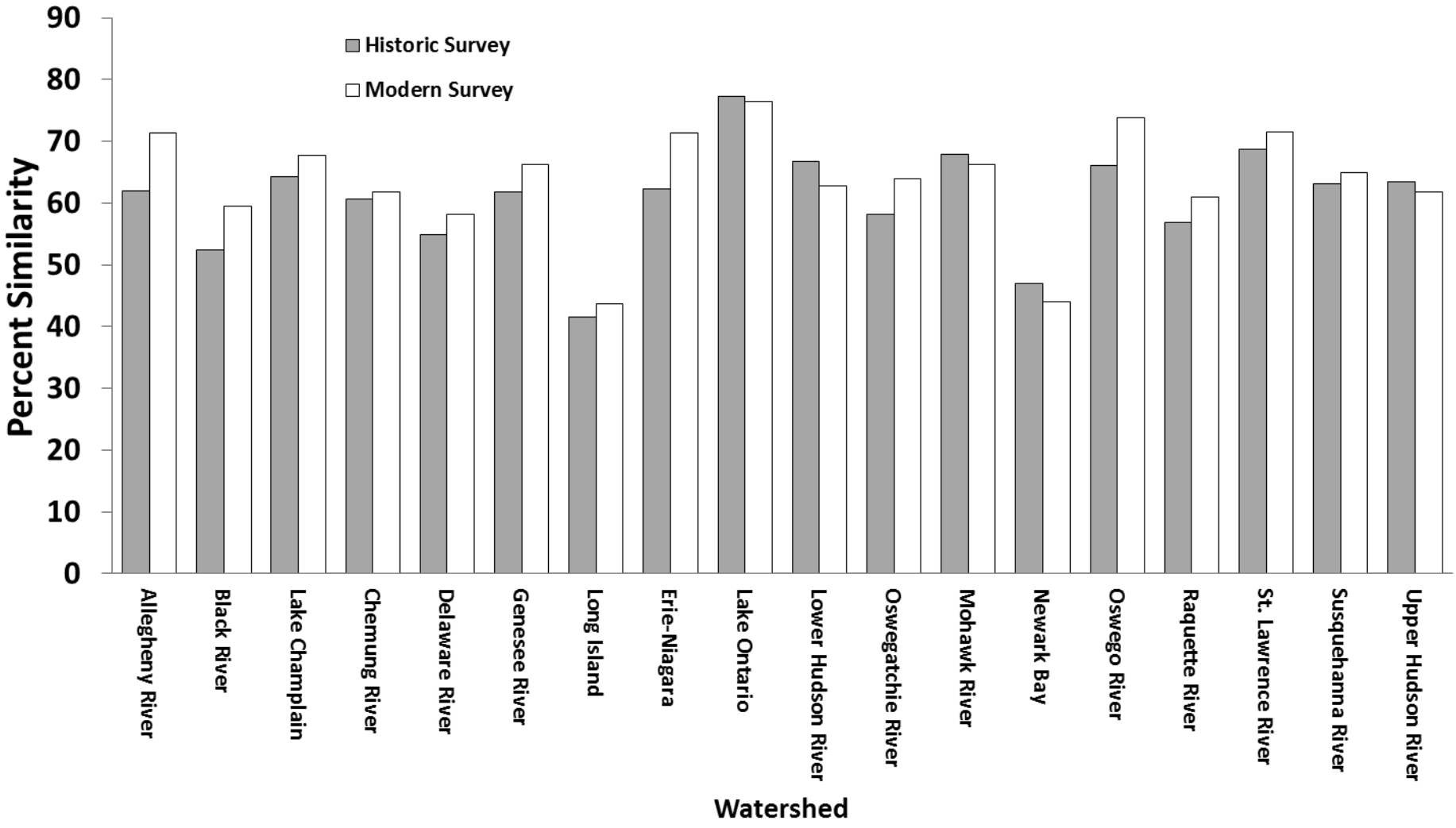
Similarity of each watershed to all other watersheds

Average Change: 4.1% more similar (note Rahel found 7.3%)



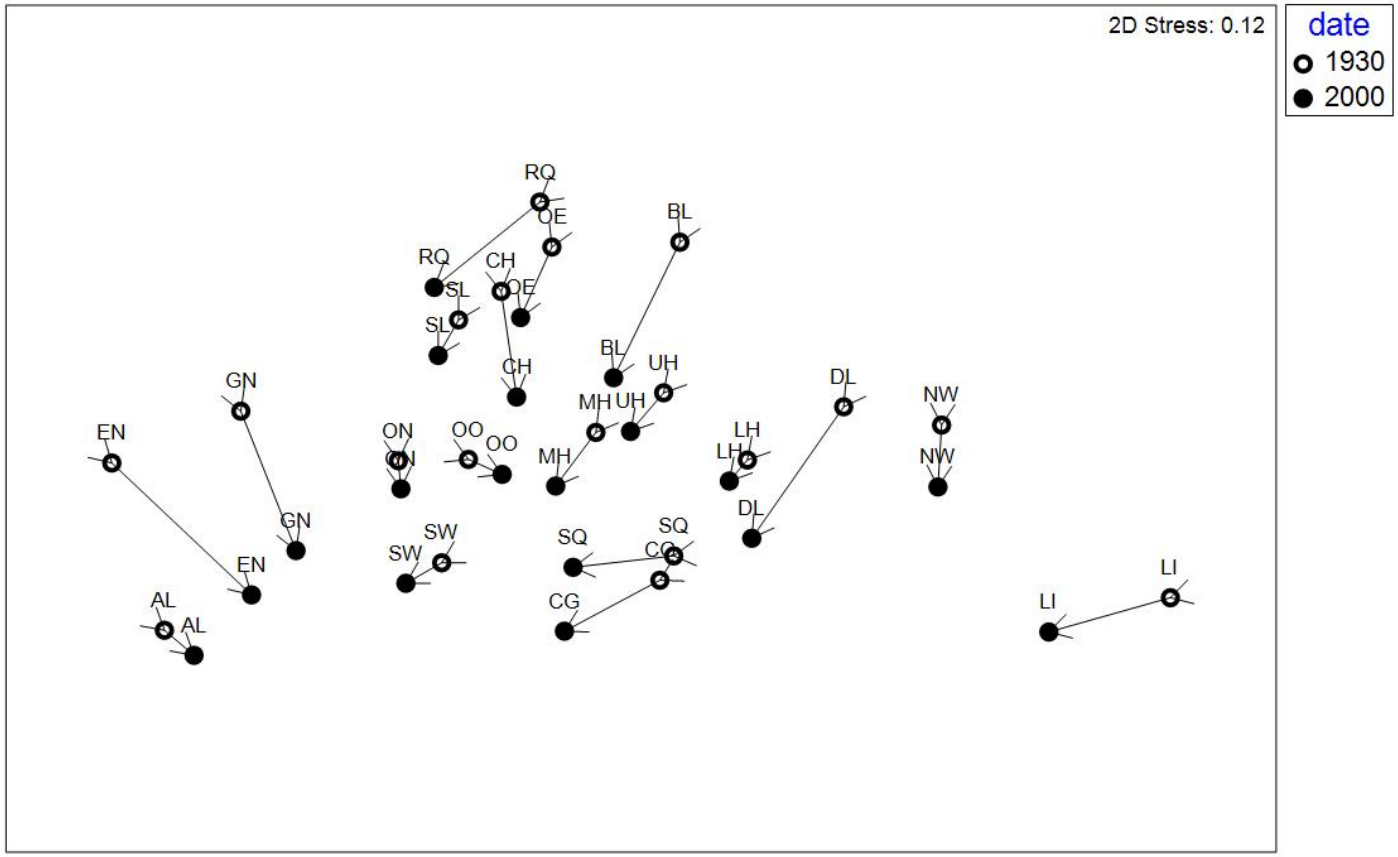
Similarity of each watershed to the State

Average Change: 2.8% more similar



Non-metric MDS

Transform: Fourth root
Resemblance: S17 Bray-Curtis similarity



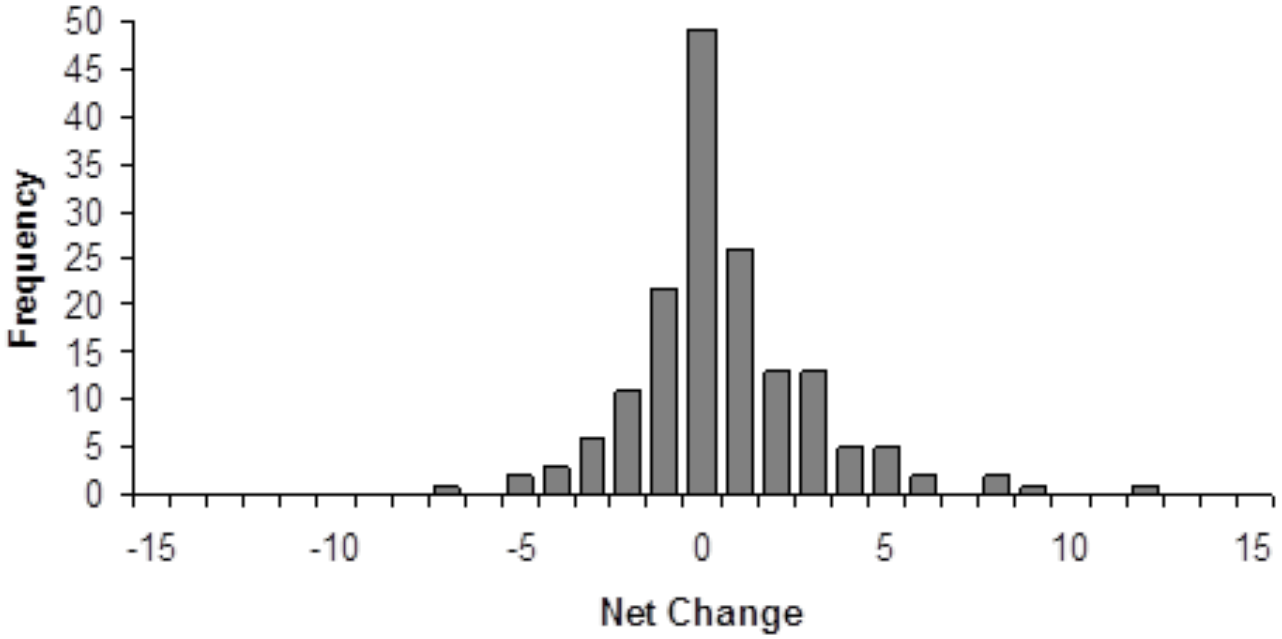
Examination of Winners and Losers in terms of Distributional Change

Broadened Scale from Site to Watershed – Net Change in Number of Watersheds Individual Species were Detected in

Examination of Winners and Losers in terms of Distributional Change

23 Species Exhibited Range Increases of 3 or more Watersheds

11 Species Exhibited Range Reductions of 3 or more Watersheds



Losers

11 Species Exhibited Range Reductions of 3 or more Watersheds

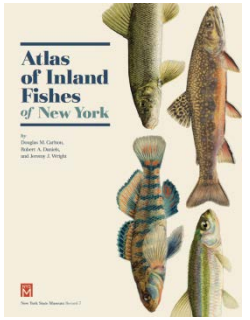
Representing:
5 Cyprinids
1 Catastomid
1 Ictalurid
2 Salmonids
1 Percid

Longnose Sucker *Catostomus catostomus* (Forster, 1773)
-3 Watersheds

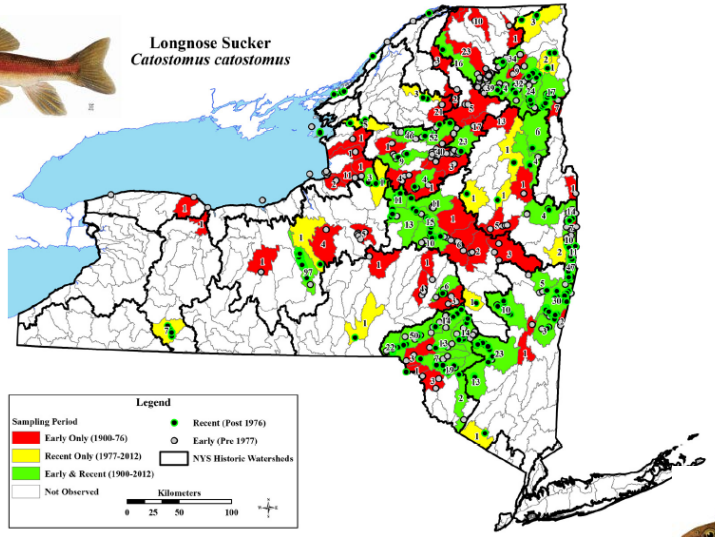
Bridle Shiner *Notropis bifrenatus* (Cope, 1867)
-4 Watersheds

Finescale Dace *Chrosomus neogaeus* (Cope, 1867)
-5 Watersheds

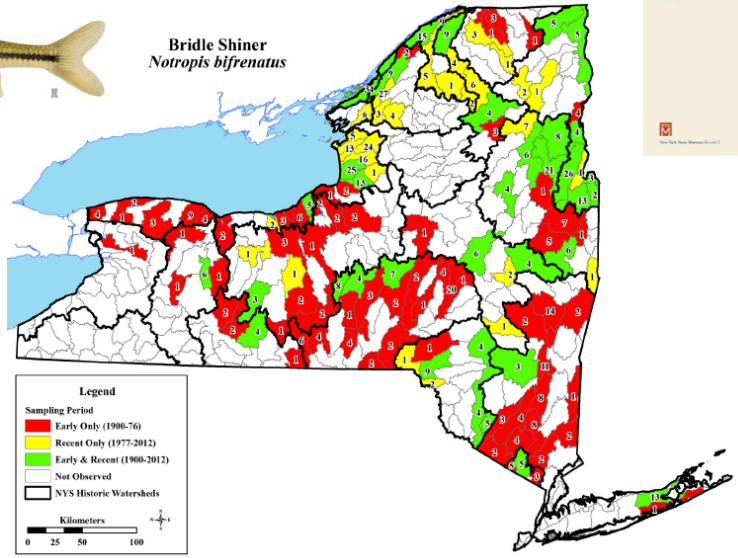
Lake Chub *Couesius plumbeus* (Agassiz, 1850)
-7 Watersheds



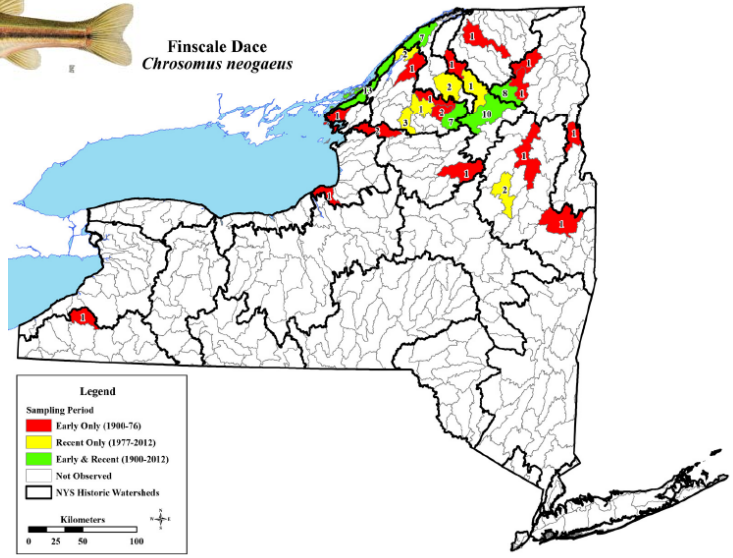
Longnose Sucker
Catostomus catostomus



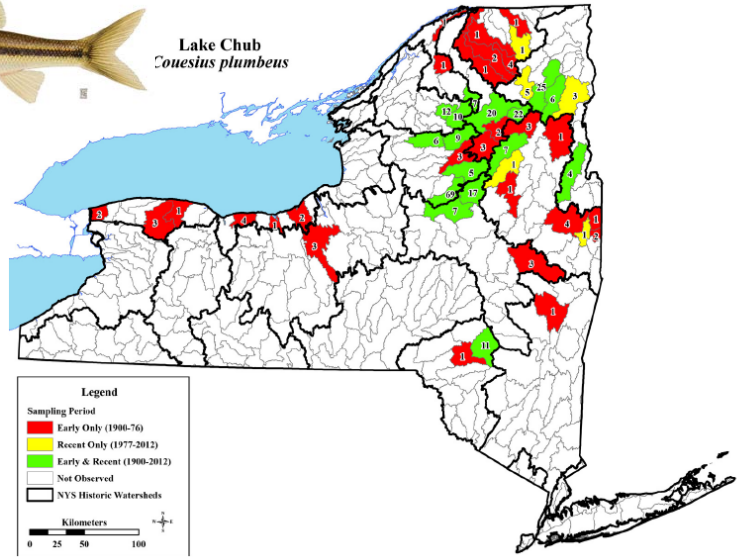
Bridle Shiner
Notropis bifrenatus



Finscale Dace
Chrosomus neogaeus



Lake Chub
Couesius plumbeus



Winners

23 Species Increased Range by 3 or more Watersheds

Representing:

1 Lepisostid

1 Amiid

1 Clupeid

7 Cyprinids

2 Catastomids

3 Ictalurids

2 Esocids

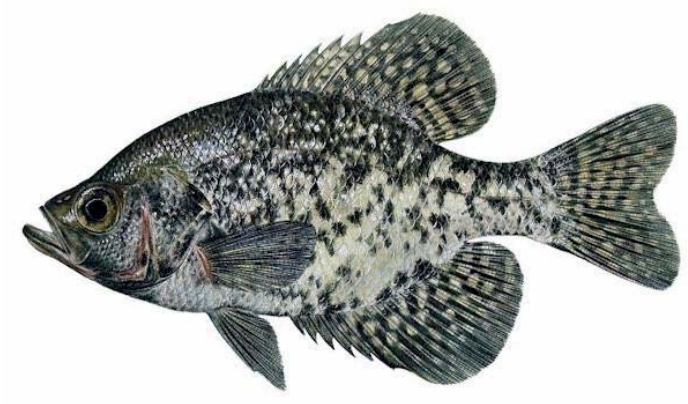
1 Atherinopsid

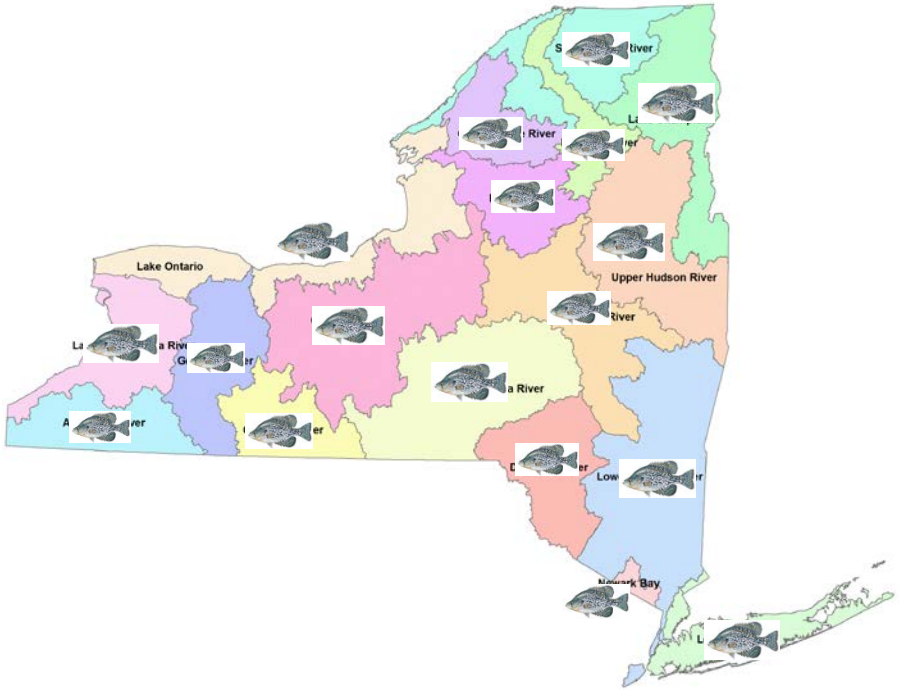
1 Fundulid

1 Moronid

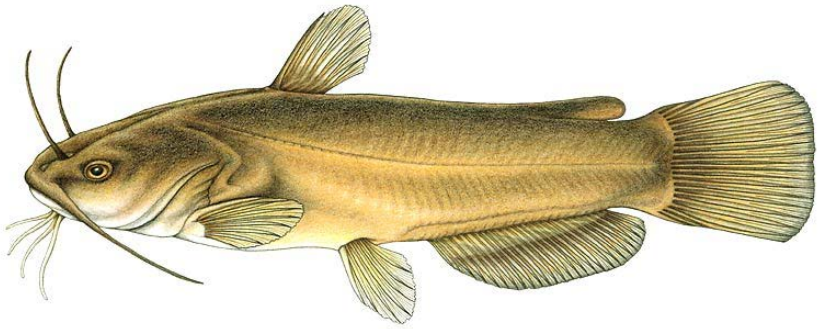
3 Centrarchids

Black Crappie *Pomoxis nigromaculatus* (Lesueur, 1829)
+8 Watersheds

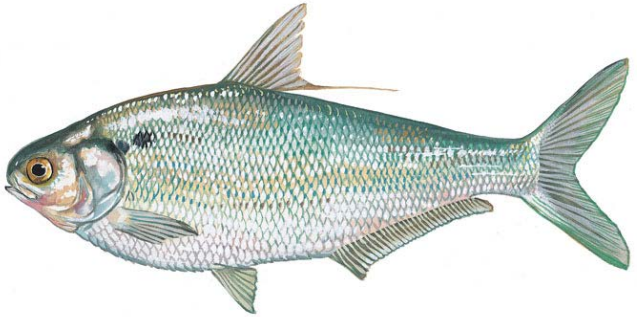


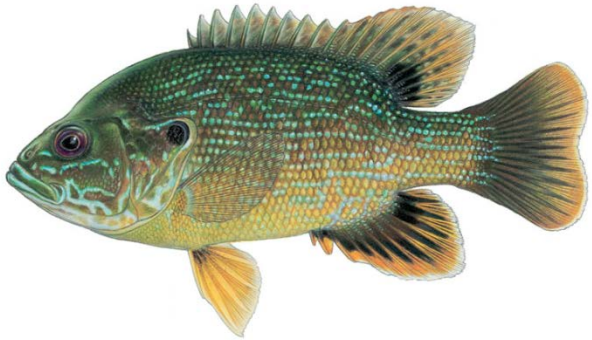


Yellow Bullhead *Ameiurus natalis* (Lesueur, 1819)
+8 Watersheds

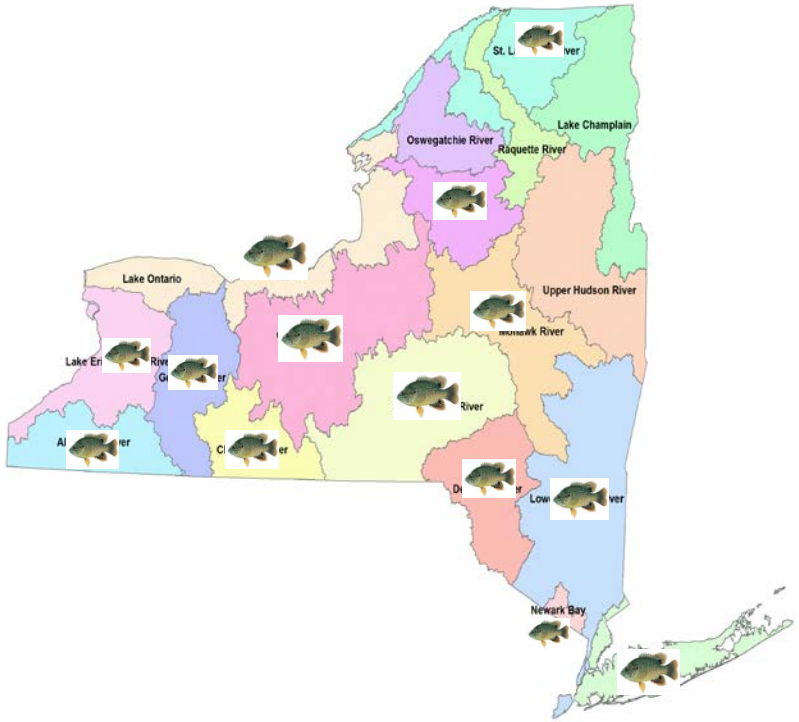


Gizzard Shad *Dorosoma cepedianum* (Lesueur, 1818)
+9 Watersheds

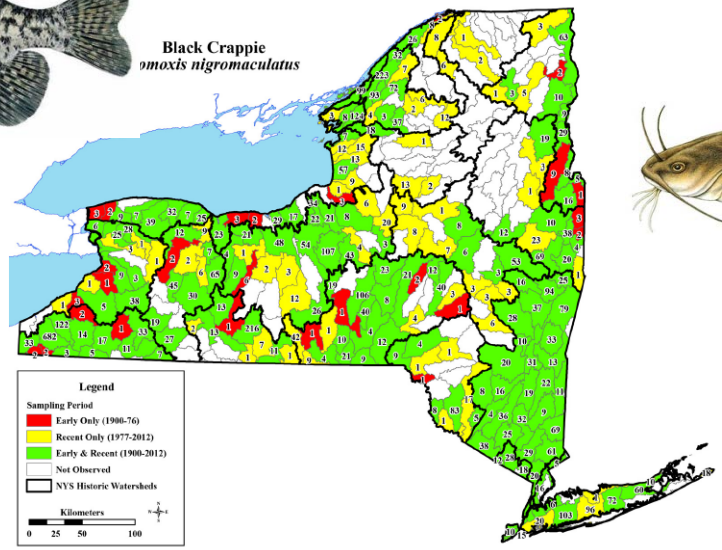


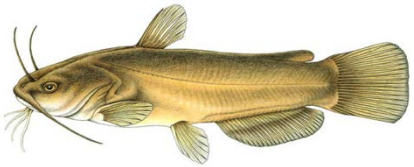


Green Sunfish *Lepomis cyanellus* Rafinesque, 1819
+12 Watersheds

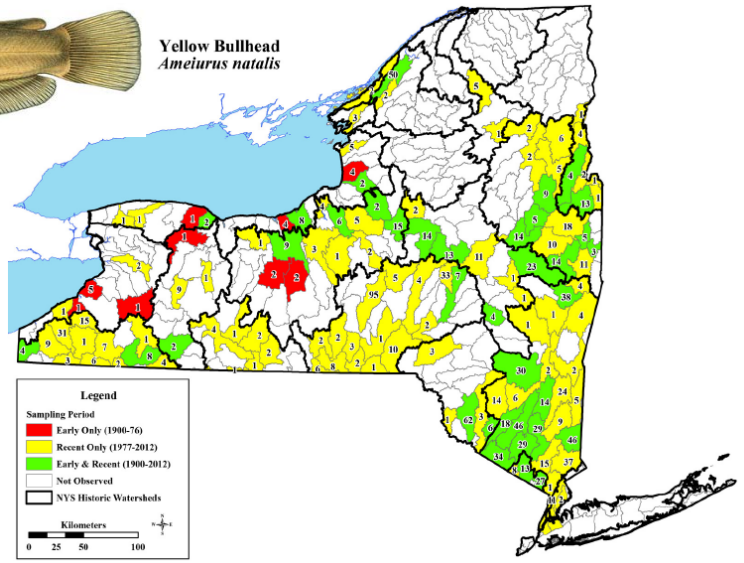


Black Crappie
Pomoxis nigromaculatus

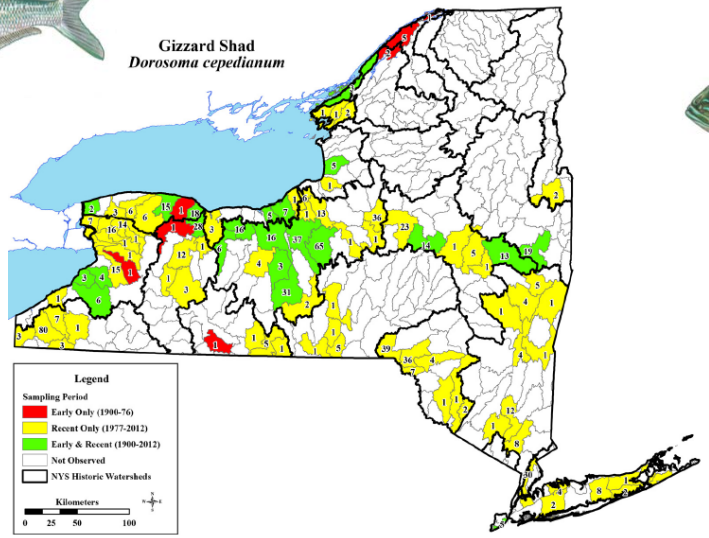




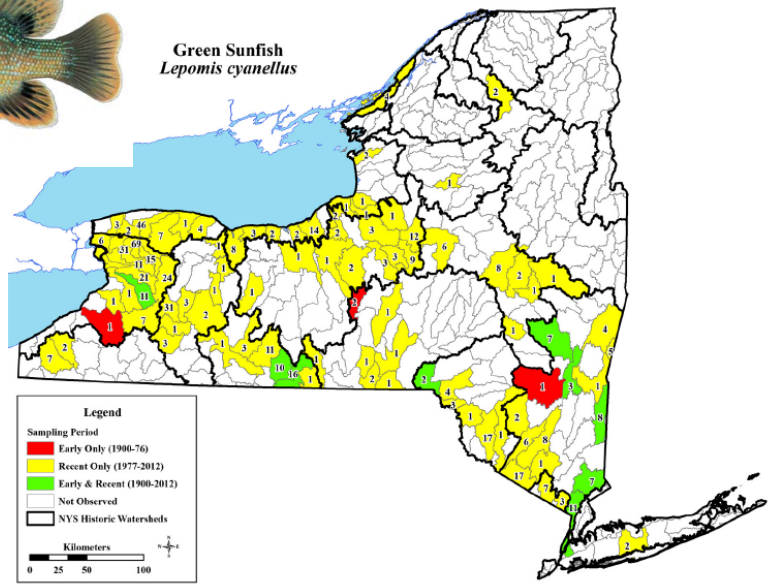
Yellow Bullhead
Ameiurus natalis



Gizzard Shad
Dorosoma cepedianum

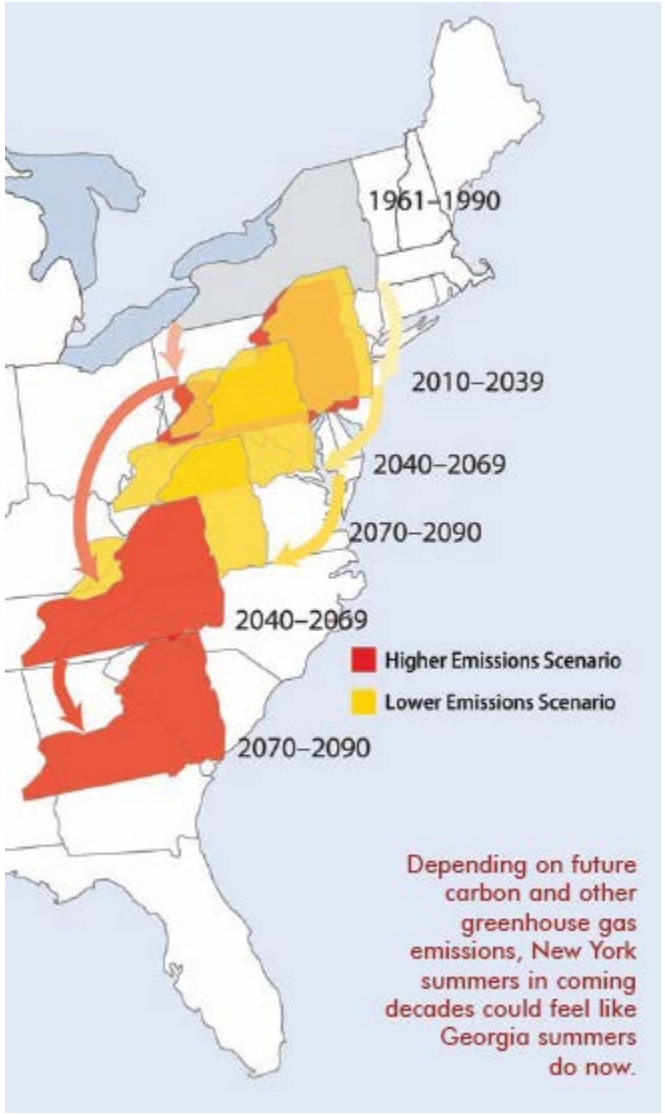


Green Sunfish
Lepomis cyanellus



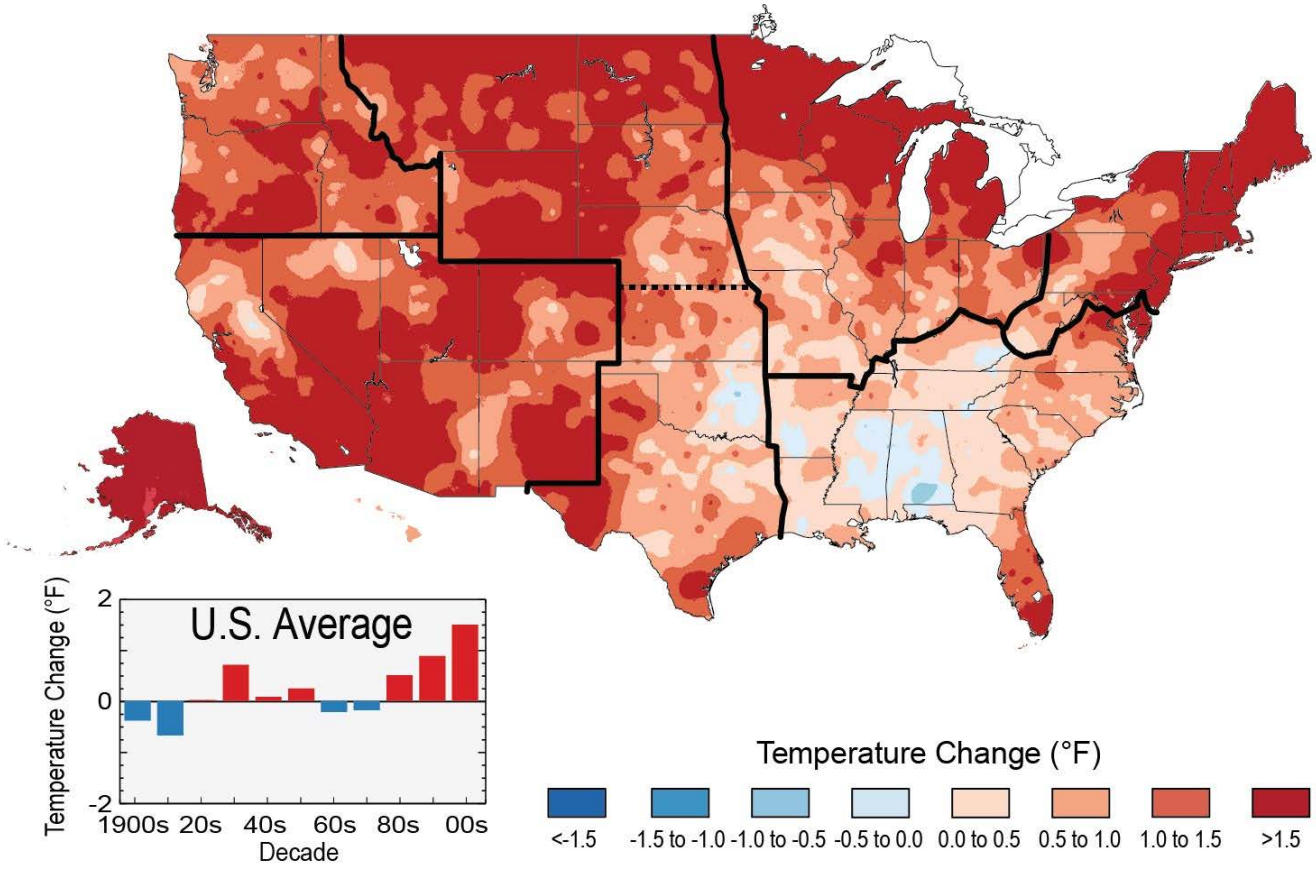
Species Exhibiting the Largest Range Expansions were Those a Southern-Trained Fish Biologist would Know Well

Climate Change Influence?



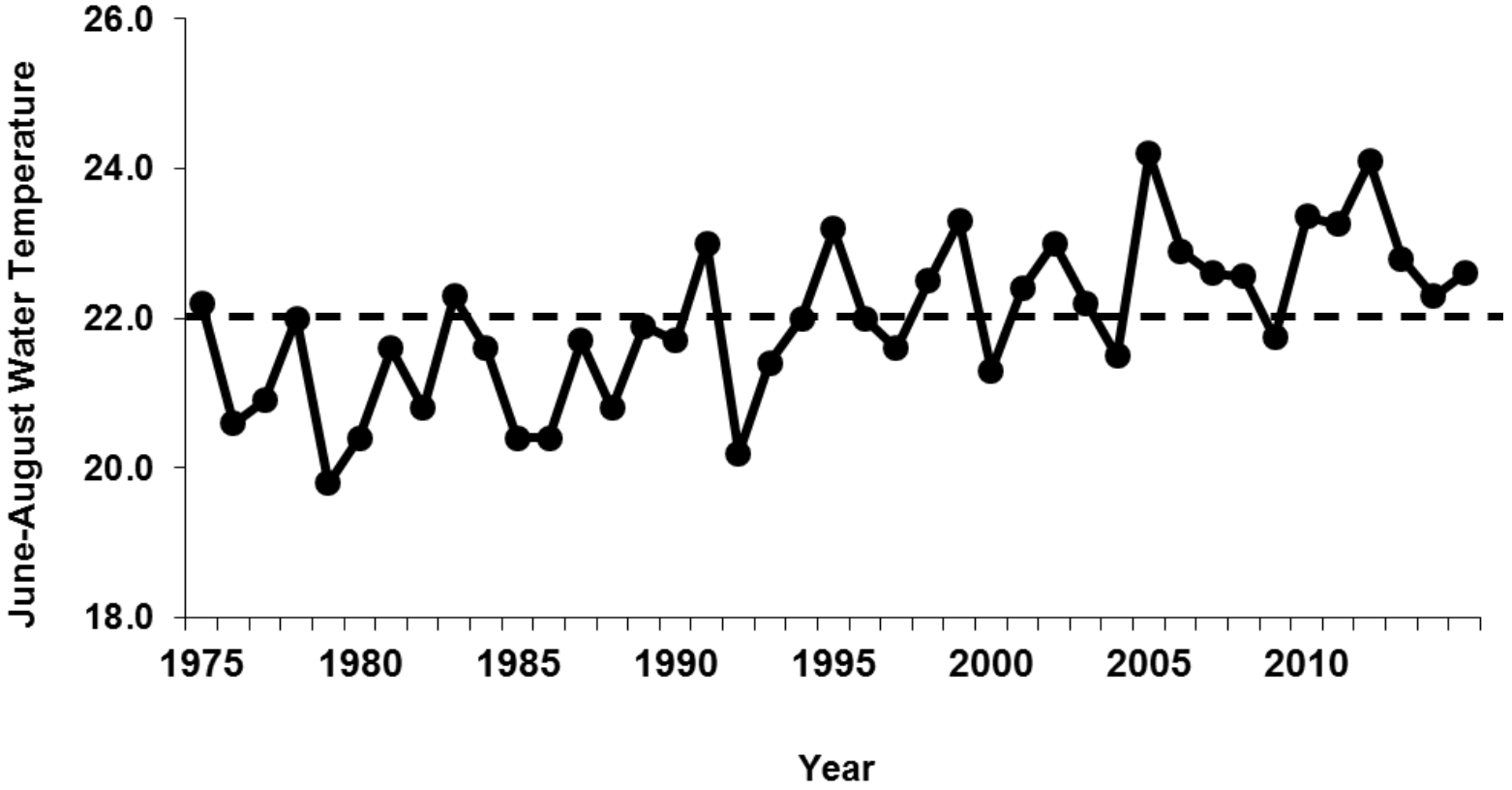
http://www.dec.ny.gov/pubs/39313.html

Temperatures have Exhibited Increases in Decades since the Watershed Surveys – the Northeast showing a particularly strong signal



http://nca2014.globalchange.gov/highlights/report-findings/our-changing-climate

Summer (June-August) Water Temperatures in Oneida Lake



Over period of record summer temperatures have increased 0.6º C/year

Models (and very limited data) suggest we would see northward expansions of warmwater species and retreat of southern extent of ranges of coldwater species

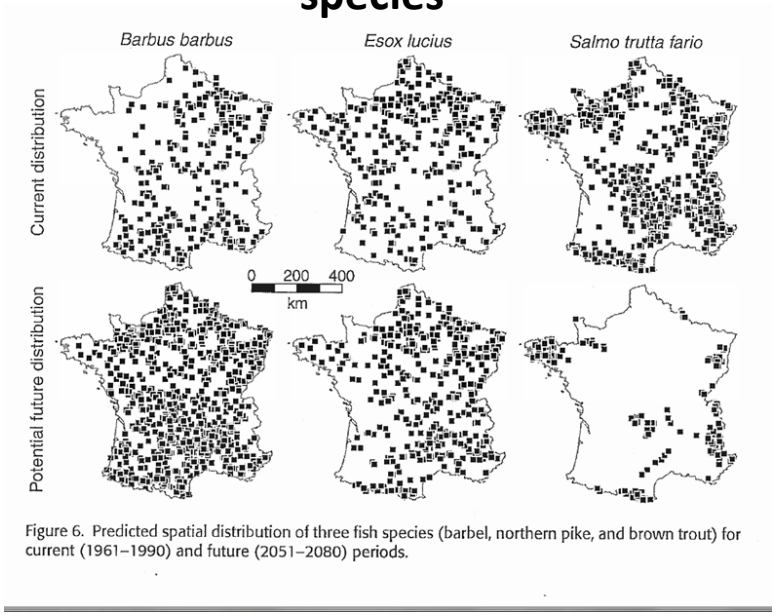
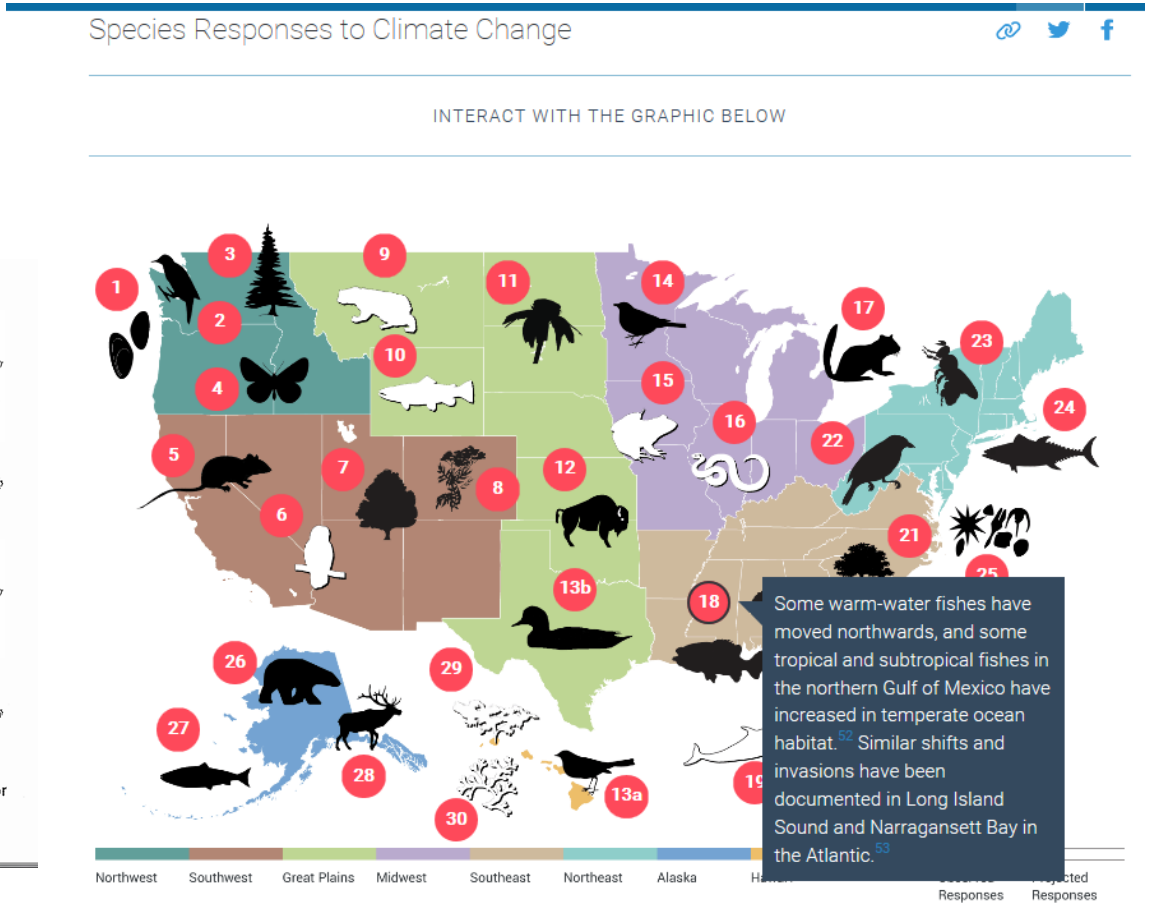


Figure 6. Predicted spatial distribution of three fish species (barbel, northern pike, and brown trout) for current (1961–1990) and future (2051–2080) periods.

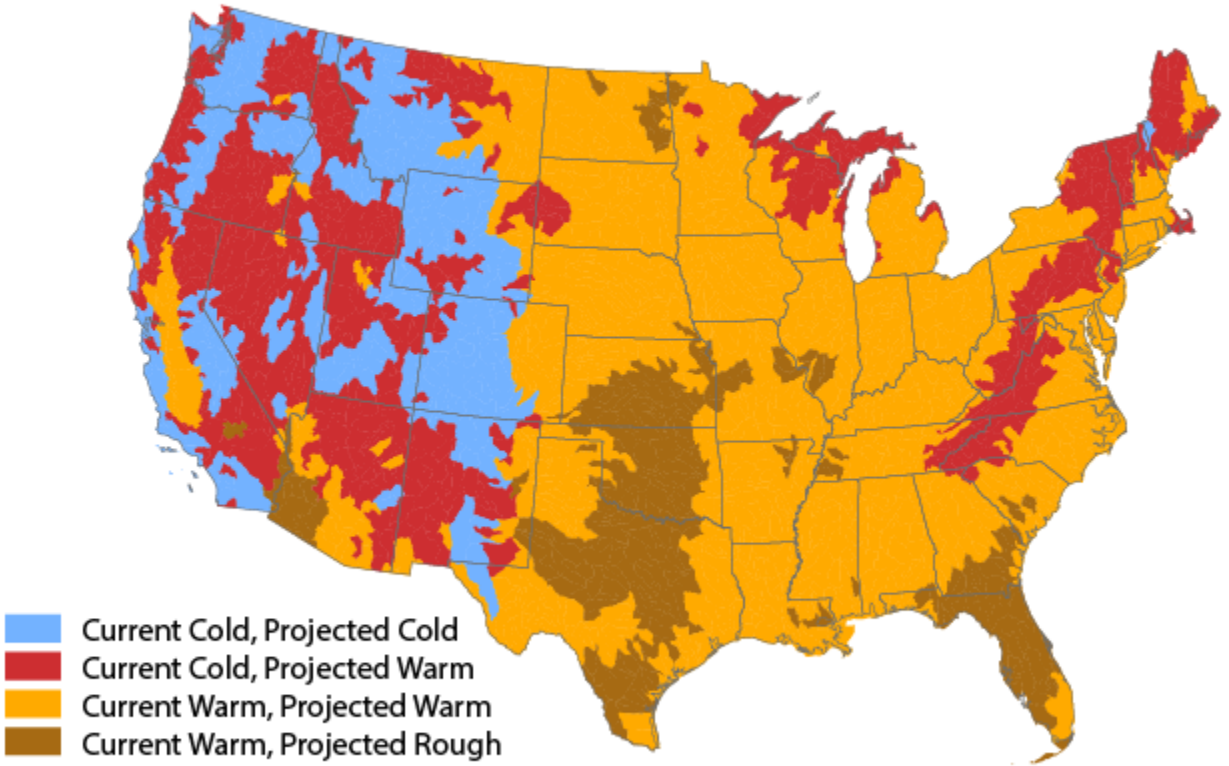


http://nca2014.globalchange.gov/highlights/report-findings/ecosystems-and-biodiversity#tab2-images

Are we seeing shifts in fish distribution consistent with the predictions?

Figure 1. Projected Impact of Unmitigated Climate Change on Potential Freshwater Fish Habitat in 2100

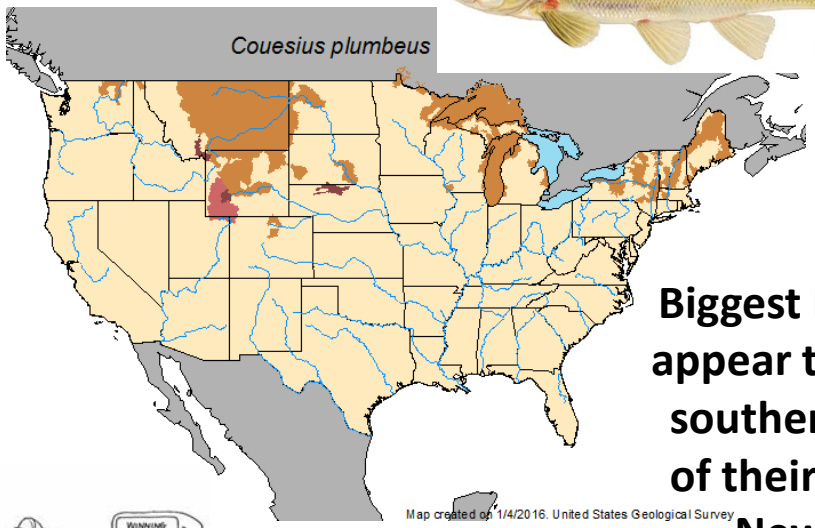
Change in distribution of areas where stream temperature supports different fisheries under the Reference scenario using the IGSM-CAM climate model. Results are presented for the 8-digit hydrologic unit codes (HUCs) of the contiguous U.S.



For more information, visit EPA's "Climate Change in the United States: Benefits of Global Action" at www.epa.gov/cira.

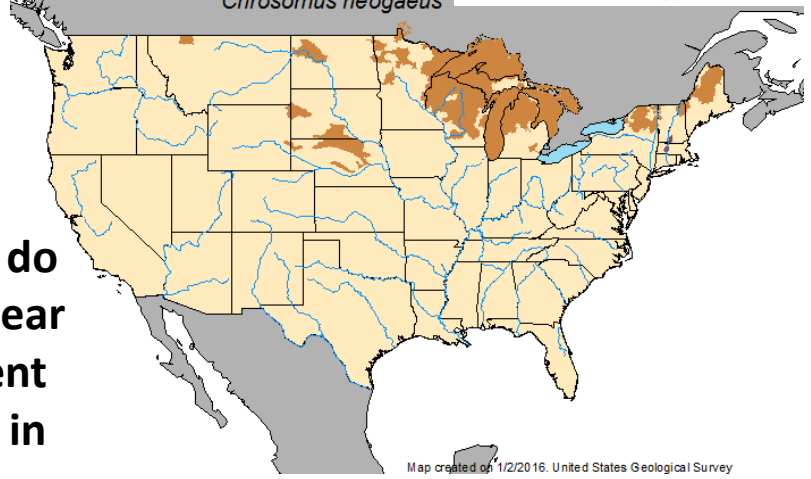
http://www.epa.gov/sites/production/files/2015-06/fish-fig-1-download.png

Couesius plumbeus



Map created on 1/4/2016. United States Geological Survey

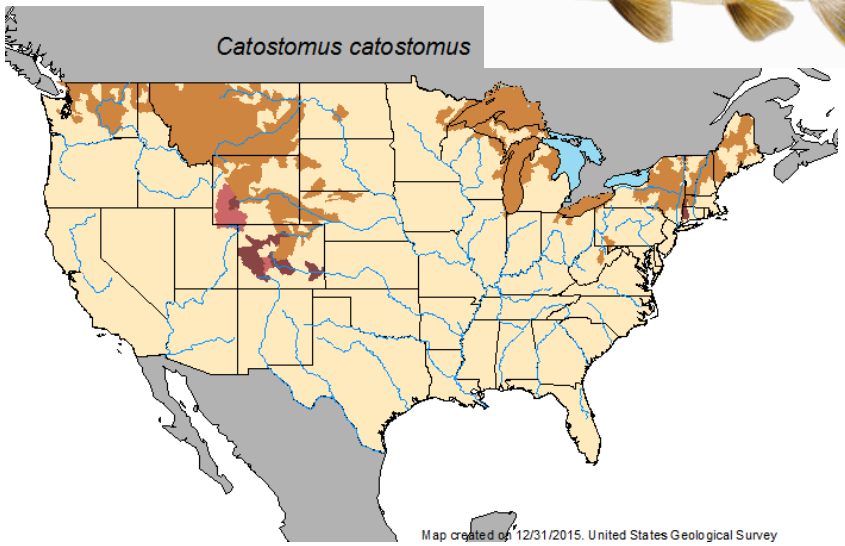
Chrosomus neogaeus



Map created on 1/2/2016. United States Geological Survey

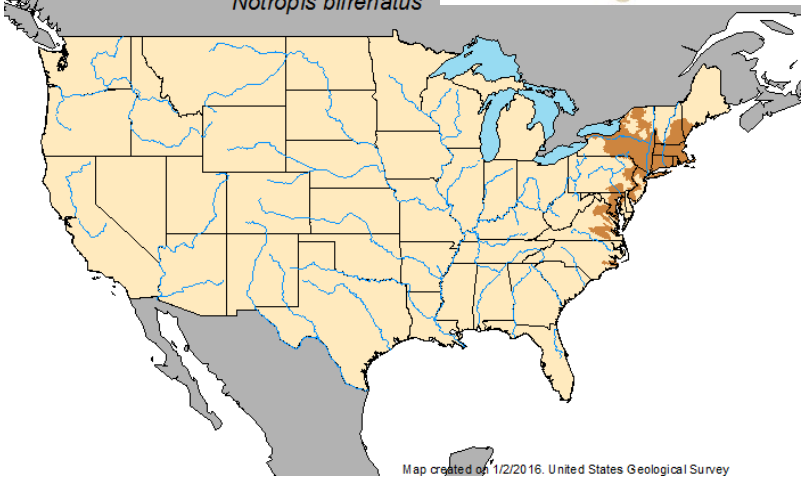
Biggest Losers do appear to be near southern extent of their range in New York

Catostomus catostomus



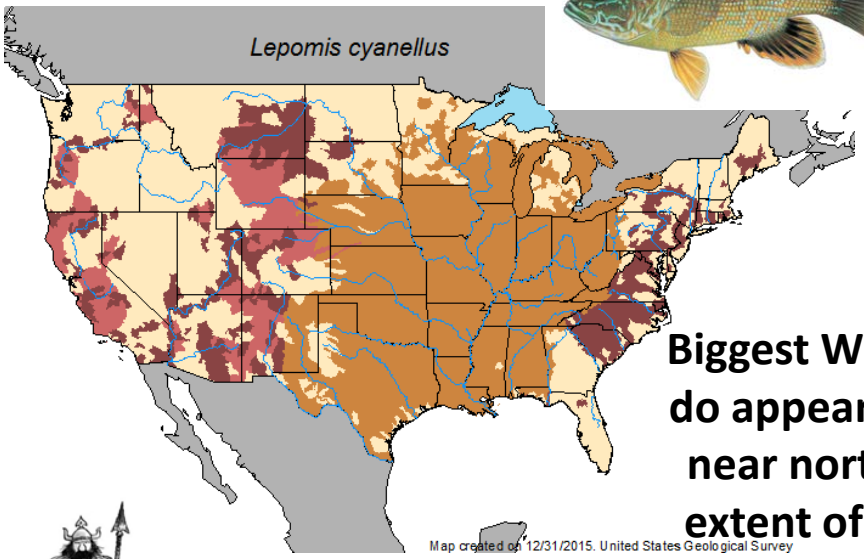
Map created on 12/31/2015. United States Geological Survey

Notropis bifrenatus



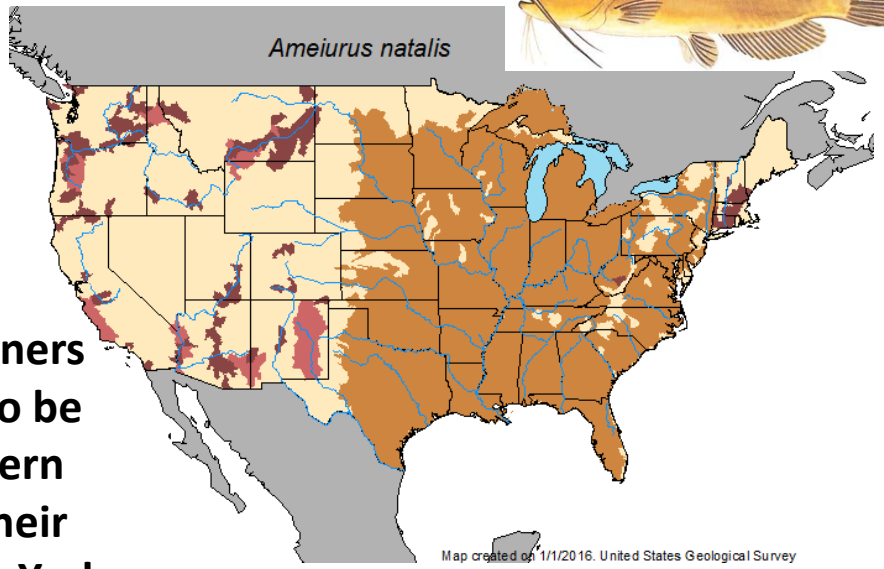
Map created on 1/2/2016. United States Geological Survey

Lepomis cyanellus



Map created on 12/31/2015. United States Geological Survey

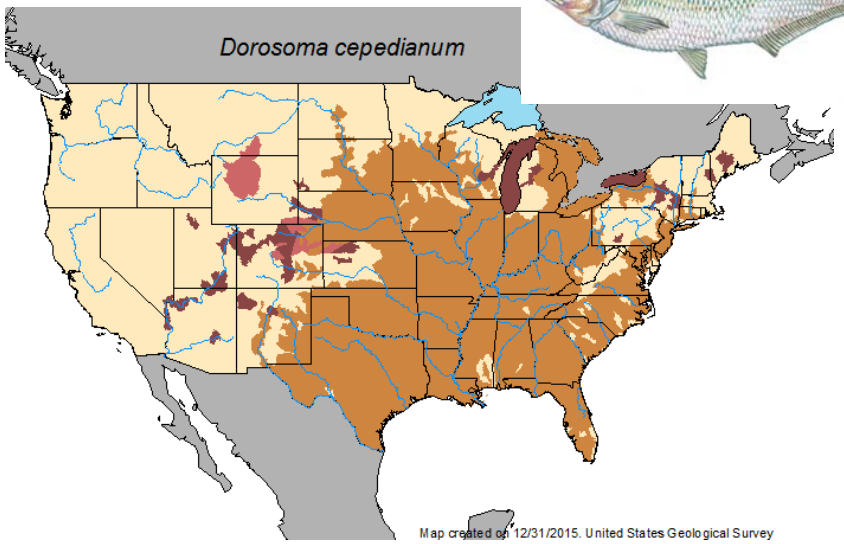
Ameiurus natalis



Map created on 1/1/2016. United States Geological Survey

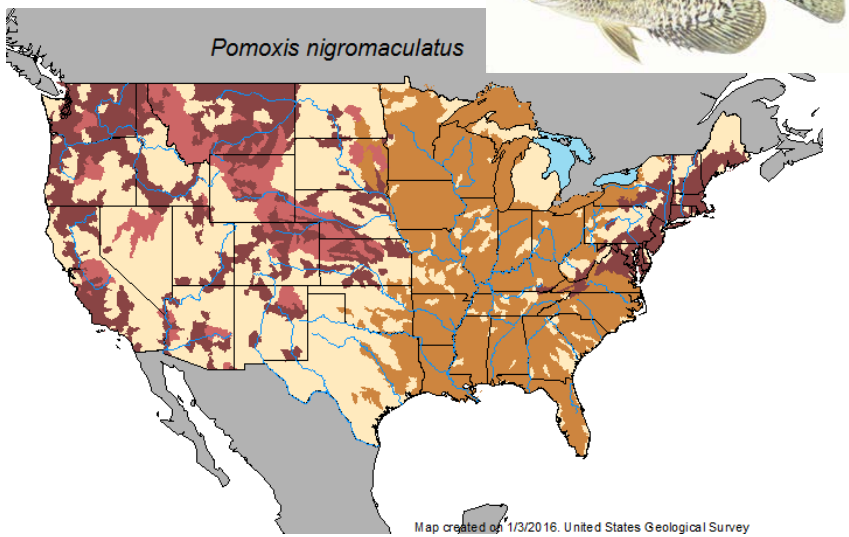
Biggest Winners do appear to be near northern extent of their range in New York

Dorosoma cepedianum



Map created on 12/31/2015. United States Geological Survey

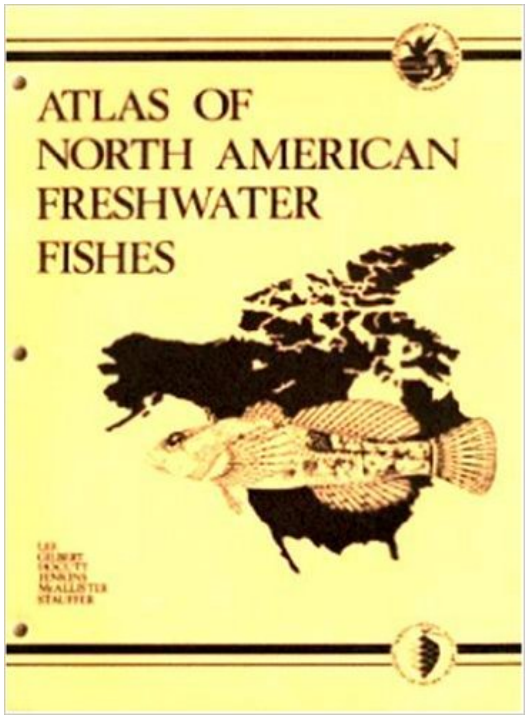
Pomoxis nigromaculatus



Map created on 1/3/2016. United States Geological Survey

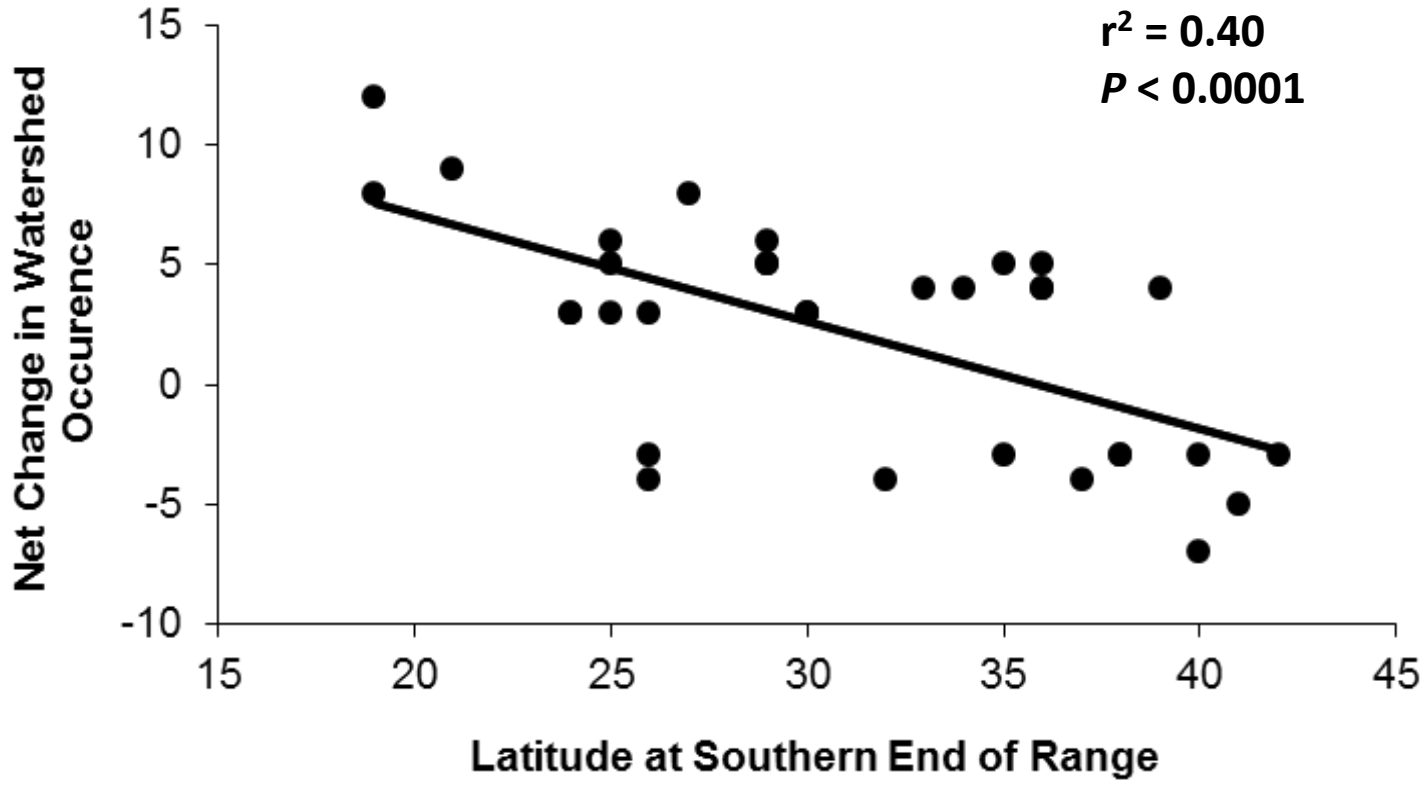
I decided that species' ranges could serve as a surrogate for detailed temperature preference data

i.e., the southern extent of species' ranges should reflect relative temperature tolerances. Species with ranges further to the south should be more tolerant of warmer water than species with ranges that extend less far to the south

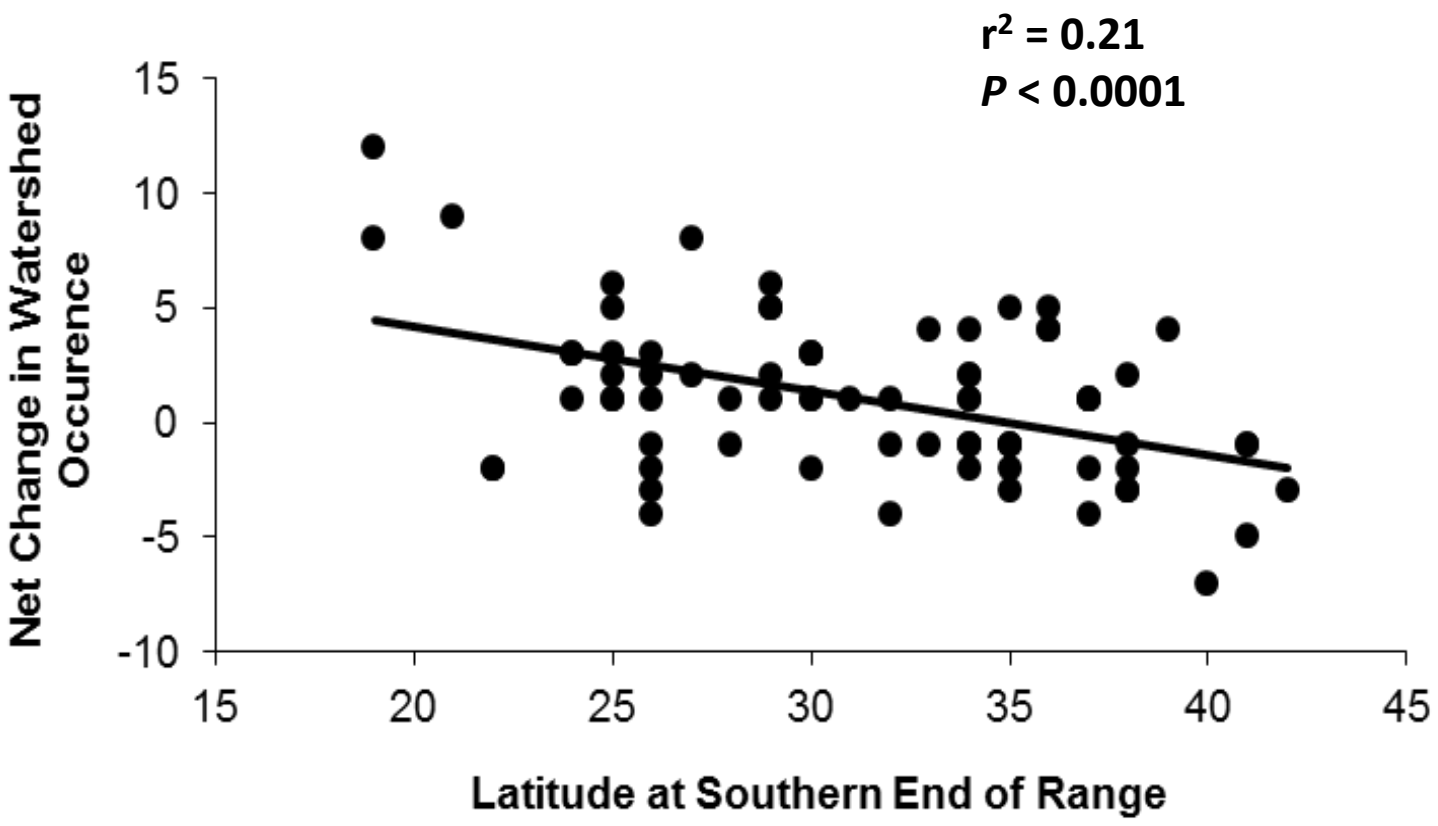


Range limits for all New York species determined from FishBase checked against Lee et al.

Southern extent of range explained 40% of the variation in watershed occurrence shifts by species changing 3 or more watersheds



Southern extent of range explained 21% of the variation in watershed occurrence shifts by species changing 1 or more watersheds (for all species $r^2 = 0.16$)

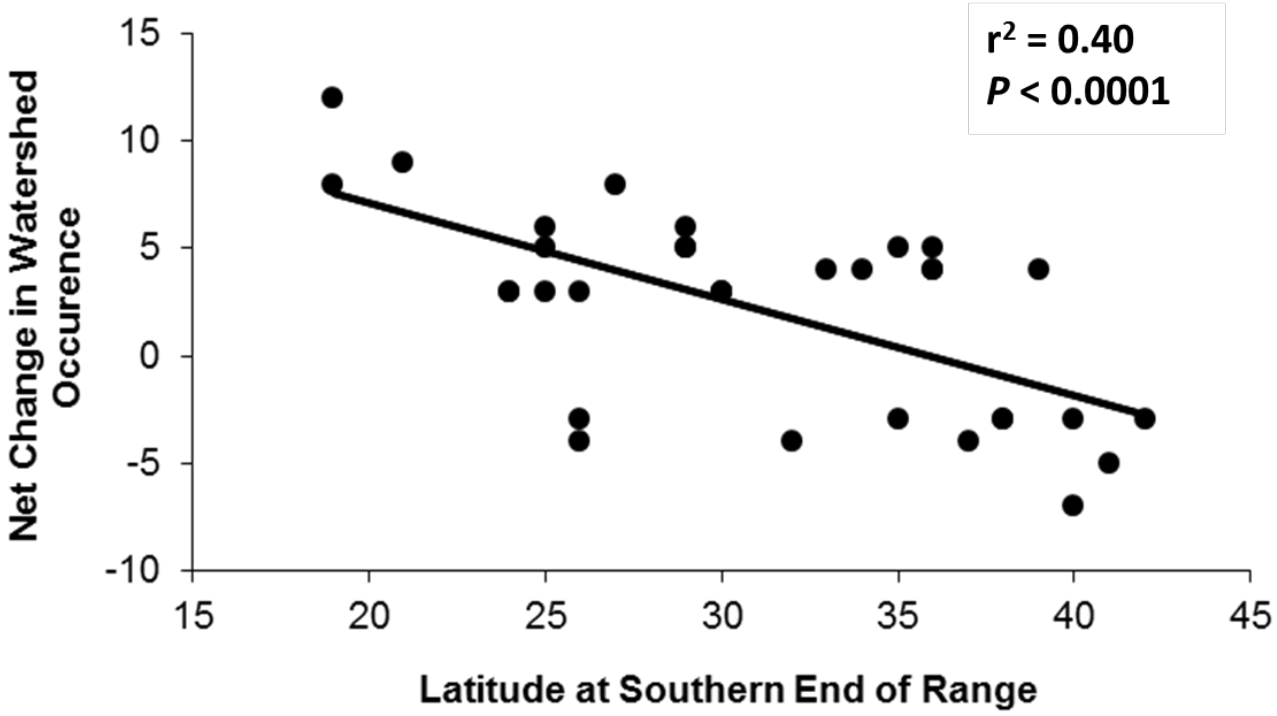


Stocking as an alternative explanation:

Widescale agency stocking started as early as the 1870s, in 1906 alone 233 million individuals of 13 species were stocked in New York (cat was long out of the bag by the watershed surveys)

Ongoing bait bucket transfers almost certainly happening – but would Green Sunfish and Yellow Bullhead be preferentially stocked over sympatrics?

Stocking and canal connections no doubt facilitate movement of fish across watershed boundaries – but results suggest temperature (and climate change) may be driving which species successfully establish populations and spread further



Resiliency to change is built into the fish fauna of New York State – but as managers we may not always like how the species sort out in response to change

These Resources Support World Class Fisheries That Contribute Substantially To the State's Economy

Activities in New York by Residents and Nonresidents

Fishing

Anglers	**1,882,000**
Days of fishing	29,874,000
Average days per angler	16
Total expenditures	$1,962,538,000
Trip-related	$1,057,916,000
Equipment and other	$904,622,000
Average per angler	$907
Average trip expenditure per day	$35

Hunting

Hunters	**823,000**
Days of hunting	18,433,000
Average days per hunter	22
Total expenditures	$1,564,205,000
Trip-related	$810,119,000
Equipment and other	$754,086,000
Average per hunter	$1,899
Average trip expenditure per day	$44