Round Goby (*Neogobius melanostomus*) Introduction and Range Expansion in the Des Plaines River Watershed, Illinois, USA

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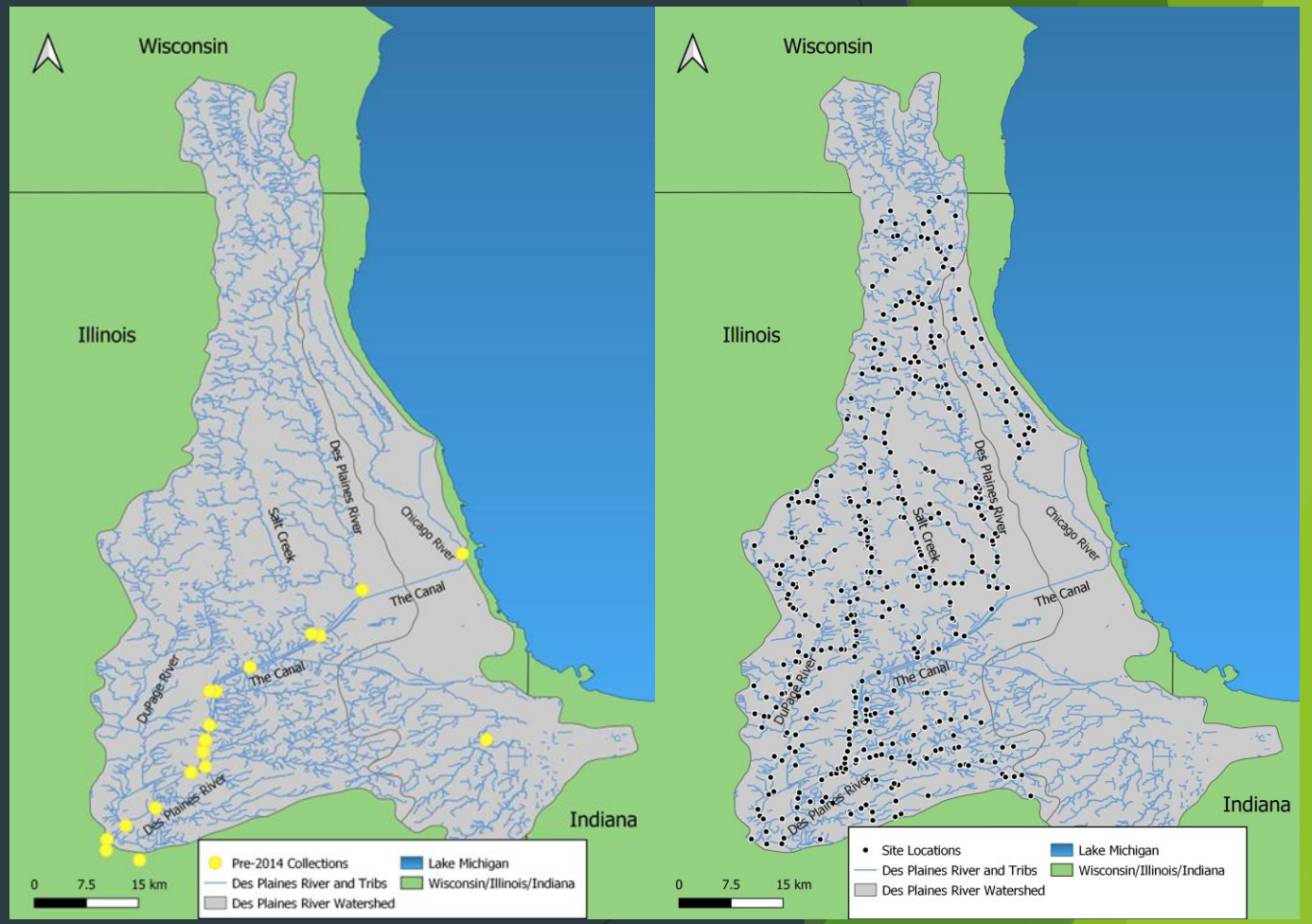
Special Thanks

Round Goby (*Neogobius melanostomus*)

- Small benthic fish reaching up to 25 cm in length
- Native Range includes Caspian Sea, Black Sea, Sea of Azov, and tributaries
- Preys on aquatic macroinvertebrates, small fish species, mussels, and fish eggs
- Nest builder for breeding

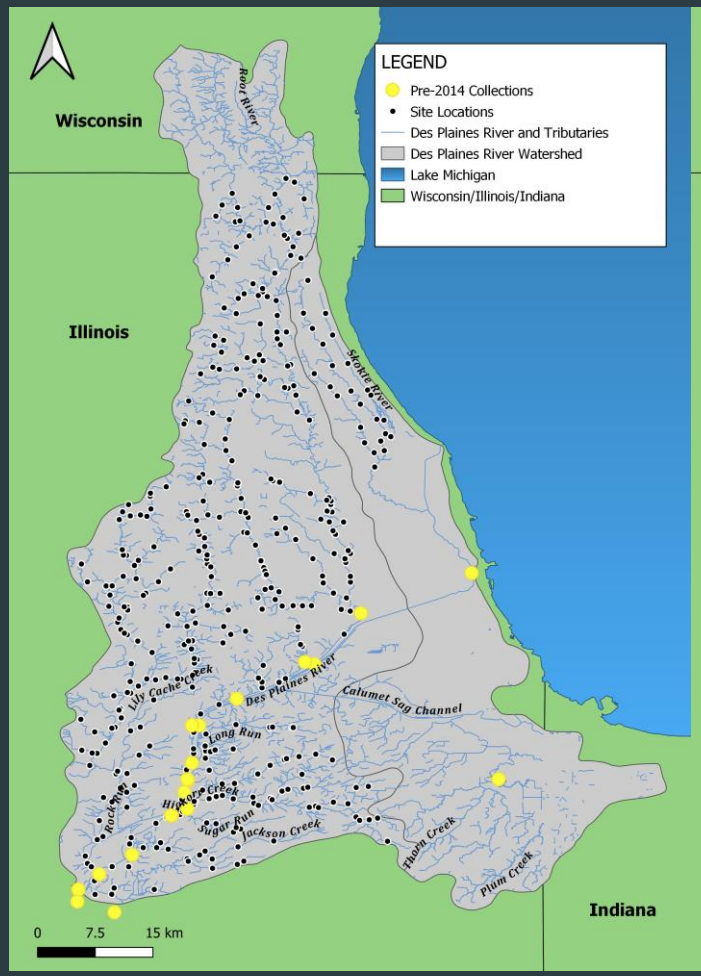
Background/Study Area

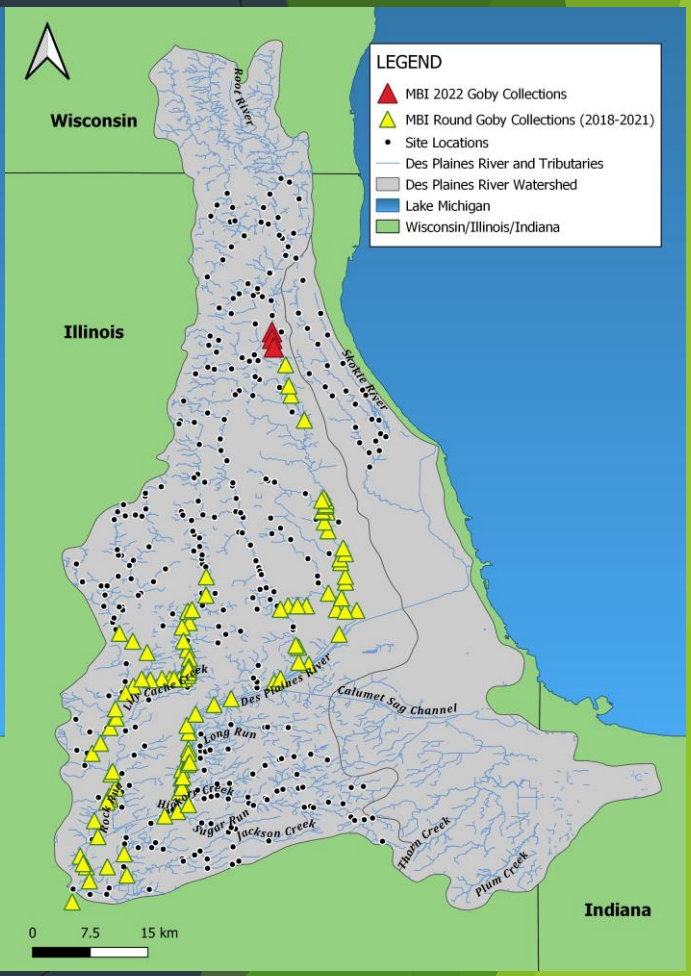
- Introduced into the Great Lakes from commercial ships in the early 1990's (Marsden and Jude 1995)
- Likely entered the Des Plaines River watershed through the Chicago Sanitary and Ship Canal (CSSC). First collections in Des Plaines River watershed occurred in 2002 in The Canal
- MBI sampled more than 400 sites 2018-2021 in 6 subwatersheds
- Drainage areas range from <2.0 sq. mi. to 2111 sq. mi.
- 196 locations used for analyses



Observed Expansion

- Significant range expansion observed since 2014
  - Upstream movement has reached Lake County, IL in the Des Plaines River
  - A further 3 sites inhabited in 2022, increasing range in the Des Plaines River by 4.60 miles





Data Collection

- Water Chemistry
  - Water samples were collected using Illinois EPA methods (Total Suspended Solids (TSS), Total Kjeldahl Nitrogen (TKN), Ammonia-N, Specific Conductance, Nitrates, Dissolved Oxygen (D.O.), Total Dissolved Solids (TDS), Chlorides, pH; Illinois EPA 2012)
- Habitat
  - Habitat quality was evaluated using the Qualitative Habitat Evaluation Index (Rankin 1989; OEPA 2006)
- Fish
  - Backpack, tote barge (wading), boat, and raft e-fishing units
  - Site length 0.15 km, 0.20 km, 0.50 km based on gear
  - Collected between June 16 and October 15 for each survey

Statistical Analysis

QHEI	Drainage	TSS	Nitrates	D.O.	TKN	Ammonia	Conductivity	Temperature	TDS	Chlorides	pH
1.338295	1.452877	1.347797	2.271014	2.800987	2.098978	1.25841	2.014726	1.290638	6.091584	6.250988	3.705956

- Variance Inflation Factor (VIF)
  - VIF above 3 not used
- Generalized Linear Model (GLM)
  - Poisson Regression – multiple variables to predict numbers
  - Akaike's Information Criterion (AIC) Table

	Models	k	AIC	AICC	d.AICC	w.AICC	evid.rat
1	qhei + tss + tkn + ammonia + conductivity + temp + nitrates + do	9	5702.838	5719.201	0	0.948084	1
2	qhei + drainage + tss + tkn + ammonia + conductivity + temp + nitrates + do	10	5704.397	5726.397	7.195919	0.025958	36.52363679
3	qhei + drainage + tkn + tss + ammonia + nitrates + conductivity + do + temp	10	5704.397	5726.397	7.195919	0.025958	36.52363679
4	drainage + qhei + tss + ammonia + conductivity + do + temp + nitrates	9	5780.473	5796.837	77.63586	1.31E-17	7.21793E+16
5	qhei + drainage + tss + nitrates + tkn * do	8	5874.388	5886.388	167.1873	4.71E-37	2.01E+36
6	qhei + drainage + tss + nitrates + tkn * do	8	5874.388	5886.388	167.1873	4.71E-37	2.01E+36

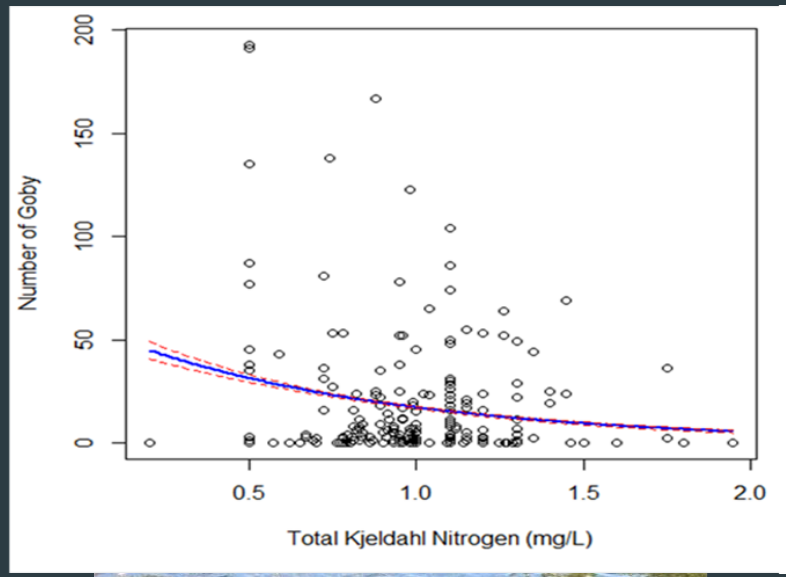
Results: Poisson Regression

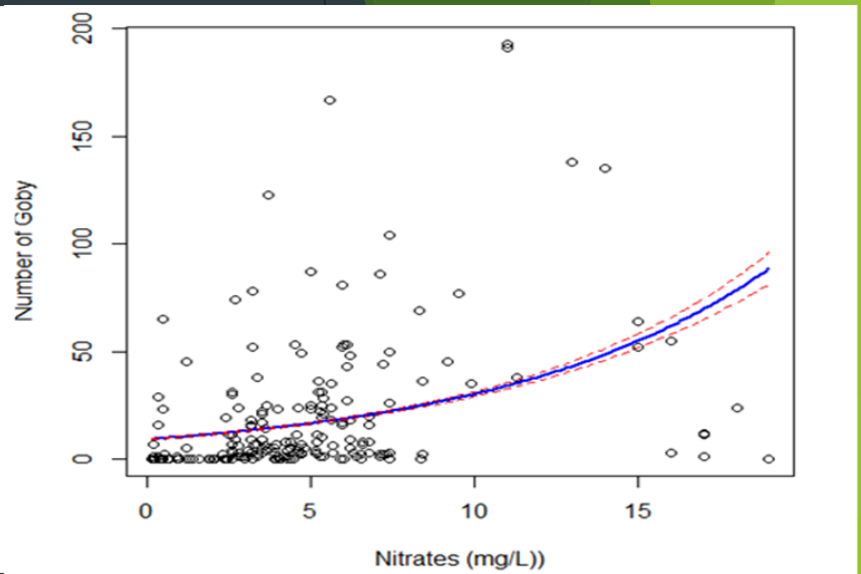
- QHEI + TSS + Nitrates + TKN + Conductivity + D.O. + Ammonia + temperature + specific conductance was determined to be the best explanation for the number of Round Goby collected at a site from the AIC table
- Ammonia was the only variable not considered significant

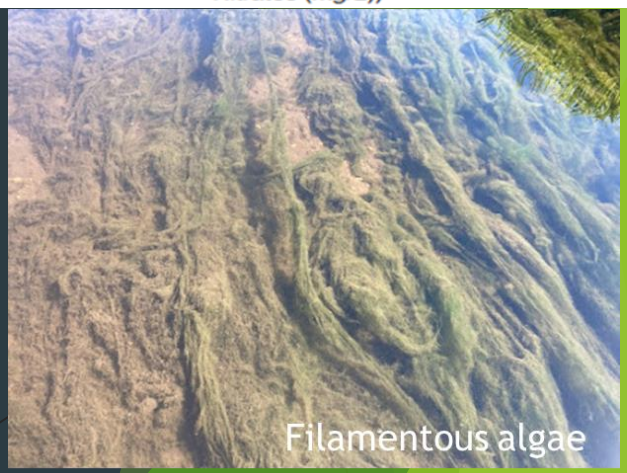
	Estimate	Std. Error	Z value	p-value
(Intercept)	2.46E+00	2.39E-02	103.304	< 2e-16
qhei	2.79E-01	1.81E-02	13.904	< 2e-16
temp	-1.37E-01	5.22E-03	-7.587	3.27E-14
tss	-8.44E-01	4.07E-02	-20.734	< 2e-16
nitrates	3.50E-01	1.45E-02	24.069	< 2e-16
do	7.83E-02	1.51E-02	5.191	2.09E-07
tkn	-1.60E-01	1.79E-02	-8.955	< 2e-16
ammonia	-8.86E-03	2.22E-02	-0.399	0.69
conductivity	1.72E-01	1.76E-02	9.8	< 2e-16
Dispersion Parameter: Taken to be 1				
Null deviance: 7652.7 on 210 degrees of freedom				
Residual deviance: 5028.0 on 202 degrees of freedom				
Number of Fisher Scoring iterations: 6				

Results: Nitrogen

- Nitrates
  - Collections ranged from median concentrations of 0.22 mg/L (7) to 18.00 mg/L (24)
  - Tolerant of high concentrations
  - Can increase susceptibility to hypoxia (Isaza et al. 2021)
- TKN
  - Collections ranged from median concentrations of 0.50 mg/L (86) to 1.75 mg/L (36)
  - Ammonia was not significant to Round Goby numbers or the likelihood of collection
  - More likely associated with high macrophyte cover or sestonic/benthic algae
  - Unknown if this is due to local avoidance or inability to see Goby

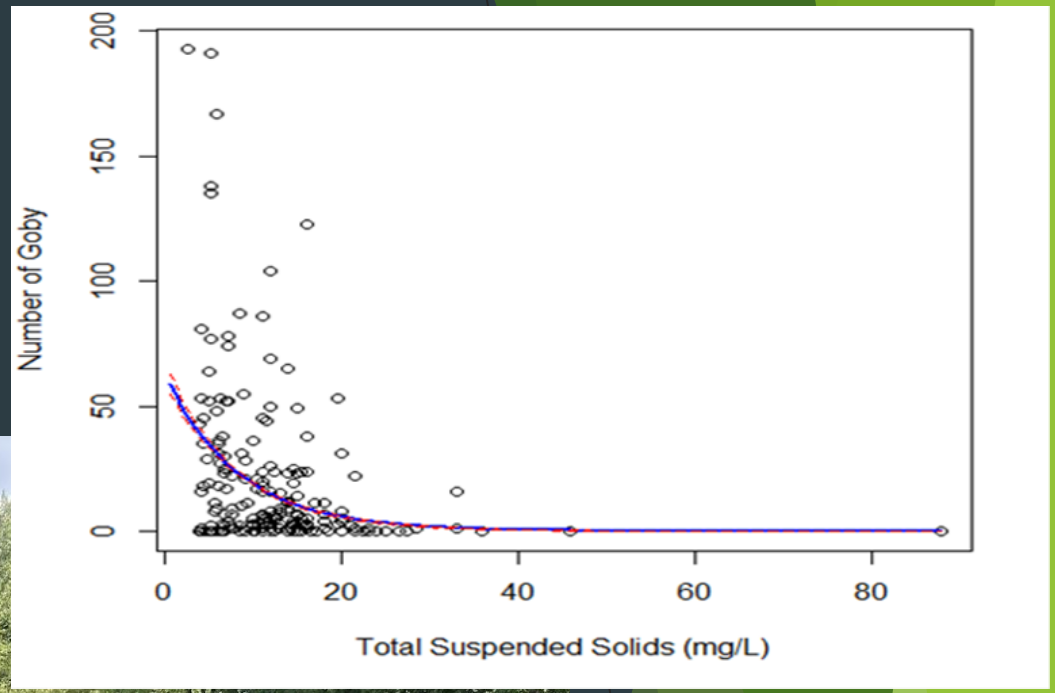


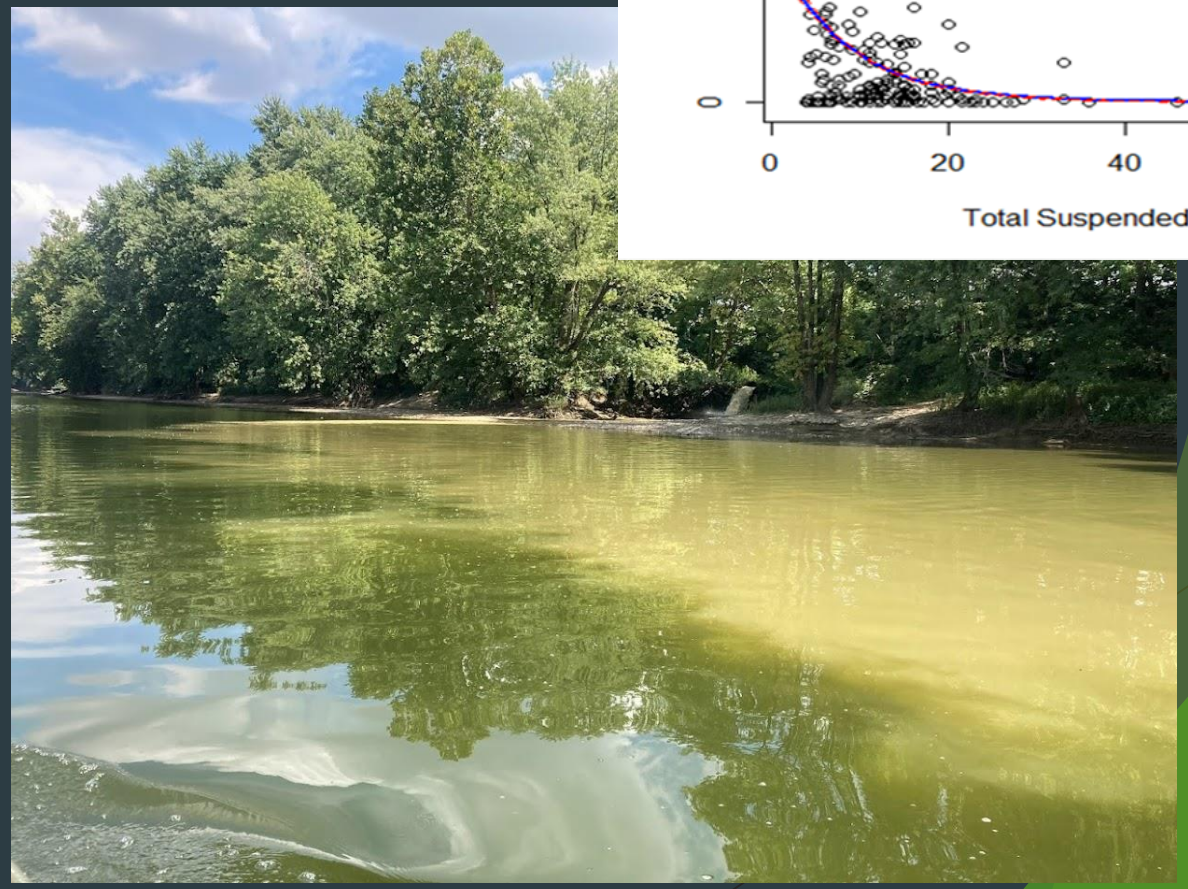




Results: TSS

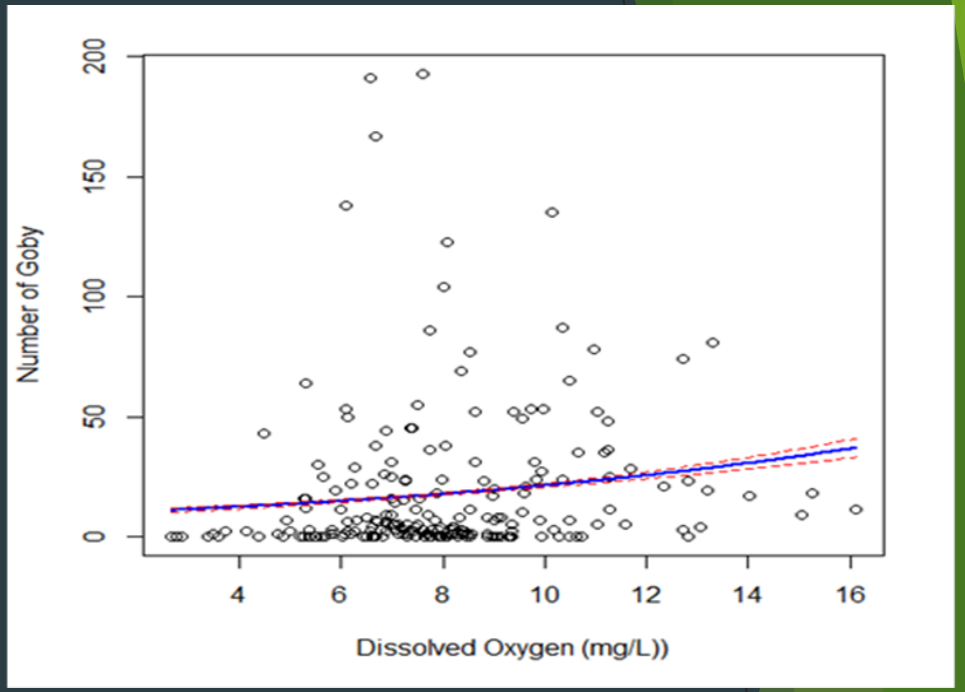
- Collection of Round Goby occurred at sites with concentrations of TSS between 2.6 mg/L (193) and 33.00 mg/L (1); highest median concentration observed was 238 mg/L in a small trib to the DuPage River
- TSS can damage gills
- TSS decreases Secchi depth, making the collection of any fish species more difficult. Especially a benthic species





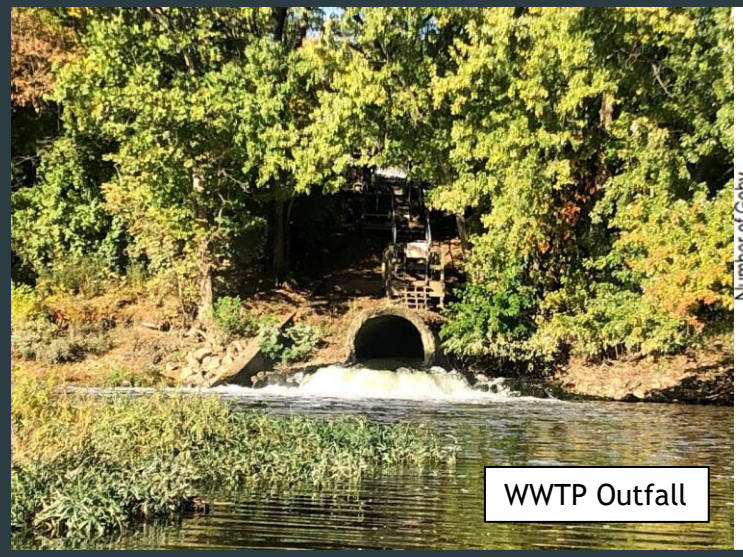
Results: D.O.

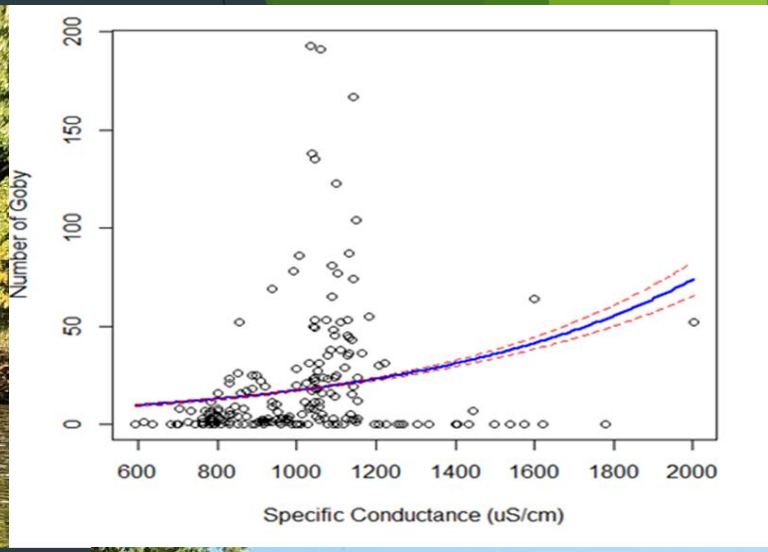
- Appears to be a preference to inhabit sites with median D.O. concentrations between 6.0 mg/L and 12.0 mg/L
- Gobies were collected at sites with median D.O. concentrations ranging from 3.50 mg/L to 16.13 mg/L
- All but one sample with D.O. concentrations above 12.00 mg/L possessed Round Goby



Results: Specific Conductance

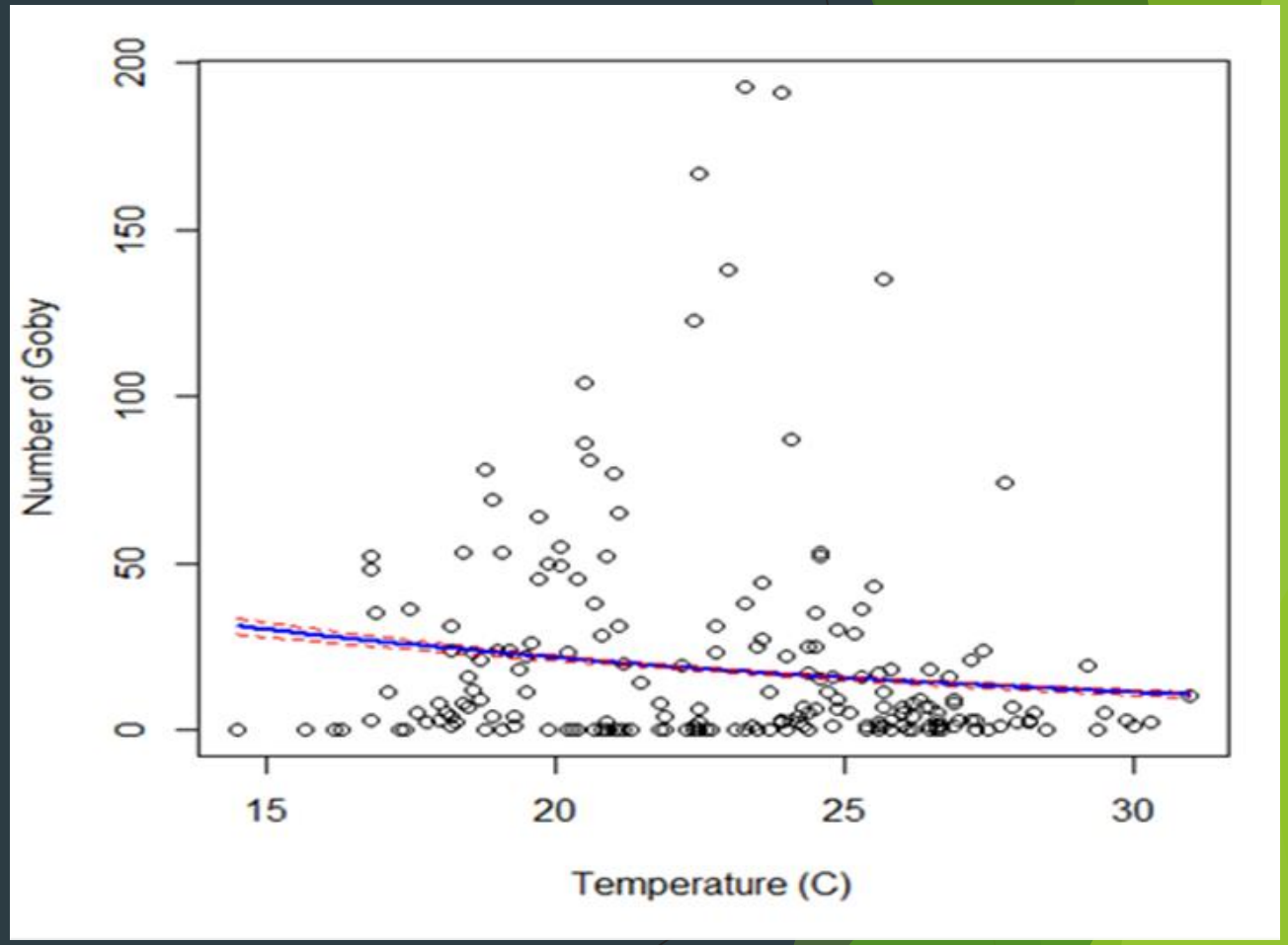
- Observed preference between 800 µS/cm and 1200 µS/cm, but ranged from 703 (8) µS/cm to 2004 µS/cm (52); max observed specific conductance was 2004 µS/cm
- Euryhaline species
  - Native range includes fresh and brackish waters
- Higher specific conductance was generally recorded at headwater sites where Round Goby were absent or in small numbers





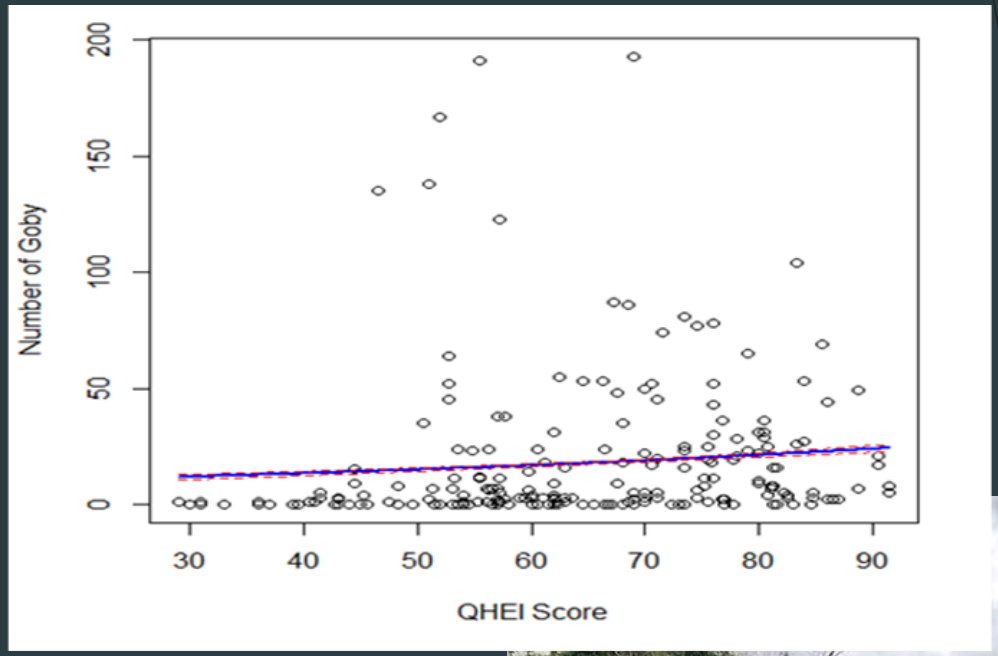
Results: Temperature (ºC)

- Collections ranged in median temperatures from 16.8˚C (3) to 31.0˚C (10)
- Preference for water temperatures between 18˚C and ~25˚C
- Temperatures above 28˚C have negative affects and prolonged exposure to temperatures above 30˚C increases mortality rates (Christensen et al. 2021)



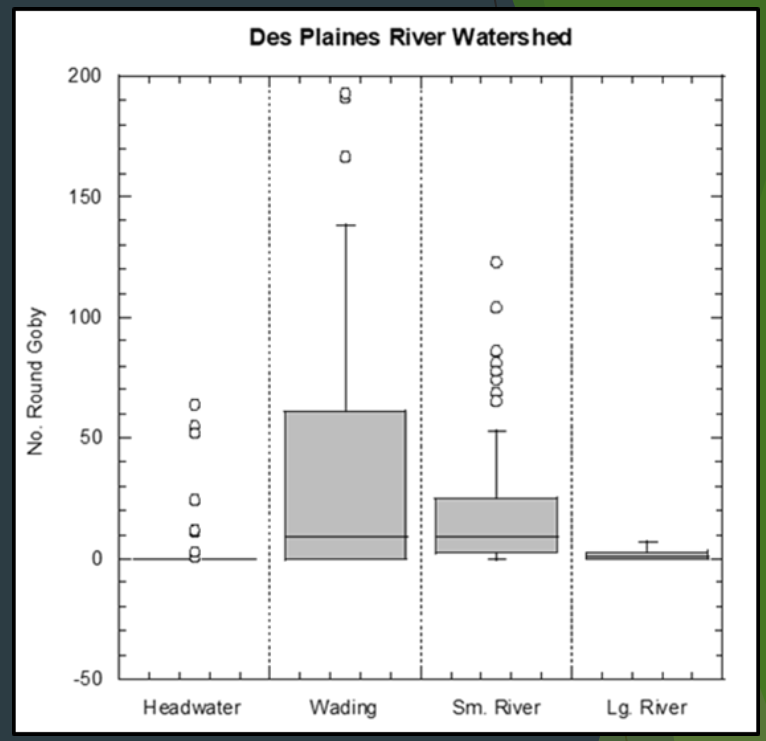
Results: Habitat

- Most collections occurred with QHEI scores above 50; collections ranged with QHEI scores of 29 (1) to 91.5 (8); 293 collected at EB33 in 2019 with a QHEI of 69
- More likely to collect the species at sites with fair to good habitat scores (NE IL IPS)
  - Coarse substrates, such as cobble and gravel, are preferred at locations with slow flows preferred (Reid 2019; Brownscombe and Fox 2012)
- No differentiation in drainage area for analysis



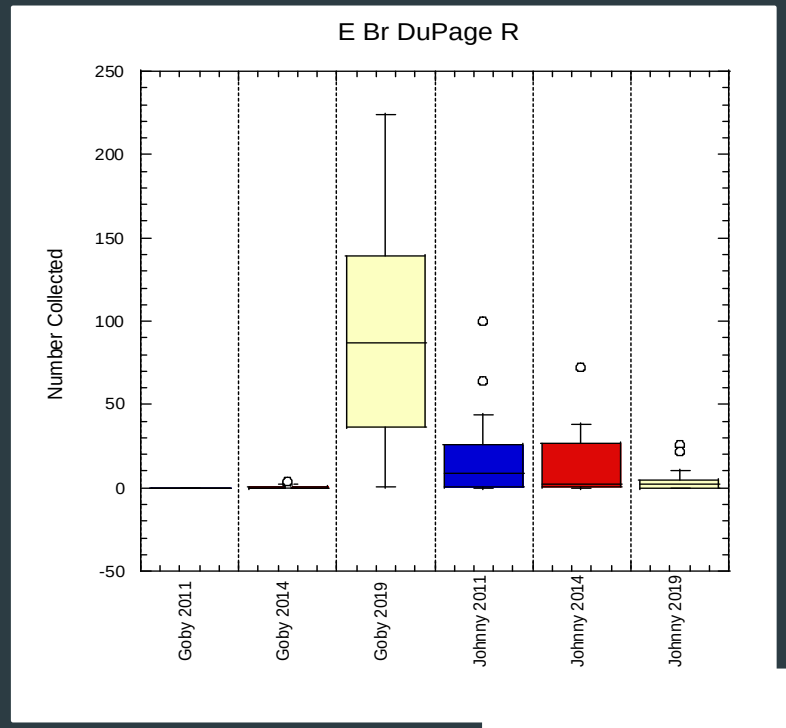
Discussion

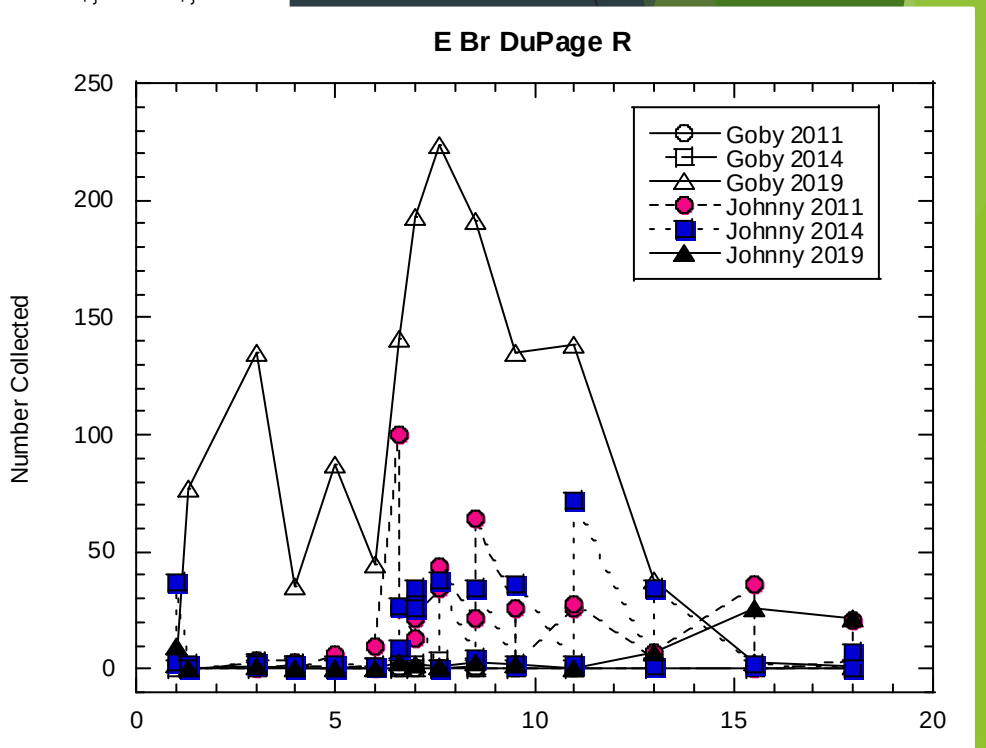
- Appears to prefer moderate-sized streams and small rivers
  - Uses major rivers as routes to new waters
  - Headwater streams may be used as a refuge during periods of high flow
- Higher concentrations of Nitrates are tolerated
- Higher TSS and TKN concentrations may not be
- Tolerant of high levels of specific conductance
  - Highest specific conductance generally recorded in headwater streams where Goby generally avoided regardless of conductance
- Likely tolerant of low D.O. concentrations and high diel swings
  - Few sites with very low D.O. were wading and small river sites (4 in Lower Des Plaines where muck and silt were dominant substrate types)
- Habitat preferences include coarse substrates and macrophytes for cover in low gradient streams, but silt and muck tolerated (Leino and Mensinger 2016; Roche et al. 2015; Taraborelli et al. 2008; Ray and Corkum 2001)
- Negatively affects aquatic macroinvertebrate assemblages and can cause local extirpation of native benthic fish species



Goby vs Natives

- Bergstrom and Mensinger (2009) observed declines in Slimy Sculpin numbers and Logperch abundance and biomass
- Mottled Sculpin have also declined in the presence of Round Goby (Jude and DeBoe 1996; Charlebois et al. 1997; Janssen and Jude 2001; Jude 2001; Ray and Corkum 2001)
- Habitat overlap with Channel Darter (Reid 2019)
- Rainbow Darter declines where habitat overlap occurs (McAllister et al. 2022)
- Reduced diversity and biomass in macroinvertebrate assemblages (Kipp and Ricciardi 2012)
- Decline in Johnny Darters post-introduction of Round Goby in East Branch DuPage River





What about overall assemblage quality?

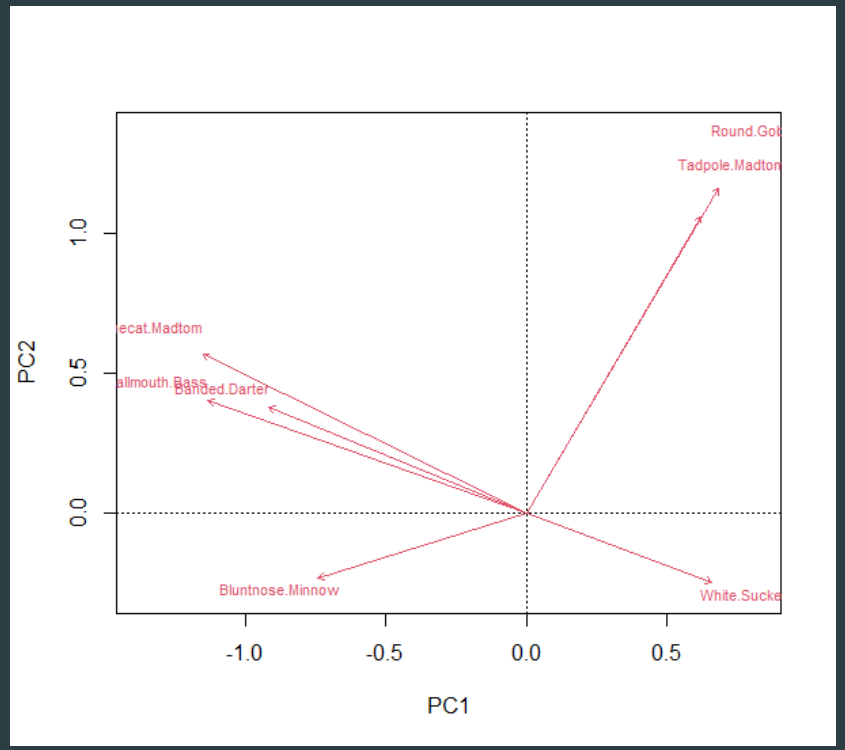
- Does the introduction and establishment of Round Goby affect assemblage quality?

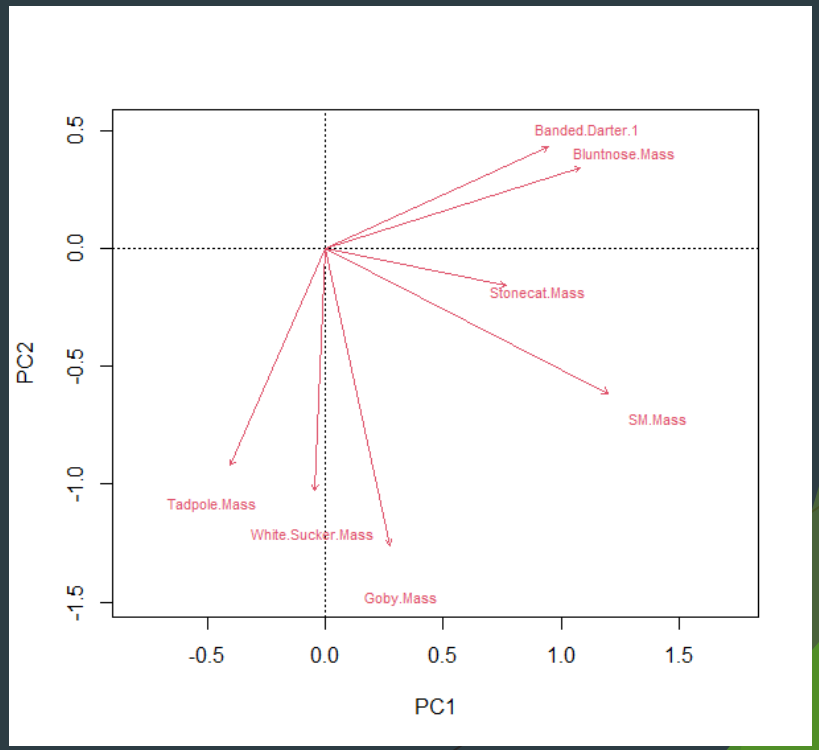
Number of Native Species					
watershed	t-score	df	p-value	mean of pre	mean of post
DuPage and Branches	1.3504	55.445	0.1824	13.69118	12.80882
DuPage Mainstem	-1.6489	26.65	0.1109	12.63333	13.8
E Br DuPage	2.2475	20.723	0.03563	14.36667	11.66667
W Br DuPage[1]	3.2998	4.4406	0.02563	15.125	13.375

[1] not enough data to make any conclusion

fIBI pre- and post-introduction					
watershed	t-score	df	p-value	mean of pre	mean of post
DuPage and Branches	0.17317	57.23	0.8631	29.89706	29.63235
DuPage Mainstem	-1.9523	27.888	0.06101	30.8	34.93333
E Br DuPage	2.3314	27.466	0.0273	28.06667	24
W Br DuPage[1]	-1.2369	6	0.2623	31.125	33.125

[1] not enough data to make any conclusion





How is this about Ohio?

- Upstream movement is slow but inevitable
  - Collected in the Mississippi River downstream of the Illinois River in 2019 at Alton, IL (USGS)
- Downstream movement is much more rapid
  - Collected in LeBoeuf Creek, a trib to French Creek of the Allegheny River watershed in Pennsylvania in 2013 (Mulhollem 2019)
- Will likely affect native fishes, particularly darter and sculpin species (Bergstrom and Mensinger 2009)
- Coupled with other studies, this could aid in creating a model to identify potential at-risk watersheds

Questions?

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