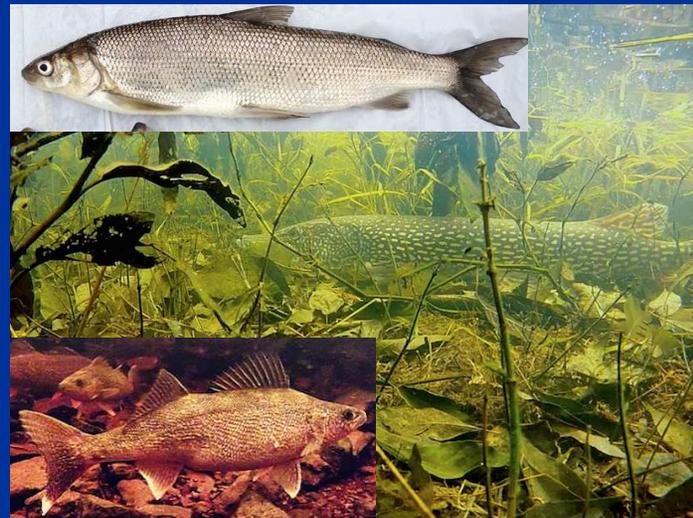


Characterizing Great Lakes Migratory Fish Species: Basin-wide Patterns and New Discoveries

Solomon R. David, M.Herbert, A.Moerke, M.Khoury,
P.Doran, E.Yacobson, P.McIntyre

State of Lake Michigan | Great Lakes Beach Association 2015



 @SolomonRDavid
@SheddResearch



Overview



- **Background & Introduction**

- Great Lakes Watershed
- Migratory Fishes



- **Great Lakes Migratory Fishes Life History & Distribution**

- **Reemergence of Lake Whitefish Migrations**

- **Effects of Dam Removal & Habitat Restoration on Northern Pike**



The Great Lakes



Photo: NOAA



Great Lakes Ecosystems





Great Lakes Fishes





Great Lakes Migratory Fishes



connecting lakes...



...rivers, streams...



...and wetlands





Overview



- Background & Introduction
- Great Lakes Migratory Fishes Life History & Distribution
- Reemergence of Lake Whitefish Migrations
- Effects of Dam Removal & Habitat Restoration on Northern Pike



Great Lakes Migratory Fishes

Life History & Distribution

- Create list of Great Lakes migratory fishes (spawning migrants)
- Trait matrix of migratory fishes characteristics
- Great Lakes basin-wide distribution map of migratory species (presence-absence by watershed)





Great Lakes Migratory Fishes

Species List

■ Polled Great Lakes fishes experts & references

- **54** species
- **19** families
- **13** introduced species

Acipenser fulvescens

Amia calva

Anguilla rostrata

Carpionides cyprinus

Catostomus commersonii

Catostomus commersonii

Ictiobus cyprinellus

Ictiobus niger

Minytrema melanops

Moxostoma anisurum

Moxostoma macrolepidotum

Moxostoma valenciennesi

Micropterus dolomieu

Couesius plumbeus

Luxilus cornutus

Notropis atherinoides

Notropis hudsonius

Rhinichthys cataractae

Esox lucius

Esox masquinongy

Neogobius melanostomus

Hiodon tergisus

Ictalurus punctatus

Lepisosteus osseus

Lepisosteus platostomus

Lota lota

Cyprinus carpio

Morone americana

Morone chrysops

Osmerus mordax

Gymnocephalus cernuus

Perca flavescens

Percina caprodes

Percina copelandi

Percina shumardi

Sander canadensis

Sander vitreus

Percopsis omiscomaycus

Ichthyomyzon castaneus

Ichthyomyzon unicuspis

Petromyzon marinus

Coregonus artedii

Coregonus clupeaformis

Oncorhynchus gorbuscha

Oncorhynchus kisutch

Oncorhynchus mykiss

Oncorhynchus tshawytscha

Prosopium coulterii

Prosopium cylindraceum

Salmo salar

Salmo trutta

Salvelinus fontinalis

Salvelinus namaycush

Aplodinotus grunniens



Great Lakes Migratory Fishes

Trait Matrix

- Reviewed Great Lakes fishes references
 - Warren & Burr 2014: 18
 - Poff & Allan 1995: 6
 - Our team: 35*
- Classify by Great Lakes basin, individual lakes



Smithsonian Air & Space Museum

Trait	Great Lakes	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario	Occur All Lakes
Families	19	18	19	19	19	19	18
Species	54	45	52	50	48	47	40
Native	41	33	39	38	37	36	29
Non-Native	13	12	13	12	11	11	11
Hist Comm	4	4	4	4	4	4	4
Commercial	13	13	13	13	12	13	12
Sport Fish	20	20	20	20	20	20	20
Forage Fish	6	5	6	6	6	5	5
Rough/None	14	9	12	11	10	11	6
Facultative	45	36	43	41	39	38	31
Obligate	9	9	9	9	9	9	9
Iteroparous	47	38	45	44	42	41	34
Semelparous	7	7	7	6	6	6	6



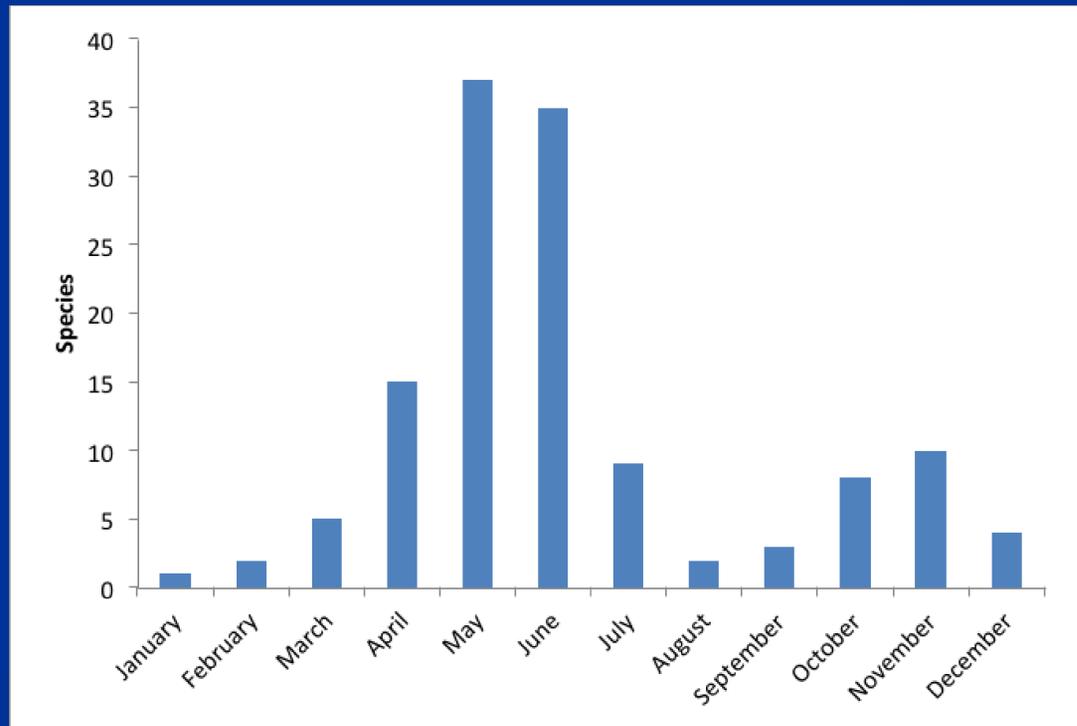
Great Lakes Migratory Fishes

Trait Matrix

Great Lakes Migratory Fishes Spawning "Calendar"

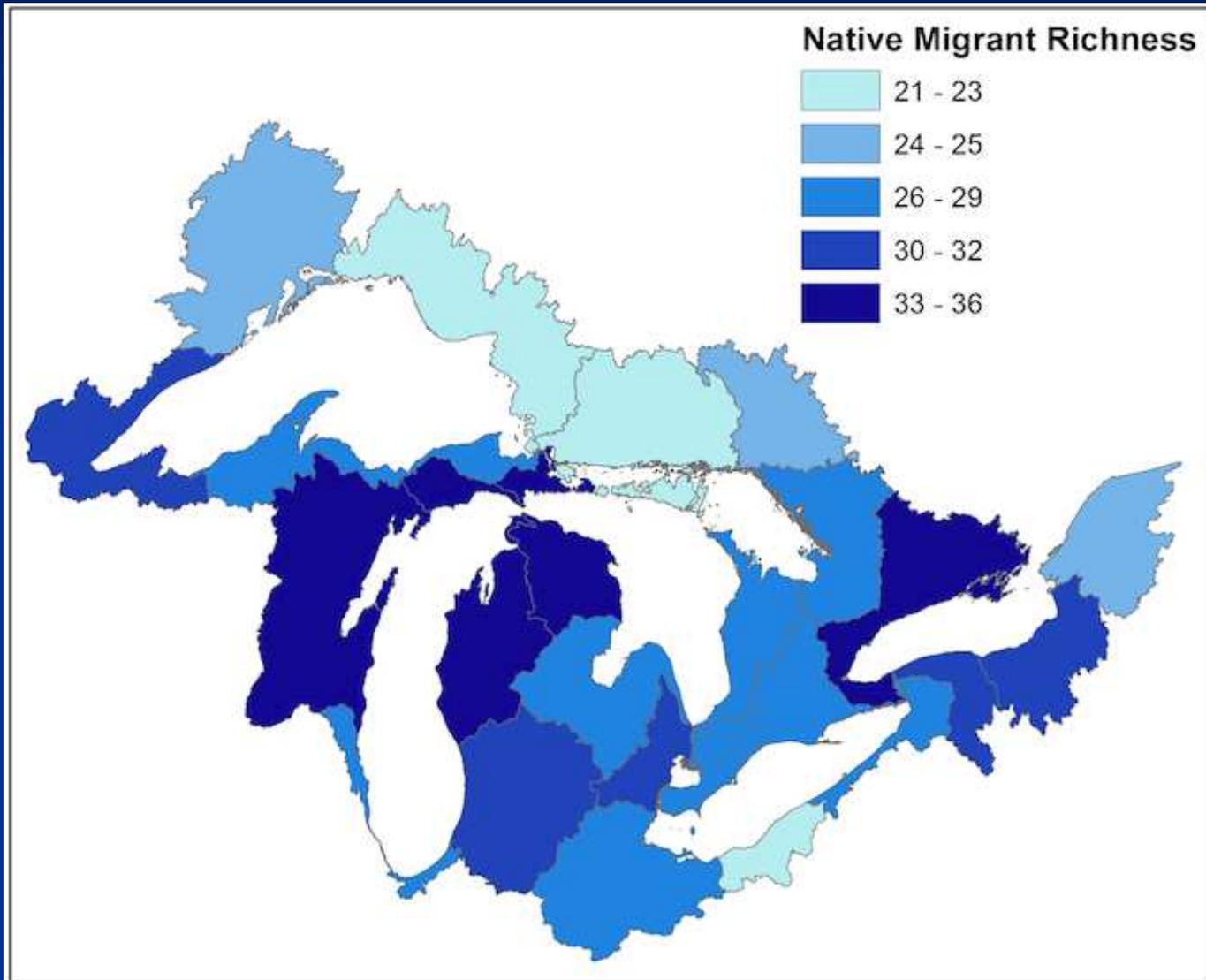


Phylo	Species	Months	Season												Total		
			Jan	Feb	Mar	Apr	May	June	July	August	Sept	Oct	Nov	Dec			
1	<i>Ichthyomyzon castaneus</i>	May-June	0				1	1									2
1	<i>Ichthyomyzon unicuspis</i>	May-June	0				1	1									2
1	<i>Petromyzon marinus</i>	May-June	0				1	1									2
2	<i>Acipenser fulvescens</i>	May-June	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2
3	<i>Lepisosteus osseus</i>	May-June	0				1	1									2
3	<i>Lepisosteus platostomus</i>	May-July	0				1	1	1								3
4	<i>Amia calva</i>	May-June	0				1	1									2
5	<i>Anguilla rostrata</i>	February	0	1	1												2
6	<i>Hiodon tergisus</i>	April-June	0			1	1	1									3
7	<i>Coregonus artedii</i>	November	0									1	1	1			3
7	<i>Coregonus clupeaformis</i>	October-	0									1	1	1			3
7	<i>Oncorhynchus garbuscha</i>	September	0									1	1				2
7	<i>Oncorhynchus kisutch</i>	October-	0									1	1				2
7	<i>Oncorhynchus mykiss</i>	March-M	0		1	1	1										3
7	<i>Oncorhynchus tshawytscha</i>	September	0							1	1						2
7	<i>Prosopium coulteri</i>	November	0										1	1			2
7	<i>Prosopium cylindraceum</i>	November	0										1	1			2
7	<i>Salmo salar</i>	October-	0									1	1				2
7	<i>Salmo trutta</i>	October-	0									1	1				2
7	<i>Salvelinus fontinalis</i>	September	0									1	1	1			3
7	<i>Salvelinus namaycush</i>	September	0									1	1	1			3
8	<i>Osmerus mordax</i>	March-Ap	0		1	1											2
9	<i>Esox lucius</i>	March-M	0		1	1	1										3
9	<i>Esox masquinongy</i>	April-Mai	0			1	1										2
10	<i>Couesius plumbeus</i>	April-Jun	0			1	1	1									3
10	<i>Luxilus cornutus</i>	May-June	0				1	1									2
10	<i>Notropis atherinoides</i>	June-Aug	0					1	1	1							3
10	<i>Notropis hudsonius</i>	May-June	0				1	1	1								3
10	<i>Rhinichthys cataractae</i>	May-July	0				1	1	1								3
11	<i>Carpiodes cyprinus</i>	April-Jun	0			1	1	1									3
11	<i>Catostomus catostomus</i>	April-Jun	0			1	1	1									3
11	<i>Catostomus commersonii</i>	April-Jun	0			1	1	1									3
11	<i>Ictiobus cyprinellus</i>	May-June	0				1	1									2
11	<i>Ictiobus niger</i>	May-June	0				1	1									2
11	<i>Minytrema melanops</i>	May-June	0				1	1									2
11	<i>Moxostoma anisurum</i>	April-Jun	0			1	1	1									3
11	<i>Moxostoma macrolepidotum</i>	April-Jun	0			1	1	1									3
11	<i>Moxostoma valenciennesi</i>	May-June	0				1	1									2
12	<i>Ictalurus punctatus</i>	May-July	0				1	1	1								3
13	<i>Percopsis omiscomaycus</i>	May-Aug	0				1	1	1	1							4
14	<i>Lota lota</i>	January-f	1	1	1												3
15	<i>Morone americana</i>	May-June	0				1	1									2
15	<i>Morone chrysops</i>	May-June	0				1	1									2
16	<i>Micropterus dolomieu</i>	May-June	0				1	1									2
17	<i>Gymnocephalus cernuus</i>	April-Jun	0			1	1	1									3
17	<i>Perca flavescens</i>	April-Ma	0			1	1										2
17	<i>Perca caprodes</i>	May-June	0				1	1									2
17	<i>Perca copelandi</i>	June-July	0					1	1								2
17	<i>Perca shumardi</i>	April-Jun	0			1	1	1									3
17	<i>Sander canadensis</i>	May-June	0				1	1									2
17	<i>Sander vitreus</i>	April-Jun	0			1	1	1									3
18	<i>Aplodinotus grunniens</i>	May-July	0				1	1	1								3
19	<i>Neogobius melanostomus</i>	May-July	0				1	1	1								3
	TOTAL		1	2	5	15	37	35	9	2	3	8	10	4	2,472		



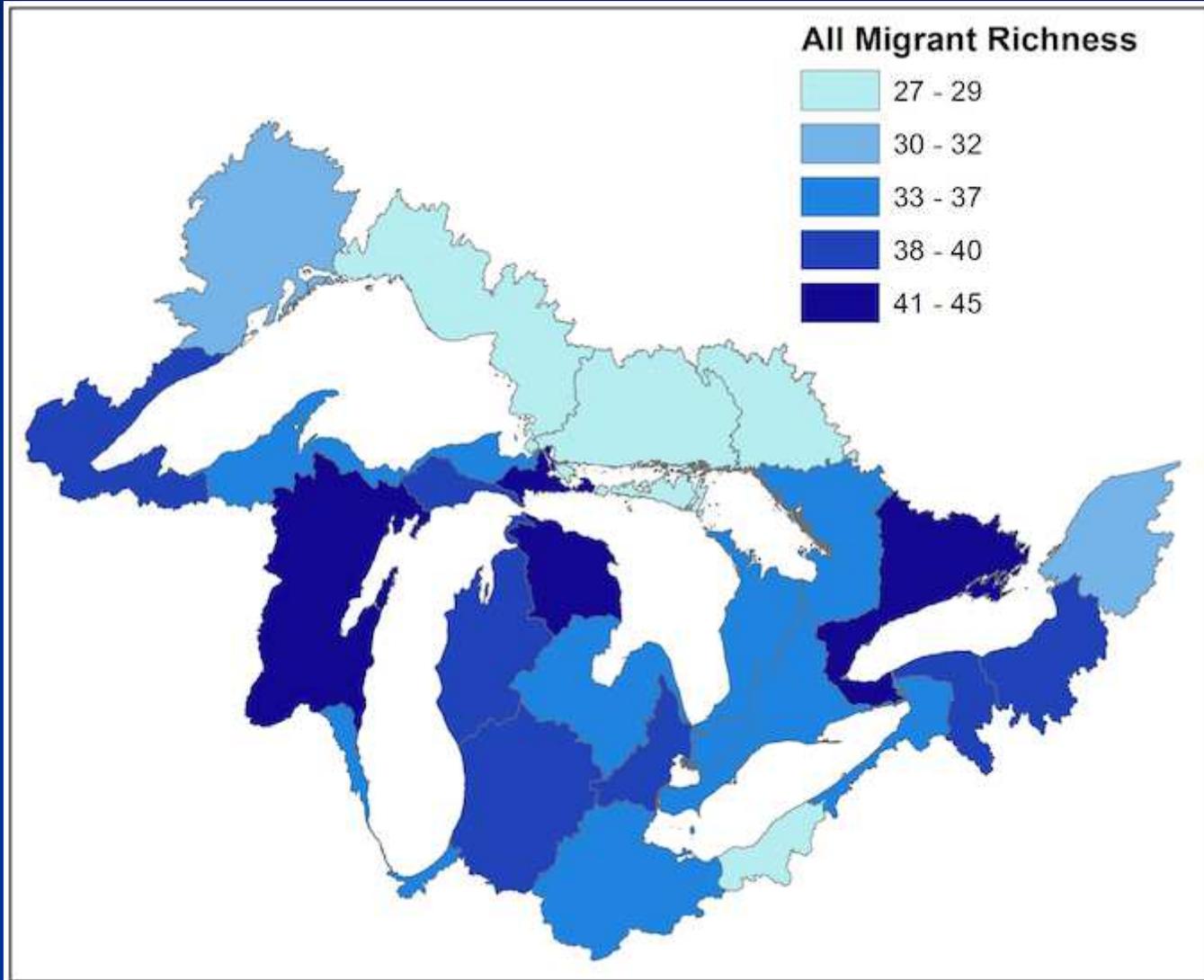


Great Lakes Migratory Fishes Distribution Map





Great Lakes Migratory Fishes Distribution Map



Great Lakes Migratory Fishes



Effects of Dam Removal & Habitat
Restoration on Northern Pike

Reemergence of Lake
Whitefish Migrations





Overview



- Background & Introduction
- Great Lakes Migratory Fishes Life History & Distribution
- Reemergence of Lake Whitefish Migrations
- Effects of Dam Removal & Habitat Restoration on Northern Pike



Great Lakes Migratory Fishes

Reemergence of Lake Whitefish Migrations



- Most economically important commercial fishery in Lake Michigan; Great Lakes
- Riverine migrations ceased ~100 years ago due to habitat loss
- Past 5-10 years migrations have returned





Great Lakes Migratory Fishes

Reemergence of Lake Whitefish Migrations

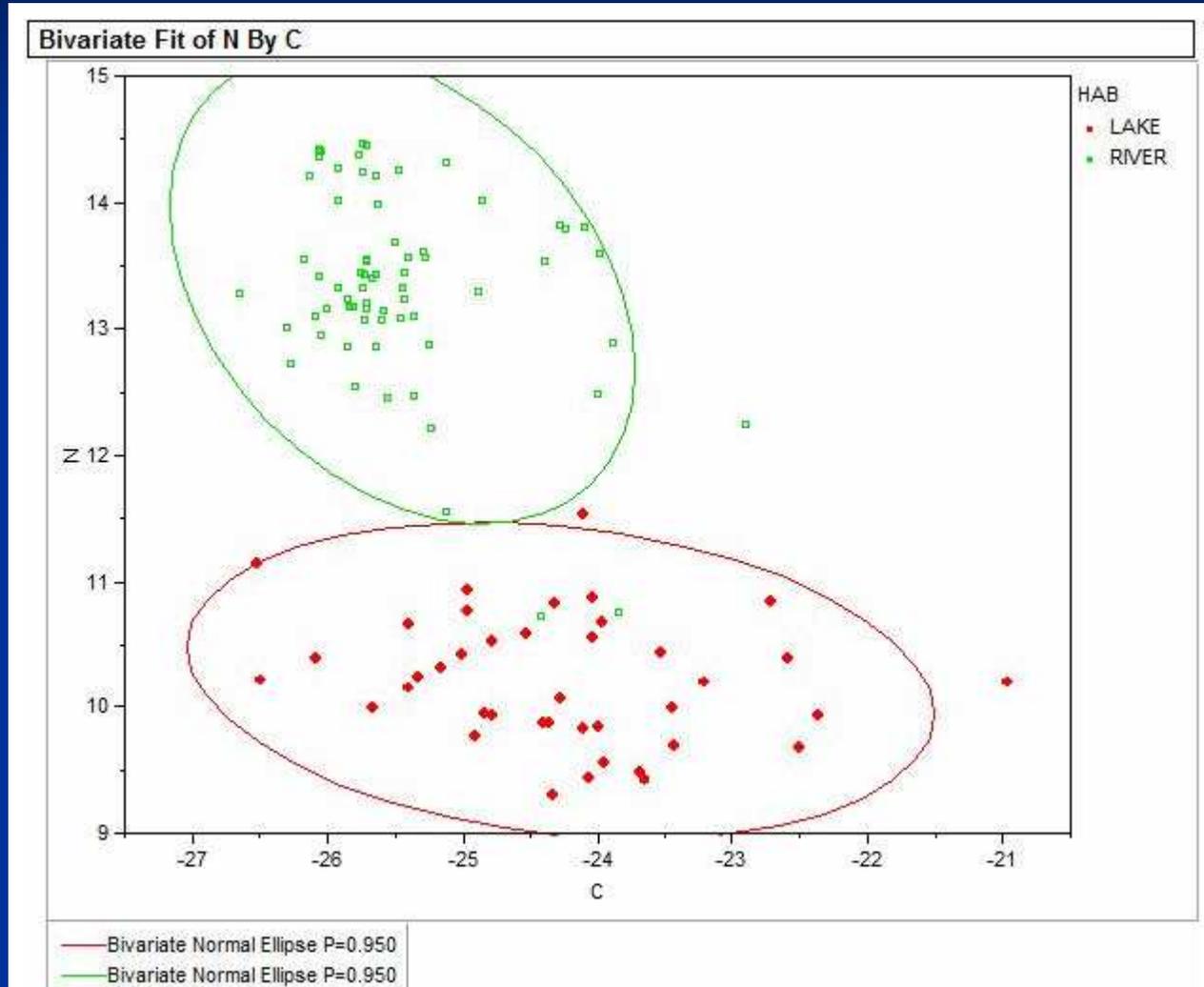
- Reemergence of Lake Whitefish Migrations
 - Collect fish from both river- and lake-spawning populations during spawning season
 - Utilize multiple analyses to determine differences (if any) between river and lake spawners
 - Stable Isotopes
 - Morphometrics
 - Age & Growth
 - Gill Rakers





Results

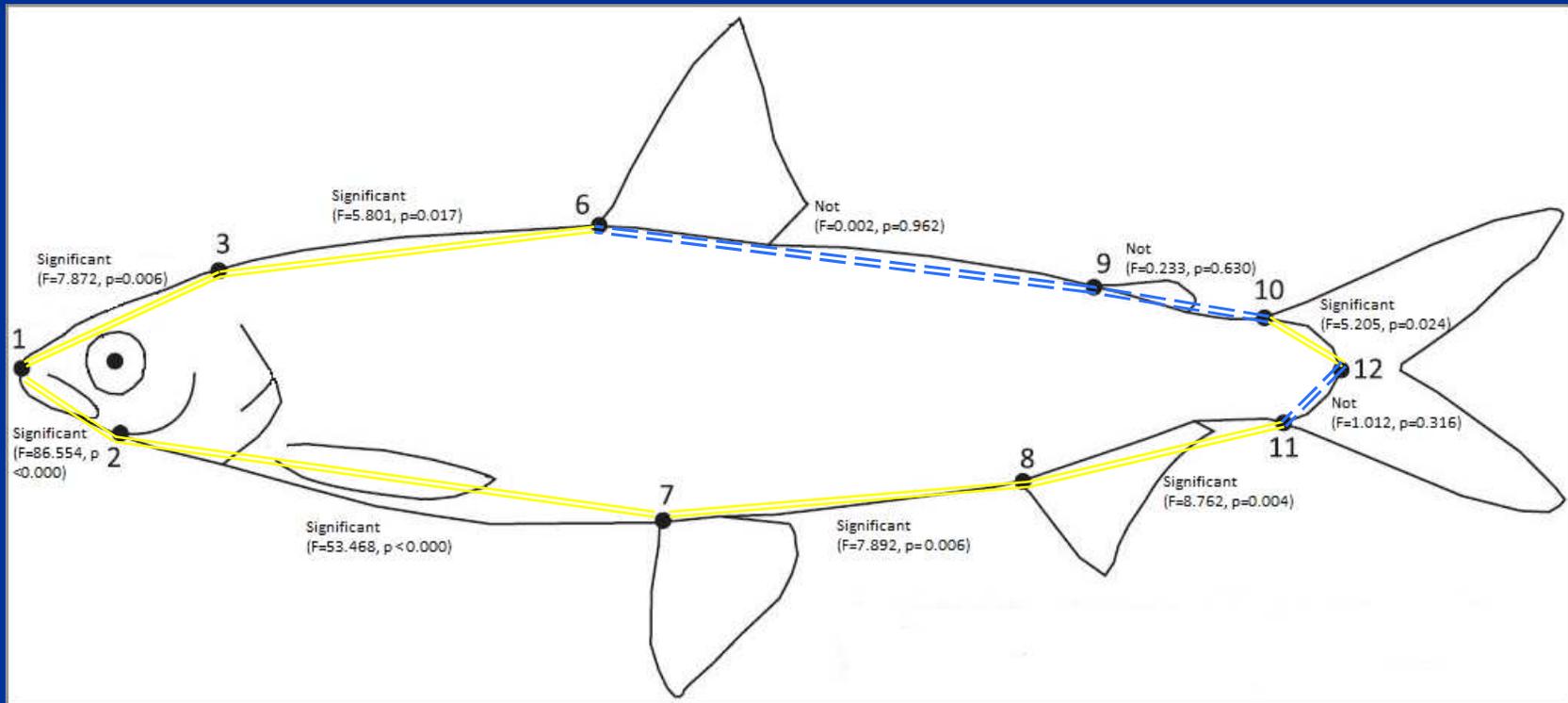
Stable Isotope Analysis



Results

Morphometric Analysis

- Seven of ten morphometrics* significantly different (ANOVA)

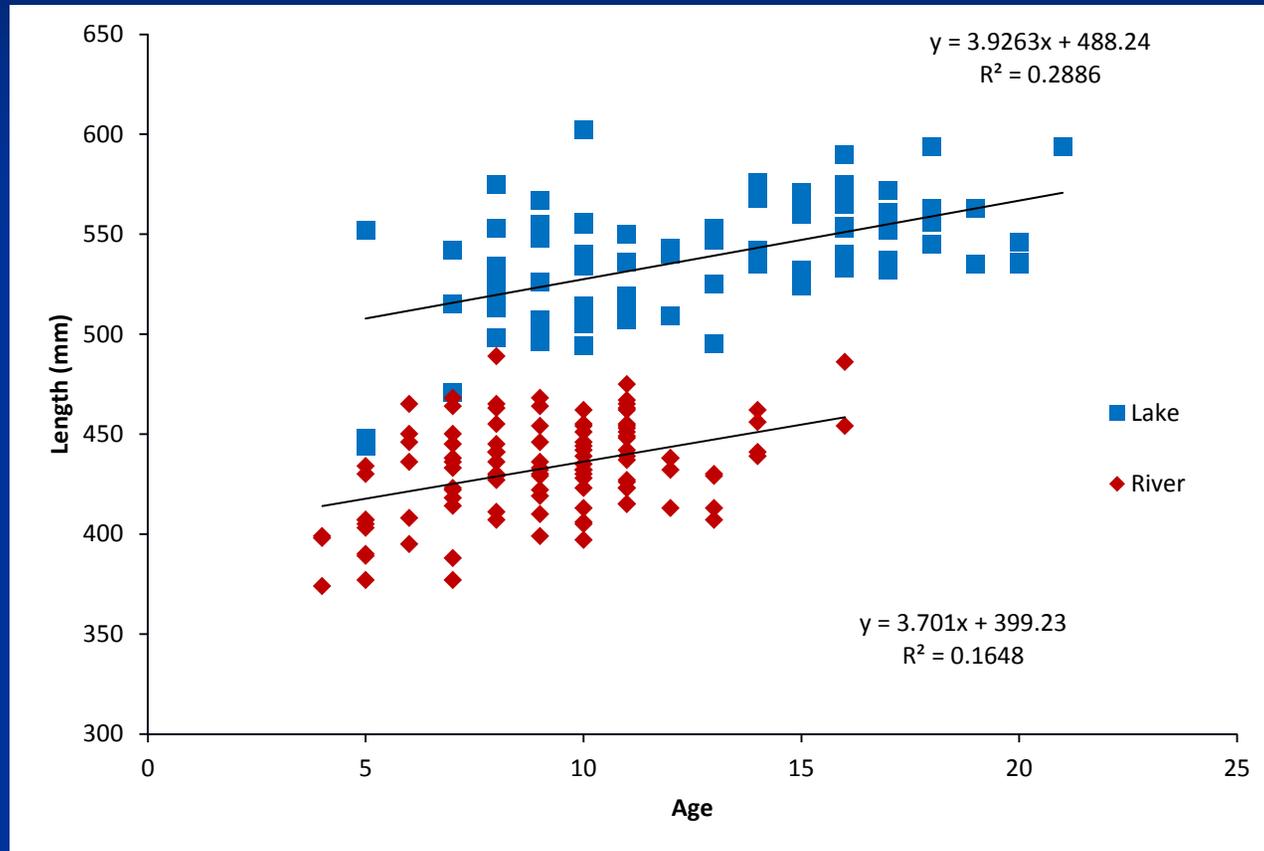


Siwertsson et al. 2013

*Procrustes analysis forthcoming

Results

Growth Rates: Length at Age



- Lake significantly higher growth rate than River fish
 - ANOVA/ANCOVA $p < 0.001$; Lake $n = 80$, River $n = 109$



Overview



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Great Lakes Migratory Fishes

Effects of Dam Removal & Habitat Restoration on Migratory Northern Pike



Dam Removal:

“politically, economically, ecologically charged issue”
Low-head dams on Duck Creek removed in Fall 2012

Restoration Sites:

State, non-profit, county invest in improving pike spawning habitat in agricultural ditches





Great Lakes Migratory Fishes

Effects of Dam Removal & Habitat Restoration on
Migratory Northern Pike

- Dam Removal & Habitat Restoration
 - How quickly do migratory fishes utilize newly available habitat after barrier removal?
 - How does habitat use/production differ between natural streams and artificial restoration sites?





Great Lakes Migratory Fishes

Effects of Dam Removal & Habitat Restoration on Migratory Northern Pike

- Note adult pike locations in tributaries & ditches
- Monitor YOY growth & production



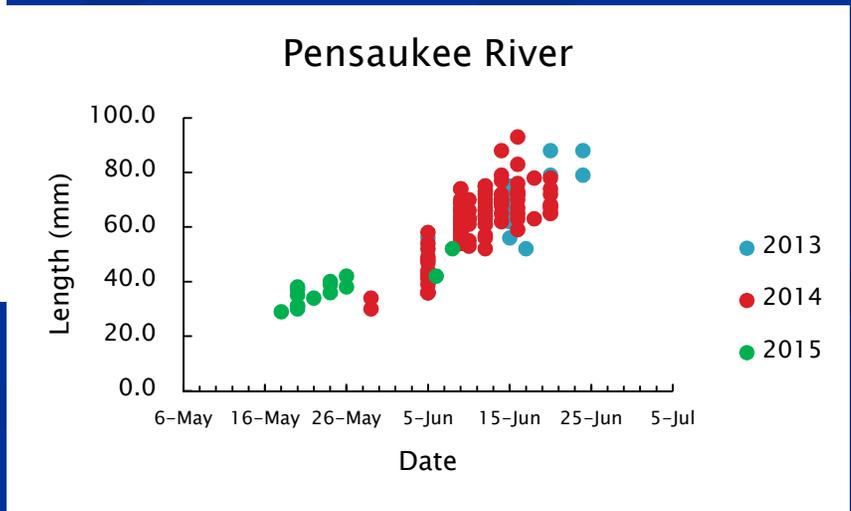
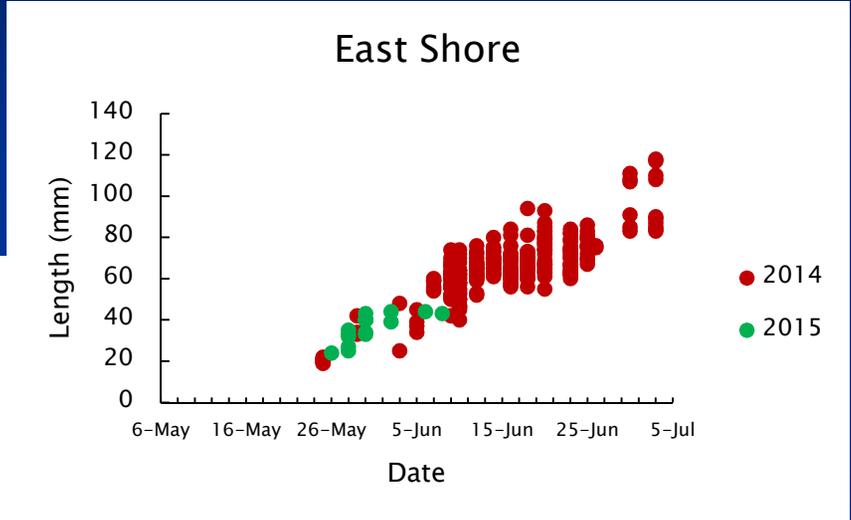
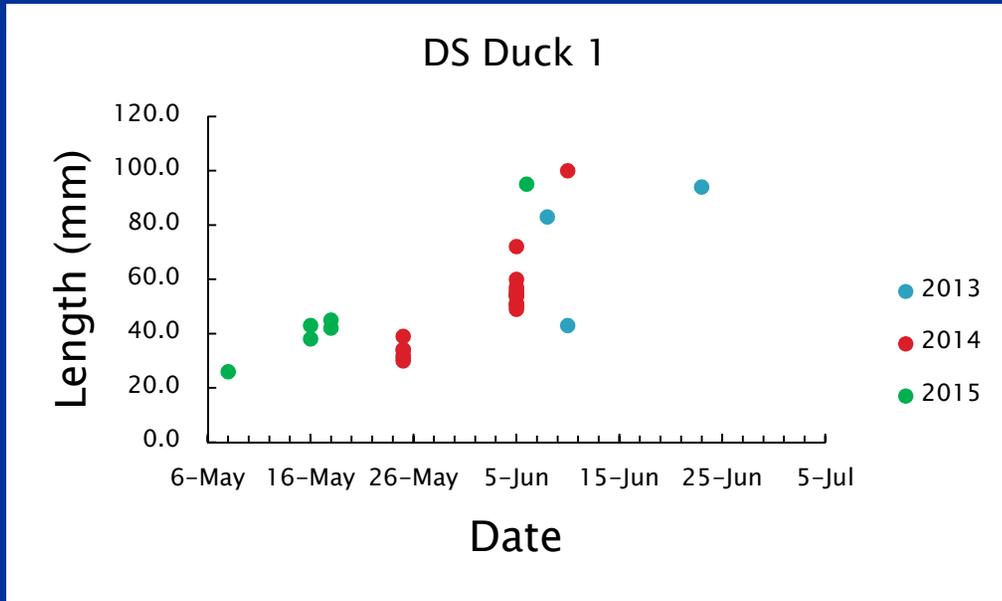
young of year pike growth





Great Lakes Migratory Fishes

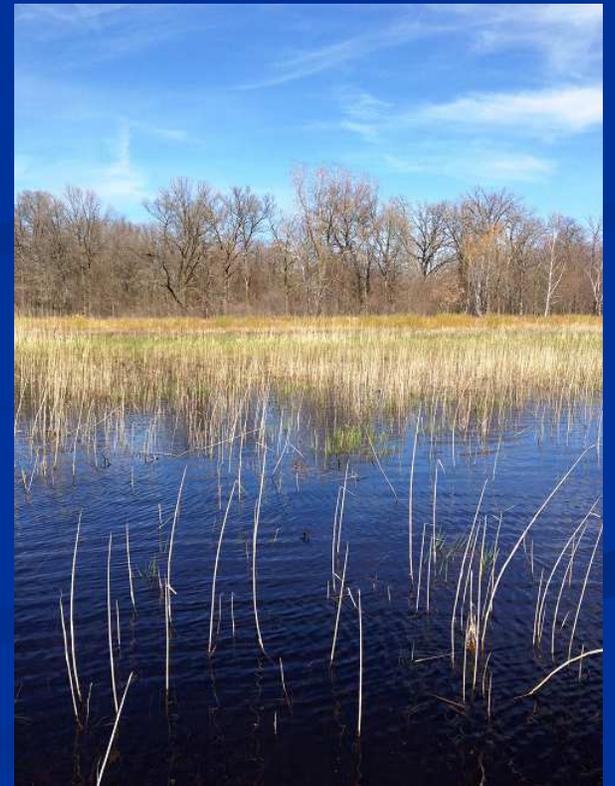
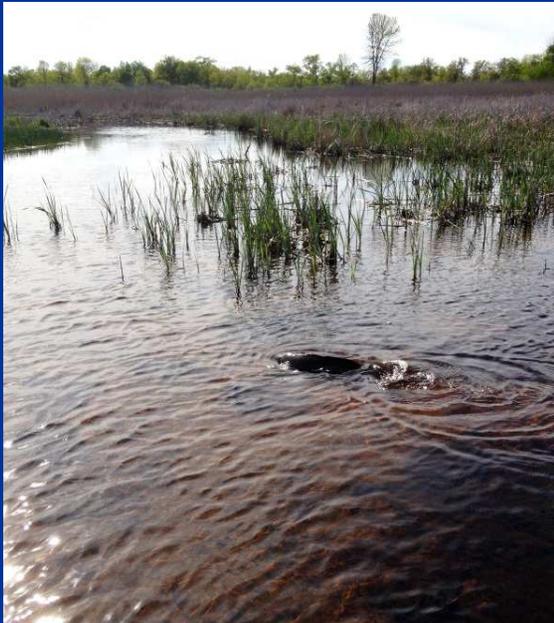
Effects of Dam Removal & Habitat Restoration on Migratory Northern Pike





Survey Other Migratory & Resident Fishes Communities

- Species diversity in natural stream habitats & restoration/ditch sites...what else was out there?



Survey Other Migratory & Resident Fishes



D.Hendricks



A. Koosmann





Survey Other Migratory & Resident Fishes Communities



Over 30 species use these habitats





Great Lakes Migratory Fishes

Discussion

- Migratory fishes connect multiple Great Lakes ecosystems and can reflect environmental health
- High diversity of migratory (and resident) species inhabit even small aquatic corridors in Great Lakes basin
- Conservation of migratory fishes & biodiversity is both ecologically and economically important



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Becky Gericke
Kelly Trace
Jeff Elliot
Elise Waugh
Tse-Lynn Loh
Mary Khoury
Chris Houghton
Kurt Hettiger
Michelle Parker
James Clark





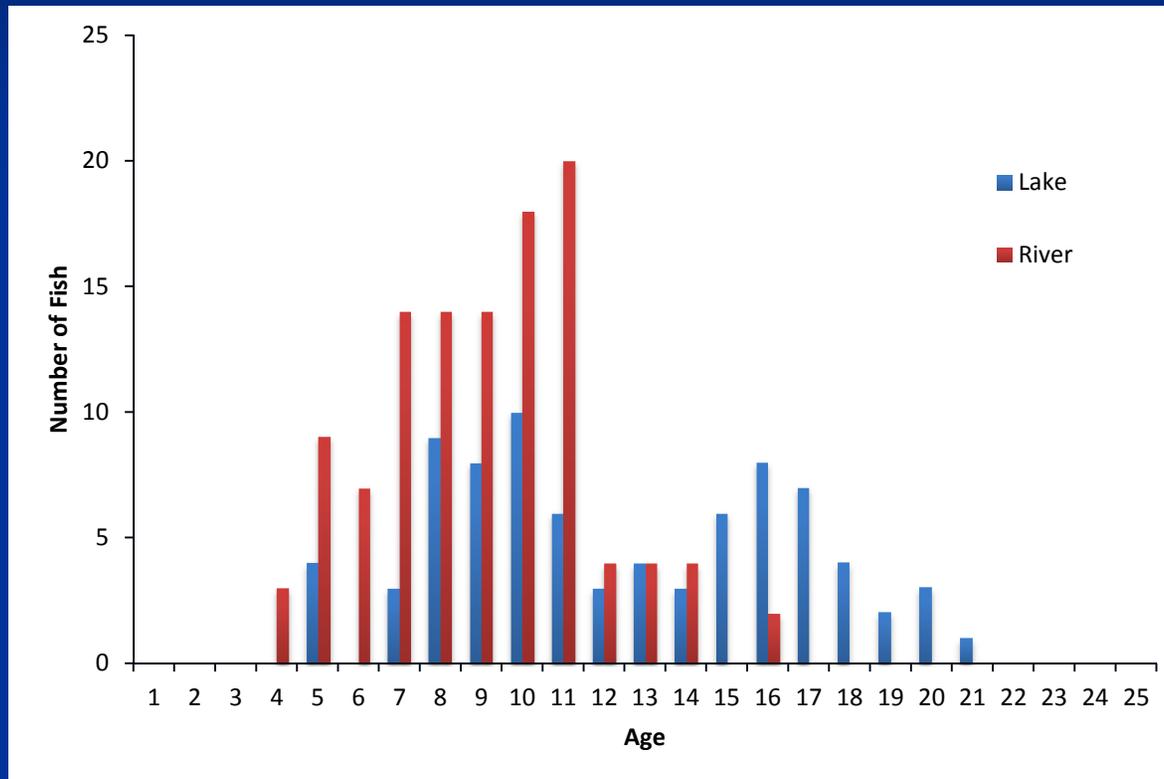
Questions?





Results

Age Distribution



- Lake significantly older than River fish
 - ANOVA $p < 0.001$; Lake $n = 81$, River $n = 113$



TRAIT MATRIX - By Lake

Trait	Great Lakes	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario	Occur All Lakes
Families	19	18	19	19	19	19	18
Species	54	45	52	50	48	47	40
Native	41	33	39	38	37	36	29
Non-Native	13	12	13	12	11	11	11
Econ Historic Commercial	4	4	4	4	4	4	4
Econ Commercial	13	13	13	13	12	13	12
Econ Sport Fish	20	20	20	20	20	20	20
Econ Forage Bait Fish	6	5	6	6	6	5	5
Econ Rough or None	14	9	12	11	10	11	6
Economic Importance Invasive	6	6	6	6	5	5	5
Economic Importance Introduced	6	6	6	6	6	6	6
Economic Importance Non-Native	13	12	13	12	11	11	11
Iteroparous	47	38	45	44	42	41	34
Semelparous	7	7	7	6	6	6	6
Troph ABS Piscivore	21	19	21	20	20	20	19
Troph ABS Invertivore	30	23	28	28	26	25	19
Troph ABS parasite	3	3	3	2	2	2	2
Trophic Piscivore	18	16	18	17	17	17	16
Trophic Carnivore	27	25	27	26	25	26	24
Trophic Invertivore	45	36	43	42	40	39	32
Trophic Herbivore	3	1	2	2	2	1	0
Trophic Detrivore	6	5	6	5	5	5	4
Trophic Planktivore	4	4	4	4	3	4	3
Trophic Parasite	3	3	3	2	2	2	2
Migration - facultative	45	36	43	41	39	38	31
Migration - obligate	9	9	9	9	9	9	9
nest-building	16	15	16	15	15	15	14
Abundance common	34	32	34	34	32	34	30
Abundance uncommon	15	11	14	12	12	11	9
Abundance rare	5	2	4	4	4	2	1
Tolerance Tolerant	7	6	7	6	6	6	6
Tolerance Intermediate	31	25	31	29	28	25	22
Tolerance Intolerant	16	14	14	15	14	16	12
Enviro Benthic	21	15	20	19	20	16	14
Enviro Benthic-Pelagic	27	25	26	25	22	25	21
Enviro Pelagic	6	5	6	6	6	6	5
Thermal Coldwater	15	15	14	14	12	15	12
Thermal Coolwater	22	20	22	21	20	20	18
Thermal Warmwater	17	10	16	15	16	12	10
Reprod Guild Lithophil	38	31	36	35	34	33	27
Reprod Guild Phytophil	3	2	3	3	3	3	2
Reprod Guild Phyto-lithophil	9	8	9	8	7	7	7
Reprod Guild Pelagophil	4	4	4	4	4	4	4
Season Spring	39	31	39	36	35	32	28
Season Summer	9	7	8	8	8	8	7
Season Spring-Summer	6	6	6	6	6	6	6
Season Fall	11	11	10	10	9	11	9
Season Winter	2	2	2	2	2	2	2
Nursery Hab Lacustrine	40	33	38	37	35	36	29
Nursery Hab Riverine	48	39	47	45	43	41	35