

Contaminants of Emerging Concern in the North American Great Lakes: Evidence of Reproductive Disruption from Field and Laboratory Studies

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In collaboration with:

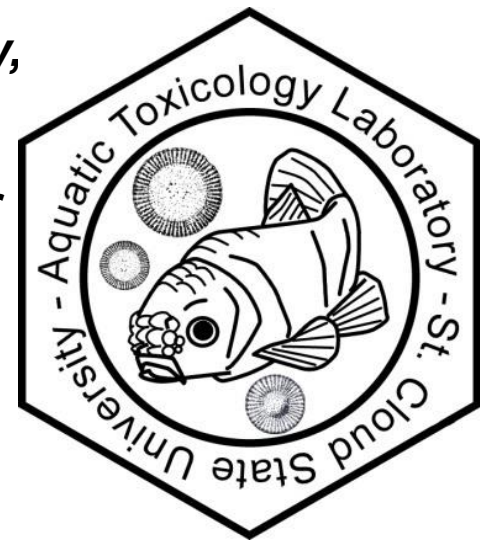
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US Fish & Wildlife Service

S.M. Elliott, M.E. Brigham - *US Geological Survey*



Acknowledgements & Disclaimer

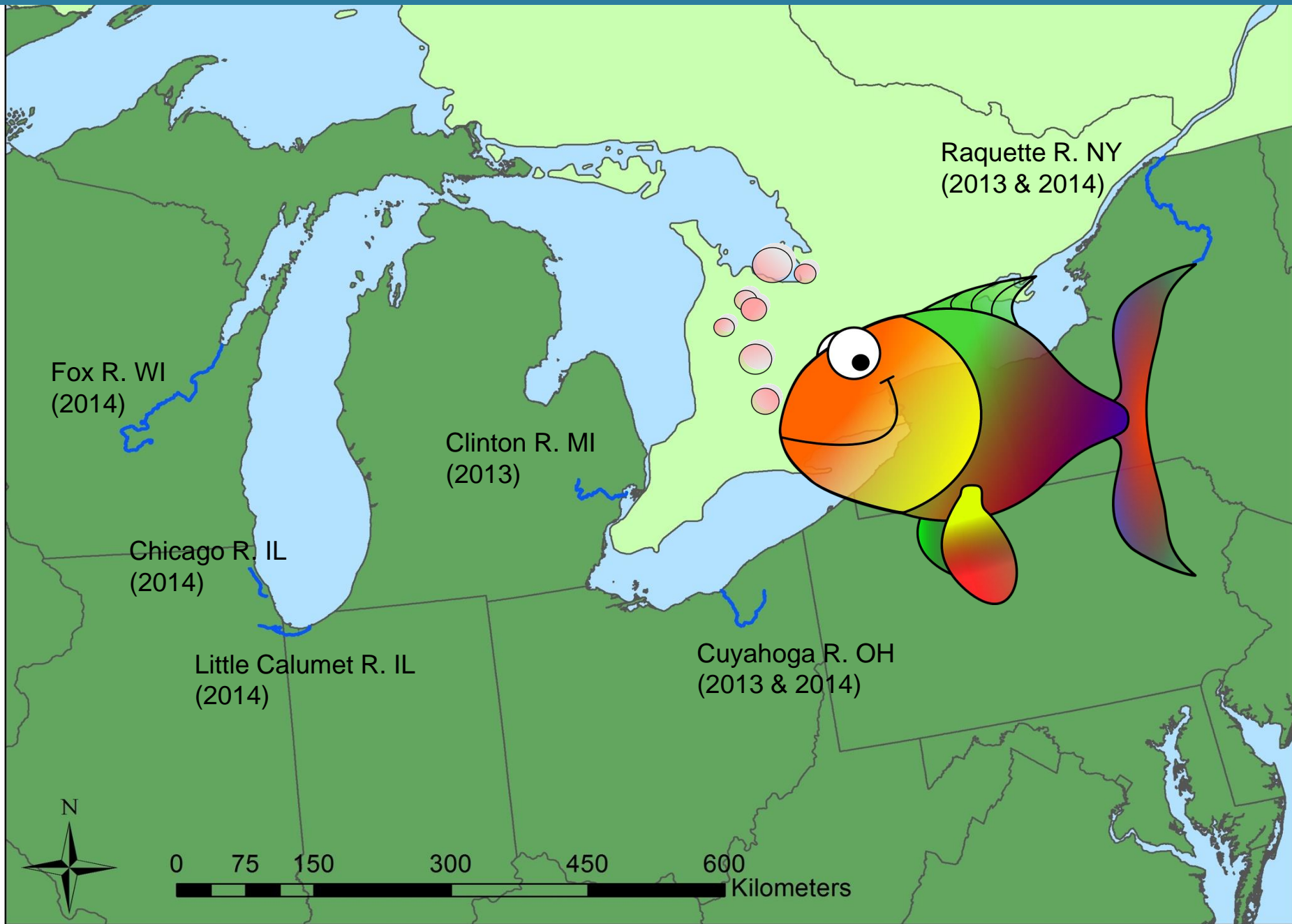


The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service or the U.S. Environmental Protection Agency

A satellite-style aerial photograph of the Laurentian Great Lakes basin in North America. The lakes are shown in various shades of blue and green, indicating different water depths and sediment levels. The surrounding land is a mix of green vegetation and brownish terrain. The text is overlaid in the upper left quadrant of the image.

Are fish populations affected by the presence of Contaminants of Emerging Concern in the Laurentian Great Lakes?

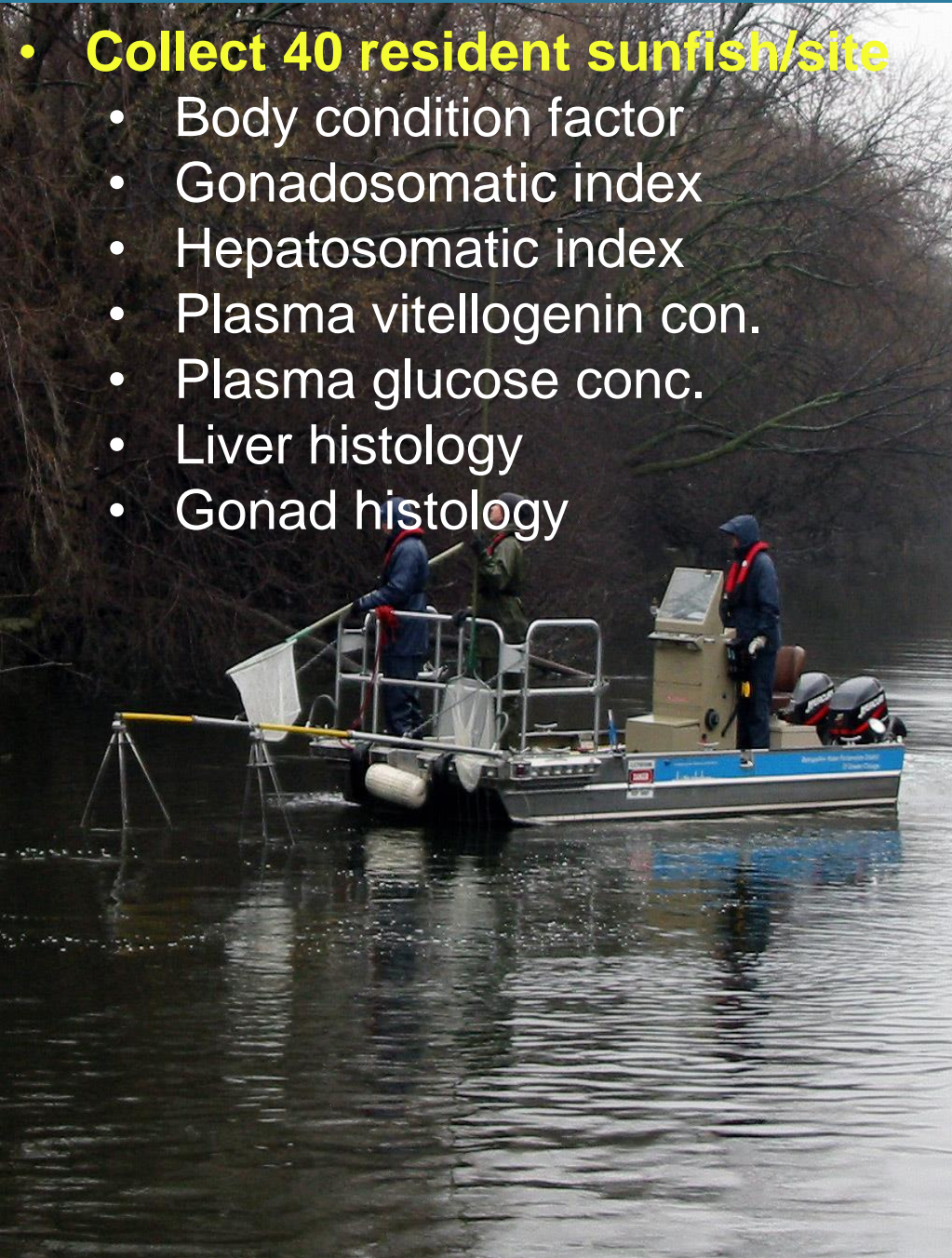
Biological Effects of CECs



Effects of CECs in "Natural" Ecosystems

- **Collect 40 resident sunfish/site**

- Body condition factor
- Gonadosomatic index
- Hepatosomatic index
- Plasma vitellogenin con.
- Plasma glucose conc.
- Liver histology
- Gonad histology



- **Cage 40 sunfish/site**

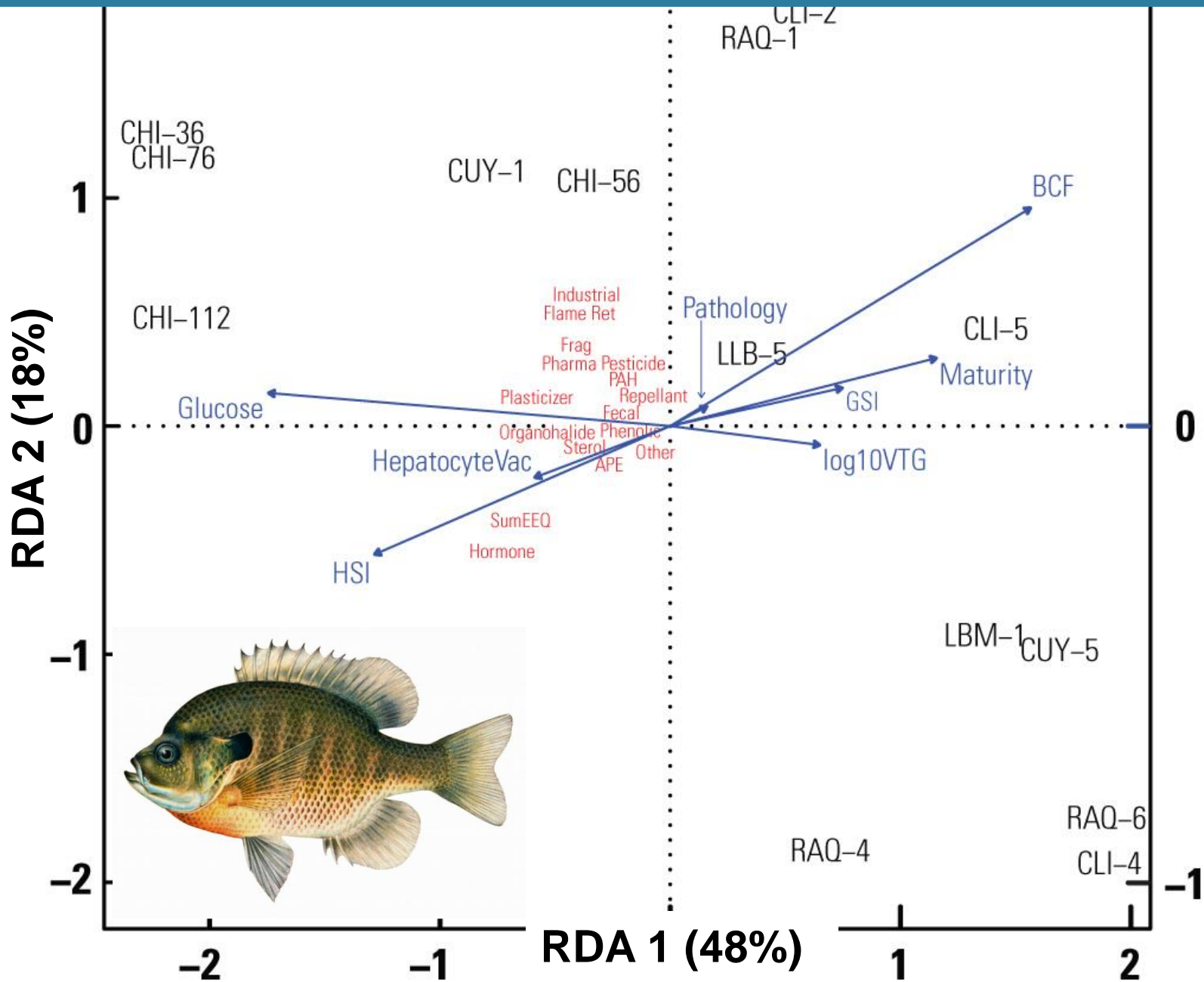
- Body condition factor
- Gonadosomatic index
- Hepatosomatic index
- Plasma vitellogenin con.
- Plasma glucose conc.
- Liver histology
- Gonad histology

Fish Collections

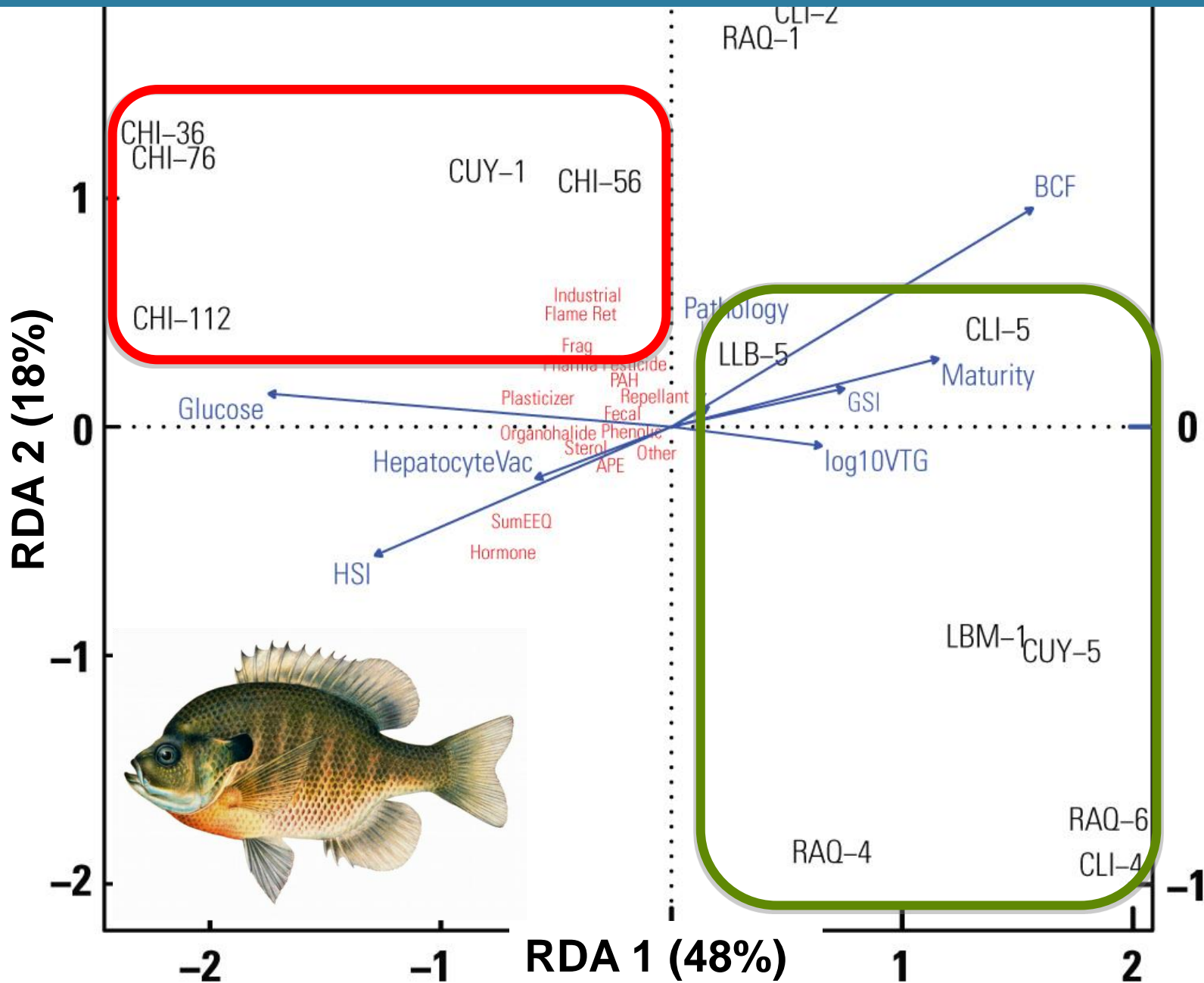
			Bass (<i>Micropterus</i> sp.)		<i>Catostomus</i>	Sunfish (<i>Lepomis</i> spp.)		Caged	
			Largemouth	Smallmouth	White Sucker	Bluegill	Other Sunfish	Caged	Recovery
Fox R. WI	2014	<i>downstream</i>	23	17	2	10	0	100	27%
		<i>middle (WWTP)</i>	19	1	35	8	18	50	54%
		<i>upstream</i>	12	2	40	34	6	100	28%
Chicago R. IL	2014	<i>downstream</i>	0	0	0	27	13	52	100%
		<i>middle (WWTP)</i>	0	0	0	<i>n/a</i>	<i>n/a</i>	52	96%
		<i>upstream</i>	0	0	0	18	22	52	98%
Little Calumet R. IL	2014	<i>downstream</i>	0	0	0	9	1	52	94%
		<i>middle (WWTP)</i>	0	0	0	<i>n/a</i>	<i>n/a</i>	52	87%
		<i>upstream</i>	0	0	0	50	0	52	81%
Clinton R. MI	2013	<i>downstream</i>	0	0	38	41	4	100	32%
		<i>middle (WWTP)</i>	0	0	3	49	0	50	6%
		<i>upstream</i>	0	0	0	30	10	100	19%
Cuyahoga R. OH	2013	<i>downstream</i>	13	7	33	25	25	100	49%
		<i>middle (WWTP)</i>	0	8	34	0	0	50	62%
		<i>upstream</i>	20	30	4	58	1	50	80%
	2014	<i>downstream</i>	2	16	8	9	1	50	74%
		<i>middle (WWTP)</i>	0	2	41	1	0	50	92%
		<i>upstream</i>	40	0	1	50	0	100	88%
Raquette R. NY	2013	<i>downstream</i>	0	25	0	2	34	110	95%
		<i>middle (WWTP)</i>	0	0	29	0	44	110	96%
		<i>upstream</i>	1	2	13	0	10	100	100%
	2014	<i>downstream</i>	32	11	2	0	42	112	98%
		<i>middle (WWTP)</i>	17	4	39	0	40	112	71%
		<i>upstream</i>	44	2	32	3	13	112	94%
All Fish		<i>downstream</i>	70	76	83	123	120	676	71%
		<i>middle (WWTP)</i>	36	15	181	58	102	422	71%
		<i>upstream</i>	117	36	90	243	62	666	74%

~ 2,500 sunfish

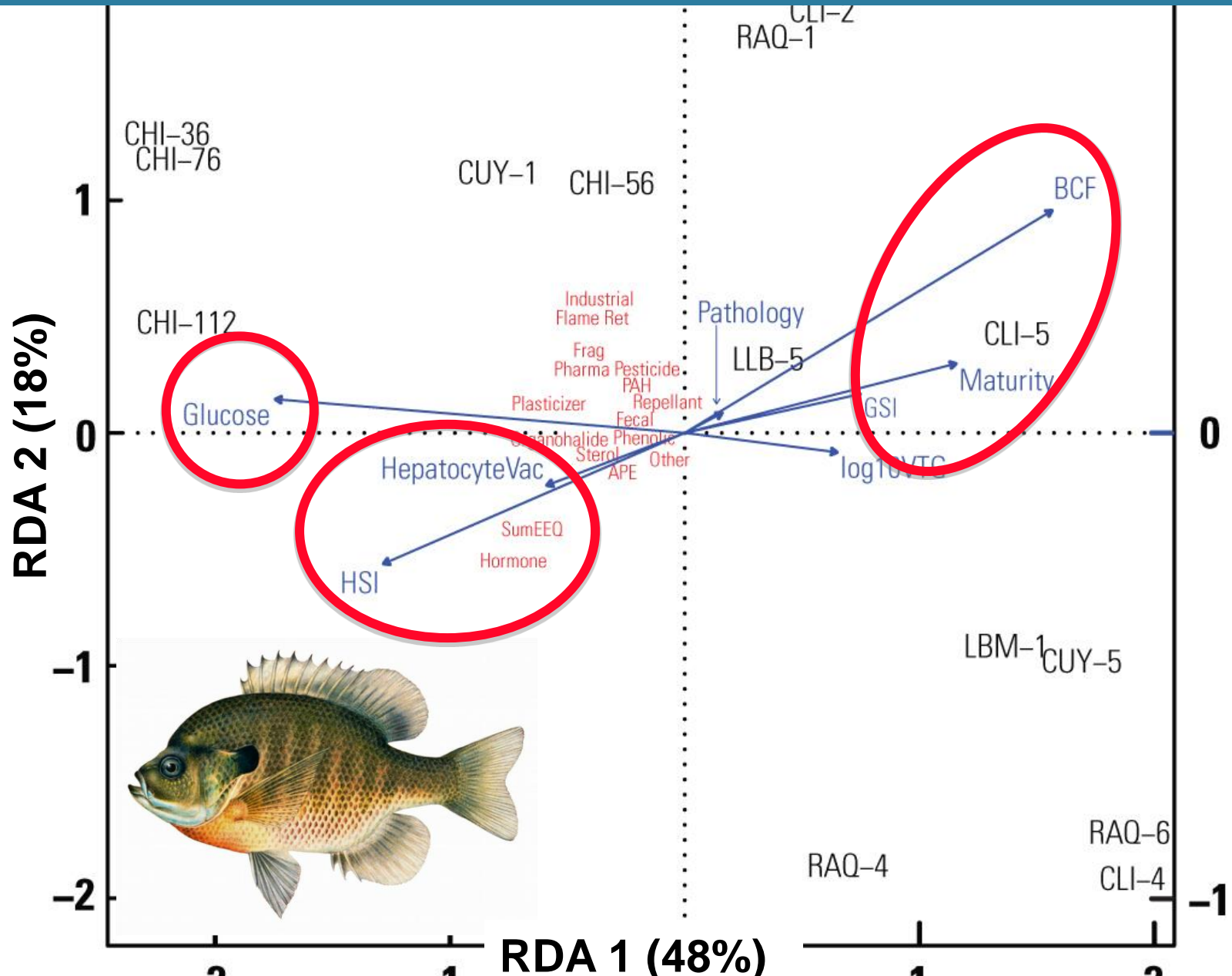
Canonical Redundancy Analysis (~100,000 values)

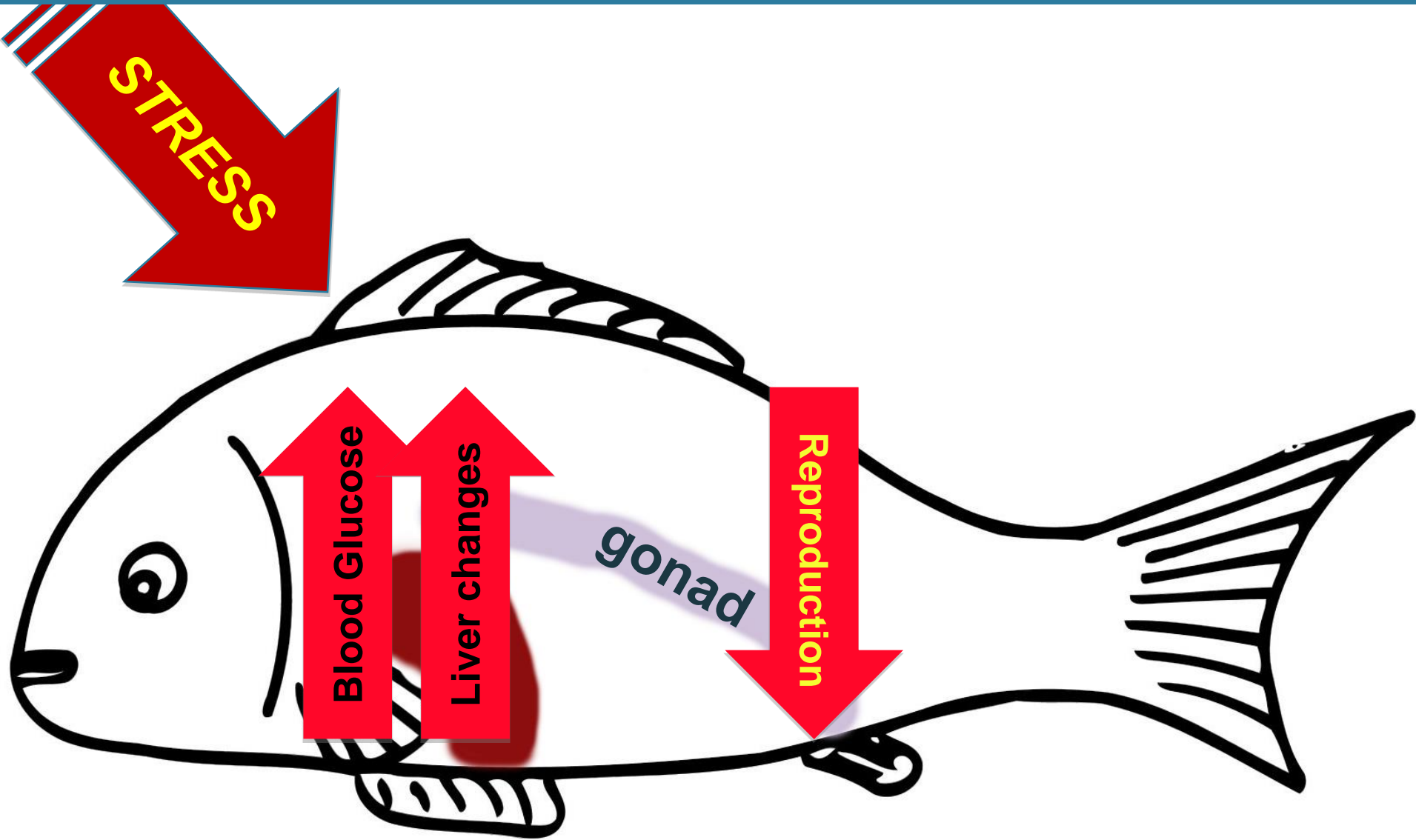


Canonical Redundancy Analysis: *Grouping by Locations*



Canonical Redundancy Analysis: *Grouping by Biomarkers*





→ Fish in Great Lakes tributaries experience energetic stress that may affect reproduction.

WATER & SEDIMENT combined

Caged Sunfish

females:	pharmaceuticals & PAHs
males:	pharmaceuticals & PAHs

Resident Sunfish

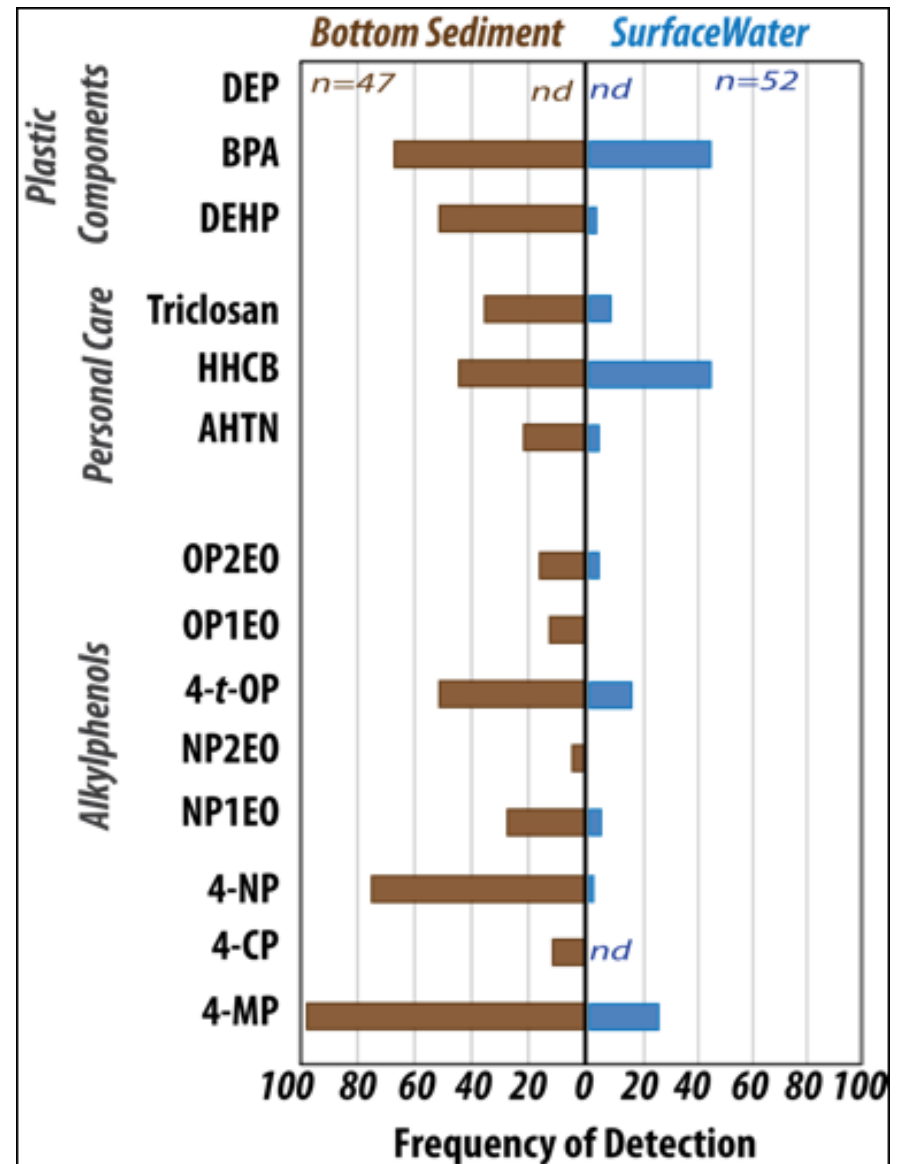
females:	n/s
males:	pharmaceuticals & PAHs

Patterns in CEC Occurrence

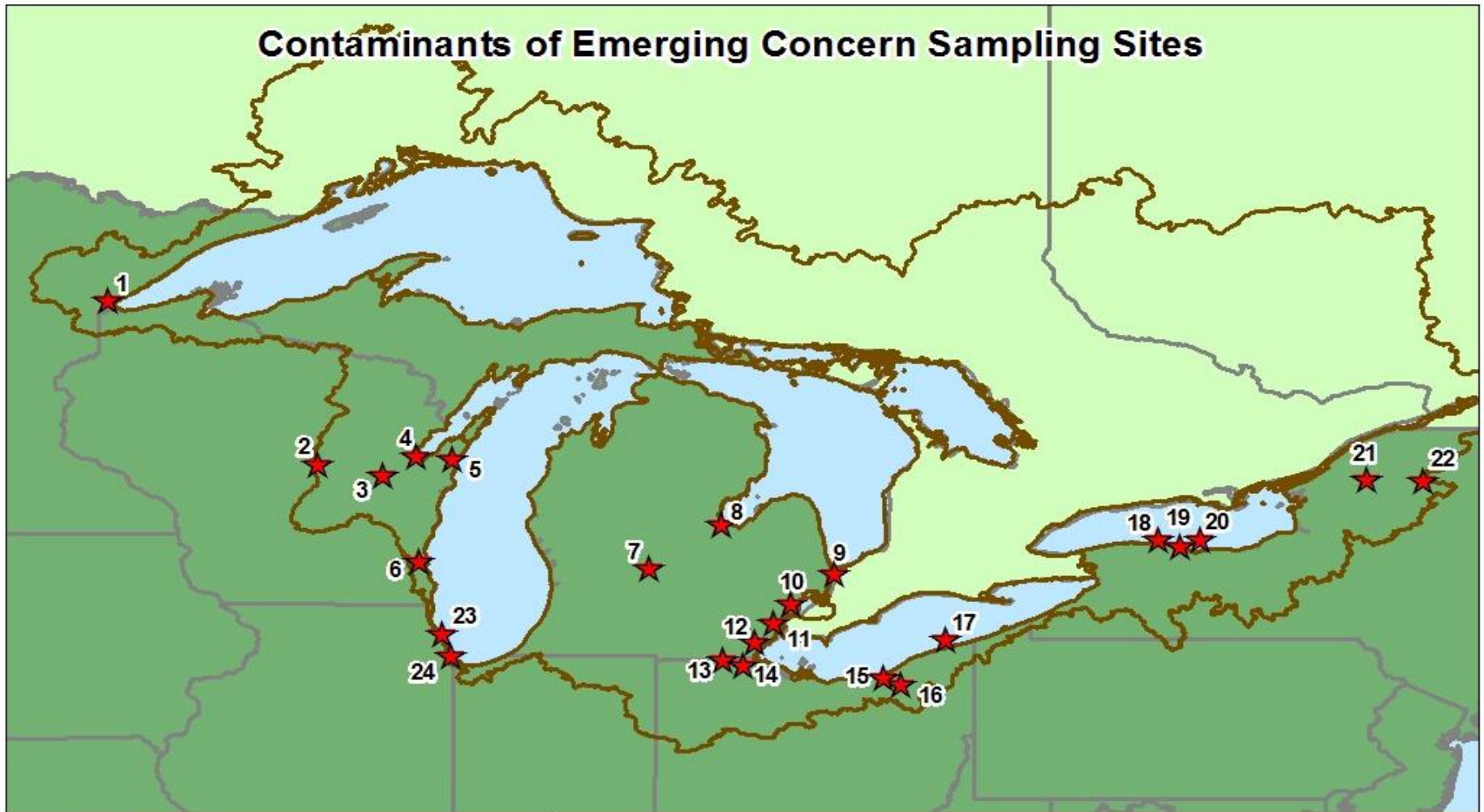
→ CECs are ubiquitous

→ Fish experience energetic stress.

→ Are there any patterns in CEC occurrence?



Contaminants of Emerging Concern Sampling Sites



Legend

★ CEC Sampling Location

Great Lakes Basin

State/International Border

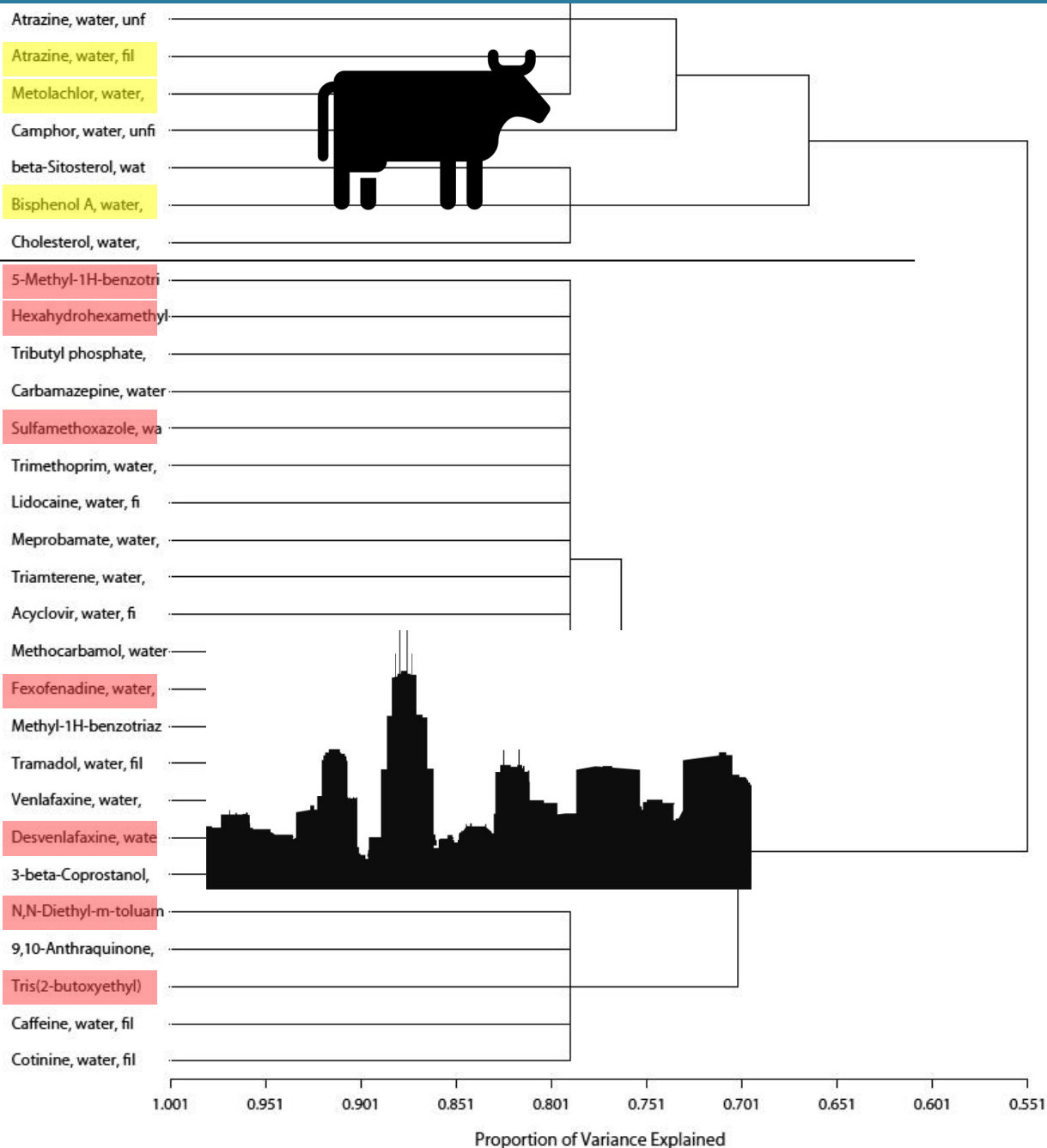
- | | | |
|--------------------------------|---------------------|-----------------------|
| 1. St. Louis River | 10. Clinton River | 19. Genesee River |
| 2. Waupaca Chain O'Lakes | 11. Detroit River | 20. Irondequoit Bay |
| 3. Little Lake Butte des Morts | 12. Raisin River | 21. Oswegatchie River |
| 4. Fox River | 13. Swan Creek | 22. Raquette River |
| 5. Kewaunee River | 14. Maumee River | 23. Chicago River |
| 6. Milwaukee River | 15. Cuyahoga River | 24. Calumet River |
| 7. Grand/Maple River | 16. Tinkers Creek | |
| 8. Saginaw River | 17. Ashtabula River | |

Identification of Environmental CEC Mixtures

“ag” CECs




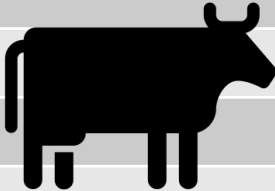
“urban” CECs



Cluster Analysis of CEC occurrence in Great Lake Tributary water samples – minimum of 30% detection frequency.

Elliott et al., IEAM 2018

Laboratory Assessment of CEC Mixtures

	Agricultural Mixture 5 mix concentrations	Urban Mixture 3 mix concentrations
Contaminant	Environmental Concentration [ng/L]	Environmental Concentration [ng/L]
Metolachlor	170	
Atrazine	400	
Bromacil	120	
DEET	200	1600
TBEP	210	13500
Estrone	24	7
Bisphenol A	60	3000
4-Nonylphenol	188	3710
Sulfamethoxazole		559
Fexofenadine		1000
Desvenlafaxine		583
Metformin		1210
HHCB (Galaxolide)		2180
Methyl-1H-benzotriazole		6680

Laboratory Assessment of CEC Mixtures

Generation #1

Physiology
Behavior
Reproduction

Adult Larvae Juvenile



Generation #2

Growth
Behavior
Feeding

Growth

Physiology
Behavior
Reproduction



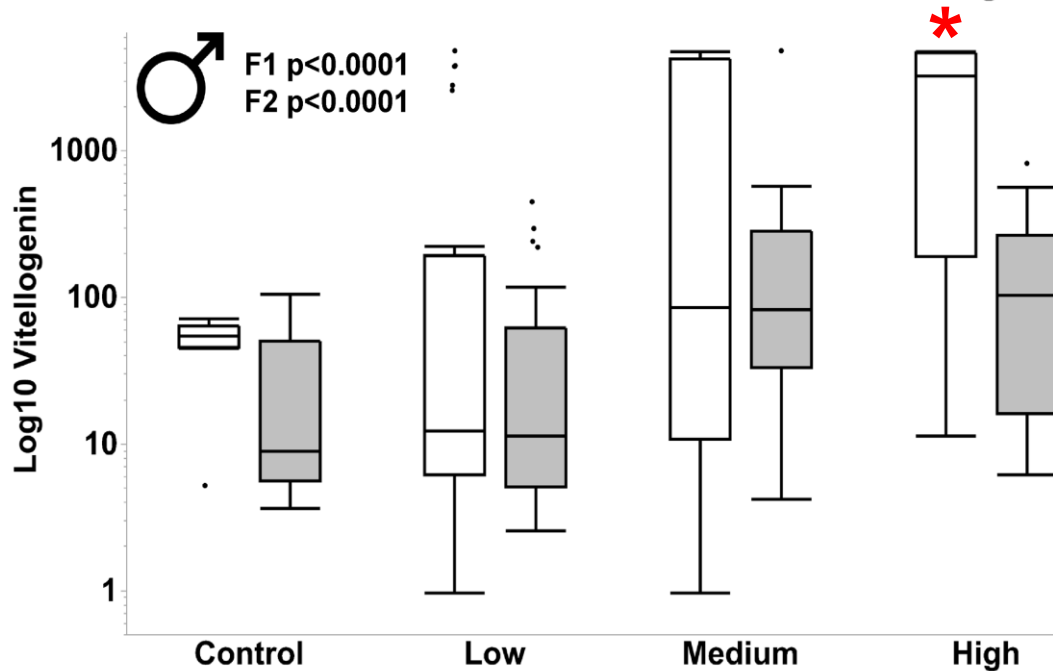
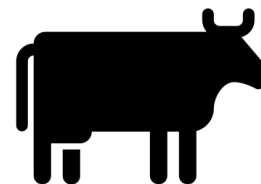
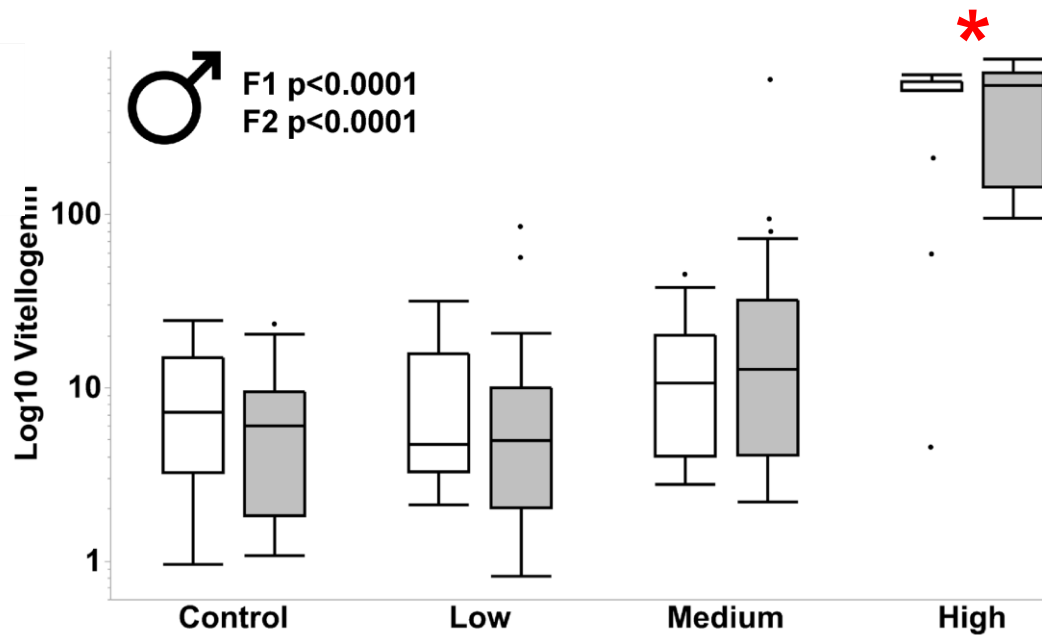
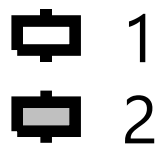
Generation #3

Growth
Behavior
Feeding

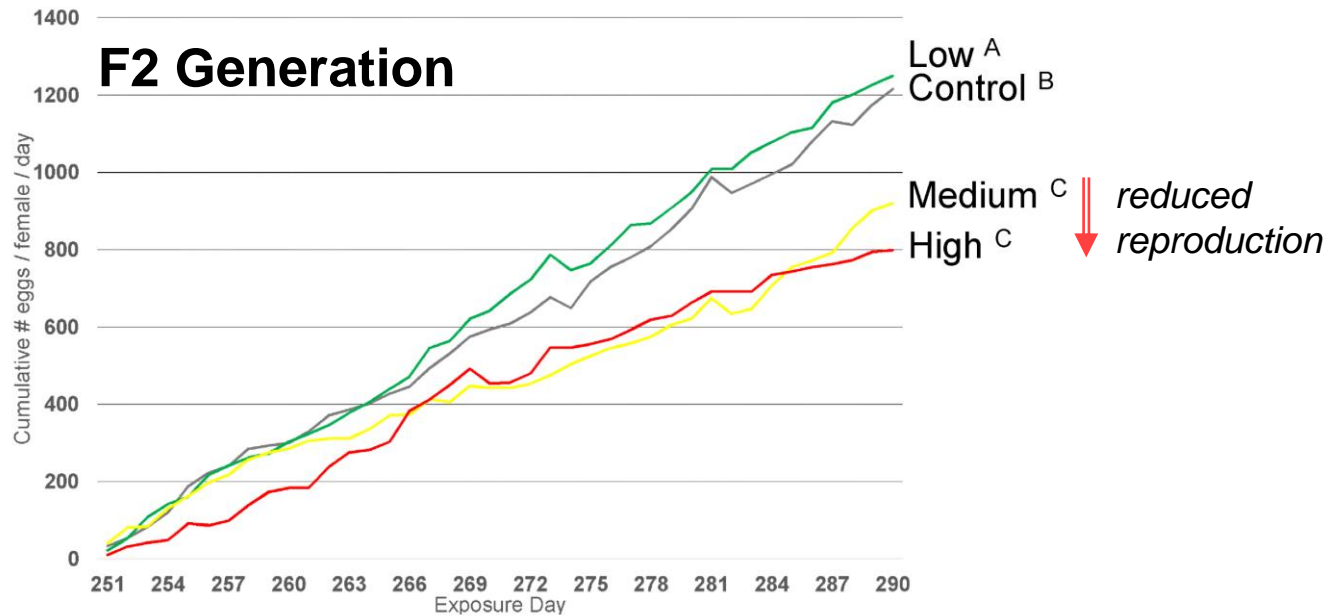
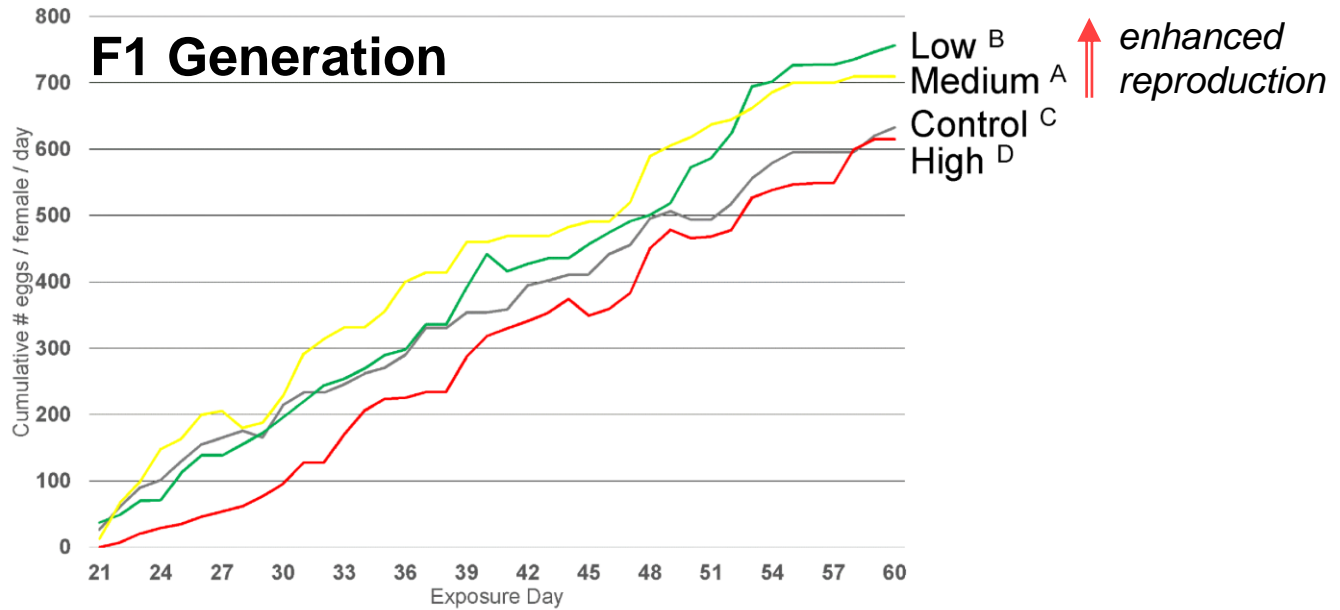
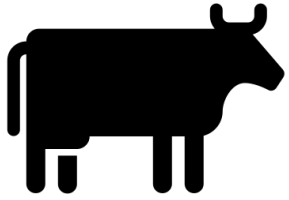
Exposure Month

1	2	3	4	5	6	7	8	9	10	11	12
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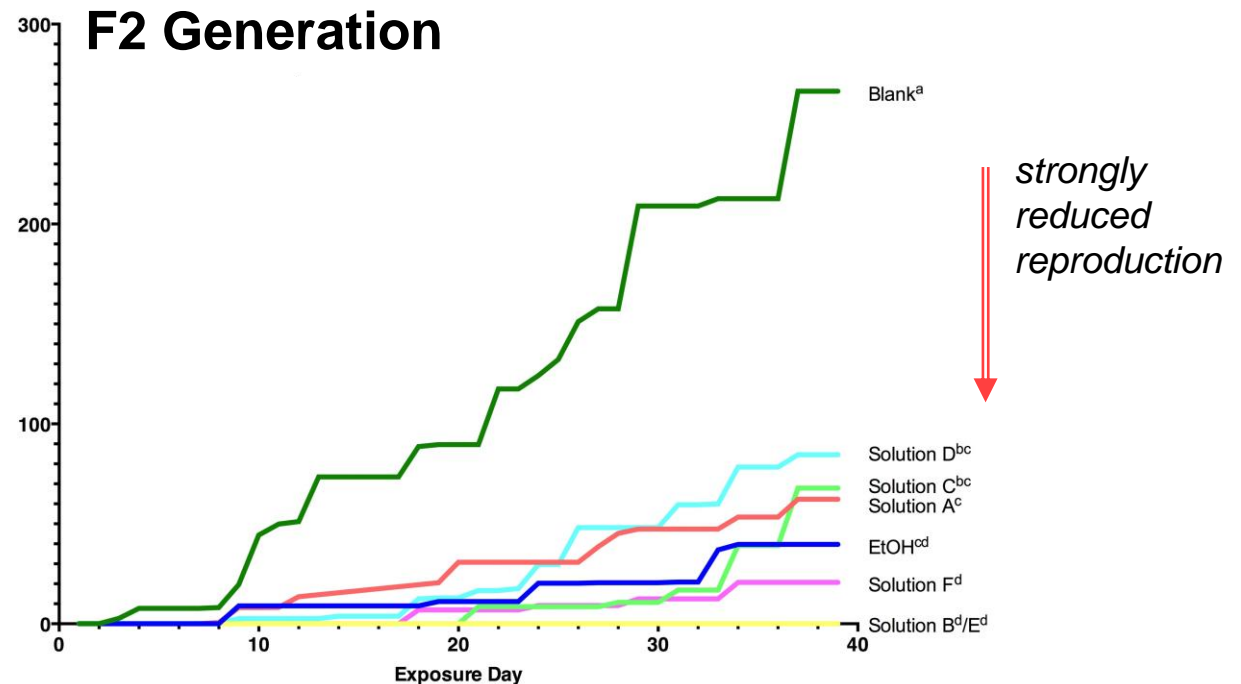
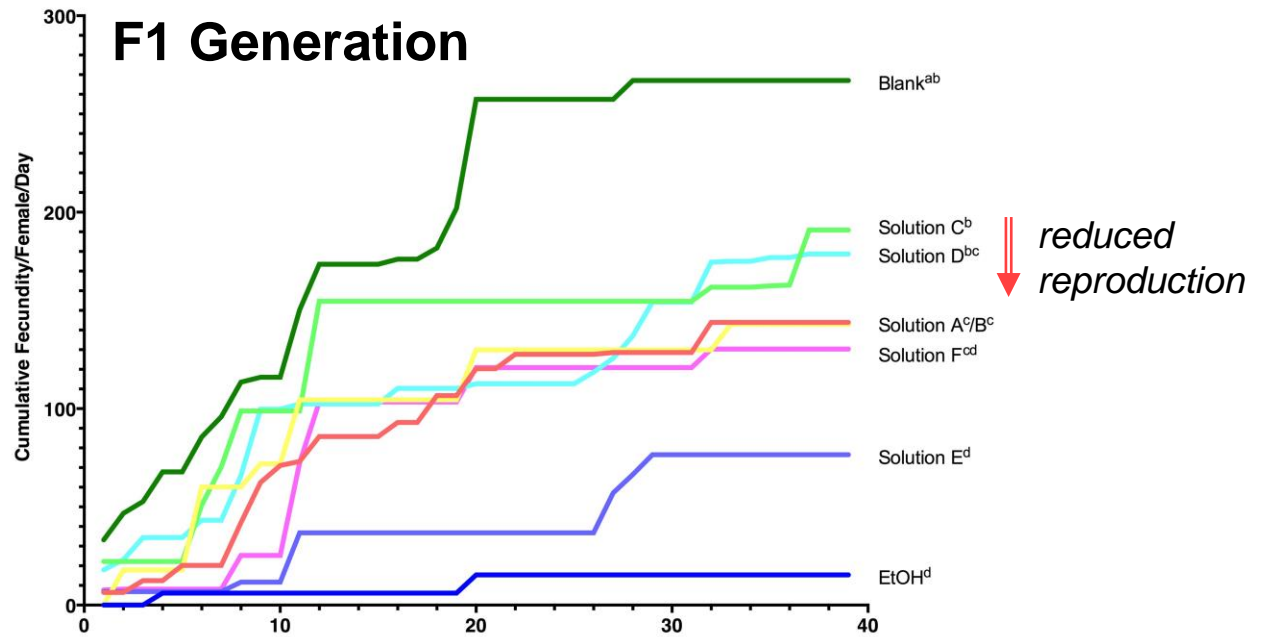
Physiological Effects of Exposure – Male Vitellogenin



Cumulative Fecundity - *Agricultural CEC Mixtures*



Cumulative Fecundity - *Urban* CEC Mixtures



Mixture Concentrations:
 $F > E > \underline{D} > C > B > A$
 (highest) → (lowest)

SUMMARY

- Both Ag and Urban Mixtures stimulate vitellogenin production – similar to Phase I studies (Thomas et al., 2017)
- Ag estrogenic response is greater than urban response.
- At low concentrations Ag mixture has fecundity-enhancing effect (F1).
- Long term exposure heightens the adverse impact of Ag and Urban Mixtures on fitness (reduced fecundity).

CONCLUSIONS

- ***CECs are ubiquitous in Great Lakes tributaries.***
- ***Resident fish are experiencing energetic stress that may result in declining fertility.***
- ***Laboratory exposed fish experience altered fertility, especially in the second generation of exposure.***



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Safety Notice
No Food or Beverage Allowed in Laboratory

For Laboratory Supplies Only!
No Storage of Food.

DEPARTMENT OF CHEMICAL SCIENCE
FACULTY SCHOLARLY CONTRIBUTION