Lower Fox River OU1 Remedy Effectiveness Characterized Through Water and Fish Tissue Long-Term Monitoring

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Session A2: Monitoring and Evaluating Remedy Effectiveness

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Overview

- Review of Remedy
- Long-Term Monitoring (LTM)
  - Objectives
  - Analysis of Covariance (ANCOVA) Approach
- LTM Results to Date
- Conclusions

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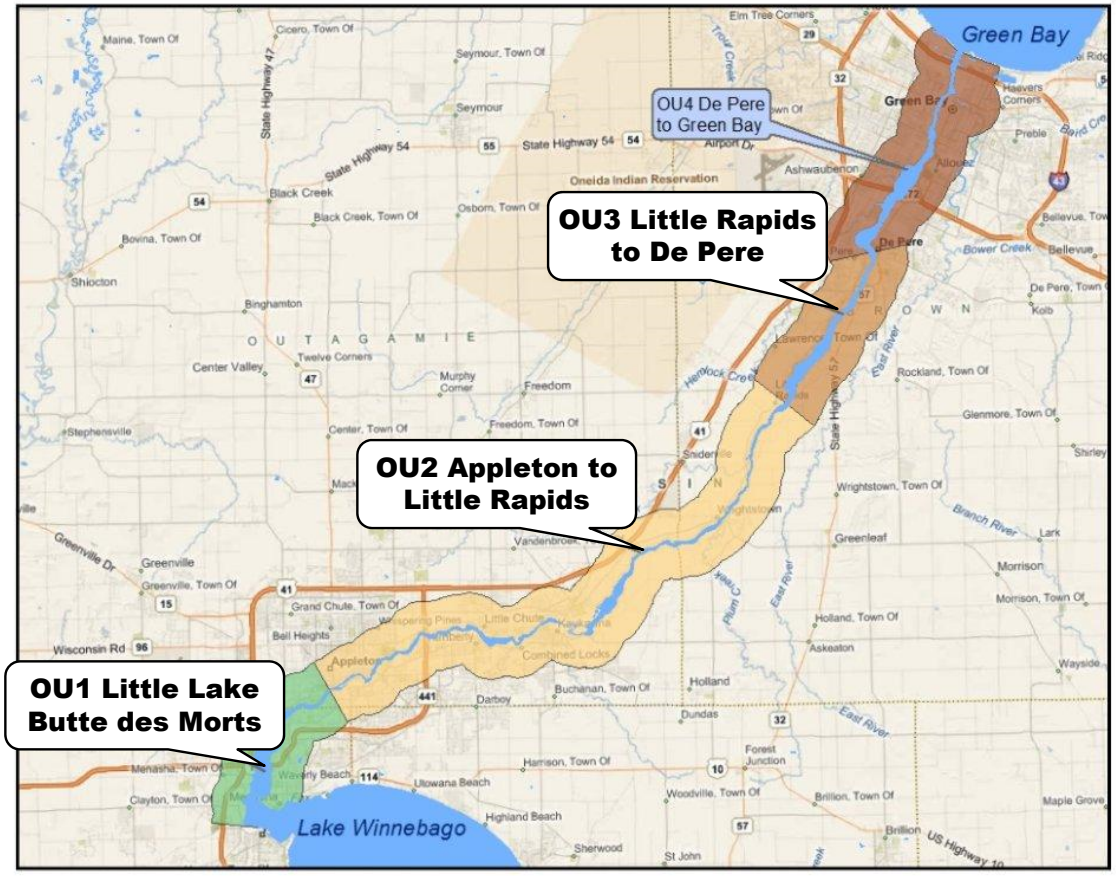
Site Location



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OU1 Remedial Action (2004 – 2009)

- Dredging
  - 371,600 cy, 257 acres (2004-2008)
- Sand Cover
  - 144 acres (2007-2009)
- Engineered Cap
  - 114 acres (2007-2009)

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OU2/OU3 Remedial Action (2009 – 2011)

OU2

- MNR
  - OU2A, OU2B and most of OU2C
- Dredging
  - 3,000 cy in OU2C and placement of cap for habitat enhancement

OU3

- Dredging
  - 236,000 cy
- Sand Cover
  - 114 acres
- Engineered Cap
  - 34 acres

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LTM To Confirm Remedial Action

- Assess Performance of the RA
  - Monitor levels of PCBs in water and fish (also sediments in OU2 for MNR and CIL in OU3)
  - Compare to Baseline Monitoring
  - Compare to Ongoing Background Monitoring in Lake Winnebago (LW)
- LTM Continues Until Exit Criteria Are Met

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LTM Timeline

2006-2007	2010	2012	2014	2018
Baseline Monitoring	OU1 “Year 0”	OU1 “Year 2”		OU1 “Year 8”
		OU2/OU3 “Year 0”	OU2/OU3 “Year 2”	OU2/OU3 “Year 6”

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Exit Criteria: Comparison to Baseline

- Sediment SWAC reductions propagate into the water column, young of year (YOY) forage fish, and eventually adult fish
  - Water
  - Fish Tissue
    - YOY forage fish species (gizzard shad)
  - 90% Reduction Relative to Baseline Conditions

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Exit Criteria: Comparison to Background

- Water and fish tissue concentrations decline to levels comparable to background (i.e., Lake Winnebago)
  - Water
  - Fish Tissue
    - Human health index species (walleye – primary, smallmouth bass – secondary)
    - Ecological index species (carp – primary, drum – secondary)
    - YOY forage fish species (gizzard shad)

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Exit Criteria: Comparison to Risk-based Target Concentrations

- Site concentrations have achieved levels that indicate fish consumption advisories may be reduced or eliminated
  - Fish Tissue
    - Human health index species (walleye and smallmouth bass)
      - achieve risk-based goals for recreational and high intake
    - Ecological index species (carp and drum)
      - achieve lowest observed adverse effects concentrations (LOAECs)

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Exit Criteria: Evaluation of Recovery Rate

- Water and fish tissue concentrations decline at rates to achieve human health and ecological goals within 30 years
  - Water
  - Fish Tissue
    - Human health index species (walleye and smallmouth bass)
    - Ecological index species (carp and drum)
    - YOY forage fish species (gizzard shad)
  - Extrapolation of regression models achieve risk levels, background, or SWAC reduction

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LTM Methodology

- **Fish** are collected once during August/September of LTM Year
- Numbers are pre-determined to provide appropriate statistical power
- Analyzed for lipid content and PCB aroclors (EPA method 8082)

- **Water** samples are collected monthly from April through November
- Samples are analyzed for TSS, TOC, and PCB congeners (EPA method 1668A)

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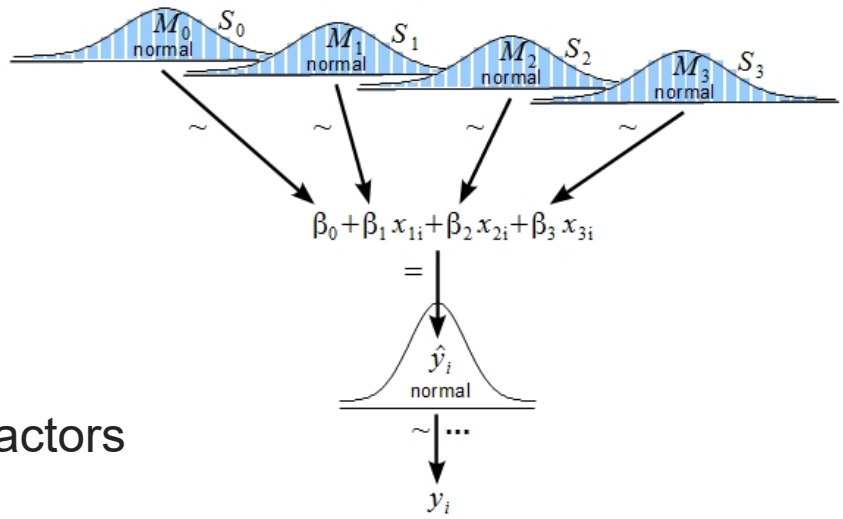
Using Covariate Data

Lipid Normalize

- PCB/fraction lipids
- Utilizes only one covariate
- Assumes isometric relationship
  - (constant slope, “0” intercept)



Analysis of Covariance Model

(ANCOVA)

- Removes variation due to multiple factors
- Model flexibility
- e.g. $\ln(PCB) = \beta_0 + \beta_1 \cdot Event + \beta_2 \cdot Length + \beta_3 \cdot Weight + \beta_4 \cdot Lipids$
- Select covariates through stepwise regression

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Surface Water Covariate Selection

-Percent Reduction From Baseline

	OU1	OU2A	OU2B	OU2C	OU3
TOC					
TSS		X		X	
Temperature		X	X	X	X
Turbidity					
Flow Rate	X	X			

PCB Correlations										
	OU1		OU2A		OU2B		OU2C		OU3	
	Baseline	2018	Baseline	2018	Baseline	2018	Baseline	2018	Baseline	2018
TOC	-0.04	0.62	0.15	0.68	0.1	0.38	0.11	0.51	-0.01	0.21
TSS	0.62	0.11	0.72	0.15	0.56	0.42	0.78	0.42	0.76	0.13
Temperature	0.9	0.14	0.86	0.89	0.86	0.8	0.85	0.86	0.96	0.85
Turbidity	0.72	0.15	0.81	0.06	0.79	0.28	0.73	0.33	0.68	-0.01
Flow Rate	-0.78	-0.91	-0.67	-0.52	-0.5	-0.27	-0.46	-0.38	-0.57	-0.23

Note: Draft data for 2018

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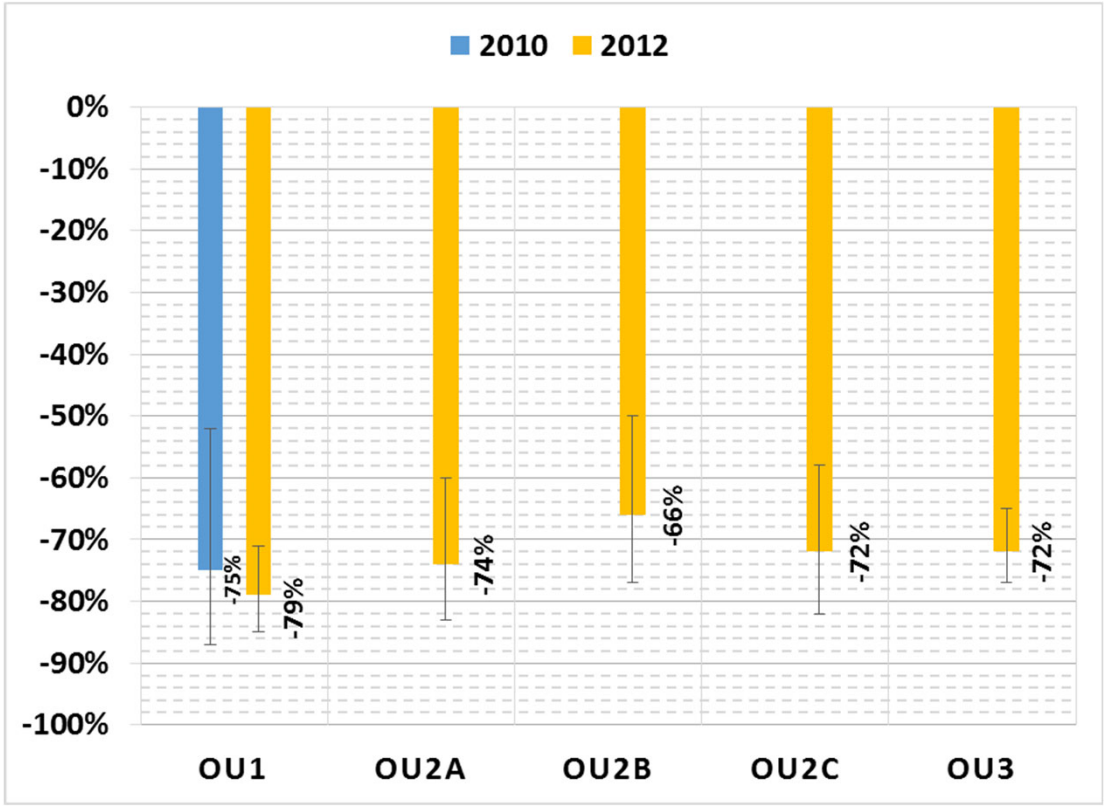
Surface Water Results
Percent Change From Baseline



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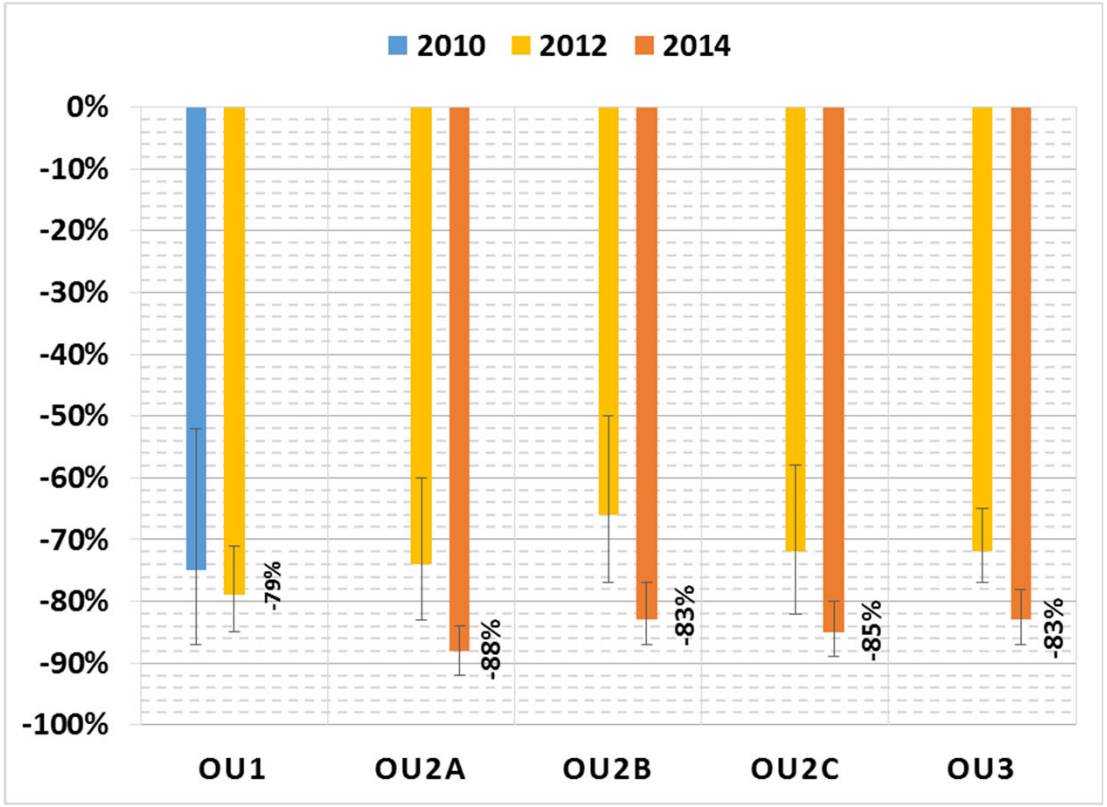

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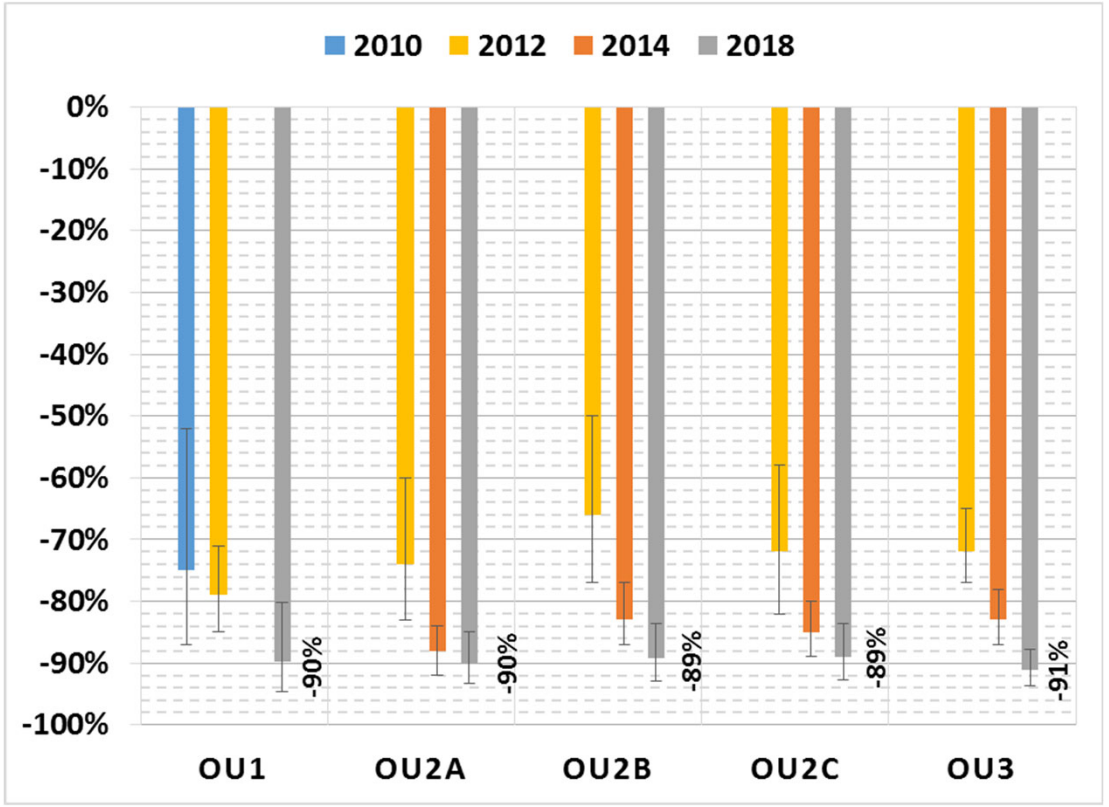
Surface Water Results
Percent Change From Baseline



Note: Draft data for 2018

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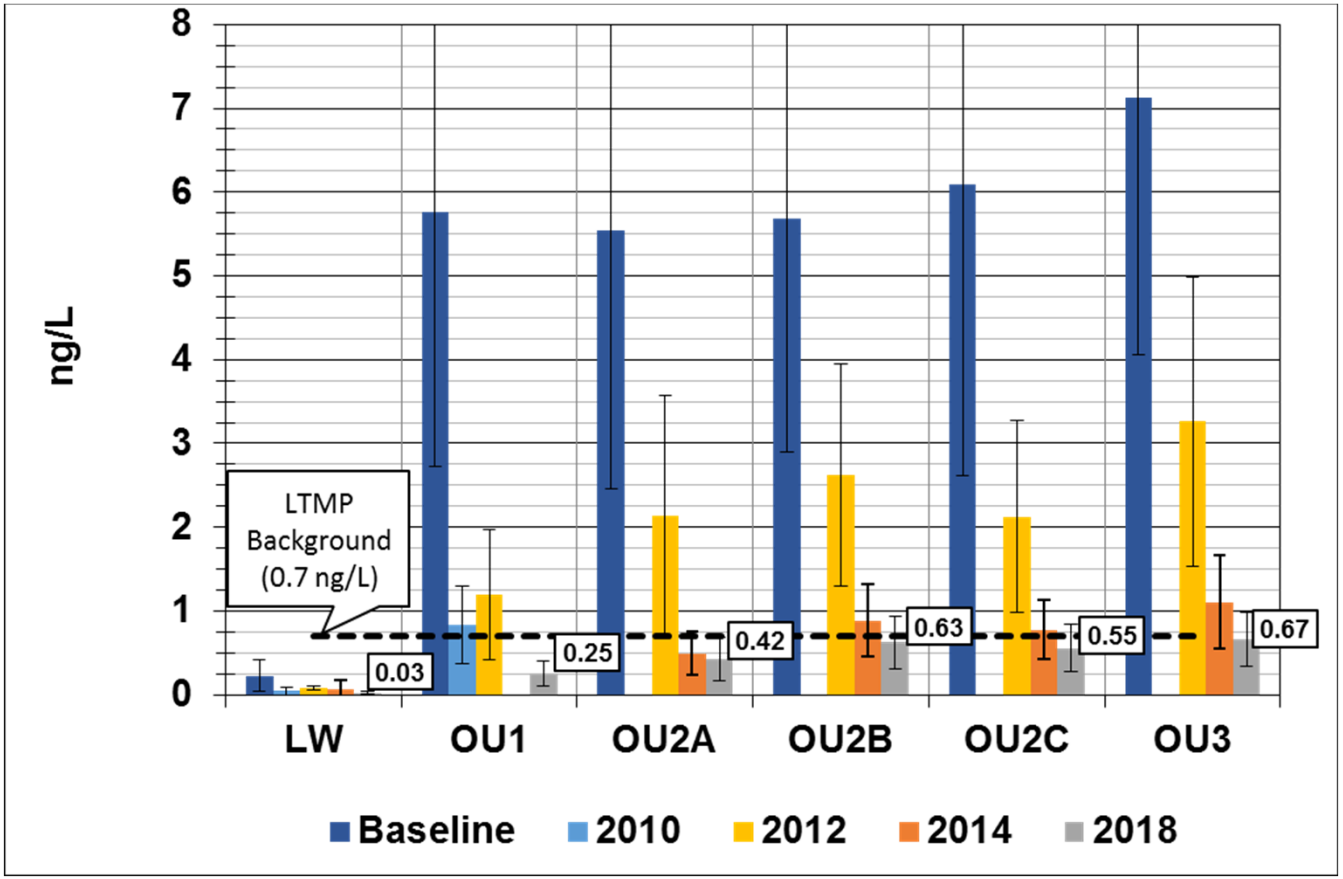
Surface Water Results
Average Concentrations



Note: Draft data for 2018

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Fish Tissue Covariates
-Percent Reduction From Baseline

	OU1	OU2A	OU2B	OU2C	OU3
Carp	Lipid	Lipid	Weight	Lipid	Length, Weight, Lipid
Drum	-	-	Length, Weight, Lipid	Lipid	Lipid
Gizzard Shad	Lipid	Lipid	Lipid	Lipid	Lipid
Smallmouth Bass	Lipid, Length	Length	Lipid, Weight	Lipid, Weight	Lipid, Length
Walleye	Length, Weight	-	Lipid	Length, Weight, Lipid	Length, Weight, Lipid

Note: Draft data for 2018

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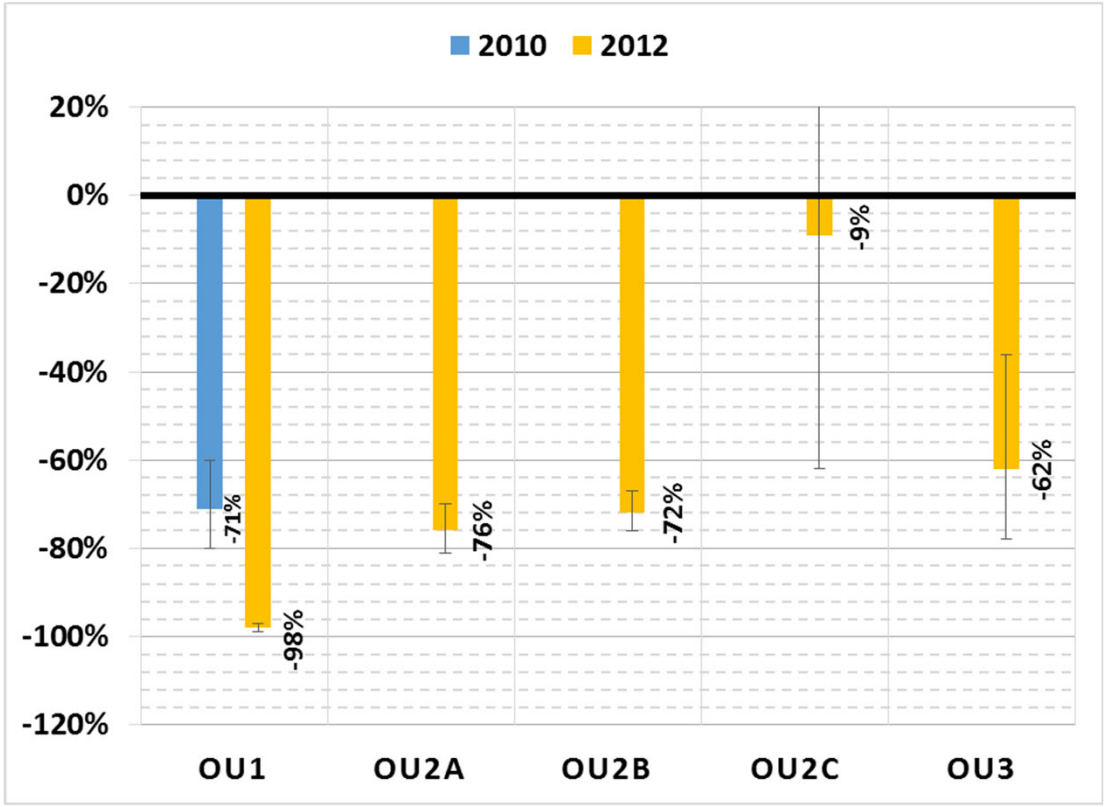
Fish Tissue – Gizzard Shad (YOY) Percent Change From Baseline



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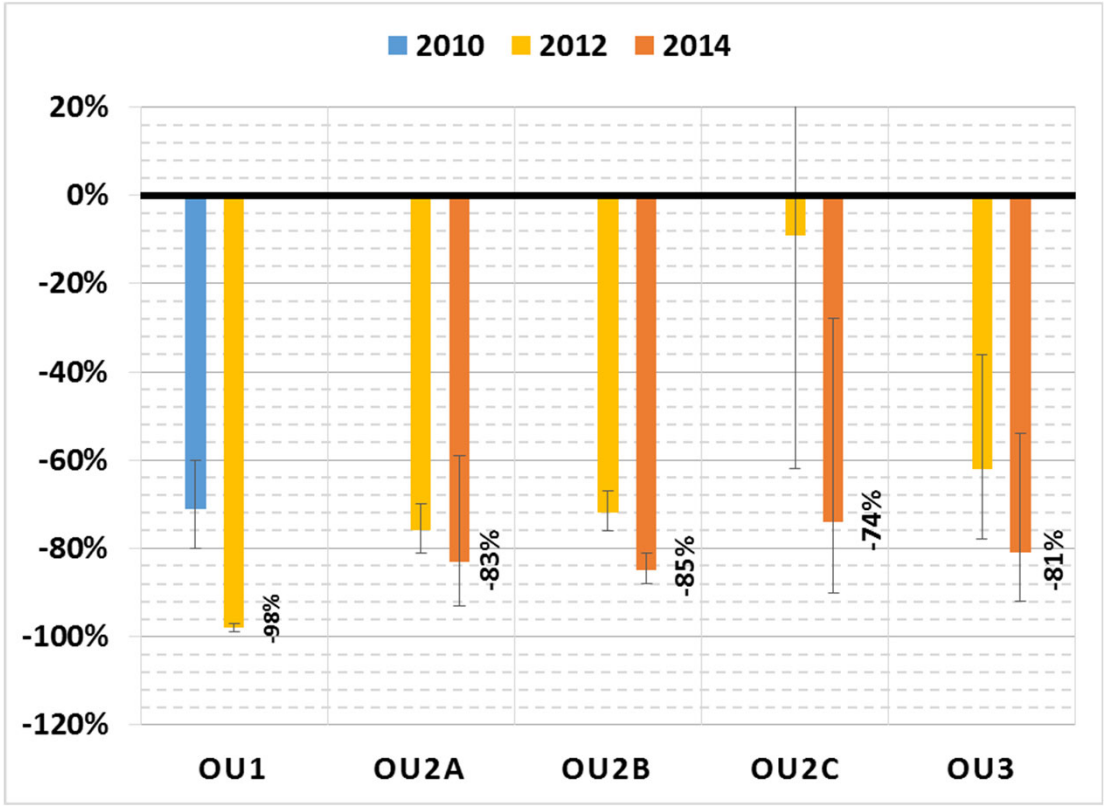

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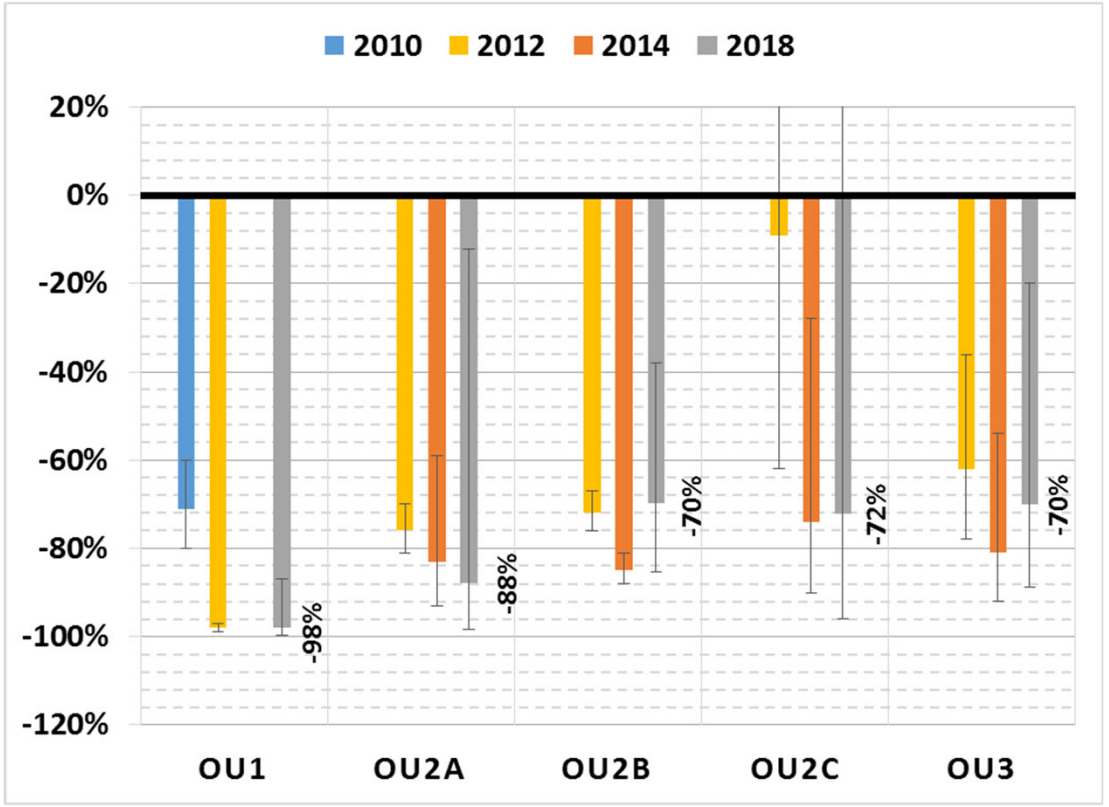

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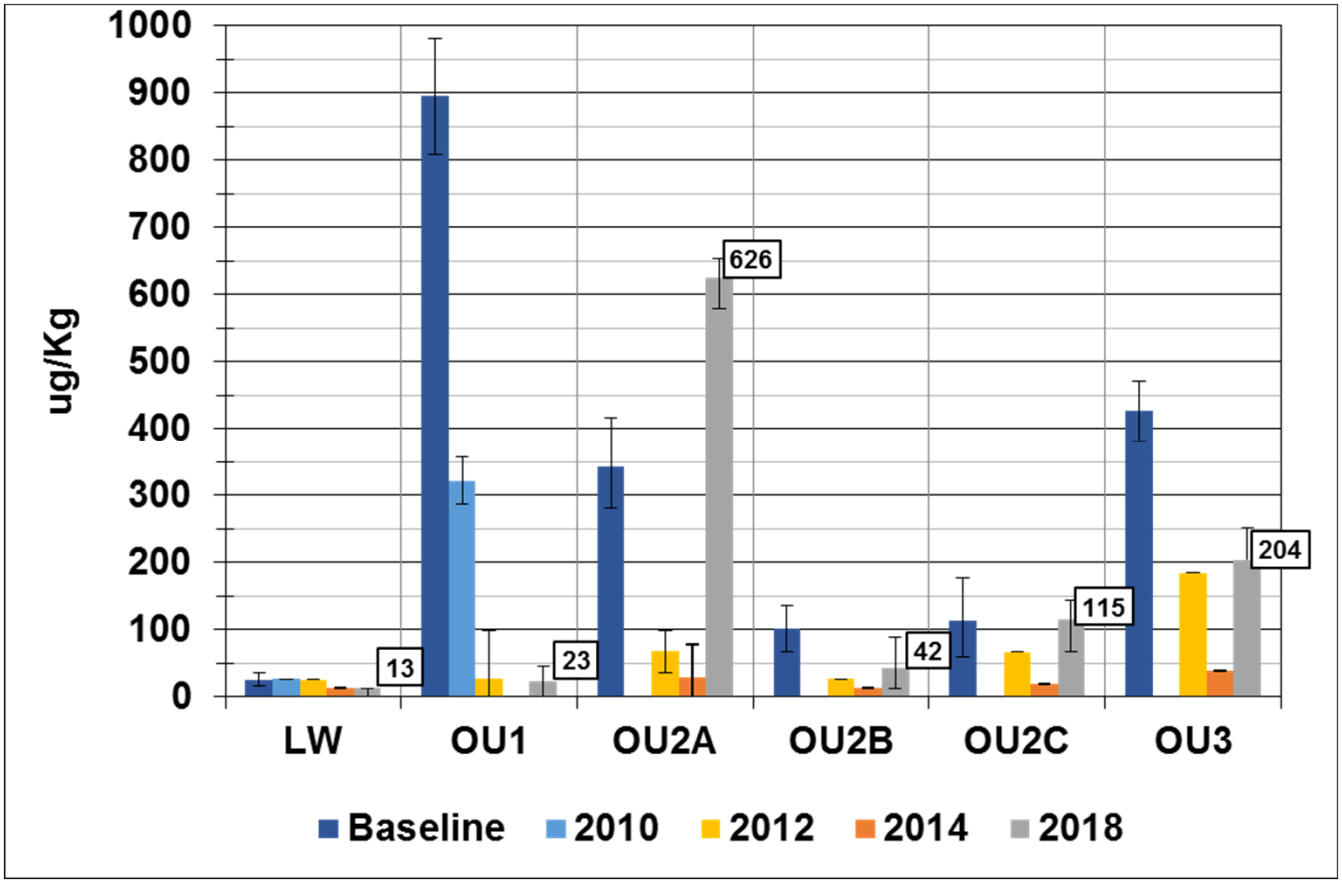
Fish Tissue – Gizzard Shad (YOY) Average Concentrations



Note: Draft data for 2018

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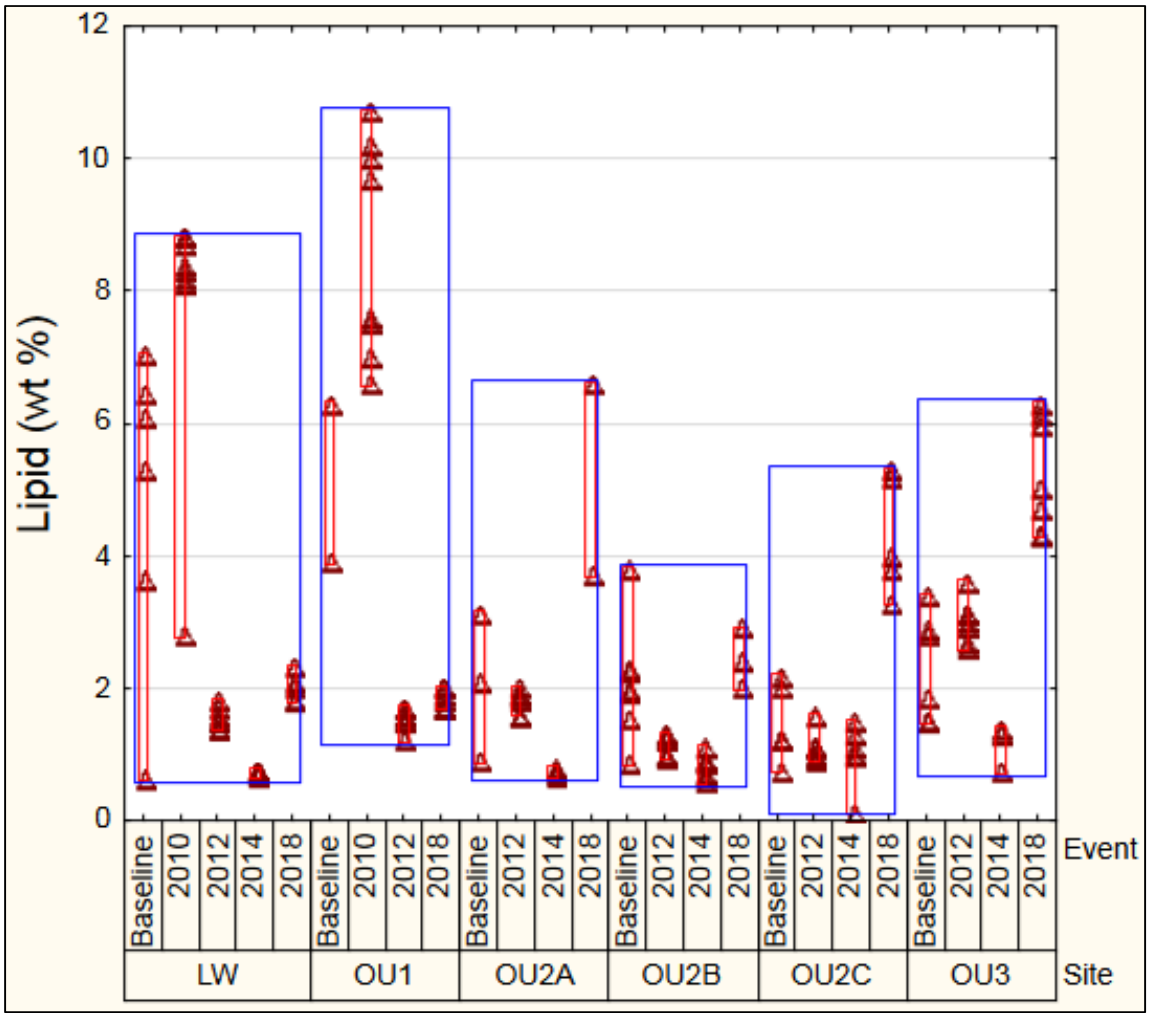
Fish Tissue – Gizzard Shad (YOY) Lipid Sample Results



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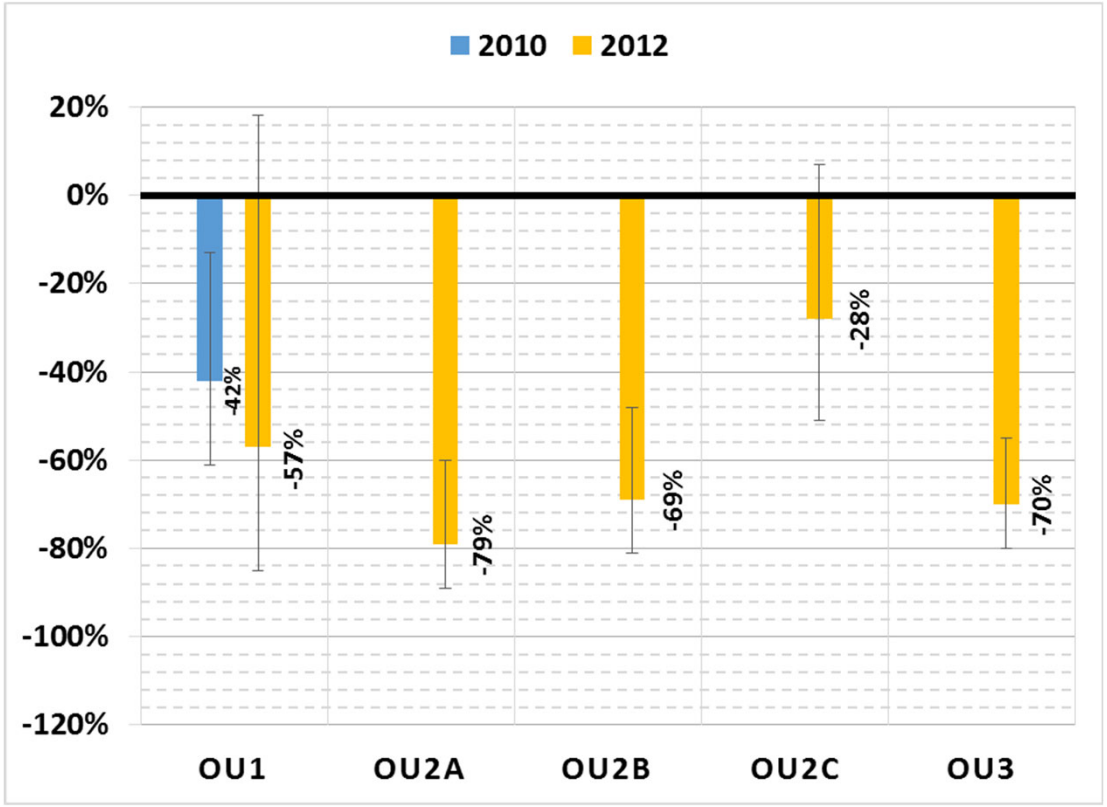
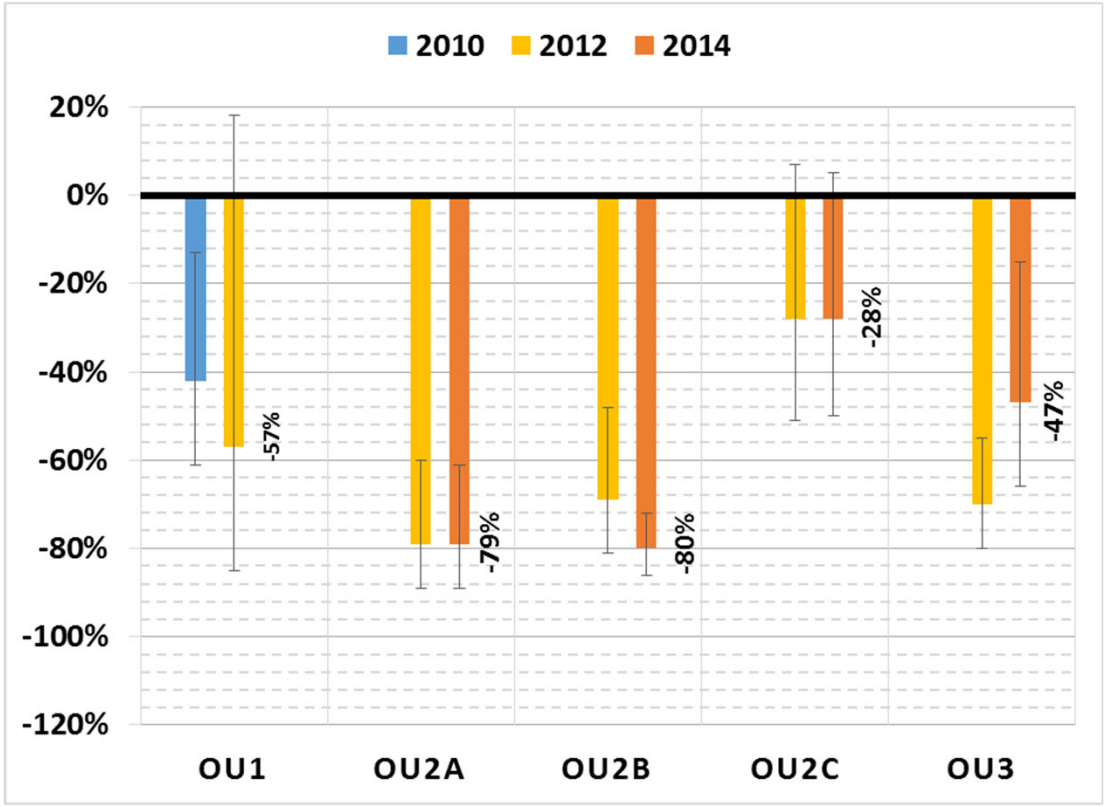
Fish Tissue – Carp (Ecological) Percent Change From Baseline



Note: Draft data for 2018

Fish Tissue – Carp (Ecological) Percent Change From Baseline



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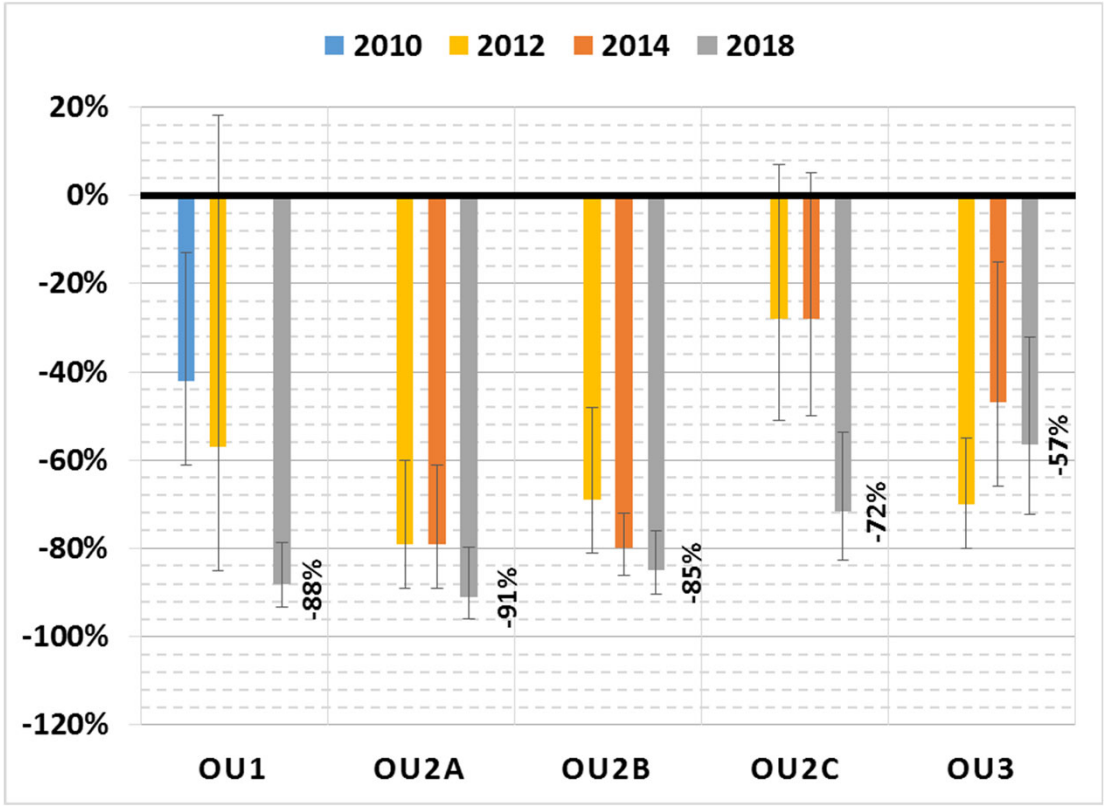
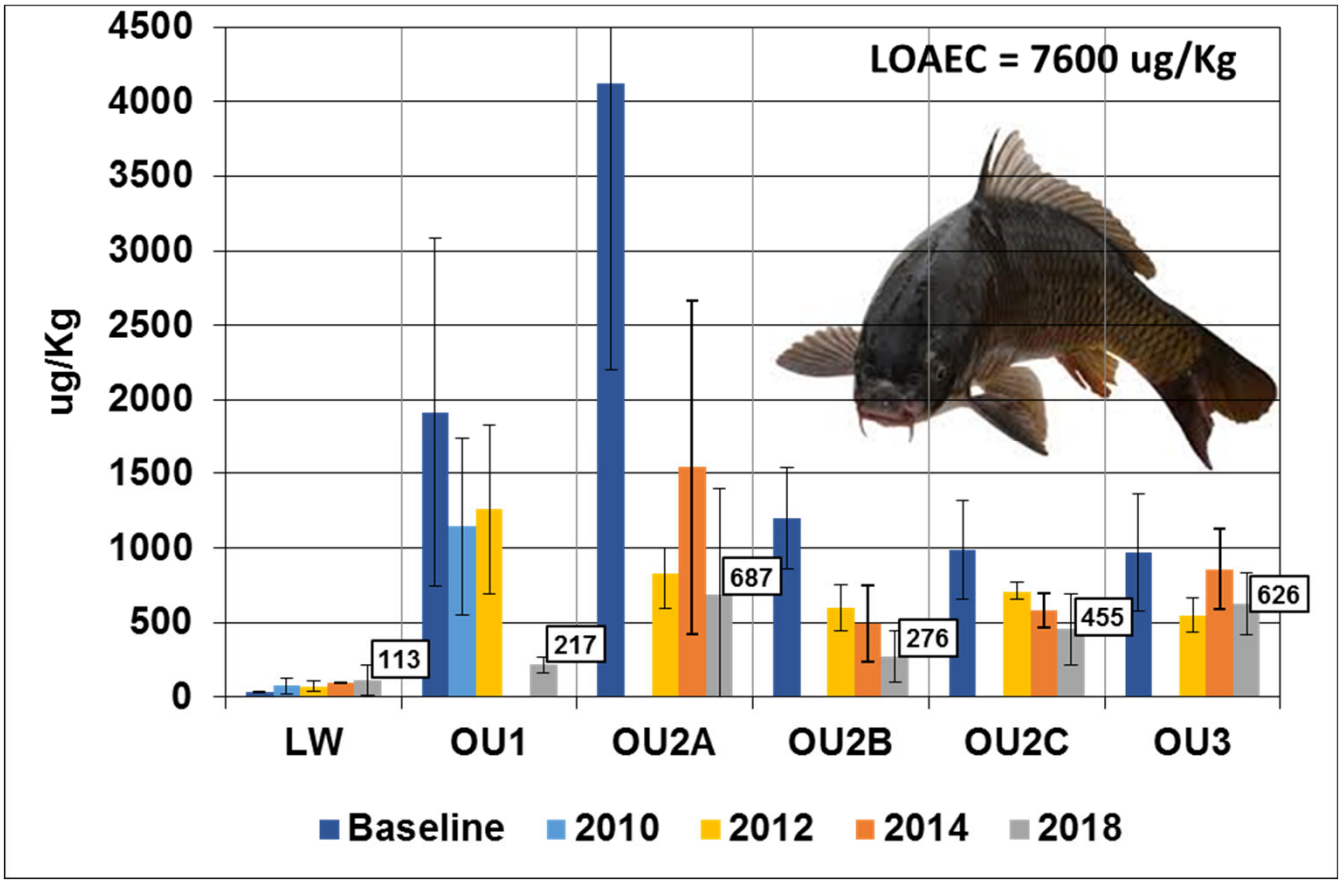
Fish Tissue – Carp (Ecological) Percent Change From Baseline



Note: Draft data for 2018

Fish Tissue – Carp (Ecological) Average Concentrations



Note: Draft data for 2018

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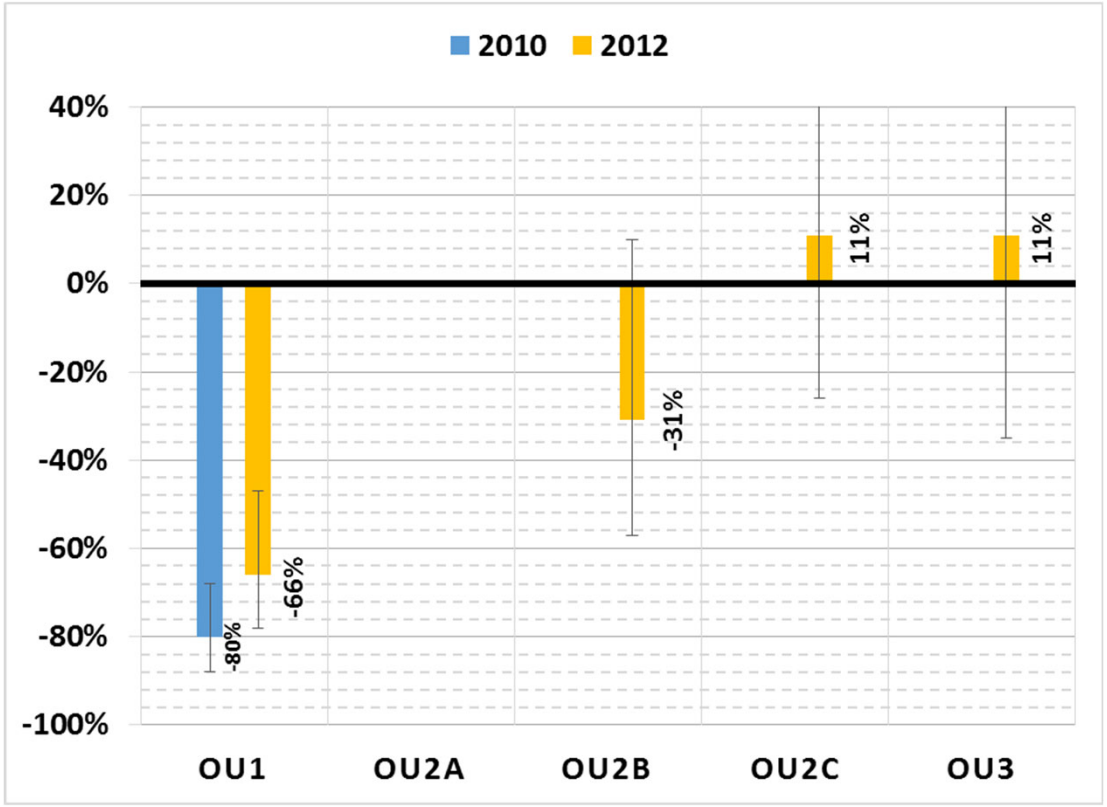
Fish Tissue – Walleye (Human Health) Percent Change From Baseline



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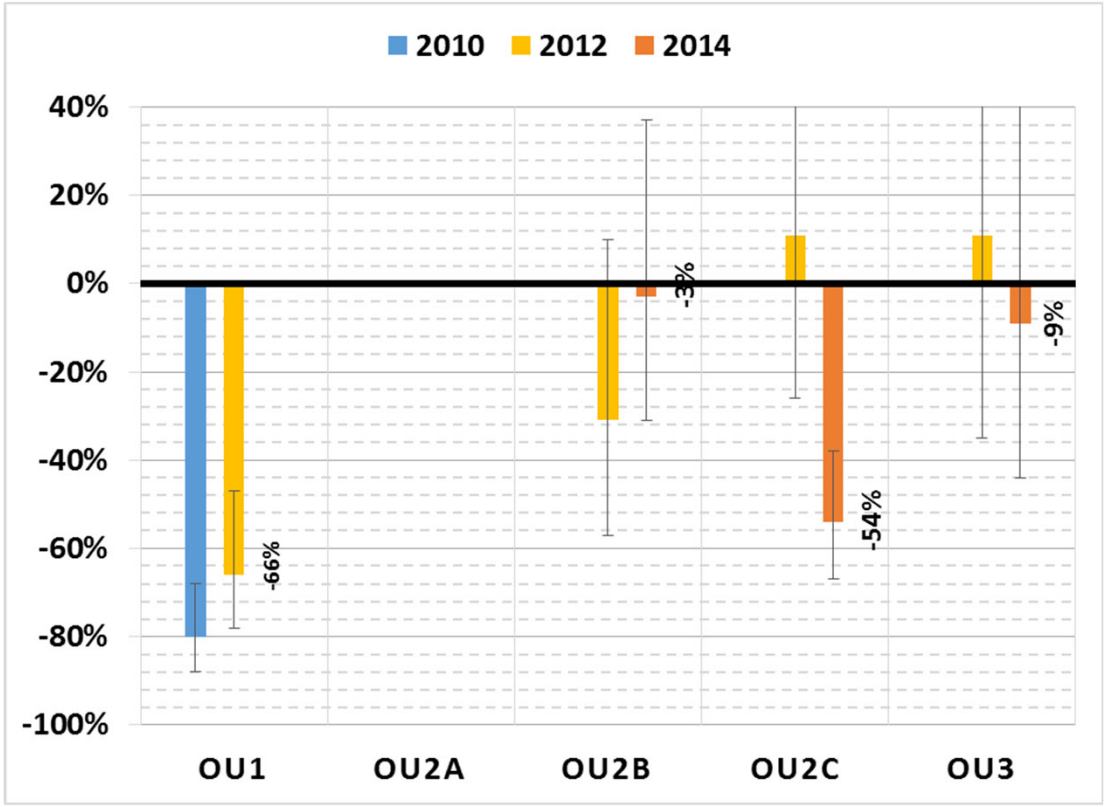
Fish Tissue – Walleye (Human Health) Percent Change From Baseline



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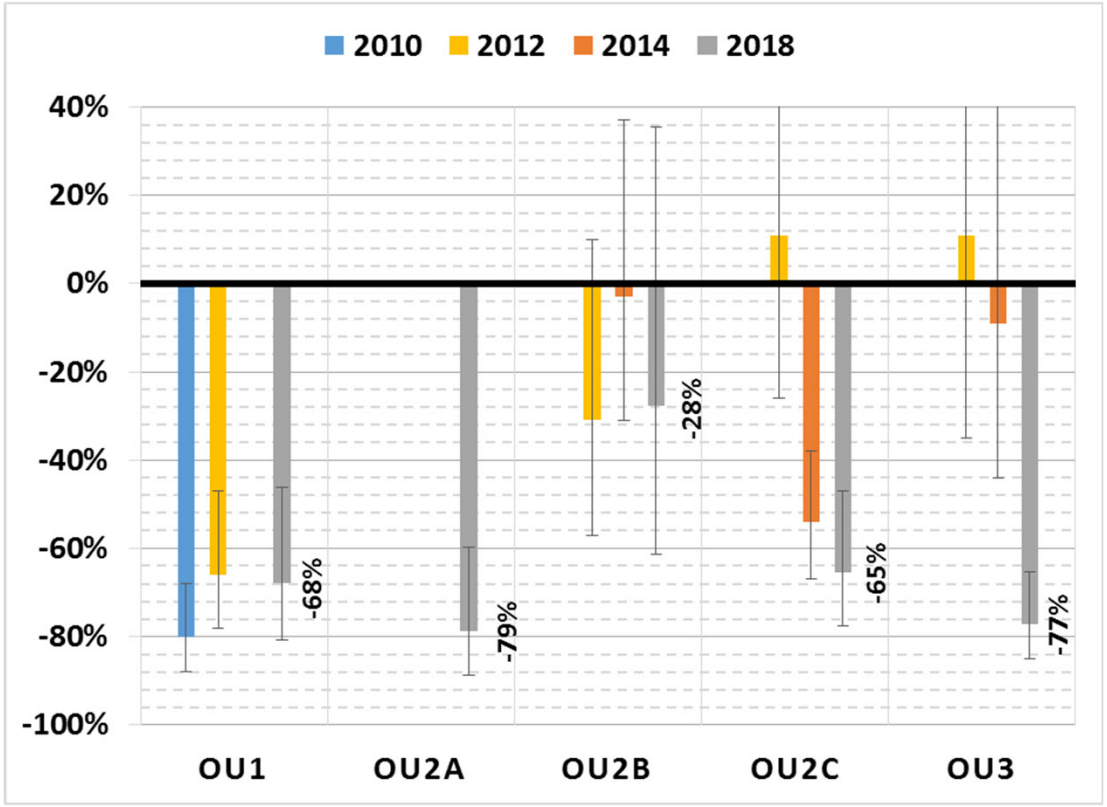
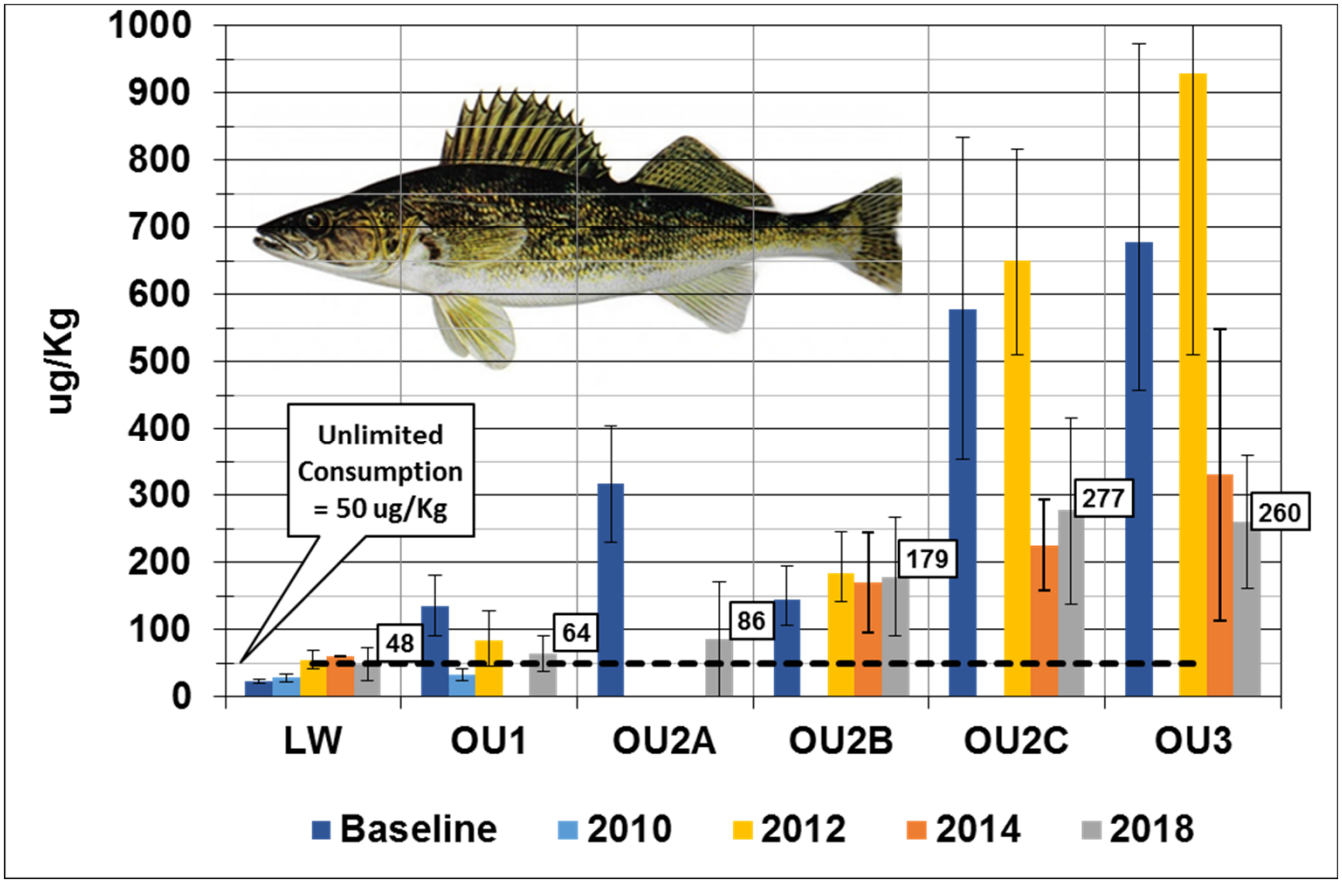
Fish Tissue – Walleye (Human Health) Percent Change From Baseline



Note: Draft data for 2018

Fish Tissue – Walleye (Human Health) Average Concentrations



Note: Draft data for 2018

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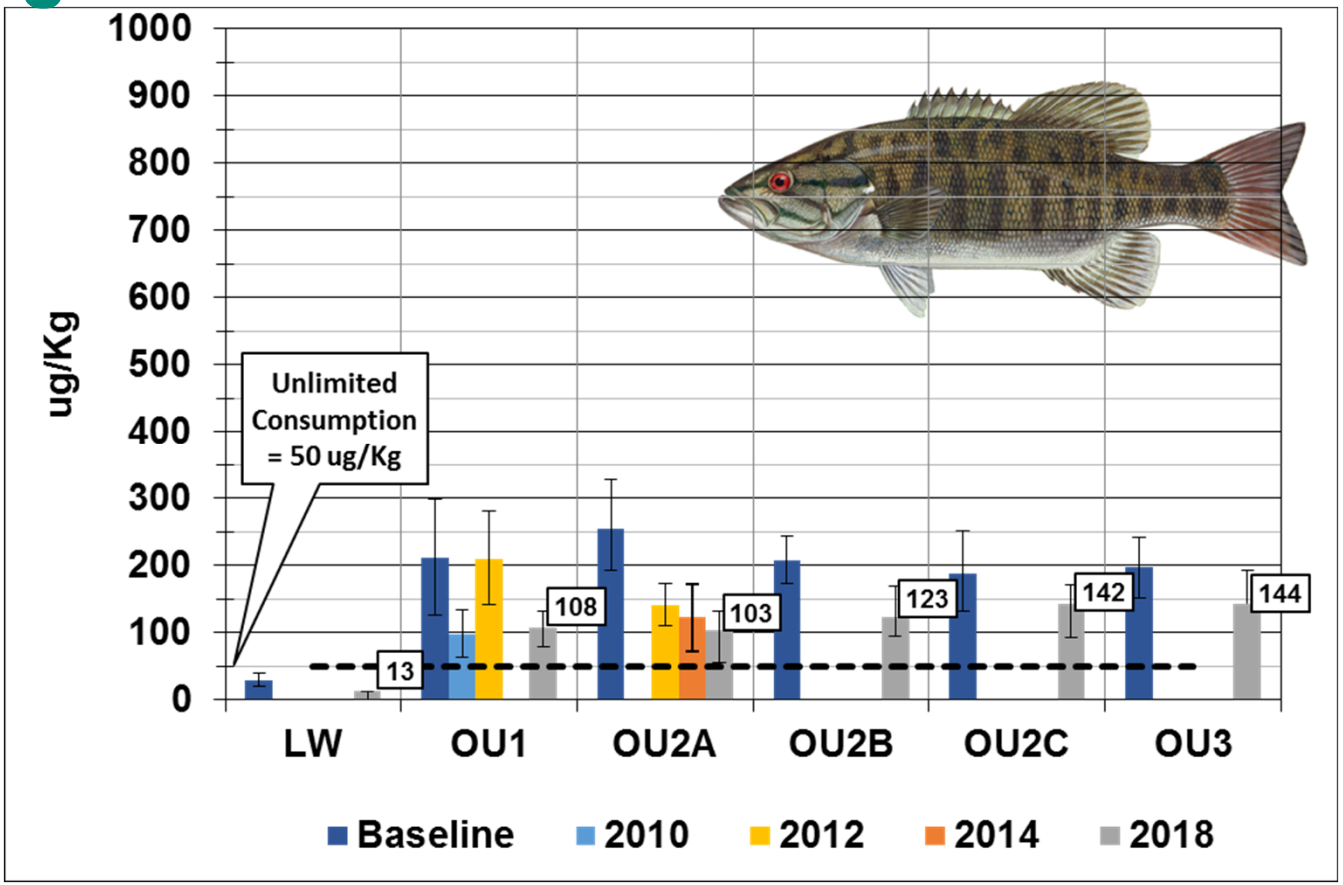
Fish Tissue – Smallmouth Bass (Secondary Human Health) Average Concentrations



Note: Draft data for 2018

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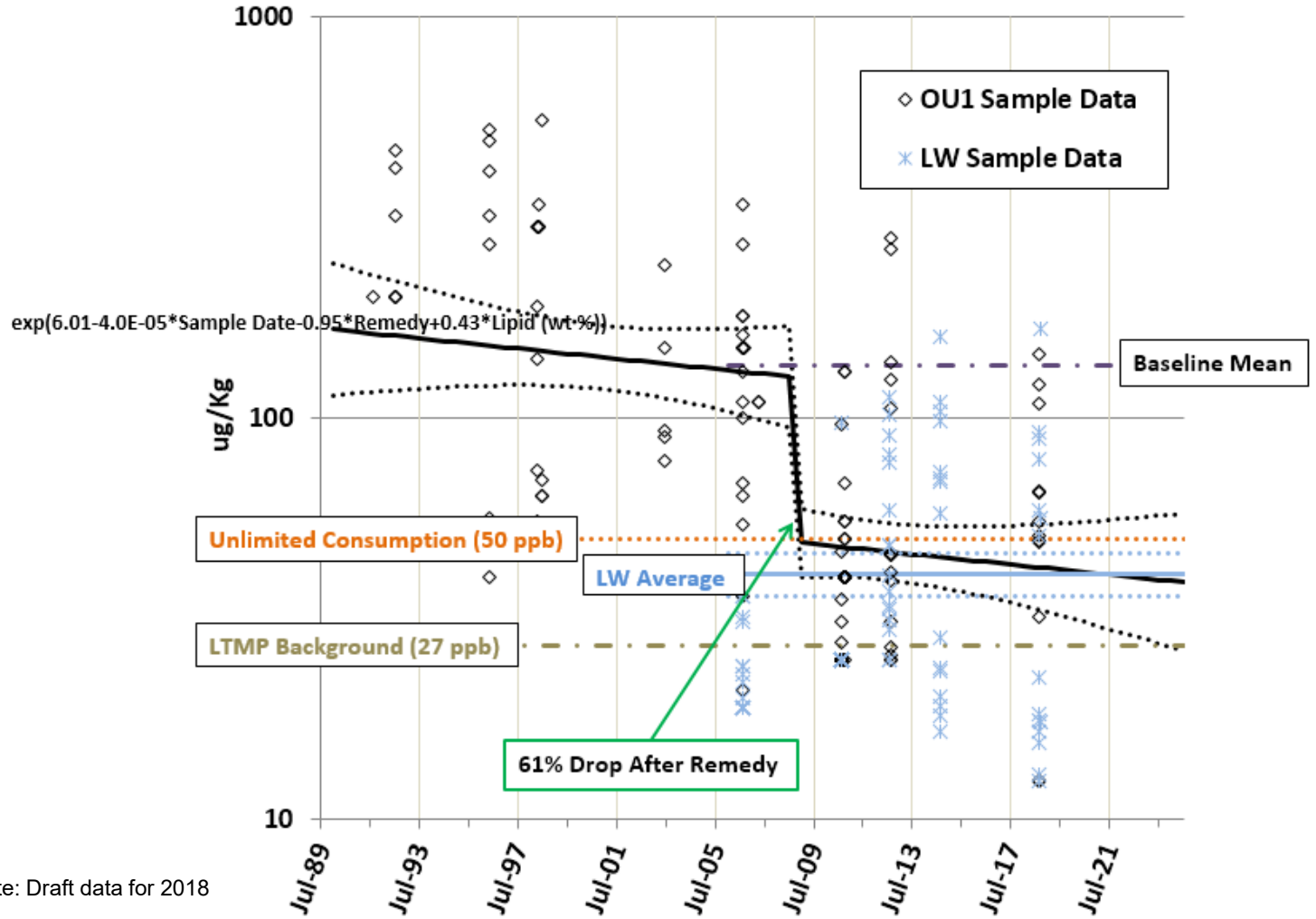
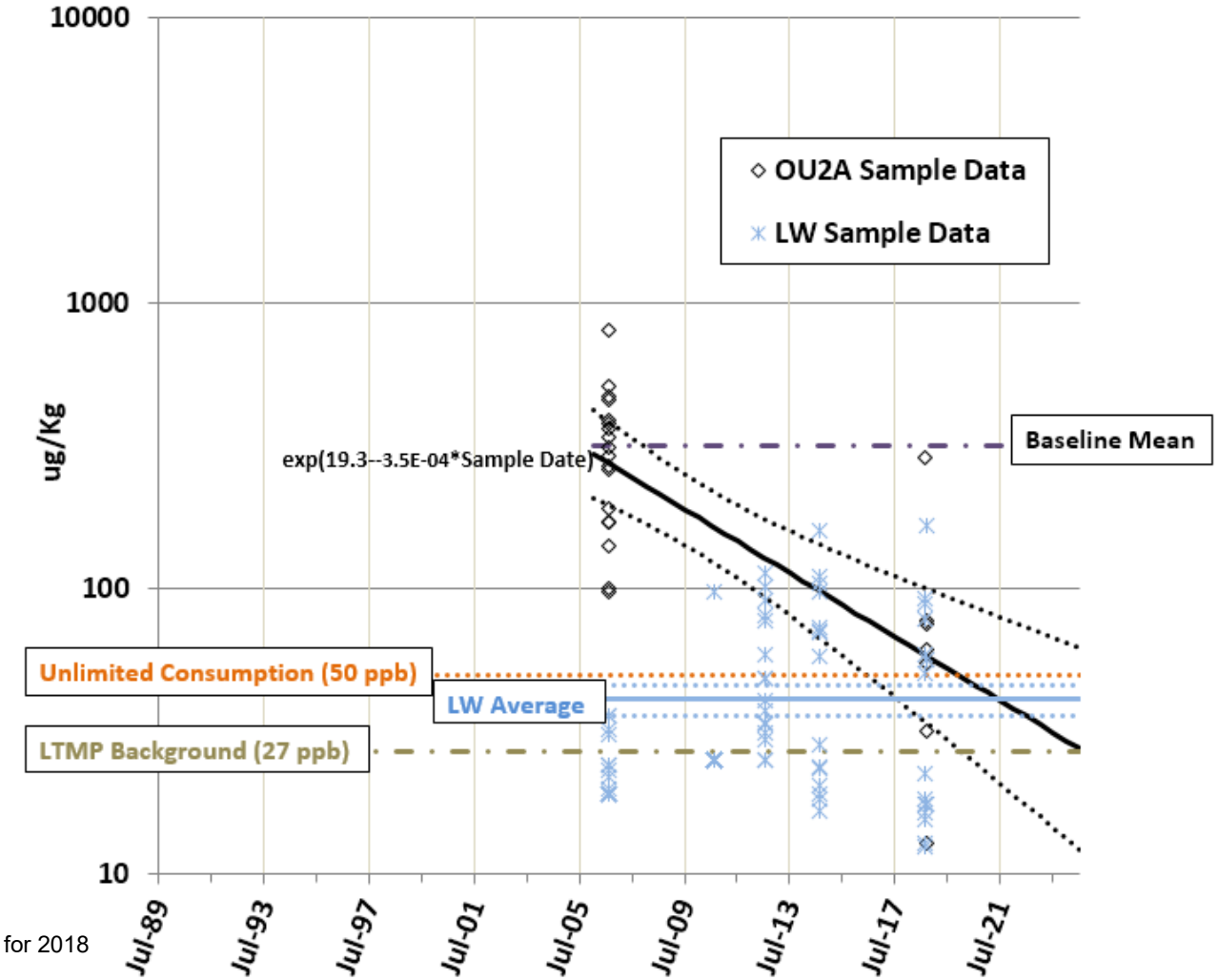
Evaluation of Recovery Rate – Walleye OU1



Note: Draft data for 2018

Evaluation of Recovery Rate – Walleye OU2A



Note: Draft data for 2018

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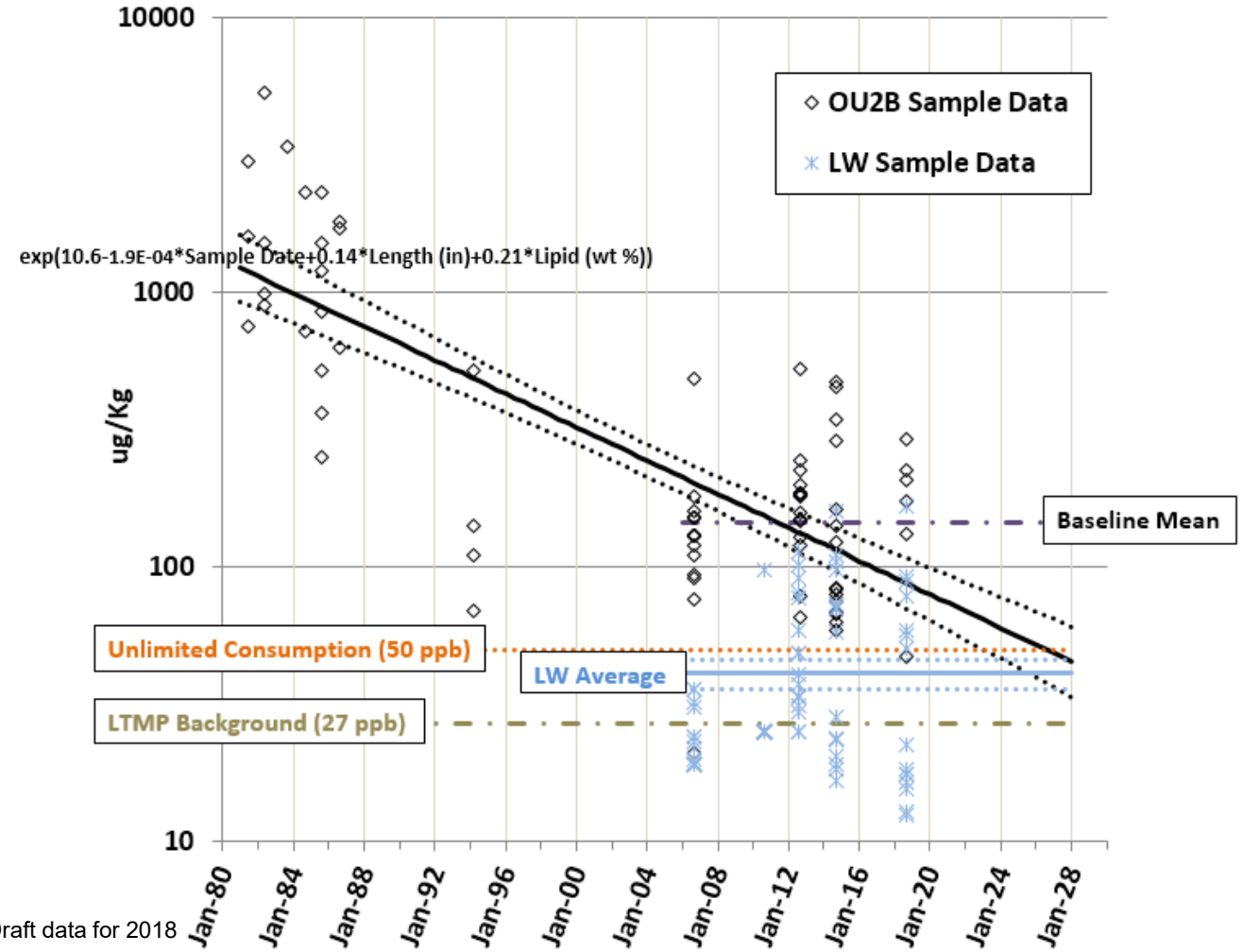
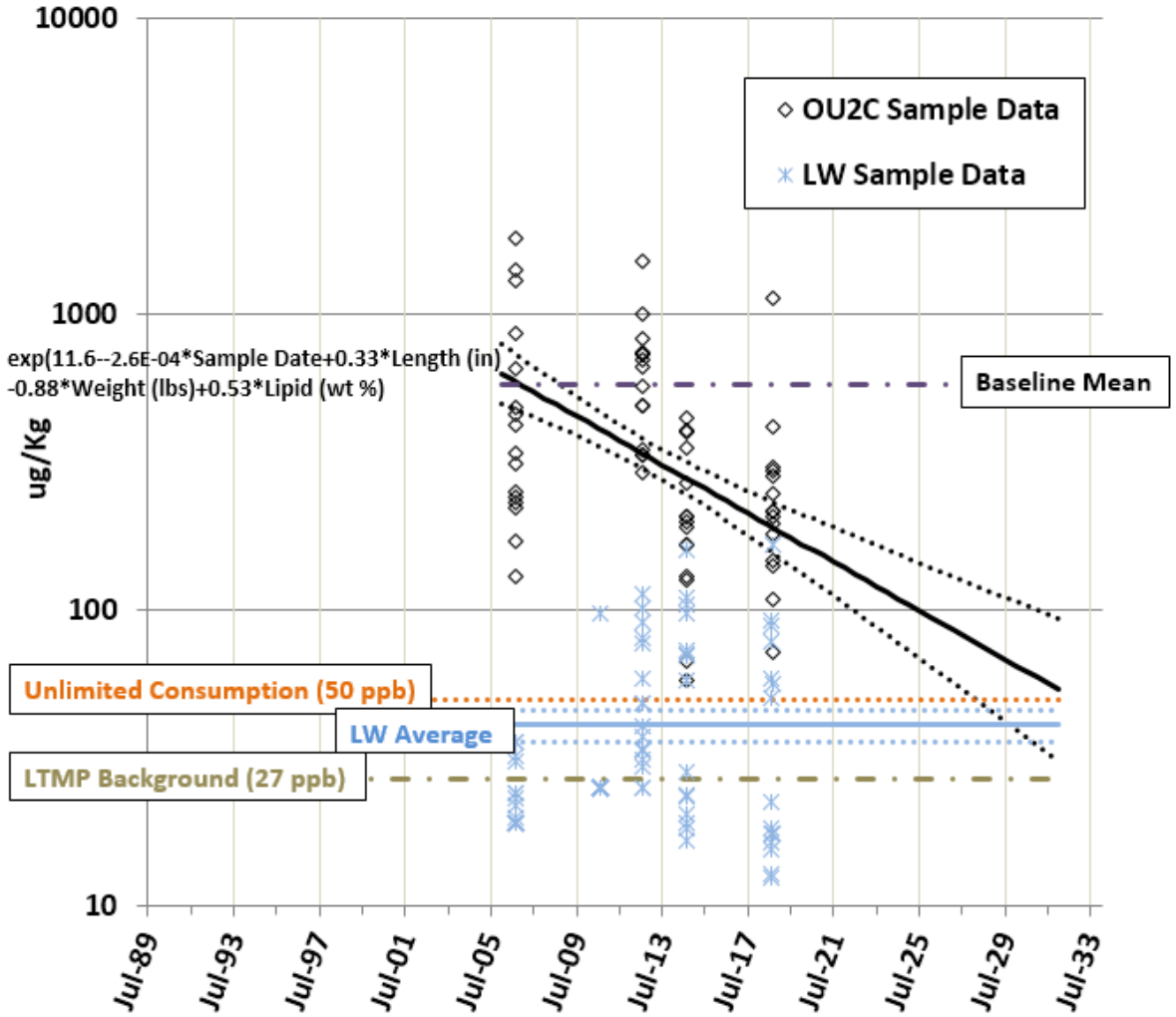
Evaluation of Recovery Rate – Walleye OU2B



Note: Draft data for 2018

Evaluation of Recovery Rate – Walleye OU2C



Note: Draft data for 2018

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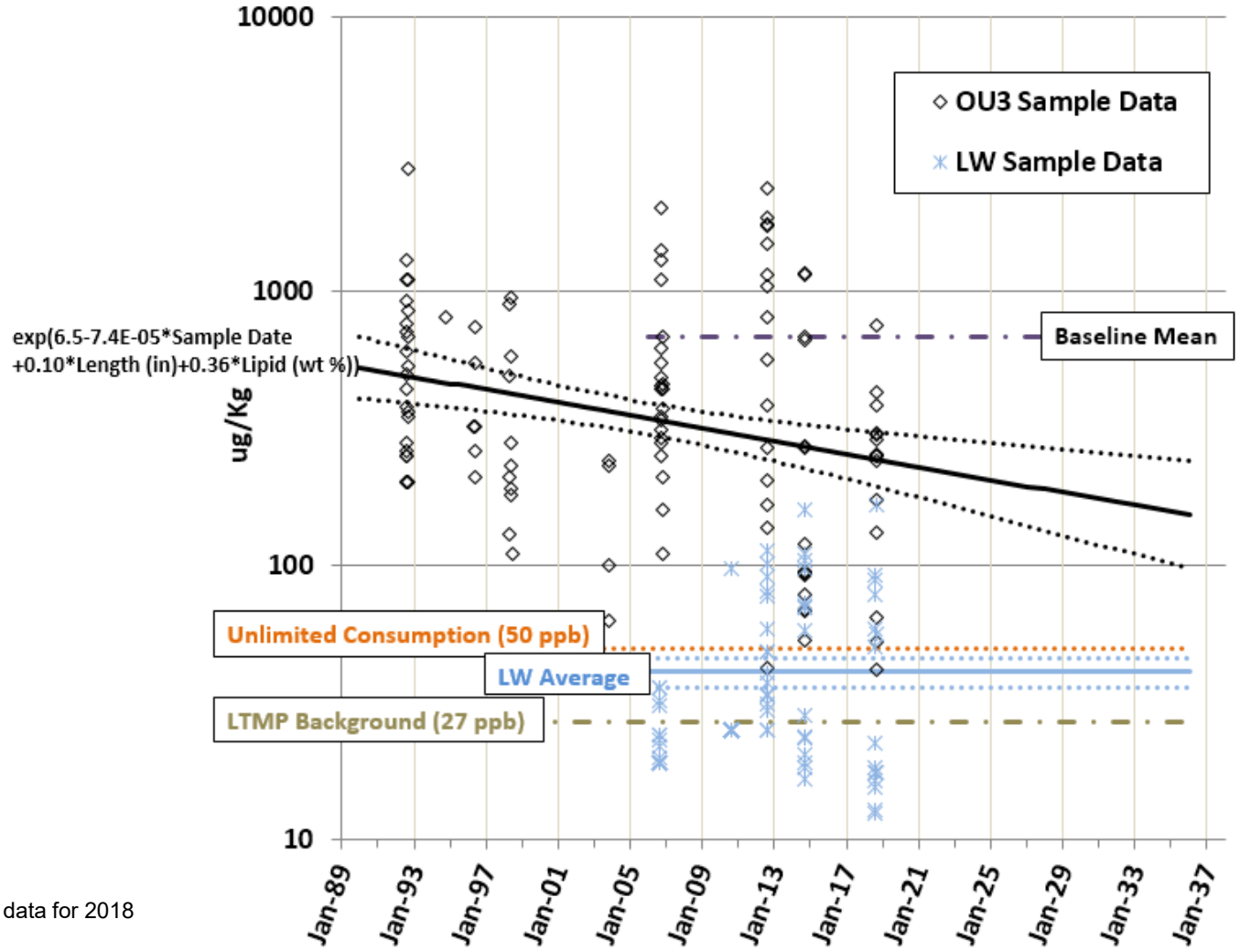
Evaluation of Recovery Rate – Walleye OU3



Note: Draft data for 2018

Conclusions

- Surface Water (Method Blank Corrected)
  - At or near 90% reduction from baseline (SWAC reduction target)
  - Averages are below the LTMP background criteria of 0.7 ng/L
- Fish Tissue
  - YOY Reduction from Baseline
    - OU1 – 98%
    - OU2A – 88%
    - OU2B, OU2C and OU3 ~ 70%
  - Ecological (Carp) Reduction from Baseline
    - OU1, OU2A and OU2B – 85% to 91%
    - OU2C, OU3 – 57% to 72%
    - Concentrations well below LOAEC of 7600 μg/Kg

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Conclusions (Cont.)

- Fish Tissue Human Health (Walleye)
  - Reduction from baseline
    - OU1 – 68%
    - OU2A – 79%
    - OU2B – 28%
    - OU2C – 65%
    - OU3 – 77%
  - OU1 and OU2A approaching unlimited consumption of 50 μg/Kg
  - OU2B, OU2C and OU3 average 179 μg/Kg to 277 μg/Kg
  - Projected number of years to reach average of 50 μg/Kg
    - OU2B ~10 years
    - OU2C ~15 years
    - Longer in OU3

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