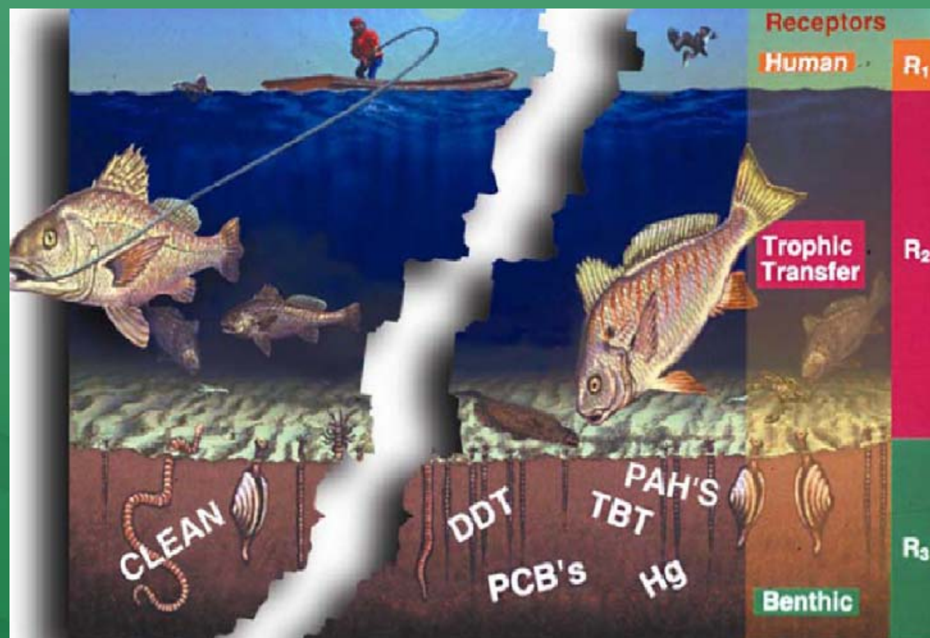
Using Fish Tissue Data to Monitor Remedy Effectiveness



OSRTI Sediment Assessment and Monitoring Sheet (SAMS) #1 Webinar

United States Environmental Protection Agency

Presenters

Moderator — **EPA**

- Matthew Lambert

Speaker 1 — **ICF International**

- Dean Gouveia

Case Study for Fox River

- Jim Hahnenberg

Case Study for Hudson River — **EPA**

- Gary Klawinski

Overview

Six Step Process

Planning Factors

Analyzing Results

Case Studies

Overview

Objective

To better understand the critical factors to consider in the design of Fish Sampling and Analysis Programs to evaluate long-term remedy effectiveness in achieving remedial action objectives (RAOs) and in reducing human health and/or environmental risk

Overview

Objective

Sediment Assessment and

Monitoring Sheet (SAMS) #1

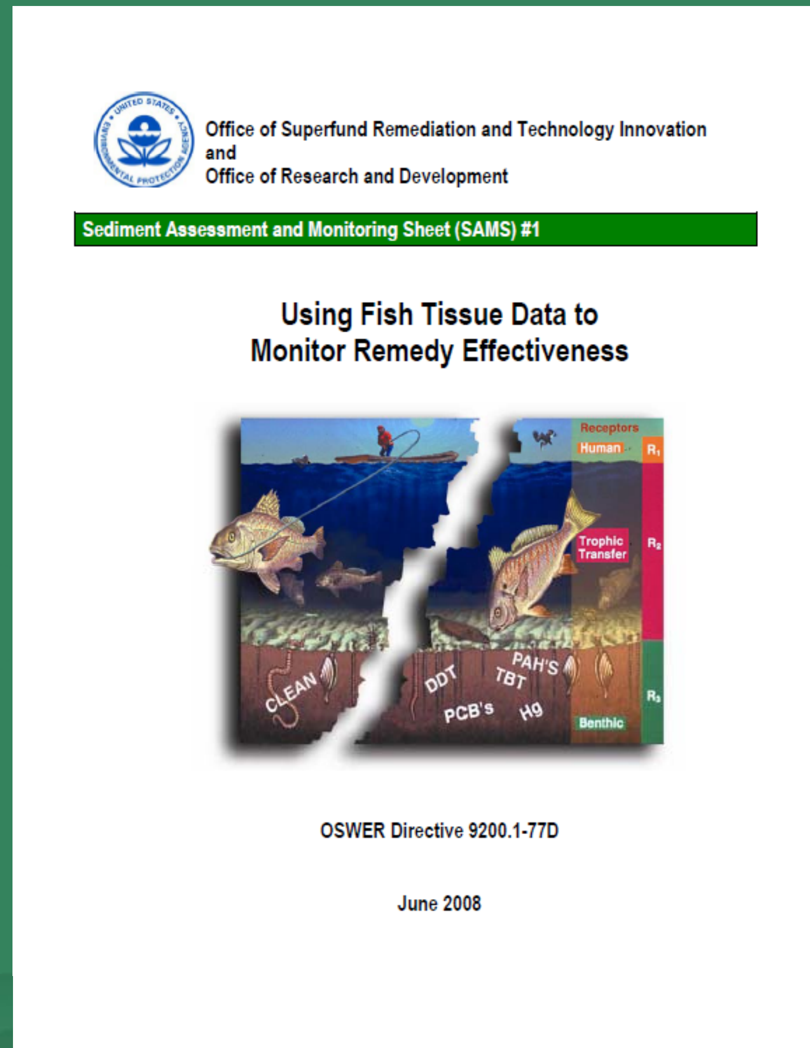
Using Fish Tissue Data to

Monitor Remedy

Effectiveness

OSWER Directive 9200.1-770

June 2008



Office of Superfund Remediation and Technology Innovation
and
Office of Research and Development

Sediment Assessment and Monitoring Sheet (SAMS) #1

Using Fish Tissue Data to
Monitor Remedy Effectiveness

OSWER Directive 9200.1-77D

June 2008

United States
Environmental Protection
Agency

Overview

Contaminated Sediment Remediation Guidance for Hazardous Waste Sites

Chapter 8: Remedial Action and Long-Term Monitoring

OSWER 9355.0-85
December 2005

Contaminated Sediment Remediation
Guidance for Hazardous Waste Sites

Overview

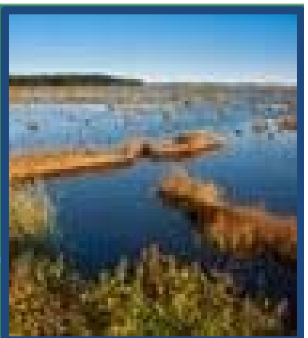
Biota sampling and analysis programs have multiple uses:

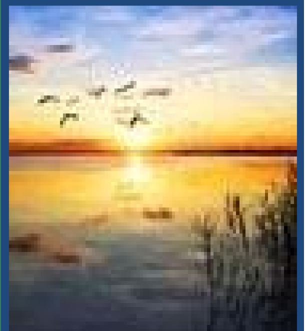
- Human Health Risk Assessment (HHRA)
- Ecological Risk Assessment (ERA)
- Fish advisories and enforcement
- Food chain model or bioaccumulation testing
- Distinguishing impacts from multiple contributors
- Assess non-traditional contaminants (pharmaceuticals/endocrine disruptors)
- Data analysis for Five-Year Review/remedy effectiveness evaluation

Overview

Key Goals of a Monitoring Program:

- Capture ecosystem behavior
- Chemical residues in biota are representative
- Focused on answering specific site requirements
- Assess decrease due to remedial actions





Overview

Six Step Process

Planning Factors

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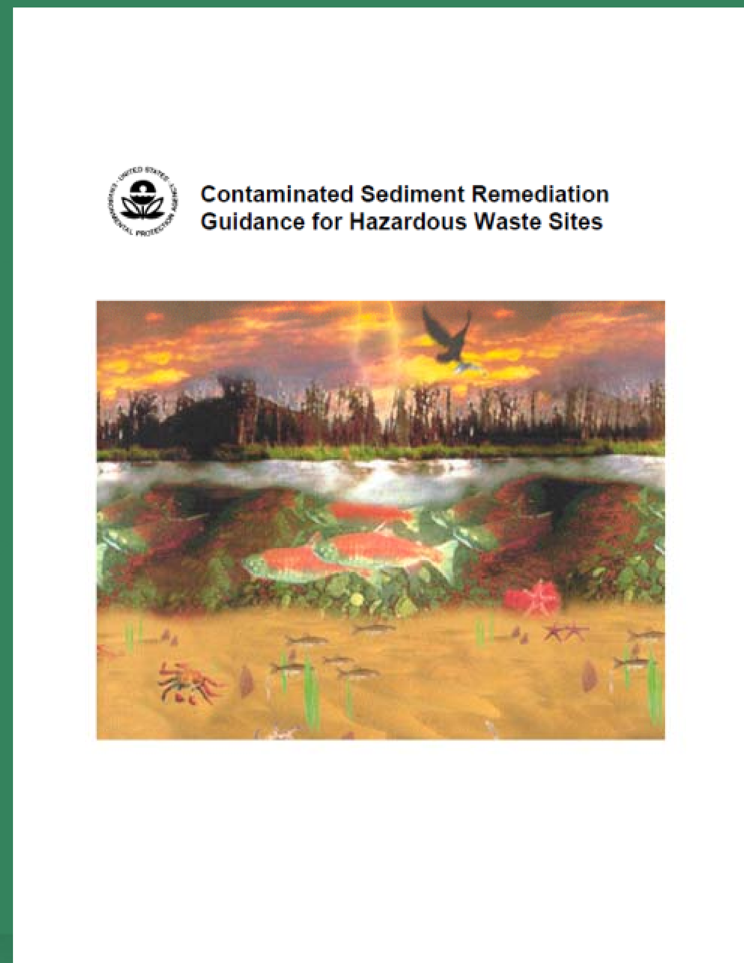
Case Studies

Six Step Process

EPA's Monitoring Guidance describes six key steps that are recommended in developing and implementing any monitoring plan.



Six Step Process

1. Identify Objectives
2. Develop Hypotheses
3. Formulate Decision Rules
4. Design Plan
5. Conduct Analysis
6. Make Decision

Chapter 8: Remedial Action and Long-Term Monitoring

Highlight 8-3: Recommended Six-Step Process for Developing and Implementing a Monitoring Plan

Step 1. Identify Monitoring Plan Objectives

- Evaluate the site activity
  - Identify the activity objectives
  - Identify the activity endpoints
  - Identify the activity mode of action
- Identify monitoring objectives
- Obtain stakeholder input

Step 2. Develop Monitoring Plan Hypotheses

- Develop monitoring conceptual models
- Develop monitoring hypotheses and questions

Step 3. Formulate Monitoring Decision Rules

Step 4. Design the Monitoring Plan

- Identify data needs
- Determine monitoring plan boundaries
- Identify data collection methods
- Identify data analysis methods
- Finalize the decision rules
- Prepare monitoring quality assurance project plans (QAPPs)

Step 5. Conduct Monitoring Analyses and Characterize Results

- Conduct data collection and analysis
- Evaluate results per the monitoring of data quality objectives (DQOs), developed in Steps 1-4, and revise data collection and analysis as necessary
- Characterize analytical results and evaluate relative to the decision rules

Step 6. Establish the Management Decision

- Monitoring results support the decision rule for site activity success
  - Conclude the site activity and monitoring
- Monitoring results do not support the decision rule for site activity success but are trending toward support
  - Continue the site activity and monitoring
- Monitoring results do not support the decision rule and are not trending toward support
  - Conduct causative factor and uncertainty analysis
  - Revise site activity and/or monitoring plan and implement

Source: U.S. EPA 2004c

Six Step Process

1 Identify Objectives

- Evaluate Site Activity
  – Identify the activity objectives

Step 1 EXAMPLE

In the ROD, EPA established a RAO of reducing PCB concentrations in fish tissue to levels that would eliminate the need for a fish consumption advisory for PCBs (for this site, 0.05 ppm). To achieve this objective, EPA selected a cleanup level of 0.5 ppm total PCBs in sediment. The short-term objective of the monitoring program is to monitor PCB concentrations in fish under the advisory to assess impact to fish tissue as the sediment cleanup level is sought.

Six Step Process

1. Identify Objectives
2. **Develop Hypotheses**
3. Formulate Decision Rules
4. Design Plan
5. Conduct Analysis
6. Make Decision

- Develop
  - Monitoring conceptual models

Step 2 EXAMPLE

The PCB concentration in sediment has reached the cleanup level of 0.5 ppm. The PCB concentration in fish tissue has reached the remedial goal of 0.05 ppm.

Six Step Process

1. Identify Objectives
2. Develop Hypotheses
3. **Formulate Decision Rules**
4. Design Plan
5. Conduct Analysis
6. Make Decision

Step 3 EXAMPLE

A decision rule could be established to assess whether progress is being made toward the RAO of reduced PCB concentrations in fish tissue by establishing an interim goal of achieving 0.8 ppm in fish tissue within five years, after which monitoring frequency will be revisited if cleanup levels have not been achieved.

Six Step Process

Step 4 EXAMPLE

Smallmouth bass spend most of their time in the PCB contaminated site area. The proposed sampling plan would consist of sampling from three areas: 2 downstream and 1 upstream of the site. Thirty (30) mixed gender bass each over the size limit will be collected in the early spring (before spawning) in each of these areas. The analysis of composite skin off fillets for selected congeners will be performed to match comparable baseline data. A power analysis indicated 10 composite samples could discern a change in tissue concentration of 0.5 ppm or greater with 0.25 ppm confidence intervals (90 percent).

Six Step Process

Until Step 4, most of the decisions are clear – frequently dictated by ROD or site.

Clearly a lot goes into this design plan at Step 4 as you can see from that example…

Here we need to dig into what factors and information do we need to make that jump from hypotheses and objectives to a decisive plan.

Overview

Six Step Process

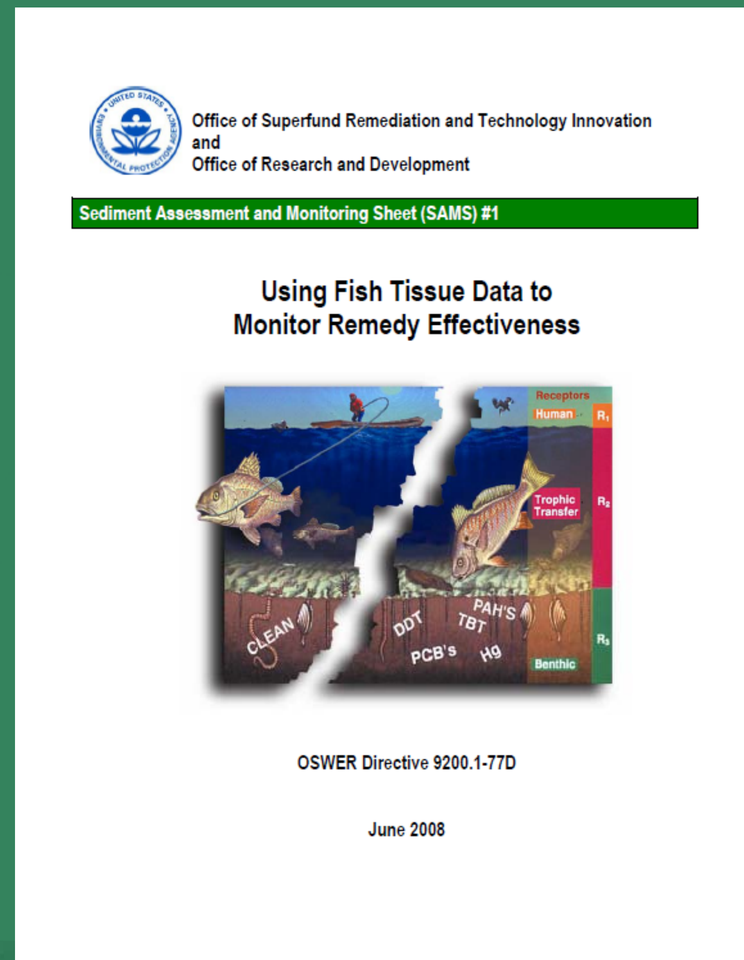
Planning Factors

Analyzing Results

Case Studies

Planning Factors

Refer to the SAMS #1 to better understand the key factors that go into design of fish tissue sampling and analysis programs to evaluate remedy effectiveness.


Office of Superfund Remediation and Technology Innovation
and
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Sediment Assessment and Monitoring Sheet (SAMS) #1

Using Fish Tissue Data to
Monitor Remedy Effectiveness

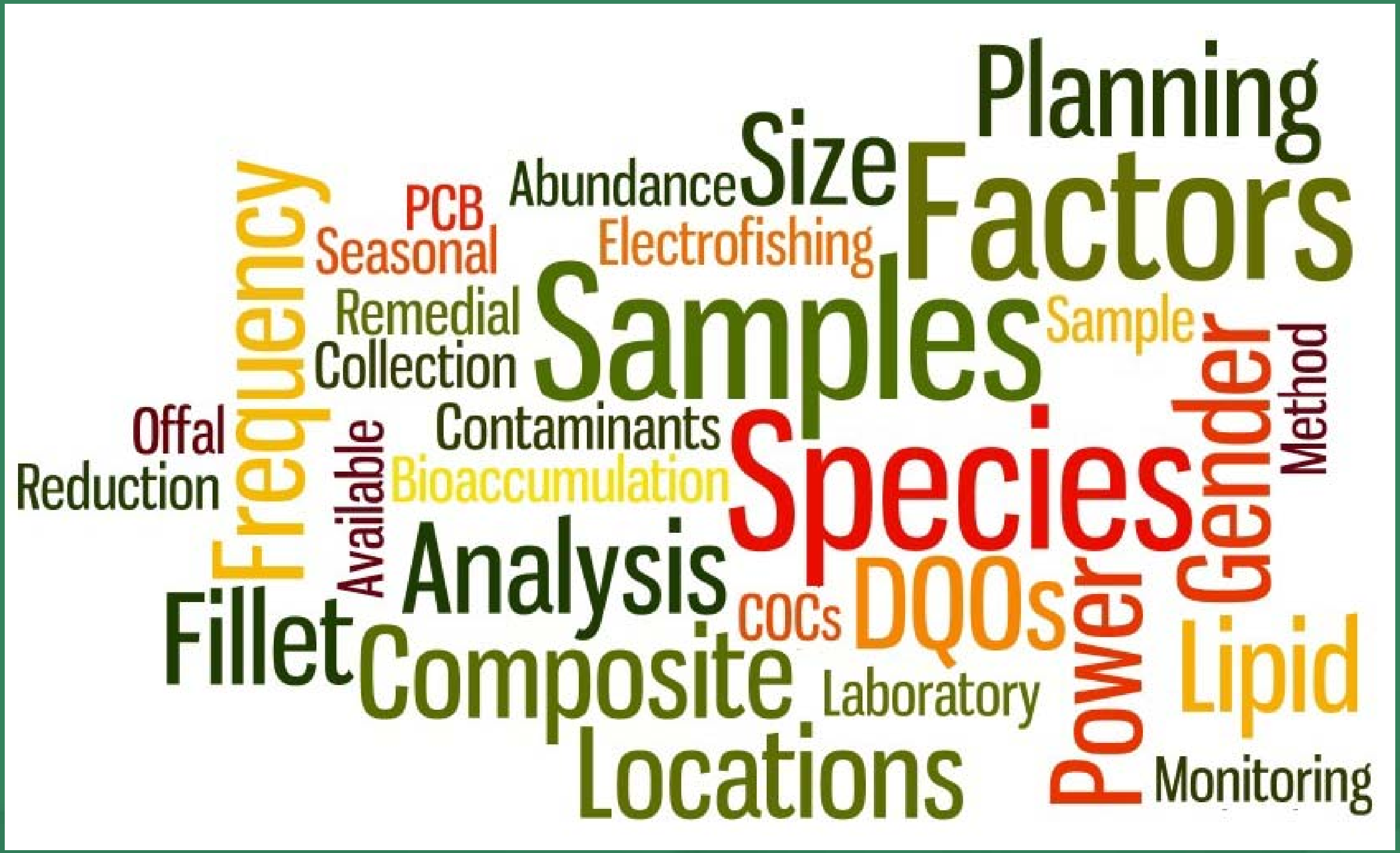
OSWER Directive 9200.1-77D

June 2008

Planning Factors

Factors

First, consider factors and information that go into plan



Planning Factors

Identify CoCs

Consider	• ROD • Baseline data • Fate and Transport
Recommendations	• Address CoCs specified in ROD to the level specified. • Ensure consistency with baseline data wherever possible that doesn't conflict with primary goal of achieving ROD limits. • Address o Bioaccumulative (nonionic, organics, KOW >105, and not rapidly excreted or metabolized) o Transformed species such as methyl mercury where mercury is a concern.

Planning Factors

What Affects Fate and Transport?

- Bioaccumulation
- Hydrophobic/hydrophilic
- Partitioning
- Excretion/metabolic rates
- Transformation (chemical/biological)

Planning Factors

Identify Species

Consider	• Prevalence and availability • Edibility and consumption by humans • Potential for bioaccumulation

Recommendations	• Consult fish consumption advisories
	• Frequency of ingestion (humans or wildlife)
	• Exposure only or primarily from site
	• Consider limited mobility species like shellfish
	• Profile multiple species separately
	    • Saltwater: at least two fish or one fish/one shellfish.
	    • Inland waters: at least one bottom feeder and one predator/game fish species

Planning Factors

What affects Bioaccumulation among Species?

- Foraging ranges
- Feeding habits
- Lipid content
- Food Chain/Trophic level
- Differences in gender & life stages





Planning Factors

Sample Type

Consider	• Gender/Life Stage (Intraspecies variation) • Size of Samples • Whole body vs fillet • Individual, Composite, vs. Multi-species Composites
Recommendations	• Game fish should be of legal size • Fillets primarily human risk, whole body for ecological risks but fillet and offal may be tested separately then combined • Saltwater: at least two fish or one fish/one shellfish. • Inland waters: at least one bottom feeder and one predator/game fish species • Similar Age: Smallest fish at least 75% length of largest fish

Planning Factors

Gender and Life Stage Differences

- Lipid content
- Feeding habits/ranges
- Elimination rates of the contaminant
- Life history
- Spawning

Planning Factors

How Many Samples

Consider	• Amount of baseline data available • Availability and abundance • Cost-Benefit of data to increase certainty • Composite Strategy (Individual, Composite, Multi-species Composite)
Recommendations	• Ensure adequate baseline data to provide a benchmark for measurement of decrease. If not increase initial data to provide basis for subsequent comparison. • Power analysis can be useful in determining the number of samples to take for composite or individual sampling. • Profile multiple species separately wherever possible • More certainty from increasing number of composites. • More cost savings from increasing fish per composite.

Planning Factors

Compositing

- A minimum of 5 composites with 5 fish per composite is often sufficient to determine a 50% decrease in concentrations with a 90% confidence level.
- More composites needed to determine smaller decrease in concentration or higher confidence.
- Composite strategy must take into account detection limits also.

Planning Factors

Determine total number of samples by hypothesis testing:

Example: Have residues decreased by 50%?

Set **Type I** (i.e., false positive) error rate

(e.g., confidence level

α = 5% or 10%)

Minimize **Type II** (i.e., false negative) error (β)

Actual Answer

Answer when Measured		True	False
	True	Correct	Type 1 False Positive
	False	Type 2 False Negative	Correct

Planning Factors

Power curves: α = 0.05
5 composites with 5 fish per composite

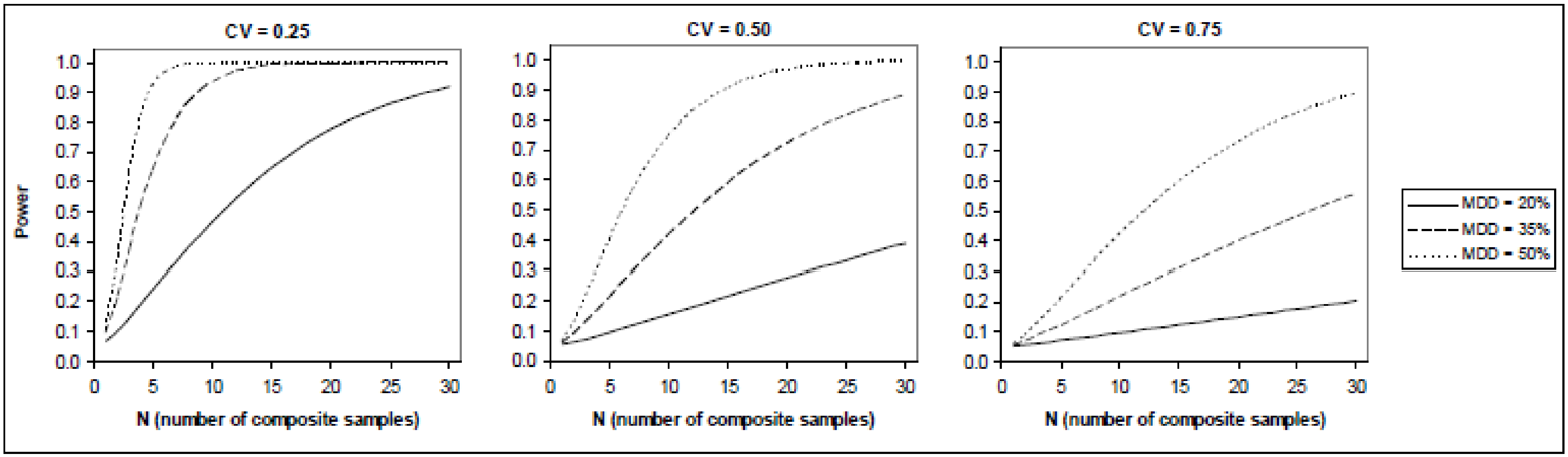


Figure A-2. Power (1-β) curves for a 25%, 35%, or 50% minimum detectable decrease (MDD) in contaminant concentrations between means at α= 0.05, two-tailed, when the coefficient of variation (CV) for between-sample variability is 0.25, 0.50, and 0.75.

CV = coefficient of variation composite

MDD = minimum detectable decrease

Planning Factors

Locations

Consider	• Site size, complexity and relative forage ranges • Known fishing locations • Fish migration patterns and habitats • Topography, bathymetry, sediment deposition/erosion • Impeding or access structures (waterfalls, ladders, dams, docks, landings, etc.)
Recommendations	• Where human health is driver, focus on identified fishing locations • Choose locations based on abundance then select sampling technique to fit accessibility of locations. • Collect samples from no fewer than three sampling stations with larger sites or riverine sites having more. • Use same locations for each year of sampling.

Planning Factors

Electrofishing

Electrofishing is a common sample collection technique

- Limitations on depth, range, and salinity
- Three primary types
  - Boat
  - Towed barge
  - Backpack

Planning Factors

Timing

Consider	• Remediation goal and expected timeline for completion • Type, scope, and speed of remedy (e.g. capping vs dredging) • Seasonality impacts life stages, habits, abundance, size, and lipid content
Recommendations	• At least two sampling events before 5-year review • Collect during comparable seasons and stream flow • Collect prior to outward migration, if applicable. • Where human health is a driver consider seasonal fishing prevalence

Planning Factors

Timing

Avoid Sample Collection

- o During spring when lipid content is typically low
- o Within 1 month of spawning season
- o Within 3 months of any fish stocking including contiguous but outside site areas

Planning Factors

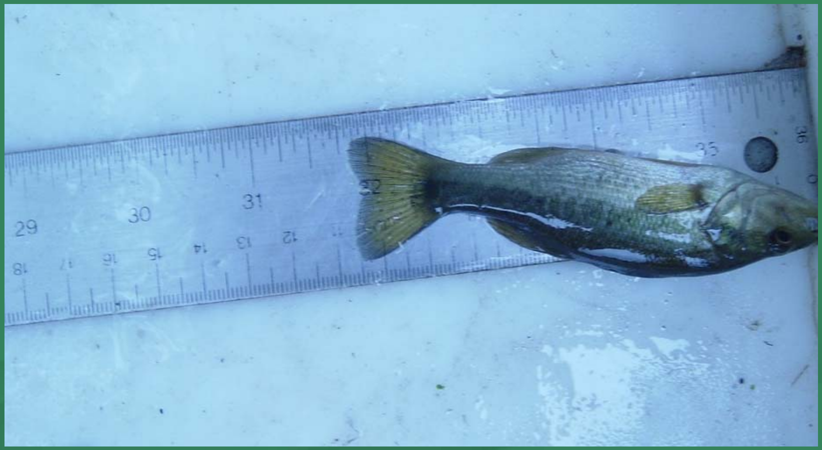
Analysis

Consider	• Required Sample Size • Reporting Limits • Field QC samples to assess precision • Archiving extracts and/or extra samples for verification
Recommendations	• Provide a minimum of 200 g per sample analysis method or laboratory minimum for analysis • Ensure Reporting limits are capable of discerning decrease • Field replicates or co-located samples particularly in the case of composites can provide an assessment of overall precision • Field Equipment Rinsate Blanks provide a sense of contamination potential but are difficult to apply

Planning Factors

Analysis

- Small species or individual fish may not meet minimum mass requirements
- Multiple analyses may not be able to share same extract increasing sample requirements
- Compositing strategy needs to be taken into account with analysis approach to ensure detection limits are achieved



Planning Factors

Putting It Together

nd

ion

Target Species

CoCs

Step 4 EXAMPLE

Number

Location

Gender

Timing

Type

Analysis

Analysis

Smallmouth bass spend most of their time in the **PCB** contaminated site area. The proposed sampling plan would consist om **three** **: 2 downstream and 1 upstream** of the site. **Thirty** (30) **mixed gender** bass each over the size limit will b the **early spring** (before spawning) in each of these areas. The analysis of **composite skin off fillets** f **selected congeners** w ed to match comparable baseline data. A power analysis indicated 20 composite samples could discern a change in tissue concentration of 0.5 ppm or greater with 0.25 ppm confidence intervals (90 percent). For cost considerations, 10 samples will be analyzed immediately and the other **10 skin off fillets and all offal will b** pending the results.

- Overview
- Six Step Process
- Planning Factors
- **Analyzing Results**
- Case Studies

Analyzing Results

Part of Six Step Process

1. Identify Objectives
2. Develop Hypotheses
3. Formulate Decision Rules
4. Design Plan
5. **Conduct Analysis**
6. Make Decision

What information is critical to ensure you can use the data?

- Understanding Error/Uncertainty
- Data Validation
- Identifying Discrepancies

Does the **data quality** allow you to make a decision or is further data required to substantiate this?

Analyzing Results

Part of Six Step Process

1. Identify Objectives
2. Develop Hypotheses
3. Formulate Decision Rules
4. Design Plan
5. Conduct Analysis
6. Make Decision

Generally 4 outcomes

1. Results demonstrate success;
2. Results suggest trend towards success;
3. Results suggest trend towards no future success; or
4. Not enough information

Does the **data content and scope** allow a management decision?

Overview

Six Step Process

Planning Factors

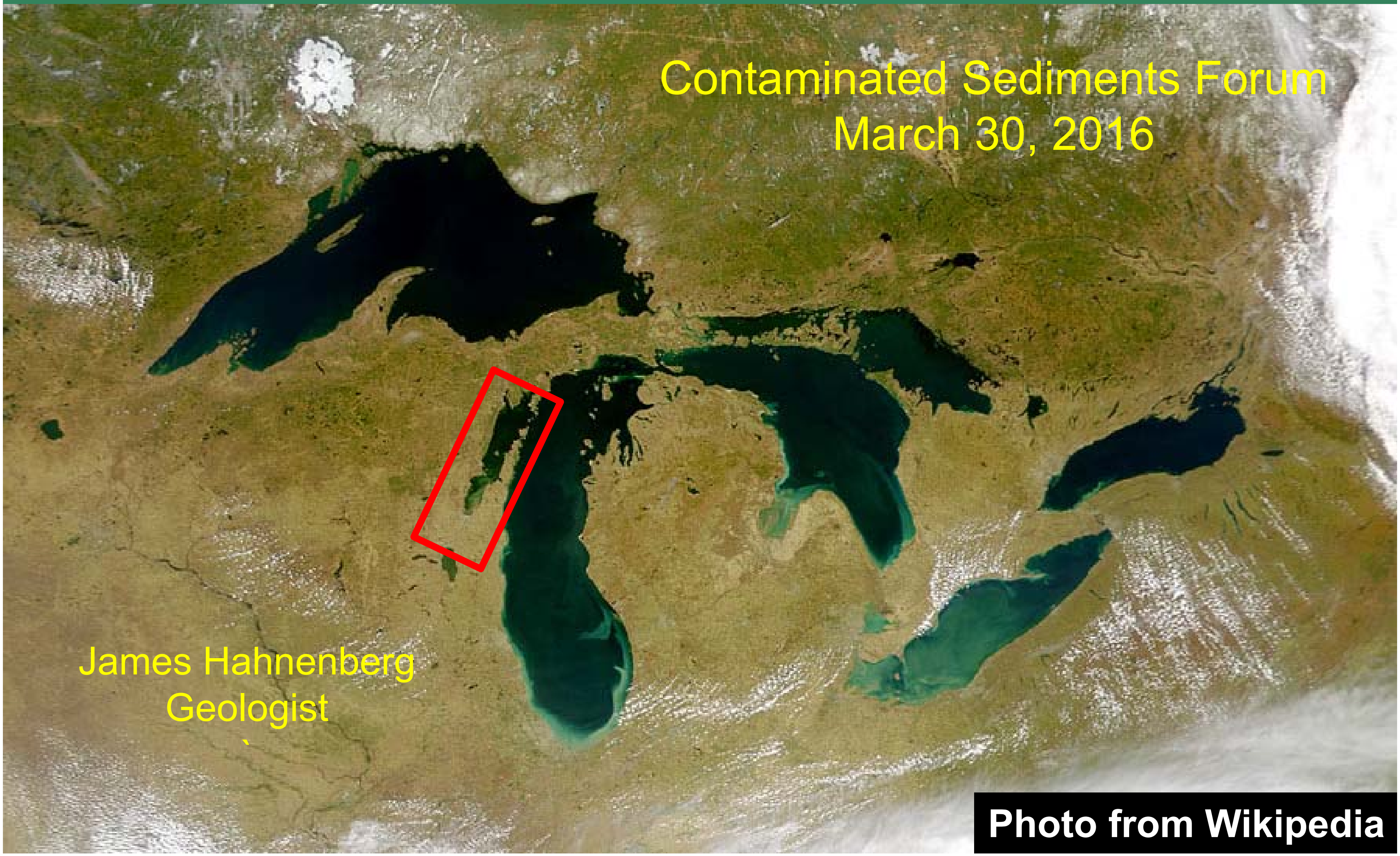
Analyzing Results

Case Studies

Case Study

- Fox River - James Hahnenberg

Fish Monitoring
Fox River, Wisconsin



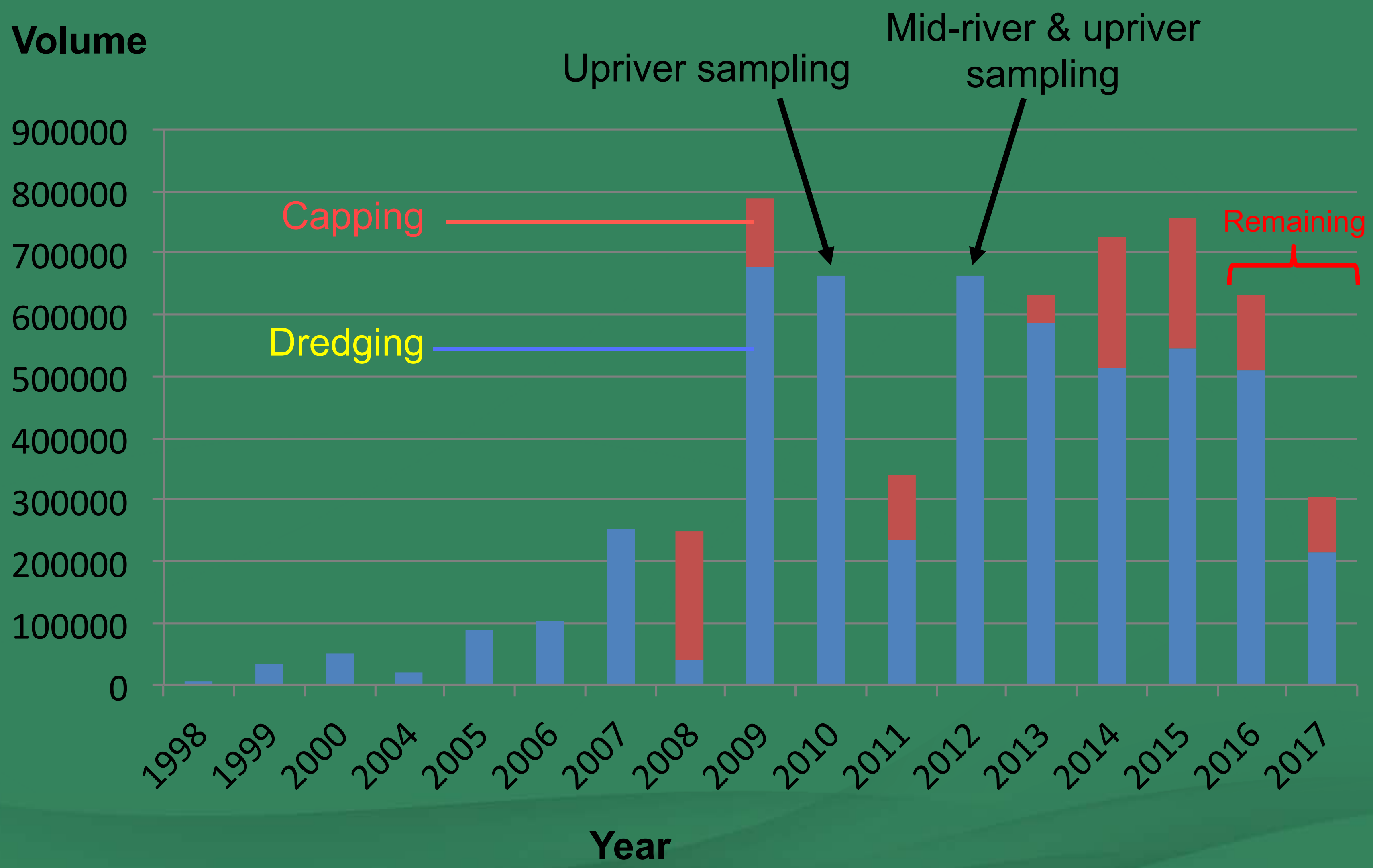
Fox River Case Study - Today

- Background
- Fish Monitoring
- Results

Fox River Cleanup

- Long-term monitoring
  - Fish and surface water
- Largest EPA sediment cleanup
  - Dredging volume: 4.5 Million cy (10 Lambeau Fields)
  - Capping: 660 acres
- Cost: ~$1 billion

Fox River PCB Remediation



United States Environmental Protection Agency

Fish/water Monitoring

Fish Monitoring
Sampling Considerations

- Monitoring stations
- Composite or individual
- Species and number of fish
- Whole or fillet
- Statistical considerations

Fish Monitoring
Sampling Considerations (continued)

- Collection methods
- Time of collection (i.e., season)
- Sample handling
- Congener or Aroclor analysis

Primary Species

Walleye (human health)

Carp (ecological)

Gizzard shad
(early *indicator*)

Secondary Species

Human Health

Ecological

Bass

Drum

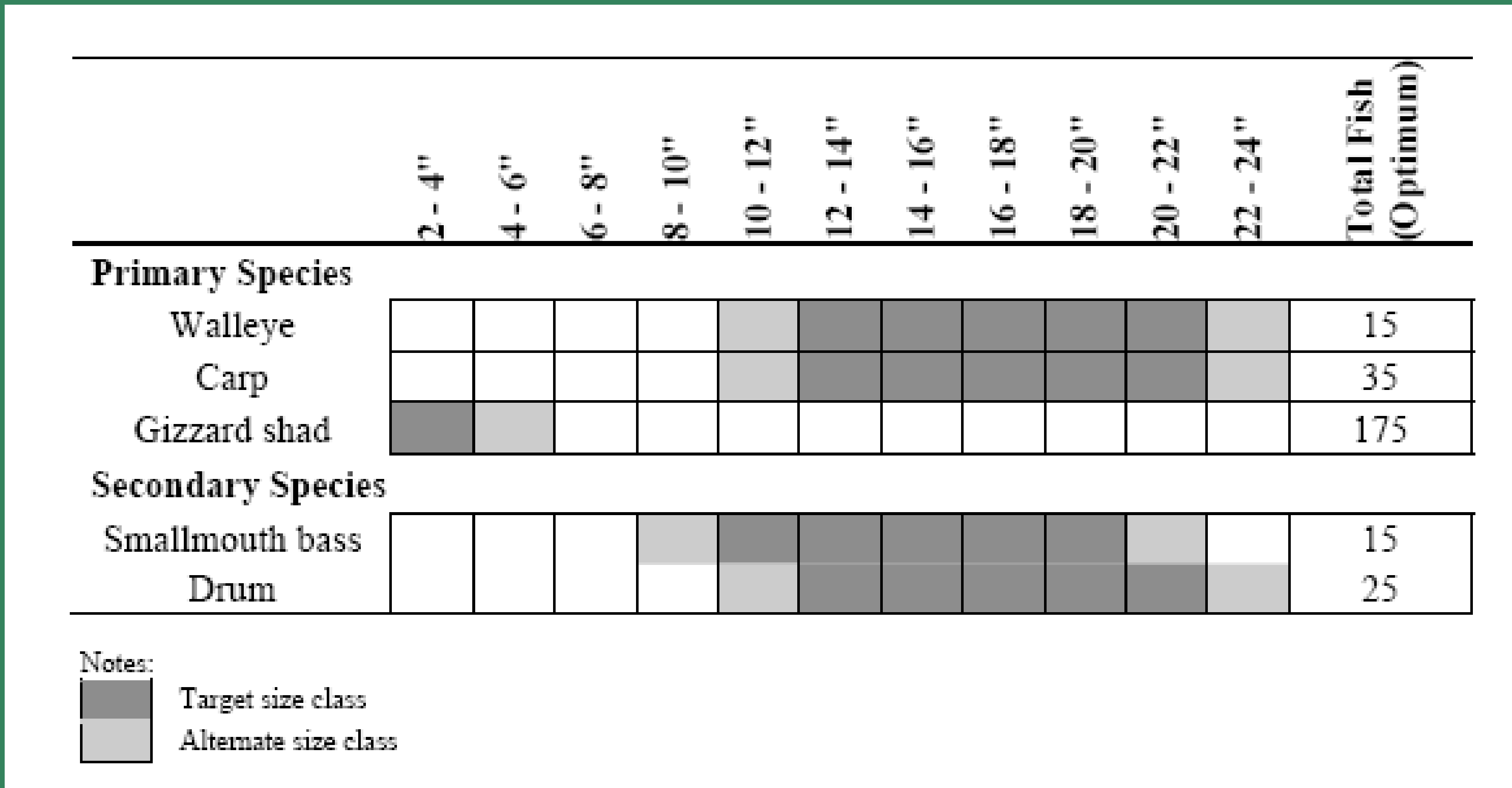
If needed, secondary species substitute for primary species

Fish Collection Details

SPECIES	SIZE RANGE	Skin-on Fillet	Skinned Fillet	Whole Fish	No. Individuals	No. Composites[(1)]	No. Fish/Composite
Walleye **Human**	12 to 22 inches	X			15		
Carp **Ecological**	10 to 20 inches			X	25	5	5
Gizzard Shad	< 3 inches **Early indicator**			X	125	5	25
Channel Catfish **Human**	12 to 22 inches		X		15		
Drum **Ecological**	12 to 22 inches			X	25	5	5
(1) Walleye and channel catfish will be analyzed as individuals, not composites							

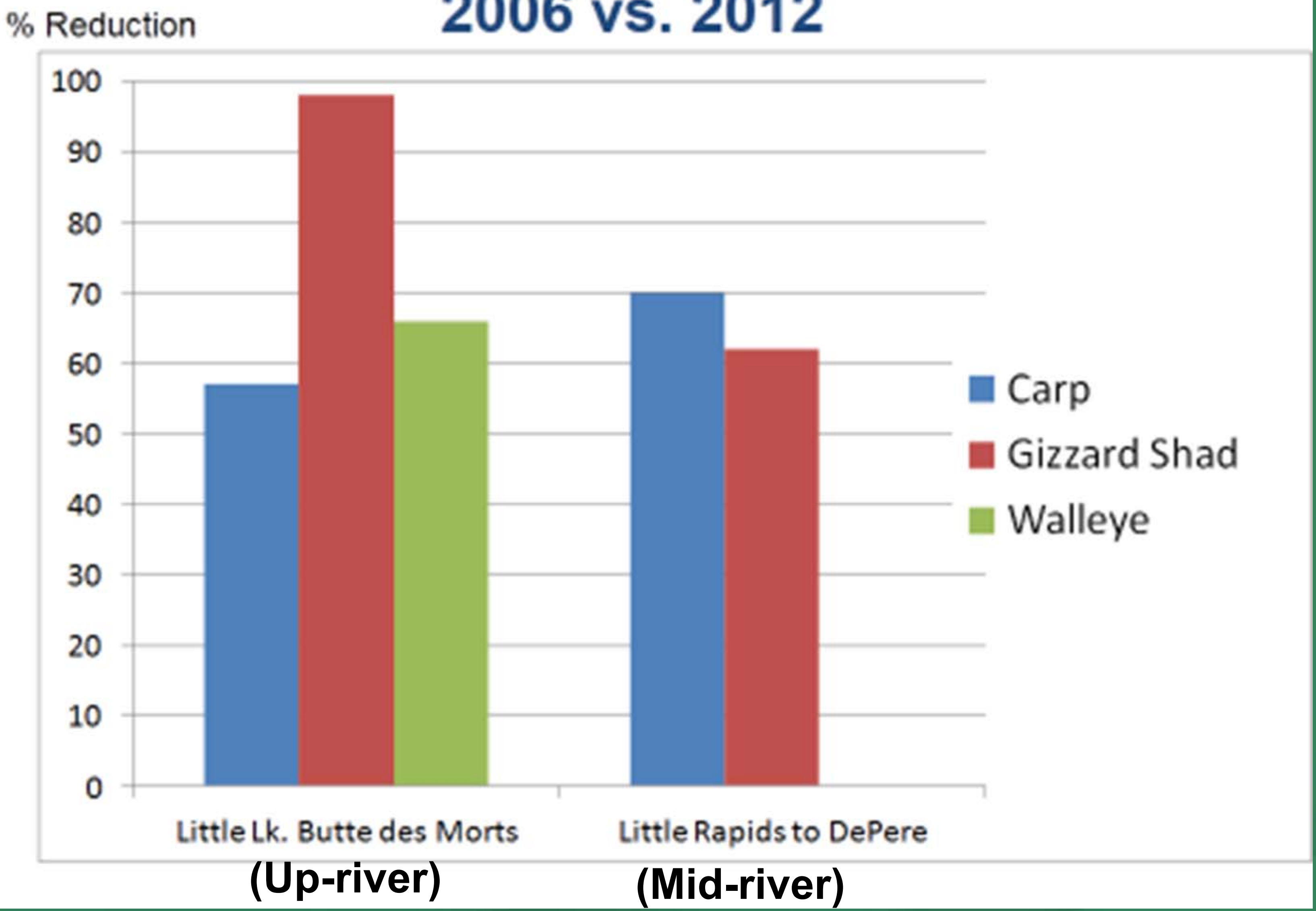
Collection period: August – September

Species and Size



From: Manchester, Jon, 2011, OU1-LTMP Year Zero Fish Collection and Compositing Memorandum.

Results: PCB Fish Concentration Reductions 2006 vs. 2012



DNR Finds Some Fish Less Contaminated, Eases Consumption Warnings

Share Tweet +1 E-mail 0 Comments and 0 Reactions Print

By CHUCK QUIRMBACH

From: Wisconsin Public Radio website August 7, 2013

Questions/Comments?

From: Wikipedia

Case Study

- Hudson River - Gary Klawinski (EPA Region 2)

Hudson River
PCBs SUPERFUND SITE

Fish Monitoring

Hudson River PCB Superfund Site, New York

Gary Klawinski, USEPA Region 2

Director, Hudson River Field Office

Hudson River PCB Superfund Site

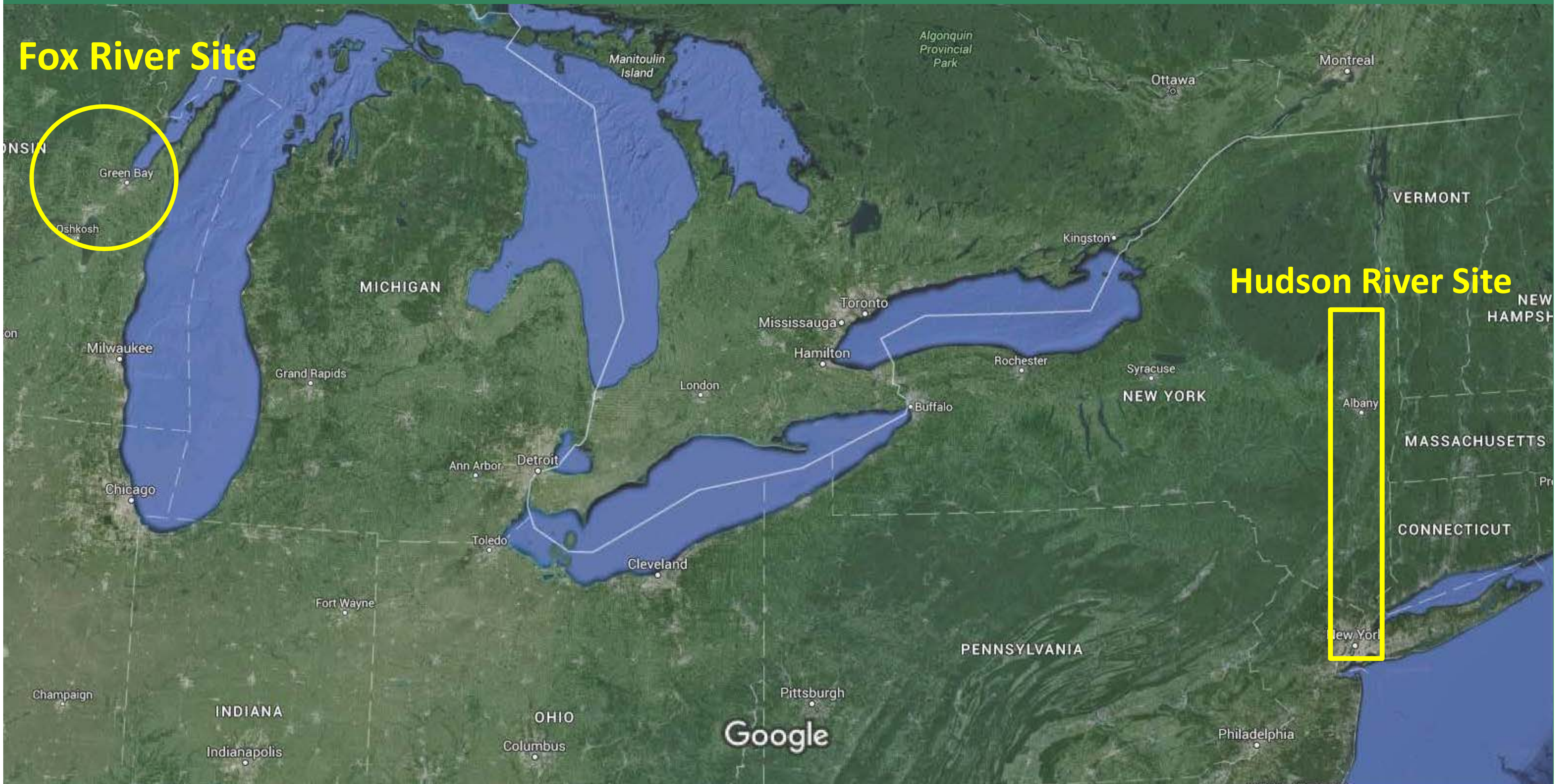


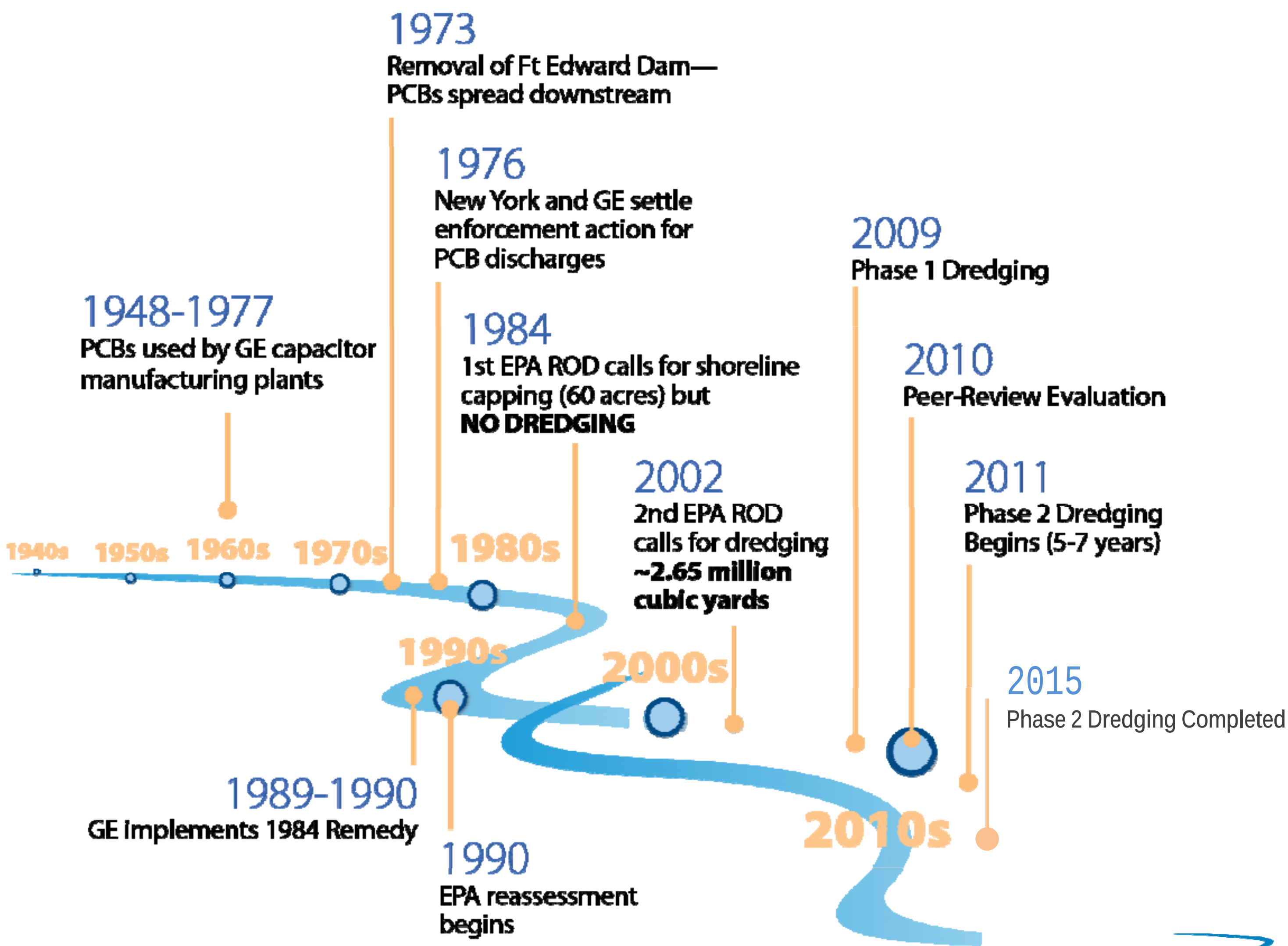
Image source: Google Maps (accessed 24 March 2016)

Hudson River PCB Superfund Site

Focus of this Discussion

- Site History and Remedy Considerations
- Fish - Role in Remedy
- Remedial Action (Fish) Monitoring Program
- Implementation (Dredging)
- Fish Tissue Concentrations

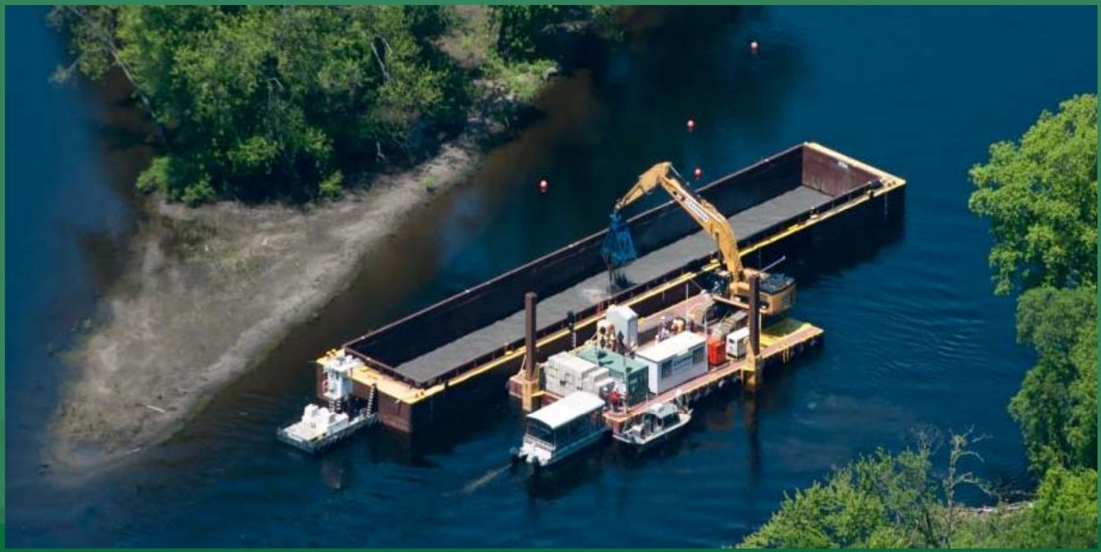
Hudson River PCB Superfund Site History



Hudson River PCBs SUPERFUND SITE

Hudson River Dredging

- **Phase 1** conducted 2009
- **Phase 2** conducted 2011-2015
  - 2.76 million cubic yards (C.Y.) removed
  - Containing 141,000 kilograms PCB
- Dredging completed in 5-acre Certification Units (CUs 1-100)
- Included 500 acres



EPA United States Environmental Protection Agency

Hudson River Remedial Action Objectives

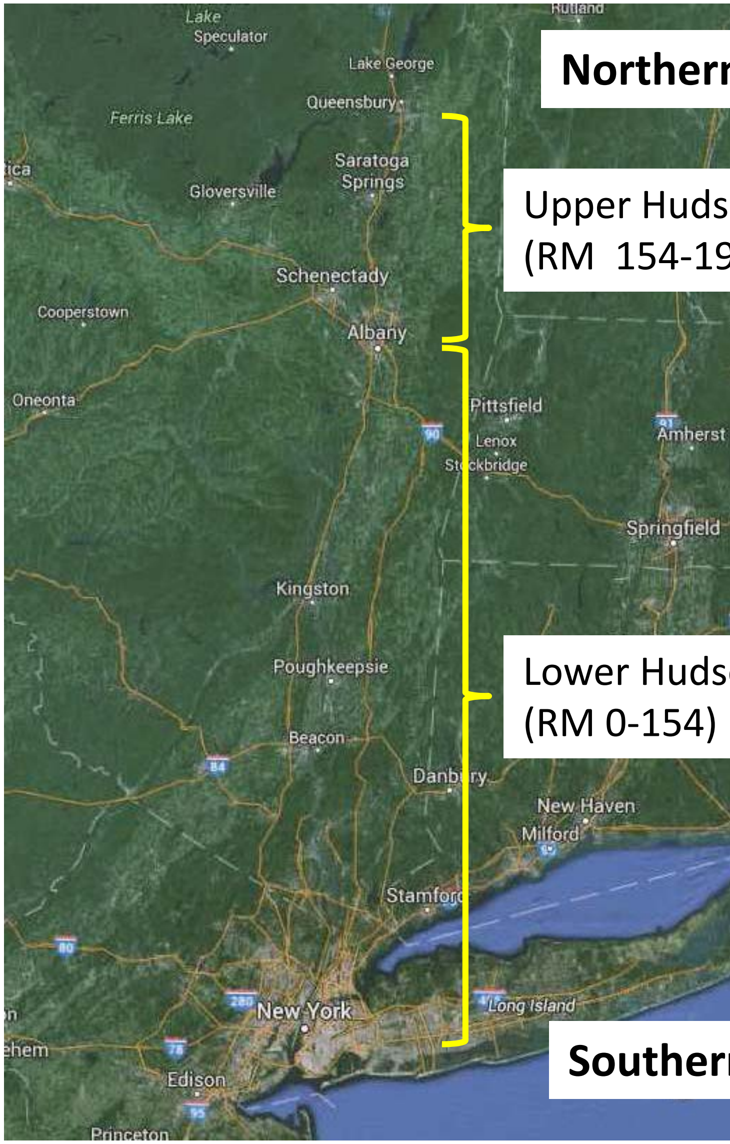
- Reduce the cancer risks and non-cancer health hazards for people eating fish from the Hudson River by reducing the concentration of PCBs in fish (targets are 0.2 mg/kg for one ½ lb. meal per month or 0.4 mg/kg for one ½ lb meal every two months; Project Goal is 0.05 mg/kg)
- Reduce the risks to ecological receptors by reducing the concentration of PCBs in fish
- Reduce PCB levels in sediments in order to reduce PCB concentrations in river (surface) water that are above surface water ARARs
- Reduce the inventory (mass) of PCBs in sediments that are or may be bioavailable
- Minimize the long-term downstream transport of PCBs in the river

Hudson River Fish and the Remedy

Risk to Humans and Wildlife from Fish Consumption was Key Remedial Consideration

- Fish monitoring in the river since 1970s and will continue
- Since 2003: Baseline, remedial action, and post-remedy monitoring was designed to provide statistical power to address both short- and long-term data needs
  - Allows evaluation of annual (short term) changes *and* establishment of long-term trends
  - Allows documentation of risk reduction following the remedial action
  - Provides data for NY State Fish Consumption Advisories and regulations

Upper and Lower Hudson River



Northern Project Limit Fort Edward, NY (River Mile 195)

Upper Hudson (RM 154-195)

Lower Hudson (RM 0-154)

Southern Project Limit Battery Park, NYC (River Mile 0)

<u>Upper Hudson River</u>

- Series of 8 pools (Reaches, NYS Canal Corp Pools)
- Grouped into 3 River Sections (RS) for dredging
- Freshwater, non-tidal
- Fish species generally not migratory

<u>Lower Hudson River</u>

- Contiguous Estuary
- Tidal
- Brackish below approximately River Mile 40
- Migratory fish species

Hudson River Fish Monitoring

Upper and Lower Hudson River

- 18 Locations
  - Upstream Reference and 17 Target Stations
  - 6 Species Groups
    Striped bass, black bass, perch bullhead/catfish, forage fish, pumpkinseed
  - Pumpkinseed slotted to focus on year-old fish, others at NY State minimum sizes
  - Approximately 400 fish collected in spring
  - Approximately 125 pumpkinseed and 50 forage composite samples in fall
  - Monitoring is on-going

Largemouth Bass (*Micropterus salmoides*)

Brown Bullhead (*Ictalurus nebulosus)*

Pumpkinseed (*Lepomis gibbosus)*

Images from NYSDEC Source: http://www.dec.ny.gov/animals/

Hudson River Fish Monitoring

Fish Species as Receptors

Piscivorous/Water Column Species
- Black bass (largemouth and smallmouth)
- Striped bass (Lower Hudson only)
- Yellow perch
- Pumpkinseed (< 2 yrs old, rapid integrators)
- Forage fish

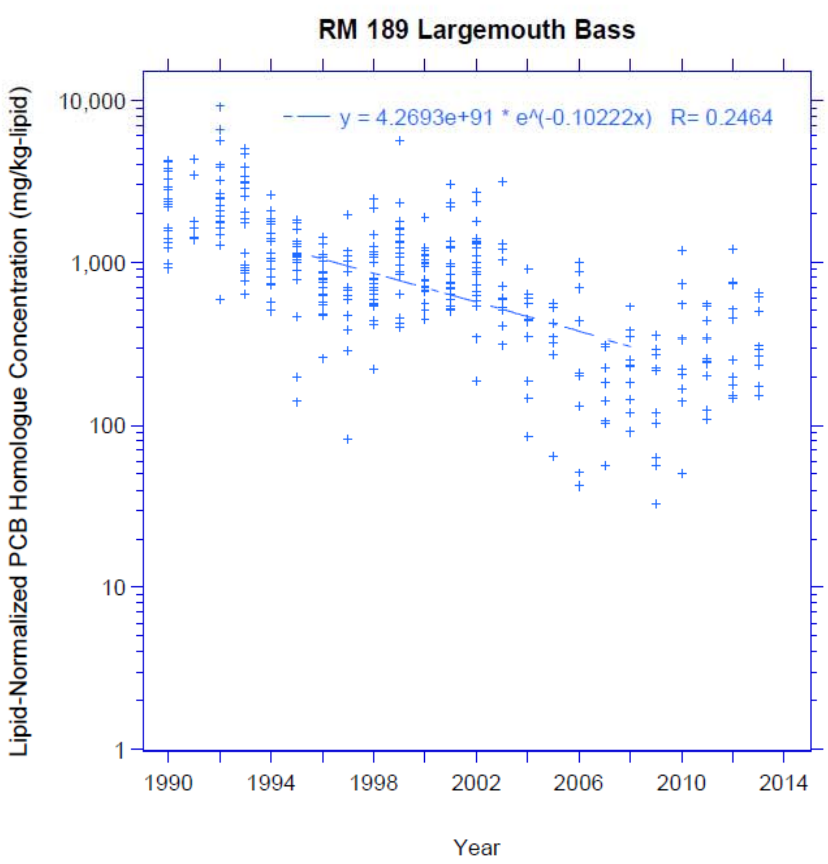
Yellow Perch (*Persca flavescens*)

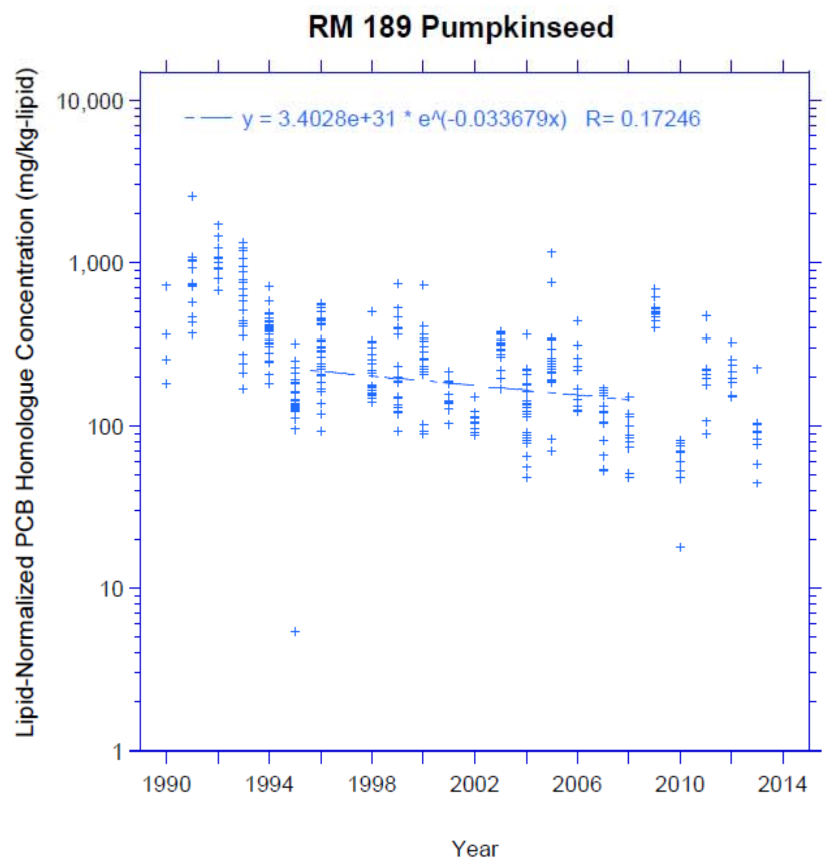
White Perch (*Morone americana*)

Benthic/Bottom Feeding Species
- Brown (and yellow) bullhead
- White perch
- Catfish (channel and white)

Images from NYSDEC Source: http://www.dec.ny.gov/animals/

Hudson River Fish Preliminary Results





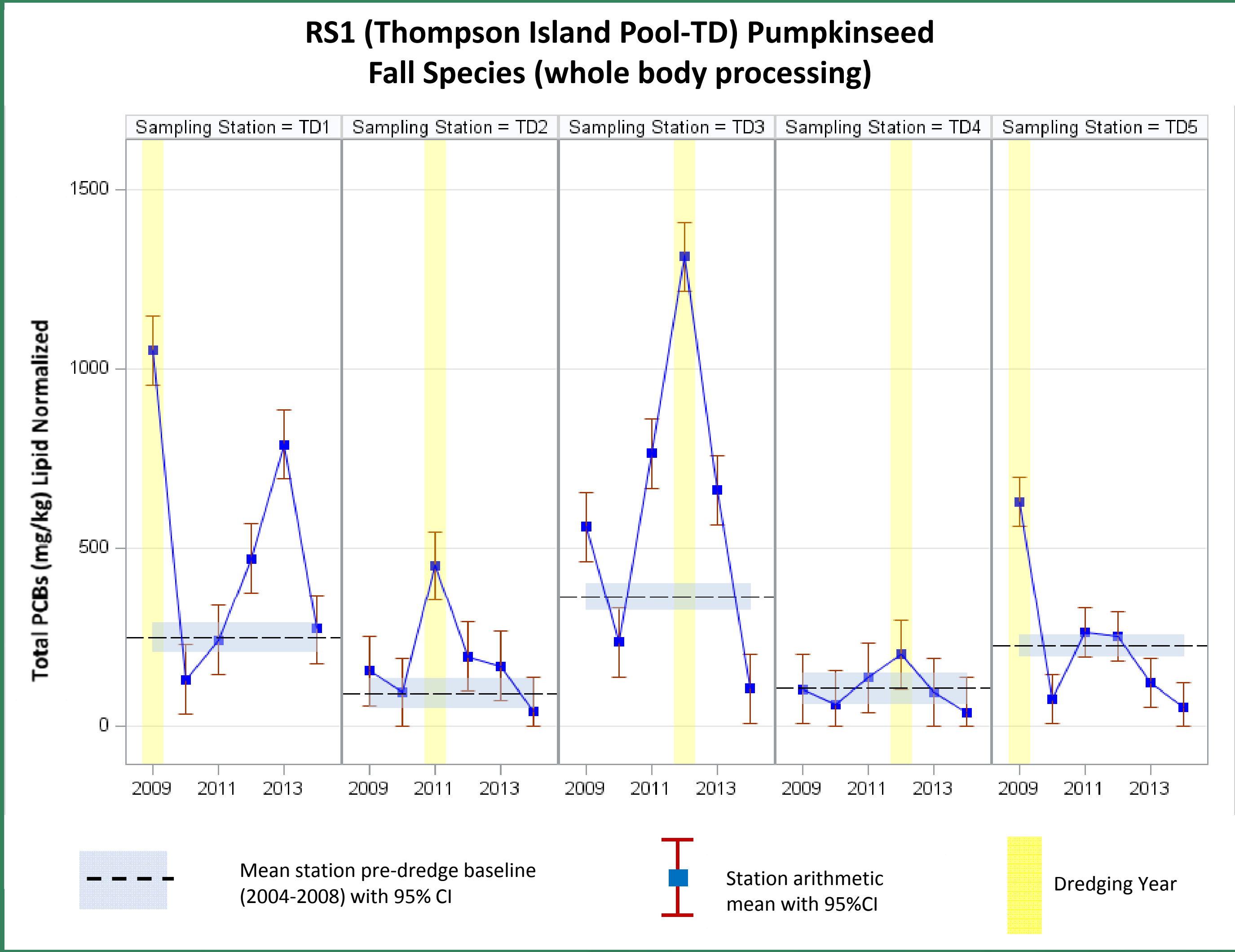
Legend

- Data Point
- Regression Line through 1995 to 2008 Data

Preliminary Analysis

Hudson River Fish Preliminary Results

Preliminary Analysis



Hudson River Fish Early Results

Preliminary (Early) Results

- Project is within 1 year of Phase 2 dredging completion
- Data for multiple species suggest declining fish tissue levels
- Data also suggest short term responses to dredging that appear to be diminishing over time
- Continued data collection is needed to better assess long-term trends
- Upper and Lower Hudson River fish monitoring is ongoing and will continue into the foreseeable future
- Long term results will be assessed as a species weighted average in terms of remedial action targets and goals

Hudson River PCB Superfund Site

Comments?....Questions?

References/Further Information

- ***Superfund Contaminated Sediments: Guidance Documents, Fact Sheets and Policies***
  - *https://www.epa.gov/superfund/superfund-contaminated-sediments-guidance-documents-fact-sheets-and-policies*

- ***Using Fish Tissue Data to Monitor Remedy Effectiveness - Sediment Assessment and Monitoring Sheet (SAMS) #1***
  - U.S. Office of Superfund Remediation and Technology Innovation and Office of Research and Development. July 2008. OSWER Directive 9200.1-77D

- ***Contaminated Sediment Remediation Guidance for Hazardous Waste Sites***
  - U.S. Environmental Protection Agency. 2005. EPA-540-R-05-012. OSWER Directive 9355.0-85.