Remediation Goals for the Fish Tissue Exposure Pathway at Contaminated Sediment Sites

--Policy & Practice--

Karl Gustavson
U.S. Environmental Protection Agency Office of Superfund Remediation and Technology Innovation
gustavson.karl@epa.gov

Sediment Remediation at PCB-Contaminated Superfund Sites

- At sites contaminated with PCBs and other bioaccumulative contaminants, sediment remediation is often conducted to decrease risk to consumers of fish.

➢ We remediate sediment to remediate fish.

The NCP on Remedial Action Objectives and Remediation Goals

The Agency shall:

- *Establish remedial action objectives specifying contaminants and media of concern, potential exposure pathways, and remediation goals.*
- *Remediation goals shall establish acceptable exposure levels that are protective of human health and the environment…*

The ROD also shall:

- *Indicate, as appropriate, the remediation goals… that the remedy is expected to achieve.*
- *Performance shall be measured at appropriate locations in the… affected environmental media.*

[National Contingency Plan (40 CFR 300.430)]

Terminology

Usage of terms associated with "remediation goals" varies during the Superfund process as information is collected and needs change.

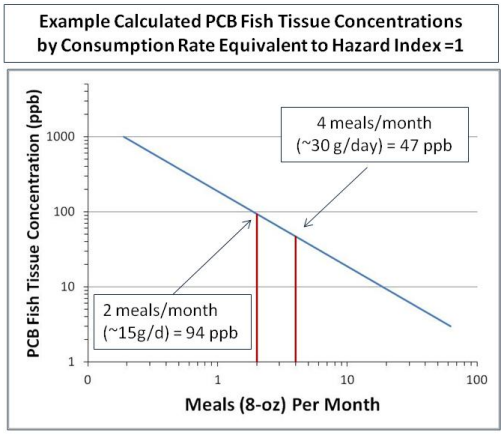
- *PRGs [**preliminary remediation goals**] are refined into **final remediation goals** throughout the process leading up to remedy selection…*
- *The ROD itself, however, should include a statement of **final clean-up levels** based on these goals…* (RAGS Vol 1 part B, Sect 1.5, EPA 540-R92-003)
- ***Final cleanup levels** establish acceptable contaminant-specific exposure levels that are protective of human health and the environment… In the ROD, it is preferable to use the term "**remediation level**" or "**cleanup level**" rather than "**remediation goal**".* (1999 ROD Guidance, fn 23, EPA 540-R-98-031)

Variation in Terminology Fosters Confusion

- *cleanup goals*
- *chemical standards*
- *remedial goals*
- *cleanup criteria*
- *performance standards*
- *target concentrations*
- *target cleanup levels*
- *conceptual targets*
- *performance goals*
- *performance metrics*

Deriving "Protective" Fish Tissue PCB Concentrations

- IRIS reference dose (RfD) and cancer slope factors combine with consumption rates to establish levels of risk.



(70kg body weight; RfD = 2 x 10^{-5}; per Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol 2 [EPA 2000])

Site-specific Exposure Modifications

Whole fish, filet, skin on/off?

Species Mix in Diet?

Concentration

Reductions from Cooking?

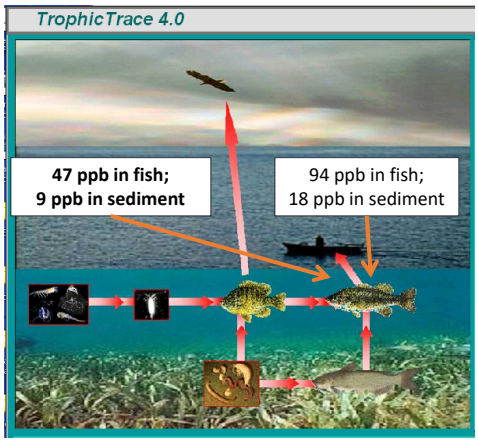
Duration?

Consumption Rates?

Deriving Sediment Cleanup Levels

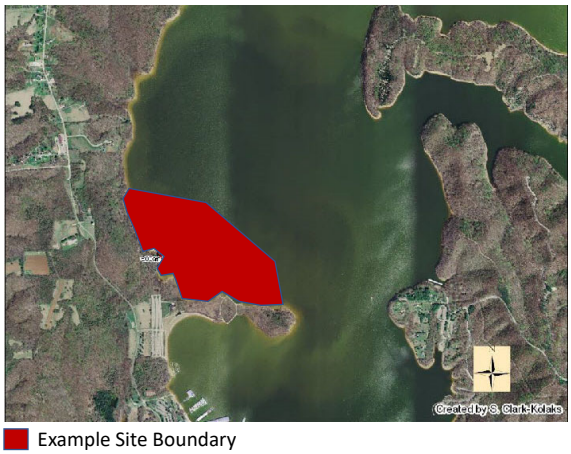
- Use of bioaccumulation modeling or BSAFs to estimate sediment concentrations.
- Sediment concentrations derived from "protective" fish concentrations are generally lower in magnitude.
- Calculated sediment concentrations may be lower than background, in which case the background concentration may be used.
- Subject to uncertainties associated with foodweb model or BSAF assumptions.

Example Foodweb Model Application to Derive Sediment PCB concentrations based on Fish Tissue



BSAF: Biota sediment accumulation factor

Linking Fish Tissue Contaminants to the Remediation: Fish Exposure Areas



Example Site Boundary

•Sediment cleanup levels derived from fish tissue contaminant levels assume a fish exposure area.

•Importance of fish movement and resulting uncertainty when selecting fish to represent

- •Risk to receptors
- •effect of remediation.

Linking Fish Tissue Contaminants to the Remediation: Fish Exposure Areas

Example Site Boundary

- Sediment cleanup levels derived from fish tissue contaminant levels assume a fish exposure area.
- Importance of fish movement and resulting uncertainty when selecting fish to represent
  - Risk to receptors
  - effect of remediation

Linking Fish Tissue Contaminants to the Remediation: Fish Exposure Areas

Fish Tracking Data from IDNR/IDFW, 2009

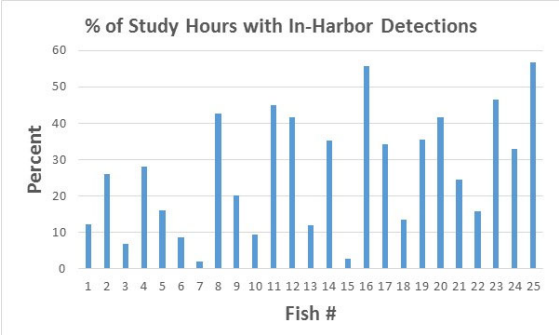
- Fish exposure areas:
  - -vary between species
  - -among individuals
  - -between seasons
- Association between area and diet

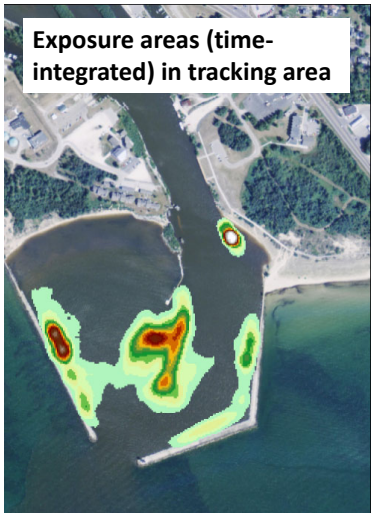
Linking Fish Tissue Contaminants to the Remediation: Fish Exposure Areas

Fish Tracking Data from IDNR/IDFW, 2009

- Fish exposure areas:
  - -vary between species
  - -among individuals
  - -between seasons
- Association between area and diet

Linking Fish Tissue Contaminants to the Remediation: Fish Exposure Areas





Linking Fish Tissue Contaminants to the Remediation: Fish Exposure Areas

- **Fish exposure areas**
  - -vary between species
  - -among individuals
  - -between seasons
- **Importance of recognizing the association between area and fish; fish and diet; and diet and contaminants**

➢ **Importance of selecting fish and exposure areas that represent**

- -the site
- -the remediation
- -the RAO

Uncertainty and Decision-Making

EPA has a stated bias for action in the face of uncertainty…

- "EPA must balance the desire to definitively characterize site risks and analyze alternative remedial approaches for addressing those threats in great detail with the desire to implement protective measures quickly… EPA intends to perform this balancing with a bias for initiating response actions…as early as possible." (NCP Preamble: 55 Fed. Reg., p. 8704, March 8, 1990).

Remediation goals consider ARARS, acceptable risk, technical limitations (incl. background), uncertainty, and other pertinent information. (NCP: 40 CFR 300.430(e)(2)(i))

- "The ultimate decision on what level of protection will be appropriate depends on the selected remedy, which is based on the criteria described in 300.430(e)(9)(iii)". (NCP Preamble: 55 Fed. Reg., p. 8718, March 8, 1990).

Site-specific Variation in How Goals are Achieved

Remediation approaches often include one or more of:

- Remedial action level (RAL) + MNR
- Institutional controls
- Remediation to a background-based cleanup level
- Using a RAL to achieve a sitewide cleanup level (RAL/SWAC CUL approach)
- Interim objectives

MNR: Monitored Natural Recovery
SWAC: Surface Weighted Average Concentration

RALs in Contaminated Sediment Management

- RALs (Remedial Action Levels) are generally not CULs (Cleanup Levels)
  - RALs: sediment contaminant concentrations to be remediated; often applied as a point concentration.
  - CULs: sediment contaminant concentrations that are acceptable; may be applied as an area average concentration.
- RALs are a risk management tool that can be used to develop and compare alternatives.
- In practice, a high concentration RAL area may be remediated to achieve a lower average CUL over a larger area.
  - Example: 400 acre site; remediating 20 acres higher than a 1000 ppb RAL may reduce the average concentration over the 400 acres to a CUL of 50 ppb.
- Important to recognize the effect of the area size and contaminant distribution on the contaminant concentration that is left behind.

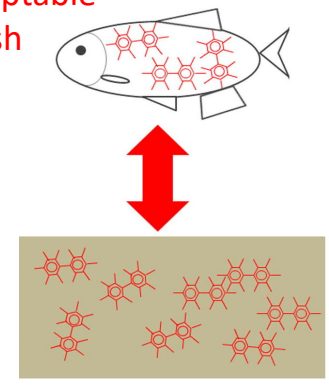
Why is a RAL/CUL distinction needed?

Risk at sediments sites is often from consuming contaminated fish

So, we remediate sediments to decrease fish tissue concentrations

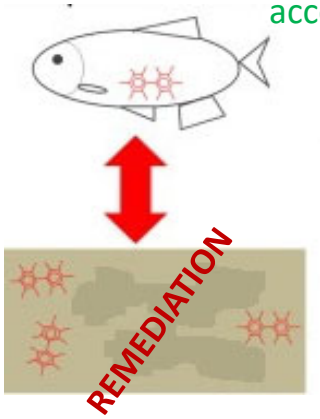
But, to what sediment contaminant concentration?

unacceptable fish



A fish to sediment relationship is used to mathematically determine the sediment contaminant concentration based on fish contaminant concentrations. **This is the Sediment Cleanup Level**

acceptable fish



If the sediment bed was all one concentration (no hotspots) or fish all stayed in one place, it would be easier.

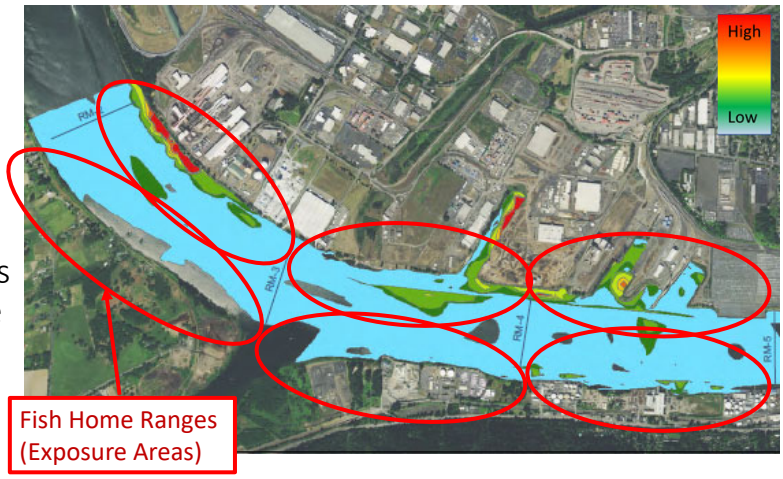
But fish move and sediments have "hotspots".

So, we use…

- Exposure areas (e.g., a fish's "home range") and map sediment contaminants

Contaminant concentrations are **averaged** in an exposure area and can be compared to sediment cleanup levels.

Hypothetical example: Exposure areas and sediment contaminants

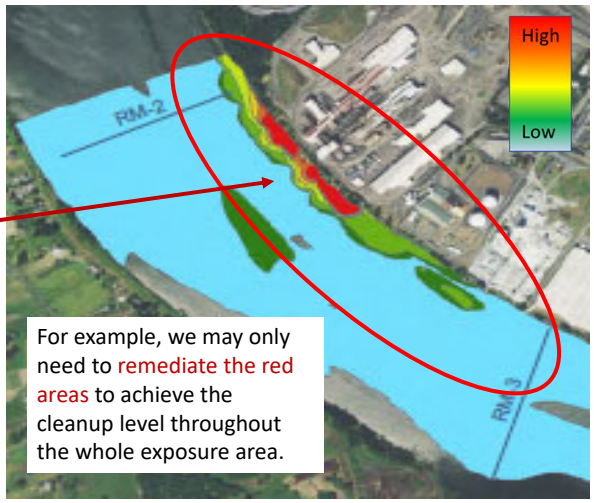


Fish Home Ranges (Exposure Areas)

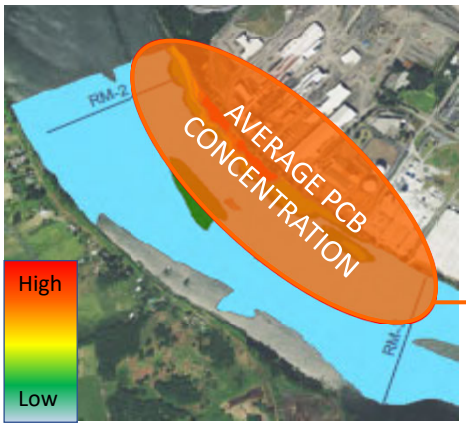
Example goal: Achieve an average sediment concentration in the exposure area that results in acceptable fish tissue concentrations

The exposure area has contaminant concentrations ranging from clean to more highly contaminated.

To achieve the cleanup level over the exposure area, we may only have to remediate the most contaminated areas.

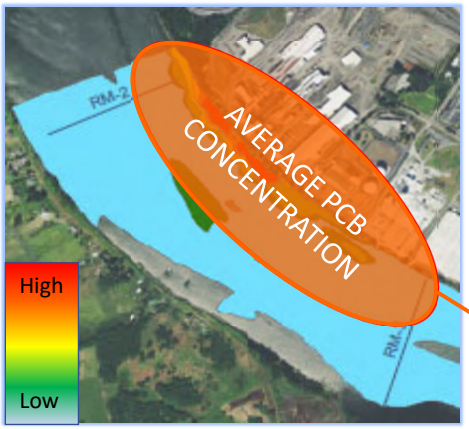


For example, we may only need to remediate the red areas to achieve the cleanup level throughout the whole exposure area.



Use of the average assumes the fish spends its time throughout the exposure area.

This is an average over an area (not the average of a list of numbers), so we use a spatial average (the "surface-weighted average concentration" [SWAC]).

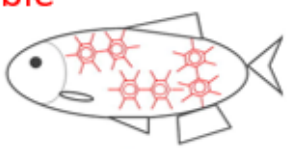


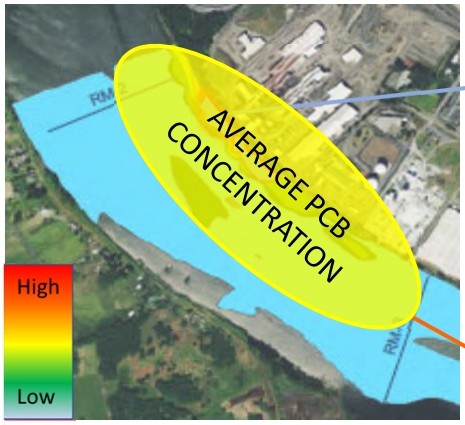
Evaluating Impact of Remedial Action

No Action: No change in sediment bed contaminant concentration.

- The average sediment concentration results in unacceptable fish tissue contaminant concentrations.

unacceptable fish



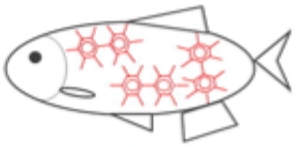


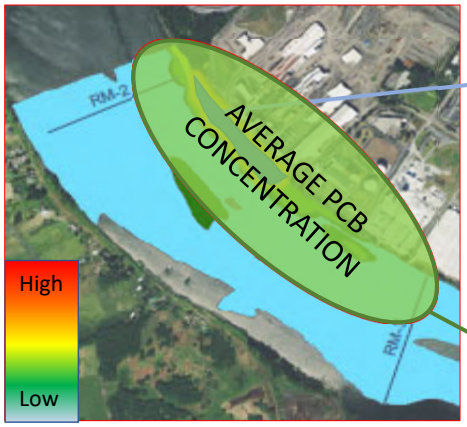
Evaluating Impact of Remedial Action

High RAL (less area):This RAL remediates the highest concentration and lessens the exposure area average concentration.

- But, the average concentration does not result in acceptable fish tissue concentrations.

unacceptable fish

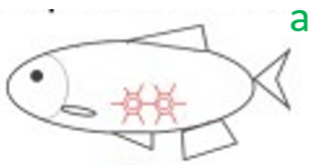




Evaluating Impact of Remedial Action

Lower RAL (more area): The RAL footprint increases in size and more contamination is remediated.

- The average sediment concentration is low enough to achieve acceptable contaminant concentrations in fish.

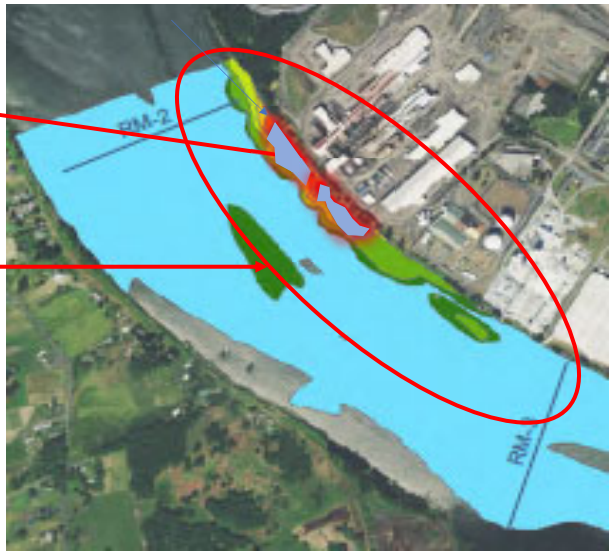


acceptable fish

Terms

RAL (Remedial Action Level). The sediment contaminant concentration that is remediated.

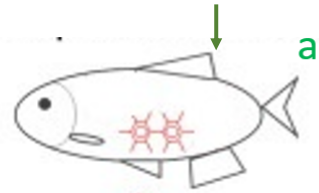
Exposure Area. The area over which a sediment concentration will be achieved. This can be a fish's home range or just the whole site.



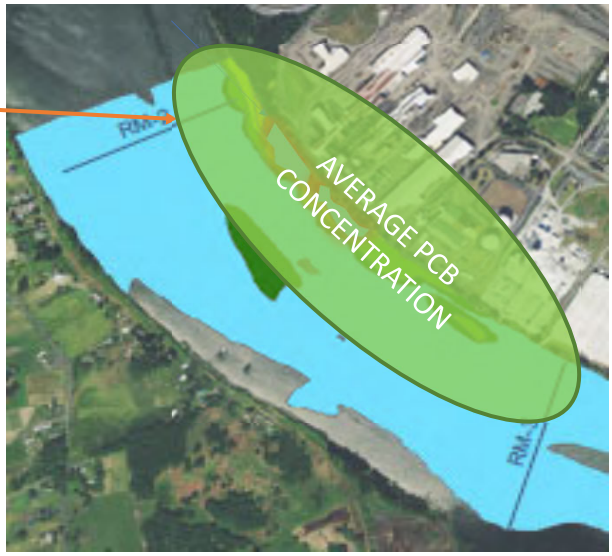
Terms

SWAC (Surface-weighted average concentrations). The average concentration of the exposure area.

Cleanup Level (CUL). The "protective" sediment concentration. (The sediment contaminant concentration [measured as a SWAC] in the exposure area that equates to the acceptable level in fish).



acceptable fish



Overview

- Examples relate to human health effects of contaminants from the fish tissue consumption exposure pathway.
- The RAL is a risk management tool that can be used to develop and compare remedies.
- Sediments above the RAL are remediated (capped, dredged, etc.).
- In this presentation's examples, the RAL is not the "protective" or "acceptable" sediment concentration, that is the cleanup level (CUL).
- But, the RAL may be set to achieve the CUL over the exposure area.
- Cleanup levels may be SWACs (average concentrations of an exposure area).

➢So, we remediate sediments above the RAL to achieve a SWAC CUL in the exposure area.

Transparency in decision documents

Remedial Action Level?	*What footprint? What Concentration?*
Cleanup Level?	*Point Location? SWAC? Over what area?*
Fish Tissue Remediation Goal?	*Species? Area? Now or later?*
MNR Timeframe?	*Recovery to what level? When? Over what area?*

Resource: Recommendations 5 and 6 January 9 2017 – OLEM Directive on Remediating Contaminated Sediment Sites

Transparency in decision documents

- Wide-ranging site and receptor characteristics result in variation in RAOs, goals, media, and approaches.
- RAOs supported by clear statements of remedy expectations.
- In sediments and fish:
  - What concentrations? What area? What timeframe?
  - What constitutes achievement of the RAO?
- Result is to increase mutual understanding of
  - Risk basis
  - What can and will be achieved
- Clear expectations establish when we're done.