Sediment Quality Objectives
for California Enclosed Bays and Estuaries

Assessment of Sediment Quality Impacts on Human Health

Steven Bay

Southern California Coastal Water Research Project

September 17, 2013

Key Framework Elements

- **Assessment conducted at the site scale**
  - **An area characterized by multiple sampling locations**
  - **Boundaries and study design reflect site conceptual model**
- **Tiered framework used to guide assessment**
- **Two indicators inform assessment**
  - **Consumption Risk**
  - **Sediment Linkage**
  - **Initial focus on PCBs and chlorinated pesticides**
- **Multiple levels of result**
  - **Categorical for regulators and managers**
  - **Numeric for scientists and alternative assessments**
- **Uncertainty in key parameters included**
  - **Monte Carlo simulation and results distribution**

Tiered Assessment Framework

- **Multiple tiers**
  - **Data requirements and complexity relate to situation**
  - **Reduced effort/cost for sites of low concern**

Tier 1: Screening
Low Data Requirements
Conservative Assumptions

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Tier 2: Site Assessment
More Data Required
Site Specific Conditions

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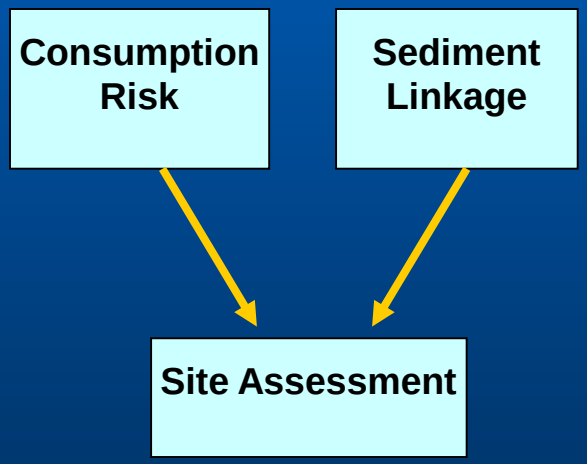
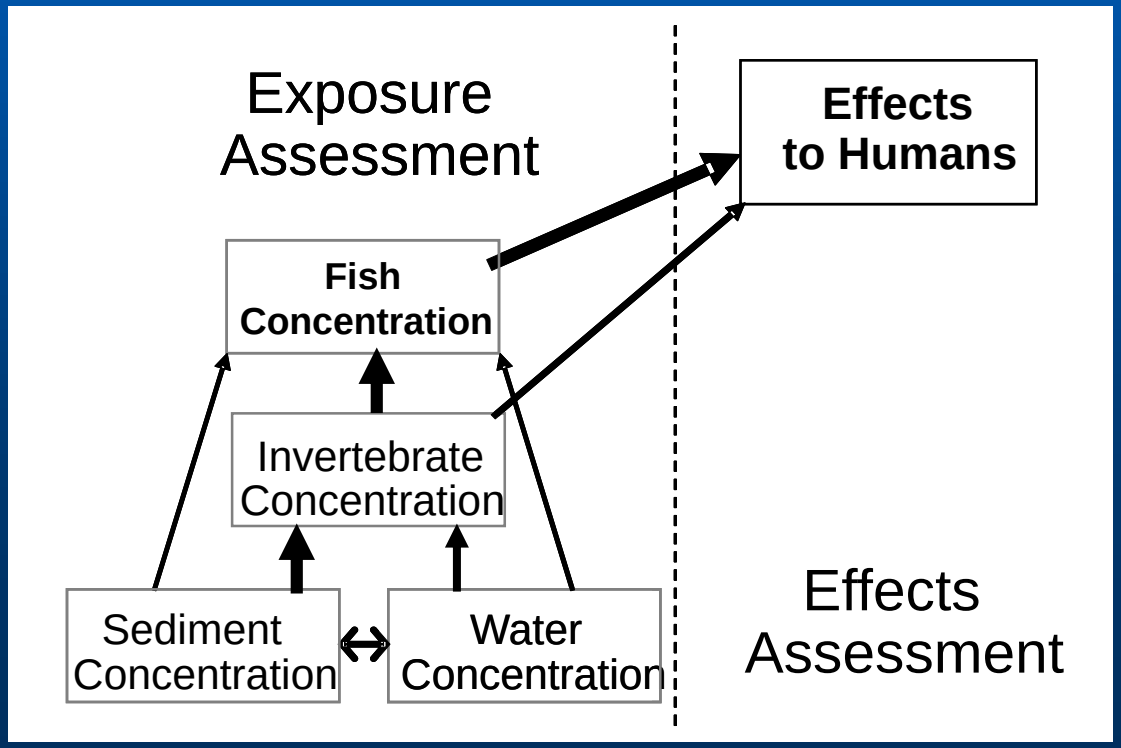
Tier 3: Refined Assessment
More Complex Situations
Evaluate Management Options

Assessment Framework

- **Conceptual framework based on two key assessment questions:**
  - **Do pollutant concentrations in seafood (fish and shellfish) pose unacceptable health risks to human consumers? (seafood consumption risk)**
  - **Does sediment contamination at the site have a substantial influence on seafood contamination? (sediment linkage)**





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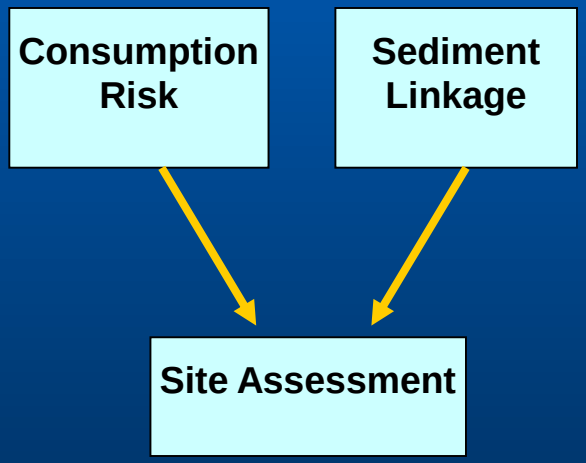

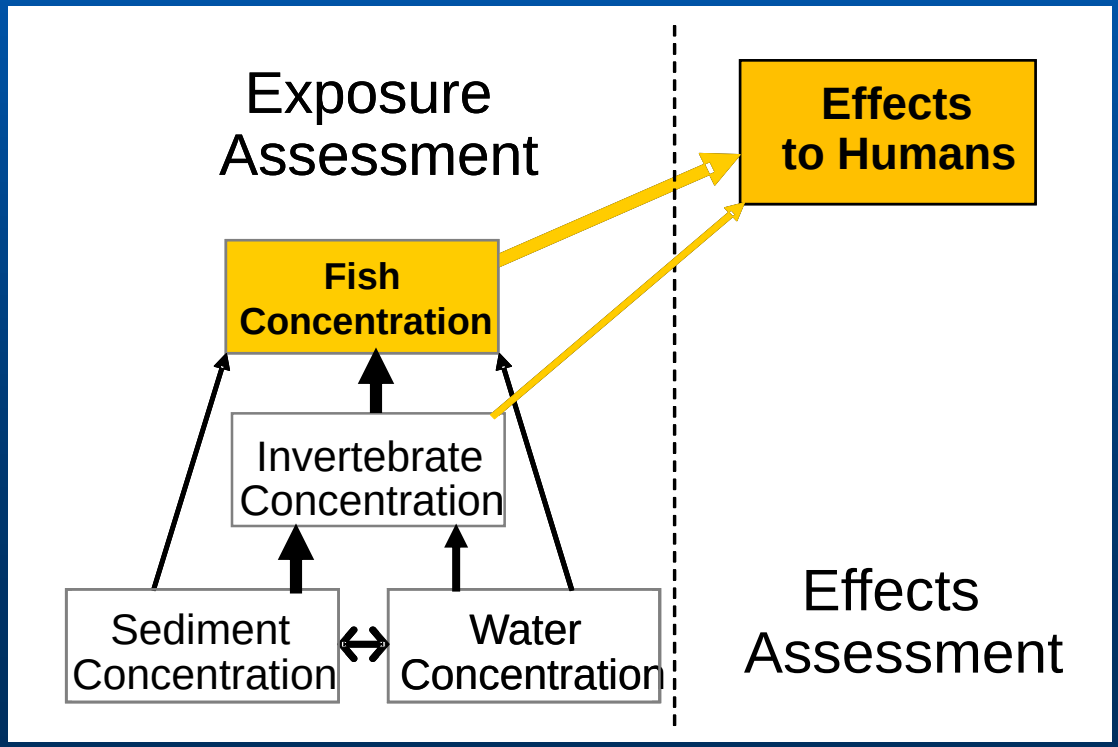

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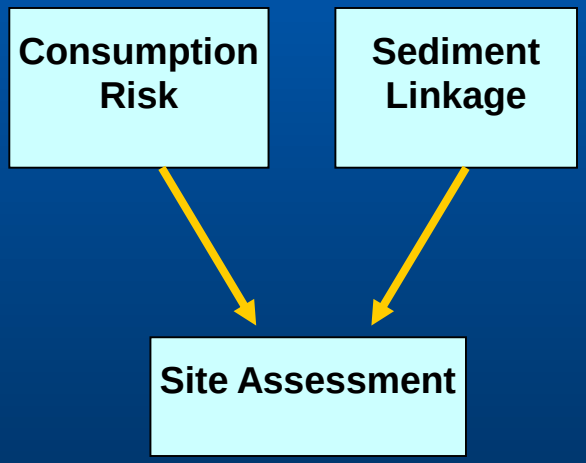
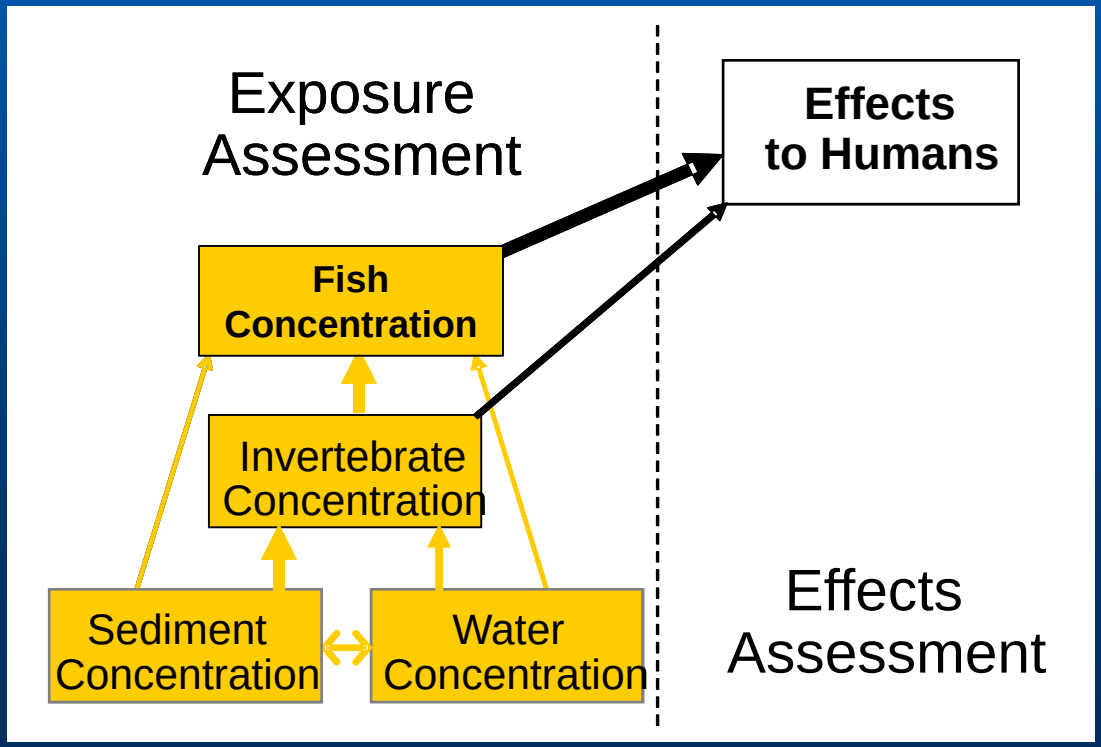




Consumption Risk Categories

Describes likelihood of consumers of site seafood exceeding health risk thresholds

- **Very Low: Virtually no (<5%) consumers with unacceptable level of risk**
- **Low: Small proportion (<25%) of consumers with unacceptable level of risk**
- **Moderate: Many (≥25%) consumers with unacceptable level of risk**
- **High: Most (≥50%) consumers with unacceptable level of risk**

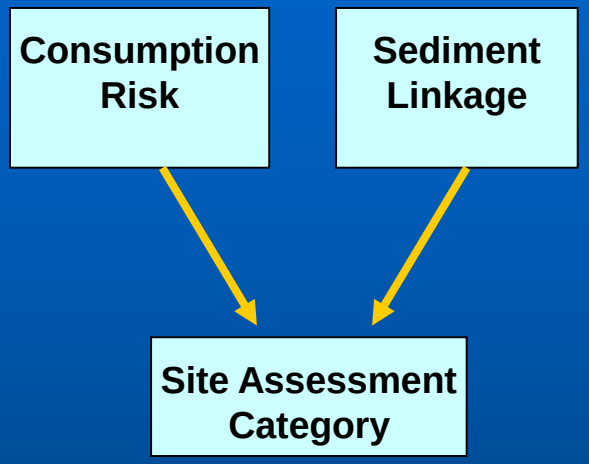
Sediment Linkage Categories

Describes likelihood of site sediment being the major influence on seafood tissue contamination

- **Very Low: Few (<25%) fish strongly influenced by site sediment contamination**
- **Low: Low proportion (<50%) of fish strongly influenced by site sediment contamination**
- **Moderate: Most (≥50%) of fish strongly influenced by site sediment contamination**
- **High: High proportion (≥75%) of fish strongly influenced by site sediment contamination**

Integration and Assessment

- **Site assessment considers both indicators**
  - **Consumption risk category**
  - **Sediment linkage category**
- **Categorical result for ease of communication**
  - **Five levels of impact relative to SQO**
  - **Similar format to benthic community SQO**
- **Classification criteria reflect policy**
  - **Provisional relationships subject to Water Board approval**



Site Assessment Categories

Describes impacts of site sediment contamination on human health risk from contaminated seafood consumption

1. **Unimpacted: Site sediments have minimal impact, due to very low consumption risk overall**
2. **Likely Unimpacted: Elevated health risk from site sediment contamination present for a small proportion of consumers, or sediments not responsible for elevated risk**

Site Assessment Categories

3. **Possibly Impacted: Unacceptable health risk for many consumers, but site sediment contamination has minor influence**
4. **Likely Impacted: Unacceptable health risk is likely and strongly linked to site sediment contamination**
5. **Clearly Impacted: Site sediment contamination is dominant factor responsible for unacceptable health risk to many consumers**

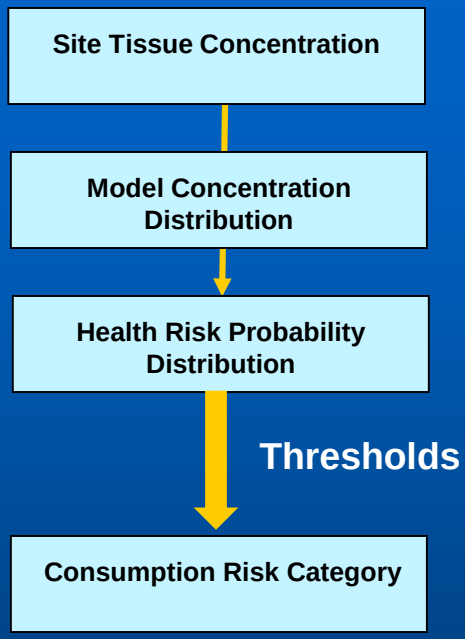
Indicator Relationships

- **Provisional relationships shown**
  - **Subject to Water Board approval**
- **Classification criteria reflects conceptual approach**
  - **Can't exceed SQO if health risk is low**
  - **Evidence of site sediment linkage needed to exceed SQO**

Consumption Risk	Sediment Linkage	Site Assessment
1. Very Low	1. Very Low	1
1. Very Low	2. Low	1
1. Very Low	3. Moderate	1
1. Very Low	4. High	1
2. Low	1. Very Low	1
2. Low	2. Low	1
2. Low	3. Moderate	2
2. Low	4. High	2
3. Moderate	1. Very Low	2
3. Moderate	2. Low	3
3. Moderate	3. Moderate	4
3. Moderate	4. High	5
4. High	1. Very Low	2
4. High	2. Low	3
4. High	3. Moderate	4
4. High	4. High	5

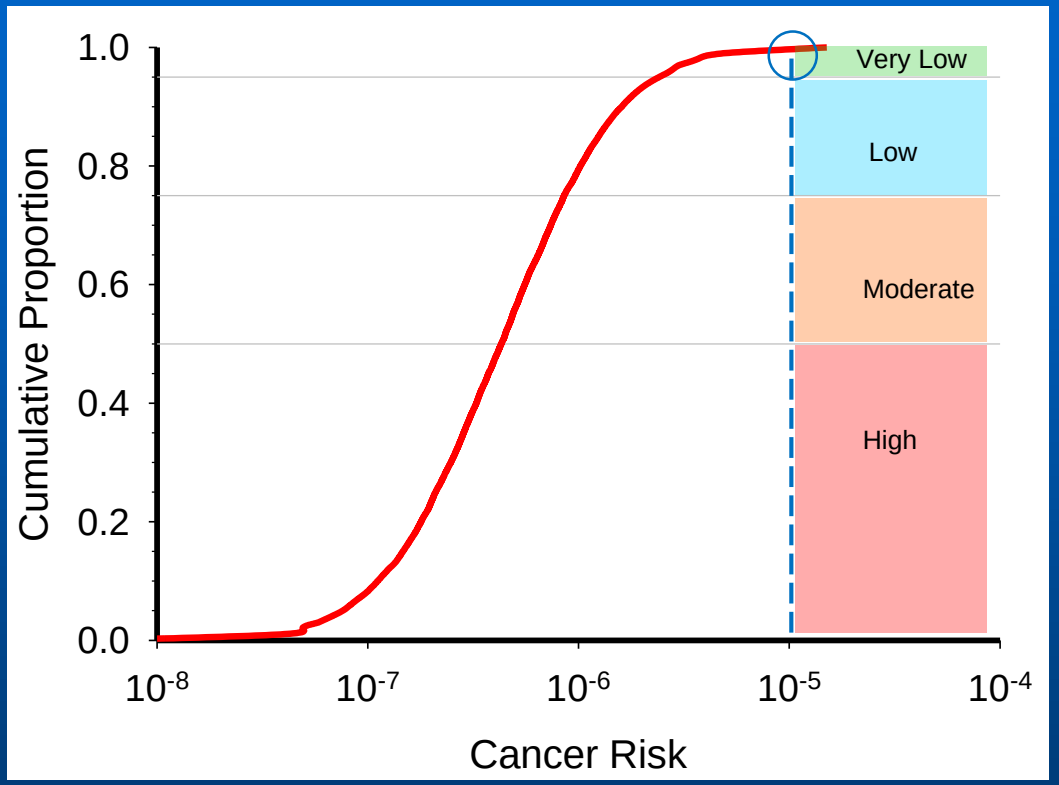
Consumption Risk Indicator

- **Risk calculation based on tissue contaminant concentration**
  - **Cancer risk and noncancer hazard quotient**
- **Tissue concentration based on integrated data for site**
  - **Stations**
  - **Species**
- **Monte Carlo simulation of key parameters to generate risk distribution**
  - **Contaminant concentration and consumption rate**



Consumption Risk Example

- **Consumption risk indicator expressed as degree of risk to human health**
  - **Cancer risk probability**
  - **Noncancer hazard quotient**
- **Proportion of distribution exceeding threshold determines category**
  - **10^{-5} cancer risk threshold used in example**
  - **Categories defined by risk at 50, 75, and 95% of distribution**



<5% of consumers exceed threshold: very low risk

8 Dietary Guilds

Guild	Indicator Species	# Species
Piscivore	California halibut	3
Benthic with piscivory	Spotted sand bass White catfish	17
Benthic and pelagic with piscivory	Queenfish	5
Benthic without piscivory	White croaker	10
Benthic and pelagic without piscivory	Shiner perch	3
Benthic with herbivory	Common carp	3
Benthic and pelagic with herbivory	Topsmelt	1
Pelagic with benthic herbivory	Striped mullet	1

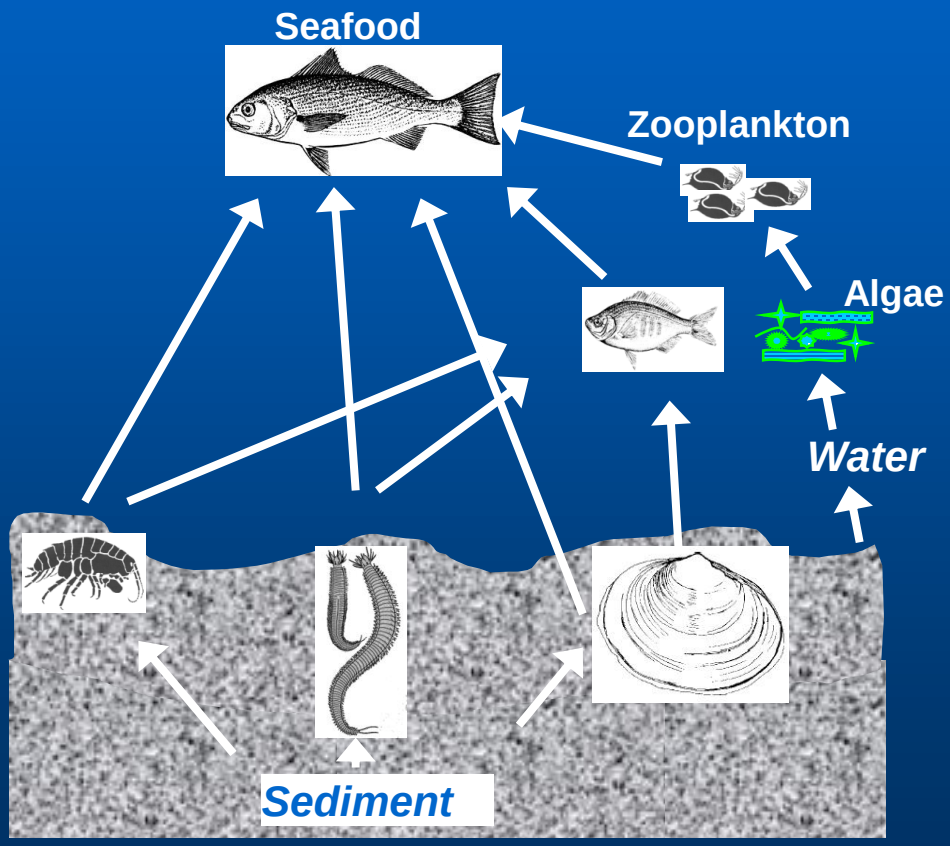
Data Integration Based on Guilds

- **Select assessment seafood species based on site conceptual model**
- **Integrate separate species results based on contribution to seafood consumer pollutant exposure (dose)**
  - **Concentration (C)**
  - **Proportion of diet (P)**
  - **Weighted mean represents tissue concentration**
    - **= C1*P1 + C2*P2 + ...Cn*Pn**

Sediment Linkage

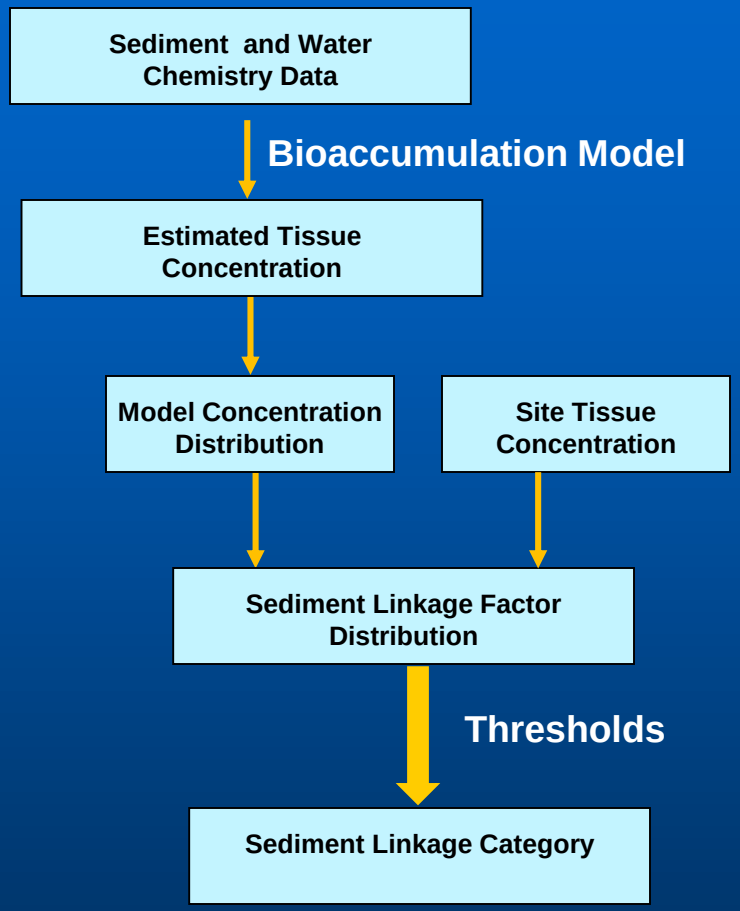
- Determine influence of site sediment on seafood tissue contamination
- Food web bioaccumulation models and assumptions
  - Biota Accumulation Factor (BAF)
- Linkage Factor =

$$\frac{\text{est. seafood conc}}{\text{measured conc at site}}$$



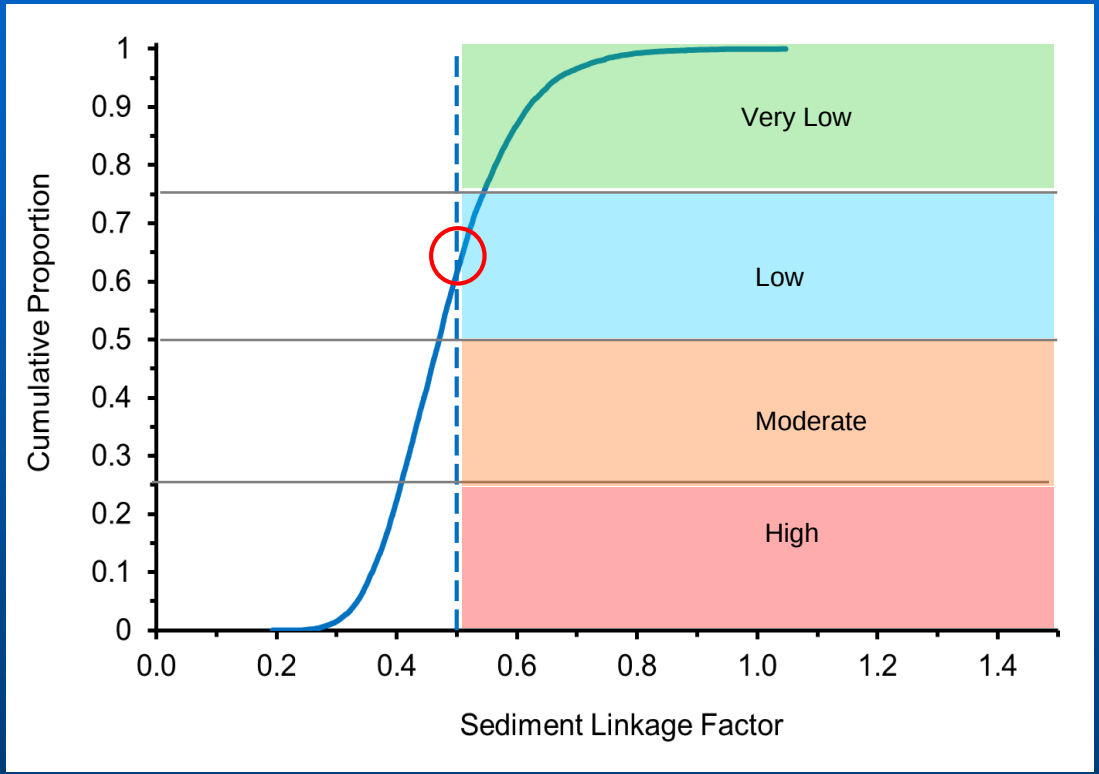
Sediment Linkage Indicator

- Linkage calculation based on estimated and observed tissue concentrations
- Food web bioaccumulation model used to estimate concentration
- Tissue concentration based on integrated data for site
  - Stations
  - Species
- Monte Carlo simulation of key parameters to generate distribution
  - Concentration, BAF, home range



Sediment Linkage Example

- **Sediment linkage factor indicates relative importance of bioaccumulation from sediment**
- **Proportion of distribution exceeding threshold determines category**
  - **0.5 threshold used in example**
  - **Categories defined by linkage factor at 25, 50, and 75% of distribution**



<50% of fish strongly influenced by site sediment contamination: low sediment linkage

Integration and Assessment Example

- **Site assessment considers both indicators**
- **Very low health risk and low sediment linkage indicate unimpacted site**

Provisional relationships shown

Consumption Risk	Sediment Linkage	Site Assessment
1. Very Low	1. Very Low	1
1. Very Low	2. Low	1
1. Very Low	3. Moderate	1
1. Very Low	4. High	1
2. Low	1. Very Low	1
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Tiered Assessment Framework

- **Multiple tiers**
  - **Data requirements and complexity relate to situation**
  - **Reduced effort/cost for sites of low concern**

Tier 1: Screening
Low Data Requirements
Conservative Assumptions

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Tier 2: Site Assessment
More Data Required
Site Specific Conditions

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Tier 3: Refined Assessment
More Complex Situations
Evaluate Management Options

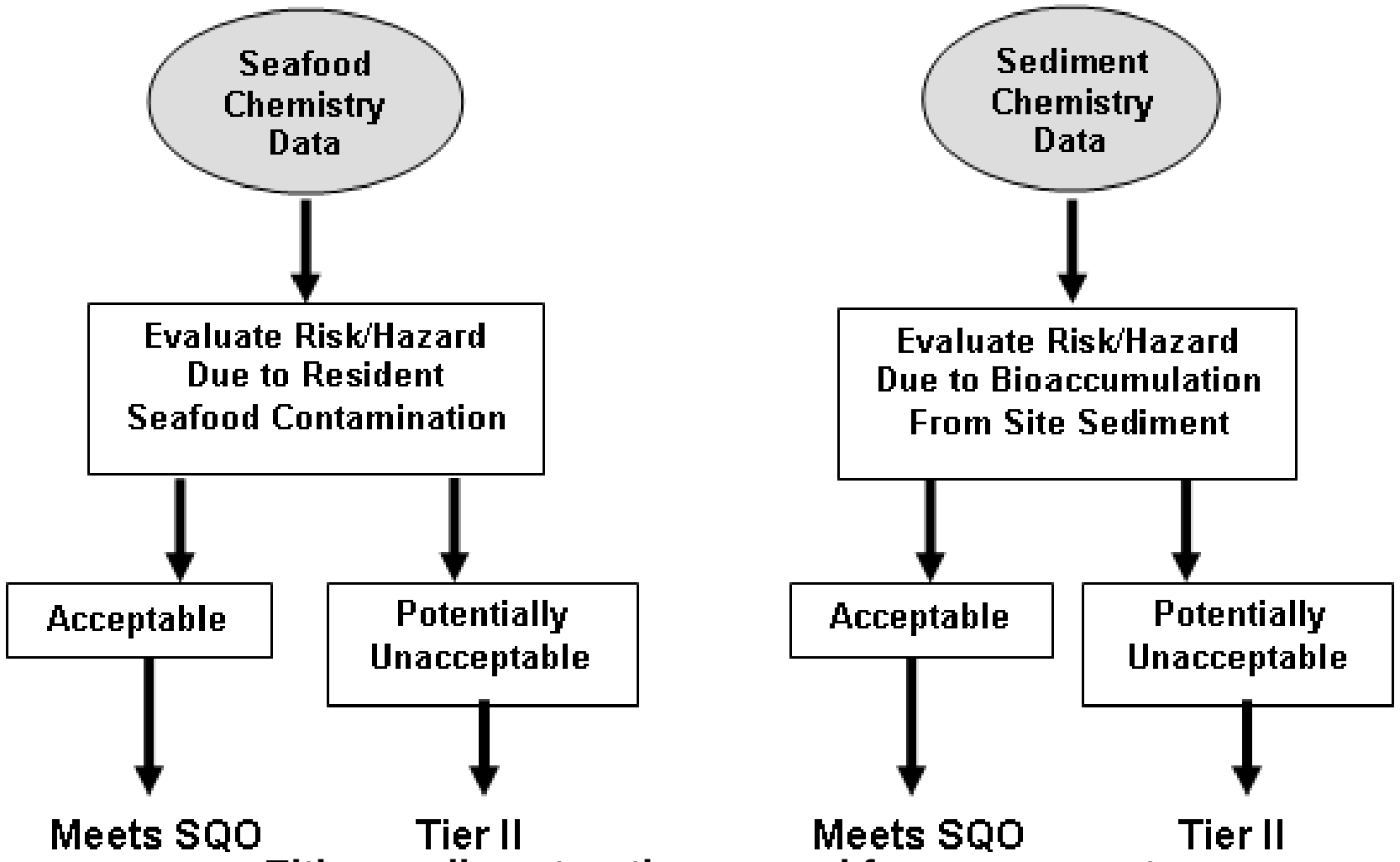
Tier I Screening

- **Do the sediments at a site pose a potential human health hazard, warranting further evaluation?**

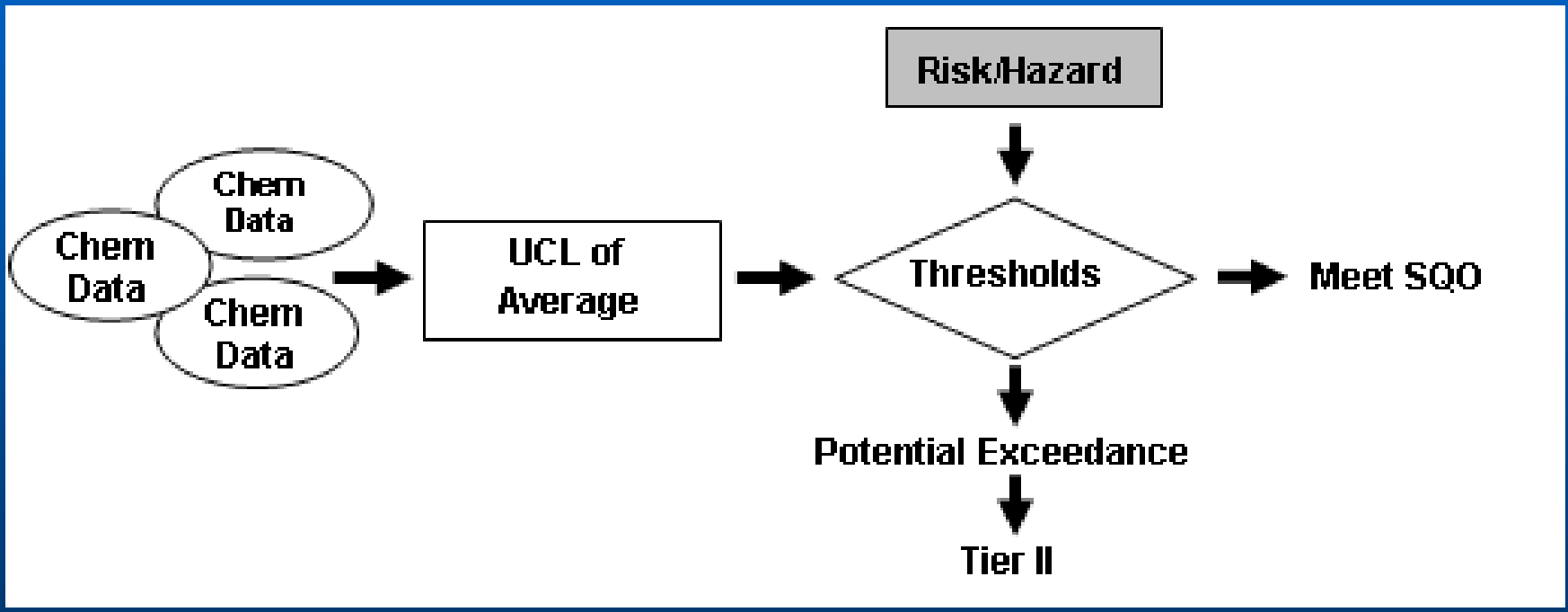
Tier I Assessment Goals

- **Streamlined and less involved than Tier II**
- **Consistent methods among sites**
- **Screen and identify sites of potential concern**
- **Low chance of false negatives**
- **Data requirements compatible with Tier II**

Tier I Assessment Approach



Seafood Evaluation



Tier I Tissue Threshold Development

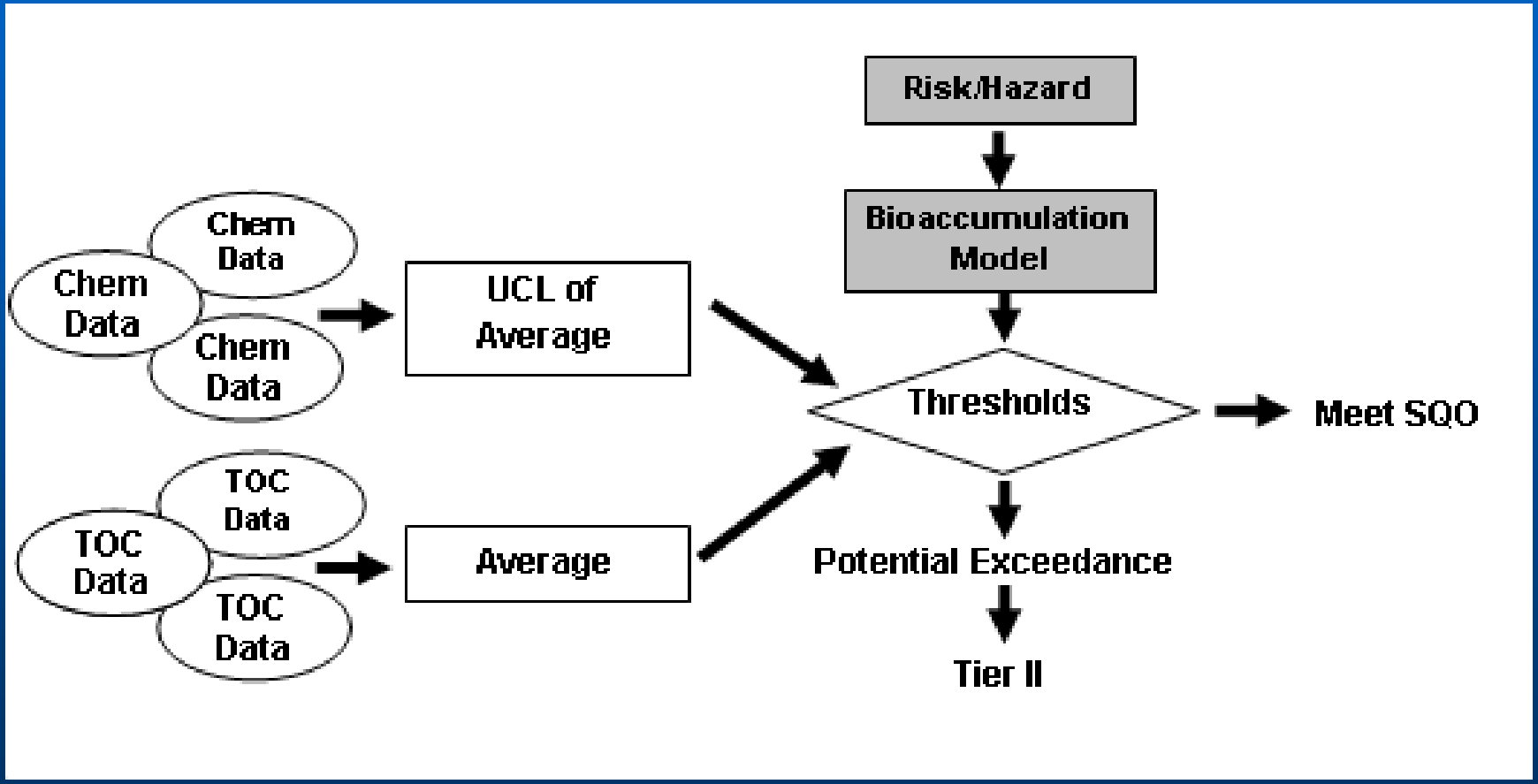
- **Using standard OEHHA equations for cancer risk and noncancer hazard**
- **Provisional thresholds (ng/g) illustrate the approach**

Parameter	DDT	PCB	Chlordane	Dieldrin
Cancer Risk	214	36	56	4.6
Noncancer Hazard	1563	63	103	156

(Based on 10^-5 allowable cancer risk, 32 g/d consumption rate, 30 y exposure duration, 70 y averaging time)

- **Final thresholds to be specified by the state**

Sediment Evaluation



Tier I Sediment Threshold Development

- **Back calculated from tissue thresholds using bioaccumulation model**
  - **Sediment threshold = Tissue threshold/BAF**
- **BAF reflects key site conditions**
  - **Feeding guilds**
  - **Sediment TOC**

Tier I Bioaccumulation Factors

- **BAFs vary depending on compound, food web (feeding guild), and sediment TOC**
  - **DDT values shown for illustration**
- **Conceptual site model and sediment characteristics determine which value to use**

TOC (%)	Bioaccumulation factor				
	1- Piscivore	2 - Benthic diet with piscivory	4 - Benthic without piscivory	5 – Benthic with herbivory	Average guild[a]
0.1	39.5	47.2	57.0	45.2	46.5
0.2	21.0	25.8	31.9	24.4	25.3
0.3	14.8	18.6	23.5	17.5	18.3
0.4	11.7	15.0	19.2	14.0	14.7
0.6	8.5	11.3	14.8	10.4	11.1
0.8	6.9	9.5	12.6	8.6	9.2
1.0	6.0	8.3	11.1	7.5	8.1
1.2	5.3	7.5	10.1	6.7	7.3
1.4	4.8	6.9	9.4	6.2	6.7
1.6	4.4	6.5	8.8	5.7	6.2
1.8	4.1	6.1	8.3	5.4	5.8
2.0	3.9	5.8	7.9	5.1	5.5
2.5	3.4	5.2	7.1	4.5	4.9
3.0	3.1	4.8	6.5	4.1	4.5
3.5	2.8	4.4	6.0	3.8	4.2
4.0	2.6	4.2	5.6	3.5	3.9

Tier Comparison

Attribute	Tier I	Tier II
Treatment of uncertainty	Conservative point estimates	Probability distribution
Model type	Mechanistic	Mechanistic
Local data	TOC	TOC, lipid, area, water quality
User tools	Look-up tables	Decision Support Tool
Number of categories	2	5

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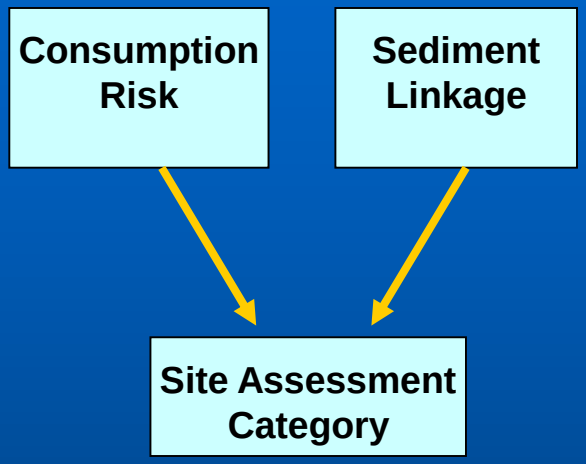
Tier III Assessment

- **Must be a compelling reason to go beyond Tier II**
  - **When site characteristics or study objectives differ from those of Tier II**
  - **Improve accuracy/precision of assessment**
  - **Evaluate different thresholds or risk-related assumptions**
  - **Address spatial variability, temporal trends, other sources**
- **Should provide evidence that Tier III will make a difference before proceeding with analyses**
  - **Change in indicator categories**
  - **Modified interpretation or management conclusion**

Tier III Results Interpretation

- Alternative methods may be used to calculate assessment indicators
- Same indicator types and categories are used
  - Consumption Risk
  - Sediment Linkage
- Same integration framework and relationships are used
  - Assessment conclusions should have same policy objectives



Site Assessment Steps

1. Determine the level of assessment (Tier I, II, or III)
2. Develop conceptual site model, study design, and related model parameters
3. Collect sediment and tissue chemistry data and site data.
4. Calculate Consumption Risk indicator
5. Calculate Sediment Linkage indicator (Tier II or III)
6. Evaluate results and determine indicator categories
7. Integrate results to determine site assessment category