

Sediment Quality Objectives
for California Enclosed Bays and Estuaries

Human Health SQO Assessment Tool Application

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Topics

- **Assessment framework background**
- **Selection of site-specific vs. standardized parameters**
- **Framework application results**

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



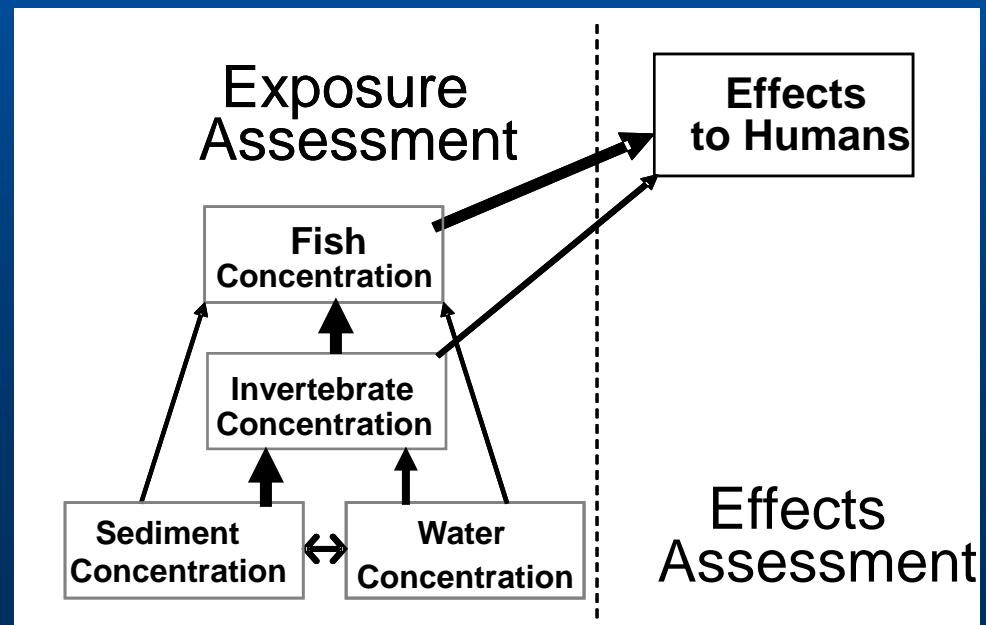
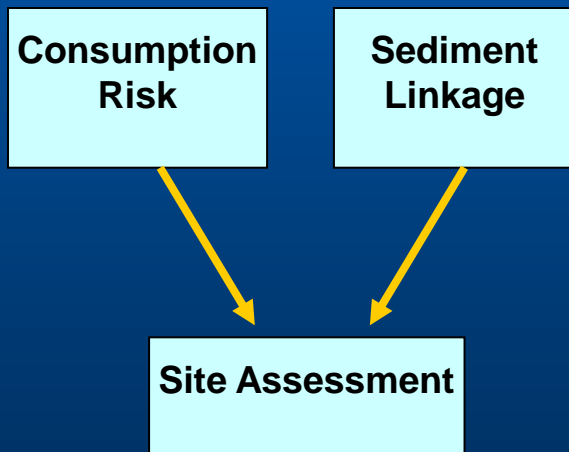
Tier 1: Screening
Low Data Requirements
Conservative Assumptions

Tier 2: Site Assessment
More Data Required
Site Specific Conditions

Tier 3: Refined Assessment
More Complex Situations
Evaluate Management Options

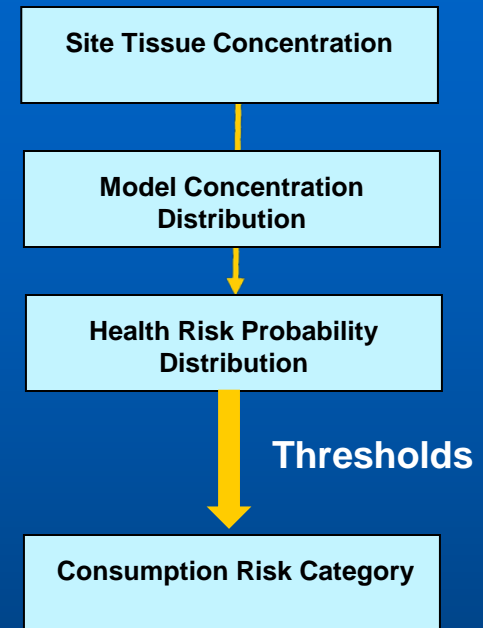
Assessment Framework

- **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)



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



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

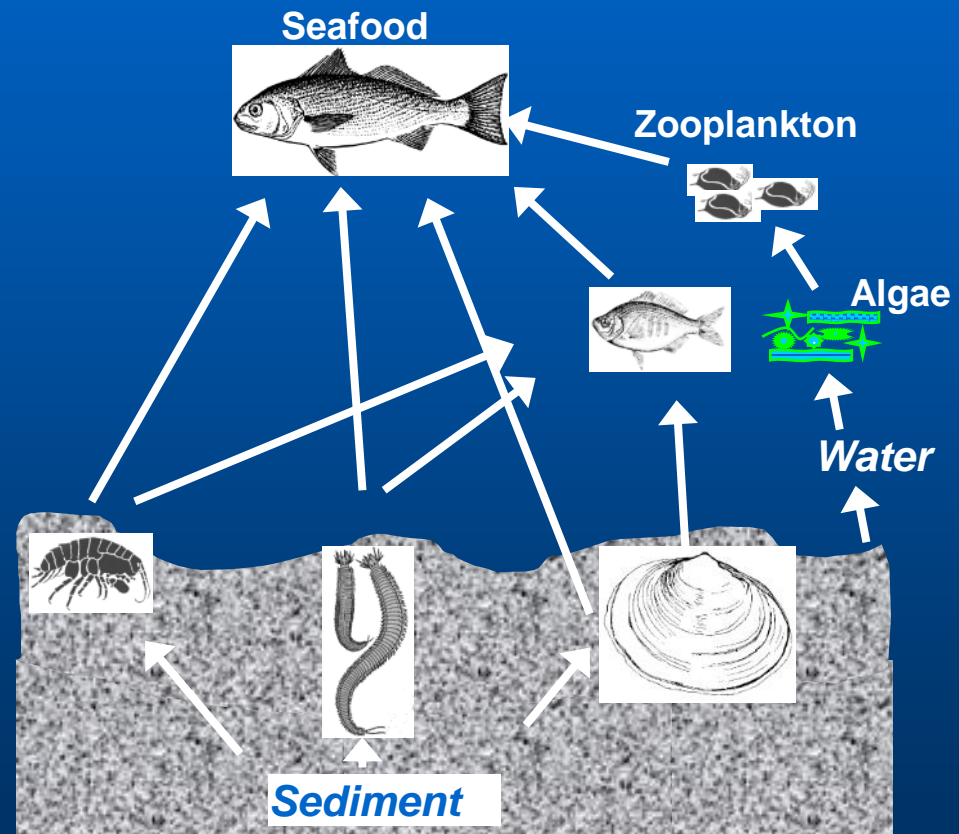
Data Integration Based on Guilds

- **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**
 - **= $C_1 * P_1 + C_2 * P_2 + \dots C_n * P_n$**

Sediment Linkage

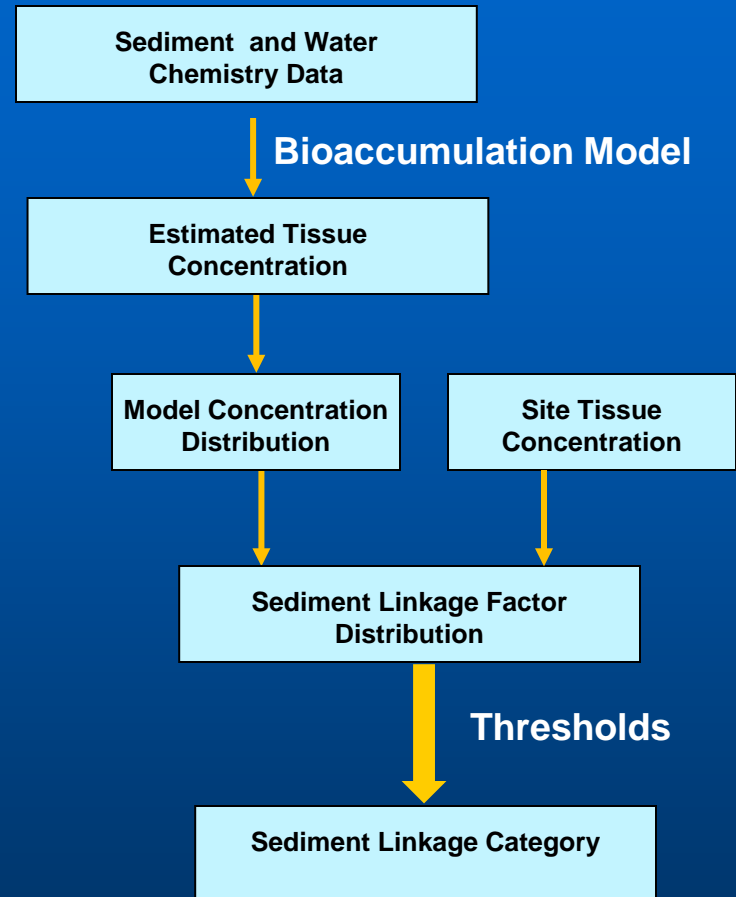
- Determine influence of site sediment on seafood tissue contamination
- Food web bioaccumulation models and assumptions
 - Biota Accumulation Factor (BAF)
- Linkage Factor =

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



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



Standardization of Parameters

- **Used sensitivity analysis to identify most influential parameters in calculation of consumption risk or sediment contribution (linkage)**
- **Based selection of local vs. standardized parameters based on analysis results and feasibility of data collection**

Sensitivity Analysis (2010)

Objectives:

- **Determine where to focus effort for consumption risk and sediment contribution tool development**
 - What parameters can be statewide estimates?
 - What parameters should be site-specific?
- **Identify parameters having high potential influence of site-specific conditions on model outcome**
 - These parameters should be site-specific
 - Include in Monte Carlo simulations

Sensitivity Analysis Approach

- **Focus on potentially important parameters**
 - Exhibit variability across sites
 - Can be measured/monitored
 - Known to have a role in outcome
- **Determine statistical distribution**
 - Based on data from California bays and estuaries
- **Simulate data sets and document outcome using model**

Methods

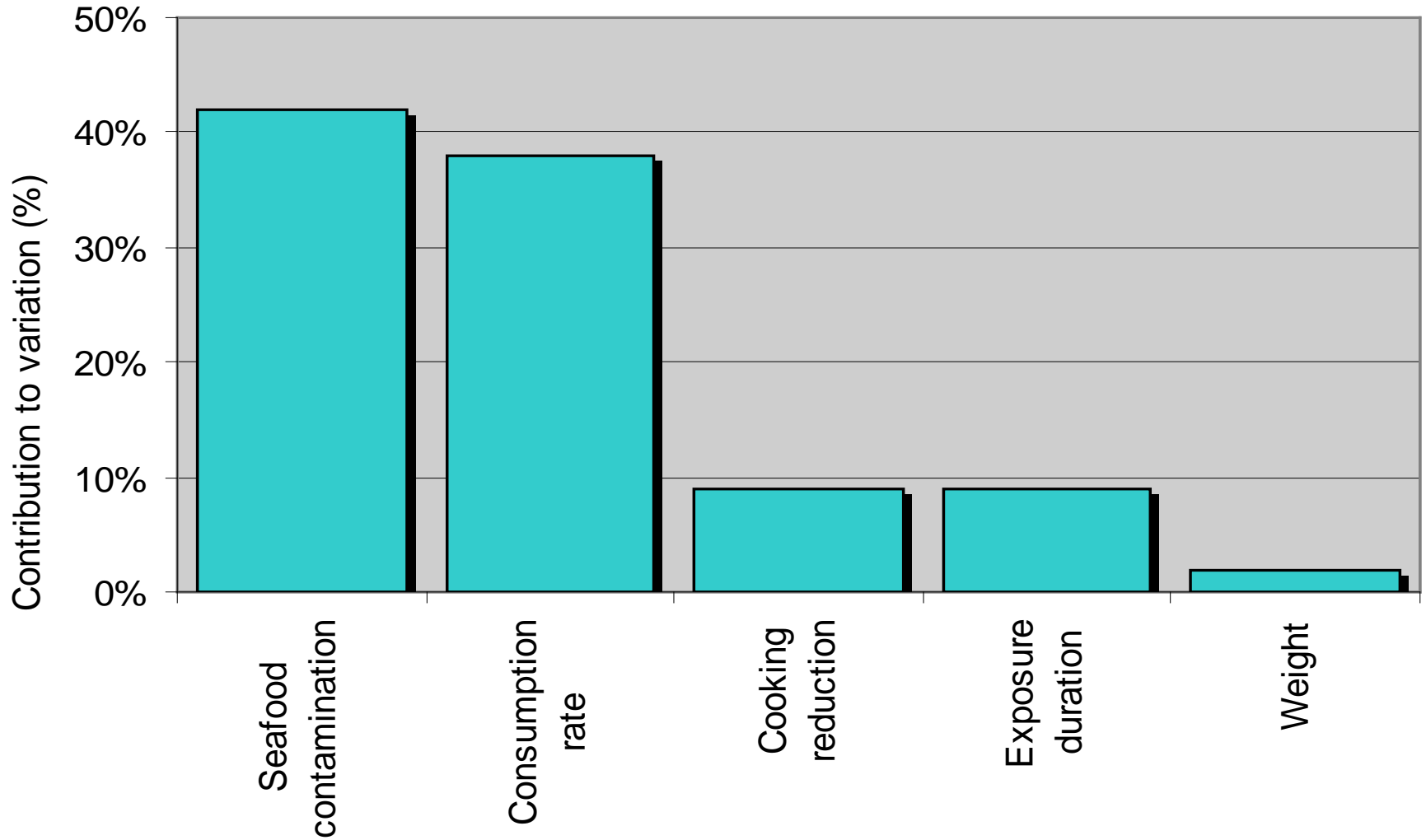
- **Results presented for DDTs**
 - Similar results for other compounds
- **Monte Carlo simulation**
 - Using YASAIw
 - Simulate 5000 outcomes randomly chosen from entire possible range of parameter values
 - Record outcomes and compare to parameters
 - Determine contribution of each parameter to variance

Consumption Risk Analysis: Parameters Evaluated

- **Seafood contaminant concentration**
- **Consumption rate by humans**
- **Cooking reduction factor**
- **Exposure duration**
- **Weight**

Results

Parameter Importance for consumption risk (carcinogenic risk)



Consumption Risk Summary

- **Seafood contamination and consumption rate most important parameters**
 - Include probability distribution in consumption risk calculation
 - Local measurement will improve accuracy of estimates
 - Standardization of consumption rate needed for improve comparability of results
- **Other parameters much less important**
 - Use point estimates in calculations
 - Statewide values sufficient

Sediment Contribution Analysis

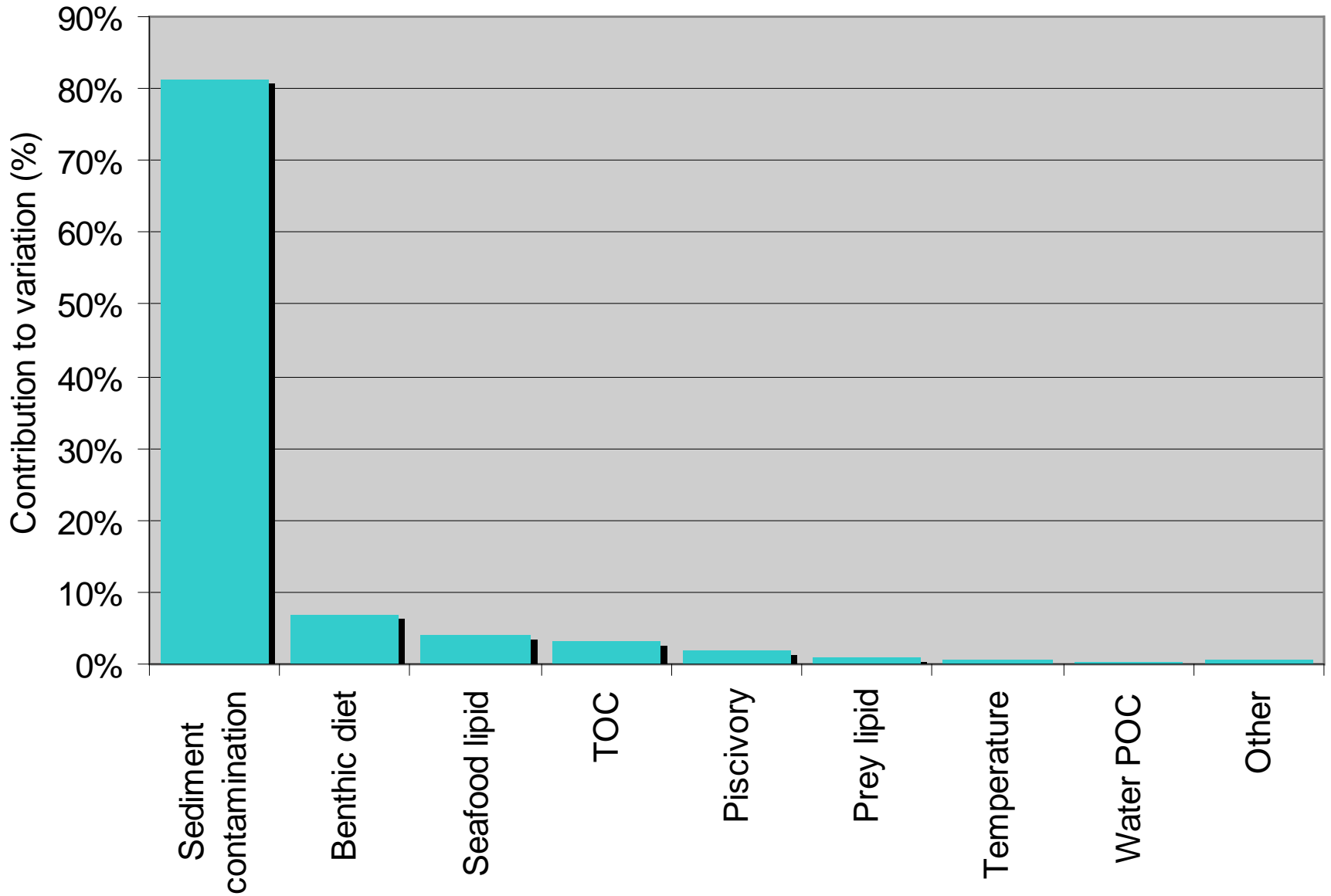
Parameters Evaluated: Sediment and Biota

- **Sediment contaminant concentration**
- **Sediment organic carbon**
- **Benthic diet**
 - Including sediments, benthic algae, invertebrates, benthic forage fish
- **Piscivory**
- **Seafood lipid**
- **Lipid of invertebrate prey**
- **Weight**

Parameters Evaluated: Water Column

- Dissolved oxygen
- Temperature
- Salinity
- Suspended solid concentration
- Particulate organic carbon
- Dissolved organic carbon

Parameter importance for sediment contribution



Sediment Contribution Summary

- **Most influential parameters**
 - Sediment chemistry and organic carbon
 - Seafood lipid
 - Benthic diet
- **Least influential parameters**
 - Most water parameters (POC, DOC, SSC, etc.)

Sediment Contribution Recommendations

- **Use local values for influential parameters**
 - Sediment chemistry
 - Sediment organic carbon
 - Seafood lipid
- **Use statewide values for influential but difficult to measure parameters**
 - Benthic diet
- **Use statewide values for less influential parameters**
 - Water column characteristics (POC, DOC, SSC)

Assessment Framework Application

- **Demonstrate the use of the Human Health SQO Assessment Framework**
- **Compare the assessment framework results to other evaluations for selected waterbodies**

Approach

- **Use recent monitoring data from readily available sources**
- **Investigate multiple sites within a water body**
- **Compare Tier I and II results**

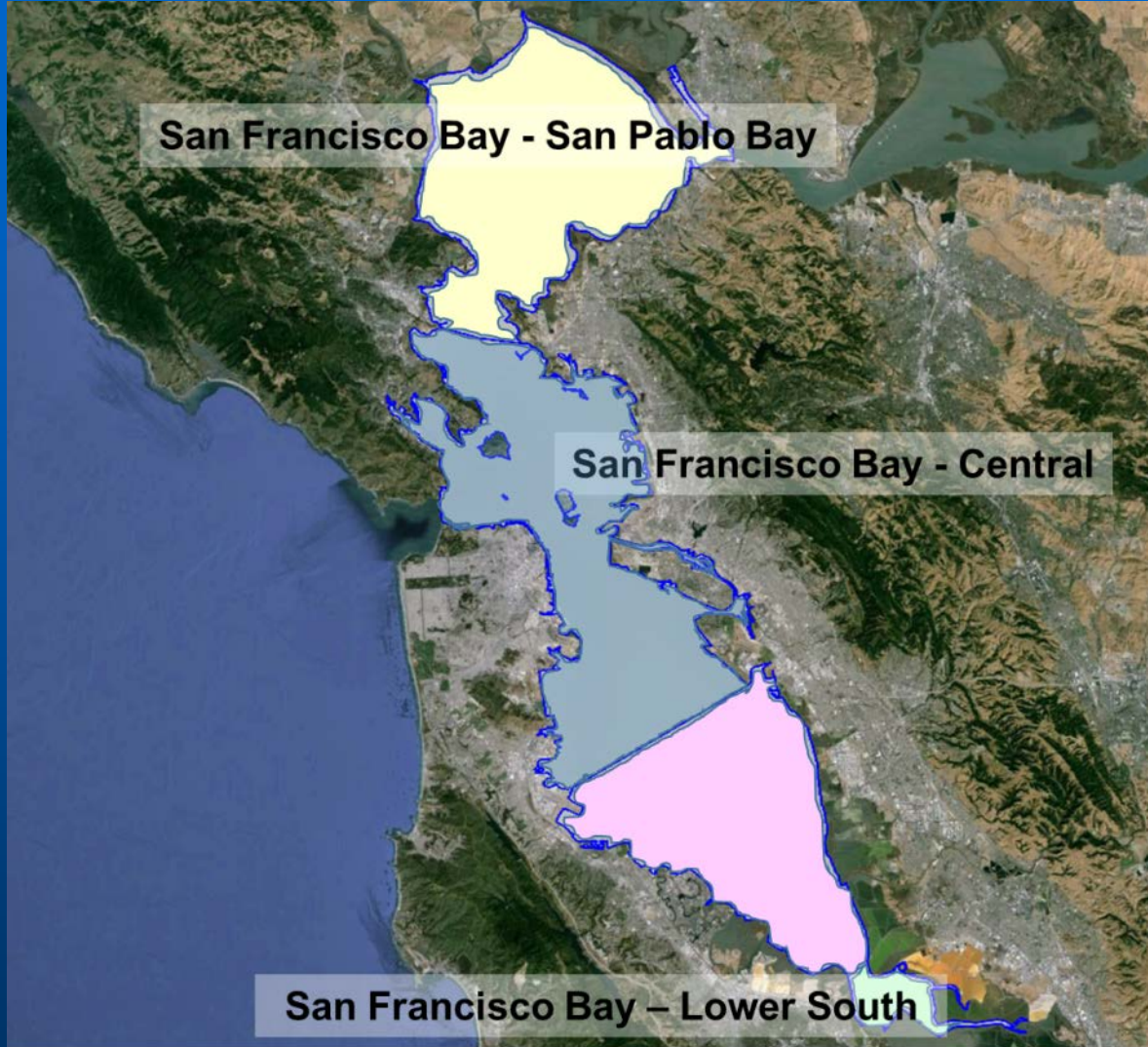
Data Selection

- **California embayment & harbor stations**
 - 2002 to 2010
- **Sediment chemistry and fish bioaccumulation analytes & species of interest**
 - Chlordanes, DDTs, dieldrin and PCBs
 - Primary indicator fish species: California halibut, white croaker, spotted sand bass, shiner perch, queenfish, topsmelt, striped mullet



Analysis Sites

Subwaterbody	Area km ²	Length km	Approximate Boundaries
San Francisco Bay_San Pablo	313.7	23.3	Richmond-San Rafael Bridge northeast to Carquinez Bridge
San Francisco Bay_Central	372.6	32.9	Richmond-San Rafael Bridge south to a dividing line between San Francisco Airport and Oakland Airport
San Francisco Bay_Lower South	26.9	12.6	South end of SFB north to the Dumbarton Bridge
Consolidated Slip	0.1	0.9	Consolidated Slip
Los Angeles Inner Harbor	5.8	6.6	Pier 400 up channel to boundary
Los Angeles Outer Harbor	6	4.7	Long Beach harbor inside breakwater including the Port of Long Beach
Cabrillo_Beach and Marina	0.8	1.8	Cabrillo Marina and Beach inside breakwater
Long Beach Inner Harbor	5.8	4.9	Inner channel areas
Long Beach Outer Harbor	9.9	4.1	Los Angeles harbor inside breakwater and Pier 400 including the Port of Los Angeles
Eastern San Pedro Bay	27	10.5	Mouth of Los Angeles River east to mouth of Anaheim Bay inside breakwater
San Gabriel River Estuary	0.6	6.4	Mouth to end of tidal portion north of 405 freeway
Newport Bay_Upper	3.1	5.6	Mouth to PCH Bridge
Newport Bay_Lower	1.4	6.8	PCH Bridge north and east to Jamboree Rd.
Mission Bay	8.1	6	All Mission Bay
San Diego Bay_North	15.8	11.2	Coronado Bridge to mouth of San Diego Bay
San Diego Bay_Central and South	27.5	10.6	Coronado Bridge to south end of San Diego Bay



San Francisco Bay - San Pablo Bay

San Francisco Bay - Central

San Francisco Bay - Lower South



Consolidated Slip

San Gabriel River Estuary

Los Angeles Inner Harbor

Long Beach Inner Harbor

Eastern San Pedro Bay

Cabrillo Beach & Marina

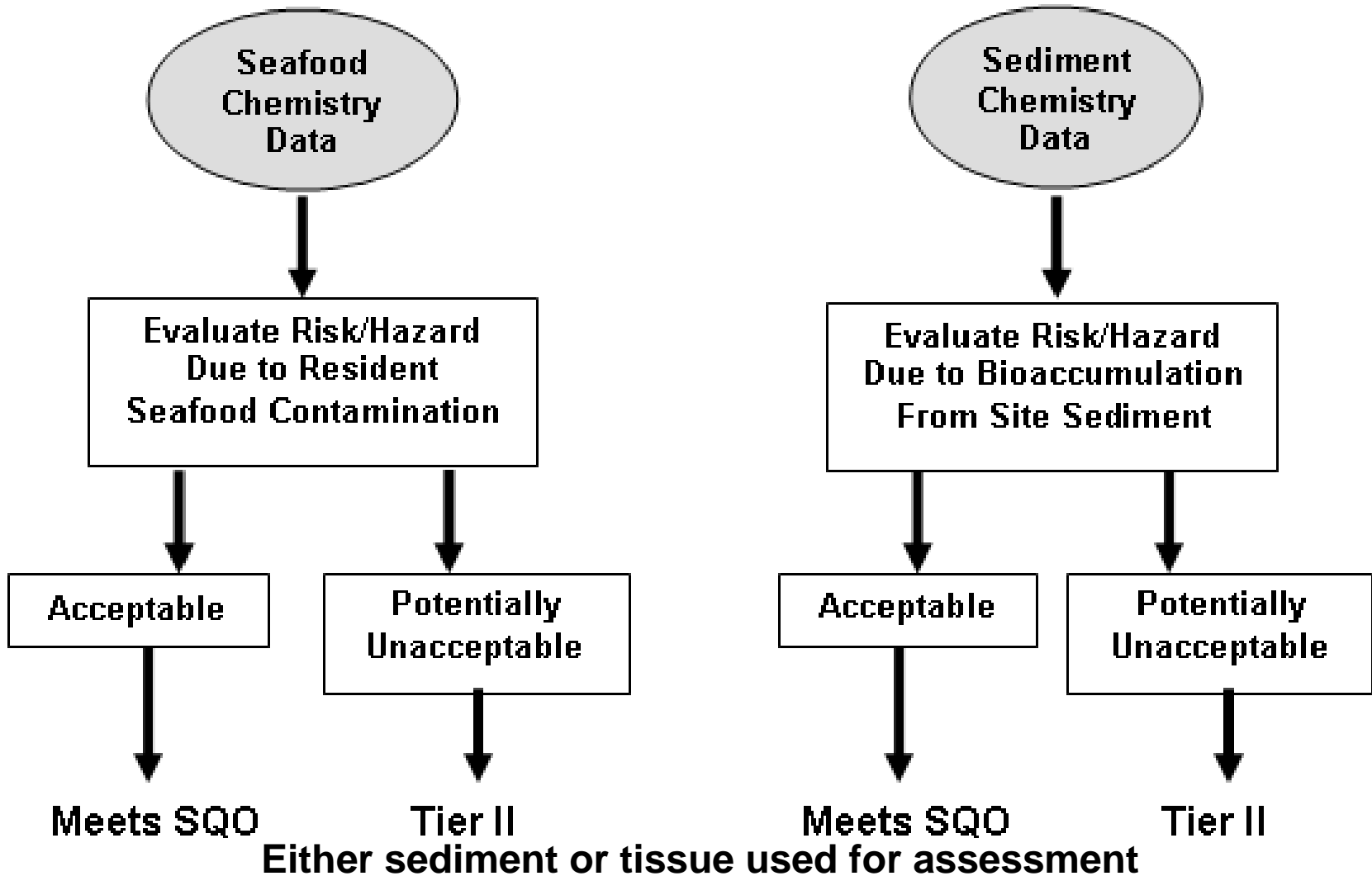
Long Beach Harbor

Los Angeles Harbor



Fish Tissue Data

Subwaterbody	Species	No. Samples	Subwaterbody	Species	No. Samples
San Francisco Bay_San Pablo	Shiner perch	6	Long Beach Inner Harbor	California halibut	4
	White croaker	3		Queenfish	16
San Francisco Bay_Central	California halibut	8		Topsmelt	13
	Shiner perch	18	White croaker	26	
	Topsmelt	10	Long Beach Outer Harbor	California halibut	6
	White croaker	26		Queenfish	11
San Francisco Bay_Lower South	Shiner perch	3	Topsmelt	18	
	White croaker	10	White croaker	27	
Consolidated Slip	California halibut	3	Eastern San Pedro Bay	California halibut	11
	Queenfish	7		White croaker	44
	Topsmelt	4	San Gabriel River Estuary	Striped mullet	8
	White croaker	9		Newport Bay_Upper	California halibut
Los Angeles Inner Harbor	California halibut	7	Spotted sand bass		7
	Queenfish	16	Topsmelt		4
	Topsmelt	11	Newport Bay_Lower	California halibut	3
	White croaker	28		Shiner perch	3
Los Angeles Outer Harbor	California halibut	5	Spotted sand bass	4	
	Queenfish	7	Mission Bay	Shiner perch	4
	Shiner perch	3		Spotted sand bass	5
	Topsmelt	5	San Diego Bay_North	Shiner perch	6
	White croaker	12		Spotted sand bass	7
Cabrillo_Beach and Marina	California halibut	7	San Diego Bay_Central and South	Spotted sand bass	5
	Queenfish	19			
	Topsmelt	18			
	White croaker	29			

Tier I Assessment



Tier I Results

Meets SQO (M) = 
 Proceed to Tier II (P) = 

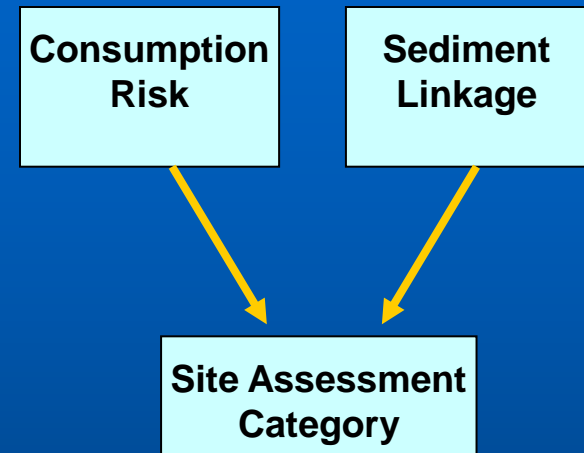
Subwaterbody	Site Assessment											
	Chlordane			DDT			Dieldrin			PCBs		
	Tiss	Sed	Tier I	Tiss	Sed	Tier I	Tiss	Sed	Tier I	Tiss	Sed	Tier I
San Francisco Bay_San Pablo	M	M	M	M	M	M	M	M	M	P	P	P
San Francisco Bay_Central	M	M	M	M	M	M	M	M	M	P	P	P
San Francisco Bay_Lower South	M	M	M	M	M	M	M	M	M	P	P	P
Consolidated Slip	NA	P	P	M	P	P	NA	M	M	P	P	P
Los Angeles Inner Harbor	NA	P	P	P	P	P	NA	M	M	P	P	P
Los Angeles Outer Harbor	NA	M	M	M	P	P	NA	M	M	M	P	P
Cabrillo_Beach and Marina	NA	M	M	M	P	P	NA	M	M	P	P	P
Long Beach Inner Harbor	NA	P	P	M	M	M	NA	M	M	P	P	P
Long Beach Outer Harbor	NA	M	M	M	P	P	NA	M	M	P	P	P
Eastern San Pedro Bay	NA	P	P	M	P	P	NA	M	M	P	P	P
San Gabriel River Estuary	M	P	P	M	M	M	M	M	M	P	P	P
Newport Bay_Upper	M	P	P	M	P	P	M	M	M	M	P	P
Newport Bay_Lower	M	M	M	M	P	P	M	M	M	P	P	P
Mission Bay	M	M	M	M	M	M	M	M	M	P	P	P
San Diego Bay_North	M	M	M	M	M	M	M	M	M	P	P	P
San Diego Bay_Central and South	M	M	M	M	P	P	M	M	M	P	P	P

All sites need Tier II evaluation for PCBs

Potential exceedances for chlordane and DDT usually based on sediment screening, not tissue.

Tier II 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






Indicator Integration

- **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	Unimpacted
1. Very Low	2. Low	Unimpacted
1. Very Low	3. Moderate	Unimpacted
1. Very Low	4. High	Unimpacted
2. Low	1. Very Low	Unimpacted
2. Low	2. Low	Unimpacted
2. Low	3. Moderate	Likely Unimpacted
2. Low	4. High	Likely Unimpacted
3. Moderate	1. Very Low	Likely Unimpacted
3. Moderate	2. Low	Possibly Impacted
3. Moderate	3. Moderate	Likely Impacted
3. Moderate	4. High	Clearly Impacted
4. High	1. Very Low	Likely Unimpacted
4. High	2. Low	Possibly Impacted
4. High	3. Moderate	Likely Impacted
4. High	4. High	Clearly Impacted

Tier II Site Assessment

Unimpacted (U) = 
 Likely Unimpacted (LU) = 
 Possibly Impacted (PI) = 
 Likely Impacted (LI) = 
 Clearly Impacted (CI) = 

Subwaterbody	Site Assessment			
	Chlordane	DDT	Dieldrin	PCBs
	1 X 10 ⁻⁵	1 X 10 ⁻⁵	1 X 10 ⁻⁵	1 X 10 ⁻⁵
San Francisco Bay_San Pablo	U	U	U	LU
San Francisco Bay_Central	U	U	U	LU
San Francisco Bay_Lower South	U	U	U	CI
Consolidated Slip	NA	U	NA	LU
Los Angeles Inner Harbor	NA	CI	NA	CI
Los Angeles Outer Harbor	NA	LU	NA	LU
Cabrillo_Beach and Marina	NA	U	NA	CI
Long Beach Inner Harbor	NA	U	NA	CI
Long Beach Outer Harbor	NA	LU	NA	CI
Eastern San Pedro Bay	NA	LU	NA	CI
San Gabriel River Estuary	U	U	LU	CI
Newport Bay_Upper	U	U	U	U
Newport Bay_Lower	U	U	U	LU
Mission Bay	U	U	U	LU
San Diego Bay_North	U	U	U	CI
San Diego Bay_Central and South	U	U	U	CI

SQO exceedances for DDT and PCB only

Within embayment variations: SF Bay and LA/LB Harbor

Tier I Tissue Screening Correctly Predicts Tier II Outcome 90% of the Time

Subwaterbody	Site Assessment											
	Chlordanes			DDTs			Dieldrin			PCBs		
	Tier I		Tier II	Tier I		Tier II	Tier I		Tier II	Tier I		Tier II
	Tiss	Sed		Tiss	Sed		Tiss	Sed		Tiss	Sed	
San Francisco Bay_San Pablo	M	M	U	M	M	U	M	M	U	P	P	LU
San Francisco Bay_Central	M	M	U	M	M	U	M	M	U	P	P	LU
San Francisco Bay_Lower South	M	M	U	M	M	U	M	M	U	P	P	CI
Consolidated Slip	NA	P	NA	M	P	U	NA	M	NA	P	P	LU
Los Angeles Inner Harbor	NA	P	NA	P	P	CI	NA	M	NA	P	P	CI
Los Angeles Outer Harbor	NA	M	NA	M	P	LU	NA	M	NA	M	P	LU
Cabrillo_Beach and Marina	NA	M	NA	M	P	U	NA	M	NA	P	P	CI
Long Beach Inner Harbor	NA	P	NA	M	M	U	NA	M	NA	P	P	CI
Long Beach Outer Harbor	NA	M	NA	M	P	LU	NA	M	NA	P	P	CI
Eastern San Pedro Bay	NA	P	NA	M	P	LU	NA	M	NA	P	P	CI
San Gabriel River Estuary	M	P	U	M	M	U	M	M	LU	P	P	CI
Newport Bay_Upper	M	P	U	M	P	U	M	M	U	M	P	U
Newport Bay_Lower	M	M	U	M	P	U	M	M	U	P	P	LU
Mission Bay	M	M	U	M	M	U	M	M	U	P	P	LU
San Diego Bay_North	M	M	U	M	M	U	M	M	U	P	P	CI

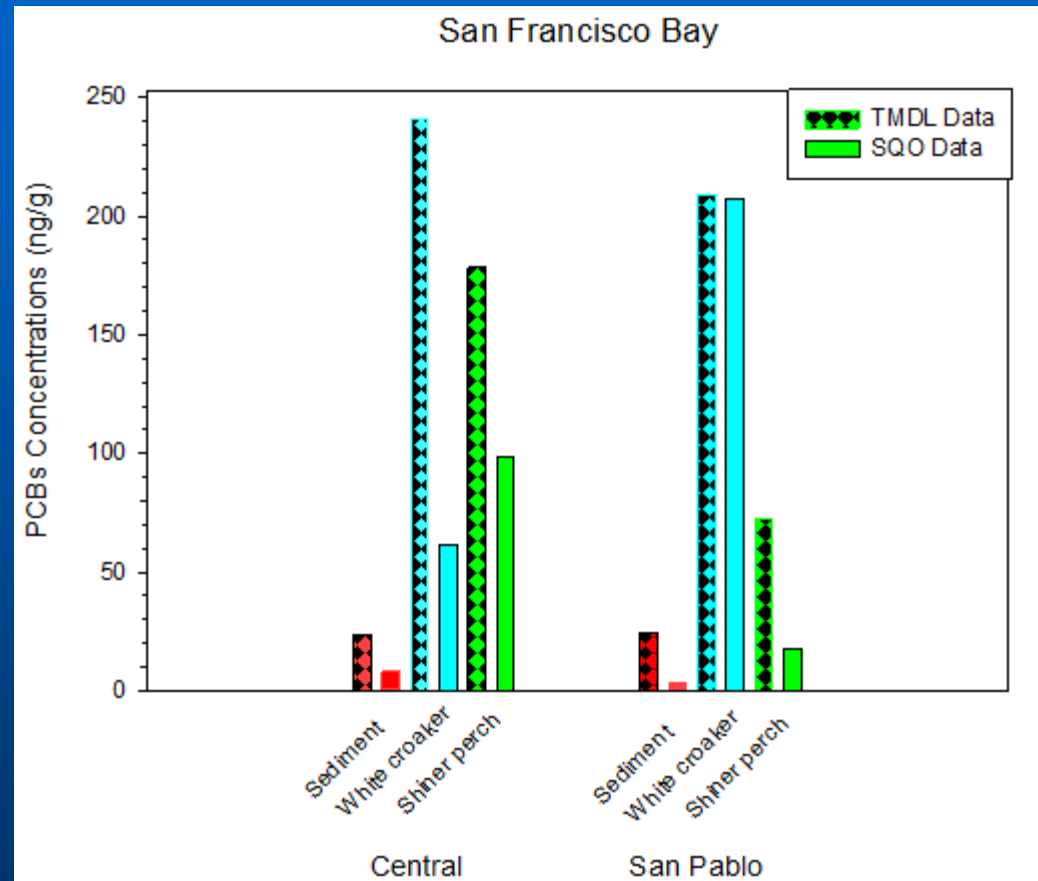
San Pedro Bay Assessments



Differences in site assessments related to small site area and lower tissue concentrations

San Francisco Bay PCB Assessments

- Differences in site assessments relative to TMDL assessment related to low sediment linkage
- Sediment linkage influenced by lower sediment contamination and fish species selection



Summary

- **Tier I effective as screening tool**
 - No false negatives
 - Sediment-based screening less reliable
- **Tier II results consistent with expectations**
 - Major differences related to data or study design
- **No intermediate results observed**
 - Consequence of high sediment linkage at most sites
 - Results highly dependent on choice of thresholds