Development of California Marine Sediment Quality Objectives Using a Multiple Line of Evidence Framework

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BACKGROUND

- **For many years, scientists have advocated a triad approach for evaluating sediment quality**
  - Individual lines of evidence; each have potential limitations

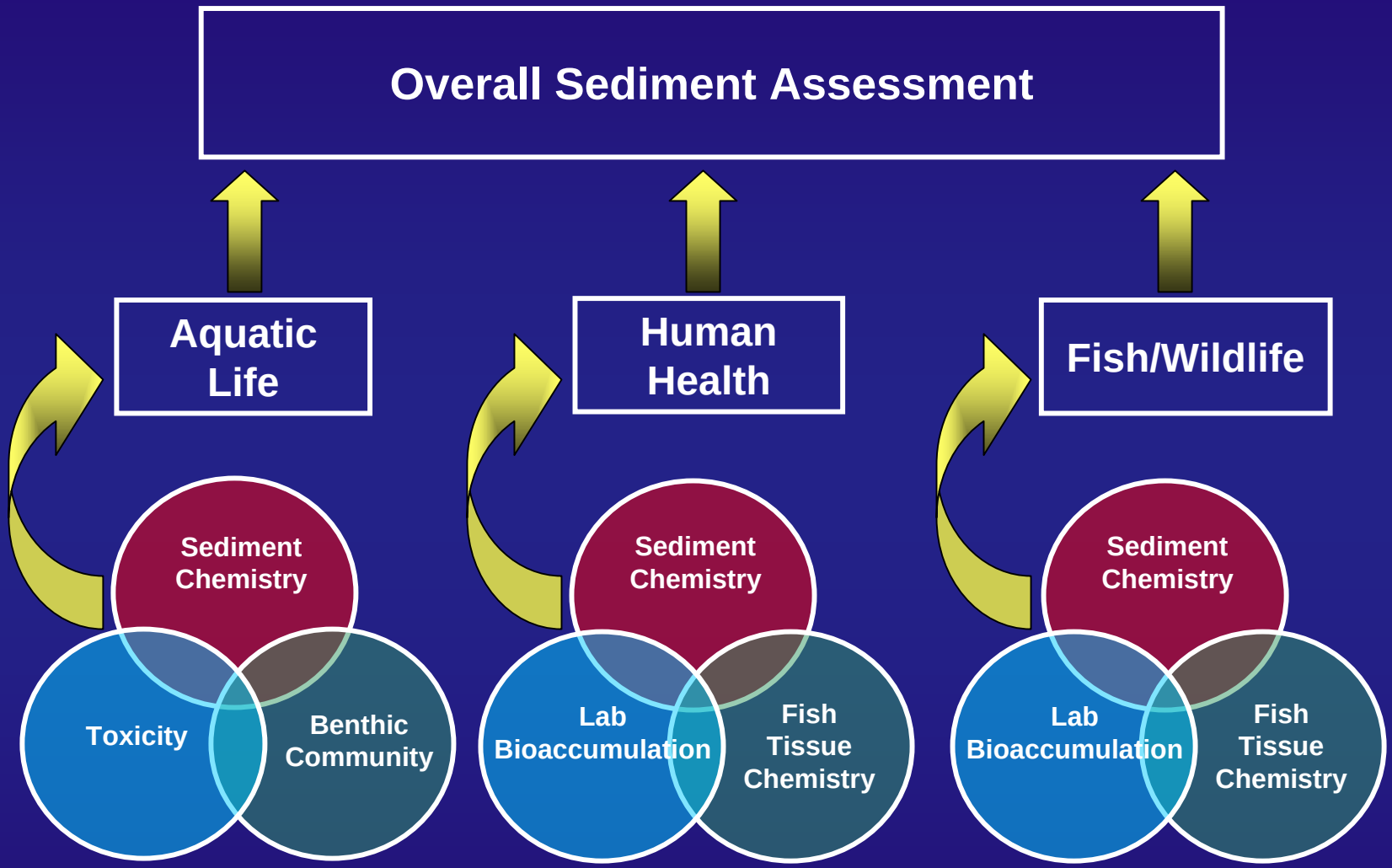
POTENTIAL FLAWS WITH INDIVIDUAL LINES OF EVIDENCE

- **Chemistry**
  - Bioavailability poorly understood (e.g. paint chip, tar ball)
  - There may be unmeasured contaminants
- **Toxicity**
  - Confounding factors (e.g. ammonia)
  - Agitation enhanced bioavailability
  - Differing sensitivity among test species
- **Benthic infaunal assemblages**
  - Physical disturbance (anchor, dredging)
  - Oxygen stress

BACKGROUND

- **The triad has been widely used in site-specific assessments, but has not found its way into most statutory frameworks**
  - Most applications are based on best professional judgment
- **California's sediment quality objectives are based on multiple lines of evidence (MLOE)**
  - There are many challenges in translating scientific concept into regulatory framework

SQO ASSESSMENT FRAMEWORK



CHALLENGES

- **Developing methods/assessment consistency across the state**
  - Multiple ecoregions
  - Numerous habitats
    - Initial focus on marine embayments
- **Standardizing data interpretation among individuals with varying expertise**
  - Engineers vs. Biologists
- **Developing assessment thresholds**
  - Interface between science and policy

SCIENTIFIC ACTIVITIES

- **Select indicators for individual lines of evidence**
  - Evaluate multiple candidate indicators for each LOE
  - Base recommendations on performance, conceptual basis, and practicality
- **Establish thresholds for each indicator**
  - Quantitative
  - Understand linkage to presence and severity of effects
- **Develop a framework for integrating across lines of evidence**
  - Clear decision points
  - Utility for prioritization
  - Simple, yet retain scientific content

TECHNICAL REVIEW

- **Indicator and assessment framework development includes several levels of technical review and input**
  - Transparent process
  - Assure sound technical basis for recommendations
  - Identify issues of concern early
- **Scientific Steering Committee**
  - Experts in multiple fields
  - Review methods, results interpretation, technical recommendations
- **Advisory Committee**
  - Key stakeholder groups
  - Communicate conceptual models and identify implementation concerns early in development process
- **Agency Coordinating Committee**
  - Users
  - Identify information needs and program conflicts

CHEMISTRY INDICATORS

- **There are numerous candidate approaches and indicators for interpreting sediment chemistry data**
  - Multiple empirical chemical guidelines available
    - ERM, PEL, AET, Logistic regression
  - Emphasis on mixture approaches
- **Our approach is to develop a California-specific data base for evaluating multiple possible approaches**
  - Includes data from more than 150 studies
  - Evaluate performance of candidates to predict toxicity and benthic community impacts

CANDIDATE CHEMISTRY INDICATORS

- **Existing national Sediment Quality Guidelines**
  - Effects range median quotient (ERMq)
  - Consensus midrange effects concentration (Consensus MEC)
  - Sediment quality guidelines quotient (SQGQ1)
  - Logistic regression (Pmax)
- **National SQGs recalibrated to California data**
  - ERMq
  - Pmax
- **New approaches**
  - Relationship to benthic community impacts
  - Relationship to magnitude of toxicity

CHEMISTRY INDICATOR RESULTS

- **Calibrated and new approaches have greater accuracy than national SQGs**
  - Will recommend a combination of chemical SQGs based on toxicity and benthic community response
- **Classification thresholds will be calibrated to California data**
  - Greater utility and accuracy for classifying sediments
- **Four categories of chemical exposure**
  - Minimal potential for biological effects
  - Low potential for biological effects
  - Moderate potential for biological effects
  - High potential for biological effects

TOXICITY INDICATORS

- **There are many types of toxicity tests with differing endpoints and exposure**
  - Acute/survival
  - Short-term and long-term sublethal effects
- **Several possible species within each type of test**
- **Various test matrices**
  - Whole sediment
  - Pore water, elutriate
  - Sediment-water interface
- **We evaluated candidate tests for suitability, feasibility, and sensitivity**
  - Consistent with program objectives
  - Established methods and technically feasible
  - Likely to provide useful information

TOXICITY TEST RECOMMENDATIONS

- **Use both a short-term survival and a sublethal test**
- **Short-term survival**
  - 10-day amphipod survival: *Eohaustorius, Rhepoxynius*, or *Leptocheirus*
- **Sublethal**
  - 28-day polychaete growth: *Neanthes*
  - Embryo development/sediment – water interface: *Mytilus*

BENTHIC ASSESSMENT CHALLENGES

- **Interpreting species abundances is difficult**
  - Samples may have tens of species and hundreds of organisms
  - Indices provide a means of summarizing complex information
- **Benthic species and abundances vary naturally with habitat**
  - Reference condition needs to vary by habitat
- **Sampling methods vary among programs**
  - Gear type sampling area and sieve size affect species and individuals captured

BENTHIC INDICATOR DEVELOPMENT ACTIVITIES

- **Determined the number of biogeographic provinces in California**
  - Index calibration/validation to be conducted separately for each
  - Six habitats; defined by salinity, grain size, latitude
- **Evaluated several candidate indices based on different conceptual approaches**
  - Presence/abundance of indicator species
  - Community measures
  - Pollution tolerance of individual species

BENTHIC INDICATOR DEVELOPMENT RESULTS

- **Calibrated and developed benthic indices for two habitats**
  - Southern California embayments
  - Central San Francisco Bay
- **Multiple index evaluation and validation steps**
  - Classification accuracy compared to assessment by benthic ecologists
  - Repeatability across replicates
  - Independence from natural habitat gradients
- **Suite of four benthic indices recommended for use**

THREE LEVELS OF ASSESSMENT

- Minimal exposure or no effect
- Low exposure/effect
- Moderate exposure/effect
- High exposure/effect

THREE LEVELS OF ASSESSMENT

SAMPLING STATION ASSESSMENT CATEGORIES

- Unimpacted
- Likely unimpacted
- Possibly impacted
- Likely impacted
- Clearly impacted
- Inconclusive

THREE LEVELS OF ASSESSMENT

- **Individual LOE**
  - Merging multiple indicators
- **Sampling station level**
  - Merging MLOE
- **Water body scale**
  - Merging multiple sampling stations
    - Uncertainty in assessment accuracy
    - Spatial variability
    - Temporal variability
    - Magnitude of impact

ADDITIONAL ASSESSMENT ELEMENTS

- **Strategy for working with imperfect information**
  - Incomplete data
  - Sites without assessment tools
- **Strategy for developing chemical-specific management actions**
  - Chemical-specific guidelines
  - Sediment TIES
- **Frameworks for bioaccumulation effects assessment**
  - Wildlife
  - Human health

Bioaccumulation Effects Case Studies

- **Apply assessment framework and candidate tools to selected waterbodies**
  - Demonstrate application of framework
  - Compare mechanistic model and empirical approaches
  - Refine indicators and identify key data needs

- **Focus on chlorinated hydrocarbons**
  - PCBs, DDT, other pesticides
  - Best understanding of linkage between sediments and tissues
  - Human health and wildlife concerns established for multiple areas

PHASE II TECHNICAL ACTIVITIES

- **Direct effects SQO tools for estuaries**
  - Update Scientific Steering, Agency, and Advisory Committees
  - Compile existing sediment quality data
  - Sample additional delta/estuary sites for chemistry, toxicity benthos
  - Data analysis and indicator development for each LOE
  - Development of indicator thresholds and data integration framework

- **Indirect effects SQO tools**
  - Compile existing tissue chemistry data
  - Refine assessment framework
  - Conduct case study to evaluate assessment framework and indicators