DEVELOPMENT OF SEDIMENT QUALITY OBJECTIVES FOR CALIFORNIA BAYS AND ESTUARIES

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WHERE ARE WE AT IN THE PROCESS?

- **Six months ago I talked to you about the scientific concepts**
- **Since then we have been conducting studies to convert concepts into assessment methodologies**
  - Which specific indicators will be used?
  - What are the thresholds for those indicators?
- **Making good progress, but not yet final**
  - Additional analyses remain
  - Vetting through Stakeholders Advisory Committee
  - Review by Scientific Steering Committee
- **Today is a mid-term progress report**

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

THE BASIC FRAMEWORK

- **Three beneficial uses to be protected**
  - Aquatic life
  - Human health
  - Fish and wildlife
  - Each will be assessed separately
- **Within each beneficial use, a multiple line of evidence (MLOE) approach will be used**
  - MLOE involves demonstration of both exposure and effect
  - No single line of evidence is sufficient
- **More complex than water column criteria because chemical bioavailability in sediments is poorly understood**

CHALLENGE

- **MLOE has been widely used in site-specific and subregional assessments**
  - Has not yet found its way into sediment quality criteria
  - Case-specific reliance on "Best Professional Judgment"
- **Challenge is to create a consistent MLOE application**
  - Primary users will often be engineers, not Ph.D. biologists
  - Need a more standardized structure than BPJ

SCCWRP's SCIENTIFIC ACTIVITIES

- **Select indicators for individual lines of evidence**
  - Many candidate indicators for each LOE
- **Establish thresholds for each indicator**
- **Develop an integration framework**
- **Prepare methods manuals**
  - Recommended collection/processing methods
- **Conduct a statewide assessment**
  - What percent of the state meets the new SQOs?

CHEMISTRY INDICATORS

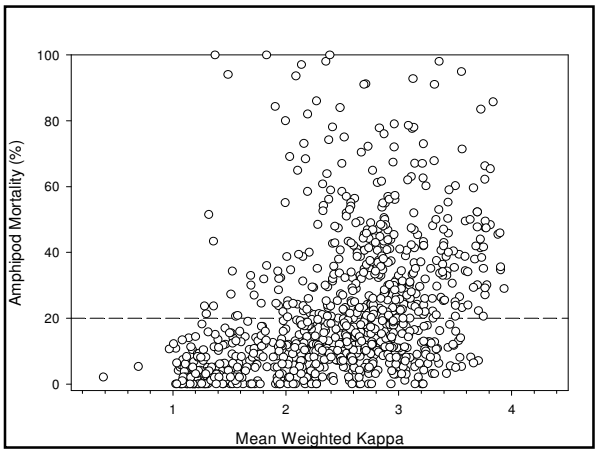
- **There are numerous candidate indicators for interpreting sediment chemistry data**
  - Biggest dichotomy is empirical approach vs. equilibrium partitioning
  - Its like the Hatfield's and McCoy's among scientists
- **There are also numerous candidate empirical approaches**
  - Individual chemical thresholds vs. cumulative chemistry thresholds
- **Our approach is to develop a California-specific data base for evaluating multiple possible approaches**
  - Includes data from more than 150 studies

CANDIDATE CHEMISTRY INDICATORS

- **Existing national Sediment Quality Guidelines**
  - Effects range median quotient (ERMq)
  - Consensus midrange effects concentration (CMEC)
  - Sediment quality guidelines quotient (SQGQ)
  - Logistic regression (PMAX)
  - Chronic equilibrium partitioning (EqP)
  - Acute equilibrium partitioning (EqP)
- **National SQGs recalibrated to California data**
  - ERMq
  - PMAX
- **New approaches**
  - Mean weighted kappa
  - Max-weighted kappa

CORRELATION WITH TOXICITY

SQG	NORTH	SOUTH
Mean Weighted Kappa	0.54	0.46
Max Weighted Kappa	0.40	0.43
CA ERMq	0.37	0.28
ERMq	0.37	0.29
CA P-Max	0.35	0.32
CMEC	0.29	0.22
SQGQ	0.28	0.25
National P-Max	0.27	0.22
Chronic EqP	-0.08	-0.06
Acute EqP	-0.09	-0.08



NEXT STEPS FOR CHEMISTRY LOE

- **Evaluate candidate indicators against benthic response**
  - Waiting for selection of benthic indicator
- **Select best chemical indicator**
  - Will possibly select more than one
- **Determine thresholds for levels of effect**
  - Reference condition
  - Marginal deviation from reference
  - Moderate potential effect
  - Severe potential for effect

TOXICITY INDICATORS

- **There are many types of toxicity tests with differing sensitivity**
  - Acute/survival
  - Short-term development
  - Long-term chronic effects
- **Various test species within a type of test**
- **Various test matrices**
  - Whole sediment
  - Pore water
  - Elutriate
- **Concerns about interlaboratory variability**
- **Which test(s) and thresholds to use?**

CANDIDATE TOXICITY INDICATORS

- **Short-term survival**
  - Four species of amphipods that have been widely used in California
- **Short-term/embryo development and fertilization**
  - Sea urchins and mussels
- **Chronic/sublethal response**
  - Clam
  - Polychaete
  - Copepod
  - Amphipod
  - Oyster

EVALUATION PROCESS

- **Separate evaluation for short-term survival and sublethal test methods**
- **Short-term survival**
  - Conducted intercalibration studies to assess sensitivity and replicability
- **Sublethal tests**
  - Feasibility
  - Consistency
  - Confounding factors
  - Sensitivity
  - Relevance
  - Cost

SHORT TERM SURVIVAL

- **Recommended**
  - *Eohaustorius estuarius*
  - *Leptocheirus plumulosus*
- **Not recommended**
  - *Rhepoxynius abronius*
    - Limited availability
    - Grain size sensitivity
  - *Ampelisca abdita*
    - Low sensitivity
    - Low test success rate
    - Limited availability

SUBLETHAL TESTS

- **Recommended**
  - Polychaete growth test (*N. arenaceodentata*)
  - Sediment water interface test using mussels or sea urchin embryos
- **Other methods not recommended mostly based on feasibility**
  - Organism supply issues
  - No standard method
  - Low test success rate
  - Lack of capacity in California

NEXT STEPS FOR TOXICITY INDICATORS

- **Develop thresholds for these tests**
  - Need to develop comparability of scoring across tests
- **Develop method for integrating multiple tests into an LOE score**
  - Scientific Steering Committee recommended use of both an acute and a sublethal test

BENTHIC ASSESSMENT CHALLENGES

- **Interpreting benthic infaunal data is complex**
  - 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

Species	Abundance	Species	Abundance
Pseudopolydora paucibranchiata	612	Diplocirrus sp SD1	4
Exogone lourei	465	Ampithoe sp	3
Fabricinuda limnicola	240	Asthenothaerus diegensis	3
Musculista senhousia	170	Euchone limnicola	3
Caprella californica	113	Heteroserolis carinata	3
Scoletoma sp	106	Lyonsia californica	2
Scoletoma sp C	99	Neotrypaea californiensis	2
Solen rostriformis	92	Sabellidae	2
Amphideutopus oculatus	51	Acteocina inculta	1
Podocerus fulanus	50	Aplousobranchia	1
Amphipholis squamata	41	Ceriantharia	1
Prionospio heterobranchia	40	Eteone brigitteae	1
Paradexamine sp SD1	27	Glycera americana	1
Mayerella acanthopoda	23	Halcampidae	1
Spiophanes duplex	20	Heterophoxus ellisi	1
Edwardsiidae	17	Macoma sp	1
Pista percyi	17	Malmgreniella sp	1
Ericthonius brasiliensis	15	Monocorophium acherusicum	1
Leitoscoloplos pugettensis	14	Monocorophium insidiosum	1
Oligochaeta	12	Nassarius tiarula	1
Leptosynapta sp	11	Odontosyllis phosphorea	1
Mediomastus sp	11	Paranemertes californica	1
Megalomma pigmentum	10	Protohyale frequens	1
Phoronida	8	Pyromaia tuberculata	1
Leptochelia dubia	7	Scleroplax granulata	1
Rudilemboides stenopropodus	6	Zoobotryon pellucida	1
Theora lubrica	5	Imogine exiguus	1
Anoplodactylus erectus	4	Planoceridae	1

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BENTHIC INDICATOR DEVELOPMENT ACTIVITIES

- **Determine the number of biogeographic provinces in California**
  - Index development to be conducted separately for each
- **Select from among several possible index approaches**
  - There are five approaches that have been previously used in California
- **Test for compatibility among sampling methods**

APPROACH TO HABITAT DEFINITION

- Use cluster analysis to segregate species groups
- Evaluate habitat differences among the species groups
  - Salinity
  - Substrate type
  - Depth
  - Latitude
- We used west coast–wide data
  - Critters don't recognize political boundaries
  - Potentially enhances size of the index development data base

IDENTIFIED EIGHT ASSEMBLAGES

- Puget Sound fine sediments
- Puget Sound coarse sediments
- Euhaline bays
- Shallow estuaries and wetlands
- Very coarse sediments
- Polyhaline San Francisco Bay
- Mesohaline San Francisco Bay
- Tidal freshwater

CANDIDATE BENTHIC INDICES

Index	Approach
Index of Biotic Integrity (IBI)	Community measures
Relative Benthic Index (RBI)	Community measures
Benthic Quality Index (BQI)	Community measures
Benthic Response Index (BRI)	Species types
River Invertebrate Prediction and Classification System (RIVPACS)	Presence/absence of expected species

APPROACH

- Give each index developer a development data set
- Withhold data for independent index evaluation
  - Classification of "known" good and bad sites
  - Repeatability across replicates
  - Independence from natural habitat gradients
- Sufficient data available only from two habitats
  - Euhaline bays
  - Polyhaline San Francisco Bay

INITIAL CLASSIFICATION ACCURACY

Index	Overall (n=35)
RIVPACS	83
BRI	77
IBI	70
BQI	63
RBI	51

CONCERN WITH THE "GOLD STANDARD"

- Present gold standard is based on extremes of chemistry and toxicity
- We noticed that many of the indices were in agreement with each other
  - But differed from the gold standard
- Asked four benthic ecologists to look at data for seven sites without giving them access to chemistry, toxicity or index data
  - Experts agreed with the indices for six of the seven sites

EFFECT OF STATUS CHANGE ON OVERALL CLASSIFICATION ACCURACY

Index	Original	After Change
RIVPACS	83	83
BRI-TC	77	89
IBI	70	76
BRI-MNDF	63	74
BQI	63	80
RBI	51	63

NEXT STEPS

- **Redefining a gold standard to be based on expert opinion**
  - Have recently given 30 new sites to the experts for their assessment
- **Continue with repeatability and gradient evaluation**

SCCWRP's SCIENTIFIC ACTIVITIES

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THREE LEVELS OF ASSESSMENT

- Reference condition
- Slight deviation from reference
- Moderate effect
- Severe effect

SAMPLING STATION ASSESSMENT CATEGORIES

- Unimpacted
- Likely unimpacted
- Inclusive
- Possibly impacted
- Likely impacted
- Clearly impacted

THREE LEVELS OF ASSESSMENT

- Individual LOE
  - Possibly merging multiple indicators
- Sampling station level
  - Merging MLOE
- Water body scale
  - Merging multiple sampling stations

CHEMISTRY: Reference

Toxicity

Benthos	Reference	Minor deviation	Moderate effect	Severe effect
Reference	Unimpacted	Unimpacted	Likely Unimpacted	Inconclusive
Minor deviation	Unimpacted	Likely Unimpacted	Possibly Impacted	Possibly Impacted
Moderate effect	Likely Unimpacted	Possibly Impacted	Possibly Impacted	Likely Impacted
Severe effect	Inconclusive	Possibly Impacted	Likely Impacted	Likely Impacted

INTEGRATION AT THE WATER BODY SCALE

- **Moves beyond sediment quality objectives into other programmatic areas**
  - NPDES permitting
  - 303d listing
  - Dredging
- **Stakeholder's Advisory Committee is developing implementation guidance for these programs**
  - We are assisting them with scientific information

REMAINING FRAMEWORK CHALLENGES

- **Strategy and guidance for working with imperfect information**
  - Incomplete data
  - Sites without assessment tools
- **Developing continuity with existing regulatory frameworks**
- **Identifying management actions without chemical specific criteria**
  - Chemical-specific guidelines
  - Sediment TIES

WHAT WE HAVEN'T YET TALKED ABOUT

- Developing the framework and selecting indicators for the other beneficial uses
- Develop methods manuals
  - Recommended collection/processing methods
- Conduct a statewide assessment
- I'd be glad to come back in the future as we finish this work and develop final recommendations